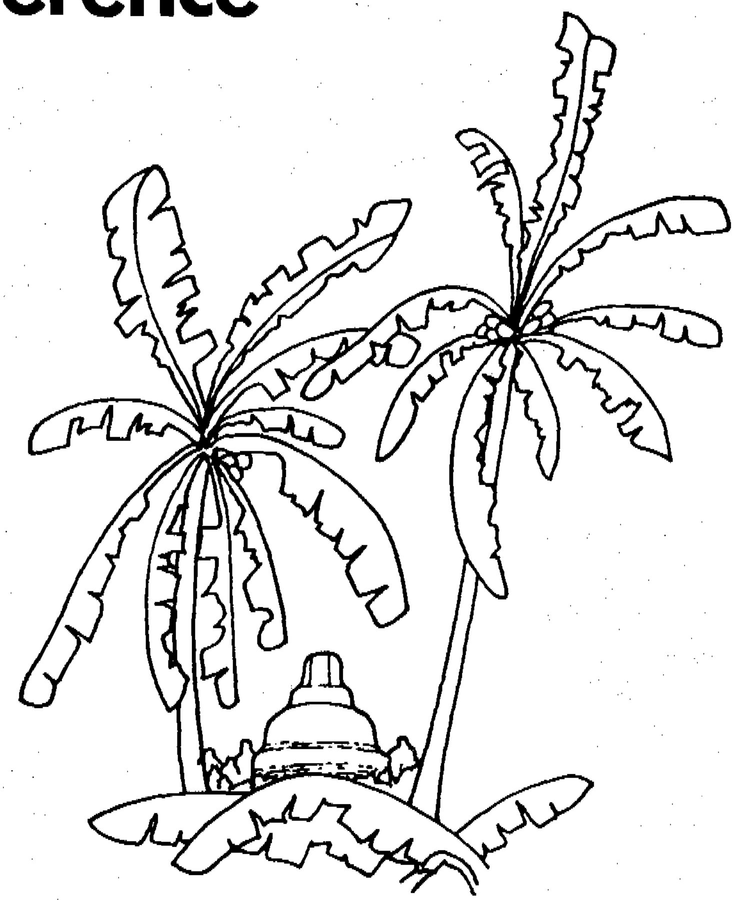
Water and waste engineering for developing countries

Loughborough University of Technology
Leicestershire England

10th WEDC Conference

WATER AND SANITATION IN ASIA AND THE PACIFIC



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10th WEDC Conference

Water and sanitation in Asia and the Pacific: Singapore: 1984

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ALL THE TALENTS

One of the distinguishing features of recent WEDC Conferences has been the wide range of subjects covered. This 10th Conference is no exception. Water and sanitation in developing countries involves much more than conventional engineering. I think this is one of the greatest attractions of our work. All kinds of talents need to be put into the job if it is to be successful.

During the Napoleonic Wars when things were going badly for the UK, Lord Grenville formed a government which became known as the 'Ministry of all the talents'. It only lasted just over a year and was not very successful in prosecuting the war - a good individual leader is best for winning battles! However, this Ministry of all the talents achieved one great thing - it made slave trading illegal on British ships half a century before slavery was abolished in the United States.

Water and sanitation require many talents. You doubtless notice this as you read the papers being presented here during the next three days. Very few of the papers are 'straight' engineering, although some have quite a large engineering component. Some of the papers have a science bias, for the treatment of water and wastewater often depends on chemical processes. The talents of the geologist are needed to get the best from our groundwater resources. Talents for dealing with economics and finance, with demography and epidemiology,with sociology and industrial relations, with regional planning and training - all these talents, and more, are needed for our work.

WOMEN'S TALENTS

It is good that so much attention is given at this Conference to the sociological aspects of water supply and sanitation because they are so important. I am glad that six of our authors are ladies. But six is not many out of a total of sixty-five authors. Even this paltry ten-per-cent is only possible because of the generous support of the Commonwealth Foundation, which sponsored three of these ladies.

As has so often been said, more than half the world's population is female and much more than half of the hard physical work of fetching and carrying water in developing countries falls to the lot of women and girls. We must use the talents of women and girls in planning and implementation of our projects and programmes.

THE DECADE

Nearly all of the work described in the papers is directly or indirectly connected with the International Drinking Water Supply and Sanitation Decade. It is now nearly four years since the launching of The Decade on 10 November 1980. Obviously most authors are 'on the same wavelength' as the Decade, although I was very disappointed to see that one author seems to be out of tune as he writes about the 'International Hydrological Decade'. Drinking water supply and sanitation is concerned with much, much more than hydrology. Hydrological information at its best can tell us how much water we can expect from a given source. At its worst hydrology is the delight of some 'academic' researchers throughout the world largely because it gives opportunities for stochastic and similar mathematical playthings.

The Decade is concerned with all aspects of drinking water supply and sanitation; with providing water for use in the homes of all the people who now have no access to safe water; with providing a least some adequate sanitation for those who now have to ease themselves in the fields of their farms, in the streets of their cities or wherever they can find some space to squat. Figures published at the start of the Decade showed that there are more people in the Third World who need sanitation than those who need water. It is therefore appropriate that we have a large group of papers which deal with low-cost sanitation. Many of those describe various forms of pour-flush latrine. They look similar and I hope the discussion will draw out their differences - the advantage of each compared with the others and of course their faults and limitations as well.

WATER AND SANITATION FOR THE POOR

Inevitably poverty is characteristic of most of the 1830 million people needing water supplies in the Decade and the 2400 million people needing sanitation. We have three papers dealing specifically with slums and others are concerned with the poor - the underprivileged of the rural and urban areas of Asia and the Pacific. There has been - there still is - a dislike of working for the poor amongst conventional professionals. Providing handpumps and low-cost household latrines lacks the glamour of more sophisticated engineering feats.

Here in this Chinese city it is appropriate that we should take heed of some of the sayings of Confucius. One of these was "When I was young we were very poor. That's probably why I can do so many different jobs now".

Low-cost simple technology is appropriate for poor people. Giving what cannot be afforded is often inappropriate. Confucius again said - "To go beyond is as wrong as to fall short".

The question of affordability is crucial to much of our work. I particularly like a question posed by Mr Nelson - a rhetorical question because he makes his own views clear. He asked "can we afford the extravagance of a cheap dam?". This question can be applied to other aspects of water supply and sanitation. Put another way we should ask ourselves "is the cheapest solution the least expensive?". Of course, there's nothing new about this - the international Banks often require us to include the cost of operation and maintenance in our feasibility studies, to consider the 'whole life' cost and so on. Engineers have always been concerned with cost.

I started this address by referring to the many talents needed to deal with water and sanitation in Asia and the Pacific, and said that this was one of the attractions of the work. The 5th WEDC Conference back in 1979 had 'Collaboration in Water and Waste Engineering' as its theme. Collaboration is important. Whatever our individual talents we must work with people who possess other talents. Whenever possible we need not ministries but 'teams of all the talents'.

However in most situations in which we work, especially in rural areas and amongst underprivileged urban communities, the team is just one person - maybe one of us! This one person has to combine all the talents.

It is this combination of activities which makes water and sanitation in developing countries such fascinating work. Confucius said "The wise find pleasure in water". All of us, whether we are wise or not, can derive pleasure and satisfaction in the use of the great variety of talents required for providing water supply and sanitation for other people - people who need them desperately. We are fortunate to have such interesting work.

This has a consequence for each one of us here at the Hilton International. Often when specialists attend other Conferences they give most attention to papers concerning their own specialisation. We who work for water and sanitation need to be multitalented people so I suggest we should take a special interest in those papers dealing with subjects we know little about.

10th WEDC Conference

Water and sanitation in Asia and the Pacific : Singapore : 1984

Design for effective implementation and efficient operation

N D Peiris, J S N Jones and D O Lloyd

1. INTRODUCTION

The design of water supply projects in developing countries must be related to the implementation resource constraints and to the operational requirements of the user. This paper discusses the practical approach to design and implementation philosophy with particular reference to treatment plant design and the Matara Water Supply Project in Sri Lanka.

The long term operational objectives of a water supply scheme must be to operate a supply system at minimum local and foreign expenditure, within levels of technical competence and to generate sufficient revenue to meet both operational and capital repayment costs. Design and implementation philososphy should reflect these objectives.

2 DESIGN PHILOSOPHY

2.1 Feasibility and Ranking of Options

Each project has its own unique source and demand centres, supply requirements, topographical features and particular problems. Having identified feasible supply systems based on alternative sources or conjunctive use, principal components need to be sized. Capital costs in both local and foreign currency together with operating costs for each option need to be estimated.

Ranking of options is normally undertaken on a purely financial comparison, but we would suggest ranking factors be extended to include:

- finance, both in foreign and local costs
- source reliability
- operations

The relative weightings given to these factors need to be considered for each project. Where projects are internally funded a greater weighting should be given to local costs rather than foreign costs; conversely where external funding is available a different weighting would apply.

Funding Agencies, particularly bilateral ones, are keen to provide external funds but not local and this distorts the "clean" ranking. There is a tendency to limit the availability of foreign exchange for plant and equipment which may not be entirely suitable for the design; this should be avoided.

Phased development of new projects in relation to demand growth projections needs to be carefully considered; very often extra system supply capacity is provided too early and the additional capital costs are reflected in higher unit water costs. Consideration could be given to smaller augmentation phases with the system base designed to achieve this objective.

The operational factor, which is subjective will depend on the number of components in the system, the level of technology and energy and chemical consumption. The reliability factor is also subjective and is based on both source and system reliability. How will the sources react to drought conditions? Will the supply system work in a power cut? Have standby generators been included? Are there alternative supply sources/systems if one fails for any reason? The overall ranking may be determined by a summation of the weighted rankings of these defined factors.

2.2 Design Philosophy

To achieve the defined objective the following principal criteria should be considered:

- straightforward system and process design
- a level of technology appropriate to the ability of local staff to operate and maintain
- minimum dependency on imported spares
- minimum energy costs and making the best use of gravity where possible
- minimum chemical requirements

These criteria are inter-related, but the overall philosophy is for straightforward, easy-to-maintain, minimum energy systems. Means to simplify process design are discussed in the next section.

It is important to assess the level of competence of operatives and maintenance staff and the degree of complexity of plant which they operate. Feedback from existing supply systems is important and can show the drawbacks of earlier designs. Keep design simple, use basic well tried and robust pumping systems, avoid complex telemetry and hydraulic control systems, complicated pumps and mechanical plant. Use simple electrode and high pressure cut-outs for pump operation; remember labour is relatively inexpensive and provides local employment and security. Often plant breaks down and cannot be repaired because of few qualified maintenance staff.

Reliance on imported spares should be minimised through stocking of sufficient spares at initial purchase. Individual spares ordered at a later date tend to be more expensive. Local enterprise should be encouraged to manufacture spares, perhaps on licence from the supplier to meet these needs more economically.

Energy costs tend to inflate at a greater rate than normal inflation, and emphasis should be given to energy efficient designs. Operational ranking should favour minimum pumping schemes; therefore, wherever possible use should be made of gravity systems, perhaps at higher initial cost but showing long term advantages. Solar pumping may be a feasible alternative for small supplies.

Chemical requirements are dependent upon process design. In developing countries chemicals tend to be expensive and sometimes difficult to obtain. KEEP IT SIMPLE should be the "motto" by using commonly available chemicals - Alum, lime etc and avoid polyelectrolytes and similar compounds.

2.3 Water Treatment

By way of example this design philosophy is related to a typical medium-sized new water treatment plant at Matara, Sri Lanka. Here, careful thought was given in defining process and performance requirements to achieve a straightforward treatment system. Whilst process design was the responsibility of a treatment plant supplier, the performance specification was specific and detailed, applying the design philosophy to treatment units. A schematic arrangement is shown in figure 1.

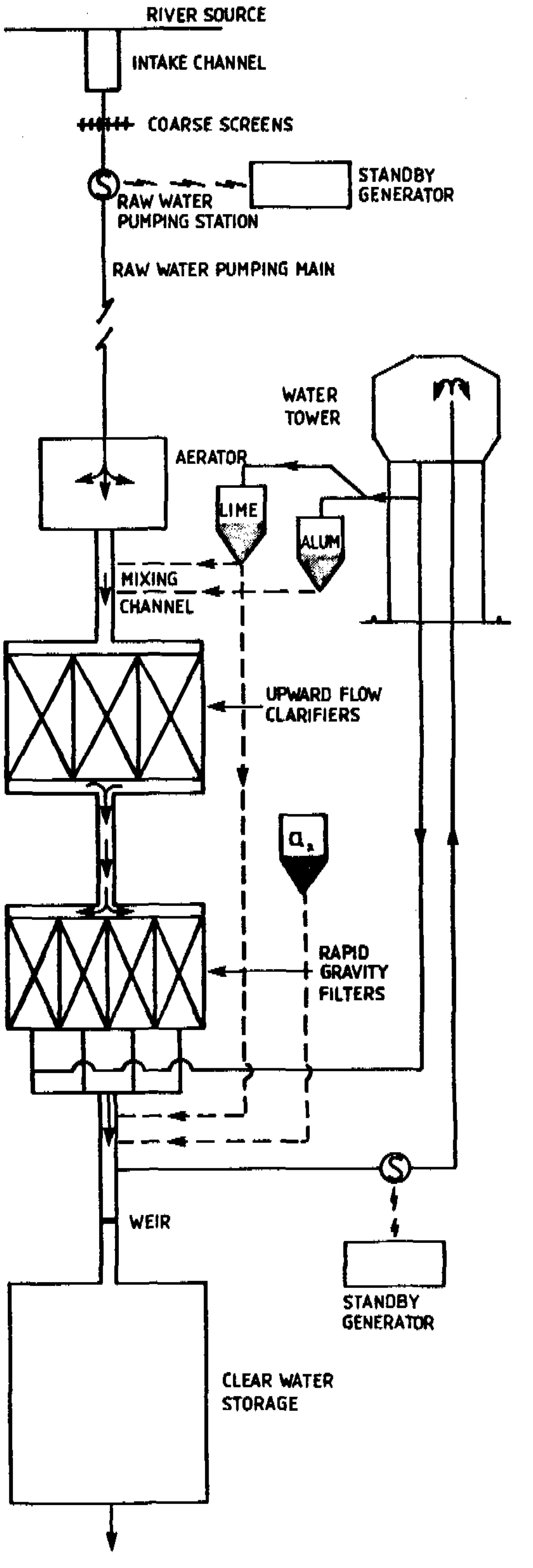

FIGURE 1 - SCHEMATIC ARRANGEMENT OF NEW WATER TREATMENT WORKS AT MATARA

Aeration

- important for removal of taste and the oxidation of iron. a simple process using side weirs and with no moving parts, using local materials.

Chemical Mixing

- Hydraulic mixing in the inlet channel using baffles; no flash mixers were required and no energy input.

Sedimentation

- Hopper-bottom upward-flow clarifers with no mechanical equipment were used and no power needs. Only pipework and sludge concentrators were required. Mechanical scrapers in horizontal or circular tanks were avoided as they are difficult to install correctly and have a relatively short life; external funds may not be available for replacement. Avoid pulsators again because of electrical and mechanical plant, design life and maintenance problems; however, fixed inclined plates may assist floculation in some instances.

Chemicals

- Low cost chemicals ie alum and lime are used. Polyelectrolytes are avoided. Gravity alum dosing is carried out after mixing in the upper floor of the chemical house. However lime needs to be kept in suspension by pumping.

Filters

- Slow sand filters were considered because of low maintenance, low technology and no power requirements. However, this was not practical because of the greater land requirements.

  Rapid gravity filtration was proposed, with the controls kept simple - removal of all hydraulic control systems - removal of all flow controllers - simplification of the control system to a butterfly outlet control valve with mechanical linkages and manual start-up and use of manual power for all valving. There is a need for airblowers but these are basic small units and should present few mechanical problems and low energy needs.

  Savings may be achieved by eliminating large capacity backwash pumps and using an elevated tank instead; this could be filled using smaller duty pumps operating over longer periods. The supply could also be made available for chemical mixing and local uses. Whilst the initial local capital costs may be higher, the savings in foreign exchange on larger pumps and associated equipment and its maintenance could be substantial.

Chlorination

- There is a need to install reliable and well tried equipment which is available. If the supply of gaseous chlorine is unreliable an alternative dosing system using chloros powder should be incorporated at the design stage and not left to improvisation by the works superintendent later. Remember this is an essential treatment process.

Flowmeters & Controls

- Avoid complex control system if you can! Pressure differential flowmeters are preferred because of minimum maintenance within the pipe system but basic maintenance of the recorder/indicator is still required.

To summarise, the philosophy on water treatment plant design is to keep all the processes and equipment straighforward and easily manageable. One should not be influenced by bilateral funding agencies wanting to make their scheme a "showpiece" for the latest technology - there may be no cost to the user at commissioning but when things go wrong, as inevitably they do, it could be expensive to rectify.

3 REHABILITATION

Rehabilitation of existing supply systems and treatment works is most cost effective as both the long term life of the plant is extended and also large capital expenditure is deferred. In the existing Nadugala treatment works at Matara, the throughput of the works was raised from 5000 cu m/day to 9000 cu m/day as a result of minor refurbishment works.

The three existing hopper-bottom type clarifiers were originally arranged on a primary/secondary basis with a maximum upward flowrate of 3.7 m/hr. The clarifiers were reconnected in parallel and the design flowrate of 2.1 m/h was able to pass the 9000 cu m/day. There was little difficulty in settling these flows.

In the rapid gravity filters, the sand was replaced and the flow controllers and instrumentation refurbished to accommodate a new loading of 5m/h. In the course of refurbishment, the opportunity was taken to simplify filter controls and ease future maintenance and spares problems. Rate of flow control is now achieved with new butterfly valves with a free outlet above sand bed level. This eliminated expensive replacement of rate-of-flow controllers and associated hydraulic systems.

Improvements to the chlorination system were undertaken and refurbishment of some items of the chemical dosing systems. A new raw water pump was installed at the inlet and because of changed pump duties, new clear water pumps were installed. Additional lime dosing was undertaken to raise the pH.

Rehabilitation may also be applied to trunk and distribution systems through

- leak detection and repair
- relining of old pipelines

The former can be cost effective in both saving treated water as well as possible deferment of future capital expenditure, however, the costs and benefits are unique to each project and an assessment of leakage, detection and repair costs against savings must be undertaken to justify the approach.

4. IMPLEMENTATION

4.1 Objectives

The overall objective of the implementation stage is to complete and commission the project within the given restraints of time, and financial, technical and human resources. To achieve this objective early consideration and planning is required at an early stage in the Project Appraisal.

4.2 Criteria

The principal criteria to be considered for effective implementation include:

- overall programme and resource balancing
- procurement of materials and equipment
- construction by contractor or direct labour
- commissioning and staff training

in addition to the establishment of a project team within the implementing authority. An efficient team of client/consultant is required for overall management from inception to commissioning; it is important to provide this continuity of staffing of both client and consultant for the efficient and timely completion of the project.

4.3 Overall programme and resource balancing

There are many factors affecting overall programme. Completion dates are sometimes determined by political needs; it is often necessary to phase completion of certain sections of the project to meet interim needs and show early financial returns. The programme will depend on financial resources, either offshore or local, being made available. Sometimes government departments/or funding agencies towards the end of the financial year have surplus money available which they cannot carry forward. Hence the need for the next phase design or document to be ready on the shelf!

In medium to large size projects, the impact of construction work on existing limited human and financial resources can be significant and market costs of labour and local materials could rise with detrimental effects on other local projects. It is therefore important to consider means of reducing this impact and balance resource requirements.

4.4 Procurement of materials and equipment

The procurement of materials and equipment requires a long lead time within the project and often takes even longer than planned. It is therefore important to:

- establish procedures and clear lines of communication with all concerned;
- identify at an early stage actual material/equipment requirements and related supply contracts
- closely co-ordinate all stages from appointment of supplier to equipment inspection, shipping and delivery to user.

Procedures need to be established at an early stage between Funding Agency, Implementing Authority and the Designers, whether they be Consultants or in-house Designers. Lines of communication need to be clearly defined and KEPT SIMPLE, something which is difficult to achieve under present procedures which tend to be lengthy, complex and can significantly delay the completion of the work and hence benefits to the users.

There may be scope for a Procurement Manager, who may indeed be the Designer or Consulting Engineer appointed by the Funding Agency (or agencies) who would:

- procure equipment under defined (and simplified) procedures;
- undertake inspection services, and organise shipping and insurance;
- arrange clearance and delivery to site; and
- manage a procurement fund under specific budget targets.

There is a need to identify, under a shopping list, specific requirements for pipes, pumps, electrical equipment, treatment plant and ancillary equipment, prepare tender "packages" and prequalify suppliers. In addition, feedback from technical resource analysis will define requirements for small tools, workshop equipment and larger plant equipment such as cranes (do not forget pipes need to be lifted!), but care is required to keep such equipment simple and easy to maintain.

As examples, ductile iron pipes may be cut just as easily, if a little longer, with a hacksaw then with a power cutter; a cable operated crane is preferable to one with hydraulic systems.

Requirements for spare parts need to be carefully considered and one should not rely completely on manufacturer's recommendations as they often leave important items out.

Some examples of problems are given here; many are commonsense, but often are overlooked:

- despatch the pipe jointing and handling equipment with the first shipment; similarly ship pipe fittings with associated straight pipes together. Invariably pipes are manufactured quicker than fittings and manufacturers are keen to be paid on delivery!

- Include sufficient spare items to make up for losses and damage.

- do not send expensive tools which are difficult and expensive to maintain.

- Ship in containers where possible, for greater security, especially for smaller items.

- Many difficulties arise from missing and incorrect Shipping Documents; careful checking and despatch is required.

- clear lines of communication at the receiver's end, through Customs, Port Officials, Government Departments and Implementing Agencies.

- give careful thought to local transport, handling, unloading and storing, particularly with delicate items - don't store PVC pipes in the sun!

4.5 Construction

Construction may be undertaken by international or local contractors or by direct labour depnding upon the size of the work, its complexity and funding arrangements.

At the design stage, careful thought needs to be given to how the structures are to be built, the type of materials to be used, the temporary works construction requirements and the complexity of the works. To keep costs down, encourage the use of local contractors, giving employment to local artisans. Detailed designs need to be carefully thought out, be kept simple and easy to construct. This does not mean that construction standards be relaxed; good concrete can be made with close inspection using volume batching, small mixer and traditional placing methods.

There is a need to develop and improve construction techniques, particularly in pipe laying and testing and the role of supervising engineer is to assist and guide as well as supervise - the conventional engineer/contractor relationship may be relaxed.

Very often local contractors have a limited financial base and delayed payments by clients have a marked effect on cash flow and hence construction progress is affected. Whilst close financial control is required for all contracts, measures should be taken to help contractors with their cash flow - it all assists in timely completion.

Direct labour works often have advantages where the work is closely related to existing supply systems, difficult to measure is disjointed or labour intensive; for example plumbing for house connections, modifications to existing treatment plants and small diameter pipe-laying; sometimes there is political motivation for direct labour works.

4.6 Commissioning and Training

Both commissioning and training are essential elements in the successful implementation of a project and consideration needs to be given at design stage to the identification of staff requirements for operation and maintenance, definition of job descriptions and training requirements. It is important here to get feedback from similar earlier projects to see where they were successful and where they were less so. Operating staff should be involved during plant installation to become acquainted with all the equipment and during commissioning to be able to effectively operate the works.

5 SUMMARY

The overall objective of a successful and timely completion to a new project should not be overlooked because of the mechanics of implementation.

To achieve this objective requires careful planning and design at an early stage in the Project to include:

- straightforward designs for ease of operation
- correct level of technology
- minimising energy requirements and chemical needs
- reducing dependancy on imported spare parts

but do not forget rehabilitation.

REFERENCE

Peiris N D and Jones J N S. Matara Water Supply Project in Sri Lanka. AQUA Vol 1 1984 - Journal of the International Water Supply Association

10th WEDC Conference

Water and sanitation in Asia and the Pacific: Singapore: 1984

Leakage in municipal water supply system: a case study in Nepal

Dr B N Lohani and T Tashi

INTRODUCTION

Development of New Sources

A rising demand for potable water is exerted by rapid urban growth, population increase and an increasing per capita demand associated with affluence. Thus, municipal water agencies struggle to meet the increased demand while a large percentage of water is not accounted for; it is lost. So far, specially in developing countries, the tendency to overcome water shortage has been to opt for capital intensive new systems. It is hardly realized that the new systems too have their share of water losses and that the emphasis on new projects have led to a deterioration of water quality and an increase in losses due to negligence of operation and maintenance of the existing systems. Kuala Lumpur in Malaysia is an example in hand where losses increased from 18% in 1979 to 23% in 1982" (ref. 1)".

Water Losses and Conservation

As pointed out, a part of the treated water supplied is lost in the system. The main causes of water losses have been enumerated as:

(i) losses at reservoirs and treatment plants due to evaporation, seepage and/or overflows,
(ii) inaccurate meters: over-and/or under-registration of master meters, domestic meters, industrial meters and commercial meters,
(iii) unknown water connections,
(iv) known but unmetered connections,
(v) underground leakage of mains and services including joints and
(vi) house wastage: wastage on the consumers' side including wastage at public standposts.

Therefore, another option for improving the useful supply is to control the losses. This becomes more attractive as enlarging the sources of supply and the plant capacity are increasingly more difficult and expensive. Studies in the developed countries show that conservation through a leak detection and repair programme brings about direct money savings, longer range savings from deferred capital investment and savings in production by reducing the cost of power and chemicals. Water conservation is often more cost effective than investment in additional capacity. Thus, a conservation programme could alleviate the poor condition of water supplies in Asia. The amount saved and the level of allowable losses is utility specific. Hence, after presenting the Asian water supply situation, this paper describes the pilot plant study carried out to quantify the losses and determine the economic level of allowable losses in the study area in Nepal.

THE ASIAN SCENE

Most Asian water systems lack a well controlled distribution system with effective man-

Table 1 - Total Losses and Their Distribution in Asian Cities

S.N.	City/Country	% of Total Losses	Distribution of Losses as a % of Total Losses	
1 a.	Dhaka, Bangladesh	45% of total capacity	open street hydrants	50%
b.	Khulna, Bangladesh	60%-40%	joint leaks	30%
2	Hong Kong	30% of law water input	illegal tapping of standposts	5%
3 a.	Delhi, India	35% of production	public hydrants	10 mgd
			treatment plants	5-6%
			transmission main and service reservoir	3-4%
			distribution pipes	20-25%
b.	Bombay, India	25-30% of total supply	consumers' connection of G.I. pipes	60-70% of leakage
4	West Java, Indonesia	40%-50%	leakage from pipes	71.2%
			metering error	27.8%
			other causes	1.0%
5	Korea	36.59%	service loss	15.00%
			distribution pipe leakage	9.00%
			loss through joints, valves etc.	12.59%
6	Metro-Manila, Philippines	51% (1982)	leakage	25%
		49% (1981)	under-registration	8%
		47% (1980)	illegal use	6%
		28.5% (1954)	public use	2%
			other causes	1%
7	Greater Colombo, Srilanka	30%	leakage	20%
			squanderage	10%
			1/3 of the leakage occurs on the consumers' side while system leakage is very low.	

agement. In general, the whole populace of a city is not served nor is the water demand of those served fully met. Despite rampant water shortages, heavy losses occur in the system. Table 1 presents the total losses and their distribution in some cities. The following addition gives a cursory review of the Asian scene.

Malaysia: The 15% or less unaccounted-for water in Malaysia increased to a shift to more development works which led to negligence of system maintenance. Now the overall losses in most districts range between 20-30%.

Kathmandu, Nepal: Binnie and Partners of London estimated that the gross leakage and wastage as 75% of the total supply. Engineering Science Inc. estimates a lower rate, 65% for 1980, assuming that metering has reduced the gross wastage.

Faisalabad, Pakistan: The existing system serves only 60% of the population. Experts estimate the unaccounted-for water at 50%.

Hyderabad, Pakistan: Hyderabad still faces 57% water scarcity. By repairing mains and reducing the length of service pipes, the 1975 estimate of 38% losses has been reduced to 30%.

Singapore: 99.5% of the main island is supplied with drinking water. As water consumption grows at 7% per annum, Singapore carries out a regular leak detection test on all mains 500 mm and below in order to conserve water to meet the future demand.

Bangkok, Thailand: By replacing old pipes and reducing the 60 types of meters used to 10 types Bangkok claims to have reduced its water losses from 65% (1972) to 49% (1975).

In addition, insufficient covering of buried pipes, use of sub-standard materials, pilferage, non-removal of old useless pipes which are replaced by new ones; inoperative and faulty valves, poor equipment like leaking pumps and poor workmanship all coupled with inadequate, intermittent supplies and a flat rate pricing policy has led to gross water losses in Asian countries. To control the losses, utilities encounter a lot of obstacles. There is a lack of good records, a lack of drawings, a lack of trained maintenance crew, a lack of incentives for employees, a lack of bye-laws, a lack of meters and necessary equipment and above all a limitation of funds. Still efforts to reduce losses are being made. Water agencies in Singapore, Manila and a few other affluent cities have seriously planned leak detection programmes. Through pilot plant studies a few cities have determined the quantity and distribution of losses; but the economic level of allowable losses have not been studied.

3. THE STUDY AREA

Background

The study area lies in Lalitpur District in Kathmandu Valley in Nepal. Three schemes: Doodh Pokhari (1896), Sundarighat (1971) and Chapagaon (1976-77, a dual purpose scheme), serve the district. The water Supply and Sewerage Board through its Jawalakhel branch is responsible for the water supply of Lalitpur.

Complaints of contamination of the supplied water and the case of isolation of the network were the prime reasons for choosing Jwagal and Chakupat as the study area.

Characteristics

Location, Population and Housing: A door to door survey revealed that 598 people live in 106 families in the study area located nearby Bagmati River (Fig. 1). The area is mainly residential with Chakupat representing relatively more affluent residences. Table 2 summarizes the detailed characteristics.

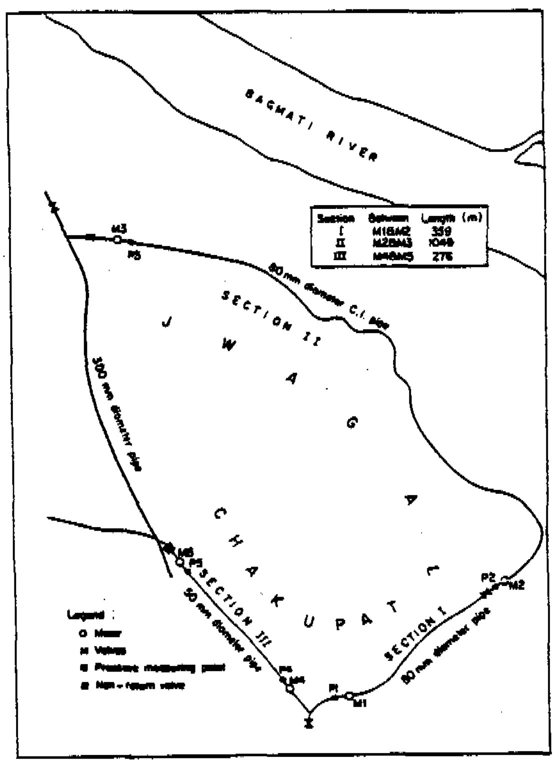

Fig. 1 - The Study Area - Pipes and Valves

Water Supply: The supply is intermittent with 2.5 hours of supply in the mornings and the evenings. Even when the valve 'X' (Fig. 1) is open Jwagal particularly, being a lowlying area, receives water for a few hours during the off-supply period. For the purpose of the study the five year old 80 mm diameter main was divided into sections I and II while the very old 50 mm main formed section III.

Table 2 - Characteristics of the Study Area

	Description	Section I	Section II	Section III
1	Area	Chakupat Jwagal	Jwagal	Chakupat
2	Diameter of C.I. pipe (mm)	80	80	50
3	Age of pipes (year)	5	5	old
4	Length of pipe (m)	359	1049	276
5	No. of joints	60	175	46
6	Total No. of connections	22	62	21
7	No. of private connections	22	60	21
8	No. of public standposts	-	2	-
9	Population served	138	370	90
10	No. of metered connections	19	48	20
11	No. of functioning meters	13	20	8
12	No. of connections not metered	3	12	1
13	No. of underground tanks	3	1	12
14	No. of overhead tanks	7	5	11
15	No. of outside taps	5	45	17
16	No. of showers	7	7	23
17	No. of bath-tubs	7	1	15
18	No. of sinks	9	6	11

Objectives of the Study

The primary objective of the study was to quantify water losses and determine the economic level of allowable losses for the study area. A secondary objective was to assess the wastage while filling pitchers and that through dripping taps and to compare these with the losses in the distribution system.

Methodology

Field Investigation: For the determination of losses in the distribution system, all the five installed integrating type master meters were read a maximum of six times a day: at the start and the end of the supply periods in the morning and the evening and twice between 2 a.m. and 4 a.m. at night when the area is supplied by the overflow of the reservoir. The corresponding residual heads at the meter points, P1, P2, P3, P4 and P5 (Fig. 1), were also noted for about three weeks in January unless interrupted by leakage or blockage of meters. To find out the metered consumption simultaneous readings of the domestic meters were taken during the supply periods.

The wastage while filling a pitcher for metered connections was assessed by noting the time and meter readings before filling, after the vessel is filled and after it is removed from under the tap. The difference among these readings gave the results. For unmetered connections, the overflow was trapped in a calibrated bucket.

The rate of leakage through dripping taps was measured in a measuring cylinder for a specified time.

Analysis: A mass balance of the flows and consumption gives the losses. The unmetered consumption is assumed to be 30% more than the measured metered consumption as the water use is primarily domestic "(ref. 3)".

As a complete leak detection and repair programme was beyond the time and resources allocated for the study, a preliminary estimate of the economic level of losses has been made. The analysis consists of finding the total cost: cost of the study plus the cost of repairing joints and replacing pipes and calculating the benefits obtained therefrom in terms of tariff. The cost of repairing joints are calculated by using the current costs for repairing joints by a passive leak control method. The savings obtained by controlling losses are computed using the prevalent tariff rates which cover the operational costs only. As far as possible, current rates have been used.

Results and discussions

Quantification of Losses: Table 3 sums up the total losses as a percentage of the inflow in sections I, II, and III. During the supply hours the loss in the 80 mm pipe is 52.29% and that in the 50 mm pipe is 62.13%. This is as expected because the smaller pipe is much older. Heavy losses in the newer pipes could be due to poor workmanship in laying them. The 32.29% loss in section II as compared to the 19.08% loss in section I during the supply hours is reasonable as the pressure in section II is more because of its elevation.

The night time results give a different picture. The 81.05% losses in section I and II is much greater than the 13.81% losses in section III. This discrepancy may have crept in as the night consumption could not be measured due to practical difficulties. Further, the high usage in section III could be because underground storage tanks were being filled and allowed to overflow.

Table 3 - Percentage Water Losses (Intermittent Supply)

Section	Description	Morning l/h	Evening l/h	Total l/h	Night l/h
I	Supply rate	3,156.07	3,206.80	6,362.8	1,901.92
	Consumption Rate	1,835.76	1,113.43	2,949.1	332.95
	Water Loss	1,302.31	1,807.80	3,168.1	1,568.97
	Total Supply in Line	8,791.04	7,211.66	16,002.7	4,830.75
	Loss (% of Total Supply)	15.02	25.62	19.8	32.48
II	Supply Rate in Section	4,032.65	3,515.78	7,548.4	2,553.79
	Consumption Rate	1,709.43	639.51	2,348.9	207.33
	Water Loss	2,323.22	2,876.27	5,199.4	2,346.46
	Total Supply in Line	8,791.04	7,211.66	16,002.7	4,830.75
	Loss (% of Total Supply)	26.43	39.88	32.4	48.57
I + II	Total Loss in 80 mm Main			52.2	81.05
III	Supply Rate in Section	5,502.82	4,451.02	9,953.8	1,607.36
	Consumption Rate	1,571.32	1,522.96	3,094.2	1,052.78
	Water Loss	3,931.50	2,928.06	6,859.5	554.58
	Total Supply in Line	5,502.82	5,502.82	11,005.6	4,075.46
	Loss (% of Total Supply)	71.45	53.21	62.3	13.61

Table 4 presents the losses expressed in terms of per meter length and per capita. The 62.13 litre/meter loss in section III as opposed to the 14.83 litre/meter loss in the other pipe shows the effect of pipe age on losses. This is reaffirmed by the per capita losses. Judging from the excessively high, 190.54 lpcd (5h), loss in in section III, the pipeline requires replacement.

Table 5, comparing the losses in Asian countries, shows that the losses in the study area speak of Asian conditions.

Cost of Water Loss: By allowing 56.3% of water losses in the study area a tariff of

NRs 61400 (£1 = NRs 23.46, Jan. 1984) is lost per annum. Table 6 presents the percentage reduction of losses and the corresponding saving. It is found that by replacing old pipes and repairing joints both equivalent to 458 joints or 111 meter length of pipes, a trade-off is reached when the losses are reduced by 23.36% to 32.94%. The cost at this point is NRs 36000. Hence the study reaffirms the advantage of loss control measures. The benefits are suppressed in this case due to the low tariff rates.

Table 4 - Water Losses per Meter of Pipe and per Capita

Section	Description	Morning	Evening	Total
I	Water loss (ℓ/h)	1,320.31	1,847.80	3,150.11
	Total loss (ℓ)	3,255.78	4,619.50	7,875.28
	Total pipe length (m)	359.00	359.00	359.00
	Loss/meter length	9.07	12.87	21.94
	Population Served	138.00	138.00	138.00
	Loss/capital (lpcd)	23.59	33.47	57.07
II	Water loss (ℓ/h)	2,323.22	2,876.27	5,199.40
	Total loss (ℓ)	5,808.05	7,190.68	12,998.50
	Total pipe length (m)	1,049.00	1,049.00	1,049.00
	Loss/meter length	5.54	6.85	12.39
	Population Served	370.00	370.00	370.00
	Loss/capita (lpcd)	15.70	19.43	35.13
Total:	Loss/meter length	6.44	8.39	14.83
	Loss/capita (lpcd)	17.84	23.25	35.13
III	Water loss (ℓ/h)	3,931.50	2,928.06	6,859.56
	Total loss (ℓ)	9,828.75	7,320.15	17,148.90
	Total pipe length (m)	276.00	276.00	276.00
	Loss/meter. length	35.61	26.52	26.13
	Population Served	90.00	90.00	90.00
	Loss/capital (lpcd)	109.21	81.34	190.54

*In a day water is supplied for 5 hours.

Table 5 - Comparison of Water Losses in this Region

No.	City/Country	% Losses
1	Dhaka/Bangladesh	45
2	Khulna/Bangladesh	40
3	Hong Kong	30
4	Indonesia	40-50
5	Korea	36.59
6	Malaysia	20-30
7	Delhi/India	35
8	Bombay/India	25-30
9	Pakistan	50
10	Metro Manila	51
11	Greater Colombo	30
12	Thailand	49
13	The Study Area	56.3

Table 6 - Percentage Loss Reduction and Savings

Sr. No.	% Losses	Cost NRs	% Reduction	Savings NRs	Cumulative % Reduction	Cumulative Savings
1	56.3	61400	-	-	-	-
2	50.0	54500	6.3	6900	6.3	6900
3	45.0	49000	5.0	5500	11.3	12400
4	40.0	43600	5.0	5400	16.3	17800
5	85.0	38100	5.0	5500	21.3	23300
6	30.0	32700	5.0	5400	26.3	28700
7	25.0	27200	5.0	5500	31.3	34200
8	20.0	21800	5.0	5400	36.3	39600

*α - 1 = NRs 23.46 January, 1984

Comparison of Wastage and Total Losses: The average value of wastage while filling pitchers for metered and unmetered connections are respectively 0.54 lps and 0.45 lps. The average wastage per tap in sections I and II was 7.041/h while in section III it was 8.48 1/h. Table 7 compares these wastage and the total losses. Compared to the total losses in the study area (56.3%), the wastage while filling pitchers (1.48%) and that through dripping taps (1.11%) are neglible. However, a water conservation programme could begin by educating the people to control such wastages.

Table 7 - Comparison of Total Losses and Wastage (Intermittent Supply)

Sr. No.	Description	Quantity ℓ/h	% of Supply
1	80 mm dia. main		
	Total supply	16002.700	-
	Total losses	8367.600	52.29
	Wastage thro' dripping taps	190.914	1.19
2	50 mm dia. main		
	Total supply	11005.640	-
	Total losses	6859.560	62.33
	Wastage thro' dripping taps	110.190	1.00
3	The Project Area (50 mm and 80 mm dia. mains)		
	Total supply	27008.340	-
	Total losses	15227.240	56.38
	Wastage thro' dripping taps	301.104	1.11
	Wastage while filling pitchers	339.720	1.48

CONCLUSION

The study shows that a leakage control programme can be conducted by isolating an area into small zones. This is useful for developing countries with limited funds. To arrive at the feasibility of such a programme a rapid assessment of the economic level as presented here can be conducted. However, such an approach is recommended for extreme cases where a leak detection and repair programme cannot be executed and that too it must be used with extreme caution.

The study further shows that for conditions as encountered in the study area, the minimum night flow is not appropriate though it is used successfully for continuous supplies.

Cities faced with water shortages can start a conservation programme right at the consumer's tap as this costs the utility nothing.

In summary, it is concluded that a leakage control programme by isolating small areas and proceeding systematically will conserve water without calling for large finances.

REFERENCES

1. ADB REGIONAL SEMIAR, Control of Water Supply Distribution System. Papers presented by Participants and Resource Sepakers at the ADB Seminar held in Singapore on Feb. 8-11, 1983. (Seminar Papers)

2. RENSHAW Edward F. Conserving Water through Pricing. Journal AWWA, 1981, Vol. 73, No. 3, 144-149 (Article from Journal)

3. MINTON Gray R. et al. Developing Conservation Program Tailored to Area Need. Journal AWWA, 1979, Vol. 71, No. 9, 486-496. (Article from Journal)

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Community organisation in rural waterworks management

G E Nepomuceno

RATIONALE

What is a "community organization?" It is a group of people belonging to a defined geographic area who have banded together to pursue a common interest or objective. For the purpose of this paper, this definition has three (3) essential elements, namely:

A. the people belong to a defined geographic area, which is the community;

B. they have banded together, or were caused to band together or form a group; and

C. they pursue a common objective, or attempt to achieve an identified set of goals.

In most cases, a community organization is not the ultimate objective, but the means to realizing a pre-determined aim. It is invariably viewed by agencies involved in development work as a technique for attaining desired socio-economic changes. It is the entry point in introducing a new project to the people; it is the forum for a new training program in the community.

GOVERNMENT SPONSORSHIP

Government agencies operating in the rural areas organize residents of communities, as part of their strategies in program implementation. From the late 1940s to the mid-1970s the various agencies have formed different rural organizations that participated in activities that ranged in purpose from sanitation to cooperatives. In most cases, these organizations were provided goals-related trainings, and many of these ended when the agency concerned terminated its program. The Philippine countryside, nonetheless gained a vast experience in community organization parts of which were successful and others, failures.

FAILURES

In order to know the value of community organization as an institution,it shall be necessary to assess the factors that contribute to failure of such organizations. When the Philippine cooperatives movement was initialed by the government, several cooperatives grew and went on to administer training activities, transportation enterprises, and other successful businesses, like rural banking. However, many other cooperative societies weakened and eventually disintegrated into oblivion.

Some of the notable factors that lead to the failure of community organizations are the following: A. lack of understanding, by members, of the group's objectives, their roles and responsibilities; B. lack of activities that attract members' interests; C. lack of funds; and D. lack of government support, in terms of incentives. If these factors could be overcome, then community organization could succeed.

WATERWORKS MANAGEMENT

In the 25 years since the early 1950s that rural drinking water supply projects have been undertaken in the Philippines, no effective approach to management and maintenance was found. No government, it seems, can afford to appropriate funds annually for waterworks maintenance, although it has always been the tendency of government to spend money for new facilities. The fact, however, is that without proper management, no waterworks project can continue to provide efficient service beyond 3 to 5 years.

Waterworks management, therefore, is a strategy that allows a drinking water supply facility to provide efficient service to the community concerned, at the least cost. In the Philippine rural areas, or in communities with population of less than 20,000, drinking water supply projects today are operated and managed by associations, composed of the members of the communities who are users of the water systems.

COMMUNITY PARTICIPATION

The organization of the waterworks association, within the universally accepted philosophy called "community participation". Adhering to this truism, in implementing the development programs of government, water supply included, community involvement became a necessary element.

In the mid-1950s, rural residents participated in waterworks projects by providing free labor and locally available materials. In several cases, however, the national government shouldered the total project costs. These facilities were left in the care of either the municipal or the village (barangay) government. In the case of the municipal government, the officials hired personnel to run the systems, while the village waterworks were operated by the local official themselves.

In almost all cases, the municipal governments lost money on their waterworks projects, in view of the following reasons: A. the hired personnel are either untrained or insufficientyly trained; B. overstaffing (with political appointees, in many instances); C. inefficient billing and collection program; and D. inefficient budgeting and fiscal management. In several cases, because local officials are politician, they avoided setting the appropriate water fees. Many such waterworks facilities eventually went into disrepair, or became virtually unserviceable and ineffective.

Of the water supply projects implemented by the government in the rural areas since the early 1950s, only about five per cent (5%) remained serviceable as of 1978. Majority of the facilities failed because of the following reasons: A. inefficient operation and management; and B. inability to raise funds for maintenance.

This experience illustrate the inadequacy of local political units in the operation and management of water supply projects. A voluntary or non-governmental entity could be trained and instituted, principally to operate a waterworks project.

FACTORS FOR SUCCESS

A community organization can become strong and successful, if the factors that contribute to its failure, can be overcome. Such group, formalized into a nonprofit corporation, can be an effective operator of a water supply project.

When the Philippine rural water resource development efforts was envigorated, it was declared as a policy that associations composed of water users shall be organized, to own and manage drinking water supply projects. These associations shall be duly registered with the appropriate agency.

In January, 1980, through Executive Order No. 577, it became a requirement to organize the heads of families within the service area of a rural water supply project into a Rural Waterworks Association. In February, 1983, Executive Order No. 869 renamed this organization the Rural Waterworks and Sanitation Association (RWSA).

Among the techniques to be employed in the formation of the RWSAs are the following:

A. acquainting the members with the aims of the association, through a series of training activities, as well as the relevant previleges and duties;

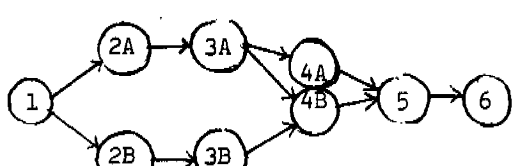
B. installing a technically sound facility that will provide benefits to residents at the least cost, and be within the community's capability to maintain;

C. encouragement of the adoption of a fiscal management strategy and a billing and collection program that will provide funds for the operation of the facility; and

D. sustained government support, in terms of incentives and provision of technical assistance.

ORGANIZATION PROCEDURE

The organization of the RWSA starts after the community, where the waterworks project shall be installed, has been identified. Its officers are given the necessary skills, through trainings, and prepared for the management of the water supply project. Below is chart showing the sequence of techniques in the implementation of a rural drinking water supply project.



LEGEND: 1. -Identify; 2A. -Training and Formation; 2b. -Design and Estimate; 3A. -Prepare the organization; 3B. -Install; 4A. -Amortise; 4B. -Operate; 5. -Evaluate; and 6. -Expand.

After the project locale has been identified and selected, the engineering unit concerned shall prepare the infrastructure design and cost estimates, while the training or outreach unit shall conduct the training of the community and the formation of the association. While the waterworks system is being constructed, the association shall be prepared for eventual ownership and management of the system. Upon completion of the project, this is turned over to the RWSA; whereupon, if the project is financed by a loan (In the Philippines, virtually all water supply projects are funded by foreign loans.), the association pay amortization, at the same time that it is operating the project, to the agency responsible for the construction of such project. Evaluation of the project is made after a predetermined number of years, and the facility may be expanded according to the feasibility for doing so as perceived by the association.

The RWSA has virtually all the means at its disposal to manage a drinking water supply facility and operate it successfully. The law has provided the means by which the RWSA shall acquire legal personality. When the water system, is conceptualized and designed, a minimum monthly water fee is determined, taking into consideration the diverse attendant operating costs, like amortization, reserves, repairs, salaries, electric bills, and others. The RWSA may raise the monthly water fee when necessary, and it shall institute its own budget and financial policies.

As an organization, the RWSA is meant to be self-sufficient and autonomous. Its board of directors are elected by the membership and serve for a term of one (1) year. Elective officials of the government are disqualified by law from becoming directors of RWSAs.

TRAINING ACTIVITIES

In preparing the RWSA for the management of its waterworks project, the following training activities are conducted:

A. Exploratory briefing - This involves formal and informal leaders of the community, who are given an overview of water supply program and the role of the community in waterworks management;

B. Information meeting - This is conducted after a feasibility study and preliminary engineering have been conducted, and intended to inform the community the amounts of monthly water fee and loan to be incurred by the community. This activity is also intended to assess the willingness of the community to accept the management of the waterworks project;

C. Pre-membership course - This is undertaken when the community has accepted the responsibility of operating the project, and consists of lessons in group development, human relations, cooperatives, and organizational management. During the course, the RWSA is formed and its initial board of directors elected;

D. Post-design meeting - The officers of the association are briefed on the plans and design of the waterworks project, and their comments and suggestions are solicited before the engineering design is finalized;

E. Leadership course - This activity is conducted while the construction of the project is under way. The participants are the officers of the RWSA;

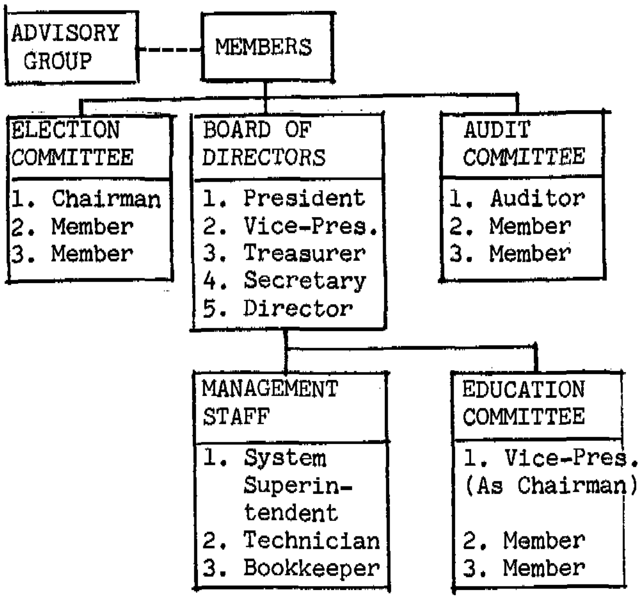
F. Pre-operations workshop - This activity is held about a week before the completion of the project. This trains the RWSA's management staff on general management strategy, records management, bookkeeping and simple accounting. By this time the RWSA shall have been registered and ready to manage the facility;

G. Post-completion course - The personnel charged with the day to day operations of the water system shall be trained, during this activity, on the technical aspects of operations, trouble-shooting, and simple repairs; and

H. Various skills training - After some evaluation has been made of project performance and of the capabilities of the association, other training activities may be designed and conducted that shall provide officers of the RWSA the needed skills that shall make waterworks management even more efficient.

ORGANIZATIONAL STRUCTURE

When finally constituted, the RWSA shall have a structure that conforms with the chart below.



An advisory group, composed of elective officials, formal leaders, and retired professional, may be formed which shall be a consultant to the association. The Audit and Election committees shall be voted upon by the entire membership, and shall be responsible to the general assembly. Only the management staff and the Education Committee are under the supervision of the Board of Directors. The Board, however, may create other permanent or special committees, when needed. In the RWSA, the Vice-President is made automatically the chairman of the Education committee. It is also permitted for the elected chairmen of the Audit and Election committees to appoint the other members. The RWSA may federate with other RWSAs.

CONCLUSION

National policy makers believe that no group of people would care for a service facility more than those who benefit from such installation. An indoctrination phase, nevertheless, shall be necessary to make the benefciaries realize thoroughly the advantages of perpetuating good service. In addition, the association should be equipped with the skills that are equal to the demands of operating and managing a water system. Those responsible for conceiving and developing this approach to rural water supply management believe that, with necessary modivations the same may be adopted in other countries initiating similar programs.

As waterworks projects in the villages proliferate, especially in developing countries, central and local governments will hardly be able to afford to allocate financial resources annually to maintain these facilities. Drinking water supply projects should be made to pay for its own operation, and it can pay for its own operation, and even expansion. In a number of rural communities in the Philippines, functional and viable RWSAs are administering projects to the satisfaction of their constinuents.

SESSION 1

Chairman: Professor Chen Charng Ning
Nanyang Technological
Institute, Singapore

Discussion

N J Peiris, J N S Jones, D O Lloyd
Design for effective implementation and efficient operation of water supply systems

1. Mr LLOYD and Mr PEIRIS described the new treatment works at Matara, Sri Lanka, and emphasised the design philosophy that the system must operate over the long term with minimum expenditure and within the limits of local technical competence.

2. Mr BRADLEY asked whether the plant and electrical supply firms were willing to provide simple, robust equipment with plenty of spare parts and tools, or whether they always tried to sell the latest 'black box' type of complicated equipment.

3. Mr LLOYD replied that manufacturers in the developed world generally tried to sell the latest in complex equipment. He felt that they would eventually lose their market to local manufacturers unless they could provide simple, robust equipment. He quoted the example of a pumping installation in Hyderabad, Pakistan, which had been working since 1910; it was unlikely that today's equipment would last as long.

4. Mr PARAMASIVAM asked for details on the previous treatment plant, and why rehabilitation was necessary.

5. Mr LLOYD said that it had proved possible to almost double the capacity of the old works by rehabilitation; this was much cheaper than constructing a new installation. Experience gained in operation and maintenance of the old plant was fully utilised in the design of the new works. In addition, the iron levels of above 5 mg/l required aeration to be included.

6. Mr RAUSCHENBERGER explained that his company had tried to convince the Technical University in Copenhagen that education in systems and methods used in the 1920s and 1930s was necessary for young engineers wishing to work in developing countries.

7. Mr LLOYD supported the proper use of information and techniques from the past, in conjunction with today's modern methods of analysis and design. He cited the example of sulphide corrosion in Cairo sewers during the 1920s and 1930s not being remembered in the designs for the Middle East in the 1960s and 1970s.

8. Mr RAY posed three questions:

What was the capital investment for the first and ultimate phases, and how many people benefited;

What was the estimated annual operation cost, and how would it be funded; and

What was the 'decade target' coverage.

9. Mr PEIRIS replied that the first phase cost was US$ 8 000 000 to benefit 50 000, and the ultimate phase to benefit an estimated expanded population of 110 000 with a capital investment of about US$ 18 000 000. The annual operation and maintenance costs were estimated to be around US$ 25 000, to be funded by meter charges on a fixed tariff basis, with government subsidy for street tap supply. The target date was now March 1985; the present coverage was 75%.

10. Mr PAVAMANI wished to know more details about the cost of water and the tariff system.

11. Mr PEIRIS stated that the financial basis was that of 'no profit no loss'. A fixed tariff was adopted using the cross-subsidy principle whereby lower income groups were subsidised by higher income groups and large consumers. The first 10 000 litres per month was at a rate of 20 cts per 1000 litres; the second 10 000 litres per month at a rate of Rs 1 per 1000 litres; the third 10 000 litres per month at a rate of Rs 3 per 1000 litres; and thereafter at between Rs 5-50 and Rs 15 per 1000 litres for larger consumers. Operation and maintenance costs of water were based on cost recovery with whatever loan debts had accrued. The capital investment cost was partly subsidised. A subsidy was also given to support the street taps used by low income people.

12. Dr VIRARAGHAVAN asked whether water quality tests for trace organics and TAMs were carried out.

13. Mr PEIRIS replied that regular tests were carried out for WHO requirements; other tests were carried out only if other problems were suspected.

14. Mr KARKI wished to know how the local community was involved in the project.

15. Mr PEIRIS said that in large schemes such as this one, representation was by their elected representatives; in smaller communities, they would be involved in operation and maintenance, and community participation could take many forms, such as contribution of direct labour.

B Lohani & T Tashi

Leakage in municipal water supply systems: a case study in Nepal

16. Mr TASHI presented the paper, and outlined the problems of assessing leakage in water distribution systems.

17. Mr. HUTTON commented that cutting down leakage was efficient in terms of energy and materials, and there was opportunity for cost effective research. More emphasis should be placed on laying distribution networks, as the investment in pipes and fittings represented a high percentage of the overall investment in a scheme. There were both quantity and quality aspects to leakage; trapped air could drive flow meters round at a very fast rate. Illegal connections were liable to leak, and leakage could be lowered by reducing mains pressure; there were considerable gains to be had from carrying out leak detection surveys.

18. Mr PARAMASIVAM observed that leakage and intermittent supplies caused problems with water quality, leading to increases in illnesses such as infectious hepatitis; this should also be considered in the economic analyses of leak detection and prevention.

19. Mr TASHI replied that although he agreed with this general statement, a door-to-door survey in the study area indicated that consumers were satisfied with the quality of the water. The quality-disease aspect was difficult to quantify because so many factors were involved in disease transmission other than water quality. It would appear that it is better to ensure a non-intermittent supply than go to the vast expense of preventing all leaks.

20. Mr KSHIRSAGAR commented that leak reduction would increase the pressure in the system; this would benefit the consumer, but could cause new leaks to appear.

21. Mr TASHI agreed on both points; the pipes supplied did not always come up to specification, and it was economically infeasible to prevent every leak.

22. Mr PAVAMANI asked the following questions.
1. The leakage figures for Manila seemed high.
2. What was the minimum achievable leakage.
3. Were any figures available for Singapore, which had a well-maintained system.

He also commented that leakage prevention was extremely expensive, and experience of Bombay city indicated a loss of about 30% of the 2000 MLD supply.

23. Mr TASHI replied that Manila figures were not obtained by detailed leak detection surveys, but were more subjective assessments. The minimum leakage attainable was specific to a particular utility. He understood that about 10% of water was lost through leakage in Singapore. The economics of leak prevention required a detailed benefit-cost analysis; savings could result from deferred capital cost on investments, savings in production, chemicals and energy. He referred to a publication 'Leak detection and waste prevention; experiences of the Municipality of Greater Bombay' by V.M. Shidhaye.

24. Mr SIDDHI suggested that previous studies had shown losses of 65% and 75%; did this study, which found a loss of 56%, suggest that the situation in Greater Kathmandu had improved, and what would a reasonable figure be.

25. Mr TASHI thought that it was likely that there had been improvements, as a result of the leak repair programme. Other studies had been done in Sorakhutte, whereas this study was in Lalitpur; the area had different characteristics, and it would not be advisable to assume that the 56% found in Lalitpur could be applied as a general figure for the whole of Greater Kathmandu.

G E Nepomuceno

Community organization in rural waterworks management

26. Mr NEPOMUCENO presented his paper, and described the role of community participation, the organisational procedure, and the necessary training activities involved in rural waterworks management.

27. Mr PEIRIS wished to know whether responsibility for management subsequently rested with the Rural Water Supply Association, rather than with the Government.

28. Mr NEPOMUCENO replied that the responsibility for managing rural water systems passed to the RWSA. A turnover and loan contract was signed by duly authorised representatives of the local Government and the RWSA, a legally constituted corporation became the owner of the project. Ownership in law and in actuality implied a proprietary role in operations. The local Government, as part of their rural development efforts continued to work with the RWSA, and exercise supervision until the liquidation of the loan.

29. Mr SIDDHI asked whether all utilities were financially viable, or were cross-subsidies more the rule than the exception.

30. Mr NEPOMUCENO stated that some RWSAs were in financial difficulty, but they constituted the minority.

31. Mrs MYLIUS wished to know the size of the populations served by RWSAs, the supporting Government structure, and the training received by 'outreach' workers.

32. Mr NEPOMUCENO said that the population size served by an RWSA ranged from 600 to 10 000. The National Government and the Provincial Governments supported the RWSA; Executive Order No 577, a national level issuance was the legal basis for the formation of RWSAs, and the philosophy stemmed from the cooperatives development movement launched by the National Government in 1972. The provincial or local government trained and supervised the RWSA. The local government 'outreach worker' was trained on community development,co-ops development, lay leadership, women and youth, health and sanitation, group dynamics, rural waterworks development, and allied subjects.

10th WEDC Conference

Water and sanitation in Asia and the Pacific: Singapore: 1984

Rural water supply planning and implementation

S Amin

I. OBJECTIVES

In the context of the overall national objective of providing water supply to all the rural areas as a part of the minimum needs programme, the present paper seeks to comment on certain aspects of the process of planning, implementation and maintenance of rural water supply schemes with particular reference to the State of Gujarat. The focus of the paper is on the few critical factors/aspects standing in the way of appropriate planning and efficient functioning of rural water supply projects, investment on which has witnessed a significant rise in the recent past. The presence of such bottlenecks has resulted in inadequate realisation of benefits from such invesement programme.

The paper begins with a brief description of the present process in case of the State of Gujarat, lists the important areas with particular reference to the planning and maintenance aspects, presents findings from a few case studies based on both field survey and official data and finally identifies a few critical factors, though based on very limited observations, which require immediate attention and call for both short-term and long-term measures.

II. THE PROCESS

There are in total 18,725 villages in the State of Gujarat with a total population of 23.4 million in 1981, comprising about 70% of the population of the State. The water supply situation in the rural areas of the State is to say the least, acute. It is a matter of concern that more than 30% of the villages in the State do not have an assured source of drinking water supply. The problem is not only severe but varies in nature across different regions of the State. Accordingly its solution required a systematic and well defined approach in terms of planning, implementation and maintenance. The creation of Gujarat Water Supply and Sewerage Board (GWSSB), as a separate agency to look after this important aspect of public policy, was a positive step in this field. Since its inception in August 1979, the Board has been instrumental in pioneering water supply schemes in the rural areas of the State. The process of commissioning these schemes is fairly detailed, starting from a thorough investigation of the problem villages - or 'no source' villages as they are named - their systematic categorisation in terms of priority, design of appropriate schemes and their implementation in due time.

For better understanding the entire process of commissioning rural water supply schemes is illustrated in the form of a flow diagram.

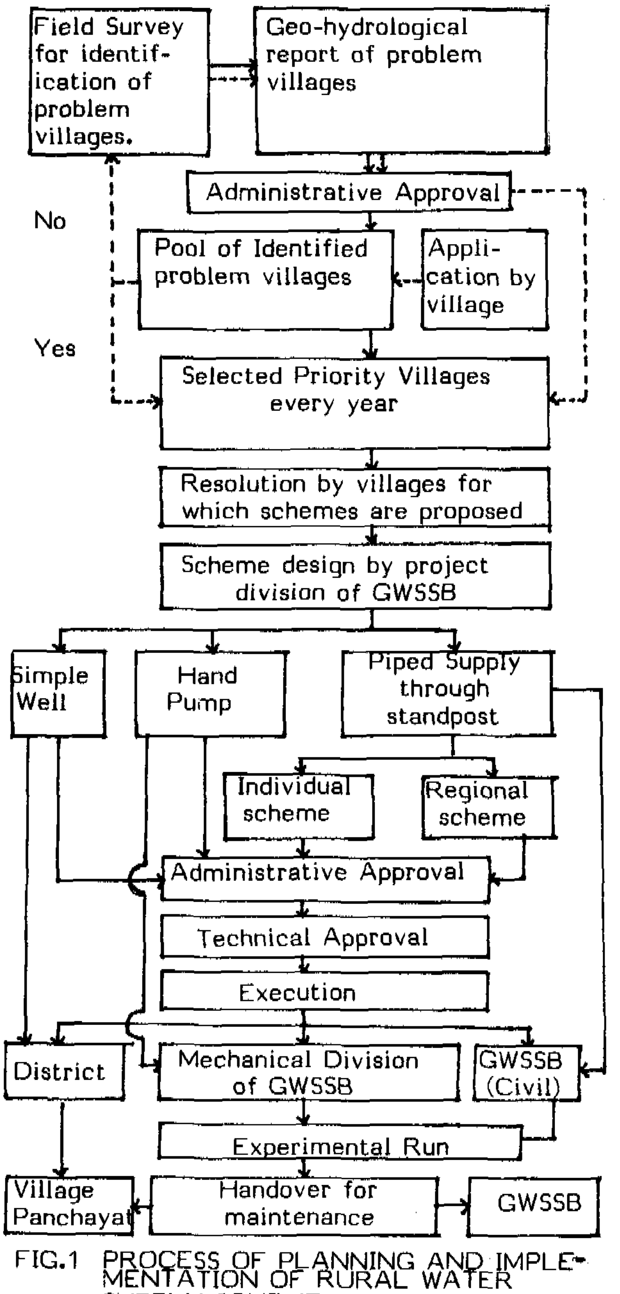


FIG.1 PROCESS OF PLANNING AND IMPLEMENTATION OF RURAL WATER SUPPLY SCHEME

It is clear from the flow diagram that the Board has adopted a well-defined and systematic approach to tackle the problem of rural water supply. This is most welcome, particularly when one considers that until the formation of the Board, provision of rural water supply schemes has been mostly in the nature of make-shift arrangements to grapple with a particular drought or disaster situation. It was only in 1976 that rural water supply received priority in the overall national plan and became more important under the Minimum Needs Programme. The creation of the Board was a direct outcome of these events. Accordingly there has been a remarkable shift in the pace with which rural water supply schemes have been commissioned prior to and the post 1976 period.

The concerted efforts of the Board in this field has resulted in a much wider coverage of the problem villages compared to that achieved during the period before its inception. The Board's achievement is illustrated in Table 1.

Table 1: Provision and Progress of Schemes in Rural Areas of Gujarat State.

AS ON	No. of problem villages	No. of villages provided with water supply	No. of villages yet to be provided	No. of villages where schemes are in progress	Annual capital outlay (Rs. in crores)*
31.3.1980	9038	4514	4524	2168	12.0
31.3.1981	10621	5123	5498	2371	13.5
31.3.1982	12000	6030	5970	2562	14.2
31.3.1983	12300	7088	5388	2102	22.1

* Exchange rate 1$ = Rs. 10.75
Source: GWSSB

III. THE MAJOR ISSUES

While the efforts of the Board in commissioning rural water supply schemes need to be acclaimed, there is little room to be complacent. There still remains a substantial number of villages which do not have any assured source of safe water supply and the number of such villages is increasing over time. For that matter, at the time of its inception in 1979 the Board had inherited a huge backlog of such villages mainly due to the absence of any well-defined policy prior to that period. This backlog had resulted in a severe burden on the Board and has been accentuated by the continuous increase in the number of problem villages in the recent years. The direct result has been that in spite of the increased tempo in the field of rural water supply, the situation is still deteriorating, if one goes by the number of villages yet to be provided with water supply schemes (Table 1). The backlog is clearly and alarmingly increasing. The increase may be due to either of the following reasons:-

(i) Inadequate identification of problem villages in the initial years. This means that any time point the number of problem villages is actually more than that identified. However, if this is the case, one can reasonably expect that the number will stabilize within a few years, after all such villages are identified, though in separate lots. Once the target becomes fixed, its fulfilment will depend on the rate at which the Board's activity is expanding.

(ii) Deterioration in the water supply situation in rural areas. This means every year new villages which were earlier having some source of water supply, are added to the total pool as their sources fail or deteriorate. Deterioration is mainly due to the following reasons, (a) increase in water salinity, (b) industrial pollution, (c) drop in water table due to drought. This may also include villages which have been already provided with water supply schemes, but the same have failed for some reason or other. If this is the case, the ambitious object of reaching one and all with safe and assured water supply may not be fulfilled in the near future.

Without going into the relative significance of these factors in explaining the increase in number of problem villages, the three major issues which need immediate attention for the fulfilment of the decade's objective can be stated as :-

(a) prioritisation of problem villages;
(b) resource allocation; and
(c) effective maintenance.

It is now proposed to discuss these three issues in detail in the remaining part of the paper. While the first two issues are discussed from a macro view point with the help of official statistics at the State level, the third issue - maintenance - is discussed at a micro level with the help of few selected case studies.

A. Prioritisation of Problem Villages

The task of prioritisation of problem villages is a direct outcome of, the rapid increase in their number on the one hand and the limitation of resources on the other. Since the competing villages are many, it is necessary that they be ranked in terms of their relative urgency and need, to decide "which village comes first". In an effort to tackle this problem the Board has adopted the following categories for grouping the problem villages.

Category 1: Villages which do not have an assured source of drinking water supply within a reasonable distance (1.6 km) or within reasonable depth (15 metres).

Category 2: Villages which suffer from excess of salinity, iron or fluoride or other toxic element hazardous to health.

Category 3: Villages where sources of water are liable to the risk of cholera or gunieaworm infestation.

The task is difficult in view of the additions of new problem villages every year. Under such circumstances if prioritisation is to reflect the ranking of villages properly, it is imperative that the list of such villages be updated every year.

B. Resource Allocation

Plan outlay for rural water supply sector has shown an appreciable increase in the recent years (Table 1). This is indeed commendable. However, if the decade's objective of providing all the villages with safe water supply is to be fulfilled, it will call for the allocation of additional funds to this effect. It is estimated that provision of water supply to all the rural areas within this decade will cost the Board a sum of Rs.350 crores (at 1981 prices) in total, which works out to Rs.35 crores annually. when seen in this context the plan allocation appears to be relatively less. As a result, the Board has been unable to keep pace with the deteriorating problem. As can be seen from Table 1, the net addition of problem villages has far outpaced the additional schemes that were provided every year. Keeping in view these factors the fulfilment of the decades objective will call for,

(a) preparation of an updated list of problem villages;
(b) systematic scheme design and estimate of the total cost involved;
(c) sufficient allocation of funds towards meeting the cost; and
(d) a well-knit organisational and implementation programme to complete the task in time.

C. Maintenance

Howsoever good may the process of planning be, and no matter how scientific is the approach adopted, a programe of rural water supply can hardly be successful unless backed by an efficient maintenance system. If the benefits of rural water supply schemes provided by expending scarce capital are to be reaped in full, it is imperative that the schemes be properly maintained, whatever be their limited number. It is an unfortunate observation that the assets so created are not maintained effectively. A survey was made in the year 1981 to know the position as to how many completed rural water supply schemes were properly utilised and how many were idle. The survey revealed that 70% of the schemes provided were working, while the remaining 30% were idle. The estimate of the number of schemes idle was possibly lower than actual in view of schemes which were working for only a part of the year. The reasons for non-working were identified as:-

(a) lack of funds;
(b) lack of repair facilities;
(c) lack of repairs of civil structures;
(d) non-payment of electricity dues;
(e) partial or complete failure of source.

National Environmental Engineering Research Institute also, independently, carried out indepth study of 83 individual village water supply schemes in the country. Out of these, 7 villages were from Gujarat. The problems and constraints as listed in the study report for these villages were:-

(a) inadequate allocation of funds towards cost of the schemes;
(b) inadequate funds for operation and maintenance of piped water supply schemes maintained by local body;
(c) Non-availability of spares in time at block/district head-quarters for repairs of pumps;
(d) inadequate number of trained mechanics;
(e) irregular power supply;
(f) lack of community participation.

In order to examine the significance of these factors in the success or failure of rural schemes it is necessary to understand:

(a) the exact organisation structure under which the schemes function; and
(b) the actual working of the rural water supply schemes.

Rural water supply projects, after completion, are handed over for maintenance to:-
(a) District Panchayats in case of regional schemes; (b) Village panchyats in case of individual schemes. Due to the inability of these local bodies to maintain the assets effectively, the Board has recently taken over the maintenance of regional water supply schemes. However, maintenance of individual schemes is still with the village panchayats. The incidence of failure of these schemes is much higher compared to the regional schemes and unless the problems are located and corrective action taken, wastage of substantial investment is bound to occur.

To understand the reasons behind the success or failure of individual schemes, case studies of 4 villages were undertaken. In 2 of these villages the schemes have been successful, in other two it has clearly failed. The villages were selected equally from two talukas - one developed and the other in the process of development in the field of rural water supply. Summary information relating to these individual schemes is presented in Table-2.

Table 2 : Summary Information Relating to Water Supply Schemes in the Selected Villages.

Taluka	Village	Population (1981)	Scheme type	Construction year
1	2	3	4	5
1. Savli	Kunpad	1813	Piped water supply	1978
	Balanapura	728		1982
2. Santrampur	Malvan	1025	-do-	1972
	Ladipur	747	-do-	1981

Village	Capital cost(in lacs)	Maintenance cost (in lacs)	Status	Period for which it worked/is working
2	6	7	8	9
Kunpad	1.24	0.15	Not working	1 year
Balanapura	0.77	0.11	Working	1 year
Malvan	1.23	0.18	Working	11 years
Ladipur	1.45	0.21	Not working	2 months

The major factors identified as being responsible for the success/failure of these schemes are as under:-

(a) availability of funds;
(b) interest of the local body vis-a-vis community involvement;
(c) attitude of the beneficiaries
(d) electricity dues and inter-department co-ordination.

(a) Availability of funds

It is normally expected that the beneficiaries would pay for the water supply services created over a period of time. The payment by the beneficiaries should cover all the operating cost if not a part of the capital cost also. There was a clear reluctance on the part of the beneficiaries to pay for these operating and maintenance cost in village Kunpad and Ladipur where the scheme failed. Payment by the beneficiaries is the only source of generating the required funds for maintenance, as the local bodies do not have power to mobilise resource in any other way. The consumers in India and for that matter in any developing country, are not motivated to pay for water, as water is erroneously considered as a free natural gift. They ignore the fact that water is free, at the spring, not at their water taps. One has to accept that one has to pay for water just one pays in case of food and other services. One has to motivate people that they have to pay for the service they expect. It may not be possible to achieve the change immediately. It may take time, one should first develop political and social will and effect the change progressively. Till such time cross subsidy and other arrangements should be developed. In particular, the local bodies should be induced to levy appropriate taxes to generate partly or fully the maintenance and repair charges of rural water supply.

(b) Interest of the local body and community involvement

The success of any individual scheme is directly dependent on the willingness of the local body which has the full responsibility of maintenance. Equally important is the interest of the community at large. In most cases the local body does not show much enthusiasm in taking over the completed work because the operation and maintenance of a scheme means the raising of money which a local body does not want to do because of political interest. Reversibly , if the local body does have sufficient desire to operate the scheme, it is well maintained. The scheme in village Malvan has been working for the last 11 years. The village panchayat is vigilant and regularly collects water charges to meet the operating expenses. On the contrary such efforts are clearly absent in Ladpur and Kunpad.

(c) Community participation (attitude...)

Community participation is another important factor. An important observation made regarding this factor was that "wherever alternative sources of water were available the community showed little or no interest in the constructed scheme. Village Kunpad is a benefitting example. The village has alternative sources of water in terms of an open pond and few private wells meant primarily for irrigation. However, villagers were using these sources for regular domestic use. These sources are not safe and hygienic still they were used in that the water was free whereas water from the scheme entailed a cost on the consumers, though it was safe. This lack of preception to distinguish between minimum water as against minimum safe water has manifested itself in the general lack of the community to restart the scheme, lying idle for the last 4 years. In village Malvan too, sources were available at a distant place about 2 kms away from the village. Since the water was free at such open but polluted wells the community preferred to adhere to the traditional sources rather than go for a safe source which however called for payment of water charges.

This is not to say that community preception is absent in all the rural areas. Village Malvan did have alternative sources, but the same were abandoned no sooner the scheme started.

The point to be stressed is this that the attitude of the beneficiaries and their ability to value the quality of water is an important determinant of the success of rural supply schemes.

(d) Electricity dues and inter-department co-ordination

The general reluctance on the part of the beneficiaries in village Kunpad and Ladpur to pay for the operating cost has resulted in long outstanding dues on electricity account. As per the present policy of the Electricity Board the connections have been promptly cut. The villagers, do not seem to be in a mood to clear the dues and consequently the Board does not re-install the connection. As a result the schemes are lying idle for many months. While the policy of the Electricity Board may be defended from the organisation point of view, it is doubtful whether the same is justified as an overall startegy from the public sector view point. Such a policy may enable it to reduce its losses but would at the same time render substantial investment in rural electrification and rural water supply ineffective. It is a matter of concern that in rural water supply alone, investment to the tune of Rs. 1 to 1.5 lacs become unyielding due to the non-clearance of a small sum of dues. This is of course, not to suggest that the Electricity Board should go on bearing the burden, but it does call for framing a more appropriate policy towards the dealing of this problem. At present there is little co-ordination between the village panchayat, district panchayat and the Electricity Board which is perhaps responsible for this unfortunate event.

IV SUMMARY OBSERVATIONS

The paper has tried to bring out in brief the present status of rural water supply with particular emphasis on some of the major problems in this regard, covering Planning and maintenance. While it is true that the activities of the Board have expanded substantially in the recent years, much more attention will be needed to complete the tasks ahead. The tasks called for are not limited to the GWSSB and the Government machinery at large but should penetrate into the root of the social system, including public motivation and community participation. In the context of the preceeding discussions with particular reference to the individual village schemes which are outside the perview of GWSSB for maintenance, the following aspects require attention and corrective measures:-

(a) development of more objective basis of resource allocation and prioritisation;

(b) resource mobilisation with a determined effort to recover a certain part of the operating costs from the beneficiaries;

(c) imposition of an indirect tax, where social reluctance to pay directly for water exists;

(d) framing of appropriate ppolicy to educate and motivate the people to participate actively in rural water supply schemes;

(e) inducing the local bodies to levy appropriate taxes and discharge their responsibility; effectively; and above all

(f) setting up of a separate maintenance division within the Board to look after the regular operation and maintenance of village water supply schemes.

10th WEDC Conference

Water and sanitation in Asia and the Pacific : Singapore : 1984

Harnessing of rainwater, the underutilised source in developing countries

Dr A Appan

INTRODUCTION

At the time of the proclamation of the International Hydrological Decade in 1980 for "providing safe water for all by 1990", one third of the world's population did not have drinking water (ref.1). In fact, three quarters of the third world countries in Asia, Africa and Latin America lack a supply of safe water for drinking and washing and 85% of these people still live in rural areas (ref.2). These statistics point towards the pressing need for establishing water supply systems that can be implemented in large tracts of the universe classified as "developing countries" where economic factors largely influence decision-making in any type of development project. One system that is simple, easily adaptable and involves low capital outlay is a Rain Water Cistern System. This is not a new concept but, in fact, has been in existence for more than three thousand years (ref.3). A rising awareness of the potential of Rain Water Cistern System (RWCS) culminated in the first international conference in 1981 (ref. 4) followed by a regional seminar in 1983 (ref.5).

COMPONENTS OF RAIN WATER CISTERN SYSTEMS

The term RWCS is synonymously used with 'rainwater catchment' and is loosely referred from methodologies adapted for the enhancement of runoff capabilities of small catchments to roof water collection systems. In this paper, the emphasis will be essentially on RWCS, as it is deemed that the basic twin collection requirements viz., roof area and rainfall already prevalent in developing countries. The system will involve the collection of roof water from an individual building or group of buildings, storage in cisterns and distribution with or without treatment. In this context, the cistern volume will be determined as a function of rainfall and demand. Mention will be made of methods of computation of cistern sizes, materials for storage, maintenance and distribution. Also, technical issues in relation to water quality, health education, socio-economic factors etc., will be touched upon.

METHODOLOGIES AVAILABLE FOR SIZING OF CISTERNS

In large-scale water supply schemes, the conventional relationship between yield (demand/supply) and storage has been well-defined and analysed by the Rippl method (ref.6) and progressed to more probabilistic methods (ref.7 and 8). All these methods utilise the rainfall or runoff patterns and the resulting large reservoir volumes balance the stochastic inputs and the constant outputs. In RWCS, the catchment area corresponds to available roof area, the input (rainfall) remains unaltered, storage is limited to cistern size and the output is the volume available for collection from the cistern. The factors that influence the sizing of cisterns are the stochastic pattern of rainfall, roof areas that are very often limited and the demand that can be highly variable.

Based on these criteria, a number of methods have been propogated for the sizing of cisterns. The methodologies have varied from stochastic assessments using deterministic models (ref.9, 10 and 11) to probabilistic (ref.12 and 13) and simulation models (ref.14), all having varying degrees of sophistication.

In all these models the four major *influencing factors remain unaltered.* The relationship between these four parameters, the frequency of failure to meet demands and the volume of alternate source required to meet the total demands are well-represented in a simple flow chart. (ref. 15). Summing up, all design methodologies will be geared towards ultimately producing a matrix of information that can be represented by simple nomograms as shown in Fig. 1 These data will be applicable only for specific catchments as rainfall patterns vary from area to area.

FACTORS AFFECTING IMPLEMENTATION OF RWCS IN DEVELOPING COUNTRIES

Large-scale implementation of RWCS could be influenced by technical, socio-economic and other factors.

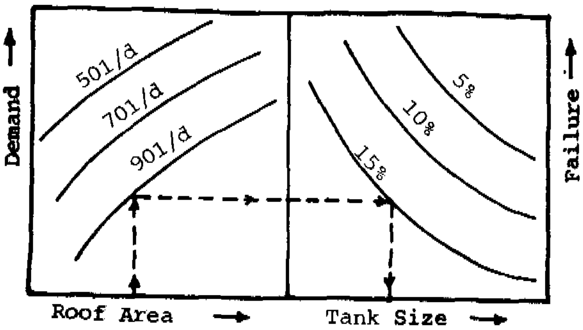


Figure 1 : Typical RWCS Nomogram

Technical Factors

Investigation of the region under consideration should include identification of dry zones, areas having very low groundwater tables or areas having brackish water. Some influencing factors requiring detailed investigation are:

Roofing Material: Roofing material can vary from conventional tiles to corrugated metal sheets and much cheaper dried palm leaves. Runoff quality will be affected according to the type of material and its existing state.

Water Quality: The quality of rain water is generally of a high order. In most locations an equilibrium pH of 5.65 is reached under normal circumstances. But there is evidence that with industrialisation the S and N gases emitted can lead to acid rain having a pH of 2.5 to 3 (ref.16). Such conditions of high pH which normally exist initially (ref. 17) call for diversion systems in RWCS which will remove the potent first flushes. In the case of roofing material affecting the physical characteristics, simple filter (ref.18) may be incorporated. If the bacterial purity of the water is affected by the cistern material, long detention or sludge build up in cisterns (ref.19), simple disinfection can be effected by boiling the collected water or by the use of a solution of chlorine or chlorine tablets (ref.20).

Cistern material and size: The overall cost of RWCS is influenced largely by the cost of the cistern. Hence, emphasis has to be placed on the economic design of size and choice of material for construction. Conventional materials like steel, reinforced concrete, mass concrete and even brick tend to be on the costly side. Extensive investigations have been carried out to utilize much cheaper material like ferro-cement (ref.21) and bamboo reinforcement, (ref.22) that reduce the cost by 2 to 4 times (ref.21). Indegenous materials are much cheaper, readily available and besides, they can be handled by personnel who do not need any special training. The shape of the cistern in terms of minimum surface area should be cylinderical but, in practice, the shape is determined by the number of units being built and the type of material being used.

Operation and maintenance: These twin aspects play an important role in the long term utilization of the system. In this respect, a simple water level indicator should be installed and the users should be made aware of the need to conserve water in relation to the existing water levels and rainfall. Besides, periodic inspection should be made of the inside of the cistern to ensure that sludge levels, if any, are not high and do not affect water quality. Also, a close watch has to kept so that the cistern does not become a breeding ground for mosquitoes.

A proper programme on operation and maintenance is very essential and there is the need to emphasis that these aspects are crucial for ensuring the palatability and safety of the water and its availability during periods of drought.

Socio-Economic Factors

In most developing countries, the cost for implementing a RWCS will be a strain on the already stretched economic resources of the potential user. This is evidenced by the implementation strategies evolved in Thailand where the villagers have had to be subsidised (ref.23) and in Indonesia where they were provided with a means to a source of income so that they could effect repayment (ref.24).

Though the locations that have potential to harness rain water may be identified, the introduction of this new source can pose problems of acceptance, particularly if it has not been used in the past. Some issues that have been encountered are the belief that its use will lead to rheumatic complaints (ref.25) and a weakness of limbs (ref.26). Consequently, before embarking on RWCS, the economic and educational level of the people, their habits and attitudes with regard to the use of water, their present sources of water etc., have to be appraised. Such information can be obtained by a field survey.

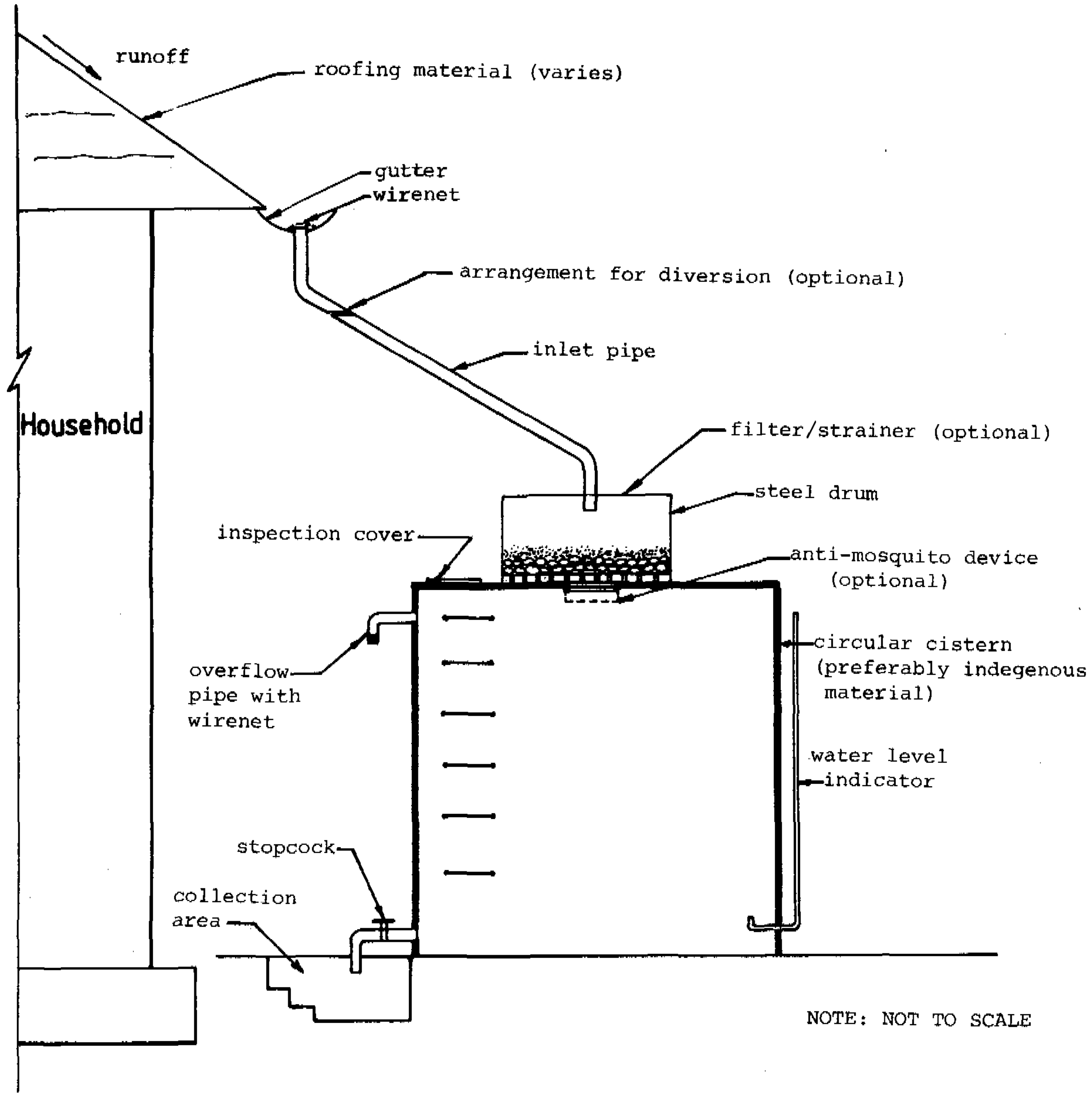


Figure 2 : Schematic Diagram of Typical RWCS

Other Factors

Though the RWCS is basically a simple concept, for it to have an appreciable impact, a large number of units may have to be installed. One important aspect of RWCS is that by having an independent system for an individual household or group of households, the responsibility of operating and maintaining the system supplying safe drinking water will be shifted from the central authority (normally the Government or quasi-Government) as in any large water supply system, to the individual or small group of individuals who, very often, are not sufficiently well-educated. Hence, the health education aspect of the programme has to emphasise the importance of water quality in terms of safety and potability. Another aspect of the implementation of RWCS is to get community involvement and to plan the whole programme such that there is almost total committment by the community. Such participation will not only go a long way towards reducing costs but will bring about an awareness in the users to operate and maintain the system properly. This type of modus operandi is exemplified in the Tungnam Project (ref.23) in Thailand.

TYPICAL RWCS IN A DEVELOPING COUNTRY

In Fig. 2 is shown a simple set-up for a RWCS. The system by itself is very simple and does not call for special skills for design or erection. The overall feasibility of putting up such a system is largely dependent on the cost which is crucial to the user. So, the material for utilization in the system has to be chosen very carefully, a health education programmes embarked upon and, most important of all, an appropriate payment or repayment programme worked out.

CONCLUSIONS

(a) The state of art of choosing a cistern size is at a stage where it can be made with a reasonable degree of certainty.

In any case, when a large number of cisterns are to be built, the economy of scale may call for only one or a few more sizes of cisterns to be built. Then, the size of the cistern becomes constant and the roof area has no bearing on the design.

(b) The identification of the most appropriate areas to establish RWCS will depend on whether the area is classified as a dry zone and whether there is no scope for development of other sources. This identification by itself will be a major motivating factor to induce the potential users to embark on RWCS.

(c) An awareness of the socio-economic level of the area is very helpful. Preferably some field survey has to be undertaken to get a better understanding of the people who are going to benefit by the scheme.

(d) A heath education programme is very necessary and will help to do away with the existing social taboos and, at the same time, implant the the importance of proper operation and maintenance.

(e) For the successful implementation of RWCS on a large scale, a total approach has to be adopted. For such an approach it is necessary to ensure that there is, to a large extent, community involvement. This will not only reduce costs but will help in subsequent operation and maintenance and will go long way towards improving the quality of life of the people.

REFERENCES

1. "World Water". D-day for the Water Decade, World Water, 1981.

2. MORRISON Alan, Civil Engineering., Oct. 1983.

3. OZIS Unal. "Outlook on Ancient Cisterns in Anatolia, Turkey". Proc. Int. Conf. Rain Water Cistern Systems, Honolulu, June 1982.

4. International Conf. on Rain Water Cistern systems, Honolulu, June 1982.

5. Rainwater Catchment Seminar, Regional Workshop, Khon Kaen, Thailand, 30 Nov. - 2 Dec. 1983.

6. RIPPL W. "The Capacity of Storage Reservoirs for Water Supply", Proc. Inst. of Civil Engineers, London, pp. 270, Vol. 70, 1883.

7. STALL J.B. "Reservoir Mass Analysis by Low-flow Series", ASCE, J. Sanit. Dn., Vol. 88, No. SA5, Paper 3283, Sept. 1962.

8. MORAN P.A.P, "A Probability Theory of Dams and Storage Systems". Aust. J. Appl. Sci., Vol. 5, 1954.

9. APPAN A. "Some Aspects of Roof Water Collection in a Subtropical Region". Proc. Int. Conf. Rainwater Cistern Systems, Honolulu, June 1982.

10. LEUNG P. and FOK Y.S. "Determining the Desirable Storage Volume of Rain-Catchment Cistern System". Proc. Int. Conf. Rain Water Cistern Systems, Honolulu, June 1982.

11. HOEY P.J. and WEST S.F. "Recent Initiatives in Rain Tank Suppy Systems for South Australia". Proc. Int. Conf. Rain Water Cistern Systems, Honolulu, June 1982.

12. FOK Y.S., FONG R.H.L., MURABAYASHI E.T. and LO A. "Deterministic and Probabilistic Processes of Weekly Rainfall". Int. Conf. Rain Water Cistern Systems, Honolulu, June 1982.

13. FOK Y.S., FONG R.H.L., HUNG J., MURABAYASHI E.T. and LO A. "Bayes-Markov Analysis for Rain Catchment Systems", Tech. Rep. 133, Water Resources Res. Center, Uni. of Hawaii, Honolulu, March 1980.

14. PERRENS S.J. "Design Strategy for Domestic Rainwater Systems in Australia". Proc. Int. Conf. Rain Water Cistern Systems, Honolulu, June 1982.

15. APPAN A. "Design and Development Aspects of Rainwater Cistern Systems in South East Asia". Rainwater Catchment Seminar at Khon Kaen, Thailand, 30 Nov - 2 Dec 1983.

16. LIKENS G.E., BORMAN F.H. and JOHNSON N.M. "Acid Rain", Environment, Vol. 4, pp. 33-40, 1972.

17. SEYMOUR M.D., SCHUBERT S.A., CLAYTON J.W. and FERNANDO Q. "Variations in acid content of rainwater in the course of a single precipitation". Water, Air and Soil Pollution, Vol. 10, pp. 147-161, 1978.

18. CAPTURED RAINFALL. "Small-scale Water Supply System", State of California, Dept. of Water Resources, May 1981.

19. BUNYARATPAN Vanasari and SINSUPAN Suparerk. "Roof Catchment: Water Quality". Rainwater Catchment Seminar, Khon Kaen, Thailand, 30 Nov - 2 Dec 1983.

20. PICKFORD John. "Water Treatment in Developing Countries". Water, Wastes and Health in Hot Climates. John Wiley & Sons, 1977.

21. VADHANAVIKKIT Chayatit. "Ferro-Cement Tank Construction". Rainwater Catchment Seminar, Khon Kaen, Thailand. 29 Nov - 2 Dec 1983.

22. THIENSIRIPIPAT Nipon. "Bamboo Reinforced Concrete Tanks". Rainwater Catchment Seminar, Khon Kaen, Thailand. 29 Nov - 2 Dec 1983.

23. HAYSSEN Jonathan. "Rainwater Collection and Storage Project (Tungnam III)". Rainwater Catchment Seminar, Khon Kaen, Thailand. 30 Nov - 2 Dec 1983.

24. ARISTANTI Christina. "Dian Desa's Rainwater Catchment, its Implementation and Development". Rainwater Catchment Seminar Khon Kaen, Thailand, 30 Nov - 2 Dec 1983.

25. MALIK U.A. "Rainwater Cistern Systems and Policy in Malaysia". Proc. Int. Conf. Rainwater Cistern Systems, Honolulu, June 1982.

26. RAJAPAKSE R.K.C. Discussion following paper "Sri Lanka's Contribution towards Rainwater Catchment Technology". Rainwater Catchment Seminar Khon Kaen, Thailand, 30 Nov - 2 Dec 1983.

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Critical studies on rural water supplies in drought prone area and coalfield area of West Bengal

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INTRODUCTION

India is actively involved, as a member country of the United Nations, in the International Drinking Water Supply and Sanitation Decade Programme. National Environmental Engineering Research Institute (NEERI) undertook a comprehensive evaluation of rural water supply schemes of 83 villages spread of 11 states in India (Appendix-I). West Bengal, situated in the North Eastern Part of India, with a population of 54.48 million having an area 87.853 sq.km. is a prominent partner in the National Decade Programme. This paper covers studies pertaining to the rural water supplies in the drought prone area of Bankura District and Coal field area of Burdwan District of West Bengal. Fluctuations in the Water level in the aquifers and low recharge of underground water during summer months create drought condition. In village of Bankura tubewells are constructed by deploying rock drilling rigs, surface water being inadequate. Like Bankura District, sinking of tubewell in the coal field area also becomes difficult due to hard rocks. Thus in the coal field areas surface water from Barakar river is conventionally treated and distributed to the villagers.

MATERIALS AND METHODS

Ekteshwar and Bikna in Bankura as well as Jemari and Ramdi in coal field loop were the typical study villages. As compared to this, Balarmpur and Jamirkuri were the corresponding reference villages. The water supply in the study villages was organised by the State PHE Department and those in reference villages there were no such organised system. Water samples were collected six times, once in each season for a period of two years. All analyses were done as per APHA Standard Method (Ref.1). During each visit engineering data and information of Health status as well as water supply were collected. These rural water supply schemes were evaluated with a view to identify technological, administrative, financial and socio-economic constraints and to propose recommendations for effective implementation, operation and maintenance to give the desired benefit to the villagers of the study area.

WATER SUPPLY AND HEALTH STATUS OF DROUGHT PRONE AREA OF BANKURA.

India Mark II hand pump tube-wells were used both in Ekteshwar and Bikna with a population of 392 and 2259 respectively. One tubewell is designed to serve 300 people where the water yield was in the range of 1200-1500 litres/hr./pump. Tubewell depth varied from 30m to 60m with a size of 3.81 cm diameter. The casing pipe diameter was 10.0-12.5 cm with a length of 6.0-9.0 meters In Balarampur village, water is drawn from openwells.

Consumption of water in study villages was observed to be about 16 lpcd. The quantity of water for drinking and cooking purposes was more or less equal. The drawal of water from tubewell was observed also to be same at morning and evening. Overcrowding of the hand pump tubewell was the main difficulty in fetching water and this was followed by the distance that villagers had to cover up to get potable water. In Balarampur, villagers were seen to travel about 1.5-2.0 Km to fetch water from the river bed during acute summer season. It was observed that 100% of the rural population go to the open field for defecation in both study and reference villages. Tubewell waters are used only for drinking and cooking purposes. Thus villagers exposed themselves to water from ponds, open wells and river, etc. for other uses and get contaminated. Even though 65% of the people are literate still it was observed that they are generally not aware of hazards of water-borne and infectious diseases. Immunization practices to prevent certain water-borne diseases are almost non-existent. Dysentery/diarrhoea and worm infestation were the common ailments in these villages. Typhoid cases have also been reported. Comparative studies between study and reference villages showed that the health and sanitation of the study villages are only marginally better because of above stated reasons.

WATER SUPPLY AND HEALTH STATUS OF COAL FIELD AREA OF BURDWAN

Treated river water from Kalyaneshwari Water Works is supplied to the study villages of Jemari and Ramdi through public stand-posts. Population of Jemari was 1875 and that of Ramdi 185 only. Design per capita supply was 70 lpcd at a per capita construction cost of Rs.66/-(1 US $ = Rs.10.0) and Rs.3.00 for maintenance and operation cost per capita per annum.

The scheme was commissioned in 1972. The service level was designed for piped water supply to be such that one stand post with one tap having 2 hours supply in the morning 2 hours in the evening may serve 250 persons. The terminal pressure was 2.5-3 m and per capita water supply was actually observed to be 40 lpcd. In Jamirkuri, the villagers are consuming the raw water of Barakar river. Almost equal volumes of water are used for drinking and cooking purposes. Similarly, villagers draw equal volumes of water in the morning and evening most of the times. Over-crowding at public stand-posts during limited supply hours has been identified to cause difficulties to the villagers. This is followed by other difficulties such as long distance, insufficient pressure, etc. Breakdown in water supply is mainly due to mechanical faults. Taps from most of the PSPS were missing and there was considerable wastage of water.

During the period of breakdown of water supply and other hours of the day, villagers use well and pond water, thereby subjecting themselves to the hazards of water pollution.

Villagers of Ramdi and Jamirkuri have no latrine in their houses and adopt open field defecation. In contrast to this, 35% of the villagers at Jemari use some form of latrine for defecation. 10-21% of the people have knowledge about water-borne and infectious diseases. Immunizational status is also poor and people are ignorant about the preventive measures to control morbidity from such human activities. Dysentery, diarrhoea and worm infestation, were common diseases in these villages, particularly in Jemari and Jamirkuri. Only in study villages, 30-40% people believe that dysentery and diarrhoea have been reduced significantly owing to the introduction of piped water supply.

RESULTS

Selected Physico-chemical and Bacteriological parameters are incorporated in Table 1.

TABLE 1. Water quality of selected villages in drought prone and coal field areas

Parameters	Drought Prone Area			Coal Field Area		
	Ekteshwar	Bikna	Balarampur	Jemari	Ramdi	Jamirkuri
PH	7.5-7.6	7.2-7.6	7.2-7.6	7.5-7.8	7.3-7.8	7.6-8.0
TDS	260-330	254-964	286-430	64-120	70-120	96-858
T. ALKALINITY ($CaCO_3$)	100-142	130-230	74-124	22-56	20-50	22-64
T. HARDNESS -do-	180-204	170-513	120-182	80-100	74-92	64-452
CARB HARDNESS -do-	100-142	130-230	74-124	22-56	20-50	22-64
NON-CARB HARDNESS-do-	42-82	42-289	8-106	25-66	24-64	22-234
CALCIUM -do-	95-120	115-322	80-100	52-60	52-60	40-247
MAGNESIUM -do-	58-86	54-239	25-86	29-41	16-37	25-202
CHLORIDES (C1)	44-69	24-214	52-108	1-5	3-6	4-111
SULPHATES (SO_4)	16.2-19.2	11.5-112.5	10.7-32.5	6.5-17.0	10.0-17.2	2.2-61.0
T. IRON (Fe)	0.02-0.18	0.08-0.5	0.06.0.14	0.02-0.32	0.02-0.22	0.02-3.8
RESIDUAL CHLORINE ($C1_2$)	-	-	-	less than 0.1	traces -0.9	-
BACTERIOLOGICAL (MPN/100 ml)						
Coliforms	32-1600	0-79	1100-7900	13-2400+	0-280	230-24000
F. Coliforms	4-1600	0-8	700-3300	0-140	0-170	0-24000
E. Coli	4-220	0-8	200-3300	0-110	0-130	0-9300
F. Streptococci	0-920	0-7	1300-4900	0-130	0-130	14-1500

(All range values except pH are expressed in mg/1)

From the results of analysis it was observed that the tubewell water at Bikna showed high total dissolved solids and high hardness, and other parameters were within the permissible limits. As compared to this, in Ekteshwar the chemical quality of water was more or less acceptable. Similar was the situation at reference village of Balarampur. Bacterilogically water quality, both in Ekteshwar and Bikna, was unsuitable for potable purposes. Lowest bacterial count was observed from water samples of Bikna. The water at Balarampur was observed to be grossly polluted and this was followed by high bacterial counts in Ekteshwar.

The source of treated water supply in two study villages in coal field area is river water and the chemical quality of such treated water conforms to permissible limits of drinking water standard. However owing to improper chlorination, residual chlorine was observed most of the time to be less than 0.1 mg/1 at Public stand posts (with the exception of one value of 0.9 mg/1). In Jamirkuri the water quality-even though untreated-from chemical point of view was comparatively acceptable except for high values for hardness (452 mg/1), TDS(858 mg/1) and total Iron (3.8 mg/1). Bacterilogical count was observed to be the highest in Jamiruri and is un-acceptable for human consumption. In study villages, bacterial counts were also observed to be occasionally high, due to improper chlorination.

DISCUSSION

From the foregoing data, it will be apparent that there has been no significant effect on the health status of the people due to poor or grossly inadequate sanitation and personal hygiene in drought prone and coal field areas. Lack of sanitary latrines, soakage pits for disposal of wastewater produced in houses and compost pits for taking care of garbage and cattle dung are possibly the biggest contributory factors for such state of affairs. People's health education and awareness, motivation etc. are lacking which accentuate the problem of appropriate resource utilization for welfare of the villagers. The water from ponds and open wells are to be cleaned and disinfected when used particularly during the breakdown periods of tubewell hand pumps and/or during acute summer months. Besides adopting measures of incrêasing the supply hours and proper chlorination in the coal field area, the State PHE authority should more systematic and rigorous aspects of operation and maintenance to improve upon the existing situation. Wastage of water at the public stand-posts be controlled by constant vigilance and effective community participation. One of the viable methods of reducing such wastage is to encourage house connections particularly in Jemari, where people can also afford to pay for such services. For online assessment of water supply to the villagers, it is imperatively necessary to resort to periodic analyses of chemical and bacterial quality of water by the State PHE so that a desired quality of water is made available.

There is little awareness amongst the villagers due to inadequate general and health education. Moreover lack of immunization have made the situation more difficult to arrest the incidence of water-based diseases. Training facilities should be provided to the staff of Gram Panchayat as additional adjunct to the existing personnel in study villages engaged for operation and maintenance of water supply. Workshop facilities, at District level, to undertake minor as well as major repairs will be useful. State Government takes complete financial responsibility for construction as well as operation and maintenance of water supply scheme in these villages. No water tax is collected from users. Statutory provision should be made-particularly if house connections are provided for levy of water tax on the beneficiaries and ensure return of part or whole of the expenditure on operation and maintenance. This will reduce the recurring expenditure incurred by the state Government in Coal Field Area.

It has been noticed that lesser drawal of water is due to inadequacy of design and the resulting overcrowding at hand pumps and public stand posts. Thus there is a need to review the norms and develop suitable design guidelines for intermittent water supply.

Based on the information gathered during the survey and other relevant conditions in the village set up of other parts of India, NEERI recommended (Ref.2) per capita rate of water supply to be as shown in Table 2. Even though these norms pertain to all India data still these serve as a useful guidelines for the study villages covered here.

TABLE 2. Recommended per-capita rate of supply (lpd)

Description	House connections	Public stand-post/hand pump
Drinking	5	5
Cooking	3	3
Ablution	10	6
Bathing	20	15
Washing utensils and house	15	10
Washing of clothes	20	15
Flushing	8	6
	81	60
Leakage/Wastage at 10%	8	6
	89	66
Say	90	70
Cattle need including leakage/wastage	20	20
	110	90

Judging the above norms it was apparent that villagers of the study area were getting inadequate water for their various uses. Available mass media, Gram Panchayat and social worker must join hands with the technical and scientific personnel to improve upon such gaps and inadequacies.

CONCLUSION

Based on onsite observation and experiences, the following structural constraints were observed :

- Scarcity and non-availability of materials in time
- Inadequate allocation of trained personnel for operation and maintenance, particularly in drought prone area
- Outmoded financial and administrative procedure causing delay in implementation
- Non-availability of adequate data on health aspects for meaningful interpretation of health impact.

Critical studies revealed that except for a few chemical parameters, water supplies, both in drought prone and coal field areas are of acceptable nature. However, the bacterial quality is of doubtful character, particularly in Balarampur and Jamirkuri, where there is no organised water supply system. Bacterial counts in water from the study villages like Ekteshwar and Bikna (drought prone area) may be reduced to appropriate level, by adopting measures like selection of proper site and aquifer, construction of suitable platform with adequate drainage system. Similarly in study villages like Jamari and Ramdi (coal field area) the bacterial quality of water can be improved by adopting effective chlorination and by constructing suitable platform with adequate drainage system at Public stand posts. Unless and untill the water supply programme is matched with the appropriate sanitation practices, the health of the villagers is not likely to improve.

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REFERENCE

1. American Public Health Association, Standard methods for the examination of water and wastewater, 14th ed., Washington, 1975.

2. NEERI Report on Evaluation of Rural Water supply schemes in India, NEERI, Nagpur, 1982.

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Three recent Malaysian dams

D W Berry and L J S Attewill

INTRODUCTION

The paper describes and contrasts the design of three dams recently completed, or approaching completion, in Johore, West Malaysia and in Sabah, East Malaysia. Although it is only by chance that these dams were designed and constructed at the same time, it is instructive to compare, in a single paper the various problems encountered at each site and the solutions that were used to deal with them The principal statistics of each dam are given in Table 1.

TIMBANGAN DAM

Purpose of the dam

Timbangan dam, situated on the Sungei Timbangan between Tawau and Semporna in Sabah, East Malaysia (Fig 1) is the most straightforward of the three dams discussed. The purpose of the dam, which is owned by the Public Works Department (JKR), is to impound water for the supply of the town of Semporna.

Hydrology

The Sungei Timbangan, which flows south into the Celebes Sea has a catchment area at the dam of 22 km^2 of steeply sloping jungle. The mean annual rainfall is 2150 mm, and the estimated annual potential evapotranspiration is 1300 mm. In the absence of any relevant streamflow data the mean annual runoff was estimated by a simple water balance approach, to be 18 Mm^3. The reservoir top level was set at a height of 11.5 m above river bed level so that the reservoir storage is equal to three months (the longest recorded period of drought) supply to Semporna at a daily rate of 9000 m3.

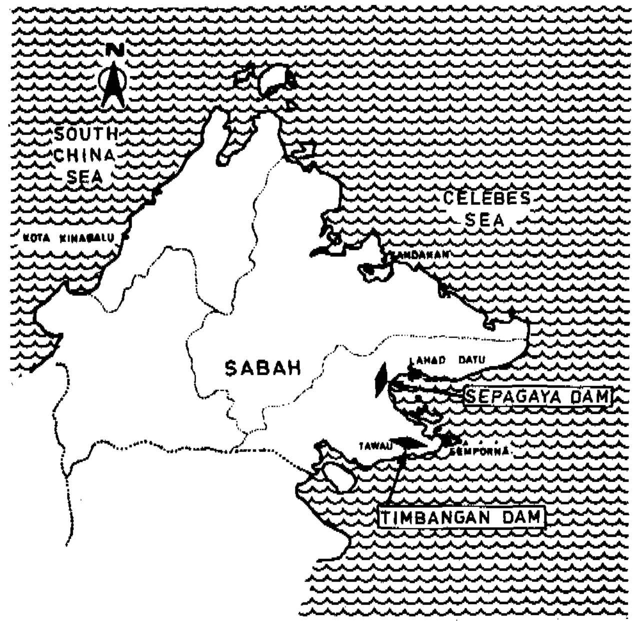


Figure 1 Sabah dams location plan

Description of the dam site

The river, at the dam site, flowed in a V - shaped valley where many exposures of bedrock a massive andesite, were evident in the river bed and on the lower slopes, higher up. Especially on the left bank, the andesite has weathered to depths of up to 5 m.

Choice of dam

The existence of the massive strong andesite at shallow depths over the site make the choice of a gravity dam attractive. Such a dam was selected, in preference to an embankment dam, as the more economical for the site, for the following reasons :

TABLE 1 - PRINCIPAL STATISTICS

	TIMBANGAN	SEPAGAYA	SEMBRONG
Dam Type	Concrete gravity	Rockfill	Earthfill
Dam Height (m)	15	23	11
Dam Length (m)	160	70	900
Dam volume (m^3)	7,500	50 000	650 000
Spillway type	Free overflow	Bellmouth	radial gates
Design flood (m3/s)	165	300	400
Reservoir volume (Mm3)	0.8	2	18
Construction cost (US $ Million)	2.2	5.0	9.4
Contractor	Pemborong Tan / Jurubena Jaya J.V.		Manong

a) the problem of river diversion during construction is minimised with a gravity dam.

b) the cost of the spillway is less with a gravity dam because the spillway is an integral part of the structure and water flows over the downstream face of the dam. This is not possible with an embankment dam where the water is spilled by means of a separate structure.
c) similarly, abstractions from the reservoir are made through the dam itself, in contrast to the need with an embankment dam for a separate draw-off structure.

The cross-section of the dam is shown in Fig 2

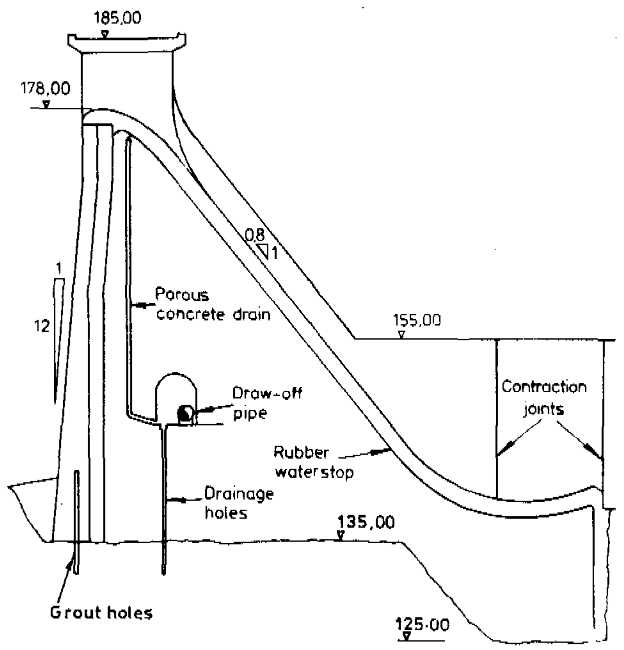


Figure 2 Timbangan dam section

Dam Construction

The dam was completed in 1983 after a construction period of 2 years. One construction problem, solved by a relatively new method, was that of the control of the temperature rise of concrete during construction due to the heat of hydration. To limit undue temperature rise, which can cause cracking, newly cast concrete was thermally cured to maintain high temperatures at the concrete surfaces and to limit temperature differentials. This method was effective and cheap, and was monitored by means of thermocouples cast into the body of the dam and into the surface of the concrete. The traditional method which is more costly, relies on the use of iced water in the concrete mix.

SEPAGAYA DAM

Purpose of the dam

This dam, the highest of the three, is situated some 70 km north of Timbangan, and is currently under construction for the JKR to provide additional storage for the water supply of Lahad Datu. (Fig 1).

Hydrology

The dam is situated on the Sungei Sepagaya a river that flows eastwards to Darvel Bay. The catchment size and characteristics, the rainfall and evaporation are all very similar to those of the Timbangan dam. Sepagaya reservoir is larger, however, as it provides three months supply of 225,000 m^3/day equivalent to a reservoir volume of 2 Mm^3 and a top water level 22 m above river bed level.

Description of the dam site

The Sepagaya river flowed in a deep steep - sided valley in highly fractured serpentenite rock, weathered at its surface so that only in the river channel did the fresh bedrock outcrop. The depth of weathering was not excessive on the left bank, where reasonably strong rock occurred at a depth of less than 5 m. On the right bank, however, weathering has penetrated to great depths and no fresh rock was encountered at any depth in the site investigation.

Choice of dam type

The absence of strong weathered rock at reasonable depths on both sides of the valley precluded the choice of a gravity dam, although such a dam type would have well suited the topography for the same reasons as given above. An embankment dam was therefore chosen, in the design of which the following problems had to be overcome:

a) high rainfall throughout the year creates difficulties for the compacting of clayfill with a controlled moisture content.

b) the diversion of the Sungei Sepagaya in the narrow valley during construction.

c) the high sided valley poses problems for the provision of spilling capacity.

The first problem was resolved by adopting a zoned embankment of rockfill and clay with the clay element, the impermeable core, as thin as possible, to minimise the clay quantity. The maximum hydraulic gradient across the core was 0.5. It was accepted that the moisture content range for the clay would be higher than normal, resulting in a more plastic, but weaker core. Consequently, to maintain stability,the slope of the rockfill shoulders were made flatter than usual, but this was found to be necessary also for reasons of foundation bearing pressures and of stability in times of earthquake. (Sabah is moderately prone to earthquakes: the last, measuring 6 on the Richter scale, occurred in 1976). Furthermore, by inclining the core upstream more working space is provided to the contractor to place rockfill in advance of the clayfill, during

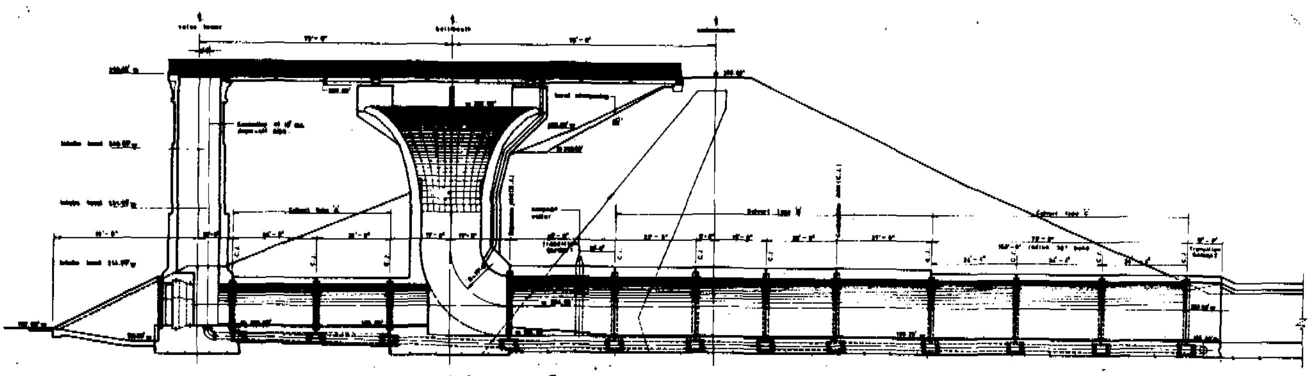


Figure 3 Sepagaya dam section

wet weather, in the downstream shoulder.

The second and third problems were solved together by the adoption of a bellmouth spillway discharging into a concrete culvert as shown in Fig 3. During the construction of a concrete dam it is possible to divert the river over concrete already poured, but the equivalent method is not available to the constructors of an embankment dam. During construction of such a dam the river must be diverted either through a tunnel driven in one of the abutments or in a culvert buried in the fill. Both alternatives were examined in the case of Sepagaya and the culvert alternative chosen on grounds of cost. Two alternatives also presented themselves for the spillway: either a simple overflow spillway in a channel excavated into one of the abutments, or a shaft spillway utilising the culvert that must be provided for diversion. Because of the relatively large flow to be provided for (300 m^3/s) and the very large volume of excavation involved in the first option by reason of the high-sided valley, the bellmouth option was found to be 15% cheaper. A model was therefore made of the bellmouth spillway, shaft, culvert and stilling basin to check its hydraulic performance and especially that of the culvert and stilling basin which are curved in plan to accommodate a bend in the river.

One radically different solution was considered but not adopted, was that of an overflow rockfill embankment. In such a dam no spillway structure is provided and all spillages pass over the crest of the dam and its downstream slope, which are reinforced with a grid of galvanised steel bars.

This idea has been tried in Australia but is still relatively new and imperfectly understood: also a reasonably strong and non-eroding foundation is necessary. For these reasons it was felt that a conventional solution should be adopted at Sepagaya.

SEMBRONG DAM

Purpose of the dam

This dam is the lowest of all three, being only 11 m high, but involves by far the greatest volume of fill and impounds the largest reservoir. Situated on the Sungei Sembrong near Air Hitam in Johore, (Fig 4) the dam, which is owned by the Drainage and Irrigation Department (JPT), is designed to provide flood protection to the very flat Batu Pahat plain, and is one part of the JPT's Western Johore Agricultural Project. The dam can also provide up to 0.5 m^3/s (43,200 m3/day) for local water supplies.

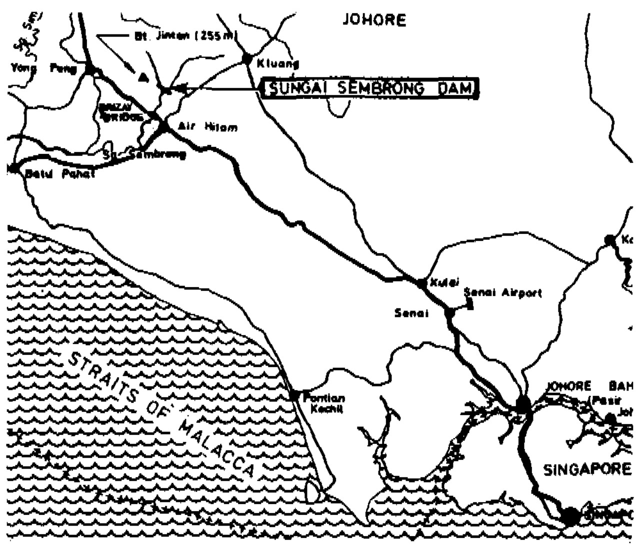


Figure 4 Sembrong dam location plan

Hydrology

The Sungei Sembrong flows south westwards into the Malacca Straits and has at the damsite a catchment area of 130 km^2. The mean annual rainfall is 2250 mm.

Description of the Project

The project comprises an 11 m high main embankment of a total length of 1700 m. Ancillary structures comprise a Flood Regulating Outlet and a free overflow spillway both discharging into a common stilling basin, both of which are founded on the hill composed of residual soil which forms the left abutment of the main embankment.

Method of Operation

During times of low flow the reservoir will be full to the normal storage level of 8.5 m od. (storage volume of 18 Mm^3) and abstractions may be made for local water supply and for compensation water by means of 700 mm ductile iron pipework. Floods of up to 1 in 100 years return period can be stored (storage 35 Mm^3) and released at a controlled rate of up to 42 m3/s through two radial gates of the Flood Regulating Outlet. Floods of intensity greater than 1 in 100 year recurrence will pass over the uncontrolled spillway. During the probable maximum flood, when the reservoir level will be 14 m, the total volume of water stored is 75 M m^3 the maximum discharge 400 m^3/s

Embankment design

The design and construction of the 11 m high embankment on the swampy foundations offers a startling contrast to the two dams previously described and is the most remarkable aspect of the overall project.

It was decided to found the embankment on the swampy deposits since their excavation which would have involved dewatering on a large scale and would have been so expensive as to render the entire scheme uneconomic.

However, to design an embankment with such soft foundations it was necessary to understand the mechanical properties of the strata. This is normally done by sampling and laboratory testing, but because the difficulty of recovery of undisturbed samples from the very soft deposits an advanced self boring pressuremeter was used to test the material in situ. The results obtained were used in a finite element stress analysis, a consolidation analysis and stability analyses. Crucial to the stability of the embankment is the pressure of pore water in the foundations, and much of the analysis was devoted to their prediction. In particular the finite element stress analysis predicted the instantaneous foundation pore pressure rise due to the loading caused by the staged construction of the embankment, while the consolidation analysis predicted how this pore pressure distribution would be modified by consolidation over the period of time actually required for construction. As a result of the analysis the embankment was designed with average slopes of 1 vertical to 5 horizontal as shown in Fig 5 and was planned to be built in stages, with the minimum construction period of the last two stages specified as a contractual requirement.

Embankment Construction

The embankment has been constructed in the following phases.

The preliminary phase in which the river was diverted through a channel excavated in the residual soil of the left abutment and roads were formed across the swamp outside the dam area by end tipping laterite gravel.

The construction of bunds in advance of the main embankment to help consolidate the foundations and to improve stability, and also to protect the foundation area of the main embankment from flooding.

The first stage of construction of the main embankment comprised the stripping of about 2 m of decayed organic matter - logs, tree roots etc, to expose the foundation material of soft organic clay. Over-excavation would expose lenses of quicksand. The first 1 m of fill was placed by end-tipping residual clay in 0.5 m thick layers and compacting with the bulldozer. Subsequently fill was placed in conventional layers 20 cm thick and compacted with rollers. Occasional blow-outs through the clay, caused by excessive foundation pore pressure, were experienced and these were dealt with downstream of the core zone, by filling the hole with sand and draining the flow to the downstream toe, to relieve the excess pore pressure. At the end of this stage pneumatic piezometers were installed in the foundations to monitor pore pressures for the control the subsequent rate of filling.

In the 2nd & 3rd stages of the main embankment foundation pore pressures were allowed to dissipate by restricting the construction period of each stage to 150 days. In no instance were the predicted results exceeded and thus it was not felt necessary to further restrict the rate of filling.

ACKNOWLEDGEMENTS

The schemes described above were designed, and construction supervised by Sepakat Setia Perunding in association with Howard Humphreys. The authors wish to thank the Irrigation and Drainage Department and the Public Works Department for their permission for them to publish this paper.

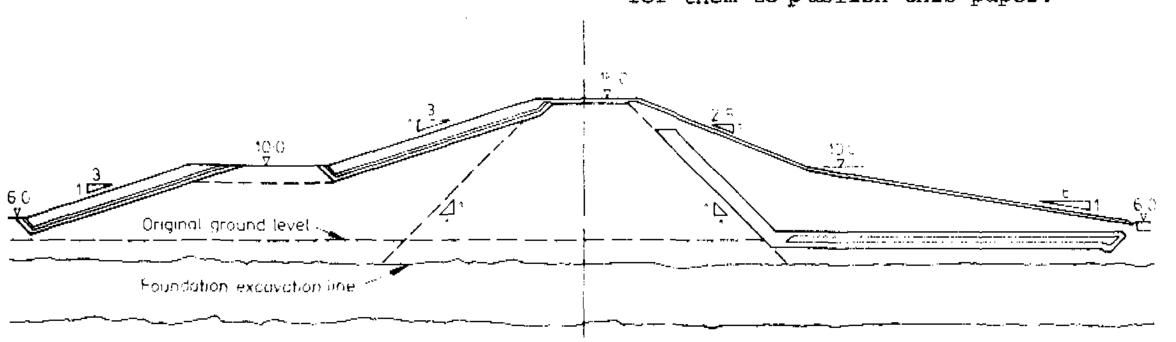


Figure 5 Sembrong dam section

10th WEDC Conference

Water and sanitation in Asia and the Pacific: Singapore: 1984

Community participation - water supply systems in Karnataka

M Chickannaiyappa and M V Ramaswamy

Community Participation in Urban & Rural Water Supply Systems in Karnataka (India)

The ALMA - ATA declaration is a global strategy for "Health For All by the year 2000 AD", expressing the need for urgent action by all governments, all health and development workers and the world community to project and promote the health of the people of the world.

This declaration embodies a number of fundamental principles of primary health care. Primary health care has been defined as : "Essential health care based on practical, scientifically sound and socially acceptable methods and technology made universally accessible to individuals and families in the community through their full participation and at a cost that the community and country can afford to maintain at every stage of their development in the spirit of self-reliance and self-determination."

One of the ALMA - ATA declarations included in primary health care is - 'adequate supply of safe water and basic sanitation to the community.'

Achieving the above objectives requires individual and community self-reliance and participation, and should be sustained by integrated, functional and mutually supportive referral system.

In the early days, water supply and sanitation projects were usually designed without community participation, ie., the beneficiaries are not directly consulted or involved in the design, implementation or operation of the facilities. In fact, public involvement is often considered of little value at best and a hindrance to progress.

In urban and rural areas of developing countries, water supply systems constructed without adequate consultations and lack of community participation in operation and maintenance have not been functioning satisfactorily.

For the success of water supply and sanitation projects, community participation should start from the initial stage of collection of basic data, selection of type of scheme, identification of users' preferences through the planning, design and construction stages, and should continue for proper operation and maintenance of the facilities. The form of community participation and the extent of involvement may vary from country to country, state to state, town to town and village to village.

In the urban areas of developing countries, the lack of community participation has resulted in water supply systems being constructed according to the models of those built in the developed countries. This adoption of advanced technology has provided reasonable water service to the middle and upper income populations and to those in very high income groups.

Increasing the present low levels of water supply service will require either a massive investment of funds and the creation of large service organisations or the use of technologies that are less expensive than conventional ones and which are easier to operate and maintain by users and smaller communities, with limited funds. The use of cheaper alternative technologies clearly offer a greater possibility for realisation of water supply needs, but it will also require greater involvement by the beneficiaries in smaller towns and rural areas to compensate for the absence of a strong centralised institution.

A urban community can probably count on the organisation providing municipal water supply facilities. Community participation will be concerned primarily with selection of service levels with relevance to community's needs, ability to pay etc.

Rural communities, on the other hand, need to develop a system which they can operate and maintain with minimum external inputs. Usually, this means operation and maintenance of the systems with the advise from a regional technical supportive organisation.

Consequently, planners and designers who formerly concentrated only on the technical aspects of the systems design to ensure efficient provision of service, are now increasingly concerned with understanding users' expectations and preferences. The hope is that with designs that are socially as well as environmentally appropriate will be more acceptable.

The objectives of community participation in water supply are the selection of : (i) technologies that are acceptable to the community and that offer benefits the community considers important at a cost it can afford; (ii) the most effective materials and methods of constructing the appropriate facilities; (iii) technologies that can be operated and maintained by the local population with minimum assistance from outside agencies.

The organisational programme to achieve the above objectives must include :

i) Determination of the community's existing practices for water use and its attitudes towards them.

ii) Identification of formal and informal channels for community leadership and communication.

iii) Determination of the community's willingness to pay for desired improvements through cash contributions, labour or materials.

iv) Organisation and execution of any self-help construction agreed upon.

v) Operation and maintenance of community facilities, assistance to users in maintaining individual facilities, and collection of funds.

<u>Institution Responsibility in Programme Planning</u>

There are many methods and models for initiating the process of community participation that may be suitable for different communities. Obviously, the approach must suit the particular community, and what is suitable in one culture may not be appropriate in another. Regardless of the agency or organisation responsible for initiating water supply projects, a team consisting of behavioral scientists, community extension workers and engineers is probably most suitable for implementing a programme for community participation. At the least, the team should consist of technicians familiar with low cost water technology and a person with expertise in public health education, personal hygiene and nutrition. Both should be employees of the agency responsible for providing the community with technical support and should have access to agency specialists such as hydrogeologists, well drillers, engineers, economists, behavioral scientists, health specialists and so forth. The involvement of the community leadership is important for the success of the programme regardless of the method used to implement the programme.

Identification of the several tasks for community participation programme to a successful project can be listed as below :

1) Unstructured interviews with community leadership and a limited number of users to identify users' attitudes and preferences.

2) Design and testing of a questionnaire for structured interviews.

3) Structured interviews conducted with a representative sample of households.

4) Presentation of feasible technologies and their costs to the community or its leaders to determine their willingness to fund the scheme.

5) Organisation of the construction and execution of the work.

6) Continued activities of operating, maintenance and monitoring, including the assessment and collection of fees.

The above first three tasks should be taken at the beginning of the project development. The fourth towards the end of the selection phase and the final two must be scheduled to meet technical requirements and community patterns.

Methodology structure for feasibility study for proposed planning will be through administering questionnaire or conducting household interviews.

<u>Programme & Methodology of Community Participation in Karnataka</u>

In Karnataka, there are 243 urban areas (cities/towns) and 26,500 revenue villages covering equal number of hamlets, thandas covering a population of 7.72 million and 26.33 million respectively.

There are 3 Sector Institutions dealing

on Water Supply and Sanitation in the State. They are :

URBAN WATER SUPPLY :

(i) Bangalore Water Supply & Sewerage Board

This Board is responsible for providing water supply to the city of Bangalore. It has its own planning, design and implementation wing and operation and maintenance wing separately. Each wing is headed by a Chief Engineer.

Coming to the operation and maintenance of the systems, this Board has a PR wing for attending to the needs of the community. The Chairman and Members and Officers of the Board visit every water supply service station in a periodical manner with prior intimation to the public of their visit through Press and T.V. The Community of the area is heard and consulted on every aspect of the water supply system maintained. Their views are noted and systems developed or revamped or improved. They are also motivated through audio-visual techniques, pamphlets etc. They are also motivated and educated on every concept of importance of water supply, its related aspects of public health care, so that the community is involved in every aspect. Even short duration films are also exhibited in important localities, theatres etc., to educate the public on how to conserve water, its usage and the amount of public participation required for maintenance of the systems in good order for the indirect benefit of the people.

The water rates fixed / revised are also circulated for wide publicity to know the opinion of the community before finalisation and levy on the consumers. This is to ascertain their ability to pay and to educate them that every drop of water has costed money and can only be reimbursed in terms of water rates for maintenance of the system on a self-supporting basis.

(ii) Karnataka Urban Water Supply & Drainage Board

All the 242 urban areas (excluding Bangalore City) come under the jurisdiction of this Board for providing water supply.

Before planning any system, first the local bodies (community/beneficiaries) are consulted regarding the existing service levels, choice of the source, preferences, financial aspects to invest and maintain the the scheme etc. The municipal bodies send such community resolutions to the Board for planning the schemes.

The Board collects baseline data in association with the community and according to the required service levels, prepare the schemes. As the community, from the stage of investigation, construction and commissioning of the schemes, is associated, the schemes will be successful both in implementation and maintenance stage. After the schemes are completed and commissioned, they will be handed over to the concerned municipal bodies for maintenance.

The systems maintained by the municipalities are found to be not satisfactory due to inadequate trained staff, lack of funds, inability to impose and collect water rates. The Board has decided to take the water works of several municipalities for maintenance.

The Board is also organising 'Drinking Water Supply Week' every year to educate the community on every aspect of water supply.

RURAL WATER SUPPLY :

There are about 60,000 Borewells with hand pumps (to the end of 1983) existing in the rural areas. During the last five years only Indian Mark II H.P. are used.

Three tier system of maintenance of hand pumps has been proposed by the conference of Chief Engineers in consultation with UNICEF. Some attempts have been made to introduce this system to a limited success. One of the most important constituent of this 3-tier system is a "Borewell and hand pumps caretaker".

The Borewell caretaker is the key person in the whole organisation of proper maintenance of the system. The Borewell caretaker is a local person with knowledge of the community in whom the community has some faith and confidence. He is also one who has ability to read and write in local language. The Borewell caretaker is not paid any remuneration or honorarium. However, he is trained at the cost of the Government or UNICEF for 3 days in the proper handling and repair of several types of hand pumps. He is also provided with a small tool kit to enable him to attend to minor repairs. It is purely a voluntary work. Therefore, it is also necessary that the Borewell caretaker should be carefully selected, taking into consideration the dedication of the individual for the voluntary work. So far the Borewell caretaker programme has been functioning very well in one District, namely Bidar District. These Borewell caretakers are periodically got together for a refresher training to imbide a spirit of voluntary service in them. The Government officials are required to meet them during their inspection tours and encourage them for such voluntary service. The community is motivated by the officers to protect the water supply installation and to cooperate with the authorities for proper upkeep.

Various media, such as documentary film, cinema slides, posters, periodical talks particularly to the students of Secondary Schools etc., are employed to get the community involvement in the implementation of the Water Supply Programme and its continued proper maintenance.

Whenever there is a major breakdown, the technical staff of the Department will go to the spot to set-right the pump.

CONCLUSION

The community participation is very crucial for effective implementation of any developmental project, moreso Water Supply and Sanitation Projects. Without the active participation and involvement of the community, the water supply and sanitation schemes will be disused and deteriorate soon. This will defeat the very object of providing safe or potable drinking water and sanitary facilities to the community. Governmental efforts alone will be totally inadequate to implement such a massive programme of providing water supply and sanitation to all the people, even if Government undertakes such programmes. Ultimately, the community has to pay whatever the Government spends.

Therefore, it is imperative that the community participation will result in considerable economy in construction and maintenance. Also, it will instil in the community a sense of belonging which is very crucial for the continued maintenance of the system. Whatever is thrust upon, does not carry much conviction, however useful it may be and hence community participation plays a key-role. Any effort towards obtaining greater participation and involvement by community is worthwhile and pays back in manyfold.

* * * *

10th WEDC Conference

Water and sanitation in Asia and the Pacific : Singapore : 1984

Drinking water for Gunung Sewu

R J Cullen, A Young and Soedaryanto

BACKGROUND

Gunung Sewu, which translates from Javenese as 1 000 hills, rises north from the coastline of the Special Province (or Daerah Istimewa) of Yogyakarta (DIY) in southern central Java. It is part of Kabupaten (K) Gunung Kidul, one of the four administrative units which, with Yogyakarta City, comprise the DIY.

Development of G.Sewu has lagged behind much of the province; with very poor quality land and relatively high population density, the area will always remain economically poor,(Figure 1).Extreme difficulty in obtaining dry season water is a major constraint.

The area covers some 700 km2 and 237 000 people are expected to live there in 1985 in 636 villages; an overall density of 340/km2 compared with 1 300/km2 in the fertile Yogyakarta plain. Another 53 000 people live in the northern fringe areas which are also very dry.

The median household income is probably less than Rp 25 000 per month. (US$1 = Rp 1 000). A typical household comprises five people and owns three goats and 1.2 cattle.

Geologically, the area consists of a mature cone karst limestone system with an associated network of sink holes, underground rivers and caves. Most of the conical limestone hills have been deforested and then severely eroded. The intervening valleys are generally covered with a mantle of red terra rosa clays. Ground elevations seldom exceed 400 m. (Figure 2).

Annual rainfall in G.Sewu averages just less than 2 000 mm, with less than 50 mm per month between June and September. There are no surface streams; virtually all runoff drains directly into the underlying karst.

EXISTING POTABLE WATER SOURCES

Provincial Setting

In the province there are only 36 piped water supply systems . These serve about 160 000 people,(4.3 % of the DIY total). However, most of the inhabitants of DIY have access to nearby open dug wells which provide readily available water. About 75% of all rural households obtain their water from dug wells. In G. Sewu the problem is far more acute.

Hydrogeology

The G.Sewu karst limestone originates from the accumulation of massive reefs when the area was once submerged. The watertable in G.Sewu normally exceeds 100 m depth, and there are no perennial dug wells.

Underground Rivers

An underground river system, which traverses from north to south, discharges large dry season flows to sea (6 m3/s at Baron alone). Runoff drains into the Baron system via a network of sink holes, of which 264 have recently been identified and surveyed. Most are not developable as water supply sources without very complex engineering works; the sink holes are often very deep and linked ultimately to the flowing river courses via a system of horizontal caves and vertical shafts. To date 45 potential underground source sites have been identified, but access infeasibility will probably rule out development of all but a few. (Figure 2).

There is a series of springs which discharge along the coastline and at the higher area to the west of G.Sewu. Some of these are tapped for water supply.

One important underground river abstraction scheme has been installed by the Health Department and UNICEF at Bribin: water is pumped to the surface from the sump created behind an underground weir built across the Bribin stream. The scheme presently serves 3 000 people, but could be expanded to 8 000.

Boreholes

Nine exploratory boreholes have been drilled in G.Sewu at depths between 100 and 250 m. Only two have been successful; generally the watertable, as mapped during the recent cave survey, is too deep. One hole, at Kanigoro, is 172 m deep with SWL at 104 m. However, improved piezometric mapping in the area indicates a band of unexpectedly shallow groundwater along the northern fringe of the area; as a result successful "fringe" wells yielding between 5 and 10 l/s have been sunk

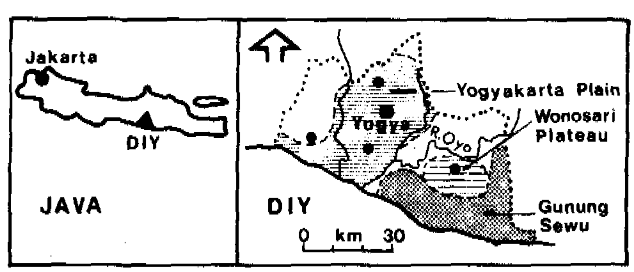


Figure 1. Location

with static water at about 25 m. Four of these have been commissioned with diesel driven Mono pumps for joint water supply and small scale irrigation use. The financial production cost of the water is about Rp 50/m3, but the consumers actually receive it for about Rp 5/m3. Three wells drilled at Krakal on the coast were also successful, although one was saline.

Telagas

Small lakes called "telagas" occur in the valleys of G.Sewu, and are sealed by accumulated clay which prevents leakage into the underlying karst.This drainage may be naturally or artificially blocked. Typical telagas occupy between 0.5 and 2.0 ha when full. Apart from providing domestic water, telagas are also vital for watering livestock.

There are some 250 telagas in G.Sewu, of which about 50 are perennial. Telagas are the most important single source of dry season water in G.Sewu, and suffer progressively from annual siltation with erosion material washed from the surrounding limestone hills. Storage is often limited by horizontal leakage into limestone fissures which starts once the telaga has filled to a certain level.

Even in perennial telagas, water becomes very polluted in the dry season. A telaga will only normally remain perennial if its maximum wet season depth exceeds about four metres.

Rainwater Tanks

A programme of installing rainwater tanks has been underway for some five years, supported by World Bank, UNICEF and other donors. Typical installations store 9 m3 which can be expected to provide about 60 l/d over a five month drought; 4 lcd for three households. Typical costs are Rp 200 000 per 9 m3 tank; (about Rp 22 per litre stored). Once empty, rainwater tanks are frequently used to store dry season telaga water.

Tankers

Areas with most acute dry season water shortage have to be supplied with water from adjacent areas; it was estimated in 1982 that 400 m3/d was being trucked into G.Sewu at a cost to most consumers of between Rp 2 500 and Rp 3 000/m3. Trucked deliveries between June and December 1982 , which peaked near 12 000 m3/month, were estimated at 40 000 m3; the total cost was some Rp 108 million.

The Problem

In G.Sewu there is a variety of alternative water sources, but all have drawbacks either for technical, cost, reliability or quality reasons. Many people walk further than 3 km to the nearest water source - telaga, spring, well or cave - and, ironically, those in the province who can least afford it are forced to pay the highest water charges for water imported by truck or tanker. The effect of the effort required to collect water on people's actual consumption is shown thus:

Daily household consumption (litres)		Distance to nearest perennial telaga (km) 0.5	5.0
Carried for people	(1)	95	15
Carried for livestock	(1)	30	8
Purchased for people	(1)	10	45
Purchased for livestock	(1)	0	18

(Source: Survey at T. Soko, October 1982)

Excluding private and government tanker operators, there are at least six government and four non-government agencies and charities directly involved with G.Sewu water supply.

Many of these agencies are concerned with providing one type of source, such as fringe area spring collectors or rainwater tanks. Their work also tends to be directed at specific community types and associated levels of water supply service. These range from the planned piped systems for the 5 main towns, to wet season dug wells for single families.

Apart from the larger schemes, widespread effort has been made to install schemes not requiring diesel driven pumps. This is understandable because most attempts to install pumping schemes have failed, often for basic reasons. Also, most villagers can barely afford to buy fuel to run pumps, let alone the cost of maintaining them.

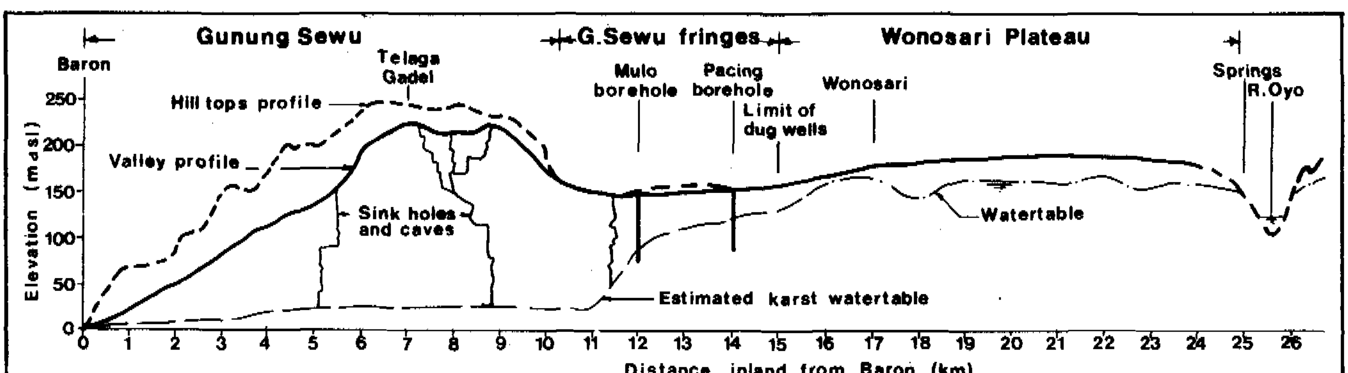


Figure 2. South-North Section through G. Sewu

However, scope for major improvements to water supply in G.Sewu is extremely limited without recourse to power pumps. Even the gravity fed piped systems in G.Sewu and the rest of DIY suffer from relatively trivial maintenance or organisational needs. What is really needed is a unified approach to maintaining schemes, an organisation capable of fielding the required mechanical expertise, and adequate funding. The latter point begs the question of financial viability of rural water supply systems: should, as is often the case, water continue to be provided totally free?

THE FUTURE

Levels of Technology

Clearly, much effort is already being directed at alleviating G.Sewu's water supply problems, but collectively it suffers from lack of co-ordination, duplication of effort, lack of preparatory work and insufficient definition of priorities. Moreover, until recently, work has often been aimed at low cost solutions which, in a marginal area, may not work.

Given that except for telagas,isolated caves or springs, the only major sources are restricted to the northern and southern limits of G.Sewu, the full solution to its water supply problems will be to pump from these points into the central area. Mains up to 9 km long, pumped at heads up to 250 m, would be needed. Clearly such options will not be cheap and, to keep operating costs low, require generous pipe sizing. The costs of triple stage pumping to villages in central G.Sewu are expected to raise water costs by Rp 200 - Rp 300/m3; about Rp 1 500 per family per month.

Development Resources

More recently however, three government agencies which routinely work at higher levels of technology have become involved at the area: these will accelerate the introduction of some of the technical innovation which is really needed to progress in G.Sewu. These are :-

(a) the Groundwater Development Project (P2AT) under the Directorate-General of Water Resources Development (DGWRD);
(b) the Small Towns Water Supply Project (PAB) under the Directorate-General of Cipta Karya, which has installed a piped scheme to exploit the major spring at Baron;
(c) the IKK Water Supply Project, also under Cipta Karya, which is working towards providing piped systems for several kecamatan towns including Panggang,Tepus, Ponjong and Rongkop in G.Sewu.These will become very important schemes, and will be vital for the surrounding rural inhabitants; it is important that their need be recognised when sizing the system capacities and associated levels of service.

G.Sewu from Krakal

DGWRD's involvement in rural water supply through P2AT has developed from an exploratory drilling programme associated with a UK Overseas Development Adminstration (ODA) funded groundwater irrigation project on the Wonosari Plateau (to the north) which then extended into G.Sewu. At the same time, communal washing facilities were built into the wellhead systems of the G.Kidul (GK) irrigation wells. Some of these have been used by people coming from 10 km away and more in G.Sewu to to wash clothes. In 1982,the 28 original GK wells (typically 30 l/s) averaged 2 200 hours each.

The successful boreholes on the G. Sewu fringes are adjacent to areas of acute dry season shortage, and a typical yield of 10 l/s makes a tremendous impact as clearly illustrated by the four wells commissioned so far.In 1983 (their first complete year) these wells served a total of some 2 500 people coming from up to 3 km. One well also supplies up to 100 m3/d at a bowsering point for trucks delivering water to G.Sewu, and is 10 km closer than the previously used sources.

DGWRD has also become involved in a programme of rehabilitating telagas. Coupled with this has been a survey of the G.Sewu caves and work on improving selected caves as water sources. With ODA assistance, DGWRD is also carrying out groundwater resources assessment and associated development planning for the province. From this work is developing an integrated plan for water supply to G.Sewu.

The major source components of the G.Sewu plan are expected to be :-

(a) telagas;
(b) pumped springs;
(c) pumped boreholes;
(d) rainwater tanks;
(e) tankers and bowsers.

The associated questions are:-

(a) which sources should be used and where?
(b) who should implement and operate them?
(c) which are the truly needy areas, where more costly methods must be considered?
(d) how to avoid duplication of effort?
(e) how to get necessary technical advice?
(f) how much, if at all, should the actual operation of the systems be subsidised?

Washing Place near Fringe Area Borehole

THE PLAN
The major source components being considered are shown on Figure 3.The main foci are recently drilled fringe area wells. These will feed pipelines routed inland. Inaccessible areas would be supported, where possible, by perennial telagas; otherwise by rainwater tanks.

The overall development would be on a step by step basis, and DGWRD's contribution could be to provide wells, sometimes install pumphouse, standpipe, washing and bowsering facilities, and then hand them over to Cipta Karya for use in its own piped schemes; also to continue with the telaga rehabiltation schemes and with monitoring groundwater use and cave schemes.

The authors are encouraged by the fact that the GK wells have been operated successfully for over five years, and that the recipient farmers now pay the whole diesel cost. Since 1982, these wells have been operated reasonably successfully by local government authorities. Also,a water authority (PDAM) has recently been set up to run Wonosari water supply and it is believed that this will also look after PAB's Baron scheme.

There is considerable scope for improving rural water supply facilities in G.Sewu. However higher technology levels must be used, and provision made to operate and maintain them.

We suggest that consideration be given to expanding the mandate of PDAM Wonosari to include rural water supplies throughout K. Gunung Kidul. To support this effectively, some revenue would be essential and a unified approach must be adopted to rural water charging; tariffs would be related to ability to pay, and a specific subsidy level set to finance and staff the operation and maintenance of rural schemes.

Close inter-agency liaison on both implementing and operating rural water supply schemes is essential: rainwater tanks really should be restricted to areas without alternative sources. We suggest a committee be set up to integrate rural water supply development.

We gladly acknowledge the interest and support of the Directorate-General of Water Resources Development of the Government of Indonesia and the Overseas Development Administration of the British Government under whose auspices this work is being carried out; the contents of this paper do not necessarily reflect the opinions or policy of the DGWRD or the ODA.

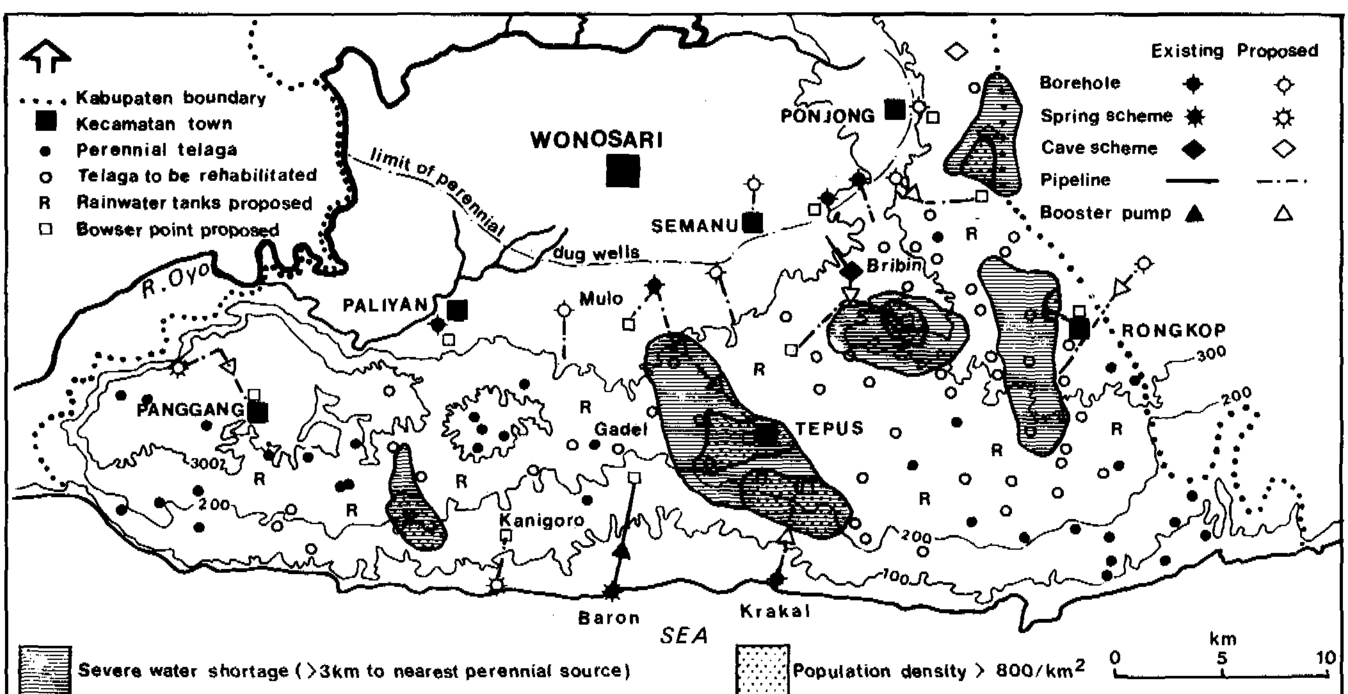


Figure 3. Gunung Sewu Development Components

10th WEDC Conference

Water and sanitation in Asia and the Pacific: Singapore: 1984

Preliminary investigations for small dams

K D Nelson

INTRODUCTION

Australians spend about US$30 million each year on the construction of small dams for scattered rural communities. Unhappily, our experience is that much of this money is wasted because about 25 per cent of these dams fail. The solution to this problem lies in more thorough investigation and improved standards of design and construction. Unfortunately such proposals are often regarded with scepticism because in many peoples' minds higher standards mean higher costs. This need not be the case.

The combined cost of field investigation and design usually represents only 5 to 10 per cent of the total capital cost of the dam. Furthermore, if the dam is constructed to a well-designed plan many cost-saving features can be incorporated. So we may well ask ourselves "Can we afford the extravagance of a cheap dam?"

SITE INVESTIGATION

The aim of this investigation is to find the most economical site for the dam. For a gully dam (i.e. an earth embankment built across a gully, stream or depression) this means the smallest embankment which provides the required storage. To compute the volumes of earth in the embankment and water in the storage, a survey must be carried out; in conjunction with this survey a sub-surface exploration is undertaken. The main considerations are:

- Reservoir site
- Foundation of dam
- Availability of suitable dam building material.

Reservoir Site

When choosing a gully site, the following topographical features should be borne in mind:

- the storage should be located in a wide valley just upstream of a narrow gorge. This will provide maximum storage for minimum earthworks.
- it should be located on the flat slope of a stream (site A) rather than on the steep slope (site B); this provides a larger capacity of stored water for any given height of dam (Figure 1).

Figure 1

One problem sometimes associated with site A is that there may be substantial depths of pervious materials (say three metres); this could mean a deep cutoff excavation for the dam. The presence of pervious materials could also result in more expensive de-watering problems during excavations.

A good reservoir should fulfil three main conditions:

- seepage losses must be low
- sides must be stable
- sedimentation must not be excessive.

Seepage Losses

These losses are affected more by the prevailing groundwater conditions than by pervious soils. For example, if an excavation is cut into sandy soil which lies well above the water-table, water will tend to seep out of the excavation (Figure 2)

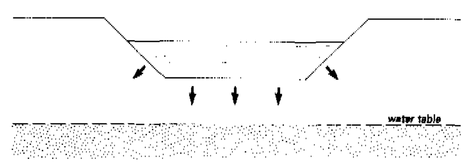


Figure 2

On the other hand if the water-table is higher than the floor of the excavation, then obviously water will seep in (Figure 3)

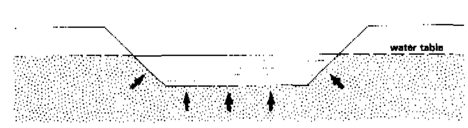


Figure 3

However, because most storages are built well above the water-table, sands and gravels are likely to be sources of seepage.

If the site is doubtful, there is a test that can be useful (ref. 1). During the site exploration, to be discussed later, several soil-sampling test holes will be put down in the borrow pit areas (i.e. areas from which soil is taken to build the earth embankment). These holes usually have a diameter of 100mm and are about three metres deep. Three or four of these holes can be selected for the seepage tests. The following procedure should be adopted:

1. Presoak each three-metre hole to a two metre depth for at least one hour before starting the test (Figure 4).

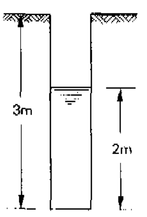


Figure 4

2. Maintain each hole at the two-metre level (i.e. one metre below ground level). The amount of water which has to be added to keep the water level constant should be recorded.
3. Continue the test for one day.

If the water added is less than 50 millilitres per minute (3 litres per hour) the site should be satisfactory. If the rate exceeds 500 millilitres per minute (30 litres per hour) the site is too permeable for a dam. For rates below these two figures (i.e. 50-500 millilitres per minute) the site should be regarded as doubtful. This indicates the need for further tests. If figures above 50 millilitres per minute are confirmed then other factors must be considered before proceeding with the project. These would include the purpose of the water supply scheme, the availability of water for the dam and the likely cost of treating the seepage area.

If it is necessary to support the sides of the test hole it can be done by packing gravel around a PVC slotted pipe.

Like sands and gravels, some rocks, too, are permeable and encourage seepage. Dams have failed due to sink-holes developing in the reservoir floor. This usually occurs when limestone underlies the soil. Water from the reservoir dissolves the rock to form vertical holes, which in turn lead to underground cavities and springs. One Australian farmer I know lost his entire water storage overnight in this way (Figure 5).

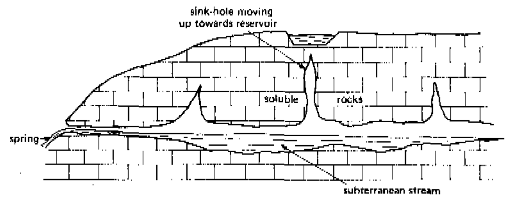


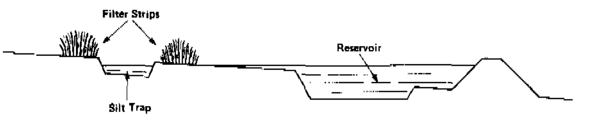
Figure 5

Stability of Reservoir Sides

As the level of stored water rises, so does the water-table in the sides of the reservoir. Soils and rocks which are quite stable when dry may become weak when saturated. This could cause a landslip which, in turn, will reduce the capacity of the storage. Frequently this problem is aggravated by cutting the borrow pits too close to the reservoir sides.

Sedimentation in Reservoirs

Sedimentation is a problem which occurs in catchments with active soil erosion. In these cases, advice should be sought from a soil conservationist. Sometimes it is possible to remedy the problem at its source; if not, it may be necessary to resort to silt traps and filter strips (Figure 6).



FILTER STRIPS AND SILT TRAP

Figure 6

Filter strips are dense stands of stiff, long-stemmed plants intermingled with grass; these strips reduce the velocity of the water and so cause silt to be deposited.

Foundations of Dams

Foundations must be capable of supporting the weight of the dam and must be sufficiently watertight to prevent seepage under the dam.

Springs, soaks or landslips indicate unstable soil conditions and should be avoided. The three main kinds of foundation material are:

- clay
- rock
- sand and gravel.

Clay

Clay foundations are usually satisfactory, provided that they are of the same material as that placed in the earth bank. However, if they are soft and saturated it may become necessary to remove them or place additional stabilising fills.

Rock

Most rock can support the weight of the dam but care must be taken to ensure that:

- seepage does not occur between the rock foundation and the earth-fill dam
- weathering of the rock does not lead to weakening of the foundation
- permeable zones are not created by joints and faults.

Sands and Gravels

The problem with this type of foundation is high seepage losses. While it is possible to build dams with these materials the cost is frequently prohibitive. Such sites are best avoided and an alternative location found.

AVAILABILITY OF SUITABLE DAM BUILDING MATERIAL

Soils placed in dams must fulfil two conditions; they must be sufficiently impervious to keep the seepage at a safe rate and they must be sufficiently stable to ensure firm side slopes.

There are three kinds of gully dams: homogeneous, zoned, and diaphragm. (Figure 7) The homogeneous dam is built from one type of soil and is the most common kind in Australia. A zoned bank consists of a centre clay core with pervious material on either side; it is considered the most stable form of farm dam. The diaphragm is built when there is only a limited amount of clay available at the site; the bulk of the bank is constructed from relatively pervious material with a thin layer (that is a diaphragm) of clay on the upstream slope. This layer varies from 0.6 to 1.0 metre thick, depending on the height of the dam.

Good impervious material contains about 25 percent clay with the balance made up of silt, sand and some gravel. Too much clay results in the embankment being weak and prone to expand and contract with changes of moisture. Insufficient clay can cause excessive seepage through the bank.

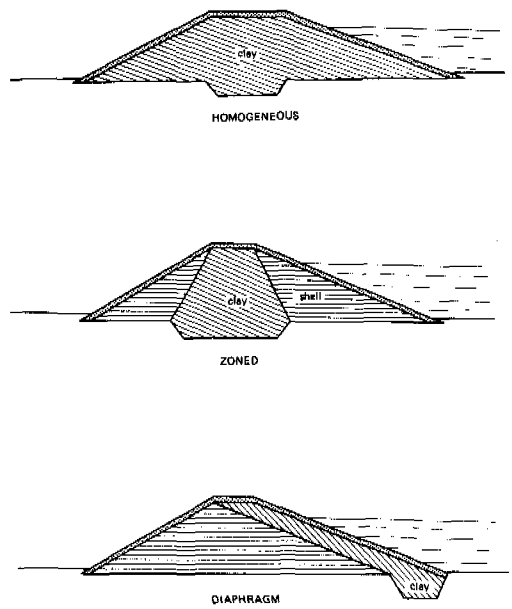


Figure 7

The usual method for exploring the area of material is hand auger boring. This is the cheapest, but it is very hard work for the operator. It is advisable to sink a test pit or trench so that the soil can be examined in its natural state.

Dam sites are tested on a fixed pattern. Small dams (up to three metres high) have a minimum of six test holes, four in the centre-line (including one on the spillway) and at least two in the borrow pit area. (Figure 8) For larger farm dams the number of test holes is increased, with holes at 20 metre intervals in borrow pits where sites are steep or complicated. This spacing can be increased to a 70 metre by 100 metre grid when the site is flat or uncomplicated. The test holes on the centre-line of larger dams are spaced at about 30 metre intervals. The test holes in the borrow pits are sunk to about 3 metres or to rock, while those in the dam centre-line are put down to at least three-quarters of the dam height or to rock (ref. 2).

When the exploration has been completed, all test holes and pits should be carefully filled to prevent human and stock injury.

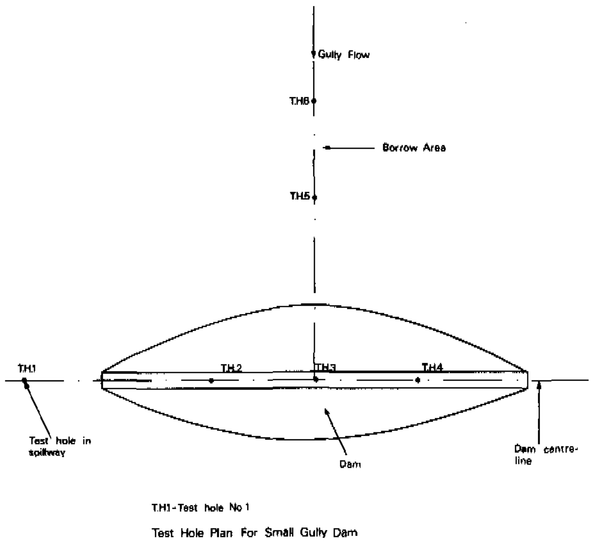


Figure 8

CONCLUSION

Most of the element of risk can be eliminated from the building of a small dam by careful attention to four basic requirements. The builder should ensure that:

- the site selected is the most economical
- the reservoir has low seepage losses, stable sides and does not silt up
- the foundations are watertight and capable of supporting the dam
- there is sufficient dam-building material.

The cost and effort expended on making sure that these conditions are met will, in the long run, save the builder both time and money. Remember the military adage "Time spent in reconnaissance is never wasted".

REFERENCES

1. U.S. BUREAU OF RECLAMATION. Earth Manual, 1974. (A book)

2. NELSON, K.D. Design and Construction of Farm Dams, Water Research Foundation of Australia Symposium, 1983 September (A paper)

10th WEDC Conference

Water and sanitation in Asia and the Pacific : Singapore : 1984

The reliability of using rainwater tank supply

Dr K C Tai and T D B Pearce

INTRODUCTION

The use of rainwater tank supply is now a matter of public policy in South Australia. It is now recognised as an allied strategy in water conservation in the driest State of the driest continent. With about 83 percent of the State receiving an average annual rainfall of less than 250mm, Adelaide's limited surface water supplies are being supplemented by additional water pumped through pipelines from the River Murray. However, water from the River Murray is very hard and since rainwater is not, its uses are favoured for drinking, washing and cooking purposes. This preference for rainwater use is significant in South Australia as consumers' utilities play a big part.

In 1982, statistics collected by the Australian Bureau of Statistics in Adelaide have revealed about 213 000 households out of a state total of about 456 000 households were using both mains and rainwater supplies (Ref 1). Of the 213 000 households, 120 350 households (56.3 percent) use only tank water for food preparation or drinking, while 73 900 (34.6 percent) use raintank water for some or all of their clothes washing.

The preference for rainwater is greater in areas outside of the Adelaide Statistical Division, where 70 150 households (80 percent) out of 87 950 households use rainwater for food preparation or drinking, as compared with 50 200 households (40 percent) out of a total of 125 000 households in the Adelaide Statistical Division.

The State Government of South Australia is encouraging the use of rainwater tanks as such a use could make a worthwhile contribution to the State's limited water resources. It has brought out a booklet prepared by the Engineering and Water Supply Department in conjunction with the Department for the Environment and Planning (Ref 2). That booklet, "Rainwater Tanks - their Selection, Use and Maintenance", provides information in situations where rainwater supply is to be used in conjunction with mains water. Recently, there has been a surge of interest for rainwater to be used as a sole source of domestic supply, because of increasing housing development beyond reticulated areas. This paper is concerned with the latter objective.

ANALYSIS

The simulation analysis uses historical rainfall data to evaluate changes in storage of a rainwater tank, using the mass storage equation (Ref 3).

The simulation evaluates an upper bound situation when demand is assumed constant and a lower bound when demand is made variable according to a self-imposed water rationing rule. This rule is arbitrary since there is no standard rule for human behaviour. Variable demand can be used to demonstrate the likely effects of human response, especially when water level in the raintank decreases and when ultimately, the supply could be used solely for cooking and drinking purposes. Hence self-imposed water rationing could occur during extended dry periods (droughts), as non-essential rainwater uses are curtailed.

The values of demand selected are 60, 100, 200, 400 and 600L/day/household. The lowest value is for a single low consumer, while the highest value is for a four person in-house consumption.

The mass storage equation is given by:

$$Z_{t+1} = Z_t - D_t + Q_t$$

subject to $0 \leq Z_{t+1} \leq S$, and

$$Z_t - D_t \geq 0, \text{ and}$$

$$Q_t = C\,(P_t - E_t),$$

where

Z_{t+1} is storage at the end of the t^{th} time period;

Z_t is storage at the beginning of the t^{th} time period;

D_t is release during the t^{th} time period;

Q_t is the inflow during the t^{th} time period;

S	is the maximum storage capacity;
C=0.8	is the catchment coefficient for roof and gutter to account for roof and gutter spillage;
P_t	is the rainfall during the t^{th} time period;
and	
E_t	is the evaporation loss from the raintank during the t^{th} time period (2mm/month)

The release rule for the constant demand D_t, is to supply all the water demanded, and if there is insufficient water in the rainwater tank to meet the required draft, the tank storage empties. The release rule for the case of variable demand is based on knowledge of current storage (assumed at the end of the month), and an appropriate release based on restriction is worked out for the next month. Hence, as the storage volume decreases, self-restrictions are imposed so that demand is adjusted to monthly fluctuations in supply. There is no universal release rule to follow. The one adopted in this study follows a step function for the variable demand and is expressed as follows:

STORAGE VOLUME (% of storage capacity)	RELEASE (percentage of constant demand)
$0 \leq Z_{t+1} < 50\%$	25%
$50\% \leq Z_{t+1} < 66\%$	50%
$66\% \leq Z_{t+1} < 83\%$	75%
$83\% \leq Z_{t+1} \leq 100\%$	100%

RESULTS

Performance Characteristics

With space restriction as the constraint, the case of Adelaide is taken as an example, with constant and variable demands displayed in figures 1 and 2 respectively. The reliability chosen is 80 percent, which is seen to be non-conservative in regard to sole supply, although reliabilities of 85, 90, 95 and 99 percent have been investigated. The curves display the relationship between the required raintank storage volume against the required roof area for a given demand and reliability.

The reliability used here is the reliability over time, Re(t), which is defined as the proportion of months in any year during which the rainwater tank is <u>not</u> empty (ref 3). It is not volumetric reliability, defined as the total volume of water supplied to the total volume of water demanded.

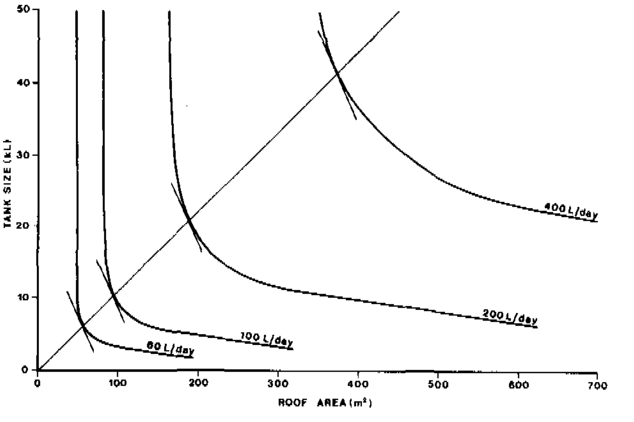


FIGURE 1 - RELIABILITY 80% - ADELAIDE CONSTANT DEMAND

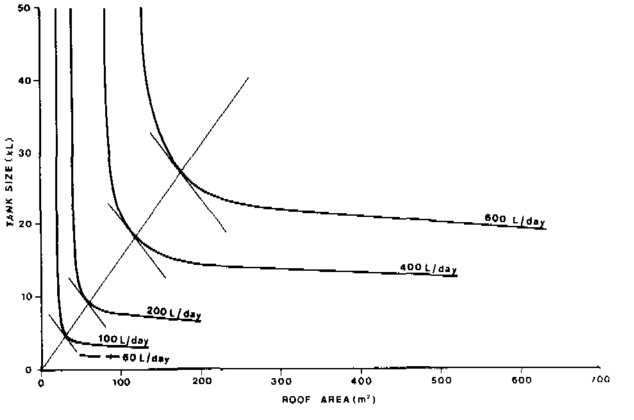


FIGURE 2 - RELIABILITY 80% - ADELAIDE VARIABLE DEMAND

The performance curves of raintank storage/roof area show three areas of interest:

a) the vertical section of the curve, showing a minimum feasible roof area, when any increase in tank size will merely add on empty storage space:

b) the almost horizontal section of the curve, showing a minimum feasible tank size, when any increase in roof area will merely add to greater tank spillage, and

c) the bend region of the curve, where there is limited substitutability of roof area or storage tank volume or vice versa.

In the bend region of the curve, the ratio of optimal tank size V_T, to the optimal roof area A_R is obtained by equating the marginal rate of substitution MRS (roof area A_R for storage volume V_T) to the slope of the budget line P_r/P_t, where P_r and P_t are the unit costs of roof area and storage volume.

$$MRS\ (A_R \text{ for } V_T) = \frac{\partial V_t}{\partial A_R} = \frac{P_r}{P_t}$$

The optimum point is given by the tangent of the budget line against the bend of the curve. At this optimum point, a ray drawn through the origin at a constant slope of V^*_T/A^*_R will exhibit constant returns to scale, which are evident in both cases of demand. The significance of this is apparent, for if and when demand is increased by a certain ratio, the optimal tank size and roof area need to be increased by that same ratio, given that unit costs of both tank and roof area remain constant.

The criterion for constant returns to scale is when demand $D_t = f(V_T, A_R)$ is increased by a scale factor m, such that $mD_t = f(mV_T, mA_R) = mf(V_T, A_R)$ for $m > o$ (see ref 4).

Hence if demand in any row in Tables 1 and 2 is expressed as a ratio of demand in the previous row, the value of that ratio applies also to the ratio of tank sizes and roof areas.

TABLE 1: Constant Returns to Scale under Constant Demand

Demand D_t L/day/ household	Vol of Tanks V_t litres	Roof Area A_R sq.m.	Reliab. Re (T)
60	5900	57	0.795
100	9800	96	0.798
200	20300	188	0.795
400	41000	375	0.796

TABLE 2: Constant Returns to Scale under Variable Demand

100	4760	32	0.845
200	9100	60	0.810
400	18000	118	0.801
600	27000	176	0.796

Severity Characteristics

Under condition of optimal selection with constant returns to scale, there appears to be a close similarity of severity characteristics deducible by run-analysis of empty and non-empty storage states.

For the case of constant demand, the frequency distributions of monthly failure are similar, with March, April and May (the autumn season) as the critical period of likely failures. For the case of variable demand, the distributions are not exactly similar, but the critical period has advanced by a month, is, February, March and April.

Although the total number of monthly failures X(t) is large, many of the monthly failures are found to be in sequence so that the number of sequential failures N(t) is less than X(t). The process X(t) is a compound Poisson process with,

$$E[X(t)] = E[N(t)].\ E[Y]$$

where E is the expectation notation and E[Y] is the expected or average length of monthly failures in any year.

If the time t represents the failure time domain and if the recurrence interval of sequential failures follows an exponential decay function, $f(t) = \lambda e^{-\lambda t}$, it could be shown that the expected recurrence interval is given by $E[T] = \frac{1}{\lambda}$

The encounter probability E_c of sequential failures could be estimated for the design life L of the rainwater tank, where (ref 5),

$$E_c = 1 - e^{-\frac{L}{E[T]}} = 1 - e^{-\lambda L}$$

But in any given year L = 1, $E_c = 1 - e^{-\lambda}$

The severity charactistics are summarised in tables 3 and 4.

TABLE 3: Severity Parameters under Constant Demand

D_t (L/day)	60	100	200	400
X(t)	345	340	344	342
N(t)	138	137	139	136
E[Y](months)	2.50	2.48	2.47	2.51
E[T](years)	0.89	0.90	0.87	0.89
E_c	67%	67%	68%	67%

TABLE 4: Severity Parameters under Variable Demand

D_t (l/day)	100	200	400	600
X(t)	260	320	355	343
N(t)	108	121	137	134
E[Y](months)	2.41	2.64	2.59	2.56
E[T](years)	1.18	0.99	0.90	0.89
E_c	57%	64%	67%	67%

Hence for a time reliability of 80 percent of success or 20% of failure, the encounter probability of a sequential failure event is about 67% for constant demand and slightly less for variable demand.

While there is an option in the variable demand to choose an optimum tank size/roof area smaller than the optimum combination given by the constant demand at the same reliability, there is a trade-off penalty involved between cost saving and a drop in volumetric reliability R_v.

TABLE 5: Trade-off between reduction in optimal tank sizes and roof area with volumetric reliability R_v.

D_t (L/day/H)	% Reduction in tank sizes & roof area		% Reduction in volumetric reliability
	V_t	A_R	R_v
100	49%	33%	61%
200	45%	32%	63%
400	44%	31%	63%

The potential saving in capital cost has to be weighed against the self-sacrifice of water rationing, which could be very inconvenient.

Apart from the consideration of trade-off, there is a potential range in the hazards of supply failures which could occur from time to time given the variability of Adelaide's rainfall regime.

The simulation analysis indicates three categories of prospective failure: mild, moderate and severe (fig 3). An estimate of encounter probability E_c for the estimated life time of the rainwater tank (25 years) suggests that the method of selection is appropriate (fig 4).

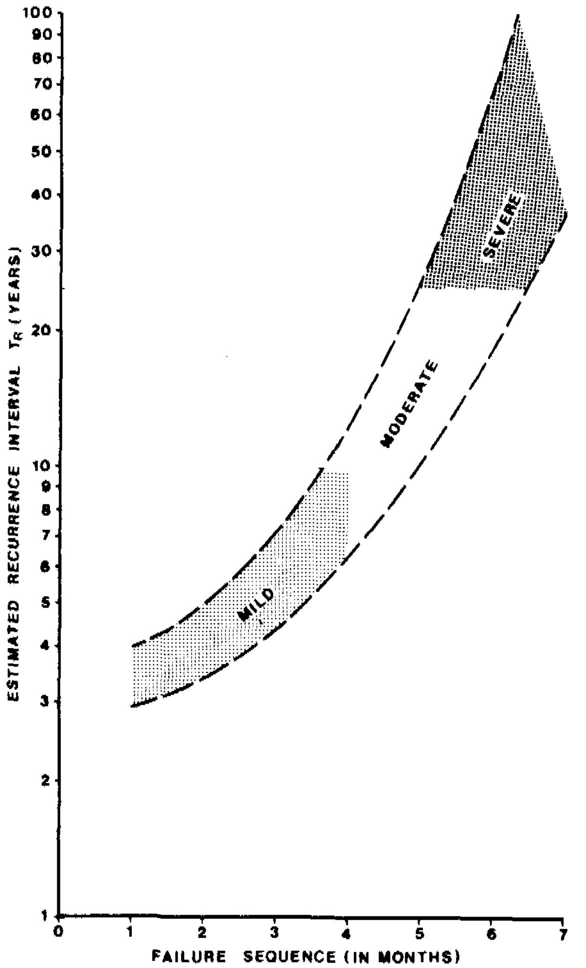


FIGURE 3 – ESTIMATED RECURRENCE INTERVAL AND FAILURE SEQUENCE

TABLE 6: Severity of Supply Failures

Severity of Supply Failures	Extimated Recurrence Interval	Failure sequence in months
Mild	Less than 10 yrs	4 or less
Moderate	10 to 25 yrs	5
Severe	Greater than 25 yrs	6 or greater

TABLE 7: Estimated Encounter Probability for the estimated life time of the tank (25 yrs)

Severity of supply Failure	Const. demand E_c	Variable Demand E_c	Recomm. Range E_c	Failure sequence in mths
Mild	85-95%	88-100%	greater than 85%	Less than 4
Moderate	66-82%	64-86%	65-84%	5
Severe	40-67%	30-56%	30-65%	6 or greater

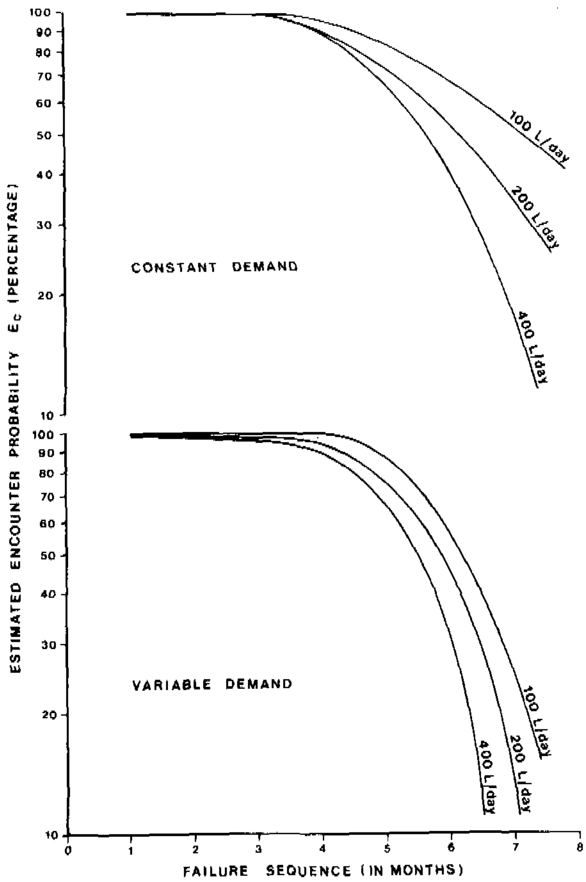


FIGURE 4 – ESTIMATED ENCOUNTER PROBABILITY IN 25 YEARS

CONCLUSIONS

Although the use of rainwater tank supply is now a matter of public policy in South Australia, more pertinent information should be made available to the potential consumer, especially in the case of sole supply. Not only performance characteristics but also severity characteristics should be evaluated. Potential consumers of rainwater tank supply will then have a sound appreciation of the hazards and risks involved in terms of supply fluctuations caused by variation of rainfall inputs. They would be able to select tank sizes for their requirements and use the water more efficiently i.e. maximize supply from their tanks.

The performance curves and the severity characteristics deduced from a given rainfall sequence are site-specific. Where there is significant variation of rainfall regime in space and in time, caution should be exercised in using such performance curves to size up appropriate combination of rainwater tank and roof area.

ACKNOWLEDGEMENT

The authors are grateful to the Director-General and Engineer-in-Chief of the Engineering and Water Supply Department, South Australia, for his permission to publish this paper. The opinions expressed by the authors are not necessarily those of the Department.

REFERENCES

1. SIMS, G.C: Use of water applicances by households, South Australia. Australian Bureau of Statistics (Adelaide) November, 1982. Catalogue No. 8709.4, 11 August 1983.

2. THE GOVERNMENT OF SOUTH AUSTRALIA: Rainwater tanks ..... their selection, use and maintenance. The Engineering and Water Supply Department and the Department of Environment and Planning. D J Woolman, Government Printer, Oct 1983.

3. McMAHON, T.A. and MEIN, R.G: Reservoir Capacity and yield. Elsevier Publishing Company, NY 1978.

4. NICHOLSON, Walter: Micro-economic theory. Basic principles and extension. 2nd Ed. the Dryden Press, Illinois, 1978.

5. SHANE, Richard M and LYNN, Walter R: Mathematical model for flood risk evaluation. Journal of the Hydraulics Division, Proceedings ASCE, No. 4119, HY 6, Nov 1964, pp 1 – 17.

10th WEDC Conference

Water and sanitation in Asia and the Pacific : Singapore : 1984

Drinking water for the Mekong Delta

Rana Zafar Alikhan

In 1980 the government of the Socialist Republic of Vietnam expanded its drinking water activities in rural areas of the Mekong Delta. This large deltaic area had, in 1979, a population of 11,865,000 according to a census carried out in that year. The annual rate of population growth is estimated at 2.5 to 3%.

The Mekong Delta includes nine provinces, but the Drinking Water Programme is, for the time being, concentrated in the three provinces of Long An, Kien Giang and Minh Hai. These activities receive fairly extensive assistance from UNICEF.

As with most other developing countries, many of the diseases which affect the population in Vietnam are water-related, and the main objective of this programme is to reduce the incidence of such diseases.

The groundwater potential of the Mekong Delta is large but related information is scarce, which makes further hydrogeological prospecting a necessity. Most of the Delta is flat and is only one to four metres above mean sea level. It is composed of recent and old alluvium underlain at unknown depths by consolidated rocks of Mesozoic and Paleozoic age, and beneath those by a basement of granite, gneiss and other crystalline rocks of precambrian or later age.

Groundwater is contained in aquifers of lenticular shape throughout the Delta. Tidal invasions of the rivers and canals during the dry season result in poor quality of the shallow ground water. Useable water can be obtained from deep confined aquifers.

The following is a summary of available technical information on the three provinces of Long An, Kien Giang and Minh Hai.

Long An: This province has a surface area of 4,600 sq.km., with a population of about one million. The highest point in the province is 1,9 metres above mean sea level. The entire western half of the province, which is part of the "Plain of Reeds", is subjected to extensive floods, the level of which reaches up to four metres. Drainage in this area is very poor, and evaporation during the dry season produces soils which are acidic, and which have a high alum content. The chloride content of the soils is very high. The depth to fresh water appears to be least in the north and greatest in the south-eastern part. The upper layer is generally salty, and it may therefore be necessary to drill bore holes down to the deepest sedimentary beds, 200 to 300 metres or even deeper, in the hope of finding a confined and protected artesian aquifer. It would also be necessary to prevent intrusion of saline water from the upper layers to the fresh water zones through the bore holes.

Kien Giang: This province has a population of approximately one million and a surface area of 6,230 sq.km., including Phu Quoc Island 50 km west in the Gulf of Thailand. Very little hydrological and hydrogeological information is available on this province. Twenty percent of the province's surface water is fresh. Of the remaining 80%, coastal areas are salty and inland areas are acidic. Many areas have never been settled chiefly for this reason.

Overburden in the western part is shallow, and in some areas bed rock has been encountered at 60 metres. Some of the wells produce water from the bed rock, which is limestone, but high chloride content has been found in some wells. There is, however, a possibility of entering the old alluvium if drilled away from this area. Deeper wells close to the sea may yield salty water. Water quality in the flood plain may prove to be a problem as some of the wells drilled in this area had a chloride content of 1,200 mg/l. Thus it appears that wells in this area will have to be drilled into the old alluvium, and special care will have to be taken to seal off the shallow aquifer which contains chlorides and aluminium sulphates.

Minh Hai: This is the southermost province of the Lower Mekong Delta. It has a population of over 1.2 millions, and a surface area of 7,690 sq.km. Flowing artesian conditions occur in most of the provinces with the north-west and central parts being exceptions.

The chief source of fresh water in this province is the old alluvium. The shallower aquifer in the old alluvium ranges between the depth of 60 and 120 metres. The deeper aquifer (450 metres) has not been positively identified and correlated but at least one well has been drilled into it. This well produced an artesian flow of 10 l/s and contained 130 mg/l of chloride. It will, therefore, be necessary to penetrate the deeper aquifer where the shallow aquifer has been intruded by salty water.

Technical know-how and facilities

Because of the events which took place in Vietnam during the past two decades, the country's technical infrastructure is weak. Qualified technicians and drillers are rare, and available technical and drilling equipment is inadequate.

Programme approach

Due to these technical weaknesses the Drinking Water Programme stresses the utilization of simple technologies. For example, manually-operated jet-boring rigs are used wherever possible, and handpumps are installed on the wells. Related training courses are conducted. Other more advanced technologies are to be introduced in those areas where hydrogeological conditions do not permit the utilization of jet-boring and/or the use of handpumps.

Manual jet-boring has also been introduced to a number of other countries. This drilling method is simple and inexpensive and has proved to be particularly successful in countries such as Bangladesh, where labour is plentiful. The entire unit, including the mud pump, can be constructed locally although it is sometimes necessary to import a few of the more specialized parts. No fuel costs are involved, which is an obvious added advantage.

Because of the fact that in most of the Mekong Delta the water level in drilled wells rises, under artesian pressure, often to within one metre of the surface, it is possible to make extensive use of suction hand-pumps. The main advantage of such pumps is that they are easy to maintain and no operational costs are involved. The pump which is currently used in the programme is the Bangladesh New No.6.

It has been reported that a total of five hundred 50 mm wells have been installed in the three concerned provinces since 1981. The depth of these wells from 45 to 130 metres. Not all of these wells have yet been equipped with pumps and, indeed, it is not clear to what extent the wells generally compare with acceptable standards of construcation. For this reason arrangements are currently being made for the National Institute of Hygiene to carry out a basic evaluation of activities to date.

As is frequently the case with groundwater, the presence of iron is common in most of the well water produced so far under this programme. In areas where the iron content is unacceptably high, it will be necessary to introduce suitable iron-removal techniques.

Mechanical drilling has to be employed in areas where manual jet boring is not feasible.

A conventional water-well drill, which is normally mounted either on a truck or trailer, weighs several tons and is of large dimensions. In most rural areas of the Delta, where roads are few and transportation is normally by waterways which are often narrow, winding and shallow, it is not possible to deploy such large rigs. An appropriate rig for these conditions would have to be small, light and easy to dismantle and reassemble. It should be capable of handling six metre lengths of pipe, and be capable of drilling to depths of 600 metres. Because there is no conventional water-well rig which meets these requirements, it will be necessary to make use of a diamond core drill rig for this specialized job.

The basic difference between a conventional rotary water-well rig and a diamond core drill is that of the bit RPM. Fortunately diamond drill rigs are now available with high-low range selectors. Some of the rigs are designed in such a way that the Bit RPM can be as low as 42. Such rigs can be operated at 100 bit RPM in second gear, which is the normal requirement for a non-coring tricone roller bit - the most suitable in this case.

Another important factor, in view of surface conditions, is the design of the mast. A drill rig with a single pole mast, if used on soft ground without anchoring, results in tilting from the front. This produces a crooked hole, and damages tools. In most cases pipes get stuck while installing the well. Since anchoring a rig consumes more time than actually drilling and installing a well, the most appropriate solution is to have a four legged mast fitted to the drill frame so that the forces developed keep the drill in place and balanced.

Because of acute shortages of qualified personnel, inability of the communities to raise enough funds to pay for fuel and, above all, acute shortages of fuel, motor pumps are to be used only where large quantities of water are required and hand-pumps cannot provide water in those quantities. Some centrifugal pumps, helicalrotor pumps and air-lift pumps are being experimented with.

Although a certain amount of experimentation will continue to be included in this programme, it is likely that, for the foreseeable future, activities will centre on manually drilled wells equipped with handpumps.

REFERENCES

1. ANDERSON H R. Hydrogeologic Reconnaissance of the Mekong Delta in South Vietnam and Cambodia. United States Geological Survey, 1978. (Water-Supply Paper 1608-R).

2. GOULET, Leo. Report on the Domestic Water and Sanitation Situation in Three Provinces of the Mekong Delta. UNICEF, Hanoi, Vietnam, 1980.

3. RASMUSSEN W C. Review of the Ground-Water Potentialities of South Vietnam, with Special Reference to the Delta. USAID/Vietnam, 1966.

SESSIONS 2 and 3

Chairman: Mr W.S. Moffat, WEDC Group. Loughborough University of Technology, U.K.

Discussion

S Amin

Rural water supply - planning and implementation

1. The author was not present, and the paper was not read.

A Appan

Harnessing of rainwater, the under-utilized source in developing countries

2. Dr APPAN outlined the components of rainwater cistern systems, methods for sizing cisterns, and discussed factors affecting the implementation of such systems in developing countries.

3. Mr CULLEN reported that the use of bamboo reinforcement in storage tanks had been unsuccessful in Java, because the bamboo rotted. However, ferrocement tanks had been very successful.

4. Dr APPAN said that this problem was being investigated in Thailand by treating the bamboo; because rural people were familiar with using bamboo, it may be worth proceeding along these lines. Although ferrocement was slightly more expensive, rural people in Thailand and Indonesia had rapidly learnt the construction techniques.

5. Mr SIDDHI stated that problems may arise if the roofing material was not suitable, and water may have to be collected at a central point and piped to individual houses.

6. Dr APPAN replied that simple filters could be used if the roof water was coloured or turbid, but that they would need regular cleaning. If the quality of the water was poor only on the 'first flush', then this water could be diverted manually, or by a semi-automatic device.

7. Mr YAU described a community rainwater catchment scheme he had seen in Israel; rainwater was collected on a surface catchment lined with plastic, and drained into a covered ditch, from where it was raised by a handpump. He thought that such a system would be suitable for community use.

8. Mr KSHIRSAGAR described systems he had seen in the mountainous Andaman-Nicobar islands, hilly areas with seasonal rainfall, and in the Rajasthan desert for obtaining drinking water. He stated the need for health education to maintain the quality of the water.

9. Mr PARAMASIVAM asked for more information on 'interlocking mortar blocks' as a construction technique.

10. Dr APPAN replied that these were still in the experimental stage; the edges of the blocks were chamfered, and the units joined by mortar. They were only used for the side walls in a circular tank; the base and roof were of reinforced concrete.

11. Mr SOEDDARWO commented that rainwater cisterns were highly appropriate providing that the support of the community could be utilised to help reduce costs, and encourage acceptability.

12. Mr de KRUIJFF described some of his experiences with rainwater storage, which had been used for many years in the West Indies. Cisterns could only be economically constructed where there was regular rainfall, with rainfall at least every month. He did not think that filters worked at all well, as tropical downpours could destroy them. Cisterns could introduce other health hazards such as mosquito breeding; he had found that keeping fish in the tank eliminated the mosquito problem.

13. Mr VAN GINHOVEN asked for more information on using fish to prevent mosquito problems.

14. Mr UPADHYAY replied that insect and larvae eating fish could be identified by the position of their mouth, which was terminal or epiterminal. These fish only inhabited the upper level of water.

A K Basu, R S Dhaneswan, A K Biswas, A K Ganguly, P B Sanyal, S R Kshirsagar

Critical studies on rural water supplies in a drought prone area and a coalfield area of West Bengal

15. The authors were not present and the paper was not read.

D W Berry and L W S Attewell

Three Recent Malaysian Dams

16. Mr BERRY presented the following introduction to his paper.

'The paper, because of limitations of space contains only a description of three dams recently constructed for water supplies to small towns in Malaysia. However, I feel that the value of collecting these three dams together for comparison, is to demonstrate that it is now practical with modern methods of design and construction to build small dams on practically any site which is topographically suitable.

Some of my remarks may overlap the paper presented by Mr Nelson and I hope he will forgive me if I trespass on his territory. Relative to Mr Nelson's paper Professor Pickford drew attention to the question "Can we afford cheap dams?". My answer is yes, provided they are also safe. There is very little saving in a cheap dam if you have to rebuild it every year. In passing, I might mention that the most common reason for all dam failures is an inadequate spillway, so some hydrological knowledge is necessary if the first tentative steps towards a rural water supply scheme are to go further.

Turning now to the paper . . .

The principal characteristics of each dam are listed in the paper, and need not be repeated here.

Very little need be said about Timbagan - it is the classical dam site, with sound rock at or near the surface and concrete materials readily available close to the site.

Sepagaya was a slightly more difficult site in that the valley is very steep sided and the foundation material was too weak for a concrete dam, or even for a rockfill dam with conventional steeper slopes. In fact it was best suited for an earthfill embankment but unfortunately there was a distinct lack of suitable earthfill materials within a reasonable distance of the site. It is for this reason that the rockfill slopes are so flat - the foundation could not withstand the loads imposed by conventional steeper slopes, and the embankment is in fact an earthfill dam which has had most of the outer shell replaced by rockfill. The strength associated with rockfill is not needed, and the overall section is governed by foundation strength.

The narrowness of the valley caused, and is still causing, organisational problems for the contractor due to the restricted working area.

Sembrong Dam is the one which best illustrates my introductory remarks about building dams on virtually any sort of foundation. Unfortunately I do not have any slides of the initial stages of construction but I hope that you will have a look at the photographs included in the poster sessions, and perhaps discuss it further.

The foundation of the embankment comprises generally a zone of 4 to 5 metres of very soft saturated organic silty clay with many roots and decaying vegetation. Beneath this is a bed of variable sand deposits to a depth of about 9 metres and below that is a residual soil - a stiff white silty clay. However, over a significant length of the dam the sand deposits are very thin, or entirely missing so that the problem was to build a dam on a very soft saturated foundation some 9 metres deep. Not really a place to build a dam! Obviously in such conditions pore pressures generated in the foundation during construction would be more severe than the long term steady state pore pressures.

For this reason a fairly extensive programme of soil testing was carried out followed by analysis to predict the likely performance of the embankment and foundations during construction.

Much of the foundation in the critical area was under 2 to 3 feet of water making it difficult to obtain representative samples for laboratory testing, and special emphasis was placed on in situ testing, including determination of effective stress profiles, shear moduli and in situ strength using a self boring pressure meter.

The analysis was carried out in four parts.

- Prediction of instantaneous rise in foundation pore pressures due to embankment loading during construction.
- Stability analysis of the embankment.
- Consolidation analysis of the foundation.
- Prediction of horizontal and vertical movements of the foundations.

The analysis showed that it would be necessary to construct the dam in 3 distinct stages, with rate of construction limited, such that stages 2 and 3 were each constructed over a period of 150 days, during which foundation pore pressures would dissipate by 50%.

Figure 1 shows the three stages adopted for construction and the location of soil instruments which were sited at four sections along

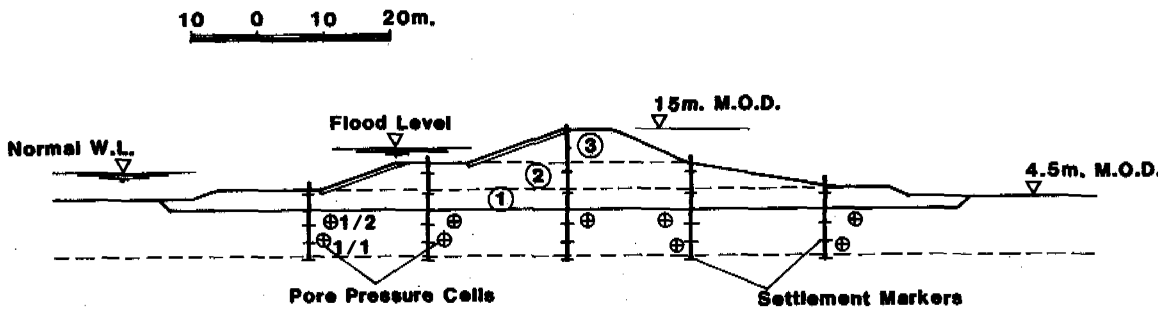


Figure 1 **Simplified Cross-section of Sembrong Dam**

the embankment. These instruments measured pore water pressures, vertical settlement and horizontal displacements and were used for control during construction.

The embankment is now almost completed, except for the rip-rap facing on part of the upstream side, and the effectiveness of the design procedures can be illustrated by comparing predicted and actual results over the construction period.

Figure 2 shows predicted and actual pore pressures at the edge and centre of the embankment, and Figure 3 predicted and actual settlements.

I hope that this brief description will convince you that dams can successfully be built in most places now that suitable site investigation and design techniques are available.

Now, just in case you are feeling that all of this sophisticated analysis is very costly, and out of reach of developing countries, I should mention that the greater part of the complete water supply projects including the dams was carried out by a well-known firm of Malaysian Consultants with only specialist advice from my own company. We supplied part time team leaders for the dam design, and a senior resident engineer during construction. We feel that this is a desirable way of working since over a period it will result in transfer of technology to the host country, which must always be part of working in a developing country.

I don't think I have quite used up my allotted time, so I will conclude with a general comment concerning the economical construction of small dams.

The ideal site has sound rock at or near the surface, and provided this is so, the cheapest dam will almost certainly be a concrete dam - usually mass concrete for which construction techniques are less sophisticated than those needed for small buttress or multiple arch structures.

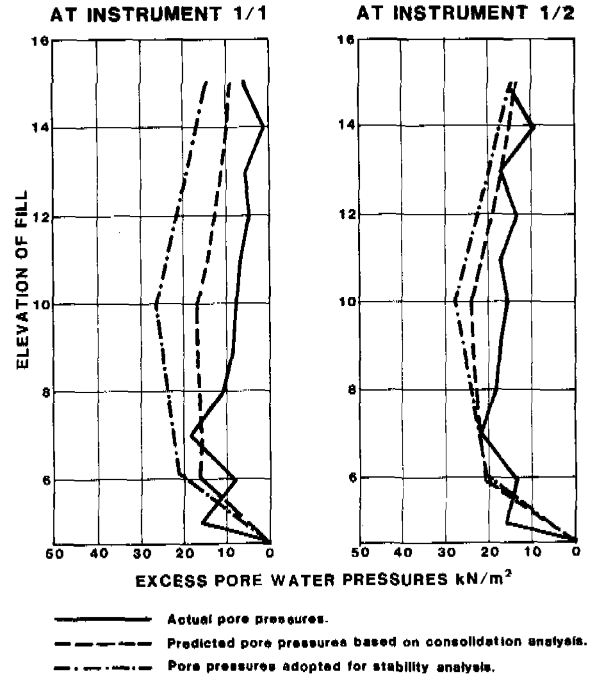
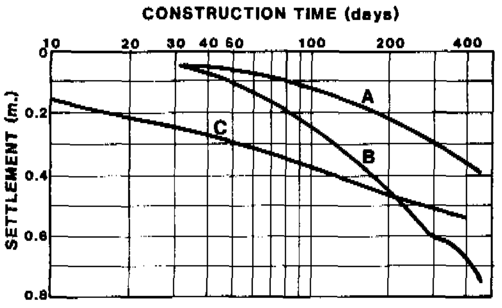


Figure 2 **Excess Pore Pressure**

If however, sound rock is at a significant depth alternative embankment designs should be considered. Generally a rockfill dam will require stronger foundations than an earthfill dam, so often, when foundation strength increases with depth, it may be cheaper to use an earthfill dam as it involves less deep excavation.

As an example I will quote comparative costs



A - Actual settlement at plate in fill.
B - Actual settlement at plate in foundation.
C - Predicted settlement at base of embankment.

Figure 3 **Vertical Settlement**

for a site which I recently studied, where an earthfill bank could be founded at a depth of about 2 metres, a rockfill embankment at about 4 metres and a concrete dam at about 8 metres - all to have the same top water level.

Taking the cheapest - the earthfill as 100 the comparative costs are:

Rockfill	125
Concrete gravity	280
Concrete buttress	220

However, if all types of dam could have been founded at the same level the position would have been reversed:

Earthfill	100
Rockfill with clay core	94
Concrete gravity	85
Concrete buttress	65

I must emphasise that these figures relate to one site only and could vary for other sites. However, I would expect the trends to be the same.

Therefore if there is good rock near the surface the concrete dam is the obvious answer. However, ideal dam sites are comparatively rare - even for low dams - and the message I wish to give is that even on apparently poor sites a small dam can usually be built with complete success. Nevertheless, such works require planning - it is never too early to set up river flow and rain gauges and this too is something developing countries must do to help their successors to plan well for the future.'

17. Dr APPAN asked the following questions.

(a) What was the basis for the recommendation of constructing the embankment in three 'layers' with 150 days for each layer for the construction of dams in very poor foundations.

(b) In the context of rural water in a developing country what sort of compaction was recommended.

18. Mr BERRY stated that:

(a) The problem with the foundation at Sembrong was the very high in situ moisture content, which would have led to development of very high porewater pressures during construction if the full height of the embankment had been placed without any control of the rate of placing.

The recommendation of three layers and 150 days per layer related to Sembrong Dam and was made after studies to predict excess pore pressures in the foundation, and these predictions were then used in the stability analyses. Prediction of settlement also affected the decision.

The recommendations for Sembrong Dam were not necessarily the best for other similar sites. However, it was vital that studies of this type should be carried out as part of the design phase of dams on weak saturated foundations.

(b) There was usually no problem in achieving a compaction of 95% Proctor Maximum Dry Density, and this should be the aim for any dam, even for rural water supply. Lower standards of compaction would inevitably require flatter embankment slopes and hence a greater volume of fill.

19. Mr C M AINGER asked what was the overall time scale for Sembrong Project, and what increase in time was needed for the more sophisticated investigations and analysis.

20. Mr BERRY replied that the investigation and design work, which was for 2 dams one of which has not yet been constructed, started in May 1979. The site investigation started in July 1979, field work was completed in 4 months and laboratory testing in 6 months.

The design and tender documents were completed in June 1980. The tender period was from October 1980 to January 1981. The order to start work on the contract was given in August 1981 and the dam was substantially complete in September 1984. Thus the overall time period from the start of the investigation to the completion of construction was just under 5½ years.

The pressure meter tests at the two sites were completed in 6 weeks and carried out in parallel with the conventional site investigation. A complete profile of pressure meter tests could be carried out more quickly than the drilling of a conventional percussion borehole with sampling. Also because of the greater portability of the equipment the time to set up on the next borehole, in the difficult conditions encountered, was reduced to hours rather than days.

The pore pressure prediction and stability analysis were carried out by computer and completed in 3 months from the end of the field work. This would be difficult to better with conventional laboratory testing and analytical techniques.

In summary, therefore, the field work could cover more ground in a shorter time and the time for analysis would be comparable with conventional techniques.

M Chickannaiyappa and M V Ramaswamy

Community participation - water supply systems in Karnataka

21. The authors were not present, and the paper was not read.

R J Cullen, A Young and S Soedaryanto

Drinking water for Gunung Sewu

22. Mr CULLEN presented the paper, and described the existing potable water sources, and how they could best be utilised to overcome the problems of drinking water supply.

23. Mr CROSS asked what experience had been gained so far.

24. Mr CULLEN replied that very little had so far been attempted, and schemes had initially been operated at no cost to the users. Now that they were being asked to pay, problems were arising. He suggested that the following points should be noted: agree the costs with the users before starting a scheme; people who were already paying for water may be prepared to pay more; costs should be accurately assessed, including operation and maintenance; self-financing of schemes was important; different agencies had different rules, which often caused problems. He gave an example of an irrigation scheme in which farmers were paying the full costs; this provided some guide, because irrigation costs tended to be higher than drinking water costs.

K D Nelson

Preliminary investigations for small dams

25. Mr NELSON described the importance of site investigation, related to improved standards of design and construction of small dams in Australia.

26. Mr RAUSCHENBERGER asked the author about the permissible seepage through the bottom of a reservoir.

27. Mr NELSON replied that different engineers held different opinions on permissible seepage values. He knew of examples where it was as low as 1 mm per day, although he had always used more generous upper limits of about 25 mm per day, or even 50 mm per day in newly constructed dams. Siltation should reduce the rate to more acceptable levels. Another factor affecting the seepage was the inflow into the reservoir; if it was very high it may be able to supply the demands, such as irrigation, and the losses due to seepage and evaporation. In this case it was assumed that high seepage did not endanger the dam itself.

28. Mr FISHER stated that under some conditions in small dams, initial seepage as shown by tests could appear to be excessive; presumably siltation could progressively reduce the seepage.

29. Mr NELSON agreed, and suggested that the seepage losses may reduce within 5 years of construction. If seepage remained a problem, it could be treated by compacting the reservoir floor, and if necessary, putting down a clay blanket.

Z A Rana

Drinking water for the Mekong Delta

30. Dr RANA discussed the provision of water in the Mekong delta region, and described the involvement of the community organisations in the project.

31. Mr KARKI commented that free labour was considered as community participation in Vietnam, and asked what criteria were considered to get free labour.

32. Dr RANA replied that within the Vietnamese social system all able-bodied men and women worked equally at any kind of work. People would get together in

small groups, similar to the panchayat system in the Indian sub-continent, and people would volunteer their services for a period of time, and sometimes provide local material such as bamboo or sand.

K C Tai and T D B Pearce

The reliability of using rainwater tank supply

33. The authors were not present, and the paper was not read.

10th WEDC Conference

Water and sanitation in Asia and the Pacific : Singapore : 1984

The softer side of software in DECADE planning

Dr M L Elmendorf

Hardware and software have become buzz words for the International Drinking Water Supply and Sanitation Decade (IDWSSD). Hardware to nearly everyone means the technology, the engineering, but to some it also means the planning, implementation and the operational side of projects. To most software covers what WHO has defined as the support services - the socio-economic studies, community participation and health education, including information, motivation, communication and training aspects.

In spite of IDWSSD rhetoric noting the importance, in fact the necessity, of support services if we expect new facilities to be operated, maintained and used effectively, relatively little funding has been allocated to these components. In fact a 1982 analysis of multi- and bi-lateral aid to Water and Sanitation in Sri Lanka revealed that nearly 50% of the thirty on-going projects did not include any support services for community participation, socio-economic studies and health education. All but two projects had a training component, but often these were limited to staff training and did not include training for the field workers who are the outreach to the communities. And none of the projects had specific training for the users.

Most engineers and planners are by now quite familiar with the importance of software in project identification and in selection of appropriate hardware. Many do accept the fact that a socio-economic study has to be completed as part of project planning, but rarely is this seen as the beginning of a change process. Behavioural changes are necessary if the decade's goals in reducing the tragic and wasteful deaths from water and sanitation related diarrhea and parasitic diseases are to be reached.

Concepts

Three concepts are basic to our discussion today:

1) Technology is not enough, but it is important.

2) Change in behaviour is more difficult than change in technology, but it can be done.

3) Germ theory alone is not sufficient motivation to effect change in behaviour, but by linking disease to current practices, behavioural change is possible.

The objective of this paper is to present women as realistic potential agents for change so that the behavioural changes necessary for effective use, operation and maintenance of improved technologies can take place. The first behavioural change needed is related to the functioning of the hardware. Software is necessary to involve the community in such a way that the people feel responsible for operation and maintenance. This concept and the second need, health education/hygiene education, are both related to women, the primary users and managers of improved systems. From the beginning it is necessary to clarify that women should not be viewed and treated as a special or separate group, but as part of the total community. Women must become more effective partners in carefully designed community participation efforts. A carefully constructed socio-cultural framework in which all community members are seen as actors in the course of the project cycle should emphasize the "non-public", informal and private roles of various groups and individuals within the community, including women who are often "invisible" but important actors. In fact women who as managers of these improved facilities in their communities and in their homes must initiate changes in their daily behaviour and train their families as well, are often forgotten or ignored. Women are the softer part of software.

Behavioural changes in water and sanitation projects require that men, women and children be partners in the project. To truly elicit user participation, understanding the socio-cultural framework makes it possible to see that people are the start and end points for any effective project, process or program. Within the framework, the roles of women in behaviour changes become visible and important.

Impact of DECADE on Women and Women on DECADE

But in this discussion, I want to go beyond a discussion of the needs for software to review a few of the "hows" and "whys" of the necessity for involving women in DECADE activities. A great deal of things have happened since 1980 when in a short, but widely circulated paper called "Women, Water and Waste" I pointed out some of the impacts of women on water and sanitation projects. Most of the emphasis before 1980, had been on the impact of projects on women, the elimination of tiring hours of drawing and hauling water. And we must never forget this part of the picture, because still today many women are coping with scarce and distant water supplies, spending hours of time and often 50% of their energy in arduous tasks.

At the 1980 World Conference of the UN Decade of Women a strong resolution was adopted that specially mandated "Member States and UN agencies, including specialized agencies, to promote full participation of women in planning, implementation and application of technology for water supply projects". Recognizing the impact which women can have on the success of water and sanitation programmes, at its 9th meeting held April 1982 the United Nations Steering Committee for Cooperative Action, composed of UN, UNDP, ILO, FAO, World Bank, UNICEF, UNESCO, UNEP, and INSTRAW, decided to establish an inter-Agency Task Force on women and the IDWSSD. A paper entitled "Strategies for enhancing women's participation in water supply and sanitation activities" was developed by the Task Force and distributed to international agencies including the United Nations agencies, the bilaterals and the international NGOs as well as governments of the developing countries.

The Strategy paper emphasized integration of women's participation as part of the general efforts in water supply and sanitation activities. It urged governments to integrate into national planning and programming for Decade activities women's needs and involvement. It recommended that governments coordinate their activities with non-government groups, including existing women's organizations. It suggested that international agencies promote awareness of the importance of involving women in Decade activities giving technical support to national efforts to promote women's participation, and share experience of how to promote women's participation in Decade activities.

Today there are new projects such as the recently funded UNDP Interregional Project on Promotion and Support for Women's participation in the IDWSSD, funded on a cost-sharing basis by the Norwegian Government with UNDP as the executing agency in association with other UN agencies and organizations. (Ref 3). As noted in the project document, the long-term objective of this project is to support the global effort of the 1980s to develop water supply and sanitation systems which will enable participating governments of developing countries to provide safe water supplies and adequate sanitation facilities for most of their people by 1990 and to improve the positive impact on the health and welfare of families in peri-urban and rural communities with a view both to enhancing effectiveness of these activities and to increasing the well-being of the women themselves and their families.

The four specific objectives of the project are:

1. To establish a sound information base documenting ways in which increased participation of women in water supply and sanitation and related health education programmes will improve their functioning, utilization and impact on health and well-being.

2. To increase the appreciation within government, bilateral and multilateral agencies and institutions responsible for implementing Decade activities of the importance of socio-cultural aspects of project feasibility; and of community participation, especially by the communities' women, in all stages of water supply and sanitation projects.

3. To provide guidance to policy makers, planners and managers on how to obtain meaningful community, and particularly women's involvement in various roles and at various stages of project implementation and follow-up.

In reviewing the 1982 draft for this project, Jane Bunnag, UNICEF Regional Advisor for Asia and the Pacific, wrote that water and sanitation projects have often been badly designed in terms of meeting community needs, and that projects designed and implemented with community involvement would naturally reflect women's pivotal role in all the activities.

Participant Observation

An operational approach using participant observation to gather qualitative data is recommended to design surveys and hygiene education messages. Ideally, the person carrying on the study lives in the community, usually for weeks or months, participating in the daily lives of the people, carrying water, using their sanitary facilities, eating with them.

For water and sanitation project planning, an "environmental sanitation walk" can be considered an abbreviated use of this technique but if limited to a 9 to 5 observation period many of the daily activities will be missed. Many activities concerned with environmental sanitation such defecation, carrying water, bathing, dumping refuse, cleaning public and private places, occur at dawn or dusk. And women are unbelievably invisible at these times. A day's visit, starting early and ending late, by a sensitive person, or better yet, a man or woman, who can work together or separately, can yield valuable data. Several days, including a weekend of intensive participant observation can produce much more of the data needed on water uses and defecation patterns - on knowledge, attitudes, and practices - than a costly survey. The importance of involving women - both as observers and as observed - in this early planning cannot be over-emphasized.

HOW TO - IMPLEMENTATION

In this paper, user participation means community involvement where the people feel a part of the project from the beginning. By opening channels of communication with all sectors of the community, a sense of ownership and pride in the new technologies can be fostered. We have seen that technology is not enough. To change behaviour in water and sanitation, the users must be partners in the project. User participation should be a prelude to all efforts, a master marketing strategy with genuine feedback so as to improve the impact of water and sanitation programmes. And who are the primary users? Women. And how can women become involved in implementation?

Behaviour change

For many people implementation is the construction phase of project. Too often self-help in the building of community water supplies or home latrines is considered enough community participation. However, the whole cycle of behavioural change needs to be discussed and planned for. The appropriate ancillary equipment is an integral part of the improvements in water supply and sanitation. Often technicians and planners assume that communities have what is needed and that people know how to use the improved facilities. To give an example, the complete chain from faeces to hand washing, to soap to drying, to appropriate disposal of cleansing materials and sullage is often assumed. And often essential equipment and knowledge is missing. The linkages between behaviour and technology needs to be stressed, and the roles of women, as individuals and in groups, understood.

Decision-Making

In fact women's decision making within the home, in the allocation of household budgets, cannot be over-emphasized. As managers of water and sanitation within the home they may decide to use their limited funds for an improvement, knowing the savings in time, energy, or recurrent costs of sweepers or water vendors (Baldia). In other studies, when women have personal income they spend a larger portion of it than men for household improvements, including water supply and sanitation (Honduras, Sri Lanka). After women have had the savings in time and energy from a closer, cleaner source of water they will agitate (Mexico), or organize to raise money (Panama) to get the facilities fixed when they break down.

HOW TO - OPERATION, MAINTENANCE AND TRAINING

A part of the necessary software is training the operators and the users of the systems. In order to have more than just more water systems and latrines, we must go beyond access to the improved technologies, to an understanding of the human elements, the operators and the users. One of the greatest problems is going beyond access to new facilities is access to women who must understand how to use the new technologies and have incentives for changing behaviour in order to break the tragic fecal-oral route of infection with its accompanying diarrhea, continuing illness and death for many children. And along with access there must be appropriate training methods and materials (8). All training of women should relate to their existing roles, help in alleviating unnecessary burdens, and improve the quality of life for them, their households and communities.

SUMMARY

The thrust of this paper is to suggest a software methodology which will enable women to identify needs, surmount problems and make decisions based on information and understanding about choices. By an integrated approach to community-defined needs women, in groups and singly, will be motivated to adopt new patterns of behaviour and attitudes so that the active and passive layers of women's participation in various sectors will be strengthened. Peer support will serve to help establish new attitudes and behaviours/activities which synergistically will improve the health and welfare of women and their familits in the most disadvantaged sectors of the population. The Pakistan case study (8) in Baldia shows how even illiterate women can be agents of change in a traditional moslem society where older men are the authoritarian figures and women are segregated. Even when invisible women have important roles to play, 'Take me to your leader' is enough.

At the conclusion of its preparatory year in June 1984, the UNDP project mentioned above had received specific expressions of interest from 25 countries, 10 project identification missions had been fielded, and draft proposals were under preparation in Kenya, Zimbabwe, Indonesia, Honduras, Nepal, Sri Lanka, Bangladesh, Upper Volta, Lesotho and Botswana. An annotated bibliography on Women's Roles in Water Supply and Sanitation is being prepared in collaboration with IRC in the Hague.

Networks of collaborating institutions and individuals have been established, workshops and seminars held. The softer side of software is being recognized as a key component in DECADE activities.

REFERENCES

1. ELMENDORF, Mary. Women, Water and Waste: Beyond Access, in Proceedings of 7th WEDC Conference, Loughborough University of Technology, 1981. Also presented at the UN Mid-Decade Conference of Women and Development FORUM, Copenhagen, 1980.

2. STRATEGIES for Enhancing Women's Participation in Water Supply and Sanitation Activities. Interagency Task Force on Women and Water of the IDWSSD Steering Committee for Cooperative Action. UNICEF, December 1983.

3. TIMPSON, Sarah. Revised project document on Promotion and Support of Women's Participation in International Drinking Water Supply and Sanitation Decade: UNDP INT 83-003. June 1983.

4. BUNNAG, Jane. Letter dated February 1982.

5. ELMENDORF, Mary and ISLEY, Ray: Public and Private Roles of Women in Water Supply and Sanitation Programs in Human Organization Vol. 42, No. 3, 1983.

6. SIMPSON-HERBERT, Mayling. Methods of Socio-Cultural Data-Gathering. TAG Technical Note No 1. The World Bank, Washington, 1983.

7. ELMENDORF, Mary and BUCKLES, Patricia. Socio-cultural Aspects of Water Supply and Excreta Disposal. Vol 5, in Appropriate Technology for Water Supply and Sanitation. The World Bank, Washington, 1980.

8. ELMENDORF, Mary. Women: the Underused Human Resource in Educacion Medico y Salud, Vol 16 No 4, PAHO/WHO, Washington, 1982.

9. BAKHTEARI, Quratul Ain. People's Participation in Slum Upgrading in Water, People and Waste in Developing Countries, Proceedings of the 8th WEDC Conference, Loughborough University of Technology, 1981.

10th WEDC Conference

Water and sanitation in Asia and the Pacific : Singapore : 1984

Community participation in project planning and implementation

Gilbert Leve

BRIEF DESCRIPTION OF SOLOMON ISLANDS

Solomon Islands is a very small country in the Western Pacific Region. It is located north of Australia and immediately East of Papua New Guinea. The position on the map is 156°E and 10°S of the Equator - therefore the climate is tropical.

The country consists of two chains of main islands. On the northern chain are Choiseul, Santa Ysabel and Malaita and on the Southern chain are New Georgia, Guadalcanal, San Cristobal and Santa Cruz. There are hundreds of small islands that are not inhabited.

The total population of the Solomon Islands is 240,000 the majority of which is of melanesian origin. There are small ethnic groups such as Chinese, Europeans, Australian mostly either doing trading or employed under various organisations.

There are also other smaller races such as the Polynesians and Micronesians. These occupy the small outlying atolls of the Solomon Islands. The climate is tropical and is normally hot throughout the year. The wet season normally starts around November until around March or April during which there may be a cyclone.

The country was formerly called the British Solomon Islands but gained independence from Britain since the 7th July 1978. The country is very much in its developing stage. The capital, HONIARA, is on the north coast of Guadalcanal, the biggest island in the group. Honiara has a population of about 22,000.

At the present stage of development in the Solomon Islands the state of poor environmental sanitation give rise to very much concern amongst health workers and the various institutions concerned in the promotion of improvement of the standard of living for rural and peri-urban dwellers.

The main concern is for the ways and methods to be used in propagation of improved sanitation to strive for the objectives of "Health for all by year 2000".

Prior to the introduction of the International Drinking Water and Sanitation Decade which was in mid 1979 in the Solomon, a review carried out in the rural and peri-urban situation showed that 24% of the rural dwellers have access to safe drinking water supplies while 19% of the rural population use some form of proper sanitation facilities.

After a period of 3 years since the introduction of the IDWSSD the situation showed that approximately 50% of the population have access to water supply. While the progress on sanitation sector was slow, only 20% achievement of the goal of the Decade had been reached during the same periods increasing the coverage to approximately 24%. Apart from cost factors, there are other factors or constraints which contribute to the propoagation of improved sanitation to rural areas and to per-urban dwellers.

In the Solomon Islands situation, these constraints include lack of information, lack of properly and adequately trained personnel to dissipate right information and the use of inappropriate technology until the launching of the IDWSSD.

The Solomon Islands has a multiculture and multilingual society where customs and taboos differ from island to island and in some cases even within the same island. Most traditional customs, taboos, habits and behaviour are in practice today especially in rural areas and even in urban settlements, e.g. because of the dirty nature of human excrement, it is forbidden to discuss it amongst people. In some communities it is forbidden for men and women to go to the same toilet. In some communities women must not be seen going to the toilet, or son-in-law or daughter-in-law are forbidden to use the toilet that is being used by all their in-laws. In some cases people prefer to answer the call of nature in the open and not under a roof or in some cases people have to dip themselves in the sea or river to defaecate and so on.

These are real facts and constraints which contribute to the inhibition of the diffusion of improvement of sanitation reaching the rural population.

Therefore when modern and improved methods of sanitation are introduced the people are exposed to different ways from the existing and the normally accepted methods that have been existing and practised for a very long time. Changing the behaviour of people is not as easy as changing technologies, especially if the institutions involved are not well prepared with the right approach and the right information. Thus as a result the people will not be prepared to use the technologies introduced or there will be a tendency to misuse or abuse them.

This has been the case of the Solomon Islands when there was a failure in an attempt to introduce modern and improved methods of human waste disposal. People just could not grasp the importance of modern technology in human waste management. They felt that modern methods belong to the "White Man" but the existing and the accepted methods belong to the people for the reason that they are in accordance with the customs etc.

A typical example of this happened in the Solomons. The settlers on the fringe of the town of Honiara were told to build toilets and to use them instead of going into the bushes or the beach. Surely enough water seal pour flush toilets were built and completed with super structure - all these were done under the supervision of health personnel.

Every time an inspection was made in the area the toilets were found to be very clean and looked new. It was then discovered that they weren't used at all. They were only built because the town regulations require that every house must be provided with a toilet. The people themselves were still going to the bush, the river or the sea.

Another example was when an institution involved in the promotion of improvement in the standard of living in a rural community. The institution, the Solomon Islands Development Trust was working amongst a community building water supplies, construction of toilets and cleaning of villages, etc. When two communal latrines were built for the villagers, the people told the members of the SIDT that the toilets would be reserved for visitors such as Government touring officers or church members who normally visited the villages and village people still preferred their existing methods of excreta disposal by going into the bush at the two ends of the village.

Even today when people from rural areas go into town and stay with relatives in a house where all sanitation conveniences are provided, they would not use the toilets but rather go to a beach or somewhere else for defaecation.

In order to get people to accept the modern and improved methods of sanitation or any other project for that matter, it is a very important that the people in the community themselves must be involved in the preparation, planning and implementation. If people understand the benefits of the change from their normal ways and if they feel that the project belongs to the people then they will be enthusiastic about it and will therefore be able to accept it, and be responsible for its continuity and maintenance.

However, due to factors such as insufficient preparation and lack of information could make community participation in planning and implementation of projects difficult.

The lack of communication between the community and the bodies and agencies who are trying to introduce projects for the improvement of standard of living could make the matter more complicated and may lead to rejection, misuse or abuse of facilities provided. It is not so difficult to change technology but it is difficult for people to accept behaviour change especially if not given sufficient time and information to understand the value of the change.

A good illustration of this situation was in the Solomon Islands after the introduction of the International Drinking Water and Sanitation Decade programme. The situation in rural areas before the commencement of the IDWSD programme was 24% of the people had access to safe drinking water and 19% of the people used some form of sanitary waste disposal.

Two years after the introduction of the IDWSD programme 50% of the people have access to portable drinking water whereas 24% of the rural people used improved methods of excreta disposal.

The reason of course was that water has been accepted by the people as an important element in life thus communities participated in the planning and implementation of the project.

To the people, the introduction of the programme was beneficial not merely in terms of the improved quality but mostly as convenience to the people. It was a great relief to the women who normally carry water in bamboos or other vessels for the home from sources which were normally at great distances.

On the contrary, the progress of the sanitation improvement programme was lagging behind due mainly to social constraints (behaviour, customs and taboos) of various communities in the Solomon Islands.

It is now obvious that in order to speed up the progress of sanitation improvement programme, an attempt must be made to get the people involved or participating in the planning and implementation of the project.

For the purpose of "HEALTH FOR ALL BY YEAR 2000" and in conjunction with the IDWSD, health workers in the various provinces in the Solomons are making alterations and corrections in their approach and in their choice of technology. The aim there is to train and instruct health personnel who are actually involved in the field and to get as many people as possible to participate in the preparation, planning and implementation of the project.

In Honiara where I work as Senior Health Inspector I have launched a project of improvement of sanitation in the settlements in the fringe of the town. I have selected various peri-urban settlements on the fringe of the town to launch a new approach on the project of improvement on excreta disposal. A survey carried out at the beginning of the year showed that the sanitation situation in the settlements were poor.

The proposed new approach is to get the communities involved in the project. The stages to be taken are:

1. Select the settlements.

The selection in this case is more or less identifying the location of the settlements, the topography of the land in order to select the type of technology that will be appropriate to the situation.

2. Assign health workers to carry out surveys in each settlement.

The survey will include details of the present situation regarding sanitation water supply, population, people and their attitude towards changes in methods of human excreta disposal in relation to customs and taboos. In fact the job of the health worker in the initial stage of the programme is to collect facts regarding the existing means of human waste disposal and other aspects of health that requires improvement.

3. Training of health personnel in methods of approaching the community.

This is to ensure confidence of the people on the agents dealing with them.

4. Get the key people in each settlement to participate in the whole project.

The key people or influential people in the Solomon Island villages are the:

Chief
Church Leaders (Men & Women)
Headman

In the Solomon Islands situation it is important that these figure heads understand the importance of any project. They have to agree to whatever changes are being proposed for their people. If they are interested and accept that the project belongs to the people and is for the benefit of the people then participation of the community will be assured and thus continuous maintenance and proper use of the facilities will also be assured.

5. Get social groups involved.

Certain groups in the villages are carrying out activities in villages in an attempt to improve the standard of living of the community. Such groups as the church women's group.

e.g. Mothers Union of the Church of Melanesia
Womens Band of the SSEC
United Church Womens Fellowship
Womens Interest Group
Youth Groups

These various groups are carrying out activities amongst the communities, things like improvement of homes, care of babies, simple personal hygiene, making vegetable gardens, cooking classes, Bible studies etc.

I believe that the influential effect of these groups could be utilised to get the communities to participate in project planning.

One other important group the old people in the villages should be involved. Their importance lies in their knowledge of the customs, taboos, traditional beliefs etc. could be utilised in project planning and implementation.

Finally the various institutions involved in the propagation or improvement of the standard of living in the rural areas must work in the same direction. There must be a closer cooperation and dialogue between these various institutions otherwise it would be difficult for people to understand what is going on and thus participation of the community could not be ensured.

In the Solomons today the various institutions involved in rural developments are the Environmental Health Division of the MHMS, Solomon Islands Development Health Education Service, Nursing Service) (Primary Health Care) and an organisation within the Bahai Faith.

I hope that with this brief paper I have presented a picture on the situation in rural areas in the Solomon Islands. It gives you some ideas of the difficulties and problems we encounter in our situation.

In this conference I am hoping to learn of your situations and how you solve your problems so that I may be able to relate these to my own situation in the Solomon Islands.

10th WEDC Conference

Water and sanitation in Asia and the Pacific : Singapore : 1984

Water, sanitation and rural women

Mrs A Mitra

A) INTRODUCTION

This presentation attempts to highlight the problems of women living in rural communities in West Bengal, related directly or indirectly to water and sanitation, which affects the quality of their lives, their health, personal hygiene and their environment. It is a presentation of experiences of social workers in implementing rural welfare schemes which may be taken into consideration when planning rural projects.

B) RURAL WEST BENGAL, INDIA

This state is one of the few states in India where a variety of geological and climatic conditions exist which may broadly be taken as representing conditions prevailing in the eastern region of India. West Bengal is divided into 16 districts. There are 38,074 villages with a population of 3;344,978.

WATER AND SANITATION. HOW IT AFFECTS THE RURAL WOMEN IN WEST BENGAL - SOME CUSTOMS AND HABITS.

Water

In the hill areas of North Bengal villages usually consist of a cluster of houses located near springs and storage tanks. The community as a whole is not very organised. Women have to carry water in pitchers or buckets up steep tortuous paths.

Drinking water from surface and ground water sources are springs, streams ring-wells, tubewells and storage tanks. About 40% of the villages have tubewells. Some springs are now being arrested and the water stored, disinfected and conveyed to the rural areas.

Water shortage in summer causes great hardship. Women and children suffer from dysentery, diarrhoea and gastro-enteritis due to the pollution of springs, streams and storage tanks. It has been noted that villages with tubewells are not prone to these ailments. It is difficult for women to bathe and wash clothes due to water shortage in summer and the extreme cold in winter.

The water has high iron content. It is deficient in iodine content in some areas, leading to goitre. Iodised salts are often supplied to the markets by the Government departments.

In the drought-prone dry hard rock areas in the plains, consisting of parts of 5 districts, women often have to walk very long distances to reach a drinking water source. Deep wells, ponds, lakes and rivers are the main source of water. Rig-bored tubewells are being sunk in large numbers by drilling through the hard underground rock formation.

Carrying water is the duty of the women who are quite aware of the need for safe drinking water from tubewells or deep wells. In some areas they spend upto 4 hours in a day for fetching drinking water. They use the water from the ponds, lakes, drying river beds and stagnant pools for lack of any other alternative.

It is the custom for rural women to have daily baths. Contaminated water causes skin diseases and eye infections. Gastro-intestinal diseases are common.

Another problem area is the saline zone in Southern West Bengal, consisting of parts of two districts, because both the surface and sub-surface water is brackish. Tubewells often have to be sunk upto a depth of 250 to 350 metres. Pond water is used for washing bathing and other domestic purposes. Deep wells and tubewells are the main source of drinking water. Two desalinization plants are now supplying water to about 140,000 people and more schemes are underway.

In the vast gangetic plains there are a large number of ponds and many wells but tubewells which supply safe drinking water are not within the reach of a large number of women.

The rural women in Bengal collect water in earthen, brass or copper pitchers. Buckets are also used. The commonly used container for drinking water is the earthen pitcher which also helps to keep the water cool. Drinking water is collected daily as water stored overnight is considered to be stale. The well is not merely a place for collecting water, it is also a place for pleasant discussions and enjoying some free time, away from domestic chores.

Personal hygiene and sanitation

Daily bathing is a ritual with rural women. They often go in groups to bathe in ponds where they also bathe their children, wash clothes, utensils and collect water for household use. Teeth are cleaned with soft branches of certain types of trees. Only the right hand is used for eating and is always washed before and after meals. It is also a custom to wash the mouth after each meal.

Houses and floors are kept very clean by the women and girls. Utensils are usually cleaned with ash. Household garbage is generally disposed of in the fields which also absorb the waste water. In some villages women's voluntary organisations working on the Gandhian principle of 'safai' or cleanliness, have successfully taught simple garbage disposal methods and channelling of waste water into kitchen gardens.

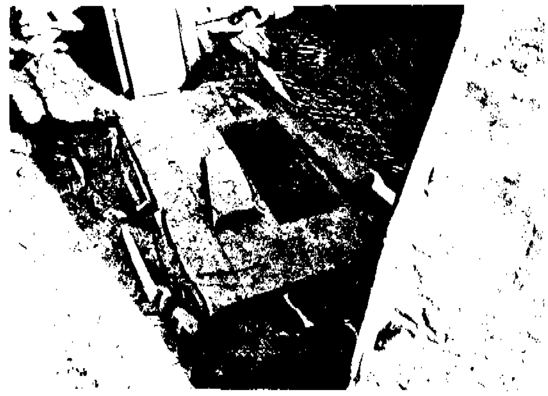
Women in the rural areas are handicapped by the lack of proper latrines. They often go in groups when it is dark for privacy. Some locations available for the use of the rural women are (a) Sheltered babmoo groves or any other area of dense vegetation near the house.

Appropriate technology for latrine superstructure in a bamboo grove.

(b) enclosed platform projecting over a ditch

Latrine superstructure over a ditch.

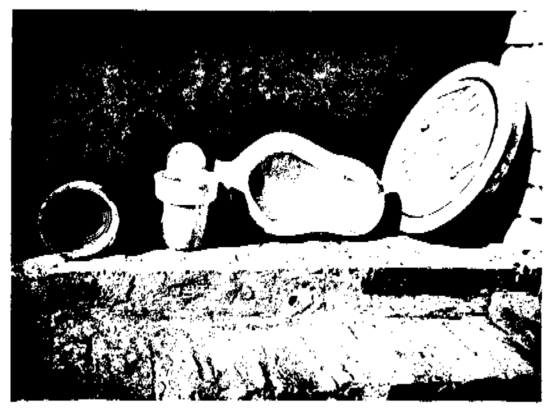
(c) trench latrines (d) various types of platforms over pits.



Cement platform over a pit (discarded after filling pit with earth)

Sanitary latrine under construction.

(e) Sanitary latrine with septic tank or (f) dug-well latrine with earthen rings lining the pit.



Parts of a sanitary and dug-well latrine in rural areas.

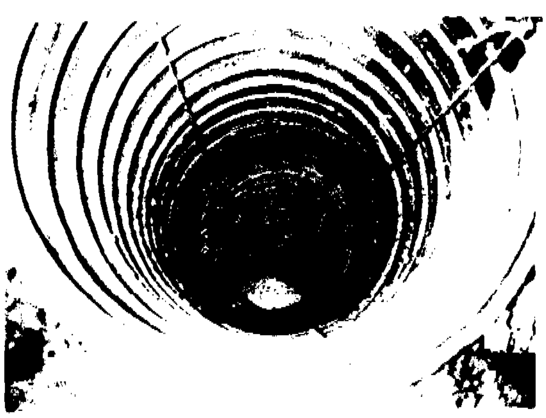
<u>Health</u>

Given below is an analysis of the cases treated at a medical-care centre of the Women's Co-ordimnating Council (WCC) which is a voluntary organisation constituted of representatives of 78 major women's organisations in West Bengal. The medical centre covers children, nursing and expectant mothers of 5 villages and reports show that the most common problems are diarrhoea and worm infestation. 922 patients were treated during July to September 1983. 478 were cases of diarrhoea and 122 cases of worm infestation.

Others were treated for respiratory tract infections, conjuctivitis, skin infection and a few for infective hepatitis.

The women in these villages use safe tubewell water for drinking but as the number of tubewells are inadequate, water from ponds is used extensively. Various other factors contribute to the high incidence of diarrhoea such as, pollution of drinking water, contamination through hands, vectors, lack of sanitation, etc.

To illustrate briefly the water and sanitation situation in two of these villages - village A has 251 households, 6 tubewells, about 170 ponds, 31 sanitary latrines, population about 2,500. Village B has 151 households, 3 tubewells, 22 ponds and 10 sanitary latrines. There are about 40 latrines of indigenous types.



Dug-well latrine pit lined with earthen rings.

The pits for dug-well type latrines are usually upto 6 feet deep. In the above picture an over-enthusiastic villager has reached the water table !

PROGRESS IN RURAL WATER SUPPLY AND SANITATION. THE GOVERNMENT AND NON-GOVERNMENT ORGANISATIONS (NGOs) - A FEW FACTS

In West Bengal, under the Minimum Needs Programme about 70 piped water schemes were taken up to benefit nearly 500,000 people. A large number of tubewell and wells have been sunk. Under the Accelerated Rural Water Supply Scheme in 1977-78 a large number of schemes to supply water to problem villages have been taken up to benefit nearly 1,200,000 rural population. Over 60 drilling rigs are being used for sinking thousands of rigbored tubewells in drought-prine hard rock areas. Inspite of the progress made in drinking water supply, a large percentage of villages still do not have safe drinking water within reach due to many reasons which are outside the scope of this paper.

NGOs - There are about 300 voluntary organisations in West Bengal and many of them are working in the rural areas. A few NGOs have equipments, such as drilling rigs, and the technicians to implement a large number of water and sanitation schemes all over the state. Many women's voluntary organisations are based in rural areas to implement rural community welfare projects such as education, crafts-training for women, income-generating schemes, education in health, nutrition, hygiene and sanitation, medical care, family planning, water supply i.e. sinking tubewells, cleaning ponds and so on.

THE RURAL WOMAN IN THE DECADE PROGRAMMES.

If any significant result is to emerge from the International Water and Sanitation Decade emphasis must be laid on the role of the women in the community to ensure the success of the programme being undertaken.

During the International Drinking Water Supply and Sanitation Decade 1981-90, the target set by the Govt. of India for rural water supply is 100% and for rural sanitation is 25%.

Designing of low cost sanitation, the pour-flush latrine with two pit system, has been completed and pilot projects for installing sanitation in villages have been started in West Bengal. The smokeless chulla (stove) has been designed to reduce environmental pollution and training is being given to social workers to install them in rural households.

Community Participation

I have found community participation to be quite positive from my own experience in 3 districts while doing relief work through the WCC during the devastating floods in 1978. Just a few of us voluntary social workers with one resident staff representative of WCC successfully constructed several school buildings, a rural library, sunk tubewells, ran medical care schemes and vocational training centres for women. We have conducted surveys, family welfare, health, hygiene, water, sanitation and education schemes.

A few steps to ensure village involvement is to (a) involve local bodies and the district administration for good co-ordination (b) hold several discussions and meetings with the local bodies and invite all interested villagers to participate and formulate development programmes based on the immediate needs of the community (c) involve active village workers, including women, to supervise and be responsible for projects (d) ensure participation of the women by making medical care, vocational training and other income generating schemes a part of all water and sanitation programmes.

Providing safe drinking water within a reasonable distance should be the first on the list of priorities. Women's priority is always adequate water supply. Other developmental programmes come later.

Village level community participation for water supply is very good. Villagers legally donate their land for sinking tubewells and wells. They are also prepared to give their labour. But a simple maintenance system must be clearly laid down which is relevant to the situation in each area.

Women are careful with the hand pump so that it does not go out of order. Many villages have people who can repair the pumps women can also be given training in basic repairs.

House-to-house survey and education programmes are very effective. House visits and discussions with the women help in planning a realistic programme based on the needs of the village community. It also encourages women's participation.

Women are receptive to the idea of a well planned sanitation system after they have been educated by social workers through house-to-house education, but men are often not receptive. The reason is usually economic. The basic needs of food, shelter, repairs, farming or perhaps constructing a cowshed takes priority over the construction of a latrine.

Financial constraints are also the main obstacle for voluntary organisations trying to implement water, sanitation and other rural development projects.

Waste water disposal systems, hygienic stora.e of drinking water anti-pollution schemes such as smokeless stoves etc. are used by the women. The women must feel the need for these facilities and believe that they will improve the quality of her life. Only then will she see to it that the latrine is kept clean, the drain that carries the waste water is kept free from clogging, the smokeless stove is kept well repaired.

A common cultural problem is the excessive reserve attached to all private functions which prevents open discussion on the problem of waste disposal. This attitude can be overcome by women social workers or voluntary organisations who are located in the area and have developed rapport with the women.

Water supply schemes should include intensive education of the women in storage and purification of water. Simple storage methods should be used such as fitting taps to the earthen pots to avoid pollution.

Education programmes must include home sanitation i.e. correct storage of food and water, disinfection, prevention from contamination, prevention of air pollution and the use of chemical and other water purification aids.

Education programmes should include visuals for maximum impact. However, the reaction of women to the picture and posters should be tested first through social workers. A poster showing a golden coloured healthy child to the fural women may only represent a child with jaundice !

Mass media such as the radio and local folk entertainment media such as puppet shows, drama etc. can be very effective.

In order to reach the rural women, schemes sponsored by the Government for training village-level workers are being run by voluntary organisations at 16 centres for groups of 50 trainees from different blocks. Their training includes water, sanitation education as well as basic health and hygiene, nutrition, education and child care.

Water and sanitation schemes should not be planned in isolation, but as a part of a project for the welfare of the community as a whole.

Both preventive and curative measures must be included for improving the general health of the village community.

The curative measures such as medical care ensures the immediate response and involvement of the community.

Every household must accept sanitation programmes for it to be successful. There must be freedom and flexibility to modify programmes to suit different areas and conditions.

In conclusion, rapid strides have been made in recent years in water supply and sanitation technology, but, if the decade programmes are to actually benefit the rural women success of the programmes should be measured in terms of improvement of her health, the health of her children and family the environment and the quality of her life.

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Environmental improvement in slums through community participation

Dr P R Thomas and Dr K N Ramamurthy

INTRODUCTION

Slums exist in every country mostly due to migration of the underprivileged from rural areas to urban centres, increased population growth and acute shortage of housing. Slums can be analysed from two view points. One is the traditional approach that views slums as 'eye sores' and illegitimate settlements which do not conform to the urban norms. The other is the present view that considers slums as communities of the urban poor which have risen in response to the acute shortage of low income housing. The latter concept is derived from an understanding of the needs of the urban poor and an appreciation of their creativity to satisfy their needs through self-reliance. These attitudes are not merely two ways of looking upon slum settlements; they give rise to two distinct analytical frameworks and policy approaches. One leads to bulldozing type solutions and evokes stringent regulatory measures and the other calls for thorough understanding of the functional role of these communities and requires public policies which would mobilise peoples' inventiveness and self-reliance.

CHARACTERISTICS OF SLUMS AND SQUATTER SETTLEMENTS

In general, the squatter settlements are formed near the sources of water irrespective of its quality. Rivers, streams, lakes and canals initially provide best conditions for drinking, bathing and washing clothes until they become polluted, and thereafter they become sources of waterborne diseases "(ref.1)". Slum settlements also appear in the vicinity of garbage dumps and sometimes literally on top of them. In India, Sri-Lanka and some of the South East Asian Countries, the sorting and resale of waste-paper from the garbage has become an important 'informal' industry. In many slums and squatter settlements, cramped housing is often shared with cows, goats, pigs, chicken etc. Where there is a central drinking water source such as well or stand-pipe, the water is more often used also for bathing, washing clothes and for various other purposes causing communal fighting due to over-crowding, and other waste and drainage problems.

The communal latrines provided in the slum areas present a major health problem due to improper maintenance and lack of individual responsibility. Furthermore in most cases the communal latrines are not properly lit and have no proper access.

Essentially the water supply and sanitation facilities must go hand in hand with any slum improvement programme. It is necessary to make the community realise the importance of protection of local environment, and proper use and maintenance of sanitary facilities. One of the ways of achieving this is to involve the community while deciding about the allocation of such facilities and their maintenance. To achieve even a minimum standard of hygiene, strict control and constant attendance of cleaners are required in addition to the realisation of the responsibility of the user in the environmental improvement. Before envisaging any environmental improvement programme, it is necessary to collect the background information on the level of awareness of the people regarding the health and sanitation.

COMMUNITY PARTICIPATION IN ENVIRONMENTAL IMPROVEMENT

While promoting any environmental improvement programme, it is necessary to consider how the people want to live, how they live at present, the effect of environment on their lives, the social characteristics of the households etc. It is here that the citizen participation in planning will provide a favourable contribution in the management of such programmes.

Participatory planning is a method which allows citizens or users of an environment to take part in the decision making process of the matters concerning that environment "(ref.2)". It is to be realised that the user participation is not aimed at, to displace or override the responsibility of the planners or the government agencies involved in promoting the improvement programmes. It is to supplement and help the professional planners in providing additional information on the realistic needs, wants and special characteristics of the community.

Random choice on the location of stand-pipes with drainage facilities without the community or user participation may sometimes completely upset the implementation programme, since, while carrying out such improvement some relocation of the hutments may have to be made. Participating the community at the early decision making stages overcomes many such problems at the implementation stage due to the avoidance of feelings of alienation and powerlessness and results in an increase in cooperative interaction leading to a more united community "(ref.3)".

In Trinidad and Tobago, community participation is being encouraged by inviting proposals from the public in the form of posters with slogans on ways of effecting environmental improvement through design competition titled 'NAGS ON THE MOVE'. It is only when a whole community takes up the idea of sanitation, perhaps with the aim of cleaning up a squalid defecation ground, a real impact can be made on the improvement in the health situation.

SLUM UPGRADING PROGRAMME IN MADRAS CITY - A CASE STUDY

Growth of slums is a phenomenon found in all metropolitan cities in the world. Slums in Madras city, India cover 6 percent of the total area in the city and they contain more than 30 percent of the city population. Under the Slum Clearance Scheme (1971) the existing slums were demolished and multistoreyed tenements were erected for the slum dwellers on the same site as alternate housing. However it was seen that the impact of the slum clearance scheme was that while planning such tenements, the technical, functional and social characteristics of the community were not considered which gave rise to community resistance to such projects. In many cases, huts used to reappear at the fringes of the tenements causing peripheral slums and were showing signs of rapid degradation.

The evolution of the slum housing programme in Madras can be presented in a conceptual form as shown in Figure 1 "(ref.4)". The first stage is the unimproved slum. This indicates a decaying situation. The second stage is the putting up of multistoreyed tenements which results in the formation of slums in the fringe zones which leads to environmental degradation. The third stage in the evolution process is the slum improvement programme which lacks community participation. The present phase in slum housing is upgrading with a complementary programme of sites and services. This represents a demand based housing solution encouraging the community participation in environmental improvement. Slum upgrading programme seems to overcome many of the above problems. It is a means by which the poorest segment of the urban population are provided with low cost shelter and with low cost access to employment in addition to providing a means of retaining and improving the existing housing stocks. Zambia is one of the countries where slum upgrading was carried out to solve the problem of squatter housing. In these programmes careful planning and great care were exercised to secure the trust, approval and active cooperation of the residents. The main components of the project were the provision of water supply, roads, street lighting, schools and health centres.

The Slum Upgrading programme initiated by the Madras Metropolitan Development Authority in Madras City is intended to benefit about 30,000 households. The improvements envisaged in the programme are the following:
Drinking water supply with public standpipes (One for 10 houses)
Community latrines (One for 10 houses)
New and improved roads, footpaths and drainage
Community facilities such as pre-schools (One for 200 houses), primary schools, clinics and cottage sheds (One for 400 houses)
Vehicular access within easy reach of each hut.

An important feature of the scheme is the provision of land tenure to slum dwellers. Once they are assured of their land titles, the community takes great care in improving their shelter and environment.

While fixing up the priorities for the improvement, the views of the local inhabitants were given due consideration. The upgrading programme was successful mainly because it provided the residents - A share in decision making, The opportunity to build, and An experience of close cooperation with the city council and among themselves. Similar approach has been followed in the upgrading programmes in Bombay, India, wherein a comprehensive environmental improvement of slums was attempted. This approach has shown the possibility of solving the problem of unimproved slums in urban centres.

CONCLUSION

Environmental Improvement in slums is greatly governed by the integrated planning approach in the provision of shelter, infrastructure and services in the sequence appropriate to the local

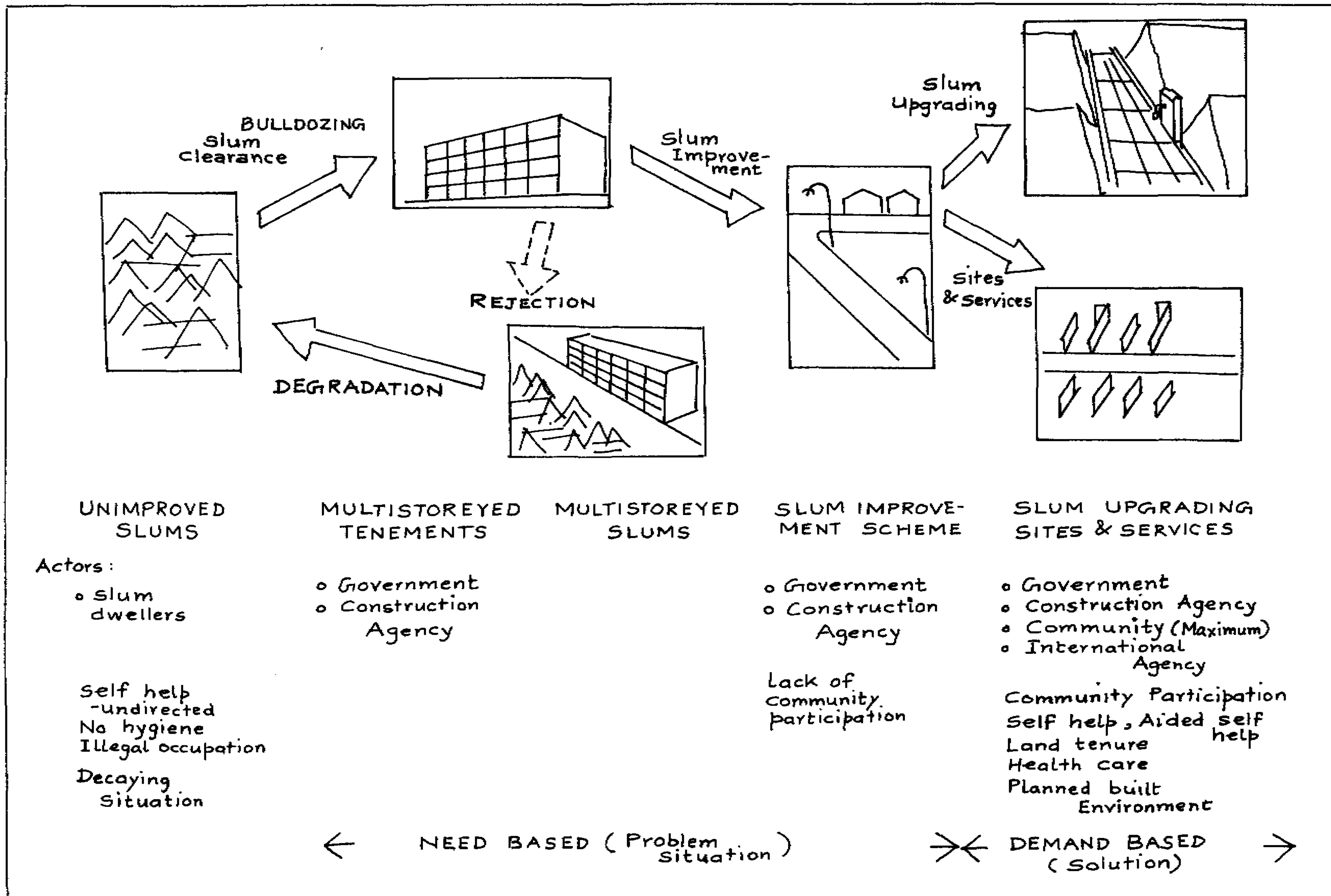

FIG. 1 - EVOLUTION CONCEPT-SLUM HOUSING

environment. Community participation is an indispensable element in the development of human settlements especially in the planning strategies and in their formulation, implementation, management and maintenance.

REFERENCES

1. ETHERTON D. Water and Sanitation in Slums and Shanty Towns. UNICEF. New York, May 1980.
2. RAMAMURTHY K N. Housing Management for Developing Countries. World Congress on Housing. Miami Beach, Nov.1983.
3. WHITE Alastair. Community Participation in Water and Sanitation. WHO Technical Paper. Rijswijk. The Netherlands, June 1981.
4. RAMAMURTHY K N and MATHEWS M S. Slum Upgrading Programme in Madras City - A Case Study. PTRC Housing Conference. University of Warwick. United Kingdom, July 1979.

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Community participation and education in sanitation programmes

Miss K N Vijayanthi

The rapid increase in population and concentration of it in a few larger cities are causing degradation of the living environment. The urgency is not only for adequate shelter but also sanitary living conditions. In most of the developing countries, failure to identify and implement suitable solutions in this area has caused deterioration in the environmental condition and the consequent illhealth.

It is generally recognised that unsafe drinking water supply and improper sanitation are two major factors leading to high incidence of water borne diseases. While the provision of protected water supply in rural areas of India has made substantial headway in the last decade, the level of sanitation, particularly due to indiscriminate open defecation has not improved. The reasons for the slow progress in sanitation is due to combination of factors viz. lack of sense of hygiene, ignorance and ineffective education to break through cultural barriers and above all low priority to sanitation.

In many developing countries, water borne diseases are the most formidable public health problems, eventhough the number of deaths due to these diseases is not exactly known. However, surveys carried out have shown that all elements of sanitation are more or less lacking which has resulted in gastrointestinal and communicable diseases.

It has been constantly affirmed by Public Health experts that about 80% of the health problems of India could be prevented through simple public health measures such as improvement of environmental sanitation by involving communities, promoting health consciousness through mass media, extended health education and preventive measures like mass vaccination.

The statistics regarding excreta disposal are not sufficient in India, a vast country spread over 3.2 million square kilometers, with a density of 195 persons per Sq.Km. According to the 1981 census, the country's population was around 684 million with a percapita income equivalent to US$ 180. With the control of epidemics and better living conditions, the life expectancy has risen to 61 years, eventhough much of the marginal population is undernourished with children and women remaining as the worst sufferers.

Provision of a sanitary excreta disposal system is listed by World Health Organisation expert Committee on "Environmental Sanitation" as the first basic step that should be taken towards ensuring a safe environment.

There is a vast disparity in the existing levels of excreta disposal within the country. Rural areas which have about 80% of the population are conspicuously deprived of this facility. Again, in urban areas these facilities are not available for economically weaker sections and slum dwellers.

In India, only about 217 out of 3,119 towns have sewerage system, most of them with partial coverage, although 2,092 towns have been provided with piped water supply.

As per National Sample Survey, only 20% of urban households in the country use toilets connected with the sewerage system, out of which only 7% have exclusive use of toilets and the rest either share with other households or make use of public toilets. 14% of the households have water borne latrines connected with septic tanks. Nearly 1/3 of the urban population is served by bucket privies. Househoios having no toilets account for the remaining 1/3.

It is universally accepted that the best way for the disposal of human waste is the underground sewer system. But it is expensive. It is estimated if sewerage system were laid to cover entire population of 225 cities of India which have a population of over one lakh, it would cost about Rs.4,000 crores (Indian Currency) at current prices, a vast country like India and becomes a critical issue as the recovery of such an expenditure from the beneficiaries is doubtful.

Recognising the close relationship between water, its appropriate use for personal hygiene and sanitation, the United Nations launched in 1981 the "International Drinking Water Supply and Sanitation Decade" and World Health Organisation declaring "Health for all" by 2000 AD in order to challenge these two interrelated concepts. In response to the United Nations sponsored Water Supply and Sanitation decade, the Government of India has set targets for achieving 80% of coverage of the Urban and 20% coverage of rural population by 1990.

Although more than 19-20 designs like conventional sewerage systems, water borne options like septic tank, hand flush water seal pit privy, acqua privy, borehole, dugwell, trench ... etc. are prevalent all over the world for the disposal of human waste, only three systems have been found technically fit for adoption on mass scale viz., sewerage system, septic tank and hand flush water seal pit privy.

The sewerage system is the most sophisticated and hygienic method, but it is the most expensive technology. More water is required for flushing which is both scarce and expensive.

The septic tank too is rather expensive. It also requires more space which is often not available in urban areas. The need for scavengers continues in septic tanks and clearing of tanks at regular intervals has to be done.

The water seal pit latrines (Leach pit) is found to be only workable solution cost wise at present in India and other developing countries. Sulabh Sauchalaya at Bihar and Research Cum Action Project toilets at Tamilnadu have been developed and are being implemented successfully for the past 25-30 years.

SLUM IMPROVEMENT

Recognising the need to improve housing conditions in slums of Madras City, Government of Tamilnadu in the 1971 launched Slum Clearance, Accelerated Slum Improvement Scheme(ASIS) and Environmental Improvement Schemes(EIS). However the realisation for the need for integrated progfamme resulted in the introduction of Integrated Slum Improvement programme under Madras Urban Development Project (MUDP).

It is a package programme which provides basis amenities like community toilets, baths, water supply, street lights and approach roads and also infrastructure for social inputs.

But in practice, this again has become another engineering exercise where funds were spent according to the allocations. In some of the slum areas, taking advantage of the available open space and low lying areas, toilets have been constructed. The results were not encouraging in these schemes as the emphasis is laid more on achieving physical and financial targets rather than human aspect involved in accepting and adopting the scheme. Realising the importance of people's involvement in the programme, a Community Development Wing was established to effect Community involvement in planning, execution and maintenance.

It would be worthwhile examining the efficacy of the existing system before evolving a strategy for improving the sanitation in slums.

Because of the enormous cost in extending the sewer system to slums, public toilets with septic tanks have been constructed. However, the sanitary conditions have not improved.

1. Lack of continued water supply to the public convenience units resulted in non-utilisation of public convenience units.
2. Overflowing of septic tanks as dispersion trenches have not been provided and irregular cleaning of septic tanks.
3. Inadequate manpower and material with the maintenance agency.
4. Lack of inbuilt system to maintain the public convenience units till such time civic bodies take over.
5. Lack of proper coordination between the maintenance agencies.
6. Lack of comprehensive policy to guide the agencies.
7. Lack of will on the part of the people to keep the environment clean.

The two pronged strategy would be removing the anomolies to make the units functional on one hand and educating the people on the better use. Both are mutually complementary. It also require alternative sanitation system within the affordable limits and effective long term propositions.

URBAN COMMUNITY DEVELOPMENT PROJECT

Urban Community Development project assisted by UNICEF is being implemented by Tamilnadu Slum Clearance Board in improved areas. It covers a population of 50,000 households. The project seeks to establish a system on an infilling basis with the objective of maximising the utility of the assets provided through community involvement.

In order to ensure better sanitation in the area involving the community, it has been proposed to transfer some responsibilities to the community itself. The agency would provide part financial and administrative support. As a parallel activity to promote awareness on the need for better sanitation through individual and community practices, educational programmes and campaigns are being organised.

How to get community participation?

How to get community participation?

Three basic premises should be considered in enlisting community participation in the programme.

i. Programme should be need based.
ii. The community should be consulted from the inception the the implementation of the programme. People identify deeply with the programme when they have contributed in the planning.
iii. People involve themselves in the programme better when they are made to feel it is their programme. They help the authorities to overcome the hurdles faced during implementation if this feeling is instilled in them.

Importance of Health Education

The principle objective of health education in sanitation programme under Slum Improvement programme is to help people achieve good health through their own action and efforts. It is an educational approach ensuring maximum community participation.

Bridging the communication gap

The low literacy level of the people in India has lead to vast gap in the communication. A communication gap exists because basic needs of the people are often overlooked. Suitable mass education programmes like audio-visual aids should be promoted.

Health Education Camps

Health Education was conceived as a major component in the sanitation programme. It is being carried out in various stages. Community is helped to form welfare Associations and responsibility is entrusted with the members.

Health Education camps are being organised in Urban Community Development areas to acquaint them well with the need for sanitation, health and personal hygiene.

Other methods are individual and group contacts, contacts with the special groups like Mothers, youth, children ... etc. Experts from Government and voluntary organisations are invited to have a dialogue with the beneficiaries. Discussions along with the slides and film shows are being held between the groups and the experts. Immediate results are seen in these problem areas in the form of campaigns organised by the youth aft er such special camps. Mass media like Radio, Television, Newspapers, Exhibitions and Workshops are effectively used for Health Education.

The need for community participation for successful improvement in sanitation programme is well known and increasingly accepted. But the importance of women's involvement as a part of community participation in order to achieve the objectives is less evident. By recognising the women as primary agents, acceptors and users of better sanitation programme, they have been involved in workshops, health education camps and weekly meetings under Urban Community Development project. The important topics covered are
i. Better environmental sanitation
ii. Health iii. Nutrition Education.

Development of a voluntary force in the community

Enlightened persons within the community have been enrolled as volunteers to act as effective link between the implementing agency and prospective beneficiaries. These people have been provided with one month training in the fields of health sanitation and nutrition. Their main task is to educate the community in the upkeep of the environment clean. Training is also imparted to the local masons, volunteers and leaders in the social, economic and technical aspects of the sanitary system i.e, individual leach pit.

Transfer of responsibility to the community

The problems that are faced by the maintenance agencies cannot be sorted easily, which requires revamping of the entire system and more resources made available. It would take a long time. It is proposed to vest certain responsibilities with the community for delivery of services. However the maintenance of systems would continue to be the responsibility of the agencies.

Though it is desirable that community takes over the maintenance of public tilets, it is recognised that nothing would be better than individual toilets as the responsibility of maintenance would be vested with individual house owner and thus simplifies entire process of management. As the sewer system is costly to provide, under Urban Community Development project, people are encouraged to install Research Cum Action Project water seal pit privies by providing 1/3 subsidy of the total cost.

SUGGESTIONS

1. Sanitation programme should be considered as an integrated approach in Slum Improvement project. EX: Improving sanitation alone in an area where the water supply remaies inadequate is unlikely to receive much popular support or to achieve substantial health benefits.

2. There should be cultural revolution as such. It is recommended that sanitation should be introduced from the preschool stages itself. The type design of the children's toilets should be modified and used. Health and sanitation should form a part of school curriculam.

3. Sanitation should be linked to community needs and activities.

4. Involvement of voluntary organisations

The Government's efforts to reach the poor in its welfare activities can become success only if the voluntary organisations are given proper recognition and adequate support sought by them. Ex: Sulabh Sauchalaya, a voluntary organisation was successful in implementation of about 80,000 leach pit toilets due to the recognition and financial support provided by the Government of Bihar.

5. Government and international support is desirable. However, planning, implementation and maintenance should be handled by small groups from the local communities with necessary support from the administration.

6. The Government should be encourage innovative schemes and there should be free exchange of schemes. Ex: Sulabh Sauchalaya (Bihar) should be adopted in other stated also.

7. Technical institutions like Indian Institutes of Technology should play an important role in invention and promotion of low cost sanitary system.

8. Pay and use latrines found to be successful in Metropolitan cities. The same should be promoted.

9. The problem of sanitation calls for reformation of the existing of different civic bodies. All these functions should be streamlined and brought under a separate Department.

10. Strict enforcement of law in metropolitan areas to penalise open defecation.

The existing manpower and resources should be utilised in the programme. There should be a stress on the motivated field staff who form link between the organisation and the people. The success of the programme lies on the rapport developed between the community and the fielo staff.

Bibliography

1. The Journal of Family Welfare Vol. XXX No.2, December, 1983.
2. Involving community leaders in family welfare programme - an experience by Dr.M.P.Dhandari and Dr.S.V.Ahankari.
3. Socio-cultural aspects of water Supply and Excreta disposal (P.U. report No.Res.15, Sept 1978.)
4. Kurushetra VolXXXI No.13 April 1.15.83
5. Survey of Housing conditions conducted by National Sample Surbey (NSS) in 1973-74 Annexures II and III.
6. Sulabh Shauchalaya (Hand flush water seal latrine) Simple idea that worked - Bindeshwar Pathak.

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SESSION 4

Chairman: Professor John Pickford
WEDC Group Leader, Loughborough
University of Technology, UK.

Discussion

M Elmendorf
The softer side of software in 'decade' planning

1. Dr ELMENDORF presented her paper, and highlighted a methodology by which women could identify needs and make decisions in matters relating to water supply and sanitation.

2. Mr de KRUIJFF commented that he had been involved in the introduction of sanitation projects in Indonesia in which the emphasis had been placed on health benefits. He had not found this to be particularly successful, and thought that other strategies such as 'status symbols' may be more successful in 'selling' sanitation.

3. Dr ELMENDORF agreed, and referred to the case studies in volume 5 of the World Bank Appropriate Technology series, in which various incentives were discussed.

G Leve
Community participation in project planning and implementation

4. Mr LEVE described the situation in the Solomon Islands, and discussed the ways in which community participation could be encouraged and utilised.

5. Mr NAIEM commented on the UNICEF-aided project on which he was working in Baluchistan, a backward area of Pakistan. The programme was aimed at rural women, and dealt with the provision of basic services of primary health care, environmental sanitation, informal education, and drinking water supply. The programme was in its early stages, and although no visible achievements could be reported, it was making bold in-roads into a primitive society where total segregation of the sexes persisted.

6. Mr LEVE replied that his own experience was that difficulties were encountered in health improvement programmes in the Solomon Islands, which was a multi-cultural and multi-lingual society. A team under the Solomon Islands Development Trust was studying the customs, ways, and behaviour of the people, and were looking at ways of improving on their existing practices, with the cooperation of the various groups of people involved.

7. Mr PEIRIS commented that in Sri Lanka, behaviour patterns were being studied with the help of WHO and UNICEF, to seek improvements through community participation and health education.

8. Mr LEVE stated that similar observations were being carried out in the Solomons; the water supply programme had presented the least difficulty. The approach was to try to obtain community participation in planning, implementation, and subsequent maintenance of the projects.

A Mitra
Water, sanitation and rural women

9. Mrs MITRA outlined how the rural water supply and sanitation situation affected women in West Bengal, and discussed the progress being made through Government and non-Government organisations.

10. Mr SHRESTHA commented that it was difficult to recommend a set pattern regarding which particular rural development scheme should be taken up to start with; it would depend upon the needs of a specific community. He had found that child health care, water supply and health education made the introduction of sanitation schemes more acceptable.

11. Mrs VERZOSA asked whether rural women linked polluted water supply with disease, as water is rarely seen as the culprit in causing children's diseases such as diarrhea.

12. Mrs MITRA replied that the link was not often understood. She thought that child health programmes were a good entry point, because most women wanted their children to be cured of diarrhea first, rather than wanting to know the cause of the disease. Once the child was cured a mother would be more willing to try the methods suggested for keeping her family healthy.

P R Thomas and K N Ramamurthy
Environmental improvement in slums through community participation

13. Dr THOMAS described the slum improvement programme in Madras, India, and how the success of the upgrading could be related to involvement of the communities.

14. Mr NANDAKUMAR stated that faulty town planning was one reason for the proliferation of urban slums. The reality was that large numbers of very poor people need shelter in large cities. A proper shelter planning programme which recognised this fact should go a long way towards solving the problem, rather than allowing slums to come up, and then having to try to upgrade them.

15. Dr THOMAS replied that it was difficult to control the formation of slums, because people often moved into cities to seek employment. It was also a problem to plan in advance the type of shelter required. Low income communities would reject shelters forced upon them if the rent was too high, or if they were too far away from their workplace.

16. Mr RAUSCHENBERGER commented that funding agencies should give more time to enable full community cooperation to occur; their stringent time controls made full community participation impossible. He also suggested that more women engineers should be encouraged to work in the developing world.

17. Dr NARAYAN PARKER discussed how it was possible to learn from the people. She never made any assumptions about people, but always listened carefully to what they had to say. In one instance in the Maldives, latrines had been built, with the location decided by planners and community leaders. Some latrines were used, and some were not; much discussion eventually revealed that the village was split into unofficial sections, and people from one section would not use the latrines in another section, even if they were close by.

18. Mr VIDODU commented that to avoid confusing the community, coordination of the various activities should be ensured at all levels.

19. Mr BOLLEN raised some general questions: how does one motivate to change behaviour and practice; is there a time of life when people are more likely to be motivated to change their behaviour; and are there any indicators which will show that changed behaviour has improved health.

20. Mr PEIRIS commented on women's role in Sri Lanka; the government had recently established 'Women's Service' in various public organisations, which had formed units to involve female employees, and the wives of male employees to undertake and participate in development, and look at areas where they could help through participation.

K N Vijayanthi

Community participation and education in sanitation programmes

21. The author was not present, and the paper was not read.

10th WEDC Conference

Water and sanitation in Asia and the Pacific : Singapore : 1984

Sewer laying in Calcutta slums

S C Dutta Gupta

INTRODUCTION

Slums in CMD

One of the biggest cities of Asia, Calcutta, is situated on the bank of the river Ganges in the Eastern part of India, about 1500 km from New Delhi, the Capital of India. About 9 million people live in the Calcutta Metropolitan District (CMD) which has 39 local bodies within it, spread over an area of 1425 km^2 on the two banks of the river Ganges. The city of Calcutta, along with its adjoining areas, has got vital importance in regional and national economy. Founded on a marshy swamp, about 300 years back, this city grew up in a most haphazard, unscientific and unhygenic way ever since its inception. Slums started growing from the middle of last century to accommodate large inflows of migrants from different parts of the country because of the increase in job opportunities caused by rapid industrialisation. Slums consist of several contiguous huts, each hut having three to eight cubicles with one family living in each cubicle. These huts, which were built up in an unplanned manner in whatever land that was available from landlords, are made up of mud, bamboos, tiles, ironsheets etc. and no substantial part of them is made of reinforced concrete, brick, steel, iron or any such materials.

Conditions in the Recent Past

The population of a slum varies from 100 to 20,000 with a density ranging from 400 to 2500 persons per hectares. Some 3,000 bustees are scattered all over CMD. One out of every 3 persons in CMD live in slums. The slums are characterised by over-crowding. It is quite usual to find more than 5 persons sleeping in a small room of about 10 m^2. The population pattern is broadly controlled by occupation, religion and language - the industrial workers working in the same organisation living in the same area, daily labourers from other parts of the country have their own pockets or the Muslim workers are brought together in one area by their common way of living.
The slum dwellers were so long denied the basic minimum civic needs. Most of the huts were without any water supply connection. One spot tubewell was, in many cases, shared by many slum dwellers. The per capita water supply was thus very much less than the basic minimum requirement. The result was that people had to fall back upon unprotected water supply sources, which create health hazards.
There were even no service latrines in each hut, and there were no arrangements for collection of human faeces in a sanitary way. All these caused faecal contamination of water and soil. Also there was no proper arrangement for collection and disposal of solid and liquid wastes of the area. In most cases, there were a few unlined drains which collected storm water, and discharged them in the nearby pond or in the roadside drain which remained stagnant with slush and filthy matters.

PREPARATION OF SCHEME

In consideration of the fact that the unhygenic and unhealthy condition of the environment in a slum area, as detailed above, is dangerous to public health, the Calcutta Metropolitan Development Authority took up a massive programme for improvement of the environmental conditions of the slums. As a part of the said programme which has made considerable progress, sewers were laid in Calcutta slums. In designing the sewers to be laid in slum areas, a rational method of design has been adopted with the following criteria: frequency 2 months, run off coefficient 70%, inlet time 15 minutes, n = .015. Once the design is finalised, the project report is prepared, indicating design considerations. Detailed drawings are also prepared showing the layout of the sewers including the dias and slopes, location of street inlets, sectional drawings of manholes and street inlets.

EXECUTION OF PROJECT

Award of Contract

The actual execution is done through local contractors. Sealed tenders are invited from bonafide, experienced and reliable contractors, for which contract documents have to be prepared. The first step is to prepare a bill of quantities showing probable items of works, quantity, unit, rate and amount. This is prepared on the basis of departmental schedule of rate for different items of works involved for sewer laying works. The contract documents consist of (i) Detailed Notice inviting tender, (ii) Clauses of contract, (iii) Schedule of items of works with amounts, (iv) contract drawings,

(v) Special terms and conditions (e.g. regarding protection/diversion of underground utilities, provision of caution board, road sign etc.).

Offers of the intending tenderers, who are also required to submit earnest money, are opened on the date specified in the notice inviting tender, in their presence. The offers are then evaluated and the contract awarded after observing other formalities, and the contractor is asked to complete the works within a specific period. They are also asked to submit a programme of works. If, after studying the layout plans, it is found that the area has to be divided into a number of parts for quicker execution of work, a number of contracts are entered into.

Construction Operations

The following operations are done in sequence for sewerlaying works.

Layout: With the help of the layout plan, the layout of the sewers to be laid in the area has to be given. In giving the layout, it has to be seen that the laying work starts from the downstream side in general. In some cases, layout had to be given at the upstream side in consideration of facility of movement of light vehicular traffic, but in such cases, levels at keypoints have to be properly maintained.

Excavation and Sheeting: At this stage, existing road crust was first picked up and excavation continued along the desired alignment with the help of shovels and minor hand tools. After reaching a depth of about 2 metres, timber sheetings were driven to prevent collapsing of the trenches. Excavation was continued up to the desired depth with driving of timber sheeting well below this depth for proper gripping. The sheetings should be sturdy and not less than 5 cm thick supported bystruts, and should be closely driven. The depth of excavation has to be checked with the help of site rails (placed at distances of 150 metres or so) and boning rods.

Dewatering and Bedding: The general ground water table being high in this part of the country, trenches excavated beyond 2.5 m - 3 m get filled up with subsoil water; then there is leakage from house drainage connections, existing watermains etc. in the trenches. Hence dewatering of the trenches has got to be done with portable pumps so that bedding can be laid. Slushes and mucks were removed manually from the trenches before laying concrete cradle bedding as per specifications, for which detailed drawings are available. The slopes of the bed finally laid are checked with the help of site rail and boning rod as before.

Pipelaying and Jointing: The work of pipe laying was done after the concrete bed had set, and the slopes and levels had been checked. The pipes were jointed with collar joints. Gaskets made out of jute thread, soaked in cement slurry were placed in the annular space between pipes and collars. A layer of bitumastic compound was placed in the grooves provided at the end of the pipes.

Backfilling: After laying and jointing of pipelines have been completed, backfilling is done with excavated materials, which are to be dumped layer by layer (each layer not excluded 20 cm.) watered and rammed.

Road Restoration: As per practice, after backfilling, the road has to be restored temporarily up to jhama consolidation level, opened to traffic, allowed to be settled, and finally restored after a considerable period of time.

EXPERIENCES DURING EXECUTION

Limited Working Space:

The lanes in the slums, where the sewers were laid are narrow, the width ranging between 3 to 5 metres. The work had to be carried out with minimum inconvenience of the local beneficiaries, and minimum dislocation of light vehicular traffic. The following general steps were taken in consultation with local beneficiaries.

(i) For the safety of the pedestrians, barricades were erected with bamboo fencing along the site of excavation after allowing some width from the edge of trench for movement of workmen.

(ii) When a particular stretch of road was closed for sewer laying work, a survey was conducted with local leaders for finding out alternative routes for diversion of light vehicular traffic. Necessary road signs and caution boards were next placed in proper locations.

(iii) Unless the work in a particular section had advanced sufficiently, excavation in the next stretch was not permitted to be taken up. Very little space was left on the sides of the trench excavated for laying sewerlines, as the lanes are narrow. As such excavation could not be done with excavators, nor could rammers be used, it had to be carried out by local labourers with the help of pick axes, shovels etc. The spoils excavated could not be dumped by the side of trenches for removal away from the site. Instead, spoils were to be carried away from the trench by head load to a distance of 200 m in some cases due to non-availability of open space. For the same reason, construction materials had to be stacked far away from the site and carried by head load to the actual spot for construction.

All these added to construction cost and delayed progress of work, which could not be avoided, the situation being as it is.

Difficult Soil Conditions:

In case the excavation depth is large, caving of sides of the trench is expected. As such, close timber sheeting was done to protect the side of the trenches, the sheeting being driven with adequate grip length beyond the trench bottom. But in one or two cases, even after precautions as above were taken, the trench became filled up with sand after a depth of about 3 metres was reached. Excavation beyond this depth could not be reached as, after removal of spoils from this depth, sand flowed into the trench and filled up the space up to that depth, again and again. This is because of sand boiling, which was countered in one case by spreading bamboo skin and matting on the trench bottom immediately after excavation and by holding it tightly with shoring. In this case, other operations like spreading soling, casting concrete bedding and laying of pipes had to be completed very quickly so that movement of soil could not take place. In another case, all attempts to counter sand boiling failed. Sheet piling could not be done due to limited working space and as the vibrations during sheet piling would damage the properties close to the trench. The alternative was to lay the pipes at the maximum depth that could be reached, and to change the design of the system.
This situation, again, supports the statement made elsewhere in this paper that sewer lines should be laid from the downstream end.
In the slum areas, tall buildings exist by the side of huts in narrow lanes. When the excavation was deep and close to these buildings, particularly in sand boiling conditions, it was apprehended that, due to movement of soil, the foundations of buildings would get exposed, endangering the safety of the structures. The situation was tackled by excavating trenches for shorter lengths in these portions, and completing all operations from excavation to pipe-laying in the shortest possible time. As a measure of additional precautions, timber sheetings were left in the trenches after back filling in these stretches. This was for restricting the movement of soil so that the buildings were not rendered unsafe.

Existence of Underground Utility Lines:

A number of existing utility lines like watermains, electric lines, gas pipes, telephone lines, became exposed at the time of excavation of trenches. These lines are maintained by different utility agencies. Hence coordination has to be maintained with all these agencies right from the stage of project preparation. All available information regarding underground utilities were collected from all these agencies. Arrangements were to be made for protecting these utility lines as per the requirement specified by the concerned public utility agency. Thus water and gas mains were not only slung, but to take care against displacement of pipes or leaking of joints, brick pillars were constructed under the pipes to give them support at short intervals. Timber posts were placed across the trench with sufficient bearing on either side at intervals and exposed cables were slung with coir rope.
Routine inspection during excavation was arranged along with different utility agencies. In some cases, required information was not available at all from utility agencies. In such cases, excavation was carried out slowly and carefully. Thus when an electrical junction box was exposed or a smell of gas was perceived, the concerned utility agency was immediately contacted, keeping the work suspended temporarily. Work was resumed again only after the concerned agency had taken the necessary steps and given the green signal. The existing water mains are rather old. Damage of ferrule connection and water main was reported frequently. Bursting of water mains caused flooding of trenches, which not only caused serious dislocation in the progress of work, but also cut off supply to the consumers. The situation was tackled by contacting the concerned utility agency, whose help is often required in plugging the main and repairing the damaged pipe. The trench was again to be dewatered and ferrule connection restored. In one case, where the depth of excavation was small, the head room available between trench bottom and the network of utility line was so small that the workers had a difficult time in laying and jointing pipes. In some other cases, the pipes could not, due to presence of utility lines, be lowered vertically in the trench, but were lowered at some other distant point and dragged to the proper place. In some other cases, the alignment of the existing water main fouled with that of the proposed sewer line. In such cases, water line was run above sewer line, taking care that the water line did not pass through the manhole. For this purpose, the shaft of the manhole was modified in one case and the water line was diverted to pass outside the manhole in some other cases. In another case, it was apprehended that the cable lines which were slung would get damaged as they were subjected to tension during excavation. As such, the timber sheeting was left in the trench even after backfilling.

CONCLUSION

It must be admitted that a water borne sewerage system is not only the most appropriate solution, but also the only feasible solution for slum areas in Calcutta. The work of laying sewer lines in limited working space and under difficult soil conditions in the presence of existing underground utility services can be best tackled by an Engineer, when he maintains good coordination with different utility agencies, so that the problems faced while working in the trenches can be solved properly and promptly. He also has to take into confidence the local beneficiaries so that they cooperate and bear with the authorities for the inconvenience caused temporarily.

ACKNOWLEDGEMENT

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REFERENCES

1. Chatterjee, A.K.: Replacement of existing sewers in Calcutta Streets. I.C.E. London, 1981.

2. W.H.O.: Masterplan for Water Supply, Sewerage and Drainage for Calcutta Metropolitan District.

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Sanitation from biogas in China

Dr Li Nianguo

As was known, biogas production is an anaerobic digestion process. Microbes of acid-forming bacteria and methanogens appearing in the forms of sarcina, bacillus, coccus or spirillum are reacting under anaerobic conditions, producing acids and successively methane the major component of biogas. The anaerobic process in a conventional biogas digester takes a retention period exceeding 25 days, aerobes are mostly killed then, including a great variety of pathogenes and parasite ova, epidemic diseases were thus eliminated. In case thermophilic digestion being applied, the higher temperature would kill even more.

In the application of biogas, conventional firewood/animal dung cooker stoves were substituted by biogas burners. This made it possible to reduce eye/lung diseases formerly caused by smoke from cooking. To supply feeding to the biogas digester, latrines are motivated to build in villages, human/animal manure once spread everywhere are collected together with grass and weed, so the environment is in better shape. Since digested slurry has a lower biological oxygen demand (BOD) than undigested wastes, the digestion of the waste helps maintaining oxygen level in ponds and streams, producing a more favourable environment for fish.

In industrial sector, anaerobic digestion has been applied in brewery, slaughter houses, sugar refineries and their subordinating workshops treating paper pulp black liquid and furfuraldehyde sewage, and in soy sauce manufacturer for the disposal of monosodium glutamate wastewater. The process has also been applied upon the treatment of other organic wastes. Besides biogas generated for supplementary energy, environmental pollution has been controlled to a certain extent.

EXCRETA TREATMENT

The studies for sanitary effects of anaerobic digestion were concentrated in the treatment of human/animal excreta which is the most common feeding to the biogas digesters in Chinese rural area. Bad management of the excreta leads not only to environment pollution as flies and mosquitoes breedding, but also to epidemic and parasitic diseases such as:

Bacterial diseases -- bacillery dysentery, typhoid/para-typhoid fever;

Virosis -- virose hepatitis, poliolities, and others;

Parasitic diseases -- schistosomiasis, ancylostomiasis, ascariasis, cestodiasis, fasciolopsiasis, amoebic dysentery, etc.

Many of the diseases are infectious to both human beings and animal. Sorts of pathogens and parasites or their ova often adhere to straws spread in piggeries and cowsheds. The straws would bring the germs and parasites back to the farm when spread as manure, if they were not properly treated.

There are various ways to dispose excrements. Sanitation criteria were set up in China for pollution control, normally investigating :

(1) Observation on fly breeding, focuses upon the density of fly maturity, death rate of maggots and eclosion rate of fly chrysalis.

(2) Value and index of coli-bacillus. Since coli-bacilli are of greatest amount in large intestine and being of largest living period among pathogenic intestine germs under identical ambient conditions, the bacteria were taken as the criterion for determination. There are two ways for indication, i.e., value of coli-bacillus and index of bacillus.

Value of coli-bacillus applies to the smallest amount (in gram or litre) of sample needed to detect one coli-bacillus. The higher the value, the smaller the amount of such germ. The value is indicated by negative index, for the sake of convenience.

Index of coli-bacillus terms the total amount of the bacilli existing in each litre of liquid. The larger the index, the greater the amount of such germ.

(3) Death rate of ascarid ova. The parasite ovum is most commonly exists in excrements, and it is of strongest viability among parasite ova. So the death of ascarid ova covers that of other parasite eggs. In practice not only the amount is counted but more importantly the death rate of which is to be discriminated.

The sanitarian criteria demanding excreta treatment with biogas digestion are: no living ovum of blood fluke nor that of hookworm is detected in digester effluent, and the decrease rate of living ascarid ova approaches 95%; value of coli-bacillus being around 10^{-4}--10^{-3}; and effectively preventing breeding of flies and mosquitoes. While for disposed biogas sludge, the death rate of ascarid ova should be 95-100% and the value of coli-bacillus should be 10^{-2} -- 10^{-1}.

DATA OBTAINED

Massive researches and investigations have been undertaken in some health-care institutions in several provinces and all the results obtained had proved that biogas digestion affects positively to sanitation.

* * * * * *

Table 1. Time Required to Kill Microbes at Various Temperature

Category \ Temperature range (°C)	35-38	45	50	53	55	60
blood fluke ova	13 days			1 min.		
hookworm ova	23 "	several hr.			imm.	
ascarid ova	18 "		20 min.		10 min.	imm.
leptospira			10 min.			
coli-bacillus					1 hr.	
lung fluke ova	8 days					
bacteriophage					9 days	

("imm." stands for 'immediately')

1. Results of Treatment Affected by Temperature

Temperature is an important factor affacting the killing of parasite ova and pathogenes in excreta treatment. Generally speaking, the temperature favourable to living and growing of parasite ovum is some 22^{o}-30^{o}C, and the temperature for non-gemma pathogens is around 37^{o}C. For pathogenic microorganism, it is within the range of 24^{o}-40^{o}C. Thermophilic fermentation (above 39^{o}C) and mesophilic process (35^{o}-38^{o}C) would suppress the growth or even kill the microbes. The reaction period is also a factor affects the death rate of microorganism. The higher the temperature, the shorter the time required for killing. The constant of velocity for thermal purification of germs is larger than 0.1/min. at 55^{o}C. Under higher temperature the thermal elimination to pathogens is more effecacious than that against bacteria. Table 1 shows the effect of temperature as a function in killing the microbes. The time listed in the table applies to the duration for killing.

One example showing real effect was taken from a 320-m^3 and three 680-m^3 digesters. At 53^{o}C internal temperature the value of coli-bacillus in excreta of 10^{-6}--10^{-12} before digestion had been reduced to 10^{-1}--10^{-2} afterwards. For ascarid ova, the living rate was 64% before and all were killed after the anaerobic digestion. Another example taken in a 384-m^3 thermophilic digester, typhoid and dysentery bacilli as well as blood fluke and hookworm ova were all killed in a 24-hr. detention period; and ascarid ova stood no longer than 48 hrs.

2. Results of Treatment under Ambient Conditions

The annual averaged digester temperature in large areas of central and southern China is within the range of 8^{o}-29^{o}C. Since most of the rural digesters run under such condition, extensive investigations viewing from various aspects have been carried out.

(1) Detecting parasite ova in digesting liquid and sludge. From one example the data obtained from several experiments are listed in Table 2.

From another example, the data taken from a night soil treatment plant may be seen in Table 3.

Still for coli-bacillus, another example taken from a rural digester showed that the indices being 1.218×10^{11} and 7×10^{7} at the inlet/outlet respectively.

(2) Viability of parasite ova. Parasite ova precipitated and gethered from the supernatant and sludge of a biogas digester would die along with the period they are steeped in the digested liquid under anaerobic condition. Table 4 shows the effect.

* * * * * *

Table 2. Living/Reduction Rates of Parasite Ova/Miracidia

Category	Retention period	Sampling point		Reduction rate(%)	Living rate(%)
		inlet	outlet		
hookworm miracidia	(3 months)	53-3499	0-259	83.7-99.9	
ascarid ova	3 months	1173	710		60.5
" "	6 months				53.5

Table 3. Bacteria and Parasite Ova Killed During Anaerobic Digestion

Sampling point	No. of parasite ova	Removal rate(%)	Death rate(%)	Value of coli-bacillus
inlet of digester	396		38.75	10^{-6}
sedimentation tank	116	70.7	62.5	10^{-4}
outlet of storage tank	31	92.2	68.06	10^{-3}

The decomposition of microorganism fermentation would generate freestate ammonia which may permeate the shells of parasite ova and spore membrane. Ammonia strength in digesting liquid is generally 0.07%. In 0.2% concentration blood fluke ova would die in 6 days, while ova of hookworm and ascarid could only stay a little longer.

Under anaerobic condition the pathogenes could stay no longer,e.g., 17 days for dysentery bacilli and leptospira, 30 days for typhoid bacilli, and 41-44 days for bacillus paratyphosas B.

PREVALENCE CONTROL

Once the domestic biogas digesters were built linking up with lavatories and pigstys, digested sludge was composted or macerated before applying, thus enhanced management of excreta. Three years have passed since this application was brought about in a village where was prevalent of ancylostomiasis. The 63.8% infectees of the total population from 500 hookworm ova per gram of excreta were all cured and new cases has not been observed as the ova/gram reduced to 50, i.e.,90% reduction.

Only in 2 years' time, the figure of 1,500 patients in a county prevalent of entiritities and bacillery dysentery was reduced for two-thirds since the practice of biogas utilization.

Experiences proved that, in connexion with medical treatment and other sanitary measures, the management and the treatment of excrements with biogas digesters is effecacious in sanitation and environmental pollution control.

REFERENCES

1. Chinese Biogas Technology. (A UNU publication to be published. Chief translator for English version: N.Li.)

2. Mahin, D. Bioenergy Systems Report (for USAID),March 1982:Biogas in Developing Countries

3. Chen, R. Up-to-Date Status of Anaerobic Digestion Technology in China. (1983)

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Table 4. Duration for Parasite Ova Living/Before Go Dysplasia

Category	Living (days)				Go dysplasia (days)	
	summer	autumn	winter	spring	sum.-aut.	win-spring
blood fluke ova	8-14		13-22		76-87	70-79
" " miracidia						
hookworm "	---- 93 ----					
ascarid ova	90(75%)		100(53%)			

Note : percentage in brackets refers to death rate

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Alternative wastewater treatment strategies

Dr H Orth and A Sahasakul

INTRODUCTION

It is very often assumed that on-site wastewater treatment in general is more economical and involves less complicated technology than centralized wastewater treatment. Although this assumption is surely correct in many practical cases, it must not be generalized. It depends on the specific situation of an individual case whether the appropriate solution is on-site or centralized wastewater treatment. This is demonstrated by the following case study, where centralized wastewater treatment offers both, lower cost as well as simpler technology.

The case study shows a situation which is very frequent in developing countries: the planning area is a fast developing industrial area on the outskirts of a metropolis. Besides the industrial area the planning area also includes a residential and commercial area. The surrounding land is still used for agriculture. Some parts of the stormwater and treated wastewater from the new builtup areas are discharged to irrigation canals. This situation has already resulted in the occasional pollution of irrigation water.

Six alternatives for centralized wastewater treatment and on-site wastewater treatment were compared. The comparison includes the cost of the different alternatives as well as an assessment of the technology involved. The following paragraphs give first a description of the planning area and of the design criteria, on which the alternative systems are based. Then the alternatives are compared in economical as well as in technical terms.

THE PROJECT AREA

An overview of the project area is given in Fig. 1. The area is located in a flat river basin. The climate is tropical with a mean monthly temperature between 20.5°C in December and 29.9 °C in April. The sub-soil conditions are marked by several layers of clay and a groundwater level close to the surface. Wastewater infiltration, therefore, is not possible. The bearing capacity of the sub-soil is very low and all heavy

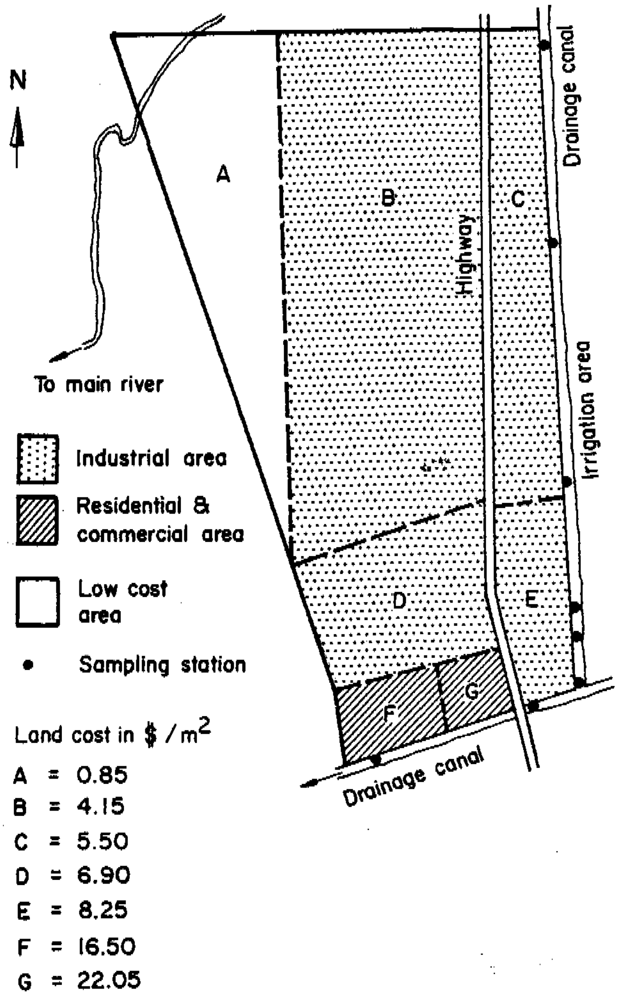

Fig. 1: Overview of the project area

structures, even septic tanks, are to be based on piles.

Because of its vicinity to a metropolis, the project area is influenced by the rapid industrial and economic development of the metropolis. The estimated annual growth rate is 8% for the population and 21 ha for the industrial area. Main types of industry are textile, food processing, and ceramic industry. For the planning period a population of 31,650 inhabitants and an industrial builtup area of 774 ha are expected. The total project area comprises about 1,900 ha.

The commercial and residential area is supplied by a public water supply scheme, whereas the water source of factories are about 80 deepwells. The total draw-off from the underground is estimated to be 21,000 m^3/d. The sanitary wastewater of the residential and commercial area is treated by on-site facilities, in most cases cesspools. The wastewater of the industrial areas is mainly process water, whereas domestic wastewater counts for less than 18%. The total wastewater flow of about 21,000 m^3/d carries a BOD_5 load of about 10,000 kg/d. The most frequent treatment processes in the industrial area are trickling filter, activating sludge, chemical coagulation, and air floatation.

After treatment the wastewater is discharged to some small ponds outside of the builtup area. The overflow of the ponds is discharged to canals which partly discharge to a river and partly are connected to the irrigation scheme. The fact that most cesspools and industrial treatment plants cannot maintain the effluent standards have resulted already in pollution of irrigation water. With respect to irrigation, the water samples taken from 6 locations at the east side of the planning area are of particular interest. They show a dissolved oxygen content between 0.2 and 1.5 mg/ℓ indicating considerable organic pollution. The maximum electrical conductivity was found to be 1500 $\mu S/cm^{-1}$, the maximum residual sodium carbonate 5.01 mg/ℓ. The values exceed by far the standards of 750 $\mu S/cm^{-1}$ and 1.25 mg/ℓ respectively.

ALTERNATIVE WASTEWATER MANAGEMENT STRATEGIES

The present on-site wastewater treatment was compared to 6 alternative systems with central treatment plants. For the centralized systems two types of collection systems were compared, a) a piped system and b) a partly open channel system. Open channels are only considered for the industrial area, whereas closed sewers are proposed for the commercial and residential area.

The wastewater from the commercial and residential area is discharged to a main sewer or open channel. For the sewer options, the main sewer is located along the highway in the industrial area. The wastewater from the factories reaches the main sewer by gravity. The open channels are located at the back of the factories for aesthetic as well as for economical reasons. The wastewater is to pumped to the open channels. Since the treatment plants of the factories are located at the back of the factories, an open sewer in front of the factories would increase the pumping cost.

Figs. 2 and 3 show the sewer and the open channel option for a centralized solution with one treatment plant.

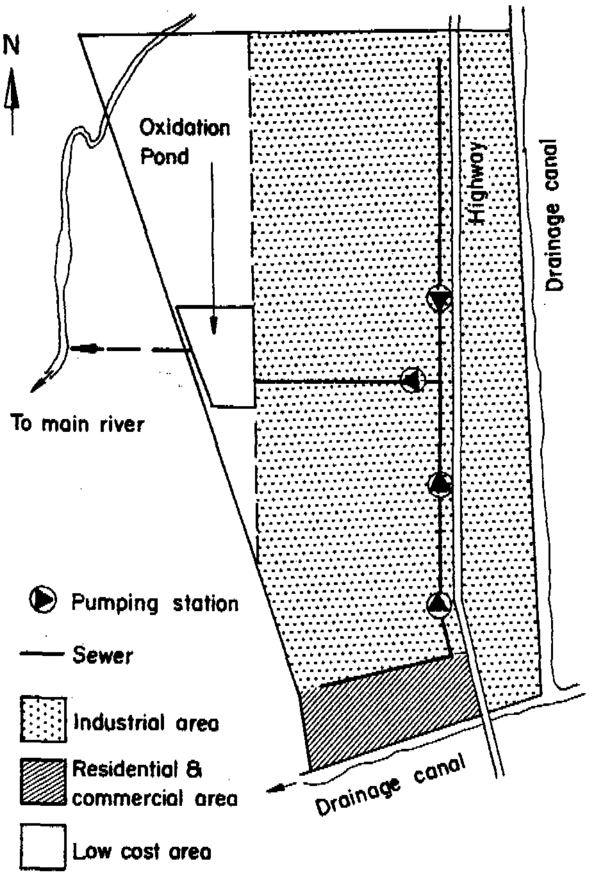

Fig. 2: Layout of the centralized wastewater treatment and collection scheme (sewer option)

The cost for a piped system is only slightly higher than for an open channel system. This is mainly due to the fact that open channels are to be built above the flood level with accordingly high cost. The further comparison between on-site wastewater treatment and a centralized solution is based on the open channel system. However, the choice between a piped system and an open channel system affects the comparison between on-site wastewater treatment and centralized treatment only to a very limited extent.

Fig. 3 shows the layout of the most economical solution. The treatment unit is a stabilization pond. The wastewater is transported to the treatment plant by two main sewers. Since the area is flat, 9 pumping stations are required. They are equipped with submersible pumps. The five other alternatives for centralized

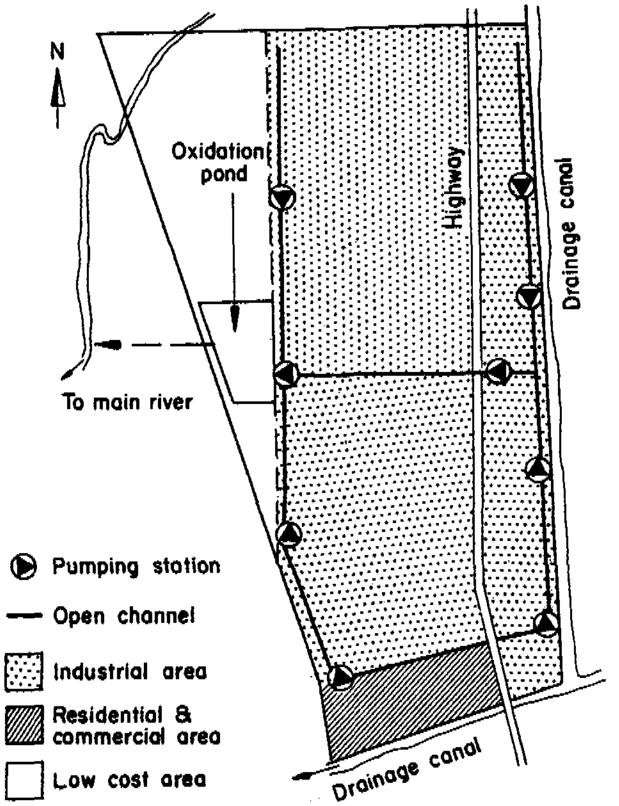

Fig. 3: Layout of the centralized wastewater treatment and collection scheme (open channel option)

treatment show similar layouts. The main difference is that instead of 1 treatment plant, 2 and 3 either aerated or unaerated plants are used.

TECHNICAL AND ECONOMICAL DESIGN CRITERIA

Preliminary designs were developed for all alternatives which were based on common design standards. Some specific design criteria are given in Table 1. The cost of all facilities is developed from the preliminary designs and local unit cost rates. The economic comparison is based on the present value. The main criteria for the economic comparison are also given in Table 1. For interest and for energy cost inflation two different rates were used. The interest rate of 14% represents the rate for public loans, the rate of 18% the commercial rate. The increase of energy cost of 25% was chosen in view of the high increase of the last 5 years, which was about 29% as annual average in the project area. The lower rate of 7% results from the consideration that the high increase of the past years was a single event rather than a long term development. The other rates are based on official statistics.

Table 1: Basic design criteria for the planning period

	Industrial area	Residential and commercial area
Builtup area	774 ha	92 ha
Pop. density	-	344 c/ha
Flowrate	1 /(s·ha)	201 /(c·d)
BOD_5	44 kg/(d·ha)	52 g/(c·d)
Infiltration	0.9 /(s·ha)	0.9 /(s·ha)
Planning period	25 a	
Interest rate	14 and 18%	
Inflation rate for		
construction	6%	
equipment	7%	
energy, operation	7 and 25%	

A difficulty arose in the estimation of the future cost for on-site wastewater treatment, since it is not known which type of treatment plant the future factories will build. To cope with this problem, the present cost of on-site treatment was extrapolated on the basis of the present and the expected future BOD load.

RESULTS OF THE COMPARISON

The most significant result is that on-site treatment is about 4 to 5 times more expensive than the various centralized treatment alternatives. The explanation is that the ponds for centralized treatment are located in an area with very low land cost (see Fig. 1). On the contrary, on-site treatment which is done on valuable industrial land employs rather expensive processes such as activated sludge, coagulation and air floatation. This general result is also not altered by the different rates of interest and the extremely different increase of energy cost. These variations change only to some extent the ranking order among the centralized treatment alternatives.

The cost relationships become apparent from Table 2 which shows the present value for the main cost items of centralized and of on-site wastewater treatment options. The cost for treatment plants is very high for the on-site solution compared to the centralized solution. For the variants with the high increase of energy cost, the operation costs are the main cost factor, which result from operating the treatment plants in the on-site option and operating the pumping stations in the centralized option. They count in these cases for about 70-80%

Table 2: Present value of on-site and centralized wastewater treatment strategies

Item	Present value in monetary units			
	Interest rate 14% Operation cost increase		Interest rate 18% Operation cost increase	
	7%	25%	7%	25%
A) On-site treatment				
Treatment plant construction	560	560	532	532
Treatment plant operation	316	2659	231	1496
Total	876	3219	763	2028
B) Centralized treatment				
Treatment plant construction	77	77	77	77
Treatment plant operation	8	67	6	38
Pumping stations construction	18	18	17	17
Pumping stations operation	53	448	39	252
Open channel construction	36	36	37	37
Open channel operation	1	11	1	6
Total	193	657	177	427

and 60-70% respectively of the total present value.

Besides the lower cost the technology employed for centralized treatment is also much simpler. Treatment is done in an oxidation pond. The most complicated elements of the centralized system are submersible pumps. This simple technology is be compared to the rather complicated processes employed for on-site treatment. This difference in technology is particularly important for operation and maintenance. Professional staff for the many individual plants cannot be expected. Another disadvantage of on-site treatment is that the plants are rather small. It is a well known experience that processes such as the activated sludge process are more difficult to operate in small units.

The centralized treatment is also advantageous in respect to the receiving water conditions. The effluent of the oxidation ponds is discharged to a small water course on the west side of the area, which directly leads to the main river. The wastewater discharge therefore is separated from the irrigation area on the east side of the industrial area. In contrast to the centralized schemes, a part of the effluent of on-site treatment plants discharges to drainage canals which at some points are connected with irrigation canals.

CONCLUSIONS

In the presented case study, centralized wastewater treatment is advantageous compared to on-site wastewater treatment. It involves lower cost as well as a simpler technology and a better protection of the receiving water. However, the study represents an individual case and should not be generalized. It simply shows that there is no general solution. Each planning problem demands an individual solution based on specific conditions. The main reason which makes centralized treatment favourable in the presented case is, that inexpensive land is available for the construction of oxidation ponds.

REFERENCE

1. SAHASAKUL A. Drainage and wastewater treatment strategy study for a semiurban area, Master Thesis No. EV-82-26, Asian Institute of Technology, Bangkok, 1982.

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Ecological parameters in oxidation ponds

A K Shrivastava
and S N Sharma

Waste Stabilization Ponds are important for tropical countries like India. With their low initial cost and multiple benefits, they could be used with advantage in developing countries where availability of land is no problem. An ecological study of the ponds, with an ecosystem approach, therefore becomes relevant.

In the present study it was found that the maximum production in pond is achieved between 0800 and 1100 Hours; the respiration is maximum in the afternoon reaching its lowest value in the morning corresponding to a minimum temperature. Minimum DO levels were recorded at around 0300 Hours, reaching near saturation value. The algae in the log phase of growth were found a shade faster than that in the decay phase in starting the production and reaching to its peak value. The pH of the pond waters were found to rise with production moving into alkaline range and as such it can be an index of productivity in an aquatic ecosystem.

INTRODUCTION

Waste Stabilization Ponds are semi-natural engineered ecosystem. Its low cost of construction, negligible recurring expenses, its freedom from mechanical equipment and skilled maintenance, as also the great potential it holds in utilization of its effluents for harvesting of protein-rich algae, pisciculture and irrigation usage etc., make it worthy of its popularity and almost a tailor-made proposition of waste treatment for a developing country with a tropical climate.

A waste stabilization pond is an excellent example of a small ecosystem having its own structural components - biotic and abiotic, as also the necessary functional components like energy circuits, food chains etc. The mechanism of treatment in waste stabilization pond is symbiotic i.e. mutualistic symbiosis exists between algae and aerobic bacteria as shown in Fig.1.

Considerable studies have been carried out on waste stabilization ponds, but mostly by engineers or botanists with one or other component in focus. An ecosystem approach to a waste stabilization pond has been lacking so far.

EXPERIMENTAL PROCEDURE

To study the variations in ecological parameters in a waste stabilization pond with varying BOD inputs, laboratory scale models, consisting of glass aquaria of size 45 cm x 30 cm x 30 cm deep with open top were taken. BOD inputs varying from 35 mg/L to 350 mg/L were taken and variations in Production (P), Respiration (R), pH, were recorded. Synthetic waste was prepared as suggested by Humeric and Hanna(1) and domestic waste was proportionately mixed for seeding and achieving desired BOD values. Standard Methods(2) was followed for physical and chemical examinations. P and R values were determined by Dark and Light Bottle

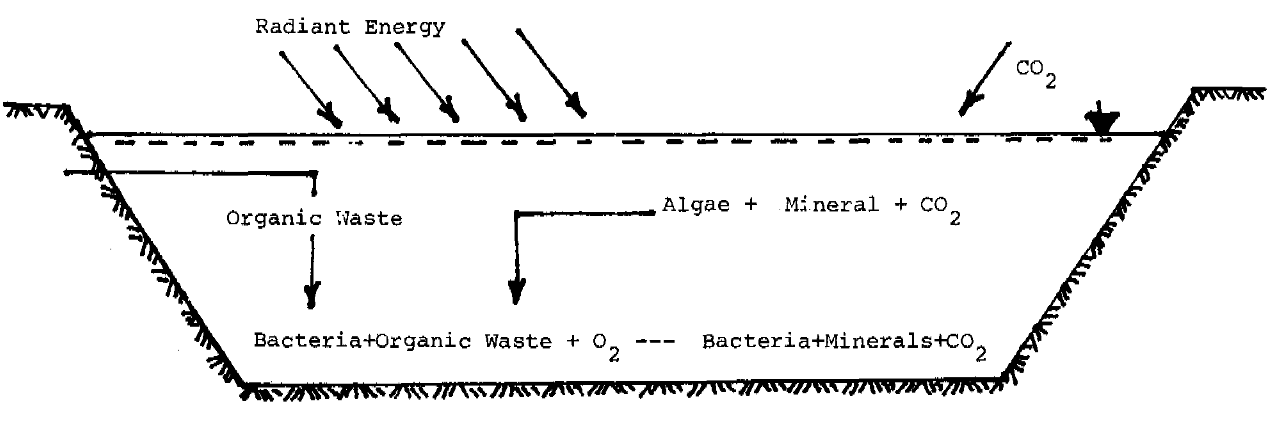

Fig.1 Algal-Bacteria Symbiosis in Waste Stabilization Pond

experiments. Diurnal studies were made on ponds in log phase as well as decline phase of the growth. The observations were recorded at every 3 Hour interval for a complete cycle of 24 Hours including the dark and light period. It would be well to keep in mind that values obtained for any ecological parameter at a certain hour, actually reflect the cumulative activity over the preceeding three hours.

The variations of pond DO and P have been plotted against time in Fig.2. The maximum DO concentration ranged from more than twice to more than four times the saturation levels. Also the peak DO concentrations declined with increase in BOD as also observed by Mackenthun et. al.(4). Minimum DO values were recorded at 0300 Hours in all the ponds reaching below saturation levels in old culture ponds, whereas in ponds with young culture DO levels never dipped below saturation. This appears to be due to reduction in photosynthetic efficiency with aging of algal cells.

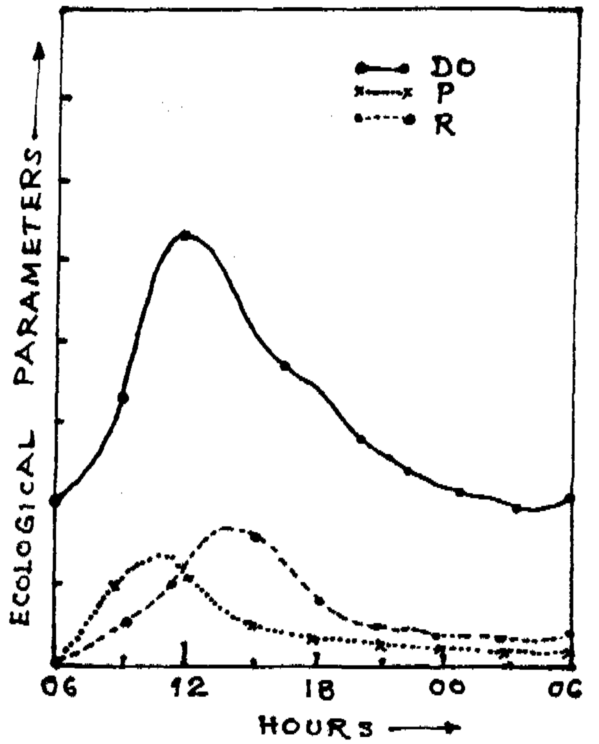

Fig.2 Variation of DO, Production and Respiration

The maximum production, P, was observed between 0800 to 1100 Hours. Apart from the right solar intensity and temperature, the rapid depletion of CO_2 appears to be the most likely cause of photosynthetic production. Bartsch(5) also reported the mid morning photosynthesis to be 50 percent greater than that in the mid-day. Strangley enough, production though greatly reduced during night hours, was never exactly zero, and all ponds had minima around 0300 Hours. The predominant algae in all these ponds was Chlorella Sp., which has been reported to be a versatile autotroph.

A study of diurnal variation of respiration, R, with time shows it to gradually increase in the morning, reach its maximum in the afternoon and decline all thrrugh the night touching a minimum at 0600 Hours. Respiration, R, has generally followed temperature in its diurnal variation.

Diurnal variations of pH has been shown plotted in Fig.3. As observed pH starts rising from the morning but highest pH levels are reached between 1500 to 1800 Hours, and remain above the mean value until after sunset. Similar results have been documented by Wilford et.al.(6). pH value depends upon CO_2 concentration in the medium, which, in turn, varies inversely with the rate of production, P. The maximum pH values are found to be lagging by 6 to 9 hours, reasons being the dark reactions continuing and utilizing CO_2 for cell synthesis even after sunset.

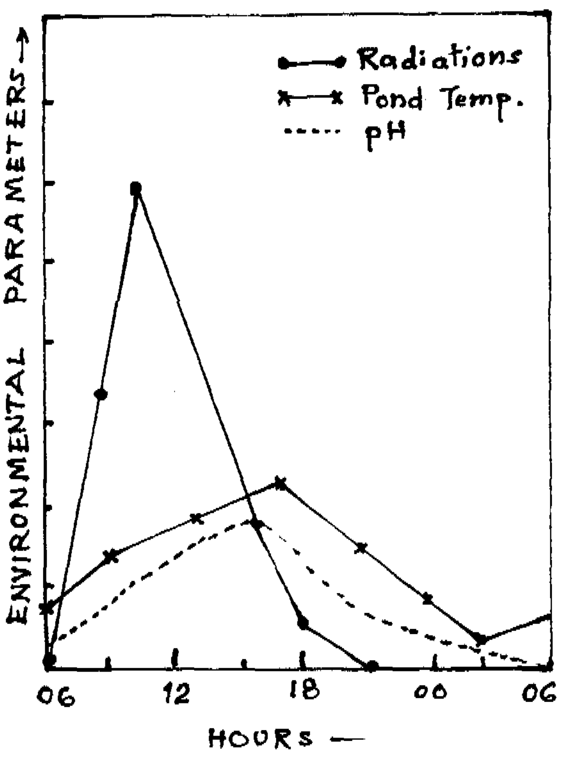

Fig.3 Variation of pH, Temperature and Solar Radiation

Further batch studies of daily variations of ecological parameters(Fig.4) revealed the DO concentration. Production and respiration followed characteristic growth pattern of algae and a distinct second peak, lower through, as comapred to the first peak. DO concentrations reached much higher than the saturation values, which are most undesirable from the ecological point of view. Not only that, part of this DO is lost to atmosphere, associated heavy algal growth results in extra BOD load on the ecosystem. Hence eco-system approach for efficient and most consistent nutrient removal from waste stabilization pond advocates algal-harvesting.

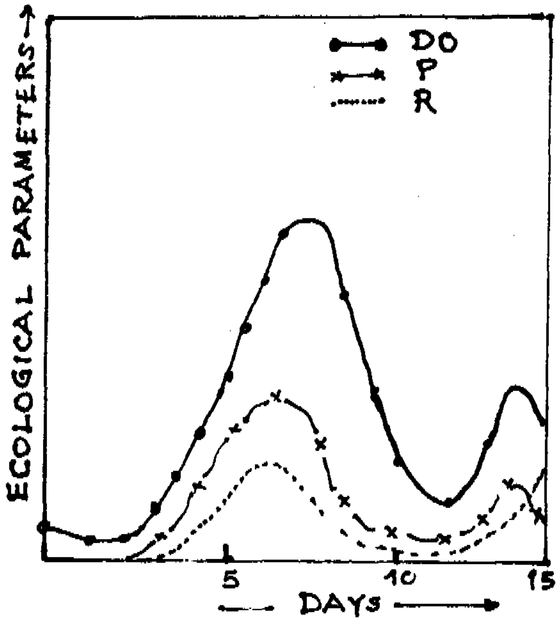

Fig.4 Daily Variation of Ecological Parameters

Fig.5 reveals that peak P values increase with increase in BOD inputs upto an optimum, then declines with further increase.It shows that the production initially increases upto an optimum nutrient concentration and further increase inhibits production due to toxic effect, less penetration of sunlight etc., explaining the failure of waste stabilization ponds with shock loadings.

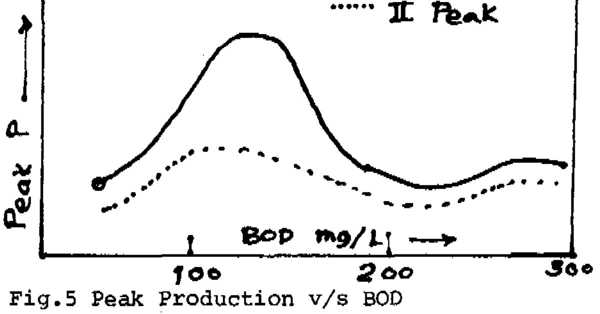

Fig.5 Peak Production v/s BOD

Respiration shows lag in occurrence of second peak and its magnitude. In fact in earlier stages both bacterial mass and algal cells extert their own respirational requirements resulting in general increase till both P and R reach their first peak almost simultaneously. Beyond this, with limiting nutrients, algal cells lead to sensescence and death, which do not produce but continue to respire. With decomposess continuing to respire on death algal cells, which have four times respiration needs than living, the respiration shoots up while production declines, thus introducing a lag in occurrence of second peak.

P/R ratio is an important factor in an aquatic ecosystem like waste stabilization pond. Higher P/R ratios are just as much undesirable as lesser ratios, the former showing excessive production indicating unnecessary BOD load on the system, and the latter showing oxygen hunger of the pond leading to anaerobic conditions. In an earlier study (7) a value of 2.26 gave maximum BOD removal efficiency, which was achieved in this study at a BOD loading of 114 mg/litre at second peak,and hence shall be taken as recommended loading for design of completely aerobic ponds at Roorkee.

CONCLUSIONS

From the present study of diurnal variations of ecological parameters in a WSP, the following conclusions are drawn:

a) The pond DO and production follow the light intensity closely. The maximum DO concentrations reached are two to four times the saturation levels.

b) Peak DO concentrations declined with increase in BOD value.

c) Minimum DO levels are recorded at 0300 Hours in all ponds. The concentrations never reached below saturation levels in young culture ponds, which are a shade faster in photosynthesis than the old cells.

d) Maximum production was observed between 0800 and 1100 Hours. Production though greatly reduced during night, never reached zero. The minimum was recorded at 0300 Hours. The predominant speci chlorella Sp. seems to be a versatile autotrough.

e) Respiration recorded was maximum in the afternoon, reaching its lowest value at 0600 Hours in the morning, corresponding to minimum pond temperature. It shows that respiration is a function of pond temperature also.

f) pH of the pond rises with production moving into the alkaline range and as such it can be an index of the productivity of the ecosystem.

The batch study of daily variations of the ecological parameter concludes that

i) the pond DO, production and respiration follow the general pattern of algal. The ecosystem tries to re-establish itself as shown by a second peak where algae too shows a secondary growth phenomenon.

ii) The peak production is a function of BOD inputs. It increases with increase BOD concentrations upto a maxima and declines with further increase. This explains the failure of ponds with shock loading.

iii) Harvesting of algae is essential from ecological point of view for efficient functioning of waste stabilization ponds.

ACKNOWLEDGEMENT

The author thanks the University of Roorkee for providing facilities to conduct the present investigation.

REFERENCES

1. Humneik, F.J. and Hanna, G.P., "Development of a Symbiotic Algal-Bacterial System for Nutrient Removal from Wastewaters", Engg. Bull. of Purdue University, I, 480(May'69).
2. Standard Methods for the Examination of Water and Wastewater, APHA-AWWA-WPCF Publication, 14th Ed.(1976).
3. Odum, E.P., "Fundamentals of Ecology", Tappan Company, Tomyo, 3rd Ed.(1971).
4. Mackenthun, K.M. and Clarance, D.M., "Stabilization Pond Studies in Wisconsin", JWPCF, 33, 12, 1234(1961).
5. Bartsch, A.F., "Algae as a Source of Oxygen in Sewage Stabilization Ponds", JWPCF, 33, 12, 239 (1961).
6. Willford, H.K. and Middlebrooks, E.J., "Performance of Field Scale Faultative Treatment Lagoons", JWPCF, 39, 12, 2008 (1967).
7. Shrivastava, A.K., Mathur, R.P. and Singh, J.P., "Ecological Studies on Animal Waste Fed Stabilization Ponds', Conf. on Appropriate Technology in Civil Engineering, London (1980).

10th WEDC Conference

Water and sanitation in Asia and the Pacific : Singapore : 1984

Wastewater - Hong Kong and Taiwan

S L Tang

ABSTRACT

The paper describes the historical development, the current situation and the expected future improvement as regard to the sewerage systems and the wastewater treatment facilities in Hong Kong and Taiwan. Water pollution control legislation in both places are then discussed and their respective characteristics are highlighted. It ends up by having a comparison of the merits and demerits of the two control systems based on the author's personal point of view.

1. SEWERAGE SYSTEMS

1.1 Sewerage Systems in Hong Kong

Hong Kong has a population of nearly 6 million and a total area of approximately 1000 km^2 of which 10% is highly urbanized (Hong Kong Island and Kowloon Peninsula) and the rest 90% less urbanized (New Territories) - Fig. 1. Although New Territories have been under tremendous development in the past two decades, as in the establishment of satellite towns/cities and industrial estates, only about 16% of the land until now is classified as built-up areas. The urban areas in Hong Kong have separate sewerage systems. According to a survey done in 1977(1), 98% of the population is served by public sewers in urban Hong Kong and 16% in New Territories, making an overall of 90% of the total population served by sanitary sewers. The remaining 10%, mainly in New Territories, have their sewage discharged to rivers or to the sea, with or without passing through septic tanks.

On the whole, the sewage collection system in Hong Kong is considered fairly satisfactory.

1.2 Sewerage Systems in Taiwan

Taiwan has a population of about 3 times and a total area of about 35 times those of Hong Kong. While the majority of the people in Hong Kong are living in urban districts, which occupy only a little more than one-tenth of the total area, the

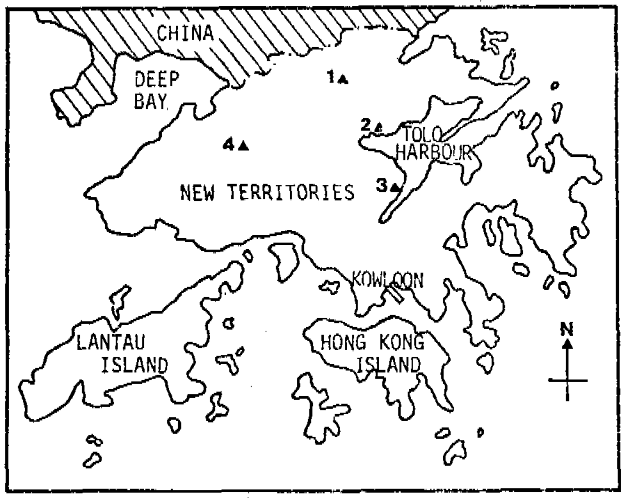

Fig. 1 Map of Hong Kong and Location of Sewage Treatment Plants: 1 - Shek Wu Hui STP, 2 - Tai Po STP, 3 - Shatin STP and 4 - Yuen Long STP.

situation in Taiwan in this respect is very different. The biggest city in Taiwan is Taipei (2.3 million people) and the second biggest is Kaohsiung (1.2 million people) - Fig. 2. The rest of the population is fairly evenly distributed in 311 towns/cities and an unknown number of villages in various parts of Taiwan, thus making it extremely difficult to have a high service level of public sewers for the whole population.

Before 1970, there was no separate sewerage system in Taiwan. The combined system, which was originally designed and constructed since the 1940s for collecting surface water, was used to serve both stormwater and wastewaters. Currently 82% of the population in Taipei and 50% of that in Kaohsiung are served by such systems(2). Due to the serious pollution problems created by the untreated wastewaters discharged from these sewers, the Government of Taiwan commissioned in the late 1960s the WHO to look into the possibility of improvement for Taipei. A master plan(3) was drawn up in 1970 in which the recommendation was made that a separate sewerage system be constructed in Taipei and that the new system be built in 3 stage. According to 1970 money value, Stage

I (1972 - 1980) costs NT$2,638m or US$64m, Stage II (1981 - 1988) NT$3,423m or US$86m and stage III (1989 - 2008) NT$9,229m or US$231m[4]. Stage I of the project has now been completed. In a recent revision of the progress it was found that the completion of Stage II has to be deferred until Year 1991. By that time about half of the population (as compared to 6.4% in 1983 and 0% in 1970) in Taipei will be served by public sewers for the collection of wastewaters[2]. As a temporary measure, at present, some of the combined sewers have had baffles installed[5], near to their discharge points, to a height of a few hundred millimetres so that in dry weather the strong sewage may be led off and discharged to the Dihua Treatment Plant*.

Besides Taipei, Kaohsiung also has its separate sewerage projects started recently, and will have about half of its population served by the system by the end of 1980s[2]. The total costs of construction (including pumping stations, treatment plant and marine outfall) were revised in 1981 to NT$3,640m[6]. For Taiwan as a whole, about a quarter of total popoulation is expected to be served by sanitary sewers by the end of this decade, the total investments on which will amount to NT$30,500m(1983 money)[2].

2. SEWAGE TREATMENT

2.1 Sewage Treatment Facilities-Hong Kong

Before 1960, when the New Territories were much less developed than today, there was no sewage treatment facilities besides septic tanks in Hong Kong. At that time a very high percentage of the population gathered around Hong Kong Island and Kowloon Peninsula which is nowhere more than a few kilometers from the sea coast. Wastewaters collected from the sewerage system were discharged without treatment through submarine outfalls to the sea where a final dilution of at least 500 times takes place due to the availability of fast moving currents. Until now this methods has been found to be most economical and efficient, and will continue to be used in Kowloon and the Island, except that screening plants (preliminary treatment) are now constructed at certain locations near the sea where discharges take place via submarine outfalls to eliminate discernible solids down to 10 mm size. There are altogether 9 screening plants at present and 17 more are either under planning or construction. The overall strategy is to use as many submarine outfalls as possible to take advantage of the natural dilution by current.

With the development of satellite towns in the New Territiories, Hong Kong experienced a decline in environmental conditions, particularly from pollution by wastewaters in areas which are at some distance from the coast and also from areas, which although near to the coast, have the sea-water adjacent to them lacking of natural currents to dilute the wastewaters. Typical examples are Tolo Habour and Deep Bay (Fig. 1). The establishment of industrial estates in Tai Po and Yuen Long in 1970s also contributed to the adverse environmental conditions. To control the problems of water pollution arising from the development, 4 secondary treatment plants, all of which are activated sludge process, have been constructed since 1974 in various parts of

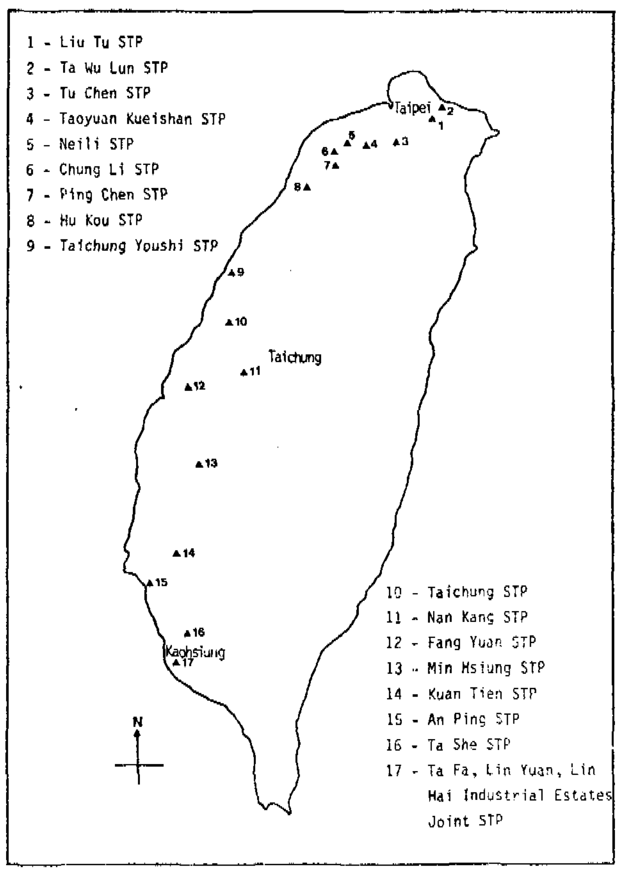

Fig. 2 Map of Taiwan and Location of Industrial Sewage Treatment Plants.

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* Dihua Treatment Plant is located at north-west of Taipei City. The first stage has been completed in early 80s and is now capable of treating sewage of 750,000 P.E. (ie. population equivalent). The second stage will be completed in 1990/91 and will have a 1,100,000 P.E. capacity.

Table 1 (7)

S.T.P.	Capital Cost	Design Capacity (P.E.)	Status	Treatment
Shek Wu Hui (Stage I)	HK$145m (1983 money)	230,000	in operation	secondary
Tai Po (Stage I & Stage II)	I - HK$11.5m (1979 money) II - HK$136m (1983 money)	I- 16,000 II-125,000	I- in operation II- construction recently completed	secondary
Sha Tin (Stage I)	HK$365m (1980 money)	400,000	in operation	secondary
Yuen Long (Stage I)	HK$207m (1984 money)	200,000	construction recently completed	secondary

the New Territories (Fig. 1). Their sizes and capital costs are given in Table 1. 7 more secondary treatment plants, together with a number of primary treatment plants, which are in various stages of planning and construction, will be established in the next ten years. The total amount invested by the Hong Kong Government in these projects is estimated in 1983 to be about HK$2,000m[7] or US$256m.

2.2 Sewage Treatment Facilities-Taiwan

The first wastewater treatment plant was constructed in Liu Tu (六堵) and has been in operation since 1963. Liu Tu is the first industrial estate in Taiwan. Currently there are 42 industrial estates (totally 7176 Ha) already established and 20 more (totally 6437 Ha) are being developed[8]. 23 central industrial wastewater treatment plants, with some of them also treating small quantities of municipal wastewater, are sited in various locations in Taiwan (Fig. 2) to provide treatment facilities for the effluents from the industrial estates. 17 out of the 23 are in operation and 6 are in the stages of construction or design. The plants designed were based on the following strategies[9]:

- (i) Large industrial estate should have a central treatment plant.
- (ii) Priority should be given to the central treatment plant serving several nearby industrial estates.
- (iii) Factories whose effluents exceed the specified standards are to pretreat them before releasing them to the sewerage system.
- (iv) Factories in small industrial estates have to treat their wastewaters individually and there will be no central treatment plant.

The treatment methods employed in these 17 already constructed plants include bio-filtration, conventional activated sludge process, oxidation ditches, aerated lagoons and so on. The total costs of construction for all the 17 plants amount to NT$2,500m (1980 money) excluding the cost of sewerage systems[8].

The development of industrial estates and industrial wastewater treatment in Taiwan is at least ten years in advance of Hong Kong. That of municipal wastewater treatment however is a little behind. This is probably due to the lack of

Table 2

S.T.P.	Capital Cost	Design Capacity (P.E.)	Status	Treatment
Stage I Dihua[10] (Taipei)	NT$800m (1978 money)	750,000	in operation	primary
Min Shen[10] (Taipei)	NT$100m (1982 money)	50,000	in operation	secondary
Chung Hsing Village[11]	NT$6m (1963 money)	16,000	in operation	secondary
Stage I Kaohsiung[12]	NT$1,600m (1983 money)	600,000	in construction	primary

efficient separate sewerage systems in the past. There are currently three municipal wastewater treatment plants (2 in Taipei and 1 in Taichung) under operation and one (in Kaohsiung) under construction (Table 2). The construction of treatment plants are planned to tie in with the development of sewerage systems as already mentioned in Section 1.2.

3. LEGISLATION AND MANAGEMENT

3.1 The Scene in Hong Kong

The first legislation, the Water Pollution Control Ordinance, was introduced in July 1980[13]. There are four characteristics in this ordinance :

i) Implementation of the legislation is in stages by dividing Hong Kong into about ten Water Control Zones. One zone will be enforced at a time**. Priority is to be given to the zone which most urgently requires the control.
ii) Different Water Control Zones have different water quality objectives. Only principles are stipulated in the objectives, leaving the quantitative standards to be decided on individual or industry-to-industry basis.
iii) Existing discharges are exempted.
iv) Pretreatment is not to be encouraged. Only minimal pretreatment will be employed when essential. Normally untreated wastewaters will be discharged directly to the sewers.

Thus the legislation in Hong Kong is very flexible. Public objections and appeals are also provided in the ordinance. The authority which formulates the policy is the EPA (Environmental Protection Agency) and the one to carry out the legislative control is the EDD (Engineering Development Department). It is believed that these authorities have been delegated sufficient power to perform their duties.

3.2 The Scene in Taiwan

The first legislation, the Water Pollution Prevention Act (水污染防治法) was introduced in July 1974. It was then revised in May 1983[14]. It differs from the one in Hong Kong in the following aspects :

i) Numerical quality limits are specified for effluents.
ii) Pretreatment is necessary for individual factories if their effluents exceed the specified limits. (See strategy (iii) of Section 2.2)
iii) No exemption is given to existing discharges.
iv) Staged implementation is not provided in the legislation.

The legislation in Taiwan is much more strict than that in Hong Kong. The disadvantage of too flexible a legislation is that it creates a very heavy work load to the authories concerned as the latter has to assess every discharge on individual basis. Some people hence think that time and effort are "wasted" in this very tedious task. Also, confusion can easily arise when the authority is carrying out the control. While the author has considerable reservation concerning the high flexibility of the Hong Kong legislation, it must be pointed out that a flexible legislation in general has some advantages. That only principles are spelled out in the legislation but not quantitative details for effluent standards allows the possibility of avoiding unnecessary expenditure in overtreating, for different locations do have different toleration in water qualities. With the provision for staged implementation together with the exemption from control of all existing discharges the new legislation exhibits a realistic and adaptable approach which most probably results in a minimum of reaction from industrialists. Finally, it is possible that large central treatment plants for the processing of wastewaters are more realistic than a number of smaller units in that not only are large plants usually more economical to create and operate but they also minimize the degree of inhouse pretreatment required at each industrial unit. The high flexibility in a legislation will naturally encourage this desired situation.

Legislations in water pollution control both in Hong Kong and in Taiwan are newly introduced and it is definitely too early yet to judge their merits and demerits. Time will reveal the pros and cons. But one common principle should be applicable to the two, that is, periodic revision and adjustment must be exercised during implementation in order that the legislation does remain alive and useful.

** The first Water Control Zone is Tolo Habour.

Reference

1. Environmental Resources Ltd., "Control of the Environment in Hong Kong – Final Report", Secretary for the Environment, Hong Kong Government, 1977.

2. 蕭江碧，"推動台灣地區下水道建設發展之策略"，下水道工程實務研討會論文集，台北6/1983。

3. Camp Dresser & McKee International Inc., "Sewerage Planning in the Greater Taipei Area – Master Plan Report", WHO/UNDP, 1970.

4. Thomas, R.H., "Wastewater System for Taipei, Taiwan", J. WPCF, Vol. 44, No. 8, 8/1972.

5. 王明，"台北市新生排水溝及環河街沿線截流設施之探討"，下水道工程實務研討會論文集，台北6/1983。

6. "高雄市仁愛河污染整治及污水下水道工程計劃簡報"，台灣高雄市政府9/1982。

7. Information obtained during the interview with Mr. K. F. Leung (梁錦輝), Senior Engineer of Hong Kong Engineering Development Department, in March 1984.

8. 於幼華編，楊萬發等著，"工業區廢水處理之研究(Ⅲ)"，國立台灣大學環境工程研究報告No.10，5/1980。

9. Che, S.; Lee, T. Y. & Chen, C. P., "Industrial Wastewater Treatment for Industrial Parks in Taiwan", Proceedings of International Conference on Water Pollution Control in Developing Countries, Bangkok, 2/1978.

10. Information obtained during the interview with Mr. W. K. Liu (劉文櫆), Director of Sewerage Engineering Department of Taipei and Mr. R. Y. Chung (鍾瑞源), Head of Dihua and Min Shen S.T.P.s in January 1984.

11. Information obtained during the interview with Prof. Yang Wan-Fa (楊萬發) of National University of Taiwan in March 1984.

12. Information obtained during the interview with Mr. C. Y. Wu (吳宗榮), Head of Kaohsiung S.T.P. and Mr. C. T. Li (李建德), Engineer of Sewerage Engineering Department of Kaohsiung in January, 1984.

13. "Water Pollution Control, Ordinance No. 41 of 1980", Hong Kong Government, 1980.

14. 1983年5月27日公布之"水污染防治法"，可參考台灣經濟部工業局暨經濟部工業污染防治技術輔導小組於1983年12月合編印之"工業污染防治有關法令"，頁11—16。

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Water and sanitation in Asia and the Pacific: Singapore: 1984

Treatment of electroplating wastes

Dr Joo-Hwa Tay

ABSTRACT

The electroplating industry has been playing a momentus role in the development and growth of engineering industries. Wastewater from the electroplating process contains high concentration of heavy metals, are harmful to aquatic life in the receiving waters. Physical - chemical method is commonly used for the treatment of electroplating wastes. The installation costs of treatment plants are 7% and 15% of the total capital investments for the small-and large scale-plants respectively. The unit treatment costs for electroplating wastes are US$1.46/$m^3$ and US$0.33/$m^3$ of wastewater treated for small and large plants respectively.

INTRODUCTION

With the rapid economical and industrial development in South East Asia in the last decade, the search for clean water for national development calls for stringent measures for pollution control. Recently, the increased demand of consumer items has resulted in the set up of many small-to medium-scale plants engaging in electroplating work. In comparison with other industries, the electroplating industry uses relatively less water. Therefore, the volume of the waste water produces are also comparatively smaller. However, the waste waters are highly toxic in nature because of the presence of metals such as copper, zinc, nickel, cadmium, chromium, cyanide and other pollutants.

In the recent ESCAP (UN Economic and Social Commission for Asia and the Pacific) Expert Group Meeting in Bangkok, it was reported (1) that there are about 280 electroplating industries in Thailand, and most of them are located in Bangkok. These metal finishing industries discharge annually about 12 tonnes of heavy metals into the water courses. In Malaysia, it was estimated that there are as many as 100 operating electroplating shops in Klang Valley. In Hong Kong, there are presently about 770 registered electroplating industries. There are also a large number of unregistered small electroplating workshops in the area. There are about 87 factories or workshops that carry out electroplating activities in Singapore (2). Most of these electroplating plants in this region has no or inadequate treatment facilities.

Heavy metals bearing wastes are harmful to aquatic life in the receiving waters. In Singapore, electroplating wastes are not allowed to discharge before pretreatment. The allowable discharge limits for most heavy metals bearing wastes are stringent, not exceeding 5 mg/l into the sewer and 0.5 mg/l into the controlled watercourse. Although the methods of removal of these toxic constituents from wastewaters are well established (3 - 11), the problem of pollution of water courses, and particularly of disposal of untreated electroplating waste waters into municipal sewers, in many countries of South East Asia is yet to be solved. One of the major problem is that the electroplating industries find it difficult to meet the effluent guideline without having to spend a large sum for treatment facilities. This paper presents the treatment methods that currently used for the electroplating wastes, and the costs of capital investment and operations for the treatment of wastewater.

SOURCES AND CHARACTERISTICS OF ELECTROPLATING WASTES

Metals used in the electroplating industries are copper, chromium, nickel, cadmium, zinc, silver and gold. The plating operations are preceded by cleaning to remove grease, rust and scale from the metal surface. After plating has been done, the plated objects are washed with water.

The two major sources of wastewater is electroplating operation are batch solutions and rinse waters, they are distinctly different in volume and characteristics. Batch solutions from vats are highly concentrated and are discharged intermittently. Rinsed waters are more dilute but form the bulk of the wastewater of the electroplating industries.

The metal bearing wastes include rinse water from chromium, cyanide, cadmium, copper, lead, nickel and zinc vats. These metals are presents in soluble ionic form and most of them are extremely toxic. The ranges of concentration of these metals in the wastewaters (11,12) are

Chromium	:	3 mg/l to 80 mg/l
Cyanide	:	0.3 mg/l to 256 mg/l
Cadmium	:	7 mg/l to 240 mg/l
Copper	:	2 mg/l to 88 mg/l
Lead	:	2 mg/l to 140 mg/l
Nickel	:	3 mg/l to 900 mg/l
Zinc	:	2 mg/l to 350 mg/l

The volume and characteristics of various wastewater streams vary considerably from one plating plant to the other and within the same plant from day to day. Table 1 summarised the characteristics of wastewater from the plating operations (1,12). Generally, the drains inside the manufacturing plants are interconnected, mainly due to facility layout of the plant and partly to ignorance of the consequences. The composite plating wastes may be acidic or alkaline depending on the type of both used. Typical analysis of composite wastewater for a few electroplating industries in Indian (1,12) is shown in Table 2.

METHODS OF ELECTROPLATING WASTES TREATMENT

Cyanide Treatment

Several methods of treating cyanide wastes are currently use. The most popular method is cyanide destruction by chorination under the alkaline condition, or referred to as 'alkaline chlorination'. Another cyanide destruction process, electrolytic decomposition, is applicable where cyanide concentration are very high. Ozonation of cyanide wastes has been employed with some success. Other cyanide treatment processes include evaporative recovery, reversed osmosis, ion exchange and catalytic oxidation.

Destruction of cyanide by alkaline chlorination method may be accomplished by direct addition of gaseous chlorine or chlorine dioxide in presence of caustic soda, or sodium hypochlorite, or bleaching powder. When chlorine is added to the wastewater containing free cyanide and sufficient alkali is added to raise the pH to 10 or higher, the free cyanide is oxidized to cyanate with cyanogen choride as a intermediate product. This reaction is normally instantaneous or takes not more than 10 minutes. With excess chlorine, cyanate could be further slowly oxidized to carbon dioxide and nitrogen. This second stage of reaction takes 30 minutes to an hour. The averall reaction with excess chloride in presence of NaOH for complete conversion of cyanide to carbon dioxide and nitrogen gas is

$$2NaCN + 5Cl_2 + 12NaOH \longrightarrow 10NaCl + 2Na_2CO_3 + N_2 + 6H_2O$$

Theoretically, 2.73 parts of chlorine and 3.08 parts of alkali (NaOH) are required to oxidise each part of cyanide to cyanate. Additional 4.09 parts of chlorine and 3.08 parts of alkali for each part of cyanide are required to convert cyanate into carbon dioxide and nitrogen gas. However, the chlorine required in practice for the complete destruction of cyanide is higher than 6.82 parts and the alkali is lower than 6.16 parts per part of cyanide.

Chromium Treatment

The most effective and economical ways of chromium treatment is to reduce hexavalent chromium, Cr(VI) to trivalent state, Cr(III) in the acidic condition, and subsequent precipitation with an alkali. Ferrous sulphate along with sulphuric acid is commonly used for this purpose, other reducing agents used are sulphur dioxide and sodium bisulphite. Maximum reduction occurs in the pH range of 2.0 to 2.5. The reduction takes about an hour. The reduced trivalent chromium is precipitated by the addition of an alkali, line or caustic soda. Lime is commonly used, since it is cheaper than caustic soda. The step-wise reaction for precipitation by hexavalent chromium with ferrous sulphate and lime are:

$$H_2Cr_2O_7 + 6FeSO_4 + 6H_2SO_4 \longrightarrow Cr_2(SO_4)_3 + 3Fe_2(SO_4)_3 + 7H_2O$$

$$Cr_2(SO_4)_3 + 3Ca(OH)_2 \longrightarrow 2Cr(OH)_3 + 3CaSO_4$$

$$Fe_2(SO_4)_3 + 3Ca(OH)_2 \longrightarrow 2Fe(OH)_3 + 3CaSO_4$$

Theoretically, 16.03 parts of copperas ($FeSO_4.7H_2$), 6.01 parts of sulphuric acid and 9.48 parts of lime (90%) are required for the complete removal of 1 part of chromium. Other processes used for chromium removal are ion exchange, carbon adsorption, electrochemical reduction and evaporation recovery.

Treatment of other metal bearing wastes

The most common method of treating cadmium, copper, lead, nickel or zinc wastewaters, is chemical precipitation. Almost all the metals precipitate completely in the pH range of 9.5 to 10.5. Other treatment processes are ion exchange, carbon adsorption, reverse osmosis and evaporative recovery.

TABLE 1 : CHARACTERISTICS OF ELECTROPLATING WASTEWATERS

Waste	Flow l/hr	pH	Cyanides mg/l	COD mg/l	Total solids mg/l	Suspended solids mg/l
Cleaning solution (rinse waters)	450-680	7.8-8.4	0	290-350	960-1120	610-720
Cyanide concentrates (rinse water)	450-680	9.2-9.9	0.3-21.2	25-42	430-600	23-35
Acid pickling rinse waters	900	4.5-5.5	-	-	450-590	76-141
Spent alkali rinse waters	2700-2650	8.8-9.8	-	300-350	800-1350	-
Chromate rinse	1360-2270	5.5-6.8	-	-	460-750	-
Copper (cyanide) rinse waters	450-680	-	7.3-11.6	-	-	-
Copper (acid) rinse waters	450-680	6.1	-	-	-	-
Nickel rinse waters	450-680	7.4-8.3	-	-	-	-
Cadmium rinse waters	450-680	8.0-8.8	3.2-4.6	-	-	-
Zinc rinse waters	450-680	8.9-9.8	5.4-9.0	-	-	-
Floor wash waters	450-680	7.6-8.0	0.1-0.3	-	350-480	65-79

TABLE 2 : ANALYSIS OF COMPOSITED ELECTROPLATING WASTES

Plating shop	pH	Total solids	Suspended solids	Cr(VI)	CN	Cu	Zn	Cd	Ni	Ag
1	8.70	5200	800	-	3.80	-	-	-	-	-
1	7.50	2100	250	-	0.31	-	-	-	-	-
2	7.00	1400	260	1.85	0.62	-	-	-	-	-
3	7.90	1360	80	0.62	1.25	1.34	-	-	-	0.01
4	7.15	4450	350	-	9.20	-	-	-	-	-
5	6.50	2630	910	4.80	0.75	16.7	-	-	6.7	-
6	6.30	1850	270	2.90	0.60	6.0	-	-	21.5	-
6	6.40	1600	170	1.90	2.30	3.4	0.2	0.1	3.4	-
6	6.80	1900	90	1.20	2.50	1.9	0.1	0.1	1.2	-
7	7.00	1250	80	3.00	0.50	0.4	1.2	-	-	-
8	2.3	-	-	25	-	15	20	5	93	-

All results except pH are expressed in mg/l

COSTS OF ELECTROPLATING WATER TREATMENT

The main items of a wastewater treatment plant for an electroplating industry are mixing, flocculation, reaction and settling tanks, pumps, floculators and chemicals. The major operating costs is the chemicals for the removal of heavy metals in the wastewater.

Information on the costs of capital investment and operating of wastewater facilities for electroplating industry are limited, particularly in the South East Asia region. One of the major reasons would be the wide variation in the flow and characteristics of the wastewater. Wastewater treatment plants of the engineering industries which have electroplating section are designed to handle the combined wastewater from all the manufacturing processes. Costs of installation and operation of such treatment platns are not representative. Other reason would be the electroplating industries which located as the urban area discharged their wastewaters into the public sewer after some minor pretreatment, therefore representative data cannot be obtained.

Table 3 compares the costs of the capital investment of manufacturing equipment and machinery with the installation costs of treatment plant facilities in Singapore. The data indicates that cost in installation for the small electroplating shops in Singapore (shops #1 to #3 in Table 3) range from US$2,500 to US$4,000 which is about 5% to 10% the cost of capital investment. Electroplating plant #4 is a large scale metal and plastic processing plant. The treatment plant consists of cyanide oxidation, chromium reduction, nickel precipitation and pH neutralization. The cost of treatment plant is US$450,000 or about 13% of the total capital investment. A bicycle parts manufacturer has a large electroplating plant mainly for nickel plating. The treatment plant includes coagulating-floculation, sedimentation and ion exchange units (Plant #5). The treated effluent is reused in the electroplating plant. The cost of treatment plant is US$1,000,000 or 16.7% of the capital investment. From these data, it shows that the installation costs of the treatment plant for the large scale electroplating shops is twice higher than the small plants.

Table 4 shows the operating costs for the treatment plants of some electroplating plants in Singapore. The unit costs of treatment for the small electroplating shops range from US$0.91/$m^3$ to US$2.27/$m^3$ with an average of US$1.46/$m^3$ of wastewater treated. However, the unit cost of treatment for the large-scale electroplating plants is only US$0.33/$m^3$ of wastewater treatment. It is quite evident that the unit treatment costs for small electroplating shops are in the order of 4 to 5 times the unit treatment costs for comparable large-scale plants.

SUMMARY

The electroplating industry has been playing a momentus role in the development and growth of engineering industries. Wastewater from the electroplating process contains high concentration of heavy metals. Heavy metal bearing wastewaters are harmful to aquatic life in the receiving water. In Singapore, electroplating wastes are not allowed to

TABLE 3 : INSTALLATION COSTS FOR ELECTROPLATING INDUSTRIES IN SINGAPORE

	Cost of Capital Investment (US$)	Cost of Treatment Plant (US$)	Percent	Reference
#1	50,000	2,500	5	13
#2	40,000	4,000	10	13
#3	45,000	3,000	6.7	13
#4	3,500,000	450,000	13	14
#5	6,000,000	1,000,000	16.7	-

TABLE 4 : OPERATING COST FOR TREATMENT PLANTS OF ELECTROPLATING INDUSTRIES IN SINGAPORE

	Operating Cost (US$/month)	Volume of Wastewater (m^3/month)	Unit Cost (US$/$m^3$)	Ref.
#1	300	180	1.67	13
#2	250	110	2.27	13
#3	400	440	0.91	13
#4	300	300	1.00	2
#5	4500	14000	0.32	14
#6	5000	15000	0.34	3

discharge before pretreatment. Physical-chemical method is commonly used for the treatment of electroplating wastes. Complete destruction of cyanide can be accomplished by the alkaline chorination process. Reduction of hexavalent chromium to trivalent state and subsequent hydroxide precipitation of the trivalent chromium is the most common method of hexavalent chromium disposal. Other metal-bearing wastes could be removed by chemical precipitation at high pH.

The installation costs of the small-scale treatment plants is about 7% of the capital investment of manufacturing facilities. However, the installation costs for the large-scale plants is twice higher than the small plants. The installation cost is about 15% of the total capital investiment. The unit treatment cost for the small electroplating shop is US$1.46/$m^3$ of wastewater treated, which is 4 to 5 times higher than the large scale electroplating plants. The unit costs of the treatment for large plants is US$0.33/$m^3$ of wastewater treated.

REFERENCES

1. ESCAP. Industrial Pollution Control Guidelines. VI Electroplating Industry, Bangkok, 1982.

2. Chiang, K. M. Water Pollution Control and Metal Finishing Industry, Proceedings Seminar on the Electroplating and Metal Finishing Industry in Singapore, Singapore, 1980.

3. Chin, K. K. and Tay, J. H. Characterization and Treatment of an Electroplating Waste, Journ of the Inst. of Engineers, Malaysia. Vol. 27, p. 19, 1980.

4. Chin, K. K. and Tay, J. H. Laboratory Scale Treatment of Nickel Bearing Industrial Effluent. Proceedings, Int. Conf. on Management in Control of Heavy Metals in the Environment, London, 1979.

5. Cheng, M. H. et al, Heavy Metal Uptake by Activated Sludge, Journal Water Pollution Control Fed., Vol. 47, p. 362, 1975.

6. Gould, M. S. and Genetelli, E. J. Heavy Metal Complexation Behaviour in Anaeobically Digested Sludge, Journal Water Research. Vol. 12, p. 505, 1978.

7. Maruyame, T. et al, Metal Removal by Physical and Chemical Treatment Process, Journal Water Pollution Control Fed., Vol. 47, p. 762, 1975.

with Completely Mixed Anaerobic Filter. Journal Water Pollution Control Fed., Vol. 51, p. 22, 1979.

9. Nemerow, N. L., Industrial Water Pollution Origin, Characteristic and Treatment. Addison Wesley, 1978.

10. Lancy, L. E., Pollution Control in Plating Operations, in Industrial Pollution Control Handbook ed. by Herbert F. L., McGraw Hill, 1972.

11. Patterson, J. W., Wastewater Treatment Technology. Ann Arbor Sc., 1975.

12. Indian, Std. Inst., Guide for Treatment of Effluents of Electroplating Industry. IS:7453-1974, New Delhi, 1975.

13. Uriante, F. A. Methods and Costs of Industrial Pollution Control in Selected Small and Medium Scale Industries in ASEAN, ESCAP EXPERT GROUP MEETING, Bangkok, 1982.

14. Report on ASEAN/UNEO. Study Tour and Technical Workshop on Water Quality Monitoring and Management, Singapore, 1981.

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Use of peat in wastewater treatment with special reference to onsite systems

Professor T Viraraghavan and A Ayyaswami

INTRODUCTION

Peat can be described as partially fossilized plant matter which occurs in wet areas where there is a lack of oxygen; the accumulation of the plant matter is therefore more rapid than its decomposition. Peat moss is a rather complex material containing lignin and cellulose as major constituents. These constituents, especially lignin bear polar functional groups, such as alcohols, aldehydes, ketones, acids, phenolic hydroxides and ethers that can be involved in chemical bonding. Because of the very polar character of this material, the specific adsorption for dissolved solids such as transition metals and polar organic molecules is reported to be quite high (ref.1).

Peat deposits are found throughout the world and these vary in thickness usually from a few metres to tens of metres. World peat resources reported by Kivinen and Pakarinen are shown in Table 1 (ref.2).

Table 1. World Peat Resources

Country	Biological Peatland ha x 10^6	Peat Production – Tonnes x 10^3 Fuel Peat	Moss Peat	Total
Canada	170.0	—	488	488
U.S.S.R.	150.0	80,000	120,000	200,000
U.S.A.	40.0	—	800	800
Indonesia	26.0	—	—	—
Finland	10.0	3,100	500	3,600
Sweden	7.0	—	270	270
China	3.5	800	1,300	2,100
Norway	3.0	1	83	84
Malaysia	2.4	—	—	—
United Kingdom	1.6	50	500	550
Poland	1.4	—	280	280
Ireland	1.2	5,570	380	5,950
West Germany	1.1	250	2,000	2,250
Total	417.2	89,771	126,601	216,372
Total (Approx.)	420.0	90,000	130,000	220,000

In addition to the developing countries China, Indonesia and Malaysia shown in Table 1, Sri Lanka is also known to have a large peat deposit at Muthurajawela (ref.3). Besides being plentiful and relatively cheap, peat has several other factors that make it an attractive medium for wastewater treatment. Peat has a greater cation exchange capacity and a greater buffering capacity than mineral soil. Peat is more extensively used in horticulture because it can result in increased microbial activity, enhance the rate of infiltration especially in fine-textured soils and provide better soil aeration. Peat moss has an adsorption capacity about three times lower than that of activated charcoal and seven times greater than that of coal.

PEAT USE IN INDUSTRIAL WASTEWATER TREATMENT

Mueller found peat effective in the removal of phenol (ref.4). Brown et al found that peat absorbed dieldrin (ref.5). Studies by Soniassy showed that peat could adsorb odourous gases such as dimethylamine, ammonia and hydrogen sulphide (ref.6). Poots et al investigated the adsorption of acid dye from textile mill effluents using peat and found it to be successful (ref.7). Alkyl benzene sulphonate (ABS) was removed using peat as an adsorbing agent (ref.8). Research by several investigators has shown that peat is effective in removing a number of elements such as antimony, copper, cadmium, lead, mercury, nickel, uranium, zinc and zirconium (ref.1,3, 9,10). Peat has been found effective in the removal of oil (ref.11,12).

USE OF PEAT IN MUNICIPAL WASTEWATER TREATMENT

Several investigations have shown peat to be an attractive medium for use in municipal wastewater treatment. Nineteen cities in Finland use a series of ditches in natural peat bogs to treat primary effluent (ref.13). In Wisconsin, effluent from a three-lagoon wastewater treatment system undergoes tertiary treatment through a peat bog (ref.14). Successful treatment of secondary effluent through spray irrigation on a peat filter bed has been reported by Farnham and Brown (ref. 15). Nichols and Boelter reported on the successful operation of a peat-sand filter bed treating secondary effluent in a campground located within the Chippewa National Forest in Minnesota (ref.16). Their studies indicated that the peat-sand filter bed accomplished almost complete removal of fecal coliform bacteria and phosphorus. About 90% of the wastewater nitrogen was removed during the second and third years of operation, but this declined to about 50% by the fifth year due to oxidation of peat and release of nitrogen. Complex landfill leachate has been successfully treated in peat filters on a laboratory scale in Canada (ref.17).

UTILIZATION OF PEAT IN ONSITE SYSTEMS

Pit Latrines

Nichols et al studied the movement of fecal bacteria, N and P from pit latrines as well as the effectiveness of peat latrine liners in reducing this movement in the Boundary Waters Canoe Area Wilderness in the Superior National Forest in northeastern Minnesota (ref.18). The study involved eight pit latrines; three latrines were reported to be constructed on deep moderately well-drained clayey soils; five were reported to be built on shallow well-drained loams/sands. One pit on each soil type was reported to be unlined; the remaining pits were reported to be lined with peat contained between two layers of o.6 cm hardware cloth, 15 cm thick on the sides of pits and 30 cm thick on the bottoms. Peat liners appeared to reduce the movement of bacteria from the latrine pits. In a three year period of sampling, fecal coliforms were reported to be found in the soil adjacent to only one of the five peat-lined pits, but some soil samples taken near each of the three unlined pits were reported to contain fecal coliforms. The one peat-lined pit from which fecal bacteria were found was reported to be located on a site where the soil was shallow and was frequently at or near saturation due to water movement along the soil-bedrock interface. No movement of P from latrine pits was reported except at one site with very sandy soil. In such soil, a peat liner would appear to be of some value if a peat with a high P adsorption capacity were to be used. A peat liner would have to be viewed as an additional protection against P and bacteria movement rather than as a substitute for proper soil conditions. Nitrogen movement was not affected because of peat liners; the study showed that nitrogen impact on water quality was minimal because of dilution.

Septic Tank Effluent Treatment

Researchers at the University of Maine have recently conducted both laboratory and field studies to evaluate the capability of peat for treating septic tank effluent (ref.19,20,21).

Laboratory studies. Laboratory columns were used to determine the treatment capacity of sphagnum peat at varying hydraulic and organic loadings. 30 cm of peat compacted to a density of 0.12 g/cm^3 was found sufficient to treat septic tank effluent at a hydraulic loading of 8.1 cm/d. BOD and suspended solids (SS) reductions exceeded 95% and 90% respectively. COD reduction was reported to be only 80% due to the organic matter leached from the peat itself. Excellent (>99%) fecal coliform reduction was obtained. A hydraulic loading of 4.1 cm/d for the typical strength septic tank effluent was suggested, as the loading rate of 8.1 cm/d proved to be excessive at low temperatures (5^{o}C).

Field studies. Three full-size sphagnum peat filter beds were installed and monitored by the University of Maine researchers to determine the treatment levels after application of septic tank effluent. Two systems were lined, with an overboard discharge and one was provided with a subsurface discharge. Gravity feed, dosed feed and pressure feed arrangements were used respectively for the three systems. All the systems were reported to have performed equally well, with 99% fecal coliform removal, with 90% BOD reduction and greater than 80% COD reduction. Phosphorus reduction was respectively 58%, 62% and 96% in the three systems. Nitrate in the effluent from the three systems was reported to be less than 4.5 mg/L as N. Based on these studies, the authors concluded that the use of sphagnum peat for septic tank effluent appeared to be an acceptable alternative in areas where conventional subsurface systems could not be installed.

RESEARCH AT THE UNIVERSITY OF REGINA

A 3-year research study to investigate the efficiency of peat filters in respect of removal of pollution parameters (BOD, COD, TSS, phosphorus, nitrogen, heavy metals and indicator microorganisms) while treating septic tank effluent and municipal secondary effluent has recently been undertaken at the University of Regina. The investigation would involve laboratory studies - both batch and column studies, to determine the adsorption characteristics of peat. Studies are proposed to be conducted to examine whether adsorptive capacity of peat can be economically increased by pH adjustment or other chemical means. The possibility of peat adsorptive capacity by resting the peat between applications will also be studied.

ACKNOWLEDGEMENT

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REFERENCES

1. Coupal, B., and Lalancette, J.M. The treatment of wastewaters with peat moss. Water Research, 1976, 1071-1076.
2. Kivinen, E., and Pakarinen, P. Peatland areas and the proportion of virgin peatland in different countries. Proc. 6th Inter-

national Peat Congress, Duluth, Minnesota, 1980.
3. Dissanayake, C.B., and Weerasooriya, S.V.R. Peat as a metal-trapping material in the purification of industrial effluents. International Journal of Environmental Studies, 1981, 233-238.
4. Mueller, J.C. Peat in pollution abatement. Proc. Symposium on Peat, Sherbrooke, Quebec, Canada, 1972.
5. Brown, L., Bellinder, G., and Day, J.P. Dieldrin in a river catchment and potential methods for removal. Journal of the Institution of Water Engineers and Scientists, 1979, 478-484.
6. Soniassy, R.N. Adsorption of odours by peat moss. The Canadian Mining and Metallurgical Bulletin, 1974, 95-98.
7. Poots, V.J.P., McKay, G., and Healy, J.J. The removal of acid dye from effluent using natural adsorbents - I - Peat. Water Research, 1976, 1061-1066.
8. Tinh, V.Q., Leblanc, R., Jannassens, J.M., and Ruel, M. Peat moss - a natural adsorbing agent for the treatment of polluted water. The Canadian Mining and Metallurgical Bulletin, 1971, 99-104.
9. Chaney, R.L., and Hundemann, P.T. Use of peat moss columns to remove cadmium from wastewaters. Journal Water Pollution Control Federation, 1979, 17-21.
10. Eger, P., Lapakko, K., and Otterson, P. Trace metal uptake by peat: interaction of a white cedar bog and mining stockpile. Proc. 6th International Peat Congress, Duluth, Minnesota, U.S.A., 1980.
11. D'Hennezel, F., and Coupal, B. Peatmoss: a natural absorbent for oil spills. The Canadian Mining and Metallurgical Bulletin, 1972, 1-3.
12. Smith, E.F., and Mark Jr., H.B. The use of modified forms of peat as an oil coalescer. Journal of Environment of Science and Health, 1976, 727-734.
13. Surakka, S., and Kamppi, A. Infiltration of wastewater into peat soil. Suo, 1971, 51-58. (Finnish-English summary).
14. Guntenspergen, G., Kappel, W., and Stearns, F. Response of a bog to application of lagoon sewage: the Drummond project - an operational trial. Proc. 6th International Peat Congress, Duluth, 1980.
15. Farnham, R.S., and Brown, J.L. Advanced wastewater treatment using organic and inorganic materials. Part 1 - Use of peat and peat-sand filtration media. Proc. Fourth International Peat Congress, Otaniemi, Finland, 1972.
16. Nichols, D.S., and Boelter, D.H. Treatment of secondary sewage effluent with a peat-sand filter bed. Journal of Environmental Quality, 1982, 86-92.
17. Cameron, R.D. Treatment of a complex landfill leachate with peat. Canadian Journal of Civil Engineering, 1978, 83-97.
18. Nichols, D.S., Prettyman, D., and Gross, M. Movement of bacteria and nutrients from pit latrines in the Boundary Waters Canoe Area Wilderness. Water, Air and Soil Pollution, 1983, 171-180.
19. Rock, C.A., Brooks, J.L., Bradeen, S.A., and Woodard, F.E. Treatment of septic tank effluent in a peat bed. Proc. Third National Symposium on Individual and Small Community Sewage Treatment, American Society of Agricultural Engineers, 1982, 116-123.
20. Brooks, J.L., Rock, C.A., Struchtemeyer, R.A., and Woodard, F.E. The use of sphagnum peat for treatment of septic tank effluent. Proc. Symposium 1982, A Symposium on Peat and Peatlands, Shippagan, New Brunswick, Canada, 1982, 442-459.
21. Rock, C.A., Struchtemeyer, R.A., Brooks, J.L., Bradeen, S.A., and Knight, M.E. The utilization of peat in onsite wastewater disposal systems: interim project report. Dept. of Civil Engineering, University of Maine, Orono, Maine, U.S.A., 1983.

SESSION 5

Chairman: Dr A.P. Cotton, WEDC, Loughborough University of Technology, U.K.

Discussion

S C Dutta Gupta

Laying of sewers in Calcutta slums

1. The author was not present, and the paper was not read.

L I Nianguo

Sanitation from biogas in China

2. Dr LI described the biogas system used in China, and gave details of the results of excreta treatment in the biogas units.

3. Mr BRADLEY asked how widespread was the use of biogas in China, and how were the digesters mixed.

4. Dr LI replied that the biogas digester was first designed in the late 1920's, and installed in Shanghai in the early 1930's. The massive surge in biogas digester construction came between the late 1950's and the mid-1970's, by which time up to 7 million units may have been built, mainly in rural areas of Sichuan province. He described the Chinese biogas unit; it was layed with bricks, plastered with cement mortar, and covered with a water sealing concrete plug, from where the gas was taken off; the high pressure units were mixed with a rake consisting of a disc attached to a bamboo pole, pushed into the opening at the outlet. The low pressure units were mixed by pumping the supernatant from the outlet back into the inlet. China was developing 'low pressure' digesters, in which gas was stored in a 'red mud plastic bag' in the kitchen of the house.

5. Mr KARTAHARDJA asked how the excreta was transported and put into the tank, and commented that in Indonesia, people were reluctant to use biogas because they thought it to be insanitary.

6. Dr LI said that farmers were encouraged to build the digesters so that they could easily be connected to the family latrine and the pig sty. Waste was flushed out, and flowed into the digester by gravity. Otherwise, people carried the waste in buckets to the digester. He also explained that in China, human and animal excreta had been used as a fertliser for centuries, and there was not the same reluctance to use biogas as experienced in other parts of the world.

7. Mr KSHIRSAGAR asked three questions: how was the moisture content in the digester controlled; how was the effluent slurry disposed of; and how often and when was the digester cleaned out.

8. Dr LI answered that in rural areas, the moisture content was controlled by observation, but that the moisture content was not critical; the effluent was often applied in the wet state to fish ponds, and was dried when it was not immediately used; the farmers cleaned the digesters once or twice a year, usually before the crop planting season.

9. Mr BEE wished to know what types of anaerobic digesters were used in China, and what industries used the anaerobic digestion system. He also commented that proper use of a distribution system using upflow would eliminate the need for mechanical stirring.

10. Dr LI replied that most domestic digesters were 5 m^3 to 6 m^3 in volume, and of cut-spherical shape. In addition, low pressure digesters were being encouraged. He referred Mr BEE to page 18.1 of his paper regarding industrial use.

H Orth and A Sahasakul

Alternative wastewater treatment strategies for an industrial area

11. Dr ORTH discussed the various strategies for wastewater disposal for the site in question, and presented results of the comparison of on-site versus centralised treatment.

12. Mr AINGER asked the following questions:
1. What was the land cost's part of the total cost comparison.
2. What arrangements would be made to overcome the likely practical and administrative difficulties in operating and financing a centralised scheme.
3. The on-site treatment involved activated sludge, which had a high energy cost; were lower operating cost systems such as rotating biological contactors considered?

He commented that on-site treatement could be cheaper for population densities less than 150 persons per hectare.

13. Dr ORTH replied as follows:

1. The land cost part varied for the presented main alternatives between 2% and 17% of the total present value. The part of the land cost present value was about two times higher for centralised treatment than for on-site treatment.
2. The question raised a very important problem, although it was beyond the scope of the presented study. However, the difficulties of a centralised administration were to be judged against the difficulties in supervising the many individual plants of a decentralised scheme. In close vicinity to the study area was another industrial estate which successfully ran a central plant without many administrative problems.
3. The most frequent treatment processes in the study area were cesspools in the residential area and trickling filters, activated sludge, chemical coagulation, and air flotation in the industrial area. Rotating biological contactors were not considered, since for this process there were no data available in the study area. However, from Table 2 it became apparent that even substantial savings of energy cost could, for the case in consideration, not balance the economic advantage of the centralised solution.
4. The population density was indeed a very important factor for the economy of centralised and on-site treatment. The break-even density varied from project to project or even within one project area. For example, in a major city in Africa with relatively low land cost, it was as low as 20-25 persons/ha. The comment confirmed the need for thorough planning in each individual case.

14. Mr KARTAHARDJA asked whether the study was also applicable to residential areas for the low-income group; when there were different industries needing different effluent treatment, was it advisable to centralise treatment; how would the cost analysis come out for residential areas.

15. Dr ORTH answered by explaining that the methodology used could be applied in a general case, but the actual results were specific to the situation investigated, and could not be generalised, but the cost for residential areas would not be so favourable due to the high cost of land. The treatment processes depended upon the nature of the effluent, and could involve combined, separate or partially combined processes.

16. Mr RAO wished to know how the additional cost of sewerage affected the cost reduction due to centralised treatment.

17. Dr ORTH stated that the sewerage system accounted for half the present value of the centralised solution.

18. Mr TANG asked why centralised treatment could lead to a lower technology solution.

19. Dr ORTH replied that the low cost of land just outside the industrial area could make waste stabilisation ponds economical. The land costs were higher within the industrial area, and on-site treatment in ponds would be more expensive, and a more complicated treatment process requiring less land may be cheaper.

A K Shrivastava and S N Sharma

Ecological parameters in oxidation ponds

20. The authors were not present, and the paper was not read.

S L Tang

Wastewater - Hong Kong and Taiwan

21. Mr TANG explained the sewerage and sewage treatment systems which existed in Hong Kong and Taiwan, and discussed the costings and legislation and management strategies.

22. Mr YAW offered some additional comments on the problems of Hong Kong. The cost of land was extremely high and advanced methods of treatment were being considered. Both short and long sea outfalls were in use, but the tidal flushing effect was very small in many parts of Hong Kong's coastal waters, and detailed marine surveys were essential to ensure proper diffuser design. As in the case of Hong Kong major investments in large and sophisticated plants may be the only suitable solution for large connurbations.

23. Mr KARTAHARDJA asked for further details on the sea outfalls regarding beach pollution, low tide dilution factors, and length; who paid for the investment, and did annual revenue cover operation costs.

24. Mr TANG replied as follows:

1. While the stormwater sewers in Hong Kong usually end at the seashore, the wastewater sewers normally extend off-shore

for distances ranging from slightly less than 1 km to 3.5 km, depending on the location of the discharges. The discharge outlets were normally not less than 20 m below the low-tide sea level.

2. The tidal effect was negligible. A dilution of 500 times referred to the places along the sea coast, ie the figure was of the final dilution level. The initial dilution was set at a standard of not less than 85 times for untreated wastewaters with or without prior screening.
3. The 500 times dilution for the wastewater to reach the seashore was considered safe if the latter was not a swimming resort. Most beaches recorded values consistently less than 1000 faecal coliforms per 100 ml, which compared quite favourably with the European standard. In some rare cases, chlorination was provided after screening (eg Repulse Bay in Hong Kong Island)in order to ensure better safety on the part of the swimmers.
4. The government of Hong Kong paid for both the capital cost and the operation/maintenance cost of the wastewater treatment plants, the former coming from the government's 'Capital Work Reserve Fund' and the latter from 'Annual Recurrent Expenditure Fund', both of which originated from the general tax revenue.

Joo-Hwa Tay

Methods and costs of treatment of electroplating wastes

25. Dr TAY described the sources and characteristics of electroplating wastes, and the different methods and costs of treating them.

26. Mr KARTAHARDJA commented that the main problem of industrial waste treatment in developing countries was the enforcement of legislation; installation of treatment plants made production costs higher, and marketing more difficult.

27. Dr TAY agreed, but felt that it was important for engineers to persuade government of the importance of treatment to protect natural resources.

28. Dr BORGHEI made three comments: the cost of cyanide treatment depended upon whether chlorine gas or chlorine compounds such as bleaching powder were used; cyanide was going out of use, being replaced by other compounds; and it was better to use sulphur dioxide, or its compounds in powder form, to reduce the chromium ions, because the use of ferrous sulphate produced a large quantity of sludge.

29. Dr TAY replied that it was safer to use chlorine compounds because small electroplating shops employed unskilled workers. He agreed with the comment about cyanide, but pointed out that the total cost including treatment would have to be cheaper than the existing methods. Although ferrous sulphate produced a lot of sludge, it was cheaper and more readily available; the cost of sludge disposal was negligible.

30. Mr PARAMASIVAM commented that NEERI in India had developed biological methods of treating phenol and cyanide wastes; was the feasibility of such a method considered, and how did it compare with the existing methods.

31. Dr TAY replied that such a system required either a large land area, or a large capital investment and skilled operators. It was thus totally infeasible for small firms in large cities.

I Viraraghavan and A Ayaswami

Use of peat in wastewater treatment with special reference to on-site systems

32. Dr VIRARAGHAVAM described how peat could be used in industrial and municipal wastewater treatment, and discussed the progress of field studies to monitor the performance of the treatment method.

33. Dr COTTON commented that although the problem of groundwater pollution from pit latrines was of great concern, it must always be remembered that the pit latrine broke the faecal-oral route of disease transmission, which was probably one of the main causes of illness in developing countries. The pit latrine solved many more problems than it produced.

34. Dr VIRARAGHAVAN replied that he agreed, but was only emphasising the need for developing better designs to minimise the risks of groundwater pollution.

35. Mr KARTAHARDJA asked whether there was a chemical analysis of the peat used, and what chemical process was taking place.

36. Dr VIRARAGHAVAN replied that adsorption was taking place, and that a chemical analysis was available.

37. Mr BERRY stated that the useful life of the peat was a vitally important factor; was there information available, and was peat self-regenerating.

38. Dr VIRARAGHAVAN replied that studies were in progress at the University of Maine, USA, on the longevity of peat used in septic tank effluent treatment. Scanning electron microscope studies of the virgin peat and peat exposed to septic tank effluent showed that structural changes occurred in peat used in septic tank effluent treatment. However, efficiency of the peat columns in treating septic tank effluent was not affected. Peat beds treating septic tank effluent were reported to be in operation for more than 3 years.

The possibility of improving the useful life of peat by the use of resting periods was being investigated at the University of British Columbia, Vancouver, Canada, while using peat columns for treating landfill leachate. These studies indicated that restoration of adsorptive capacity may be achieved by allowing a sufficiently long rest period between applications and that a one month rest period was not adequate.

10th WEDC Conference

Water and sanitation in Asia and the Pacific: Singapore: 1984

Water Supply for Tehran

Dr M Borghei

Tehran ,the capital city of Iran is facing problems to supply potable water and suitable sanitation for its increasing population. Due to immigration from villages and other cities to the greater Tehran area , nobody knows exactly how many people live there but estimates range from 6 to 9 million. Taking the more reliable statistics released by the government in 1982, Tehran's population has expanded to 7 million which shows a 40 percent rise in less than five years. This unexpected growth has created headaches for TRWB- Tehran Regional Water Board- The body responsible for water supply and sewerage. In summer 1983 many areas within the city experienced water cuts and it will be no surprise to see water rationing coming into force during the peak demand periods of the present and future years, unless some action is taken today. Under a scheme , called the "Lar project", TRWB will be able to meet part of the crisis in a few years time, however in the mean time as well as several years to come , the shortages are inevitable and thus a reasonable solution must be found for this complex situation. The present research study has been taken up to assist TRWB in utilizing the scarce water resources in the area to the best advantage. Having drawn water as much as possible from the nearby rivers ,extra water must be found from underground. Surface waters within the city area could contribute to this balance, although they only exist in part of the year and in the form of flood waters. There has been signs of increasing pollution in underground supplies recently, and thus plans to increase the utilization of this important source for treated water supplies has been slowed down. Further more the quantity of water which could be available from underground and from rivers is under question. To meet the increasing demand for treated water supplies for domestic use, industrial consumption and agricultural purposes, an overall program which should include utilization of resources and re-alocation of fresh waters for uses other than domestic must be pushed forward.

Tehran's Water Resources

Like most cities in Iran, Tehran was entirely dependent upon groundwater until 1933 that water was brought into the city from river Karaj some 40 km. to the west of the city. Now Karaj source, through Karaj dam, is a major supplier for TRWB. The dam's reservoir provides some 210 mcm. (million cubic meters) of live storage and regulates the river flow which at the dam site amounts to 465 mcm. per annum. The operation of this reservoir has been based on 184 mcm./a for Tehran area and 160 mcm./a for irrigation of south Tehran plain. However in recent years up to 280 mcm. per annum has been taken up by TRWB in the expence of irrigation and forestry.

Latian dam on Jaje-rud river, east of Tehran provides a further 95 mcm. storage, while the average flow of the river is 310 mcm./a. At the present, over 130 mcm./a of this water is pumped to treatment works while the rest is passed downstream for industrial raw water and for irrigation. This reservoir too was designed to supply only 80 mcm./a for treatment works, but is currently over drawn by more than 50 percent.

Lar dam, constructed on river Lar, 50 km. north west of Tehran, was designed to storage 860 mcm., which is about twice the average annual flow of the river. It was expected that the reservoir would provide over one year's storage capacity, in 1976, when TRWB had estimated Tehran's water demand at 500-600 mcm./a. Unfortunately this reservoir which was planned to come into operation in 1983, has been the centre of much controversy as it is loosing water through a ground leakage and is unable to hold any appreciable amount of water. Tracer studies has detected the leak and work is going on to repair the reservoir, although it is not hoped to be completed before mid 1985. Once brought into operation, Lar dam, will provide a further 180 mcm/a for TRWB.

Groundwater has been used in Tehran from the beginning and abstraction has been on the increase ever since, particularly since the development of the modern drilled pumped well. But TRWB developed its first groundwater source in 1963. They now operate several groups of wells situated in the south of the city, abstracting about 50 mcm./a, which is chlorinated and distributed directly.

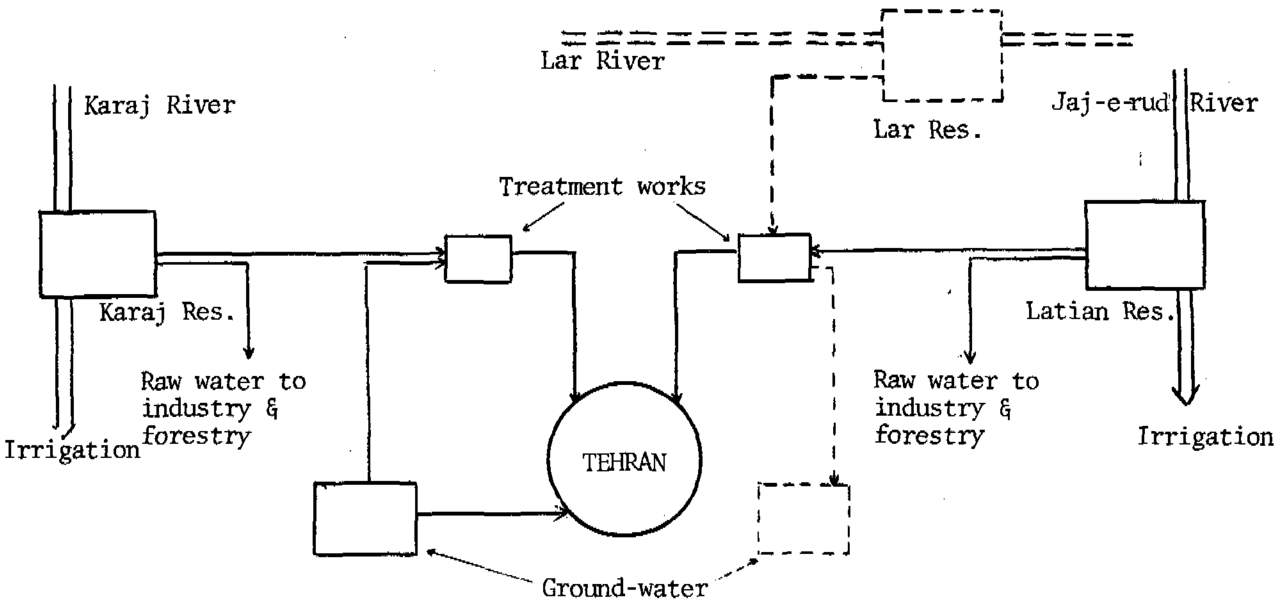

Figure 1: Layout of Tehran's water resources.

Figure 1 shows the bulk water supply system for Tehran. It must be added that many industries within or around the city area are using groundwaters independently and this source (through boreholes or qanats) is also used to irrigate well over 50'000 hectares of agricultural land.

Demand Projection

Table 1 ,shows an overall picture of TRWB's activities in the past 20 years. The supply of treated water and the number of connections has been increasing to meet the demand. As this trend shows, industry has been forced to look for other resources, rather than depending on TRWB's supplies. It is estimated that only less than 2 percent of total water used by the local industry is provided by TRWB. The amount of groundwater developed show a decrease in the second half of 1970's and an increase in recent years, due to the necessities. It must be mentioned that abstraction of groundwater has been carried out by private sector (industry,farms,private dewellings) of which an exact account is not known. The demand for treated water is not shown in this profile, but it is understood that the TRWB has great difficulties in supplying more treated water to meet the demand. Looking at the number of connections and taking an average of 8 persons per connection shows that nearly 5 million people are using the privilage of tapped, treated water and yet it leaves more than 2 million without.

Table 1 , TRWB's treated water and consumption profile.

Year	TRWB treated water supply		Raw water (TRWB)		Connections
	Rivers	Groundwater	Industry	Forestry	
1963	49.3	3.04	0.36	--	172000
1967	106.2	6.51	0.72	5.62	384500
1971	214.3	55.6	1.52	15.7	429300
1975	317.4	34.6	3.90	13.3	500312
1977	327.9	31.2	4.20	11.1	527023
1978	360.3	22.7	4.45	12.7	532041
1979	393.2	32.3	4.20	10.2	549161
1980	397.1	37.0	4.30	9.1	565614
1981	401.5	41.8	3.95	15.9	579717
1982	417.2	53.0	2.40	17.0	596656

All figures except the number of connections are in million cubic meters per annum.

The rate of increase of treated water has slowed down during the past five years, due to diminishing of new resources. Rivers have surpassed their capacity and it is impossible to transfer more water from them under the present situation without seriously damaging the cultivation of farm lands.

FUTURE DEVELOPMENT

To meet the growing demand, new resources must be looked upon. Although once brought into operation, Lar dam will contribute fairly to the present supplies, diversion of more water from reservoirs is not possible unless water is made available for irrigation from other sources.In the longer term water will have to be transferréd from some 150 km north from Alborz mountains, with great expense. In the medium terms, other supplies notably surface waters and groundwater within the greater Tehran area must be fully utilized.

Surface Waters

Notable surface waters within Tehran area are divided into three different categories which are listed below:

1 -Inflow from Alborz mountains
2 -Flow within the city area
3 -Outflow towards the south

Inflow is in the form of small rivers primarily as a result of floods and snow melt during the spring months. Total annual inflow has been varied between 200-280 mcm/a ,depending on the precipitation.

Flow within the city area occur as a direct result of precipitation, and flows through open canals. As the average rainfall within Tehran area is about 225 millimeter per year this flow is not appreciable.

Outflow from this area are the canals which divert the floods and surface runoffs, including some industrial effluents.Due to the addition of untreated or primarily treated only, domestic and industrial effluents to the open canals, flow within or outgoing the city is heavily polluted and not suitable for treatment and distribution into the network. So far it is used for irrigation only. The inflow into the city from the mountains happens during the winter and early spring months and is not significant in other seasons of the year. In the present time this water is only helping to recharge the aquifer otherwise it is almost wasted. It is notable that the flow exists in the time of year when it is least required for irrigation.

The pollution of the inflow at the upstream is mostly physical pollution,i.e. turbidity and suspended solids, therefore it can be treated in conventional treatment works which already exists. But once this water is in the city area it becomes heavily polluted and is not safe anymore.

On the whole it seems to be feasible to construct reservoirs at the upper end of inflow streams to control and collect the floods. It is estimated that in this way some 80-100 mcm/a of fresh water could be added to existing supplies.

Groundwater Supplies

Groundwater was first looked upon as an aid to reservoirs during the dry seasons. But as the demand exceeded forecasts, this source became an important part of the supplies for Tehran's suburb's and the local industry. It has been estimated that 500 mcm/a is currently abstracted through boreholes, but TRWB's share has not exceeded 53 mcm/a so far. To rely further on this source a very clear picture of the quantity and quality of this water must be available. To estimate the quantity, modelling techniques which would take into account all the components of water balance, could give valuable information on aquifer characteristics, such as storage capacity and abstraction limits under varying hydrological conditions.

Water Balance of the aquifer includes such terms as recharge due to precipitation and surface waters, recharge through sewage wells

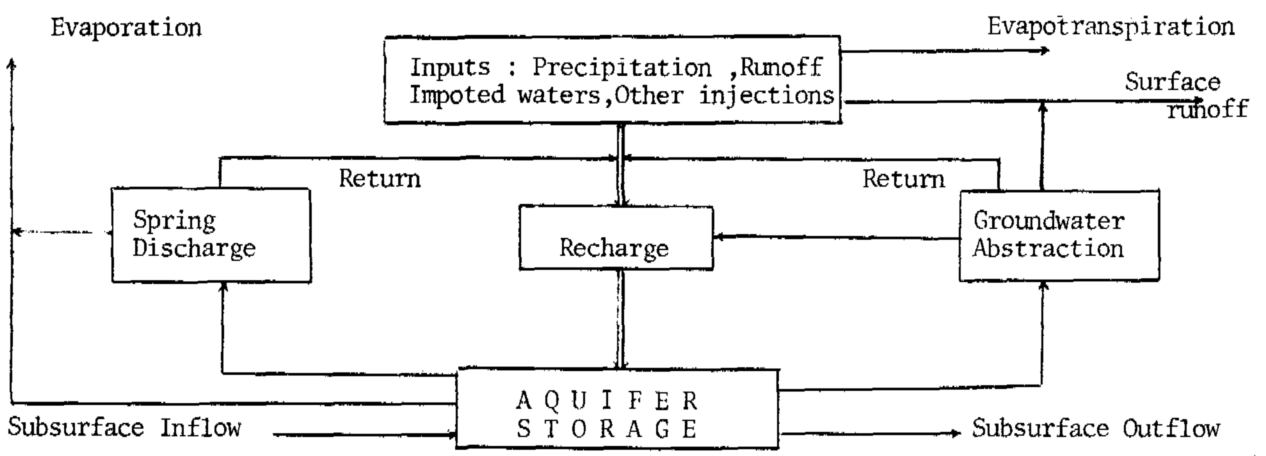

Figure 2 : Water balance of the aquifer

Table 2 : The quality of ground water (new TRWB wells)

Sample	EC 10^6	Na^+	Cl^-	NH_3	Detergent(ABS)	Oil & Grease
1	693	60	40	0.36	0.21	80.0
2	927	44	71	3.6	0.43	110.0
3	600	90	72	0.15	0.70	45.0
4	912	81	165	0.12	0.00	20.0
5	1020	108	184	0.26	0.37	45.0
6	510	20	78	0.14	0.18	40.0
7	500	19	75	0.16	0.08	20.0
8	330	18	35	0.08	0.12	40.0
9	550	35	45	0.28	0.13	60.0
10	480	51	70	0.11	0.16	20.0

All figures except electro conductivity are in mg/1. EC figures are in mohs.

under flows, qanat transfers, qanat-borehole abstractions and evaporations. It is important to note that the large and increasing quantities of surface waters imported to the area and such features as qanats, natural springs and sewage wells make this an exceptionally complex hydrological situation.
A simplified diagram of the main components of the water balance and the relationship between the individual terms is given in Figure 2. It has been estimated that on average 70-80 percent of water used in Tehran is joined the aquifer through sewage wells.

The Model of an aquifer system is a representation in mathematical form of the flow through an aquifer together with the known or estimated recharges and abstractions. The parameters of the model describe the resistance of the aquifer to store water. This hydrological system is extremely complex as accurate estimates of recharge, evapotranspiration, runoffs and subsurface movements are not at hand. But, if provided with accurate hydrological records on one side and the aquifer water level fluctuations (well water level) on the other side over a period of several years, then this model will be able to forcast abstraction limits under all given conditions such as wet or dry seasons or even under drought conditions.

A mathematical model such as described above has estimated that TRWB could abstract on average , 120 mcm/a safely which could increase to 180 mcm/a on very wet years. But so far the expansion has not been possible due to pollution. The groundwater pollution is as a result of the method of sewage disposal normally practiced, that is to say by means of sewage wells (Tehran is not served by a sewage systems). Despite this long term practice the quality of groundwater has been remarkably good until recently. Table 2, shows the result of chemical analysis of ten samples of waters from new wells which were expected to be used by TRWB. These wells are over 170 m deep and are situated in in the south of the city. It was planned to use this groundwater to supplement supplies in the pre Lar period. However the presence of the exotic chemicals, notably detergent, indicated that the contamination of the aquifer is taking place as a result of sewage wells. This uncertain quality, has discouraged its direct distribution into the network. On the other hand treatment costs are very high as new treatment works, being capable of treating this water, must be designed and constructed. Even so, unless the whole are is served by a sewage system, the risk of groundwater pollution will continue to grow.

CONCLUSIONS & RECOMMENDATIONS

Water is scarce in the Tehran area and can be a limiting factor in the expansion of the city. To avoid shortages in the near future the following points must be considered in planning.

1-Water resources development ,planning, and management should be consistent with ecology health and economy. More water from the existing resources could create more arid land, or lower food production.
2-Reservoirs could be constructed to collect the flood waters and thus provide 80-100 mcm/a of fresh water.
3-Modelling the aquifer for quantity and quality would provide useful information on the extent of utilization of this resource. Groundwater of low or acceptable levels of pollution can be distributed for domestic use while more polluted waters should replace fresh river waters for irrigation. Therefor more water from the rivers will be released for use in the city.
4-Industrial and domestic effluents must not be discharged untreated into the sewage wells.
5-Conservation could represent the most economical source of new water supply. This could be pursued in a variety of ways, planning management, technology and education.

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10th WEDC Conference

Water and sanitation in Asia and the Pacific : Singapore : 1984

Aspects of field testing of water

L G Hutton

This paper describes some field techniques available for water testing in developing countries. It concentrates on the bacteriological testing of water for faecal coliform organisms and possible ways of reducing costs. Short descriptions of chemical and physical tests follow a discussion of water quality guidelines.

1. Water Quality Guidelines

Basic requirements for drinking water quality are:

1) Absence of pathogenic (disease causing) organisms
2) Absence of compounds that have an adverse effect, acute or in the long term, on human health.
3) Clarity (i.e. low turbidity, little colour)
4) Total dissolved solids below 3000 mg/l
5) Absence of compounds that cause an offensive smell or taste.
6) Freedom from tainting of food cooked in it, staining of clothes washed in it, or corrosion or encrustation of the water supply system.

The World Health Organisation recently published their Guidelines for Drinking Water Quality which outlines in great detail their latest advice and recommendations for water quality criteria. (WHO, 1982).

This paper is not the place to discuss the validity or values of water quality criteria, but if progress in improving quality is to be made, a pragmatic approach to the latest recommendations is essential. It should be determined by each country and each district based on routine survey data e.g. at least 5-10 consecutive weekly samples.

Table 1 gives some suggestions on bacteriological criteria.*

1. Chlorinated samples post treatment collected from distribution system.

A) at least 80% of samples taken over a 12 month period should have a zero *E. Coli* count per 100 ml. and b) The *E. coli* should never exceed 10 per 100 ml.

If guidelines are not met, a sanitary survey should investigate and rectify the cause of contamination.

B) Unchlorinated water sources eg hand pumps, wells, springs, gravity flow systems, etc.

Mean Count** E. Coli	Comment
0	Excellent
1-10	ACCEPTABLE but regular sanitary and O & M checks needed.
10-100	UNACCEPTABLE Corrective action needed quickly, repair, rectify and disinfect.
More than 100	More than 100 GROSS POLLUTION. Look for better source or disinfect.

**E. Coli* detected by incubation at 44°C by membrane filtration with appropriate media.
** At least 10 consecutive weekly samples.

2. Bacteriological Testing

Pathogens are not normally looked for when examining water samples for pollution because it is not practically possible. The testing procedure for pathogens is complex and takes several days. The pathogens themselves may only be present occasionally in the water although pollution by faecal material might be occurring continuously. So the normal procedures determine if the water is polluted by faecal material. This means the determination of the presence or absence of types of bacteria which are ALWAYS present in the excreta and intestines of man and other warm blooded mammals (such as sheep, cows, pigs, poultry etc) and whose presence therefore INDICATES faecal pollution.

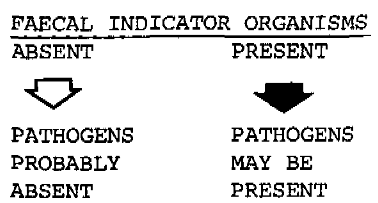

Fig.1. Rationale for use of indicator organisms.

The most commonly used indicator organism for field surveillance of the bacterial quality of water is Escherichia Coli (or E. Coli for short) which have the ability to ferment lactose at 44°C. Other organisms in the coliform group able to ferment lactose at 37°C but not at 44°C occur in faeces but also in the soil naturally and are not definite for faecal pollution. Small numbers of the coliform group of organisms 1-10 per 100 ml may not be necessarily of sanitary significance.

Incubation at 44°C provides the most direct route to detecting faecal coliform in drinking water.

Sample

Incubate with lactose at 44°C

Positive → Faecal coliform organisms present → Faecal pollution

Negative → No evidence of faecal pollution

Fig.2 Faecal coliform organism determination

2.2 Aseptic procedures

In many cases we are looking for very low levels of indicator bacteria perhaps only 1 or 2 per 100 ml of sample, it is important that the sample or testing apparatus must not be contaminated by careless handling.

At this point a timely reminder of the numbers of organisms excreted into the environment from various sources will not be amiss.

Table 2 (based on Mara, 1974)

Animal	Average wet wt. faeces g/day	Estimated no. faecal coliform organism per capita per day
Man	150	2000×10^6
Sheep	1130	18000×10^6
Cow	23600	5400×10^6
Pig	2700	8900×10^6

So before we analyse our water sample we need:

1. Clean the dust and draught free working area
2. Wash our hands
3. Use only media, diluting fluids and equipment known to be sterile
4. Avoid touching any part of a container, petri dish, pipette etc which will come in contact with our sample.
5. Only open sterile packs or petri dishes for as short a time as possible.
6. Use disinfecting cloths with self indicating strips for both preparing the working area and cleaning hands before and after testing.
7. Use a small gas torch or burner for sterilizing taps, forceps and stainless steel apparatus.

2.3 Sampling

Sampling for representativeness is an art. A saying among analysts is "the analysis is only as good as the sample". It is extremely difficult to obtain representative samples and it is very easy to contaminate samples during sampling.

Where several samples are being taken for water quality testing at the same location, the sample for bacteriological examination must be collected first to avoid danger of contamination of the sampling point.

Samples for bacteriological analysis must only be collected in sterile containers.

In tropical areas where schistosomiasis (bilharziasis) is endemic the sampler should be aware of the dangers of exposing himself to the water.

The reader is referred to standard texts such as APHA (1980) and WHO (1976) for details on sampling frequency and methods.

2.4 Methods

There are two main procedures for the detection and counting of indicator organisms:

A. The membrane filtration technique
B. The multiple tube fermentation technique (MPN method)

For field work only the membrane filtration method will be discussed.

Several researchers are investigating various ways of making bacteriological testing cheaper and hence more widely available; a listing of new developments may be helpful. Most equipment has to be sterilizable in an autoclave or pressure cooker.

A. Filtration units

Stainless steel types from Millipore, Sartorius or Gallenkamp cost £30 to £210. Millipore plastic (disposable) type cost £25.

B. 2-way Vacuum Pump Plastic

Millipore £12. Mitivac £23.

C. Resterilizable plastic, glass or metal petri dishes

Glass Pyrex £20 for 10
Metal Oxoid Co £2.50 for 10

Plastic disposable* Millipore £11 for 100
+ absorbent pads Millipore £14 for 100

* but can be re-used, see Mara (1974)

D. Selective Growth Media

Sterile ampoules (Millipore) MFC broth
24 x 2 ml £15 store in refrigerator

Prepared dehydrated McConkey MFC membrane broth is available from Oxoid or Millipore for making your own media. £15 for 100 g.

E. Membrane filters

Often the most costly item. Individually wrapped and made with cellulose acetate esters with grid markings and controlled pose size of 0.45 μm are manufactured by Millipore, NEERI, Sartorius, Oxoid, Nuclepore and Gelman. Prices are around £25 for 100. Oxoid Nuflow filters are possibly reusable (Cheesbrough, 1984) but I prefer to open a new one especially under field conditions

F. Diluted water

Now easily prepared by using Millex filters and large syringes.

G. Incubators

The most costly item for bacteriology is the incubator. In most developing countries the electrical power supply is unreliable with frequent cuts and fluctuations in voltage and frequency. This unreliability is often the cause of early failure of water works and pumping equipment. For proper incubation of faecal coliform organisms at 44°C it is preferable to use a laboratory incubator.

Laboratory incubators can be bought for around £140. For field work a battery powered portable incubator is recommended. However the price of these is high, £1300 for a Milli-pore battery/mains portable incubator. Although this instrument is an excellent performer its cost is prohibitive for most situations.

At Loughborough we are experimenting with the production of a battery-powered incubator capable of incubating 12 petri dishes at 44°C or 37°C. The material costs are less than £100. The most expensive items are the Platinum wire contact thermometers at £18 each and the 12V motor and fan at £10. The latest results of this device will be presented in Singapore.

H. Transport Media

In most parts of the world it is possible to bring samples to a laboratory in an ice box within 24 hours. However in remote locations it may be advisable to filter the sample as normal and place the filter onto an absorbent pad saturated with "transport media" and sealed in a petri dish. The filter is transferred to a pad saturated with the MFC broth on arrival at the base laboratory and incubated for the normal times at 44°C.

The algorithm (Fig. 3) shows the possible choice of procedures (from Hutton, 1983).

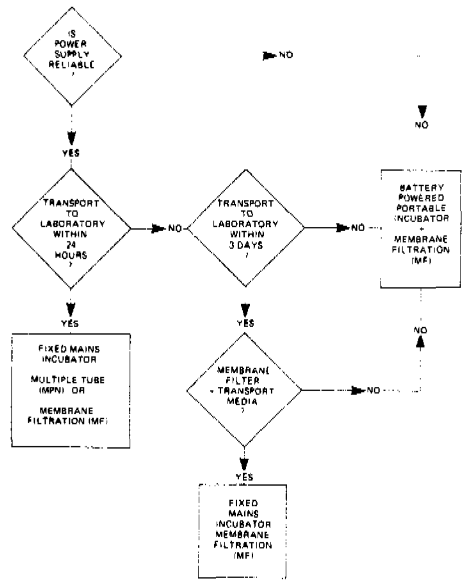

Fig. 3 Algorithm for choice of procedures for bacteriological testing of water in developing countries

2.5 Negative bacteria testing = positive chlorine testing

When chlorination is carried out the most important parameter to be determined is the free residual chlorine content. If we find free residual chlorine in a sample we can assume that, provided sufficient contact time between chlorine and the water has passe passed, the water will be bacteriologically SAFE, at the point when and where the sample is taken. This is no guarantee that contamination is not occurring elsewhere in the distribution system. A small amount of free residual chlorine 0.2-0.5 mg/l is unlikely to be strong enough to kill any bacteria invading via leaks or cross connection.

The method used currently employs the property of D.P.D. (Diethy-para-phenylene diamine) to turn pink in the presence of free chlorine. (See Figure 4)

Chlorinated water sample	+ DPD
Pink colour	no colour change
Chlorine present and	no free chlorine
Bacteria probably	possible pollution
absent	possible pathogens

Fig. 4. Positive chlorine = negative bacteria

2.6 Summary

The costs of bacteriological testing can be reduced by appropriate selection of materials and techniques but are still often prohibitive.

3. Chemical Analysis

Chemical analysis of water samples is rapid compared with bacteriological analysis and also detects pollution not caused or reflected by organisms. Many parameters of water quality such as nitrates, nitrites, dissolved oxygen, chlorine, iron, carbon dioxide, alkalinity and acidity change on transportation to a laboratory and field tests can overcome the need for preservation of samples prior to laboratory analysis. A comparison of field and laboratory determinations is made in Table 3.

FIELD	LABORATORY
Requires less skilled personnel	Requires skilled personnel
More immediate results and possible action	Loses immediacy - urgency and can be lost
Not always as accurate	Can be highly accurate
Portable	Not always portable
Equipment can be used in field and laboratory	Usually only laboratory
Cheaper to operate	Overheads can be high
No need for preservation	Sophisticated preservation often necessary.
Limits of detection sometimes above guideline values	Low limits of detection
Easily repeated	Costly to repeat
Simple sampling	Often requires multiple samples

There are several techniques used in field chemical analysis based on colour reactions, titrations and electrodes. Hutton, (1983) describes these field tests in detail.

Most notable developments include:

1. Merckoquant test strips for nitrate, nitrite and sulphate
2. Hach and Lovibond colorimetric tests using comparators for many parameters
3. The Hach digital titrator for field titrations of alkalinity, HCO_3^-, CO_3^{--}, CO_2, O_2, Cl^-, Ca^{++}, Mg^{++}
4. Specific ion electrodes for Fluoride and dissolved oxygen.
5. Field atomic absorption spectrophotometer for trace metals (The cost £26,000).

4. Physical Analysis

A visual and nasal examination of a sample in a clean glass can indicate purity, clarity, colour, smell, and iron and manganese.

pH can be measured with paper strips, colour reagents or dipstick probes.

There are now portable instruments for turbidity, pH, eH, conductivity, dissolved oxygen and several other parameters.

5. Concluding Remarks

There is a very wide choice of techniques and equipment for field testing of water and the field worker needs to check what is available to do the tests to the accuracy described. More are being developed and the user should choose equipment which can be used for more than one application.

References

APHA, 1980 — Standard methods for the examination of Water and Wastewater, 15th Ed., New York, APHA/AWWA/WPCF

Cheesbrough, M 1984 — Medical Laboratory Manual for Tropical Countries, Vol II, Bacteriology Tropical Health Technology Ltd., Doddington, UK

Hutton, L.G. 1983 — Field Testing of Water in Developing Countries, Water Research Centre, Medmenham, UK.

Mara, D.D. 1974 — Bacteriology for Sanitary Engineers Churchill Livingstone, London.

WHO, 1976 — Surveillance of Drinking Water, WHO Monograph No. 63, Geneva.

WHO, 1982 — WHO Guidelines for Drinking Water Quality, Volumes 1-3, EPF/8239 WHO, Geneva.

10th WEDC Conference

Water and sanitation in Asia and the Pacific : Singapore : 1984

Potable water exploration: Kavaratti Island

T V Jacob

1.0 INTRODUCTION

1.1 Kavaratti is one among the several islands in the group called Lakshadweep in the Indian Ocean within the territory of India and is the seat of administration for the group. It is long and narrow with an area of 3.6 sq.km and a population of 6608 as per 1981 census. It has a lagoon on the western side and a storm beach on the eastern side.

1.2 The island is very much under developed and is without protected water supply. This paper is based on the studies made to explore the possibilities of providing protected drinking water to the islanders.

2.0 EXISTING FACILITIES

2.1 The inhabitants draw their requirements of water mostly from unprotected shallow wells. Some of them are masonry open-draw wells and a few are walk-in types. Enquiries indicated that the islanders are tolerating the existing quality of the unprotected water which contains some chlorides and sulphates.

3.0 SCOPE OF THE STUDY

3.1 Time available for the study was short. There were no seasoned bore wells in the island to analyse water samples at various depths from different parts. The study therefore, was limited to observations of shallow existing wells, enquiries with the inhabitants and limited field studies based on established theoretical concepts using available equipments.

4.0 INVESTIGATION APPROACH

4.1 Investigation was mainly aimed at finding out whether good ground water of adequate quantity is available for a protected water supply scheme. Field observations revealed that the ground water tables in the existing wells fluctuate with tidal variations indicating hydraulic continuity of ground water with sea water. Therefore it is inferred that the water that is available is in the form of "fresh water lens".

5.0 THEORETICAL CONCEPT OF "LENS"

5.1 In an island surrounded by the ocean rain water percolates depending on the nature of the subsoil. This water joins the body of fresh water of earlier collection which remains in a lens-shaped body that lies over salty ground water that seeped in from the surrounding ocean. Depending on the permeability of the strata and the amount of percolating water, the underlying water may flow outwards into the sea on all sides, from the lens maintaining equilibrium. In the equilibrium condition, the ground water table attains stability.

5.2 Ideal "Ghyben-Herzberg" lens: The lens shaped fresh ground water bodies that exist in oceanic islands called "Ghyben-Herzberg lens" is shown in Fig.1. The

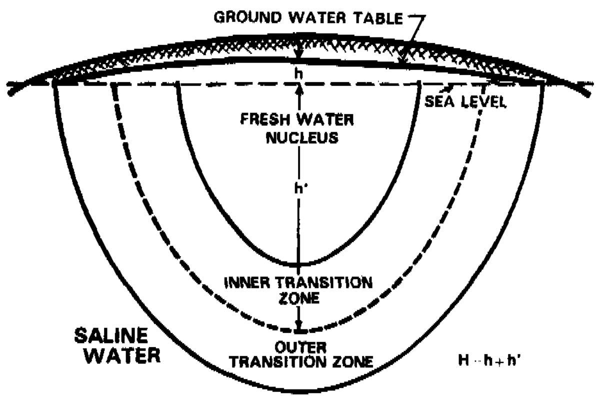

FIG. 1. GHYBEN-HERZBERG LENS

upper surface is the water table that separates the aerated zone from the underlying saturated zone. The middle line (dotted line in Fig.1) is taken as the interface separating fresh ground water and the underlying saline water by the "Ghyben-Herzberg principle". In the simplest case, the lens is in hydrostatic equilibrium so that the elevation of the water table above sea level and the depth of interface below sea level are mututally related. This relationship is the "Ghyben-Herzberg principle". In mathematical terms, it can be expressed as:

$$h' = \frac{p_f}{p_s - p_f} \times h = ah$$

Where h' is the depth of interface below sea level,
h is the elevation of water table from sea level,
p_s is the density of sea water (= 1.025)
p_f is the density of fresh ground water (= 1)
ah is the Ghyben-Herzberg balance (= 1/0.025 = 40)

The total thickness of fresh water column:

$$H = h'+h = ah + h = h(a+1) \text{ or}$$
$$H = 41\ h$$

That is, the thickness of the lens at any point is 41 times the elevation of the water table from sea level at that point. This implies that lowering of the water table above sea level by one unit height by extraction of fresh water creates a corresponding rise of the interface by 40 times at the point of extraction.

5.3 It is to be noted that fresh water and the saline water are not separated by surface of zero thickness like ice-berg floating on sea water. In reality, the water table and the interface are continuously fluctuating and the two waters do mix. The result is a transitional zone of mixed water, the percentage of sea water progressively increasing away from the fresh water. Thus the fresh water nucleus is the interface (middle line) bounded lens minus the upper half of the transition zone (Fig.1)

6.0 EFFECT OF MONSOON ON THE LENS

It is assumed that rain water percolates into the ground and gets stabilized in the "fresh water lens". Once the water that is drawn from the saturated lens is recharged and equilibrium established, further infiltration will not add to the quantity of "fresh water lens". The excess quantity of percolating water during the times of excess rain will be purged into the sea from the "fresh water lens".

7.0 RAINFALL AND QUALITY OF GROUND WATER

7.1 Rainfall: Rainfall details of Kavaratti are not available. Assuming that the pattern of rainfall is similar to Amini, a nearby island in the Lakshadweep group whose rainfall details are available, the probable rainfall is assumed to be around 1500 mm in an year. Allowing for marginal area in the vicinity of ocean and narrow strip of island area, the effective catchment area is assumed as 2.27 sq.km. Data regarding evaporation and evapo-transpiration losses are not available in the island. Only 15% of rain is assumed as useful percolation (Ref.1). To allow for fluctuations in rainfall, it is assumed that only 75% of the percolating water, i.e. $2.27 \times 10^6 \times 1.5 \times 0.75 m^3$/year or $0.38 \times 10^6 m^3$/year or 1×10^6 l/day will be available for extraction from ground water without seriously affecting equilibrium conditions of fresh water lens. This quantity is sufficient for the domestic requirements of the island.

7.2 Quality: Laboratory tests of water samples from various parts of the island indicated that the quality of water can be brought to drinking water standards by simple treatment followed by filtration and disinfection.

8.0 PRINCIPLE ADOPTED IN TRACING "LENS"

8.1 Procedure adopted is based on the assumption that interface bounded lens under saturation condition is in equilibrium and its volume is constant. Therefore the depth of fresh water in the lens is constant at any point irrespective of the position of the lens. That is, even when the lens oscilates due to tidal fluctuations, the depth of fresh water remains constant. According to Ghyben-Herzberg principle, depth of fresh water is 41 times the thickness of fresh water above sea level. Therefore, the depth of fresh water above sea level in the lens remains constant irrespective of the position of the lens. This means that the profile of the ground water moves up or down in unison with the oscillation of the sea level maintaining the depth of fresh water above sea level constant.

8.2 The volume vacated by the lens as it rises during the course of an oscillation is immediately filled with sea water that flows into the island. In a similar way this volume of sea water is purged from the island during the declining phase of of the water table oscillation. The effect of oscillation is of decreasing magnitude inland depending on the amplitude and period of oscillation, the distance from the shore line and permeability of the sub-strata.

8.3 If the average ground water profile for a section and the average sea level are determined simultaneously, the difference between sea level and the ground water profile will give the depth of fresh water above sea level for that section. By extending this process for other portions, the difference between average ground water table and average sea level can be determined for the entire area. This difference at any point will be constant under saturated equilibrium condition of the lens as the volume does not change.

9.0 TRACING GROUND WATER TABLE

9.1 To determine the profile of ground water at a section of the island on a particular day, the average water levels for the day at different points in the section are necessary. The average water level for the day at a point (well) is determined by monitoring the fluctuations of water level at that point for 24 hours using simple levelling instruments and accessories. A graph is plotted with the observed fluctuations against time. From the curve of fluctuations, the average water level at that point is determined by measuring the area covered by the curve for 24 hours and averaging the area for 24 hours (Fig.2). This

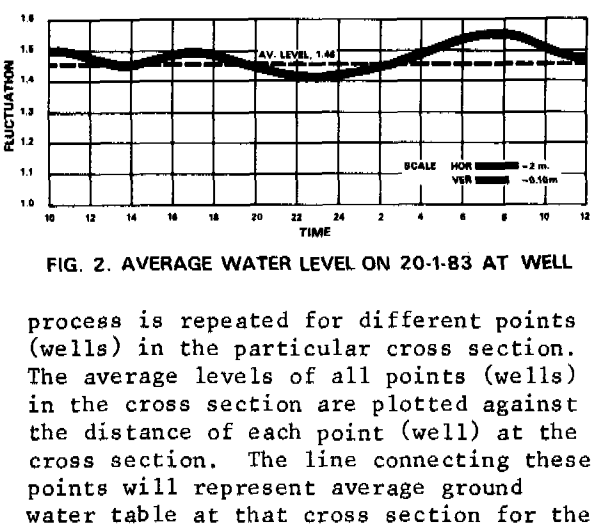

FIG. 2. AVERAGE WATER LEVEL ON 20-1-83 AT WELL

process is repeated for different points (wells) in the particular cross section. The average levels of all points (wells) in the cross section are plotted against the distance of each point (well) at the cross section. The line connecting these points will represent average ground water table at that cross section for the day (Fig.3). This process is repeated for

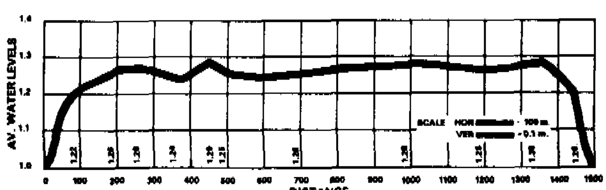

FIG. 3. AVERAGE GROUND WATER TABLE AT CROSS SECTION ON 20-1-83

other cross sections also.

10.0 AVERAGE SEA LEVEL

10.1 Sea level fluctuations due to tidal variations for 24 hours are observed. The readings are plotted and a graph is drawn. From the curve of fluctuations, the average sea level is determined by measuring the area covered by the curve for 24 hours and averaging the area for 24 hours (Fig.4).

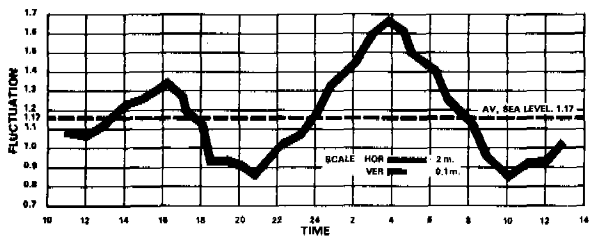

FIG. 4. AVERAGE SEA LEVEL ON 20-1-83

11.0 MAPPING THE PROFILE OF THE "LENS"

11.1 The line of average sea level for a particular day is interposed on the curve of average ground water profile for the section for that day. From this graph, applying Ghyben-Herzberg principle of 1:40 ratio, the profile of fresh water lens below ground water table can be drawn by measuring the depth of water above average sea level. The bottom profile will then represent the middle line of the transition zone. The real fresh water profile which lies above the middle line cannot be determined for want of detailed data regarding salinity content. For practical extraction purposes, Bugg and Lloyd (Ref.2) suggest a ratio of 1:25. In view of many possible limitations in this study, a depth ratio of 1:20 is assumed and the bottom profile is drawn accordingly (Fig 5). Similarly the profile of fresh water lens for the different cross sections are drawn. From these data contour of safe fresh water depths in the island is mapped (Fig 6).

12.0 LIMITATIONS OF FIELD OBSERVATIONS

12.1 The reliability of the findings entirely depend on the measurement of the fluctuations of ground water table and the sea level. Any error in field observations in this regard will reflect on the ultimate findings. The possible time lag due to the effect of permeability of sub soil on ground water fluctuations was ignored. The fresh water lens is

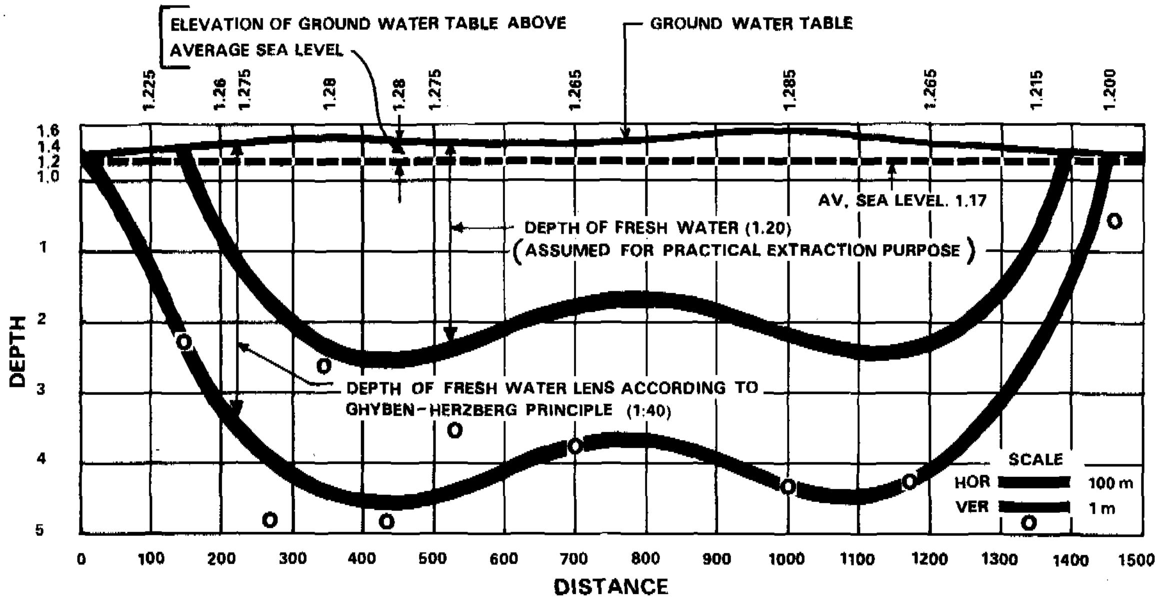

FIG. 5 FRESH WATER PROFILE AT CROSS SECTION

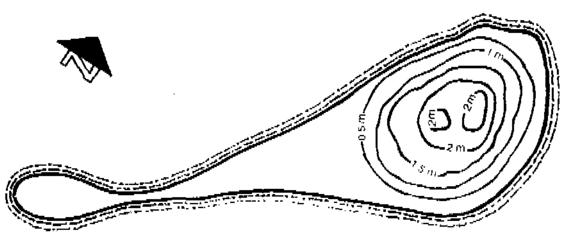

FIG. 6. KAVARATTI ISLAND
CONTOUR OF FRESH WATER DEPTHS

assumed to be in saturated equilibrium. Also, the findings of this study were not compared with the actual determination of the salinity of water at various depths.

13.0 CONCLUSIONS

13.1 The findings of this study indicate that in an island where fresh water is present in the form of fresh water lens, an approximate mapping of the profile of the lens can be done by measuring the fluctuations of sea level and ground water table. Even though the reliability of result greatly depends on the accuracy of field observations, the method provides a simple means of determining the profile of the lens with limited equipments in a short time. The procedure adopted in this study could be used for conducting similar studies in under-developed country situations by the available local technical expertise.

REFERENCES

1. Vacher, H L, Ground Water Hydrology of Bermuda, Report to Government of Bermuda, 1974 (Unpublished).

2. Bugg, Stephen Frederick and Lloyd, John William, A Study of Fresh Water Configuration in the Cayman Island Using Resistivity Methods, Quarterly Journal, Engng. Geol. Vol.9, 1976.

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10th WEDC Conference

Water and sanitation in Asia and the Pacific: Singapore: 1984

Appropriate technology for water filtration

Dr (Mrs) T R Mampitiyarachchi

Introduction

Effective methods of water treatment are of great importance to both developing and developed countries. Developing countries have to seek for treatment processes that are less expensive to construct and operate. Also the process involved has to be simple as the skilled manpower available is limited.

Filtration of water through granular media is widely used either for removal of solid material from water or for removal of flocs and the solid material after coagulation, flocculation and sedimentation processes. Although various types of filters are available, slow sand and rapid sand filters are used very widely. The usage of former is restricted to the rural areas while the latter is extensively used in the urban areas. Both types of filters use sand as the filter medium, but the rapid sand filters require uniformly graded sand. Generally slow sand filters are operated at or around 10 $m^3/m^2/d$. However rapid sand filters can be operated at rates equal to or greater than 120 $m^3/m^2/d$. Slow sand filters require cleaning after long intervals of time (upto 60 days or more) where as rapid sand filters are back washed at least every 24 hours.

Filter media other than sand have been used in practice, with varying degrees of success, examples are anthracite coal and plastics. The diatomaceous earth filter aid, is used in precoat filtration. A thin film of this fine filter material is sufficient for this purpose. The applications of this type of filters are limited due to high cost of the filter medium.

Rice hull ash - as an alternative filter medium

Rice is one of the major food crops of the world and is widely consumed in Asia. The majority of paddy cultivating areas lie within the developing countries. Milling of paddy yeilds a by product, rice hull, which amounts to about 20% of the weight of the paddy. Hulls have peculier properties such as abrasiveness due to high silica content, low nutritional value and a slow rate of decomposition. Although there are several potential uses for rice hulls at present the majority of hulls is disposed on land, causing land pollution. Rice Hull contains about 21% silica. The combustion of hull yeilds an ash which can contain as much as 90% silica. Ash retains the original texture of the hull particles and hence gives a porous structure. Thus it can be used as a filter medium. Utilization of rice hull ash as a filter medium requires the evaluation and comparison of its performance in relation to removal of turbidity and bacteria with that of a conventional filter medium.

Properties of rice hull ash

Rice hull on combustion yields a porous ash with a density in the range of 1900 to 2200 kg/m^3. The carbon content of this ash was found to vary between 3 to 6% and silica content between 85 to 87% with 4% moisture.

Ash particles are of fibrous nature and the average length and width are found to be 2.12 mm and 0.74 mm, respectively. Mechanical seiving of ash particles indicate that the effective size and non uniformity coefficient are 0.135 mm and 2.96, respectively. X-ray diffraction analysis shows that the silica in the ash exists in amorphous form.

Model filters

Laboratory filter columns 2.25 m high, 144 mm internal diameter were constructed of clear perspex tubing. Each filter column was fed using a lateral pipe located 150 mm from the top and a constant water level was maintained by having an overflow pipe, 50 mm below the top. Ten pressure tappings were located at the lower half of the column and provision was made to measure the head loss through the column by connecting them to water manometers. Outflow from each column was from the base and the flow control was done at the outlet section using a needle valve and a precalibrated rotameter.

Turbid water for experimental filter runs was made by adding kaolin clay to tapwater and the water was stored in a 1000 litre capacity galvonized iron tank. 4 grammes of kaolin clay dispersed in 100 litres of tapwater produced a turbidity of 40 FTU. Turbidity measurements were made on a Spekkar Absorptionmeter (Hilger & watts Ltd., England) which was calibrated using formazin standards. Turbid water was pumped into a 200 litres overhead tank which in turn fed filter columns.

Bacterial suspensions were made by adding a pure culture of 'Escherichia Coli' into dechlorinated tap water. The bacterial counts of inflow and outflow water was measured using the plate counting technique.

Details of Filter media

Filter sand used in comparison studies had an effective size of 0.64 mm and a non uniformity coefficient of 1.41. The density of sand was 2640 kg/m^3. The depth of the filter medium was 750 mm. Both media (i.e sand and rice hull ash) were mounted on 200 mm deep layers of graded gravel. The initial porosity of the sand medium was 44% and that of rice hull ash was 93.5%.

Semi rapid filtration rates between 0.25 m^3/m^2 h and 2.0 m^3/m^2 h were adopted. In general, a head loss of 1m was used as the criterion for termination of any particular filter run.

Performances of alternative filter media

Table 1 summarizes and compares the performance of rice hull ash and sand filter media operated at semi rapid filtration rates in relation to the removal of turbidity from water. Both sand and rice hull ash filters at a given filtration rate were operated simultaneously.

A typical comparison of performance is given in Fig. 1. In general filtrate (outflow) turbidity of rice hull ash filters was equal or less than that of a sand filter operated at the same rate. Filtration efficiency, based on ratio of influent turbidity to filtrate turbidity appears to increase with time for rice hull ash filters.

Based on a head loss of 1m and the maximum amount of water produced, a filtration rate 1m^3/m^2 h appears to be the optimum rate of filtration for rice hull ash filters.

Filtration of water that contained Esherichia-Coli at selected filtration rates through sand and rice hull ash filters indicated that a certain amount of bacterial removal can be expected in both filters. However at the rates adopted, it was not possible to achieve 100% reduction to avoid disinfection of the water. Typical results obtained are shown in Figs. 2 & 3.

Series filtration

Rice hull ash filters when operated in series and can be used to attain better reductions of turbidity. Typical results are shown in Fig. 4. In this filter run, the primary filter which reduced a major proportion of turbidity was operated at 0.5 m^3/m^2 h, while the secondary filter was operated at 0.5 m^3/m^2 h. The resulting turbidity of filtrate of the combined system was less than or equal to 2 FTU for an influent turbidity range of 30-60 FTU. The primary filter was cleaned twice, while secondary filter did not require any cleaning for a period of 60 days.

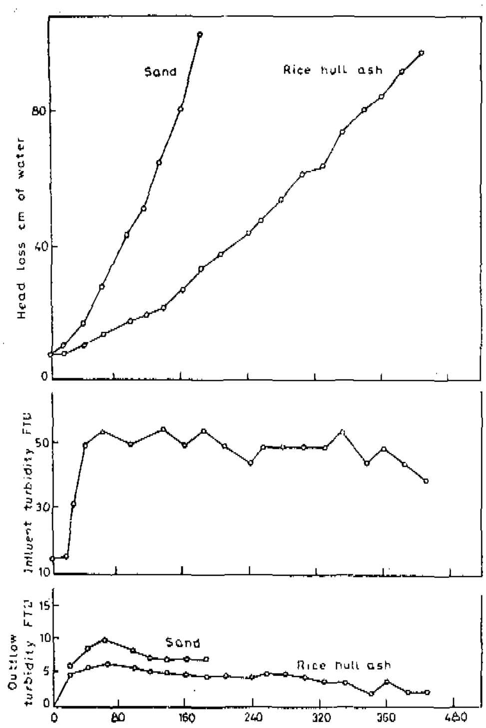


Fig. 1 Performances of sand and rice hull ash media at 1 m^3/m^2 h
Depth of medium = 750 mm

Table 1 Comparison of Filter Performance

Rate of filtration m^3/m^2 h	Type of medium	Turbidity Range F.T.U. Influent	Turbidity Range F.T.U. Filtrate	Rate of head loss, mm/d
0.25	Rice hull ash	30 - 60	1.0 - 3.0	very low
0.25	Sand	30 - 60	1.0 - 5.0	75.0
0.5	Rice hull ash	35 - 55	1.5 - 5.7	29.0
0.5	Sand	35 - 55	3.0 - 5.0	154.0
0.75	Rice hull ash	30 - 60	1.5 -11.0	59.5
0.75	Sand	30 - 60	1.3 -18.0	240.0
1.0	Rice hull ash	40 - 60	2.5 - 7.0	52.0
1.0	Sand	40 - 60	5.0 -11.0	129.0
2.0	Rice hull ash	20 - 25	5.0 - 7.0	212.0
2.0	Sand	20 - 25	7.0 -10.0	387.0

Cleaning of rice hull ash filter medium

Due to the fibrous nature of the particles it was not possible to clean the rice hull ash medium by fluidization techniques. Hence a cleaning procedure similar to that of a slow sand filter was adopted. This involved scraping of the upper layers of the medium and refilling to a proper depth using fresh rice hull ash.

Prediction of filter performance

Two techniques namely that suggested by Ives (ref.1) and that suggested by Hsuing and Cleasby (ref. 2) were used to arrive at a suitable method to predict the performance of rice hull ash filters at semi rapid filtration rates. The statistical model based on

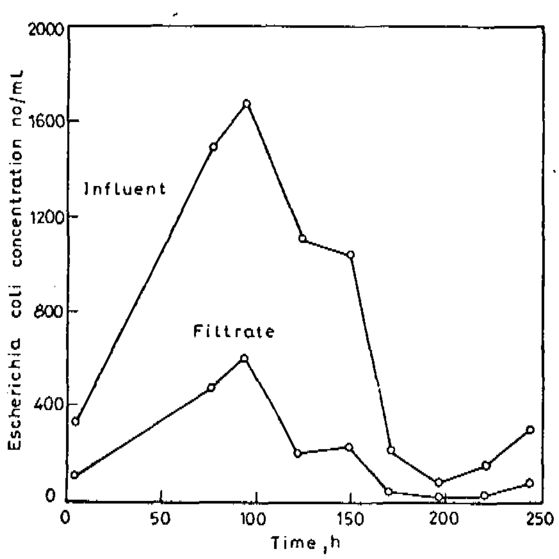


Fig. 2 Bacterial removal by sand medium
rate of filtration = $1.0 m^3/m^2$ h
depth = 750 mm; porosity = 44%

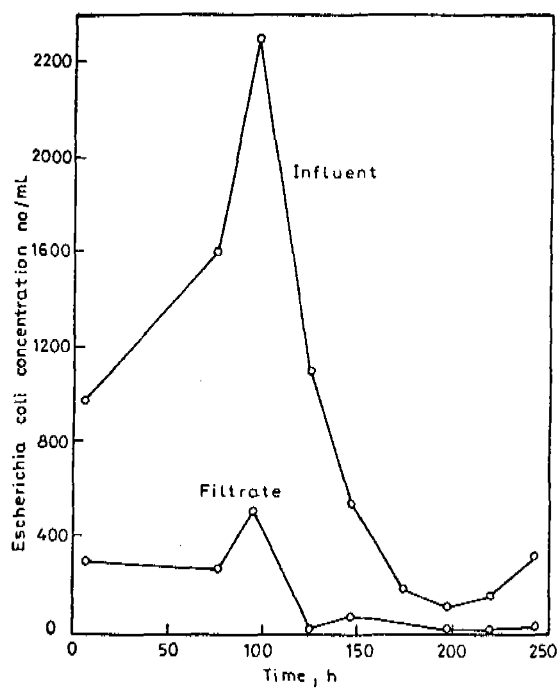


Fig. 3 Bacterial removal by rice hull ash medium
depth = 750mm ; porosity = 93.5%
rate of filtration = $1.0 m^3/m^2$ h

Table 2 Prediction of Filter Performance
Medium - Rice hull ash
Depth - 685 mm,
Rate of filtration=0.5 m^3/m^2 h

Time h	Filtrate suspended solids concentration/ influent suspended solid concentration	
	Observed	Predicted
75	0.038	0.048
100	0.040	0.035
150	0.036	0.039
200	0.036	0.045

chi - square distribution analogy (ref.2) appears to be more suitable for the purpose. This method requires data from at least three thin layer filters, operated under similar conditions, to predict the performance at the same rate at any depth of the filter medium. It was necessary to express the turbidity of influent and filtrate in terms of suspended solids concentration. In the analysis of the data a time interval of 25h was taken as one degree of freedom. Typical comparison of predicted and observed values are give in Table 2.

Conclusions

Rice hull is readily available in rural areas of developing countries of the world. Combustion of hull yeilds porous ash which is rich in silica and can be used as a filter medium. When used as a granular medium, it effectively removes turbidity from water at semi-rapid filtration rates. The performance is better than that of a sand filter operated under the same conditions. The high porosity and the fibrous nature of ash particles, lower the head loss through the medium, and hence, a longer operating period is ensured for a given head loss.

A filtration rate of 1m^3/m^2 h appears to be the optimum rate for this medium. Series filtration appears to be an attractive solution to treat high turbid water as well as moderately turbid water. However disinfection after the process is required.

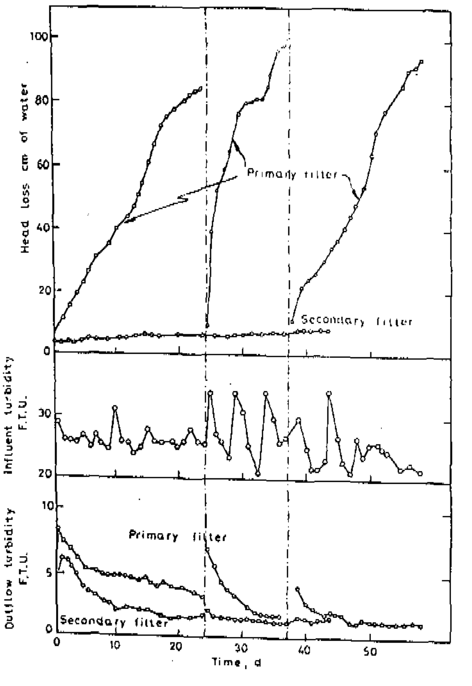


Fig. 4 Series filtration using rice hull ash medium.

rate of filtration of the primary filter = 1.0m^3/m^2 h

rate of filtration of the secondary filter = 0.5m^3/m^2 h

References :

1. IVES K J. Rational Design of Filters, Journal of Institution of Civil Engineers, Vol 16,1960,189 - 193

2. HSUING K and CLEASBY J L. Prediction of filter performances, Journal of Sanitary Engineering Division, Proceedings of American Society of Civil Engineers, Vol 94, 1968,1043 - 1067.

10th WEDC Conference

Water and sanitation in Asia and the Pacific: Singapore: 1984

Benefit-cost analysis of an irrigation tank in the north-east of Thailand

Dr J C S Tang Dr R W A Vokes and M Kunapinun

INTRODUCTION

Thailand is a predominantly agricultural country with rice farming constituting the most important economic activity. Among the four regions of the country, the Northeast is the least developed and much attention and resources have been allocated to the region to help alleviate the problem of widespread poverty. The major economic activity in the Northeast - as in the rest of Thailand - is farming. The farming economy in the Northeast is of a semi-subsistence type, dominated by wet season rice production, although there has, in recent years, been a major expansion in the production of upland crops, notably cassava. The farmers of the Northeast have to depend on irregular and unreliable rainfall as well as suffering from flooding in lowland areas in some years. The scarcity of alternative on-farm and off-farm employment opportunities and a relatively high rate of population growth have combined to make the Northeast a problem area that demands urgent attention and help.

To augment the irregular rainfall during the wet season and to provide new employment opportunities during the dry season, a large number of irrigation tanks have been constructed during the last 25 years. Lam Chamuak, the irrigation tank under study here, was completed in 1963. However, like most of the tanks built in the Northeast, the Lam Chamak irrigation system has suffered considerable damage, primarily as a result of poor maintenance. At the time of the study, only 600 rai (1 rai = 0.4 acre) could be irrigated in the wet season and not more than 1900 rai in the dry season. In the dry season up to 1900 rai received irrigation although most of this area did not receive an adequate supply throughout the dry season, resulting in very low crop yields. It is envisaged that, after the rehabilitation, a total of 10000 rai (7400 rai on the right and 2600 rai on the left of the canal) will be irrigated in the wet season plus up to 4000 rai in the dry season. The purpose of this study is to evaluate the economic and financial viability of rehabilitating the Lam Chamuak Irrigation Tank. The criteria used to judge the viability of the project are internal rate of return (IRR), net present worth (NPW) and benefit-cost ratio (B/C).

PROJECT AREA

The Lam Chamuak reservoir was formed by construction of an earth embankment across the Lam Chamuak stream. The head works (one embankment, one overflow spillway, the head regulators) of this reservoir were found to be in good condition and no remedial work was considered necessary. Water in the reservoir is supplied to the right and left of the main canals by the head regulators and then it is supplied directly to the rice fields adjacent to the canals. At the moment, only 6000 rai of farm land are irrigated and this is mainly due to the fact that the right and left bank distribution systems are damaged with rehabilitation needed for both canals. Most of the damage was caused by concentration of run-off where the canal crosses the drainage channels, erosion of soils, as well as the lack of proper maintenance during the past few years. Out of the 7400 rai served by the right canal, only 4500 rai are currently being irrigated; and 1500 rai out of 2600 rai served by the left canal are also being irrigated. When rehabilitation is completed, it is expected that all the areas on both sides can be irrigated during the wet season.

The land in the project area can be divided into three categories with most of the farmers operating some of each. Category A consists of lowland that is presently irrigated. Category B consists of lowland that will be irrigated once rehabilitation is completed. The final category, type C, consists mainly of upland, both within the boundaries of the canals and surrounding the irrigation system, which will not be affected by the project. Thus, only land in categories A and B is considered in the subsequent analysis. It is worth noting that almost all of the land within the project areas is owned by the farmers. Tenancy is not widespread in the Northeast as a whole. Prior to rehabilitation, the crops being cultivated in the lowland areas were traditional Long Duration Variety (LDV) rice and vegetables in the wet season and small areas of groundnut, mungbean, maize and vegetables in the dry season.

After rehabilitation, cropping patterns are expected to be as follows:

High Yield Variety (HYV) and Long Duration Variety (LDV) paddy during the wet season (w/s); vegetables in both the wet and dry seasons (w/s, d/s); and mungbean and groundnut during the dry season (d/s). In the wet season, it is envisaged that by the time the project reaches full development in the seventh year, approximately 60 per cent of the area planted with paddy will consist of HYV's with the remaining 40 per cent under LDV's. However, significant improvement in the yields of LDV's are expected with the project as a result of the provision of improved irrigation and improved farming practices. For the dry season, groundnuts and mungbeans are the two recommended crops. These are already cultivated by a number of farmers in the project area and their marketing prospects are good. It is envisaged that only very small areas will be planted with vegetables in both seasons. The six year build up to full project development will allow for the gradual change in cropping patterns and improvement in farming practices.

There are 499 households (HHs) in the Lam Chamuak project area with a total population of 3,892

RESULTS OF ANALYSIS

To take into account the risks of underestimating both the investment and operating and maintenance costs, a 15% contingency was also included in the analysis for both the financial and economic analyses. These results are denoted by 'BASE' in the respective Tables. Further, due to uncertainty, the results obtained for both the financial and economic analyses need to be qualified by performing sensitivity analyses. Six scenarios were included in the sensitivity tests. They are:

1. Incremental yield down by 20%.
2. Incremental production cost up by 20%.
3. Project investment cost up by 20%.
4. Use of tank only during wet season.
5. Operating cost up by 20% and incremental yields down by 10% once every 3 years.
6. Operating cost up by 20% and incremental yields down by 20% with no dry season cropping once every 3 years.

Some of these scenarios need further elaboration. Number 4 assumes that, even after the rehabilitation of the tank, farmers still plant only during the wet season as they have done thus far. Numbers 5 and 6 were included because the pattern of rainfall shortage in the tank area seems to follow a three year cycle. When this happened, additional pumping would then be required resulting in higher operating and maintenance costs, while crop yields would be adversely affected.

Results of the analysis are presented in Tables 1 and 2.

Table 1 Results of FINANCIAL ANALYSIS (including 15% contingency on investment and operating & maintenance costs).

	Case	NPW'000 (Baht) at 12%	IRR (%)	B/C Ratio
	BASE	19,179	20.08%	1.420
Sensitivity Analysis	1. Yield down 20%	6,218	18.24%	1.136
	2. Prod. cost up 20%	14,952	25.72%	1.300
	3. Invest. cost up 20%	16,413	24.55%	1.339
	4. Use tank in w/s only	5,629	18.15%	1.161
	5. Oper. cost uo 20% & yield down 10% every 3 yrs.cycle	16,854	27.21%	1.368
	6. Oper. cost up 20% & yield down 20% & no d/s crop every 3 yrs. cycle	11,789	23.29%	1.278

Table 2 Results of ECONOMIC ANALYSIS (including 15% contingency on investment and operating & maintenance costs).

	Case	NPW'000 (Baht) at 12%	IRR (%)	B/C Ratio
	BASE	19,179	20.08%	1.420
Sensitivity Analysis	1. Yield down 20%	6,218	18.24%	1.136
	2. Prod. cost up 20%	14,952	25.72%	1.300
	3. Invest. cost up 20%	16,413	24.55%	1.339
	4. Use tank in w/s only	5,629	18.15%	1.161
	5. Oper. cost up 20% & yield down 10% every 3 yrs.cycle	16,854	27.21%	1.368
	6. Oper. cost up 20% & yield down 20% & no d/s crop every 3 yrs. cycle	11,789	23.29%	1.278

CONCLUSIONS

Results of the analysis indicate that the project of rehabilitating the irrigation tank is feasible from both the financial and economic points of view. The project also remains acceptable on the basis of the assumptions used in sensitivity analyses. The results of the economic appraisal are found to be more favourable compared to those from the financial analysis. This is to be expected because the shadow wage rate of agricultural and unskilled labour for the Northeast is very low and when incorporated into the economic analysis, reduced significantly the cost stream during the life of the project. At the same time, since the domestic price of rice and paddy is kept artificially low by the operation of the Thai Government's rice export tax and premium, the shadow price of paddy is higher than its market value which in turn increased significantly the benefit stream. Both effects combine to explain why the results from economic analysis is better.

In all cases, the project is found to be most sensitive to changes in yield (case number 1), particularly of paddy, and to whether or not there are any dry season crops (case number 4). These two factors seem to have a very strong influence on the viability of similar (agricultural/irrigation) projects introduced to the Northeast of Thailand, and indicate the importance of ensuring that government extension programmes to support the improvement in farming techniques in the Northeast are effective.

REFERENCES

1. ASIAN INSTITUTE OF TECHNOLOGY, "A Feasibility Study of the Rehabilitation of Tank Irrigation Systems in Northeast Thailand", The United States Agency for International Development, Volume I - Main Report, August 1980.

2. ASIAN INSTITUTE OF TECHNOLOGY, "A Feasibility Study of the Rehabilitation of Tank Irrigation Systems in Northeast Thailand", The United States Agency for International Development, Volume X - Appendix IX, Lam Chamuak, August 1980.

3. GITTINGER, J.P., "Economic Analysis of Agricultural Projects", The John Hopkins University Press, Baltimore, 1972.

4. LITTLE, I.M.D.; MIRRLEES, J.A., "Project Appraisal and Planning for Developing Countries", Heinemann Educational Books, London, 1974.

5. KUNAPINUN, M., "Review of the Techniques of Project Appraisal and Their Application to the Irrigation Project in the Northeast of Thailand", AIT Thesis, Bangkok, December, 1982.

10th WEDC Conference

Water and sanitation in Asia and the Pacific: Singapore: 1984

Slow sand filtration and appropriate technology

R Paramasivam, V A Mhaisalkar and B B Sundaresan

1. INTRODUCTION

Community water supply systems have to be technologically sound, economically viable, socially acceptable and within the local capabilities to operate and maintain. Slow sand filtration is such a technology for purification of surface water in rural areas. The advantages of the process such as its simplicity,reliability and ability to produce a high quality water have been demonstrated at village level by a recently concluded research and demonstration project in India(1).

Because slow sand filters require a larger area and are usually cleaned manually, they are considered expensive and are opted out in preference to rapid filters while planning new schemes. This is not, however, always true and for many small water supplies slow sand filters are cost effective. This paper presents a rational approach to the design and construction of slow sand filters and a cost comparison between slow and conventional rapid sand filters.

2. BASIC DESIGN CONSIDERATIONS

2.1 Design Period A major constraint in the provision of water supplies in developing countries has been inadequate finances(2). When money is scarce and interest rates are high, long-range investments are less preferred to investments that bring immediate benefits. Since there is very little economy of scale in slow sand filter construction as shown by cost analysis later, the design period should be short; for example, 10 years.

2.2 Design Population and Per-capita Supply The design population should be estimated with due consideration to all factors governing the future growth and development of the community; transportation, agriculture, electrification, education and health services .

In most of the developing countries the per-capita water supply ranges between 40 and 70 lpd. A recent study (3) recommends a minimum of 70 lpcd when supply is through public stand posts and 90 lpcd when house connections are provided. The per-capita demand multiplied by an estimate of the future population gives the total design volume.

2.3 Rate of Filtration The traditional rate of filtration adopted for normal operation is 0.1 m/h (2 gph/sq.ft.). Pilot plant studies (4) have shown that it is possible to produce safe water at a rate of 0.2 m/h or even 0.3 m/h. Ofcourse, at these higher rates, the filter runs are shortened, but the treated water quality does not deteriorate. The 0.2 m/h rate is considered a maximum desirable rate during periods when some filters are out of service for cleaning or repairs. This recommendation deviates from the general practice in many developing countries of providing one extra unit so that the overload filtration rate is kept to 0.1 m/h. A design that does not allow even occasional overload seems to increase the size and cost of the facility unnecessarily .

2.4 Mode of Operation Pilot studies (5) have shown that intermittent filter operation is not desirable. A short time after start-up, the bacteriological quality of filtered water deteriorates and becomes unacceptable. Because the purification process is as much biological as physical, the biological organisms do best when conditions are nearly steady. In rural areas where continuous pumping may not be feasible, 24 hr operation of filters can be ensured by providing a raw water storage reservoir of adequate capacity to feed by gravity to the filters during non-pumping hours. This is being practised in several installations in India and has proved cost effective .

2.5 Number of Filter Beds To ensure uninterrupted production, a minimum of two filter units should be built irrespective of plant capacity. Three or more units may be required because the size of each unit can not exceed certain maximum practical dimensions, or three or more units may reduce overload on working filters when one unit is out of service for cleaning or repairs. It will be shown later that for a given area, the number of filter beds can be increased for higher flexibility and reliability for a marginal increase in cost of construction.

2.6 Filter shape and plant layout

Filters may be circular or rectangular. Circular filters are not economical except for very small installations. The common wall of two rectangular units may offset the inherent structural advantages of circular shape. Rectangular filter dimensions can be determined so that the wall perimeter for a given area and thereby the cost of construction is minimum .

2.7 Depth of filter box The elements that determine the depth of filter box and their suggested depths are: freeboard (20 cm.), supernatant water reservoir(100 cm.) filter sand (100 cm.), supporting gravel (30 cm.) and under-drainage system (20 cm.) with a total depth of 270 cm. The use of proper depths for these elements can reduce the cost of filter box considerably, without adversely affecting efficiency.

2.8 Choice of filter sand and gravel Undue care in the selection and grading of sand for slow sand filters is neither desirable nor necessary. Studies (4) have shown that builder grade sand could be as effective as graded sand and also reduce the cost of construction. Similarly, rounded gravel, which is often quite expensive and difficult to obtain, can be replaced by hard broken stones to reduce cost.

3. ECONOMIC AND COST CONSIDERATIONS

3.1 Minimum filter cost The cost of a filter excluding pipes and valves is made up of two components: the total cost for floor, underdrains, sand and gravel; and the cost of walls of the filter box . This cost in general is :

$$C = K_A A + K_p P \qquad \ldots \quad (1)$$

where A is the total filter bed area in m^2, P the total wall length in m, K_A the cost per unit area of filter bed, and K_p the cost per unit length of wall.

For rectangular filters arranged in a row with common walls, the problem is to minimize C subject to:

$$A = nlb \text{ and } P = 2nb + l(n+1) \ldots (2)$$

where n is the number of filters, b is the breadth, and l is the filter length.

The term $K_A A$ is constant for any value of n and any filter shape. Hence, the minimum cost solution is the solution that minimizes P, which is :

$$l^2 = \frac{2A}{n+1} \qquad \ldots \quad (3)$$

and

$$b = \frac{(n+1)l}{2n} \qquad \ldots \quad (4)$$

The equation for b, when rearranged shows that $2nb = (n+1)l$, or the condition for minimum filter cost is to have the sum of the lengths equal to the sum of the breadths.

The general expression for the minimum cost is found by substituting Equations 3 and 4 for Equation 1 :

$$C = K_A A + 2 K_p \left(\sqrt{2A(n+1)} \right)$$

A detailed cost estimate based on 1983 prices (Nagpur, India) and excluding contractor's profit for various materials and items of work has shown that the filter bed cost per square metre is Indian Rupees 500 and the wall cost per metre length is Rs. 830 .

Therefore, $K_A = 500$ and $K_p = 830$, the specific cost function written in terms of area A is :

$$C = 500 A + 1660 \left(\sqrt{2A (n+1)} \right)$$

3.2 The cost of operating flexibility For a given area, the cost of filter media and underdrain is practically the same for any number of filter beds. However, when the number of beds is increased, the cost of construction will increase because of increased wall length. The extra cost to be paid for higher flexibility and reliability is only a fraction of the cost of the least flexible acceptable design, which has only two filters and may often be judged a good investment. The percentage increase in cost with reference to the minimum of two filter units is shown in Table 1 .

TABLE 1 - PERCENT COST INCREASE FOR 3,4 & 5 UNITS AS COMPARED TO 2 UNITS ONLY FOR A GIVEN AREA

Area (m^2)	% Cost Increase		
	3 units	4 units	5 units
100	6.9	13.0	18.6
200	5.6	10.6	15.1
400	4.5	8.4	12.0
800	3.4	6.5	9.2
1000	3.2	5.9	8.5
1600	2.6	4.9	7.0
2000	2.4	4.5	6.4

The table of costs shows that for filter areas upto 2000 m^2, the number of filters can be raised from two to three by spending roughly 2 to 7 per cent more money. Building five units instead of two, costs roughly from 6 to 18 per cent more. The smaller the total area the greater the additional cost for building more than the minimum of two units. However, it would not be wise to build more units for small areas, as the unit size would become too small for practical construction. Too many filters would also demand greater attention from the operator.

If it is assumed that for a given filter area, the per cent increase in cost to provide a given number of units (against a minimum of two) should not exceed a pre-determined value, (based on the cost equation $C = 500\ A + 1660\ (\sqrt{2\ A}\ (n+1)\ )$), the lower limit of area A can be worked out for different values of n. The number of units for a given area and the cost thereof have been worked out for 5 per cent and presented in Table 2 which can serve as a ready recokener for a design engineer.

3.3 Economy of scale   A general cost model for the filter beds can be written as :

$$C = K(A)^a$$

where 'A' is the total area of filter beds, K(A) is the cost per unit area of filter bed construction including walls, and 'a' is the exponent that represents the economy of scale factor.

The cost data given in Table 2 has been used to determine the parameters 'K' and 'a' of the function by the method of least squares. The resulting equation is given by :

$$C = 1617\ A^{0.869}$$

Slight changes in the unit cost of filter bed and box wall, from the values of 500 and 830 used to derive Table 2 do not significantly change the value of the exponent 'a' .

TABLE 2 - OPTIMAL NUMBER,SIZE AND TOTAL COST OF FILTER UNITS FOR A GIVEN AREA

Area (m^2)	Capacity* (m^3/hr)	No. of units	Length (metres)	Breadth (metres)	Total cost (Rs. in million)
100	10	2	8.2	6.1	0.09
200	20	2	11.5	8.7	0.15
300	30	2	14.1	10.6	0.22
400	40	3	14.1	9.4	0.29
800	80	3	20.0	13.3	0.53
1000	100	3	22.4	14.9	0.64
1400	140	3	26.5	17.6	0.87
1600	160	4	25.3	15.8	1.00
2000	200	4	28.3	17.7	1.23

* At a filtration rate of 0.1 m/hr .

Large economies of scale are associated with small values of the exponent. Until the exponent decreases to about 0.6 or 0.7, there is no economic incentive to overdesign. Thus, very little saving is accomplished by increasing the size of the project in order to provide service over a long time into the future. It has been shown (6) that the best economic policy in slow sand filter construction is to use initial design periods of not more than 10 years and to provide for frequent expansion to meet future demand.

3.4 Cost comparison between Slow Sand and Rapid Sand Filters

An analysis of comparative costs of conventional rapid sand filters vis-a-vis slow sand filters has been presented in this section. The costs (1983 prices) for conventional plants (flash mixer, clariflocculator and rapid sand filter) were obtained from reputed construction companies in India. Based on a regression analysis of the cost data, a model has been developed for cost of rapid sand filters (Fig.1).

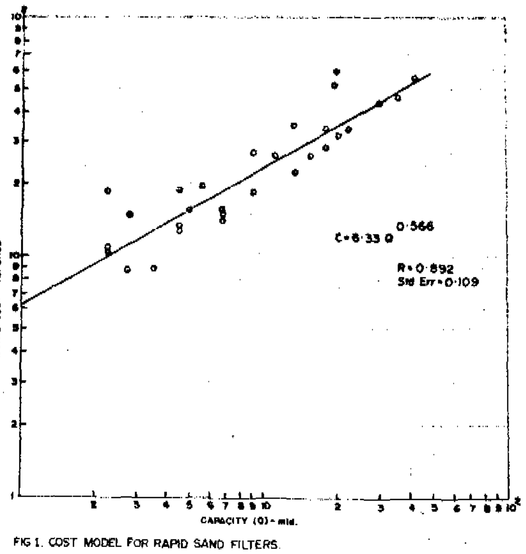


FIG 1. COST MODEL FOR RAPID SAND FILTERS.

The costs (1983 prices)for slow sand filters with no pre-treatment have been worked out for various items of civil engineering construction including cost of land. In both the cases, the costs are inclusive of overheads and profit margin. The comparative costs thus obtained for rapid and slow sand filters are given in Table 3 .

TABLE 3 - COST OF SLOW SAND Vs RAPID SAND FILTERS

Capacity (mld)	Cost (Rs. in million) SSF	RSF *
1.0	0.5	0.6
1.5	0.6	0.8
2.0	0.8	0.9
2.5	1.0	1.0
3.0	1.2	1.2
4.0	1.5	1.4
5.0	1.9	1.6
7.0	2.5	1.9
10.0	3.4	2.3
15.0	4.8	2.9
20.0	6.2	3.4

* From regression model

It can be seen from the table of costs that the capital cost of slow sand filters is less than that of conventional plants upto a capacity of about 3.0 mld. It is well established that the operation and maintenance cost for slow sand filters is always less than that for rapid sand filters. Therefore, a rational comparison has to be made on the basis of capitalised cost or total annual cost of the two systems. The capital and operation, maintenance and repair (OMR) costs for rapid and slow sand filters of different capacities have been considered and capitalised costs worked out. From the cost-capacity curves (Fig.2), it can be seen that slow sand filters are economical upto 8.0 mld., which is equivalent to serving a population of approximately 1,20,000 at 70 lpcd water supply .

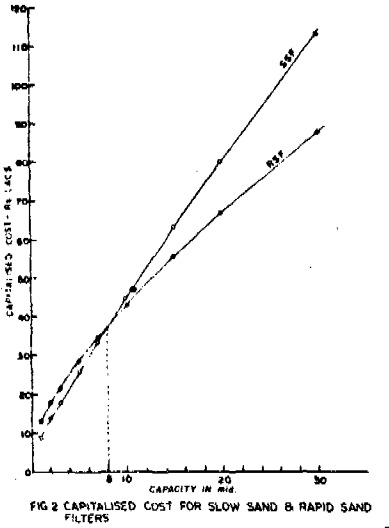


FIG 2 CAPITALISED COST FOR SLOW SAND & RAPID SAND FILTERS

Almost all the villages and towns that still remain to be covered with protected water supply in India and in many developing countries have a population of a few thousands only. Even if regional water supply schemes covering a number of villages are considered, the total population may seldom exceed 1,00,000, for which water treatment by slow sand filtration can prove appropriate and cost effective.

4. SUMMARY

In the light of recently completed research, a rational design of slow sand filters has been discussed. A cost model for filter has been suggested and it has been shown that there is no economy of scale in slow sand filter construction. Cost comparison between slow and conventional rapid sand filters has proved that for plants of capacity upto about 8 mld, slow sand filters are cheaper .

REFERENCES

1. Slow Sand Filtration Project Report, Phase II, NEERI, Nagpur, India, (1982) .
2. PINEO, C.S. & SUBRAHMANYAM, D.V. Community Water Supply and Excreta Disposal Situation in the Developing Countries - A Commentary, WHO, Geneva, (1975).
3. Report on Evaluation of Rural Water Supply Schemes in India - Sundaresan, B.B., Kshirsagar,S.R., Paramasivam, R., NEERI, Nagpur, India, (1982).
4. Slow Sand Filtration Project Report, Phase I, NEERI, Nagpur, India, (1977) .
5. PARAMASIVAM, R. et al . Effect of Intermittent Operation of Slow Sand Filters on Filtrate Quality. Indian J.Environ.Hlth. Vol.22, No.2, (1980), 136-150 .
6. PARAMASIVAM,R. et al . Slow Sand Filter Design & Construction in Developing Countries, AWWA Journal, (1981),April, 178-185 .

SESSION 6

Chairman: Mr Ian Vickridge, Nanyang Technological Institute, Singapore

Discussion

M Borghei
Water supply for Tehran

1. Dr BORGHEI described the water supply problems facing Tehran, and outlined the available water sources and how they could best be used to help solve the problems.

2. Mr YAW reported that his firm had undertaken the masterplan for the sewerage of Tehran, and one recommendation was that treated effluent should be used for irrigation; such schemes were in use in other parts of the Middle East.

3. Dr BORGHEI replied that although this would release potable water for drinking, it would take over 10 years to implement such a treatment scheme, and at enormous cost; it was no solution in the short term. However, polluted underground water could be used for irrigation, releasing river water for treatment and distribution.

4. Mr KSHIRSAGAR asked what was the soil type around Tehran, and could it continually absorb vast quantities of wastewater.

5. Dr BORGHEI replied that most of the city was on a sandy soil, which had a very high absorptive capacity. Four small treatment plants were under construction to deal with the problem in some areas of the city.

L G Hutton
Aspects of field testing of water

6. Mr HUTTON discussed the techniques of bacteriological testing in the field, and described the equipment necessary in different circumstances.

7. Mr SPENCER asked what were the minimum educational levels and training requirements before staff could competently use chemical and bacteriological field testing equipment.

8. Mr HUTTON replied that he had successfully trained operators with only three years of secondary education; it would take about one week to train somebody to use membrane filtration equipment, although this depended greatly on the ability of the trainer to put over techniques of asepticity. It was probably more important to have a trainee who was keen and willing to learn, rather than worry about formal qualifications.

9. Mr VICKRIDGE wished to know what stage of development had been reached with the field incubator.

10. Mr HUTTON said that the field incubator was being tested for its long term operating characteristics, and various types of temperature control were being assessed. He suggested that Dr B LLOYD of Surrey University had done more work on this, and that he should be contacted for further details.

11. Dr BORGHEI asked for the author's comments on microfiltration units which are claimed to produce bacteria-free water.

12. Mr HUTTON stated that if they were correctly installed, operated, and well-maintained, they should work well. The specification of the filter pore size needed to be carefully investigated. However, microfiltration would not remove viruses.

13. Mr AINGER asked for advice on sampling water for bacteriological analysis.

14. Mr HUTTON quoted the following passages from his book on field testing of water quality:

"There is a saying that 'the analysis is only as good as the sample'. The sample should be representative of the bulk of the water being examined and care should be taken to ensure that there is no accidental contamination of the sample during sampling. Sample collectors should be trained and made aware of their responsibilities. The samples should be clearly labelled with the site, date, time, nature of the water and either analysed on the spot with field kits, or sent to a suitable laboratory for analysis without delay in a suitable transport and storage container. Samples which cannot be analysed within 24 hours of sampling could be membrane filtered on site and transferred to transport media before final examination and incubation within 3 days. (WHO, 1983). When several samples are being taken for water quality testing at the same location, the sample for bacteriological examination should be collected first to avoid danger of contamination of the sampling point.

Samples for bacteriological analysis must only be collected in sterile bottles. The bottle should be kept unopened until it is to be filled. The stopper should be removed and during sampling neither it nor the neck of the bottle should be allowed to touch anything. The bottle is best held by the other hand around the base of the bottle. Do NOT rinse out the bottle with the sample and do not completely fill the bottle. This will allow the sample bottle to be shaken prior to analysis.

In some cases it may not be possible to collect the sample directly in a sample bottle, and a sterile stainless steel jug or cup should be used. The stainless steel container can be sterilised by igniting methyl or ethyl alcohol inside it. The water collected should be transferred to the sample bottle.

Samples are taken to be representative of the bulk of the water under examination. Surface waters such as rivers, lakes, streams, reservoirs, should be sampled away from the banks if possible. In tropical areas the sampler is putting himself at risk from schistosomiasis (bilharziasis) when he is in the water and he should therefore wear waterproof gauntlets and long boots to prevent the cercariae from penetrating the skin and invading his body. The outside of the sample bottle also needs to be carefully rinsed with disinfectant to kill off any cercariae on the bottle. A Wipex cloth could be used to wipe the bottle. In tropical regions the medical authorities should be consulted about the risk of schistosomiasis and for advice before sampling takes place.

It should be remembered that the numbers of bacteria being determined can be very small and the sample being collected should not have any contact with the person, clothing or any object used to assist the collector in approaching the sample site.

If by accident the sample bottle thread or the inside of the cap or stopper is touched the sample bottle should be discarded and another sterile bottle should be used. It is good practice to have some spare sterile sample bottles on your person when sampling.

If the sample is being taken from a source of supply make the collection as close as possible to the intake to the treatment plant. Samples should be taken about 30 cm (1 foot) below the surface or at mid-depth if the depth of the stream is less than 30 cm. Hold the bottle by the base with the opening into the current.

When full bring the bottle to the surface and CAREFULLY replace the cap on the bottle.

For wells or boreholes equipped with a pump, the pump should be operated to clear any standing water in the water column (this pumping could be at least 20-30 minutes depending on the depth and diameter of the borehole) before the outlet pipe is sterilised using either a gas torch or alcohol flaming. Operate the pump for a further 2 minutes and take a sample in the flowing stream of water. For shallow, open wells a weighted bottle or shallow sampling device may be used.

A sample from the water carrier's pot or bucket may be more representative of what is actually being drunk so take a sample poured into the bottle from her bucket as well.

If the water is stored in the household then the household container would also need to be sampled. Positive results from the household would indicate bad hygiene in the household rather than polluted groundwater.

To sample from a tap:

First check that the tap is fed directly from the pressure mains and not a cistern or roof tank. Remove any nozzles or filters from the tap and if the tap leaks replace the washer. Clean the outside of the tap. Turn the tap full on and allow it to run to waste for 4-5 minutes. Close the tap, dry it with a clean cloth (Wipex are useful for this) and sterilise the opening of the tap with the gas torch or alcohol flame. Turn on the tap and after 1-2 minutes carefully collect a sample from a flow run at the normal usage rate but avoiding splashing. When sampling from copper or galvanised iron pipes, the flushing time should be increased as the metals can have a bactericidal effect on the sample.

If a supply is chlorinated it is necessary to neutralise any residual chlorine in the water otherwise any bacteria present will be killed or prevented from growing on the culture medium. Sodium thiosulphate is used to inactivate the chlorine and is usually added to the sample bottles in solution before sterilisation. It is normal practice to add the sodium thiosulphate to all sample bottles so that the sterile bottles can be used for chlorinated or unchlorinated supplies.

Because sodium thiosulphate has been added sterile sampling bottles are not rinsed with the samples before sample collection for bacteriological analysis.

Determine the concentration of residual chlorine at the sampling point at the time of sampling."

T V Jacob

Potable water exploration: Kavaratti Island

15. Mr JACOB discussed the water supply situation on the Island of Kavaratti, and described the existence of a freshwater

lens, and how it was mapped out, to help provide drinking water for the island.

16. Mr BERRY provided the following description of a similar project in the Bahamas. The general formation was permeable coral limestone, and in most places the ground level was only a few feet above mean sea level, which also approximated to the ground water level. This was because the high permeability permitted fairly rapid seawater flow, and the freshwater surcharge was only a few inches. Consequently the total depth of the freshwater lens was limited. The object of the research project was to try to build up a thicker layer of freshwater by constructing continuous vertical barriers to prevent the lateral loss of freshwater. The freshwater so retained should then float on the salt water, with a shallow diffusion zone at the base of the barrier, with tidal fluctuations causing some mixing of fresh and saline water. Six enclosed areas were formed using vertical membranes either of butyl rubber or bentonite slurry; various depths of membrane between 8 ft and 20 ft were used. Observations of water level and salinity were made. Before construction, the groundwater salinity was the same as that of the sea, and the 'tidal' movement of groundwater about 90% of the sea's tidal range. After construction, at the most successful unit, which was the deepest one, the salinity had fallen from 30 000 ppm to 200 ppm at the surface and 1200 ppm near the base; the tidal movement was damped down to 20%. These improvements took 8 months to occur. Theoretical calculations indicated that 20 inches of freshwater per year could be recovered, with a saline limit within that recommended by WHO. The disadvantage of the method was the time lapse between construction and use.

T R Mampitiyarachchi

Appropriate technology for water filtration

17. Dr MAMPITIYARACHCHI presented her paper, which considered the use and performance of alternative filter media, such as rice hull ash, in reducing the turbidity of water.

18. Mr PARAMASIVAM observed that the results could indicate that impurities were penetrating deep into the filter bed; if this was so, cleaning along the lines of slow sand filters would not remove all the impurities; he asked if an economic comparison with conventional filters had been carried out.

19. Dr MAMPITIYARACHCHI replied that the evidence was that most impurities were removed at the surface; economic analyses had not been carried out.

20. Mr KSHIRSAGAR stated that the filtration rate was slow, which meant that a large filter area would be required; he asked whether a two-layer filter had been considered, and whether the author was aware of the work on dual media filters, using crushed coconut shells.

21. Dr MAMPITIYARACHCHI said that these filters were operated at semi-rapid rates and pointed out that at the optimum rate, they required less land than slow sand filters. They were appropriate for rural areas where husk was available, and land was cheap. The possibility of a dual filter system had not been considered; the author was aware of the work on coconut shells.

22. Mr BRADLEY requested the author to comment on the lifespan of the filter material, which could break down naturally. He asked if the author was aware of the use of this filter material for intermittent secondary or tertiary biological treatment of wastewater, as this may well be a useful application.

23. Dr MAMPITIYARACHCHI replied that she did not know how durable the material was, but the lifespan would be less than conventional filter sand. She had not heard of any application of the method to wastewater treatment, but added that this could be worth investigating.

24. Mr SIDDHI remarked that the study was both interesting and relevant, and wished to know whether field trials had been carried out, and whether this media could be used in the dual filter media filtration process.

25. Dr MAMPITIYARACHCHI said that field trials had not yet been done, and that there seemed to be a strong possibility that the media could be used in a dual media process.

26. Mr YONG commented that studies on rice husk and coconut fibre as filter media had been carried out at AIT in Thailand, and some treatment units had been built; papers were still available from AIT.

J C S Tang, R W A Vokes and M Kunapinum

Benefit cost analysis of an irrigation tank in the north east of Thailand

27. Dr TANG presented the results of an economic analysis of rehabilitating an irrigation tank, and discussed the sensitivity

of the analysis to various parameters.

28. Mr CULLEN pointed out that Internal Rate of Return value in Table 1 should be 29%, otherwise the other data did not seem to fit.

29. Dr TANG agreed, and pointed out that he had mentioned this during his presentation.

R Paramasivam, V A Mhaisalkar and B B Sundaresan

Slow sand filtration and appropriate technology

30. Mr PARAMASIVAM presented a rational design method for slow sand filters, and demonstrated that there was no economy of scale in slow sand filter construction.

31. Mr YONG asked about the possibility of using slow sand filters to treat water with a turbidity of 100 units, and a colour of 200 units.

32. Mr PARAMASIVAM replied that if the turbidity conditions only occurred infrequently, the filters would work reasonably well, but if the conditions persisted, pre-treatment would be needed to reduce the turbidity to about 10 units. This could be achieved by storage and pre-filtration. Slow sand filters could reduce the colour by about 80% if it was natural in origin, but not if it was due to industrial waste discharge.

10th WEDC Conference

Water and sanitation in Asia and the Pacific : Singapore : 1984

Solid waste management: the Philippine experience

Melchor T Gadi

1.0 INTRODUCTION

Throughout the Philippines, inadequate resources have been allocated to the important aspect of solid waste management, As a result, the solid waste management systems can no longer cope with the burdens placed upon them. The collection and disposal facilities of all major cities and municipalities are in need of repairs and replacements. Inadequate handling and disposal of refuse is causing health, social and environmental problems such as the transmission of pathogenic microorganism, contamination of air, water, and land, and the emergence of scavenging as a way of life.

The Philippines is a developing country. It is composed of 60 cities and 1,502 municipalities. It has a population of 48, 098,400 and a density of 160.3 persons per sq. km. with a growth rate of 3.04%. The country is in the process of industrialization, consequently, the population residing in urban areas are increasing. There is more consumption of resources and production of more solid wastes in the country's growth centers.

The problem of solid waste is emerging as an urgent national problem. Yet, while funds are often devoted to the construction of roads and bridges, building of airports, and developing the tourism industry, the problem of solid waste management is starved of resource inputs.

In this light, the National Environmental Protection Council, (NEPC) implemented the National Solid Waste Subsidy Program (NSWP). The NSWP hopes to solve these problems by providing the necessary financial and technical assistance to local government units to effect a more vigorous and coordinated effort to contain waste collection, transportation, processing and disposal problems.

2.0 THE PRESENT SOLID WASTE MANAGEMENT SYSTEM

Solid waste management in cities and municipalities is being administered by the respective local government units. However, data regarding the operation components of solid waste management has been comparatively inadequate. Cities and municipalities made no measurements, and in few cases, the data presented only suburban area and not the peripheral rural communities. The NEPC recently coordinated a nationwide survey to determine the status of solid waste management in the country. The following are the results of that survey.

2.1 Solid Wastes Sources

The primary sources of city and municipal solid waste are households or residential areas, street sweeping, commercial and industrial establishments and the agriculture sector. The main constituents of solid waste are more or less similar but proportions vary widely due to the population factor and differences in income levels. As income levels rise, the percentage of paper, metals and glass increase while the percentage of household or kitchen refuse decline. In Metro Manila, the per capita waste generation is 0.40 kilo per day. It is 0.10-0.20 kilo lower in the other areas.

The surveys indicate that household or residential waste constitute the bulk of municipal and city solid waste, averaging 50% of the total wastes generated. Wastes from industrial and commercial establishments is the second largest source of solid waste (30%), followed by street sweeping and agricultural wastes (20%).

2.2 Solid Waste Storage

Various storage containers are presently in use throughout the country, many of which are unsuitable for proper storage. In major thoroughfares, 200-liter communal containers are findings greater use.

In residential areas, it is a common practice for housewives to keep handy receptacles inside their premises to avoid loss or theft and bring them out only for collection and disposal. Individual containers are mainly metal or plastic pails, paper and plastic bags, baskets, cardboard cartons sacks, with the exception of the plastic containers such as plastic bags, all are uncovered and poorly maintained. When communal containers are filled to capacity, excess waste is dumped beside the containers.

2.3 Collection and Transportation

Collection systems are operating in all of the cities and majority (62%) of the municipalities in the country. The typical collection system is relatively simple in operation and organization, consisting of refuse pick-up by two or three crews from the place of storage, transfer of refuse to a transporting vehicle and delivery of the refuse to a point for disposal. Simplicity, however, does not connote uniformity of operation. Collection practices across the country area as varied as they are numerous, each having a peculiar set of conditions. Variations are found in the points of refuse pick-ups, frequency, of pick-ups, types of containers, methods of transfer, types of transporting vehicles, crew sizes and disposal methods. The frequency of collection is governed by the volume of wastes and the budget for solid waste collection. Collection service is limited to the poblacion or city proper.

Collection is generally done by the collection crew who pick up the refuse containers at the street curb or just outside the buildings or residence involved. Street cleaners and sweepers are employed to collect refuse materials from the public areas including market places, using carts, and for delivery to containers which are picked up by collection crews. As indicated by field investigations the percentage of urban population served by collection system varies between 16% to 71%, with an average of 27%.

Although collection of solid waste is reportedly being made daily in some areas, the service is generally inadequate and ineffective, particulary in peripheral barangays. Collection is further hampered by very limited budget for solid waste management. The dump trucks are frequently out of service because of lack of maintenance and repair. Most of them are obsolete. Another dilemma facing local government is the rising oil prices. The result is deficient service which lead to public dissatisfaction and a general feeling of indifference of people towards solid waste management.

The deficient collection system consequently result of burying of uncollected garbage in crude pits in individual backyards if available, or worse, to indiscriminate dumping in vacant lots, river banks and other water bodies.

2.4 Resource Recovery/Recycling

Throughout the country, recycling is already being practiced to a considerable degree at the household level. Organic wastes are largely being utilized as food for chickens, pigs and animals. Many household operate manual backyard composting and use the resulting compost of their plants. The utilization of animal waste for the production of methane gas is also gaining popularity. To certain extent, resource recycling is also being practiced by the collection crew. Being underpaid and working under harsh conditions, segregating materials such as tin cans, plastics, bottles from organic garbage provides additional income for their families. This is done in the collection vehicle usually by the crew receiving and emptying the garbage containers. Aside from this, several syndicated junk dealers are in operation as attesting to the viability and profitability of such a venture.

Salvaging is done by private individuals (scavengers) who usually live with their families in shacks near dumpsite. These scavengers in turn sell the salvaged materials to dealers. In Metro Manila alone, it is estimated that there are about 10,000 scavengers at various dumpsite.

Scavengers lead a miserable life. They worked on freshly-tipped uncompacted, putrescent materials. They are exposed to the weather during the process of sorting, subjected to obnoxious odors from rotting materials. They are exposed to pathogenic organisms from nightsoil and septic tank sludges.

2.5 Solid Waste Disposal

Open dumping in land and water system is the method utilized throughout the country. This method is simple and cheap. However, this practice poses serious threats to the environment.

A pilot composting plant, using pre-sorted shredded materials was operated in Manila in early 1960. It reportedly demonstrated the feasibility of a 21-day cycle with forced aeration. The installation still exists, but was not able to operate due to technical problems.

2.6 Financial Support Systems

The matter of financing a solid waste management system is one of the most aggravating problems facing administrators. The total problems of solid waste in the municipalities and cities reflects years of financial neglect.

The municipal reports indicate that expenditures for waste management average less than ten percent (10%) of the municipal budget with some even going as low as one percent (1%). Most of the expenditures are concentrated mostly on the collection phase such as wages, fuel, repair and maintenance of vehicles and do not include non-budgeted expenditures. Solid waste management activities are greatly underfinanced and the additional expenditures will be necessary to improve conditions and procedures for effective control. General revenues come most often from property taxes, and other tax sources which may be used by the municipality or national government. Solid waste management financing has traditionally been financed through the general revenue process.

3.0 THE NATIONAL SOLID WASTE SUBSIDY PROGRAM (NSWP)

Improved solid waste management systems and practices can be achieved. However, a concerted effort at all levels of the government and the populace is required. The National Solid Waste Subsidy Program (NSWP) was launched in 1979 to serve as a catalyst to achieve this end. The goals of the program are:

(1) To provide assistance to local government units for more efficient and effective collection, transportation, processing, recycling and disposal of wastes to protect the health and aesthetic conditions of the community;

(2) To encourage, promote and stimulate technological, educational, economic and social efforts in preventing environmental damage and unnecessary loss of valuable resources of the nation through recovery, recycling and re-use of wastes and waste products.

To achieve the aforementioned objectives, the following actions are being undertaken:

. Provide financial assistance for the design, construction, acquisition of refuse equipment and facilities.

. Discourage open dumping of refuse and promote the conversion of existing dumps to sanitary landfills.

. Provide technical assistance to local government units for the development of solid waste management plans that will promote improved refuse management techniques, more effective organizational management, improved methods of collection, processing, recovery, and disposal of refuse.

. Promote the demonstration, construction, and application of solid waste management practices that preserve and enhance the quality of the environment.

. Provide for the promulgation of rules, regulations, guidelines for solid waste management.

. Promote research and development programs for resource conservation techniques and environmentally safe disposal of solid wastes.

Any provincial, city or municipal government, represented by their respective local executive can avail of the subsidy by submitting a project proposal to the NEPC. The proposal must include the description of the solid wastes problem in the area, the proposed solution, the needed resources, and the workplan. In addition, a survey form, which will describe the existing solid waste management practices of the area must be accomplished.

The project proposals are evaluated based on the following criteria:

1. Environmental significance: The project should contribute to the direct improvement of the existing state of ecological balance (i.e, water quality, air quality).

2. Impact of the project on the locality: The project should have a general impact on publicly-held resources. It should provide the greatest benefit to the largest number.

3. Economic acceptability: The proposed project should not be too capital intensive, it should be capable of being replicated in other areas of the country.

4. Implementation capability: The proposed project should be operational within a short time as possible. The project should utilize existing resource, skills and capabilities of the implementing agency.

5. Political and public acceptability: The public should be willing to accept the new system. The local agency should be able to demonstrate the overall benefits to the local populace to achieve acceptability.

With its limited annual budget of ₱1,000,000 (US $71,900 as of February 27, 1984) the program has extended assistance to 44 municipalities and 14 cities towards the improvement of their solid waste management systems. Among the projects that were implemented under the program are:

. <u>Push-A-Cart (Collection and Disposal):</u> The project involves the use of appropriate technology as an answer to the rising cost of equipment and capital outlay attendant to high technology. Pushcarts, instead of dump trucks, are utilized for refuse collection. Out-of-school youths and the unemployed are recruited to collect the refuse from the household for disposal in small sanitary landfill sites. The projects have provided a relatively inexpensive yet sanitary method of collection and disposal. Further, it has maximized the collection of household wastes in peripheral areas not serviced by the existing collection facilities.

. <u>Cash-in-Trash (Resource Recovery):</u> The project recruits scavengers (people who earn their living in the dumpsites) to serve as Eco-Aides. The Eco-Aides are trained and fielded to buy the recyclables wastes from the households. The recyclables are then sold to the end-buyers.

The resource recovery project have provided a more decent means of living for scavengers. It has minimize their exposure to excessive filth at the dumpsites. Through the project the volume of garbage is reduced. In turn, the household earn extra cash, no matter how small, from what are commonly considered useless garbage.

. Sanitary Landfill:
Through the program, the first sanitary landfill operation was established in Lucena City, a 120,000-population community, 120 kms. east of Metro Manila. Other communities are contemplating on the adoption of the landfill method in their area because of the excellent response of the public on the project.

. Biogas System:
Most markets and slaughterhouses are plagued by poor sanitation practices. The biogas project utilizes the abundant wastes in these places as energy sources through the installation of biogas digesters.

A sub-component of the project is the use of septic tank as biogas generators. The project involves the construction of toilet facilities coupled with methane gas generator which augment the energy requirements of the household.

. Toilet Construction
Ten thousand (10,000) water-sealed toilets were constructed around the Laguna Lake, the Philippines' largest lake and the chief source of our fish supply. The toilets were constructed to prevent the environmental deterioration of the lake due to improper disposal of excreta.

. Preparation of Solid Wastes Master Plan:
A solid wastes plan was prepared for Metropolitan Manila to strengthen its capability in solid waste management. The master plan identifies appropriate technology, for the efficient collection and disposal of solid waste. Alternatives solid waste management systems are studied and the least cost solution identified for an integrated resource recovery and solid waste management program.

. National Solid Wastes Management Seminars:
The first national seminar on solid waste management was conducted to enhance the managerial and technical capabilities of solid waste administrators. Similar seminars will be conducted on a regional and provincial basis.

4.0 CONCLUSIONS

The accomplishments of the National Solid Waste Subsidy Program are insignificant when compared with the solid waste problems facing the country.

Given to usual financial limitations characterizing a developing country like the Philippines, it can optimize its meager resources alloted for solid waste management by taking into consideration these strategies:

. Use of systems approach in solid waste management:
This does not mean the application of complex mathematical models but rather the use of systems orientation in dealing with problems. This implies the recognition of interdependence between all elements of the solid waste systems, definition of objectives, constraints, etc.

. Use of available, low cost and appropriate technology:
Careful analysis should be made regarding the utilization of imported equipment and technology. Although foreign assistance are available in forms of loans, grants and aids, most of the technologies and equipment offered are inappropriate for the local conditions. Most of these equipment are mechanized, labor displacing and require special and expensive maintenance.

. A grassroot public awareness campaign:
People are just naturally opposed to change, hence, a new system must demonstrate a change for the better if acceptability is to be achieved. An information campaign demonstrating the benefits of the new system should be undertaken before any system is implemented.

"Let everyone sweep in front of his door and the world will be clean". What Goethe said used to be true in our country. But we have run out of backyard spaces for disposal. Solid waste management has become a messy, complicated and expensive operation requiring huge resources. The problems have outraced our capabilities to solve them. The National Solid Wastes Subsidy Program is desperately trying to close the gap.

5.0 REFERENCES

5.1 National Census and Statistics for 1982, National Census and Statistics Office (NCSO), Manila, Philippines, 1982.

5.2 The Philippine Environment, NEPC, Quezon City, Philippines, 1982.

5.3 National Survey on Current Solid Waste Management Systems and Practices, National Environmental Protection Council (NEPC), Quezon City, Philippines, 1983.

5.4 National Solid Waste Subsidy Program Accomplishment Report (1979-1983) NEPC, Quezon City, Philippines

10th WEDC Conference

Water and sanitation in Asia and the Pacific: Singapore: 1984

Composting of urban solid wastes

Professor K J Nath and S K Dasgupta

1. INTRODUCTION :

The paper reviews the present status of composting in various cities and towns of India and brings into focus some of the basic short comings in the technology that is holding up the progress of an otherwise sound programme. The authors suggest an appropriate technology with optimal degree of mechanisation suited to the refuse characteristics and techno-economic resources of the local government bodies in India, in the light of their experiences in the pilot compost plant in South suburban municipality, Calcutta.

2. COMPOSTING : BASIC PROCESS KINETICS :

In composting the aim is to provide Optimal areation, moisture, and temperature for the bacteria, moulds fungi and other form of life to flourish and perform their task in the stabilisation and decomposition of the wastes at rapid pace.

The organisms work on the surface of the organic wastes. Therefore, the speed, thoroughness, and uniformity of decomposition are improved if the material is first shredded in smaller pieces to increase the surface area exposed to biological activity. However grinding the particles to sizes less than 2" adversely affect aeration.

Mechanical compost plants for Municipal Solid Wastes consists of the following steps.

i. Reception
ii. Segregation and picking
iii. Compost preparation (shredding, pulverisation, magnetic removal of metals etc).
iv. Decomposition-In Windrows. -Aeration in enclosed cells.
v. Stabilisation in maturing yards.
vi. Post treatment (screening).
vii. Marketing.

These are the basic steps which are to be found in almost all process designs that are currently available in this country.

3. PRESENT STATUS OF COMPOSTING IN INDIA :

The physical and chemical characteristics of Indian city refuse, show that 40 to 60% of it is compostable and that it has adequate nutrients (NPK), optimal moisture content of 40 to 50%, and Carbon to Nitrogen ratio of 25 : 1 to 40 : 1. Hence, composting of city garbage can produce good quality organic manure and soil conditioner, at a cost which is much lower than that of artificial fertilisers. Considering the scope, need, value and importance of conversion of city refuse into organic manure, in the interest of both agriculture and sanitation, Indian Ministry of Agriculture, is subsidising city compost plants and assisting them in management and maintenance of plant as well as marketing their products. At the moment in India, two methods of composting is practiced by different municipal organisations.

a) Pre-treatment or Post-treatment windrowing (Mechanical/semi-mechanical/mannual) : Larger City Corporation/municipalities.

b) Indore or Bangalore method of composting of refuse with night-soil in masonary pits or earth-trenches : Small and medium Municipalities.

Pre-treatment or Post-treatment Windrowing :

During the last decade, Mechanical compost plants of the above type, have been constructed in 25 cities which now treat 10 to 20% of Urban Solid wastes in most of the important cities in the country. A careful study of the Indian situation will reveal that.

i) Designs of various mechanical components of pre-treatment or post-treatment is yet to be standardised. In many of the existing plants inappropriate technology and unnecessary mechanisation has resulted in higher cost of production. Advantages of mechanisation should be made

TABLE : 1 - Relative Cost Effectiveness of Different Methods of Composting in INDIA

Method of Composting	Capacity tonnes/day	Area required (M^2)	Production cost. Rs./tonnes	Sale Price Rs/Tonnes	Remarks.
1. Indore/Bangalore Method(Manual)	1 to 20		1 to 30	1 to 35	36% of the plants. are self paying.
2. Windrow composting Post-treatment (Manual)	3 to 10 T	500 to 1000	30 to 50	30 to 50	Self paying
3. - do -	10 to 20 T	1500 to 2000	20 to 40	30 to 50	Self paying
4. -do-(Semi-mech)	50 T	4000	20 to 30	30 to 50	
5. Post-treatment (semi-mechanical)	200 T	10,000 to 20,000	50 to 60	40 to 50	Could be self paying.
6. Pre-treatment (Mechanical-Western type)	200 T	10,000 to 20,000	100	40 to 50	Losing

use of, but-turn-key projects of patented process developed for western conditions requiring high degree of skills for operations and maintenance, as have been done for many of the present plants in India, would be counter productive.

ii) Costly pre-treatment units like, hammer mills, magnetic seperator, mechanical aeration system etc. may not generally be required for Indian refuse, which comes mostly in sizes less than 2" and contains negligible amount of ferrous metals.

iii) Manually operated windrow plants would be cost effective upto 30 Tons/day capacity i.e. for a population of 60,000. At this level the transportation cost of refuse and compost would also be minimal. Hence, manual composting could be an ideal disposal method for small and medium suburban towns at close proximity of agricultural hinterland.

iv) For plants receiving 100 tons or more some mechanisation would be necessary for handling and turning of windrows and post-treatment.

v) One ton of finished compost produced from the Indian city refuse, would contain about 20 Kg. of Nutrient (NPK) value. At the current market conditions, it would be worth Rs.100/- (£ 1 = Rs.15/-, 1983). A semi-mechanical compost plant, with minimum mechanisation for handling and turning of windrows and post-treatment, would be able to produce it @ Rs. 50/- to Rs.60/- per ton. But the paradox of Indian situation is that unnecessary and avoid-able mechanisation, have pushed the production cost to Rs.100/- per ton and in absence of adequate sales-promotion efforts, most of the City Corporations are finding it difficult to sell their product at that price. Inadequate planning, inappropriate technology and poor management, is holding up the progress of a basically sound programme. However, one should not lose track of the fact, that even at the present level of production cost and market price, the net disposal cost of urban solid waste through composting, varies between Rs.15/- to Rs.20/- per ton, which is marginally higher than the cost of sanitary land filling as practised by the Delhi Municipal Corporation and almost comparable to the cost of crude dumping carried out by the Calcutta Corporation. Table-1 shows the relative cost effectiveness of different methods of composting. Table-2 shows the break up of capital O & M costs for manual, compost plant.

4. PILOT STUDIES ON MANUAL/SEMI-MECHANICAL COMPOSTING :

The pilot compost plant was developed to study the following aspects:

i) Considering the characteristics of Indian city refuse, effect of mechanical pre-treatment like shredding, grinding pulverisation etc. on the quality of finished compost.

2) Technical and economic feasibility of completely manually operated wind-row compost plants in respect of Land and labour requirement, production cost, quality of compost and its marketability and minimal and maximal plant capacity.

3) Optimal level of mechanisation needed for larger plants in respect of land requirement, production cost and capacities of municipalities to operate and maintain them.

A layout plan of the pilot compost plant is shown is fig. 1, and land requirement, labour, capital and O & M costs etc. are shown in Table-2.

TABLE : 2

Unit Cost of Manual Composting.

Capacity	= 10 T refuse per day.
Required land area	= 15000m^2 = 0.15 Ha.
A. Capital Costs	(In Rs.)
1. Land Cost @ Rs. 5,97,600/- per ha.	89,600/-
2. Screen	5,000/-
3. Fencing gate, flooring	50,000/-
B. Operating Costs (Annual average)	
1. Amortization @ 17%	9,350/-
2. Labour	33,600/-
3. Tools and Plants, etc.	3,000/-
	45,950/-
Add 12½% for establishment and contingencies etc.	5,743/-
	51,693/-

O & M Cost = Rs. 17.23 per ton.

Disposal Cost through manual composting = Rs.17.23 + Rs. 3.00 = Rs.20.23/Ton

Production Cost = Rs.40.46/Ton compost.

Anticipated Income = Rs. 40 per ton of compost i.e. Rs. 20 per ton of refuse.

5. SALIENT FINDINGS OF THE STUDY :

On the basis of the experiences gathered so far the following observations could be made.

(a) It could be seen from Table - 3 that manually operated windrow compost plants, without any mechanical pretreatment like pulverisation, grinding, shredding etc. could produce compost manure of chemical quality comparable to those produced by mechanical compost plants.

(b) A period of windrow-aeration between 16 to 21 days, with 3 turning in between and a turning period of four weeks would be necessary for manually operated plants. The process becomes more efficient with minimal pre-treatment of chopping of larger organic metters, which could be done by simple manually operated machines.

(c) A higher windrow-aeration time and a higher maturing time would be necessary for plants without any pre or post treatment whatsoever.

(d) Optimum watering is a prerequisite for efficient composting.With a manually operated tube-well with a force-lift pump and a 25 mm polythene pipe, an worker can water effectively all the windrows of a plant of 10 T/day capacity.

(e) An efficient system of screening is an essential post-treatment, in absence of which the compost contains lot of fine grits, which are not liked by the farmers.

(f) For larger plants, scope of mechanisation is there for windrow turning and handling, watering, post screening and grinding. Mechanisation beyond this level would result in increasing the cost of production.

(g) A relative evaluation of production costs and returns from compost plants with varying levels of mechanisations are shown in Table - 1. It could be seen that small manually operated plants are more viable compared to highly mechanised plants. Semi-mechanical units would be appropriate for larger plants.

(h) Even though the actual production cost of compost manures, in the pilot plant was only about Rs. 40 per ton, the farmer had to pay about three times this amount, because of the high transportation charges, they had to pay to the private carriers. Unless the local government or the state government takes up the responsibility of marketing and distribution these plants would not be commercially viable. In order to minimise transportation cost of compost, they should be located close to the agricultural fields.

TABLE : 3 - Manually Operated Compost Plant Vs. Mechanically Operated One.

Type		Nutrient Content (% by weight)			Carbon / Nitrogen Ratio	Production cost Rs./Ton of compost
		N.	P	K		
1. Mech. Compost Plant,	Calcutta	0.52	0.7	0.66	20	100
2. - Do -	Delhi	0.66	0.51	0.87	17	100
3. Manually operated (Pilot project)		0.8	0.7	0.65	12 to 15	40

REFERENCES :

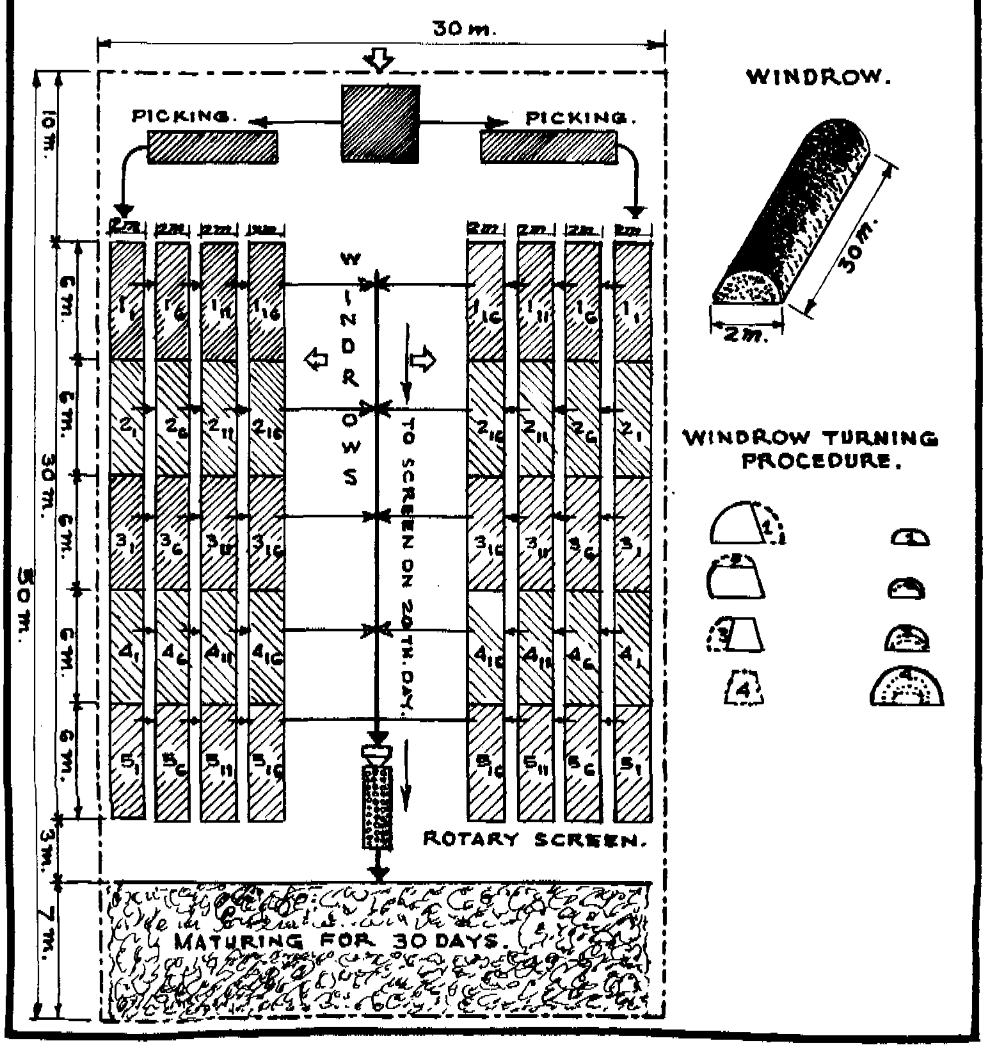
1. Pilot Studies on Solid Waste Management in Municipal Towns.(Conducted by All India Institute of Hygiene & Public Health, supported by C.M.D.A./ World Bank). Report under submission.

2. 'Urban Solid Waste Management'- A report by Ministry of Works & Housing, Govt. of India.

3. FRANK FLINTOFF ' Management of Solid Waste in Developing Countries', WHO Publication.

FIGURE - 1. LAY-OUT PLAN FOR A MANNUALLY OPERATED WIND-ROW COMPOST PLANT.

CAPACITY=10 TONS REFUSE/DAY (POPULATION-20,000)
PRODUCTION = 5 TONS OF COMPOST MANURE/DAY.
AREA = 1500 M².



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Solid wastes management - aspects and practices

S Selvapaskarathurainayam

It is the intention of this paper to create a possibility to transfer knowledge to and exchange opinions between the participants in this 10th W.E.D.C. Conference in the far much neglected field of solid wastes management. The rapid emergence and multiplication of complex scientific technological and social problems outpaces the ability of any nation, however rich and determined to seek all the prerequisite solutions to these problems and to explore all the alternative options open to it. A global cooperative effort is the only logical response to the issue challenging humanity. It is for this season that nations seek to share knowledge and experience pertaining to their common problems and for the attainment of common goals.

It is a fact that directly or indirectly, all human activity produces effects that produce an environmental impact on the receiving media. The contamination that inundates the world does not end in the air, in the waters and in the soil. Nor does it appear in the form of waste but goes so far as to deeply influence our daily lives. It even manages to enter our bodies. It is present within us and can modify and change not only our surroundings but even our very behavior, reducing possibly even our degree of freedom.

Among all the environmental problems faced by mankind, management of the ever increasing quantities of wastes produced by society is certainly one of the most urgent one. The problems of waste management differ, of course from country to country and solutions in certain area cannot be simply applied elsewhere.

Man has always produced solid wastes! Today, however, waste production is greater due to the freightenings estimates of population explosion. Hence more wastes are produced and more discarded products accumulate from our way of life. The "No deposit, No return" practice is convenient for a moment but "throw away" objects and convenience packing materials finally become a large part of our solid wastes problem. They accumulate because they are not easily broken down or degraded. It seems that man as the supreme being of creation has not adapted to what we call living together, as one with other beings of the creation, his immense technological creativity having led him to violate the laws of nature to extents that may even be irreversible.

Therefore, it is imperative that the proper management of waste is an essential prerequesite of a safe and pleasant environment. The progress of the waste management practice must be derived from specific technical developments and by the establishment of appropriate institutions. Before changing an existing system, the local situation must be carefully studied and, preferably the proposed system should in the first instance be tested on a pilot project.

Solid wastes management development activity entails a variety of socio-economic consequences and only very thorough and rational planning can lead to an actual improvements in the solid wastes collection, transport, treatment and disposal. Changes are necessary in the use of the considerable scientific and technological knowledge which has been used in ways now recognised to be harmful. It must be kept in mind that while designing solid wastes management systems it must provide direct or indirect environmental benefits.

Wastes management facilities may be publicly or privately owned. Conflict may arise in wastes management system from the fact that there is divergence between "private costs" and "social costs". Wastes management problems must for these reasons be viewed on the wider context of their economic and environmental implications. It is very important to rather plan at an early stage, than to consider and allow for the making of changes in the existing infrastructure.

Now there is a new trend that most of the countries feel that they need to pay more attention than in the past to deal with the environmental factors in order to improve the quality of life of their population and to economically and wisely use their resources in order to develop an environmentally sound solid wastes management programme, as the existing models of development have been misappropriate and unsatisfactory to cope up with the new problems. Hence a satisfactory solution must be found to the problems related to wastes managemnet aspects and practices in order to control the environmental related diseases. To achieve this the quality, role and the establishment of an information system to improve the flow of knowledge on all matters related to solid wasts management is a must.

The necessity to establish new institutions or the inclusion of this knowledge by way of syllabuses in the existing technical and professional institutions will be an asset in reducing the environmental and health risks, as a result of the application of bad solid wastes management practices.It is clear that in most countries financial constraints are the limiting factor in arriving at a proper waste management. To overcome this aid could be obtained by the respective government from the World bank, WHO, UNEP, US AID, etc., as these international organisations are deeply concerned with the development of good practices of the solid wastes management.

Essential to any wastes management practices is the knowledge of the composition of wastes and draw up a successful programme. Waste sampling and refuse analysis programme must be initially carried out. Wastes management may be described as a system incorporating all the measures necessary to ensure the safe and most economic methods of disposing wastes. Everybody knows that wastes cannot be wholly destroyed,they can only be converted to substances which eventually reach the air, soil or water with minimum environmental effects.

Solid wastes is a general term used to define waste material other than liquids, produced as a result of domestic,commercial industrial or agricultural activities. By definition, liquid and gaseous wastes are excluded but no hard and fast line can be drawn in the case of sludges from some industrial premises, which are partly liquid and partly solid. As an extension of solid wastes, the expression "Solid Waste management" is now used to embrace all activities involved in the storage, collection, transports, treatment and disposal of solid wastes.

The wastes management practice requires a multidiamensional approch. It doest not stop with the financial approch alone, but institutional legal, social and technological considerations also must be taken into account in planning, execution and control of wastes mangement. It may be useful that we skip through in brief, some of the aspects and practices in solid wastes management in a few countries to get an idea of good and bad practices.

Srilanka

So far no serious studies on refuse in any urban areas have been carried out. Most of the present practices in solid wastes managment are developed on the basis of past experiences.The wastes collection gets preferential treatment over the disposal systems, and due care is not given to the improvement of the techniques of disposal menthods.The entire Colombo area is not covered with sewerage system and as a result the cleansing division is shouldered with the responsinility of managing the collection and disposal of night soil,catch-pit and septic tank contents. The contents are tipped into the sewerage treatment works,which have more or less outlived the period of usefulness.The effluents which are untreated are discharged into the neighbouring rivers which cause pollution of water.

The wastes collected are disposed dumping in the name of sanitary landfill due to severe financial constraints. As a result of poor environmental sanitation practices nearly 60% of the total number of patients who come for treatment in hospitals are found to be suffering from preventible diseases.

The quality of labour engaged in solid wastes mangement deserves commendation and the very same manpower from Srilanka who are engaged in the public cleaning services in Middle East have earned a good reputation in this field. inspite of possessing good labour, the achievements of solid wastes management services in Srilanka as a whole can be counted on fingers and the situation is not good as it should be. This example is very clear to illustrate that quality of man-power alone is not the sole criteria in deciding the success of wastes management.

India.

A vast land with an urban population of 110 million (1971) census generates approximately 15 x 10^6 tonnes of solid wastes every year and an estimated US.$70-100 million was being spent annually in urban areas alone during the period 1971-73 Inspite of incuring a considerable amount, this activity pose a large number of persistant problems.The collection and disposal is labour intensive. The man-power provision for collection, transport and disposal of wastes per million inhabitants served is about 1000-3000 persons. To obtain best possible performances at the least possible expenditure, the workers should be properly organised. The performance in turn can be judged, by the efficiency of collection as evidenced by absence of nuisance, and by proper disposal of the wastes.The disposal of solid wastes did not receive as much attention as it should. The collection and transport has to be properly organised,so that the same job can be done more effectively with reduced cost. Uncontrolled dumping was a common practice. In many cities proper dust-bins are not provided with the result city refuse get mixed with dust and earthy matter.

Saudi Arabia

Saudi arabia's solid wastes management is remarkably at a high level and it depends largely on imported technology and manpower. Manufacturers ,suppliers, and consultants in industrialised nations have perfected machinery, systems and services which are used for the special needs of the country's solid wastes management programmes. The operations of services are given on contracts and its supervision is done by the respective municipalities and industrial organisations. In this context special mention must be made on the solid wastes management of the Arabian American Oil Company, who operate a model service through its contractors. The author himself is engaged by a well known Establishment "Hassan Mansoor Sihati" who operates from Dhahran.

In the industrial areas of "ARAMCO" the cleansing of public toilets are usually done by cleansing crew, who travel in mobile vans to remote points alongwith their cleansing materials and equipments. The collection of wastes is done in covered compact vehicles and disposal is strictly done in properly maintained sanitary landfills. The Saudi Arabian government has set-forth environmental standards and is strictly enforcing them.

Singapore

Singapore's 2.4 million citizens transform their 238 square miles tropical island nation from a slum ridden former British colony into a bright modern land. It will be of great significance to review the solid wastes managment services in the emerging Singapore,the hardworking republic with communial harmony, that enjoys prosperity, while honouring ancient ways. The Singapore city with nearly a million inhabitants has a separate cleansing department, within the memory of even the employees with the longest record of service. A salient feature of the cleansing department is the extensive use of its legal powers in the enforcement of the laws.

A clause of para 903 section (4) of the local governement ordiance helps to put teeth into the bye-laws, to presume that refuse in front of a dwelling or commercial building is the responsibility of the occupier of the premises.Singapore charges for permits to distribute hand Bills, as these eventually add to the work load of the cleansing department. It is not surprising that the department is able to maintain an efficient service to keep Singapore " the cleanest city in the East". The delegates of the conference can themselves find out the secret of success of Singapore's wastes management services, while being here and during technical visits which is scheduled in the conference programme.

usually the management of solid wastes programmes create problems, which in many areas have become critical. The treamendous development of technology and change in life styles have given rise to an extremely wide range of materials discarded as wastes, ranging from innocous inert material to complex chemical substances requiring special measures in handling and disposal because of their toxic or potentially hazardous nature.

Ideally, solid wastes, should bot contain any faecal matter or urine, and the mixture of the latter wastes with houshold wastes should, as in the case in some countries, be prohibited by law.The handling of pathological wastes, slaughter house wastes, and similar wastes, and similar materials in association with household wastes should be also prohibited. There are also some longterm problems of man's food chain that have to looked into when a good wastes management practice is to be introduced. When good standards of operation are not maintained at disposal sites and improper discharge of wastes in open drains, rivers etc. may result in serious health problems. Rain water passes through a deposit, of fermenting solid wastes emerges as a leachate, which contains a very high proportion of fermenting organic matter. Leachates from industrial solid wastes may contain dissolved chemicals,particularly heavy metals, which are poisonous. It has been demonstrated that such materials may be concentrated in nature by some organisms in man's food chain, specially when highly toxic wastes are dumped at sea or deposited in landfills.

Toxic substances like heavy metals, like mercury, and Cadmium from batteries and lamps are commonly present even in remote places of the world. In the elimination process , we should be aware that the end products may not be dangerous to environment including the employees handling such wastes.

The main source of air pollution is the old or inefficient incineration plant. Combustion causes a large amount of dust to be supended in flue gases and if dust eliminators are not installed it may be very unpleasant to live in the immediate environment of the plant. Hence it is essential that plants are equiped with electrostatic precipitators.Uncontrolled and incomplete combustion of wastes materials can result in the release into the atmosphere of a number of undesirable pollutants including particulate matter, sulphur dioxide nitrogen oxide, various hydrocarbons and other noxious gases that may have deleterious effects on the health of those who inhale them.

Wastes collection

some authorities who are responsible for collection of community wastes have an attitude that the wastes should be disposed of as quickly and cheaply as possible. In many cases, invariably the reasons given for the breakdown of wastes collections has been the non-availability of vehicles due to frequent breakdowns and it is common to see the refuse uncollected for days.

When the collection services fails the refuse itself forms a danger by harbouring cockroaches, flies, rodents etc. The battle against these pests is difficult and an year round active pest control campaign may have to be launched. The expenditure incurred in pest control could be minimised by upholding good practices of solid wastes management right throughout the year without any ups and downs. Further many cities in developing countries do not have an adequate system of wastes collection,which itself requires considerable capital investments and operating funds. Authorities responsible for wastes management fail to understand the simple theory that collection and disposal services are inter-related .It is essential that hospital wastes must be handled with utmost care, as the substances used for irradiation of tumours, and such (radium Cobalt) should not be discarded in the environment. They are part of one of the many major health hazards to the society.

Wastes disposal

The establishment of disposal facilities requires, careful site selection, knowledgeable engineering and good management. Very often the last named is the key factor. The landfill method involves depositing the wastes in layers and covering exposed wastes,with soil daily as work proceeds to prevent breeding of flies or other vermin.

Incineration

Countries where there is financial constraints do not accept incineration method as solution to waste disposal problems. In some countries like Spain, a service of local scope of collection and disposal of dead animals is growing inspite of the limitations and problems imposed by the urban living. The collected carcasses and the offal from public markets are finally disposed by incineration in special furnace. The WHO recommends, that the hospital wastes must be disposed by incineration. It is desirable if this service could be extended to the wastes from Zoos,Dairies,Stables,Laboratories and research centres too.

Composting

The wastes which contains more than 60% of organic material is very suitable for composting. The United Nations Industrial Development Organisation give assistance to countries for the production of composting from urban wastes. A regular supply of wastes is an essential prerequisite for composting. Unless carefully planned to reduce capital and operating expenditures and to overcome the many problems of infrastructure,organisation and marketting, compost plant will not become vioble ventures in developing countries.

Energy From Wastes.

With increasing industrialization in developing countries, the demand for and cost of raw materials will continue to grow, while their longterm availability can no longer be taken for granted. Commercial and industrial solid wates represents potential sources of re-usable material and energy, and much research is being carried out in Europe and USA to determine the most practicable and economic methods of materials and energy recovery from solid wastes.

Solid wastes management control has become a specialized discipline to ensure that the environment is adequately safeguarded at all times and pollution risks avoided. In this vital area of public service, the oldest professional authority is the British "Institute of Solid Wastes Management" and its monthly publication "Solid Wastes" keep its readers abreast of the latest developments in the wastes management aspects and practices.In this field WHO plays a leading role, in the development of good practice in all its aspects.The activities include literature on the subject, seminars, training programmes, and country projects.

I conclude this paper, with the fervent hope that the international Community can play an important role in this sphere by declaring technologies as common heritage of mankind and be made freely available to all those who need them.

REFERENCES

1. SOLID WASTE DISPOSAL AND UTILIZATION IN DEVELOPING COUNTRIES- Bulletin 310,Department of Agricultural Research Amsterdam (1982)

2. W H O REGIONAL OFFICE FOR SOUTH EAST ASIA (1976) Management of Solid Wastes in Developing Countries.

3. REPORT OF COMMITTEE ON URBAN WASTES (1975) NEW DELHI Ministery of works and Housing.

4. SOLID WASTES DISPOSAL AND CONTROL -WHO Technical Report Series 484 (1971)

5. REPORT OF THE INTERNATIONAL SOLID WASTES CONGRESS AND EXHIBITION (June 1980)

6. A STUDY OF THE CLEANSING DEPARTMENT - CITY OF SINGAPORE (Report) DR.L.V.R.Fernando -Sri lanka.

7. NATIONAL GEOGRAPHIC JOURNAL. (April 1981)

10th WEDC Conference

Water and sanitation in Asia and the Pacific : Singapore : 1984

The water and sanitation programme in Bangladesh - success or failure?

Dr K Laubjerg

1. Introduction

At the dawn of the UN Water Decade, World Water, in its December issue 1979, referred to the water programme in Bangladesh as "successful". The count of public tubewells stood at approximately 520 000 by June of this year, which implies less than 200 people per tubewell. Sanitary latrines are owned by 1% of rural families.

Recently, the donors of the water and sanitation programme have become disturbed by the fact that despite the apparent high per capita coverage of tubewells, the incidence of water-related diseases in Bangladesh has remained more or less unchanged over the last ten years. The International Centre for Diarrhoeal Disease Research in Bangladesh lists diarrhoea and dysentry as the most frequent causes of death.

2. Community Surveys

To discover the actual coverage and distribution of the handpumps as well as of the sanitary latrines, a number of socio-economic surveys were started in mid-1983. Based on these studies, experiments with village involvement in planning, implementation and daily operation and maintenance of the handpumps will be undertaken. More affordable latrines will be constructed through village self-help activities, built from locally available materials, instead of relying on costly subsidised materials.

Though these studies and experiments are still in progress, and thus incomplete, some points have emerged relevant for the planning of water and sanitation programmes in general and not only for Bangladesh.

3. Programme Problems

To highlight the issues involved we will draw on three examples.

1. Most handpumps are located more according to the power structure in the village than according to the UNICEF/Government site selection criteria. About one-third of all public tubewells are placed in the inner yard of the pump caretaker, thereby making access difficult for the potential users.

2. The water seal latrines which are promoted by the government and UNICEF are mostly affordable for the relatively well-to-do rural families. Landless families, who constitute about 60-70% of the rural population with a yearly income of approximately US$ 100 (per family), cannot afford to pay $ 6 for a latrine, excluding the superstructure.

3. Health awareness is extremely low. Though 25% of the villagers in a study mentioned contaminated water as a cause of diarrhoea and cholera, nobody mentioned the use of tubewell water as an activity which could promote good health. Presently, no health education is integrated with the water and sanitation programme.

Until very recently the programme was looked upon primarily as a technical activity, i.e. how many tubewells could be sunk and how many latrines could be sold within a given time. Today some of the results of this practice are known:

- 30% of all public tubewells are sunk in the backyard of some influential village persons;
- 20% of all tubewells have been out of order for more than 6 months; and
- 3% of the tubewells are 'temporarily' out of order.

4. Community Participation

Village participation in development projects is today mentioned by all well-meaning development agents as the panacea, the cure to all problems. But even if the government and the present power structure supported such an approach - and did not pay only lip service - it would not automatically solve our problems.

Surely it must be assumed that given appropriate organisational arrangements which would enable the villagers (including the primary users of the water supply, the women) to decide on the site location of the handpump it would result in better accessibility and consequently higher water usage, which is one of the conditions for improved health.

It also seems self-evident that consultation and discussion with the villagers on how to meet their sanitation needs would result in more appropriate latrine technologies than the water seal latrine type used today. At least it might lead to the villagers getting a choice between different types of latrines.

It is also highly probable that health education could have more impact on the formation of 'healthy' attitudes and changed behaviour patterns if health promoters were selected from the villagers, in connection with the water and sanitation programmes.

5. Food and Clothes, Not Water and Latrines

For villagers to participate they must be motivated. Water and sanitation must be perceived to be important problems for them.

In one of the surveys undertaken it was found that water supply and sanitation in most cases were not perceived as important problems for the families. More important were shortage of food, inadequate clothing and lack of agricultural land. However, it was significant, but not surprising, that more women felt water and sanitation to be problems, though never very high-ranking ones.

6. Conclusions

What conclusions can we draw from these few observations mentioned above? The message seems to be that water and sanitation should not be separated from other development activities. Increased impoverishment has rendered water and sanitation of less importance for the villagers than food and clothing. If we want to sell the inputs for the water and sanitation decade, we need to wrap them up with <u>income generating activities</u>; that means reorganising most water and sanitation programmes. Initially, this will lead to a reduced rate of completed projects, but for those who evaluate the success of a programme by its social impact and not by the number of wells sunk/latrines sold and funds spent, it may be worthwhile giving it a try.

The answer to the questions raised in the heading of this paper will therefore depend much on the willingness of the Bangladesh Government,as well as the donors involved, to reorganise the programme and perhaps for a short time proceed at a slower implementation speed.

10th WEDC Conference

Water and sanitation in Asia and the Pacific : Singapore : 1984

Community education and participation in the Maldives

Dr D Narayan Parker

1. Introduction

The purpose of an evaluation is usually two-fold. The first is a thorough analysis of the project as it exists and second is the making of recommendations for the future. Often the study of a project is strong but the recommendations are general, weak and often unrealistic.

For an evaluation to be useful, the entire evaluation exercise from the planning to the field work must keep the aim of making specific recommendations to the forefront. In projects dealing with toilets, for example, if the existing designs are socially unacceptable, an evaluation should make specific recommendations for changes in the design or opt for new designs. However, if this is done in isolation by the evaluator after the field work, it may only prolong the trial and error process of deriving designs that are acceptable to the users.

The argument of this paper is that even conventional evaluations can be made more meaningful if they make specific, detailed recommendations that have been discussed and approved by the users. This can be done by incorporating some elements of community education and participation in the research process. The focus of this paper is on use of group meetings and models of toilets, to ensure community education and participation in finalising recommendations for future toilet designs. This process, it is believed, will result in toilet designs that are acceptable technically and socially, thus increasing the probability of success. For illustrative purposes experience is drawn from a recent study of community and private toilets in the Maldives.

2. Water and Sanitation in Maldives

The Republic of Maldives consists of over 1200 small coral islands of which 202 are inhabited. The primary source of drinking water is a thin shallow fresh water lens floating on sea water within the confines of the island. The proximity of the water lens to the surface and the porosity of the soil leads to contamination of the groundwater. Safe drinking water is obtained through public wells that are kept chlorinated at mosques, and through public rainwater tanks that are increasingly being built.
The traditional and still the most common method of human waste disposal is defecation on the beach. However in crowded islands with little or no beach space left, inappropriate disposal of human waste has become a major health hazard. In an environment of limited financial resources, the Government of Maldives with the assistance of UNICEF and UNCDF undertook the provision of community toilets built on the beach in crowded islands.

The toilets are built in a block of five cubicles facing inward, towards the island. They are of the pour-flush variety with water for cleaning and flushing being provided through a well located in a compound outside the block. The waste is discharged through sewers directly into the sea. The project was supposed to have been implemented utilising a community education and participation approach.

Informal observations made by government officials made it clear that the community toilets were plagued by a host of problems resulting in low use. In 1984, the Ministry of Health through the UNDP IDWSS Decade Advisory Services Project executed by WHO, SEARO, undertook an evaluation of the toilets in the atolls. The aim of the evaluation was to enable the decision-makers within the government to:

1) fully understand the attitudes of villagers towards the use of public and private toilets;
2) consider a range of alternatives for the implementation of public and private toilet programmes; and
3) make decisions regarding future toilet programmes based upon guidelines provided in the report.

3. Evaluation Methodology

No single methodology can obtain information on attitudes while at the same time evaluating the design and use of a technology. Hence a combination of 6 methods of data collection were used. They were:

1) interview with 228 adults using a questionnaire;
2) interviews with key informants;
3) observation of toilets for use and rating of physical conditions of toilets;

4) informal household visits and meetings with ad hoc groups;
5) group meetings with committees; and
6) use of models of toilets with interchangeable parts in group meetings.

In all the islands, group meetings were conducted after completion of household interviews, interviews with key informants, observation of the community toilets for use and rating of the physical conditions of the toilets. The information gathered prior to group meetings through the above techniques was useful in assessing the existing problems with the project and in providing the social cultural context within which the community toilets had to function. They also provided data on the social, cultural, organisational, personnel and financial constraints within which the old and any new designs would have to function. Although the questionnaires and interviews yielded some indirect information on design problems, they did not yield any detailed information on modifications needed in the existing toilets and possible options for the future.

It was here, to make the transition from data on attitudes and general statements of problems related to design, to specific alternative toilet types, that the use of group meetings and models of toilets became crucial.

However, for group meetings to yield meaningful information, careful attention needs to be paid to four factors:

1) the composition of the group;
2) type of information desired;
3) structure or format of the group; and
4) communication aids.

Equally important is the interaction between these factors.

1. Composition of the group. Any information gathered is a reflection of the opinions and ideas of the people interviewed. In any project that requires community participation and aims to include the disadvantaged, it is imperative that information be gathered from a cross-section of the population. Meetings with existing groups is an efficient way of gathering information. The problem is that most traditional and government initiated groups are powerful but tend to represent the élite to varying degrees.

An additional complication is that often governments require both private and government initiated development efforts to work through the existing power structure. If one is required to work through the existing power structure, what strategies can be used to involve groups, gain their approval and support and yet get information from the not so powerful?

In Maldives, every island has one or more Island Chiefs assisted by Assistant Island Chiefs and the Island Development Committee (IDC). The IDC consists of some nominated and some elected members, almost exclusively men. It assists the Island Chief in planning and implementing development activities for the community. Each island, in addition, has a Women's Committee that is less powerful and active than the IDC. Additional groups found in some islands are fishermen's clubs, youth clubs, garden groups and educational groups. Several factors pointed to the need to schedule meetings with the IDC.

In Maldives for a project depending on community education and participation it is essential to have the support of the Island Chief and the Island Development Committee, since they are the planners and implementors. Secondly the IDC was supposed to have implemented the community toilet programme. Finally, since the focus was on toilets, and even most members of the IDC did not have individual toilets at home, they were also potential users.

However, it is undeniable that the committees represent the more powerful. Additionally, since they are essentially political structures, in any discussion political considerations can come into play. Further, the Island Chief is a member of the IDC and hence, present at all their meetings. His presence obviously affects group dynamics.

Four strategies were adopted to get meaningful information from the committee meetings and yet ensure wider representation of the people in the island.

a) Meetings were held with the Women's Committee so as to take into account opinions of both men and women. This was important because the Women's Committee had not been consulted at any point in the project even though in most islands toilets had been built exclusively for women.
b) Unscheduled meetings were held with ad hoc groups of men and women near the community toilets, near traditional private toilets and outside people's homes.
c) Information was gathered utilising an open-ended questionnaire from men and women from randomly selected households.
d) The Island Chiefs were not present at the Committee meetings. 'Key informant' interviews were done with the Island Chiefs prior to the Committee meetings. The first interview focused on an overview of the island, and the second on details of the community toilet programme. By the end of these meetings not only had valuable information been obtained but rapport and trust had been established. All the Island Chiefs then agreed that their presence at the meeting would inhibit a forthright exchange. However, they all came to introduce the evaluator to the Committee and then left.

2. Content of the meeting. Whether or not the dominant members have been eliminated, careful thought has to be given to the content or purpose of the meeting. Group meetings cannot be used to obtain information on aspects of the problem that will divide the group and bring into play factional interests.

In the Maldives study, the purpose of the meeting was stated as trying to understand how the community toilet project had been implemented. It was emphasised that the purpose was to understand the process and not to find 'scapegoats'. The focus was on factual information, on design preferences and alternative designs for the future. For example, the question of location of facilities was avoided because it would have introduced divisive elements. Questions that would have produced socially desirable answers were also avoided completely.

3. Format of the meeting. What actually happens at a meeting, although influenced by the group composition and purpose of the meeting, depends also on the format or structure of the meeting. In a meeting which aims at wide participation by the members and education of both sides, it is important to create an environment in which a dialogue is generated. In such an environment both sides actively listen and respond to each others ideas, problems and solutions. To generate dialogue, researchers cannot go with fixed solutions to a problem but need to listen to what is being said by the people or users. However, this does not mean that the researchers accept everything that is being said just because 'the people know best'. It is important to simultaneously understand, clarify, question and even challenge statements made by the people. It is here that participation and education begun to merge and result in solutions acceptable to both users and planners.

In one of the Maldivian islands visited, it was found that the community toilets had taken over two years to build. In addition they were little used and were not being kept clean. Yet this same island which is experiencing acute land shortage had reclaimed land to provide space for the building of community toilets. When the group was asked why the toilets were not being kept clean, after vague answers one man said that the real problem was that they did not have money to buy cleaning detergent!

Instead of accepting that as the root of the problem, the investigator challenged the answer and said that surely a community that could reclaim land and raise Rf.2000 (US$250) for skilled labour could raise Rf.7 (US$ 1) for cleaning supplies if they wanted? The group looked surprised, then started laughing and then agreed that what had been stated was true. The discussion then proceeded to identify more serious root problems.

Group meetings can also be used to educate or clarify misconceptions. In Maldives, there is a strong desire to have the Government provide central sewers to which individual households can connect. Some people are somewhat aware of pollution problems and know of ways to avoid contamination of the groundwater. For example many men said that if a septic tank or soakaway was situated in a certain direction at a distance of 20 m from a well, the well water was not affected. However, this is impossible to practise on crowded islands. Despite this, arguments presented by planners based on pollution problems associated with central sewers have been rejected by the people.

However, sewers also lead to scarce fresh water being flushed into the sea. People are very aware of the limited quantity of fresh water in the ground. When the undesirability of central sewers was explained both within the context of pollution and depletion of the groundwater, people accepted the undesirability of a central sewer and flush toilets. This not only changed their attitude towards community toilets but also brought forth other possible toilet designs.

One of the toilets discussed was a 'Divehi Phakhana' which is built on a pier over the sea. It is made of logs or wood planks and a cubicle with waist high walls and no roof. The floor has a hole for defecation. Water for washing is obtained from the sea with a container. Tide action carries the waste away. This type of toilet has not been considered by planners as an option. However, when the possibilities were discussed with the communities, on the crowded islands it was viewed by the people as an acceptable option that overcame the problems of cleanliness, maintenance, costs, shortage of land, etc. In one island, the men brought back drawings of the toilet before the team left early next morning.

4. Aids to communication. Audio-visual aids play an important part in communicating ideas at a meeting. If a toilet project is at a stage where problems have been identified with the design and there is a need to alter the existing design or consider new designs, how can information on toilet types be obtained from users?

The most commonly used audio-visual aids are films, pictures, flannel boards, flip charts, slides, puppets and folk theatre. However, none of these methods lend themselves to eliciting detailed feedback on toilet designs and their components.

The use of films and theatre is useful in generating interest but not useful in getting specific feedback on design criteria. Rural people, the world over, depending upon their degree of isolation have difficulties in seeing three dimensions in a two-dimensional media. Often too, the medium becomes the message.

Use of pictures to get feedback on toilet designs is fraught with problems. People have even more difficulty in interpreting plans and gaining a three-dimensional perspective in a two-dimensional medium. People's traditional association with colour and other forms of pictorial representation can also lead to different interpretation of a picture than was intended.

A method that is little used but lends itself to discussion of toilet types in sanitation projects is the use of models in group meetings. There are several advantages in use of models both to enhance community education and participation and to obtain feedback on the advantages and disadvantages of different toilet types from the users.

The first is financial. To build real-life demonstration models of many types is not only expensive and time-consuming but it may not be possible. Models on the other hand can be quickly and cheaply built of any material.

The second advantage related to costs is that ideas that seem far-fetched can still be presented as options and may eventually be picked up with modifications as the most appropriate. Models can also be built with interchangeable, movable parts so feedback can be obtained not only on the design in its totality but also on the various components. Thus a toilet design can be presented with different types of walls, doors, roofs, wells and seats. What actually happens is similar to children's play with'Lego blocks'. Adults through discussion, experiment concretely with the various components and come up with a toilet that they have designed and is most acceptable to them.

The third advantage is that models are portable. They can be used not only with formal groups but during house to house visits or with other informal groups in the schoolroom, at the well or at the beach. They are transportable to different villages or islands and hence feedback can be obtained very quickly from villages close to or at a distance from one another.

The last and most important advantage of models is that they overcome the constraints involved in the use of pictures, films and dialogue unaccompanied by any visual aids. Even non-literate people can relate to physical models. The only transformation they have to make is that in size.

In the Maldives study, two wood models of community toilets with interchangeable parts were used. One represented the existing five cubicle block with a well outside, and the other a new design consisting of four cubicles built around a central well. Both were presented to groups with and without doors, roofs, etc. In every meeting they generated excitement and involvement. Both men and women spontaneously came forward, moved parts, added stones and sticks to present new ideas and explained the advantages and disadvantages of the different components.

Thus, involving existing local committees in discussion of sanitation facilities in conjunction with models of two toilet designs led to design of community toilets that were more acceptable to them.

The evaluation was thus able to make specific recommendations on the weaknesses and strengths of different toilet designs, both from the user's viewpoint and the planner's or engineer's viewpoints.

4. Conclusion

Community education and participation is not always possible or appropriate in its entirety in a project. However, elements of it incorporated in an evaluation can yield immediately useful information in a short time. People involved in sanitation projects need to boldly cross the frontiers of their own discipline and borrow and adapt techniques and ideas from other disciplines to ensure success in sanitation projects.

Reference.

Narayan Parker, Deepa.

Community attitudes towards public and private toilets in Maldives MWSA, Ministry of Health, Republic of Maldives. May 1984.

SESSION 7

Chairman: Mr Richard Franceys, WEDC Group, Loughborough University of Technology, UK.

Discussion

M T Gadi

Solid waste management: the Philippine experience

1. Mr GADI described aspects of solid waste collection, transfer and disposal, and discussed the National solid waste subsidy programme which aimed to bring about improvement in solid waste management systems.

2. Mr CROSS requested the author to elaborate on incineration and sea dumping, and asked about the charges for solid waste services, and how they were collected.

3. Mr GADI explained that the incinerator was obtained from Japan, but it could not cope with the high moisture content of the local waste. Sea dumping had been practiced for about 20 years; waste was dumped on the shore and washed away. The author was not aware of the actual charges, but they formed a component of general taxation.

4. Mr KARTAHARDJA asked if financial assistance was given to municipalities as a loan or a subsidy, and how revenue was collected.

5. Mr GADI replied that financial assistance was provided as a subsidy; however, counterpart funding had to be provided, perhaps in the form of manpower, or utilisation of existing equipment or facilities. The subsidy was conceived to be an incentive to communities to show more concern for an effective solid waste management service.

6. Dr LAUBJERG wished to know if the scavengers were organised into cooperatives to avoid exploitation by middlemen or syndicates.

7. Mr GADI said that they were not organised, but that attempts were being made to form cooperatives. This had been started by training and fielding people to buy recyclable waste from households. However, middlemen and syndicates had evolved an informal but very powerful network which was difficult to break.

9. Mr NUGRUHO asked whether there were problems with plastic wastes, and what measures could be taken to overcome them, as it was possible to convert plastic waste into paint.

10. Mr GADI stated that most plastics were recovered and resold by householders; the remaining waste was scavenged at the dump sites. A local inventor had recently patented a process which converted plastic waste into paint, at a cost of US$ 4 per gallon; this had stimulated the demand for plastic waste.

K J Nath and S K Dasgupta

Composting of urban solid wastes

11. The authors were not present, and the paper was not read.

S Selvapaskarathurainayam

Solid waste management: aspects and practices

12. The author was not present, and the paper was not read.

K Laubjerg

The water and sanitation programme in Bangladesh - success or failure?

13. Dr LAUBJERG discussed the hand pump programme in Bangladesh, the possible reasons why so many handpumps were in a state of disrepair, and aspects of community involvement in the handpump programme.

14. Mrs MITRA asked why water was not felt to be a priority by the people; were there ponds within easy reach, and was the situation the same in drought prone areas.

15. Dr LAUBJERG thought that although social survey data had not yet been fully analysed, there was a strong indication that increasing impoverishment had caused the population to have other priorities; this was likely to be the case in Bangladesh throughout the year. He suggested that this might not be the case in parts of Africa, where people had to walk many miles to fetch water. It indicated the importance of thorough socio-economic studies in the planning of water supply and sanitation programmes.

16. Mr ROGERS enquired as to the reasons for such a large proportion of handpumps being out of action for long periods, and suggested it might be due either to poor design, poor maintenance or inaccessibility to the majority of users.

17. Dr LAUBJERG replied that there were a multitude of reasons for failure, such as poor

maintenance, blockage, and incorrect siting. Most pumps were Bangladesh No.6, which was an internationally accepted design suitable for poor developing countries.

18. Mr NANDAKUMAR raised several points: the location of handpumps would be determined by the economic and social power structure within the village community, even when there were organised village governments; the existence of effective voluntary organisations had contributed to the success of community participation, but on large programmes it was not easy to locate a good voluntary organisation in every area; how was it possible to ensure that the more influential sections of the community did not corner all the benefits.

19. Dr LAUBJERG thought that the powerful elite were able to abuse their privileges because most villagers were unaware of their rights; hence water supply and sanitation programmes should be associated with educational activities; if villagers were more aware, better site selection of handpumps may result. He agreed with the comments on voluntary organisation; government was ultimately responsible for development in the whole community. Non-government organisations were often better able to deal directly with people, and should be supported and coordinated by government.

20. Mr de KRUIJFF commented that for water depths greater than 12 metres below the surface, the Blair pump, designed by Peter Morgan in Zimbabwe, was an excellent design. It had two simple backflow preventer valves rather than seals which would wear out.

D Narayan Parker

Community education and participation in the Maldines

21. Dr NARAYAN PARKER discussed the implementation of sanitation in coastal communities in the Maldives, with reference to the involvement of the community.

22. Mr de KRUIJFF asked whether the communal sanitation blocks were segregated for men and women, and wondered why such elaborate structures were built on the beach, which disposed of untreated sewage directly to the sea; an overhung latrine would have been simpler.

23. Dr NARAYAN PARKER replied that it was left to the communities to decide; on most islands the latrines were designed to segregate the sexes; in one island where both sexes were supposed to use the latrines, nobody at all used them. Three latrine designs were considered suitable by the communities; one was built on a platform over the sea, and was now being considered as an option by government planners.

24. Mr KARTAHARDJA commented that he saw no good reason for building the communal latrines near the sea shore; he thought that people would just go to the shore without using the latrines.

10th WEDC Conference

Water and sanitation in Asia and the Pacific: Singapore: 1984

Sanitation improvements in Indonesian Kampungs

G J W de Kruijff

THE KAMPUNG IMPROVEMENT PROGRAMME (KIP) IN INDONESIA

Based on earlier Dutch models, KIP was initiated on a large scale in Jakarta in 1969. It was found that no services were provided to the dense, lower-income areas with the worst environmental conditions. It has since become an ambitious nation-wide programme for upgrading the informal unplanned and unserviced 'urban villages', which house over half of Indonesian population. The principles of KIP are to insert basic infrastructure into kampungs with minimum disturbance or removal of the residents. The improvement components vary according to the condition in the kampung, but normally include local roads, footpaths, micro-drainage, water supply, public sanitation facilities, solid waste improvements and sometimes schools or clinics (Ref.1), Standards vary according to the availability of local and foreign funds; costs per hectare can be as high as Rp 12 million and as low as Rp 2 million *. In the early days of the Jakarta KIP most emphasis, approximately 50% of all expenditure, was given to roads and drains. Sanitation facilities, MCKs (mandi=bathing; cuci=cleaning; kakus=toilet), are still given a low priority usually not exceeding 5% of total expenditure. Foreign aided programmes tend to give more emphasis to sanitation, but even so it usually accounts for a small proportion of the total. Only in Jakarta, KIP provided private sanitation facilities by a construction programme of approximately 3000 leaching pits.

WATER SUPPLY IN KAMPUNGS

Shallow Wells and Handpumps

Most of the people in kampung areas rely on shallow wells. A widespread problem in kampung areas is the insufficient distance between handpumps, shallow wells and leaching pits. This is the result of space limitations on the plot and, therefore, the risk of water contamination in shallow wells is high: a survey in Jakarta revealed that more than 70% of these wells are located less than 7 metres from the nearest leaching pit (29% even within 5 metres) (Ref.2). As a result the shallow wells are grossly polluted (recorded counts were up to 6500 coliform per 100 ml). People living in kampung areas are in general well aware of the pollution level of their water source and normally boil their water for consumption if obtained from a shallow well. However, teeth brushing takes place in general with non boiled water.

Public Water Supply

If water is available from the public water supply it is often only used for drinking and cooking (to save money). Public water supply is in general scarce, often taps are non-operational due to low pressures. When public water is supplied for the low-income dweller it is relatively expensive. Low-income people normally obtain water from standpipe operators or water vendors, which further increase the cost of water. In addition public water standpipes are not very popular with the water authorities. Normally a high percentage (up to 50%) of the total water production is unaccounted for. Besides leakages and losses, water is consumed through illegal connections or not charged due to faulty water meters.

Water consumption by use

Use	Litres/cap/day
Drinking	10
Washing	22
Bathing	35
Toilet use	13

Water charges in kampung areas

Supplier	US$/1000 litres
House con.	0.08
Stand post	1.39
Vendors	2.78

EXCRETA DISPOSAL IN KAMPUNGS

Leaching Pits

Where possible direct defaecation into waterways is the most popular choice in low-income housing areas. Open privies extending out

* Currency exchange rate is Rp 1000 = US$ 1.

over the water, so-called helicopters, or floating privies on bamboo rafts or in-house toilets with short discharge pipes into water ways are usual. For the user himself, a reasonably clean, odor-free and hygienic method. From the water pollution viewpoint this is unacceptable. It has been estimated that 70-90% of the water pollution in rivers through Indonesian towns is the result of human waste (Ref.3). In particular the lower branches of all waterways in Jakarta have turned septic, while the upper streams have also become grossly polluted. Small roadside ditches are used by the smaller children to defaecate. The majority of kampung houses use handflush waterseal toilets connected to an unlined leaching pit outside or within the house. The direct discharge type (pits directly under the squatting slab) is also used. These leaching pits are primarily used for a variety of reasons: (a) the limited space available, which precludes the use of a septic tank/leaching system; (b) the fact that relatively little water is needed for the toilets. Bathing/washing water is separately drained into the roadside drain. Most of the people construct their leaching pits from brick or concrete. Where high groundwater tables are present, bamboo hampers are used for structural support. Elsewhere, unlined dug holes are used, the soil being sufficiently stable so that no shoring is needed. The usual size of a leaching pit is about 0.8-1.0 metre diameter by 3.0 metres deep, which serve a family of up to 8 people. In spite of their low status in public health engineering practice, leaching pits generally give a satisfactory service and moreover are well suited to the socio-economic condition of the kampung environment (Ref.4).

Cleaning Services

At regular intervals septic tanks/leaching pits have to be desludged. While a recent survey revealed that approximately 91% of the leaching pits have never been desludged, approximately 71% of the leaching pits were constructed in the last 5 years and probably still did not require any desludging services. But over the years this requirement will increase. Leaching pits after their first desludging will require desludging more often due to a gradual decrease in the permeability of the pit walls. All vacuum trucks in Jakarta are equipped with a suction hose of 80 metres length. Unfortunately, there are still many houses that cannot be reached with this cleaning equipment. Aerial photograph interpretation reveals that approximately 15-25% of all houses are located at a distance greater than 75 metres from an accessible road. Desludging services are provided for a minimum fee of Rp 4000 for 2 m^3 and an extra Rp 2000 for each additional m^3 of sludge. However, it is common practice to pay an extra tip to the cleaning crew to obtain the emptying service. Actually desludging of a leaching pit will cost a minimum of Rp 10,000. Also it has been observed that the cleaning crew has little interest in going to the official dumping site through all the traffic congestion. Most of the sludge is, therefore, dumped in the nearest available waterway, aggravating the already existing pollution levels. Solid removal efficiency from the pit is shown to be low, and in general only partial desludging of leaching pits takes place with the present equipment. There is a need for improved equipment, which will make all leaching pits in kampung areas accessible for desludging. An over-capacity of equipment, better remuneration of personnel and competition could divert desludging services from wealthy customers to lower-income people. During the rainy season leaching pits are often scooped out manually and discharged to the roadside drain. The costs involved for this type of operation are normally a fraction of the fee charged by the official desludging service.

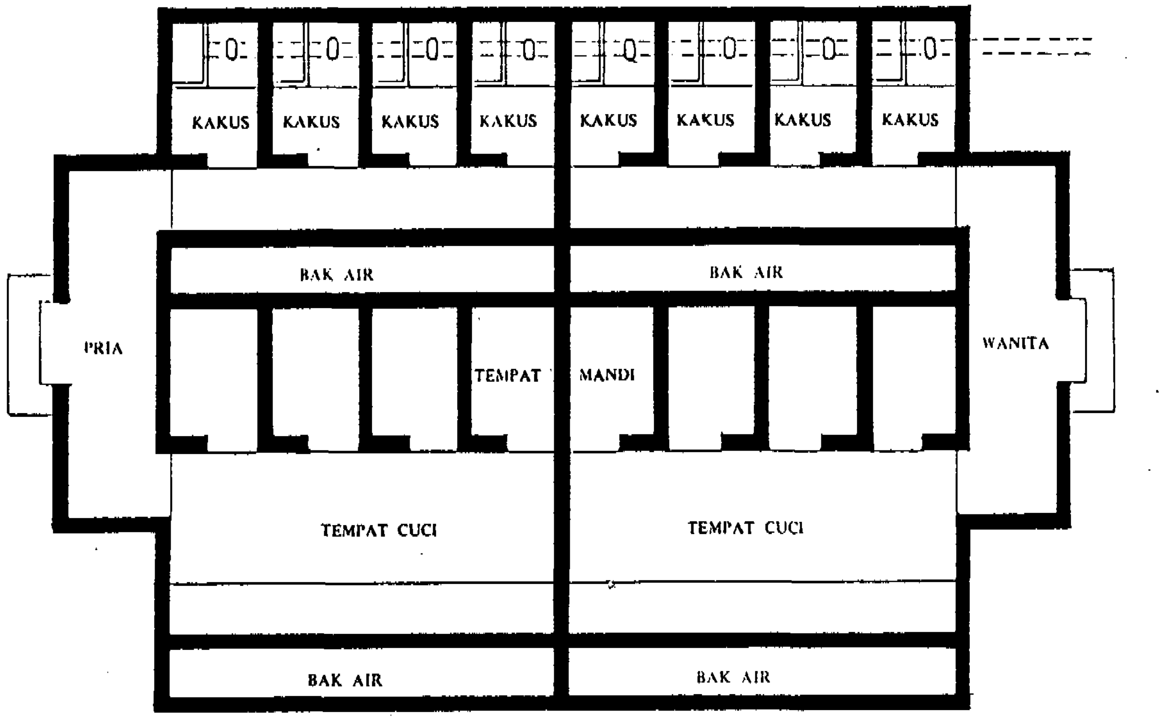
SANITATION PROVISION BY KIP

Public Facilities (MCKs)

In the high-density, low-income areas, the KIP provides communal sanitation facilities. These sanitation facilities, MCKs, can contain up to 16 toilet seats (see Drg.1). However, the 4 toilet seat unit is now the more popular type. Toilet wastes are discharged into a septic tank which is built below ground level normally next to the MCK unit. These septic tanks often overflow to the roadside drain. Water supply is usually with a handpump, but many MCKs are built with an internal water distribution network, which is, however, not operational. The numbers of MCKs provided by the KIP are, however, insufficient to meet the minimum desirable needs. Design figures of 120 people for every toilet seat are not unusual. However, it is physically impossible to accommodate more than 25 people for each toilet seat. The large MCKs have not become very popular in KIP projects. One of the main difficulties in using the standard MCK is the size of plot required (14m x 13m) which has proved to be simply too large to find and acquire in dense kampungs.

Operation and Maintenance

Operation and management of these large MCKs is often beyond the capacities of the local community. The communities arrange the operation of the MCKs in different ways. Some MCK operators charge a direct user fee for every visit to the MCK. Typical charges are:



Drawing No.1 Communal sanitation facility, MCK, provided by KIP

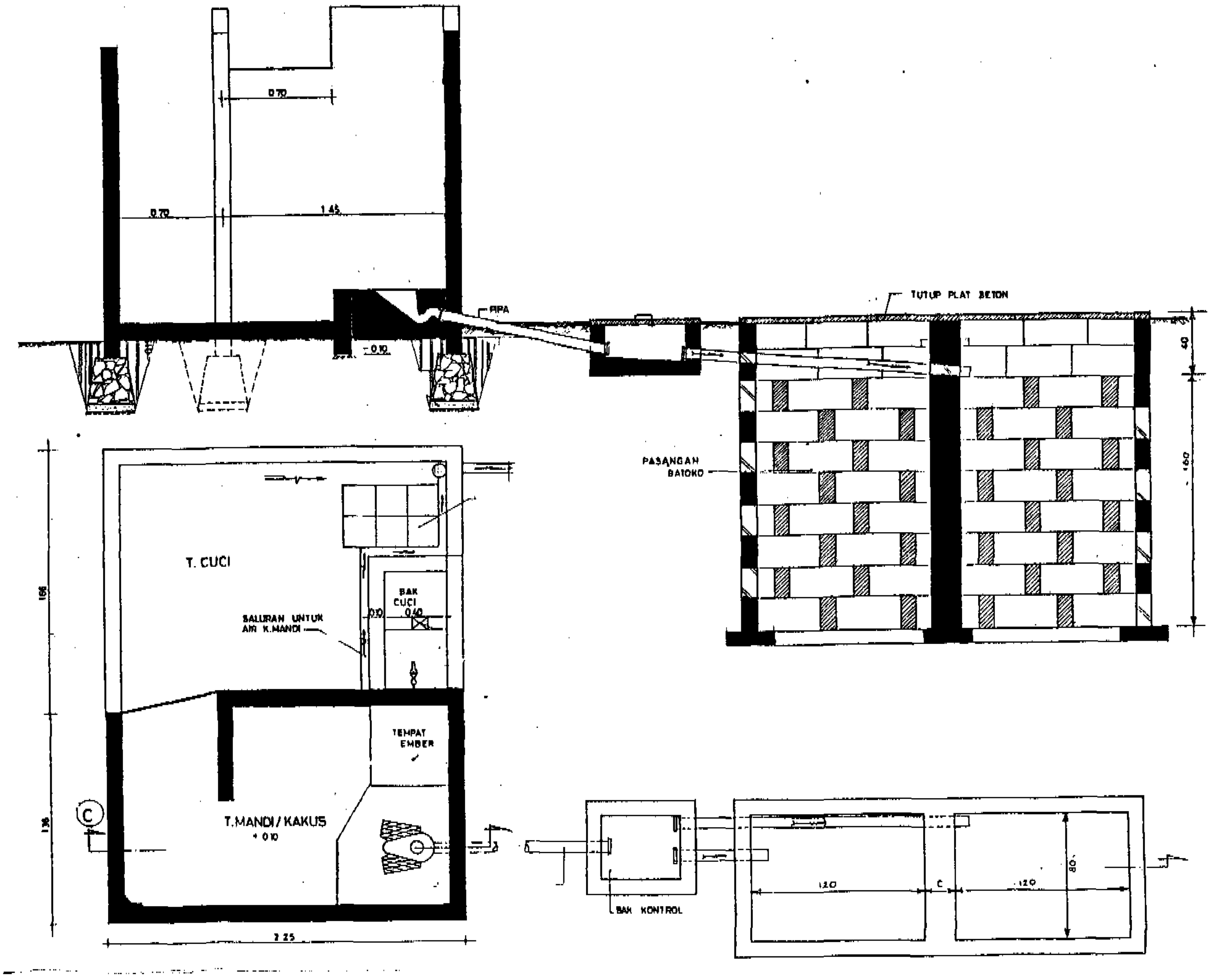
for toilet use Rp 10, bathing and washing Rp 20. However, it was observed that on a number of occasions the operator requires a payment of Rp 50 for the use of the MCK. Direct user charges do not encourage use of the sanitation facilities. Another method in use is that the local village head collects from every family which uses the MCK a designated sum. These collections are based on the financial capabilities of the families. The village head pays the caretaker. A method in use also is that the village head receives in advance for each week a list of persons,selected by the families concerned, who will clean and maintain the MCK. The village head regularly checks their work and the MCK can now be used free of charge. Only for the desludging of the septic tank is money collected via the village head from people using the facilities. However,a large number of these MCKs have become non-operational due to lack of maintenance.

Semi-Private Facilities

Discussions with local leaders reveal that it would be relatively easy to find and obtain permission to use relatively small plots of land, on which smaller versions of the MCK could be located. In the Dutch-financed kampung improvement schemes steps in this direction have been taken. A greater number of smaller MCKs, the so-called MCK-Keluarga type, serving up to 5-6 households (30 people) each equipped with its own handpump and septic tank/anaerobic upflow filter were built. Bathing and washing wastewater is discharged directly to existing footpath drainage ditches. After an initial reluctant acceptance by the local community these sanitation units have become popular. Unfortunately, all MCK-Keluargas were provided with septic tanks of an effective volume of only 900 litres. For several reasons, these small septic tanks started to malfunction within 3-6 months and made the small MCKs non-operational for toilet purposes (Ref.5). In general it was felt that the small MCK is a step forward in the direction of adequate sanitation provision in kampung areas. Future designs of these MCK-Keluargas will replace the septic tank/anaerobic upflow filter with double leaching pits, eliminating earlier problems (see Drg. 2).

THE FUTURE SANITATION PROGRAMME IN KIP

The Government of Indonesia plans that 60% of the urban households should have access to sanitation facilities. This would mean that approximately an additional 26 million people will require sanitation facilities



Drawing No. 2 The MCK-Keluarga in combination with double leaching pits.

during this decade. Pilot sewerage projects have been initiated in a number of selected cities but are too costly for mass implementation. The current programmes show that there are a number of problems associated with existing excreta disposal practices. Social constraints are a low awareness of residents on the subjects of hygiene and sanitation and the unpopularity of large public MCKs. It is clearly beyond the financial capability of the Government to implement in each and every town a full sanitation programme. One of the major strategies will be to increase the awareness and education level of the population by using mass information campaigns, in combination with a human waste disposal programme which is based on a simple technology which can be implemented or supported by self-help activities. The technology of pourflush toilets connected to double leaching pits appears to be the most effective and will eliminate all major problems related to human waste disposal. Therefore, the Government of Indonesia expects to spend 20 million US$ in KIP programmes for an improved public information campaign to encourage the construction of toilets in combination with leaching pits.

REFERENCES

1. Devas Nick: Indonesia's Kampung Improvement Programme - an evaluative case study. DAG occasional paper 10, University of Birmingham, 1980.
2. Ministry of Public Works: Jakarta Sew. & San Project, vol.8 Sanitation, Jakarta, 1982.
3. Ministry of Environment/UNDP: Environmental review report, Jakarta, 1984.
4. WHO/UNDP: Jakarta Sew. & San. Project. Vol.7, Immediate programme for sanitation, 1977.
5. Kruijff Gerd Jan de: The performance of the MCK-Keluarga in KIP, DPMB, Bandung, 1984.

10th WEDC Conference

Water and sanitation in Asia and the Pacific: Singapore: 1984

Refugee camp water and sanitation

Carlos E Herrera and Surasan Sataviriya

INTRODUCTION

History of the Refugee Situation in Thailand

In 1975, political changes in Vietnam, Cambodia and Laos drove about 160,000 people across the border into Thailand. The majority of these people came across the Mekhong river from Laos and were granted asylum by the Thai government.

From 1976 until 1978 the refugee population in Thailand remained more or less stable. There was a continual, relatively small inflow of refugees from Kampuchea, Vietnam and Laos which was offset by a steady, though smaller, number leaving for resettlement.

In 1979, a series of events occurred which greatly increased the flow of refugees into Thailand. In January, the exodus of boat people from Vietnam took a sharp increase to the extent that the monthly rate of arrivals increased by as much as four-fold. Again in June, tens of thousands of Khmer crossed the border into Thailand, followed by another near 200,000 in late 1979 and early 1980.

After 1980, the number of refugee arrivals decreased to pre-1979 levels, as shown in Figure 1.

The approximate present-day camp populations are presented in Table 1.

The Problem

During the initial stage of the 1979-80 refugee crisis, there was an urgent need for food,

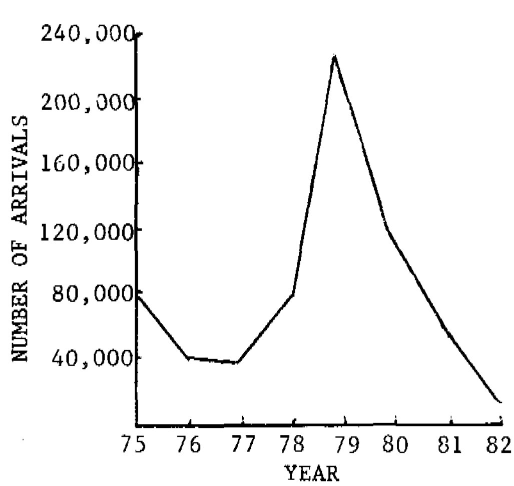


Figure 1. Refugee Arrivals in Thailand (ref. 1)

Table 1. Approximate Refugee Camp Populations 1983

Camp	Country of Origin	Population
Chiang Kham	Laos	3,300
Ban Nam Yao	Laos	7,300
Ban Vinai	Laos	38,000
Ban Na Pho	Laos	17,000
Khao-I-Dang	Khmer	45,000
Sikhiu	Vietnam	5,100
Phanat Nikhom	Laos,Khmer,Vietn.	17,200

housing and medical aid. Sanitation and public health facilities were generally insufficient. Latrines were not properly constructed, systems for the disposal of wastes and refuse were inadequate, and there was poor, if any, drainage in the camps. These problems were compounded by the continual expansion of the population accommodated in hastily-built facilities and the fact that many refugees from rural areas were unused to living in crowded conditions. As the emergency subsided and the health of the population began to stabilise, public health and sanitation problems in the camps persisted. The communities in the camps continued to have high rates of water-related diseases such as typhoid, malaria, gastroenteritis, diarrhoea, cholera, parasites and skin diseases. (ref. 1)

Later in 1980, when the focus began to shift from curative medical care to preventative health programmes in the camps, the problems of water and sanitation became of more concern. Water and sanitation became integral parts of preventative public health care programmes, the objective being to create and maintain conditions that will promote health and prevent disease by maintaining a safe supply of water, providing effective disposal of human and household waste, eliminating stagnant pools and controlling the population of rodents and mosquitoes and other insects which are likely to spread disease.

WATER SUPPLY

As refugees come into Thailand and are organised into refugee camps and holding centers, an urgent need in terms of public health is always the procurement of a potable water supply. Generally, several options for water supply are open to the UNHCR and the implementing volunteer agencies. These include rain water collection, surface water, hand-dug shallow wells, bore-hole deep wells and trucked-in water supply. A summary of the water sources for the refugee camps is presented in Table 2.

Rain Water

Rain water constitutes a fair percentage of the total consumption in many camps during the rainy season. Rain collectors used include bamboo baskets with plastic sheets placed inside, cement jars, galvanised tanks, stacked concrete rings or discarded 200-L oil drums and are placed to collect rooftop run-off. Although a valuable supplement to the water supply during the rainy season, rain water has not proven to be a viable alternative for year-round supply.

Hand-dug Shallow Wells

Although hand-dug shallow wells can be an appropriate water supply on the village level, the extensive use of shallow wells in the refugee camp has shown that shallow wells are not suitable as a drinking and cooking water source.

A good example of the problem with shallow wells is found in Ban Vinai Camp, where water quality analysis has shown positive foecal coliform concentrations in all shallow well water samples tested. Even the inclusion of design features such as concrete aprons, cement seals, and locking covers, as well as the location of latrines at over 30 metres from the wells, has not solved the problem.

The contamination of the shallow ground water itself (not necessarily the individual well) is the main reason why shallow wells are not acceptable as a potable water source for refugee camps. The dense populations in the camps and such practises as indiscriminate defecation, urination and disposal of washwater invariably pollute the shallow ground water.

Another appropriate village-level technology which has been found inappropriate for the refugee camps has been the hand pump. The problem is that hand pumps are subjected to very heavy use (12 hours per day non-stop pumping) and rapidly break down.

Trucked-in Water Supply

Trucked-in water supply has been used as a temporary supply, as well as a permanent main water source, for several camps. Although the quality of trucked-in water can be controlled and kept at high standards, the transportation costs are usually restrictive. At Khao-I-Dang, where trucked-in water comprises 76% of the total water supply, the 1983 cost per month of the water supply program exceeds ฿512,000. This equals an approximate cost of ฿1.39 per cubic metre.

Another problem with trucked-in water supply is that with this type of source there is no storage capacity, as water is consumed on a day-to-day basis. Any cut in the supply will immediately have a severe impact on the population.

Borehole Deep Wells

The technology which has had the most widespread use and success in providing a reliable, potable water source has been the borehole deep well, equipped with a submersible or direct drive pump. Although expensive to install (at Ban Vinai, a 1983 cost of approximately ฿6,944 was incurred in the drilling of a 35-metre deep well and the installation of a pump and distribution stations), these systems can withstand the heavy demand placed on them by the large refugee populations.

Table 2. Water Sources for Thai Refugee Camps

Camp Name	Source	Quality	Production (L/c/d)	Use
Sakaeo	4 Deep wells	Good	15	D,C
	Rain collection	Good	5	D,C
	Shallow well	CONT	10	B,W,Wa
	Reservoir	CONT	-	B,W
Phanat Nikhom	Trucked	Good	15	D,C,B,W
	2 Deep wells	Good	8	D,C,B,W
Kamput	River	CONT	10	D,C,B,W
	20 Hand pumps	Good	1	D,C,B,W
	4 Deep wells	Good	4	D,C,B,W
Ban Na Pho	6 Deep wells	Good	23	D,C
	Numerous shallow wells	CONT	-	W,Wa
Sikhiu	City system	Good	40	D,C,B,W
Khao-I-Dang	Trucking	Good	10	D,C,B,W
	13 Deep wells (only 4 productional)	Good	5	D,C,B,W
Ban Vinai	15 Deep wells	Good	20	D,C
	+ 150 Shallow wells	CONT	10	W,B,Wa

CONT=Contaminated, D=Drinking, C=Cooking, W=Washing, B=Bathing, Wa=Watering

Deep wells, however, are not a viable solution in all cases, and the hydrogeological conditions of an area should be investigated before wells are drilled. This obvious point is sometimes neglected in the hurried rush to provide a permanent potable water supply, as occurred in Khao-I-Dang, where only 4 of 13 deep wells are productional.

HUMAN WASTE DISPOSAL

One of the more difficult problems in the refugee camp situation is the collection and disposal of human waste. The selection of a suitable waste disposal system design can be influenced by the population, layout, soil conditions and water availability in the individual camps. In addition to the need for appropriate design, education about the use of sanitation facilities should be included, particularly when rural people are obliged to live in overcrowded conditions which they have not previously experienced.

Historically, the waste disposal systems in the Thailand refugee camps have evolved from the initial use of pit latrines, to aquaprivies and finally to water seal latrines and waste stabilisation ponds.

Pit Latrines

The pit latrine has been used in the camps as a quickly constructed response to the sanitation problem. The basic design (ref. 2) used is shown in Figure 2.

As an initial response to indiscriminate defecation, the pit latrine has shown some promise. However, the experience in the camps has been that because of very heavy use, objectionable fly and odour problems soon drive people away from using the latrines. In the Khao-I-Dang refugee camp, long trenches of 3 to 4 metres depth were used under long rows of toilet cubicles, crude timber ventpipes at the back of the cubicles reduced odours, while lime was added into the pit after each use. The capacity of the latrines proved to be great but flooding and collapsing of the pits plagued the system. (ref. 3)

The main cause of the problems associated with the pit latrine design shown in Figure 2 is poor ventilation. The bamboo superstructure lets in a great deal of light, and therefore a hole cover must be used to keep flies from emerging. The hole cover, in turn, blocks off the air flow which should proceed through the hole and out the vent pipe. As a result, objectionable odours accumulate.

Aqua Privies

The problems with pit latrines led to the investigation of other alternatives, one of which is the aqua privy. The application of aqua privies to the refugee holding centers originally appeared very favorable, as reported by Suwarnarat and Nawarat. (ref. 4)

The actual operation of the aqua privy, however, proved difficult. Bielik et al. (ref. 5) reported that the failure of the privies was due to several factors, including improper toilet shed and seepaway design. Seepaway design was especially critical. Due to impervious soils and a high water table during the rainy season, the aqueous effluent from the aqua privies rather than seeping away from the system, filled the seepaway and backed the fluid up into the aqua privy.

Presently, water seals are being used on the aqua privies and the sludge and aqueous portions are pumped out on a regular basis. This has reduced the aqua privies to mere holding tanks where active anaerobic digestion can begin.

Water Seal Latrines

The system which has gained the widest acceptance and success in the refugee camps has been the water seal pit latrine. Essentially its design is the same as that of Figure 2, with the introduction of a water seal (Figure 3). The water seal separates the pit and the latrine compartment, and prevents the smell from getting from one to the other. In addition, the cisterns are sealed to prevent contact with the ground water.

The pit or cistern serves as a holding tank and primary anaerobic digester. Once the cisterns are filled, their contents are removed and transported to a disposal site.

Oxidation Ponds

In many of the refugee camps, the wastewater from the latrines is transported to a stabilisation pond system by pump trucks. The design most widely employed includes an anaerobic pond followed by a facultative pond and two aerobic ponds in series. The design and

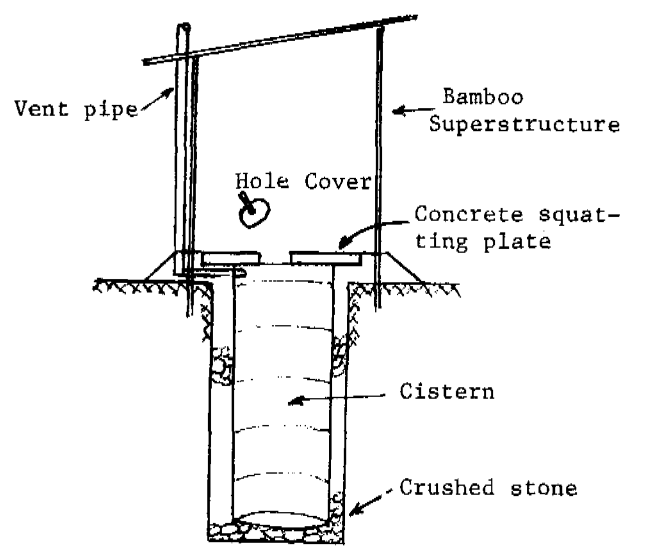


Figure 2. The Basic Features of the Thailand Refugee Camp Pit Latrine

Table 3. Water Quality of Lagoon Effluents

Lagoon	pH	COD (mg/L)	BOD (mg/L)	Ortho Phosphate (mg/L)	Ammonia (mg/L)	Nitrite (mg/L)	Nitrate (mg/L)
Anaerobic	7.6	923	120	7.5	1.8	0.026	44
Facultative	8.5	850	90	7.8	1.9	0.040	40
Aerobic I	8.5	555	80	5.9	1.9	0.023	48
Aerobic II	8.5	397	80	4.5	1.6	0.016	50

operational parameters used are according to Tam. (ref. 6)

Normal BOD removal efficiency is over 80% for the anaerobic and facultative ponds and good pathogen removal occurs in the aerobic ponds. Listed in Table 3 is typical water quality of the effluent from the lagoons. This information is based on data from the Ban Vinai and Na Pho treatment lagoons.

Based on the positive results reported by McGarry (ref. 7) on fish culture in oxidation ponds, an attempt at fish production was carried out in the Ban Vinai lagoons. A polyculture of silver, chinese and common carp was introduced into the facultative and aerobic lagoons, and all the fish died within minutes. The immediate deaths were due to ammonia toxicity which occurs with high ammonia concentration at pH greater than 7. If the ammonia toxicity problem can be overcome, fish culturing in oxidation ponds can improve the functioning of the pond as well as provide an additional food source.

CONCLUSION

Several water supply schemes have been implemented in the various refugee camps. Generally it has been found that water systems employing borehole wells have been the most appropriate to the refugee situation in Thailand. In most instances pit latrines and aqua privies have been unsuccessful in disposing of the large quantities of human wastes in the refugee camps due mostly to inappropriate application of the technology. Water seal latrines have proved more effective when coupled with the use of stabilisation ponds.

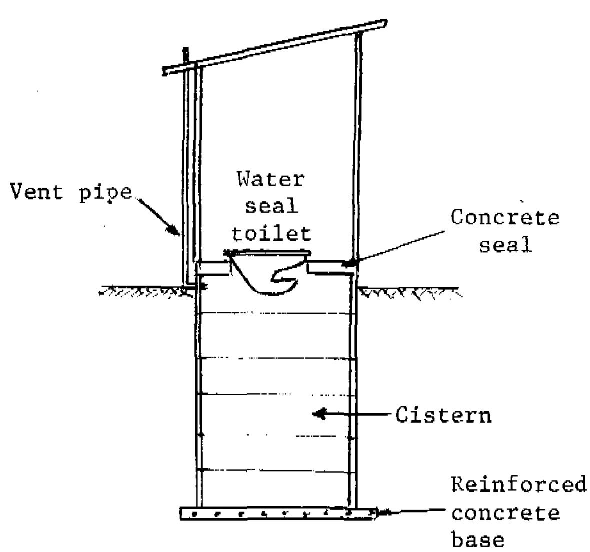


Figure 3. Water Seal Pit Latrine

REFERENCES

1. CCSDPT. The CCSDPT handbook: refugee services in Thailand. Craftsman Press, Bangkok, 1983.

2. DIAMANT, B Z. Pit latrines, sanitation in developing countries. J. Wiley and Sons, Great Britain, 1978.

3. NIMPUNO, K. Viable low cost sanitation options. International Seminar on Human Waste Management. Bangkok, 1983.

4. SUWARNARAT, K. and NAWARAT, C. Aqua privies as applied to the refugee holding centers in Southeast Thailand. International Seminar on Human Waste Management. Bangkok 1983.

5. BIELIK, R, HENDERSON, P, RESSLER, E, and TIMM, I. Lessons learned from the use of aquaprivy sanitation units in Khmer holding centers in Thailand, 1979-1982. Disasters 6(3), Intertect, Dallas, 1982.

6. TAM, D M. Stabilization ponds for sewage treatment practical considerations. Environmental Sanitation Information Center, Asian Institute of Technology, Bangkok 1982.

7. McGARRY, M G. Oxidation ponds and fish culture, water supply and sanitation in developing countries. Ann Arbor Science, Ann Arbor, 1982.

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Experiences in planning and implementing low cost sanitation

S R Kshirsagar

Introduction

The Government of India as part of its commitment to the International Drinking Water Supply & sanitation Decade has placed a target of providing hygienic means of sanitation to 80% of its estimated urban population of 189. 4 millions by 1991 at an estimated cost of Rs.3685 million. At present(1984) only about 200 towns and cities out of 3245 in the country have some partial underground sewerage. In view of the stupendous task to be undertaken to meet the decade's target it is quite apparent that some type of simple and low cost sanitation system and which can be easily converted later on to a regular sewerage system would have to be developed and adopted. The National Environmental Engineering Research Institute (NEERI), Nagpur, India while working on its sanitation projects in rural areas, had developed water seal pour flush offset pit latrines and which are found to be best suited for the purpose. The Technology Advisory Group of UNDP on confirming the feasibility (through actual trials) of adopting such latrines initiated their project No.IND/81/014 in India and requested all the State Governments to participate. NEERI has been very much associated with this project not only for giving its expertise but also in the monitoring and the evaluation of the system. Some of the experiences gained in the implementation of this programme in the country are narrated in this paper.

The new system of low cost sanitation

The sanitation system (fig.1) is of "On-site treatment and disposal type" and does not need any costly underground sewerage. The excreta of the users is collected by pour flush (2 liters of water at a time) type of pan having a shallow (20 mm) water seal and passed on into two covered pits (one at a time) constructed behind or nearby the latrine cubicle. The pits work both as septicatanks and soakage pits and are made of a capacity to last for about 2 to 3 years for the number of users at about 45 to 50 liters per capita per year in dry soils and with 50% more capacity in wet soils i.e. where ground water level rises to within one meter from ground. A filled up pit is left out for over two years when its contents decompose and get converted into humus containing rich organic manure while most of the pathogens (if any) in the mass die on account of the long (over 2 years) storage (in the pit)under unfavourable entironmental conditions. The pit is then emptied and kept ready for connecting to the latrine through the bifurcation chamber and the system works thus uninterrupted. When used carefully the system is perfectly hygienic and does not cause any nuisance from odours or insects and can be placed close to (or forming part of) residences. The gases produced in the pits during digestion of excremental matter get absorbed and arrested in the soil alround and no vent pipe is required. The system can be converted into conventional sewerage system if and when required.

Factors contributing to the success of the system

Availability of water:- Experience shows that the success of implementing and working of this system depends upon a number of factors like the availability of required quantity of water, space and sites suitable for construction in different house holds, right type of materials, community participation, dedicated officials and simplified administrative and financial procedures etc. These will now be discussed.

Water is a necessity for working this system. Considering that for each use about 2 lit. of water would be required for flushing with hand the pan and also that it will have to be thoroughly cleaned once every day, a family of five may require about 30 lit. ((maximum) of water per day for flushing and ablution purposes in the latrines. This quantity of water will have to be made available to the people in the town in all and especially in hot and dry seasons. The quality of water to be used for flushing need not be potable but it should be clean and clear. Since there are possibilities of ground water pollution where the system is adopted treated piped water supply from a distant source be provided to the town at least for meeting the needs of drinking, cooking and washing of utensils (i.e. about 100 liters per day for a family of five).

Space and suitable site conditions

There should be sufficient space for accomodating the two pits and latrines cubicles in all houses. The sites chosen should not be subjected to flooding by rain/storm water. The strata under ground should again not be hard and rocky type for a depth of 5 meters. Similarly the ground water table in the area should normally be 5 meters below ground and should not rise to above 1½ meters below ground. It would then be possible to accomodate the latrines, construct the digestion cum soakage pits without any difficulty and there would be lesser possibility of pollution of ground water through the leaching of digesting excremental matter from the pits.

In some houses apparently there may not appear sufficient space or suitable site in courtyards for accomodating a latrine cubicle with the two pits and the bifurcation chamber. A corner of the varandah in the houses can be then used to accomodate the cubicle only and the pits (fig. 2a) be kept out in the courtyard. When there is no courtyard at all, (fig. 2b) the pits may be accomodated in the adjacent varandah/room and properly covered so that its normal usage can be continued as before.

In some localities service lanes are provided for removal and transport of excreta by scavengers from existing bucket type of latrines. Such service lanes can be conveniently (fig. 2c) utilised for locating the pits. Where there is no space available at all and there are no such service lanes, pits may be located under the foot paths and some times even under (the low density traffic) roads.

Construction materials

All the construction materials and pans and traps of proper design should be available at fair price so that the construction of the system would be economically feasible. Pans and traps are to be made of special design with verticle sides and steep longitudinal bottom slope and of shallow (15 to 20 mm) water seal. These are available in different materials. Cement concrete pans and traps are found to be the cheapest (cost Rs. 40 per set) and strongest but are heavy. These are again not smooth enough and cause sticking of the excreta and would require more water or frequent mechanical cleaning using a brush with handle. Stoneware white glazed pans and traps are heavy, brittle and costly (price per set is Rs. 125 - 150). Fiber glass reinforced plastic and PVC pans and traps coated from inside with 2 mm thick polyurethane are light and smooth but require full uniform and unyielding support from the bottom to prevent cracking and breakings due to uneven load from above. These are however, cheaper (price Rs. 90 to 120) smooth and inert due to the coating and can remain so after prolonged use.

Flexibility of design and layout of the system

Space necessary to adopt the standard layout (fig. 1) is normally available only in a few houses. The layout of the system has to be therefore varied to suit the site situations. Thus the digestion-cum soakage pits may be located to the sides or to the front (figs. 5a,b) and made even abutting to one another (with certain modifications) when very little space is available (fig. 4). At places where ground water table is high (<2m below ground), 0.6 to 0.8 m high earth embankment (fig.5) be constructed and the latrines and the pits kept over it to ensure some distance (1.5 to 2 m) between the bottom of the pits and the (high) ground water table. Where such embankments are not possible an annular layer of fine (0.2 mm size) sand (fig. 6) ½ meter thick is placed outside the lining of the pits, to effect filtration of the leachet before it can join the ground water from the sides the bottom of the pit of-course being sealed completely by some impervious material (i.e. cement concrete) to prevent downward percolation.

Risk of ground water pollution

So far, not much work has been done in the country on the pollution aspects of ground water due to construction of such latrines since the programme itself has been new. Some investigations were carried out about 30 years back by Bhaskaran and Subrahmanian of ICMR (Indian Council of Medical Research) at Singur in West Bengal using experimental bore hole latrines to study the horizontal distance travelled by polluting organisms. They indicated a safe distance of 8 days of travel in saturated soil below ground water between the pits and wells, when the leaching organisms got completely intercepted. The velocity of ground water flow is very slow and depends upon the type of soil Coarse sandy soil allows the ground water to flow fast at a velocity of 1½ to 2 meters (maximum) per day and hence a safe distance of 15 meters between latrine pits and wells is advocated. In other soils the safe distance can be suitable deduced. It is generally observed that the pollution does not travel even beyond 3 meters from the pits in clayey type of soils. Although the risk of ground water pollution from such latrines is low, it is safer to recommend and adopt such latrines at places where piped public water supply from a distant source has been provided and the community is educated/instructed not to use water from the wells in the town for drinking, cooking and washing of hands and utensils in the houses.

Use of acquaprivys

If the site where latrines are to be constructed is having ground water level or hard rock at a shallow (<1m) depth, it will be impossible to excavate the pits and arrange soakage of the water and leachets from the digesting sludge. Under such site conditions acquaprivys made of water tight masonary or RCC chambers of 120 l/capita served capacity be provided. Sludge accumulation is estimated at 30 to 40 liters per capita per year and this be removed once after 2 to 3 years to obtain safety in handling and while using the same as manure.

It will be better to construct anaerobic upflow contact filters to treat the effluent of acquaprivys so as to reduce further the BOD, pathogenic organisms and the suspended solids in it. Availability of space for construction of such filters has however been a problem in some urban localities. This filter is made of 2-3 cms size metal for a depth of 60-65 cms and the BOD loading can be kept at about ¼ kg per M^3 per day. The size of this filter unit thus roughly comes to about 2/3 the size of the acquaprivy. Such a filter can remove 70-75% of incoming suspended solids and BOD within a detention period of 8-10 hours and can also remove helminths and eggs of ascaris by 100%. It's effluent can be then easily discharged out into open surface drains or be absorbed in shallow soakage trenches where space and suitable, strata is available for constructing these.

Simplified administrative and accounts procedures

This system involves highly scattered type of construction activity to be undertaken in hundreds of residences having different site and space conditions so that each one becomes a separate small micro-sanitation project. Conventional procedures of giving a mass scale construction contract and its execution through licensed agencies may therefore not work and would have to be suitably modified. Similarly the accounts procedures for giving advances to petty contractors executing such work and paying their bills may have to be also adjusted to effect speedy implementation. Without such flexibilities in administrative and financial procedures it would be difficult/impossible to carry on/complete the work and within the stipulated period.

Dedicated Public Health Workers

The work of construction of such sanitary latrines has got a very important bearing upon the health of the community. Hence dedication to the cause of the community and public health rather than development or application of a high degree engineering technique (which is normally being valued more amongst the Engineering profession) will have to be the motivating force for the personnel engaged in the execution of this work.

Community and Individual Participation

The construction of this system of sanitation and its regular use later cannot be ensured without the active participation of all the landlords and their tenants in the towns. All the residents of the town where the project is to be taken up will have to be therefore first convinced of the utility of the new scheme, its advantages over the existing system and particularly its non reliance for day to day operation on scavengers.

General and health education in the community would also very much help the programme. Medical practitioners in the town should explain and publicise the new sanitation system and its effect on clean environment and better health through lecture meetings. Social workers and service clubs be got involved in promoting the acceptance of the new system.

Present situation of sanitation in the country and strategy for introducing the new system

In most of the small and medium size towns in the country (India) about 25% of the households may have 'bucket or service type' of latrines which are cleaned once in a day by scavengers. Part (10-15% of the total) of the remaining population uses public latrines of the same type and more than half of the house-holds go out to the fields or bushes for defecation. In order to change over to the new system of sanitation, general and health education will have to be first given to the people through group meeting held in different wards. The new system of sanitation would be explained to them simultaneously and its personal/ practical (to the family) and health benefits (to the society) will be emphasized.

The elected representatives of the local body and/or the leaders of the communities in the town should be simultaneously told to adopt the new system of sanitation. These new latrines water seal pour flush pit type should serve as demonstration units and will help the general public in understanding its usage and benefits and would promote its acceptance.

It may then be notified by the local authority that the scavenger service of the town is to be discontinued and the people be asked to either convert their existing latrines into the new type and/or construct latrines of new design within a stipulated period eg. two years For such simple small and scattered type of work regular contractors may not be available and skilled workers in the town may have to be trained and enrolled as small petty contractors, and the conversion/new construction work will have to be got done through them under the supervision of the Municipal Engineers.

It is again better to start the programme at such places where site conditions are suitable and the house-holders are progressive and cooperative. The latrines construdted in these houses will be naturally used properly and maintained better so that these would work as additional demonstration units and would lead to further adoption of the system by the remaining households.

Financing of the scheme

For converting existing bucket type of latrines into the new system, the present day (April 84) cost is about Rs. 800/- in the country. Since most of the house owners in towns would belong to the lower middle income group they could be given for conversion purpose a loan plus subsidy of that amount repayable within a period of about 10-15 years. The Municipal or local body should construct these latrines at it's own cost by borrowing money in bulk from a scheduled bank or other public financing agency and(continue to) charge the same amount(ie.about Rs.50 per annum per family) equivalent to old annual taxes for the scavenger services towards refund of the loan amount. Such a system of financing and recovery of loans has been found to be working satisfactorily. The local body should also at its own cost arrange through contractors removal of digested excremental matter from the pits after it is fully matured and dried. The manure will fetch an income of Rs.200 biannually per family of five and would meet the service charge for alternating and emptying pits and would also help the repayment of loan charges as well by the municipalty.

Summary and Conclusions

To fulfill the targets of the International Drinking Water Supply & Sanitation Decade (1981-90) low cost sanitation programmes comprising of construction of house hold pour flush water seal pit latrines have been taken up in India on a massive scale. Experience in the implementation has shown that it is better to initiate such programmes at places where sufficient water is available all the year round for hand flushing of the latrines, and space and suitable sites are also available for the construction. In congested urban localities great ingenuity is necessary to accomodate the system by making suitable modifications in the layout. Acquaprivys followed by anaerobic contact filters will prove more appropriate where the ground water strata is hard and rocky or ground water level is high. The success of the implementation programmes would also depend upon the motivation and participation of the communities for whom the work is being undertaken, deployment of dedicated technical personnel having a sense of social service, simplified administrative and accounts procedures and availability of sufficient finances on easy terms and conditions.

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10th WEDC Conference

Water and sanitation in Asia and the Pacific: Singapore: 1984

Low cost sanitation in India

Professor K J Nath and P K Chatterjee

1. INTRODUCTION :

Extremely poor level of environmental sanitation, particularly in respect of human excreta disposal, has been a major factor behind the high prevalence of soil and water borne diseases in India. Open defeacation in the fields is a common and traditional practice in the rural and urban under-served areas. Even in big municipal towns, thousands of individuals from poorer localities and young children use open fields, passages and road side drains for this purpose. Apart from the most insanitary dry bucket latrines which are still being used by about 40% of the urban population, as much as 50,000 to 100,000 metric tons of human faeces is directly deposited on the soil every day.

The paper reviews the existing status of human excreta disposal in the urban areas in India and examines the feasibility of large-scale provision of low cost on-site sanitation facilities (Two pit pour flush latrines) in the urban and peri-urban areas. The paper is based on the feasibility study conducted by TAG (UNDP) in 100 Indian towns in the 1st phase and also on the findings in some of the towns in Eastern India in the 2nd Phase.

2. EXISTING STATUS OF HUMAN EXCRETA DISPOSAL FACILITIES IN URBAN AREAS IN INDIA

As of to-day only about 27% of Urban population and 0.5% of the rural population are having access to minimal sanitation facilities. The household survey of over eight hundred thousand houses in 110 small and medium towns in India covered under the Phase I Feasibility study, revealed that 23% of the population have flush latrines and 29% bucket or dry latrines, while 47% have no latrines whatsoever and resorts to open defecation. Based on this survey and those carried out by the National Sample Survey, the overall situation in the urban communities in India could be that nearly 27% have facilities of sanitary latrines (connected privies, Septic tank etc.) and 40% dry latrines and nearly 33% have no latrines in their premises. In some of the Eastern States the situa-tion is even worst. As for example in the 12 towns in West Bengal, where house-to-house survey conducted, only 18.67% houses are having flush latrines, 20.69% have dry bucket latrines and more than 60% of the houses are without any latrines at all.

2.2 Status of Collection & Disposal of Night Soil from Bucket Latrines.

The maintenance of bucket latrines and facilities of collection, transportation and disposal are extremely poor. In a survey conducted by the All India Institute of Hygiene and Public Health in 34 Municipal towns in the Calcutta Metropolitan district, it was revealed that only 60% of the generated night-soil are collected and transported regularly. As a result, overflowing night-soil from the latrine buckets are largely towards spread of faecally transmitted diseases. The operations at the disposal ground are also very poor. Night-soil is emptied into pits of any size and shape and no coverage with ash or mud is given. In some Municipalities, night-soil buckets are emptied into road-side ditches or water bodies. On the whole the dry bucket latrines remain major health hazards in the municipal towns, apart from being socially degrading for the collectors and handlers.

3. DECADE'S TARGETS AND PROGRAMME FOR URBAN SANITATION IN INDIA.

During the decade on water and Sanitation, Govt.of India would endeavour to provide sanitation facilities to about 80% of the total urban population. Considering the prohibitive capital cost of providing sewerage systems, a higher priority has been accorded to providing low cost on-site sanitation facilities in most of the small and medium towns. In order to prepare a replicable model of low cost on-site sanitation system which could be adopted in other similar towns, preliminary engineering and feasibility studies of low cost water-seal latrines were carried out in 110 small and medium towns in seven Indian States, covering a population of nearly 5 millions. Along with techno-economic feasibility of these studies also identified organisational and financing pattern for expeditious implementation of low cost sanitation programme in the small and medium towns. In the 2nd phase, such studies are being carried out, in another 100 towns. In 11 States and 3 Union Territories some of the salient findings of these studies are discussed hereafter.

3. FEASIBILITY OF TWO-PIT POUR FLUSH LATRINES

The twin pit pour flush latrines, which was originally developed in India, through the pioneering studies at the A.I.I.H & P.H and other Institutes, the design of which was subsequently optimised by TAG (Group) (Details shown in Fig.I), was found to be the most suitable means of on-site sanitation in India, both from the point of view of affordability and environmental protection. Such latrines requiring $1\frac{1}{2}$ to 2 litres of flushing waters, could be constructed without much difficulty, for each household by :

a) converting the existing dry bucket latrines,

b) constructing new units where they do not exist,

c) providing community latrine blocks where individual latrines are not practicable and for the floating population.

4. TECHNO-ECONOMIC ASPECTS

The unit cost of conversion and new construction of two pit pour flush latrines would vary from place to place depending on cost of material and labour. Average cost figures, valid for the towns in the Eastern States in India are given below :-

No.of Users	Unit cost for Conversion (Rs)	Unit cost for New Construction (Rs)
5	800	1100
10	1000	1400
15	1300	1600

This means that a family of five would have to bear a financial burden of Rs.6 to 8 per month per household, if the entire amount is advanced as loan to be repaid in monthly instalments in 25 years.

Since a sizeable portion of the urban population has a rather low income, it was felt that even this much of financial burden may be too heavy for some section of the population and an element of subsidy from the Federal or Provincial Government would be necessary to make this type of sanitation affordable to the whole of the urban community. To evolve a rational and optimal combination of grant and loan for people in various income-groups, the maximum monthly repayment rate was fixed at 2% of the monthly income of the family. On this basis, it was recommended that the people in the income group of 0 to 400/- p.m (medium value Rs.200/-), should be provided with as 75% of the construction cost as grants and 25% as loans. Similarly, people in the income group of Rs.400/- to Rs.1000/- should be provided with 50% grants. Socio-economic status of the people could also be assessed on the basis of utility services like, water, electricity, latrine etc. provided in a house. On this basis, households with no utility services should receive the maximum subsidy.

The feasibility study also examined whether the local Government Authorities have the capacity to execute the latrine programme and take responsibility of operation and maintenance of sanitation facilities including de-sludging and disposal of humus from the private sanitary latrines. The income and expenditure patterns of all the Municipal towns covered under the 1st Phase and 2nd Phase, were closely examined. It was concluded that though some of the Municipalities were having marginally surplus budgetary provision and there is potentialities of augmenting their revenue by means of fresh taxation and improved collection, the municipal authorities could hardly be expected to shoulder the additional responsibility of financing the programme independently. The requi -rements of funds should be met from external sources. The Central and State Government grants may be matched by loans from financial Institutions like the Nationalised Banks, Life Insurance Corporation, Housing Development Corporation etc. Aids from International and Bilateral Agencies may also be sought. Voluntary Agencies may also play a significant role in implementing the latrine programme.

4.1 Soil & Water Pollution Aspects.

One of the very important aspects to be considered for the large-scale implimentation programme of the low cost pour flush water-seal latrines with twin leach pits, is the extent of possible soil and water pollution hazards arising from these pits in different hydro geological conditions. During the 1st phase of the feasibility study, pollution travel from latrine pits were studied in six sites in Bihar, Gujrat and Tamilnadu, in collabora-tion with the concerned State Water Pollution Prevention and Control Boards, National Environmental Engineering Institute and State Public Health Laboratories. In Gujrat, where the soil is very fine with 20% clay, effective size less than 0.002 mm and low permeability of the order of 0.34 to 1.5 x 10^{-7} Cm/Sec, and water remains well below the bottom of the latrine pit throughout the year, the study findings reveal that :

i. Bacterial pollution was not present in soil samples as close as 1.5 m from the pit.

ii. Water samples collected from wells at 8 m from the pit did not show any evidence of faecal pollution.

iii. There was no significant increase in the nitrate content in well waters at 8 m and 16 m as compared to that collected from wells at 100 m.

The findings from Bihar site, where the soil contains high percentage of silt and clay, with effective size less than 0.05 mm and permeability of the order of 0.032 to 290.5 x 10^{-5} CM/Sec, the findings were more or less similar to that of Gujrat.

In Tamilnadu, sites were located in rocky region with rock out crops occupying at varying depths. The overlying soil strata is coarse with 75 to 80% gravel and sand and high permeability ranging from 8.5 x 10^{-3} to 19.5 x 10^{-3} CM/Sec. The results showed that bacterial pollution within 8 m zone is possible and nitrate pollution upto 16 m from the pit. However the results of this site showed high baseline pollution.

However based on the findings of these studies it could be stated that under favourable hydro-geological conditions, i.e fine soil profile (silt, clay and fine sand) and water table remaining more than 2 m below the bottom of the pit, bacterial travel would not take place beyond 3 m.

A further study has now been taken up, in collaboration with the All India Institute of Hygiene and Public Health and Kerala State Water Pollution Prevention and Control Board, to assess the risk of pollution travel under adverse hydro-geological situations such as :-

a) Coarser soil profile with effective size more than 0.2 mm.

b) High ground water table, less than 2 m from the bottom of the pit.

c) High ground water slope, more than 0.01.

Under this study which is being financed by the I.R.C.W.D, effectiveness of sand envelope having sand thicknes of 12" to 24" and E.S 0.2 mm, in preventing travel of pollution from leach pits, under such adverse hydrogeological situations would be evaluated. The study is presently being carried out in two sites at West Bental and Kerala.

However from the studies which have so far carried out in this field, both in India and abroad, it could be safely concluded that the introduction of pour flush pit latrines does not pose any serious pollution hazards to ground water or water mains, if proper precautions are taken.

4.3 Legal & Institutional Aspects.

The study of the municipal laws and other relevant laws of the seven States covered under the 1st Phase has revealed that there are a few inadequacies in the legal provisions under the respective municipal acts relating latrine programme and hence some amendments are needed to accelerate the implimentation of the programme. Given below are some of the suggested amendments :-

i) Conversion of old bucket latrines a nd construction of new sanitary latrines, which includes Two pit Pour Flush type as well, should be made obligatory for the local bodies.

ii) Legal provision should be made so that no new building could be constructed or any extension of existing building taken up, unless the owner agrees to provide excreta disposal facilities approved by the Municipal Authorities.

iii) In case the owner of a house defaults, the municipality should have the power to compel the occupier (tenant) to build necessary sanitation facilities even without the consent of the owner.

iv) Open air defecation should be legally prohibited not only in public streets and public places, but in any open space public or private.

v) The municipal authorities be empowered to recover the loan amounts given to the beneficiaries for construction/conversion of latrines through distrainment like taxes.

Several studies of the ongoing low cost sanitation projects in different States, revealed that one of the main reason for slow progress is the non-availability of a proper institution for executing the programme at a reasonable service charge and also for doing the necessary promotional and follow-up measures. Perhaps, a project Management Cell, at the State Government or Local Government level may be set up for co-ordination between Central Government, State Government, Local Authorities, target house-holds, and various other international and voluntary agencies involved in the programme. This Cell should also guide and assist the municipalities in publicity, motivation and health education.

References:-

Reports prepared under UNDP International and India Projects on Low Cost Sanitation.

10th WEDC Conference

Water and sanitation in Asia and the Pacific: Singapore: 1984

Performance of pour flush toilet

Dr S Niyogi and D K Das

INTRODUCTION

In search of an appropriate low cost sanitation system for the unsewered areas in Calcutta Metropolitan District (CMD), India, the Pour Flush (PF) toilet was selected from the various sanitation technology options proposed by Kalbermatten, et.al.(ref 1) for a thorough situation specific techno-economic appraisal. This led to the initiation of the present 9-month duration investigation on an experimental PT toilet at Jadavpur, Calcutta, to study the following functional aspects :

subsoil dispersion of effluent,
rate of sludge accumulation,
problem of odour and other nuisance,
subsoil travel of pollutants and potential danger of ground water pollution,
cost of the system.

MATERIALS AND METHODS

The details of the toilet along with the twin ecentric seepage pits as illustrated in Figure 1 were as per the specifications of the National Environmental Engineering Research Institute (NEERI), India.

The subsoil travel of leachate was monitored through analysis of the ground water samples collected from appropriately located monitor wells around the toilet pits. The auger bored monitor wells were 100 mm.dia. and 3m. deep and were left unlined but provided with a top cover. Seven monitor wells were operated as shown below.

monitor well	direction from pit 1	distance from pit 1, m
1	south	2.40
2	south	18.00
3	east	2.35
4	east	12.00
5	north	4.20
6	north	9.60
7	west	2.30

Soil samples were collected from 0.3m, 0.9m, and 1.5m depths from the identified location for the twin seepage pits and were tested for textural classification, permeability with remoulded samples, field density, percent moisture and shear stress. Field percolation tests at three test holes around the seepage pits were also carried out.

The experimental toilet was commissioned in early Aug, 81, and the investigation was carried out till April, 82. At the outset seepage pit 1 was operated and the other was cut off.

Ground water quality monitoring included determination of the virgin ground water quality followed by subsequent monthly testing of water samples collected from these wells during the experimental run. The water quality parameters monitored were pH, EC, COD, Cl, NH_3-N, NO_3-N, total and fecal coliforms, in accordance with the Standard Methods (ref 2).

The quantity and composition of sludge were determined immediately after the close of the present phase of the work. Sludge samples were analysed for moisture, organic matter, N, P_2O_5, and K_2O.

Besides, the number of users each day, average water use per pour-flush, rainfall and water level in the monitor wells were also determined during the study.

RESULTS

The maximum values of quality parameters as observed for the virgin ground water, as well as the maximum observed values in monitor wells at 2.4m, 4.2m, and beyond subsequent to the commissioning of the toilet are shown in Table 1.

Table 1 - Ground water quality

parameter	virgin ground water	monitor wells at 2.4m	at 4.2m	beyond 4.2m
pH	7.25	7.25	7.10	7.25
EC(mmhos/cm)	3.20	4.20	4.30	4.10
COD, mg/l	28	62	61	50*
NH_3-N, do	0.10	1.35	1.25	0.15*
NO_3-N, do	1.51	1.76	1.95	2.10*
total coliform MPN/100 ml	11	540	540	70*
Fecol coliform MPN/100 ml	2	70	140	17*

* in well 6

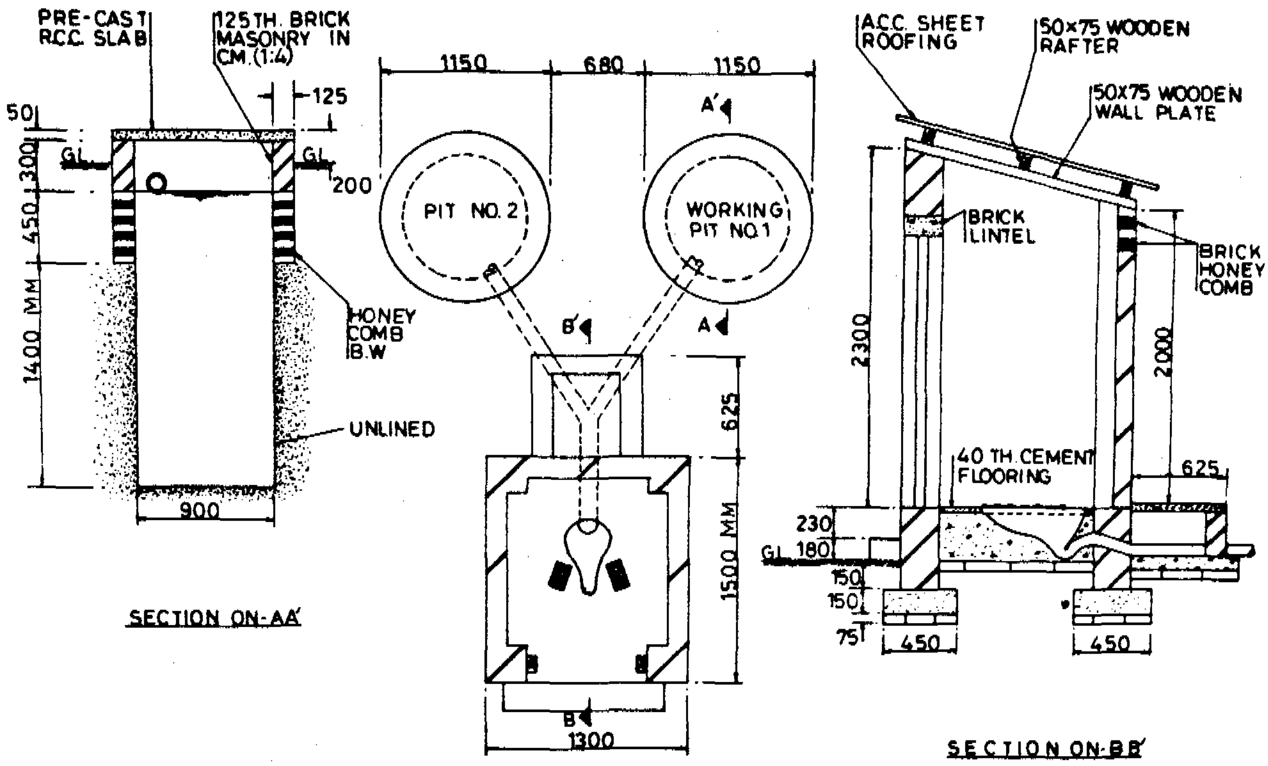

FIG 1 - Experimental PF toilet

The observed data on sludge accumulation and its characteristics appear in Table 2.

Table 2 - Sludge characteristics

parameter		value
wet sludge in 270 days, m^3		0.42
wet sludge, m^3/cap/day		0.00025
% moisture		70
% organic matter, oven dry,		49
% N - - - - - -,	do	1.40
% P_2O_5 - - - - -,	do	0.82
% K_2O - - - - -,	do	0.46

Rainfall, level of ground water in monitor wells, average water use etc., as observed are shown in Table 3.

Table 3 - Rainfall, ground water level and water use

parameter	range
rainfall, mm/month	nil - 312
ground water level in monitor wells, m	0.40-1.10
liquid level in pit 1,m	0.40-0.80
pour flushes/day	8 - 17
water used for flushing, litres/day	16 - 42
hydraulic loading, litres/day/sqm	35 - 59

The salient characteristics of the soil in the study area are presented in Table 4.

Table 4 - Soil characteristics

parameter	value
texture	clayey-silt
field percolation rate, cm/min	0.23
laboratory permeability, cm/sec	2.3 x 10^{-5}
field density, kg/m^3	1.96 x 10^3
shear stress, kg/cm^2	0.29

It is also worthy of mention that the trend of ground water movement was in the northerly direction.

The observed COD, total and fecal coliforms in the seven monitor wells at the commencement and at close of the investigation are shown in Figs.2 and 3.

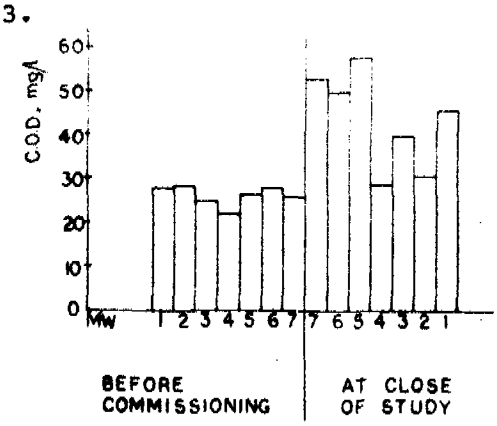

FIG 2 - Change in COD

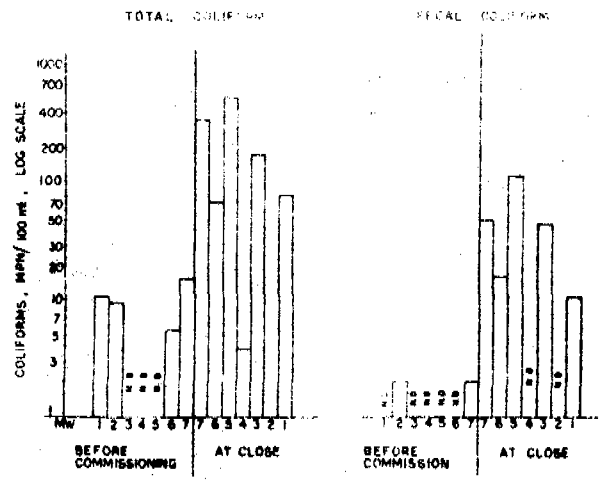

FIG 3 - Change in total and fecal coliforms

DISCUSSIONS

The soil texture in the study area was clayey-silt with an average permeability of 2.3 x 10^{-5}cm/sec and the field percolation rate was 0.23 cm/min. During the reported study, the ground water levels were at 1.10 and 0.40m below the ground surface during summer and rainy seasons respectively, accordingly, the effective leaching surfaces through the working seepage pit under extreme summer and wet conditions were 2.68 and 0.71 sqm.

The average quantity of flushing water was 25 litres/day, however, the upper limit went upto 42 litres/day. Hence, the average and maximum hydraulic loadings during rainy season were respectively 35 and 59 litres/day/sqm of leaching surface. The dispersion of the effluent, however, was always satisfactory.

The experimental toilet could be taken to be equivalent to six users using it twice a day in case of domestic installation. Thus, the minimum leaching surface under worst condition during rainy season should be 0.12 sqm/user for design of domestic installation.

The seepage pit was 2m deep, hence, the lower 0.9m of the pit below the lowest ground water level remained ineffective from the consideration of sub-soil dispersion. However, this under-water space could effectively serve as sludge storage and the constant pool of water would provide some dilution of the concentrated waste from toilet. So reduction of the depth of seepage pit to less than 2m was not considered essential.

As regards leachate movement and pollution of shallow level ground water, it was observed that the leaching fluid (effluent) from the seepage pit had distinct pollutional effect upto a peripheral distance of 4.2m. As shown in Table 1 and Figure 2, the range of COD in monitor wells 1,3,5 and 7 located within the stated distance was 40-62 mg/l at the close of the study as compared to 25-28 mg/l before commissioning of the toilet. Furthermore, the total coliforms in these monitor wells at the beginning were between ND-14 MPN/100 ml and at the close the densities were 79-540 MPN/100 ml. Fecal coliforms also increased and ranged between 11-140 MPN/100 ml at the close.

It was alarming to note that the water quality in monitor well 6, which was located at a distance of 9.6m north of working seepage pit was also affected, and this could be attributed to the northerly movement of the ground water as observed during the study. For example, the COD in this monitor well 6 increased to 50 mg/l from the initial 26 mg/l. The total and fecal coliforms at the close were 70 and 17 MPN/100 ml respectively as compared to the initial densities of 6 for total and ND for fecal coliform. The monitor wells 2 and 4 at distances of 18.00m south and 12.00m east were not affected due to the movement of leachate.

On the basis of the reported observations, it would be reasonable to mention that in clayey silt soil, ideally, the separation distance between seepage pit and unlined shallow wells should be minimum 10m, however, under extreme constraint of space, closer location could be permitted in which case impermeable lining of the shallow well extending to a depth of minimum 8m from the surface should be obligatory.

The rate of wet sludge accumulation was estimated to be 0.00025 m^3/cap/day. The sludge as abstracted at the end of the 270-day study period was fairly digested with good de-waterability and could be applied on land only after sun drying for a couple of days. The sludge possessed modest fertiliser value besides the desired properties as a soil conditioner. It was also felt that the second seepage pit was not essential either for permitting further anaerobic digestion of the accumulated sludge or for maintaining continuity in service.

COST

PF toilet with properly designed seepage pit, and septic tank with subsoil dispersion facilities are the two appropriate on-site sanitation systems in unsewered areas with modest water supply level. Cost estimates as per 1981 price index in India showed the capital cost of construction of the septic tank system (excluding the toilet structure and pan) was nearly US \$30 per capita and the cost of single seepage pit of the PF system was US \$3 per capita. The cost of toilet structure including pan would be mostly same for the two systems. Again the annual recurring expenditure (repayment of capital plus OM&R) for septic tank system was nearly US \$4 per capita against US \$0.50 only per capita for the PF toilet system. The economic aspect, therefore, is worthy of consideration in planning sanitation programme for settlements of subdued economic level.

CONCLUSIONS

With good design and operation compatible with local geological and climatological factors, the PF toilet could be a satisfactory on-site sanitation alternative in developing countries.

In sub-soil with field percolation rate around 0.23 cm/min, the minimum leaching surface at worst condition during rainy season should be 0.12 sqm /capita. The hydraulic loading rates in such worst conditions could range between 35-59 litres/sqm/day which could be taken up by clayey silt deposits.

Sub-surface travel of organics and coliforms along with the leaching fluid was significant upto a peripheral distance of 4.2m, and was also noticed upto a distance of 9.6m in the direction of ground water movement. Hence, ideally, unlined wells should not be located within 10m from the seepage pit, however, under extreme constraint of space, closer location may be permitted in which case 8m. deep impervious lining of the shallow water well should be made obligatory by necessary regulation.

The accumulation of wet sludge was 0.00025 m^3/capita/day. The moisture content of 70% and good drainability indicated fairly digested sludge. Organic matter, N, P_2O_5 and K_2O in the sludge were 49, 1.40, 0.82 and 0.46 percent respectively on oven dry basis. The 270-day old sludge could be applied on land without further anaerobic digestion but after sun drying for several days.

Provision of the second seepage pit was not essential either for permitting further anaerobic digestion of the accumulated sludge or for maintaining continuity in service. One seepage pit, 0.9m internal dia. and 2m deep, with annual desludging schedule could serve 6 users continuously as the desludging operation would not take more than a few hours. The depth of the single seepage pit should not be less than 2m. The lower under water volume could be effective for sludge storage.

The capital cost of construction of one seepage pit was US \$3 per capita excluding the cost of toilet structure, and the annual recurring expenditure (repayment of capital plus OM&R) was estimated around US \$0.50 per capita. Thus the system indicated techno-economic merits.

ACKNOWLEDGEMENT

The authors thankfully acknowledge the financial support and facilities provided by the Jadavpur University, Calcutta 700032, India, for running the project.

REFERENCES

1. Kalbermatten J.M., Julius D.S., and Gunnerson C.G., Appropriate Technology for water supply and sanitation, The World Bank, Washington, 1980.

2. American Public Health Association, Standard methods for the examination of water and wastewater, 14th ed., Washington, 1975.

10th WEDC Conference

Water and sanitation in Asia and the Pacific: Singapore: 1984

An approach paper for adoption of "Bona" tank type Latrine

Gyan Sagar

SUMMARY.

In this paper alternative to water seal pit latrine has been discussed Certain advantages in adopting new proposal have been mentioned and a plea has been made for its inclusion in the 'DECADE'S PROGRAMME' which may go along-with the water seal pit latrine with synergestic action.

INTRODUCTION.

In the developing contries,no doubt, rapid strides are being made on drinking water supplies in this international water supply and sanitation decade (1981-90). However,the sanitation component could not still get its due place. It has been universally accepted that water-seal pit privies where water is used for ablution would serve as magic wand. This may or may not be true in all the cases. Many things may come in conflit-cultural differences among the people on one hand and the techno-economic aspects on the other. In India both for rural and urban areas alike, water-seal pit latrines have been considered as the only low cost solution. But there could be many alternatives now. In fact search for alternatives was started nearly fifteen years back with experiments at PRAI (India). A low cost dwarf (Bona) septic tank resembling acqua privy was subsequently evolved for the needs of individual families of 5 to 10 person from theoratical aspects to extensive field work taken up during this period, Refer fig. 1.

Dwarf (bona) septic tank.

While developing the design a reference was made to Indian standard secifications. Although typical in design the construction is simple as it can be made with 4½'' thick brick/conc. block wall. Desludging can be done periodically (12 months) under hydrostatic pressure of one foot only. The size of tank is much reduced and quality of effluent improved for flushing is possible with 10 to 15 pint of water due to small water-seal (¾''). Infact a bath cum toilet can been made with in the small space. The effluent can be disposed of in many ways such as (i) evepo-transpiration system,(ii) dilution with sullage water by discharging the contents into the drain (iii) into a soakage pit. (iv) treating with anaerobic filter and utilising the effluent in kitchen garden.

The cost wise design is quite economical and may be termed as low cost.

Extension of this approach.

With the initial success, further designs have been developed up to 500 persons with or without community latrines which are economical both in initial and maintenance cost. Where this is away from latrine enclosure, circular shape of dwarf septic tank is preferred for greater strutural strength. Designs for biogas plant with latrines around have also been worked out recently. and a pilot plant is under construction at Gopeshwar(India). Our experience with evolving basic designs and the pilot study after field investigations have been well documented in more than two dozens of published technical papers.

COMPARISON OF DWARF SEPTIC TANK LATRINE.

Comparision of this design with two pit water-seal latrine has been shown in table. 1.

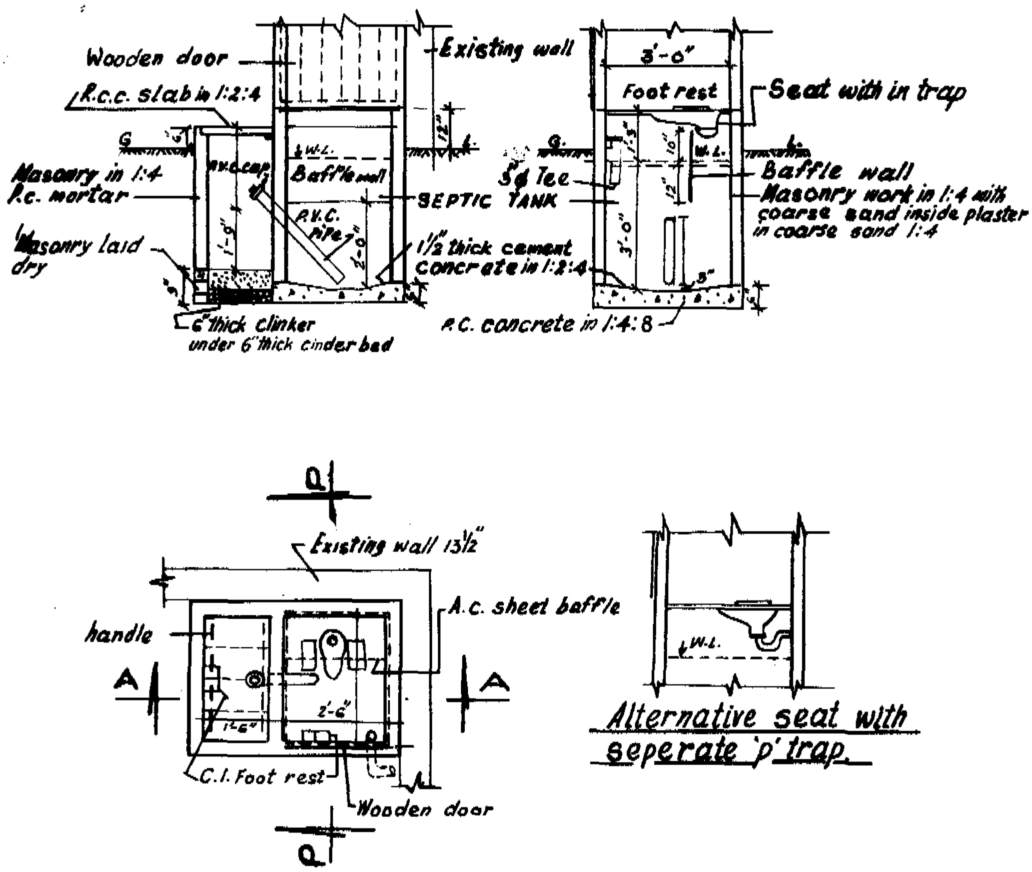

FIG. 1-DRAWING OF DWARF SEPTIC TANK FOR 5 USERS

CONCLUSION.

A review of the data produced here would lead to a valid question that with obvious advantages why the extension of dwarf (Bona) septic tank latrine has been deferred for long. It is perhaps due to the belief that the design and construction of water-seal pit latrine is very simple. At this juncture, it may be mentioned that the design in question is also very simple in construction and can be adopted as a valid alternative with the technical expertise already available with in the developing countries including India.

Implementation strategy.

U.P. Jal Nigam like many other organisations have adequate technical expertise for handling innovative programmes confidently. The authors feel that in order to make a dent, an interaction is desirable with in ourselves to harnessing the best possible talent available and thereafter with support agencies such as HUDCO, WORLD BANK, UNICEF etc. with an open mind. Perhaps then, it would be possible to achieve the DECADE targets for minimum sanitation services in the developing countries.

Table .1. COMPARISION OF DWARF (BONA) SEPTIC TANK TYPE LATRINES WITH WATER SEAL PIT LATRINE.

DWARF SEPTIC TANK LATRINE	WATER SEAL PIT LATRINE
1. NATURE OF INSTALATION.	1. NATURE OF INSTALATION.
A. It is a permanent type of installation. This is an extension of acqua privy/septic tank concept. (Page 40 Wagner -ref .1)	A. The life span of a pit privy will vary from 5 to 15 years depending upon the capacity of the pit and porosity of the soil. (p.40, Wagner -ref.1)
Reasons.	Reasons.
1. Sludge can be removed hydrostatically without any difficulty at one year interval into the manure pit. Here it gets converted into the sludge cakes and its removal is easy. As far effluent nearly 85% of suspended solids and 90% of B.O.D. are removed. As per test data B.O.D. of the effluent is around 450ppm. The effluent contains some impurities in finely divided & colloidal form and can be disposed of in:-	(i) If the soil through which the pit has been dug is not sufficiently porous, the effluent will slowly accumulate and will ultimately overflow. Even in porous soils such a situation is common as the earthern walls become choked by the deposit of the finely divided matter carried by the effluent and the solid built up by the life activity of the zoological organisms thriving on the grains of the soil in contact with the effluent. (p.125, Wagner)
(a) A specially designed soak pit where the porosity of the soil is reasonable. The pit will last for about 5 years. This pit can be used after cleaning and washing its contents. In this design soak pit wall does not choke and porosity remains intact.	(ii) It has been reported that an average pit of 3ft dia and 8 ft deep. fills up in 2½ to 3 years (PRAI pub. No 340 p.35 ref-2 & also as per design criteria mentioned on page 48 Wagner) This pit will be filled up in 3 years (2cuft per capita per year). This pit shall however, be filled up much quicker for aforesaid reason on subsequent filling. (Annual report PRAI 1968-69 -ref.3)
(b) In non absorbtive soils anaerobic filter can be provided and the effluent can be utilised for kitchen gardening, also the effluent could be utilized for growing of fruit trees without any further treatment. (Evepo -Transpiration system).	
(c) The effluent from dwarf septic tank be diluted with drain water in area of good water supply. To mentain cleanliness about 10-15 pints per capita per day will be sufficient for the latrine. When mixed with 100 to 150 pints per capita per day of sullage the over all B.O.D. and suspended solid will reduce to much lower limit, generally permissible for surface waters and the waste stablization shall be taken care of by the self purification power of the surface water itself. (Practice adopted by CMDA Calcutta (India) & also Wagner Page 122)	

2. WATER POLLUTION DUE TO HIGH SUB SOIL WATER LEVEL:-

A. A dwarf (bona) septic tank will not be affected in areas of high sub soil water level as they are shallow and can be constructed partly above or below the ground without any problem. They are also water tight. Also instead of soak pit, a soak trench could be provided to avoid any pollution of ground water or the effluent may be discharged above ground level as mentioned earlier; also Wagner p. 79)

Fissureld rock

B. No such difficulty in case of dwarf septic tank.

3. IMPERVIOUS SOILS.

No such problem as for the pit privy.

4. DISTANCE FROM BUILDING FOUNDATION

A. It can be placed very close to a dwelling.

Reasons.

(i) Dwarf septic tank is a shallow water tight container, no damage to building foundation is expected

(ii) Even in case of conjusted localities construction of dwarf septic tank is possible which could be accommedaded with in existing dry latrine enclosure.

5. DISTANCE BETWEEN THE TWO PITS

No such problem exists in case of dwarf septic tank type privy and the soak pit may be constructed in close proximity.

6. PROBLEM WITH PAN FLUSHING AND KEEPING THE LATRINE CLEAN.

With this design more water can be used for keeping the latrine as clean as possible. In fact a tap can

2. WATER POLLUTION DUE TO HIGH SUB SOIL WATER LEVEL:-

A. It should have atleast 5 ft cushion (dry earth covering) above the highest subsoil water level. It is desirable to keep minimum 5 ft depth in which case the water table should be lower than atleast 10 ft from the ground level. By injecting excreta directly in to the subsoil water long distance travel of bacteria has been reported (PRAI pub. No 340 p.37; Wagner p-29 to 32)

Fissured rock

B. In fissured rock and lime stone formation, soak pit construction is difficult and risk of water [illegible] pollution is high (Wagner p.32)

3. IMPERVIOUS SOILS.

In impervious soils pit privy has very little use as the contents overflow quickly.

4. DISTANCE FROM BUILDING FOUNDATION.

A. Pit privies should preferably be built at some distance about 20ft or more away from dwellings (Wagner p.68 and 103)

Reasons.

(i) Inleaching pit system, the foundation as well as superstricture may be adversely affected by the liquid containg salts rising up due to capillary action.

(ii) For very conjusted localities pit privies may not be feasiable (Wagner p.125)

5. DISTANCE BETWEEN THE TWO PITS.

The minimum distance between the alternating pits should be (5-6ft) or more (Wagner p. 117)

6. PROBLEM WITH PAN FLUSHING AND KEEPING THE LATRINE CLEAN.

As a result of evalution study (p.103 ref-4)it has been repprted that out of the latrines which

be fitted inside where piped water supply facility exist. Instead of 4 to 5 pints of water per flush as recommended for pit privies we can conveniently use about 10 to 15 pints (Wagner p.82)	were used only about 50% were found to be clean. Reason. Water source can not be located inside a latrine enclosure for fear of filling of the pit early. Difficulty exist in water use if the source is located out side and therefore keeping the latrine clean
7. PROBLEM OF PIT EMPTYING.	7. PROBLEM OF PIT EMPTYING.
Dwarf septic tank has been provided with a desludging pipe for removal of digested slurry once in a year. This sludge is dried on site and its removal is easy.	Pit emptying is a major problem both in case of two pits and single pit. Top portions remain in liquid form whereas bottom sludge becomes too hard. This is difficult to handle with conventional means. (Annual report PRAI 1968-69)
8. NON AVAILABILITY OF SPACE.	8. NON AVAILABILITY OF SPACE.
It requires small space as the latrine pan could be built right over the dwarf septic tank itself.	It requires very large space which may not be generally available in big towns and cities.
9. WHERE PEOPLE USE STONE GRASS PAPER FOR ANAL CLEANING.	9. WHERE PEOPLE USE STONE GRASS PAPER FOR ANAL CLEANING.
Dwarf septic tank latrine can still be used with slight modification by replacing the water-seal with straight pipe projecting below the water level in tank(Old aqua privy concept)	This type of latrine can not be used at all.
10. MANURIAL VALUE.	10. MANURIAL VALUE.
The recovered dry digested sludge cakes have high manurial value and low cost of handling.	The sludge produce have high moisture contents in upper layers with loss in nitrogen . Sludge at the bottom is difficult to remove as it becomes harder with time. Cost of recovery is high whereas the manurial contents are low.
11. COST OF PRIVY.	11. COST OF PRIVY.
Cost though higher because of supervision, it is quite comparable to pit privy. This may be adopted with advantage in lower to upper middle class housing where water supply facilities are available.	Cost is quite low as it does not require much supervision. This may be adopted where ever feasiable.

Reference:-

1. WAGNER, F.G. and LONIX, J.N. Excreta disposal for rural areas and small communities. WHO monogram series.
2. Planning research and action institute Lucknow U.P.(India) publication no. 340 WHO.
3. Annual report of the sanitary Engineering Programmes-Rural Health section.
4. P.RAI Publication 1967 . Induced change in health behaviour . A evaluation study of the pilot environmental sanitation project in . U.P. (India)

10th WEDC Conference

Water and sanitation in Asia and the Pacific : Singapore : 1984

Aspects of sanitary engineering works in developing countries

P Sutcliffe

INTRODUCTION

Provided that they ensure that the measures which they take are appropriate the so-called developed countries can contribute a great deal to the betterment of conditions in the developing nations. In the past many of the peoples of these developed countries have suffered similar afflictions to those which now affect their less priviledged fellow beings.

The factors affecting the relevant works are many; in principle they are common to the entire world but their individual significances vary from place to place. For those working in developing countries they must be put into proper perspective.

This work requires financing (though appropriate technology designed to adequate, rather than over-adequate, standards need not be unduly expensive) and the money has to come from somewhere. In developing countries the primary sources are (1) the sales of natural produces (subject to fluctuation) and (2) grants/loans from international agencies and richer countries. An additional source of income arises, if manufacturing industry be established, from the export of the resulting products - but it is respectfully suggested that, in the order of planned development, community health and good agriculture/forestry practices should precede industrialisation.

PHASES OF PROJECT

Any engineering project involves three major phases - (1) design, (2) construction and (3) operation - and two preliminary phases - (i) identification of the problem and formulation of the design brief and (ii) collection of data.

Various factors are encountered during each phase, some being peculiar to two phases only whilst others are more widely relevant. Table 1 tabulates the factors and their relevances.

TABLE 1

Factor	Problem and brief phase	Data collection phase	Design phase	Construction phase	Operation phase
Climate	x	x	x	x	x
Hydrology	x	x	x		
Geology	x	x	x	x	
Site conditions/investigations		x	x	x	
Ecological considerations	x	x	x	x	x
Natural landscape			x	x	
Population patterns	x	x	x		
Disease patterns	x	x	x		
The existing built environment	x	x	x		
Available finance			x	x	x
Planned life of scheme			x		
Availability of materials			x	x	
Labour problems			x	x	x
Local customs and society			x	x	x
Contractor's experience			x	x	
Availability and use of plant			x	x	
Communications			x	x	
Contract documents and specifications			x	x	
Supervision/contract organisation				x	x
Simplicity/complexity of equipment			x	x	x
Problems of handing over			x		x

Problem and brief

Generally the problem will be evident; for example, the need to provide potable water or to eradicate some source of infection. But the possible solution(s) may not be as evident as the problem - alternatives may well be available. Any solution must be relevant - environmentally, technologically, financially and sociologically.

Collection of data

It is essential that design be based upon adequate information. For public health engineering projects long-term records are desirable - typically rainfall, run-off and groundwater variation figures and information on vegetal patterns and changes therein. Distribution patterns of water-borne diseases must be known.

Other data required include the geographical and historical backgrounds to the affected areas, the economic position, physical planning proposals, water supply needs and sources, geology, flora and fauna and land drainage.

THE FACTORS CONSIDERED

These will be reviewed in turn.

Climate

The climate ambient to a public health engineering project is critical. Climate exhibits temperature variations, wind, precipitation and humidity; these can affect:

Materials - e.g. high and low temperatures affect setting and curing of concrete and have expansion/ contraction effects.

Construction procedures - progress may be delayed by rain or wind-borne sand; completed work may be damaged.

Transportation - routes may be rendered impassable.

Mechanical plant - wind-blown grits can be a problem.

Working hours - may be varied from "normal" to accommodate climatic conditions.

Labour efficiency - extremes of temperature and rainfall, together with climatic effects upon food and hygiene, may induce sickness and lethargy.

Biology/microbiology - may cause illness or inefficient operation of treatment plants.

Hydrology

Hydrology is an offspring of climate, concerned with precipitation, run-off, groundwater, transpiration, evaporation and infiltration; it has great influence on water supply problems.

Geology

Geology is fundamental to any of man's activities; it is the backcloth on which he builds, dictating the availability of materials and the suitability of sites.

Site conditions/investigations

Thorough investigations must be made of the site of any proposed works so as to confirm its suitability and also to determine local availability of building materials and to reveal the degree of skill of local labour.

Ecological considerations

The ecological consequences of projects can be considered; damage to the ecology may endanger the livehood of local people and lead to bad feeling between them and the promoter of the work.

Natural landscape

The completed project structures should either blend in with the pre-existing scene or contrast suitably with it. Sometimes there may be a case for disguising the work!

Population patterns

Upwards of seventy per cent of the people of the developing countries dwell in the countryside and so problems of providing sanitation and water resemble those in the rural areas of so-called developed countries - dispersal, long service lines serving small numbers and supervision difficulties. But dispersal can have advantages - concentrations of putrefying matter are not so intense as in built-up areas. The extent to which people are mobile or static is important, as is population growth potential.

Disease patterns

Areas which are particularly subject to (water-borne) diseases obviously deserve urgent attention in terms of remedial works, but relatively healthy zones, when subject to urbanisation and increasing concentration of population, may suffer outbreaks of illness.

Existing built environment

Localities which have become urbanised may have done so at a rate which has outpaced the rate of provision of sanitary services. Moreover, where services are initially adequate they may become overloaded and so impending increased needs should be anticipated. Ideally, the provision of sanitary services should precede full development.

Available finance

When the funding of a project is under consideration there can arise a "chicken and egg" situation - "which comes first - the design or the money?" Should the design solution be formulated and costed and a request made for funding or should the maximum amount of money likely to be available be the first determined and then a design produced to fit this cash?

Planned life of scheme

Conditions in developing countries are liable to rapid change; hence construction in these countries may be better based upon the short term rather than the longer. Traditionally the civil engineer builds work which will last for many years; implied is the need for a change in philosophy on the part of the engineer, introducing a new requirement into the training of a person who is to serve in a developing country.

Availability of materials

Normally locally available materials are utilised to the greatest possible extent. But there can be disadvantages to this approach - the local materials may be different to those to which the engineer is accustomed and so a flexible attitude is needed. Local materials may be difficult to exploit; much time can be expended in bargaining for and opening up quarries and sandpits. Simple methods of materials testing are required.

Importation brings problems; proximity of ports and railheads, existence of roads and co-ordination of deliveries from various places. Again the qualities of flexibility of approach and ability to improvise are essential in the engineer if he is to cope satisfactorily with delays and other snags.

Materials bought from a number of sources will vary in quality and specifications must allow for this. Pipes, steel items, mechanical and electrical equipment etc. will not be available locally because of the absence of manufacturing industry.

Labour problems

Labour is needed in terms of both numbers and skills. Three broad approaches are available for construction - (1) by an ex-patriate contractor with his own labour force, (2) by an ex-patriate contractor using, at least in part, local labour, and (3) by a local organisation using local labour. Governments of developing countries may require that local labour be utilised as fully as possible, with priority over imported workers; but local labour may require training. Part of the labour force may have to be imported by virtue of special skills - supervisors, plant engineers, skilled craftsmen. There may be administrative complications over work permits and visas. The team may be international with language and social behaviour difficulties, unfamiliar with local customs.

On a large project the feeding, housing and entertainment of the personnel can be a large task; places of rest and worship may be needed. Imported labour may become unhappy, discontented and resented by the indigenous people.

Local customs and society

In all countries there are customs, codes of conduct, accepted practices and varieties of morals and ethics; these vary from place to place. They must be observed, tolerated, respected; courtesy alone dictates this. Festivals and public holidays are a feature of life everywhere; some are held on fixed dates, observed for many years, while others may be called at short notice.

These functions affect project planning and progress - some can be accommodated from the inception of the scheme but others will cause unforeseen delays. So tolerance is demanded of those in charge.

Long established rights (e.g. of grazing or thoroughfare) must be respected.

Contractor's experience

The contractor should have experience in similar climates and terrain and with similar labour and other constraints. Lack of appreciation of local conditions will lead to delays and friction on site.

Availability and use of plant

Mechanical plant will often have to be imported. If local labour is available the question might be asked ... "Is it morally and financially correct to use mechanical plant?"

Plant must be able to withstand the climate; it should be simple and rugged. Maintenance and spares are vital; the ability of the engineer and operative to improvise is essential.

Communications

Transfer of people and goods is essential; lack of facilities hinders progress. These may have to be created; where inadequate they will have to be improved.

Delays in telephone and post mean that those "on site" have to make major decisions without reference to head office. Late arrival of supplies makes flexible construction programming essential; there may have to be changes in construction sequences and substitution of materials.

Poor roads and handling facilities lead to breakages. Seaports, airstrips, roads and railheads can be vital, whilst the tracked vehicle and helicopter provide invaluable facilities in rough terrain.

Contract documents/specifications

Tenders for international contracts are difficult to draft; language difficulties and legalistic variations may cause unintentional or intentional differences in interpretation by contractors from different countries. Considerable flexibility is needed. Allowance should be made for the possibility of using locally made items (maybe fabricated on site) instead of the more normal units which may have to be brought thousands of miles at great expense and with risk of delay. Conditions of contract must also allow for local conditions, customs and requirements.

Supervision/contract organisation

Often the supervision of work in developing countries has to be more detailed than elsewhere. Labour tends to be inexperienced and unfamiliar materials may be used. The contractor may be from a third country.

Engineers will often have to work directly alongside the labour force, training them as the job proceeds. This has advantages; workers are keen to learn new skills and good workmanship can be instilled. At the outset as much responsibility as possible should be given to indigenous personnel; this gives them a sense of pride in the scheme with which they are going to live in subsequent years.

Simplicity/complexity of equipment

Permanent equipment incorporated into a project requires three major qualities:-

ruggedness;

simplicity in mechanism/operation;

ease of maintenance.

Training of staff

Training of staff is required at two stages:-

training for construction, and

training for operation of the completed project.

Problems of handing over

Neither engineer nor contractor should quit the site until they are satisfied that those persons who are to be responsible for the operation of the scheme are fully trained. There should be a period of "co-existence" before final handover.

CONCLUSIONS

The conditions surrounding the promotion, design, construction and operation of sanitary engineering projects in developing countries can be very different to those pertaining in the developed countries.

Whereas in the latter areas the engineer is frequently effectively subservient to a pre-existing political, social and economic "establishment", in the developing countries he has a chance to be an influencing factor from the inception of a project.

So he must possess a broader outlook than if he were working in a "western" context.

Technological training and ability are but two necessary qualities; they form only part of his required expertise. Additionally he must be able to understand the totality of the environment within which he is designing, building and operating. This total environment has several facets - physical, cultural and economic to mention but three. He must rise above the normal confines of his profession - he becomes a practical sociologist.

The engineer must inherently possess or consciously develop qualities of flexibility, adaptability, initiative and independence, patience, prudence, tact, understanding, tolerance and compassion - a very "tall order" which is exceptionally demanding. The engineer is being asked to become a kind of alternative missionary.

In all that he undertakes the engineer must bear in mind that he is a transient person; eventually he will move away from the scene of his endeavours and the project will be inherited by the local people and so he must, at all times, encourage them to take pride in the project, to respect and protect it. They are more likely to do this if they have worked on its construction for they will then know why it is there and how it was built; it becomes a part of the local history as it takes its place in the environment.

10th WEDC Conference

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Experiences with low cost water supply

R G Campen, C M Engelsman and H van Mulligen

INTRODUCTION

Within the course of the third five-year plan (Repelita III) the Government of Indonesia initiated a programme for the provision of water supply facilities for sub-district capitals (IKK). The aim of the programme is to provide the inhabitants of some 2200 IKKs with safe drinking water at minimum costs by the end of the decade.

To implement such a large number of water supply facilities within a relatively short period and to overcome constraints in funds and skilled human resources, an unconventional system concept has been adopted. Survey, design and implementation procedures have been standardised to the maximum extent possible.

By now several systems have been implemented and put into operation. Experience with implementation, operation, cost recovery and acceptance by the consumers has been gained. The initial experience indicated that the adopted implementation procedures enable a quick and relatively low-cost development of water supply facilities. The IKK water supply concept has several inherent problems, however, one of them being that much attention in the fields of community education and training is required for a successful implementation.

This paper gives a brief description of the IKK water supply concept and related aspects such as selection, survey, design, implementation, operation and maintenance, cost recovery, consumers' acceptance, community education and training.

The experience is mainly originating from the authors' involvement in the implementation of several IKK water supply projects in North Sumatra and Aceh Provinces. The projects are carried out as parts of the Indonesian-Netherlands bilateral cooperation programme.

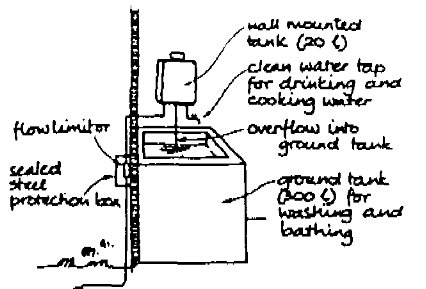
IKK WATER SUPPLY CONCEPT

The IKK water supply system has the following features:

(a) system storage is completely decentralised, and located at the system outlets (public taps and house connections);

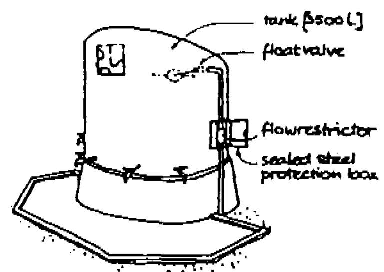
(b) at public taps, storage is provided by 3.5 m^3 tanks. Public taps are designed for use by a maximum of 200 persons, who can draw up to 30 l/c/d from the tap.

(c) at house connections consumers are expected to install their own indoor ground storage tanks (approx. volume 300 l: mainly for washing and bathing) and small elevated wall-mounted tanks (approx. volume 20 l: for drinking and cooking). Water is provided at a fixed rate of 600 l/d.



IKK house connection

(d) the inflow into public tap tanks and indoor storage tanks is restricted by pressure independent flow limiters. The use of water-meters is therefore not necessary. Fees are charged at flat rates which simplifies administrative procedures.



IKK public tap

(e) By introducing decentralised storage and 24-hours-a-day restricted flow to the service connections, water can be distributed equally to all consumers through relatively small diameter pipes. Decentralised storage and restricted outflows result in considerable savings in construction costs. Peak flows are virtually eliminated, allowing for a reduction of pipe diameters, of pump capacities and of capacities of miscellaneous facilities.

(f) water is provided at a rate of 60 l/c/d to house connections and at a rate of 30 l/c/d to public taps. The supply rate does not cover all needs, which implies that people still have to rely on another source such as a river, shallow well or rainwater collector.

SELECTION OF IKKs

The selection of IKK towns eligible to receive a new water supply system is carried out by the Indonesian Government through its provincial planning boards. For the first batch of IKK systems preference has been given to small and relatively cheap systems, in order to include as many IKKs as possible in the initial programme and to serve a maximum number of people.

It has been recognised however that more emphasis should be given to the needs of the community as the guiding criterion in setting a priority ranking for implementation.

SURVEY AND DESIGN

Surveys have been carried out by small teams of Indonesian Consultants. A specially developed IKK survey manual is used for this purpose.

On the average surveys have taken one week per IKK. Single check visits to each of the IKKs have been carried out by experts, to verify source selection and to evaluate the survey manual procedures.

Designs have been prepared by the same teams as for the surveys. Use has been made of the IKK design manual and standard drawings, standard bills of quantities and specifications, which were specially developed for the IKK programme. On the average a two-week period is required for completion of detailed designs and tender documents.

Modifications on the original design approach have been made to allow for more flexibility in terms of numbers of house connections and public taps. To increase revenues from water sales and to match the needs of the community more closely, more house connections are presently installed, while simultaneously the number of public taps is reduced. Further simplification of the production unit designs is being contemplated, to enable easier and more reliable operation and maintenance.

CONSTRUCTION

For the supply and installation of materials specific approaches have been adopted such as stockpiling of materials and packaging of construction components.

Standardisation of type and quality of materials has allowed for the interchange of materials from one system to another without too many problems. In addition the central purchase of materials has the advantage that relatively low prices can be achieved. Construction costs for IKK systems, if built in batches and with stockpiling are as follows:

Source type	Module size l/s	Pop. served	Average construction costs US$	US$/c
Spring	2.5	3600	54 000	15
	5	7200	72 000	10
	10	14400	115 200	8
Deepwell	2.5	3600	100 800	28
	5	7200	144 000	20
	10	14400	216 000	15
Treatment	2.5	3600	118 800	33
	5	7200	151 200	21
	10	14400	230 400	16

The construction of deepwells, the supply and installation of pumps, generator sets and other mechanical/electrical equipment, and the standardised water treatment plants have been covered by larger contracts, in which works for groups of IKK systems were combined. The packaged contracts were made sufficiently large to be able to attract the larger and more qualified contractors.

All civil works, pipe laying works, construction of public taps and installation of house connections have been executed by small contractors from regency level. As in some areas experience with construction of water supply systems is low or even absent, the supervisory staff sometimes had to put considerable effort into coaching and training of the contractors. It should be noted that some years ago tender regulations were introduced by Presidential Decree, which prescribe the involvement of contractors from regency level for all small and simple construction works.

To further improve the quality of construction work it is presently considered to arrange for training programmes for contractors, suppliers of water supply materials and their staff as well as local consultants.

It has furthermore been recognised that the implementation planning should be modified to enable a smooth and speedy starting up of the system once the construction has been completed. Slow starting-up with irregular supply in the initial stage of operation of the system leads to disappointment among the consumers.

Construction is now carried out in the following order: (1) production unit, (2) transmission main and distribution system including public taps, (3) testing of the entire pipe system, (4) trial running and full operation, (5) installation of house connections.

Installation of house connections, which during the first phase of the programme was carried out by contractors, is now being done by trained staff from the water enterprise. House connections are only made after the applicant has installed his indoor ground storage tank, to enable him to use the full allocated daily flow of 600 l directly from the beginning.

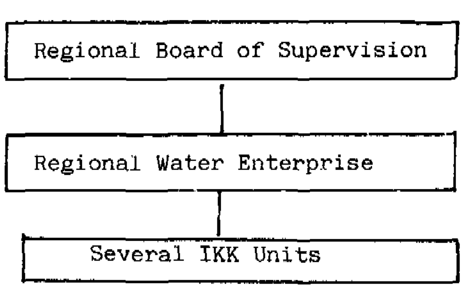
Installation of a 20 l wall-mounted closed container in addition to the ground storage tank is now being planned to be included as a standard facility for all house connections.

These tanks enable the users to draw an adequate volume of unpolluted water straight from the tap, hereby eliminating the possible annoyance from consumers who draw directly from the flow-restricted house connection or from their open ground storage tank.

To make future owners of a house connection fully aware of the benefits but also the limitations of the IKK type of house connection, people are encouraged to view the model house connection before an application for connection is made. The model house connection is now being made available at the IKK unit.

OPERATION AND MAINTENANCE

Although other organisation alternatives exist in North Sumatra and Aceh the IKK units which are responsible for operation and maintenance are being integrated with the regional water enterprise which is supervised by a regional board.



The Regional Water Enterprise which, during the first years of operation is technically and financially supported by the central government through its provincial project offices, is responsible for:

- support for trouble-shooting and repair of equipment
- financial assistance, where required in the early stages
- technical planning concerning major extensions of enterprise facilities
- monitoring of the overall performance of the IKK system
- training support

The staff of the IKK unit itself is kept as small as possible, with a senior operator/ head of IKK unit, assisted by two to four operators/administrators. At IKK-unit level the following responsibilities are assumed:

- day-to-day operation and maintenance of facilities
- repairs to pipelines
- purchasing and controlling stocks of consumable materials
- billing and collecting payments
- preparation of budgets
- installation of house connections

It has been recognised that IKK unit staff and staff from the Regional Water Enterprise should play an increasing role in consumer information and education.

COST RECOVERY

The Government has adopted as a guiding principle that cost recovery from water sales should be sufficient to cover operation and maintenance costs, while replacements and system extensions are covered from government grants. Operation and maintenance costs for treatment systems and the small deepwell systems however, are at such a level that subsidies appear to be unavoidable.

For IKK schemes the monthly O&M costs are as follows:

Source type	Module size l/s	Approximate O&M costs in US$ per month
Spring	2.5	300
	5	350
	10	470
Deepwell	2.5	650
	5	980
	10	1530

River water/ treatment	2.5	1230
	5	2020
	10	3230

Particularly for the systems using river water and requiring treatment facilities, water bills would have to be as high as US$ 4-6 per month for house connections and US$1-1.5 per month per household for public tap users.

The impression is obtained that such high levels of water bills would not be accepted by the community and would lead to a high rate of bad debtors. Although no firm information is available yet a monthly bill of around US$ 2 per household is considered to be a maximum. Only the systems using spring sources and the larger size deepwell systems are therefore expected to reach the break-even point. The smaller deepwell systems and treatment based systems will require a continuing subsidy on operating cost deficits.

Monthly water bills to recover O&M costs

Source type	Module size l/s	House connections		Public taps	
		No.	Monthly water bill US$	No.	Monthly water bill US$
Spring	2.5	180	1.5	9	0.4
	5	360	0.9	18	0.2
	10	720	0.6	36	0.15
Deep-well	2.5	180	3.2	9	0.8
	5	360	2.4	18	0.6
	10	720	1.9	36	0.5
Treat-ment	2.5	180	6.1	9	1.5
	5	360	5.0	18	1.2
	10	720	4.0	36	1.0

(a ratio between house connection and public tap consumers of 50/50 has been assumed).

To improve cost recovery and limit subsidy requirements the following steps are taken:

- installation of as many house connections as possible
- instruction and training of fee collectors to increase the number of paying consumers and disconnect bad debtors
- introduction of alternative methods to enable fee collection from public taps

COMMUNITY INVOLVEMENT

From the start of the programme community involvement has been recognised as an important feature to increase acceptance of the programme. During the various stages of development of the water supply systems future system users have to a limited extent been involved in locating public taps and supply areas. Consumers have been informed about the specific features, benefits and particularly the limitations of the IKK system. It has been observed, however, that officials and communities only slowly gain sufficient understanding of the typical features of the IKK water supply system and it is recognised that a much greater effort will have to be made to inform, educate and involve the community.

CONCLUSIONS

The IKK water supply concept as introduced to Indonesia in 1981 has been applied on a limited scale so far. Presently gained experience with the implementation and operation of IKK systems indicates the following:

- the IKK concept provides a low cost water supply facility which can be designed and constructed within a very limited time span
- inherent system features such as the restricted 24 h flow at the system outlets and the limited per capita water quantity are difficult to understand by the consumers
- a thorough and comprehensive supporting community education and training programme is required to achieve a sufficient level of acceptance of the system

REFERENCE

Rahardjo,Engelsman, C M, Mathijssen J. "Mass provision of water supply to subdistrict capitals (IKK) - Experiences in Aceh, North Sumatra and West Java Provinces, Indonesia". 4th Asia Pacific Regional Water Supply Conference and Exhibition, Jakarta, Indonesia, 5-11 November 1981.

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Tests on the wear in handpump cylinders

S T Goh and W Tee

1. Introduction

Most traditional handpump piston designs employ a reciprocating piston fitted with cup seals made from leather or rubber (ref.1). For a leather cup seal to operate efficiently, it is essential to maintain good quality control over its manufacture. The experience on rubber cups is that they are not very durable and they require regular and frequent replacement. A study of a new plastic IDRC-UM handpump in which the pumping element consists of a plastic PVC cylinder through which slides a PVC piston equipped with two polyethylene (HDPE) ring seals was reported in an earlier work (ref.2). The piston is made slightly smaller than the cylinder and the sealing action is achieved by the piston rings which expand or contract to fit the dimensional variations of the cylinder. It has been shown that differences in diameter between the piston and cylinder of up to 0.4 cm. did not significantly affect the mechanical performance of the pump as characterised by the volumetric and mechanical efficiencies. This is a major advantage because the components of the pumping element do not have to be made with very precise tolerances. This is particularly relevant for local manufacture in a developing country where quality control may be difficult to maintain. The ring seal design also enables the handpump to be operated at a higher piston speed without a corresponding increase in friction. In fact, it may be shown that the sealing efficiency of the ring seals increases with piston speed (ref.3). Acceptibility surveys of village users give the frequent comment that the handpump is "light and easy to operate" (ref.4).

A major problem of the present design is excessive wear of the PVC cylinder when fine sand particles are present in the water. The intention of the present design is for the softer polyethylene ring to wear in preference to the harder PVC cylinder. This was found to be true if the rings were rubbed against the PVC cylinder in clean water. However when fine sand particles are present in the water, wear on the PVC cylinder was very pronounced while no significant wear was observed on the piston rings (ref.1).

2. The present study

Much of our recent effort has been directed to finding a solution to the PVC cylinder wear problem. A simple solution is to switch the materials of the rings and the cylinder. The PVC rings rubbing against the polyethylene cylinder will wear off much faster and they may be readily replaced. Unfortunately such an arrangement has other disadvantages as polyethylene cannot be solvent welded together and the pump cylinder has to be designed with special threaded couplings. The VLOM (Village Level Operation and Maintenance) handpump concept (ref.5) requires the handpump to be designed for easy maintenance and repairs by villagers themselves. It is also important to encourage local fabrication of the handpump as it guarentees technology transfer as well as ensuring the availability of spare parts. PVC pipes, which are relatively cheap and commonly available in most developing countries, are the obvious choice for use as handpump cylinders at the moment.

3. Some field results

All of the 17 prototype handpumps installed for field tests in two rural areas in Malaysia are still in operation after approximately three and a half years. The PVC cylinders of five of these handpumps were removed and cut into halves along the longitudinal axis so that the wear on the cylinder section can be measured in the laboratory. Figure 1 shows a plot of the wear (which is represented here as the total volume of material removed due to wear) against total accumulated sliding distance. As field monitoring was carried out only for a eight and a half month period, the total accumulated sliding distance at any time is obtained by extrapolation using the average accumulated sliding distance computed from counter readings over the monitored period. It may be observed that the cylinder wear is higher initially but stabilises to a lower but constant rate. The piston ring seal is not perfectly circular as it is formed after cutting off a small segment from a circular ring which is of a slightly bigger diameter than the pump cylinder. "Bedding-in" of the piston ring seals may have contributed to the initial higher rate of wear as observed in the field data. The cylinders of handpumps No. NS008PL and No. PK004L have worn through causing water to leak through the cylinders. It was also observed that the cylinder wall has worn so thin that it has become flexible. This may account for the scatter in the readings of wear for these two handpumps.

4. Comparison of field data with laboratory tests

An experimental rig for testing handpumps in the laboratory, which has been described in an earlier paper (Ref.1), was used to investigate wear of the PVC cylinder when sand particles are present in the water. Initially 1.27 cm. thick HDPE piston ring seals similar to those used in the field tests were fitted to the pistons. It may be observed from figure 1 that the measured wear after 400,000 strokes fall on the wear curve of the field results. A further test using 0.635 cm. thick HDPE piston rings showed a reduction in wear after the same number of strokes. This is to be expected as the effective accumulated sliding distance is half that for the 1.27 cm. thick piston rings. To overcome the inevitable reduction in spring tension in the thinner ring, a stainless steel wire spring is inserted in a groove on the inside of the ring. Figure 2 shows a comparison of the measured mechanical efficiency of the handpump when 1.27 cm. and 0.635 cm. thick ring seals were used at 2 different stroke lengths of operation. The results show that the mechanical efficiency of the handpump fitted with 0.635 cm. thick piston seals is not significantly different from that of the handpump fitted with 1.27 cm. thick piston ring seals.

5. Variation of wear of PVC cylinder with different ring materials

A laboratory investigation was also carried out to determine the PVC cylinder wear rate when ring seals made from different materials are used. In this experiment, ring specimens were rubbed against flat PVC pieces in horizontal motion in water containing fine sand particles.

Figure 3 shows the results of cylinder wear when ring specimens made from Polycarbonate, PVC, Acetal, Nylon, HDPE, a combination HDPE/copper oxide and lastly plasticised PVC were rubbed against PVC plates. It may be observed that with the exception of the last two materials, all the rest cause more wear than if HDPE were used as the ring material.

A plausible explanation of the behaviour of polymer-sand-polymer wear is that the sand particles, when trapped between two polymer surfaces in sliding contact, becomes embedded in the softer of the two polymer surfaces forming an abrasive surface which wear off the harder polymer surface. When a combination of HDPE and copper oxide is rubbed against PVC, the copper oxide is shed and acts as a solid lubricant which prevents the formation of the abrasive surface. Plasticised PVC , on the other hand, behaves differently. Because of its "rubber-like" property, it is difficult for the sand particles to get embedded in the plasticised PVC surface - hence no abrasive surface is formed. It also reduces the abrasive action by "giving-way" when pressure is applied and by expelling the sand particles from its surface when the pressure is released.

6. Conclusions

The results showed that wear in the handpump PVC cylinder may be reduced by decreasing the piston ring thickness and by the selective choice of ring seal materials such as a combination of HDPE and copper oxide or a plasticised rubber. Depending on the chosen ring seal material, it may be neccessary to modify the ring seal design to maintain the high mechanical efficiency of the handpump.

References:

1. McJunkin F J. "Hand Pumps". International Reference Centre Technical Paper No.10, The Hague, July 1977.
2. Goh S Y. "Final report on Water Pumping Technology-Global (Malaysia) project" Village Handpump Technology,IDRC, Ottawa Pub.No.IDRC-204e, pp39-52(1982)
3. Goh S Y. "Operating characteristics of a reciprocating water pump" Proceedings of the 2nd Asian Congress of Fluid Mechanics, Oct 1983, Beijing, China, pp501-507
4. Goh S Y and Low K S. "An appropriate plastic handpump for rural use in Malaysia" to appear in Proceedings of the International Symposium on Technology, Culture & Development, 12-14 Dec 1983, Kuala Lumpur, Malaysia
5. Appleton B. "First VLOM prototypes expected this year" World Water, Feb 1983, pp28-34

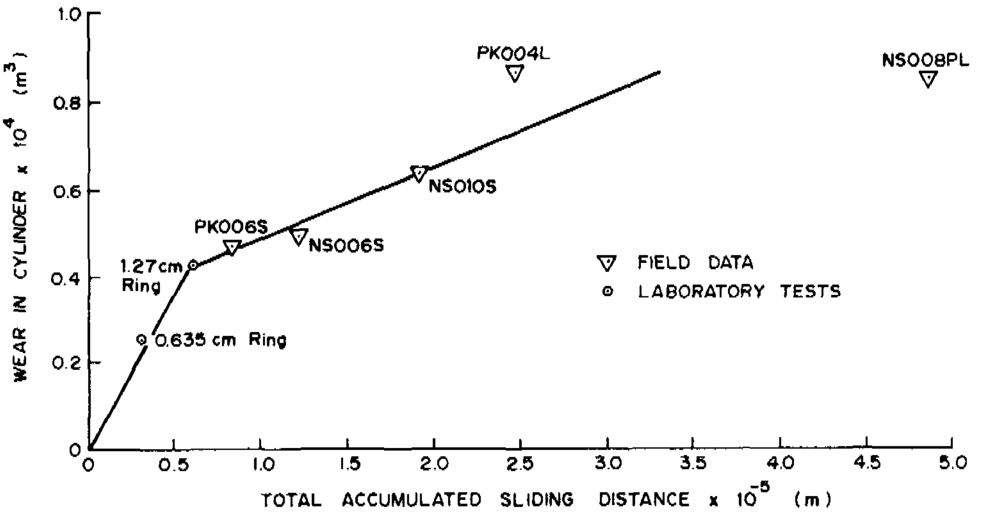

FIG. 1 VARIATION OF WEAR OF PVC CYLINDER WITH TOTAL ACCUMULATED SLIDING DISTANCE

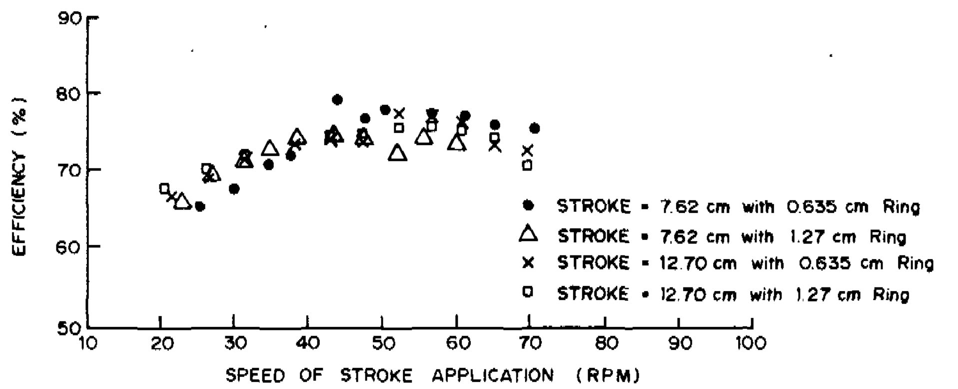

FIG. 2 VARIATION OF MECHANICAL EFFICIENCY WITH SPEED OF STROKE APPLICATION AT 612 cm WATER HEAD

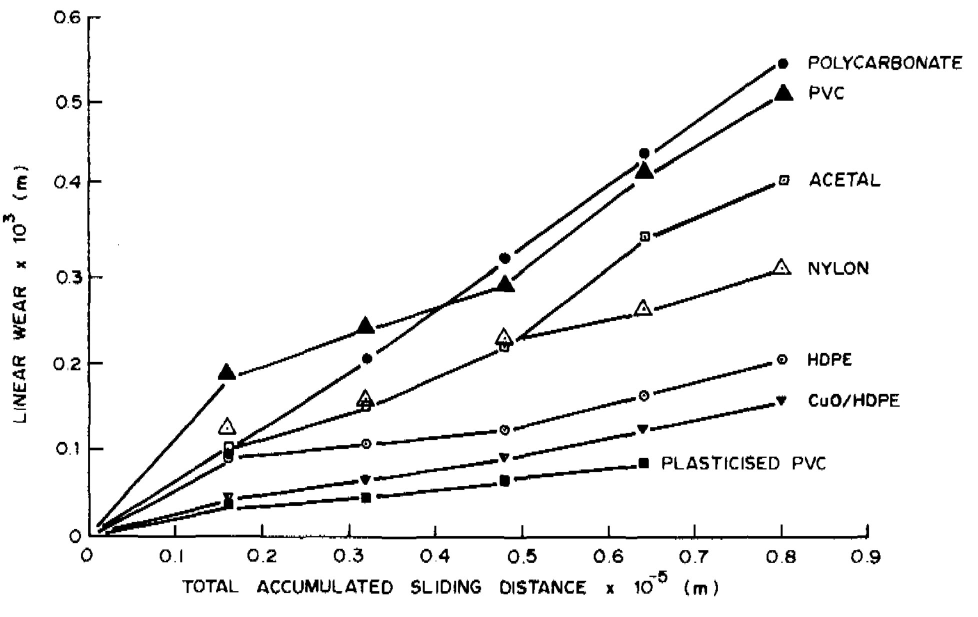

FIG. 3 VARIATION OF WEAR OF PVC CYLINDER WITH TOTAL ACCUMULATED SLIDING DISTANCE FOR DIFFERENT RING MATERIALS

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A manual for the installation, repair and maintenance of the IRDC-UM handpump

Mrs C C Verzosa, Dr R T Mahoney and Mrs M M Villanueva

INTRODUCTION

This is a report on a project concerned with the development of a manual on the installation, repair and maintenance of the International Development Research Centre (IDRC)-UM handpump. This manual was meant for use by the villagers in developing countries. The project covered four Asian countries: Malaysia, Thailand, the Philippines and Sri Lanka. It was implemented by the Program for Appropriate Technology in Health with field activities undertaken by its developing country affiliates.

In response to the belief that the selection, development, and use of reliable handpumps that can be locally produced, installed, maintained and repaired at an affordable price is a major step in the goal of providing safe drinking water and water for domestic use to rural communities, the International Development Research Centre of Canada has supported research in the development of more effective pumping systems. One of these is the IDRC-UM handpump which has been developed together with the University of Malaya. Due to the introduction of plastics technology and wide availability of polyvinyl chloride (PVC) piping in Asian countries, this was researched on as a possible simple, low-cost material for the handpump. After field trials in several developing countries proved the PVC handpump viable, mass production of the handpump is currently underway. Mass production of the handpump meant it was now ready for larger scale introduction in other developing countries.

It was at this stage that the concept of developing a villager's manual on the handpump evolved. Initial interactions with the villagers during field trials, demonstrated the need for a community-based program in which villagers themselves would participate in the introduction of the technology. The development of a villager's manual on the installation, repair and maintenance of the handpump sought to address the initial need of users for educational materials orienting them on the handpump. More specifically, it aimed to:

1. Obtain qualitative data on villagers knowledge of perceptions and concepts of water potability, its relation to health, uses of water, water supply problems and experiences with water supply systems including the handpump.
2. Develop instructional materials for illiterate and semi-literate rural villagers on the installation, repair and maintenance of the IDRC-UM handpump. This will be conducted in collaboration with the University of Malaya, Department of Mechanical Engineering.
3. Begin to develop a strategy for introducing of the PVC pump at the village level and encouraging its acceptance and use by village community organizations.

Based on the prototype material developed in collaboration with the University of Malaya, printed support materials were further developed in four Asian countries: Malaysia, Philippines, Sri Lanka and Thailand.

PROTOCOL

Since the project hoped to link technologies in water supply with the end users, the protocol for materials development was user-oriented. Thus, the materials development team worked closely with the end-users, the low-literate rural villagers with little or no mechanical background, through the various stages of materials development.

Materials Development Process

Development of the manual underwent the following process:

1. Conduct of in-depth qualitative research on the men and women villager's knowledge of, perceptions and concepts of water potability, its relation to health, water supply problems as well as their experiences with water supply systems including the handpump.
2. *Identification of key instructions*

   With the assistance of the engineers who developed the handpump, key instructions were initially identified. Based on the qualitative baseline data gathered in the first step, these instructions along with forseen problem areas were conceptualized and executed through photographs and in artwork form. These were repeatedly pretested among the villagers and sections were simplified or expanded to respond to the information requirements of the villagers.

3. Materials pretesting

   The manual was subjected to an iterative process of repeated pretesting and revision among both men and women until a targeted level of comprehension was reached. The first wave of pretests involved pretesting the manual without text to determine whether the message carrying potential of the illustrations was maximized.

4. Fieldtest

   Once the manual was understandable to the villagers, a fieldtest was undertaken. Villagers were provided a handpump and all the required parts for assembly together with a manual. They were then asked to install the handpump using the manual as their primary source of information. Any errors or group's suggested modifications were again reworked and upon final revision, the manual underwent printing.

Introduction strategy

Based on the data gathered from the numerous discussions held with both men and women villagers, the materials development work conducted at the village level, and on the consultations carried out with government and private agencies doing water projects, an introduction strategy will be drawn up. This will include specification of the key decisions makers at the local, regional and national level that should be involved in the introduction process to assure cooperation and support as well as suggested techniques for involving these individuals, their organizations and most importantly the villagers themselves.

The introduction strategy pursues the belief that for a technology to build and be able to retain interest in the community, it is necessary for the end-users, the villagers themselves to become part of the project, to participate in the decision-making and actual implementation.

It is at this point that this paper was written. The formulation of the above mentioned introduction strategy is currently being undertaken.

FINDINGS

Knowledge and perception of water potability, use, supply and its relation to health

The following perceptions were elicited from the various group discussions held among men and women villagers, some of whom use handpumps and some who resort to other sources of water such as springs, rivers, canals.

1. Potable water is clear, tastes good and fresh with no fishy or rusty taste. It is always cold and has no unpleasant smell such as that of mud or rust. Clean water should have no dirt, residue or floating objects in it. The non-pump users group in the Philippines remarked that clean water should come from a natural source and, that one sign of clean water is the presence of shrimps.

2. The relation of water to health was quite clear to the participants. To them, water quenches man's thirst and keeps them healthy. It facilitates good hygiene, cleanliness and sanitation of one's environment. Dirty or non-potable water would cause stomach cramps, diarrhea, vomitting and skin diseases. Dirty water is polluted, turbid, foul smelling and has garbage and other debris floating in it.

3. Women were agreed to be the principal users of water for domestic use. To them, an adequate water source should have the capacity to supply enough water for a family's drinking, cooking, cleaning and bathing purposes everyday.

4. Sources of water mentioned were numerous such as irrigation canals, rivers, open wells, springs and handpumps. Other than handpumps, springs were perceived as the cleaner and safer water source because it was continuously flowing and was a natural source. Handpumps, though, were perceived as more preferred because of its hygiene, safety qualities and its being convenient and time saving. Some disadvantages mentioned were the difficulty of repair and replacement of parts. its having rusty water and a fishy taste.

5. Acceptability and adoption of the IDRC-UM handpump technology could be ascertained by meeting such conditions as convenience, durability, safe and hygienic quality, clear appearance, sense of modernity or being up-to-date in style. It involves a continuous explanation/clarification and involvement of its recipients. Likewise, a continuous test of its acceptability to the locale should be a primary concern.

Materials Development

In developing the villager's manual on the IDRC-UM handpump, there are some lessons learned:

1. Keep it simple

   The step-by-step procedure in the installation process should show only the important steps in proper sequence. However, it must be complete and adequate enough to cover the entire installation procedure without marked gaps.

2. Tools should resemble those locally available

   If new tools have to be introduced, special effort must be made to ensure there is concrete understanding of how it is to be used.

   For example, in the Philippines, the mallet known locally is made out of wood. Therefore, the red colored mallet available in Malaysia was not recognized. Furthermore, the extractor rod (used for extracting the foot valve) was unknown in the Philippines and villagers mistook it for a PVC pipe meant to be left inside the pump's metal case.

3. Use illustrations rather than words

   Illustrations presenting the steps one goes through to install, repair and maintain the handpump are more understandable to villagers, particularly those with low levels of education. For non-readers, a textual presentation of the instructions renders the technology difficult to understand and accept.

   Illustrations were found to be superior to photographs in that it enables one to emphasize the fine details of handpump parts and mechanism of action. The photographs had complicated backgrounds that made villagers have a difficult time understanding what the main message in each photograph was. Also the numerous photocopy reproductions that was necessary for the pretests often resulted in a loss of clarity.

4. Emphasize repair and maintenance problems most likely to crop up

   Instructions on the repair and maintenance of the handpump should emphasize the problems most likely to crop up. It should first identify the outward manifestations of a potential repair and maintenance problem is that there is no water coming out of the spout. There are several possible reasons for this and the manual should guide the villager in identifying the reason, and then provide a solution.

   Simple line drawings were used to illustrate the more technical installation section. The drawings in the repair and maintenance section was done in caricature so as to provide some sort of comic relief from the more serious and technical installation. Thus the layout of this section became one of identifying "the problem", "the cause", and "the solution or what to do".

A villager's manual on the installation, repair and maintenance of the handpump not only promotes correct use of the technology but also proves a useful tool for technology instroduction. The villager's manual explains the technology, thus reducing people's resistance brought about by a lack of knowledge. Development of the villager's manual prior to large-scale introduction promoted an active dialogue between the technology developers and users. The handpump, seen from the perspective of the villagers who were potential users of the technology, required final technology "packaging" to facilitate acceptance and proper use of the handpump. Another dimension to the value of instructional materials is that it encourages village women to take an active interest and participate in the introduction of the technology into the village. Women have traditionally shied away from any involvement with handpumps and mechanical appartuses saying that machines are meant for men. But with a step-by-step instructional manual on the handpump, women felt that with inital hands-on experience, they can now handle installation, repair and maintenance of the handpump on their own. They no longer need to wait till their husbands or other menfolk find the time to repair the handpump.

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Single copies of handpump manual available through Senior Author.

SESSION 8

Chairman: Dr A Appan, Nanyang Technological Institute, Singapore

Discussion

G J W de Kruijff and A Kartahardja

Sanitation improvements in Indonesian Kampungs

1. Mr de KRUIJFF described the Kampung Improvement Programme (KIP) in Indonesia, including the provision of water supply, and the present and future sanitation programmes.

2. Mr PARAMASIVAM asked how it was ensured that the effluent pipes did not block, because the hand-flushed bowl was a considerable distance away from the leaching pit.

3. Mr de KRUIJFF replied that the number of joints was kept to a minimum; for distances greater than 5 metres, only smooth bore pipe, such as PVC, was used. The users were recommended to flush the bowl with 10 litres of water at the end of the day. To date, no problems had been encountered.

4. Mr YAW wished to know the cost effect of moving from MCK level facilities, to smaller scale family level facilities.

5. Mr de KRUIJFF stated that the larger scale MCK facilities were often based on a theoretical design standard of 100 people per toilet, although in practice 25 people was the limit. The theoretical per capita cost was thus low, but when the actual number of users was considered, the cost was high. Family units serving 30 people could be constructed for about Rp 600; there was no significant increase in the actual per capita cost.

C E Herrera and S Sataviriya

Refugee camp water and sanitation

6. The authors were not present, and the paper was not read.

S R Kshirsagar

Experiences in planning and implementing low cost sanitation

7. Mr KSHIRSAGAR discussed aspects of low cost sanitation being implemented in India, with particular reference to the alternating double pit latrine, and to community participation and general health education. He also described the use of aqua privies and upflow filters.

8. Mr de KRUIJFF stated that he had experienced operation and maintenance problems with anaerobic upflow filters, and asked if the author had found similar problems. He asked how loans made to householders for on-site sanitation schemes were recovered.

9. Mr KSHIRSAGAR replied that blockage of the filter frequently occurred because the septic tanks were not cleaned out sufficiently often; some system of institutional supervision may improve matters. Money could be recovered in cases where bucket latrines were being converted to pour flush latrines; people already paid a charge, and this charge would continue to be levied after the latrine conversion. Within 10 years the loan would have been repaid. No system had been evolved for new constructions.

10. Mr RAO commented that a major programme of converting dry latrines into pour-flush latrines was well underway in India. The programme was financed 50% by government grant, and 50% by loans from other agencies such as HUDCO; the loans were made to municipalities, who subsequently gave loans to householders.

R G Campen, C M Engelsman and H van Mulligan

Experiences with low-cost water supply

11. Mr CAMPEN presented his paper, and outlined the use of the flow restrictor on water supply schemes in Indonesia.

12. Mr YAW observed that some problems were likely to be encountered with flow restrictors; blocking may be a problem; the concept that restrictors allowed the minimum size of main pipe to be used would limit the flexibility of the system to respond to changing demand patterns. Many funding agencies were involved with procurement of materials, and some attempt at standardisation would reduce the problem of finding spare parts.

13. Mr CAMPEN replied that contrary to what was expected at the start of the projects, blocking turned out to be not a major problem in practice; only minor cleaning and flushing

activities were required in the initial start -up phase of the project. In general the blocking problems, if any, would be caused by small particles in the water supplied and/or the construction of the piped systems as such. Proper deep well and intake constructions were in this respect of paramount importance to prevent small particles entering the system.

Recommendations from evaluations and studies of the IKK projects included measures to include in the layout and design a certain spare capacity to allow for possible upgrading in a later phase without abandoning the IKK scheme. This implied that already in the design phase the engineer had to investigate the possible location of water reservoirs, large diameter pipelines, etc. for the event that the IKK system was upgraded to a BNA system. A pre-requisite was that the cost related to inclusion of measures to allow for future expansions should be very limited to prevent cost over-runs.

The need for standardisation was well-known and based on logical consideration regarding spare parts, operation and maintenance. A disadvantage could be the consequence that one or some suppliers would be put in a monopoly position in the market which could turn out to be a major setback.

Another item that should be mentioned with regard to the standardisation in general was the tremendous size of Indonesia, its variety of hydrological conditions and the diversity of its population in terms of culture and income. Taking into account this variety of conditions meant that the aspect of standardisation should be more related to a design and implementation approach rather than to types and construction of hardware.

14. Mr BOURTON asked whether education alone would be sufficient to stop beneficiaries from tampering with the flow restrictors, and if other methods of control should be investigated.

15. Mr CAMPEN stated that the acceptance of the flow restrictor principle by the consumer was the major requirement to arrive at a proper function of the system. His experience in the present projects showed that in those cases where the concept of the system was not fully understood, the consumer would damage the system to increase the flow even when the restrictor was protected by concrete covers or steel boxes. Additionally, besides education, attention should be paid to further development of a flow restrictor device and construction that would prevent easy damaging.

15. Mr PARAMASIVAM wished to know whether the cost of household storage had been included in the economic analysis, and observed that there could be a problem of contamination of stored water.

16. Mr CAMPEN replied that the individual household tank, or 'bak mandi' had not been included because most Indonesian households possessed a 'bak mandi' in the bathroom regardless of the degree of sophistication of the water supply; the IKK set-up thus took this into account, and based the concept of decentralised storage on it. The population were used to taking measures to protect the water in the 'bak mandi'; moreover, the quality of the water supplied was better than that of the traditional sources, and the water passed initially into a sealed 20 litre reservoir before flowing into the 'bak mandi' from a tap in the reservoir.

17. Dr RANA commented that for such a large programme to be successful it would require a large team of operators and maintenance technicians and asked for further details on the supply and training of technicians.

18. Mr CAMPEN referred the questioner to the sections on 'Operation and Maintenance' and 'Cost Recovery' in his paper. The Ministry of Public Works and the Directorates of Water Supply and Sanitary Engineering had embarked upon large training projects, in which one component was designed to train the skilled staff required for IKK schemes. In general, four staff were required for an IKK scheme, and sufficient suitable candidates for training appeared to be available.

19. Mr BRADLEY commented that in New Zealand, flow restrictors had been used successfully in rural water supplies to farms; he stressed that it was important for possible future demands to be identified, because problems had arisen when the hydraulic capacity of the systems had been unable to meet the increased demands; it was important to explain to people just how much increased demand a given system could cope with.

P Sutcliffe

Aspects of sanitary engineering works in developing countries

20. Mr SUTCLIFFE presented his paper, and considered the many factors which had to be taken into account in the design, planning and implementation of water supply and sanitation schemes.

K J Nath and P K Chatterjee

Low cost sanitation programme in India: problems and prospects

21. The authors were not present, and the paper was not read.

S Niyogi and D K Das

Performance of the pour-flush toilet: a case study in the Indian context

22. The authors were not present, and the paper was not read.

G Sagar

An approach paper for the adoption of the "Bona" tank type latrine

23. The authors were not present, and the paper was not read.

S T Goh and W Tee

Tests on the wear in handpump cylinders

24. MR GOH described the problems associated with the wearing of leather and rubber seals on handpump pistons and discussed the results of field trials, and methods of reducing wear on PVC hamdpump cylinders.

C C Veroza, R T Mahoney and M M Villanueva

A manual for the installation, repair and maintenance of the IRDC-UM handpump

25. Mrs VEROZA presented the paper, and outlined processes undergone in order to develop a manual suitable for village level use.

10th WEDC Conference

Water and sanitation in Asia and the Pacific: Singapore: 1984

WEDC training programmes in Sri Lanka

Dr A P Cotton

Summary

This paper describes the format and development of three extended training programmes in water supply, waste disposal and sanitation which have been carried out in Sri Lanka over the period 1981 - 1984. It is concluded that professional training for graduate and senior engineers is best carried out centrally, but that training of supervisors of rural construction schemes should be devolved as far as is possible down to district level to be effective.

1. Introduction

The WEDC Group, based in the Civil Engineering Department of Loughborough University of Technology U.K. has provided three extended training programmes in water supply, waste disposal and sanitation for various agencies in Sri Lanka during the period 1981 - 1984. The main agencies involved have been the National Water Supply and Drainage Board (NWSDB) and the National Housing Development Authority (NHDA). In addition, a considerable number of specialist short courses have been held, and teaching assistance to the University of Sri Lanka, Moratuwa Campus, has been provided.

The main thrust of WEDC training programmes is to relate training to practical needs, and to enable participants to become more proficient in their work. Discussion and practical problem solving have formed an integral part of the programmes; site visits have provided opportunities for specific problems to be discussed and analysed, and for questions regarding design, operation, maintenance and management of systems to be dealt with.

All of the WEDC staff involved have considerable overseas experience, and the on-going nature of the programmes has permitted extremely good relations to be established with the agencies concerned, and has enabled the WEDC staff to build up an invaluable pool of experience of specific local conditions and problems. Staff have visited Sri Lanka for periods of two to four weeks, and during the first two programmes, a resident tutor from WEDC was based in Sri Lanka to coordinate visiting staff.

2. National Water Supply and Drainage Board Programme

Several approaches to the provision of relevant professional training for the graduate engineers employed by the NWSDB have been tried. During the first program in 1981-82, engineers were released for two days each week over a four month period to attend the course at the Board's headquarters in Colombo. The advantage of this "day release" type of system was that the engineers were able to carry out some of their duties during the remainder of the week. Disadvantages included the total duration of four months, with consequent difficulties in maintaining continuity, and the commitment of WEDC staff for such a long continuous period.

The second program was amended to provide a ten week full-time course. This enabled a better degree of continuity to be achieved, but had the significant problem of requiring engineers to be released from all duties for that period.

Both courses were wide ranging, with emphasis being given to those topics highlighted by the senior management of the Board.

Participants were assessed by both coursework and written examination. Apart from the fact that all participants passed the assessment, their overall enthusiasm and good attendance provided a further indicator of the success of the courses. A vital ingredient in this success was the presence of a resident WEDC tutor, who provided continuity for the participants, coordinated the local arrangements and maintained regular contact with the Board and the British Council, who administered the programmes on behalf of the Overseas Development Administration.

Having run two extended, broad-based courses, it was decided that future training needs would be best met by a series of shorter, more specialized courses for selected staff. Three such courses, each of two weeks' duration were run during 1983-84, namely:

1. Operation and maintenance of water treatment plants;

2. Groundwater and drilling;

3. Control of pollution.

The training team from WEDC also included associated non-university specialists having wide experience, which ensured maximum relevance of the courses. As in the previous programmes, site vists and discussion provided a valuable input.

In addition to the training of graduate engineers, a series of short, informal seminars was held for the senior managers of the Board. The subjects covered reflected specific problems and areas of interest of the participants, and were arranged on an informal basis.

3. National Housing Development Authority Programme

The NHDA has been responsible for substantial housing programmes throughout Sri Lanka. In its initial programmes, it took overall responsibility for design and construction, whereas in the latest "One Million Houses Programme" launched in late 1983, the NHDA has set out to facilitate the construction of homes by householders themselves. There is a tremendous enthusiasm for this ambitious programme which extends to the provision of safe water supply and adequate sanitation for householders.

NHDA employees are in the main qualified in the area of building, and do not usually have specialist knowledge of water supply or sanitation. Participants included graduate engineers, building inspectors, health inspectors, housing officers and development workers, all of whom are vital for the success of NHDA's work. The approach to the provision of training thus had to be radically different from that at the NWSDB, and in the light of experience, has been considerably modified.

The basic approach has been to carry out seminars on a Regional level, whereby the WEDC staff move from region to region in a "travelling circus". During the first programme, six one-day regional seminars were held; group discussion was used to good effect. However, it was felt that one day was insufficient to have the necessary impact, and in the second programme, two days of site inspection and on-the-spot problem solving followed the seminar. This proved much more satisfactory, and the participants showed more interest and commitment. However, this arrangement was not entirely satisfactory, because up to 40 participants would be present, from all over the region and it was difficult to sustain interest on the site inspections. It was felt by the WEDC staff involved, that site inspections should be carried out with fewer participants. Thus the third NHDA programme involved a one-day seminar at a Regional centre, after which the site inspections were carried out with separate groups of participants. The following structure was adopted in each Region:

1. At each centre, the formal one day teaching seminar was complemented by site visits on the following days to housing schemes constructed by NHDA.

2. The taught component covered aspects of water supply and sanitation which related specifically to the region concerned. For example, in Anuradhapura, water supplies from groundwater sources only were considered, whereas in Badulla emphasis was placed on surface water sources for those working in the hill country.

3. An important and successful feature of the taught seminars was the direct involvement of the participants; formal lecturing was kept to a bare minimum, whilst the participants discussed problems and their solutions in small working groups. This technique stimulated much interesting and relevant discussion; language problems were minimized, because the discussion could take place in the local language, although it was ensured that at least one competent English speaker was placed in each group to report back on the results of the discussion.

4. Subsequent site visits served to emphasize and highlight certain problems and solutions which had been raised during the taught component of the seminar, thus increasing the awareness of the participants.

5. For the site visits, participants were split into two groups; the staff then accompanied each group in turn on a series of site visits, in order to inspect sites in the districts in which participants worked. This avoided the lack of interest which can arise if the sites being inspected are totally dissimilar from those concerning some of the participants.

An interesting difficulty arose relating to the ideas on low cost sanitation. During the many site inspections, severe problems were found with the much-heralded alternating double pit pour flush latrine. Many of the participants did not fully understand the way in which the latrine works, and the majority of householders interviewed did not appreciate the necessity for pit emptying. The simpler single deep pit latrine seemed to work very well.

The NHDA have a standard design for the twin pit latrine which is to be used on their housing schemes; however, direct criticism of this latrine was avoided at all costs because it was felt that such criticism of what may have been a matter of policy would be potentially damaging and negative. At all times a positive approach was maintained, emphasizing the vital constructional details, and the great care which had to be taken to ensure that the householders would use and maintain such latrines. The responsibility of such training programmes is to be supportive, and at all times to work from within the organization, and to avoid adopting a stance of being highly critical "in public" from outwith. The third programme proved to be the most successful, largely due to dealing with problems almost at District level, thereby enabling participants to relate to similar problems which they had themselves encountered.

4. Specialist Courses

Throughout the three programmes, many specialist short courses of up to several days duration have been held; they have proved popular, and an encouraging feature has been the number of participants from a wide variety of state and para-Government organizations and private industry.

Such courses can be arranged at relatively short notice, to fit in with the demands on the visiting staff. An important feature of these courses has been the bringing together of participants from different organizations and companies who may have similar problems to deal with.

Table 1 indicates some of the courses which have been run.

5. Conclusions

5.1 It is appropriate to provide training for graduate engineers centrally at the headquarters of the NWSDB. Subsequent to broad-based courses, shorter courses covering more specialist topics for selected staff are relevant.

5.2 In dealing with the wide range of backgrounds of the NHDA staff, decentralizing seminars down to District level has produced the most successful results. At this level, participants can appreciate the relevance of the seminars and site inspections in relation to their own specific problems.

5.3 Short courses on specialist topics have continued to attract a wide and enthusiastic audience.

5.4 The on-going relationship between WEDC and Sri Lanka has made the training programmes successively more worthwhile. Staff have become increasingly familiar with local conditions, and are able to use a wide variety of local case studies and anecdotes in the training programmes.

5.5 The wide variety of courses within an overall programme has enabled a large coverage of participants to be achieved (Table 1).

6. Acknowledgements

The author wishes to thank all members of the WEDC Group, in particular Len Hutton and Adrian Coad, who were Course Tutors during the first and second programmes respectively. Our thanks is especially due to ODA and the British Council for funding and locally administering the programmes.

	NHDA	NWSDB		SPECIALIST SHORT COURSES	
Programme 1 1981-82	Six regional centres 190	Junior Senior	17 8	Solid Waste Management Groundwater Water Analysis Industrial Wastewater Low cost sanitation Canal Pollution [Also: resistivity; septic tanks; isotope techniques]	14 10 29 42 26 13
Programme 2 1982-83	Five regional centres 175	Junior Senior	15 8	Industrial water supply Water pollution Sewer safety	40 10 15
Programme 3 1983-84	Four regional centres 145	Operation and maintenance Groundwater drilling Regional Managers Course Pollution control	18 18 10 22	Water pollution monitoring	47
Totals	510		116		246
				GRAND TOTAL	872

Table 1 Number of participants attending WEDC Training Programmes in Sri Lanka

10th WEDC Conference

Water and sanitation in Asia and the Pacific: Singapore: 1984

Education and training in India - problems and solutions

Professor S K Gajendragadkar

INTRODUCTION

The environmental degradation and ecological disruption has become a global problem. The problem is more serious in developing countries for various reasons. The major reason being illiteracy and lack of education. The other two, equally important reasons are the growth of population and poverty. All these three are interdependant. However, I feel the need of education in every field can be named as the basic reason. It is no wonder that the environmental education has been absent from even the thoughts of educationists who were more interested in educating the masses with the 3 Rs and other necessary techniques to earn the daily bread. During the last decade or so this problem has started worrying the developing countries and slowly but surely some steps are being taken in the right direction

DELAY IN STARTING THE PLANNING OF ENVIRONMENTAL EDUCATION

No doubt there has been unexcusable delay in starting the planning of education. In spite of the experiences of the environmental problems in the developed countries, India could not and did not take any lesson.

1. There was a certain amount of negligience and disrespect towards environmental problems because of the material profits one could see due to industrialisation. Economic gains were only looked for and gigantic irrigation projects and dams, Hydel projects, Iron and Steel industries, Fertiliser and Petrochemicals added to the choas.

2. The industrialists were harping on the same string of pollution as a necessary evil' India was trying to attain the non-attainable aim of minimising the distance of development between India and USA. Telescoping the industrial revolution time in less than one twentieth times taken for Western countries had created some serious threats to environment and ecology.

3. The political scene and wars have their own share in concentrating the forces on other different issues of immediate interest and thereby delaying the thought and action about environmental education.

PROBLEMS

1. After experiencing various deleterious effects on health of men and animals, vegetation, forestry and crops, etc. due to environmental pollution and ecological imbalance there was a slow awakening in India. In a vast country that had nearly two decades altered physical landscape through the continual clearing of forests to pave way for gigantic human settlements schemes, the digging up ground for mineal and fuel exploration, the setting up of manufacturing industries which filled the air with smoke and the like, flooded the rivers with toxic muck, it is not an easy task to imbibe and inculcate the conscious concern to establish a balance between economic development and environmental needs. The decision makers and executives still remain developers rather than conservationists. Quick gains and benefits are yet their mottoes and industrialists and contractor's lobbies are able to influence the major decisions.

2. The majority of the population is poor, ignorant and superstitious in their attitudes and beliefs. Unless there is a force of either an economic gain or fear of future disaster and pain, the lethargy will not be shed off. Therefore the socio-economic problems and their relevance to the disaster of the ecology and environment must be told to them in their own language and by the local people of their cast, religion or creed which will make the project of conservation locally accepted.

3. India has another typical problem of growth of population, urbanisation and industrialisation. Industries are concentrated at few centres in every state. These centres are very much developed and have the complex industries like Petrochemicals and Fertilisers or Iron and Steel industry, Thermal Power and Paper industry etc. While the rest of the country is as backward and undeveloped as it was left by the British rulers. In other words, the unbalanced development within the country and for that matter within few kilometers changes the emphasis to be given to the environmental problems. For an industrialised urban area, the environmental pollution will be a hazard while for other urban

and rural areas sanitation aspects will be of genuine importance. Further in rural area agricultural ecology would form a major field.

4. There is a large percent of children and young people who do not go to school where formal education is imparted. This population group, with the women folk, forms a big percentage of the people who need to have basic education and awareness of the environmental problems. Their participation in the action against environmental degradation is one of the most important factor.

5. In the urban industrial complexes, university education at graduate and post-graduate level in specialised fields like environmental sciences, ecology or environmental engineering and allied fields is being imparted at some level and in some way. However, the greatest lacuna is in training for operation and maintenance of the treatment plants and the equipments. Due to this lack of trained personnels there is not a single water treatment and sewage treatment plant in India which is working entirely satisfactorily. Even in industrial waste treatment plants the machinery remains idle and untreated waste is being bypassed to the land or water course or in the sewers.

6. The teachers who are to teach the environmental subjects, themselves are not trained. As such they neither have the background or the visualisation of the problems. This defeats the purpose of the system and students (esp. those in primary school) do not get involved in the problem. The trained and educated teachers are the foundation of the entire education system.

7. The average percentage of literacy in India is only 30 percent which means that thre are many areas where it is even less than 30%. The purchasing power of an average Indian is far low. Therefore, very negligible percent of the population can buy the news-paper. Hence the 'mass media' cannot be really the mass media in the sense as is used in developed countries. The communication depends on the socioeconomic situations of the country and therefore the 'printed word' has practically no siginificance in the "Oral Society" of the rural poor.

These are only a few important problems.

Agreeably the environmental education in our country is as complex a problem as the vastness and complexity of the texture of our society. The problem has also the dimensions of religious, lingual and cultural variations. Therefore, half hearted and patchy efforts will not do any good to the society or to the environment.

Government of India has made a good beginning. The National Council of Education Research and Training has given due importance to the ecology and environmental sciences. It has introduced these topics at various levels in primary and secondary schools.

POINTERS TOWARDS SOLVING THE PROBLEMS

It is impossible to prescribe a prescription for solving all these problems. However, a few suggestions based on the experience of other workers in the field and myself can be putforth.

Formal and Non-formal education

The first and foremost action should be about bringing about awareness of environmental problem. It must be acknowledged that this cannot be done only by the formal education. In India NCERT has formed various syllabii at various levels, wherein the subject has been introduced initially as relation of man with nature, (wild life, plants etc.) and then at the high school level pollution with its sources and effects has been discussed. Therefore the students have some idea of the subject but without audiovisual experience primary school children do not react. Their involvement needs to be encouraged. Unfortunately in most of the schools this aspect is neglected - probably due to non-availability of materials and/or the teachers themselves being not interested and educated enough in environmental field. Real life experiences and studies of actual environment should be followed. Hence some exercises like 'Invent your environment' need be introduced in the system.

The young students in the primary and secondary schools are very enthusiastic and my experience of 20 years tells me that once these kids and young boys are convinced then they give you far better approaches of teaching than we can think. Once the school boys have certain background about the totality of the environment and its importance in their future lives the syllabii the college education obviously have inter-disciplinary approach with specific concepts from each discipline. All graduate courses should allocate a minimum period for class room instruction discussion or other suitable presentation of environmental topics. It is observed that ecology courses revolve around botany, zoology and similar life sciences while environmental engg. courses discuss only technology. While the social and behavioural sciences have neither of these. Therefore it would be proper to have some course like Human ecology and human adaptability or social ecology wherein the man's relationship with the environment and also with other animal world in the environment is presented to the student as an integrated whole. In some Indian Universities such courses are introduced but the response for interdisciplinary of 'Mixed' courses is not very encouraging. But probably they will become popular shortly.

VOLUNTARY ORGANISATION

Hence Non-formal education in addition to formal in the form of extracurricular activities with the help of various non-governmental organisations or volunteer groups must be arranged. Such meetings and picnics or outings not only acquaint them with live problems and increase the interest of the students but also train and orient the teachers also. The experience of SOCLEEN Bombay or Regional College, Bhopal proves that such activities like essay competition, elocution competition, painting competition have been most welcomed by the students. It was observed that their awareness had increased immensely after this exposition.

Second important fact to be remembered is the differences in urban, rural and tribal environment. And therefore the environmental education should be relevant to the problems. It has been experienced that the tribals, rurals can teach you more about the forestry, botany and zoology, soils etc. than any outside doctorates. They have grown with the soil and nature hence culturally they are part and parcel of the enrivonment. As such it would be beneficial to accept suggestions from those local stalwarts as a part of the education.

The real force in the democratic country like ours is the people. Therefore educating the masses, making them aware of the future disasters is the most important aspect of education. This has to be undertaken at every level. There are voluntary organisations and political parties who have devotedly brought these problems to the front. It is not that the rurals do not know the importance of a tree to their survival. But governmental agencies buy their leaders. But once the population stands by the conservation there is nothing like it. In India we have two glorious success stories viz., Himalayan Forestry (Chipko Andolan) and silent valley project where due to the public pressure and demands of the masses the politicians had to change their decisions in favour of environmental conservation.

The population was enlightened. The social workers and environmentalists informed the people of the impending dangers and the local people themselves came up with similar expressions which made a tremendous impact. The local language, relevance to local culture and socioeconomic problems were the keys that could change the minds of the people.

In India especially in the rural part, television and films are the best mass media that could be used for dissemination of information and educating the rural masses. The message through the documentaries or special films should be hammered again and again and again to give better results.

The administrators and judiciary is being educated through various types of mass media 'printed words' being the most useful ones. In some cases continuing education (for younger generation) programmes are arranged so that they understand the environmental impact on the life of future generations.

The operation and maintenance of any treatment plant is the most neglected part in India. Therefore it is imperative that there should be specialised courses in Operations Maintenance. The person without such a certificate that he has undergone the course successfully should not be allowed to take up the job. There should be three fixed courses and the rinerachy and thereby economic motivation to get more knowledge. These courses should be started by the govt. aided institutions or by the professional institutions like Institution of Engineers, IWWA, but the government should give its backing. Like 'boiler operators' Certificates these certificates must become a necessity otherwise spending lakhs of rupees on building the plant and instruments would be wasted (as they are today).

CONCLUSION

The problem of environmental education is very complicated. Basically it has to deal with values and attitudes. The faith in technology and progress are the roots of environmental disaster. The environmental education will have to dispel this faith and replace it with harmonious life with Nature and all creations of God on this earth.

The environmental education should therefore be a total attack on the entire population to enhance the environmental awareness from the preschool days to the adulthood. The problem solving attitude needs be developed either by formal or non-formal education with the help of the NGO and volunteer groups. Whenever the masses have understood the problem they stood against the project which spelt ecological disaster. It is already late. If we do not hurry up and inculcate and imbibe the environmental principles in the coming generation, there is no hope of stopping the disaster.

Reference

1. Pooniah N.D. "Present status of environmental education in the Asian region" in Education for Environmental Planning and N.L. Ramanathan for Indian Environmental Society (1982).

PRINCIPAL PROBLEMS IN DEVELOPING ENVIRONMENTAL EDUCATION PROGRAMMES FOR PRIORITY SECTORS (INDIA)

Edc. Sector	Legislation	Funds	Institutional aid	Physical facilities	Personnel	Organisation
Pre School		High Importance			Low Importance	
Primary	Low Importance	Low Importance			Medium Importance	Medium Importance
Secondary		Low Importance			Medium Importance	
Territory					High Importance	
Youth	Low Importance					
Adults			Low Importance			

Note : Blank is absence of Env. Edu. Problems.

Table I (From Ref. 1)

10th WEDC Conference

Water and sanitation in Asia and the Pacific: Singapore: 1984

Manpower Development for Urban and Semi Urban Water Supplies in Indonesia

A L Spencer and Mrs Sri Redzeki

INTRODUCTION

This Paper is presented in two parts.

Part A is presented by the Head of Training Section of the Sub-directorate for Development (SDD) and gives an overview of the present water supply and training situation in Indonesia.

Part B is presented by the expatriate consultant, who has been working in SDD since 1981, initially as training consultant in the Netherlands-supported Manpower Development Programme, later as manpower development adviser. This Part discusses progress in a number of key human resource development (HRD) activities and includes suggestions for HRD programmes elsewhere.

PART A

BACKGROUND TO INDONESIA

The so-called archipelago of Indonesia extends over a distance of approximately 6,400 km. It comprises some 14,000 islands, making up a total land area of more than 2 million km^2.
The population in 1980 was assessed at 147 million, 32 million of these living in urban environments. This is predicted to grow to around 182 million by 1990, when it is expected there will be 75 million in urban and semi-urban situations (ref.1).

Travel between regions is not easy. There is a good network of air services but this method of travel becomes expensive if used regularly, a factor which has to be borne in mind when considering a strategy for human resources development.

For administrative purposes Indonesia is divided and sub-divided into 27 Provinces, 247 Kabupaten (Regions) and approximately 3,400 Kecamatan (Districts). Each has its own level of local government.
In addition there are some 70 cities (Kota Madya and Kota Administratip) which possess there own administrative identity.

PRESENT WATER SUPPLY SITUATION

During the years of the Dutch administration many small water supply schemes were constructed, particularly on the main islands of Java and Sumatra. But during the years of the 2nd World War, and the subsequent struggle for Independence, the country suffered severe economic problems. Construction of new water supplies came to a standstill and it was not possible to give existing systems more than scant attention. In 1969, however, things changed. President Suharto created the 'New Order' of Government. The economic position stabilised and the first of a series of 5-year Development Plans (Repelita) was created. By mid-1970's momentum in water supply was picking up. By the late 1970's Indonesia had developed a large measure of self reliance in terms of technical know-how for design and construction of water supply schemes.

At present there are 245 'water enterprises'. These are based either in a Kota Madya, Kota Administratip, or the mother-town of a Kabupaten (Ibu Kota Kabupaten). The latter also have responsibility for water systems in the mother-towns of their respective Kecamatan (Ibu Kota Kecamatan). Thus these 245 enterprises together represent about 310 separate water supply systems, comprising over 900,000 house connections and 7,000 public hydrants, and serving an estimated 12 million consumers. The present workforce is about 14,500.

Many of these systems are at present very small, having capacities of 20 l/s or less and a staff of only 5-15 persons. The three major cities (Jakarta, Surabaya and Medan) together account for 32% of the total house connections and 28% of the staff.

INSTITUTIONAL ARRANGEMENTS FOR WATER SUPPLY

The national organisation of water supply in a country such as Indonesia is not easy. The need for rapid regional development, steered and funded by Central Government in Jakarta, must be tempered with the need for a certain amount of regional autonomy. These two factors have led to the following arrangements for water supply :

1. Planning and construction of urban and semi-urban water supplies is largely the responsibility of the Ministry of Public Works, and is implemented through its Directorate of Sanitary Engineering (DSE).

On completion, a new water system may continue to be supported financially and otherwise by DSE for 2 years or so, until it is strong enough to 'stand on its own feet'. During this infancy stage the enterprise is known as Badan Pengelolah Air Minum (BPAM).

2. At the end of the infancy stage the status of the enterprise is changed by regional decree to a Perusahaan Daerah Air Minum (PDAM). As such the enterprise has its own legal and managerial identity and can incur and discharge financial obligations. Its activities are overseen by a 'Supervisory Board', representing local government and commercial interests, and it is accountable to the Head of the Local Administration. It then comes indirectly under the jurisdiction of the Ministry of Home Affairs. Of the present 14,500 workforce in water supply, more than 75% are employed in PDAM's.

3. Rural water supplies (usually defined as non-piped systems) are the responsibility of the Ministry of Health.

WATER DECADE TARGETS

Targets for Indonesia were confirmed during the Bali conference in 1982 (ref.1), and are as follows :

1. 75% of urban population to be supplied with water
2. 50% of these to be supplied via public taps and 50% by house connections
3. 60% of the rural population to have access to clean water.

Target (1) implies a water supply system in every town down to Ibu Kota Kecamatan level, or approximately 3,700 systems, grouped into 317 separate enterprises.

The magnitude of the task to be undertaken can perhaps best be appreciated from the planned growth in the numbers of consumers, which will increase from approximately 12 million (1983) to 46 million by 1990.

PRESENT ARRANGEMENTS FOR HUMAN RESOURCES DEVELOPMENT

Within the Directorate of Sanitary Engineering, the Sub-Directorate of Development (SDD) is responsible for developing staff of newly-created enterprises (BPAM's).
Two types of development activity are pursued:

1. Classroom training

   These are courses usually of 2 weeks' duration and cover a range of water enterprise jobs : managerial, financial, administrative and technical. The courses are implemented with the assistance of local consultants. To minimise travelling costs of trainees the courses are held in provincial locations as well as in Jakarta.
   During 1983/84 seven different courses were provided for enterprise staff, plus three courses for other groups (e.g. consultants). Each course ran a number of times, resulting in a total of 30 training events, or about 1,450 man-weeks of training.
   Most recipients of training are employees of BPAM's. There are arrangements for staff of PDAM's to participate in training, but few PDAM's take advantage of this. This is partly due to the limited number of places available and partly due to the fact that PDAM's, unlike BPAM's, must find the tuition fees, accommodation and travelling expenses from their own budgets. This is unfortunate, as there is little training available elsewhere for staff of PDAM's, except where a PDAM is the recipient of foreign aid (which often includes a training component).

2. 'Inservice' training

   This is a form of assistance given to newly formed BPAM's. It includes elements of 'on-job' training and coaching, and is carried out with the assistance of local consultants. Usually between 20 and 30 BPAMs receive in-service training each year.

The task of human resources development, both now and in the future, is a formidable one. In common with the rest of the world, Indonesia is having to cut-back on government spending. External aid has been made available from a number of sources and for this Indonesia is most grateful. However, SDD must continue to work with a very limited budget, and must try to combine maximum effectiveness in human resources development with minimum cost.

PART B

DEFINITION AND SCOPE OF HUMAN RESOURCES DEVELOPMENT (HRD)

It has been recognized that in Indonesia there is a need for HRD support to a number of groups who are involved, in some way, in water sector activities (refs. 2 and 3). These include water enterprise personnel, consultants, contractors, staff of government departments, educational and professional bodies, suppliers, consumers.
During recent years, however, funds have been limited, and attention has been focussed

mainly on development of water enterprise personnel. To meet this end it was felt, at the start of the Manpower Development Project, that there was need of a short definition of HRD to help clarify the project goals. The following was adopted :"HRD is an activity which is undertaken to ensure an adequate supply of personnel, having sufficient knowledge skill and motivation to satisfactorily carry out the work required of them". (A broader definition has more recently been published by the IDWSSD Steering Committee (ref.4)).

A number of water enterprises were visited to ascertain, from discussions and observations, the current human resource situation and the priority development needs. These visits revealed that :

1. Education and experience levels of senior staff were often lower than would be considered appropriate in a "developed" country.
2. Outside the main cities it was difficult to find professionally qualified people who were prepared to join water enterprise.
3. Few technical staff had received formal training.
4. In general there were many areas where performance of enterprises could be improved, and to which training could contribute.
5. Provision of training alone would not necessarily produce all the desired improvements in performance. Equally relevant were problems concerning institutional arrangements, enterprise organisation, management attitudes, and others.

Based on the Definition of HRD, and the factors listed above, a tentative proposal for the scope of the project was prepared (see figure 1) (in this figure the currently favoured term "HRD" replaces the original term "Manpower Development").

However, it was recognized that from a base within SDD there were very real limitations over what the project could achieve. For instance :

1. The nature of the link between SDD and PDAM's was an unclear one. Where institutional and organisational problems had been identified as contributing to poor enterprise performance, what authority did SDD possess to correct the situation ?
2. It was unlikely that the project would be able to influence career and salary structures, especially the latter, which are fixed by central government or by local authorities.

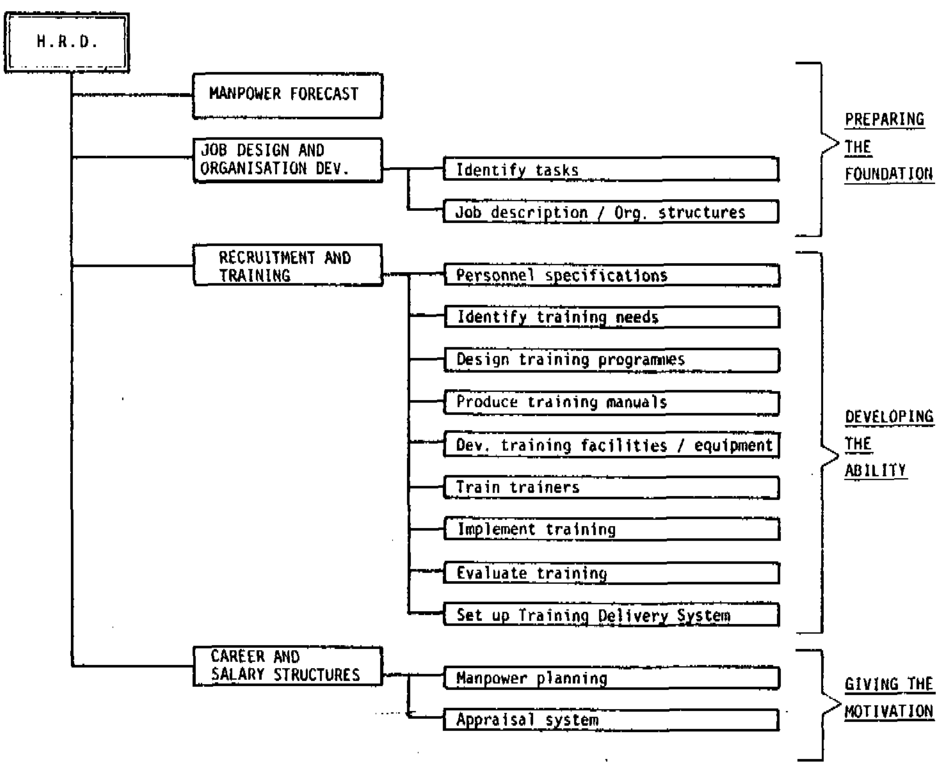

Figure 1. Scope of the Manpower Development (HRD) Project

HRD SUPPORT TO SUBDIRECTORATE OF DEVELOPMENT 1981-1984

Limited space precludes anything more than a brief overview of the main activities :

Manpower Forecasting

Forecasts were prepared for the 1990 situation, based on water decade targets, and these were interpolated for intervening years. Each water enterprise was examined individually, in terms of the natural growth of population and the planned increase in percentage to be served.
Assumptions had to be made concerning :

- the average number of persons per household (which determines the number of house connections required)
- the ratio between number of enterprise staff and number of house connections

A range of forecasts was produced, according to different assumptions used. A "median" value for total number of employees required by 1990 is 38,000.

Job Descriptions and Organisational Development

Government guidelines exists for setting-up new water enterprises. These contain "standard" organisational structure and job descriptions for senior staff. It was felt there was a need for complementary guidelines:

- which would show how the "standard" organisation structures could be adapted to fit individual circumstances (for instance, according to the type and complexity of facilities operated by the technical department).
- which would encourage and assist preparation of full job descriptions for all staff.

Accordingly, a "Manpower Classification System" and a "Simplified Guide to Manpower Classification" were produced (ref.5).

Identification of Training Needs

Early visits to water enterprises revealed that two priority groups for training were (a) senior managers and (b) technical staff. As a first phase of training, "general background" courses were provided for these two groups. A second phase programme is planned for the future which will comprise in-depth training in selected topics. To identify more accurately these and other future training needs, three approaches are being adopted :

1. A "Training Needs Questionnaire" is being completed by each enterprise.
2. A "Manpower Inventory" is being compiled for each enterprise.
3. The monthly reports from enterprises are being subjected to computer analysis to compare the progress of each enterprise against a number of "performance indicators". It is felt these will be useful pointers to possible training needs.

Trainers and Training Materials

In Indonesia at present the number of people having in-depth experience of water supply, who are available to act as trainers, is not high. Those who are available are not necessarily skilled at passing their knowledge and experience on to others. Production of comprehensive training manuals helps to alleviate the problem, in that the quality of the training then becomes less dependent on the quality of the instructor.

A number of manuals have been produced in SDD, with the help of a group of Netherlands consultants, and this work continues to receive attention. To further improve the quality of training, consultants appointed to deliver training are first given a 4-day course in Group Instruction Techniques.

Implementation of Training

On the whole this continues to go smoothly to the extent that limited resources will allow. Facilities for courses held in the provinces have to be hired, and these often leave much to be desired. Difficulties are also experienced with the selection of trainees and the provision of audio-visual equipment. The need for a stronger organisation to handle training in the provinces is discussed below.

National Training Delivery and Support System

A target for the Manpower Development Programme was the establishment of a National Training Delivery and Support System. A key element in this was the creation of provincial training officers who, amongst other things, would :

- identify training needs in their province
- organise the necessary training, through a combination of SDD courses, training courses provided by others, "on-job" training, staff secondment between enterprises, etc.

Attempts to achieve this situation have up to now been only marginally successful. It is felt this is partly due to lack of a physical focal point for training officers' activities. Experience would seem to indicate that establishment of permanent provincial training facilities (i.e. "bricks and mortar") might be necessary from a psychological as well as a physical point of view, for the development of a complete Training Delivery and Support System.

SETTING-UP HRD PROGRAMMES

Until recently, in developing countries, the vast bulk of foreign aid and local budget was directed towards developing the "hardware" components of water supply. "Software" such as HRD was often given only marginal attention. However, it has become apparent that successful development of water supply must take account of both elements, and nowadays HRD is coming to be viewed with greater interest. In selecting HRD projects for external support, or in setting up internal HRD programmes, experience is showing that a number of factors should be borne in mind :

1. HRD is a long-term activity. Funds directed to short-term development of staff of particular water enterprises may only produce correspondingly short-term benefits, unless there is a strong "central" resource capable of providing continued support for HRD. To foreign investors it is suggested that a part of the aid presently used in this way to support individual water supply projects could be more usefully diverted to strengthen a national HRD function.

2. HRD requires flexibility of approach. Bureaucratic organisations are, by their nature, inflexible creatures. They are capable of carrying out routine work efficiently (although not all do !), but they are slow to change their methods of working to adapt to changing circumstances. This should be remembered if the creation of a new national body for HRD is being considered.

3. HRD programmes may be slow to produce measurable results. This can be a problem when there is a need to win support for HRD from other groups, who perhaps will be persuaded only by "results". The HRD activities should be programmed so that some observable benefits are obtained at an early stage.

4. HRD requires specialist, dedicated staff. All-round skills in HRD take several years to acquire. An HRD team requires capable, self-motivated people, who are prepared to stay in the team for a minimum of three or four years. It is disruptive if team members are transferred to other work just as they are beginning to make a positive contribution.

5. HRD appears expensive, even if it is only a very small percentage of construction and operating costs. For a programme to be successful it needs support and commitment from the very top levels of decision making, to ensure that adequate resources are made available. Foreign investors need to obtain this commitment at an early stage, when the nature and extent of foreign support is being discussed. Although HRD appears expensive, lack of HRD will be more expensive in the long-term.

REFERENCES

1. Conference on water supply and sanitation 1981-1990. Bali, 1982.

2. UK NATIONAL WATER COUNCIL. Indonesia : Manpower development in the water supply sector, 1979.

3. MINISTRY OF PUBLIC WORKS, INDONESIA. Report of the working group for manpower development overall programme for urban water supply, 1982.

4. INTERNATIONAL DRINKING WATER SUPPLY AND SANITATION DECADE STEERING COMMITTEE. Basic strategy document on human resources development 1982.

5. MANPOWER DEVELOPMENT PROGRAMME FOR COMMUNITY WATER SUPPLY, INDONESIA. Simplified guide to manpower classification, 1982.

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Manpower development for the Water Decade in SE Asia

I and Mrs R Vickridge

INTRODUCTION

Shortage of manpower is often given as one of the principal factors in failure to meet water decade goals. This paper examines the roots of the shortage in S.E. Asia, and sets the question of manpower development for the decade within the larger context of education policies in S.E. Asia, since it cannot, we feel, be considered in isolation from the question of educational priorities within national development planning.

Of the many problems relating to manpower development we have chosen to focus on one specifically which we refer to as the "missing link", a product of historical circumstances, value orientations, and previous education policies.

ALLOCATION OF EDUCATIONAL RESOURCES

Universities, Polytechnics and Trade Schools

Ideally, the pyramidal structure of manpower requirements (from artisan to technician to engineer) should be mirrored by the availability of training and education facilities (from apprenticeships and vocational schools to polytechnics to universities). An analysis of post-secondary education however reveals, an imbalance in favour of the universities at the expense of a network of localised trade schools or vocational centres. This stems from the unrealistically high expectations, typical of the 50's and 60's, of the university as a catalyst of economic growth, which skewed the education budgets of many newly independent states at that time (1). Furthermore in previously colonized countries it reflected the perpetuation of a system for creating an indigenous bureaucratic elite, and the immediate post-colonial need to quickly fill vacancies in a newly independent government (2). Educational investment has as a result been highly concentrated within a few urban centres and within a small educated elite, which has subsequently been able to defend the perpetuation of an expensive and arguably wasteful syphoning of resources by universities.

Most S. E. Asian governments have now recognised the need to expand provision of technical and trade schools and have made plans to accelerate manpower development in these areas. In part this stems from saturation of government departments following rapid tertiary expansion, and growing unemployment among graduates. Furthermore, it represents a recognition that university expansion does not of itself ensure socio-economic development. In Thailand, students are now being encouraged to take vocational training instead of entering universities (3). The Malaysian government has planned more polytechnics, vocational and trade schools and stress is to be placed on vocational subjects (3,4). Although the first polytechnic in Indonesia was not established until 1976, six more were in operation by 1982 and eleven more are now being planned. Development and upgrading of vocational schools throughout Indonesia is also under way (5).

One of the major obstacles to expansion however, is the lack of qualified and experienced staff required for the new institutions. Whereas in industrialised countries it is possible to recruit experienced technicians from industry, in developing countries industry is in its infancy and skilled experienced personnel is more rare (5). This fact and the excessive value placed on formal paper qualifications (see below) means that many teachers are selected with little or no hands-on experience. A recent workshop on industrial training in technician education supplied examples of polytechnics recruiting staff from their own graduates without their being able to meet requirements of industrial experience, and this is reflected in curricula within vocational schools "which are still too theoretical and academic in nature without proficient skill training facilities" (5). In addition the wage differentials between industry and teaching act as a deterrent in recruitment of teaching personnel in Thailand, Malaysia and Indonesia (5).

Regionalisation

The top heavy distribution of educational resources has had an added geographical dimension in that universities have been heavily concentrated in capital cities or other major urban areas. Lack of community and regional establishments has heightened the gap between city and rural hinterland and has strengthened the pull and primacy of the capital. For those students from rural areas who have succeeded in gaining access to university, there has been little benefit to their community of origin since most graduates choose to remain close to the jobs and opportunities of the metropolis.

The current concern with regional and especially rural development however has led most S.E. Asian countries to adopt some form of regionalisation of its tertiary education. Thus in Malaysia, although the universities are concentrated in Kuala Lumpur, the MARA Institute of Technology has set up four regional campuses offering lower level courses which can prepare students for more advanced courses at the main campus (6). Indonesia has a number of universities outside the Jakarta area and has recently developed a Teleprogrammed Educational System, whereby educational programmes can be transmitted from Boger/Jakarta to eight state universities (3). Since 1964, three regional universities and a community college have been established in Thailand. Other Thai innovations designed to make education more accessible to the rural population include the Open University (established in 1978) and the rural doctor scheme operated by Mahidol and Chulalongkorn Universities in Bangkok. Under this scheme, 10% to 15% of places in the medical schools are allocated to applicants from rural areas in anticipation that they will return to practice there on completion of their course (7). It is understood that this scheme is to be extended to engineering schools of some Thai universities.

While innovations like these mark significant breaks with the centralisation of the past, one could argue that institutional decentralisation has no impact on regional development unless incorporated within a comprehensive and multi layered system embracing local and regional levels. Whereas tertiary education may have a role in rural development, many would now argue that this is only as one part of an integrated system made up of primarily non-formal education through for instance adult education, apprenticeship programmes and vocational training, and on to a step system of education linking lower to higher level institutions. Such a system would have an important geographical dimension in that it would create a network of opportunities incorporating village, district and regional centres, and would increase the regional significance of tertiary institutions. We suggest that this would also be a prerequisite for tackling the training needs of the water decade, since this would create the decentralised and integrated structure necessary both for manpower training and project implementation (8).

Meeting Regional and National Needs

The orientation of the typical engineering department limits its contribution to national and regional development programmes. Thus curricula compare closely with their counter parts in industrialised countries, more because of the educational backgrounds of their teaching staff (many of whom train in the west) than their appropriateness to local needs and circumstances. This has been variously explained as a particular type of post colonial dependency in the form of the 'captive mind' (9) within the academic population, or perhaps more correctly, as an indication of the orientation and personal career aspirations of the staff to the status and privilege of established western institutions. Whatever the reason, the result has been a failure, for the most part, to interpret theory creatively or to develop curricula appropriate to local circumstances. This absence of a local or national orientation within the universities has been critical in view of the limited development of alternative forms of post-secondary education. The implication for the water decade is that graduate engineers are poorly equipped to deal with the pressing problems of environmental and community health (e.g. in terms of rural development or urban squatter upgrading), in which the role of the water and sanitation engineer is crucial.

Nevertheless the university in some S.E. Asian countries has seen some substantial curricula restructuring in areas central to a diversifying economy. For instance the "advanced developing" countries of Singapore and Malaysia have achieved considerable success in linking specialized research and curricula development to key economic targets i.e. finance and marketing, and agriculture respectively (1). By contrast there are few direct economic pay-offs to be had from water decade objectives and there has been no comparable motivation in curricula restructuring. The current concern with rural development, particularly in Malaysia and Thailand has encouraged some universities to set up multi disciplinary field projects and yet even these have not yet included engineers within their development teams (7). However, there are degree courses in Water Resources and Rural Development being offered by universities in Thailand (10). An optional subject in rural engineering is also offered as part of the engineering degree programme at Chulalongkorn University in Bangkok.

On the whole, in the absence of external pressure for appropriate curricular development, academics seem slow to recognise and respond to the needs and challenges of regional and national development, which clearly call for a rethinking of conventional approaches and imported solutions. Lack of funds, shortage of staff and facilities, problems of co-ordination and communication have all been cited as obstacles to innovations in Thailand (7). However severe these obstacles may be, we suggest that it is the conservatism of academics, who are often constrained by inappropriate and outdated notions of academic excellence and lack the confidence to initiate curricula reforms which have not originated in established institutions of the west, that is the major stumbling block to any innovation. Curriculum reform may prove impossible when 'appropriate' and 'practice-oriented' engineering is seen as a threat to the aspirations of academics who equate 'appropriate' with unprestigeous, rural with backward, and 'practice' in engineering as best befitting operative, technician and non-professional levels. It is to this latter problem of value orientation among graduate engineers that we now turn.

VALUE ORIENTATIONS, THE 'MANDARIN' SYNDROME AND 'DIPLOMA DISEASE'.

We suggest that, in S.E. Asia, there is a cultural and historical predisposition to regard manual and practical work as being of low status and personally demeaning, whilst the 'mandarin', whose long fingernails symbolise a life of the intellect, devoid of labour, still represents for most students the promise and meaning of higher education (11). This cultural tradition in, for example, both Chinese and Indian societies was preserved and perpetuated in colonial periods around a formal and qualification - oriented education system, and exists still as a deep rooted bias which clings tenaciously despite changed economic circumstances. Thus the irony is that engineering students aim, not at a career on the factory floor or construction site, but rather one which emphasises desk work. Many students newly returned from higher education overseas have moved immediately into administrative positions with no experience of engineering practice other than that acquired during their education.

Even in the relatively well developed nation of Singapore, which has a well established tradition of engineering education at university and polytechnic levels, it is apparent that the majority of engineers are employed as administrators or designers in government departments or consultancy firms. There is only a small proportion of civil engineers employed by construction companies with the inevitable result that the country is largely dependant on the services of overseas contractors for major civil engineering works. However, it is interesting to note that, in this case, a strong government with a pragmatic approach has been able to establish a totally new institute (Nanyang Technological Institute) which publicly adopts a 'practice-oriented' approach to engineering education in order to meet the demands of the manufacturing and construction industries. The establishment of the Nanyang Technological Institute (NTI) in 1981 was in itself an implicit recognition of the 'mandarin syndrome' and an attempt to overcome it. The majority of academic staff employed by the Institute have recent industrial experience and emphasis is placed on laboratory work, projects, design and industrial attachments. More importantly, in terms of overcoming the 'mandarin syndrome', the degree course incorporates a ten-week in-house practical training programme, which, for civil engineering students, involves the actual construction of a reinforced concrete structure (12). The greatest resistance to, and sceptism towards, such innovative programmes has come, not from government administrators or local engineers, but rather from the academic staff themselves. The success of these innovations has now largely overcome this resistance, but the point is that, even with strong government direction backed with substantial financial resources, it may still be difficult to implement radical innovations in educational programmes, particularly in long established institutions.

Secondly, the screening or selection theory of education is extremely widespread and resilient in S.E. Asia (2). According to the theory, the principal purpose of education is to screen students for entry to a small elite (ie. the modern-day mandarin concept). Formal qualifications thus become of supreme importance as a determinant of social position, and students aim at a university education for the qualification it brings rather than its content, and for the economic security this guarantees. Even the present incidence of graduate unemployment has failed to diminish the aspirations of school students to eventual university entry. "As a means of selecting a small colonial or post-colonial elite ... qualification-oriented schooling was a feasible (if arbitrary and expensive) method" (2). However it makes less sense in technologically emerging societies. An excessive 'qualification-consciousness' begets the 'diploma disease' (13) which has a stultifying and economically dysfunctional effect on practising professions like engineering, by undervaluing the crucial importance of experience and overrating paper qualifications.

Thus figures on manpower availability often conceal the true potential of a population by excluding those who may already be practicing as plumbers, fitters, welders etc. but have not received formal training as such. Furthermore, engineering education is overloaded with qualified teachers with no practical experience (5), and whose teaching reflects this absence, yet qualifications still have more weight than experience in all but the most innovative of programmes. It could however be argued that experience is as, if not more, appropriate at all levels, but especially in artisan and technician training, where current shortage of teaching staff is said to be most severe.

THE MISSING LINK

The lack of 'practical' professionals and 'educated' artisans has resulted in what might be described as the 'missing link' in the operative-professional chain - a link which is vital to the successful implementation of civil engineering works in general, but even more so in the context of water decade objectives. It is the void that exists between designers and implementers of projects - a void that should be filled by an overlap in training and experience to provide a common ground and common language.

This problem of the missing link in the administrative chain is compounded by its geographical dimension. Professional engineers tend to be heavily concentrated in the urban areas whereas it can be argued that it is the rural areas which have the most urgent needs in water and sanitation. Rural artisans and technicians have little opportunity for upgrading their skills, and graduate engineers show little desire to return to or work in rural communities. Thus, the problems of implementing plans made at a national or even regional level are immense and plans made at community level are liable to be either unworkable or ineffective due to insufficient input from suitably qualified engineers.

CONCLUSIONS AND RECOMMENDATIONS

In conclusion we put forward proposals which fall roughly into two categories - those which need to be accepted and operationalised at government policy making level, and those which relate to existing institutions and which normally could be adopted without reference to a higher authority.

Within the former category, we recommend firstly a 'stepped' system of education whereby students could move from trade to technician to professional engineer levels, preferably with periods of practical work experience between each step. This training and education should take place in regional centres, should be specifically geared to water and sanitation and should incorporate a substantial amount of practical training and project work.

Secondly, there should be continued expansion of 'lower level' trade and vocational schools, combined with apprenticeship schemes, and furthermore, that the value of 'non formal' education be recognised and its expansion included within development planning.
Thirdly, that this multi level system of manpower training and education be developed at regional and district level thus providing a decentralised training structure to which rural village as well as urban squatter community would have access.

These recommendations stem from our belief that 'bottom-up' skills development as opposed to 'top-down' formal knowldege filtering is the only framework within which water decade objectives can be met. However, redirecting educational resources and establishing new training institutions takes political will, time and money. The goals of the water decade and the training required to meet these do not have the same political pull or clear-cut economic payoffs as areas more central to national economic growth.

Unless, therefore water and sanitation are incorporated under a politically more fashionable, or growth-related umbrella (like for instance 'rural development' which has high current acceptability in S.E. Asia) then they are likely to receive low priority, despite official statements to the contrary.

With regard to existing educational institutions, we recommend firstly that substantial curricula reforms be made in order to reflect and meet national and regional needs. The boundaries between the traditional engineering disciplines (civil, mechanical and electrical) are, after all, fairly arbitrary and there seems no reason why courses in, for example, rural development engineering (as opposed to municipal engineering) or water resources engineering (as opposed to structural engineering) should not be offered. Secondly, practical training should form an integral part of engineering courses at all levels and although practical training project can be expensive (12), we suggest that costs can be minimised and benefits gained by organising real field projects rather than simulated ones.

Although reforms within existing education institutions may be more economically feasible than the more far reaching national reforms previously recommended, we suspect that there is likely to be strong resistance from within the institutions to such change for reasons already outlined.
Thus, the recommendations made so far, would appear to have little prospect of successful implementation in the short term. Lastly, however, there is one major innovation that governments could make which may have a substantial effect on skilled manpower availability for national development generally and the water decade in particular. That is the explicit recognition of the importance of practical experience as opposed to paper qualifications, in assessing ability at all levels from engineer to artisan. The 'learning by doing' argument is gaining increasing support, and in terms of decade objectives it may be necessary to follow the Japanese example, set in the period of national reconstruction following World War II, when requirements for formal qualifications were shelved in the face of the massive task of reconstructing and upgrading water supply facilities (14).

All recommended changes, including this last one, are likely to meet with resistance and some may require substantial financial resources to implement. Realistically therefore, we suggest that, until this opposition can be overcome or the necessary finance made available, there will continue to be a need for and reliance upon the industrialised nations to provide specialised education and training through consultants and contractors (who are becoming increasingly aware of and able to meet the need for training) and specialised university departments (such as WEDC) who are able to tailor courses to specific needs.

REFERENCES

1. Altbach, P. G., Higher Education in the Third World. Maruzen Asia, 1982.

2. Snodgrass, D. R., Inequality and Economic Development in Malaysia. Oxford University Press, 1980.

3. RIHED Bulletin. Regional Institute of Higher Education and Development. 1983, Oct-Dec, Vol. 10, No. 4.

4. RIHED Bulletin. 1983, Jan-Mar, Vol. 10, No. 1.

. F. J. C. Pala, Regional Workshop on Industrial Training in Technician Education. Journal of Engineering Education in Southeast Asia. 1983, June, Vol. 13, No. 1, 25-47.

6. RIHED Bulletin. 1983, July-Sept., Vol. 10, No. 3.

7. Wichit Srisa-an. Innovations in Higher Education for Development in Thailand. Maruzen Asia, 1982.

8. I. and R. Vickridge. The Water Decade - The Need for an integrated approach to training and education. 4th Asia Pacific Regional Water Supply Conference, Jakarta, 1983, Nov.

9. Syed Hussein Alatas. The captive mind and creative development. Asian values and modernization (ed. Seah CM), Singapore University Press, 1977.

10. Paiboon Suthasapa et al. Tertiary Education and Rural Development in Thailand. Maruzen Asia, 1982.

11. Ho Wing Meng. Asian Values and Modernization, in Seah, C.M., op. cit., 1977.

12. C. N. Chen, I. G. Vickridge, W. K. Yip and P. Ang. In-house practical training programme for civil and structural engineering students. Recent Developments in Engineering Education, AEESEA, 1983, Dec.

13. Dove, R. P. The Diploma Disease; Education, Qualification and Development. University of California Press, 1976.

14. Hidenori Aya. Efficient system for dissemination of water supply technology. 4th Asia Pacific Regional Water Supply Conference, Jakarta, 1983, Nov.

SESSION 9

Chairman: Mr D O Lloyd, Director
Halcrow Water, UK.

Discussion

A P Cotton

WEDC training programmes in Sri Lanka

1. Dr COTTON described the various training programmes carried out by the WEDC group in Sri Lanka, and emphasised the difference in approach for different levels of staff.

2. Mrs MYLIUS observed that training tended to emphasise technical and administrative aspects, whereas many schemes required staff to possess skills in education and community participation; she asked what was being done in that area.

3. Dr COTTON replied that technical training was only a part of the overall training activities of the National Housing Development Authority of Sri Lanka, and that such skills as mentioned by the questioner formed a part of the overall training programme. However, such training would not be appropriate for all staff in all organisations; the National Water Supply and Drainage Board provided technical services and technical support to other organisations, and ability in technical and administrative matters was probably most important for staff involved in major capital works.

4. Mrs MITRA asked how the use of group discussions was structured in order to draw out answers from participants.

5. Dr COTTON stated that the discussion groups were based around a number of specific questions, which were structured to try to assist the participants to discuss and analyse the most important problems.

S K Gajendragadkar

Education and training in India - problems and solutions

6. The author was not present, and the paper was not read.

A L Spencer and S Redzeki

Manpower development for water supply in Indonesia

7. Mr SPENCER discussed the background to the training programmes in the water supply sector in Indonesia, and outlined the structure and scope of the training being undertaken.

8. Mr SHRESTHA emphasised the importance of selecting the correct person for the job in question; he commented that with all UNICEF assisted schemes in Nepal, local manpower was trained, and that the staff needed both job security and incentives.

I Vickridge and R Vickridge

Manpower development for the water decade in S E Asia

9. Mr VICKRIDGE discussed the needs for trained manpower, and criticised the teaching provided by many higher education institutions. He highlighted a missing link in the chain as being the 'practical professional' and 'educated artisan'.

10. Dr RANA agreed with the author's remarks, but was unsure as to what changes in the present system would ensure an improvement in the situation of inexperienced engineers supervising highly experienced technicians.

11. Mr VICKRIDGE replied that the selection of technicians and artisans was often made on the basis of paper qualifications only and suggested that, due to the practical nature of the job, this was inappropriate. More weight could be given to the candidate's experience and practical ability which could be assessed from previous employers' reports, interviews and simple practical tests. It may be easier to train experienced artisans to interpret or even prepare drawings than to train inexperienced draughtsmen in the skills necessary for implementation of engineering plans and designs.

The paper made a number of suggestions on how the 'system' could be changed and these focused on ways in which the 'missing link' could be bridged. They felt that all engineers should have a knowledge and appreciation of the skills required to implement their plans and one way to achieve this would be through a 'stepped' system of engineering education, whereby a pre-requisite for entering a diploma or degree course would be some competence in a relevant artisan skill.

12. Mr KSHIRSAGAR commented on the higher education system in India, and on the in-service training programmes being held to help cope with the 'decade' requirements.

10th WEDC Conference

Water and sanitation in Asia and the Pacific : Singapore : 1984

CLOSING ADDRESS

Dr Nay Htun

I regard it as a great privilege to be invited to sum up the proceedings of the 10th WEDC Conference on Water and Sanitation in Asia and the Pacific. There have been many informative papers and interesting discussions; we have had over 150 delegates from a large number of countries, and over 40 papers have been presented. The following important areas have been addressed.

OPERATION AND MAINTENANCE

1. Operation and maintenance is a vitally important subject, and there is a need for appropriate designs and effective implementation.

2. Operation and maintenance expenses are not properly allocated vis-á-vis the capital investment.

3. There is a tremendous wastage due to water leakage; this problem, discussed by Lohani and Tashi, is already a serious problem in developed countries, and even more so in developing countries. If part of the huge amount of money spent on new water supply systems could be used to minimise leaks, more water would be available, and the cost/benefit ratios must be extremely good.

RURAL WATER SUPPLY

1. Maintenance schemes must involve the community.

2. Some form of levy is desirable not only to recoup costs, but to foster careful use, and an appreciation of the service, as discussed by Amin.

3. We have heard interesting remarks from Nelson, Appan and others regarding the possibility of increasing the availability of water through small dams, and rainwater collection.

4. All authors have strongly advocated public involvement and participation in all aspects of rural water supply.

COMMUNITY PARTICIPATION

1. There is potential to make water supply and sanitation schemes, and slum improvements more relevant to the needs and requirements of the beneficiaries.

2. All of the authors have stressed the role of women in all aspects of the problems, the important role of non-government organisations, and stressed the integrated approach for shelter, infrastructure, and services.

APPROPRIATE WASTEWATER TREATMENT TECHNOLOGY

1. We have heard innovative papers, which considered: converting waste into biogas in China; alternative strategies for managing industrial waste in Thailand; the treatment of electroplating wastes in Singapore; optimising ecological parameters in waste stabilisation ponds in India; and using peat in Canada.

2. The aim must be to optimise the engineering processes using appropriate local materials and skills, and taking into account the socio-economic constraints.

WATER SUPPLY

1. The papers have suggested ways of improving both the quantity and quality of water. The quantity can be increased by developing aquifers; using simple and inexpensive methods to identify potable water sources; and improving the design and location of handpumps. A wide range of equipment for field testing water quality has been described, along with a promising new filtration system using locally available materials.

2. Borghei stressed the need for integrated water resource planning and management; conservation of water is a very important aspect. Water resources need protection from industrial, agricultural and domestic discharges of effluent.

SOLID WASTE MANAGEMENT

1. The only paper, by Gadi from the Philippines, described an integrated strategy, by using a systems approach, appropriate low cost technologies, and increasing grass-root level participation.

LOW COST SANITATION

1. We have heard of major low cost sanitation programmes in two of the most populous countries in the world, India and Indonesia; different designs and operational characteristics of pit and pour-flush toilets have been considered.

2. The progress towards improving sanitation facilities has been slow; there is a lack of proper institutional mechanisms for implementation, promotion, and follow-up, as well as the lack of a reasonable service charge.

TRAINING

1. The whole Conference has agreed the importance of training. Many issues have been raised, for example, who should be trained ? How should training be carried out, should it be centralised or decentralised ? What should the content be, and what proportion of the training should be practical? There is a problem to be resolved, namely how much training should be at University level, of an 'élitist' mentality, and how much vocational, or 'hands-on' training ?

2. Many water supply and sanitation projects lack the necessary funds to provide adequate training, that is, for the 'software' part of the package.

CONCLUSION

I will conclude my remarks by considering three aspects of the problem.

1. Technical considerations. The technical aspects are not a constraint; there is a lot of information and experience available, particularly on the choice of technology appropriate to sociological, economic, political, and technical conditions.

2. Financial considerations. Although finance may seem to be a major constraint, I do not think that it is so. Funds are available for good projects, but the dilemma is the tendency for bilateral and multilateral aid to support large projects, because of high overheads associated with small projects, greater recognition, and more prestige. Many appropriate systems for water supply and sanitation are low cost, and suitable for small projects.

3. Institutional considerations. I regard this as the greatest obstacle of all. Many institutions are weak, non-existent, or duplicate the work of other ministries. There also needs to be an effective way of coordinating NGO activity, and community involvement and participation. Integrated planning and implementation is lacking, as are suitable legislative frameworks, incentives, and penalties. There has to be a greater degree of awareness, through information, education, training, and manpower development. Decision-making causes problems, because it is often unclear who is responsible for what, and is duly held accountable.

Asia and the Pacific have over one half of the world's population; by the end of the century it will have approximately one billion more people. Unless an holistic integrated approach, not only in planning, but also in implementation and follow-up, is taken, the challenge before us is indeed a grim one regarding the mass of urban and rural people in Asia and the Pacific.

I wish I could take a more optimistic view to conclude with, but the challenge is enormous.