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Water and waste engineering for developing countries

8th WEDC Conference
4 - 5 February 1982

water and waste engineering in Asia

at the Centre for Environmental Studies, Guindy, Madras, India

Proceedings
edited by Andrew Cotton and John Pickford

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INAUGURAL ADDRESS

Dr V C KULANDAISWAMY
Vice-Chancellor, Perarignar Anna University of Technology

Mr President, John Kalbermatten, Mr Pickford, distinguished delegates and guests, members of the faculty and friends:

It gives me very great pleasure to be with you here today to inaugurate this Eighth International Conference on Water and Waste Engineering for Developing Countries which the Perarignar Anna University of Technology is conducting in association with Loughborough University of Technology, U.K. The theme for the Conference is water and waste engineering in Asia and we are indeed very happy that the Senior Adviser in Water Supply and Sanitation for the World Bank has found the time to be here with us today to preside over this function. His presence signifies the importance that international lending agencies such as the World Bank attach to the provision of water supply and sanitation facilities in the developing countries. According to a 1975 estimate, fewer than 500 million of the more than 2000 million people living in the developing countries excluding China had access to adequate supplies of safe water and adequate waste disposal facilities. More than 80% of the total rural population and half to two-thirds of the urban population in these countries still lack the basic facility of protected drinking water and sanitary excreta disposal. The magnitude and dimensions of the problem of providing the facility to the poor of these countries are staggering. Unprecedented levels of investment in terms of money, materials and manpower will be called for if the World community commits itself to ameliorate the tragic living conditions of the poor in these countries by contributing to the provision of safe and adequate drinking water and improved sanitation. It is in this context that the International Conference here today assumes significance. It is also a matter for recognition and appreciation that Loughborough University of Technology's water and waste engineering group, though based in the U.K., have decidedly aligned themselves towards water supply and sanitation manpower development efforts in the developing countries - every alternate year they hold this International Conference in a developing country, I understand. Mr Pickford and his group are very knowledgeable about the technology, institutions and constraints of our countries and we hope that the Conference will provide a forum for two-way exchange of information and benefit all concerned.

It will be conceded by everyone that access to safe drinking water and sanitary disposal and management of wastes should be an important social goal of every nation. The experience of advanced industrialized countries shows that water-related communicable diseases are now very rare due to running water in all dwellings coupled with proper sewage and waste disposal facilities. These are, of course, reinforced by the availability and knowledge of health care. The situation in developing countries is quite different. Water borne and water-related diseases still take a heavy toll in human lives and contribute much to human misery. In making plans to correct this situation, environmental health agencies must determine from epidemiological evidence which are the communities or districts at highest risk of water-borne or water-related diseases. They must establish appropriate quality standards for drinking water and set up and run drinking water quality surveillance programs. The tasks will be numerous; however, it would be appropriate at this juncture to take a bird's eye view of the objectives, aspirations and problems of the International Drinking Water Supply and Sanitation Decade Programme launched at the beginning of this Decade as part of the laudable efforts to provide water for all by the year 2000 A.D.

The consequences of the absence of adequate protected water supply and sanitation are, as we all know, disease, sufferings, hardship, stunted growth and development, both physical and mental, reduced productivity and premature death. This is a sort of a 'permanent disaster' prevalent in developing countries which, in my opinion, is the most compelling justification for the Water Decade. As Arthur Brown said "no matter how much it may cost to provide clean water and sanitation, the cost is far less than we are paying for its lack". It was this kind of reasoning that ultimately led the UN Conference on Human Settlements (Habitat) in Vancouver in 1976 to set the 'clean water for all by 1990' target that has now become the objective of the Decade. This objective was approved in the UN Water Conference held at Mar del Plata, Argentina in March 1977 and it was also decided that 1981-1990 will be declared as the 'International Drinking Water Supply and Sanitation Decade'. The 31st UN General Assembly which met in late 1977 endorsed the recommendations of the Water Conference.

The International Conference on Primary Health Care held at Alma Ata, USSR in Sept. 1978 recognised and emphasised that sanitary facilities must also be provided to the hundreds and millions without them. Among the long term goals agreed, the Conference gave adequate supplies of safe water and basic sanitation high priority. Thus the International Drinking Water Supply and Sanitation Decade idea that was conceived became a reality and the baby was born last November bringing in its birth great hopes and expectations all over. In the next ten years, it has to attain targets the like of which were never dreamt before nor attempted in this sector.

The challenge of the Decade has to be met. It is more challenging than a war, for a war is always won by someone but if we lose this war of the Decade, then everyone of us will be a loser! Provision of water supply for 640 millions of urban and 1570 millions of rural population and provision of sanitation for 650 millions of urban and 1670 millions of rural people in the developing countries is no mean task. Besides this, about 250 millions of people who have at present access only to systems that do not work properly also have to be taken care of. This is going to be one of the most gigantic constructive efforts of the human race on a global scale.

The official slogan 'Clean Water and Adequate Sanitation for ALL by 1990', aiming at 100% coverage was to many an ideal difficult to realise. To be more realistic, this has already been adjusted and slightly modified by WHO as 100% for water supply, both urban and rural, 80% for urban sanitation and 50% for rural sanitation; a degree of flexibility in this regard has been provided. The signatory Governments have exercised the option to amend this target slightly to make it more realistic based on self-assessment. Government of India being a party to this programme have modified the Decade target for the country as 100% for water supply both rural and urban, 80% for urban sanitation and 25% for rural sanitation. The magnitude of the problem however, is still formidable. The capital investment required to achieve the Decade target is estimated to be over Rs. 14,000 crores for India as a whole and Rs. 1,450 crores for Tamilnadu alone. At the global level, the total cost of the Decade programme is estimated to be in excess of 600 billion dollars, about ten times the total investment made at present in this sector. However, with a wider mix of service levels and the application of appropriate technologies in rural and urban areas alike, the cost could be cut down to 300 billion dollars or so.

Granting, for the moment, that the figure is 300 billion dollars for the Decade, this will be nearly 30 billion dollars per year as against the current level of spending on water supply and sanitation of a mere 6 to 7 billion dollars by the developing countries. This works out to 80 million dollars a day and, at this rate, the call of the Decade on national and international financial resources will indeed be unprecedented. However, this figure need not be that alarming when we know that about 240 million dollars a day are puffed off as cigarettes in the world, about 10 million dollars a day are used for tranquilisers alone and about 1400 million dollars a day are spent on the global arms bill! It is said that if the developed countries alone could divert just ten days a year of their arms spending to the Decade, it will generate all the finance needed for the success of the Decade programme and the world will be a much better place to live in. These are interesting statistics indeed! However, to expect the world to change its strategy and political ideologies and priorities overnight or to expect people to change their habits is only wishful thinking. It is not going to happen. Somehow resources have to be found for this historic task. If the Countries could somehow manouvre to divert substantial funds for the Decade programme in the early years, the beneficial effects of improved health and productivity will in themselves generate revenue to pay off loans, maintain and operate the new systems, subsidise new schemes and boost the national economy itself. In fact, the investments are minimal when compared to the benefits that acrue as a result of the implementation of the programme. The number of water taps per 1000 population is probably a much more meaningful health indicator than the number of hospital beds per 1000 population. Success in achieving the Decade objective would mean several million fewer children dying annually by the year 2000 than what the UN projects now, the approximate equivalent of one Kampuchea each year!

Money is not the only constraint in the implementation of the Decade programme. In fact, materials and manpower are also equally important. How are we going to attain self-sufficiency with regard to these resources? When we look at the present state of affairs, it is really appalling. We have to go a long way. Out of the total estimate for the Decade, the materials component alone constitutes nearly 80%

Even if money is readily forthcoming for the purchase of the materials, the availability of the materials will pose a major problem, particularly when all the states in the country and all the countries in the region and the world are geared to meet the Decade challenge. Unless the production process begins far ahead, materials supply will be interrupted and the pace of demand will far outstrip the pace of supply.

Another aspect of the problem is the manpower requirement for the implementation of the Decade programme. Belonging to the academic community and heading this University, I may briefly elaborate on this aspect. Manpower cannot be created instantaneously. It needs time and infrastructure. The available infrastructure can scarcely be adequate to meet the staggering demand of the Decade. Any effort to generate manpower in this field hereafter is going to yield results probably only after the end of the Decade. So massive and intensive short-term and in-service training programmes are immediately to be taken up besides intensifying and expanding the regular education and training programmes in the field.

In India alone, it has been estimated that about 2,000 post-graduate and 40,000 graduate engineers and an equal number of diploma holders in environmental engineering will be required for the Decade programme. Such estimates are probably available in other countries of the region. Compared to these requirements, what has been done now through the available engineering colleges and polytechnics in the country is merely scratching the surface. The situation in some countries such as India may be better than in some others. However, as a general rule, it may be said that intensive manpower development efforts at post-graduate, graduate and diploma levels in environmental engineering is called for if we are to even hope for a reasonable degree of success.

Currently, in water supply and sanitation departments and boards the professional manpower is essentially provided by the Civil Engineering Graduate who is a generalist for all practical purposes. There is a clear need at the undergraduate level to suitably orientate civil engineering curricula such that more subjects relating to water supply and sanitation are covered and the degree is awarded in environmental engineering. It is necessary to consider at this juncture introducing environmental engineering as a specialised branch at the undergraduate level. The existing institutions offering post-graduate degree courses in environmental engineering are grossly inadequate to provide all the post-graduate engineers who may be needed for the Decade. Expansion of the training opportunities at the post-graduate level to selected institutions in the region is also called for.

The manpower development problem has to be viewed with a sense of urgency and all the facilities in the region could be shared and made full and effective use of. The developed countries and some of the developing countries that are a little better placed in this regard can come to the aid of the other countries of the third world. The present Conference in fact is an outcome of such a thought. A forum for sharing knowledge and experience between the developing countries and, between the developing and the developed countries, is highly useful and will contribute to the successful implementation of the Decade programme. This 8th WEDC International Conference, I am happy to say, provides such a forum. I am quite hopeful that the deliberations of the Conference will enthuse the participants and provide them with the necessary impetus in spreading the Gospel of the Decade programme and in its implementation.

During preparation for the Decade, constraints to the fulfilment of the Decade's objectives must be identified and programmes developed for overcoming them. In the field of water supply, efforts in this direction are well underway due to considerable experience and priority given by the countries. For example, the incidental infrastructure needed to expand services efficiently and quickly and pricing policies have been under development for several years in many countries. Water supply technology appropriate to the region has also been evolving, thanks to the commitment of professional engineers who understand the need. It has been pointed out by the World Bank that achievement of the Decade target for water will depend more on mobilising funding and the training of adequate staff to expand the present programmes than on the need to develop new programmes. However, the picture in respect of sanitation is quite different. Water-borne sewerage, the conventional method of sanitation in developed countries, continues to be thought of <u>first</u> even in developing countries, while considering the technical options available for sanitation. However, the experience in several developing countries would indicate that the large water requirements, very high cost and the need for treatment and management of the collected wastewater at one or more central points, call for a critical examination of this and other technological options available in each region.

In this context the lead provided by International agencies such as World Bank, World Health Organisation and others in identifying appropriate technologies for sanitation in developing countries is most useful. It should enable the national and local agencies to consider the appropriate options in depth and formulate suitable sanitation programmes which can be implemented effectively in their areas.

It is heartening to note that in the approach to the Decade, seven essential elements have been identified. Towards successful implementation of the Decade programmes they should definitely contribute significantly. It is, of course, essential that improvements in community water supply have to be closely co-ordinated with the sanitary disposal of wastes and health education if they are to have significant impact on health conditions. In line with the emphasis provided by the United Nations Water Conference of 1977, the strategies of the Decade Programme should give precedence to segments of the population in greatest need, both rural and urban. The programmes have to serve as models for self reliant, self sustaining action by the community. They must lead to socially relevant systems that the people can afford. Efforts must be directed towards promoting local initiatives and then responding to them. Community participation is vital at all stages of planning, construction, financing, operation and maintenance of systems if the Decade objectives are to be realised. Water supply and sanitation programmes are closely linked to development programmes in other sectors such as primary health care, rural development, water resources development, agriculture, housing development and others. Co-ordination of water supply and sanitation programmes with those in the other sectors is absolutely essential.

It is simply not enough to just appreciate these principles. All concerned must come up with procedures, programmes and means of co-ordination and planning, thus facilitating funding and support of joint projects. The major weakness of inter-sectoral programmes has been identified to be institutional: it is common knowledge that Departments and Ministries responsible for traditional sectors tend to resist change. You should recognise such positions and evolve solutions that will work.

Lastly, I must mention the importance of 'management concepts' in this endeavour. The method of administration of every society has been changing to keep pace with the emerging social, economical and political environment.

In India, our political system is democratic; our professed economic organisation is socialistic. Our administrative set-up however is bureaucratic. We have here certain inherent contradictions. For our growth and development we need not merely more of what we have, but to change those that exist; invent and innovate new technologies. Any change involves additional preparation and new learning; in other words much more work than keeping the routine. Bureaucracy has a strong inclination to maintain the status quo and it is generally hostile to radical and far-reaching changes. It is bound to exert an inhibiting influence on the development of new techniques. In an era, when the economic prosperity is influenced by innovations more than any other factor, we need an administrative system that would promote change, favour experimentation and welcome challenges. Unfortunately, we have not organised our administrative machinery to respond positively to these challenges. The effective employment of the huge scientific and technological manpower developed in this country, would depend upon how radically we reorganise our management. This is not merely a problem for administrators or politicians. It is a problem with which every citizen and more so the Scientists and Technologists, should be concerned.

Creation of resources is important; equally important is their effective utilisation. A management system anachronistic and unequal to the challenges may result in rendering even the most modern and sophisticated tools ineffective. Evidence of realisation of this aspect is seen in the speeches and statements made by those at the helm of affairs; but the realisation has not resulted in any significant reform. It is an area to which all of us should pay attention with objectivity and seriousness.

It is clearly felt in India that a National Commission on Water Supply and Sanitation is an important need. The commission should be entrusted with the task of implementing the Decade programme with the following specific tasks:

1. Critical appraisal and evaluation of water supply and sanitation programmes currently under progress.
2. Critical evaluation and development of design criteria for water supply and sanitation systems.
3. Evaluation of equipment and materials, and technology forecasts.

4. Providing an effective information system on field and technological data through co-operative linkages at local, state and national levels.
5. Assessing manpower needs and developing training programmes at all levels.
6. Supporting and co-ordinating research and development work.

I do realise that my discussion this morning has been rather general; it is because of my feeling that we need to have a mental picture of the macroscopic aspects of the problem so that the planning and implementation at the microscopic level will have more meaning and better direction.

OPENING ADDRESS

JOHN PICKFORD

WEDC Group Leader

SUMMARY

It is a privilege at the start of this 8th WEDC Conference to congratulate the local organizers for the excellent arrangements which have been made here in Madras. So many people have been involved in so many different ways that it is invidious to select any for special mention. However, even though it may be invidious, I must single out Dr. R. PITCHAI, without whose enthusiasm, encouragement and energy over the past eighteen months this Conference would have been impossible.

I often think that engineers and scientists who are involved in water and waste in developing countries are tremendously fortunate. We enjoy our work - at least I do - and at the same time we are able to help other people, to improve health, to improve the environment, to make life more convenient and above all to improve the lot of women and children.

At this time the International Drinking Water Supply and Sanitation Decade is very much in our minds. I imagine that most of you are familiar with many of the statistics. We need to be constantly reminded that the present situation - poor water, inaccessible water, lack of sanitation - results in the death of over twenty thousand children every day. We need to be constantly reminded that without the efforts which are going into overcoming the present situation there would be nearly two thousand million people without proper water, and more than two thousand million people without proper sanitation, by the end of the Decade in 1990.

Statistics show us too that the area with the greatest need is Asia. That is one reason why this Conference, which deals specifically with water and waste engineering in Asia, is tremendously important. It is the rural areas and the poorest people who need most help. Inevitably, these people are least able to help themselves. In the Decade providing safe and accessible drinking water and providing low-cost sanitation to those who lack these facilities has the highest priority. However, just providing new facilities is not enough.

A second task which we must all face is making sure that what is provided can be kept going. In other words, attention must be given to maintenance and operation. In a way these things are more important than design and construction. It may take only a few days to build a twin-pit pour-flush latrine or to dig a shallow well and fit a hand pump. But these things must go on providing a good service day after day. In ten years a family latrine may be used twenty thousand times or more; the handle of a hand pump may go up and down crores of times. I said that in a way maintenance and operation are more important than design and construction but there cannot be separation in this way. The design and the construction must be such that maintenance and operation can be carried on.

A third task is sometimes hidden beneath the statistics. It is to improve the facilities that already exist. In any case the statistics of water supply and sanitation are unreliable. You all know the old adage 'lies, damn lies and statistics'. The returns made by Government departments and the like for those who have satisfactory water supply and sanitation now really only tell us the number of people who are supposed to have this water and sanitation. I know - and I am sure you know too - of people who are supposed to have a piped water supply, but water is only available for a few hours a day. The statistics show these people as being provided with water, but they suffer great hardship and inconvenience. Moreover, whenever supplies are intermittent (and 91% of water supplies in Asia are intermittent) there is always a danger if not a certainty that the water becomes polluted - contaminated with disease - causing micro-organisms. Similarly there are many many places where the statistics show that a population is served with sewers, but the sewers are blocked, the pumps broken down, the treatment works are derelict. And there are places where water pressure is so low that water only dribbles out of taps, and places where there is plenty of water but no proper drainage so that wastewater lies in pools all around the houses, an ideal breeding place for Culex mosquitoes. I could go on, but have said enough to remind you that much of our existing water supply and sanitation systems need improvement, and need it badly.

We are often told that to achieve the objectives of the Decade the technology should be APPROPRIATE. This is a much abused word. 'Appropriate technology' is sometimes called 'intermediate technology'. I have seen reference to 'modest technology'. To some people this kind of thing is second-class (or even third-class). Even the word 'appropriate' is abused. I have always maintained that ALL technology should be appropriate. It should be appropriate for its purpose and appropriate for the conditions under which it exists. So if you have a complex, modern and highly sophisticated chemical engineering plant, it is likely that the appropriate technology for the treatment of its wastewater will also be complex, modern and highly sophisticated.

For poor people barely able to keep themselves alive it would be quite inappropriate to provide expensive waste systems. For rural areas it is appropriate to provide facilities which they can construct and maintain themselves.

At a Conference such as this it is right and proper that some attention should be given to new technology, to recent research and to technological developments which are likely to take place in the near or distant future. However, technology is only a part of the problem. In some ways technological problems are the easiest to deal with. I often think it requires little real ability to design, for example, an activated sludge plant.

What is more difficult, and what is infinitely more important, is the ability to manage and to deal with people. We need to use whatever resources we have to the greatest possible benefit - that is what management is all about. And the resources, the money, the material, the technology, the research - all the other components of water and waste engineering must be used for the best interests of people. People, women and children as well as men, old and young, rich and poor, clever and stupid, rural and urban, all need good water and all produce waste. If the systems we provide are to be appropriate for all these different kinds of people we must understand the people and the way they live, the way they live as communities, the way their lives are influenced by their traditions and their hopes of the future.

Appropriate engineering for water and waste then requires very special skills. We will be dealing with many of these aspects during the two days of this WEDC Conference.

If you are fearful that this calls for too much from mere engineers I would remind you of the origins of the word 'engineer'. It comes from the Latin word 'ingenium' which meant 'cleverness or natural capacity'. From the same root we get the modern English word 'ingenious' which means 'clever at contriving'. We all need to be clever at contriving. There is yet another word from the same root, which should describe engineers - or certainly water and waste engineers - it is the word 'genius'.

So we are the geniuses of this modern world. As geniuses let us see how we can discuss water and waste in these two days - how we can combine technology, management and an understanding of people to the benefit of those people.

8th WEDC Conference: Water and waste-engineering in Asia: MADRAS: 1982

DECADE PROGRAMME IN TAMIL NADU

BY R KRISHNASWAMY AND S A JAGADEESAN

1. PRELUDE

The Tamilnadu Water Supply and Drainage (TWAD) Board is an organisation in Tamilnadu State (INDIA) created by an Act of the State Legislature as an autonomous body on a statutory footing vested with the task of provision of water supply and sewerage facilities in the entire State excepting the Madras Metropolitan area.

Tamilnadu is one of the 22 States in India with a population of 48.30 million as per the provisional 1981 census figures. Of this, 21.30 million live in 740 Urban towns. The rural population of 27.00 million is scattered in about 12600 villages comprising about 47000 habitations in 376 Panchayat Unions.

In the Urban Sector, about 75 percent of the urban population is covered by water supply while only 32 percent is covered by sewerage facilities. In the Rural Sector, about 22 percent of the rural population is covered by water supply while the coverage under rural sanitation is practically nil. Though the global goal is safe water and adequate sanitation for all by 1990, India has consciously fixed the target for the International Drinking Water Supply and Sanitation Decade Programme at 100% coverage in Urban and Rural Water Supply, 80% coverage in Urban Sewerage and 25% coverage in Rural Sanitation.

Based on this, the following financial assessment is projected by the TWAD Board to achieve the objectives of the Decade Programme.

	Rs. in million
(a) Water supply to all the people in the Urban towns.	2950
(b) Sanitation with full sewerage and treatment to benefit 100% of all Class I towns (Population more than 100,000) and low cost sanitation methods to benefit about 50% of the other urban towns making the total urban population to be benefitted as not less than 80%.	1990
(c) Water supply for all the Rural habitations.	4170
(d) Sanitation for 25% of the rural population with economical and safe sanitary toilets for the disposal of human wastes.	350
	9460

1 Sterling = Rs.17.20 (From 2-11-81)

2. URBAN SCHEMES IN TAMILNADU

Water supply schemes in Tamilnadu were initiated about a century ago. The first two water supply schemes in the State were in Madras, the capital city, and in Uthagamandalam, the well known hill station both completed in 1874. Subsequently by 1900, water supply schemes were provided in four more towns and by the time of Independence in 1947 Water Supply was available in 45 towns. Soon after Independence in 1947, a Water Supply and Drainage Committee composed of Legislators and Officials was set up in the State to go into the progress of water supply and sanitary drainage in the State. Since then during the three successive five year plans, work on water supply was carried out based broadly on the priority list drawn up by the Committee giving recognision to the importance of water supply to different towns in the State depending on their proneness to water borne diseases, scarcity of drinking water, population, religious commercial and historical importance etc.

The TWAD Board came into existence on April 14, 1971 and took over the duties and responsibilities of the erstwhile Public Health Engineering and Municipal Works Department of the Tamilnadu Government.

Of the 740 towns in the state, 222 towns have been provided with water supply and works relating to provision of water supply to 70 towns are in progress. Thus 448 towns with a population of 4.88 million (1981) remain to be provided with water supply. Augmentation of water supply in respect of 72 towns is also to be taken up. The total investment on Urban Water Supply Schemes in Tamilnadu excluding Madras city from commencement to date is of the order of Rs. 1218 million.

An unfortunate factor impeding water supply works in Tamilnadu has been the poor water resources position in the State. The average rainfall in the State is only about 100 cm. There are only a few perennial rivers in the State. Also in the case of most rivers, irrigation rights have developed to a very great extent leaving little water to be tapped for Public Water Supply.

Tamilnadu is not rich in ground water sources either. Deep aquifers which can yield potable water in substantial quantities for Urban Water supply have been found only near the coastal belt. Most of the inland areas of the State have hard rock substratum which can yield only limited quantities of water.

The poor water resources of the State have necessitated distant sources for many water works. Inadequate yield has made it necessary for several towns to depend on more than one source of water supply.

The lack of adequate water sources within reasonable distances has also induced an unfortunate tendency in the State to design water supply schemes for low rates of supply in an attempt to keep down costs.

The water supply schemes in operation in the State may be classified on the basis of sources of supply as Surface water from perennial rivers, Impounded water across rivers, in artificial basins or storage reservoirs, Infiltrated surface water from perennial rivers, Subsurface water from seasonal rivers and Ground water from deep or shallow aquifers. The water quality position in the State has been fairly satisfactory.

Regarding sewerage schemes, only 20 out of 740 towns are provided with underground sewerage facilities. It is proposed to take up underground sewerage schemes in the case of class I towns (towns with a population of over 100,000) in the first instance. There are twenty such class I towns in the State. Of these, sewerage schemes have been completed or works are in progress in respect of 8 class I towns. Hence provision of underground sewerage facilities in respect of the remaining twelve class I towns is contemplated during this Decade. Regarding the remaining towns, low cost sanitation facilities are proposed. The report of the studies conducted by UNDP on its Global Project is expected shortly. The technical aspect of the low cost sanitation will be mainly based on the result of studies of the Global Project Team.

3. RURAL SCHEMES IN TAMILNADU

The rural habitations in the State of Tamilnadu are categorised under six types depending upon the nature of source available as tabulated below:

Classification.	Definition	No. of habitations.	Population (1981) in million
Type-1	Habitations with no source within the habitations.	3454	0.98
Type-2	Habitations where the source yield only non-potable water.	1966	1.02
Type-3	Habitations where water is potable but source is not perennial.	6487	2.28
Type-4	Habitations where water is potable and perennial but the source is either privately owned or unprotected.	4955	2.17
Type-5	Habitations where there is no good source within the habitations but an alternative good source is available within 1 km.	1107	0.36
Type-6	Habitations where there is good source available.	29106	20.06
	Total.	47075	26.87

Water supply to all the habitations under types 1 and 2 is almost completed. Works on the remaining types of habitations are taken up in stages with due preference to the priority on the need of water. The Government of Tamilnadu has evolved the self sufficiency programme by which it is proposed to provide water supply to all the habitations within the sixth Five Year Plan period itself.

Regarding Rural Sanitation, it is to be stated that at present there is no co-ordinated Rural Sanitation programme in Tamilnadu. Hence setting up of an agency solely responsible for tackling the problems in this sector has to be the main objective. Planning, programming and implementation of the facility will have to be geared up during the Decade so as to achiee the target fixed for the coverage.

4. DECADE TARGET AND THE TWAD BOARD PLAN

A. Financial

In the words of Mr.James P.Grant, Executive Director of the UNICEF, the goal of the Decade is a reasonable and dischargeable commitment. It is an affordable and a practical commitment. It is an imperative humanitarian and developmental commitment.

If we look into the history of this sector during the last 8 decades, the progress made in 1971-1980 in this sector is many times more than what was done during the previous 7 decades. Till 1970, only 133 towns were provided with the facilities whereas during the decade 1971 to 1980 the facilities were extended to 89 towns.

Therefore, it will not be a surprise if we could provide safe drinking water to all the people by the end of the decade provided, the political will and the community participation are encouraging. The capital investment for this sector in Tamilnadu, during the last 5 years (1975-76 to 1979-80) was Rs. 92 crores. The revised 6th Five Year Plan now finalised has provided Rs.180.75 crores. In order to implement the programme successfully, the tempo of investment in this sector will have to be increased further. It is hoped with confidence that the aid from Bilateral and International Agencies may fill the gap, if any, to achieve the target with the available resources in 6th and 7th Five Year Plans and the first year of the 8th Plan. Tamilnadu has approached the World Bank for loan assistance for executing Water Supply Schemes in medium sized towns and also improvements to the existing schemes in major towns and low cost sanitation facilities for small towns.

B. Material

A major portion of the cost of Water supply and Sewerage Schemes will be represented by materials such as pipes, specials, valves, pumps, jointing materials etc. The experience in the State is that more than 70 percent of the cost of any such scheme is accounted for by materials used therein.

Among materials, the most important are pipes like Cast Iron, Asbestos Cement, Prestressed Concrete, Reinforced Cement concrete, Poly Vinyl Chloride etc. Stoneware pipes will be required in sewerage schemes. The procuring of these materials itself is a challenging task under present conditions and in the quantities involved. To achieve some stability in prices, long term contracts or arrangements may be necessary. The Central Purchase and Stores Organisation (CPSO) now in existence in TWAD Board will be able to meet this challenge. The State and Central Government may endeavour to set up factories to meet the demand. Also action may be taken to increase the production capacities of the existing factories and productivity of the labour force. The Government should also come forward to help in procuring the pipes either within the country or by importing.

The availability of essential materials like Cement and Steel is a pre-requisite. The State Government and Central Government should give priority in allocating these materials required for the Urban and Rural Water Supply Programme.

C. Man Power

The Personnel available at present may be sufficient for the top and middle level to manage the programme for 1981-90. But the lack of trained personnel in the lower cadre is a constraint that has to be overcome. For this, the inputs to Technical Institutions have to be increased and junior level personnel should be given necessary training in technical and accounting during their recruitment.

To maintain or improve project performance, information should be obtained from regular monitoring of the project performance as a routine activity of the project management system. Insights from both monitoring and evaluation can assist in the preparation of detailed project reports and their appraisal. Monitoring and evaluation of project performance should receive high priority in order to have effective and real appraisal of the project.

A massive training programme for all levels of personnel should be undertaken for the successful implementation of the Decade Programme.

5. CONCLUSION

India is the first among the developing nations which has made an impressive beginning to tackle the problem immediately after the resolution by the United Nations. A rapid assessment of the situation was undertaken by the World Health Organisation with the help of Government of India for a clear picture to emerge in respect of the problems. The sector study in the field of Water Supply and Sanitation was also carried out by the State of Tamilnadu.

A Global effort to bring safe water and sanitation to all people in developing countries within the next 10 years was launched by the U.N. General Assembly on 10th November 1980 when it adopted unanimously a resolution to that effect. The resolution proclaimed 1981-1990 as 'The International Drinking Water Supply and Sanitation Decade' and called upon member states to commit themselves to improve substantially the standards of drinking water supply and sanitation by 1990 to rid the World of water borne diseases that claim millions of lives. It also called upon them to develop policies, set national targets, accord high priorities for water and sanitation projects and strengthen the institutional framework for carrying out the programme. The United Nations agencies, the United Nations Children's Fund, the World Health Organisation and the United Nation Development Programme affirmed they would co-operate in making the Decade purposeful.

The Minister for Works and Housing and Parliamentary affairs, Government of India, has pledged the country's full support to the aims of the Inter-National Decade 1981-90 for Drinking Water Supply and Sanitation launched by the United Nations on 10th November 1980. The Minister for Health, Government of Tamilnadu launched the Decade Programme on 24th June 1981 and affirmed Tamilnadu's faith in fulfilment of the goal.

The general goal of the decade is to greatly improve the water and sanitation service enjoyed by the population of the developing countries. The particular goal (ratified at the United Nations World Water Conference at Mar del Plata in 1977) is to provide all the World's population with adequate access to safe water and to hygienic latrines by 1990. The Indian goal will be to provide adequate access to reasonably safe water to all the population and easy access to sanitary toilets to sizeable portion of its population.

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RESEARCH AND DEVELOPMENT NEEDS RELEVANT TO THE DRINKING WATER SUPPLY AND SANITATION DECADE 1981-1990

by R PITCHAI and R GURUSWAMY

One of the major objectives of International Water Supply and Sanitation Decade programme is to provide access for protected water supply and sanitation to all, both rural and urban, in tune with the Mar-del-Plata conference theme. In this connection, a few significant Research and Development needs are identified, the fulfilling of which will further the objectives of the Decade programme.

Water Supply and Treatment

Planning factors in water treatment and supply

1. Basic assumptions on per capita rate of water supply to be provided, the minimum pressures to be maintained at the various draw off nodes of the distribution system, the time horizon into the future for which various components of the scheme are to be sized, and others, should be subject to vigorous economic and engineering analysis so that more rational design criteria could be drawn. A team of engineers and ecomists working together could try to construct appropriate demand functions which could provide a basis for rational decision on the per capita water supply.

2. The concept of minimum needs (particularly with regard to rural areas) should also undergo examination.

3. Application of techniques of cost effectiveness, and studying the utility of the scheme vis-a-vis investments made can be of great benefit.

A study of schemes recently completed as well as those with an established record of service may prove valuable in this context.

Sources

1. There is a need to achieve cost reduction in ground water collection systems, particularly for use in rural areas.

2. The techniques of construction need to be simplified to enable participation by local labour.

3. Cost effectiveness of alternative materials should be investigated for the piping.

4. Developing improved methods for geophysical exploration for ground water which, at present, is extremely cumbersome and costly, is necessary.

5. Reduction of evaporation and seepage losses at the source and during conveyance is necessary to conserve water, particularly in areas prone to water shortage.

6. Know-how must be developed and continuously updated for the manufacture of simple equipment like hand pumps and motors locally.

7. Training facilities must be created for developing the necessary skilled manpower to construct and maintain the ground water collection systems.

Treatment

1. A review of the drinking water quality standards prescribed at present is essential to resolve inconsistencies, if any.

2. It is necessary to take up regional or area-wise classification of raw water quality from surface and ground water sources. This will facilitate quick decisions on treatment and preparation of cost estimates and also help to identify 'problem regions' which need special solutions and alternatives.

3. Simple and more effective methods of dosage of chemicals at a desired rate for coagulation purposes should be developed.

4. Controlled desludging and backwashing operation that will help to improve the performance of the treatment units and avoid wastage of water are necessary.

5. Recycling of backwash water and recovery of alum for reuse in the treatment plant should be attempted.

6. As far as possible, surface water treatment, where required in rural areas, may be by slow sand filters and the design of the filters should be improved.

7. Low cost technology for removing iron and manganese, total dissolved solids, fluorides, hardness and brackishness is to be evaluated and/ or developed.

8. Transfer of such a technology to the field for a wider implementation needs to be intensified.

9. Cost effective desalination techniques using natural, renewable sources of energy such as solar energy need to be investigated and appropriate design criteria developed and distributed widely.

10. Development of a reliable and sturdy chlorinator that will be simple and safe to use is urgently called for; this necessity is more pronounced in rural areas.

11. Development of simple, rugged laboratory instruments for instant testing of the water quality will be useful.

Transmission and Distribution

1. Factual data on demand pattern and its variation seasonally and hourly is needed. It can be obtained by conducting surveys of the diurnal and seasonal water demand patterns in representative cities and towns of various sizes.

2. Ways and means of improving the existing distribution pattern to ensure equitable distribution of flow, maintenance of adequate pressures, avoidance of leakages etc will help to realise the objectives of a protected water supply system. Identification of sources of wastage and pollution (both preventable and avoidable) is necessary.

3. Development of criteria for sizing distribution zones and arriving at rational decisions regarding capacity and heights of reservoirs will enhance effective performance of the distribution system. Water transmission and distribution arrangements in the rural areas also need a careful review.

4. Training of personnel and development of techniques to manage and carry out preventive maintenance of distribution system (waste detection and control, maintenance of capacity of the distribution system and cleaning of the interior of pipes, etc) are necessary.

5. Appropriate cost reduction measures such as the use of cheaper but sturdier and safer materials, joints that are cheaper and easy to make, etc., need to be tried out and the experience documented.

6. Simplified instrumentation and techniques are needed for the alignment of pipes, detection of leaks, flow and pressure measurements and cleaning of pipe lines.

7. Water quality survey of individual house sumps and overhead tanks in representative communities will help to provide a clearer picture of the quality maintaining efficacy of water treatment plants, distribution systems and house service arrangements and it may then be possible to pinpoint the deficiencies and the defects in the existing system and take suitable remedial or corrective measures.

Wastewater Collection, Treatment and Disposal

Wastewater collection

1. Emphasis should be laid on community sanitation measures wherever appropriate. Wastewater collection and disposal assumes high priority in this context for urban fringer areas and larger towns.

2. The total problem of wastewater management as existing at present in developing countries needs a thorough review. The technology, economy and policies concerning existing systems should be subjected to careful examination in the light of the energy-environmental crisis and appropriate systems evolved.

3. Development of rational design criteria for sewer design in medium and large communities taking into account the actual sewage flow patterns and the actual sewage characteristics is a long-felt need.

A study on the diurnal variation of sewage flow in communities of different sizes has to be conducted based on which the design flow estimation could be rationalised.

4. The choice of system of sewers itself needs to take into account the design of houses, particularly in the old areas of cities and in old towns.

5. Data on the grit content in wastewater also needs to be collected in representative locations to rationalise the design of wastewater collection, treatment and disposal systems.

6. There is a need to develop devices and methods that could ensure maintenance of free, unhindered flow in sewers under Indian conditions (i.e. where large quantities of dung and other solid wastes are dumped into the sewers).

7. The development of a cost-effective, simple and safe wastewater collection system for rural areas should be given utmost priority.

Wastewater Treatment

1. Development of appropriate design criteria for conventional and low-cost, simple wastewater treatment systems under Indian conditions should be intensified.

2. In particular, low-cost waste treatment systems that will use local materials and labour and renewable sources of energy have to be developed and their design, construction and operation rationalised.

3. Identification and documentation of operation and maintenance problems in working the existing treatment plants should be done with a view to provide guidelines for overcoming them.

4. There is a great need for documentation of the feasibility of wastewater reuse for such purposes as aquaculture, agriculture, industrial use and for flushing and other non-potable purposes.

5. There is a need to investigate the feasibility of physical-chemical treatment methods for advanced waste water treatment in metropolitan wastewater treatment plants.

6. In view of high cost of energy, alternative sources of energy, readily available and renewable, should be investigated and employed in wastewater treatment.

7. The use of wind energy for aeration in simple waste treatment systems, the use of biogas from an organic waste digestion plant or a wastewater treatment plant as fuel and the use of digested sludge as manure for land, hold promise and measures to tap these sources of energy to the maximum extent possible should be deviced.

Wastewater Disposal

1. The development of comprehensive criteria for disposal of wastewater into water courses or on to land taking into account beneficial uses, flow regulations, weather and local conditions is warranted.

2. There is a need to selectively use modern technical tools such as systems analysis and water quality modelling for realising water quality objectives economically.

3. The several factors that inhibit or promote eutrophication in the various regions in the country need to be carefully studied.

4. Cost effectiveness of alternative control measures such as limits on nutrients to be discharged, treatment of water before use, algal control in water courses including their recovery and a combination of these, needs to be worked out.

5. Because algae have a good food value, the feasibility of alternative methods of algal harvesting needs to be evaluated under local conditions.

6. While attempting to introduce cheaper non-water carriage systems for excreta disposal as alternatives to the present water carriage system (which is generally costly), substantial research and development effort concentrating on the public health, techno-economic and socio-cultural implications of the proposed alternatives is called for before the alternatives are shown to be feasible.

Solid Wastes Collection, Treatment and Disposal

1. Investigation of existing collection methods and development of cost-effective methods of refuse collection in rural and urban areas are needed urgently.

2. The economics of larger and better storage versus greater collection frequency needs to be analysed in some of the large and medium urban complexes and semi-urban areas.

3. The study of actual operation of land fill sites and compost plants to document operational and maintenance problems will facilitate developing proper disposal techniques to suit the local conditions and to structure a management system for solid wastes taking into account local factors such as the income levels, food habits, the tradition and culture of the people, the political and the administrative framework within which to operate, the cost involved, the suitability of the different methods of disposal and others.

General Sanitation

1. Collection of information on the existing pit privies and improving their design for adoption on a large scale in rural areas will help improve rural sanitation to a great extent.

2. Development of a viable technological alternative between a privy and a sewer system which will be acceptable from the public health point of view is an urgent need.

3. Steps should be taken to evolve designs of flushing tanks, bath tubs and wash basins (to suit local conditions) requiring minimum use of water.

4. A comprehensive study on the mechanism of travel of pollution to provide a better insight into the location of points of waste collection and disposal with respect to ground water and other drinking water sources, is necessary.

5. The design of the Intermediate treatment systems such as the pit and borehole latrines and septic tanks with soak pits should be standardised for size, materials and methods of construction giving due regard to soil and climatic conditions, presence of ground water table, etc.

6. Development of package plants for treating domestic sewage for isolated or small communities and for industrial waste treatment needs to be taken up urgently.

7. Similar package plants should be developed for water treatment, particularly for rural areas where special treatment is involved. (eg. iron removal, defluoridation, etc.)

Training Needs

1. Assessment of manpower needs and developing training programmes at all levels to generate the required manpower is an immediate necessity if the decade programme is to register any appreciable measure of success.

This catalogue of Research and Development needs in the field of water supply and sanitation is by no means exhaustive or comprehensive. The several points raised in our opinion, deserve high priority in selecting Research and Development projects during the International Decade for drinking water supply and sanitation. There are many other needs in this vast field which cannot be fully described in a paper such as this. The attempt made in this paper has been to highlight and focus on the more important basic issues. Even a 50% success rate in initiating and funding projects designed to fulfil the needs would be a significant achievement indeed.

8th WEDC Conference: Water and waste-engineering in Asia: MADRAS: 1982

AFRICAN PUBLIC HEALTH ENGINEERING DURING THE DECADE

BY K O IWUGO

1. THE DECADE PROBLEM

In 1976 the World Health Organization reported (1,2,3) that 62% of developing countries, some 1250 million people in all (excluding China) did not have reasonable access to safe water supply while a greater percentage 68% had very inadequate facilities for the sanitary disposal of human excreta. The current situation in the Africa region has been reviewed elsewhere (4,5) and it is currently estimated that about 84% of the total African population, some 280 million people, does not have access to safe water supply while 91% has very inadequate facilities for excreta disposal. Over 80% of the African population lives in the rural areas and well over 90% of the rural population does not have access to safe water supply and any form of excreta disposal facilities.

This gloomy situation in the developing countries prompted the United Nations Conference on Human Settlements (HABITAT), (6) in 1976 and the United Nations Water Conference (7) in 1977 to recommend that the decade 1981-1990 be designated *THE INTERNATIONAL DRINKING WATER SUPPLY AND SANITATION DECADE (IDWSSD)*. Briefly state, the objective of the Decade is to provide about two billion (2×10^9) people with *basic water supply* and *excreta disposal facilities* at an estimated cost of about three hundred billion (3×10^{11}) U.S. dollars in the decade 1981-1990(8). Considering this level of investment and the per capita cost estimates (4,5,8) for the various water supply and sanitation facilities, it is apparent that a substantial mix of both standard wester (10) and low-cost (11) water supply and sanitation technologies is essential even in the urban areas for the accomplishment of the objective of the Decade. In fact, the low-cost technologies would have to predominate if any substantial level of coverage (above 60%) is to be provided in Africa.

Apart from financial constraint, the next major constraint to be overcome for the successful implementation of the Decade is the provision of the *appropriate type* of technical manpower needed for the planning, designing, implementation, operation and operation of water supply and sanitation facilities. This paper reviews the existing manpower availability, current academic training programmes; and then proposes potential training programmes for the various cadres of manpower in the water and sanitation sector in Africa.

2. MANPOWER AVAILABILITY AND EXISTING TRAINING PROGRAMMES

The lack of trained manpower has been highlighted (7) as one of the major constraints to the effective and efficient development of the water and sanitation sector in the developing countries. Unfortunately, little or no quantitative information exists to be able to define the problem adequately, particularly in Africa (12,13,14). The seriousness of the situation is perhaps best illustrated by comparing the targets for the first United Nations Development Decade (1960-1970) with the situation as at 31st December, 1971 as presented in Table 1(15). The targets of the first decade have now been carried over to the 1970-1980 decade. The achievements over this period will be of considerable interest.

Table 1

Comparison of targets for the first United Nations Development Decade with the situation as at 31st December 1971 in Africa (15)

Objectives of 1st Development Decade (1960-1970) carried into the Second (1970-1980)	Situation as at December 1971
1 Physician for 10,000 pop	1 phys. for 17,500 pop.
1 Nurse for 5,000 "	1 Nurse for 6,000 "
1 Midwife for 5,000 "	1 Midwife for 17,000 "
1 Lab. Tech. for 5,000 "	1 Lab. Tech. for 62,000 pop.
1 Health Insp. for 15,000 "	1 Health Insp. for 37,000 pop.
1 San. Eng. for 250,000 "	1 San. Eng. for 2,370,000 "
1 Health Aux. for 1,000 "	1 Health Aux. for 3,250,000 pop

The cadres of manpower that have the principal role to play in the water and sanitation sector during the Decade are:

(i) the environmental (public health/ sanitary) engineers and scientists,

(ii) the professional sanitarians (health superintendents/inspectors) and water technicians; and

(iii) the health assistants (community aides) and water artisans (borehole and pump maintenance mechanics).

2.1 Environmental Engineers and Scientists

The cadre of manpower termed environmental engineers and scientists in this paper are those graduate engineers and scientists who are actively engaged in water supply and wastes disposal technology in the governmental agencies, parastatal organizations and the private sectors of the economy. The functions of such persons may involve the planning, designing, construction, operation and maintenance of water supply and wastes disposal schemes.

Available data ([5,12,15,16,17]) suggest that there is acute shortage of this cadre of manpower. This shortage may persist during the present decade because graduating engineers and scientists show very little desire to either specialize in environmental engineering or take up appointment in the water and sanitation sector. The attitude of the graduating engineer and scientist to a career in the water supply and wastes disposal industry partially attributable to the undergraduate curricula in the established or traditional science and engineering disciplines. For instance, civil engineering departments emphasize the teaching of environmental engineering/science much more than any other science and engineering departments. However, environmental engineering/science is generally allocated much less time than the other civil engineering subjects. The relatively short period of exposure to the fundamentals of environmental engineering is usually insufficient to motivate the undergraduate to a postgraduate specialization in environmental engineering or to a career in the water supply and wastes disposal industry.

Current environmental engineering syllabi ([5,12]) of undergraduate courses in civil engineering are of traditional nature in that they emphasize publi water supply and sewerage and there are mentions of refuse disposal and air pollution. They also contain substantial amounts of materials on low-cost or "appropriate" water supply and sanitation technologies.

The syllabi would appear to be suitable for introducing prospective African civil engineers to public health engineering. However, some of the objectives of the syllabi are rarely achieved mainly because of the constraints imposed by the non-availability of suitably experienced academic teaching staff. In many Universities, departmental budget estimates rarely provide for more than one specialist public health engineering lecturer in a civil engineering department. Furthermore, most public health engineering lecturers have been trained in the industrialized countries and most regrettably have had little or no field experience in planning and executing water and sanitation projects in developing countries.

Two African Universities namely: The Ahmadu Bello University, Nigeria and University of Nairobi, Kenya run postgraduate courses lasting over 12-24 months and leading to higher degrees/diploma in public health engineering ([12]). This is a recent development and the first group of graduates from these courses are yet to justify the usefulness of their training.

The detailed syllabi of these postgraduate courses have been presented elsewhere ([12]). In general these postgraduate courses are of traditional nature emphasizing public water supply and sewerage, with related courses in sanitary chemistry, sanitary microbiology, epidemiology, hydrology and statistics. Low-cost water supply and waste disposal technologies, health education, rural sociology and anthropology which are all very important for the successful implementation of the Decade programmes are either barely or not covered at all in both syllabi. Like the existing undergraduate programmes, the syllabi emphasize the design aspects of public health engineering systems in preference to the operational and maintenance aspects.

2.2 Professional Sanitarians and Water Technicians

The cadre of manpower termed professional sanitarians and water technicians are respectively public health inspectors/superintendents who hold the Royal Society of Health (RSH) diploma or its equivalent and diploma holders in engineering and applied science who are engaged in water supply or waste disposal work in governmental agencies or associated organisations. In general their functions may involve assisting professional public health engineers in the design, construction, operation and maintenance of water and sanitary installations and also the general supervision of other operational staff.

There is a serious shortage of this cadre of manpower ([5,13,14,18]). Added to the problem of shortage is the fact that the sanitarian sees his functions as being confined to epidemiology, malarial control, health education and general sanitation *inspection*. His employer is invariably a health department or ministry which normally does not consider the planning, designing, construction, operation and maintenance of water supply and wastes disposal facilities as its function. The ministries of works, housing, public utilities or water resources are more likely to have responsibility for the planning, installation and maintenance of water supply and wastes disposal facilities. These ministries employ the engineering/science diploma holder and subsequently "convert" him to a water engineering technician by on-the-job training.

The major training route for the public health sanitarians is via the Royal Society of Health (RSH) diploma and certificate ([18,19]). The post-secondary school three years course leading to the RSH diploma not only provides a very broad training in environmental health but also has a high content of public health engineering topics ([2,3,11,20,21,22]) which are very relevant to the successful implementation of the Decade. It is of interest that apart from subject matters which deal directly with water supply and sanitation technologies, other topics such as health education, rural and community organisation, public health administration, plumbing and management of sanitation programmes which are all very important for the successful implementation of the Decade programmes are also covered in the RSH diploma courses. These apparently ancilliary but very important subjects are not covered in any of the existing public health engineering syllabi of civil engineering undergraduate curricula of any African university.

There are very few post-secondary school diploma courses in environmental engineering/ water resources in Africa ([5,13,14]) and these emphasize hydrology and irrigation engineering and *not* water supply and waste disposal engineering technology. For most water technicians, water supply and wastes disposal technology have been taught as a component of major engineering or technology courses such as environmental services, town planning, building services, civil engineering, water resources, analytical and environmental chemistry, food technology and plumbing technology in the local technical colleges and polytechnics. The academic training programmes for prospective water technicians (water supply and sewerage scheme operators) are either non-existent or are grossly inadequate for the needs of the Decade.

2.3 Health Assistants (Aides) and Water Artisans

The health assistant or sanitary overseer is a junior sanitarian who generally works under the direction of a public health inspector/ superintendent. He has had about 3 or 4 years of secondary school education before receiving an additional training of about 2 years in a School of Hygiene. He is usually attached to a ministry of health or a local authority where his work may involve the construction of wells, latrines, operation and maintenance of rural water supply and sanitation facilities, pest and malaria control and the promotion of health education particularly in the rural communities.

The water arisan works under the direction of the water technician or operator. In general, he would have had some primary school education before undertaking local apprenticeship in plumbing, electrical or mechanical plant maintenance and repairing. Unlike his health assistant counterpart, he has had no form of training in environmental health. His duties involve general maintenance and repairs of water supply and waste disposal installations and in the rural areas these may also include the operation and maintenance of the installations.

This cadre of manpower whose role is very crucial for the successful implementation of the Decade would appear to be in short supply particularly in some of the West African countries. They are perhaps more available in some of the East and Central African countries where the basic institutional infrastructure helps in highlighting the importance of the role which they can play in the water and sanitation sector.

The number of trained personnel in this cadre of manpower is difficult to estimate since their training is not formalised in many cases; and secondly there is a continuous turn over as career advancement and prospects for this cadre would appear to be relatively slow. In any event, it is unlikely that the required 333,000 personnel required in Africa in this cadre has been attained.

3. RECOMMENDATIONS AND CONCLUDING REMARKS

The appropriate educational and training needs of the technical manpower in the water and sanitation sectors are not being provided in African universities, polytechnics and technical colleges. This situation is likely to persist in the foreseeable future mainly because environmental engineering, in any of its ramifications, is not yet offered as a separate undergraduate degree or diploma programme in many higher institutions of learning (23,24,25). Secondly, the "polyvalent" character of the environmental technology "discipline" is such that it cannot be adequately accommodated in a conventional university/college department at the present stage of the development of higher technical institutions in African countries. Thirdly, the high *practical* orientation required of all cadres of technical manpower in the water and sanitation sector, particularly during the Decade, is such it may be more beneficial for the graduate scientist/engineer to graduate after fulfilling the practical requirements of the technicians' undergraduate course than for him to follow a purely academic training as currently envisaged in some institutions (5). In other words, a very flexible approach (5) both in the intake and training of graduate scientist and engineer (managerial personnel) and the technician/sanitarian (operational personnel) is greatly needed. This flexible approach may be unacceptable in conventional African university faculties.

The Decade technical manpower educational and training needs are likely to be best catered for within Environmental Technology Training and Research Institutes. Such institutes which should be national or regional centres can be either constituent colleges of universities or they can be autonomous institutes with statutory powers to award degrees, diplomas and certificates in environmental science and technology.

An Environmental Technology Training and Research Institute can satisfy other needs:

(i) Organise and run trade and craft courses which are orientated to the water and waste industries;

(ii) Organise and run postgraduate courses in environmental health technology;

(iii) Organise and run short refresher courses for subprofessionals and senior professionals in the water supply and waste disposal industries;

(iv) Undertake *applied* research in appropriate water and sanitation technology; and

(v) Serve as a focal point for research and training matters in the water and sanitation sector.

Potential training routes for the various cadres of manpower which can be implemented within the proposed Training and Research Institutes are summarized in Figure 1.

It is to be recognised that many African countries do not as yet have institutions or centres that serve as focal points on environmental technology matters. The establishment of this type of centres in India (National Environmental Engineering Research Institute, Nagpur), Pakistan (Institute of Engineering and Public Health Research, Lahore), Thailand (Asia Institute of Technology, Bangkok) and Brazil (School of Hygiene and Public Health, Sao Paulo) seem to have curtailed the fragmentation of scarce resources available for tackling environmental health engineering training and research problems in these countries. The World Health Organization (WHO), with its successful record in this sphere of activity in these countries, should extend its endeavours in Africa by initiating and encouraging the establishment of the forementioned Training and Research Institutes.

Another area deserving international assistance in the development of public health engineering education is the *formulation of guidelines for appropriate course syllabi.* By and large, public health engineering problems in the developing countries are of very similar nature with the differences being in the degrees (13,14). Because there are currently very few institutions that offer public health engineering as part of their curricula and also because of the severe shortage of funds, it has been very difficult to establish national or regional forums where public health engineering teachers can exchange ideas on curriculum development. The WHO Regional office for Africa (AFRO) has in the past organised and sponsored meetings for teachers of environmental health in Africa (12). This type of meetings should be encouraged during the Decade and in addition a Standing Committee on public health engineering education should be set up. This committee should have as its major terms of reference the formulation and revision of guidelines for the training of various cadres of manpower in the water and sanitation sector. National governments should also encourage the establishment of training committees (consisting of academics and practitioners in the water and sanitation sector) to formulate course syllabi based on the proposed WHO guidelines and tailored more appropriately to their national needs.

Finally, national, bilateral and multilateral donor agencies should involve African public health engineering teachers in the planning and execution of their projects during the Decade. Most public health engineering teachers have received their specialist training in the industrialised countries and there is a very urgent need to increase the perception of the different nature of African public health engineering problems by adequate exposure to field projects. These field projects or fact-finding missions can be undertaken by many university staff during the long summer vacations. Ironically, the "experts" that are currently being hired from the other WHO regions to undertake these missions in Africa are neither older nor more academically qualified than their African counterparts. They may, however, have been offered more opportunity for field experience by the WHO regional office for their home country or other international agencies involved with the development of the water and sanitation sector. In "training" the highly qualified but "not-too-experienced" African public health engineering teacher. It is important to bear in mind the often quoted (or "misquoted") Chinese aphorism which says:

If I hear it I forget
If I see it I remember
If I do it I know.

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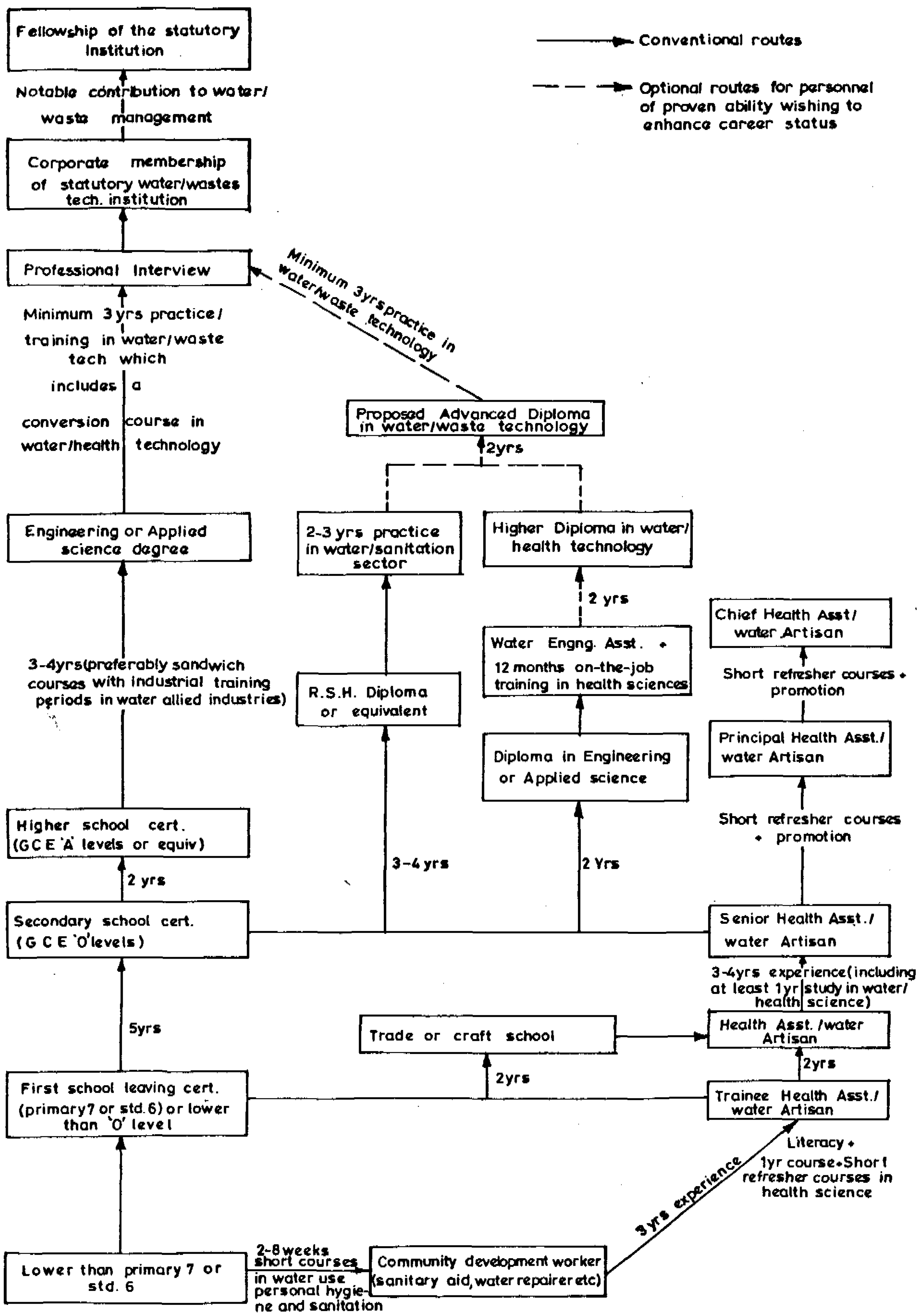

FIG. 1 PROPOSED TRAINING ROUTES FOR CADRES OF MANPOWER IN THE WATER/SANITATION SECTOR IN THE AFRICAN REGION

8th WEDC Conference: Water and waste-engineering in Asia: MADRAS: 1982

RESEARCH AND DEVELOPMENT DEMONSTRATION NEEDS IN WATER AND WASTE ENGINEERING IN ASIA

by T VIRARAGHAVAN and T DAMODARA RAO

Introduction

As of 1975, 128 million (69%) out of the total 185 million urban population of the South East Asia Region (SEAR) countries (Bangladesh, Burma, India, Indonesia, Nepal, Sri Lanka and Thailand) enjoyed water Supply, 40% through house connections and 21% through public standposts. Only 26% (48.2 million) were connected to a sewer system, 47.8 million (26%) were served by pit privies and septic tank, and 26% by the bucket privy system (ref. 1). Only 145.1 million (19%) of the total 1975 rural population of 750 million in this region had reasonable access to safe water. Rural sanitation in general and excreta disposal in particular were receiving but marginal attention in Bangladesh, India, Indonesia and Nepal, but the 1980 target had been exceeded in the case of Burma, Sri Lanka and Thailand. The coverage for adequate excreta disposal in rural areas of SEAR countries in 1975 was only 6% (ref. 1). The colossal needs in funds, manpower and material on the SEAR countries for their current and future programmes in community water supply and sanitation are quite apparent. Severe limitations in their current resources make it imperative that alternative and simple economical and low energy technologies be given serious consideration for adoption. Research and development by each country supplemented by inter-country research on a regional basis is of paramount importance in this context (ref. 1).

This paper examines the trends in sanitary engineering research and development in Asia during the last decade with particular reference to SEAR countries which include India. Research philosophy, research management, coordination and technology transfer are analyzed with special reference to India.

RESEARCH PHILOSOPHY

Ideally there must be a balance between pure and applied research. Pure or fundamental research is time consuming, not always goal-orientated and often very costly requiring sophisticated instrumentation.

In the areas of water and waste engineering the developing countries of Asia and elsewhere pure research is of little practical or immediate value and it is quite evident that the majority of research and development needs should be orientated towards applied research - research applicable to national needs. Such research should take into account the appropriateness of the technology or the technology level feasible in the implementation of the final project; such a research and development effort of course does not rule out any sophisticated technique or instrumentation to evaluate the feasibility of a process for possible adoption in a developing country. Examples of this in water and waste engineering field include the use of isotopes as tracers in sedimentation, groundwater pollution and dispersion studies, satellite imagery and remote sensing techniques as well as advanced geophysical techniques in groundwater investigations, and sophisticated instrumentation in the estimation of organics and other elements in water, leachates and in air in trace concentrations. The General research philosophy applicable to a developing country in this area does not preclude any well established university department undertaking work of a fundamental nature within its known limits of expertise, instrumentation, and funds. The emphases for national and state research centres would definitely be applied research of immediate practical value. In this connection, the keynote address delivered in Kanpur by Prof. Nurul Hasan, Vice-President of Council of Scientific and Industrial Research (CSIR) of India at the National Seminar on the development of science and technology is of interest. He is reported to have said that India must go in for advanced science and develop sophisticated technology to eradicate poverty, achieve self-reliance and ensure national security. He mentioned "We cannot any longer remain satisfied with intermediate or appropriate technology" and added that the word 'appropriate' should not be a euphemism for inferior science or technology (ref. 2). Appropriate technology, or research orientated towards it, need not to be low-level or inferior technology.

The range of options for the development of appropriate technology is large and some of the options are: adapting or improving existing indigenous technology; adapting evolving modern technology; reviving old technology; developing new technology and transferring technology within or among developing regions and countries. Research to investigation, and any development needed to evaluate and adopt modular incineration concept with energy recovery for municipal solid waste disposal in a large Indian city with no landfill sites in our economical reach would be a case of adapting evolving modern technology. Research and development related to slow sand filtration of water would be a case of improving existing technology, possibly reviving an old technology as well. Research into the use of large scale composting for municipal solid wastes would be a case of improving existing indigenous technology.

RESEARCH OBJECTIVES AND PRIORITIES

Sundaresan outlines the following research and development objectives for environmental engineering in India (ref.3).

1. Determination of technical and economic feasibility of various options which are available for water supply and waste disposal.

2. Evaluation of economic and environmental system effects of technologies which provide for conservation of water, reclamation and re-use of wastewater.

3. Development of energy saving devices.

4. Technological innovations at intermediate technology levels to improve efficiency and enhance appropriateness.

Sundaresan has also presented an evaluation criteria based on benefits accruing from Research and Development project (ref.3). Guidelines for applied research, the organization of research and development, research priorities, project selection criteria, implementation and evaluation are outlined in a thought-provoking paper by Hindle and Berthouex (ref.4).

As a first step, research trends should be analysed and research priorities should be arrived at by a consensus process. This needs to be done in each developing country to establish a research agenda for its scarce scientific and engineering manpower. Sundaresan et al have presented information on research projects in progress between May 1977 and May 1978 and those which were continued beyond May 1978 in the field of environmental engineering and science in India (ref.5).

The breakdown of the projects totalling 462 into various subject areas is presented below.

Water - 169; Wastewater - 98; Solid Waste - 30; Air Pollution - 68; Noise Pollution - 7; Pesticidal Pollution - 20; Radioactive Material Pollution - 1; Industrial Hygiene - 7; Rural Sanitation - 8; Environmental Sanitation (general) - 10; Allied Subjects - 44.

This categorization indicates very clearly that the rural sanitation is a neglected field of research contrary to what one would expect. The development of research priorities should take into account this imbalance. No attempt has been made in this paper to discuss the relevance of various projects included in the context of India's national needs.

Research findings are regularly issued by the Division of Environmental Engineering of the Asian Institute of Technology, Bangkok. The research projects generally reflect the needs of Thailand and the region. The procedure adopted in the selection of research projects by AIT and the benefits of these projects to the country or the region are not readily available for appraisal. A meeting of Directors of Institutions collaborating with the WHO International Reference Centre (WHO IRC) for community water supply held in 1973 had identified specific activities and projects for research and development with priority allocation in research centres in developing countries (ref.6). A global workshop on appropriate water and wastewater technology for developing countries convened by WHO IRC for community water supply in 1975 identified areas of study and research in water supply, waste disposal and socio-economic sectors in developing countries, (ref.7). Dave and Paramasivam presented research and development needs in community water supply in India at an international training seminar on community water supply in developing countries held in Amsterdam in 1976 (ref.8).

A workshop on research and development needs for water supply and sanitation decade in India conducted in 1979 had identified research priorities and recommended topics for research and development under the following groups: water, sanitation, manpower development and information system planning (ref.9). No attempt has been made in this paper to analyse the research priorities developed.

RESEARCH ORGANIZATION, CO-ORDINATION AND INFORMATION TRANSFER

Two research centres in environmental engineering in the SEAR with a high level of international exposure are National Environmental Engineering Research Inst. (NEERI)of India and AIT at Bankok, Thailand. These by virtue of their status and contacts have also become focal points in any transfer of technology from the west.

NEERI does not of course hold monopoly on environmental engineering research in India, there are other institutes, universities and state government research units engaged in environmental engineering research.

Central Public Health and Environmental Engineering Organization (CPHEEO) in the Ministry of Works and Housing is the organization directly involved in the National Water Supply and Sanitation programme, co-ordinating this activity with the various state governments, and advising them of design aspects. Design criteria and manuals are developed by CPHEEO for national use. NEERI is one of the many institutes/laboratories under the CSIR in the Ministry of science and Technology. An attempt by the user (user of research) ministry to bring NEERI (CPHERI then) at its inception into its fold was not successful; subsequent attempts in recent years have not altered the status quo. Thus the research unit (NEERI) and prime user of research results remain in different ministries posing its normal share of co-ordination problems. Some measure of co-ordination was achieved in the sixties with the head of CPHEEO (Adviser) acting as the chairman of the technical sub-committee of NEERI which reviewed and approved research projects. Research co-ordination was at best patchy. CPHEEO did not attach much importance to this function in the sixties, in effect ignoring its primary role in research co-ordination and technology transfer. It is believed that CPHEEO had not taken aggressive leadership role in this area in recent times as well. Khare, a former adviser, had termed CPHEEO as a weak and an ineffective organization and had expressed doubts about its ever becoming a strong and effective organization; he attributes lack of feed-back and poor information transfer to the weak central organization (ref. 10).

It is very important that CPHEEO should play an active leadership role in this area of research co-ordination and technology transfer if the results of research are to find their way to the users (state governments). The organization must be strengthened either in the present set-up or as part of the Ministry of the Environment; there should be a shift in emphasis of its functions as well as changes in attitude so that it can abandon its passive role as a marginally interested bystander and take on a productive role in the interest of a successful transfer of technology within the country leading to the success of water supply and sanitation decade targets in India. Technology transfer seminars would be a useful venture in this context.

Another matter of real concern relates to the mechanisms available within India for information on dissemination. There are only four primary journals on the subject namely: 1. Journal of the Institution of Engineers (India) Environmental Engineering Division; 2. Indian Journal of Environmental Health; 3. Journal of Indian Water Works Assoc; and 4. Journal of the Institution of Public Health Engineers (India). There are a few magazines issued by some state government departments such as Public Health Engineer (Kerala State) and Tamilnadu. A newsletter is issued by the Indian Association for water pollution control and a technical digest is issued periodically by NEERI; one would normally consider the number of publications available not adequate. In some of the journals publicationdelays of more than 18 months are not uncommon; in the case of some journals, publication dates are not kept up. A few of these journals response characteristics are very poor, chasing any prospective author miles away. In addition to this, many faculty members do not attempt to write papers based on research conducted by graduate students under their guidance; there is no incentive to publish, as publishing does not influence faculty promotion or standing. Thus very little of university research in this area is even published. There is a pressing need for a central organization such as CPHEEO as a part of its function to periodically issue a bulletin which contains in addition to other material, abstracts of theses accepted for graduate degrees in Indian Universities. CPHEEO should also consider issuing a publication consolidating all abstracts of theses.

AIT has been issuing a periodical publication once a year or so containing abstracts of theses approved in the environmental engineering area; it has also recently started issuing Environmental Sanitation Abstracts and Environmental Sanitation Reviews. There is also another magazine called Asian Environment published from Thailand.

CONCLUSIONS

Each developing country should develop a list of priority research projects. Information transfer should be strengthened in all the developing countries to benefit research locally done and in the region.

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INTERNATIONAL WATER AND SANITATION DECADE. IS IT A DREAM OR A REALITY?

by G SAGAR and V K AGARWAL

In the past great weight has been given to the safety of drinking water against disease and thus the piped water systems were recommended in general. In the succeeding paragraphs the author has made a comparative study of piped water supply, hand pumps and open wells. The age old belief that the piped water supplies are the safest is not true. The hand pump water is comparatively safer. As for the open wells, its water can be made quite safe with the use of a simple device known as pot chlorinator.

If the aim of the "International Water Decade" to provide safe water and sanitation to all the communities by the year 1990 is to be realised, the priorities will have to be redefined and we should take up chlorination of village wells in a big way. Secondly, we should give preference to hand pump and sanitary dug well schemes over piped water supplies which are very costly. Thirdly, we must also insist on drainage around the wells and hand pumps. Fourthly, carry out a programme of health education paralled with the development of community water supply and sanitation in order to highten people's awareness with respect to health, seeking their full support in planning, operation, maintenance and financing of the above services. And lastly but not the least, develop appropriate technologies in the context of existing socioeconomic conditions.

STATUS OF WATER SUPPLY & SANITATION IN UTTAR PRADESH

The progress with regard to the provision of drinking water in rural areas of Uttar Pradesh is quite slow. This is mainly because of our decision to extend only the piped water systems for safe water. Till March, 1980 only 10,056 (Ref.1) villages could be covered out of total number of 112,624. As regards rural sanitation practically nothing has been done so far. The requirement of funds to cover just 50,000 villages with piped water supply works out to Rs. 1600 crores (Ref.2) (1£ = Rs. 17.50), proposed to be spent in the "International Water and Sanitation Decade" (1981-90). A provision of Rs. 120 crores has been kept under 'sanitation'. But the availability of such huge sums is a big question. In the central sector provision of only Rs. 88 crores (Ref.3) exists for rural water supply in Uttar Pradesh for VI Five Year Plan (1978-83). With water supply largely covered, the sanitation is lagging behind in the urban areas. If our aim is to achieve 100% of water supply and sanitation coverage, conventional technology will have to be replaced with more appropriate systems.

WATER QUALITY

Tap water is regarded as being better than hand pumps and open wells. The argument which is generally put forward is that open wells are subjected to contamination even when sanitary protection is given. This is because the dirty rope and bucket that goes inside the well can impair the bacterial quality of water. As regards the hand pumps, many public health engineers hold the view that they usually draw water from the first layer of acquifer which is generally polluted.

PIPED WATER

It flows through a closed system and draws water from deep acquifers, or after proper treatment in case of surface waters, and so it should be safe. But it is not true in general; below are the recent finding (Ref.4) from two prestigious water works A and B. These water works supply water from deep tube wells as well as from the river after treatment. Water samples were drawn from the distribution network in September 1980 and January 1981 respectively. In water works A, 222 samples were examined out of which only 10 samples (4.5%) contained residual chlorine. Number of samples falling within excellent and satisfactory ranges were 154 (70%). Total number of unsatisfactory samples reported were 60 (27%). The remaining 8 (3%) samples fall in suspicious category. In water works B where efforts were made to carry out E-coli test as well, the situation was still worse. Out of a total of 182 samples examined, only 15 samples (8%) contained residual chlorine. Samples up to satisfactory limit reported were 117 (64%) whereas unsatisfactory samples were as high as 52 (29%). The remaining 13 samples (7%) fall in suspicious category.

38 samples (21%) contained E-coli that confirms feacal contamination. If these results are examined in the background of the Water Supply Manual, (Ref.5) it would be seen that the bacterial quality of water obtained from these water works is highly unsatisfactory. According to the recommended norms 100% of the samples should have residual chlorine of minimum 0.2mg/l.; no sample obtained should be unsatisfactory and at the same time all samples should be E-coli free. If this is the state of affairs it may be pointed out that piped water systems are also liable to high degree of contamination. Mara (Ref.6) writes: "Some economists argue that a piped supply of water is beneficial, irrespective of its quality. Yet there is evidence that intestinal disease has increased after untreated rural water supplies have been installed". Unfortunately, supplies drawn even from the purest source such as a deep tube well get contaminated during conveyance in the pipeline. This is mainly because of the leaky joints and the intermittent nature of water supply sucking in untreated water during sudden interruption in the water supply.

HAND PUMPS

In the case of hand pumps, water gets percolated to deeper soil layers and thus gets filtered. Safe water can be drawn even from the first layer of acquifer if some minor precautions are taken (Ref.7). These are: where sub soil water is subjected to direct contamination such as from the open wells or the bore hole latrines where the bottom of the bore hole penetrates the sub soil water level, a minimum distance of 7.5 metres should be kept from the source. Sanitary protection should be provided consisting of puddle clay lining around the pipe in the top 1.5 metres, with the surrounding soil carefully repacked. A pucca platform should also be provided round the hand pumps. In addition drainage should be provided. This should consist of a soakage pit located at a minimum distance of one metre from the hand pump. A minimum cushion of one metre should be kept between bottom of the soak pit and sub soil water level; a platform may be raised and a soak trench may be provided instead of a pit. Where some sort of drainage system exists a drain connection may be provided. In non porous soils, underground drainage may be laid consisting of small bore sewers (Ref.8). This could be more effective and should precede piped water supply.

In village Attari, block Mal, district Lucknow, water samples were tested from 12 hand pumps (appendix A).

It may be seen that water from 6 hand pumps is excellent and the remaining 6 are unsatisfactory. The author had occasion to inspect them and found that unsatisfactory quality of water was mainly due to the direct contamination occurring through the annular opening in between the casing pipe and the bore hole in the absence of proper sanitary protection discussed earlier.

On Feb. 27, 1981, author learned from Mr. A.K. Poddar, Chief Engineer, Public Health Engineering Department, West Bengal, that many people in Calcutta are using only hand pump water for drinking while the water supplied by the Calcutta Corporation is being used for other purposes. Thus it may be concluded that hand pump water can be safer than that usually supplied.

OPEN WELLS

Next comes the question of open wells. No doubt these wells are subjected to high contamination through the unprotected rope and bucket system. However, the experiments (Ref.9.) conducted by the U.P.Jal Nigam with the pot chlorinator have shown that with the disinfection of the well water, safe water supply can be achieved in even such cases where adequate measures for drainage and sanitary protection of wells do not exist. Out of 61 water samples examined where the pot chlorinators were suspended in wells, in village Kanchanpur-Matiyari, 55 samples (90%) were found up to satisfactory limits and the remaining 6 samples (10%) were classified as suspicious. However, no sample was found unsatisfactory after chlorination. Residual chlorine was present in well water at all times. Improved pot chlorinators developed as a result of further experimentation in UNICEF assisted 'Mall Sanitation Project' Lucknow, can provide effective chlorination for 60-80 days.

In the plains of Uttar Pradesh the cost of piped water systems varies from Rs. 200 to Rs. 250 per capita, on present population. In the hard-rock and mountainous regions it may cost Rs. 400 to Rs. 600. This does not however include the cost of waste water disposal system. For hand pumps the cost varies from Rs. 15 to Rs. 25 for plains, and Rs. 50 to Rs. 100 for hard rock areas including the drainage facility. The cost has been worked out for 200 people per hand pump. The capital cost of a pot chlorinator programme is negligible. Considering 100% grant for construction, the maintenance cost of a piped water system works out to something like Rs. 7.50 per household per month. In case of hand pumps Rs. 0.50 to Rs. 2.00 per household per month have been reported based on a three tier system of maintenance. For a pot chlorinator programme the cost per household per month may vary from Rs. 1.00 to Rs. 2.00 only.

Uttar Pradesh is the only state that enjoys the legacy of the piped water system. Other states have switched over to hand pump and sanitary dug well construction programme much earlier. Orissa has almost completed the first priority scarcity villages in this way and other states are also much ahead including Bihar and West Bengal.

INTERNATIONAL WATER DECADE

If in the International Water Decade our aim is to provide safe water and its sanitary disposal for all the communities, our priorities need to be re-defined. In the first instance, pot chlorinators should be put in all the existing open wells and spring collecting chambers. In the second place, preference should be given to hand pumps and sanitary dug wells particularly in the rural areas. "Piped Water Supply Schemes are costly (Ref.3) and would be adopted only when less expensive measures such as hand pumps and sanitary dug wells are impracticable on account of geographical and terrain condition" as stated in the VI Draft Five Year Plan 1978-83.

APPROPRIATE TECHNOLOGY

India is a vast country with varying culture and topographical features. More practical low-cost, labour intensive, self reliant technologies with emphasis on maximum use of local resources - both material and labour - need to be evolved. Our technology policy (Ref.10) should largely dwell upon these considerations.

HEALTH EDUCATION

Much has been said about health education (Ref.11) and human motivation but not all is practised in the field. In the International Water Decade this has to be persued vigorously. Public opinion should be mobilized regarding the provision of basic water supply and sanitary services and developing appropriate procedures to ensure active participation of the communities in the programme.

ACKNOWLEDGEMENT

Views expressed in this paper are the author's own and need not necessarily be of the U.P. Jal Nigam. I am grateful to Mr. S.K. Sharma, Additional Chief Engineer, U.P. Jal Nigam, Lucknow for his inspiring guidance and permission to publish this paper.

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Code No.	

APPENDIX A

STATE HEALTH INSTITUTE, UTTAR PRADESH, LUCKNOW

Result of bacteriological examination of water sample which were received from co-ordinator, P.R.A.I. Scheme, Atari, Block Mall, District Lucknow.

Sl. No.	Date of collection.	Date of receipt and inocutation.	Source of water (Hand Pump)	Colony Count on Agar 48 hrs At 37°	Colony Count on Agar 72 hrs Room Temp	Presemptive Coliform Count: Quantity of sample in each T. T. / No. of Test tube	50 ml. / 1	10 ml. / 5	1 ml. / 5	0.1 ml. / 5	Probable no. of Co-liform organism.	Mg./l. free residual chlorine.	Remarks.
408/D	—	8-10-80	H.P. of Raja Balbir Singh, Atari.	10	15	—	0	0	0	—	0	No	Excelent.
409/D	7-10-80	8-10-80	H.P. of Pt. Siya Ram, Atari.	Innumerable		—	1	5	1	—	35	No	Unsatisfactory.
410/D	7-10-80	8-10-80	H.P. of Raja Ram, S/o Sakhi.	13	20	—	0	0	0	—	0	No	Excelent.
411/D	7-10-80	8-10-80	H.P. of Kallu Yadav, Atari.	Innumerable		—	1/0	5/0	5/0	—	180	No	Unsatisfactory.
412/D	7-10-80	8-10-80	H.P. Pt. Ram Shanker S/o. Badri Prasad, Atari	Innnmerable		—	1/0	5/0	5	—	180	No	Unsatisfactory.
413/D	7-10-80	8-10-80	H.P. of Maiku, Atari.	Innumerable		—	1	5	5	—	180	No	Unsatisfactory.
414/D	7-10-80	8-10-80	H.P. of Madari Yadav, S/o Thani, Atari.	Innumerable		—	1/0	5/0	4	—	160	No	Unsatisfactory.
415/D	7-10-80	8-10-80	H.P. of Siya Ram, S/o. Raja Ram, Atari	10	15	—	0	0	0	—	0	No	Excellent.
416/D	7-10-80	8-10-80	H.P. Niranjan, Atari	10	16	—	0	0	0	—	0	No	Excellent.
417/D	7-10-80	8-10-80	H.P. of Munni Lal S/o Sakhi, Atari	9	14	—	0	0	0	—	0	No	Excellent.
418/D	7-10-80	8-10-80	H.P. of Ramchandra S/o Sakhi, Atari.	Innumerable		—	1/0	5/0	5	—	180	No	Unsatisfactory.
419/D	7-10-80	8-10-80	H. P. of Shivmurti S/o Kanhyalal, Atari.	12	18	—	0	0	0	—	0	No	Excelent.

Session 1

Chairman : Mr J Kalbermatten
World Bank Advisor

Discussion

R Krishnaswamy & S A Jagadeesan

Decade program in Tamil Nadu

1. Mr JAGADEESAN outlined the proposals of the Tamil Nadu Water Supply and Drainage Board for the Water Supply and Sanitation Decade. Both urban and rural proposals were presented, with emphasis on the financial, materials, and manpower requirements.

2. Several delegates raised the question of the definition of adequate sanitation.

3. Mr JAGADEESAN referred them to the details given in his paper.

4. Dr SUNDARESAN advised that there could not be global standards; it was important to design to an objective based on what was needed, and was socially and culturally acceptable.

R Pitchai and R Guruswamy

Research and development needs and priorities pertaining to the Drinking Water Supply and Sanitation Decade

5. Dr PITCHAI outlined areas which he considered required research and development effort in the Decade.

6. Dr SUNDARESAN requested Dr PITCHAI to elaborate on the 'non engineering' aspects of most significance.

7. Dr PITCHAI thought that community involvement would, to a considerable extent, influence the success of many schemes.

8. Mr PEREIRA enquired if manpower requirement figures were available.

9. Dr PITCHAI replied that whilst not having exact figures, it was clear that more effort was required to produce trained personnel at all levels.

10. Mr NAVANEETHA observed that water hyacinths have a flocculating ability which may be of use.

K O Iwugo

African public health engineering during the Decade

11. Mr L G HUTTON presented the paper due to the absence of Dr IWUGO. It was concluded that African institutions could not provide the appropriate training to meet the requirements of the decade. It was essential to expose people to field projects; at present there was a tendancy to bring in foreign experts, whereas locally trained personnel would benefit enormously from working on such projects.

12. Mr A RICHARDS asked Mr HUTTON if he knew of proposals to improve the level of public health engineering education, and if there were any training programs at the supervisory level.

13. Mr HUTTON replied that he personally did not know of any such proposals or training programs.

T Viraraghavan and T Damodara Rao

Research, development and demonstration needs in water and waste engineering in Asia

14. Mr DAMODARA RAO emphasized the importance of the transfer of information, and the role that central organizations such as NEERI and CPHEEO (in India) should play in the collection and dissemination of information.

G Sagar and V K Agarwal

International Water and Sanitation Decade - is it a dream or a reality?

15. Mr SAGAR'S paper illustrated the problems and practices in rural Uttar Pradesh, with reference to water quality, piped water, hand pumps, open wells, and the prospect of the decade. It was confirmed that prices were for 1980, and that detailed questions on chlorination could best be answered by representatives of NEERI.

16. Dr SUNDARESAN offered some general comments. Research and development needs for the decade had been identified at a meeting held at NEERI in 1979; community participation was felt to be a top priority.

17. A certain percentage of funds should be allotted to research and development in areas to be identified by those concerned with the implementation of the decade plans, such as senior engineers and managers.

18. A wealth of useful information exists within different institutions, but lack of communication and interaction between these institutions inhibits the interchange of ideas and results. The CSIR is taking on a more collaborative role in this respect.

8th WEDC Conference: Water and waste-engineering in Asia: MADRAS: 1982

DEVELOPMENT OF APPROPRIATE TECHNOLOGY IN MEETING DRINKING WATER DEMAND OF RURAL INDIA

S BASU and R N PATRA

INTRODUCTION

More than 99% of the Global Water resources are not accessible for direct human consumption, 97% being confined to seas, and over 2% being fixed up in polar regions as ice-caps.

With much of this available water, which constitutes hardly 1% of the Global water, getting contaminated, due to unrestricted outpouring of domestic and industrial effluents, water supply is fast becoming one of the costliest resources to sustain the industrial growth in most of the developed, and developing countries of the World.

In most of the Third World Countries, there are vast regions of arid lands, where there is no source of surface water (in the form of rivers and lakes), and the underground water is highly brackish having salinity level ranging from 3-10,000 ppm as NaCl, and as such not drinkable.

According to the survey conducted by the Central Ground Water Board, Govt. of India, (Annual Report 1974), underground water sources of large coastal and inland rural areas of India, is brackish, and it has been estimated that nearly 20 million people living in nearly twenty thousand villages in different arid regions of the country, are affected by the salinity problems.

The people in these areas either fetch water from long distances, or they have to survive with the saline water. Consumption of water unfit for drinking, on account of bacteria/viruses, or excess salinity, is the biggest health hazard to millions of rural villagers scattered all over the Third World Countries, where non-availability of drinking quality water is the biggest problem.

The World wide awareness for providing clean drinking water, particularly in the developing countries, has led to the eighties being declared by the United Nations Organizations as the International Drinking Water Supply and Sanitation Decade.

The extremely alarming drinking water situation in Third World Countries, faced by more than half of the World population, has been highlighted recently in a moving documentary "Journey for Survival", produced by the UNO.

The primary requirements of drinking water and health care, needed urgently in rural regions of the developing countries, could be approached if an appropriate and cost-effective desalination technology, and community sewage treatment facility were developed, for implementation in mini units, which could be operated without external power supply, as far as possible.

During the last two decades, extensive exploratory research and engineering studies have been carried out in the field of Membrane techniques-Reverse Osmosis (RO), and Electrodialysis (ED), which has resulted in the commercialization of RO/ED as a cost-effective technique, in the desalination of sea/brackish water for potable water (Ref.1-3), and in different chemical industries as an economically attractive separation operation, for concentration of useful products, along with pollution abatement (Ref.4-7).

Considerable amounts of work have been undertaken during the last decade, on the development of low-cost waste treatment processes based on water hyacinth culturing, which offers promise as an economically attrative, and environmentally sound sewage treatment process for implementation in rural areas, for pollution control, along with generation of water for re-utilization, and production of bio-gas and fertilizers, if applied as an integrated project for the development of rural areas, with respect to improvement of the environmental quality, and sanitation. (Ref.8-13).

In our earlier communications (Ref.8-10), applicability of RO/ED, in treatment of industrial effluents, along with reclamation of water/chemicals have been highlighted. In the present work, an attempt has been made to study the feasibility of developing a mini-RO module, and low-cost sewage treatment process, based on culturing of water hyacinth (Eichhornia cressipes), particularly suited to rural arid regions, where eletrical power may not be available.

EXPERIMENTAL WORK

Brackish water with salinity level ranging from 5-10,000 ppm as NaCl, was used as the feed for studies in RO modules, as per the experimental details reported in earlier communications (Ref.8). Three different RO modules-tubular, plate, and spirally wound have been used, to evaluate best performance, with respect to permeate quality, flux stability and permeate recovery.

To study the development of low-cost stabilization lagoons based on water hyacinth culturing, experimental investigations have been carried out in 100 litre capacity earthen pots with sewage effluents contaminated with some industrial effluents from pulp and paper industries with and without water hyacinth.

Percent reduction of pollutants (biodegradable as well as non-biogradable constituents) were estimated in terms of BOD_5, and COD/PV at different time intervals (ranging from 1 to 30 day's detention time) under varying conditions of feed pH, SS, BOD load, and degree of coverage with water hyacinth.

RESULTS AND DISCUSSIONS

Since it has been decided to develop a hand-operated mini RO module for desalination of brackish water into drinking quality water, attempts have been made to incorporate a turbulence promotion device inside the tubular RO module for the elimination of concentration polarization effect at the membrane interface.

It has been estimated that maximum power output from human efforts is limited to around 100 Watts, giving output capacity of the hand-operated mini-RO module to one litre product water per minute, at RO operational pressure from 30-40 kg/cm^2.

Due to limitations of human power, two types of turbulence promotor, mentioned as (i) tube with flow modifier-I, and (ii) tube with flow modifier-II, were developed and used in this work.

Improvement of water flux rate, and desalination ratio, by turbulence promotions, at different level of feed velocity (expressed in terms of Reynolds No.), is presented in Figures 1 and 2.

As depicted in Figures 1 and 2, flux improvement with flow modifiers was found to be 50 to 80% as compared with RO operation in a bare tube, without turbulence promotion devices.

Similarly, the desalination ratio was improved to the extent of 2.0 to 2.5 times as compared to bare tube RO operation, under similar conditions of feed pressure, and velocity.

Dependence of turbulence promotion on flux and desalination ratio with a high flux low salt rejection cellulosic membrane, is presented in Figures 3 and 4, which gave similar patterns observed with a low flux high salt rejecting cellulosic membrane in Figures 1 and 2.

Further RO experiments were carried out with plate, and spiral wound modules, and comparative studies indicate that equivalent level of flux rate and desalination ratio could be obtained with a spiral module, as found with tubular RO module, with turbulence modifier-II, under similar operational conditions of feed pressure and velocity.

Apart from improvements in permeate flux rate and desalination ratio, the tubular RO module with turbulence promotions, and the spiral wound RO module gave improved performance (measured in terms of concentration polarization modulus) as compared to tubular RO module (without turbulence promotors) and product water quality was found to be within 500 ppm, with feed salinity around 5-6,000 ppm.

Experimental investigations carried out with water hyacinth culturing, with sewage effluents contaminated with pulp and paper mill effluents, furnished the following results:
(i) pronounced enhancement on the reduction of pollutants, biodegradable as well as non-biodegradable, were found with water hyacinth culturing, (ii) under optimal conditions of surface coverage (60 to 75%) with water hyacinth, 50-55% pollutant reduction was observed in three days, which was increased to 80-85% within 14 days, as compared to pollutant reduction of 50% in 9 days and around 60% even after prolonged detention time of over 28 days when waste stabilization was carried out without water hyacinth, (iii) within the surface depth level of 0.3-1.5m, a significant improvement in pollutant reduction is observed in a shallower container in terms of percent reduction of initial level of pollutants, (iv) pollutant removal capacity of water hyacinth per unit quantity of wet hyacinths initially maintained is independent of effluent depth, and remains more or less constant.

CONCLUSIONS

1. Hand-operated mini RO module with tubular (modified with flow modifier) or spiral module offers great promise as a cost-effective and appropriate rural technology for meeting drinking water demand of millions in isolated arid and rural areas.

2. Development of community sewage/waste treatment plant with water hyacinth culturing in stabilization lagoons, offers great potential in rural areas as a low cost appropriate waste treatment technology for the improvement of environmental quality and sanitary conditions.

ACKNOWLEDGEMENT

One of the authors (RNP) offers his grateful thanks to the authorities of the BARC (Govt. of India), Bombay for giving facilities of RO at the Desalination and Effluent Engineering Division (DEED), which enabled him to undertake work on desalination of brackish water in tubular RO modules.

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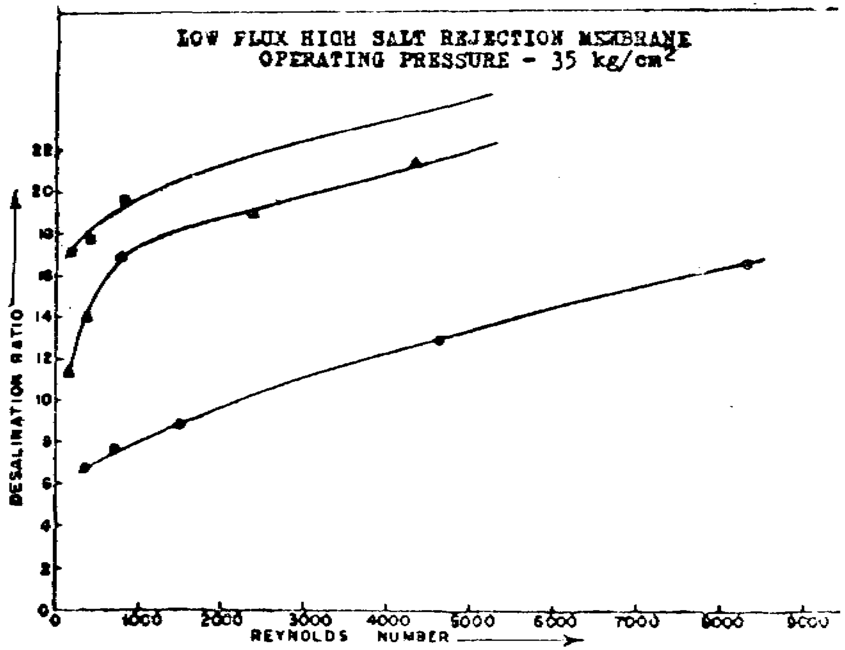

FIG.1 DEPENDENCE OF DESALINATION RATIO ON REYNOLDS NO

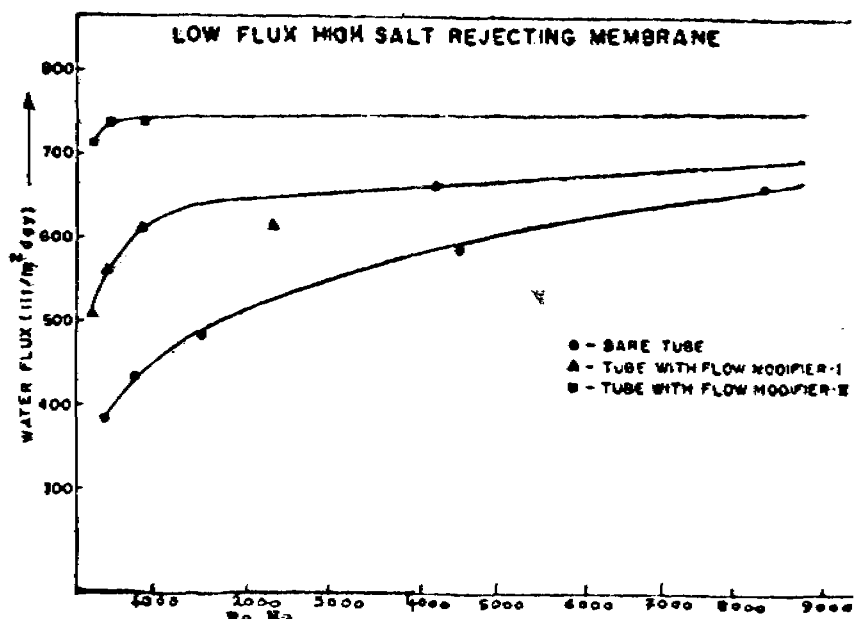

FIG.2 DEPENDENCE OF WATER FLUX ON REYNOLDS NUMBER

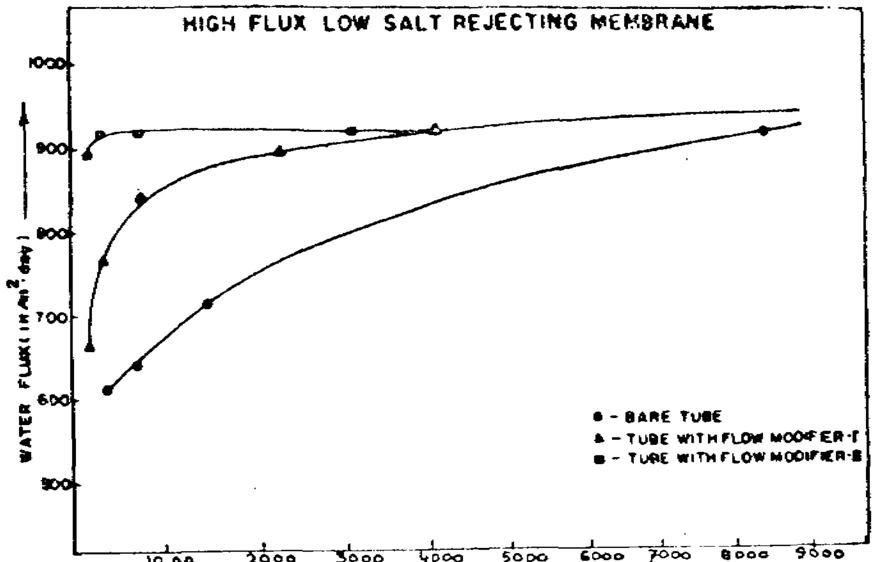

FIG.3 DEPENDENCE OF WATER FLUX ON REYNOLDS NUMBER

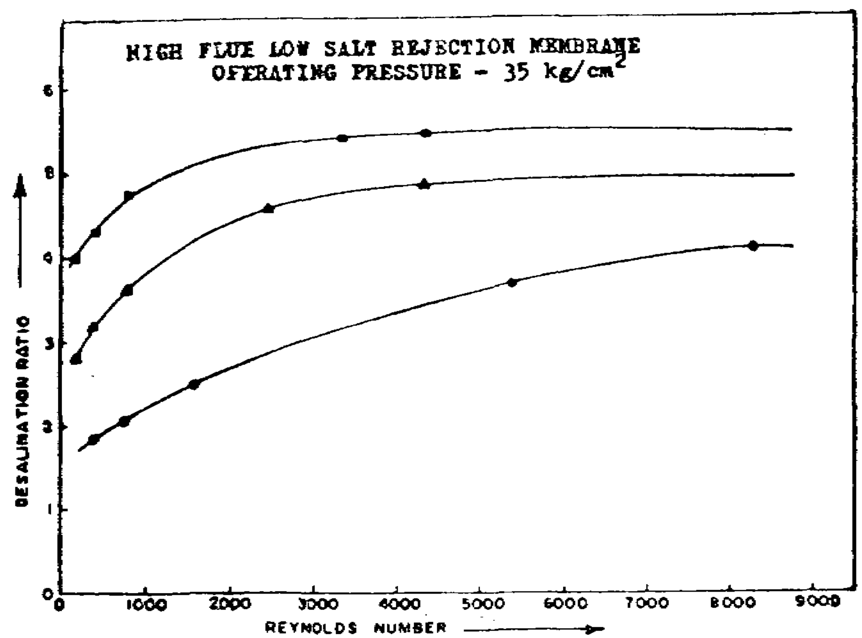

FIG.4 DEPENDENCE OF DESALINATION RATIO ON REYNOLDS NO

8th WEDC Conference: Water and waste-engineering in Asia: MADRAS: 1982

DESALINATION BY AQUATIC WEEDS

BY K RAGHAVAN NAMBIAR AND T S RAMANATHA IYER

INTRODUCTION

Coastal areas are generally faced with scarcity of fresh water. In states like Kerala, where population density along the coastal belt is very high, it would be really a blessing if fresh water could be made from the locally available saline water. Because of heavy rains and surface run-off, the degree of salinity of the water in shallow ponds and wells in coastal Kerala is only of the order of 3000-4000 mg/l. Water hyacinth grown in such open ponds can effectively remove the chloride concentration and render the water useful for most domestic purposes. The experimental results obtained from a batch reactor study in the environmental engineering laboratory of Engineering College, Trichur indicated that this method is feasible for reduction of salinity of such water sources.

WATER HYACINTH

Water hyacinth is an aquatic weed which is considered to have originated from Tropical America and has now spread over 50 countries of the world. Botanically known as *Eichhornia crassipes*, this aquatic weed has been considered as a menace in water bodies. This weed has a fleshy vertical stem, a rhizone which floats just beneath the water surface and is protected by sheds of folded leaves. This weed reproduces largely by vegetative means and are interconnected by stolons. Its fine feathery roots are fibrous and branched. This weed, which floats in water, can double in 8-10 days in warm and nutrient rich waters. The daily increment factor at the period of maximum growth is reported to be 1.066-1.077 for plant number and 1.090-1.060 for wet weight (ref. 1). It contains 95% by weight of water.

CAPACITY OF WATER HYACINTH IN REMOVAL OF ORGANICS AND INORGANICS

The ability of this weed to remove 80% of nitrogenous compounds and 40% of phosphorous compounds from sewage within 2 days has been reported by Wolverton (ref. 2). This aquatic plant has remarkable capacity to filter out and concentrate heavy metals such as gold, silver, cadmium, nickel mercury and chromium and other toxic materials. *Eichhornia crassipes* can effectively remove phenols and phenolic compounds from waters. In India, water hyacinth has been utilised for the treatment of industrial waste waters and toxic effluents (ref. 3). Raman (ref. 4) stated that these aquatic weeds are capable of removing upto 95% of BOD from waste waters. Harvested water hyacinth can be used as a manure, animal feed, and as a raw material for biogas generation and plastics manufacture. In this paper the capacity of water hyacinth for chloride and ammonia N removal is reported.

MATERIALS AND METHODS

Eichhornia crassipes was grown in a cement plastered square tank of dimensions 3.0 m x 3.0 m x 0.9 m, with arrangements for taking samples at various depths. This tank shown in figure 1 is located in the open courtyard of civil engineering laboratory. The liquid depth was maintained at 0.75 m throughout the study. The tank was filled with 0.75 m depth of tap water with calculated quantities of ammonium chloride, potassium dihydrogen phosphate and sodium chloride. Initial concentrations of chloride and ammonia N were determined soon after addition of these chemicals. At the end of 3-7 days, samples were collected and analysed for the chloride and ammonia N concentrations as per Standard Methods (ref. 5). The experiments were carried out for a period of 20 days.

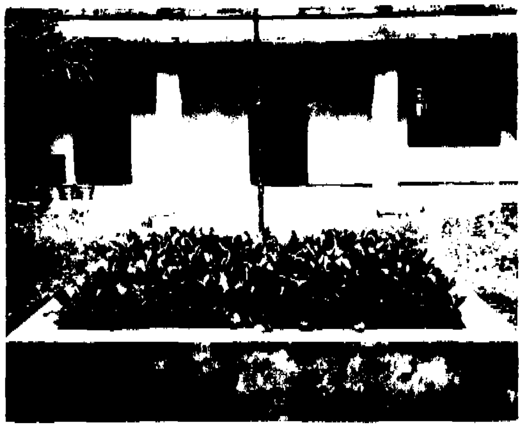

Figure 1. Experimental Tank

RESULTS AND DISCUSSION

The results obtained from a batch reactor study are presented in table 1.

Table 1. Removal Percentages of Chloride and Ammonia N.

Time in days	Chloride Concentration mg/l	Chloride Removal %	Ammonia N Concentration mg/l	Ammonia N Removal %
0	3000	0.0	32.48	0.0
5	2010	33.0	11.76	63.79
12	1200	60.0	5.60	82.86
15	1078	64.1	3.92	87.93
20	693	69.9	2.20	93.40

The chloride and ammonia N removal pattern can be seen by referring to table 1 and figure 2.

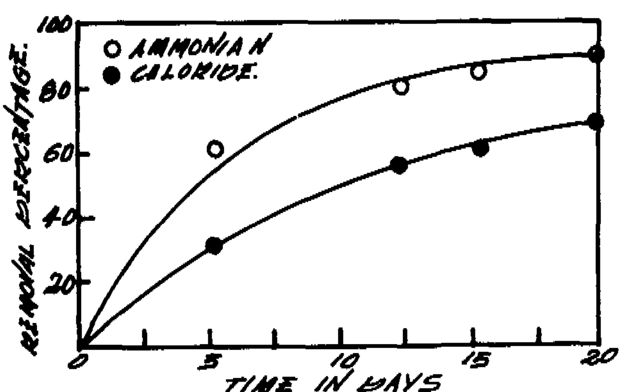

FIG.2. AMMONIA N. AND CHLORIDE REMOVAL VS. TIME

The percentage rate of ammonia N removal was rapid during the first 5 days; thereafter the rate declined. But the chloride removal rate was steadily increasing with time upto 12 days and thereafter the rate was declining. The total removal of chloride at the end of 20 days was found to be 69.9%. The weed pond removed 2317 mg/l of chloride from water with an initial chloride concentration of 3000 mg/l. As soon as chloride and ammonia N feed was given, the weed flourished with fresh shoots and attained a dark green colour. However, at the end of the experimental period, the weeds became slightly pale. This might be due to depletion of nutrient supply as indicated by low ammonia N levels in the reactor. The root system was as long as 65 cm and very thick. It might be due to the uptake of chloride ions and ammonia N through the roots, rhizome, floating leaves and stem that the removal of the above ions and nutrient took place to such a great extent. Such phenomena have been reported in cases of water plants by Luttege *et al* (ref. 6) and for mung beans by Bowling (ref. 7).

DESALINATION BY WATER HYACINTH

The capacity of water hyacinth to remove chlorides is of great significance in using them as a means for desalination. *Eichhornia crassipes* is reported to be capable of reducing total coliform bacteria from septic tank effluent from 170,000 to 10 per 100 ml in 24 hours (ref. 8). The weed has a high efficiency in the removal of BOD and suspended solids.

From the experimental results discussed in this paper, it is clear that these aquatic weeds can reduce chloride concentration from saline waters. The decaying parts of the weeds may contribute to BOD; but this BOD may get removed by the metabolic uptake in these plants. As such, slightly saline waters can be purified and desalinated by these weed ponds. If two ponds are put in serial operation, the desalination may be more effective. This type of saline water renovation does not require much of energy input. Thus this method has to be viewed as a vital one in the present context of energy and fresh water crisis. A pilot plant study is necessary to evolve detailed designs of such a process.

CONCLUSION

Eichhornia crassipes are capable of removing chlorides to the extent of 69.9% from saline waters containing 3000 mg/l of chloride in 20 days. Desalination and purification of slightly saline waters can be accomplished effectively by water hyacinth ponds. As such, hyacinth ponds provide a promising low cost method for renovation of saline waters for various uses.

Acknowledgement The authors express their thanks to Messrs Davis, Hari, Govindan and Paul, who have carried out a part of the work documented in this paper.

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8th WEDC Conference: Water and waste-engineering in Asia: MADRAS: 1982

LOW-COST HOUSEHOLD WATER TREATMENT FOR DEVELOPING COUNTRIES

BY S M DHABADGAONKAR

INTRODUCTION

The task of supply of safe drinking water to the people in developing countries is gigantic. With reference to India, it may be seen that a large population of the country use dug-wells to obtain their drinking water. A number of studies "(ref.1)" in the country revealed that the water from these wells is grossly bacteriologically contaminated, so much so, that mere disinfection methods are not sufficient to render it safe.

The situation where treated water is supplied is equally unsatisfactory. Most water supply systems in the country operate on intermittant basis. With the result recontamination of water in the distribution system is quite common "(ref. 2). A number of reports of outbreak of waterborne diseases from the urban area supplied with treated water substantiate this fact.

As per the goal of the Water Supply and Sanitation Decade, it is proposed to supply safe water to all by the year 1990. Until the situation actually improves, one of the positive ways to overcome the problem is to encourage household water treatment by the people. This is not a new idea. WAGNER and LANOIX "(ref. 3)" have adequately emphasised the need and have reviewed the various household drinking water purification methods. The chief considerations in the choice of any one method from the different alternatives available would include the performance capability, ease of operation and maintenance and cost. In view of these considerations a facility combining the slow sand filtration followed by disinfection by copper ions for added safety is considered most appropriate for developing countries. The background that has led to this proposal together with a typical design of the household water treatment facility is presented in this paper. The operation and maintenance of the unit has also been explained.

SLOW SAND FILTRATION

General performance

Slow sand or biological filtration is the only single step reliable means of treating polluted surface water with turbidity not exceeding 50 JTU. It simultaneously improves the physical, chemical and biological quality of water. Slow sand filters are simpler to operate than any other alternate technologies. Absence of any machinery renders them more adaptable for household use. The technology is tried and proven having the largest operating experience.

Pathogenic micro-organism removal

Pathogenic micro-organism removal capability of biological filter needs to be specifically emphasised.

Bacteria removal efficiency of the slow sand filter is the highest of all. It has been reported "(ref. 4)" that after slow sand filtration it is not uncommon to find the total bacteria count reduced by a factor between 1,000 to 10,000 and E.Coli count by a factor between 100 to 1,000. And that, starting with average quality of raw water, it is usual to find E.Coli absent in a 100 ml sample of filtered water thus satisfying normal drinking water standards. In the studies on slow sand filters by the author at Visvesvaraya Regional College of Engineering, Nagpur 440011 (India), with well water coliform count exceeding 1600/100 ml, most filtered water samples showed total coliform count to be zero, while all the samples less than 10/100 ml.

Virus removal efficiency of slow sand filter is also comparable to bacteria removal. According to Metropolitan Water Board "(ref. 5)", a slow sand filter operating at a standard rate of 0.2 m/hr and a temperature of 11°–12°C, reduced 'poliovirus 1' by 99.999 percent. The virus removal efficiency of the same filter at 6°C was observed to be 96.8 percent. Improved virus removal efficiency of the filter at a higher temperature was atributed to the increased biological activity at higher temperature. This aspect should be of special significance to the developing countries where average water temperatures are above 20°C.

DISINFECTION BY COPPER IONS

The germicidal property of heavy metals, e.g. mercury, silver and copper, in minute concentrations is termed as "oligodynamic" property. The mechanisms of heavy metal disinfection are not fully understood, but probably relate to the activity of metal ions in reacting with cell matter to cause protein coagulation. Use of silver for disinfection of drinking water is widely known. Copper is well known as a strong algaecide and is also known to possess weakly bactericidal property "(ref. 6)". Being relatively much cheaper than silver, the low bactericidal property of copper may be harnessed for wide application.

Storing drinking water in contact with metallic copper

In India, since ages, the water stored in clean copper vessels is considered to be more hygienic for drinking. The noted use of metallic copper for purification of water in "Susruta Sanhita" and 'Neghrund Bhushan', the Indian Sanskrit literature of about 2000 B.C., is well documented "(ref. 7)".

In the studies by the author "(ref. 8 and 9)" it was observed that, when water is stored in a clean copper vessel the copper ions dissociate from the surface into the water. It was also observed that the bacterial kill in the water stored in copper vessel was considerably greater than for the water stored in a polythene container. These studies further revealed that for well water with total coliform count as high as 1600/100 ml, the water stored in contact with clean copper metal for a period of 48 hours showed the total coliform count to be less than 10/100 ml for 90 percent of the samples. In 60 percent of the cases the coliform count was less than 10/100 ml in 24 hours.

Although the bactericidal action of copper ions is slow and will be dependent on a number of factors such as raw water quality, temperature, effective area of contact of metallic surface per unit volume of water stored etc., the method can be conveniently used as a second barrier of safety since it offers following advantages. (i) Disinfection of water by storage in copper vessel eliminates the use of conventional disinfecting chemicals containing chlorine. Therefore, all problems related to the supply and proper use of these chemicals are completely eliminated. (ii) The method is economical in the long run since the recurring cost of chemical is avoided. (iii) The method is quite simple and can be easily adopted in rural areas. (iv) Copper is an essential trace element for human metabolism. The drinking water stored in copper container will incidently cater for this need.

The limitations of the method are : (i) The process takes a much longer time compared to the disinfection by bleaching powder. (ii) Initial cost of the copper vessel is involved. The cost can however, be reduced by substituting a suitable copper element which may be kept submerged in an earthen container. (iii) Thorough cleaning of the copper vessel or metallic element is essential at regular intervals.

Copper sulphate solution

An alternate way of obtaining copper ions for disinfection is by application of copper sulphate solution to the water. The author "(ref. 9)", for the well water with copper ion concentration of 0.1 - 0.2 mg/l, observed the reduction in coliform count from as high as 1600/100 ml to well below 10/100 ml in a contact time of 8 hours.

DESIGN OF HOUSEHOLD DRINKING WATER TREATMENT FACILITY

The slow sand filter

The treatment facility "(fig. 1)" is essentially a slow sand filter modified to suit household requirements followed by disinfection by copper ions as a second barrier of safety. The main components of the installation are filter box with inlet and outlet control valves, raw water barrel and filtered water barrel. The installation is designed for a family of 4, with water requirement of 10 litres/capita/day for drinking and culinary purposes.

The filter box may be 150 mm dia. A.C. pipe providing area of cross-section of 176 sq.cm. The filter may be operated at the rate of 0.1 m/hr to obtain about 40 litres of water. The filter box is 1500 mm high and is provided with end cap at the bottom. The filter outlet and piezometer tube connections are made to the bottom end cap. The filter box contains 150 mm supporting gravel and 700 mm filter sand (E.S. 0.15 - 0.20 mm and U.C. 2 - 3). Supernatant water depth of 600 mm and 50 mm free board has been

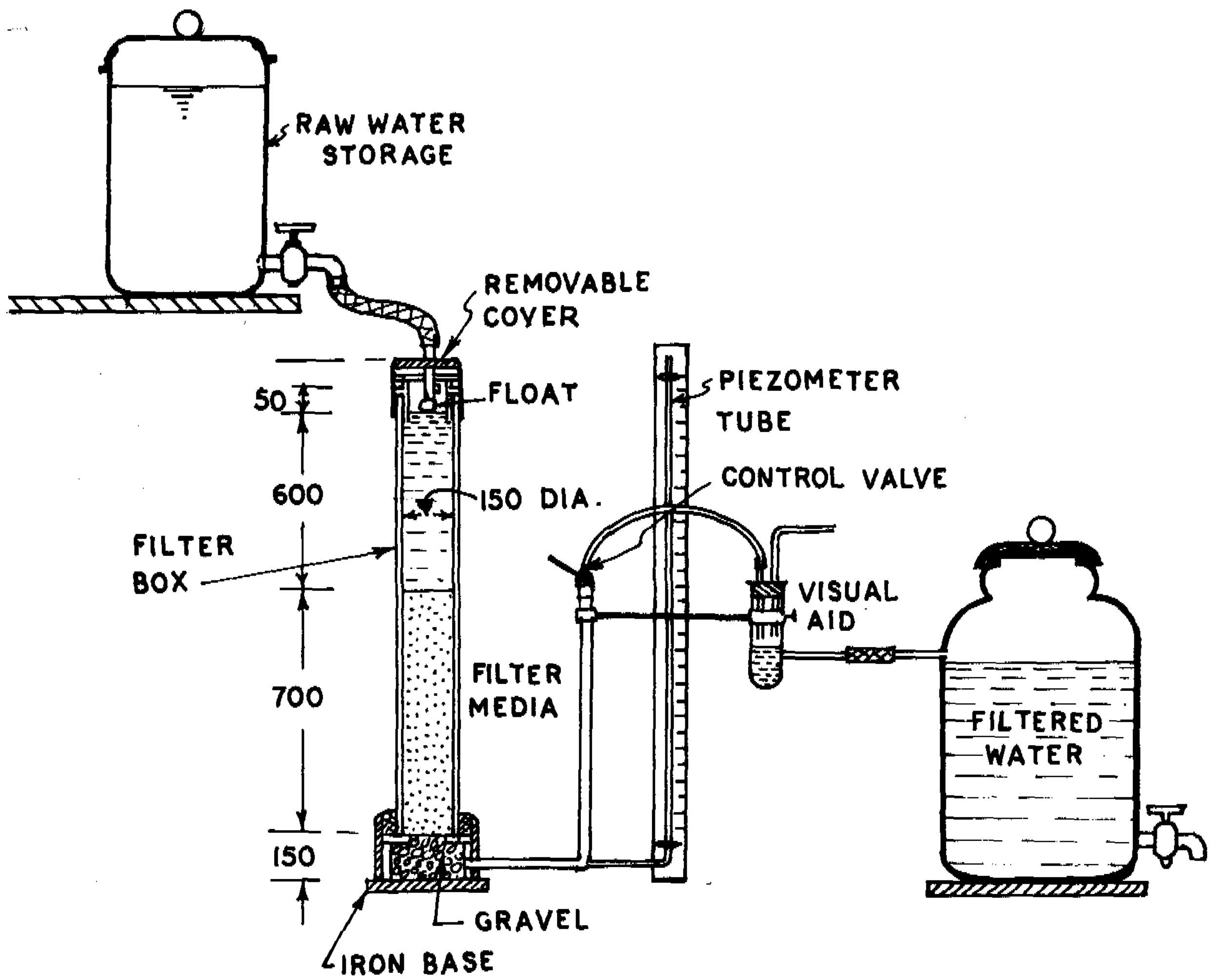

FIG.1 - DOMESTIC BIOLOGICAL FILTER

provided. The control valve with the help of visual aid helps to adjust the rate of flow through the filter. The development of negative head can be checked by properly positioning the outlet end of the tube. A removable cover is provided to the filter box. The float valve, which maintains raw water level 50 mm below the top edge of the box, is an integral part of the cover. The raw water barrel is connected to this float valve by a flexible tubing. During cleaning operation, the cover with the float valve may be removed to have full clearence to filter tube cross-section. Top layer of the sand may then be easily scraped by a suitable scraper manually.

Raw water storage may be in the form of an earthen pot of about 50 litres capacity. This will necessiate raw water filling only once in a day.

Filtered water storage should preferably have a capacity of two days water requirement.

Working of household slow sand filter

The operation of the filter is exactly identical to any community slow sand filter. The filter works continuously for 24 hours. The raw water barrel should always contain some water to maintain constant level in the filter box. Water trickles down the sand bed at a predetermined rate to be adjusted by the control valve. By practice the user can easily master the technique of adjusting the desired filtration rate. As the headloss goes on building, the filtration rate would decrease which will have to be restored by manipulation of control valve as necessary. When the headloss reaches 600 mm the filter should be drained to a level 150 mm below sand level and upper 10-20 mm sand layer carefully scraped by the scraper. The filter is again ready for the next run. 5 to 10 runs extending over a period of 4 to 8 months would be possible before the sand is reduced to 600 mm. It would be necessary to put fresh 100 mm sand in the filter box when the sand depth reduces to 600 mm.

Copper ion disinfection

Copper ion disinfection is provided as an added barrier of safety. When copper ions are to be obtained by way of storage of water in contact with metallic copper, either the filtered water container will have to be of copper or a suitable copper plate immersion device will have to be used. It is necessary to clean the copper surface from time to time to facilitate disociation of copper ions into the water. When copper ions are to be obtained from copper sulphate solution, the user is required to be initially trained to administer a dose of 0.1 - 0.2 mg/l of copper ions.

COST ASPECT

The slow sand filter including earthen raw water storage container will cost approximately Rs.300 (exchange rate 1 rupee = 0.0592 sterling pound as on 1/10/81). A 40 litre capacity thin copper container would cost Rs.200/-. Two containers which would provide 2 days storage time together, would cost Rs.400/-. Relatively cheaper solution would be to use a specially designed copper immersion element in conjuction with earthen filtered water storage container. If 99 per cent pure copper sulphate ($CuSO_4.5H_2O$) is used for disinfection, for 1 mg of copper ions, approximately 4 mg of the chemical will be required. The weight of chemical required annually for 40 litres of water per day with copper ion concentration of 0.1 - 0.2 mg/l work out to 6 - 12 gms. The cost of this quantity of copper sulphate is quite insignificant.

SUMMARY

The task of supply of safe drinking water to all the people is gigantic. The Water Supply and Sanitation Decade aims at achieving this goal by the year 1990. Until the public water supply systems actually deliver safe water at the consumer end, it may be advisable to encourage the use of household water treatment, which is considered as one of the positive ways to obtain bacteriologically safe water for drinking. Household water treatment facility consisting of a modified slow sand filter followed by disinfection by copper ions is suggested. Filtered water may be stored for 24 - 48 hours in a clean copper container for this purpose. A relatively cheaper specially designed copper-plate immersion element may be used along with earthen container. Alternately copper sulphate solution may be systematically added to the filtered water. The facility is most moderate in cost and is highly suited for application in developing countries.

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THE DESIGN OF FILTERS WITH LOW COST MATERIALS FOR SMALL COMMUNITIES

S VIGNESWARAN

1. Introduction

Filters are used for the final clarification of liquids, often to a very high degree of removal. In practice there are two principal types of filters namely (i) slow filters and (ii) rapid filters, depending on their flow rates. The removal mechanism in slow filters is physio-chemical and biological. The major disadvantage of slow filters is that they require very large areas compared to rapid filters. Anyhow it is not a problem as far as water supply for small communities is concerned, particularly in Asian countries.

The principal objectives of this study are:

1) to see the possibilities of utilizing sand as conventional sand medium and locally available other media such as coconut fiber and burnt rice husk and 2) to study the performance of horizontal pre-filters followed by a conventional slow sand filter.

2. PERFORMANCE OF SLOW FILTERS WITH LOCALLY AVAILABLE MEDIA

Slow sand filters using local materials as filter media are considered to be an attractive alternative for producing potable water in rural communities in Asia. The availability of land, labour, local materials, no chemical required and climatological conditions in Asia favour the use of slow sand filters which would be an inexpensive method of treating surface water.

The selection of the media should satisfy the following criteria.

1. The first consideration in choosing filter media should be based on (a) longer filter run and (b) reasonable quality.
2. Availability and abundance: One of the prime considerations in the selection of filter media should be the availability and abundance. The selection of locally available media would considerably reduce the transport cost and most efficient utility of local resources.
3. Applicability for the raw water condition: To suit the applicability the raw water condition should be considered. The one that is selected for the low turbidity conditions may not be suitable for the highly turbid conditions.
4. Ease of preparation: In the preparation of media the following physical parameters have to be considered; (a) effective size; (b) shape; and (c) uniformity coefficient.

The physical parameters like density, durability, structural strength should also be considered along with the storage ability, and the cost of the media in the selection of filter media.

The following materials which are abundantly found in Asia can be successfully used as filter media, (Jaksirinont, 1972):

(a) pea gravel-pebble;

(b) charcoal;

(c) raw rice husk;

(d) burnt rice husk;

(e) shredded coconut husk;

(f) sand.

Different above mentioned materials were tried and following procedures and combinations were found to be the best (Sevilla, 1971 - Jaksirinont, 1972 - Thanh et al, 1976).

Suitable Combinations

(i) Series slow filtration system:

In this system coconut fiber filter was used as roughing filter followed by sand or burnt rice husk filter as polishing filter.

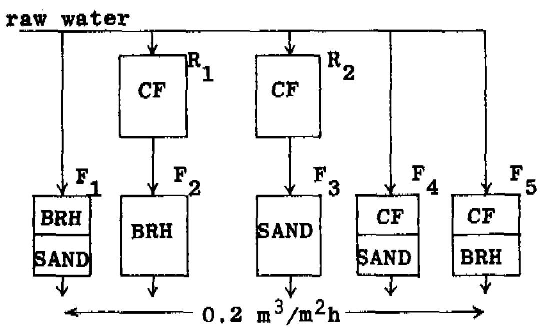
(ii) Dual media slow filtration system:

In this system coconut fibre-burnt rice husk and coconut fibre-sand combinations were used.

The pilot model used for the study is as shown in Figure 1. Table 1 summarizes a few of the results obtained. From the vast number of results obtained (Thanh et al 1976) the following conclusions can be made.

(i) Coconut fibres proved to be a reliable medium in prefilters for removal of gross impurities from highly turbid surface waters. At lower filtration rate of 0.5 m /h, head loss development through the filter bed was slow and longer filtration run can be achieved. Another characteristic of coconut fibres as a prefilter tolerate turbidity fluctuations in the raw water.

(ii) Although filtrate quality was constant and superior in the case of sand filter as polishing filter, the burnt rice husk demonstrated a net superiority over sand as a polishing filter in terms of length of filter run.



CF = coconut fibre, BRH = burnt rice husk

FLOW DIAGRAM OF SERIES-FILTRATION AND DUAL-FILTRATION

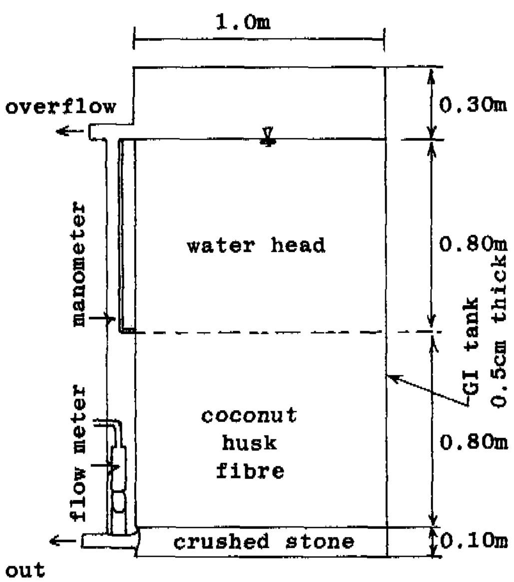


Fig.1 - ROUGHING FILTER (TYPICAL)
SCALE 1:50

(iii) Although the dual-media filter consisting of coconut fibre and sand produced a good quality, in respect of village water supply, it was not suitable due to short filter run requiring frequent filter cleaning. The dual-media filters consisting of burnt rice husk and sand, burnt rice husk and coconut fibres produced a good quality water with a slow rate of headloss development. These filters could be used for a duration of a few months without cleaning. However, the disadvantage of this dual-media arrangement resides in the production of an unpleasant odour resulting from the prevailing anaerobic conditions forcing premature shutdown of the unit. The odour problem arises after a continuous use of three months.

(iv) With regard to the microbiological aspects of water quality, all the treated waters still contained relatively high numbers of total coliforms, rendering them unsuitable for village domestic consumption if bacteriological International Drinking Water Standards are rigidly applied. However, the removals of faecal coliforms and Faecalis were quite substantial.

3. PERFORMANCE OF HORIZONTAL PREFILTERS FOLLOWED BY A CONVENTIONAL SLOW SAND FILTER

The horizontal flow prefiltration technique using coarse gravel or crushed stones as filter media is also a sound alternative in handling turbid waters. The main advantage of horizontal flow filtration is that when raw water flows through it a combination of filtration and gravity settling takes place which invariably reduces the concentration of suspended solids. The effluent from the prefilter, being less turbid, can be further easily treated by the conventional slow sand filter.

Figure 2 shows the layout of the water treatment plant at Jedeethong village in Thailand which uses the horizontal prefilter facilities. This plant is constructed for the population of 1000. The design details are presented elsewhere (Thanh, 1978). A few of the results obtained during operation is summarized in Table 1.

From the past three year's operation, following conclusions can be made:

a) The removal efficiency of the prefilter was around 50 per cent. The filtrate quality was consistent after the "ripening Period" (about 20 days after the starting of operation). The overall efficiency of the system was of the order of 92 per cent.

b) The horizontal prefilter accounts for 80 per cent removal of coliform organisms while the total system accomplished 96-99.99%. Once the ripening period was attained (about three weeks after the starting operation), highest removal of coliforms was observed, ensuring safe treated water for drinking purposes.

c) DO content was found to be higher in the prefilter effluent than that of the raw water.

d) The average head loss development rate 0.6 cm/day leads to the conclusion that filter runs of five months could be achieved in the case of horizontal filter if extrapolation of headloss is permitted.

4. GENERAL CONCLUSIONS

1. The dual media filter consisting of coconut fibre and burnt rice husk demonstrated its potential for treatment of tropical surface waters for village community water supply.

2. With proper maintenance and careful supervision, longer filter runs can be achieved by the implementation of slow sand filtration coupled with horizontal prefiltration.

ACKNOWLEDGEMENT

This paper is based on the research projects titled "Application of Slow Filtration for Surface Water Treatment in Tropical Developing Countries" and "Functional Design of Water Supply for Rural Communities" both sponsored by WHO International Reference Centre for Community Water Supply. Grateful acknowledgement is made to Dr. N.C. Thanh, Chairman of Environmental Engineering Division, Asian Institute of Technology, Bangkok, Thailand, and principal investigator of these research projects for allowing the author to use the results and also for his valuable suggestions.

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TABLE 1

System	Filtration velocity (³/m² h)	Turbidity (JTU) Influent (average)	Turbidity (JTU) Effluent (average)	Total Coliform MPN/100 ml Influent (average)	Total Coliform MPN/100 ml Effluent (average)	Headloss: Headloss Rate cm/day	Headloss: Filter Run (day)
1. Series Filtration System							
(i) Coconut Fiber	0.5	100	20	1500	25	0.5	more than 3 months
+ Burnt Rice Husk	0.2		3		15	2.4	60
(ii) Coconut Fiber	0.5	100	20	1500	25	0.5	more than 3 months
+ Sand	0.2		10 (Effluent quality improved gradually)		12	2.4	33
2. Dual Media System							
(i) Coconut Fiber + Burnt Rice Husk	0.2	100	5	1500	20	1.3	90
(ii) Coconut Fiber + Sand	0.2	100	2	1500	15	3	41
(iii) Burnt Rice Husk + Sand	0.2	100	3	1500	30	0.5	more than 3 months
3. Horizontal Prefilter	—	25	12	5000	1000	0.6	more than 5 months operation
+ Slow Sand Filter			3		100	0.5	

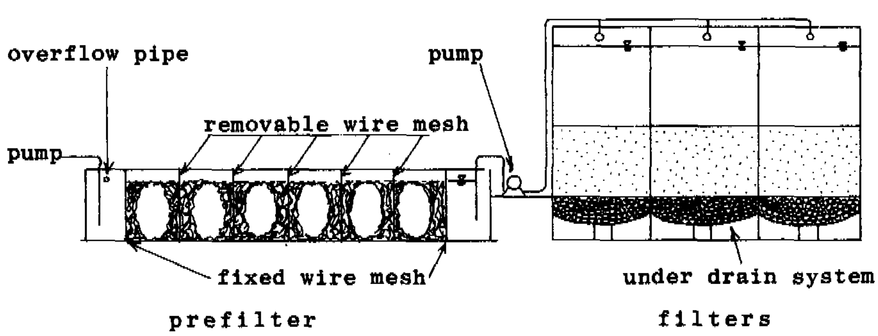

Fig.2 - Section A-A of Horizontal Prefilter and Slow Sand Filters
Scale 1:50

Session 2

Chairman : Mr J A Pickford
WEDC Group Leader

Discussion

S Basu and P N Patra

Development of appropriate technology in meeting drinking water demands of rural India

1. Dr BASU presented performance data for a hand operated reverse osmosis module for desalination of brackish water to drinking water quality; he also discussed results obtained using water hyacinths to improve the quality of sewage effluent contaminated with pulp and paper mill waste.

2. Mr DAMODARA RAO observed that human energy input was likely to be limited to 50 watts, which could be improved to 200 watts if a 6 ft to 8 ft diameter windmill were used.

3. Dr BASU confirmed that this would be the case, and that any energy source would power the module.

4. Dr BANERJEE asked Dr BASU to comment on the fact that water hyacinths appeared to remove more COD than BOD.

5. Dr BASU replied that under certain conditions bio-refractory constituents could be removed; both bio-degradable, and bio-resistant species can be absorbed.

6. Dr COTTON requested to know the basis on which the module had been stated to be cost effective, considering the requirement of pretreatment.

7. Dr BASU answered that membrane replacement was the most costly feature, and pretreatment could reduce the frequency of replacement.

8. Mr COAD asked about the maintenance and pretreatment requirements for the module.

9. Dr BASU stated that the influent pretreatment depended upon the physical and chemical characteristics of the influent water; correct pretreatment was essential for the efficient operation of the module.

10. Mr NAJUNDAPPA posed two questions: what was the cost per 1000 litres of treated water and how does it compare with other methods? How much gas production was obtained from the water hyacinths?

11. Dr BASU replied that the cost of treated water could be about Rs 1.5 per 1000 litres, for salinity upto 10,000 ppm, and that the energy costs were between a factor of 0.25 and 0.33 of the evaporation and distillation methods. Gas production from biogas using water hyancinth was about 4 to 5 m^3 per kilogram dry weight of water hyancinth. The methane content is about 70%.

12. Mr SARAF asked about virus removal in the module, and the surface area requirements of the water hyacinth ponds.

13. Dr BASU answered that virus and bacteria removal depended upon membrane characteristics, and that about 2.5 acres of pond, having a 70% water hyacinth coverage, should be adequate for 0.1 mgd of effluent having a BOD of about 250 mg/l.

K Raghavan Nambiar & T S Ramanatha Iyer

Desalination by aquatic weeds

14. Dr NAMBIAR presented results from a laboratory scale study investigating the removal of chloride and ammonia from a synthetic influent by water hyacinths. He claimed that the 70% removal of chlorides could render saline waters more useable.

15. Mr RAMAN asked if there had been a reduction in sodium concentration in addition to chloride reduction.

16. Dr NAMBIAR replied that sodium analysis had not been carried out.

17. Mr DEWAN requested clarification of the reduction in total coliform bacteria.

18. Dr NAMBIAR answered that results had been quoted from other sources, but no studies had been done in this case.

19. Dr KRISHNAMOORTHI suggested that fly breeding could create a nuisance in ponds.

20. Dr NAMBIAR agreed, adding that no specific information was available.

21. Mr MUNUSWAMY enquired as to the suitability of using aquatic weeds in polishing lagoons for sewage treatment.

22. Dr NAMBIAR thought that this would be useful in reducing salinity.

23. Dr CHOUDHARY commented that aquatic weeds have also been used for fertilizer and animal feed.

24. Mr RAJAGOPALAN asked if the technique could be successfully applied to sea water rather than synthetic influents.

25. Dr NAMBIAR replied that such studies were now being undertaken.

26. Mr KUMAR thought that the process was unlikely to be useful because it was a batch process requiring much manual labour.

27. Dr NAMBIAR answered that the two factors were not related, and it would be possible to develop a continuous process.

S M Dhabadgaonkar

Low cost household water treatment for developing countries

28. Dr DHABADGAONKAR presented his paper, outlining the operational characteristics of slow sand filtration and copper ion disinfection. He described the household filter system which essentially consisted of a slow sand filter with the possibility of disinfection using copper ions.

29. Mr KALE asked for further details on the apparently poor performance of some commercial household filter systems, and wondered if they should be banned.

30. Dr DHABADGAONKAR referred to a NEERI report, and suggested that NEERI should advise the government on banning production.

31. Mr ALAGARSAMY commented that successful household systems were commercially available.

S Vigneswaran

The design of filters with low cost materials for small communities

32. Dr VIGNESWARAN presented his paper, outlining possible materials which were readily available, and suitable for use as media in slow rate filters.

33. Data were presented for the performance of a horizontal flow pre-filter, followed by a conventional slow sand filter. The pre-filter achieved satisfactory improvements in raw water quality of a turbid surface water.

8th WEDC Conference: Water and waste-engineering in Asia: MADRAS: 1982

RURAL WATER SUPPLY IN THE 1980's

by A C CHATURVEDI

ABSTRACT

Eighty percent of the population of India live in villages and seventy percent of these people do not have assured potable drinking water supply. Hundreds of people die every year because they had inadequate water or sanitation facilities. Thousands of people spend half their day walking in the hot sun to carry polluted water which will poison them and their families. Future rural water supplies have to project for a fifty year period, and a second thirty year period. This plan has to take into consideration the rapidly increasing water demands, quantitative and qualitative modification of the present water resources. The planning comprised (1) valuation of the competitions and gathering useable solutions, (2) analysis of solution variations and the possibility of combining part solutions and (3) economic evaluation and election of optimal project variations.

A model of linear programming was prepared for each independent district, which were considered as basic models. These models contained continuous decisive variables, possible water supply solutions or their variables. Investment variables and quantity of water supplied to the users, operation variables, (dimensions cubic metres per day) were also considered. The cost sensibility of the solution was worked out along with the result of variation of the 12% discount factor, the effects of the modifications of resource demand structure, and the inter-relation between the districts considered as independent. The sum of the investment costs together with the maintenance and 12% discount factor was kept minimal.

1. INTRODUCTION

A fifty year plan for providing drinking water supply to Utta Pradesh was programmed. This took into account requirements for communal, household, institutional, local industrial, drinking and production purposes. The peak water consumption in the first 20 years and the later thirty year periods were calculated.

It is required that a large scale water supply network should bring harmony between water resources and water demands relating space and times as well as quantity and quality.

The area of the country may be divided into easily separable consumption districts on the basis of their geographical and economical structure (Ref.1).

2. VILLAGE NEEDS

The size of water project that will serve a village should at least meet basic water requirements. An average Indian village has 160 farm families, each of which has 6 persons, 3 heads of animal, 2 hectares of land holding for rice cultivation and 2 hectares for wheat. On the basis of 35 litres per day per capita, and 50 litres per day per head of animal, 180 days of the dry season require 1000m^3 for domestic use and animals. Since the onset of the wet season, monsoon is often late for nursery beds it is preferred to allocate a certain amount of water for this activity; the nursery beds for a village of 100 hectares require 30000 m^3 of water. (Ref.2).

2.1 POPULATION

The Indian rural population lives near available river supplies. Much of the country's fresh water lies in large slow moving rivers, in lakes, or as ground water. In each case the water must be pumped to higher ground before it can be used for culinary, industrial or agricultural purposes. (Ref.3). The pumping of water, even in small quantities may be costly compared to the financial resources of the user. (Ref.4). This solution is particularly true in India where subsistence diet are the horon and a family's welfare is dependent upon their ability to work out a living on a small plot of ground.

2.2 ENERGY SHORTAGE

Pumping water in India is compounded by the shortage of available energy to operate pumps. Many people of the country are so short of fuel that they use animal dung for their source of fuel to cook food; with rising fuel costs, there is little possibility that a large capital investment for pumping equipment plus the sustained and rising cost of fossil fuel can be afforded.

The result is that small farm agricultural communities are dependent upon the rainy season for growing crops. During the dry season, water may be nearby, perhaps a few metres beneath the surface of the earth, but without a cost effective means of lifting it on to the land, the water lies wasted and fertile lands are idle. (Ref.3).

2.3 WATER DEMANDS

Water supplied for rural purposes is used in a great variety of activities. The total water use within a community is the aggregation of many individual uses, each such use being determined by a different set of variables. Therefore, the quantities of water used vary widely among different communities and sometimes unexpected changes occur over time. In order to develop a practical capability for describing, estimating and forecasting water use, it is necessary to introduce at least some generalisation and aggregation, since neither suitable models nor data are available for all individual water uses. (Ref.4).

2.4 HOMOGENOUS SECTORS

A contrasting set of assumptions would treat water use separately for each of a number of user classes defined to separate all water uses into a number of relatively homogenous sectors. Water use in each user class is assumed to be explained by a number of factors including price. Since a possible relationship between price and quantity is thereby included, this flexible approach permitted the definitions and numbers of user classes, as well as the explanatory variables to be considered.

3. DEMAND MODEL

The use of disaggregate approach was coupled with selective use of demand models. One operational use of water forecasting procedure applied demand models to the residential sector only, including user classes, employing unit use coefficients. Still, price was retained as an explanatory variable wherever feasible. Many current forecasts assume, implicitly or explicitly, that the price elasticity is zero. This is often justified by two types of assertions that the estimates of price elasticity are useless and that in the long run people revert to their old habits anyway. Both assertions are false. The wide variations in the published estimates of the price elasticity result in many cases from the different definitions of price.

3.1 PLANNING NEEDS

In projects for water supply four parameters have to be well defined:

1. The difficulties of measuring the supply.
2. Identification of a base period for supply estimates.
3. Forecasting changes in water supply and conservation.
4. Selection of an equitable base for allocating the available supply, the river gains and losses including water evaporating from storages and conveyance losses.

For purposes of identifying suitable forecasting methodology, a useful distinction was made among water conservation measures. Some measures consisted of changes in the marginal price of water, change in rate level or rate structure. The remainder related to other kinds of behaviour at changes, and to technological change.

3.2 SYSTEM FAILURE

Annual reservoir failures were determined for several different forecasting methods. Two series of simulations were concluded with average demands. This indicated that for the supplies from reservoir systems, forecasting and conservation had more impact on reducing failures when the probability of failure was high when it is low. However, it was seen that forecasting a drought on the average of once every three years was too frequent for public needs and economic stability. The forecasting by model studies aided by computer provided that the conservation mode was stored for years in which subsequent inflows provided the projected shortage. More pessimistic six months forecast resulted in an increase of only 8 years of drought forecast, when no drought occurred and a decrease of 12 in the number of years of failure.

3.3 FORECAST PERIOD

It was observed that increasing the forecast period beyond four months increased the number of failures with the optimistic forecast but decreased the number of failures in the more pessimistic forecost. For those years when there was no reduction in supply the public got full use and supplies. The longer forecasting period had a better chance of including months with high average flows than the shorter forecasting period. The pessimistic forecasts reduced inflows for the months with higher average flows. Any attempt to ensure provision of minimum stream flows for environmental purposes explicitly confronted the state system and either complied with or superseded it.

3.4 THE RE-USE SYSTEMS

The most important perspective for saving water and energy was to have re-use systems, convert siphon tube and gated pipe systems to automatic gated pipe systems so that they would change their set times from their normal 12 or 24 hours set to 3 hours or less were used. A technology transfer programme to propagate re-cycling use was taken up. It was found cheaper and easier to substitute water for labour, the latter being expensive and in many cases unavailable. The 12 to 24 hour time on each set fitted their labour schedule and they used water for this length of time whether they required it or not.

3.5 INTEGRATED PLANNING

Attempts were made to prepare an economic framework for integrating municipal water supply and waste water systems to create situations for better living conditions. The many economic problems facing municipal and regional planning are source capacity, expansion policy, treatment level requirements and disposal. Water re-use is envisaged to bring a significant improvement of the current quality of living standards. The traditional adhoc planning approach was discounted. Hasty decisions on rural water supply schemes without much attention to disposal of waste water eventually created situations whereby the source of supply got threatened by pollution problems to an extent that its cure necessitated termination of further use of source.

3.6 DEMONSTRATION PLANT

Potable re-use was resorted to by treating the secondary effluent to a quality which could without reservation or restriction be supplied through the existing potable distribution system to the rural areas. The implications of this programme are resounding. The programme was demonstrated on a large enough scale to provide adequate and accurate data for a fair and complete evaluation of potable water re-use technology. The design, operation and re-use of demonstration plants have been taken up. These plants are designed to link various unit processes together, which will provide consistent and reliable treatment of a secondary effluent and produce a potable quality water.

4.0 EXCHANGE

Water re-use by exchange was found to be the simplest form of successive use. It involves no treatment, had relatively low cost and was thus most attractive.

The used water at the sewage treatment plant outfall was exchanged for less polluted water at the treatment plant intakes upstream. Unfortunately the amount of relatively unpolluted water available in the river is limited; therefore, exchange could not utilize all of the return flow resource available. The re-used water made additional water supplies available to the continued growing demand. Responsibility was assumed for monitoring the programme. The efforts to re-use and progress towards achieving the goals set forth were constantly revaluated. The goals for subsequent targets were recommended. Future diversions required elaborate and length up transmission systems.

4.1 BASIN TRANSFER

The available surface water is sufficient to meet the requirements in the plain areas. But the water is not available in the desired quantities in all plains. There is no national planning system, and a surplus or saving in one region has little use in another region far removed. But basin transfers can be effected in neighbouring regions. With the growth of population, water use will rapidly increase and difficult areas will suffer from further shortages. In order to remove the widening imbalance of the geographic imbalance between water supply and water demand, it became necessary to transfer the water from surplus sources to deficit areas.

4.2 INTER STATE WATER LINES

Ganga river carries 65 to 70% of the total water during the monsoon months while Godavari and Krishna carry out 90 to 95% during the 4 monsoon months. The technique of transferring water from one basin to another has been practised in our country and many more are contemplated for construction. These schemes are necessary to meet local problems of deficiency. It is imperative that a more detailed study to evolve a more accurate picture of the imbalance of water supply, and water supply on national levels, will have to be worked out. Approximate routes for necessary inter-state and inter-regional water lines and volume of water to be transferred after meeting fully the requirements of the basin states have to be determined.

4.3 CO-OPERATION

It is necessary to have co-operation of basin states for undertaking further investigations after identification of the projects and their vital components. With the availability of more data it would be possible to re-define and finalise the schemes envisaged.

The basin plan would bring about an equitable distribution of water resources and remove the imbalances and provide increased safety of water supply and water demands in different areas. This has an added advantage of effecting a reduction in overall costs as compared to a multitude of smaller schemes to derive limited localised benefits.

5.0 WIND MILLS

A wind assisted pumping system has been designed for use, in areas which are short of diesel, with an existing well and electric turbine pump to supply water in rural areas. The system has operated satisfactorily and has effectively utilized the unsteady output of a wind turbine. Wind assisted power systems are proposed to be utilized in rural and remote locations where a second power source is applicable.

5.1 TURBINE PUMP

A 200 mm vertical turbine pump, installed in the well was used without modification to the pumping system. The well produces approximately 90 m^3/hour and the total dynamic head on the pump is about 100m. The induction motor used to power the pump is a three phase vertical, hollow shaft type normally used with vertical turbine pumps. The 56 kw motor has a full load operating speed of 1500 r.p.m. the same as the pump. In addition to being the primary power source, the electric motor controls the speed of the wind turbine. Since the wind turbine provides less power than the motor, the motor speed varies between 1780 r.p.m. and 1800 r.p.m., the synchronous speed of the motor. This maintains the rotor speed of 90 r.p.m. or slightly more.

5.2 PUMPING SYSTEM

The wind assisted pumping system effectively utilized the unsteady power output of the wind turbine. The system has operated satisfactorily and the concept has proven to be sound. All components are available and proven and the mechanical drive is simple. The over-running clutch has proved to be a simple and a reliable method of synchronising the two power systems. Any correctly sized wind turbine can be mechanically connected to the system and operated at constant speed.

5.3 POWER

Where the wind turbine power exceeded the total load on the system the induction motor was driven above the synchronous speed and became an induction generator.

6.0 CONCLUSION

Increased awareness of the rural water supply problem has to be propagated. Top priority has to be provided to the poor and the less privileged and to water scarcity areas. Larger allocations have to be made to the water supply sector from local resources available for general economic and social development. Manpower planning has to be provided at the intermediate and lower levels. Instruction in appropriate and low cost technology has to be provided in engineering institutions. All water projects should be managed in such a way that the rural folk can fully benefit from the project.

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THE USE OF MARKOV RENEWAL THEORY IN RURAL WATER SUPPLIES

by K ACHUTHAN

1. Introduction:

Water has quantitative, qualitative, spatial, temporal and state dimensions. The objective of a rural potable water supply system is to satisfy the demands for water delivered in required amounts at times and places desired by users. Stated this way the objective of the system cannot be met acceptably by decreasing demand. Demand is encouraged to fall during periods of short age, but this is not regarded as an acceptable solution for imbalances.

There are alternative paths to system objectives - new sources, (traditional and untraditional ones), recycling and reuse, spill capture, increased production from old sources, runoff in the service area, and network redesign. A revealing dichotomy is apparent - excepting the first, each of the approaches refers to water already flowing within the network itself, or in its area of geographic occupance. The significance of this is that the latter solutions may make it unnecessary to tap distant sources, thus reducing the level of inter-rural area competition for dwindling available watersheds.

2. Linked Trip:

In rural areas, a designer is subjected to varieties of water supply system and the performance of the system also varies according to geographical location. Three dimensions characterize linked trip making behaviour. The first of these is the type of water supply system (i.e., new sources - traditional and unconventional ones, recycling and reuse, spill capture, increased production from old sources, runoff in the service area and network design), the second is the system performance (supply - demand) in the area. The time spent by the system at the area forms the second dimension. The spatial location of the area forms the third dimension of the linked trip.

In order to understand how these dimensions form the structure of rural linked trips, it is first necessary to consider a system of states or conditions into which a designer might enter. Each state is defined by two parameters: a geographical location and the type of water supply he has to provide in the area.

Geographical locations may be designated by dividing a region into zones and numbering these zones. Likewise, type of supply may be defined and given numbers. Then if r refers to the type of supply, and s indicates zone s, in which the type of supply is located, Y_{rs} defines a state. One may think of a state as being uniquely defined by combinations of measures along the type of supply and spatial dimension.

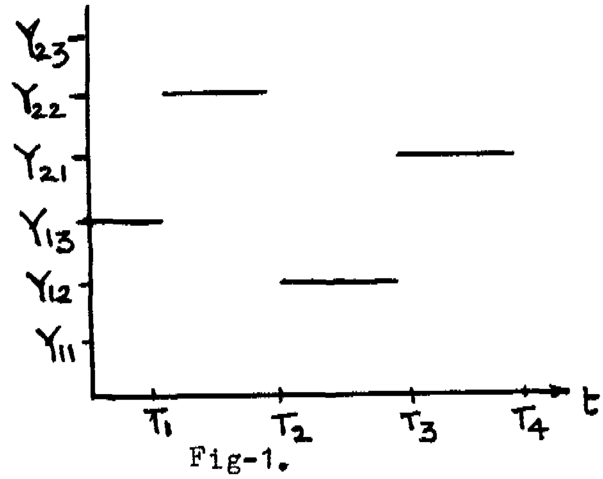

Fig-1.

Fig-1 shows one possible realization of a linked trip journey through a system of states Y_{rs}. In this example, a system of three geographical zones and two types of supply is considered, thus there are only six possible states.

It is possible that not all types of supply would be found in every zone; thus it is expected that the number of states would be less than r x s. At time T_1 the designer moves from state Y_{13} to state Y_{22}. Then after remaining in Y_{22} for $(T_2 - T_1)$ time units, he again moves, this time to state Y_{12}. After $(T_3 - T_2)$ time units he makes a transition to state Y_{21}, and so forth.

Although Fig-1 shows the journey of only one designer, it does point to two processes which together determine the structure of linked trips. On one hand, the designer has chosen to visit the sequence of states (Y_{13}, Y_{22}, Y_{12}, Y_{21},). At the same time he has decided to remain in these zones the lengths of time T_1, $(T_2 - T_1)$, $(T_3 - T_2)$ and $(T_4 - T_3)$. His journey may therefore be viewed as two simultaneous series of design decisions; where to go next and how long to stay in each state. Furthermore, because these processes are not predictable in a deterministic manner, they must be considered to be two simultaneous stochastic processes.

3. Markov-Renewal Process

It is a stochastic process in which the choice of states follows a Markov chain but the time spent in any state is a random quantity depending upon both that state and perhaps the next state to be visited.

This theory extensively developed by Cinlar (1969) essentially combines two stochastic processes; a Markov process and a Renewal process. In applying Markov Renewal theory to the linked trip making process, two basic assumptions must be made. First it must be assumed that the choice of states, $(X(n);\ n = 0, 1, 2, ..)$ forms a time homogeneous Markov chain. Second, the travel time between any two states is assumed to comprise part of the so-journ time in the origin state. This assumption is necessary in order to view designers as making instantaneous transitions between states. Thus, designers are always considered to be within a state, and no artificial states need to be constructed to accommodate designers in transit.

4. Transition Probabilities

The first aspect of linked trip making which is of interest is the probability of a trip between any given pair of states i, j.
Let
$F_{i,j}(t)$ = Distribution function of times spent in state i for designer who will next visit to state j.

Also, let
$\tilde{A}_{ij}$ = Probability of going next to state j from state i.

Then,
$$A_{ij}(t) = \tilde{A}_{ij} \cdot F_{ij}(t) \quad \ldots (1)$$
= Probability of going in one transition from state i to state j within the time interval (0, t).

5. So-journ time

The time spent in state j for those designers going next to state k is $(T_{n+1} - T_n / X_n = j,\ X_{n+1} = k)$.
Let
U_{jk} = Expected length of stay in j for those going next to k.
Therefore,
$$U_{jk} = E(T_{n+1} - T_n / X_n = j,\ X_{n+1} = k)$$
or
$$U_{jk} = \int_0^\infty t \cdot f_{jk}(t)\, dt \quad \ldots (2)$$

where $f_{jk}(t)$ = density function

$$= d/dt\ F_{jk}\ (t) \ \dots\ (3)$$

6. Number of visits to state

The number of visits to any state j in a time interval (O,t) is of obvious interest in any analysis of linked trip making. This information will be useful in providing the number of designs

with its merits and demerits.

The Markov-Renewal matrix R(t) provides just this information. Specifically, R_{ij} (t) is the number of expected visits that a designer in state i will make to state j in the time interval (O,t), its Laplace transform does this.

$$R^*(s) = I + A^*(s) + (A^*(s)) + \dots \quad \dots (4)$$

or, as the number of states is finite, then

$$R^*(s) = (I - A^*(s))^{-1} \dots (5)$$

7. Number of transitions

One aspect of linked trip making which may be of interest is the expected number of states visited by a designer during his tenure. That is, how many incomplete designs is he likely to make during a project which begins in state j. This characteristic is an indication of quality requirements in water supply of various types. Let

M_i (t) = Total number of expected states visited during a project which begins in state i,

$$= \sum_j R_{ij}\ (t) \ \dots\ (6)$$

8. Conclusion

The chief objective in linked trip-making analysis is the prediction of the effects of public policies upon linked trip patterns of "supply-demand". This objective may be accomplished using the Markov-Renewal model by performing two tasks. First, the effects of a policy upon

$\tilde{A}$ and F(t)

must be determined. Second, the resulting effects upon linked trip structures must be predicted and evaluated (Achuthan, 1981).

The numerical part of this model is in progress.

9. Acknowledgement

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GROUND WATER FOR RURAL DEVELOPMENT - A CASE STUDY

by K M GURAPPA, M R GAJENDRAGAD, G RAJENNA AND A N SEETHARAN

INTRODUCTION

The area under investigation lies along the west coast of Karnataka, a State in South India. It covers about 6 Sq. Km. around Karnataka Regional Engineering College, Surathkal. The National Highway No. 17 (Bombay - Kanyakumari) passess through this area. The belt lies between longitude 74°46' E and 74°48'E and latitude 13° N and 13°2' N (Fig. 1). The economic complexion of

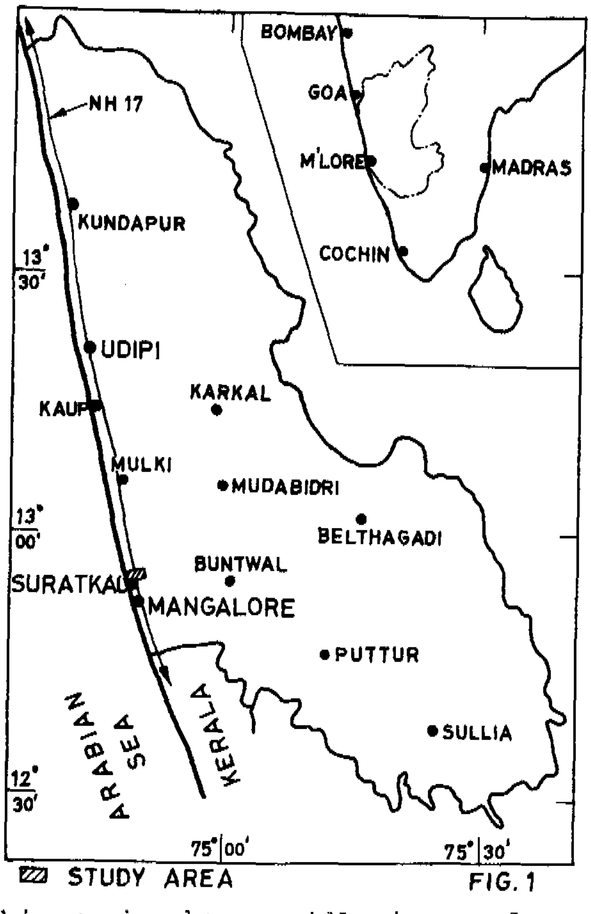

FIG. 1

this region has rapidly improved after the establishment of New Mangalore Port, Mangalore Chemicals and Fertilizers. Completion of Hassan-Mangalore railway line, near completion of Kuduremukh iron ore project and starting of small scale industries in the neighbourhood have also contributed to economic growth.

The Karnataka State Land Reforms have forced many a land owner to return to and settle down in their villages to attend to agricultural improvement. A considerable number of educated and affluent families have taken to scientific and mechanized agricultural activities. They have also started small scale ancillary industries which support fish and paddy based enterprises. All these establishments have led to rapid influx of population besides improving the economic conditions of the farm working class. Dakshina Kannada district enjoys the highest density of population in that it ranks 6th among the 19 districts in Karnataka in the matter of population while areawise it occupies the 12th place. Agriculture and labour are the chief occupations of the population in the district and yet the percentage literacy here is the highest in the entire state. This speaks highly of the socio-cultural awareness among the inhabitants here. No wonder sanitary conditions maintained by the people are the best in the district and no epidemic has ever infested this district for well over a centuray. People here are familiar with modern methods of waste disposal to enrich the nutrient value of farm yard manure and yet get gobar gas as domestic fuel.

All the above factors have demanded a heavy quantum of freshwater for domestic, irrigational and industrial needs. As this belt is very close to the Arabian sea, the Pavanje river which joins the sea, is rendered so saline by the backwaters that the river water becomes unfit for use. Surface reservoirs are not practicable because this belt is a flat terrain with highly porous laterites, clay and sand. Groundwater is therefore the only dependable source of water, since it is relatively cleaner, fresher and abundantly available almost round the year.

Innumerable wells are, however, sunk indiscriminately to meet the demand for water; but many of them get polluted due to sea water intrusion during summer, resulting in shortage of freshwater.

The aim of selecting this area for investigation is to assess the groundwater potential, and to harness it without adverse effects. Such an investigation is, of necessity, multidisciplinary in nature and hence this collective effort.

PHYSIOGRAPHY AND GEOHYDROLOGY

The area under study receives very heavy rainfall with an annual average of 4000mm, July being the month of heaviest rainfall. The temperature ranges from 37.8°C in hotter months to 16.7°C in cooler months. High humidity in monsoon and sultry weather in summer months are experienced.

A large portion of this area is covered by mounds of ferruginous laterites. The coastal belt is flat and is covered with thin layers of sand over laterites and clay. The fertile soil is suitable for paddy, coconut, arecanut and banana. Two to three crops of paddy could be raised during a year. It is rather peculiar that the eastern portion of the area is situated about 3m below the sea level. The creek that flows in the centre of the valley is contaminated with salt water during high tides. A small portion of the valley remains water-logged throughout.

The groundwater is stored in laterites and also in weathered, jointed and sheared gneisses. The water is found at a depth of 2m in regions nearer to the coast and at 4m to 5m farther from the coast.

A large number of open wells and the only dug-cum-bore well yield good water suitable for all purposes. The bore wells in the area are all abandoned either for poor yield or for acidic waters.

AQUIFER CHARACTERISTICS

Groundwater occurs under phreatic water table conditions. The open wells are sunk for domestic and irrigational purposes. They are generally shallow and vary from 3m to 13m in depth and 2m to 4m in diameter. The depth to water ranges from 2m to 5m. Wells in the valley overflow during rainy seasons. For the present study, 60 wells are inventoried in detail to assess the hydrogeological properties of the aquifer. Out of these, 6 wells are selected for pumping tests. From the test data, aquifer characteristics viz specific capacity, transmissivity, permeability and specific yield are calculated using relevant formulae (ref. 1). The results of analyses are presented in Table 1.

The pumping tests reveal the presence of a rich unconfined aquifer which can be developed and exploited without any hazardous results.

TABLE 1 : Pump Test Results

Sl. No.	Well No.	Measured Discharge 'Q' (m^3/min) $Q=C \times S_1$	Specific Capacity $C=(A/t) \times \log_e(S_1/S_2)$ (m^3/min/m) Slichter's recovery formula (ref.2)	Permeability $P = T/M$ (m/day)	Transmissivity $T= 264Q/\Delta s$ (m^2/day) Theis modified Jacob's formula (ref.4)	Specific yield $Sy=4Tt/R^2$ (%) Ramsahoye and Lang formula (ref.3)
1	24	0.149	0.11	16.59	30.7	0.719
2	28	0.085	0.12	54.43	52.8	0.962
3	29	0.102	0.11	35.29	45.52	1.897
4	33	0.02	0.03	42.90	45.91	0.56
5	39	0.02	0.03	26.69	22.96	0.13
6	41	0.446	0.638	286.31	250.52	3.09

QUALITY OF WATER AND SOIL

With a view to determining the quality of groundwater, samples are collected from all the 60 wells at regular intervals and chemical analyses are carried out by volumetric and gravimetric methods to estimate Cl^-, HCO_3^- and SO_4^{--}. The Mg^{++} and NO_3^- contents are computed from these results by conventional methods. Electrical conductivity, pH, and alkali and alkaline earth cations are determined by using conductivity bridge, pH meter and flame photometer. Almost all the inventoried wells excepting just a few, yield water with pH around 7.2, electrical conductivity around 345 micromho per cm and alkali and lime cations around 28 ppm and 50 ppm respectively. The results of analyses are plotted to get Stiff diagrams and to locate the quality of water on the Piper trilinear diagram (ref. 5).

Fertility indices are also determined for soil samples to assess the suitability of a crop to the soil and water of the area. The results of chemical analyses show that the water is quite suitable for domestic, irrigational and industrial needs. The soil is mostly either lateritic or lateritic clay. At some places the soil is acidic and that seems to be the main reason for low productivity. The farmers are therefore advised to use lime or sea shell to correct the acidity and to enhance the yield. They are also advised to use improved varieties of paddy seeds which are resistant to pests and diseases so as to reduce the risk in cultivation. Cost of manuring can be reduced to a greater extent if green manure plants like gliricidia (Gliricidia maculata) are grown along the borders of the paddy fields and their foliage used for the soil. Salt-sensitive crops like paddy may be gradually replaced by less salt-sensitive crops like groundnut, soyabean, garden-beet and barley.

DRAFT AND EFFECTS

Two small land holders deepened their wells nearer to the sea shore in order to get larger supply of water for irrigation. Although the yield increased, the water was found contaminated due to salt water intrusion and so was rendered unfit for any use. As a result, wells which yielded freshwater earlier had to be abandoned and the small land holders who ventured to deepen the wells have found their efforts counter-productive.

In a similar way indiscrimiate sinking of wells unmindful of requisite spacing between wells has also proved unproductive; for, close spacing results in severe interference particularly during pumping. This has induced farmers to resort to starting their pumps much earlier than their neighbours in order to tap maximum quantity of water. Such an unhealthy competetion among farmers resulting in overdraft is indeed deterimental to their overall interest.

Yet another factor which deserves consideration is that the Government of Karnataka have modified their power tariff to help the farmers. Power charges are levied on the basis of capacity of the pump rather than the actual power consumption. This, too, has indirectly encouraged the farmers to pump out more water than what the crops really need. Due to all these factors depletion of groundwater levels and ruinous over-draft are the consequences. In turn scarcity of freshwater is experienced well before the onset of summer.

As aforesaid, the land in the eastern portion of the belt is below the sea level and a creek is flowing towards the sea. During high tides, back-water flows into the creek thus spilling salt water into the adjoining paddy fields. To prevent the spill-over, two earthen bunds of 2m height are constructed on either bank of the creek. This has mitigated the salt water encroachment.

WELL DIMENSIONS AND SPACING

Depth, diameter and well spacing are important factors for efficient management of groundwater regime. The main criteria for realising optimum yield are :

(i) pumping rate commensurate with irrigation requirement of crops

(ii) transmissivity of the aquifer and

(iii) radius of influence.

The groundwater potential of the belt is enriched by the annual rainfall, seepage from the river and return flow from irrigation. The annual recharge to the groundwater regime is estimated on the basis of seasonal fluctuation of water level in wells and specific yield of the aquifer. This is of the order of 9,67,500m^3 from all sources as against an annual draft of 7,20,000m^3. This leaves a groundwater balance of 2,47,500m^3, which can safely accommodate 20 additional wells and cater to the needs of small scale industries as well as irrigation.

To be economically viable, an open well should yield 12,000m^3/year. Taking into account the extent of irrigable area, type of crop and crop-water requirements, one can deduce that 80% of the existing wells in the area under investigation can yield enough water to irrigate 1.6 ha for three crops of paddy. If one or two of the crops of paddy are replaced by less water-requiring crops like groundnut, millets and/or pulses, much larger area can be catered to by the same amount of water. Hydrogeological data indicates that 2m of saturated thickness of water can be tapped during the peak period of crop-water requirement. The study of seasonal water level fluctuation suggests a minimum depth of 8m for a well so as to tap 2m at a time conveniently. However, in the vicinity of the coast, the depth should not exceed 6m in order to prevent salt water intrusion.

Based on the formation constants, the optimum diameter of a well works out to be 6m with a spacing of 60m between adjacent wells.

CONCLUSIONS

This small belt is selected as a representative of the coastal area so as to carry out a micro-scale study. The investigations reveal the presence of a potential unconfined aquifer which can be economically exploited as a dependable source of freshwater.

None of the wells contain water contaminated with organic pollutants or excessive inorganic salts. The water is therefore quite suitable for all civic and commercial needs. The slight acidity, in some cases, can be readily corrected with requisite additions of lime.

The farmers normally cultivate paddy repeatedly. As a result, the soil nutrients are not properly utilised and the yield of paddy gradually depletes. Introduction of rotation of crops with high yielding and salt-tolerant crops is therefore recommended. These recommendations have been tried by farmers with encouraging results. Such developmental activities would certainly increase food production, create job opportunities to the rural labour, overcome freshwater scarcity during summer months and safeguard the interest of farmers.

Suggestions regarding optimum depth, diameter and spacing of wells have also been followed by farmers. Their experiences show that these measures are indeed rewarding.

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APPLICATION OF VECTOR MECHANICS IN A MANUALLY OPERATED TURBO-PUMP

BY S S GARG

INTRODUCTION

In view of present energy crisis that has gripped the entire industry and agriculture, this country has been forced to hunt for the alternate sources of energy such as solar, wind-power, tidal, bio-gas, geo-thermal, nuclear, water power, waste heat, plant fuel and so forth. These resources, some of these being available naturally in abundance, can be converted into useful sources of energy, if appropriate technology based on sound engineering principles and modified to suit local conditions, can be developed. Yet another resource overflowing and crying to be utilized in this country is, of course, the manpower. In this write-up, an attempt has been made to use the manpower by applying high technology in devising precise mechanisms or mechanical systems, that would otherwise have required the already depleted fuels like petroleum products or electricity.

The objective of this research problem, therefore, was to develop a machine operated by manpower to lift water for drinking or for irrigation at a head under three metres and a discharge between 15-20 cubic metres per hour. At the same time, the machine had to be portable and cheap, so that it could be used by a small farmer, who could not afford an internal combustion engine or electric motor driven pump. For this purpose, a turbo-pump (an axial flow pump or a centrifugal pump) with mechanisms to transmit power efficiently from two men to the turbo-pump, has been developed and fabricated as shown in Fig. 1, 2 and 3.

FEATURES

The main features of manually operated turbo-pump are :

1. A speed increasing gear-drive.
2. A 4-bar linkage.
3. A turbo-pump (centrifugal).

Fig. 1. Manually operated turbo-pump (portable).

To obtain a high speed required to run the turbo-pump, a speed increasing gear train has been designed. Although a worm gear drive would have been preferable to keep the number of gears at a minimum, the fabricated machine uses six spur gears giving an over-all gear-ratio of 1 to 120. The gears have 120-20, 80-20 and 110-22 teeth respectively and all having a diametral pitch of 3.78 per cm. The gear shafts are placed in five brackets and run in ball bearings. The maximum final speed at the driven shaft was approximately 2400 r.p.m.

To transmit the manual power, which is in the form of to and fro motion, a 4-bar linkage, called "crank and rocker mechanism" was provided. The linkage has two handles for two men to operate. The lengths of the linkages, crank or driver, follower or rocker, connecting rod and the fixed link or frame were computed to be 10

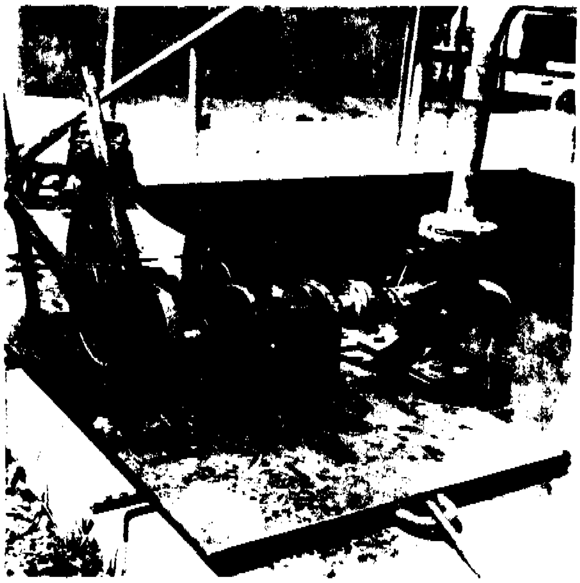

Fig. 2. Manually operated turbo-pump (close-up).

Fig. 3. Manually operated turbo-pump (in operation).

cm., 20 cm., 38 cm. and 46 cm. respectively. The follower link is extended to form a handle, one metre long. The driving gear is connected by a pin to the crank of the linkage. With this arrangement, two men could easily operate the first driving gear at a speed of 10-20 r.p.m., which gives an impeller speed of 1200 to 2400 r.p.m.

MATHEMATICAL MODEL OF FLUID MOTION

To suit the local operating conditions, the basic mathematical model applicable in design of the turbo-pump was modified as shown in the following discussion. From the field of vector mechanics, the angular momentum equation (1) was used with reference to Fig. 4 to compute the net torque required :

$$\int_{c.s.} \vec{r} \times d\vec{F}_s + \int_{c.v.} \vec{r} \times \vec{B}\, d\forall = \frac{\partial}{\partial t}\int_{c.v.} \vec{r} \times \vec{V} \rho\, d\forall + \int_{c.s.} \vec{r} \times \vec{V} \rho \vec{V} . d\vec{A} \quad ---(1)$$

where, $\vec{r}$ = position vector from the reference origin to the point where the force is acting,

$\vec{F}_s$ = surface force vector,
$\vec{B}$ = body force vector,
$\forall$ = volume,
ρ = mass density
t = time,
c.s.= control surface,
$\vec{V}$ = velocity vector,
$\vec{A}$ = surface area vector,
c.$\forall$.= control volume fixed in space and bounded by c.s.

In equation (1), the integrand of the first term ($\vec{r} \times d\vec{F}_s$) gives the moment around the origin attributed to the force $d\vec{F}_s$ at the control surface. The integrand of the second term is the moment about the reference point / origin due to the body force acting on the infinitesimal volume element $d\forall = dm/\rho$ (m = mass of the matter). The integrand of the third term is angular momentum of the infinitesimal mass element $\rho\, d\forall$. The integration gives the total angular momentum of the mass within the control volume. The last term is the rate of efflux of angular

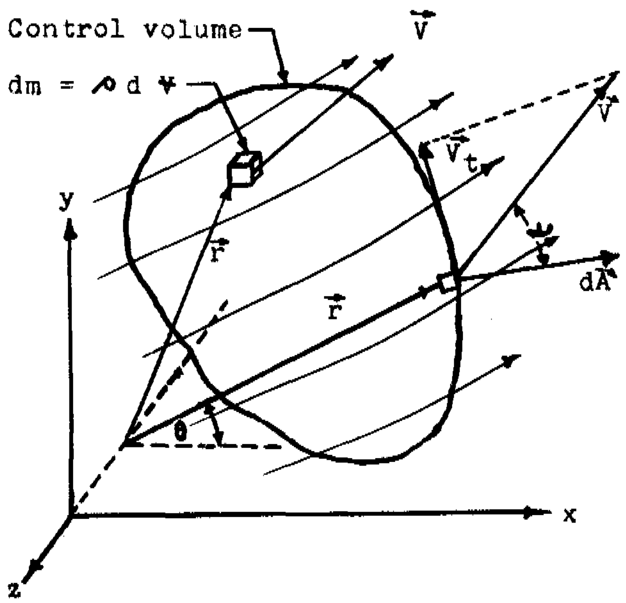

Fig. 4. Angular momentum of the mass within the control volume about z-axis.

momentum through the control surface.

In the present problem, however, the flow is assumed to be steady, the body forces negligible and since the control volume is fixed, the second and third terms of Eq. (1) vanish. Taking z-axis about which rotation of flow takes place, we have

$$\vec{T}_z = \int_{c.s.} \vec{r} \times d\,\vec{F}_s = \int_{c.s.} (\vec{r} \times \vec{V})_z \, (\rho \, \vec{V} \cdot d\,\vec{A})$$

where $\vec{T}_z$ represents the net torque acting counter-clockwise on the control volume about the z-axis and

$$(\vec{r} \times \vec{V})_z = r\,V_t \, ,$$

$$\rho \, \vec{V} \cdot d\,A = \rho \, V \cos\alpha \, d\,A$$

where V_t is the component of the velocity vector and perpendicular to the z-axis and α is the angle between the velocity vector and the area $d\,\vec{A}$. Then

$$T_z = \int_{c.s.} r\,V_t\,V \cos\alpha \, d\,A \quad \text{--- (2)}$$

Let us assume that the entire flow enters the control volume at an area A_1 and leaves at an area A_2 over each of which ρ, V and $\cos\alpha$ are uniform over the entrance section 1 and exit section 2. Also define $(r_2 V_{t_2})$ as the mean value of $r\,V_t$ over A_2 and $(r_1 V_{t_1})$ as the mean value over A_1, then

$$r_2 V_{t_2} = (1/A_2) \int_{A_2} r\,V_t \, d\,A \, ,$$

$$r_1 V_{t_1} = (1/A_1) \int_{A_1} r\,V_t \, d\,A$$

The continuity equation gives,

$$\rho_1 A_1 V_1 \cos\alpha_1 = \rho_2 A_2 V_2 \cos\alpha_2 = \rho_1 Q_1$$

Here, Q_1 is the volumetric flow rate at A_1. Eq. (2) now becomes

$$T_z = \rho_1 Q_1 (r_2 V_{t_2} - r_1 V_{t_1}) \quad \text{--- (3)}$$

Fig. (5) shows the velocity diagram for a radial flow impeller of the turbo - pump, in which $\mathcal{V}$ refers to the impeller (relative velocity) and $\vec{V}$ denotes as usual the absolute velocity relative to earth.

In the present problem (Head = 2 m., Q = 12 m.^{3}/hr. = 0.1177 cu. ft./ sec., N = 1800 r.p.m., Effy. = 57.6 %, T = 6.14 kg. cm. = 0.443 ft.-lb$_f$. and B.H.P. = 0.152 H.P.), since the flow at the impeller inlet is in the axial direction, the tangential component of velocity there, $V_{t1} = 0$. Hence, Eq. (3) is further reduced to

$$T_z = \rho_1 Q_1 (r_2 V_{t_2}) \quad \text{--- (4)}$$

Substituting the values of this problem into Eq. (4), where $\omega = (2\pi \times 1800/60)$ radians/sec. = 188.4 rad./sec.

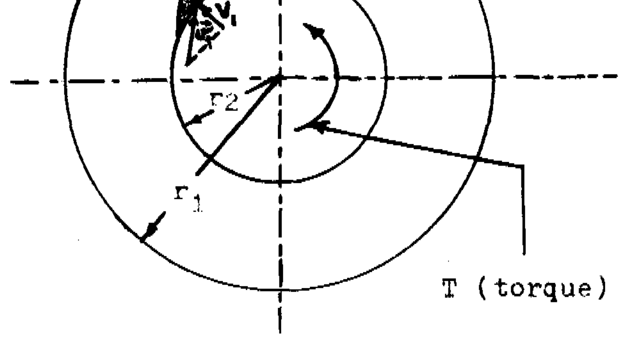

Fig. 5. Velocity diagram for a radial flow impeller of the turbo-pump.

$$0.443 = \frac{62.4}{32.2} \times 0.1177 \times \frac{r_2}{12} \times 188.4 \times (r_2 / 12)$$

$$\text{or} \quad \frac{0.443 \times 32.2 \times 12 \times 12}{62.4 \times 0.1177 \times 188.4} = r_2^2$$

$$\text{or} \quad r_2^2 = 1.488, \quad r_2 = 1.2 \text{ in.} = 3.1\text{cm.}$$

Hence, d_2 = 6.2 cm. and by keeping a ratio of 5:3 between d_2 and d_1, we have $d_1 = 6.2 \times (3/5)^2 = 3.72$ cm. However, due local manufacturing problems, the impeller diameter was doubled and kept to 12.5 cm. The other dimensions computed for the turbo-pump were as follows :

1. Diameter of suction flange = 3.75 cm.
2. Shaft diameter = 1.25 cm.
3. Impeller hub diameter = 2.25 cm.
4. Impeller eye diameter = 7.5 cm.
5. Impeller inlet diameter = 7.5 cm.
6. Vane angle at inlet = 27°
7. Impeller outlet diameter = 12.5 cm.
8. Vane angle at outlet = 35°
9. Passage width at outlet = 0.375 cm.
10. Passage width at inlet = 0.6 cm.
11. Angle of water leaving impeller = 33°.
12. Number of impeller vanes = 12.

The design data of the spiral volute for this impeller were obtained as follows (Table 1) :

Table 1. Volute design data

Reference angle	Volute width	Volute radius
0.0°	2.0 cm.	6.25 cm.
28.4°	2.4 cm.	6.50 cm.
92.6°	3.0 cm.	7.00 cm.
247.6°	4.0 cm.	8.00 cm.
430.6°	5.2 cm.	9.00 cm.

PERFORMANCE

Although the machine developed and fabricated so far is by no means perfect, the accomplished work indicates a potential for commercial development of such a unit for use of small farmers. Approximate discharge against different heads as achieved in field trials are shown in Table 2.

Table 2. Performance of manually operated turbo-pump

Head (metres)	Discharge (cu. m./hr.)
1.00	9.5
1.50	7.5
1.75	3.0
2.00	1.5
2.25	0.7

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Session 3

Chairman : Mr R Krishnaswamy
Chief Engineer, T.W.A.D. Board

Discussion

A C Chaturvedi

Rural water supply in the 1980's

1. Dr GURUSWAMY presented the paper in the absence of Mr CHATURVEDI; the main points covered included village requirements and water demands, models for planning, water re-use and intercatchment transfer, and energy requirements.

K Achuthan

The use of Markov renewal theory in rural water supplies

(The author did not attend, and had not appointed a presenter in his absence; the paper was not considered for discussion).

K M Gurappa, M R Gajendragad, G Ranganna and A N Seetharam

Groundwater for rural development - a case study

2. Mr GURAPPA introduced the paper, which presented data from a case study in the south west coastal belt of Karnataka state. Groundwater quantity and quality data were interpreted in the light of drawdown and saline intrusion, and recommendations for well dimensions and spacing made.

3. Mr DAMADORA RAO commented that a number of infiltration galleries using long laterals were giving satisfactory yields in similar conditions in the Madras coastal region.

4. Mr GURAPPA thought that this system would be applicable to the situation in many coastal regions.

5. Mr HUTTON asked whether the ion balance method had been used to check the chemical analysis before plotting the data; this in itself required a full chemical analysis.

6. Mr GURAPPA assured Mr HUTTON that this had been done, and checks and comparisons made.

7. Dr CHAUDHARY wished to know if the recommended well spacing of 60m was suitable for maximum output.

8. Mr GURAPPA replied that the annual average requirement of 12,000 m^3 has been used; observation wells had been sunk to obtain information on the cone of depression around the well.

S S Garg

Manually operated turbo pump

9. Dr GARG described experiments with a turbo pump operated by hand, which could deliver between 15 and 20 m^3 per hour against a head of less than 3 metres. The machine is cheap and portable. The vector analysis required to correctly dimension the pump was outlined.

10. Mr SHANKARAPPA asked a number of detailed questions:

11. Dr GARG replied that the pump weighed about 50 kg and was 40% efficient; the cost was Rs 750, although it was not yet commercially available; a flywheel was not required, and the main application of the pump was for small scale irrigation.

12. Mr SIVAKUMAR wondered for how long the pump could be continuously operated, and would a foot operated mechanism be more effective.

13. Dr GARG answered that 30 minutes pumping with 10 minutes rest seemed reasonable; more force was exerted in hand operation.

14. Dr BASU enquired as to the discharge pressure at a delivery of 7 m^3 per hour.

15. Dr GARG replied that it was about 7 metres.

16. Mr SARAF asked if labour and power costs had been compared, and about the problem of operator exhaustion.

17. Dr GARG replied that the pump could be used in areas which had no power; more rest periods may reduce the problem of exhaustion.

18. Mr KRISHNASWAMY remarked upon the problems in persuading people to use such a pump; experience in Tamil Nadu suggested that people were not keen on operating hand pumps. Lowering of the groundwater table created additional problems in terms of the extra energy required to raise water.

8th WEDC Conference: Water and waste-engineering in Asia: MADRAS: 1982

REUSE OF CAMPUS SEWAGE FOR PISICULTURE AND AGRICULTURE

by R PITCHAI and V S GOVINDAN

INTRODUCTION

Treatment of waste waters by stabilisation pond method has been widely accepted in tropical countries because of its simplicity, easy operation and maintenance and low cost. The waste water in a stabilisation pond is treated by the symbiotic action of aerobic bacteria and algae. Aerobic bacteria decompose the complex organic matter into simpler soluble forms which, in turn, are absorbed by algae as nutrients for their metabolic activities. The algae multiply rapidly in the system and, in turn, supply photosynthetic oxygen to bacteria to break down organic matter. The algae-laden effluent can be used for pisciculture and harvesting algal protein. The nutritive value of algae and the utilisation of effluents from fish ponds for irrigation are widely discussed in the literature. In this paper, the studies conducted on the performance of series stabilisation ponds, algal yield, utilisation of algae-laden effluent for pisciculture, rate of growth of fish in primary and secondary ponds, conversion of algal biomass into fish biomass and the utilisation of fish pond effluents for irrigation, have been discussed.

EXPERIMENTAL STUDIES

Experimental studies on waste water treatment and reuse were conducted at the Centre for Environmental Studies, Perarignar Anna University of Technology, Guindy Campus, Madras, India in a series of stabilisation ponds of size 43.5m x 16m x 1.5m. The campus raw sewage, about 160,000 lpd, was admitted, after screening, into the stabilisation pond system. The characteristics of raw sewage and effluents from ponds are presented in Table 1. The rate of purification in terms of BOD and bacterial reduction was better in the secondary pond than in the other two ponds.

ALGAL HARVESTING

The algae-laden effluents from the ponds were used for harvesting of algae by centrifugation. The amount of algae thus harvested was found to vary from 27 to 389 kg/hect/day in the stabilisation pond and 37 to 348 kg/hect/day in the primary pond. The yield of algae in the secondary pond ranged from 62 to 391 kg/hect/day.

TABLE 1. Characteristics of raw sewage and effluents

Parameters	Raw sewage	Stabilisation pond	Effluents from Primary pond	Effluents from Secondary pond
pH	6.1-7.1	6.9-8.2	8.0-9.1	8.7-9.6
D.O.	-	0-14.6	0.8-21.6	1.2-29.2
BOD	108-349	42-136	18-104	14-80
Ammonia (N)	9-18	5-10	2-6.7	1-2
Organic (N)	8-15	6-1[illegible]	5-11	2-9
Nitrite (N)	0.1-0.3	0.3-0.5	0.4-0.7	0.6-1.0
Nitrate (N)	0	0.6-1.6	1.2-3.7	3-5
Phosphate	9-19.5	8-12.6	4.6-10.9	2.3-8.0
Coliform reduction in percentage	-	97.95-99.88	99.88-99.99	99.99
Primary productivity $g\ O_2/m^2/day$	-	1.8 to 13.4	13 to 25.48	7 to 45.48

All values except pH and primary productivity are expressed in mg/l.

PISCICULTURE STUDIES

Fingerlings of four varieties of carps, viz. Cyprinus carpio, Cirrhina mrigala, Labeo rohita and Labeo fimbriatus with an average weight of 1 g and length of 1.3 cms were stocked in the ponds in a polyculture system and the growth of fish was observed by periodic netting. The results are shown in Fig.1. The average weight and length of Cyprinus carpio in primary and secondary ponds were 656 g and 32.7 cm and 831 g and 35.1 cm respectively in 205 days. In the same period, Cirrhina mrigala grew to an average weight and length of 612 g and 39 cm in primary pond, while the corresponding figures were 532 g and 35.7 cm in the secondary pond. Similar observations on comparative growth were made in the case of L.rohita and L.fimbriatus. It is interesting to note that the growth rates of C.carpio, L.rohita and L.fimbriatus were higher in the secondary pond whereas the growth rate of C.mrigala was higher in the primary pond. The total yield of fish in the primary pond was estimated to be 4245 kg/hect/yr and in the secondary pond, 7300 kg/hect/yr. The conversion factor for algal biomass into fish represented by the ratio Fish : Algae (F/A) in the primary pond ranged from 0.71 to 1.452 and in the secondary pond ranged from 0.47 to 1.24.

UTILISATION OF WASTE WATER FOR IRRIGATION

The effluent from the fish pond was used for irrigating 146 coconut trees and the yield from each tree was of the order of 50 to 120 kernels per year which could be further increased with improved agricultural practice. The data collected on the utilisation of fish pond effluents for cultivation of vegetables (Hibiscus esculentus) are recorded in Table 2. Higher yields were obtained from the plots irrigated with waste water. It is interesting to note that the number of vegetable pieces per plant and average weight were larger in all the waste water-irrigated subplots. The pieces obtained from waste water-irrigated subplots were longer and larger in circumference when compared with those obtained from fresh water irrigated subplots.

TABLE 2. Observations on growth of Ladies Finger crop

Description	Fresh water irrigated plots		Fish pond effluent irrigated plots (without fertilizer)				
	with fertilizer	without fertilizer					
	1	2	3	4	5	6	7
Number of plants	68	51	133	126	137	92	156
Total yield obtained (kg)	6.443	2.782	13.963	20.169	20.157	14.445	21.301
Calculated yield (kg/hect)	9500	5500	10500	16000	16200	15700	13700

Thus, it could be concluded that substantial benefits could be derived by controlled reuse of waste water.

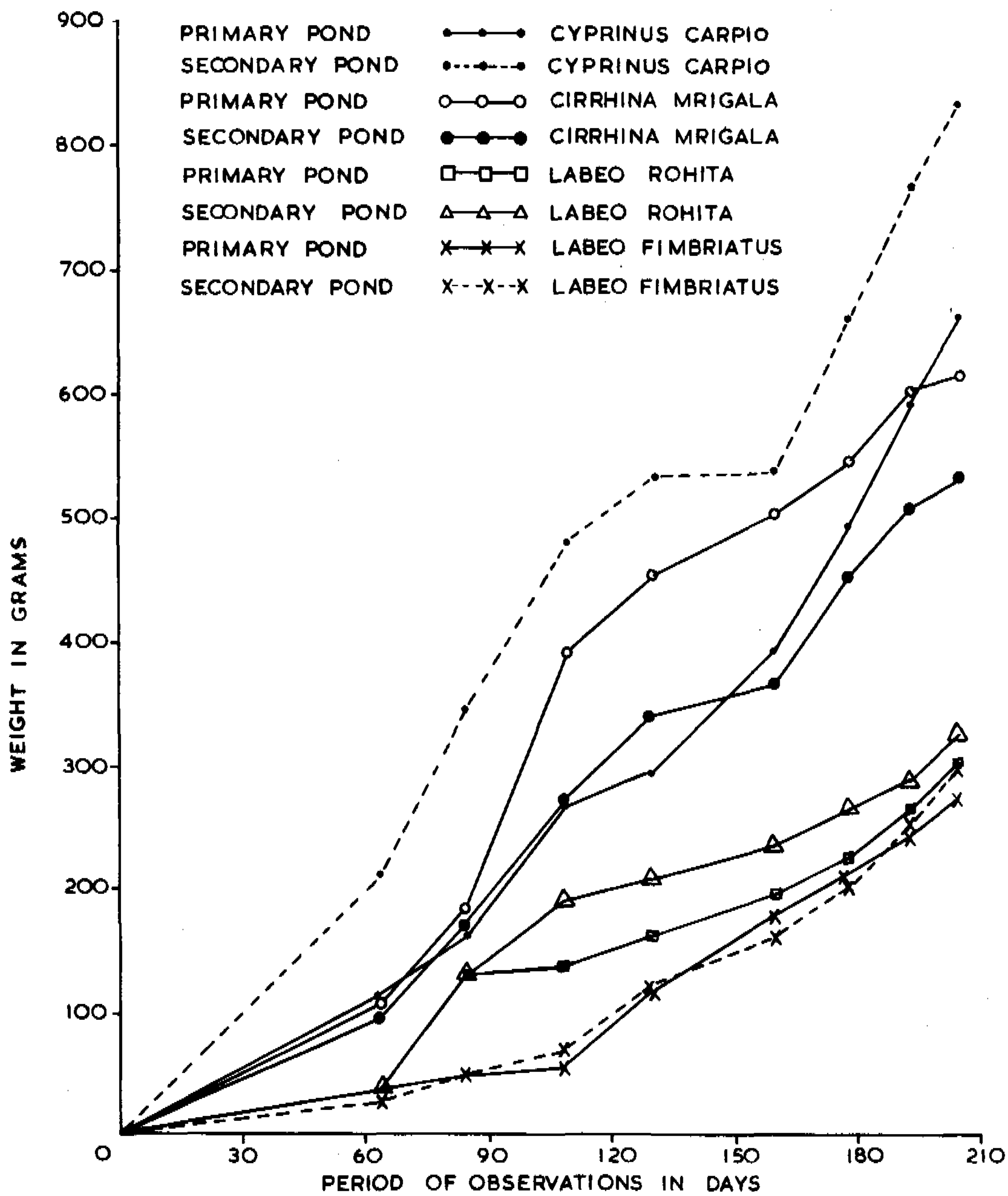

FIG. I FISH GROWTH PATTERN IN PRIMARY AND SECONDARY EFFLUENT PONDS

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INNOVATIVE ON-SITE SOIL DISPOSAL SYSTEMS FOR SEPTIC TANK EFFLUENT

by PURUSH K TERKONDA

There are many areas where the conventional septic tank-soil absorption field is not a suitable system of wastewater disposal. Sites with very slowly permeable soils, excessively permeable soils, or soils over shallow bedrock or high groundwater, for example, are simply not suited for the conventional system. However, alternate systems can be used which still utilize the capabilities of soil to absorb and purify wastewater.

Slowly Permeable Soils

Slowly permeable soils constitute a major group of problem soils. Soils with percolation rates faster than 120 min/in often have seasonal perched water tables within 2 feet of the ground surface, especially during the spring and fall. Infiltrating surface water during these wet periods is unable to percolate through the subsoil fast enough and flooding occurs from lateral movement of water through the topsoil from higher elevations. Such conditions are not suitable for conventional soil absorption systems.

To overcome these conditions, one alternative is to raise the absorption field above the natural soil by building the seepage system in a mound of medium sand. This raises the seepage system above the wet slowly permeable subsoil and places it in a dry permeable sand (see Figure 1). There are several advantages to this. First, the percolating liquid enters the more permeable natural topsoil over a large area and can safely move out laterally until absorbed by the less permeable subsoil. Second, the clogging zone that eventually develops at the bottom of the gravel trench within the mound will not clog the sandy fill to the degree it would in the natural soil. Finally, smearing and compaction of the wet subsoil is avoided, since excavation in the natural soil is not necessary.

The design of the mound is based upon the expected daily wastewater volume it will receive and the natural soil characteristics. It must be sized such that it can accept the daily wastewater flow without surface seepage when perched water exists in the natural soil in the spring and fall, as well as when the water table is lower during the summer and winter. Size and spacing of the seepage trenches is important to avoid liquid from rising into the fill below the trenches when the water table is high. In addition, the total effective basal area of the mound must be sufficiently large to conduct the effluent into the underlying soil.

A clean, medium sand is used as the fill material in construction of the mound and the gravel trenches constructed within consist of 1 - 1-1/2 inch stone. As in any seepage trench, a clogging mat will develop at its bottom. The ultimate infiltration rate through this zone has been shown to be 5 cm/day. Therefore, one consideration must be to insure that sufficient trench bottom area is available for the design flow.

If more than one trench is included, another consideration is the spacing between trenches. The area between trenches must be long enough for the underlying natural soil to absorb all the liquid contributed by the upslope trench. Infiltration rates into the natural soil is based on the hydraulic conductivity characteristics of the least permeable soil horizon below the proposed site. The basal area required for the mound is based on this as well.

To distribute the wastewater to each of the trenches a pressure distribution network is used. This provides uniform application which is necessary to prevent local overloading and eventual surface seepage.

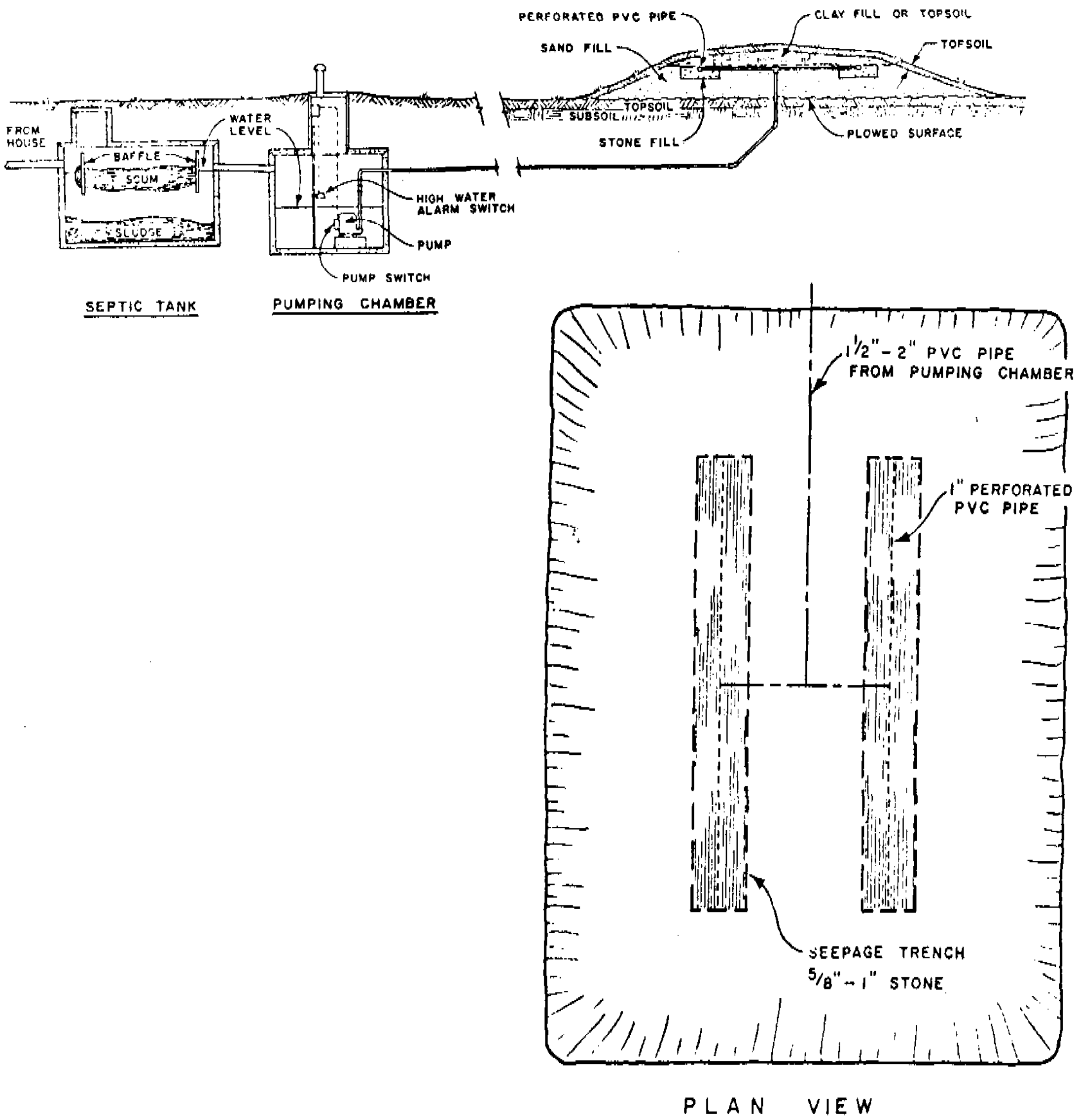

Figure 1 A plan view and cross-section of a mound system for problem soils (After Otis, et al.)

Shallow, Permeable Soils Over Creviced or Porous Bedrock

Shallow, permeable soils over creviced or porous bedrock constitute a major group of problem soils because inadequate soil is available to purify the percolating waste before it reaches the porous bedrock which leads directly to the groundwater. To overcome these limitations, the absorption field can be raised above the natural soil by using the mound system (see Figure 1). This increases the amount of soil available for percolation and with uniform application of effluent, purification will be adequate by the time the percolating effluent reaches groundwater.

The design of the mound follows the same procedures as described for the mound in slowly permeable soils. However, the seepage system within the fill may have nearly any shape desired, since the permeability of the natural soil is not a limiting factor. A bed is usually more suitable than trenches.

Permeable Soils With Seasonally High Groundwater

Mound systems

Homes should not be built in areas with a permanently high groundwater table. However, in some areas, homes are built where the water table is high only occasionally during the year. During high water table periods, a conventional septic tank-soil absorption system cannot function properly due to flooding of the system and improper purification. A properly designed and constructed mound system provides sufficient unsaturated distance for purification before the effluent reaches the groundwater (Figure 1). The design of the mound follows the same procedures as described for the mound in slowly permeable soils but the seepage system within the mound is usually a rectangular bed. Normally the permeability of the natural soil is not a limiting factor but the mound must be designed to prevent the intrusion of the perched water table to the base of the mound.

Curtain or underdrain systems

Conventional subsurface trenches can be constructed where periodic high water tables are a problem if the natural soil is drained. Agricultural drain tile is used to lower the water table and to discharge the water to the ground surface. Careful placement of the drain is necessary to insure a sufficient depth of unsaturated soil is maintained for purifying the wastewater to avoid short circuiting.

There are disadvantages to these alternate systems. Construction of mound systems depends upon a source of suitable fill material and relatively large lots. Mounds cost $2500 to $3500 or more to construct depending on hauling costs. Underdrain systems may be cheaper but systems not dependent on soil for disposal sometimes may be more desirable.

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REARING OF FISH FRY OF INDIAN MAJOR CARPS IN SEWAGE STABILISATION PONDS

by H L BHATIA and C A SASTRY

Introduction

While much work has been done on the design, construction and performance of stabilisation ponds in India (1), very little information is available on the rearing of fish fry in them (2) even though utilisation of sewage for fertilising fish ponds is in practice since long in and around Calcutta (3). The present investigation was undertaken to study the suitability of secondary sewage stabilisation ponds for rearing cypronoid fish fry and comparing their rate of growth with those reared in regular nursery ponds.

Materials and Methods

The observations reported in this communication were made in Shahpura sewage stabilisation ponds at Bhopal. These stabilisation ponds are located 3 k.m south of T.T.Nagar and are designed to treat 13.5 Mld of domestic sewage from different areas. Sewage from these areas is collected in a sump near Habibgunj Railway Station from where it is pumped to stabilisation ponds. There are four pond ponds each of 220 m x 55 m x 1.3 m. Each pond is divided into two equal compartments known as primary pond and secondary pond. There are three inlets and three outlets in both the primary and secondary ponds. The outlet of the primary and the inlet of the secondary pond are connected by cement pipes. The sewage enters the primary pond through three inlets and the effluent goes out from the second pond through these outlets.

Fish fry were introduced both in secondary stabilisation pond and the nursery pond in Patra Fish Farm, Bhopal and growth rates compared. A consignment of 48000 of fish by (C. catla 1.2% average size 30 mm, L. rohita 9.1% average size 25 mm, L. calbasu 0.8% average size 20 mm and C. mrigala 88.9% average size 30 mm) was put in one of the secondary ponds. Another consignment of 15000 fish fry (C. catla 0.5% average size 20 mm, L. rohita 0.5% average size 16 mm, L. calbasu 0.7% average size 18 mm and C.mrigala 98.3% average size 18 mm) from the same stock was put on the same day in a regular nursery pond of 26 m x 13 m x 1.3 m at Patra fish farm, Bhopal, about 11.2 km north of the stabilisation ponds for studying the comparative rate of growth of young fish. Before introducing the fish fry in rearing pond, the pond was dewatered, limed at 120 kg per hectare and manured with cow dung at 10000 kg per hectare after filling with water. The young fish in the pond were daily fed on powdered mustard oil cake.

Plankton samples were collected by passing 50 litres of sewage or effluent through a plankton net and samples were immediately preserved in 4% formaline. Chemical and biological analysis was carried out as per Standard Methods.

Physico-Chemical and Biological Conditions of Sewage in Stabilisation Ponds and Water in Nursery Pond

Physical

Sewage in waste stabilisation ponds was greenish in colour and was weak. Temperature varied from 26.5° to 32° C while turbidity varied from 60 - 150 mg/l.

Chemical

Chemical Composition of influent to and effluent from secondary stabilisation pond and water in nursery pond are shown in Table 1.

Biological

Secondary stabilisation pond was found to be devoid of macrovegation through out these investigations. Plankton samples were periodically

Table 1

Chemical Composition of Influent to and effluent from secondary stabilisation pond and nursery pond

Chemical Analysis	Influent to Secondary pond	Effluent from Secondary pond	Rearing or nursery pond
pH	7.8-10.0	8.2-9.6	7.8-8.0
Free Carbon-dioxide	0.0-6.0	0.0-6.0	0.0-4.0
Total alkalinity ($CaCO_3$)	104-256	142-270	186-274
Dissolved Oxygen	2.4-23.6	1.8-16.8	3.2-10.0
Hydrogen Sulphide	Nil	Nil	Nil
Total Phosphate(P)	2.1-4.3	0.6-1.8	2.6-5.8
B.O.D	39-76	30-44	-

collected and examined. Observations made are shown in Table 2.

Secondary stabilisation pond was found to be rich in zooplankton which are more needed for faster growth of young fish. Plankton present did not show any qualitative or quantitative uniformity. Among phytoplankton, Crucigenia and Apacystis dominated in secondary pond. Among zooplankton forms, Eubranchipus and Cyclops dominated.

Diurnal Variation in the Chemical Composition and Plankton in Secondary Pond

Diurnal variation in chemical composition and plankton was studied. Samples were collected round the clock at the interval of every three or four hours and they were analysed on the spot. Results obtained are

Table 2

Qualitative and Quantitative Composition of Plankton in Secondary Pond

Plankton	Percentage by number of plankton in secondary pond on different days			
	1	2	3	4
Total Plankton (ml/50 ml)	0.2	0.6	2.5	1.3
Zooplankton				
1. Protozoans	2.5	-	0.7	1.7
2. Crustaceans				
Cyclops	35.0	8.5	48.0	9.0
Eubranchipus	10.0	12.0	24.0	2.0
Diaphanosoma	10.0	2.1	-	-
Moina	2.5	-	0.6	-
Nauplis	7.5	1.4	10.0	-
Simacephalus	-	-	3.3	8.3
Scapholeberis	-	1.4	-	-
Polyphemus	-	0.7	-	-
3. Ostracods	7.5	-	-	10.0
4. Rotifers				
Branchionus	10.0	-	0.7	1.0
Chromogaster	-	-	5.3	-
5. Phytoplankton				
Myxophycea	2.5	-	4.7	72.0
Chlorophyceae	2.5	73.9	0.7	-
Closterium	2.5	-	-	1.0
Diatoms	7.5	-	2.0	4.0

shown in Table 3 and 4.

Dissolved oxygen in secondary pond was never below 4.8 mg/l. Hydrogen sulphide was also absent. Phytoplankton were represented by more varieties of forms in the afternoon than in the early hours of the day. Rotifers and crustaceans which form the basic food of young cypronoids, constituted majority of the zooplankton present in secondary pond.

Table 3

Diurnal variation in chemical composition of sewage in secondary stabilisation pond

Time	pH	D.O	Carbonate alkalinity ($CaCO_3$)	Bicarbonate alkalinity ($CaCO_3$)
1.30 PM	9.0	11.6	54	154
4.30 PM	9.5	16.8	50	148
7.30 PM	8.5	13.2	44	154
10.00 PM	9.0	11.2	22	158
1.30 AM	9.0	5.2	36	160
4.30 AM	9.0	4.8	36	160
7.30 AM	9.6	7.2	44	148
10.30 AM	9.9	7.6	40	156

Table 4

Diurnal variation in percentage Composition of Plankton in Secondary Pond

Plankton	Time			
	1.30 PM	7.30 PM	4.30 AM	10.30 AM
Total Plankton (ml/50 L)	0.5	0.7	1.9	1.1
	Percentage by number			
Protozoans	3.8	-	-	-
Crustaceans	31.4	12.7	47.9	48.3
Rotifers	1.9	-	-	-
Myxophyceae	57.1	78.2	51.2	48.5
Chlorophyceae	-	-	-	1.1
Bacillorophyceae	5.8	17.1	-	2.1

Growth of Fish Fry in the Secondary Stabilisation Pond and in the Rearing Pond

The growth rate of fish fry in secondary stabilisation ponds was compared with the growth rate of fish fry in a well managed nursery pond over a period of 2 months. The average size and weight of the fishes in all the ponds were found out at different times by netting them out using nursery nets. Results obtained are given in Table 5 and 6.

No fish mortality was noticed in the ponds during the period of study. Fish were found to be quite healthy both in secondary stabilisation pond and nursery pond.

The rate of growth of young fish in the secondary stabilisation pond was faster than in the nursery pond. It is known that it is difficult to maintain the same density of zooplankton in nursery ponds with a heavy population of fish fry in them (5). As sewage is fed regularly to the ponds the density of zooplankton is maintained in the secondary pond. The rate of growth of young fish was high in secondary sewage stabilisation pond as it maintained comparatively rich zooplankton crop and provided ideal hydrological conditions for the rearing of carp fry.

Conclusions

1. A study was made on the possibility of rearing fish fry in secondary sewage stabilisation pond. Rate of growth of fish fry of C.catla, L.rohita, L.calbasu and C.mrigala was compared in secondary waste stabilisation pond and a well managed nursery pond.

2. The rate of growth of fish fry was more in secondary sewage stabilisation pond as it was found to provide the optimum hydrological conditions for their growth. This was ascertained by analysing the samples from both the ponds on different days and by studying diurnal variation in chemical and biological characteristics on some other days.

Table 5

The growth rate of young fish in secondary stabilisation pond

Fish species	Days				
	0	17	30	43	49
C.catla					
Length (mm)	3.0	-	-	-	187
Weight (gm)	0.34	-	-	-	100.7
L.rohita					
Length (mm)	25	55	-	-	125.0
Weight (gm)	0.16	3.0	-	-	26.3
L.calbasu					
Length (mm)	20	-	94	128.5	142.0
Weight (gm)	0.1	-	11.4	26.9	33.0
C.mrigala					
Length (mm)	30	26	73	98.5	111
Weight (gm)	0.33	2.0	4.6	9.2	15.3

3. Nutrient materials present in the effluent in the secondary pond can thus be profitably utilised for rearing fish fry in them.

Table 6

The growth rate of young fish in nursery pond

Fish species					
	0	20	33	43	49
C.catla					
Length (mm)	20	45	70	120	120
Weight (gm)	0.08	0.55	18.2	30.0	30.0
L.rohita					
Length (mm)	16	-	65.0	72	72
Weight (gm)	0.3	-	3.05	3.33	3.35
L.calbasu					
Length (mm)	16	38.0	58.5	-	65.0
Weight (mm)	0.035	0.44	2.65	-	3.0
C.mrigala					
Length (mm)	18	48	65	-	68
Weight (gm)	0.03	0.50	4.02	-	6.00

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LOW COST WASTE TREATMENT METHODS FOR TREATING PHARMACEUTICAL WASTES

by B V S GURUNADHA RAO and C A SASTRY

INTRODUCTION

One of the industrial wastes of serious consequence from the point of view of water pollution in India is the waste water from pharmaceutical industry. A large number of pharmaceutical units are there in India discharging waste waters containing various organic and inorganic pollutants.

While considerable work has been carried out in other countries on the treatment of pharmaceutical wastes (ref. 1,2), no work has been carried out in India (ref. 3,4). With this in view the studies presented in this communication were carried out. An inplant survey was carried out in a pharmaceutical factory producing Calcium sennocide, diosgenin, Mebendozole benzyl ether, cycloester and sennocide tablets. The treatability of the waste waters from this industry using low cost waste treatment methods was studied. Results obtained are presented in this communication.

PROCESS DETAILS

There are six units in the factory studied producing different products as described below.

Calcium sennocide unit

The basic raw materials used are senna leaves and ethyl alcohol. An extract of the senna leaves is prepared using alcohol and sennocides are precipitated from the extract as calcium sennocides with calcium chloride solution. The mother liquor is distilled and distillate recovered. The remaining mother liquor amounting to 100 lpd is discharged as waste water.

Diosgenin unit

Dioscorea roots are treated with hydrochloric acid and the mixture is filtered.. The filtrate containing acid is neutralised with lime and discharged into the drain. From the solid retained on the filter, diosgenin is extracted with petroleum solvent. The spent cake is used as fertiliser while the petroleum solvent is recovered. The diosgenin extract is concentrated and used.

Mebendozole unit

In the mebendozole unit 3,4-diaminobenzophenone is converted using thiourea and acetic acid into mebendozole. In a month about 10 batches are processed. About 2400 litres of waste water per batch containing unreacted methyl chloroformate, acetic acid and dimethyl sulphate is discharged.

Benzyl ether unit

In the first step a mixture containing acetyl methyl salicylate, aluminum chloride, ethylene dichloride and dimethyl sulphate is reacted with benzyl bromided and the intermediate obtained is precipitated using 40 litres of hydrochloric acid. The quantity of waste water generated during this step is about 1200 litres per batch including wash water. In a month 20 batches are processed in this way. Hence the total quantity of waste water discharged is 24000 litres per month or 80 lpd. In the second step the prcipitated intermediate obtained with benzyl bromide and dimethyl sulphide to produce benzyl ether. In a month six batches are processed using second step and discharging 6000 litres of waste water per month.

Cycloester unit

In the first step, diethyl oxalate is treated with methanol and sodium and converted into an intermediate which is further treated in second step with sulphuric acid to produce cycloester precipitate. The precipitate is filtered and the filtrate is discharged as waste water. The quantity of waste water discharged from first and second steps are 7200 litres and 30000 litres per month respectively.

Sennocide tablet unit

Calcium sennocide is made into tablets About 15 million tablets are produced per month. As this is dry process there is no liquid effluent from this operation.

TABLE 1

CHEMICAL CHARACTERISTICS OF WASTE WATER FROM DIFFERENT UNITS IN THE FACTORY
(All results except pH are expressed in mg/l)

Unit	pH	COD	BOD	Chlorides (Cl)
1. Calcium sennocide	4.6	501120	205800	16600
2. Diosgenin	10.5	92016	45080	1600
3. Mebendozole	0.5	122750	65750	1550
4. Cycloester				
(a) First step	2.2	48168	20150	325
(b) Second step	0.5	156780	80900	4100
5. Benzyl ether				
(a) First step	6.5	171071	80350	120
(b) Second step	3.2	-	-	190

NATURE AND CHARACTERISTICS OF WASTE WATER

Water is used in the process for extractions and washing of various units of the plant. Floor washings also contribute to the waste flow. Raw water of about 45 cum/day is obtained from a bore well. About 20 cum/day is used in the process and the rest for gardening, laboratory, canteen, boiler feed etc.

Waste water is discharged from the processes where calcium sennocide, diosgenin, mebendozole, benzyl ether and cycloester are produced. Waste water is also discharged from water treatment plant, boiler house, laboratory and canteen. Equipment and floor washing waters are discharged as waste water. The total quantity of waste water discharged is about 30 cum/day. Waste water from calcium sennocide unit, diosgenin unit, cycloester unit, water softening plant, boiler house, equipment and floor washings are discharged daily but intermittently. Effluent from mebendozole unit is discharged once in three days. The waste water from benzyl ether unit is discharged once in 36 hours in the first step and once in 120 hours in the second step.

Samples of waste water were collected on different days and analysed as per procedures given in Standard Methods. Results obtained are shown in Table 1.

Combined waste water is obtained after proportional mixing of various sectional wastes based on flow and analysed. Results obtained are shown in Table 2.

LABORATORY STUDIES ON TREATMENT

Equalisation and preaeration

As the nature of discharges from various operations are intermittent, it is felt necessary to equalise the effluent flow. Effluents from different sections as well as from canteen are equalised for 5 days and the characteristics of equalised effluent was studied. The equalised waste showed a pH of 4.0, BOD of 95000 mg/l, COD of 100000 mg/l and suspended solids of 2000 mg/l.

As the equalised effluent still contained volatile substances like benzyl ether, alcohol, petroleum solvent it is felt necessary to preaerate the effluent. The equalised effluent is preaerated using diffused aeration with an aquarium aerator for different aeration periods. Samples were analysed at different aeration periods. It is found that aeration for 2 hours resulted in a BOD reduction of 30% and BOD of the aerated effluent was 66500 mg/l.

Neutralisation and settling

The equalised and preaerated effluent is then neutralised with sodium bicarbonate to a pH of 7.0 and settled for 3 hours. Samples were drawn from the settling unit and analysed. The neutralised and settled effluent had a BOD of 46550 mg/l.

TABLE 2

CHARACTERISTICS OF COMBINED WASTE WATER FROM THE INDUSTRY
(All results except pH are expressed in mg/l)

Characteristics	1	2
pH	3.6	3.4
Acidity ($CaCO_3$)	35	50
COD	219520	320000
BOD	120000	130000
Suspended Solids	2000	1200
Nitrogen (N)	5700	4080
Phosphorous (P)	1300	1200

TABLE 3

PERFORMANCE OF ANAEROBIC LAGOON IN THE TREATMENT OF NEUTRALISED AND EQUALISED WASTE WATER

Raw waste characteristics : BOD : 46550 mg/l pH : 7.0

Parameters	Detention Time in days				
	70	60	50	40	30
pH	8.2	7.9	7.2	7.0	6.7
Volatile acids as CH_3COOH mg/l	2000	2100	2500	3100	4700
BOD mg/l	3724	4655	9310	13965	23275
% reduction in BOD	92	90	85	70	50
BOD Load (kg/cum/day)	0.33	0.39	0.47	0.58	0.78

TABLE 4

PERFORMANCE OF SECONDARY ANAEROBIC LAGOON USING EFFLUENT FROM PRIMARY LAGOON

Influent characteristics : BOD : 4655 mg/l pH : 7.9

Parameters	Detention Time in days			
	50	40	30	20
pH	8.6	8.4	8.2	8.1
Volatile acids as CH_3COOH mg/l	1400	1690	1950	2800
BOD mg/l	1496	1512	2794	3700
% reduction in BOD	68.5	67.5	40	20.5
BOD Load (kg/cum/day)	0.09	0.12	0.15	0.23

Biological treatment of waste water

Anaerobic lagoon : Since the effluent after neutralisation and settling has a BOD of about 46550 mg/l, it is felt necessary to treat the effluent biologically to remove the biodegradable organics. Experiments were carried out to study the possibility of treating the waste water in anaerobic lagoon. Laboratory lagoon with a capacity of 5 litres was used with 1.65 litres of seed sludge made upto 5 litres with waste water. The lagoon was initially operated at 70 days and 60 days detention time. Detention time was then gradually reduced to 40 and 30 days. Performance data of the lagoon is shown in Table 3.

With gradual decrease in detention time from 70 days to 30 days the pH of the waste water in the lagoon reduced from 8.2 to 6.7. The BOD removal varied from 50% at a loading of 0.78 kg/cum/day to 92% at a loading of 0.33 kg/cum/day. At 60 days detention time and a loading of 0.39 kg/cum/day, the BOD removal was 90%.

From the results in Table 3, it can be seen that the effluent from the lagoon at a detention time of 60 days showed a BOD of about 4655 mg/l. It was felt necessary to treat the effluent by a secondary lagoon. The effluent from the primary lagoon was further treated in a secondary lagoon. Detention time was varied from 50 days to 20 days. The results of performance of secondary lagoon are given in Table 4.

The BOD removal in secondary lagoon varied from 20.5% at a loading of 0.23 kg/cum/day to 68.5% at a loading of 0.09 kg/cum/day. It would appear that 40 days detention time in secondary lagoon would be sufficient to bring down the BOD to 1512 mg/l. The waste water has to further treated in an aerobic system to bring down the BOD to 30 mg/l.

Extended Aeration : The system was initially started with sewage and as the sludge built upto 4000 mg/l, the substrate was replaced by dilute effluent from the secondary lagoon of 40 days detention. The concentration of the effluent was increased in several steps and finally undiluted effluent was fed. This was to acclimatise the sludge to the new waste water. When stabilised conditions of operation was evidenced by the presence of active bacterial culture together with ciliate protozoa, experiments were started. The effluents were drawn after fixed time of aeration. and analysed. The

TABLE 5

PERFORMANCE OF EXTENDED AERATION SYSTEM USING WASTE WATER AFTER SECONDARY ANAEROBIC LAGOON

MLSS : 4000 mg/l

Detention Time in days	BOD mg/l	% reduction
0	1512	-
1	302	80
2	100	93.3
2.5	45	97
3	30	98

results are presented in Table 5.

From the table, it can be seen that the BOD of the waste water is reduced to 30 mg/l after aeration for 3 days.

CONCLUSIONS

1. An in-plant survey was carried out in a typical pharmaceutical unit producing calcium sennocide, diosgenin, mebendozole, benzyl ether, cycloester and sennocide tablets discharging a waste water of 30 cum/day.

2. The combined waste water from the factory had a pH of 3.4 - 3.6 and a BOD of 120000 to 130000 mg/l.

3. Equalisation of the combined waste water for 5 days reduced the BOD to 95000 mg/l which is further reduced to 66500 mg/l by preaeration for 2 hours.

4. When the equalised and preaerated combined waste water is neutralised to a pH of 7.0 and settled for 3 hours BOD reduced to 46550 mg/l.

5. Treatment of the preaerated combined effluent in two anaerobic lagoons in series with a detention time of 60 and 40 days respectively reduced the BOD to 1512 mg/l.

6. When the lagoon treated effluent is further treated in an extended aeration unit with a detention time of 3 days the BOD could be brought down to about 30 mg/l.

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UNCONVENTIONAL LOW COST SIMPLIFIED SEWAGE TREATMENT BY ROTATING BIOLOGICAL CONTACTOR AND ANAEROBIC (UPFLOW) FILTER SYSTEM

by V RAMAN and A N KHAN

ABSTRACT

Rotating biological contactors or biological discs and septic tank systems followed by anaerobic (upflow) filter or composite anaerobic (upflow) filter are some of the simple treatment devices relevant to semi-urban and urban fringe areas, rural areas and institutions where localised collection and treatment of sewage could be expedient. Laboratory, pilot plant and field scale studies carried out at National Environmental Engineering Research Institute, Nagpur have clearly established the feasibility of these systems and brought out the process design criteria and operational aspects. The paper brings forth briefly the salient features of the studies.

INTRODUCTION

Considering the various constraints that stand in the way of providing conventional sewerage and sewage treatment systems, the alternative is to go in for low cost simplified sewage treatment or sanitation systems, which are also hygienic and appropriate to local conditions. Low cost pour flush sanitary water seal latrine systems for individual houses is one alternative. In water logged and flooded areas, rocky areas, fissured rocks and chalk formations, these may become unsuitable from construction and underground pollution travel point of view. Adoption of alternative systems need to be given consideration. Rotating biological contactor (or biological disc), septic tanks followed by anaerobic (upflow) filter or composite anaerobic filter system followed by polishing by grass plots, are some of the unconventional simple treatment devices applicable to treat domestic sewage from small communities, institutions and urban fringe areas. The aspects regarding the feasibility of these systems, operational data and the process design criteria based on laboratory and pilot plant studies are presented briefly.

ROTATING BIOLOGICAL CONTACTOR (RBC) OR BIOLOGICAL DISC.

Experiments were conducted at NEERI, Nagpur on a prototype rotating biological contactor or biological disc followed by a secondary settling tank for treating domestic sewage. The disc chamber consists of mild steel hermispherical drum with 40 PVC circular discs of one meter diameter centrally fixed to a revolving horizontal cylindrical shaft, rotating at 5 rpm and with a clear spacing between the discs of 2.5 centimeters. The discs are half immersed in sewage and the shaft is driven by a 1.5 KW geared motor and pulley drive (Fig. 1). The treatment process is basically aerobic.

Observations (Ref. 1,2) were made with pumped screened raw sewage, and settled municipal sewage during the period 1977-1980. Flow rate was controlled at 0.45 to 0.55 cubic meter per hour, which provided detention time of 1.25 to 1.3 hours in the disc chamber and 1 to 1.2 hours in the settling tank. The experiments were conducted with the disc chamber closed with a mild steel hemispherical cover with small perforations. Summary of the results are presented in Table-1 for RBC system treating raw sewage, without presettling.

Reduction of BOD_5 and suspended solids to the extent of 77 to 90 per cent and 65 to 94 per cent respectively was observed at organic loading rate of 16.0 to 22.3 grams of BOD_5 per square meter of disc area per day for treating screened raw sewage of BOD_5 varying from 200 to 250 mg/l, and the power consumption was found to be 1.0 to 1.2 kilowatt hours per kilogram of BOD_5 removed. The dissolved oxygen in disc chamber was around 1 mg/l. The systems efficiency was not significantly affected due to intermittent sewage flows especially when there was no flow in the night time.

The efficiency of biological disc (Ref. 3) with reference to BOD_5 for treating settled sewage improved

Table -1 : Performance Data of Pilot RBC* system for treating raw sewage.

Raw sewage Temp.: 25° to 33°C. (Average values)

Parameters		Period 1979	1980
Hydraulic Loading, $m^3/m^2/day$		0.078	0.09
Organic Loading, BOD_5 gm/m^2/day		20.7	16.7
BOD_5, mg/l	Inf.	255	186
	Eff.**	45	31
COD, mg/l	Inf.	662	608
	Eff.**	72	105
SS, mg/l	Inf.	466	156
	Eff.**	54	22

* enclosed with perforated cover.
** after settling.

to an extent of 10 percent compared to that of treating raw sewage. It was also observed that a reduction of 5 to 10 per cent in the overall BOD_5 removal efficiency of closed disc system compared to that of the disc chamber kept open or exposed.

The cost of the prototype biological disc system (including motor drive, settling tank) comes to Rupees 16,000/- (£ 1 = Rupees 18/-) based on rates as in 1977. Such a unit is capable of treating 0.5 cumeter per hour of domestic sewage, equivalent to a contributory population of 80 to 100 persons. The major portion of the cost is consumed by the PVC discs to the extent of Rs. 5,000/-. If the PVC discs are replaced by netted plastic or natural cane webbed over circular steel or wooden rib with spokes, the cost of the discs comes down to about Rupees 1,500/-.

Two of such modified discs were installed in the chamber and were found to function well. Further experiments are under way using inexpensive discs consisting of web or mesh with plastic or wooden cane, netted in a circular steel or wooden rib with some spokes.

ANAEROBIC (UPFLOW FILTER)

The anaerobic filter is an upflow submerged contact filter where the wastewater is introduced from the bottom, unlike the conventional trickling filter. The microbial growth is retained on the stone media making possible higher loading rates and efficient digestion anaerobically. The anaerobic (upflow) filter was successfully tried for low strength settled and raw domestic sewage. This was also used as secondary treatment device for treating septic tank effluent (Ref. 3,4) in areas where dense soil conditions, high water table and limited availability of land preclude conventional soil absorption or leaching system for effluent disposal. The effluent from the anaerobic filter could be further 'polished' by passing through a grass plot, where the effluent could pick up some dissolved oxygen, resulting also in further reduction of BOD. The observations on the performance of field filter treating raw sewage, and the grass plot for polishing the filter effluent are briefly discussed.

A masonry filter box rectangular in plan of dimensions 1.6m x 1.6m x 1.4m deep (Fig. 2) was constructed in the NEERI campus, Nagpur. The filter was filled with stones of 2.0 to 2.5 cms diameter sizes to a depth of 1.2 meters supported over 15 cms thick of stone media of size 7.25 cms. The media rested on wire

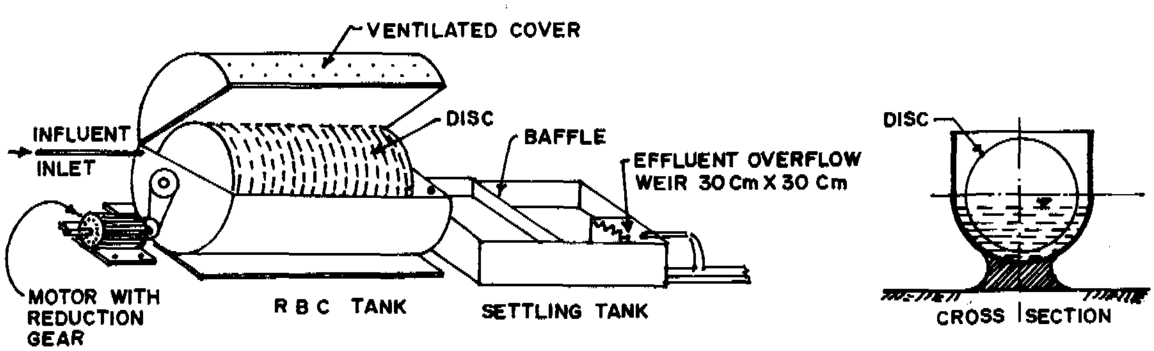

FIG. 1. RBC PILOT PLANT WITH COVER, WITH SETTLING TANK

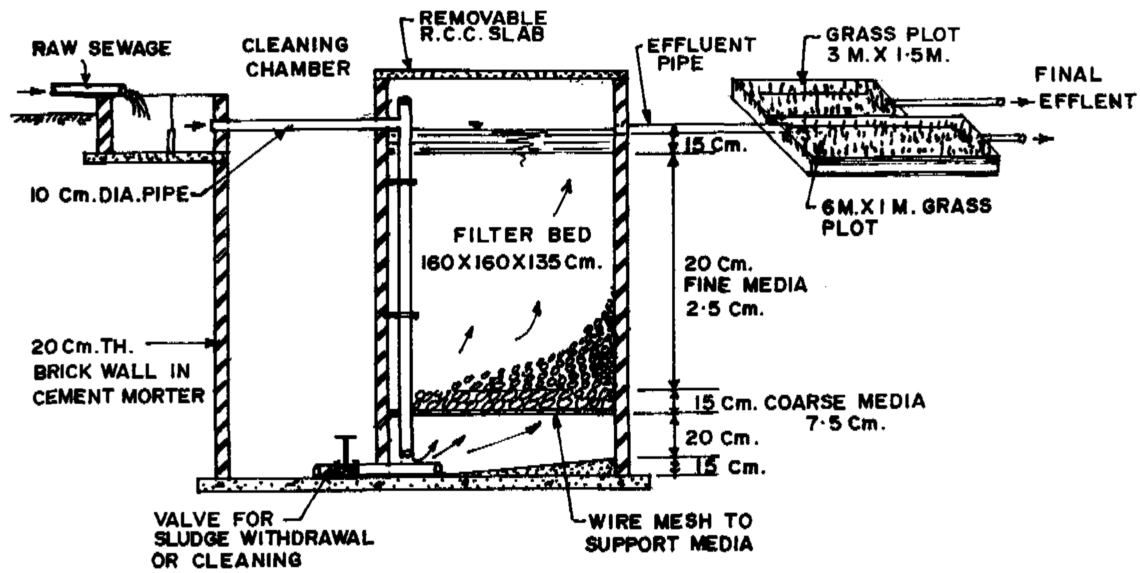

FIG. 2. UPFLOW ANAEROBIC FILTER

mesh. Municipal domestic sewage pumped from a municipal sewer was discharged over a V-notch and passed through the filter from the bottom. The pilot field filter can treat sewage from a small community of 40 to 60 persons. The flow was maintained at a rate of 0.42 m^3/hr for a period of 8 to 10 hours daily while during the rest of the period in a day there was no flow. The detention time works out to 6 to 8 hours. The results are summarised in Table.2. Reduction of BOD_5 to the extent of 70 to 85 per cent was obtained depending on influent BOD_5 concentration while suspended solids removal was of the order of 80 to 89% and turbidity reduction of 70 to 75 per cent. Increase in ammonia concentration in the effluent was noted. The effluent was relatively clear and did not emanate any noticeable odour. The filter could work continuously for a year to 1½ years before clogging sets in. By flushing water from top and desludging from bottom, the filter can work continuously.

GRASS PLOT

Overland flow through grass plots was used for 'polishing' of the anaerobic filter effluent. Dub-grass (Cynodon sp.) was grown in small plots of size 3m x 1.5m and 6m x 1m (Fig. 2). The filter effluent was allowed to flow over these grass plots every alternate day. There was build up of dissolved oxygen (1 to 2 mg/l) and further reduction in BOD as the effluent flowed out of the grass plot (vide Table 3).

Table-2: Performance Data of Anaerobic Contact Upflow Field Filter Treating Raw Sewage (Average Values)

Hydraulic Loading: 0.42 m^3/hour
Average Temp. of Sewage: 29°C to 30°C
Detention Time: 6 hrs.
Period: 1979.

Parameters	Influent	Effluent	Efficiency %
BOD_5,mg/l	210 (112-310)	43 (12-82)	79.5
S.S	272 (54-336)	22 (10-44)	88.5 -
NH_3-N	41	52	-
pH	7.3	7.4	-

Table-3 : Overland Flow Grass Filtration of Anaerobic Filter Effluent.

Period: 1980.

Parameter	Influent Raw sewage	Anaerobic filter Effluent	Final Effluent after grass plot
BOD_5 mg/l.	230 (120-310)	74 (35-132)	49 (14-105)
S.S	212 (98-350)	92 (35-132)	55 (14-87)
D.O.	nil	nil	1.0 (0.2-2.0)

CONCLUSIONS.

Rotating Biological Contactor (RBC) and Anaerobic filter systems are simple to construct, and operate at low head loss and are relatively free from odour nuisance. RBC system is compact, has simple mechanical gadgets and power consumption is moderate, while the anaerobic filter does not have any mechanical gadgets. Both can function satisfactorily when the flow of sewage is intermittent.

RBC can be operated with raw sewage instead of settled sewage, thereby eliminating presettling tank. Even though the efficiency is lower with raw sewage compared to settled sewage, the performance can be improved by increasing the detention time of disc and settling chamber of pilot plant and decreasing the organic loading rate to get an efficiency more than 90 per cent.

The anaerobic filter can function as a composite secondary treatment device in which case the sewage should be free from grit and preferably partly homogenised. The filter can also be used as a secondary treatment device for treating effluent from septic tanks. Overland grass filtration treatment of filter effluent will be an useful adjunct for further 'polishing' the effluent from filter or RBC. The RBC system, septic tank followed by anaerobic upflow filter and grass plot, or composite anaerobic upflow filter followed by grass plot are suitable for treating sanitary sewage from institutions, small communities and individual houses. Based on the studies so far, the process design criteria can be briefly stated as follows:

<u>RBC</u> for <u>treating raw sewage</u>.

Organic Loading rate to disc chamber: 16 to 20 gms BOD_5/m^2/of disc area/day.

Overall BOD removal efficiency: 90%

Detention time in disc chamber	: 1.5 hrs.
RPM of disc	: 5
Temp. of sewage	: 23 to 32°C.
Influent BOD concentration	: 200 to 300 mg/l

<u>Anaerobic Filter</u>

Media (Gravel, broken stone)
Size of media : 1.9 cms to 2.5 cms.
Depth of media : 115 cms to 125 cms.
Hydraulic Loading rate: 3.4 m^3/m^2/day.
Temp. of sewage : 23°C to 33°C.
BOD removal efficiency: 70 to 80% for influent BOD concentration of 110 mg/l to 300 mg/l.

<u>Grass Plot</u>: Hydraulic Loading 0.8 to 1.5 m^3/day/sq.meter of area minimum 2 plots.

ACKNOWLEDGEMENTS

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8th WEDC Conference: Water and waste engineering in Asia: MADRAS: 1982

STUDIES ON THE PRODUCTIVITY OF AIR BREATHERS AND CROP PRODUCTION IN WASTE WATER

by K P Krishnamoorthi, M M Parhad G B Shende and B B Sundaresan

INTRODUCTION

Recycling and reuse of nutrients and other valuable materials in domestic and industrial wastes is one of the effective methods for utilising the waste waters. Use of sewage for aquaculture followed by agriculture could be adopted in several regions of the developing world. Consideration is to be given not only to cost but also to health and environmental factors. Utilisation of waste waters through reuse and recycling is increasing in importance, since waste water is a resource rather than waste, as it contains appreciable amount of nitrogen, phosphorus and potash.

The stabilisation pond which functions utilising solar energy and bacterial algal symbiosis is an effective low cost system. Effluent from the stabilisation pond contains nutrients, phytoplankton, zooplankton and bottom fauna which are ideal fish food. An integrated and environmentally compatible system can be practised for fish culture and the effluent can be used for cultivation of short-term, long-term, ornamental, commercial and fodder crops.

Data on pilot plant studies with stabilisation pond followed by fish pond with effluent utilisation for cultivation of ornamental and other crops are discussed briefly.

MATERIAL & METHODS

An integrated system of stabilisation pond and fish ponds are located at Nagpur 21°N in Central India. The stabilisation pond has a dimension of 30.5 m x 24.4 m x 1.2 m followed by 6 fish ponds of 5.5 m x 16.5 m x 1 m depth each. Domestic sewage from NEERI campus as well as city sewage is being treated in the stabilisation pond at an organic loading rate of 150 Kg/hect/day. A fish pond receiving only fresh water was operated as a control. Fish ponds II & III directly receive effluents from stabilisation pond is parallel, whereas ponds IV, V & VI are in series. Monoculture with air breathers such as Clarias and Heteropneustes with a loading of 20,000/hect were adopted. The series ponds IV & VI were stocked with Heteropneustes and V with Clarias.

Combined effluents from all the fish ponds are discharged into a sump from where it is utilised for cultivation. A field layout consisting of 24 plots of $9m^2$ with a net plot size of $4m^2$ are used for cultivation of regular crops and plot size of $6m^2$ for Jasminum (ornamental flowers) crop. The plots were prepared under randomised block design. Wheat and Jasmine were grown using the fish pond effluent as an irrigant.

Samples from the stabilisation pond, fish ponds and combined effluent were subjected to physico-chemical analysis, such as temperature, pH, DO, BOD, different forms of nitrogen and phosphate as per the Standard Method '(Ref.1)'. Samples for dissolved oxygen were collected from surface and bottom. Biological samples include phytoplankton, zooplankton and bottom fauna. Diurnal variation, primary productivity measurement, protozoa and helminthic cyst and fish biometry formed part of the observation. Microbiological analyses consisted of Salmonella sp. total and faecal coliforms.

OBSERVATIONS & CONCLUSIONS

(i) Fish ponds in parallel (II & III) : The BOD of raw sewage ranged from 110 to 510 mg/l, with about reduction of 65% in the stabilisation pond with a detention time of 4 days and the effluent BOD was in the range of 58 to 165 mg/l. In ponds II & III, a further BOD reduction took place with a detention time of 1 day. The effluent BOD was in the range of 35 to 112 mg/l. In both the ponds,except on very few occasions, surface and bottom showed critical levels of dissolved oxygen specially during the predawn hours. However, on some occasions DO at the surface rose upto 4 mg/l but less than 2 mg/l at the bottom. Dissolved oxygen reached critical levels on several occasions.

Zooplankton mainly comprised of Protozoa, Rotifera and Cladocera in the range 200 to 17,000/l of Rotifera and 250 to 28, 250 Cladocera/l respectively. Benthic fauna was mostly represented by Chironomus larvae in the range of 2 to 10,000 per Eckman Dredge.

Tubificidie were recorded occasionally in the pond system indicating that the bottom of the fish ponds did not tend to become septic which is a pertinent observation in fish culture.

In all 36 different genera of algae were observed in the pond system representing green and blue-green algae. Among the blue-greens, the dominant forms were Spirulina and Microcystis. The presence of algal blooms was found useful for the pond ecosystem in view of oxygen donation through photosynthetic activity. The blooms did not give any harmful effects nor fish kills due to oxygen depletion. The succession of the different algal forms did not follow a regular trend. In the tertiary system, Spirulina Sp., was dominant which contains 70% of the protein. Moreover, these algal populations serve as food for the herbivorous fish such as Cyprinus carpio which were successfully cultured in these ponds on earlier occasions.

Microbiological studies indicate that the raw sewage had Salmonella Sp., in the range of 16 to 385/100 ml. Effluents from the stabilisation pond is in the range of 3 to 82/100 ml with a reduction of 55.2 to 93.7%. Ponds II & III had a Salmonella count of 1 to 23/100 ml, with a reduction of 89 to 99%. The coliforms in the raw sewage were in the range of 8.3×10^6 to 8.9×10^7 per 100 ml. The percent coliform reduction in the stabilisation pond ranged from 58 to 99.2% and in fish ponds 90 to 99.95%. The faecal coliforms in raw sewage ranged from 5.5×10^6 to 5.7×10^7 with a reduction of 93 - 99.9%.

Helminthic cyst and protozoa were found in raw sewage in large numbers, but could not be detected in the effluents of the stabilisation pond and fish ponds indicating a 100% removal in the pond system. It provides additional evidence that it is safer to use treated effluents for agriculture rather than raw sewage.

(ii) Fish ponds in series (IV, V & VI) ; BOD of the effluent is in the range of 28 to 127 mg/l with a detention time of 1 day in each of the ponds. DO on most of the occasions during pre-dawn hours was about 4 mg/l at the surface and 2 mg/l at the bottom. The DO collected during pre-dawn, mid-day and post sunset indicated that the tertiary pond system (IV) do not deplete dissolved oxygen to critical levels especially at the bottom at pre-dawn hours. It would thus be advantageous to culture carp (poly-culture) in this pond system. Zooplankton mainly represented by Rotifers and Cladocera were in the range of 200 to 22,500 and 250 to 15,250/l respectively. The bottom mostly comprised of Chironomus larvae in the range of 2 to 10,000 per Eckman Dredge. The effluents from these fish ponds had Salmonella in the range of 0 to 21/100 ml. Most of the times one litre of the sample was found to be devoid of Salmonella. Coliforms and faecal coliforms showed reduction of 97 to 99.99% and 99.5 to 99.99% respectively. Ponds in series gave better removal of Salmonella and coliforms and faecal coliforms rather than ponds directly receiving stabilisation pond effluents.

Heteropneustes stocked in pond IV & VI attained a maximum growth of 151 gms and 147.5 gms at the end of one year. The Clarias stocked in pond VI attained a maximum weight of 374 gms. Of the 2 varieties of fish, Clarias had a better growth. The control pond indicated a growth of 75 gms at the end of one year. The air breathers in general do not depend upon the dissolved oxygen in water and can tolerate adverse environmental conditions such as low levels of dissolved oxygen and septic decay. Moreover, the ponds have rich bottom fauna and also forage fish like Lebistes. Fishes during trial netting did not show any visible signs of injury or malformation. They were swift in their activities.

CROP PRODUCTION

Studies on the effect of irrigation with the fish pond effluent have shown that the nutrients available through irrigation with fish pond effluent (without additional fertilizer) were adequate to maintain the growth and yield level of wheat crop on par with that resulting from the standard practice (well water irrigation + recommended dose of NPK through fertilizers). Application of fertilizers to the fish pond effluent irrigated wheat crop to the extent of 100% supplemental dose (recommended dose - NPK contributed by the F.P. effluent) resulted in an appreciable but satistically insignificant increase in the yield of the crop (about 22%). Application of half supplemental dose did not result in any appreciable increase.

Effect on soil properties indicated that fish pond effluent irrigation tend to increase the soluble salts, total nitrogen, organic carbon, nitrate and available phosphate content of soil in relation to the respective base values (in the beginning of the experiment) but there were no significant differences in comparison with the control. There was, however, no apparent change in the exchangeable cations, Cation Exchange Capacity and Exchangeable Sodium Percentage of the soil.

The data on uptake of major plant nutrients by wheat have shown that there was significant to highly significant increase in the uptake of nitrogen, phosphorus and potash as a result of irrigation with fish pond effluent in comparison with the control (Standard practice). Application of supplemental NPK to the fish pond effluent irrigated crop tend to further increase the uptake of NPK. As a result, the N, P and K content of the wheat grain as well as the straw also increased in comparison with the control, indicating the enhanced nutritional quality of the wheat grain as well as the straw.

The data also revealed that the level of combined nutrient utilisation efficiency (Kg of grain produced per Kg of nutrients NPK) under irrigation with fish pond effluent was relatively better than that under standard practice while the specific nutrient utilisation efficiency in respect of nitrogen was poor. There was a considerable improvement in the combined (NPK) as well as a specific (nitrogen) nutrient utilisation efficiency due to application of supplemental dose of NPK (100 percent) in comparison with the standard practice as well as the unfertilized fish pond effluent irrigation.

Economic evaluation of the treatments have shown that the net profit available from utilisation of fish pond effluent for production of wheat crop was 50% higher than that under standard practice (control) while it increased further when supplemental dose of NPK (100 percent) was applied. This increase was about 11 percent over the unfertilized irrigation with fish pond effluent and 67 percent over the standard practice.

This indicates the potential benefit of the recycling of renovated waste water in the development of agriculture as well as the prevention of environmental pollution.

In another set of field experiment, ornamental flowering crop of Jasmine (Mogra) is also under observation which show promising trend.

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Session 4

Chairman : Dr B B Sundaresan
Director, NEERI

Discussion

R Pitchai and V S Govindan

Re-use of campus sewage for pisciculture and aquaculture

1. Dr PITCHAI summarized the studies concerning algal harvesting, irrigation, and the growth of fish, using the system of waste stabilization ponds at P.A.U.T., which treated the sewage from the University campus. The ponds had consistently shown that substantial benefits, in terms of food production, could be derived by controlled use of wastewater.

2. Dr PITCHAI made a number of generalized comments resulting from questions asked, because a number of delegates posed similar questions.

3. The economics of the operation of the P.A.U.T. treatment works were difficult to assess accurately; with fish selling at about Rs 10 per kilo, and vegetables at Rs 5, the cost of labour and land requirement were approximately covered.

4. Regarding the problem of people consuming produce grown using sewage effluent, it was the responsibility of those who cultivated to ensure good quality. The presence of health problems was still uncertain, although providing the food produced was well cooked, problems should be minimal. From the marketing point of view, as long as the purchaser did not know the method of food production, he would not be deterred!

5. The economic balance was not solely dependent on the sale of produce; skilled manpower was necessary, but given favourable conditions, treatment costs would be reduced.

P K Terkonda

Innovative on-site disposal for septic tank effluent

6. Mr MOHANRANGARAJ presented the paper in the absence of Mr TERKONDA. The mound system of effluent disposal was discussed in relationship to slowly permeable soils, shallow permeable soils over porous bedrock, and permeable soils with seasonally high groundwater levels.

7. Dr DHABADGAONKAR asked whether percolating filters or sand filters had been considered, and suggested that the pumping arrangement shown in figure 1 of the paper should be eliminated whenever possible.

8. Mr MOHANRANGARAJ agreed with the comment about pumping, but emphasized that the mound system was proposed as an alternative method of disposal.

9. Mr KALBERMATTEN commented that bacteria in septic tank effluent could be reduced by filtration through appropriate media.

H L Bhatia and C A Sastry

Rearing of fish fry of Indian Major Carps in sewage stabilization ponds

10. Dr SASTRY presented his paper, which gave details on the growth of fish fry in stabilization ponds. Detailed chemical analyses of the pond influent and effluent, including diurnal variations, were given, and the optimum conditions for fish growth were concluded.

11. Mr ALAGARSAMY asked if the limitations of fish rearing were understood.

12. Mr SASTRY replied that information was available, and that NEERI had set up demonstration plants in Tamil Nadu and Harayana; it was important to transfer the technology to the field.

13. Mr NAJUNDAPPA wished to know if the species Gambusia had been reared, and whether it would be suitable for mosquito control.

14. Dr SASTRY thought that it may be suitable, but that it had not been a part of this study.

B V S Gurunadha Rao & C A Sastry

Low cost waste treatment methods for treating pharmaceutical wastes

15. Mr GURUNADHA RAO described the various industrial processes and the waste products produced from a number of units in a pharmaceutical factory. Wastewater characteristics were presented, and the effects of neutralization and settling, treatment in an aerobic lagoon, and extended aeration were discussed.

16. Dr DHABADGAONKAR thought that an equalization period of 5 days was too long to be practical.

17. Mr GURUNADHA RAO stated that this was necessary due to the variable volume and characteristics of the waste.

18. Mr SARAF asked whether the soluble BOD which was of the volatile type could be recovered by stripping, and asked about the effect aeration had on volatile acids removal.

19. Mr GURUNADHA RAO replied that the volatile substances were better removed by pre-aeration; volatile acids could not be removed at low temperatures by simple aeration.

20. Mr ALAGARSAMY asked a number of detailed questions, and wished to know if there were any working installations of this type elsewhere in India.

21. Mr GURUNADHA RAO supplied the following technical information: the food to micro-organism ratio in the extended aeration plant was 0.125; 25% of the sludge was wasted; the sludge volume index was less than 100; a factor of safety of 25% to 30% was provided. There were no other such installations to the best of his knowledge.

22. Mr VENKATARAMAN observed that the ratio of tank volume to aerator power was large, and would give a low power density, and asked about the mixed liquor suspended solids (MLSS) in the aeration tank.

23. Mr GURUNADHA RAO thought that sufficient power was available, but had no information on MLSS because the plant had only just been commissioned.

V Raman, A N Khan and B B Sundaresan

Unconventional low cost simplified sewage treatment by rotating biological contact reactors and anaerobic upflow filter system

24. Mr RAMAN began by pointing out that the title of the paper should refer to "anaerobic" and not "aerobic" filters.

25. Performance characteristics of the treatment unit were given; data included the changes in BOD, COD, suspended solids, pH and ammoniacal nitrogen. Design values for sizing the treatment unit were recommended.

26. Mr KALBERMATTEN asked whether the anaerobic filter could be used for sullage treatment, and if plastic filter media had been tried.

27. Mr RAMAN replied that the anaerobic filter could work for dilute strength waste, and with proper choice of media, could lower the BOD of sullage. It was advisable to pass the effluent through a grass plot for final polishing. Plastic filter media would be expensive, and local materials, such as stones, were more appropriate.

28. Mr VENKATARAMAN wished to know the optimum speed for the RBC, the disc submergence, and cost details.

29. Mr RAMAN replied that the rotation speed was between 3 and 5 r.p.m., which was within the usual limits of 1 to 8 r.p.m. The disc submergence was about 40% to 45%.

In the NEERI system which could serve up to 100 people, 40% of the cost was involved in the manufacture of the PVC discs; alternative materials were being investigated, such as bamboo and plastic cane webbed together on a frame, which reduced the cost by about 70%.

K P Krishnamoorty, N M Parhad, G B Shende and B B Sundaresan

Study on the productivity of air breathers and crop production in wastewater

30. Dr KRISHNAMOORTHY discussed the results obtained from an integrated series of waste stabilization ponds at Nagpur. The growth of algae, fish, zoo-plankton, and effects of using the fish pond effluent for irrigation were reported.

31. Mr MUNUSWAMY asked why growth rates in effluent from percolating filter and activated sludge plants differed when the BOD in each effluent was the same.

32. Dr KRISHNAMOORTHY replied that DO was more relevant than BOD, and that ammonia levels should also be checked.

33. Dr SUNDARESAN commented that much work had been done on waste stabilization ponds, to the extent that they are known to be scientifically sound, technically feasible, and are likely to be economically viable. Health studies are required to check on any adverse side effects from using sewage effluent in food production. However, the management problems in running systems of large ponds have yet to be satisfactorily resolved, and the good work so far carried out must be transferred to successful practice on a large scale; Chief Engineers should take this problem on board.

8th WEDC Conference: Water and waste-engineering in Asia: MADRAS: 1982

MANAGEMENT OF PROTECTED WATER SUPPLY SCHEMES

BY GEORGE MATHEW AND S A JAGADEESAN

Best of all things is water. Water supply is a basic need of the day and the Government is giving much importance for its implementation. Not only urban towns, rural areas also require potable water in plenty.

It is no doubt that water is an essential commodity, next to air, given by Nature. The natural resources of water, either surface or sub surface, have to be tapped suitably, treated scientifically and distributed judiciously according to the usage either for human consumption, or for animal or plant life or for industrial purposes.

Major determinants of prosperity of any Nation are its natural resources and the extent to which they have been exploited. One such resource is water which is essentially vital for sustenance of life but no less important is its utility in other developmental activities. This resource tends to be scarce with the increase in demand in all sectors.

We know that of the total quantity of available water on our Planet, about 3% only is fresh water, the rest 97% being saline. This fresh water is available in various forms such as Polar ice caps, ice-bergs, glaciers, ground water, lake water, river flows, soil moisture and atmospheric vapour. Of this 3% of water, ice constitutes about three-fourths i.e. 74%. Ground water which occurs at a depth of less than 1 kilometre constitutes 11% and that which occurs at a depth greater than 1 kilometre constitutes 14%. Lakes and rivers constitute 0.3% and 0.03% respectively. The balance is present in the form of soil moisture and atmospheric vapour.

The fresh water supplies and the exchanges in the hydrological cycle are important for mankind. With the progressive exploitation of our utilisable water resources, we are rapidly confronted with problems which might have serious repurcussions on our environment and grow acute as we approach the developmental limits.

Present environmental concerns have generated greater awareness about the importance of this precious resource. Water resources development has now come to be regarded as a powerful tool for raising the living standards and for stimulating the social and economic changes.

Broadly speaking, water is never lost. With a few exceptions, water finds its way back into the natural cycle. Our water supply system draws water, say from river and the waste water disposal system discharges back into it. If those wastes are treated, there will be practically no net change. Within a given region, water may not be available where it is needed. Such problems can be solved by moving water from where it is to where it is required. Thus wise management starts with a knowledge of the world of water.

The next step is a better understanding of surface water which is our important source of supply. We cannot ignore ground water either. We must understand how the ground stores this rich resource and nature's way of recharge. Locating and drilling of wells must be guided by facts resulting from a professional survey as is being done now by the Government of Tamilnadu through the TWAD Board (Tamilnadu Water Supply and Drainage Board) on a massive scale for supplying water to the thirsty millions in rural areas.

The value of any source depends on Water Management. For top economy, water use is to be integrated with effective control of pollution. Carefully planned waste treatment system curbs stream pollution and also recovers water for reuse.

It is absolutely necessary that Water Supply Systems should be run on a self supporting basis and should be operated on commercial lines. Otherwise,the local bodies will not be able to repay the loans obtained from Financial Institutions like the Life Insurace Corporation of India as well as the State Government for executing the schemes by way of annuity and maintenance charges. There should be an efficient system of collecting water tax and water tariff so as to accumulate necessary funds for future expansion and modification of the existing systems. Citizens should realise that the water supply has been provided at an enormous cost and so water too has a price tag on it just like any other commercial commodity.

Water distribution should be carried out in a rational way such that wastage of treated water is avoided. It is also important to see that there is equitable distribution of water in all areas. Public taps should be provided in localities inhabited by the poor and economically weaker sections of the society. The Engineer concerned should take corrective measures whenever called for in order to keep the entire system run properly, efficiently and profitably.

The Tamilnadu Government is very much interested in providing protected water supply to every citizen whether living in urban area or in rural area and substantial funds have been ear-marked for this purpose. Hence it is the duty of those incharge of protected water supply schemes to manage them in such a way that wholesome water is delivered in sufficient quantities to the satisfaction of all concerned. Moreover, it should be so managed that the systems are run on a commercial basis to raise sufficient funds both for capital improvements and for proper maintenance.

An adequate and well maintained water supply system can result only from far sighted planning, sound engineering and constant vigilance. Any undertaking, as a matter of fact, despite its being economical and efficient, will end up in failure if it is badly managed. Wise management starts with a thorough knowledge of the system. An effective water management not only provides an improved and equitable supply to the public but also helps to reduce the running cost of the schemes.

Proper Financial Management is necessary to ensure an efficient water supply. A water utility should receive a gross revenue sufficient to enable it to provide adequate service to maintain the system, to pay the taxes required to earn a reasonable return and to secure financial status necessary to obtain money at reasonable interest rates for expansion of the system.

Equipment Maintenance is one of the keys to an efficient operation of a water utility wherein continuity of service is of prime importance. Good maintenance is good management. Effective maintenance ensures long life of the plant, low maintenance cost and better quality control. Preventive maintenance designed to eliminate breakdown repairs should be aimed at.

Water Management could be effected successfully with public co-operation. The public should be educated about the necessity of conserving water and making proper use of the potable water.

A meaningful Management Programme involves a proper co-ordination between Planning and Implementation. The Planning covers the aspects of water survey, water use, standards setting, corrective action, manpower training, financing and legislation. The implementation includes monitoring and surveillance programme, inspection, licensing and enforcement of law. The support programmes needed for implementation will cover the development of consultancy services, research and development activities, data collection and health education.

While concluding, it is to be mentioned that in India it is an usual feature to witness floods in one place and famine in another place at the same time. It is indeed a paradox that while some parts of the country are reeling under heavy floods, other parts are experiencing drought. The country is spending several crores of rupees on flood relief and drought relief alternatively. Since water is a problem of National concern and pressing importance, the only permanent solution to the problem is the formation of an All India Water Grid. Rivers should be declared as National assets. Judicious utilisation of river waters should be ensured through an All India Grid. Only through co-ordinated action guided by those who understand all the complex aspects of Water Management, we could make the fullest and wisest use of the water sources which Nature has blessed the Indian soil with.

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KNOWLEDGE MANAGEMENT IN PUBLIC WATER SUPPLY SYSTEM UNDERTAKINGS

by V VARADARAJAN S SUNDARAMOORTHY and S SIVAPRAKASAM

INTRODUCTION

The prime task during the International Water Supply and Sanitation Decade is (a) to appraise as a matter of urgency the status of the community water supply, sanitation facilities and services and their control and (b) to formulate within the context of national development policies and plans, by 1980, to programmes with the objectives of improving and extending those facilities and service to all the people by 1990. Its successful accomplishment depends on the familiar three major inputs of finance, materials and men.

The financial adequacy is a question of budgetary priorities which can be reviewed and reworked at any time. Similarly, the material needs are area where reworking of manufacturing and production philosophies can help.

In the realm of manpower development, the problem sub-divides into one of optimising the existing manpower and producing additional future manpower. The production of additional future manpower is obviously a time related effort to be nurtured and developed through its entire time span of evolution. Distinctly different from this is the need for optimising the existing manpower. The concern in this sphere is both immediate and imperative. Its planning and implementation forms the primary objective of what can be more comprehensively termed as 'knowledge management'. Its pathways and development in the sphere of public water supply system management are analysed in this paper.

THE MEANING OF KNOWLEDGE MANAGEMENT

The word 'KNOWLEDGE' in modern professionalyzation encompossess such a wide spectrum of meaning that led the management author Kenneth Boulding to observe that for all its importance in the world system, knowledge is difficult to define and even more difficult to measure "(ref. 1)". True knowledge emanates from out of a validation of all available information. Its implementation and utilisation to beneficially control all subjective operative processess becomes knowledge management "(ref. 2,3)".

THE PATHWAYS OF KNOWLEDGE MANAGEMENT

In simple terms, knowledgemanagement is a group exercise in first developing reliable knowledge bases by marshalling and validating all available information and secondly the implementation and utilisation of such knowledge to control every professional's subjective operative processes. If we break this down to sequential tasks, these can be identified as communication, co-ordination, information dissemination, documentation and manpower training. These are amplified herein.

COMMUNICATION

The fundamental conviction to allow one's dictums to be tempered in its different branches by associated personnel irrespective of stature is the basic approach of a meaningful communication activity.

An useful approach would be to organise in every water supply system undertaking a periodic round table of views from all concerned irrespective of hierarchy and following it up with a certain degree of experimentation before the succeeding meeting with a view to continue the efforts. These, for one thing, serve to enable themembers to first of all become aware of where they stand. Such an awareness is the basic crystal over which the professional importance and conscience grows. Gradually, such home round-tables can be widened into objective type workshops in order to locate and identify areas of mutual help between different local water supply system undertakings, a form of effort, normally called as co-ordination.

CO-ORDINATION

The logical extension of local communication consensus is always in the form of mutual co-ordinated efforts. Thus, for example, in the classical illustration of down the stream water utilities, the last in the line suffering the maximum onslaught of all the higher up utilities & pollutions, can be helped to a large extent if only the upstream personnel are made to understand the difficulties caused by their waste discharges. Such extensions on the water supply front is something, which, in its present state of total absence is causing undue hardships to many a local water supply systems undertaking. It is only these co-ordinated workshops which can generate and identify precise areas of immediate overlapping responsibilities of water supply system undertakings at sequential levels.

INFORMATION DISSEMINATION

There are some limitations in the earlier ventured ideas of Communication & Co-ordination in their becoming the sole pathways of overall success. The main difficulty is the even theoretical, leave alone practical, impossibility of all related people from converging into a single spot at a given time of occurence. This is all the more true of Cooperation based workshop type of ventures. It is in these situations, that information dissemination becomes one of paramount importance. By a simple comparison, if our daily news media can admirably bring international developments into the grasp of even the remote population, then, there must be an equally effective way of technical information dissemination also.

DOCUMENTATION

The fact that knowledge as validated from the foregoing sequential efforts has to be documented for immediate and future needs is well recognised. The journals and newsletters as brought out have shown a significant growth in recent times and consequently documented information of progresses and events in far off locations become available for the Public Health Engineer more easily and more readily nowadays.

But, most of the journals originate and propogate from the developed countries. Among the developing countries also, such journals and newsletters have to now become more popular. The example of the Indian Water Works Association, The Institution of Engineers - India, The Institution of Public Health Engineers - India, The Indian Association for Water Pollution Control and the Indian Standards Institution which bring out a substantial amount of information in their journals needs to be followed by many of the developing countries.

MANPOWER TRAINING

This task forms the logical culmination of the aforediscussed sequential tasks and is the basis for any public organisation as summarised in Table 1"(ref. 4)"

Generally, a majority of personnel dealing with water supply systems may be discharging their duties in more or less traditional and accustomed way. One reason for this absence of enterprise is the non-availability of spare time and private funds to go in for a voluntary technical advancement. It is precisely at this juncture that manpower training as imparted by the organisation comes in as an accentuated necessity.

The primary aim of such a training must be to expose both professionals and sub-professionals to selected and aptitude oriented course works. A possible training outline is illustrated in Table 2. Such courses are not totally devoid as of now. Some courses are organised at state levels. some at country levels and some at inter country levels by universities, professional institutions and international agencies. But, mostly, these narrow down to the middle level management personnel and leave the sub-professionals and junior management personnel out from their coverage.

Hence, it becomes necessary for each water supply system undertaking to evolve and sustain an intra departmental training school of its own.

THE METROWATER TRAINING SCHOOL AT MADRAS

Recognising the need for a training school as discussed in the foregoing section, the Madras Metropolitan Water Supply and Sewerage Board, (METROWATER) has embarked on a program of systematic training for its staff. The training programme has been evolved under the joint auspecies of the State Government, the National Government and the Overseas Development Administration of the United Kingdom through the British Council under the Colombo Plan. The programme is a constituent of a UNDP aided project for the implementation of a Master Plan for improvements to Water and Sewerage services.

A full fledged training school building costing nearly Rs.2 million is nearing completion. Some of the notable components of this school would be facilities such as teaching rooms, workshop areas, projection room, closed circuit Television facility, film storage and retrival facility etc. The Overseas Development Administration of the U.K. would gift essential training equipment to the value of nearly 47,000 British Pounds and finance the visits of Specialists from the National Water Council, U.K.

TRAINING COURSES ALREADY CONDUCTED AND IN THE OFFING

Parallel to the construction of the training school building, the activity of developing the required course outlines and going through some of the courses with the guidance of a resident training manager from the U.K. has been in progress by utilising a spare building space in the Board's Kilpauk Water Works premises.

These courses have been evolved for certain levels of the staff like,

(i) Craft Apprentices
(ii) Engineering Diploma Holders
(iii) Technical Supervisors
(iv) Professional Engineers
(v) Clerical Supervisors
(vi) Professional Managers and
(vi) Professional Accountants

The courses so far developed and imparted from 1979 are listed in Table. 3.

TABLE 1

TRAINING FACETS CONSTITUTING EFFECTIVE PUBLIC ORGANISATION DEVELOPMENT

GENERATE EFFECTIVE MANAGEMENT SKILLS AS	DEVELOP A FRAMEWORK FOR ADEQUATE ACTION BY	INCREASE ORGANISED AND KNOWLEDGEABLE KNOWHOW IN	SOLVE PRESSING ORGANISATIONAL PROBLEMS AS
Holding productive staff meetings and encouraging free and frank transmittals.	Assisting in development of managers skilled in the use of training tools	Conducting training programme to improve the quality and quantity of work	Orienting the employee and teaching him(in so far as is necessary) his job
Improving and making more effective prevailing organisation-employee relationships	Creating an organisational climate for the agency for its own improvement	Using on the job Training as a management tool for more productive efforts	Training ' supervisors in name' to become 'supervisors in fact' for realistic efforts
Permitting the involved administrator to freely improve administration	Developing & maintaining a management and employee communications net work.	Meeting management responsibilities in planning, control & decision making	Using the employees' brain power to solve pressing organisational problems
Giving the administration access to organisational problem solving techniques	Giving employees responsibility for making the organisation better.	Thinking about proper and efficient employee utilisation and his involvement	Increasing the ability to consider the trouble spots in the organisation.

TABLE 2

SUGGESTED TRAINING OUTLINE FOR PUBLIC WATER SUPPLY SYSTEM PERSONNEL

CATEGORY I	CATEGORY II	CATEGORY III	CATEGORY IV
Administrative Head Engineering Head, Financial Head, Senior Engineers	Middle Level Engineers Junior Level Engineers Chemists	Operative Engineers Electrical Operators Site Operation Heads	Skilled Craftsmen, Plumbers, Mechanics Filter Operators
COURSES	COURSES	COURSES	COURSES
Management Practice	Basic management	Basic supervision	System Appraisal
Financial Analysis	Engg. Standards	W.S. Fundamentals	Basic Job skills
SWOT Analysis	Engg. Accounting	Sewerage Fundamentals	Pipe & Fittings
Problem Identification	Materials Management	Building Technology	Trench Excavation
Programme Design	Computer Techniques	Ele. Water quality	Backfill Techniques
Orientation	System components	Water supply laws	Leak Detection
Programme Evaluation	Water Collection	Ele. Hydraulics	Pipe Location
Action Training	Water Treatment	Flow & pressure	Valve location
Review & Feedback	Water Distribution	Pumping Station O&M	Pipe cutting
Transmittal Techniques	Billing	Treatment Plant O&M	Pipe jointing
Motivation & Awards	Budgetting	Valves and meters O&M	Pressure drilling
Leadership & Rationale	Codes of works	Pipe laying	Road cutting
Humour & Tension	Planning	chlorination	Road Repair
Documentation	construction	sanitation	Plumbing
Organisation development	W.S. System O&M	Maintenance	valve operation
	Sew.System O&M	Fault location	Masonry
Consultancy Management	Water Supply laws	Fault corrections	Carpentry
Priorities	Quality control	Concrete work	Bar bending
Posteriorities	Metering	Billing	Meter installation
Managing Transitions	Health & Job safety	Accountancy	Meter reading
Quality Control	Records & Upkeep	Materials Accounting	Meter repair
Myths & Realities	Motivation	Safety techniques	Water quality
Work & Leisure	Documentation	Road repair	Reading & Records
Business Ethicks	Training	Road laying	Materials storage

TABLE 3

COURSES DEVELOPED AND IMPARTED SO FAR

1. Induction Course to the new personnel
2. Water Treatment Plant Operation
3. Ground Water Technology
4. Water Supply Fittings Course
5. Attending to the Burst in water mains
6. Filter Operation
7. Water Meter Reading
8. Sluice Valve Maintenance
9. Fitter Water Supply
10. Principle & Operation of Treatment works
11. Sewer Maintenance
12. Principles of Supervision
13. Main Laying
14. O&M of Sewage Pumping stations
15. Analysis of sewage
16. Design of Sewage Pumping Station
17. Induction course to the new chemists
18. Laboratory Management
19. Principles & Operations of Maintenance
20. Fault finding of Mechanical Plant
21. Fault finding of Electrical plant
22. Maintenance of Registers and Records
23. Complaint Registration
24. O&M of Sewer Cleaning Mechines.

CONCLUSION

In modern contemporary management of public service systems and in Water Supply system undertakings in particular, knowledge management is the vital key. The magnitude of this task is quite huge in this International Water Supply and Sanitation Decade.

The pathways of a successful knowledge Management programme have been presented in this paper. Sequentially, these component activities are communication, co-ordination, information dissemination, documentation and manpower training. There is an urgent need for the initiating and sustaining of these activities in the water supply system undertakings in the developing countries.

Sometimes, such a programme could well meet some initial resistance. Because, knowledge management aims at shaping the individual to respond to certain stated situations in certain stated ways and hence implies a change in behavioural response from one of what he might be doing so far to one of a more scientific and positive response. After all, in many situations, we encounter individuals serving for many years. Seldom they relish a demand for a change. But, then, these are normal human attitudes and they have to be first convinced that the knowledge management programme would not embrass them by exposing their inadequacies, but, on the contrary, would effectively enrich their skills, they would like the programme.

After all, history teaches us that such initial resistance and later willing embracing is but a normal occurance whenever a change has been sought to be brought about. An apt example would be the case of the now famous Management By Objectives(MBO) programme when it was implemented initially as illustrated by the following American anecdote.

In one highly publicized incident the entire decentralization MBO process was nearly scuttled because a state truck ran over a cow. The Owner wrote an indignant letter to the legislature and the state office bureaucracy attempted to use the incident as proof that MBO produced reckless and irresponsible behaviour at lower levels, implying that every cow in the state was endangered by MBO Fortunately, the direction of administration for the state was able to resolve the question quickly. One of the major influences was the fact that a speedy response was forthcoming. Within an hour of the report's eaching the state capital, a responsible official from the region was on the scene, viewing the bovine's remains and making specific arrangements with the farmer for fair reimbursement from local funds. Under a more centralized system, the payments would have been years in coming, for, the state capital was more than a hundred miles from the cow. (ref. 5)". It is the very same Americal Society, which has subsequently not only embraced MBO but has grown to be a trend setter ever since.

Similarly, an effective knowledge management programme is surely bound to be highly instrumental in helping us reach our committed goals in the International Water Supply and Sanitation Decade.

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AN APPROACH TO WATER SECTOR TRAINING IN DEVELOPING COUNTRIES

by A M RICHARDS

INTRODUCTION

Background

The importance of water to the wellbeing of mankind is universally recognised. It is now a critical factor in the public health and economic development of many countries throughout the world, particularly in the developing countries.

The United Nations Water Conference and World Health Assembly held in March and May 1977 respectively, endorsed this view and the decade 1981-90 was subsequently designated the International Water Supply and Sanitation Decade with the target of providing minimum levels of service and access to safe water supply and sanitation for all by 1990.

Need for training

Implementation of Decade Programmes can only be achieved by considerable financial investment in engineering works, materials and manpower. A survey of 86 developing countries carried out by the World Health Organisation in 1970 reported that as a major barrier to providing water supplies in developing countries, lack of trained personnel was second only to the problems of insufficient finance. WHO concluded that efficient utilisation of funds provided for improvements to water supplies would not be successful unless qualified management and trained personnel were also available to plan, build, operate and maintain the facilities.

The expansion of the manpower infra-structure necessary to implement the Decade Programmes in Developing Countries will create a need for training new as well as existing personnel. This need will apply to all levels of staff; managerial, supervisory, technician, craftsmen and labour.

For training to be efficient and effective it must be systematic and controlled in its establishment and operation.

Scope of paper

This paper describes a systematic approach to water sector training which has been used in Developing Countries and examines the way in which the Approach has been put into practice in the Madras Metropolitan Water Supply and Sewerage Board in Southern India.

THE TWO PHASE APPROACH

Objectives

The Two-Phase Approach has been developed to assist water sector undertakings in Developing Countries in providing job orientated training within their own organisation to meet current and future manpower needs.

In many countries there is provision for adequate theoretical training in Public Health Engineering at both graduate and postgraduate levels. Very few countries, particularly in the developing world, have facilities for the systematic training for non-professional, technician and operative staff in the water sector.

The objectives of the Approach are to:
- provide a sound basis for meeting present and on-going manpower development and training needs of a water sector undertaking
- establish a self-sufficient and self-perpetuating training system
- provide facilities for job-orientated practical training for all staff levels in a water sector undertaking in skill areas not provided by existing academic and technical institutions.

Phase I - analysis and planning

During the first phase of developing a training system, effort must be concentrated on analysis of the current and future situation and development of a manpower strategy.

It is essential that a very close liaison is maintained between the Manpower Development team and staff of the undertaking. To gain cooperation and commitment from the senior staff, a short seminar is conducted at the start of Phase I to explain the aims and objectives of the work and the methods to be used. A further seminar is presented at the conclusion of the Phase to enable the findings and preliminary recommendations to be discussed with the senior staff.

In general terms the methodology of this Phase may be summarised under two headings:

Situation and needs analysis involves an initial familiarisation with the undertaking and its work together with any proposals for reorganisation or expansion. This would be followed by an examination of current training methods and facilities that are available within and outside the undertaking for staff training.

The manpower development and training strategy is then prepared from an assessment of the present arrangements and future proposals as identified in the situation analysis with due regard to the views of the management team of the undertaking. The outline strategy developed would for example try to:
- quantify the total development and training task and resources available
- identify and recommend plans to satisfy short term priorities
- recommend a balance to be aimed for between "on-the-job" and "off-the-job" training.

Specific tasks which are carried out during Phase I are as follows:
- examine the design, construction, operation and maintenance of existing water supply and sewerage systems including support services
- identify proposed extensions of sources, systems, methods and any changes in technological approach
- examine existing and proposed organisational structures
- identify, assess and quantify training needs
- draw up a recommended equipment and tooling list
- identify key task areas and agree job descriptions
- assist and advise in forecasting additional manpower and the range of skills that may be required in the future
- advise on the selection of suitable training staff, and prepare and arrange training programmes
- examine existing methods and facilities for staff training, noting suitable external facilities and any plans for development
- evaluate data, prepare training plans, discuss and agree training implementation strategies with senior staff.

Time required for Phase I will vary depending on the size of the undertaking and the logistical problems of geographical size, but would generally be of the order of two months' site investigation and two weeks' report preparation.

Phase II - Implementation

During this Phase an experienced project leader supervises the implementation of the manpower development and training plan agreed in Phase I and trains counterpart staff to continue future operation of the training system. The Phase is carried out in two stages.

Module and facility investigation/preparation is expected to include the following specific tasks:
- draw up training specifications for key tasks as identified and agreed in Phase I
- specify "off-the-job" facilities required to meet the identified needs and investigate possibilities of setting up and/or extending existing "in-house" training facilities
- enumerate the training manuals required to meet the needs identified in Phase I and commence preparation of the most important
- prepare training courses to meet priority needs identified in Phase I
- advise on design and preparation of "off-the-job" training facilities
- establish a system for monitoring and evaluating training programmes and for the maintenance of appropriate training records
- establish a system for the overall management, financial control and administration of the undertaking's training function.

Manpower development and training is expected to include the following specific tasks:
- finalise arrangements for the overseas training programmes for trainers
- implement training courses to satisfy the key task needs identified in Phase I
- modify and refine the training plans as necessary
- train, advise and counsel counterpart training staff on performance as trainers
- implement induction training courses for new recruits
- implement training courses in line with agreed programmes
- monitor "on" and "off-the-job" training and planned practical experience components of the programmes
- devise a forward training programme for all key staff involved in the day to day running of the organisation
- arrange for follow-up visits by consultants over an agreed period to monitor effectiveness of the programmes
- maintain a dialogue with senior management of the organisation to ensure that they are kept fully informed of the progress and effectiveness of the training function.

Time required for Phase II will again vary depending on the size and geographical responsibilities of the organisation, but is expected to take of the order of two years.

Visiting specialists would be used during Phase II in the development and implementation of training courses in the priority areas identified in Phase I. They will advise on areas of work where new or improved technical methods or equipment are being introduced or the undertaking lacks sufficient in-depth practical experience for counterpart staff to develop appropriate training courses. The duration of these visits is normally one/two months.

Use of the Two Phase Approach

The National Water Council, Overseas Manpower Development Group from the United

Kingdom is currently engaged in assisting the Madras Metropolitan Water Supply and Sewerage Board to establish a training system and training facilities in Madras. Having set out the reasons for, and methodology of the Two Phase Approach, the paper now examines the way in which the Approach has been used in Madras and the potential value of the Metrowater Training Project both for Madras and other water sector undertakings in India.

METROWATER TRAINING PROJECT (MADRAS)

Madras Metropolitan Water Supply and Sewerage Board (MMWSSB)

In 1975 the World Health Organisation initiated a pre-investment study into the water supply and sanitation facilities in the Madras Metropolitan Area. The objectives of the study were to:
- develop systematic long range plans for water supply and waste water systems for the Madras Metropolitan Area
- lay down a programme for obtaining short-term relief from current deficiencies.

One of the goals of the short term objectives was to recommend a programme of training for all levels of water sector staff.

In line with the pre-investment study recommendations, the MMWSSB was established in August 1978 from appropriate staff of the Corporation of Madras and the Tamil Nadu Water and Drainage Board.

The scope of operations of the MMWSSB includes full responsibility for the supply, treatment and distribution of 250 mld of water to domestic and industrial consumers in the Metropolitan Area and waste water collection, treatment and disposal for the area. The Area has a population of approximately 3.5 million, 30% of whom rely on public fountains for water supply and have no provision for sewage disposal.

The staff of the MMWSSB number approximately 6500 of whom 350 are professional staff holding a minimum qualification of a diploma or degree and the remainder are skilled, semi-skilled or labour cadres. Of the total staff approximately 5000 are involved in the engineering operations of the Board.

The water supply and sewerage systems in Madras were installed around the turn of the century. Rapid development of the city and expansion of the population have not been accompanied by adequate improvements to the systems. The MMWSSB is now faced with the dual problems of repairing or replacing old and inadequate facilities and implementing a major programme of new engineering works to bring the systems up to a satisfactory standard. To carry out this work the Board requires staff who have the necessary skills required to design, construct, operate and maintain existing and future facilities.

Initial study

In 1978 the National Water Council carried out an initial study of the situation in Madras and the training needs arising from the work due to be carried out by the newly formed Water Supply and Sewerage Board. The work was carried out following the Phase I Approach outlined earlier and led to initial recommendations in a number of areas.

The situation and needs analysis clearly identified the need for implementation of a substantial training programme in the practical operation of water and sewerage systems. The lack of suitable facilities for this type of training led to the recommendation that the MMWSSB establish its own Training Centre to meet its needs. The training to be provided at this centre would be augmented by the training of key staff in the NWC Training Centres in the United Kingdom.

The manpower development and training strategy set out the method by which the MMWSSB should set up the Manpower Development function, obtain information on current skills and abilities of staff transferred to the new Board against the skills and abilities required in their new posts and recommended a training scheme.

Having determined the need for a separate training facility, the study recommended the size, layout and resources required to meet the priority needs. The recommendations included the manpower and organisational requirements to operate the training facility and proposals for training the staff as Trainers.

Financial assistance was obtained from the World Bank (IDA) and the Overseas Development Administration (ODA) following acceptance of the study recommendations.

The World Bank have provided Rs28 lakhs (Exchange rate Rs16.5/£1, October 1981) for the buildings and Rs6.11 lakhs for equipment and furnishings as a loan. The ODA have granted Rs6.9 lakhs for training equipment in addition to funding the services of the National Water Council.

Establishment of the Training Centre

Terms of reference for the NWC assistance in establishing the Training Centre were based on the Two-Phase Approach and included a re-assessment of Phase I work carried out previously and, if necessary, preparation of a revised training strategy, followed by implementation of the proposals.

Work on the project commenced on 2 July 1979 for a contract period of two years with the

NWC providing a Resident Training Manager.

Initial work concentrated on the appointment of training staff and arranging training in Instructional Techniques at Training Institutes in Madras. The counterpart staff appointed at the start of the project comprised a Training Centre Manager, Chief Training Officer, two Training Officers and two Instructors.

The Board also established a temporary Training Centre in a laboratory within the area allocated for the new Training Centre. The building provided space for two classrooms, a demonstration area, a store and administrative offices and was occupied in December 1979. The design for the new Training Centre was agreed to include two classrooms, administrative offices, course development room in one block, three workshops, a laboratory and an external model water distribution layout.

The original Phase I plans were reviewed and a programme of Specialist visits was agreed for the development of courses in priority areas.

The training equipment and tooling list for the new Centre was prepared for both indigenous and imported items. By January 1980 the Phase I tasks were substantially completed and the training centre was in operation.

Implementation of forward plans centered on the programme of Specialist visits and the development of priority training courses. The Specialists covered the following key areas:

- operation and maintenance of sewage treatment works
- operation and maintenance of sewerage systems
- mains and service laying
- supervisory techniques
- operation and maintenance of water treatment works
- maintenance of mechanical plant
- maintenance of electrical plant
- maintenance of vehicles
- water meter testing and repair
- training course development
- manpower development and training planning.

These courses were aimed at the first line supervisor level which had been identified as the key area. The counterpart training staff modified these courses and developed additional courses in Tamil for the lower cadres. During 1980 a total of 17 courses were developed and presented to 500 trainees.

The training of counterpart staff continued with a four month training programme at the UK Water Sector Training Centres for the Training Centre Manager and Chief Training Officer and with the local training of two additional Training Officers.

By May 1981 much of the Phase II work was complete but because of delays in the construction of the new buildings and delivery of training equipment from the UK, the contract was extended until March 1982.

Consolidation of Phase II continued and in addition to developing a further 11 courses during 1981, visiting Specialists supervised the start of an individual training needs analysis of operation and maintenance staff. Work is still continuing on this study but initial work has resulted in a programme of training courses to be prepared for the new Centre for 1982. This will cover 42 courses with 4200 trainee places. Before completion of the project a forward programme for the Training Centre operation will be prepared for the next three to five years.

The new Centre is scheduled for completion in March 1982 and an additional eight trainers will be recruited.

Overseas training of key personnel has continued with eight British Council Training Awards having been utilised by the end of 1981.

THE FUTURE

The use of the Two-Phase Approach has enabled the MMWSSB to establish a training function to meet the Board's present and future needs in a systematic manner.

The opening of the Metrowater Training Centre in 1982 will provide Madras with the first training facility in India designed for water sector staff of all levels.

The facilities have been designed to provide job-orientated practical training and it is intended to make the facilities available to other water sector undertakings in India.

The application of the approach outlined in this paper will assist Developing Countries to meet the training needs created by the implementation of the Decade Programmes and improved standards of operation and maintenance of existing facilities.

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A SUGGESTED PROCEDURE FOR THE EVALUATION OF BIDS FOR CONSULTANCY SERVICES

by S SUNDARAMOORTHY

INTRODUCTION

In the implementation of public water supply or sewerage schemes, the tendering and evaluation of bids has hitherto been recognised as a legitimate prerequisite of construction activity. However, with the recent advent of schemes funded by the International lending agencies especially in the developing countries, these tendering and bid evaluation functions have also to be extended to the area of consultancy services as well.

Consequently, the engineer, who is burdened with this relatively not hitherto familiar aspect of decision making finds himself in an unenviable situation for precisely two reasons namely (i) He has to evaluate certain personnel and firms of whom, at best he would have only heard of and (ii) His accustomed method of evaluating a construction bid seems to be inadequate to justifiably cover the basically different scope of a consultancy service bid.

The dilemma is accentuated by the nonavailability in our literature of suggested evaluation procedures for such bids and engineers normally tend to use the hitherto familiar definitive procedure wherein, the capacity and experience of a stated firm in handling certain specified engineering tasks are evaluated in some traditional detail whereas certain other and perhaps more vital considerations in the context of a useful consultancy service are left out. Written in this background, this paper presents a non-traditional procedure for evaluation of especially, consultancy service bids.

VITAL BASIC CONSIDERATIONS

For a meaningful evaluation of consultancy service bids vital considerations to be looked into would be, the Experience of Personnel, Experience of the firm, Adequacy of the consultancy offer and the approach of the firm towards evolving solutions for tasks stated in the terms of reference. These can be sub-divided into certain facets as in Table 1.

For the purpose of Evaluation, these facets have to be looked for in the bid submissions and scores depending on the extent of compliance have to be allotted for each facet. The description of what really each of these facets implies as well as a suggested scoring system are presented herein.

TABLE - 1

SUGGESTED CRITERIA AND FACETS FOR EVALUATION

PERSONNEL	Knowledge of Problem Sources of knowledge Needed knowledge Analysis
EXPERIENCE	Orientation Problem Identification Opportunity Identification Reconnaissance Power Status & Locus
ADEQUACY	Aspirations Results Analysis Evaluation Feedback Compliance
APPROACH	Experimentation Programme Design Contract Setting Implementation

Orientation

Forms the basis on which the firms' bids have emanated. Obviously, a firm which is directly oriented to community water supply and sewerage design and construction supervision is better suited than multi disciplinary firms. Scoring example: Direct Involvement - 100, Multi-Disciplinary - 75, Marriage of Convenience - 50.

Problem Identification

A clear amplification of the stated problem which further enhances the scope and identifies problems in greater detail than in the Terms of Reference is obviously the most welcome of the proposals. A repetition of the Terms of Reference in a clear manner, is the second of choice. Statements confusing and mis-representing the intentions as in the Terms of Reference only indicate a lack of Technical competancy. Scoring example: Clearcut & Amplified - 100, Repetition of Terms of Reference - 50, Confusing of Terms of Reference (-)50.

Opportunity Identification

The ability of the firm to identify its opportunities in carrying out the works in the work region and explicitely spelling out their advantages has to be given the due credit. Consequently, such a firm can be expected to give out a set of good alternatives as means to the end of the project. Mention of only modest alternatives is of course an indication of the run of the mill type. Absolute lack of mentioned alternatives is a source of lack of enterprise. Scoring Example: Good Alternatives - 100, Modest Alternatives - 50, No Alternatives (-) 50.

Knowledge of Problem

Spelt out knowledge of the problem as it exists now is a means of knowing the ability of the firm to understand the existing situation, and its needs and from out of all these, generate an adequate knowledge for the best efforts needed to be put in. Scoring Example: Adequately spelt out - 100, Inadequately spelt out - 50, No elaboration (-) 50, No mention (-) 100.

Reconnaisance

It is to be expected that, based on the field visits and discussions which the firms would have had prior to bidding, the firms have to come up with original considerations in the design and construction programmes. While this will eventually be attended to by whichever the firm is, there is no escaping from the fact that, a quick and alert eye even during bidding is an alert beginning. Scoring Example: Appreciable - 100, Agreeable - 70, Inadequate (-) 50, Totally Lacking (-) 100.

Sources of knowledge

Essentially, a matter of personnel in the service of the firm, as it is the personnel and their own knowledge that ultimately forms the basis and sources of the firm's knowledge. The Scoring system has to be for the qualifications, experience and known abilities of the personnel as reflected in their biodata which should find a place in the bid itself.

Needed knowledge

In other words, drawbacks of the firm and wanting areas in its armoury for finding the solutions for the tasks now assigned as clearly relating to personnel and their limitations in their claimed disciplines. Should the firm land personnel who are inadequately equipped technically, the demand and draw on the user agency's reserve of engineers would eventually be more than anticipated. To that extent this criteria becomes significant both technically and financially.Scoring has to be again based on bio-data evaluation and a minus figure.

Power and Status Locus

The achievement of any firm in a chosen undertaking is directly a result of its desire to gain a status signal consequent on a satisfactory completion and also from out of a desire to sustain its past status. The crucial connection in the chain leading to the successful accomplishment of this status signal is its power locus, locationwise. For, getting away with a bad job overseas would not affect the native status of a foreign firm in its country. Contrary to this, the doing of a bad job in the firm's native country is something no aspiring firm may afford to. The scoring system has to be with respect to nativity in relation to the work location.

Aspirations

Forms the live wire of all intentions for activity. This is borne out of the past experience accumulated by the firm and has to be clearly spelt out by the firm. For example, whythey want to come over and do the job? Making profit is of course a common denominator to all the firms, but, more important from the user's view would be a firm who is known to be world wide with a desire to get a footing, here in the user country. Scoring Example: Spelt out clearly - 100, No mention (-) 50, Tendency to outwit the user agency (-) 100.

Analysis

Closely resembling reconnaissance, but, in reality, totally different in scope, this criteria evaluates the firm's capabilities to analyse its strengths, weaknesses and opportunities, thereby evolving its personnel, social and situational analysis. For example, a firm with a lot of personnel strength who have had a technical and social exposure to situations here, would not only save on the take off and acclimatisation time, but in all probability would be willing workers when they decide to come over. Scoring Example: Adequate Personnel Strength - 100 max, Adequate social strength - 100 max, Adequate Situation Strength - 100 max.

Experimentation

A trait of successful work accomplishment in original style in engineering projects is the willingness to question the adequacy of prescribed norms in a condusive manner and to go in for experimentation of other known norms before deciding on firm work bases. Scoring Example: Design Aspects - 100 max, Review Aspects - 100 max, Construction Aspects - 100 max.

Result Analysis

An offshoot of analysis and experimentation, this criteria represents the willingness of the firm to adequately pronounce and openly express the results analysis. Most often, miscalculated earlier versions are simply changed to later found versions without either mentioning the reasons or admitting earlier inadequacies. A firm which comes out with the result analysis and admits the findings is naturally to be preferred as it is an indication of its own welcome admission levels of unintended mistakes. Scoring Example: Commitment on Design - 100 max, Commitment on Review - 100 max, Commitment on Construction - 100 max.

Programme Design

Otherwise called as work plan, this is a critical consideration in evaluating a firm's offer of consultancy. If the firm cannot even design a programme adequately, it can never conclude its assignment on any mentionable note. The user agency has perhaps the best knowledge of an adequate programme required for accomplishing the specified tasks. Scoring Example: Adequate - 100, Inadequate (-) 50, confusing (-) 100.

Contract setting

An area where, bidding agencies may not state clearly the real tenure and work responsibility of the personnel and activities. An explicit commitment in terms of specific personnel and their stated tenures and with respect to committed and identified tasks of the project would be ideal. Consequently, vague and camoflaged statements have to be discouraged. Scoring Example: Commitment by personnel, activity and tenure - 100, Activity and Tenure only-70, Designation and tenure only - 50.

Implementation

The clear cut commitment to a stated length of time and the optimisation of the activity time intervals into a PERT format is the least that any firm can be expected to prepare and furnish. Consequently, a mere bar chart of activities is inconsequential. Further, the past records of the firms in having kept their claims in regard to time intervals has also to be considered. Scoring Example: Adequate - 100, Inadequate (-) 50, Confusing (-) 100.

Evaluation Feedback

In long term contractual obligations, particularly with firms who claim to have an international experience, a logical post contract service to be legitimately expected is the evaluation feedback of its works from time to time as improved upon in other locations. So much so, the expectation, needs to be backed up by a convincing commitment on the part of the firms. Scoring Example: Committed - 100 , Noncommitted (-) 50.

Compliance

The most significant though not the most important of all criteria is the compliance of the firms for certain details which were explicitely spelt out in the Terms of Reference. Complete compliance has to be encouraged fully. Lack of mention being the midline and the demand of contrary details is to be discouraged. Scoring Example could be from the aspects of Arrangement of Work Plan, Duties of user agency staff, Experience on Specific works, Accomodation and Transport Commitments, Taxation Commitments and turning over of all basic records to the user agency on completion of the project. The scoring could be a minus figure in certain cases.

THE NET SCORING SYSTEM

Depending on the nature and scope of the works for which the consultancy bids have been invited, the relative importance of each of the afore discussed criteria would vary. Thus for example, if the consultancy is for a socio-economic pre-investment survey, criteria nos.3 & 5, i.e. opportunity identification and reconnaissance may be more important. They however would be the least important in a consultancy for construction supervision. Hence relative weightages have to be awarded for each criteria and is a matter of decision for the user agency. An illustrative weightage for an hypothetical water supply consultancy project for design and construction supervision is illustrated in Table 2. It is however important that the scoring system for alloting scores to each of the facets and the relative weightages of the facets have to be finalised by the user agency before receipt of the bids. Similarly, wherever minimum qualifying scores are contemplated, the requisites to meet these minimum scores must be adequately spelt out in the Terms of Reference itself.

T A B L E - 2

SUGGESTED WEIGHTAGES IN ORDER OF PRIORITIES

Criteria	Weightage
Orientation	2
Problem Identification	3
Opportunity Identification	2
Knowledge of problem	5
Reconnaissance	1
Sources of Knowledge	2
Needed knowledge	2
Power status & Locus	1
Aspirations	1
Analysis	1
Experimentation	1
Results Analysis	1
Programme Design	6
Contract setting	3
Implementation	4
Evaluation Feedback	1
Compliance	4

CHOICE OF THE SUCCESSFUL BID

The stage now gets set for deciding the successful bid. Certain alternatives in this regard are discussed herein.

In one alternative, the successful bid would

T A B L E - 3

ILLUSTRATIVE EVALUATION USING THE SUGGESTED PROCEDURE (1)

Facets for Evaluation	No.	Scores Max.	Scores Min.	Scores Awarded Bid 1	Bid 2	Bid 3	Bid 4	Bid 5
Scores on Technical Bid	1	100	40	63	50	47	40	40
Cost of Offer, Rs.Lakhs(10^5)	2	-	-	5.14	4.56	3.49	3.32	1.99
Scoring to Cost Ratio	3	-	-	12.26	10.96	13.47	12.05	40.20
% of Ratios in item 3	4	50	-	15	14	16	15	50
Originality	5	15	10	10	10	10	6	0
Compliance	6	15	15	15	15	15	0	0
Orientation	7	20	15	15	15	15	20	8
Total of items 4 to 7		100		55	54	56	(2)	(2)

N.B.: (1)Scope of Bidding for design and construction of a pressure filter recirculation system for a hitherto fill and draw type of swimming pool.
(2)Bids 4 & 5 not totalled and rejected as minimum scores have not been obtained in respect of itmes (5), (6) & (7).
(3)Choice can be either Bids (1) or (2) or (3) depending on investment capability as all three bids represent commensurate levels of return on respective investments.

be that bid which has met the stated minimum scores in each facet and has obtained the highest net weighted score. The bidder has to be called in, his cost bid opened and the price level negotiated with respect to a prior estimated value.

In another alternative, for all the firms who have met the minimum qualifying scores for each of the facet, their cost bids could be opened and the scores to cost ratio computed. The successful bidder would be one whose bid obtains the maximum ratio of scores to cost. It may be noticed here that, the question of price negotiation with any or all of the bidders does not arise in this alternative, as, should it be done, the bidders would be encouraged to offer price reductions knowing fully well the needed margins for obtaining the maximum score to cost ratios.

A third alternative would be to restrict the scoring to cost ratio to only the scores in respect of certain work items and thereafter convert these ratios into a prorata percentage score. To this are added scores obtained in respect of the remaining facets and the resulting highest score indicates the successfull bidder.

Each of these alternatives have their own areas of importance in actual use. For example the first alternative is better suited for consultancy service biddings for socio economic studies which are mostly a routine type of data collection and documentation efforts of a short duration. The second alternative is better suited for consultancy bids for detailed engineering design. The third alternative is better suited for bids where emphasis is more on construction of a project than its design and detailed engineering.

An example of the usefulness of this evaluation procedure using the third alternative is presented in Table 3 which reproduces the evaluation sheet used by the author in rating bids for design and construction for a pressure filter recirculation system.

POSSIBLE ADVANTAGES

The suggested procedure has certain advantages as follows.

It is easier to build up this suggested procedure into a standard programme which could be subjected to a sensitivity analysis when biddings have to be evaluated in an uncertain investment climate with associated doubts in regard to the time factor.

Further, the engineer who evaluates, simply assigns a score which he feels justiciable & there need be no elaborate arguments on record which are so often difficult to draft to concisely present the intended statements and have a tendency to warrant criticism and comments depending upon the reviewer's understanding of such written records.

Moreover, it is easier to quantify one's judgements for posterity than writing and piling up huge volumes of qualitative write ups which are both cumbersome and voluminous. This is all the more significant with the availability of computer facilities in many locations.

8th WEDC Conference: Water and waste-engineering in Asia: MADRAS: 1982

SEWAGE TREATMENT AND ITS ESSENTIALS

by P S RAJVANSHY and S K MISHRA

Jaipur city, today envelopes about 10 lac souls. It is flanked by two major sewerage outfalls (North and South). During the past couple of years it became very essential to treat the sewage and consequently a fool proof sewage treatment plant was commissioned in the year 1979. This was implemented to remove risk to Public Health, to avoid foul smells and objectionable sights and to prevent the pollution of streams and wells.

In its conceptual design consideration for the first time the new waste water treatment facility, PHED Rajasthan incorporated several inovating features. One of these features was that biological treatment was used with aerobic digester attached with sludged thickner. This treatment unit has been in full operation for approximately two years and this paper describes the facilities being used and discusses some of the design and basic mechanism involved in every treatment unit. Figure 1, shows the present plant layout, and reflects the complete sewage treatment and disposal cycle. The present design capacity in use is 3mgd with the total capacity for 6 mgd. Sewage receives primary treatment prior to biological treatment and the effluent is discharged to the Jalmahal lake. The excess sludge is thickened and digested to pass on to the drying beds for final disposal as manure.

Extended Aeration: Extended aeration, total oxidation or aerobic digestion is the system in which water borne wastes of domestic origin are aerated in the presence of flocculent cultures of micro-organisms, the so called activated sludge, to oxidize the organic compounds in the presence of molecular oxygen to carbon dioxide, water, and new cells. Flocculeted mass can be separated by sedimentation. Quantities of the waste water then can further be added, and the procedure is repeated until a sufficient concentration of flocculent activated sludge has been built up to permit operation under continuous flow conditions. A high mixed liquor suspended solids (MLSS) concentration and extended period of the aerations are essentials of this process to seek a reduction of BOD over 98 percent. The essentials in this process are:-

Sludge Age (days): 10, Residence time (Hrs.): 15-30; Removal efficiency (%): 85-98; Reactor solid concentration(Mg ML SS/1): 3500-5000; Recycle Ratio: 0.7-1.5; Lb BOD/ft cu.days: 0.025

Sewage purification and sewage works: Sewage is a water borne waste which contains enormous variety of waste products of human, animal, vegetable or mineral origin in dissolved and undissolved form. Efficient and successful sewage treatment involves the healthy and proper functioning of all operations. Each unit of treatment plant relies on the harmoneous functioning of the previous one. Every unit differs in design, strength and quantity of sewage it receives and the time period of contact.

Screening: The sewage from the half of the city Jaipur is led to this treatment plant by a 1200 mm dia. masonary sewer. The total quantity of the sewege received by the treatment plant is about 3 mgd with a maximum flow in the morning/evening hours. The first step is the removal of the objects by screens of size 3" and 3/4". The bar screen has been set with the bars, sloping in the direction of the flow, and the angle with the horizontal is 60°. Bar screens are cleaned by hand alternatively, substituting another set of screen of the same size.

Grit Removal Unit: Removal of grit is based on the fact that grit is heavier than organic solids present in the sewage. The specific gravity of quartz material is about 2.65 and of organic matter ranges from 1.0 to 1.2. Practically, a detention period of 1 minute and a velocity of about 1 fps. have been found to be most effective in removal of grit. Theoritically this unit should eliminate inorganic material large than about 0.2 mm. The removal is effected by means of a small settlement tank from which the grit is removed by pump. The four parabolic channels with 2.286 meter top width, 0.6m bottom width, and 0.85m deep, also play vital role in removing the grit from sewage. This unit is equipped with mechanical device for washing and removing the grit. The grit unit makes a use of small detention where after being washed, the grit is lifted out by a conveyor. The conveyed material is dumped into the trolly standing just below it for final disposal.

Biological Reactor: This sewage after grit removal is led through the channels to the surface aeration system. The system of aeration in this plant involves the latest technology. The mechanical aeration system introduces oxygen into the liquid and the activated sludge is kept in suspension by an agitator, rotating at or near the surface of the aeration tank. Aeration cone consists of an inverted rotating funnel shapped agitator equipped with vanes on its upper surface, surmounting on masonary uptake tube, situated in the centre of each aeration pocket. Circulation and aeration are produced by the aeration cones drawing liquid from the draught tube and spraying over the tank surface, entraining and dissolving oxygen in the process. The intensity of aeration can be controlled by varying either or both the rotation speed of the cone and its degree of imersion in the liquid. The rate of oxygen transfer is affected by the nature of aeration device, depth of submergence, temperature turbulance in the tank, depth of the tank and the chemical character of the sewage. The MLSS has to be kept 3500-5000 mg/1.and is so adjusted that dissolved oxygen remains 2-3 mg/1. The very important part of this unit is the maintenance of recirculation ratio, which is kept commonly in between 0.5 to 1.5 in treating domestic sewage but ratio upto 10 are employed to the strong industrial waste. The re-circulation is from the under-flow of the final settling tank.

Final Settling Tank: From the aeration tank the sewage flows to a final circular settling tank whose storage capacity is 5675000 Lit. The detention time allowed is 2.3 hours. The aerated sewage enters at the centre and flows to the periphery to form a sort of influent well at the centre by means of a pipe through the body of the tank or more appropriately it is more or less an upward flow through a central riser from a pipe entering under the tank. A circular baffle provides a satisfactory distribution of the flow. The baffle is perforated. Scraper has been provided to remove and concentrate the sludge to hopper, which is removed from the tank by pumping.

Sludge Thickener: Twenty percent of the settled sludge is pumped to a gravitional thickner while about eighty percent of the same meets the sewage entering aeration tanks. The feed solids entering in the middle are distributed radially and the sludge solids are collected as underflow. By thickening the volume of sludge going to the aerobic digester is reduced and the thickner over flow is returned to the f s t inlet. Here thickening means solid concentration to less than 15 percent, but practically to produce the sludge with 6 to 10 percent of solids. This sludge is then onwards passed on to the aerobic disgester.

Aerobic digesters: Waste biological sludge so produced is stabilished by simply reserving aeration in four aeration basins. The basic reaction of the aerobic sludge stabilisation is conversion of complex organics into carbon dioxide and water by action of aerobic organisms. Stabilization process has a very mixed, varied complete food chain which results into non-fragile ecology. Unit has been designed to eliminate all sludge disposal problems and to allow only inert solids to escape over the drying beds. Dewaterability is tremendously effected by it.

Drying Beds: The digested sludge is pumped on to twelve beds at a depth of 6-12" from which water drains out into the sand and accumulates into the drains to out. A considerable fraction of the water is drained by settling of the solids and general compaction, followed by the formation of channels that further the process of dewatering. Further dewatering occurs by evaporation. Beds consist simply of shallow ponds with sand bottoms and tile drains. The time required for the sludge to dewater to a liftable consistency ranges from 10-15 days.

The plant has been in operation since September, 1979. On the basis of the operating experience today, it is interesting to note that the obtained results confirm the design specifications. BOD_5 removal is to the extent of 95 to 98%. The effluent is more than of excellent quality with a minimum and maximum BOD_5, 7 and 15 respectively. Though design requirement is 10 against the influent BOD_5 450 mg/1. The sewage sludge contains substances of considerable fertilizing value such as nitrogen (3-4%); phosphorous (1.5 to 2.5%); potassium (0.3-0.6%), humus, and organic growth producing substances. It is a soil conditioner and can be used as a filler for true fertilizer.

Maintenance Cost and Revenue Return: The expenses incurred annually in the maintenance of sewage treatment plant are given herein as under:-

Electricity Charges:	Rs.4,80,000/-
Labour Salary & Wages:	Rs.3,00,000/-
Miscellaneous expenses:	Rs. 60,000/-
Total annual maintenance cost:	Rs.8,40,000/-

Revenue Return of sewage sludge has been evaluated not only to give a coverage to the expenses incurred in maintaining the plant but proves to be of an asset to the income. Annually the production of sewage sludge is about 10,000 cum which (@ Rs.80 per cum) yields Rs.8,00,000/- annually. 2.9 mgd effluent which is passed on to Jalmahal amounts to Rs.96,000 per annum. Therefore, Rs.8,96,000/- is the estimated revenue return against the maintenance cost shown. The revenue returns are furthered if the plant runs to 6 mgd. The economics enough cannot be compared with the invaluable efforts to safeguard the public health but conversely for a state which is already under so many economic strains, this facility with returns is of vital importance and considerations.

Conclusion: The system to date has been capable of meeting a process effluent guarantee of 10 mg/1, BOD_5. There was no evidence of filamentous growth and associated problems and no major system design problem could be noticed. Efficiency determining factors have revealed that there is no undue economic penalty and rather number of benefits can be ascribed to the aeration of this plant.

Details of Design Specifications of the Plant:

Unit : 1 Inlet Chamber: Out fall sewer 1200 mm dia. with capacity of 12 mgd.

Unit : 2 Screen Chamber: Two chambers of 6 mgd capacity. Velocity of flow: Max. 0.76 mt/Sec. at peak flow. Screen size: Coarse screen 3" opening, Fine Screen 3/4" opening.

Unit : 3 Grit Removal: Capacity : Ultimate 6 mg. Velo. of flow: 0.772 mt/Sec. Size of grit settling: 0.2mm settling time: 65 Sec.

Unit: 4 Aeration Tank: (42) Detention time in the tank: 13.28 Hrs. Proposed MLVSS concentration: 2520 Proposed MLSS:" 4200 Oxy.capacity: 1.15 Kg/Kg of BOD_5. Capacity of aeration tank: 15.08 Million Lit. (358660 x 42). Proposed SVI: 50-100 Volume of surplus sludge: 2250 Kg./day Proposed F/M: 0.1485 Proposed SRT: 525 Kg/1000 cum. Aeration tanks: 10.36x10.36x2.47 Mt. Hopper bottom tanks: 10.36x10.36x5.56x1M Aeration concs: 1.8 mt.dia.

Unit: 5 Final Settling tank: Surface overflow rate: 53750 lit/day/sq.mt. Detention period: 2½ Hr. Total capacity: 5.675M.Lt.

Unit: 6 Return Sludge Pump House: Pumping capacity: 6 mgd. with 2 mgd stand-by.

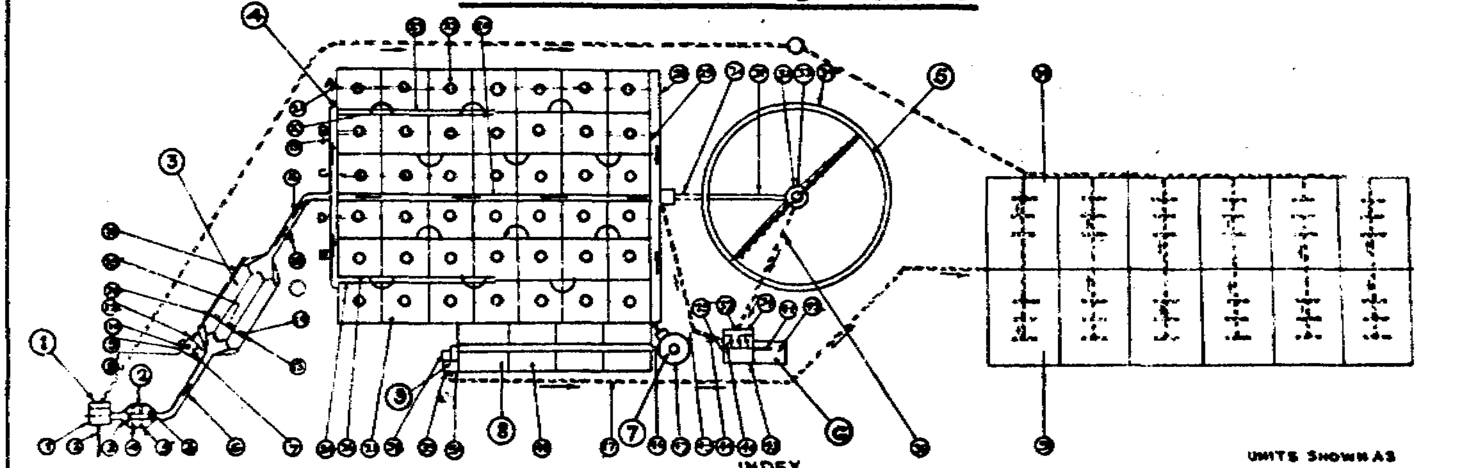
Unit: 7 Sludge Thickner: Capacity: 186140 lit. Size: RCC 6.1 circular tank with 3.96 meter depth with hopper bottom. Inlet: 200mm dia.C.I.Pipe Outlet: -do-

Unit: 8 Aerobic disgestors: Detension time: 12 days Oxy.capacity: 0.08 Kg.of Oxy. per Kg. of BOD removed.

Unit: 9 Secondary Sludge Pump House: Pump capacity: 27.2cum/hr.

Unit: 10 Sludge drying beds: Area: 4366 sqm. Drying time 10 days. 12 Nos. Sludge drying beds. Size: 22.87x17.62 meter (each).

LAYOUT CHART OF UNITS



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1	ILC	INLET CHAMBER	18	FM	FLOW METER	35	STOC	SETTLING TANK OUTLET CHANNEL
2	OFS	OUTFALL SEWER	19	ATIC	AERATION TANK INLET CHANNEL	36	SSP	SLUDGE SUCTION PIPE
3	G	GATE	20	CMDC	CENTRAL MAIN DISTRIBUTION CHANNEL	37	SSPV	SLUDGE SUCTION PIPE VALVE
4	CS	COURSE SCREEN	21	AT	AERATION TANK	38	WS	WET SUMP
5	FS	FINE SCREEN	22	ABCDEF	AERATION TANK ROWS	39	DS	DRY SUMP
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8	VSP	VORTEX SEPARATOR PIPE	25	WSG	WEST SIDE GATE	42	OCP	OPERATOR CONTROL ROOM
9	VSC	VORTEX SEPARATOR CHAMBER	26	ESG	EAST SIDE GATE	43	MSPH	MAIN SLUDGE PUMP HOUSE
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11	GL	GRIT LAUNDER	28	ATOC	AERATION TANK OVERFLOW CHANNEL	45	STIP	SLUDGE THICKNER INLET PIPE
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14	GP	GRIT PUMP	31	WWB	WALK WAY BRIDGE	48	SSPH	AEROBIC DIGESTORS
15	GVP	GRIT VACUUM PUMP	32	CP	CONCRETE PIER	49	SSPH	SECONDARY SLUDGE PUMP HOUSE
16	MC	MEASURING CHANNEL	33	SP	SCRAPER PIER	50	FR	FLOW RECORDER
17	SRM	SLUDGE RISING MAIN	34	WSDB	WEST SIDE DRYING BED	51	ESDB	EAST SIDE DRYING BED

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Figure-1

8th WEDC Conference: Water and waste engineering in Asia: MADRAS: 1982

PERFORMANCE OF SOME BIOLOGICAL TREATMENT PLANTS FOR INDUSTRIAL WASTE WATER TREATMENT

by DEEPAK KANTAWALA

During the 12 years of its existence Environmental Engineering Consultants (EEC) has designed and commissioned a large number of Industrial Wastewater Treatment Plants. The primary purpose of this paper is to present data on some of the Biological Treatment Plants which have been in operation for the last 5 years in various industries around the country.

TREATMENT PROCESSES

Basically Industrial Wastewater Treatment Processes can be divided into 2 groups, namely Primary and Secondary.

Primary Treatment generally consists of Equalization, Neutralization, Clarification and Chemical Treatment if necessary. Secondary Treatment generally consists of Biological Treatment Unit Processes.

The purpose of Primary Treatment is to prepare the wastewaters for subsequent Biological Treatment. Equalization for example results in a generally uniform quantity and quality of wastewater entering into the Biological Units. Neutralization similarly ensures a proper pH for the biomass. In addition to this, the Primary Treatment Processes like Chemical Precipitation or Chemical Coagulation would result in removal of pollutants which may inhibit Biological Process.

The Primary Treatment Processes would also result in removal of Suspended Solids, Oil and Grease and some incidental reduction in organics (Biochemical Oxygen Demand). The removal of organics through Chemical Coagulation is especially significant for industrial wastewaters which contain a major portion of the organic load in the form of colloidal or suspended matter. Typical examples are Milk Processing or Food Canning Wastewaters.

The Biological Treatment Processes generally employed in the treatment of industrial wastewaters are either aerobic or anaerobic. The processes may also be divided into those employing suspended biomass as against those employing biomass attached to a fixed surface. In general all the Biological Treatment Units employ a mix culture with one or more groups of microorganisms predominating depending upon the major organic component of the wastewater.

TREATMENT PLANT

The basic Treatment Plant Process Flow Diagram employed in the present discussion is presented in Figure 1. Biological Treatment Process employed in all these treatment plants is that of Extended Aeration which results in an aerobically stabilized sludge.

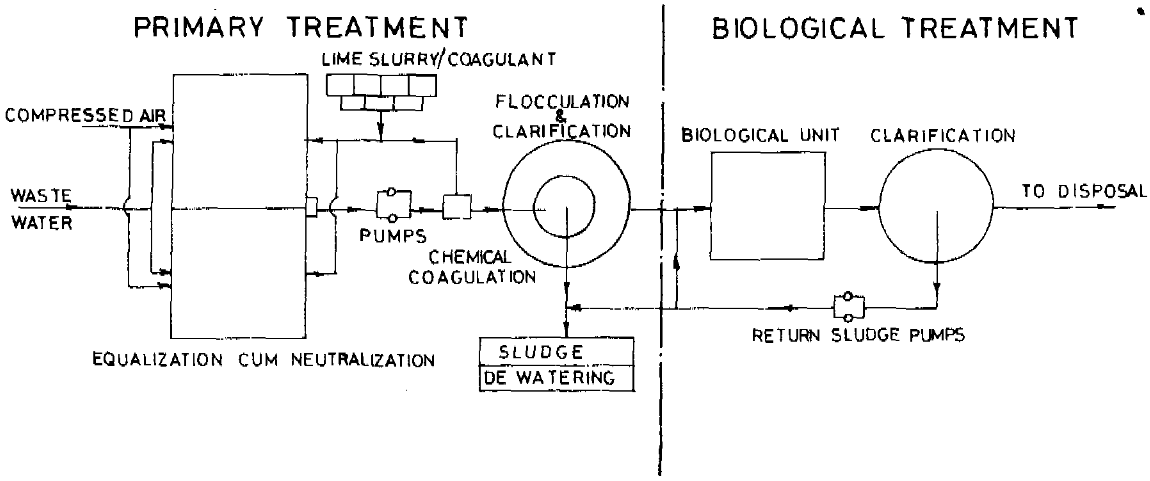


FIG-1
TYPICAL PROCESS FLOW DIAGRAM FOR INDUSTRIAL WASTE TREATMENT

PERFORMANCE DATA

The data on performance of the various Industrial Wastewater Treatment plants for Industries manufacturing milk products, organophosphorus, pesticides, petrochemical, pharmaceutical and fine chemicals, Synthetic fibres and textiles is presented in Table 1. The data is from actual full scale treatment plants except in the case of the petrochemical plant where the data is based on Pilot Plant Studies treating 1 cum per hour of the wastewaters. All the treatment plants were designed after conducting an extensive laboratory study to determine design concentration of pollutants and design criteria for various unit processes. Based on these data, a detailed Feasibility Report was prepared considering various alternative methods of treatment and selecting the final system based on techno-economic consideration.

The data indicates the design concentration based on which the plant was designed. These concentrations are the 90 percentile values based on laboratory studies.

TABLE 1

Sr. No.	Parameter	* Sample	Unit	Concentration Min.	Concentration Avg.	Concentration Max.	90% of samples were less than or equal to
A.	MILK PRODUCTS (Plant influent - Raw wastewaters)						
1)	pH	(1)		4	-	6	-
		(2)		4.8	-	6.7	-
		(3)		5.0	-	7.4	-
2)	Suspended Solids	(1)	mg/l	-	-	-	1000
		(2)	mg/l	20	190	435	260
		(3)	mg/l	10	45	120	90
3)	Chemical Oxygen Demand (C.O.D.)	(1)	mg/l	-	-	-	4950
		(2)	mg/l	480	1085	2400	1480
		(3)	mg/l	60	155	300	240
4)	Biochemical Oxygen Demand (B.O.D.)	(1)	mg/l	-	-	-	2650
		(2)	mg/l	325	625	1150	780
		(3)	mg/l	10	35	100	80
5)	Oil and Grease	(2)	mg/l	9	44	86	64
		(3)	mg/l	2	10	30	12
B.	ORGANOPHOSPHORUS PESTICIDES (Plant influent - Equalized & Neutralized wastewater)						
1)	pH	(1)		0.2	-	12.7	-
		(2)		8.5	-	11.2	-
		(3)		6.4	-	7.4	-
2)	Suspended Solids	(2)	mg/l	10	125	408	340
		(3)	mg/l	10	43	132	110
3)	Chemical Oxygen Demand (C.O.D.)	(1)	mg/l	-	-	-	1880
		(2)	mg/l	600	1250	2338	2209
		(3)	mg/l	75	175	364	350
4)	Biochemical Oxygen Demand (B.O.D.)	(1)	mg/l	-	-	-	1050
		(2)	mg/l	360	795	1800	1700
		(3)	mg/l	8	23	45	42
5)	Oil and Grease	(2)	mg/l	0	6.4	18.4	16
		(3)	mg/l	-	2	8	5.6
6)	Dissolved Oxygen	(2)	mg/l	-	-	-	-
		(3)	mg/l	1.8	3.0	5.7	4.2
7)	Zinc (Zn)	(2)	mg/l	4.76	5.84	8.3	-
		(3)	mg/l	0.503	0.638	0.82	-

TABLE 1 (Contd.)

Sr. No.	Parameter	*Sample	Unit	Concentration Min.	Avg.	Max.	90% of samples were less than or equal to
C.	PETROCHEMICALS (Plant influent - Equalized & Neutralized wastewater)						
1)	pH	(1)		0.4	-	13	-
		(2)		6.2	-	10.2	-
		(3)		7.1	-	7.8	-
2)	Suspended Solids	(1)	mg/l	-	-	-	300
		(2)	mg/l	10	127	850	250
		(3)	mg/l	10	28	60	45
3)	Chemical Oxygen Demand (C.O.D.)	(1)	mg/l	-	-	-	4440
		(2)	mg/l	416	2620	9464	4023
		(3)	mg/l	72	103	170	144
4)	Biochemical Oxygen Demand (B.O.D.)	(1)	mg/l	-	-	-	2500
		(2)	mg/l	360	1487	5690	2550
		(3)	mg/l	15	31	95	50
5)	Chloroform Extractables	(1)	mg/l	-	-	-	114
		(2)	mg/l	9	40	130	71
		(3)	mg/l	6	12	22	15
D.	PHARMACEUTICALS & FINE CHEMICALS (Plant influent - Equalized & Neutralized wastewater)						
1)	pH	(1)		1.4	-	10.2	-
		(2)		6.5	-	7.5	-
		(3)		6.5	-	7.5	-
2)	Chemical Oxygen Demand (C.O.D.)	(1)	mg/l	-	-	-	1730
		(2)	mg/l	40	745	1180	1020
		(3)	mg/l	50	100	195	160
3)	Biochemical Oxygen Demand (B.O.D.)	(1)	mg/l	-	-	-	1200
		(2)	mg/l	215	555	1030	955
		(3)	mg/l	10	60	90	90
E.	SYNTHETIC FIBRE (Plant influent - Equalized & Neutralized wastewaters)						
1)	pH	(1)		7	-	7.5	-
		(2)		5.7	-	7.4	-
		(3)		6.6	-	8.5	-
2)	Suspended Solids	(1)	mg/l	-	-	-	210
		(2)	mg/l	45	155	480	215
		(3)	mg/l	6	30	104	60
3)	Chemical Oxygen Demand (C.O.D.)	(1)	mg/l	-	-	-	1420
		(2)	mg/l	470	1058	4040	1550
		(3)	mg/l	45	210	610	545
4)	Biochemical Oxygen Demand (B.O.D.)	(1)	mg/l	-	-	-	900
		(2)	mg/l	240	595	2600	880
		(3)	mg/l	5	85	230	180
5)	Oil and Grease	(1)	mg/l	-	-	-	180
		(2)	mg/l	17	34	52	-
		(3)	mg/l	0	4	10	-
F.	TEXTILE MILL (Plant influent - Equalized & Neutralized wastewater)						
1)	pH	(1)		-	-	11.0	-
		(2)		6.5	-	11.0	-
		(3)		7.5	-	10.5	-
2)	Chemical Oxygen Demand (C.O.D.)	(1)	mg/l	-	-	-	800
		(2)	mg/l	780	1670	3160	1300

TABLE 1 (Contd.)

Sr. No.	Parameter	*Sample	Unit	Concentration Min.	Concentration Avg.	Concentration Max.	90% of samples were less than or equal to
		(3)	mg/l	300	800	1860	1080
3)	Biochemical Oxygen Demand (B.O.D.)	(1)	mg/l	-	-	-	600
		(2)	mg/l	375	960	2537	1300
		(3)	mg/l	25	240	700	475

* (1) Design Concentration (2) Plant influent (3) Plant effluent.

COST ESTIMATES

Cost curves have been prepared based on the cost of already constructed Treatment Plants or based on plants for which detailed engineering was completed and where detailed cost estimates were available. These costs curves have a cost basis of 1978 costs and should be used with appropriate escalation factors for present estimates. It should be emphasized that these cost curves will only provide Budgetary Estimates.

ACKNOWLEDGEMENT

We would like to gratefully acknowledge the cooperation and assistance given by the various Industries from which the data on performance and cost was collected and used in this paper.

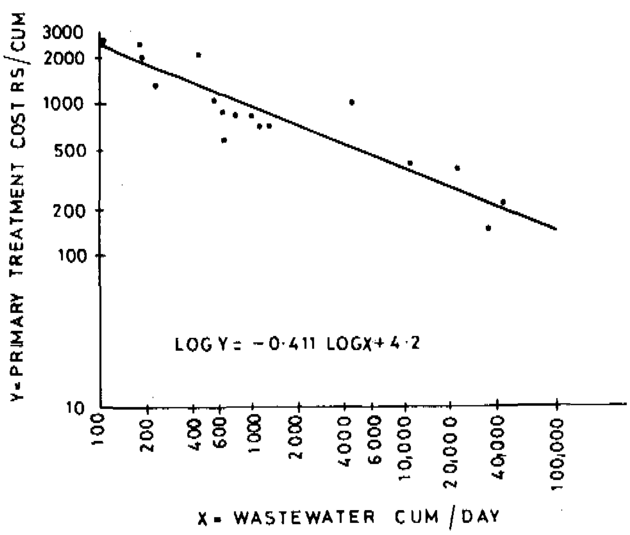


FIG-2.

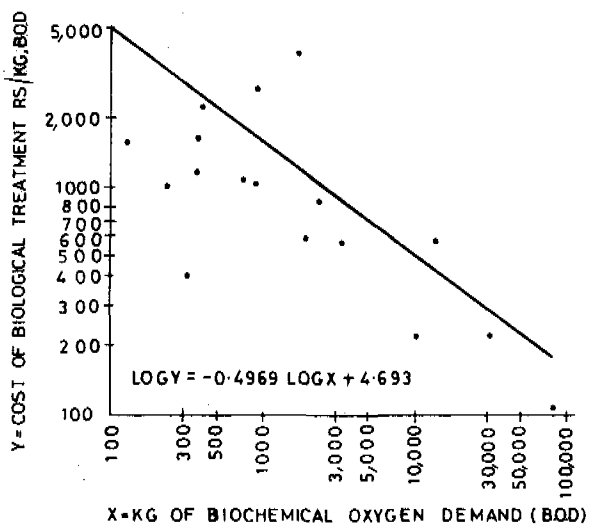


FIG-3

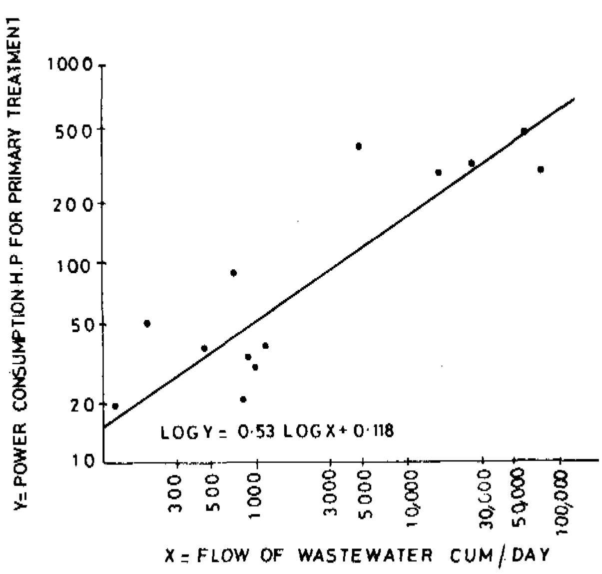


FIG-4

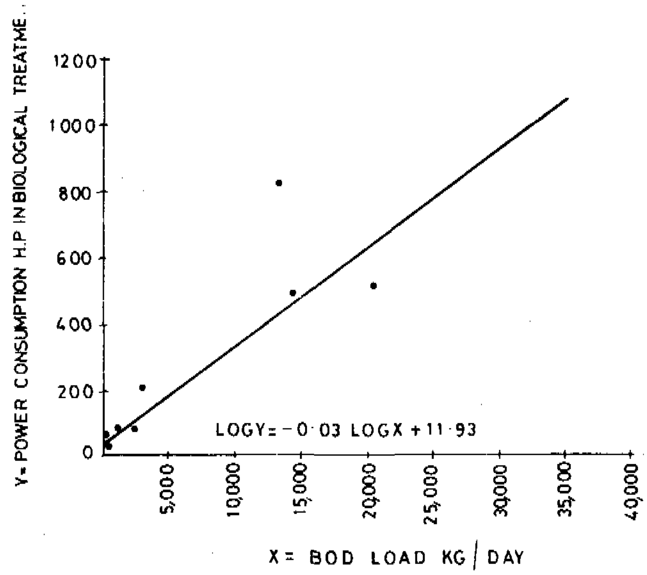


FIG-5

Session 5

Chairman : Mr M S Sandhu
Managing Director, Punjab W.S.S.B.

Discussion

G Mathew and S A Jagadeesan

Management of protected water supply schemes

1. Mr JAGADEESAN spoke generally about the financial and managerial aspects of water supply with particular reference to : self financing systems; water distribution networks; equipment maintenance and materials; co-ordination between planning and implementation; and public cooperation.

2. Mr SHANKARAPPA asked for a breakdown of budget costs in Tamil Nadu, and wondered if there was a ratio of "manpower per litre of water".

3. Mr JAGADEESAN provided the following budget information : 10-15% on storage and treatment; 80% on transmission and distribution; 5% on maintenance. He knew of no such ratio.

4. Dr DHABADGAONKAR stated that the quality of water received by the consumer was important, and asked if the T.W.A.D. board checked on the quality received at distribution points.

5. Mr JAGADEESAN replied that the board carried out such checks, but that he had no results immediately available.

6. Dr CHOUDHARY wished to know the water quality parameters investigated.

7. Mr JAGADEESAN listed biological and bacteriological quality, solids content, chloride and iron content as important factors. However, this depended on the facilities available at regional laboratories.

8. Mr SUNDARAM took up the point that economically weak sections of the community required water supply, and that the cost of this social obligation had to be met. Had any practical solutions been evolved?

9. Mr JAGADEESAN thought that only a certain percentage, for example 40% or 60%, could be borne; assessment had to be made on the ability to pay.

V Varadarajan, S Sundaramoorthy and M Sivaprakasam

Knowledge management in public water supply undertakings

10. Mr SIVAPRAKASAM introduced the paper by discussing the concept of knowledge management, and outlining the basic components of communication, co-ordination, information dissemination, and documentation.

11. Manpower training was highlighted as a logical culmination to the above tasks, and lists of training requirements for all levels of personnel associated with water supply undertakings were suggested.

12. Mr DHEENA SHANKAR thought that the training and reorientation had to be voluntary, and wondered how successful Metro Water had been.

13. Mr SIVAPRAKASAM agreed that the training had to be voluntary, and that this was the case with Metro Water. The board felt that people required motivating to bring up the standard of their work; if a person knows why an activity has to be done in a particular way, he is more likely to accept it.

14. Mr KEKAR asked how motivation could be achieved within public bodies, and how the cost benefit of training is derived.

15. Mr SIVAPRAKASAM replied that recruits should be motivated initially, and as far as possible the motivation should be maintained. Meetings, seminars and consideration of professional advancement were useful. The benefit could only be assessed in terms of optimizing the use of existing manpower, which should ultimately lead to financial benefit.

16. Mr SHANKARAPPA wished to know what type of training was suitable for supervisory and technical staff.

17. Mr SIVAPRAKASAM felt that practical appreciation and "on the job" training should be provided.

A M Richards

An approach to water sector training

18. Mr RICHARDS discussed the approach to training by considering a first phase of analysis and planning, in which requirements were assessed, and a second phase of implementation of both "on the job" and "off the job" training.

19. This approach was illustrated using the Metro Water training project in Madras, which has established a training centre and is running programs of courses on a variety of related topics.

20. Mr BUKHARY asked if such training schemes could be applied in other developing countries, and whether cost benefit analysis could show that training was beneficial.

21. Mr RICHARDS stated that this approach was being applied elsewhere, but that the Madras program was at a more advanced stage than others. Cost benefit analysis would be possible, but the present situation was that of an emergency, with the demand for a type of training which hitherto had not existed. Resources need not be as large as those available for the Madras project, but what was required was a systematic approach, rather than the previous haphazard approach.

22. Mr SHAMKARAPPA asked for Mr RICHARDS' opinion on providing training on the maintenance of specific items of equipment.

23. Mr RICHARDS stated that the job-orientated training naturally included the teaching of such skills; the Madras training centre incorporated considerable workshop and laboratory facilities.

24. Mr NOBRE suggested that the method of using a structured interview with staff in order to assess training requirements may be somewhat intimidating, and that an anonymous questionnaire would be better.

25. Mr RICHARDS thought that the ability to interview personnel to assess training needs was an essential requirement of trainers; staff must understand the reasons for analysing the needs, and once they do so, will cooperate. This has worked successfully in Madras; the skilled training analyst can encourage the person to discuss his training needs and those of his superiors and subordinates. Questionnaires rarely provide any meaningful information because of a general reluctance to admit deficiencies.

S Sundaramoorthy

A suggested procedure for the evaluation of bids for consultancy services

26. Mr SUNDARAMOORTHY discussed a possible framework within which consultancy bids could be evaluated. After listing a number of points which should be taken into account, each factor was given a weighting; using these values, bids could be assessed in the light of a score; this would help to produce a rational basis for accepting a particular bid. An example was used to illustrate the method.

27. Mr RAJAGOPAL stated that advancing management techniques such as the "Delphi technique" were quoted as providing good results; would they be applicable?

28. Mr SUNDARAMOORTHY agreed that the method was used, but could not compare its effectiveness.

29. Mr PEREIRA asked whether the technicality, pre-qualification and price were still the points on which decisions should be made.

30. Mr SUNDARAMOORTHY replied that the minimum points score allowed for more factors.

31. Mr KALBERMATTEN congratulated the author on tackling a difficult problem with imagination. He suggested that the example quoted in the paper did not resolve the problem completely, and suggested that he personally would choose the cheapest bid if the technology was well known, and the most expensive if it was complicated. The classical dilemma remains.

32. Mr KALBERMATTEN suggested that it would be useful to be able to rate the cost sensitivity of design errors; using the rating system may still leave problems of choice.

33. Mr SUNDARAMOORTHY agreed that the extent to which design was important was significant; he agreed with the final problem of choice, but thought that arguments were less likely to be exposed using the rating system.

34. Mr NAJUNDAPPA commented that he had recently used a similar rating system and had found it most useful.

35. Dr CHAUDHARY asked how the reliability could be checked.

36. Mr SUNDARAMOORTHY replied that a minimum required score could be set before accepting bids, but checking could be difficult except in retrospect.

37. Mr COLVALAR thought that bids which deviated from the terms of reference should not be accepted, and that he would apply different weighting factors from some of those indicated.

38. Mr SUNDARAMOORTHY replied that the weighting factors would be changed depending upon the nature of the problem.

P S Rajvanshi and S K Mishra

Sewage treatment and its essentials

39. Mr RAJVANSHI drew attention to a number of errors in his paper on page 112 ; these were duly noted.

40. He described the performance characteristics of a sewage treatment plant at Jaipur, consisting of screening, grit removal, aeration, final settlement, sludge thickening, aerobic digestion and drying beds. Maintenance costs and revenue were included.

41. Mr HUTTON commented that even a 99% removal of coliform bacteria resulted in an effluent which would have a high coliform count, and would constitute a health hazard.

42. Mr RAJVANSHI agreed, but pointed out that ascaris and salmonella would be removed; effluent used for irrigation is allowed to settle for a further 20 to 30 days. Chlorination of effluent is not justifiable.

43. Mr KALE wished to know whether the collection of sewage in a lagoon had caused health problems and a nuisance to nearby residents and animals.

44. Mr RAJVANSHI replied that a lagoon was a health hazard and created bad odours. The new works was operating well and there was no longer the odour problem or other disadvantages.

45. Dr DHABADGAONKAR observed that when extended aeration was provided, further sludge treatment was unnecessary.

46. Mr RAJVANSHI answered that the plant was designed to use as little energy as possible. Addition of oxygen to the sludge converts organics into carbon dioxide and water; in the biological reactor only a part of the oxygen required for complete oxidation is supplied; in this way it is a partially extended aeration process.

D Kantawala

Performance of some biological treatment plants for industrial wastewater treatment

47. Dr KANTAWALA introduced his paper by outlining the stages involved in an industrial wastewater treatment plant. The performance of the plant was discussed using results from the following industries: milk products; organophosphorous pesticides; petrochemicals; pharmaceuticals and fine chemicals; synthetic fibre; and a textile mill.

48. Mr ALGARSAMY observed that in the examples quoted, the degree of treatment was not specified, and in a number of cases the effluent was stronger than the required standard. The overall cost data had been obtained from plants treating different types of waste, and would therefore be somewhat misleading when other industries used it to obtain cost estimates.

49. Dr KANTAWALA said that the plants generally met the prescribed limit of 100 mg/l BOD, apart from the milk plant which had exceeded the limit of 30 mg/l. The textile mill was designed to have a second stage biological treatment unit which was not yet commissioned. He emphasized that the cost curves were for preliminary estimates only, but that the correlation coefficient was very high.

50. Dr SHUKLA asked how the charges were split between feasibility reports, project reports, design, and erection.

51. Dr KANTAWALA stated that it depended upon the terms of reference and scope of each job.

52. Mr JANIKIRAMAN wished to know if the author had any suggestions for the disposal of the solid waste generated by the treatment processes, with the view to recovering material.

53. Dr KANTAWALA replied that he had not been involved with this, although a number of articles were available on the subject.

54. Mr SANDHU closed the session by commenting that good management was vital to overcome many short-comings in projects. Relevant training was too important to ignore any longer and training institutions needed to reorientate themselves to provide suitable teaching, incorporate field work, and to recognize the importance of finance, accounting, and management.

8th WEDC Conference: Water and waste-engineering in Asia: MADRAS: 1982

SULABH SHAUCHALYA (HAND FLUSH WATER SEAL LATRINE)

by BINDESHWAR PATHAK

I deem it a privilege to be amidst you, though I have brought with me only my experiences in the latrine conversion programme undertaken by our organisation in Bihar and many other States in India. I would seek your guidance in tackling some of the problems which we are facing in the implementation of our programme of conversion of dry latrines into water flush ones.

Sanitary engineers, social scientists, planners and administrators all over the world are feverishly searching for economical, safe and hygienic system, other than the sewerage system and septic tank, for the disposal of human excreta which can be adopted on mass scale. The safe and hygienic disposal of night-soil is posing a problem both in urban and rural areas. The problem is particularly acute in cities and towns. So far no India-wide survey has been made to determine the depth of the problem. But whatever random survey has been made reveals that over 70 percent of the urban people are bereft of the sewerage or septic tank facility. They use either service slatrines, drains, roads or open spaces for defecation which pollutes the atmosphere andleads to many types of diseases like cholera,diarrhoea, hookworm, tapeworm etc. Open air defecation and service latrines breed germs which cause disease like diarrhoea leading to dehydration and ultimately mass death among children.

Now here is a question mark. The sewerage and septic tank systems came into being in the years 1400 and 1460 respectively for the proper, safe and sanitary disposal of human wastes, yet why even today is a big chunk of the population deprived of this facility? When we think deeply over these issues we come to the conclusion that economic constraints, lack of space and political will, all these combine to bar mass adoption of the sewerage and septic tank systems. The Septic tank system too is regarded as a safe and hygienic method for the disposal of human excreta. But even this system is so expensive that its adoption on mass scale has not been possible so far.

Growth of cities started in India after the Second World War. It was so rapid that town planners and engineers were taken aback. Expansion went on in a hotch-potch way. Those who migratedto cities had rural orientation and began construction of their houses without caring for guide rules and regulations. Sewerage did not exist and the septic system was too costly.Hence they started constructing service latrines in their houses. As the system was cheap it attracted mass adoption.

Though negligible efforts were made earlier also, since 1940 onwards experts and engineers started hectic search for a safe and economical alternative to the sewerage and septic tank systems for disposal of night-soil. Various international agencies, notably the WHO, UNICEF and UNDP, have been engaged in evaluating the methods so that if there are any defects they could be removed and recommended for mass adoption. Here it is worthwhile to quote an eminent sociologist, Tylor's principle of 'psychic unity of mankind' and 'parallel growth of inventions'. A study of various books reveals that since 1950, in various countries of the world a search was on for an alternative to the sewerage and septic tank systems and some solutions were evolved according to their geographical, cultural and social conditions. Although all the alternatives may not have been useful, yet they were tried on an experimental basis and some success was achieved. Here it is to be noted that though all Asian, African and Latin American countries were busy searching for an alternative, there was no contact among them on the subject. VIP latrine, vault latrine, PRAI, ESP, Vietnamese latrine, RCA and Sulabh Shauchalaya etc. were the products of the above experiments. What to speak of other countries, even in India the research carried out in one State was not known to the other States till 1978.

THE BEGINNING

I took up this work in 1969 when I joined the 'Liberation of Scavengers Sub-Committee' of the Gandhi Centenary Celebrations Committee as a social worker. The Works and Housing Ministry of the Government of India at that time directed all the State Governments to convert all existing service latrines into flush latrines during the

Gandhi Centenary period, as a tribute to Mahatma Gandhi. It also directed them to connect service latrines with sewers wherever avalable and with leaching pits where there was no sewerage system. The design of the leaching pits was also sent by the Union Government. The same year the Harijan Sevak Sangh also sent several designs of hand flush latrines including PRAI, ESP and RCA. At that time I came across the book 'Excreta Disposal for Rural Areas and Small Communities' by Wagner and Lanoix. I read the book thoroughly and came to the inescapable conclusion that the pit privy system alone was the best among all the heterogeneous mass of latrine designs produced in the World. Mr Rajendra Lal Das, my co-worker in the field , was then propagating the 'Sulabh Swaksh Shauchalaya'. In the designs sent by the Government of India, there was provision for only one pit and it was suggested that when one pit was full the second one should be constructed. This did not convince me and I decided that the two pit system alone could serve the purpose, as it was not practicable to construct a second pit over-night. Secondly, the cost of construction of the second pit would go up with the passage of time; and thirdly, the very objective of relief of scavengers (Bhangi Mukti) would be defeated as fresh excreta will need cleaning by scavengers alone. Hence I fell in line with Mr Das's design and made certain modifications. The modified design was named 'Sulabh Shauchalaya' and I started popularising it for adoption on a large scale.

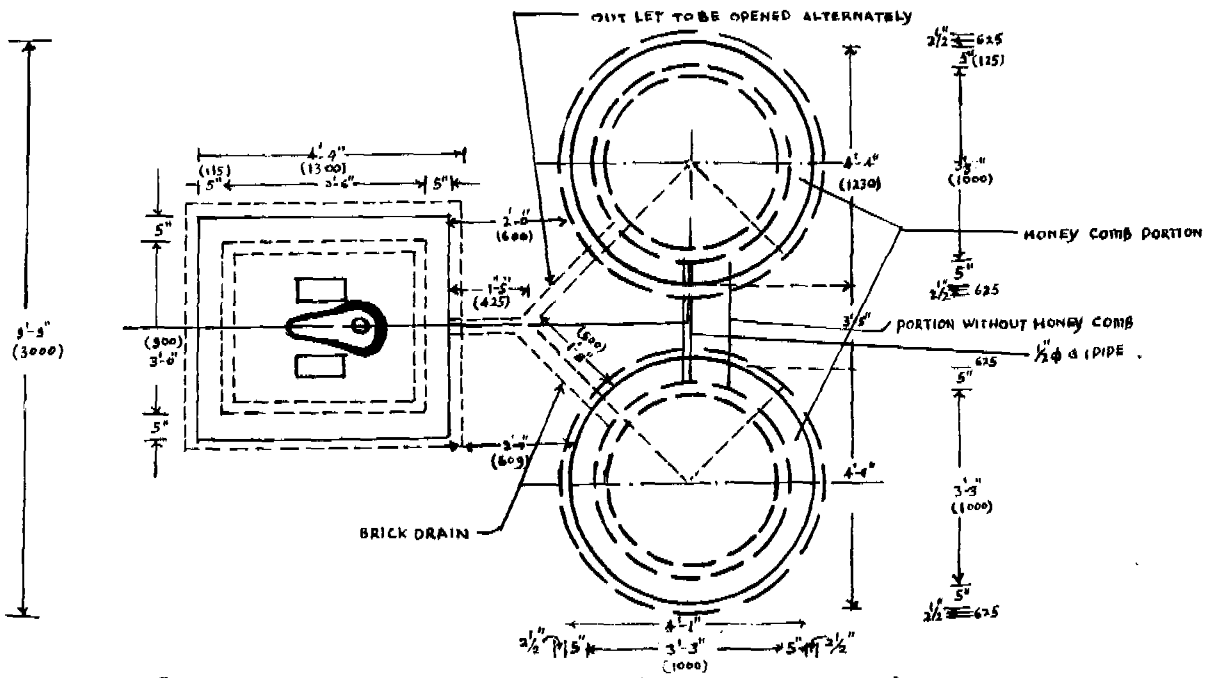
SULABH SHAUCHALAYA

'Sulabh Shauchalaya' is a hand-flush water-seal latrine. Wagner and Lanoix in their book have laid down seven conditions for a sanitary latrine. Sulabh Shauchalaya fulfills all those seven conditions.

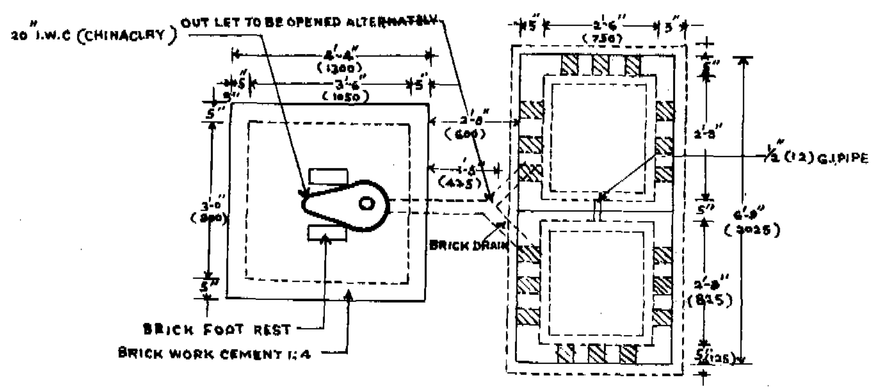
Sulabh Shauchalaya mainly consists of plinth, pan, water-seal, drain, tanks and tank cover. The pan and water-seal are connected with two leaching pits, out of which one functions at a time while the other is kept closed. The second pit is opened for use when the first is filled up. While the second pit is in use, the human excreta gets transformed into manure in the first tank. Under this system one pit is filled up in about 3-4 years when used daily by 6-8 persons.

Design of Sulabh Shauchalaya:

The design of Sulabh Shauchalaya is illustrated in the following diagrams:



PLAN OF SULABH SHAUCHALAYA (CIRCULAR TYPE)



PLAN

SULABH SHAUCHALAYA (RECTANGULAR TYPE)

Salient Features:

Some of the salient features of the Sulabh Shauchalaya are given below:

1. It is quite odourless as the gases produced in the tank are absorbed by the soil.
2. There is no danger of air pollution as the water-seal prevents the gases from leaking out of the pit and, as such, no gas-pipe is needed.
3. It is very easy to construct and it also involves less cost.
4. It requires a small space and can be provided even in the corridor, verandah or the bedroom of the house.
5. It can be constructed in different soil conditions and under varying depths of sub-soil water-table.
6. The human excreta collected in the pit is transformed into organic manure which can be used in fields and gardens.

Sulabh Shauchalaya is not only cheaper than other designs, but its construction materials are also locally available. Even the pan is locally manufactured. Further, no royalty is imposed on it and, to top all, it is free from patent registration. It is a concept and any individual or organisation can use its name freely. This goes to prove that it is an appropriate technology. We have developed designs ranging in cost from Rs.100/- to Rs.800/- (£ 1.0 = Rs.16.65 as on 14.10.1981) so that it can be adopted by the rich and poor alike. It is an alternative to sewerage and septic tank.

DEVELOPMENT

In Bihar nearly 50,000 service latrines have been converted into Sulabh Shauchalaya with the help of the Urban Development Department of the State Government, and 2,50,000 more will be converted in the next five years. In West Bengal, about 4,000 service latrines have been converted with the collaboration of the Calcutta Metropolitan Development Authority(CMDA) and 1,50,000 more will be converted within next few years. About 1,000 Sulabh Shauchalaya have been constructed each in Andhra Pradesh and Orissa. A similar project is to start soon in Tripura, Uttar Pradesh, Madhya Pradesh, Haryana and Jammu and Kashmir. So by all accounts, the two pit system with water-seal which we have developed is the finest and most acceptable in the world for those who use water for cleaning. The basic functioning of the Sulabh Shauchalaya system will remain the same though its size, construction cost etc. may vary from place to place. The technique of Sulabh Shauchalaya was unknown outside Bihar till 1978. Its diffusion started just after the national seminar convened by the Government of India, in collaboration with the WHO and the UNICEF, in Patna in May 1978; and presently it is functioning in four States of the country and is likely to cover the remaining States in the near future. The technology has now been accepted on an international level. About 1,000 Sulabh Shauchalayas have been constructed so far in the neighbouring country of Sri Lanka. Bangladesh and Nepal are also contemplating adoption of this technology. The UNDP is also evaluating its technique and it is expected that the system will be recommended for mass adoption. If the Government of India wants to achieve the sanitation target of UN Decade by 1990, the Sulabh Shauchalaya could be only solution. According to our assessment, there are 41,00,000 service latrines throughout India which will need about Rs.300 crores for conversion.

BIRTH OF SULABH INTERNATIONAL

It will not be out of place to mention here that technology alone won't lead to mass acceptability. The people will have to be motivated for its adoption and follow-up action will also be needed. Propagation of technology was the main object of the Bhangi Mukti cell of the Gandhi Centenary Celebrations Committee, with which I was previously associated. I was firmly of the view that without active participation in the implementation of the scheme, mass adoption of the of the technology was out of question. As the officials of the organisation did not agree to my views, I had no option but to resign and form a new organisation which is now called the 'Sulabh International' (formerly Sulabh Shauchalaya Sanstan). This was registered under the Societies Registration Act XX of 1860. I evolved a methodology for adoption of the technology on a mass scale. The Government of Bihar took four years to scrutinise and accept my methodology, according to which workers of our organisation go from house to house and maintain contact with the house owners. When house owners agree, further action is taken by the organisation in securing grant and loan for the beneficiary from the concerned Municipality. Its workers carry out the construction. A five year guarantee card is issued to the house owner, during which, if any defect is found in the construction, it is corrected free of cost.

PUBLIC CONVENIENCES

The Sulabh International constructs public latrines, baths and urinals and maintains them well. In Patna alone 551 public latrines, 52 urinals and 33 baths have been constructed at 36 places. About 50,000 people are daily availing the facilities. In the Metropolitan City of Calcutta a 60-seat public latrine and bath complex has been constructed and about 1,500 persons are using this facility daily. Two more public conveniences have also been constructed there recently. Similar facilities have been provided in some other States like Orissa and Madhya Pradesh. In Andhra Pradesh, Uttar Pradesh Haryana and Jammu and Kashmir this system is going to be introduced soon.

SOCIO-ECONOMIC ASPECTS

The Xavier Institute of Social Services, Ranchi (Bihar), India, has conducted a survey on the socio-economic aspects of the Sulabh Shauchalaya system at Ranchi. The beneficiaries have expressed the view that the incidence of epidemics has decreased after the introduction of the Sulabh Shauchalaya system.

ROLE OF VOLUNTARY AGENCIES

Here I want to make it clear that neither governmental nor non-governmental agencies can execute the scheme independently. It requires the close cooperation of both as each of them has its own limitations in arranging funds and materials. I want to emphasise that if Sulabh Shauchalaya is adopted on a mass scale, the sanitation problem can be solved to a large extent.

Now I request the participants of this seminar to consider the need for a co-ordinated effort through the help of a voluntary agency in achieving the targets. The voluntary agencies will also provide useful feed-back to the municipalities, the State Governments and the Central Government. Such an agency can also coordinate efforts in various developing countries and help smooth flow of information about the problem and the methods being adopted to solve it in different countries.

It is my firm conviction that today or tomorrow all the under-developed and developing countries will have to adopt the Sulabh Shauchalaya System for sanitary disposal of human excreta. Sewerage and septic system are not the answer.

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UP-GRADING OF BASTI SAIDAN SHAH

BY SATTAR SIKANDER

INTRODUCTION: Since idependence(1947) of the country slums of various kinds and sizes have emerged in big cities like Karachi and Lahore. Mostly these slums are known as "Katchi Abadis or Bastis". Such Abadis are scattered in various parts of City of Lahore. Due to high demand of housing this type of squatting is quite pr vailant on open land in the city. The inhabitants of these abadis are living in squalid environment devoid of even minimal civic facilities. The abadis even do not have regular streets, water supply, sewerage, drainage, open spaces and other community facilities like health, education etc.

There are about 100 recognised Katchi Abadis in Lahore. They are situated on state as well as private lands. Most of the Abadis are being improved at the existing sites and others will be shifted to the built up quarters. It was decided by the Government in 1978 that all the Katchi Abadis located in big Urban Centres will be improved and upgraded. Few Abadis which are located at strategic/akward points will be provided with alternative sites or built houses. But in 1979 the decision was amended and it was declared that the Katchi Abadis which are situated on the State lands will be regularized and improved and decision regarding the others which are located on private lands will be taken later. The first abadi which was selected for upgradation in Lahore was Basti Saidan Shah.

LOCATION: The Basti Saidan Shah is located in Lahore City. It is an old settlement named after Saint Saidan Shah. It was since partition (1947) when the population of Basti has increased manifold. It is situated on the state land between the Tomb of the Saint and the Railway Line - an ideal site for the squatters.

PEOPLE AND THEIR CHARACTERISTICS: There are 1144 dwelling units in the Abadi. The total population is 6810. About 55% population comprised of male members and remaining 45% female. 37% population is in the age group of 6-25 years. 62% members of the household were unmarried. The data revealed that about 29% of the household heads were bron in Lahore but none within the Basti. 27% took brith in those parts of the sub-continent which are now in India. Out of the remaining heads of the households 11% were bron in Sialkot 7% in Kasur 8% in Kashmir and 4% each in Jhelum and N.W.F.P.

When inquired about the last place of residence where from the households moved to Basti a high proportion, 79% mentioned some other parts of Lahore 6% hailed from Sailkot, 4% from Kasur. 49% of heads of households have reported the living period in Basti from 16-20 years, 24% have reported 6-10 years while 13% have reported 11-15 years and 9% have reported less than 5 years. Only 5% have reported more than 20 years stay. The most frequent reason for residing in the area expressed by the majority (44%) was the availability of land without any cost. A good location being near to the work place was mentioned by 25% followed by 21% for whom existance of relatives in the area was the main reason to stay. Availability of cheap land was another reason forwarded by 10%. The basic reason to stay in area was free or cheap land. 84% of the residents were members of the welfare committee operating in the area.

ECONOMIC CHARACTERISTICS: The occupational profile of the heads of the households of the Basti indicates variety of occupations. 52% of heads of households are working as Government servants on various jobs like chowkidars, clerks, drivers, etc. 11% are in private jobs, 16% are shopkeepers, 12% are unskilled labourers and 5% are retired or unemployed.

The income distribution of the household heads show* that the income of 55% range between Rs.301-500, 17% have income in the range of Rs.501-600 while 13% have income ranging between Rs.601 to 1000, 7% have income range of Rs.1001 to 2000, 8% reported their income upto Rs.300.

* £.1 = Rs.22 October, 1981 (Exchange Rate)

The data indicates that 18% members of the households move within the area for jobs and education. The movement pattern shows that about 60% travel 1-4 miles and 15% travel from 5-8 miles on working days. A negligible percentage (2%) travels more than 8 miles. A sizeable majority (86%) cover the distance mostly on foot or bicycles while 11% travel by us.

HOUSING CHARACTERISTICS: 40% of houses are Kutcha (mud), 30% are semi pucca (mud and bricks, concrete etc) and 21% are pucca (bricks, concrete etc). In the abadi majority, 98% heads of the households are owner of the dwellings and 2% are reported to be renters. 75% dwellings have minimum size of plot from 1-3 marlas (i.e. 25-75 sq.yards), 24% are between 4-6 marlas (100-150 sq.yds), 1% plots are 7-10 marlas (175-250 sq.yds). The average number of households is 1.25 per dwelling while the average size of plot comes to be 2.5 marlas (62 sq. yards). The survey data indicates that 54% of houses have single room, 40% have two rooms, 6% have more than 2 rooms. Nearly 40% households having size of 4-10 persons live in a single roomed house. 45% of houses have courtyards where as 55% do not have any courtyard.

The data analysis indicates that 15% houses have separate arrangements for cooking and 50% use their living rooms and 35% use their verandahs for cooking purposes. 22% households have separate arrangements for bathing and 78% use living rooms or verandahs for this purpose.

ENVIRONMENT CHARACTERISTICS: 75% houses have latrine arrangements. All the latrines have dry system. 25% houses have no such facilities. There existed no sewerage and drainage system in the Basti. The water was allowed to stagnate in the streets and open areas.

The water supply was also non-existant. Majority of the households had no water supply system. They got water from outside the Basti. Very few households had water from the hand pumps which were installed within their premises.

A POLICY OF KATCHI ABADIS (SQUATTER SETTLEMENTS)UPGRADATION:

In search of a solution to the housing problems and also because of the deplorable conditions of the Katchi Abadis, Government had no choice but to upgrade them. In 1978 it was decided by the Federal Government that the Katchi Abadis in the major urban centres will be improved and upgraded. The households which are living prior to Ist January, 1978 in any such abadis will have the access to the proposed improvements and anybody who tries to build a house or occupies land after this date will be ejected from the Abadi. For this purpose physical and topographical surveys were conducted much earlier without indicating their objective. The policy decision had the following major points :-

1) All the Katchi Abadis of the major urban centres will be upgraded.

2) All the residents of such Abadis who have settled in them before Ist January, 1978 will be given proprietory rights of the land which is under their occupation.

3) Special police force was deputed to make it sure that no one settles or builds any structure after this date.

4) The private lands on which the Katchi Abadis have been built will be acquired by the Government.

To further upgrade the abadis the following steps will be taken :-

i) Existing layout will be re-adjusted and alignment of streets will be done.

ii) Streets will be widened where ever possible.

iii) The streets will be paved.

iv) Open drains on both sides of the streets will be provided.

v) For water supply community taps will be provided.

vi) Drainage scheme will be prepared and implemented.

vii) Community centre, shops, etc. will be provided.

viii) School, Dispensary and open space, if possible, will be provided.

UP-GRADATION OF BASTI SAIDAN SHAH

LAYOUT PLAN: To facilitate the provision of adequate streets wid-ths, water supply drainage and other major infra-structure in the area it became necessary to make adjustment in the existing layout. Since this involved re-allocation of houses it was not possible without the help of the local people. Three representatives of the residents were picked up to help the team of experts. The community leaders played a very vital role in making the adjustments in the layout of the area and removing the bottle necks. Many house holds were shifted to new sites and some to the built houses. About 150 house-holds had to surrender some area of their houses for the adjustment of the new functional layout of the Basti. No compensation was paid to them. 35 houses were shifted to the new sites in the process of the revision of the layout. The residents were not paid any money for their structures.

Widening of Streets: The minimum street width was adopted 10 feet. Two feet on each side of the street was ear-marked for the open drains and central 6 feet strip to be used for the movement of people. The streets were paved with bricks. At one or two points where heavy demolition was involved the street width could not be achieved according to the minimum standards. Where ever necessary the residents voluntarily removed their structures to widen the streets.

Water Supply: It was not possible to supply piped water at individual house level. The stand pipes were provided at the street junctions. Each group of 10-15 houses is served by one connection.

Drainage and Sewerage: The drainage and sewerage disposal is done through the open drains which are provided on both sides of the streets. However, the human excreta is directly disposed of from the houses, it is not thrown in the drains.

Other Social Services: When the layout plan was revised some of the houses were removed and in their place sites for schooll, dispensary and park was provided. The school and dispensary are under construction and will start functioning in near future. The Government Depart-ments of health and education are looking after them.

UNICEF & the Project: From the middle of 1981 the UNICEF has also started some projects in the Katchi Abadis where upgradation has taken place. In Basti Saidan Shah the organization of UNICEF has started a project of community house where the women are given vocational training of knitting, embroidary and secretarial services. Through such projects the people are motivated to further develop the Basti and improve its environment. The courses are also conducted regarding family planning, adult education and environmental hygiene.

Title of Land: After completing the upgradation programme the Government, according to its commitment handed over the lease (for 99 years) documents to the 25% of the house holds to see the reaction of the residents. It was reported that some of the households attempted to sell their rights of ownership to the property dealers in order to leave for some other Katchi Abadi. Since then the lease documents are with-held by the Government and will not be given to the other households until the community leaders will guarantee that this kind of thing will not happen again.

Resource Generation: In order to make the upgradation programme possible it was decided that the development charges will be paid by the residents of the Basti. The community leaders were taken into confidence to this effect who had already discussed this matter with the residents of their sectors and persuaded them to pay the cost of the services. The total expenditures of development were divided over the total area of the Basti and was found out that the development charges will be collected at the rate of Rs.450 per Marla (225 sq. feet or 25 sq- yards). The households will pay the development charges according to the size of their plot at the above mentioned rate. When the head of the house hold will receive the documents of the title of land he will make the payment of the development charges prior to that. The title of land was given free of charges provided the plot size is not bigger than five marlas (125 sq. yards). If the plot is bigger than five marlas then the occupant will have to pay the price of the extra land at the rate of Rs.10.000 per marla (25 sq. yards). The experience has shown that the residents have paid the development charges and cost for the extra area of plot without any hesitation or delay. Through these sources of income entire cost incurred on the up-gradation of the project of Basti Saidan Shah was recovered.

Monitoring of the Project: In one of the recent evaluation surveys of the abadi it has been discovered that 12% of the house-holds have done some renovation, 8% have added new rooms, where-as 1% have built new houses and 75% do have some improvement plans for their houses and the remaining have no plans for the time being. This shows that some positive contribution is being made by t the residents on self help basis towards the upgradation of the Abadi.

Conclusion: This project has to a certain degree given the residents(i) a share in decision making (ii) the opportunity to improve their housing (iii) title to land and (iv) above all an experience of close co-operation with the local authority and among themselves. Taking into account all problems and sensitivity, results are encouraging. There is a reason to believe that squatter upgrading really does hold the key question of how best man can provide suitable shelter for this generation. It is very hard to judge at this juncture whether or not the project is a complete success. Yet when one knows what has already been achieved one has hope that this squatter upgrading exercise many really benefit the people for whom it was intended and it may also serve a useful model for other countries to provide reasonable shelter that enhances the dignity of man.

8th WEDC Conference: Water and waste engineering in Asia: MADRAS: 1982

ENVIRONMENTAL PLANNING OF BUSTEE AREAS IN CALCUTTA METROPOLITAN DISTRICT

by Dr MANAS BANERJEE and S K MUKHERJEE

INTRODUCTION

The effective environmental planning of a bustee area is a thoughtful task. The term environmental planning refers to both the idenfification of the system structure and the design of the individual systems so that the desired objectives can be fulfilled. Although the primary goal may be the supply of drinking water and the removal of waste water, decisions regarding garbage collection and disposal, improvement of pathways & street lightings can have significant impacts on total environmental planning.

In the preliminary phase the designer needs to efficiently evaluate the existing facilities and conditions in a bustee area. This requires a thorough survey over the area and detail studies to know the surface drainage pattern of the area. This paper describes a study made on a particular bustee area in Kamarhati Municipality within the Calcutta Metropolitan District where underground sewerage system is not in existence. Water supply is in adequate and drainage system is defunct.

EXISTING FACILITIES

The bustee area is located at Kamarhati Municipality as shown in Figure 1. The area is approximately 12 acres and the total population is found to be 2260. There is in existence a pretty old water supply systems with a few number of street taps but practically there is no flow in the system and is very much inadequate to the existing population. Out of 151 holdings in the area 76 have sanitary latrine facilities, 39 have service privies with a bad state of repair and 36 holdings have no latrines.

Though there is in existence about 710 metres of pucca surface drains for want of maintenance they are not functioning properly. Most of the surface drains are kuchha in nature and are silted up. As a result there is severe waterlogging during the rainy season. The main outfall drain of the area is passing through the area of the Baranagar Kamarhati waterworks and ultimately discharging into the Bagjola canal. The outfall drain as mentioned has inadequate capacity for taking the entire run off of the area. Another outfall drain which caters southern part of the area is passing by the side of Dr.R.N. Tagore Road and presently discharges into the nearby low lying open fields.

PROPOSED FACILITIES

Water Supply

It is proposed to provide new water pipelines along the approach roads to the bustee so as to make water available to the people residing in the area. There is in existence water main of dia. 100 mm. in D.D. Mondal Ghat Road and 150 mm. dia. in Dr. R.N. Tagore Road. From these water pipelines 100 mm. pipes are to be taken off to serve the consumers. Masonry platform is to be provided for each standpost. The existing pressure and flow in the pipelines are found to be adequate to serve the community.

Sanitary Latrines

The existing service privies which are in a bad state of repair are proposed to be converted into sanitary latrines with septic tanks. The effluents of the septic tank will be discharged into surface drains after chlorination. It has been found that soakpits of the septic tank do not function properly particularly during the rainy season.

Drainage

A main surface drain is proposed to be constructed on the northern boundary of the area which will ultimately drain into the existing outfall kuchha drain of the area. Other existing kuchha drains are proposed to be made of masonry rectangular section to improve the hydraulic condition and to remove waterlogging in the area. A two-month frequency storm with 70% roofs and pavements are considered for the design of the surface drainage systems. It is to be mentioned that the outfall drain which is passing through Baranagar-Kamarhati waterworks area need resectioning and lining upto a point where it discharges into a low lying area and ultimately to Bagjola Canal.

Pathways, Street Lighting and Garbage Collection

All the passages and pathways are proposed to be paved with bricks to make it convenient to the use of the people. Street lightings are provided in suitable locations. For garbage collection it is proposed to provide masonry dustbin at the suitable place for proper removal of the same. Due to very narrow nature of the pathways and passages it is sometimes very difficult to find the place for the location of the garbage collection bins.

GENERAL NORMS AND CRITERIA

In order to make a comprehensive environmental planning in the area a few norms and criterias are considered for effective utilisation of the proposed facilities. They are summarised as follows :-

1. Arrangement of potable water supply has been made through one water tap per hutment or one tap per 100 persons whichever is found advantageous to the beneficiaries.
2. Water distribution pipelines are provided in all the passages or pathways maintained by the municipality. The diameter of these pipelines are kept at 100 mm.
3. Conversion of existing service latrines to/and or new constructions of sanitary latrines with septic tanks and chlorination Chamber (CMDA type pre-fabricated latrine) are provided because the area under consideration is unsewered.
4. The latrines are provided on the basis of one latrine for each holding or every 25 persons whichever is advantageous to the beneficiaries.
5. When space for installation of pre-fabricated standard latrine is not available, conventional type of latrine with septic tank may have to be utilised as per standard norm.
6. The septic tank is to be placed in such a position that the effluent pipe can discharge to the nearest surface drain under gravity flow.
7. In order to have appropriate drainage of the area, open surface drains are provided as far as practicable to all the pathways all of which will ultimately drain into the main surface drains provided along the boundary of the area. As far as possible a slope of .001 is to be maintained in the drains for proper functioning. If possible a slope of .0015 is to be provided for 300 mm. x 300 mm. surface drain.
8. All drains will be constructed of masonry with a minimum width of 300 mm. so that proper cleaning operations can be done.
9. Cover slabs are to be provided on all the surface drains to give proper and safe pathway to the people of the area.
10. Cross surface drains are to be provided whereever necessary and

have to be provided with cover slabs.

11. The area is located in the Bagjola Basin, as such the outfall drains will ultimately be connected to the Bagjola canal.

12. Construction of the outfall drain leading to Bagjola Canal may be considered as a separate project because this drain will have a bigger tributary area than the particular area under consideration.

13. Dustbins are to be provided for collection of garbage at suitable locations or on the basis of one for every 400 persons whichever is found advantageous to the people.

14. It is desirable that the insanitary ponds situated in the area is to be filled up for improving the environment of the area and to minimise health hazards of the community.

15. All the existing pathways in the area are considered to be properly paved with brick layers as far as practicable.

16. So far as the servies previes, sanitary latrines and number of holdings are concerned a detail spot survey was made with the help of the staff of Kamarhati municipality and number of items were based on that survey.

17. The existing pucca pathways which are found to be in good condition should be relayed with proper specification.

COST OF THE PROJECT

TABLE 1 provides information regarding the per capita costs of the different facilities incorporated in the scheme.

TABLE - I

FACILITIES	COST per capita*
1. Water Supply	Rs.49.90
2. Sanitary Latrines	Rs.98.87
3. Drainage	Rs.76.34
4. Pathways	Rs.30.51
5. Miscellaneous (Garbage removal & piling works etc.)	Rs. 2.96
Total per capita cost	Rs.258.67

($1 = Rs.8.00 approx.)

*based on 1978-79 Schedules of rates. (West Bengal P.W.D.)

CONCLUSION

The improvement schemes that are contemplated in this report will not be a permanent solution. But slum clearance and redevelopment schemes will take a very long time period and enough resources. And redevelopment schemes are possible only where land values are high. Hence as a short term measure improvement schemes as depicted in this paper for overall environmental improvement shall have to be continued at least to help these slum dwellers from their deplorable condition of living. This is, however, a curative measure but it is also very much necessary to take adequate measures so that further growth of slums in newly developed areas can be prevented by providing adequate housing facilities for the people of the low income group and by effective land control.

Though the Socio-economists claim that slums are an inevitable part of a town or city by proper environmental planning this could be avoided and to make an end to the slums which have existed as a curse to the Society for centuries.

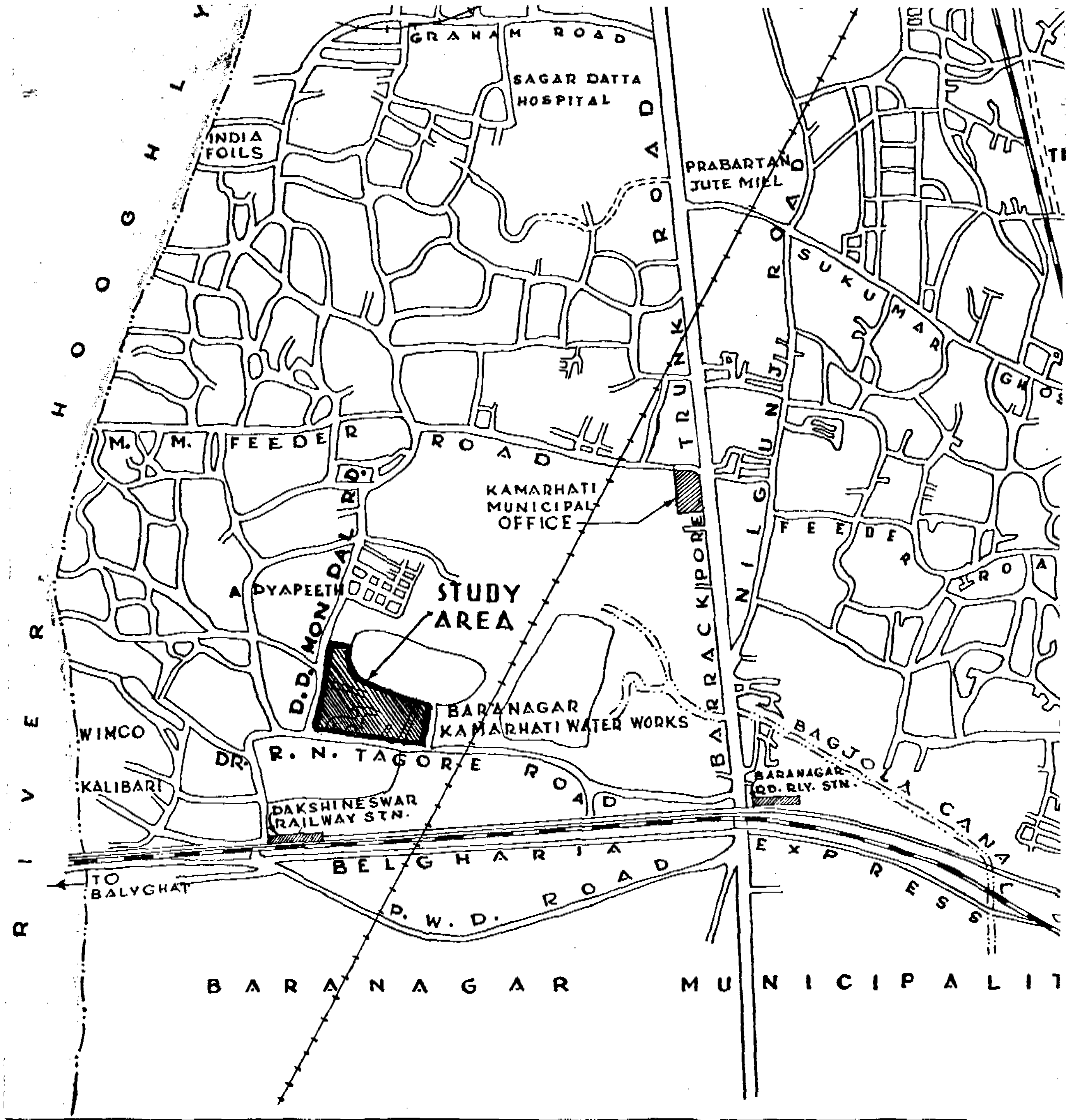

FIG: 1. LOCATION OF THE STUDY AREA.

Session 6

Chairman: Mr P S Rajvanshi
Additional Secretary P.H.E. Jaipur

Discussion

B Pathak

Sulabh Shauchalaya (hand flush water seal latrine)

1. Mr PATHAK described how he had become involved in sanitation improvement work as a social worker in Patna, Bihar. The double pit water sealed type latrine was developed and accepted, and the advantages were listed. A large number of these latrines had been installed in Patna, and later on in other towns and states in India. Emphasis was placed on acceptance by the people of a particular form of sanitation, and that sewerage and septic tanks were unlikely to solve the sanitation problems of the developing world in the near future.

2. Mr DAMLE expressed doubt that the latrine would work satisfactorily in areas of high groundwater table.

3. Mr PATHAK replied that the latrine could be raised above the ground, and that in rocky areas one foot of soil could be placed on the bottom of the pit to aid percolation.

4. Mr SANTHANAM wished to know if groundwater pollution studies had been carried out.

5. Mr PATHAK informed him that Bhaskaran had carried out early studies, and that U.N.D.P. were investigating the matter.

6. Dr RAMAN commented that similar problems had resulted from the disposal of septic tank effluent, where sand packing in the drainfield had been used.

7. Mr HUTTON commented that a sand lining on the base of latrine pits was potentially one of the most effective means of reducing groundwater pollution. Although bacterial contamination could be avoided, there was still the likelihood of contamination by nitrates and nitrites, which could be used as indicators of pollution. In addition to the studies mentioned by Mr PATHAK, information from Botswana has been summarized by Lewis, Foster and Schertenlieb. There was still a need for studying the effects of different soil and hydraulic conditions. The World Bank TAG Unit based at the Ross Institute in London could be contacted for further information.

A Sattar Sikandar

Upgradation project of Basti Saidan Shah

8. Dr COTTON presented the paper in the absence of Mr SIKANDAR. The demographic and economic characteristics of the population of the area were described along with the housing and environmental conditions. The improvements to the squatter settlement were listed, and emphasis was placed on the involvement of the inhabitants at all stages of the planning and execution of the improvement schemes. Monitoring of the success of the project was in progress.

9. Mr OTI commented that by giving a sense of involvement and pride, community participation was one of the most powerful elements that would determine the success of a scheme.

10. Mr SHANKARAPPA observed that provision of services required financing, and that the population growth was often rapid in such squatter settlements, creating a shortfall in services within a couple of years.

11. Dr COTTON stated that the initial improvement costs had been recovered from the residents, and that the project was being monitored.

12. Mr KRISHNAN commented that package water treatment units for 50-100 people were available.

13. Dr COTTON replied that the cost would have to be very low, and the maintenance requirements negligible.

M Banerjee and S K Mukherjee

Environmental planning of bustee areas in Calcutta Metropolitan District

14. Mr BANERJEE outlined the living conditions in the bustees of Calcutta, and listed the facilities which were to be provided, namely water supply, sanitary latrines, drainage, pathways, street lighting, and garbage collection. Criteria for each improvement were discussed, and it was concluded that whilst this did not constitute a permanent solution, living conditions could be vastly improved.

15. Mr KALE commented that in Bombay, slum dwellers on government land were provided with some basic amenities; there was a greater problem with private land, and the dwellers do not pay tax.

Did a policy of 'have's' contributing to 'have-nots' need to be applied?

16. Mr BANERJEE replied that the government of West Bengal aimed to provide facilities to all bustee dwellers by means of grants; the facilities were still only very basic.

R Saraf

Need of environmental education for better environment

17. Mr RAJVANSHY permitted Mr Saraf to present his paper, which had not been submitted beforehand to the conference organizers.

18. Mr SARAF discussed the detrimental effects of population growth and industrialization on the environment. There was now considerable awareness of the problems in the West, but the third world was using many harmful chemicals. More emphasis should be given on education at all levels in order to explain the limited availability of resources and their use.

19. Dr COTTON wished to know how banning the use of pesticides would improve food productions, and would not more food have to be imported.

20. Mr SARAF replied that better crop management would improve matters, and non biodegradable pesticides should not be used.

8th WEDC Conference: Water and waste-engineering in Asia: MADRAS: 1982

BRIQUETTE MAKING EASES SOLID WASTE DISPOSAL

by J N RAMASWAMY and N SATHIYA KUMAR

DEFINITION

Solid waste includes all putrescible and non-putrescible discarded material including but not limited to garbage, rubbish, ash, street cleanings, dead animals, sewage plant sludge and industrial waste solids. Garbage is defined as putrescible animal and vegetable wastes resulting from the handling, preparing cooking and consuming food. It also includes wastes from markets and storage facilities that handle and sell other food products. Under rubbish are included the non-putrescible solid wastes (excluding ash) consisting of both combustible and non-combustible wastes. Combustible rubbish includes paper, rags, cartons, wood, furniture, rubber, plastics, yard trimmings, leaves and similar materials. Non-combustible rubbish includes glass, crockery, tin-cans, aluminum cans, dust, metal furniture and like material which do not burn at ordinary incinerator temperatures of 870°C - 980°C (1600°F to 1800°F). Ash is the solid residue from burning of wood, coal, coke or other combustible material.

THE PROBLEM

For centuries man has been polluting his environment with the by-products of his development and progress. Each generation has left for the next generation some improperly disposed of waste material. Each new generation has not only pushed aside its elders wastes but piled its own waste to be left to the succeeding generation.

Striking examples of this behaviour of man-kind throughout the centuries have been unveiled by archaeologists who have found whole cities buried under their own discards. In some cases three or even more layers helping to identify different periods have been found.

An ever-increasing amount of discarded materials has been a concomitant result. These discarded material are being produced now at such high rates that they are becoming a nuisance almost at the same time they are produced. Because of the neglect and the ever mounting quantities of wastes being produced and its indiscriminate disposal, many natural resources have been rendered useless or have become health hazards or at least have become scenic blights.

Solid waste and its management through final disposal have become a major problem. Open dumps are noteworthy examples of full environmental pollution at its best, by causing major impairment to surface and ground waters, contaminating the air, rendering the land useless and becoming shelter for disease carrying rodents and insects.

With the present trend of population migration towards the urban centres, large volumes of domestic refuse are being generated in small areas, making its management a major concern with many problems to be resolved. This problem is being worsened in every community with the increased waste production from commercial establishments, industries, restaurents and in many cases with agricultural waste from cattle, swine and poultry.

The problem is more acute in industrialised nations. In 1979, the per capita production of solid wastes was found to be 2.7 kgs (6 lbs) in USA, and it was 1.8 kgs (4 lbs) in Europe and Japan. In India, it was found to be 0.45 kgs (1 lb). Though the per capita production in India is much less than that in the developed nations, the total amount produced from a population of over 600 million people is considerable. It is projected that at the present rate of growth, in the year 2000, the total solid waste production will reach 300 million tonnes per year.

DISPOSAL METHODS

Too often, refuse disposal methods are open dumps festering scars that disfigure the landscape. Flies, rats, and other disease carrying pests find large quantities of food, a favoured breeding media, and suitable harborage in the piles of exposed refuse. The polluted drainage from open dumps is an additional insult to ground and surface water supplies in the area. Refuse fills are found to pollute the ground water by the following three basic mechanisms (ref.1)

1. Direct horizontal leaching of the refuse by ground water.

2. Vertical leaching by percolating water, and

3. The transfer of gases produced during refuse decomposition by diffusion and convection.

The characteristic foul odours produced by the decomposition of refuse, together with the smoke created by inefficient open burning, are often identifiable for miles.

The practise of feeding raw garbage to swine has both public health and economic implications.

Incineration disposes of garbage but it is costly. It is drawing increasing criticism because of the objections to air pollution. Single chamber incinerators and backyard trash burners especially contribute large amounts of air contaminants. The ash produced remains to be disposed of in other means. If incinerator ash is dumped on land, movement of water through these dumps will leach soluble salts and alkalies from the dump (ref.2).

Sanitary landfill is another method of disposal. It is consuming much of the accessible open area around many cities. Ground water in the immediate vicinity becomes grossly polluted by continuous or intermittent contact with deposited refuse. It was found that continuous leaching of a hectare-meter of sanitary landfill extracted a minimum of approximately 1.4 tonne of Sodium plus potassium, 0.9 tonne of calcium plus magnesium, 0.8 tonne of chloride, 0.2 tonne of sulphate, and 3.5 tonne of bicarbonate (ref.3). Composting is yet another method of disposal. In composting, the calorific value of the refuse is continually increasing but the nutrient composition is continually decreasing. Inability to dispose of large quantities of compost at a favourable price greatly affects the economy of the process in developed countries. Although compost contains some plant nutrients and trace elements, its principal value is in its use as humus for soil building or conditioning.

A second problem in composting relates to the hygienic aspect in plant operation and compost utilisation. Cleanliness and prompt handling of the wastes are essential to avoid the production of odours and propogation of such vermin as flies and rats.

Whatever the method, volume reduction of some kind has to be resorted to in order to conserve land areas for long term refuse disposal. Volume reduction may be achieved by various types of individual on-site disposal methods, such as burning, garbage grinding, and salvage or by the municipality employing incineration or composting.

IMPACT OF ENERGY CRISIS ON DISPOSAL

After the advent of the oil crisis resulting from the OPEC nations' oil embargo in 1973, the concept of solid waste disposal has changed. Refuse is no more treated as 'solid waste' but instead treated as 'wasted solid' thereby implying that it has high potential values. It is attributed to have the following unique desirable characteristics

1. It is available at no cost or perhaps at a negative cost.

2. The supply is increasing in amount.

3. The supply is concentrated at population centers where potential users are located.

4. Per calorie available from combustion, it contains less sulphur than coal or oil.

5. There are no vested interests to fight for legislation to stop complete depletion of this resource.

It was not usual to practice resource recovery or heat recovery from this material up until the energy crisis due to the following reasons:

1. The character of refuse makes material handling and treatment a major problem.

2. The capital and operating costs are so much higher, and efficiency so much lower than coal, that they over-shadow the negative raw material cost of refuse.

3. Incinerator methods utilised in past have not proved economical

Despite the fact that refuse is difficult to handle thanks to the energy crisis, there is now a renewed interest in incineration to recover energy. Several developed countries are now practicing resource recovery and heat recovery. Heat recovery is practiced by incinerating the combustible part of the refuse in suitably designed incinerators. Sophisticated mechanical process plants have been designed and are functioning to classify and segregate the non-combustible and combustible material. For developing countries like India, it is not necessary nor desirable nor feasible to copy the expensive sophisticated resource recovery systems of the developed countries. Nevertheless the concept is valid and can be adopted in an appropriate manner. Energy recovery can be practised at the household level itself. The householder segregates the metals, glass and other noncombustible material and prepares the refuse for its combustible portion. The combustible portion, being difficult to handle, is suitably subjected to a process wherein the handling problem is made easier. Once the handling problem is solved, it is used in domestic cooking ovens and can satisfy the fuel needs of the household. Handling problem is made easier if volume reduction is practised on the combustible part of the segragated refuse. This is achieved by making briquettes of handlable size. After proper drying, the briquettes can be used in the home burner. With this objective in mind, research work was initiated at the Center for Environmental Studies of Perarignar Anna University of Technology recently.

EXPERIMENT

Ten grab samples of 1C kgs each were collected from the Madras city refuse and were mixed together. Cut of this 100 kg refuse, four equal divisions were made, each division containing 25 kgs. Two diagonal portions were discarded and the remaining two were mixed together making a heap of 50 kgs. This heap was again divided into 4 heaps of 12.5 kgs each. Again 2 diagonal heaps were discarded and the other two diagonal portions were mixed together making up a total of 25 kgs. This was again divided into 4 heaps, each of 6.25 kgs. Two diagonal heaps were discarded and the remaining two diagonal heaps were put together and thus a final sample of 12.5 kgs was obtained. The individual components such as paper, cloth etc. were segregated and their weights were determined and shown in Table 1 below.

<u>TABLE 1 Characteristics of raw refuse in Madras</u>

	Item	Percent by weight
1.	Paper	14.0
2.	Cloths and fibers	7.3
3.	Iron	0.1
4.	Coal	0.5
5.	Leaves and grass	43.2
6.	Fine Earth	20.1
7.	Plastic	8.6
8.	Leather and Rubber	2.6
9.	Glass	0.5
10.	Wood and stick	3.1
	Total	100.0

All the combustible items were mixed together and a homogeneous mass obtained. This was then chopped into small pieces of size 1 cm or less. Sufficient quantity of water was added to adjust the water content to 30% by weight. A split type cast iron mould of size 6 cm x 3 cm x 3 cm as shown in fig.1 below was utilised. The chopped wet refuse was then pressed into the mould by hand and a plunger (shown in fig.1) was finally used to compact

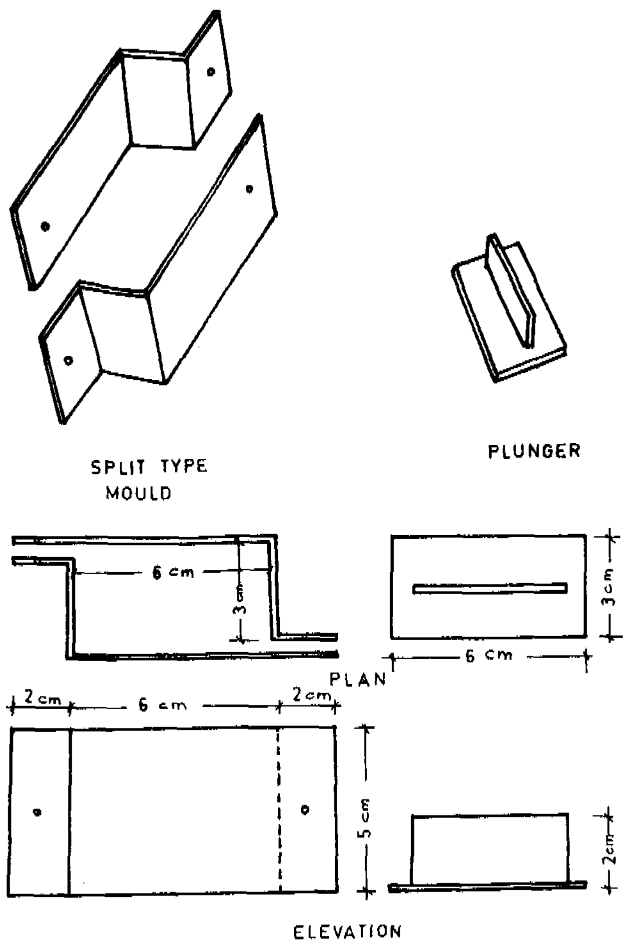

FIG.1 DETAILS OF MOULD

the refuse and to force the excess water out. Moderate pressure only was applied as too much compaction was not considered helpful for combustion. The refuse was kept in the mould for 24 hours before it was removed and dried in the natural sun for 4 days. At the end of this 4-day period, the briquette was burnt in a kitchen oven. As the sun drying took 4 days, it was investigated as to how to cut short the drying time. Drying in a laboratory oven at 104°C was tried. The calorific value of the briquettes was then determined using a bomb calorimeter. Totally 21 briquettes were tested for the calorific value along with 4 samples of coal (leco) for comparison purposes.

RESULTS

It took about 5 hours in a drying oven kept at 104°C to achieve the same amount of dryness as obtained in sun in 4 days. A well dried briquette spontaneously caught fire and needed no auxiliary fuel. A semidried briquette however required an auxiliary fuel in the form of kerosene. But all briquettes, when kept in a laboratory muffle furnace at 600°C, got burnt out completely leaving a residue of ash. The percentage of ash content varied from 35 to 45.

Table 2 below indicates the details of the briquette such as weight, calorific value and percentage ash for the 21 samples tested.

TABLE 2 Details of refuse briquette

Briquette weight gms	Calorific value cal/gm	Percentage ash
31.3	2459.8	43.16
32.8	1982.4	44.46
36.7	1929.8	41.26
37.9	1742.2	42.34
35.5	2072.4	44.49
33.9	1964.1	42.79
34.1	1603.3	47.77
39.5	1857.8	45.90
32.6	1748.8	46.28
36.2	1863.7	44.17
38.8	2288.3	49.07
32.4	1781.0	44.73
35.7	1992.5	46.27
34.6	1945.8	49.78
38.1	2517.2	48.84
37.4	1918.8	46.47
34.8	2040.3	51.32
33.9	1907.7	48.84
40.2	2436.0	43.32
36.9	1963.8	46.36
35.0	2127.5	41.00

Mean weight of briquette	39.82 grams
Standard deviation	2.35 grams
Mean calorific value	2006.85 Cals/gram
Standard deviation	236.51 Cals/gram
Mean ash content	45.72%
Standard deviation	2.85%
Mean calorific value of coal samples	5000 Cal/gram

CONCLUSION

From the limited experimental data available, it can be said that it is a viable proposition to make briquettes out of domestic refuse and to use them in cooking ovens at homes. This highly solves the handling problem of the refuse material and also eases its disposal problem with the attendant drawbacks and defects. Indirectly it helps to solve the energy problem to a great extent.

The briquette manufacturing can be resorted to in a mass scale also at a central location by the municipality. A central briquette manufacturing plant can be built and operated in the same manner as a disposal plant like a sanitary land fill or a compost plant. The briquettes may have a competitive market and so a self supporting project is envisaged. In the absence of specific cost data further comment on this aspect is withheld for the present.

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CATTLE WASTE PROBLEMS IN MADRAS METROPOLITAN SEWER SYSTEM - A PRACTICABLE SOLUTION

by S DAIVAMANI S ANANDAPADMANABHAN & S SUNDARAMOORTHY

INTRODUCTION

Public sewer systems are intended to carry only the liquid wastes from dwellings like the toilet wastes, bath wastes, kitchen washings etc. At any rate, they are not intended for carrying animal wastes and solid refuse. The situation in the city of Madras in South India however presents a complex ingress of all these wastes into its sewer system, causing quite some problems by way of sewer blocks.

The severity could be understood by the fact that an intense sewer block with the consequent backing up and overflow of sewage through manholes etc. are not uncommon at least once every week in certain locations.

A detailed evaluation of the mechanism of these cloggings revealed that the one major factor is the ingress of cow and buffalo dung into the sewer system washed into it from the many cattle sheds in the city. Further evaluation of the nature of quality variations in the sewage revealed the increase of its organic content also.

Details of these evaluations and a practicable remedy as tried out successfully by the interposing of a diaphragm (Settling)Chamber are presented in this paper.

THE MADRAS CITY AND ITS SEWER SYSTEM

The city of Madras is spread over an area of 130 square kilometers. It has a population close to 3.5 million. It is situated on the East coast of India in Latitude 13° 04' North and Longtitude 80°15' East. It has a warm moist climate of the tropical maritime monsoon type. The mean temperature is 33°C in summer and 18°C in winter. Relative humidity varies from 65% to 80%. The mean annual rainfall is 127 centimeters occuring over a total of 60 days mainly during the Northeast monsoon period of October to December and to some extent in the Southwest monsoon period of June to September. Thunder and cyclonic storms are rather common during these periods and have been recorded at speeds close to 130 Kilometers per hour in the past. The entire area is relatively flat.

The sewer system installed during 1910 has been steadily improved and expanded and as of now it has about 1100 Kilometers length of stoneware and cast iron sewers with about 25,500 manholes and 54 sewage pumping stations. The flat terrain and high water table necessitate a large number of relay sewage pumping stations. These pumping stations divided into five zones relay and funnel the city sewage of nearly 230 million litres a day into the zonal sewage treatment plants three of which have been completed and two are being taken up.

The sewers are designed for a minimum velocity of 0.9 metres per second at full flow for the smaller laterals and 0.76 meters per second for trunk sewers and major gravity lines.

The sewage pumping stations are traditionally operated manually and do not effectively control the surcharge in the sewer system. Automation of these pump operations and installation of higher duty pumpsets are now being provided in about 15 of the more critical pumping stations under a funding programme of the International Development Association to the tune of Rs.50 million. Sewer cleaning has been traditionally handled by manual labour with long bamboo splits for piercing the blocks and later removing them by buckets with the help of labour. Recently however, these are being obviated by the use of rodding and bucket machines. A vactor jet rodder is the recent addition to this fleet.

THE CATTLE DUNG PROBLEM

Among other ills which are incidental to any overloaded and old sewerage system in a developing society, the one problem which has been identified as causing the most severe bottleneck in terms of effective operation of the system has been the ingress of cattledung into the sewers from the nearly 1,500 licensed and a significant number of unlicensed cattle sheds in the city. Each shed accommodates about 4 to as much as even 16 cattle in a cramped location. By law, the shed owners are required to construct a holding chamber which would seggregate the solid matter from the cattle-dung wastes and allow only the liquid effluent to flow fast into the street sewer.

But, in course of time due to the conflicting pressures of life in a fast crowding urban set up in Madras, as in any other society under similar socio-economic stresses and strains, these chambers were not effectively provided and supervised and were conveniently put into intentional disuse by the shed owner and the entire gamut of the cattledung gets conveniently washed into the street sewers. When effective supervision was clamped, it only ended up in the surreptitious dumping in of the cattledung during certain parts of the day by these shed owners

This situation has grown to such major proportions that almost a weekly clogging of a street sewer by the dung and consequent backing up and overflow of sewage into the road from upstream receptacles are not uncommon as of now in certain cattle-dense areas of the city. By a tentative cost projection, the labour and materials needed to periodically attend to these cases of sewer blocks computes close to Rs. 18 million annually.

MECHANISM OF CLOGGING BY CATTLEDUNG

The feed given to most of the cattle in these sheds is mainly paragrass grown in the City's peripheral sewage farms and dried straw. The grazing of the cattle in green pasteurs is only a dream for these animals. Further, by nature, these animals do not straightaway digest the feed and merely ingest it in the first instance and the feed undergoes a detention in its body awaiting digestion. When a more tempting feed is made available to the animal, it merely pushes out the earlier ingested feed without completing the digestion. As such, the fibrous matter like straw and stems of grass get tightly bound into a composite mass with the dung and unbroken by the scanty water used for washing these, they enter the sewers as miniature plugs and soon conglomorate to become a lumpy block.

Moreover, the time of such dung washings is invariably after the peakflow has already passed through the sewers in the mornings or before the rather low peakflow attempts to pass through the sewers in the evenings. Inevitably, over a few days interval, the plugging becomes so complete that sewage backs up and overflows causing public harm.

OTHER EFFECTS OF CATTLEDUNG

In addition to causing the sewer blocks, the cattledung has been found to increase the organic content of the sewage. The 5 day 20°C Bio-chemical oxygen Demand (B.O.D.) of the sewage has a mean of 315 mg/l with a standard deviation of as high as 65 mg/l as compared to a mean B.O.D. of about 250 mg/l with a standard deviation of 20 mg/l for sewage from a nearby comparison habitation with no cattledung ingress in its sewage.

The ratio of the chemical oxygen Demand (C.O.D.) to B.O.D. for the city sewage is about 3.3 as compared to about 2 for the sewage free from the cattledung ingress.

The Total and soluble Tannin & Lignin content for the city sewage is 47.5 and 38 mg/l as compared to 5 and 2.5 mg/l for the sewage free from cattledung ingress.

These increases in the organic content of the sewage warrants additional investments in the treatment of the sewage as caused by an increased oxygen demand and a retarted reaction rate.

Moreover, the anaerobic digestion of the cattledung that proceeds in the sewers releases its own end products of Methane and Hydrogen sulphide gases which are super saturated in the sewer atmosphere and damage the sewer surfaces.

SOME POSSIBLE REMEDIES

One remedy for the problem is a long term goal of moving the cattle away from the city and involves the rehabilitation of the people whose life and social survival are tied up with the city and their transplantation to faraway locations. This would take time. Some cities in India like Bombay & Bangalore have however achieved this by initiating the programme fairly early. At Madras this would take time.

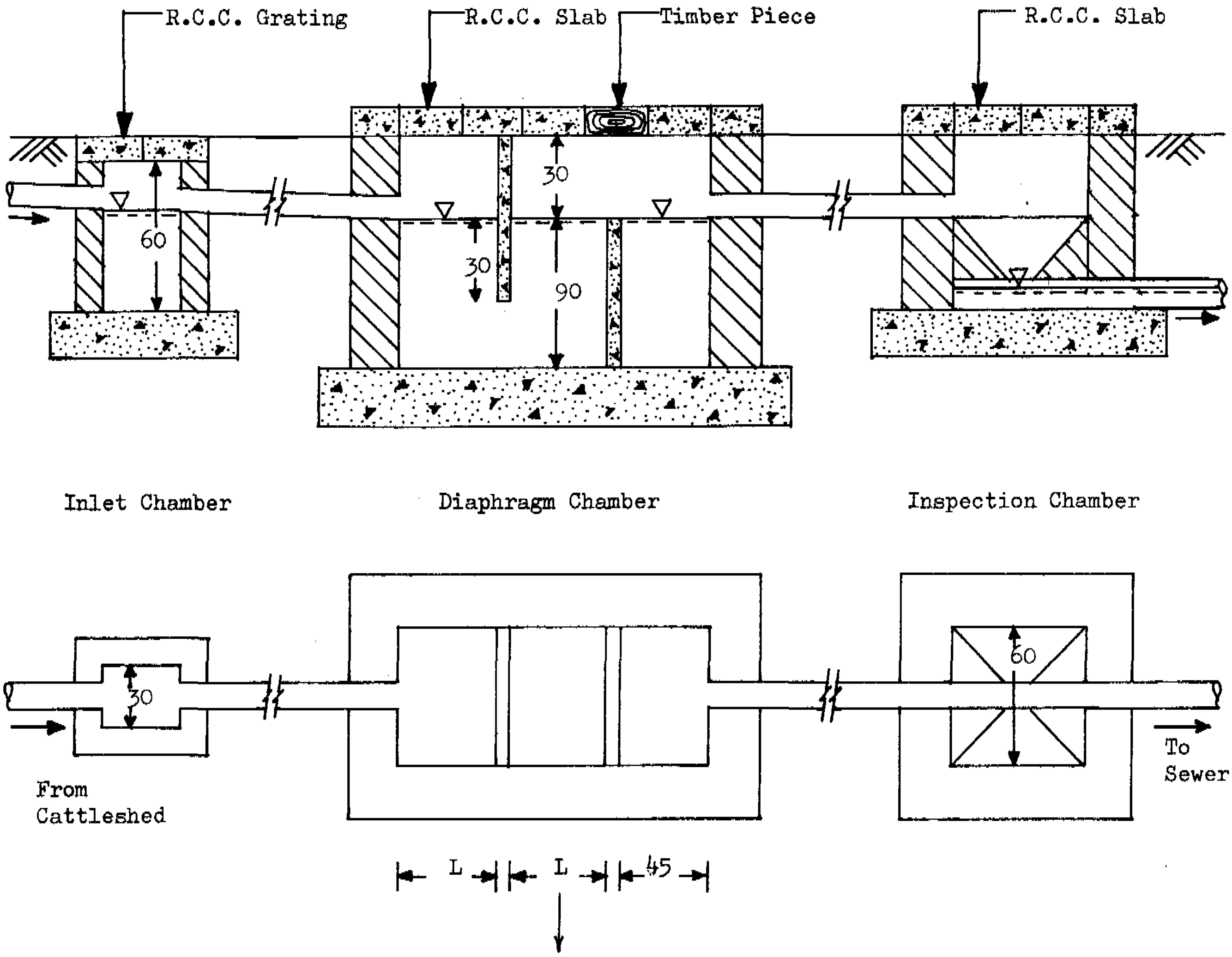
Among some of the other remedies which could be thought of to obviate the cattledung problem, the logical one would be to remove the dung at the source. This needs a virtual parellel conservancy system to be operated in the entire city with a possibility of using a central or regional cattledung digestor as an incidental energy source as well. Such programmes invariably would need a capital governmental funding and take time to come through.

An alternative for this would be for each of the shedowners to put up his own digestor and use the dung as a fuel source. The problem here, in most locations in the city are lack of adequate space and the absence of adequate water for rendering the dung into the requisite slurry.

This leaves the only possible alternative of installing a suitable diaphragm chamber so that, atleast the solid matter could be separated out and periodically removed instead of a daily removal as would be needed under the foregoing alternatives.

RESULTS OBTAINED WITH THE DIAPHRAGM CHAMBER

After studies of the nature and variations of flow from selected cattlesheds and applying the known principles of solid liquid separation, a practicable and simple to construct and operate type of diaphragm chamber was evolved and is shown in Fig.1. In essence, it represents a three compartment chamber with an initial underflow and subsequent overflow baffles as creating the three compartments in a masonry rectangular tank. The sizes would vary depending upon the number of cattle.



For Cattle Strength	0-10	30
" " "	10-20	45
" " "	20-30	70
" " "	30-40	90

FIG.1. TYPICAL DIAPHRAGM CHAMBER ARRANGEMENTS
(Dimensions in Cm)

This chamber was installed at a cost of Rs. 1,800 in a shed with 20 cattle hitherto letting out all its wastes into a 225 mm street sewer. Operational results over a four month period indicate a reduction in settleable solids from 30% in the shed washings as entering the chamber to about 2% in its effluent. Cleaning of the chamber to arrest carryover was needed once in seven days.

During this period, there was not even a single sewer block in this street, which used to witness a near ritual of atleast one block per week prior to the installation of the chamber. The savings consequently, on labour and materials was about Rs. 8 per month.

Cleaning of the chamber has to be carried out by the cattleshed owners and so this requires a social awareness and commitment on their part, to ensure the success of this facility.

By a theoretical comparison, the capital cost for installation of Diaphragm Chambers in all the city's cattlesheds is around Rs. 5.3 million as compared to an annual cost of Rs. 18 million for sewer cleaning.

INFERENCES

The obviating of the cattledung problem in Madras sewers could be either by removing the cattle away from the city or by living with the problem in a less hazardous way.

Some alternatives like in place inceneration of the dung & use as farm compost is not practicable due to limitations of space and fuel scarcity.

An immediate practicable alternative is the provision of diaphragm chambers as presented in this paper.

The study reveals that, technology for developing countries has to be tempered with prevailing social and economic settings of the region & could be successfully implemented.

8th WEDC Conference: Water and waste-engineering in Asia: MADRAS: 1982

METHANE PRODUCTION FROM DISTILLERY WASTES IN ANAEROBIC CHARCOAL FILTERS

by T DAMODARA RAO and P VENKATACHALAM

Introduction

There are about 15 distilleries in Tamil Nadu spread over the entire State. The Industrial process adopted by the distilleries is almost same viz., fermenting the diluted Molasses with yeast and distilling the alcohol produced by passing a counter current of steam while allowing the fermented wash to come down a tall column. Only about 10 per cent molasses is utilised in the process and the major remaining part comes out as effluent in the process. The liquid wastes from the process mainly consist of spent wash besides yeast waste sludge and floor washings. Yeast waste sludge is separated out and dried on the nearby land and used as animal feed. Anaerobic lagoons or digestors are being suggested and tried out for treating distillery waste. In the anaerobic digestion, removal of organic matter results in generation and release of methane gas. One gram of Methane gas released equals 4 gms of biochemical oxygen demand satisfied. Recovery of methane gas also results in fuel recovery which can be used.

Previous Work Done at Kodungaiyur

Earlier studies conducted in this unit indicated that an admixture of carbon particles with spent wash resulted in copious methane gas production due to anaerobic activity. Hence it was planned to use charcoal pieces instead of broken stone in a specially fabricated anaerobic filter for treatment of distillery spent wash. Consequently studies were undertaken to explore the feasibility of anaerobic charcoal filter to treat distillery spent wash for methane recovery. This paper discusses methane recovery in the anaerobic charcoal filters on continuous loading resulting from these studies.

Materials and Methods

The spent wash used for the purpose of the study was obtained from a distillery unit at Chingleput and the characteristics of spent wash are given in Table I. Earlier studies at Kodungaiyur had shown that anaerobic ponds operating in series gave good performance in respect of removal of organic content though smell problems were noticed when the primary lagoon went sour. In the present studies two anaerobic charcoal filters were installed and the performance studied. Details of the filters are shown in Fig.1 and Fig.2.

Anaerobic Charcoal Filter I

This was essentially a downward flow reactor. This was 0.2 m dia cylindrical tank and of 1.52 m depth filled with charcoal pieces of size varying from 25 mm - 38 mm to a depth 0.90 m. The remaining portion was arranged such that influent could be admitted and effluent drawn out.

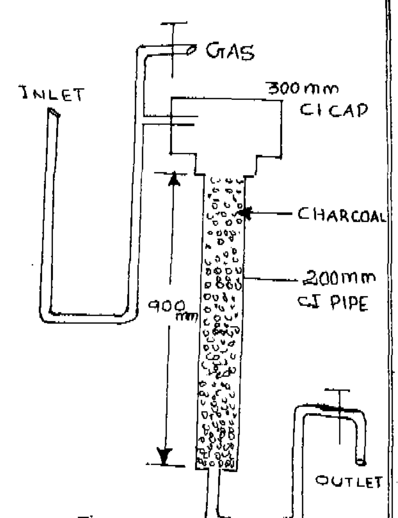


FIGURE 1
DOWN FLOW CHARCOAL ANAROBIC FILTER

Table I : Characteristics of Typical Spentwash from a distillery

	Characteristics	Average Value
1.	Colour	Dark Brown
2.	Odour	Molasses
3.	pH	3.5 - 4.0
4.	Total Solids	59000 mg/litre
5.	Volatile Solids	33000 mg/litre
6.	Total C.O.D (Dichromate Value)	84000 mg/litre
7.	Volatile Acids as acetic acid	1000 mg/litre

Anaerobic Charcoal Filter II

This was an upward flow reactor of 0.11 m dia cylindrical tank and of 1.2 m depth filled with charcoal of same size used in the downward flow reactor to a depth of 0.6 m from bottom. The inlet and outlet for the spent wash was similar to the first filter.

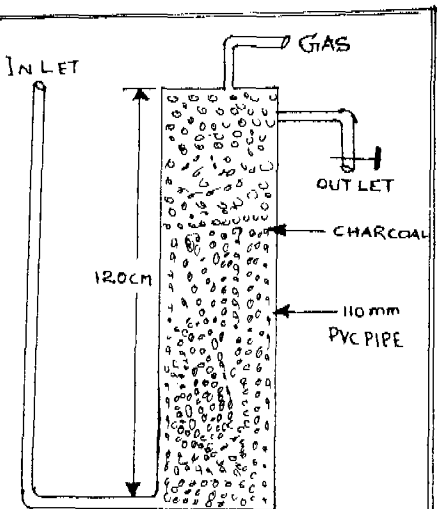


FIGURE 2
UPFLOW CHARCOAL ANAROBIC FILTER

In Filter I, spent wash was admitted from top and an equal quantity was withdrawn from the filter at the bottom. In Filter II the spent wash was admitted from bottom and the effluent was collected from top. In both the filters the gas was drawn from the top of filter and collected in the gas holder by water displacement system. Details of the gas collection chamber is shown in Fig.3.

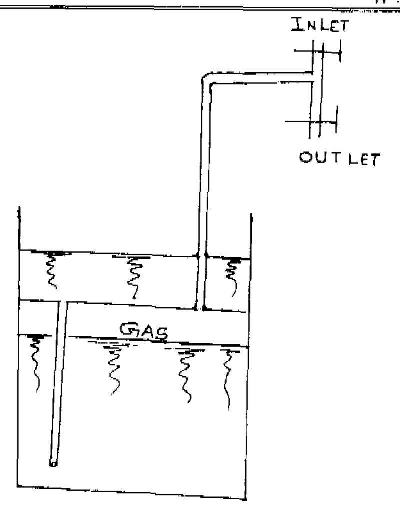


FIGURE 3
GAS STORAGE TANK

Initially both the filters were seeded with digested sludge from anaerobic pond treating sewage. Performance of the filters was observed for nearly one year and the results are shown in Table II. To commence with, in the downward flow reactor 1 litre of spent wash per day was introduced. The filters established themselves very quickly and it was found that they were giving effluent having a pH of 8.0 or more. Gas evolution was also fairly good. Since pH 7 is found to be optimum for production of gas, loading of spent wash was gradually increased. It was found that the pH was 7.5 when the loading was 2.5 - 3.5 litres per day for the downward flow reactor and 0.3 to 0.4 litres for upward flow reactor. At a loading 2.0 - 3.5 litres per day for downward flow and 0.25 to 0.4 litres per day of spent wash to upward flow reactor respectively, it was possible to maintain pH in the region 7.0-7.5. So this loading was taken as the normal and the experiment continued on that basis. It was found that the methane gas evolved readily from both reactors and had a tendency to build to a peak and then to reduce. In the upward flow reactor a steady increase of gas production as shown in graph was observed. The gas production in terms of volatile

Table II : GAS PRODUCTION IN CHARCOAL ANAEROBIC FILTERS

Sl. No.	Date	Downward flow filter: Volatile solids destroyed in mg/l	Quantity loaded in litres	Total V.S. destroyed in gms	Gas collected in litres	Upward flow filter: Volatile solids destroyed in mg/l	Quantity loaded in litres	Total volatile solids destroyed in gms	Gas collected in litres	pH D.F.	pH U.F.	Gas generated per kg of volatile solids destroyed in m^3 D.F.	U.F.	Remarks
1.	28.8.78	21000	1.75	36.75	25.00	14950	0.2	2.99	6.0	8.0	8.0	0.680	2.007	
2.	14.9.78	16500	2.00	33.00	30.00	16700	0.2	3.34	5.0	8.0	8.0	0.909	1.497	
3.	11.10.78	12300	2.00	24.60	35.00	10500	0.2	2.10	5.5	7.5	7.5	1.425	2.619	
4.	18.10.78	12250	2.00	24.50	36.00	11750	0.2	2.35	5.5	7.5	7.0	1.460	2.340	
5.	8.11.78	6250	2.00	12.50	35.00	8750	0.2	1.75	5.7	7.5	7.5	2.800	3.257	
6.	27.11.78	12500	2.25	28.13	35.00	14750	0.25	3.69	5.7	7.5	7.5	1.244	1.545	
7.	5.12.78	12500	2.25	28.13	44.00	13500	0.25	3.38	5.2	7.5	7.0	1.564	1.538	
8.	21.12.78	13000	2.25	29.25	43.00	14000	0.25	3.50	5.7	7.5	7.0	1.470	1.629	
9.	4.1.79	11800	2.25	26.53	27.00	1300	0.25	3.27	8.0	7.5	7.5	1.017	2.447	
10.	20.1.79	11400	2.25	25.65	39.00	12900	0.25	3.23	9.0	7.5	7.5	1.520	2.386	
11.	13.2.79	12900	2.25	29.03	36.00	13900	0.25	3.48	9.0	7.5	7.0	1.240	2.586	
12.	20.2.79	13300	2.25	29.92	37.00	14300	0.25	3.58	9.15	7.5	7.5	1.236	2.559	
13.	12.3.79	12800	2.50	32.00	41.00	13500	0.30	4.05	9.00	7.5	7.5	1.281	2.222	
14.	20.3.79	14700	2.75	40.43	41.00	15400	0.30	4.62	9.10	7.5	7.5	1.014	1.963	
15.	11.4.79	12400	3.00	37.20	52.00	14300	0.30	4.29	9.10	7.5	7.5	1.398	2.335	
16.	17.4.79	12700	3.00	38.10	52.00	14700	0.30	4.41	9.50	7.5	7.5	1.364	2.200	
17.	6.5.79	13100	3.50	48.50	57.00	14500	0.30	4.35	8.70	7.5	7.5	1.175	2.000	
18.	15.5.79	12100	3.50	42.30	60.00	14500	0.40	5.80	8.10	7.5	7.5	1.418	1.307	
19.	6.6.79	10700	3.50	37.50	49.00	13000	0.40	5.20	7.10	8.0	7.5	1.307	1.366	

solids destroyed ranges from 1014 litres to 1564 litres/kg of volatile solids destroyed for the downward flow anaerobic charcoal filter and 1307 litres to 2963 litres/kg of volatile solids destroyed for upward flow reactor respectively. This quantity of gas is very high and how such an increase comes about has to be explained yet.

The detention period calculations are given below:

Calculation of Detention time in Charcoal Filter I

Diameter of Filter	=	20 cm
Area of cross section	=	314 cm^2
Depth of filter	=	90 cm
Volume of filter	=	28260 cm^3
Assume 50% void in charcoal		
Volume of void	=	14130 cm^3
	=	14.13 litres
Volume loaded/day	=	1.75 litres to 3.5 litres
Detention time	=	$\frac{14130}{1750}$ to
	=	$\frac{14130}{3500}$ days
	=	8 days to 4 days

Detention time in charcoal filter II

Diameter of filter	=	11 cm (outer diameter)
Assuming 5 mm wall thickness, inner diameter	=	10 cm
Area of cross section	=	79 cm^2
Depth of filter	=	60 cm
Volume of filter	=	79 x 60 cm^3
	=	4740 cm^3
Assuming 50% void, volume of void		
	=	2370 cm^3
	=	2.37 litres
Volume of spent wash loaded	=	.2 to .4 litre /day
Detention period	=	$\frac{2370}{200}$ to
	=	$\frac{2370}{400}$ days

= 12 days to 6 days

Discussions of Results

The gas production seems to be ensured in anaerobic charcoal filter in a small volume compared to 60 days detention time required for primary anaerobic ponds for distillery spent wash. For this particular set up the detention time was ranging from 4 to 8 days for downward flow and 6 to 12 days for upflow filters. Also the gas production was quite satisfactory and establishment of gas production was quick too. These are possible due to the following reasons.

i) Perhaps the filters operated as a complete mixing unit so that the micro organisms were spread uniformly, both in total mass and species. It was also possible to achieve uniform mixing of the feed at all times in all points of the filters due to this complete mixing pattern.

ii) Organic concentration of feed to the micro organisms at all times was kept constant in the reactors.

iii) The charcoal particles possess the adsorptive capacity which helps in adsorbing NH4 ion concentration and consequent inhibition in digestion.

iv) The charcoal provides a surface for anaerobic micro organisms to establish themselves and thrive. Probably this resulted in prevention of upsets due to changes, in loading rate.

Further gas generation even when pH was 8 and more shows that volatile acids were present and were getting gassified. They were probably adsorbed by charcoal and released gradually for methane generation. Investigations are required to establish the parameters in respect of the variation in the quality of effluent, period of operation, and rate of gas evolution with reference to loading.

The gas generation for downward flow shows a maximum value of 1564 litres/kg of volatile solids destroyed for a loading rate of 2.25 litres/day. The value for upward flow is 2886 litres/kg of volatile solids destroyed at a loading rate of .25 litre/day. However, by volume the max. quantity is got for downward flow is 57 litres per day at the loading rate of 3.50 litres per day. It is 9.50 litres per day at the loading rate of .30 litres per day. Still higher loadings adversely affected both gas yield and rate of gas yield per kg of volatile solids destroyed. All these rates are high compared to the accepted rate of about 18 cubic feet of gas per pound of volatile solids destroyed (1300 litres/kg of volatile solids destroyed). As mentioned, a satisfactory explanation is yet to be formulated for the higher gas yield from anaerobic charcoal filters.

The B.O.D values for effluent from anaerobic charcoal filters could be done only in a few cases and hence not included here. The values were about those obtained by treating distillery spent wash in two anaerobic lagoons of 60 days and 40 days in series. This probably represents the maximum **removable** B.O.D by anaerobic digestion in both cases.

Summary and Conclusions

1. Use of charcoal in size indicated viz 25 mm - 38 mm is novel and due to its structure as well as its adsorption the charcoal anaerobic filter has shown a favourable methane production rate by permitting anaerobic organism to grow on its surface and also by adsorbing excess NH_4 ions which tend to be toxic in excess for anaerobic digestion.

2. Probably the adsorption helps in keeping the volatile acid concentration down so that even at higher loadings the pH was in the region of 7.0. At lower loadings, the pH was observed to be 8.0 and more which again may be due to adsorption of volatile acids. The volatile acids were probably slowly released for methane production by anaerobic microorganism.

3. The upward flow anaerobic filter gave nearly 50 per cent more gas which may be attributed to the better bacterial action due to the vertical upward flow of the anaerobic filter as against the downward flow anaerobic filter. The vertical flow probably results in better mixing and bacterial action.

4. Though the waste was very high in organic content and BOD, the detention period was low compared to the detention provided in anaerobic lagoons coming to $\frac{1}{10}$ of conventional requirement.

5. The gas yield was quite high both for downward flow and upward flow anaerobic charcoal filters. It was remarkably high for the upflow anaerobic charcoal filters. This is yet to be satisfactorily explained.

6. The arrangement was found easy to set up and gas generation was found to be quick.

7. The water displacement method for gas collection was also unique in that there was no moving gas dome.

8. Further studies are to be carried out for confirming and applying the findings in treating strong organic effluents effectively and with recovery of methane.

9. The B.O.D. of the effluent from the anaerobic charcoal filters compares favourably with the BOD of effluent from anaerobic lagoons in series. This means that all removable BOD is removed as efficiently in anaerobic charcoal filters.

The authors acknowledge the help and assistance rendered by various helpers in the Kodungaiyur Research Unit and the help and encouragement received from the Superintending Engineer (Central Designs) Thiru S.A.Jagadeesan in carrying out this work.

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REMOTE SENSING WITH SPECIAL REFERENCE TO POLLUTION

by H S MEHTA and A N PATEL

ABSTRACT

The recent development of satellites has made available enormous quantities of photographic and other forms of data about the surface of earth. These data have great potential for helping to solve human problem such as monitoring and controlling environmental pollution. All the wavelength regions for UV through microwave have practical applications. The synoptic regional coverage availability of data from inaccessible areas, and repeated coverage are advantages of satellite imagery. The great mass of industry and population creates pollution at a scale we are now not capable of handling. Even the monitoring of sources of pollution is beyond our present capabilities. The monitoring is the first step in pollution control and it can be accomplished by carefully designed remote sensing system. The feasibility of employing this technique in monitoring water pollution is indicated in this paper.

INTRODUCTION

Environmental pollution and ecology have become commonplace words in our vocabulary. In prehistoric times the pollution was thin and with the advent of civilization and growth of urban areas, the effect of pollution began to be noticed. It is sad irony of events that progress of mankind in every sphere of activity is closely associated with the deterioration of the environment. The subject of pollution and human environment is of topical interest in Madhya Pradesh which is one of the States of India. The pollution of rivers by industries must have had its beginning at the time of industrial revolution. As the industries expand their plants, so there is a corresponding increase in the discharge of pollutional wastes. The wastes are contaminated with acids or alkalis, chemicals, floating and suspended solids, silt, oil, organic matters etc. Moderate quantity of these wastes can be absorbed without damage to a healthy river. But when they are discharged in excess and the river discharge is low the water becomes grossly polluted; unsuitable for fish life, unsafe for domestic and recreational purposes.

The development in remote sensing technique has brought a revolutionary change in the methods of detecting sources of pollution and monitoring pollution dispersions (ref.1). Aerial photography has been used extensively in studies of water pollution. Even from the satellite altitudes, the radiance level measurements has correlations with the level of pollution in the river water. Multiband photography, by virtue of its ability to record subtle differences in reflectance provides a powerful tool to detect pollution.

The remote sensing technique is employed in the case study of one of the rivers of India polluted by wastes from paper mills.

CASE STUDY

The river Tapti is one of the perennial rivers of Madhya Pradesh (India), flowing from east to west. The National News Print and Paper Mills of Napanagar is situated in the District of Khandwa on the banks of the river Tapti. The quantity of waste water effluent from this industry is about 3,75,000 m^3/day and is discharged in this river. The effects of pollution are perceptible at places even beyond 40 Km from the waste discharge point. The water supply scheme of Burhanpur, a major town on the bank of this river about 24 Km downstream, has been badly affected. The characteristics of composite waste from this Paper Mill is shown in Table 1.

Table 1

Characteristics of Composite Waste

S.NO.			Characteristics
1. Colour		:	Brown
2. pH		:	7.8 - 9.0
3. Total Solids	mg/l	:	1200 - 1640
4. Suspended solids	mg/l	:	624 - 870
5. B.O.D.	mg/l	:	296 - 410
6. C.O.D.	mg/l	:	784 - 1210

The MSS data in band-6 of ERTS-1 imagery is employed to study the pollution of river Tapti.

The Landsat-1 frame of MSS-6 has central co-ordinates:

N 21°22′ and E 75°47′

The transmittance at various points along the river course is measured using micro-densitometer (ref.2). The results obtained are presented in Figure 1.

The spectral response of the effluent and clear water (ref.3) is shown in Figure 2.

CONCLUSIONS

Pollutant presence in water is one of the major factors affecting spectral response of water bodies. The polluted water has higher reflectance than clear water. This indicates that water pollution can be effectively studied by Landsat imagery.

ACKNOWLEDGEMENT

The authors wish to thank the Director, G.S. Institute of Technology and Science, for providing facilities to conduct this investigation.

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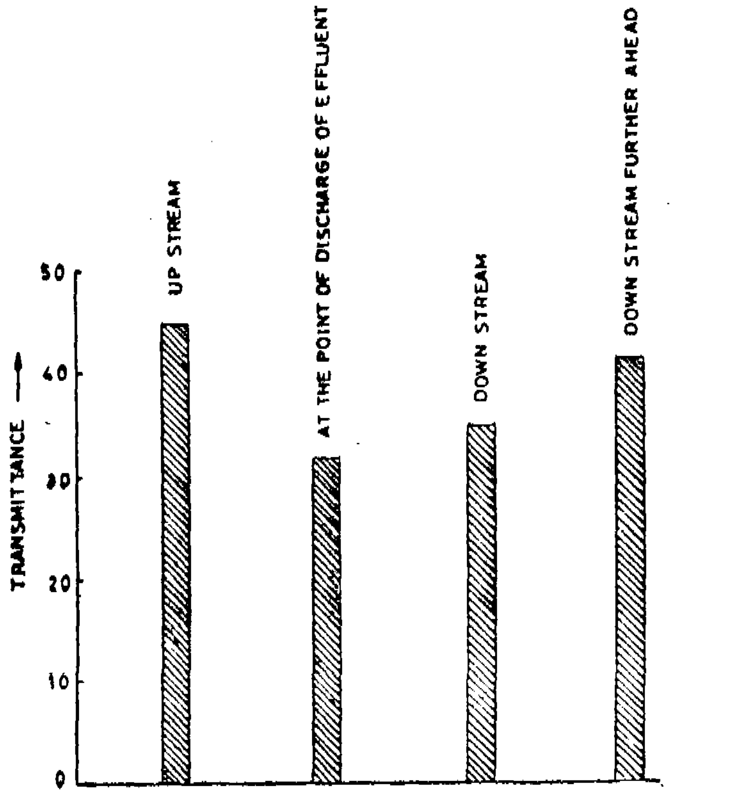
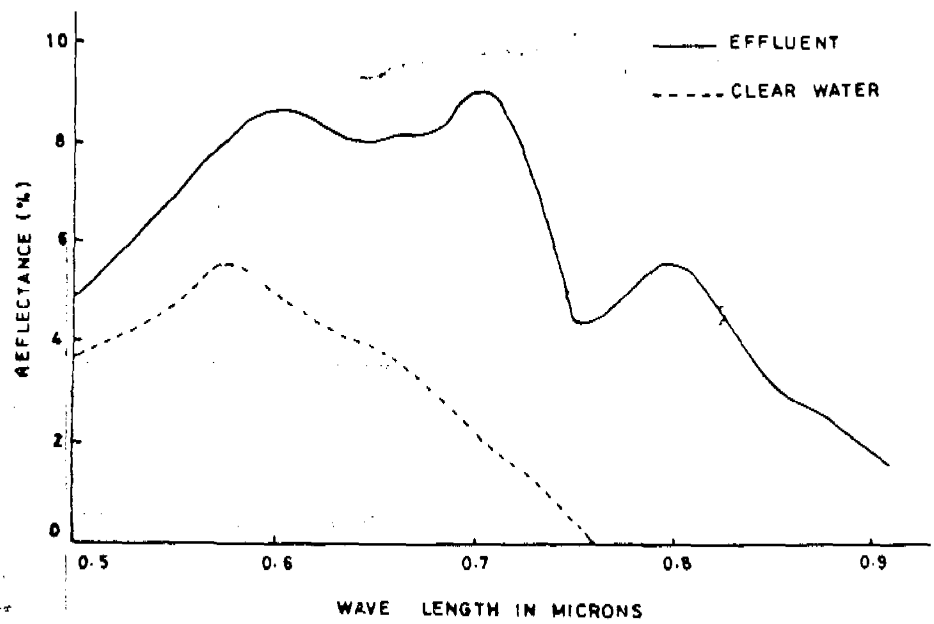


MEASURED TRANSMITTANCE ALONG RIVER COURSE

FIG.: 1



SPECTRAL REFLECTANCE CHARACTERISTICS OF EFFLUENT & CLEAR WATER.

FIG.: 2

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STUDY OF WATER POLLUTION IN RIVER JHELUM OF KASHMIR

by N CHOUDHARY, N P SHUKLA, RIAZUL-AMIN and S P QALANDAR

ABSTRACT

This study pertains to water pollution in river Jhelum. In order to take stock of water quality, samples were collected from various points along the course of the waterbody and analysed for identification of source, nature and type of pollutants present. The main parameters investigated include pH, alkalinity, acidity, total solids, dissolved oxygen and BOD. It was found that the quality of water was satisfactory at most of the points. However, at some points, minor deviations from International Standards for Drinking Water were observed in respect of BOD, CO_2 and total solids. The growing industrialisation and organisation of Kashmir demands constant monitoring of water quality.

INTRODUCTION

Environmental deterioration is an inevitable result of human activities and a natural phenomenon as well. Therefore, the regulation and control of contamination, so that it does not become pollution, becomes important. A proper management of the contaminants requires the knowledge of the quantity and quality of the contaminants as well as sensitivity of the recepter system (Ref.1). It is in this regard that stream flow assumes paramount significance.

River Jhelum runs all along the length of the valley and then crossing the border it looses its identity in the mighty Sindh in Punjab, Pakistan. All through its course, Jhelum is characterised by a slugish flow and a tortuous path both arising from the high level nature of the valley (Ref.2). With the rapid industrialisation and urbanisation, the danger of degradation of river Jhelum, the chief waterbody of Kashmir, has increased. Consequently there is an obvious need of water quality determination.

The present study aims at (i) physiochemical analysis of water samples collected from different points, (ii) identification of source, nature and type of pollutants, and (iii) suggestions for suitable preventive techniques, if required.

WATER POLLUTANTS

Foreign material, either natural or otherwise, contaminates water and thereby renders it harmful to mankind because of its toxicity, aesthetically unpalatable effect and disease-causing agents. The pollutants which affect the quality of water may be categorized as:-

1. Physical Pollutants. Colour, temperature, taste, odour, and turbidity.

2. Chemical Pollutants. (a) Organic effluents - Pesticides, herbicides, oil and greases. (b) Inorganic effluents - soluble gases and compounds.

3. Biological Pollutants. Sewage effluents, wastes from slaughter houses, food and vegetable industries.

The industrial wastewater is usually released directly into the river generally in an untreated and unstabilized condition. Such water carries pathogenic organisms which can cause a variety of ailments like dysentry, gastroenterities, typhoid, giardiasis, hepatitis (Ref.3).

EFFLUENT TREATMENT METHODS

The nature and quality of industrial effluents is as varied as the industries themselves. A general view of the industrial wastes finding way into river Jhelum may be had from Table 1.

Table 1

EFFLUENTS FROM INDUSTRIES AROUND RIVER JHELUM

Type of Industry	Nature of pollutants in raw waste.
1. Leather and Tanneries	Deep colour, high organic and salt soluble and insoluble contents.
2. Dairies	High BOD, High colloidal solids, fats and grease, acids or alkalis, odours on stagnation, iron salts, bio-degradation matter.
3. Slaughter houses	High BOD, colour, offensive odours on stagnation, iron salts.

4.	Fruit canning	Acids, high BOD, colour and dissolved salts.
5.	Agriculture/ Horticulture	Organic matter, suspended solids, toxic matter from insecticides and fertilizers.
6.	Textiles, Silk/Wool	Alkalis and sodium salts, organic matter, toxic matter and colour.
7.	Soap and Detergents	BOD, sulphur, pH, sodium salts.
8.	Cement	Suspended and dissolved solids, pH and Heat.
9.	Power Plants (steam)	BOD, turbidity, heavy metals, sulphur, heat, COD and dissolved oxygen.
10.	Cattle feed	BOD, NO_2, dissolved sulphur, E-Coli, phosphorous.
11.	Grain Mills	Sulphur, pH, Nitrogen, phosphorous, BOD and heat.
12.	Timber products	BOD, dissolved and suspended sulphur, colour, COD, toxic matter.

The great diversity in the nature of pollutants suggests that it is not possible to devise a single unit to treat wastewater from these industries. However, knowing the characteristics of effluents, it becomes simpler to identify the treatment methods to be employed. These could be classified into three main groups as given below.

1. Physical Treatment	Cutting, grinding, screening and separation.
2. Chemical Treatment	Neutralization, flocculation, coagulation, destruction of toxic substances.
3. Biological Treatment	Anaerobic and aerobic treatments.

SAMPLING AND TESTING PROCEDURES

A minimum of three water samples were collected at each of the points, representing the maximum concentration of pollutants. Sampling methods and analytical techniques used for determination of the parameters of the study were in accordance with 1S1 : 3025-1964 (Ref.4).

RESULTS AND DISCUSSIONS

The mean values of the parameters obtained from analysis are reported in Table 11, wherein all values are in mg/l., excepting temperature and pH. Out of the numerous evaluations carried out, the main parameters of the study include pH, alkalinity, acidity CO_2, DO, BOD and total solids. These results refer to May 1980. The salient features of each parameter are discussed.

1. pH

It indicates the acidity of a solution. In natural water, it is largely dependent on the CO_2 equilibrium and lies between 7.0 and 8.5 the exact desirable range as per the International Standards for Drinking Water (Ref.5). Too low or too high pH makes water distasteful and effects corrosion.

In river Jhelum, a peak value of 9.1 at Shalteng, which is less than the limiting value of 9.2 was observed. It can be explained in terms of many sewers that join the river between Safakadal and Shalteng.

2. TEMPERATURE

Variation in temperature causes changes in pH and increased solubility or precipitation of bottom deposits. At elevated temperature a faster depletion of oxygen in water takes place due to increased rate of biodegradation and loss of solubility (Ref.6).

Water becomes less palatable as temperature rises above 10°C. The most desirable range for public supply is 5° to 10°C and it becomes undesirable above 27°C. Jhelum water even during summer was found markedly below this limit. The steady increase in temperature along its course may be due to a number of factors including higher temperature prevalent in the valley and contribution of submerged springs.

3. CARBONATES AND BICARBONATES

Carbonates and bicarbonates are undesirable foreign materials in water. Many industries such as brewing, distillery, rayon, paper and ice need soft water. In canning, hard water causes toughness of some vegetables, notably beans and peas. In textile finishing, the precipitates formed by lime of water combining with soap leaves spots on the fabrics or reacts unfavourably with dyes. Hard water deposits scale in pipelines and boilers which results in vast economic waste, due to failure of tubes and attendant shut down. So industrial water is softened to reduce its contents of calcium and magnesium.

4. TOTAL ALKALINITY

Alkalinity is caused by the presence of bicarbonates, carbonates and hydroxides of calcium, magnesium, potassium and sodium. These compounds also cause temporary hardness. The values of alkalinity for soft water and that for fair domestic water are 50 and 125 mg/l respectively. No harm is caused even if it is 400 mg/l. As such Jhelum water may be categorised as soft water. The peak value of 220 mg/l at Zainakadal may be attributed to a lot of washing going on around the area when the samples were collected.

5. TOTAL ACIDITY (as mg of $CaCO_3$)

The most usual cause of acidity is free CO_2 and decomposing organic matter especially of peaty origin. There is no defined limit for acidity of water. pH value in conjunction with other characteristics is used to determine the acidity of water which, in turn, indicates whether it is corrosive or not. All through, very low values of acidity were observed.

6. CARBON DIOXIDE

CO_2 in water is the result of decomposition of organic matter or the metabolism of some organism. Water drawn from iron-bearing formations often contain high quantity of CO_2 . At higher concentrations, it poses the danger of bringing toxic metals into solution and damaging pipes.

Carbon dioxide is desirable in water at a concentration known as the carbonate balance. At this concentration, it should impart a desirable taste and should affect the solubility of the carbonates (ref.7).

In the river Jhelum, CO_2 concentration was generally high, as high as 92 mg/l at Banyari, in comparison to the desired limiting value of 10 mg/l. This indicates a high degree of biological activity going on in the river, since oxidation of organic matter furnishes CO_2 . However, the BOD results suggest otherwise. The high value of CO_2 concentration may be due to a large number of submerged springs bringing in enough groundwater rich in CO_2 .

7. DISSOLVED OXYGEN

Dissolved oxygen (DO) is the content of free oxygen in water. Surface water of satisfactory quality should normally be saturated with oxygen. Undersaturation and oversaturation indicate pollution. There should be an optimal minimum of 5 and minimum of 2 mg/l of DO. Aerobic bacteria consume dissolved oxygen of water. If the consumption is greater than its make-up by freshly dissolved oxygen obtained from the surface, oxygen deficiency is produced in water. More demanding, high quality fish migrate into other zones. A severe deficiency with oxygen contents less than 2-3 mg/l leads to general fish death.

In the case of the river water, the oxygen content was generally satisfactory, both in regard to human consumption and fish hatching. In certain congested areas, like Habbakadal and Safakadal, DO was rather on the lower side, being 3.6 and 3.2 mg/l respectively, which is still within the safe limit.

8. BIOCHEMICAL OXYGEN DEMAND

Biochemical oxygen demand (BOD) is a measure of the amount of oxygen required in 5 days by living organisms in water to oxidise organic matter present as food. The BOD test suffers from the following severe limitations. First it requires a long time and then only a fraction of biodegradable compounds are determined. Also inorganic pollution may be there even if BOD is low. This calls for a judicious interpretation of BOD data.

If the load of organic matter does not exceed a moderate level at which the aerobic bacterial life is maintained, the organic pollutants are partly degraded by the bacteria through oxidation and partly used for the growth of new living biomass. This self-purification process requires the regulation of organic load into the stream.

The most desired level of BOD in water for domestic supply is zero and should not be above 0.5 mg/l. A higher content is a pointer to the higher number of living organisms like bacteria etc. in water. In general, the BOD of Jhelum water was not high indicating its suitability for public consumption. Slightly higher BOD values at Athwajan, Rajbagh, Habbakadal and Zainakadal do cause concern and indicates organic loading at these points.

9. CHLORIDES

High concentrations of chlorides affect the taste of water and result in corrosion in hot water systems. Its main source in water is sewage. This is also evident from the analysis of water samples collected from the source points of the river like Pahalgam and Verinag, which are completely devoid of chlorides. All along the length of the river Jhelum, the chloride level was found, in general, to be very low, with a maximum of 5.2 mg/l at Zainakadal which is well below the desirable limit of 200 mg/l.

10. TOTAL SOLIDS

A high concentration of solids in water deteriorates its taste and causes gastro-intestinal irritation. The desirable level of total solids in water is 500 mg/l. and the maximum permissible in household water is 1500 mg/l. The total solid content in Jhelum water has been found to be mostly within the permissible limit. However, it varied widely in the range 90 to 1990 mg/l. This variation may be appreciated in its proper perspective if we take into account the fact that so many Nallah from highland areas open into the river bringing in a lot of hill soil. This causes a high level of total solids in the river. The amount of solids is primarily dependent on the amount of rainfall experienced prior to the collection of samples. This explains the high solid content at Habbakadal and Banyari.

11. DISSOLVED SOLIDS

The predominant constituents of dissolved solids are cations such as calcium, magnesium, sodium and potassium and the anions as bicarbonate, sulphate, chloride and nitrate. Higher concentrations are detrimental to public health and also these result in excessive scaling on boiling. The amount of dissolved solids in Jhelum water was generally not very high. The peak value of 11600 mg/l at Banyari can be explained in terms of excessive agricultural run-off finding way into the river. At Shalteng, the low value of dissolved solids especially in view of higher total solids may be ascribed to the greater contribution of rain-water towards the solid content.

CONCLUSION

In the light of the above discussion it is evident that pollution in river Jhelum is yet to gain dimensions. Certain parameters indicate no pollution whereas some like BOD, CO_2 and total solids do pose concern. Should the remedial measures be initiated now, possibly the evil could be contained.

Sewage systems, tourism, industry, agricultural run-off, industrialization and urbanization of Kashmir valley will add new dimensions to the quality of water entailing greater efforts both from public and government. Constant monitoring of the quality of river water in conjunction with planned development of the industry in the valley seem to be the need of the hour so that problems of pollution do not aggravate further.

ACKNOWLEDGEMENT

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TABLE-II

Mean Values of Different Parameters

Sampling Stations Parameters	Pahal-gam	Veri-nag	San-gam	Athwa-jan	Raj-bagh	Habba-kadal	Zaina-kadal	Safa-kadal	Shal-teng	Ban-yari	Ningli
Temperature °C	8.5	11	13	21.7	19.6	22.3	19	22	23	19	20.2
pH	8 3	8.2	7.9	7.6	8.1	7.5	8.5	7.5	9.1	8.2	8
Carbonates	0	0	0	0	0	0	0	0	0	0	0
Bicarbonates	2	3.7	1.3	1.7	1.5	3	10.4	2.3	1	1.6	1.3
Total Alkalinity	10	22 3	9.2	17	9	10	22.2	9.3	2	4	3
Total acidity	2	3.0	4.3	3.5	3.6	2.7	1.8	2	10	10	11.3
CO_2	15	32.5	59.3	15.3	20.6	29.1	6.2	26	21.6	92	82.3
DO	5.4	5.3	4.7	4.5	5.9	3.6	4.8	3.2	6.7	7.4	9.1
BOD	0.6	0.4	1.1	1	2.6	1.9	1.1	0.6	1.5	0.9	0.8
Chlorides	0	0	0.7	2.5	2	1	5.2	1.3	1	2.3	1
Total solids	90	92.5	286.6	1474	1370	1696.7	930	403.3	1466.7	1986.7	506.7
Dissolved solids	80	87.5	210	582	277.5	473	266	183.3	66.7	1160	86.66

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POLICIES FOR TREATMENT AND DISPOSAL OF INDUSTRIAL WASTES

by SYED MUNAWAR HUSAIN BUKHARY

INTRODUCTION

Bangladesh, a new nation, is facing environmental disasters. Water borne disease is a common feature of suffering of this part of the world. Lack of pure water supply and proper environmental sanitation is the major cause responsible for this. Pure drinking water is in less supply and sewerage system is almost non-existent. Waters available in ditches, pools and small streams are mostly contaminated and help generation of germs and diseases. Above all, industrial wastes,fertilizer, toxic chemicals and synthetic detergent also create water pollution (1).

NATURE OF INDUSTRIAL WASTES AND NATURE OF POLLUTION OF ENVIRONMENT

From the industrial survey of our country undertaken by Environmental pollution control cell, we can know the nature of industrial wastes and the nature of pollution they create on environment (2). The industries have been identified and detailed study has been undertaken to find nature of industrial wastes and their pollution effect. It has been found that mostly liquid and gaseous wastes pollute the environment. Effluents of Fertilizer, chemical, paper Mills, TSP (Triple Super-Phosphate), Tanneries, DDT, Chemical Industry and Pulp and Paper Mills etc. are mostly in the form of liquid and gas. As it is not possible to make study of all the industries responsible for pollution, we will try to study a few specific cases which are more prone to undesirable waste and create pollution of environment.

Pollution by Karnaphuli Paper Mills and Rayon Complex

First let us take the case of Karnaphuli Paper Mill (KPM) and Rayon Complex. These two enterprises discharge their effluents into the river Karnaphuli. The per day discharged effluents amount more than 10-12 million gallons of untreated waste liquors. The result is the mortality of fish in the river in a stretch of five miles down stream and one mile upstream from the mill every year. In the study undertaken by Environmental pollution control cell, to analyse the effluents and to find out economic method of treatment and disposal of the effluents it was found that KPM and Rayon Complex discharge generally : (3)

a) Waste liquor from
   i) Digester House
   ii) Pulp bleaching plant
   iii) Washing and screening plant
   iv) Soda recovery plant
   v) Chips washing plant
   vi) Blow down

b) Black liquor from black liquor tank evaporators and soda recover pits. Quantity of effluents being 8-10 millions gallons per day.

c) Waste bleach liquor from
   i) Washing Leakage
   ii) Caustic chlorine and
   iii) Bleaching liquor pits.

Further from the analysis of the effluents, it was found that the effluents had high chemical oxygen demand (COD) and therefore reduce the oxygen content of river water quickly, which is responsible for fish killing.

There is also air pollution problem in the mill area. Exhaust gas emitting from the chimney of the mill (So_2, marcantan) are responsible for air pollution. The mill authority has been asked to take precautionary measure immediately.

Pollution by Hazaribagh Tanneries

Hazaribagh area, situated on the south-west periphery of Dacca city, is a locality which is both residential and industrial having tannery industries distributed all over it. There are 126 tanneries in the area. In addition to general insanitary condition, the tannery industries are responsible for air pollution because of production of intolerable odour. The liquid waste consisting of waste water, organic particles and toxic chemicals used in the process are finally discharged through small individual drains leading to neighbouring river Buriganga (4).

The table below (Table 1) gives statistics of production in ten selected tanneries including quantity of liquid waste. It is apparent that the volume of liquid waste is quite substantial in each of the tannery.

Pollusional aspects of the effluent (5) Discharge of effluent from tannery wastes into river, streams is the prime cause of pollution. The presence of biologically oxidizable material in wastes exerts a deoxygenating effect in the rivers, streams etc. Odour pollution is created by suspended matter in the wastes which forms sludge banks on the bed of river, streams. Chrome tan wastes are toxic to fish and aquatic life. Vegetable tan wastes colours the water in which "tannins" decompose slowly. Tannery wastes containing chromium and arsenic have rendered drinking water unsuitable for human consumption.

In certain exceptional cases, it was found that 10,471 lbs. of total suspended (organic and inorganic) solids discharged as a waste. Different kinds of oil amounting to 1,700 - 1,800 lbs. used in the industries are likely to be present in the waste every day. The effluent has a high PH value which lies between 7.5 to 10. The variation of temperature recorded as maximum 85°F in March 1975 and minimum 75°F in January, 1975.

Pollution by Urea and Fertilizer Factory, Ghorasal (6)

The Ghorasal Fertilizer Factory is located on the Sitalakhya River about 20 miles north of Dacca. It produces about 3.4 lakh tons of urea annually. The raw materials are natural gas, air water and power. The pollution occurs due to the catalysts, the chemicals used to treat the various kinds of water used in the factory and the ammonia which is an intermediate product in the production of fertilizer. These chemicals such as arsenic, sulphuric acid potassium chromate, chlorine etc. are harmful to fishes.

TABLE 1 : Statistics of Production in Selected Tanneries.

Production Name of Tanneries	Wet Blue Leather (cow) in lbs./day	Wet Blue Leather (goat) in lbs./day	Finished Leather in lbs./day	Water consumption in Gallons/day	Liquid Waste in Gallons/day
Bangladesh National Tannery	-	167	-	60,000	48,000
Bangladesh Crome Tannery	-	3,000	-	16,000	13,280
Dilkusha Tannery	200	1,667	-	80,000	64,000
East Bengal Tannery	-	2,000	-	23,000	18,400
Mahtab Tannery	250	-	4,500	13,750	13,000
North East Tannery	500	2,000	-	11,150	8,920
Razzaq Tannery	67	-	1,500	11,950	16,360
Taj Tannery	500	3,000	-	11,400	9,120
Rahmania Tannery	-	3,000	-	14,800	13,840

Source : Year Book, Water Pollution Control Project (September 1973 to June 1975) Government of People's Republic of Bangladesh.

If we consider the type of chemicals used and the process, the particular parameters of pollution can be taken as shown below :

(1) Physical
 i. Solids
 ii. Grease or oil
(2) Organic
(3) Toxic Chemicals.

However the major water pollution occurs in this factory is form ammonia. It has been found from plant laboratory records that on 3.3.1974 the plant effluent had an ammonia content of 7400 mg/L and on 27.3.1974, 940 mg/L on these dates the middle of the river sewer-outlet had 87 and 62 mg/L of ammonia. No fish could survive for any length of time in water containing 87 or 62 mg/L of ammonia. These large ammonia discharges occurred due to accidents, but ordinary discharge is much less although an objectionable amount.

Pollution by Other Industries (7)

Air pollution caused by TSP factory by emitting SO_2 and SO_3 and acidic gas in air made a problem for neighbouring regions. These gaseous fumes, specially in the winter season, forms a blanket in the atmosphere and creats a suffocating situation for respiratory system particularly in the adjacent Naval base. The DDT Factory and CIB (Chemical Industries of Bangladesh) Factory at Barabkunda, Chittagong are responsible for discharging Chlorine gas and acidic effluent which created dangerous condition for agriculture and surrounding inhabitants. Chattak Pulp and Paper Mills is creating water pollution of Surma river and as a result the aquatic organism are being eliminated from the river. It has been revealed from the monitoring analysis reports that the industry is responsible for polluting the river water. Underground (Deep Tubewell) at Tejgaon industrial areas was contaminated as a result of secretly dumping of condemmed insecticide by the insecticide industry. Due to this type of insecticide contamination the water of Dacca Water and Sewerage Authority (WASA) becomes unfit for drinking purpose.

TREATMENT AND DISPOSAL PROCESS : SCIENTIFIC AND ECONOMIC PROCESS

Most of the industries in Bangladesh have no treatment plant and they dispose the wastes into the rivers creating pollution for the neighbouring environment. For detecting pollution of environment there are ten monitoring stations in various places all over Bangladesh.

They collect water samples near, the industries and analyse it twice a month during low flow and once a month during high flow and alerts the industries to take possible remedial measures. To give some examples of treatment and disposal process the KPM complex has no treatment plant for its waste disposal. So, a few monitoring stations have been established along the river and analysis is being carried out to find possible discrepancy. If any discrepancy is found, attention of the authority is drawn to take preventive measures. Environmental pollution control has asked KPM complex authority to construct treatment plant for remedial purposes and to treat their effluents before discharge into river water (8).

In the Hazaribagh Tannery area, no industry has got any treatment plant. As an alternative, the following immediate preventive measures can be adopted (9).

1) With treatment, no effluent of tannery wastes should be discharged into sewer. Co_2 produced during biological decomposition reacts with lime present in the effluent inside sewer to form carbonate and to form hard incrustation which ultimately blocks the sewer.

2) It is essential that good housekeeping is maintained inside the tannery so that the wastage of materials and water is reduced to minimum by proper utilization. Improved manufacturing process and techniques of operation can curtail the quantity and pollution load of waste waters. Salinity in waste water can be minimized by dusting the salted hides, skins before washing.

3) The flesh, hair etc. can be separated from waste streams by passing them through suitable screens. It has been seen that at least 5 per cent of BOD and 5 to 10 per cent of suspended solid can be reduced by this process.

Urea and Fertilizer Factory Ghorasal has got no treatment plant. The major pollution is Ammonia. It was decided that bio-assays be run routinely at the factory to establish the water pollution hazard of the factory to fish. Bio-assays should be carried out both on the factory effluent and on the river itself. On further survey and laboratory test, it was found that the mortality of fishes in Sitalakhya in several times was caused by the high value of the concentration of dissolved ammonia in water. The Urea and Fertilizer Factory, Ghorasal, has been informed by the Environmental Pollution Control to treat the effluents before discharge into the river. It is expected that they will construct proper treatment plant for neutralizing the toxic effluents before discharge (10). Similarly other industries have got no treatment system as discussed below (11). The TSP has no treatment plant to stop air pollution. The Chairman, Bangladesh Chemical Industries Corportion has been asked to take special care for the exhaust gas emission. A plan is being prepared by them. It is hoped that after treatment of the exhaust gas the problem will be minimized. Similarly DDT and CIB factory has no treatment system for its effluents. The plant has been monitored by Environmental Pollution Control and the factory authority has been asked to instal treatment plant and not to discharge the liquid and gaseous effluents directly into nearby stream and the surrounding atmosphere without further loss of time. Chattack Pulp and Paper Mill is discharging untreated effluents into the Surma river. The mill authority has been cautioned not to discharge their waste directly in the river water. In this regard in investigation was conducted and it was found that the industry is polluting the river water and it was agreed they would treat their effluent before discharging. It is expected that the mill authority will go forward for treatment plant. The insecticide industry at Tejgaon which is responsible for underground water pollution has been asked to remove the pollutants and not to discharge the untreated pollutants in future. Constant pumping out of water from dug well of insecticide factory is continuing. Dacca WASA has been asked to supervise the activities of the factory as the elimination of the pollutant from ground water is a time consuming and difficult job.

In this was industries that are polluting the water courses and environment have been identified and contacted for taking remedial measures by constructing effluent treatment plant and treating their harmful effluent before disposal in the river water. Further, new industries that are to be set up and seeking clearance from Environmental Pollution Control have been asked to construct treatment plant for their effluent.

ALTERNATIVE POLICY MEASURES

The environmental pollution, created by industrial wastes in Bangladesh, is a growing problem because of rapid industrialization which unless checked immediately will make things worser in this overpopulated country. For controlling the pollution of environment in Bangladesh, a high powered sixteen member interministerial Environmental Pollution Control Board has been set up to co-ordinate the various environmental activities. The function of Environmental Pollution Control Board is mainly policy making and supervisory. The executing authority of the policies of the Board is Environmental Pollution Control Cell. The activities of the Environmental Pollution Control Cell have been given Legislative support through environment Pollution Control Ordinance of 1977 (12). For carrying out his work to control Pollution of environment, the Director of Environment Pollution control, may, be order in writing "require any person or commercial or industrial undertaking to adopt such measures including construction, modification, extension or alteration of any disposal system, as may be specified therein for the prevention, control and abatement of existing or potential pollution of environment" (13). The Director is also empowered to know about the wastes, sewerage system or treatment works of any undertaking and can depute any officer to inspect and test any waste, air water, soil, plants, materials or disposal system and the officer should be provided with all possible help to perform his duties. It is felt that this law should be strictly enforced and further modified to include a) Any industry which is responsible for creating any sort of pollution should establish economical and scientific treatment plant immediately. b) No industry from henceforth should be established without treatment plant. Further project planning must ensure ancillary treatment facilities in any new undertaking. The comprehensive survey of industries undertaken by Government should be completed immediately to assess present position and to make future policies. The existing network for monitoring pollution caused by effluents be expanded over a wider area and the frequency of monitoring be increased.

The present laboratory facilities be improved and the proposed establishment of 4 laboratories in all the divisional headquarters of the country to carry out survey and investigations in respect surface and ground water be established immediately. Moreover the proposed mobile laboratory (both air and water)be established immediately. The data bank which can help in many ways in abating and curtailing pollution and encouraging research for improving pollution control technology may be made operational immediately with continuous feedback system. Ways and means should be divised to put waste products into best possible economic case.

Finally if any industry is found to violate the provisions of the existing ordinance or modified ordinance as suggested earlier, in other words, to induce the firm to adopt pollution control measures to the point where the discharge is reduced to efficient level, tax may be imposed so that social welfare remains intact and environment remains much clear (14). If all these measures are adopted, it is hoped that treatment and disposal of industrial waste in Bangladesh will have an effective solution in the near future.

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Session 7

Chairman : Mr V Varadarajan
Engineering Director, M.M.W.S.S.B.

Discussion

J N Ramaswamy and N Sathiyakumar

Briquette making eases solid waste disposal

1. Mr RAMASWAMY discussed the problems and current practices of solid waste disposal, and described experiments carried out on solid waste from Madras. Combustible items were compacted, dried, and then used as a fuel, and the calorific value determined. This would seem to provide a way of removing solid waste and supplying a fuel.

2. Mr PANNIRSELVAM asked if the samples were representative of Madras area.

3. Mr RAMASWAMY replied that it was only representative of certain areas; there was poor salvage of items from richer areas.

4. Mr NOBRE VILLA wondered about the need for a binding agent.

5. Mr RAMASWAMY answered that it may be satisfactory without one, but it was preferable to bind the constituents together.

S Daivamani, S Anandapadmanabhan and S Sundaramoorthy

Cattle waste problems in Madras metropolitan sewerage system - a practical solution

6. Mr DAIVAMANI described the problems which were being caused in the Madras sewerage system due to blockage by cow dung, causing backing up and overflowing of sewage. To alleviate the problems, a three compartment chamber was installed between the cattle shed drains and the main sewer. Over a three month period, the system had worked well and without blockage, providing that the chamber was cleaned every seven days.

T Damodara Rao and P Venkatachalam

Methane production from distillery wastes in anaerobic charcoal filters

7. Mr DAMODARA RAO explained the nature of distillery waste products, and described the experiments carried out using upflow and downflow charcoal filters. Gas production rates were compared, and design criteria for the filters presented.

8. Mr RAJAGOPALAN was surprised by the large quantity of gas produced.

9. Mr RAMAN asked if there was any influence due to pH; whether chokage occurred; and observed that there was little time for gas evolution.

10. Mr DAMODARA RAO replied that pH had a considerable effect, but that there had been no chokage problems.

11. Dr SHUKLA asked whether plain or activated charcoal had been used; he pointed out that if the phenol number was below 12, the carbon was activated.

12. Mr DAMODARA RAO thought that the charcoal could be considered to be 'slightly activated'.

H S Mehta and A N Patel

Remote sensing with special reference to pollution

13. Dr PATEL described the use of remote sensing using Landsat, and presented transmittance characteristics to show how pollution from a paper mill would be identified.

14. Mr HUTTON commented that Landsat could only produce an image of the same place once in 18 days; it was thus unlikely to be of much practical use in pollution monitoring.

N Choudhary, N P Shukla, R Amin and R P Qalandar

Study of water pollution in river Jhelum

15. Dr CHOUDHARY presented an analysis of the water quality characteristics of the Jhelum river, including pH, temperature, carbonates, bicarbonates, total alkalinity, total acidity, carbon dioxide, dissolved oxygen, BOD, chlorides, total solids and dissolved solids.

16. Dr COTTON asked whether the author felt that BOD was a relevant parameter, when compared with faecal coliform numbers, in assessing river pollution.

17. Dr CHAUDHARY felt that BOD was important, as were faecal coliforms, which had not been evaluated in this study.

18. Mr RICHARDS asked whether a nitrogen balance had been carried out.

19. Dr CHAUDHARY replied that it had not been done.

S M H Bukhary

Policies for treatment and disposal of industrial wastes

20. Mr BUKHARY described a number of industries in Bangladesh which contributed significantly to industrial waste pollution, including paper mills, tanneries, and fertilizer factories. Proposals for controlling the problem were discussed, and the Environmental Pollution Control Ordinance of 1977 was outlined.

21. Mr RICHARDS commented that although the Ordinance allowed right of entry to inspectors, it may be very difficult to enforce in practice.

22. Mr VARADARAJAN, commenting on the papers presented in this session, thought that these types of study would only bear fruit when translated into action to serve the population. We must realize that however skilfull at drafting and policy making we may be, it is the actual implementation which is difficult and most important, and involves the successful co-ordination of all involved parties.

Closing Session

1. Mr DURAIRAJAN introduced the session by praising the standard of the papers presented, and thanking Dr PITCHAI and the organisers for putting on the seminar.

2. Mr PICKFORD and Dr PITCHAI proposed the following recommendations from the conference:

3. On the whole, the technology required to achieve the objectives of the International Drinking Water Supply and Sanitation Decade is available, but there are some data gaps which need to be filled.

4. To a large extent the people who live in rural areas, small towns, squatter areas and city slums are not sufficiently aware of the need for safe water supplies and proper sanitation. There is therefore an urgent requirement for greater interaction between technologists and those involved in community development and health education.

5. The total waste management programme should be evaluated with a view to making recommendations regarding energy and nutrient conservation.

6. To achieve the objectives of the Decade, attention should be given to quantifying material requirements so that there can be an adequate flow of the right materials to the right places at the right times.

7. Training of all levels from village pump caretakers to the most senior engineers and managers should be expanded.

8. Technological cooperation between all countries and regions should be expanded by interchange of personnel and greater flow of technical information to all levels.