[Various Papers on Egypt for the Fayoum project]

Cairo, Egypt, UNICEF

1991 -

[Various Papers on Egypt for the Fayoum project]

Cairo, Egypt, UNICEF

1991 -

Contents:

LOW COST TECHNOLOGIES FOR RURAL DRINKING WATER SUPPLY

ENGINEER M. ZAKI, ENGINEER Y. SEOUD
WATER SUPPLY SECTION - UNICEF EGYPT
8 ADNAN OMAR SIDKY, DOKKI

ABSTRACT

Drinking water, supplemented by proper environmental sanitation has become a crucial element in the overall process of human development. From the health point of view, lack access to these services causes high percent of infant mortality rates.

UNICEF Egypt country Office (ECO) has become actively involved in drinking water and environmental sanitation projects for that reason.

In 1982, as a result of observations during field trips, survey of existing water schemes with different technologies, and discussions with local officials, the following conclusions were reached:

- Some of the water supply technologies introduced to the region were not successful.

- The small size communities (hamlets, satellites) which have a population in figures of hundreds are difficult, if not impossible, to be served by types of technologies implemented.

- The groundwater in the region are generally saved for drinking.

Accordingly, the decision was to use the groundwater as a safe source for drinking. Two types of low cost technologies were adopted:

* The Small Scale Water System (SSS).
* The Deep Hand Pumps.

Both interventions have technically several advantages and include number of innovations in their designs. The paper, hereafter, discusses in details these points.

INTRODUCTION

Diarrhoeal diseases are the greatest single cause of death among children of Egypt. Many studies indicate that breast feeding, measles immunization, personal and domestic hygiene and the increased use of clean drinking water are the most effective actions to prevent diarrhea.

The scarcity of safe drinking water in many rural areas of Upper Egypt, particularly in remote satellite villages, causes also high incidence of other water-related diseases. In the absence of safe drinking water sources, the communities have to rely on the use of contaminated water sources.

According to official CAPMAS statistics (1987), only 45% of the households in rural Upper Egypt have access to safe drinking water which is far beyond the expected standards. These reasons altogether had furnished a good ground for UNICEF to intervene in this sector.

UNICEF ASSISTED WATER & SANITATION PROGRAMME

UNICEF Water and Sanitation assisted programme of Upper Egypt came as a result of numerous field trips to the remoted areas of Upper Egypt; technical surveys of the existing schemes; discussions with local officials, technicians, and villagers. While developing the Water and Sanitation programme, the characteristics of the existing technologies were highly considered.

Accordingly, UNICEF joined forces with the Organization of Reconstruction and Development of Egyptian Villages (ORDEV) to implement a programme for Water and Sanitation to serve some selected areas along the four governorates of Upper Egypt, namely Assiut, Sohag, Qena and Aswan.

The two main components of this programme regarding the water supply are:

a. The Small Scale Water System (SSS).
b. The Deep Well Hand Pumps

In the following discussion, the main features of each technology is being highlighted with focus on the new innovations tested and the low cost aspect.

The Small Scale Water System (SSS)

The Small Scale Water Systems are intended for rural communities of a population ranging from 3000 up to 10000 inhabitants.

a. **Selection of the Small Scale Water Systems**

The selection of the SSS in UNICEF Assisted Water Supply Programme for Upper Egypt, comes as a result of a screening of technical solutions used in old existing water schemes. It was found that large existing water supply schemes are expensive, are technically over complicated and suffer from numerous malfunctions, subject to necessity of maintenance. Furthermore, the initial capital cost of the large water schemes was usually very high, running into several millions of pounds in some instances.

In addition, the selection of the SSS was based on the fact that the underground water is the cheapest source of drinking water is available in almost all areas in the region of the Nile Valley, and the reserves available are replenished by the Nile directly or indirectly.

Use of the underground water as a source of drinking water is not a new concept in Egypt, but the innovations and modifications introduced to the traditional designs have made this source more reliable, efficient and less costly.

b. Technical Description of the SSS

The SSS consists of five main components:

1. A productive water well drilled and properly equipped with necessary lengths of casings, screens and gravel pack. Such a water well is thereafter a permanent source of safe drinking water. The new element in the design is to use the P.V.C. casing/screens which resists rust/corrosion to a great extent. The operational life of the wells in this case are much longer than the traditional wells with iron casings.

2. A submersible electric pump installed in the water well. By this pump, water is being pumped from the well to the elevated water tower. The advantage of having this type of pumps is to eliminate totally all needed civil works for housing the pumps/engines. This in its turn cuts the capital costs greatly and consequently minimize the area of land required for the water system.

3. An elevated water storage tank, wherefrom water flows by means of gravitation through a distribution network to the taps of the standposts conveniently located throughout the village. The presence of the elevated tanks in these systems are essential because of two reasons:
   1. To keep the systems functioning during the times of electric cut-offs.
   2. To keep the distribution network always under pressure from inside, particularly during night time. This prevents contamination to occur from the outside the pipes in case of leakages.

   The tank material was chosen to be coated iron (inside/outside). This choice again, cuts the capital costs greatly compared with the concrete tanks.

4. A network of distribution pipes leading to a number of standpipes. This distribution network consists basically of galvanized pipes and in some cases P.V.C. diam. 4" and 2" properly connected and laid down. The average length per SSS is 2000ms of pipelines of both diameters. In many cases the length of the distribution network was significantly different from the average length. This is due to the size and the shape of the selected village.

5. Public standposts are made of a concrete platform equipped with surface channel for the proper drainage of waster water. The tap used is a new type of self-closing tap, which ensures minimum wastage.

c. Delegation of Responsibilities

At the very beginning, it was clear that the serious involvement of the local authorities in the process of planning, funding implementation as well as maintenance and operation is a vital necessity to assure the success of the programme. Accordingly, a joint workplan was prepared and the delegation of responsibilities were listed as follows:

UNICEF to supply all the materials needed for the implementation, this includes the supply of casings and screens for the water well, electrical submersible pump, water tank, galvanized pipes for the distribution network and related fittings.

ORDEV to provide the needed funds for well drilling, submersible pump installation and construction of the distribution network. ORDEV was in charge of follow-up on the implementation and coordination with other local authorities, mainly the Housing Directorates at the concerned governorates.

d. Cost Breakdown of SSS

The following represents the cost of a SSS. (The calculations are based on the average quantities and the US$ exchange rate of December 1989).

d.1 Cost of productive well	
Casings and screens	$1440
Drilling	$3000
Sub-total	$4500
d.2 Cost of Submersible Pump	
Pump price	$4500
Pump installation	$ 650
Sub-total	$5150
d.3 Water tank 25 cu.m (Turnkey)	$9500
d.4 Distribution network	
Pipes	$8000
Installation	$4400
Sub-total	$12400
d.5 Equipment clearance & transport	$4700
d.6 Connections to electric supply	$9000
d.7 Value of project land	$3000
Grand Total	$48,200

* The rate of exchange applied is $ = L.E.2.3

Deep Well Hand Pumps (India Mark II)

The deep well hand pumps were introduced to Egypt for the first time through the water supply programme of UNICEF in Upper Egypt. These pumps are in wide use in many Asian and African countries and proved to be suitable for supplying potable water for small communities in the range of 1000 inhabitants and less.

a. Selection of the Deep Well Hand Pumps

It is well known that the traditional hand pumps (Karga or Al Habashia) are widely used all over Egypt. Unfortunately, these pumps are tapping the water of the subsurface aquifer which is highly polluted due to its contact with many sources of contamination.

A study supported by the World Bank recommended twelve types of hand pumps to be used for small communities. The India Mark II is one of these recommended pumps. The selection of this pump is based on the following facts:

- It has the capacity to lift water from a depth up to 60 mts.
- It does not require preparation before pumping water.
- It is durable and needs minimal maintenance
- The Upper part is closed to prevent contamination from surrounding sources.

b. Technical Description of the Deep Well Hand Pumps

- Water well of 35 to 45 mts. depth where the water bearing layers are located. This water well is equipped with P.V.C.casings and double wall screens to assure long life time for the well and safe performance for the pump. The diameter of the casings is 6".

- The pump is consisting of two main parts. The first is allocated at ground level and includes the handle, pump head, the spout and the pedestal. The second part, which is the pumping cylinder has to be installed inside the water well at a depth up to 40 mts. These two main parts are connected to each other by connecting rods of 1/2" and raising main pipe of 1 1/2".

- The water is being lifted by moving the handle, which is connected to the pumping by the connecting rods, up and down. Accordingly, the pumping cylinder pumps the water up to the spout through the raising main pipe.

c. Cost Breakdown of a Deep Well Hand Pump Installation

India Mark II well hand pumps are produced in different countries. It was observed that the prices fluctuate significantly from one supplier to another. Meanwhile the local expenses are more or less constant for the last 3-4 years. The cost breakdown made for the India Mark II hand pump installation considered the following:

- The price of the pump and its accessories is based on average price.
- The rate of exchange applied is $ = L.E.2.3
- Since this component is an experimental stage, UNICEF is financing the entire work.
- Maximum depth of the pump cylinder in the well is 40 mts. and the calculations are based on this maximum depth just to show the cost for the deepest pump installation.

In view of the above, the breakdown can be presented as follows:

c.1 Hand Pump India Mark II

- Pump head	$ 194
- Connecting rods	$ 30
- Raising main pipes	$ 60
- Cylinder	$ 66
Sub-total	$ 350

c.2 Water Well

- Casings and screens	$ 900
- Drilling	$1530
- Pump installation	$ 200
- Concrete foundation	$ 200
Sub-total	$ 2830
Grand total approximately	$3000

In order to assure a successful results from the Water and Sanitation Programme, UNICEF is supporting the following additional activities:

- To ensure a sustainable programme componants, UNICEF is focusing during the planning/implementation stages to encourage local authorities and community members at village level to be involved directly in all project steps.
- A training courses for O & M of both technologies are implemented and considered in the future. Community members were trained in O & M for the Hand Pumps to handle this task directly. It is our hope to apply the same approach for the SSS.

- Number of evaluation and assessments were made or under planning to evaluate the whole experience, to spot the weak points that needed to be emphasised in future plans, and to document the gained experiences for the local authorities and different donors to consider a wider replication of these technologies.

For more information about these technologies and UNICEF WES Programme please contact UNICEF Office.

PERFORMANCE EVALUATION AND OPERATIONAL MODIFICATION OF THE UNICEF UPWARD FLOW WATER FILTER

Vinay Pratap Singh and Malay Chaudhuri

Department of Civil Engineering, Indian Institute of Technology
Kanpur 208016, Uttar Pradesh, India

ABSTRACT

Performance of a sand-charcoal-sand upward flow water filter (the UNICEF filter), promoted by the UNICEF Eastern Africa Regional Office for household use in rural areas, was evaluated using a laboratory test filter of similar specification and the Lower Ganga Canal water (turbidity 12-48 NTU, heterotrophic plate count 100-500 CFU/mL and fecal coliforms 50-320 MPN/100 mL). Effluent characteristics (turbidity 1.5-3.0 NTU, heterotrophic plate count 10-50 CFU/mL and fecal coliforms 10-20 MPN/100 mL) indicated moderately good performance of the filter; however, it was for a limited period following a long maturation period. Use of alum pretreated (2.5, 4.0 and 6.0 mg/L) raw water as an operational modification to improve filter performance did not show much promise. The filter with a downflow polishing sand filter (60 cm deep) produced superior effluent (turbidity 0.5-1.5 NTU, heterotrophic plate count 10-40 CFU/mL and fecal coliforms below 10 MPN/100 mL). This operational modification appeared to be a feasible approach to improve the performance of the UNICEF filter for use as a household water treatment device in rural areas of developing countries.

KEYWORDS

Water filter; sand; charcoal; alum; turbidity; bacteria; heterotrophic plate count; fecal coliforms.

INTRODUCTION

Providing safe drinking water to the rural population of the developing world has been a challenging task. Consumption of unsafe water is known to be responsible for a large proportion of the disease burden in these regions (Esrey and Habicht, 1986; Briscoe, 1987; Grant, 1987). The International Drinking Water Supply and Sanitation Decade was launched by the United Nations in December 1980 with the goal "to provide all people with water of safe quality and adequate quantity and basic sanitary facilities by 1990." However, according to an estimate by the World Bank, the rural water supply coverage did not probably exceed 45 percent in 1990 (Rotival, 1991). It has become apparent that traditional water purification methods and simple household water purification devices would provide a major solution to the challenging task. A number of household water purification devices are available in the market; however, these are beyond the reach of the target population. A low-cost sand-charcoal-sand upward flow water filter (the UNICEF filter), suggested by Childers and Claasen (1987), is being promoted by the Technology Support Section of the UNICEF Eastern Africa Regional Office for household use in rural areas.

The present study was aimed at evaluating the performance of the UNICEF filter, using a laboratory test filter of similar specification, and suggesting possible operational modification to improve its performance.

THE UNICEF FILTER

The UNICEF filter (Figure 1) consists of two cement tanks, a 40-litre untreated (raw) water storage tank placed on the top of a 175 to 200-litre filter tank. The filter tank contains a layer of 25 to 30 cm of crushed charcoal (about 5 mm grain size) sandwiched between two 20 to 25 cm layers of fine sand and separated from the sand layers by thin cloth screens or sheets of fine gauze. Stones are placed around the inlet to prevent blockage, and a 5 cm layer of gravel is packed above the stone layer. The raw water from the storage tank enters the filter tank at its base through a 1.25 cm hose and pushes upwards through the filter bed. The clean filtered water (effluent) accumulates above the filter bed for collection via an outlet hose.

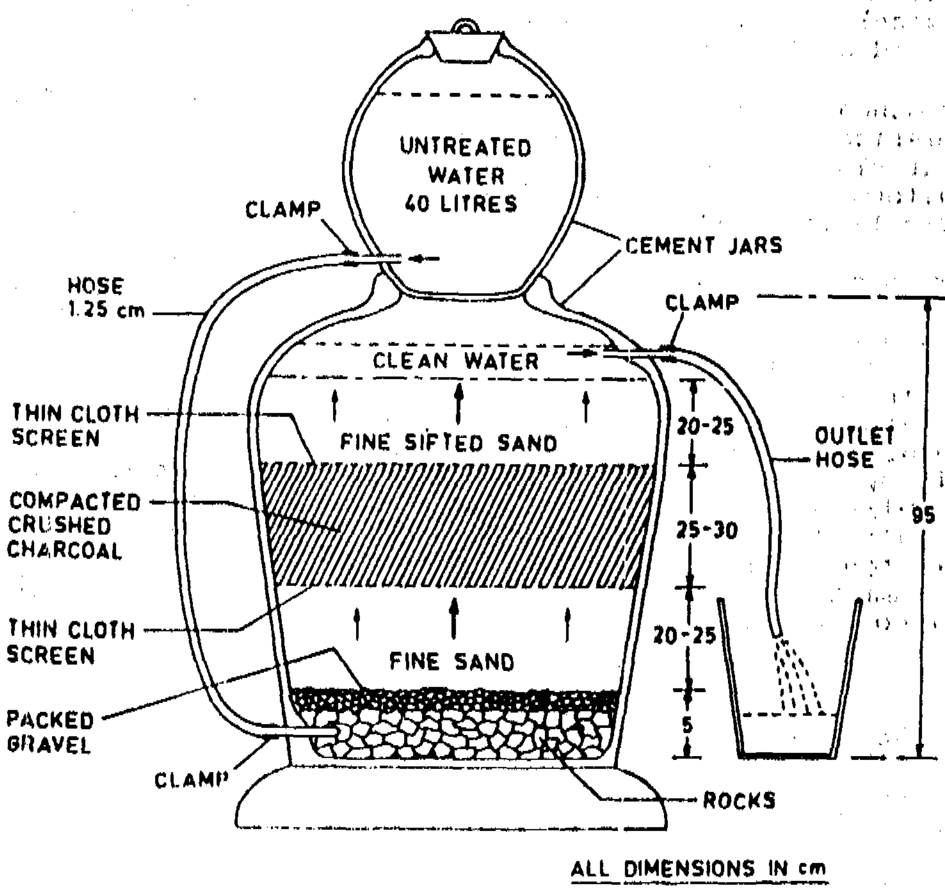


Fig. 1. The UNICEF upward flow water filter

To establish the filtering action of the filter bed, the same water is allowed to pass through the filter some ten to twenty times until the outlet water begins to clear. The raw water hose is then disconnected from the filter tank for a short time to allow the worst of the sediment to flow back out at the bottom. When this water no longer looks dirty, the hose is reconnected. The top 5 to 10 cm of the fine sifted sand layer is removed and replaced with clean sifted sand and water is passed through the filter several times to re-establish the filtering action. The filter is then ready for use. For maintenance of the filter, the top surface layer of sifted sand must be checked regularly to see whether the filter bed needs cleaning. When sediment shows, the top 5 to 10 cm must be removed and replaced with clean sifted sand. When changing the top layer of sand no longer has the effect of re-establishing good filtration, all the layers must be removed and replaced.

The filter is inexpensive to construct, simple to use and will provide the water requirement for a family or a group of about ten people. Depending on the quality of the raw water, it will operate up to one year before cleaning is required.

EXPERIMENTAL

The laboratory test filter consisted of a 100 cm long and 5 cm ID perspex tube with a rubber stopper at the base. A 5 mm hole was provided at the centre of the stopper to allow entry of raw water from a 10-litre storage bottle placed 95 cm above the base of the test filter. The filter bed was placed above a 5 cm layer of gravel (2 cm mean size) and mimicked that of the UNICEF filter (Figure 1) - 25 cm bottom sand layer (0.3-1.3 mm grain size), 25 cm crushed charcoal layer (5.0 mm grain size) and 25 cm top sifted sand layer (0.71 mm grain size).

The Lower Ganga Canal water was used as the raw water and its pertinent characteristics were pH 7.9-8.5, turbidity 12-48 NTU, heterotrophic plate count (pour plate method, 35°C/48 h, plate count agar) 100-500 CFU/mL and fecal coliforms (multiple tube method, lactose broth 35°C/24 h and brilliant green lactose bile broth 44.5°C/24 h) 50-320 MPN/100 mL.

Seven litres of water were filtered in each run to mimic the normal use pattern of a household water filter. The water was allowed to pass upward through the filter without any rate control and it usually took 3 to 4 hours for the water to be filtered. The filtered water (effluent) was collected through a port 90 cm above the base of the filter. Before initiating the first filter run, seven litres of raw water were passed through the filter ten times when the effluent became clear. The top 5 cm of the upper sand layer was removed and replaced with sand of same size and water was passed through the filter several times to re-establish the filtering action. Usually, one filter run was made per day and the filter bed was kept submerged between successive runs. Raw water and effluent samples were analysed for turbidity, heterotrophic plate count and fecal coliforms.

RESULTS AND DISCUSSION

Figure 2 shows the performance of the test filter in terms of raw water and effluent characteristics of thirty-three filter runs (231 litres throughput). Raw water and effluent samples corresponding to 1.0, 3.5 and 6.0 litres were collected in each run. Raw water samples at 3.5 litres were analysed for heterotrophic plate count and fecal coliforms and those at 1.0 and 6.0 litres for turbidity. Effluent samples at 1.0, 3.5 and 6.0 litres were analysed for heterotrophic plate count and tur-

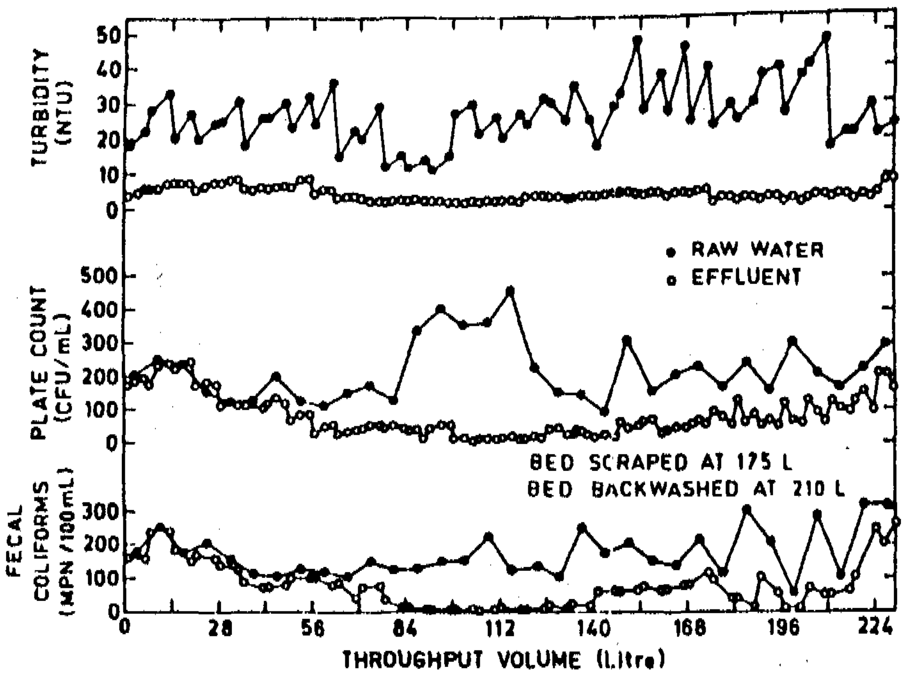


Fig. 2. Performance of the test filter

bidity, and those at 1.0 and 6.0 litres for fecal coliforms. First nine runs (63 litres throughput) were somewhat erratic in terms of turbidity and heterotrophic plate count after which both stabilised (physicochemical maturation). Fecal coliforms in effluent stabilised (microbiological maturation) after twelve runs (84 litres throughput). The best effluent characteristics (turbidity 1.5-3.0 NTU, heterotrophic plate count 10-50 CFU/mL and fecal coliforms 10-20 MPN/100 mL) were observed between the twelfth and eighteenth runs (84 to 126 litres throughput) after which the effluent quality gradually deteriorated. Following twenty-five filter runs (175 litres throughput), 5 cm of the top sand layer was scraped and replaced with clean sand of same size. Seven litres of raw water were passed through the filter bed five times to re-establish the filtering action. However, the effluent characteristics did not improve appreciably following scraping and after five runs(210 litres throughput), the filter bed was backwashed. Following backwashing, filter performance was as erratic as that of a new filter bed.

As a first step to improve filter performance through operational modification, the test filter was operated with alum pretreated raw water, using alum dosages in the range (2.5 to 6.0 mg/L) necessary for destabilisation of the raw water particulate matter as determined through standard jar test and zeta potential measurement. According to particle destabilisation and filtration theories, the destabilised particles would have a higher removal potential in the filter. In all filter runs with alum pretreated raw water, the water was dosed with alum, hand-stirred for 2 to 3 minutes, settled for 15 minutes and the supernatant was passed through the filter. Figure 3 shows the performance of the test filter with alum pretreated Lower Ganga Canal water - seven runs (49 litres throughput) with 2.5 mg/L alum followed by five runs (49 to 84 litres throughput) with 4.0 mg/L alum and seven runs (84 to 133 litres throughput) with 6.0 mg/L alum. Even though alum pretreatment with 6.0 mg/L alum showed improvement in effluent turbidity as well as heterotrophic plate count and fecal coliforms, the effluent characteristics in terms of heterotrophic plate count and fecal coliforms were not noticeably superior to those without alum pretreatment (Figure 2) and hence this operational modification was not considered beneficial.

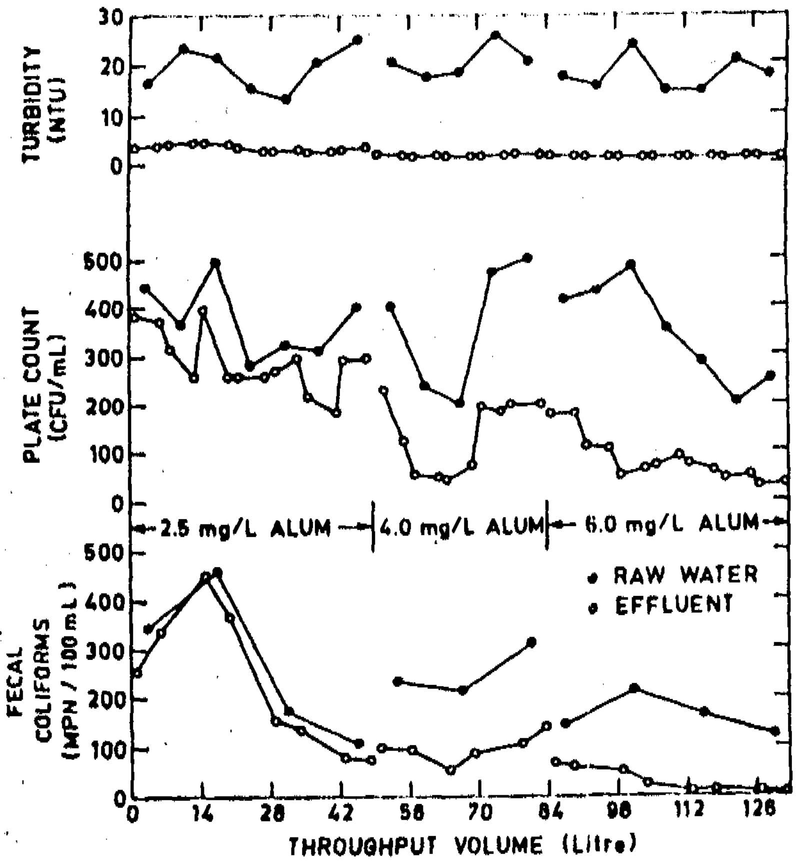


Fig. 3. Performance of the test filter with alum pretreated raw water

Based on the observations by Gregory et al. (1983) that up to 50 percent removal of bacteria and other microorganisms of fecal origin in tropical waters can be achieved by upflow filtration using lower filtration rates and fine media and that even if upflow filtration alone cannot adequately clarify water it might substantially relieve the load on slow sand and other filters, the test filter was operated with a downflow polishing sand filter as the second step to improve filter performance through operational modification. A 60 cm deep sand bed (0.15 - 0.45 mm grain size), similar to a slow sand filter, was used as the polishing filter. The effluent from the test filter was allowed to flow directly into the polishing filter and the final effluent was collected for analysis. According to the effluent characteristics of twenty-two filter runs (154 litres throughput) presented in Figure 4, performance of the test filter with the downflow polishing filter was commendable - turbidity 0.5-1.5 NTU, heterotrophic plate count 10-40 CFU/mL and fecal coliforms below 10 MPN/100 mL. This operational modification appeared to be a feasible approach to improve the performance of the UNICEF filter.

CONCLUDING REMARKS

The UNICEF sand-charcoal-sand upward flow water filter, with a downflow polishing sand filter of slow sand filter specification as an operational modification, is able to substantially improve the quality of tropical surface water and appears suitable for use as a household water treatment device in rural areas of developing countries. However, the filter should be tested in terms of its efficiency in removing enteric viruses and protozoan cysts.

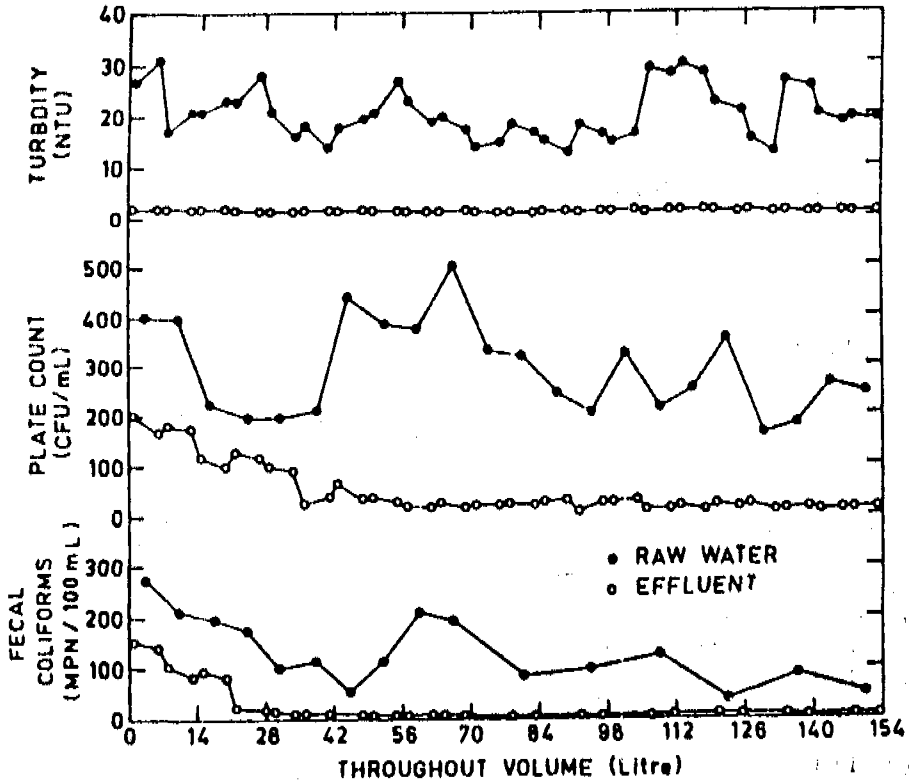


Fig. 4. Performance of the test filter with a downflow polishing sand filter

REFERENCES

Briscoe, J. (1987). A role for water supply and sanitation in the child survival revolution. PAHO Bulletin, 21, 93-105.

Childers, L. and Claasen, F. (1987). UNICEF's upward-flow water filter. Waterlines, 5, 29-31.

Esrey, S. A. and Habicht, J. P. (1986). Epidemiologic evidence for health benefits from improved water and sanitation in developing countries. Epidemiol. Rev., 8, 117-128.

Grant, J. P. (1987). The State of the World's Children. UNICEF, New York.

Gregory, R., Mann, H. T., and Zabel, T. F. (1983). The roles of upflow filtration and hydraulic flocculation in low-cost water technology. Wat. Supply, 1, 97-112.

Rotival, A. H. (1991). Beyond the decade: a framework for global co-operation. Wat. Sc. Tech., 23, 211-213.

THE MANAGEMENT COMPONENT OF THE KAFR EL SHEIKH WATER SUPPLY PROJECT

J. E. ROSE

Team Leader, Management Component,
KESCON J.V., 52 Mathaf El Manial Street,
PO Box 88, Manial, Cairo, Egypt

ABSTRACT

The Kafr El Sheikh Water Supply Project is a comprehensive endeavour to provide the physical and institutional resources for an effective and sustainable water supply system for 2 million persons in a developing rural Governorate in the Delta region of Egypt. The paper describes the aims of the Management Component, the institutional development of an integrated water supply and sewerage company and the main activities to-date. These include training, operational improvements, health education and finance development. Further support is required until all engineering and institutional development work has been completed.

KEYWORDS

Institutional development; management structure; training; operational improvements; finance; tariffs; sustainability.

INTRODUCTION

The Governorate of Kafr El Sheikh is located at the extreme north of the Delta region of Egypt and covers an area of 3,400 sq km (fig. 1), with a population approaching 2.0 million. The entire Governorate lies within the Delta plain, is only marginally above sea level, and is dissected by an extensive system of irrigation canals and drainage channels. In the northern part there are large tracts of sandy soil, which are currently being reclaimed for agricultural purposes, while the southern part is intensively cultivated.

Because the Governorate is bordered on the north by the Mediteranean Sea, groundwater is saline and 97% of potable water is produced at six surface water treatment plants, supplemented by local compact units, all abstracting water from irrigation canals. The concentration of the main production facilities in relatively large plants requires an intensive trunk mains and distribution network to supply customers throughout the Governorate. An integrated water supply system, as has developed in Kafr El Sheikh, is conducive to the adoption of an integrated water company covering the whole of the Governorate, as the basis of system management, rather than a multiplicity of organisations based on city and district councils.

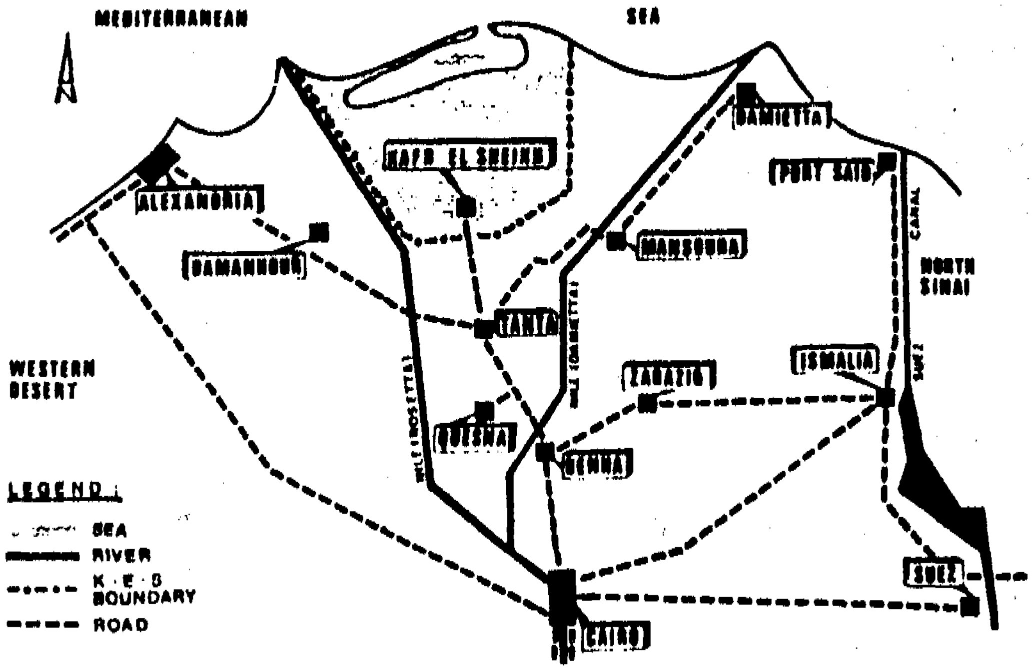


Fig. 1. Location plan

PROJECT AIMS

The overall aim of the Project is to provide, at least cost, an adequate supply of potable water to meet the demands of the Governorate. The Management Component is designed to develop the Company to be:

- operationally reliable and financially sound

- able to maintain the buildings, plant and equipment provided under the project

- self-financing in respect of recovery of operating and maintenance costs from charges

Under the Engineering Component, facilities for water production and distribution are being rehabilitated and developed to meet the needs of the Governorate to the year 2000. Also included are a headquarters' building, district maintenance centres and the supply of meters, tools, equipment and vehicles.

The Project, which is financed jointly by the Arab Republic of Egypt and the Federal Republic of Germany, is a comprehensive endeavor to provide both the physical and institutional resources for an effective water supply system. The current cost of the Project is LE 95 million and DM 105 million

DEVELOPMENT OF THE COMPANY

The Kafr El Sheikh Water Supply Company (KWC) was formed on 01 July 1983 by the amalgamation of local water undertakings within the Governorate, but it was not until 01 July 1988 that all water supply services came within its jurisdiction. On 03 December 1990, the Kafr El Sheikh Water Supply and Sewerage Company (KWSC) was established, to take over responsibility for the operation and maintenance of both water supply and sewerage services within the Governorate. During 1991 steps were taken to obtain the additional finance required for the sewerage service and transfer staff and assets from city and district councils. It is anticipated that the formal transfer date will be on 1 July 1992, at the start of the financial year. Since its inception, the Company has been responsible to the Governor for the effective operation and maintenance of services, while the National Organisation for Potable Water and Sanitary Drainage (NOPWASD) has been responsible for the development of major capital schemes. NOPWASD is also involved in the institutional development of the Company and with tariff increases.

WORK OF MANAGEMENT COMPONENT

Phase 1

Work commenced in January 1987 in accordance with the Terms of Reference and proposals made by the Consultant KESCON J.V. in their offer for Consultancy services of January 1983. These proposals included a review of the 1980 Binnie Taylor Report on Provincial Water Supplies and the preparation of 10 Interim Reports, dealing with the main aspects of the Company's future structure, management and financial affairs. This work was completed in January 1988.

Phase 2

Work commenced in February 1988 and to December 1991, nineteen Egyptian and European experts have worked and total of 210 man-months, on either a full-time or part-time basis, with all levels of the Company's staff. The main activities have covered institutional and financial development, training, operational improvements and health education

INSTITUTIONAL DEVELOPMENT

During Management Component, Phase 1 the overall management structure was determined as follows:

- a Headquarters comprising the Chairmans office, Technical and Finance/Administration departments
- Four decentralised Divisions for operation, maintenance and income collection

Subsequent organisation structures have followed this form. Locations of offices, principal works and other organisational features are given in Fig. 2.

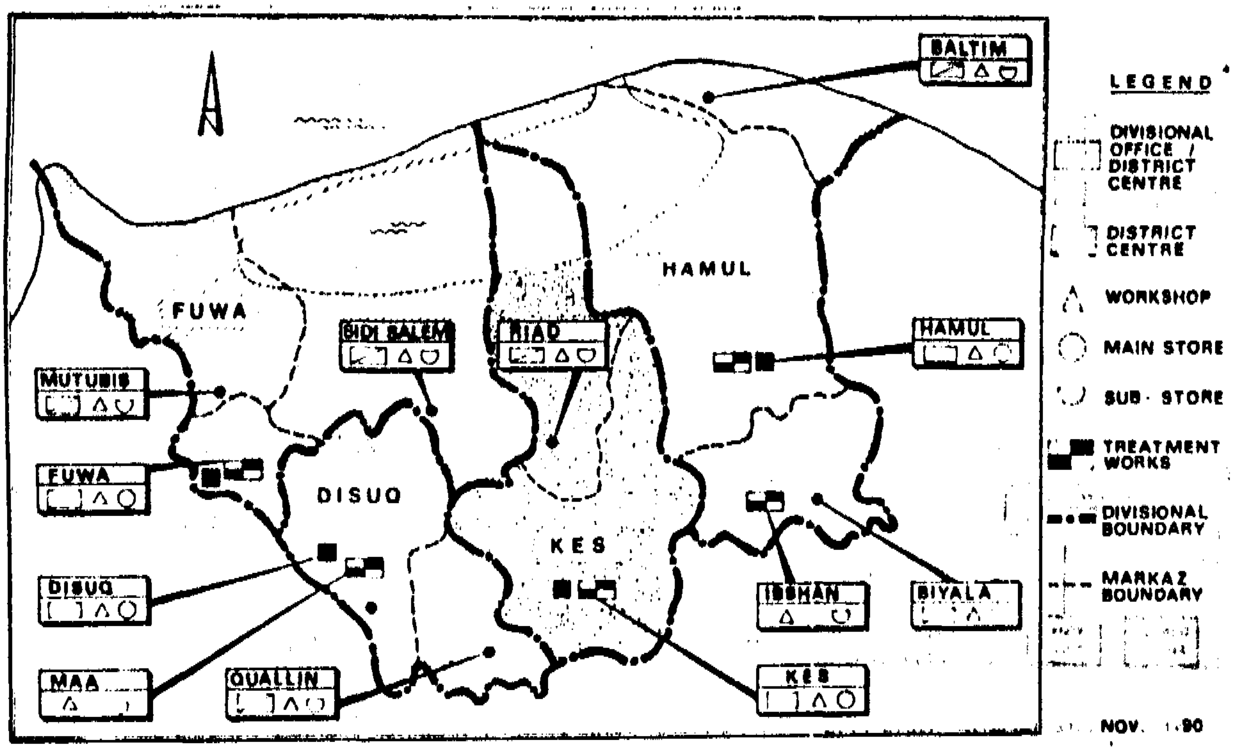


Fig. 2. Locations of offices and principal works.

KAFR EL SHEIKH WATER COMPANY

In December 1988, the senior/intermediate staff structure and accompanying job descriptions had been prepared covering 209 posts in the grades of Under Secretary - Class 1, Under Secretary, Director General and Grades 1, 2 and 3.

This was followed in December 1989 by the organisational structure and accompanying task schedules, covering 1116 front line posts in Grades 4, 5 and 6 employed in production, distribution, transport, stores, income and administration. The numbers of posts took account of organisation and methods studies, previously undertaken and described later in this paper.

KAFR EL SHEIKH WATER AND SEWERAGE COMPANY

As a result of the decision to establish a company to be responsible for both the water supply and sewerage services, NOPWASD held local consultations and prepared a management structure for the enlarged company in September 1990 (Fig. 3).

This necessitated job descriptions and task schedules for Headquarter's staff to be revised. However, Divisional structures have remained largely unaltered (Fig. 4).

Placement of existing staff against available posts has been made by a staff placement committee appointed by the Company's Chairman and supported by KESCON. The organisation structure for sewerage operations will be prepared after staff and assets have been transferred in July 1992 and requirements assessed.

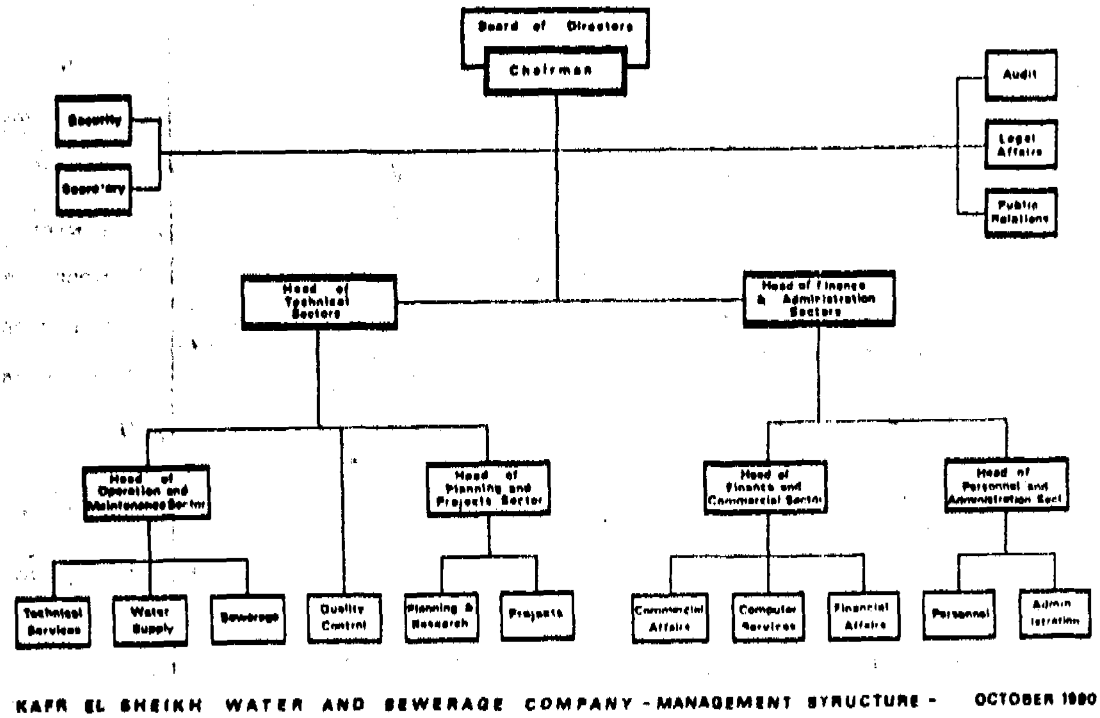


Fig. 3. KWSC headquarter's management structure

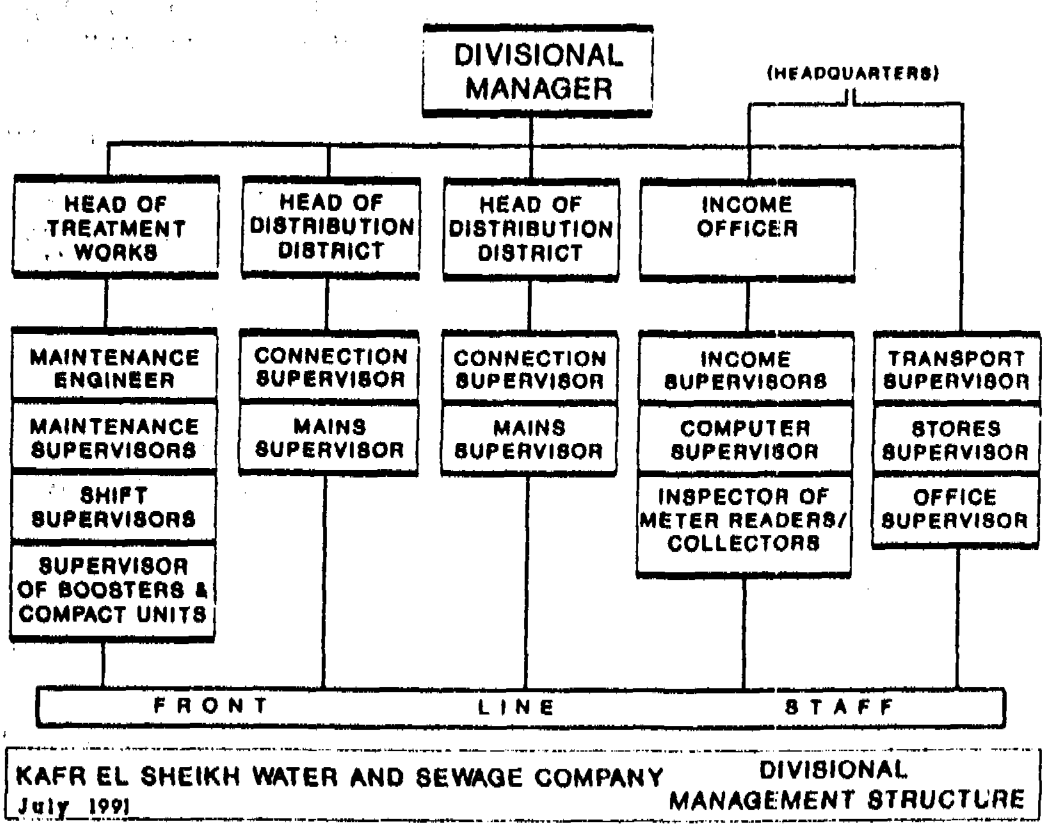


Fig. 4. Divisional management structure

TRAINING

In early 1988, the technical training programme at Embaba Water Works of the Greater Cairo Water Supply Organisation, was nearing completion and a senior engineer from this programme joined KESCON's team to develop a technical training programme for engineers of KWSC. By selecting this group of staff for training, two immediate objectives of Management Component Phase 2 were achieved, namely:

- early impact on key staff
- improvement in operation of treatment works.

The courses covered task analysis, maintenance, water quality and treatment processes, pumping, electrical systems and instrumentation.

Training commenced in October 1988 and was completed in September 1990. The overall number of trainees was 74, of which 63 received certificates on successful completion of the programme.

Other courses have been designed to cater for all levels of staff, from the Chairman to ordinary workers, and have included:

- management training for top management in Cairo
- management development training for senior and intermediate managers by visiting university professors
- training of trainers courses at NOPWASD's Damanhur Training Centre.
- distribution operation and leakage control for engineers and supervisors
- water treatment for plant operators

OPERATIONAL IMPROVEMENTS

Six organisation and methods studies have been completed. These were designed to study existing methods of working and to recommend improved methods and numbers of staff required. The studies have covered distribution work, meter reading and income collection, production and maintenance staffing, transportation, stores and computer operations.

Protective mechanical and electrical maintenance schedules have been prepared for the six operational treatment works by trainees during the technical training programme. These have not been implemented satisfactorily at most works.

Twenty four hour flow and pressure measurements have been made of sourceworks' outputs and bulk transfers at the Governorate boundary. The estimate of total water produced is 250,000 cu m/day.

Practical improvements have been made to the operation of water treatment processes at the four main treatment works.

Regular reports have been prepared for the management of KWSC on bacteriological sampling and testing, distribution work and the condition of treatment works.

HEALTH EDUCATION

Recommendations have been made for a pilot health education programme in two villages. These are heavily polluted, with household sewage tanks discharging into adjacent open drains and water supplies that are continuous but at low pressure. These current conditions will provide a base line from which to measure changes in hygiene behavior with adequate water supply and sanitation. The villages have been surveyed and levelled and estimates made for installation of sewerage systems. Initial implementation meetings have been held, together with negotiations for funding.

FINANCE

Development of the Company's financial systems has proceeded without interruption since 1988 for two important reasons:

- the overiding necessity to increase income

- these systems are independent of progress on the construction contracts.

KESCON's current programme includes development of the meter income, payroll/personnel and stores systems, while future work includes purchasing, contracts and tendering procedures and the central accountancy system.

Tariffs

Since 1988 KWSC has been advised to adopt a programme of tariff increases that will comply with the terms of the Loan, Financing and Project Agreement, which requires the Company to recover its operation and maintenance costs by the end of 1992. The following basic domestic tariff increases have been approved by the Minister of Reconstruction:

EFFECTIVE DATE	FINANCIAL YEAR	TARIFF (LE/cu m)
1 January 1988	1987/88	0.045
	1988/89	0.06
	1989/90	0.065
	1990/91	0.075
1 January 1991	1990/91	0.09
	1991/92	0.10
1 November 1991	1991/91	0.15

It has been calculated that in 1991, the required charge to recover operation and maintenance costs, is LE 0.21/cu m. Recommendations have also been made to reduce the quantity of water supplied at the basic rate from 30 - 15 cu m per month. This has not yet been accepted.

Meter Income System

Development of the income system has been given high priority throughout the project. Following a study of the existing methods of meter reading, computation, billing, collection and recording, a pilot scheme covering 12,000 customers in Disuq city was installed using 286 personal computers. Work commenced in September 1988 and the trial was operational in May 1990.

Currently work is in progress to extend the system to all four Divisional income centres to cover the 168,000 customers within the Governorate. Each centre will be provided with a 386-33 main computer with 3/4 terminals and 2 printers. System operation is entirely in Arabic and has been designed to allow for expansion to cover metering of illegal connections, additional customers following improved water supplies, and population growth.

Payroll and Personnel System

This system is based on a single personal computer and is designed to calculate the monthly salaries and additional payments for all staff and to maintain updated personal records. The system is currently undergoing trials.

Stores Accountancy System

This system will undertake all stores control calculations and provide information on stock levels, re-order quantities and pricing. Software is currently being developed to meet the Company's requirements. There are at present 4,600 stock items and it has been necessary to prepare a new stores index and revise all commodity codes.

THE FUTURE

It is anticipated that the Management Component will continue to give institutional support to KWSC for at least a further two or three years, until all engineering work has been completed and is fully operational. In particular, the completion of the new headquarters' building and district maintenance centres are essential for the proper conduct of the Company"s affairs. Further training is required in the use of tools and equipment, supplied under the project for the maintenance of plant and the distribution network.

Special emphasis will also be given to leakage control training, in order to maintain the improved condition of the distribution network after rehabilitation. Further work is also planned on purchasing and contract procedures and the central accountancy system.

ACKNOWLEDGEMENTS

The author thanks Eng. Mahmoud Abd El Halim, Chairman of NOPWASD for permission to publish this paper and acknowledges the support received from Eng. Abdullah Nahas, Chairman of KWSC, members of the Company's staff and his colleagues in KESCON's management team.

SOFT APPROACHES TO MAINTENANCE MANAGEMENT OF COMMUNITY HANDPUMP WATER SUPPLY IN RURAL AREAS - EXPERIENCE OF INDIA

Dr. J.C. Srivastava

Ex-Scientist & Joint Advisor, CSIR and Ex-Consultant (S&T), Ministry of Rural Development, National Drinking Water Mission, Government of India (R-1 Green Park Extension, New Delhi 110016, India)

ABSTRACT

The paper presents development of concepts, thoughts and approaches to 'participatory management' of the deepwell handpump (India Mark II and VLOM Mark III) based drinking water supply in rural areas of India for cost-effectiveness, sustainability, cost sharing and effective use of safe water for health for all.

KEYWORDS

Handpump rural water supply; Maintenance system, breakdown analysis; Harnessing solutions; Community management; Cost-sharing.

INTRODUCTION

Drinking water is the basic need not only from the point of view of the basic human consumption, but also as a tremendous tool for socio-economic change. Development of India Mark II deepwell handpump in

India brought a boom to community water supply in rural areas. It emerged as one of the few technological improvements and innovations which repay as a long-term health benefits. Being socially acceptable, women and children friendly, reliable for uninterrupted water supply even from deeper aquifers, dependant on muscle power and a cost-effective system, this spot-source water supply occupies nearly 85 per cent of country's rural water supply programme, perhaps largest in the world. Close to 2 million handpumps (Hps) have been installed so far (1991-92) covering a population of nearly 500 million. The annual rate of installation is 0.2 million Hps covering nearly 25 million population in 50,000 villages. The role played by UNICEF in the development of the technology, its standardisation and manufacturing; drilling capabilities and water-well drilling; handpump installations and maintenance; and sociological models is of special significance and has been strength to the programme.

While a significant achievement has been made in 'coverage' (atleast one assured spot-source in each village) during the Decade (1980-1990), it was increasingly felt that unless these community Hps function regularly, faith of the users in this system cannot be created. The challange, therefore, was of sustainability of Hp based rural water supply services (RWSS) to the community, its effective management and decentralised maintenance.

MAINTENANCE SYSTEM

In India, RWSS is the responsibility of state government and the implementing agency for this programme is the state Public Health Engineering setup (PHED). For maintenance, a two tier system is generally followed by most of the states. This consists of a mobile team located at the Block (a rural development sub-division of the district, consisting of nearly 100 villages). The mobile team is expected to cover 500 Hps for regular monitoring and breakdown maintenance. At the village-level, Hp caretakers (local volunteers, generally male) are identified to look-after preventive maintenance and paid an honorarium of Rs.250 (US $ 10) per Hp/year. Inspite of this arrangement, the breakdown rate of Hps continued to be an anxiety of the implementers.

Experiments in Village Level Maintenance

A decentralised maintenance system was conceived (through idenfication and training of local mechanic) by a social voluntary agency in Tilonia, and a bilateral agency (under the project SWACH) in Udaipur of Rajasthan state and by DANIDA in Orissa. Under this system, after receiving 3 months training, the trainees are posted as 'barefoot mechanic' to maintain 30-40 Hps within a radius of 5 Km of their village (place of stay). In Udaipur, two women mechanics work together. In another experiment in Palghat (Kerala state), the mechanics are identified by the community itself ('panchayat') and made responsible for both installation and maintenance of Hps. Here also two mechanics work together. The Kerala Water Supply Authority of the government provides free training and tools, but spares are charged at cost price. The 'panchayats' (community institution at the village level) also choose Hp caretakers (one for each Hp) generally the volunteer women of the same village and pay honorarium. U.P. Jal Nigam also experimented this system in Lakhimpur Khiri (UP) where also community women caretakers were engaged. These caretakers are responsible for preventive maintenance including keeping the surroundings of Hp installation clean. These agencies, claimed that by adopting the village level maintenance system, the reparation cost was reduced from Rs.750 (US $ 30) of the 2 tier system to Rs.250 (US $ 10) per Hp/year.

Breakdown Analysis of Hps

Because of continued problem of breakdown of Hps, a study was undertaken jointly by the National Drinking Water Mission (Ministry of Rural Development, Government of India) and UNICEF, New Delhi (1988-89). This study found that 'efficiency of even the popular 2 tier system have gone down due to pressure of increasing number of Hps on mobile team which correspondingly had unmatched capacity and resources. 'It was noted that 20 per cent of India Mark II Hps were always non-functional in a year'. (Nilanjana Mukherjee Dr., 1990, People, Water and Sanitation - What they know, believe, and do in rural India, Ministry of Rural Development, National Drinking Water Mission, Government of India publication).

Cause of breakdown of Hps were noted as under:

1. being freely used by every body, the Hp is subjected to all sort of handling, mishandling and even misuse;
2. pressure on handpumps due to increase in population resulting in higher pumping rate;
3. users consider the community Hps a government property and responsibility;
4. low profile of maintenance services including lack of availability and timely availability of required resources and inputs;
5. adopting shortcuts in source development;
6. siting of Hps with negative approachability (particularly by womenfolk) or its installation in low lying location prone to flooding during rainy months;
7. inadequate training of maintenance personnel and absence of career structure for them;
8. corrosive effect of groundwater;
9. over exploitation of groundwater in the surroundings (for irrigation) resulting in deterioration of water yield in Hp and also tending frantic strokes to handpumps (applied to lift water which is not there). Users take it a mechanical failure; and
10. lack of involvement of community in decentralised maintenance management and related training and health and environmental sanitation education and awareness programme.

HARNESSING SOLUTIONS

While above causes of breakdown are self-explanatory, following thoughts emerged as possible solutions:

Installation Norms: Reduction of pressure on Hps by revising the present installation norms from 250 persons per Hp to 150 persons. Here itmaybeadded that as per government policy, Hps are installed on priority basis in small habitations, scattered and segregated hamlets generally inhabited by weaker sections of society and having population even less than 100.

Other suggestion in this regard came for revising the installation norms on persons per functional Hp as this might bring pressure on increasing levels of timely repair by mobile team;

Minimising Wastage: In a study conducted in the state of Tamil Nadu, it was revealed that atleast 2 litres of water spills over from each vessel in each time of filling. Thus nearly 3000-5000 litres of safe and potable water is wasted from each Hp every day. Can this wastage be minimised?

The linked issue in new installation in densely populated villages will depend on availability at a women compatible location including disposal of waste water.

Sanitary Wells: The study (op.cit) also noted that despite widespread coverage through Hp RWSS, open dug-wells continue to be preferred (for convenience, behaviour and tradition) as primary source of drinking water by 40 per cent of community women. Their preference also related to soft water for quick cooking and resultant saving of fuel. Nearly 25 per cent of all those who draw water from Hps do not use for drinking and 32 per cent never cook with it. Hence, these traditional sources should also be converted into sanitary wells, maintained for sanitary use and prevented from contamination.

Rainwater Harvesting: In areas with good rainfall, roof-catchment system for rainwater harvesting be introduced to supplement domestic water needs. Similarly, the traditional water harvesting structures in arid zones ('Tankas' as in Rajasthan) should also be improved structurally and in terms of sanitary storage of rainy water, and maintenance of water quality. In India, structural Engineering Research Centre (SERC) and Central Arid Zone Research Institute (CAZRI) have developed these technologies and undertake training and demonstration programmes.

Two Tier System: The 2 tier system should be optimised and the mobile team made accountable to the community. Social mobilisation and training of local volunteer caretakers should also be their responsibility. Such a team should involve the community all through implementation development, operation and maintenance.

Human Resources Development: Competence should be created among the engineers in the application of modern S&T and software for source development including groundwater exploration involving remote sensing, geophysical survey, geological mapping and geomorphological studies. This should also involve studies for seasonal variation and movement of water table during summer months and application of mathematical modelling to further evaluate the location of groundwater hydrology within the boundry conditions of watershed to assure the feasibility and continuous groundwater round the year in the spot-source. National Geophysical Research Institute, India (NGRI) has developed the competence and imparting training to engineers and professionals.

Engineers, NGO/Voluntary agencies and school teachers should also be trained and actively involvedin environmental sanitation, and related awareness generation programmes.

Management information system (MIS): This helps in minimising risks, monitoring and improving maintenance inputs, quality of services required/provided, and performance of equipment and expenditure. This also includes rig monitoring system. Computer compatible modules should, therefore, be introduced and strictly followed. The National Industrial Development Corporation (NIDC), New Delhi have developed the required competence and provide consultancy and training in MIS

Village Level Operation and Maintenance Handpumps (VLOM)

The following two designs of VLOM Hps have also been developed in India (1988-90):

India Mark III: It is a revised version of India Mark II deepwell handpump. It has decentralised maintainability almost to 90 per cent against Mark II. This VLOM Hp has enhanced the scope of community management at village level and even extended its scope to involve community women.

India Mark IV: It is an improved technology for low water-table lift suitable as family owned asset as well as installation on shallow wells. India has also adopted design of 'Tara' Hp of Bangladesh. Trials with these Hps are in progress by UNICEF, New Delhi and the Central Mechanical Engineering Research Institute (CMERI), Durgapur (India). While this technology has an edge over other Hps, (in terms of cost and maintenance), its application is limited to certain geohydrological zones. Also the risk of groundwater contamination in such shallow spot-sources is more. Hence, these Hps require a close and continuous water quality monitoring and surveillance.

COMMUNITY MANAGEMENT

The Decade experience has brought into focus an urgent attention to sustainability of RWSS. The New Delhi Statement (Global Consultation on Safe Water 2000, September, 1990 New Delhi) notes 'the overall objective is achieving sustainable facilities which could be used effectively by the beneficiaries. Unless village community as a whole particularly community women are involved, the intended sustainability cannot be achieved'. Community management (full control and responsibility of the community over the RWSS of the village), therefore, emerged as a significant solution to the maintenance management problems.

In India, the government implementing agency (PHED) has a continuing role to play as an unseperable partner to RWSS. As per national policy, they are answerable and responsible for RWSS. In view of this situation, following thoughts emerged about 'Community Management':

* it should be within the comprehensions and assimilative capacity of the rural community (of the developing countries, particularly in case of India) and not stretched too far;

* it should have support of both implementing agency as well as the village community as a whole as a part of holistic approach;

* it should fitin the national policy (state governments policy in case of India);

* it should clearly define the role of implementers, community (proposed water and sanitation committee of panchayat), schools, primary health centres, women groups, social voluntary agencies/NGO, etc.

Participatory Management

In view of above thinking, 'participatory management' was conceived as a starting point till the 'community' itself takes over full management functions independently. These management functions have been described in Annexure. Here, three kinds of approaches were given trial by different agencies with varying merits and demerits.

Participatory management with community (Panchayats in India:) Under this, responsibilities are defined and shared. This was considered to be an ideal system, but it has yet to generate confidence and sense of belonging of the community to the asset and related environmental sanitation;

Participatory management with social voluntary agencies/NGOs: This is a system which covers twin objective of social mobilization (for community participation and management) and responsibility to provide required services. Such a system can be undertaken only where the voluntary agencies have roots; and

<u>Participatory management by giving maintenance contract to private contractors:</u> Here tenders are invited and contract given under an agreement and deposit of an earnest money by the contractor. It was, however, noted that contractors not only provided desired services, but also pressurised the community to pay for the job under the plea that their (contractors) bills are pending with the implementers and hence to regulate the supply of water urgently, community should pay or provide necessary financial advance. This system, therefore, breeded malpractices and bad name to managers of RWSS.

In all the above approaches, however, the overall responsibility of RWSS remained with the government implementing agency (PHED) as they were answerable to government, state assembly and the parliament.

<u>Implementer's Role</u>

The participatory management broadens the role of implementers in terms of consideration of human factors with a social goal and a shared outlook for the community from provider to promoter and facilitator. This also creats enabling environment for the community to practice management skills. This role of implementers would, however require their orientation in community dynamics, situational analysis; and techniques of communication, MIS, health education and environmental sanitation. Voluntary agencies/NGOs having roots in villages should be involved in awareness generation and social mobilisation for effective community participation. The cutting edge in participatory management were credibility of the implementing agency and the desired assurance of sustainability of services.

<u>Action - Research</u>

Due to diverse nature of socio-economic and cultural situation in villages including income and education levels (as in India) and emergence of above approaches, it would be advisable to undertake action-research to develop regional models. The output should spell out the minimum level of services, related standards, delivery services and resources required for sustainable maintenance; its cost; and role to be played by implementers, voluntary agencies and the community. The outcome of this could perhaps be a starting point for building bridges between implementers and the community and pave the way to community management.

Involvement of Community Women

Women in rural areas are the managers of domestic water supply so they are not only first to detect the breakdown of Hp, but also to suffer most from this. Global conciousness is therefore, building up for recognition of community women of developing countries as managers of RWSS. While this global anxiety has its own significance, involvement of community women required village community's own decision and sanction (as in India); creation of opportunities for women's active participation in RWSS; facilitating their capacity building and their organisation; and providing enabling environment for them to function as effective managers. National Drinking Water Mission of the Government of India, however, took little initiative in direct implementation of the 'community women management programme' and left the subject for experimentation wherever feasible. It was generally felt that viable model appropriate enough to be accomodated in government's policy for RWSS has yet to emerge. There was also the administrative sensitivity in terms of social and cultural limitations of the implementers (who are basically engineers, professionals and ofcourse men) in working with womenfolk even in participatory management system. Ghosh notes (G. Ghosh, Ex-Water Mission Director, India) 'one need not push the all women programme as their role cannot be stretched too far. The female mechanic/caretaker services where availablè/possible could be pooled in along side rest of village community (Panchayat) management through their identified mechanics and caretakers. Further, the involvement of women in rural areas is mainly dependent on cultural acceptability levels which are widely variant in different parts of India (Ghosh.G., Women and Handpumps - an Indian experience, UNDP/ADB Regional Seminar, Manila, 1989).

COST RECOVERY

This is yet another global anxiety and concern as a soultion to sustainability of RWSS in developing countries. It was conceived that only by cost realisation that a genuine participation and sense of ownership to the RWSS and its maintenance responsibility could be generated in the community. This thought, though valid, perhaps missed the roots of inter-relationship between level of services required/provided (based on competence, capability and resources of the implementing agency) and the willingness/capacity of the user community to pay. This also included provision of drinking water to community livestock (cattle) specially in drought prone and arid areas.

Parcipatory Cost-Sharing

In India, as per national policy towards societal services for meeting basic minimum needs, all cost of RWSS are met by the government. Accordingly, the government is committed to reach out all the 59.91 million villages with safe drinking water (nearly 5000 villages still to be covered by 1992 to be followed by covering partially covered villages). In addition, it aims at enhancing quantity of water supply (present norm being 40 lpcd for humans and 30 lpcd for cattle in arid zone) duly supplemented with water management and decentralised improvement of water quality of contaminated sources. In view of these objectives and the present management set-up and resources, the 'participatory cost-sharing was conceived as an appropriate approach.

This cost-sharing means participatory action in creating cost conciousness and awareness of benefits particularly in health/productivity; demystification of breakup of all costs of services and related standards, required, and definition of affordable share to be borne by the community (either/or in cash, kind, services, donation, hospitality, etc.). This also meant definition of role of implementers, voluntary agencies, bilaterals, and the community. Here, the risk diffusion and absorption are inalienable components. Care should, therefore, be taken that those falling under the category of poor and below poverty line do not opt to remain out of it.

SUMMING UP

The National Drinking Water Mission, in a massive operation, of spot-source water supply reduced the number of villages without a source of safe drinking water from 161,722 to nearly 8000 in just 5 years India thus got a definite breakthrough in the form of Hp RWSS. It was, however, noted that participatory management of Hp RWSS and related cost-sharing is a human discipline and soft option intervoven into behaviour and will to change. This takes time to catch mind and ground. Action-research to develop regional models could facilitate this process of change and human development. This would also need intervention of communication system, software and human resources development including a continuing education and awareness generation programme. The development of thoughts, and approaches discussed here need to be clearly reflected in policy, administrative and financial decisions and in the proposed MIS and strictly followed.

The little achievement made by India's Water Mission should not be measured in numericals, far more interesting is the way the systems were innovated in the face of changing expectations and challanges and conceptualised with the cooperation of scientists, engineers, sociologists, managers, communication experts, policy maker/planners, bilateral agencies and ofcourse the industries producing the hardware. This is the strength of the programme. The aim of the Mission has been making best better of the implementing agency and the rural community in fulfilment of the basic minimum needs. Hence the Mission, innovated a programme which may not satisfy all, but provides atleast a minimum for most of the rural community and ensures a reasonable measure of equality. There could perhaps be many commonalities of experiences and more thoughts to solutions which need to be shared regionally and internationally among the developing countries.

EVALUATION OF HOUSEHOLD WATER FILTERS AS AN ALTERNATIVE FOR IMPROVING DRINKING WATER QUALITY FROM UNDERGROUND

N.Dous[1], S.G.Saad[2], L.M. Saad[3], M.Akel[4]

(1) Chemist, graduate student , High Institute of Public Health
(2,4) Prof. Sanitary Chemistry, High Institute of Public Health
(3) Assistant Prof. of Environmental Health, High Institute of Public Health
High Institute of Public Health, 165 El. Horreya Av. Alexandria, Egypt

ABSTRACT

Drinking water quality is facing several challenges, the intake of water may be underground or surface from the Nile river and/or its branches. Both sources are suffering from pollution introduced to them mainly from agriculture activities and wastewater disposal. Drinking water from underground sources is not treated before distribution to consumers, and the conventional treatment of surface water doesn't remove several pollutants from it. Thus, consumers try to produce pure water from their taps by using point-of-use house hold filters.

There are several types of these filter devices shown in the market, and available to consumers. Each device is advocated to have a special merits as for producing pure water free from odor, turbidity, chemical and biological contaminants.

Household tap filters are now common in use in Egypt. The types which are available varies from simple strainer to filters with disposable cartridges, which can be, active carbon or combination or primary filter and active carbon, or cellulosic fibers. All these types are advertised by the manufacturers to reduce turbidity, rust, some heavy metals, the bad taste and odors.

The aim of this research is to evaluate six of the most available types of filters in the local market using drinking water sources from underground sources in Assuit. The results showed the variable capabilities of the different filters as far as removing certain parasitic, algal and chemical constituents.

Bacterial contaminant was not removed but on the contrary it did flourish upon the prolonged use of most filters. odors were not efficiently removed with respect

to cellulosic fiber filter and regular strainers. Active carbon filters were the only successful type in odor removal to prolonged time, with special precautions during its use not mentioned int the technical bulletin accompanying the filter.

KEYWORDS

Point-of-use; filter; underground water; strainers; active carbon cartridge; Iron removal; Braun filter; Aqua-pure filter; Bacterial removal; Parasistic removal.

INTRODUCTION

Drinking water quality in rural as well as urban suburbs are facing severe challenges due to the escalating levels of pollution affecting both underground and surface water resources. Areas relying on underground water in the Delta and Upper Egypt as their drinking water source showed their main concern about its quality and started to use tap water filters as a technique to improve the drinking water palatability and potability. Proceedings published in "Water Quality International", 1988, on protection of soil and water aquifers against non-point source pollution indicated that, intensive use of fertilizers can introduce nitrates and heavy metals. Increasing levels of pesticides, herbicides and animal wastes also contributes to pollution of underground water. Pollution of aquifers by leaks from underground storage tanks and from sites of waste disposal is a common problem in several countries. Where a well or spring is known to derive water from the subsoil, the sources of pollution must not be in the vicinity, but the water of a "deep" well or spring may be polluted at a point several miles a distant. In fissured formations, whether of chalk, limestone or sandstone, the wells may yield water of unsatisfactory bacteriological quality from an undiscoverable source. Taylor (1949)

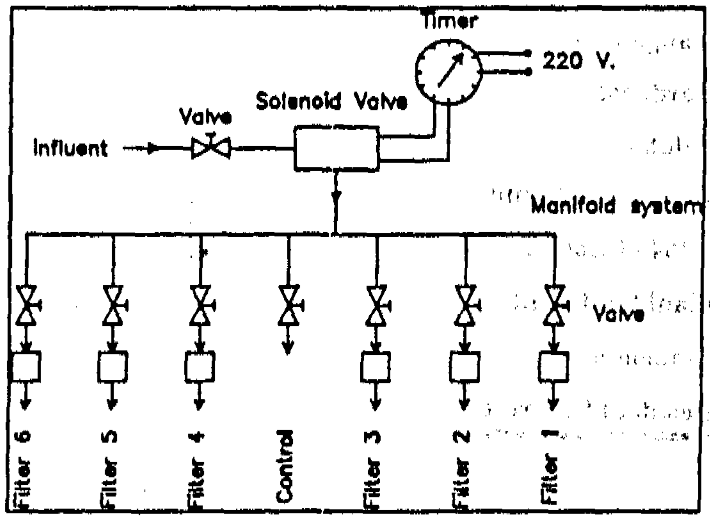
Tobin *et al* (1981) indicated that public awareness of the health implications of drinking water quality and the continuing demand for aesthetically pleasing water resulted in a rapid increase in the types and numbers of point-of-use treatment devices sold. Filters are available in the market based on different modes of action : exchange, reverse osmosis (basically to treat high salinity water), particulate filtration and active carbon adsorption (Martin and Shackleton, 1990). The great majority of the devices currently available in the local market utilize the principle of particulate filtration, active carbon or both in a single design. Regardless of the reasons for purchasing these units, consumers are buying and installing them at an increasing rate, with little or no guarantee of their efficiency for water quality improvement and no knowledge of the possible bacterial growth that may occur within the granular activated carbon cartridge or on the filtering media as supported by Taylor *et al* (1979).

MATERIALS & METHODS

Six different filters were purchased locally and installed in the laboratory on a manifold system using one source of water as shown in Fig(1)

A system of solenoid valve and a timer set to operate on a cycle of 3 min "ON" and 27 min "OFF" for 7 hours per day from 9:00 am to 16:00 pm was chosen to simulate the pattern of use in a household. The flow rate from every filter was adjusted at the beginning of the study using a manual valve ahead of each filter by means of a graduated cylinder and a stopwatch. The parameters and the methods used for carrying the different tests on water samples are shown in table (2). Parameters were measured according to the 15th edition of standard methods of water & wastewater analysis.

Figure (1) : Experimental setup of filters



The different characteristics and the initial flow rate from the six filter units tested, are shown in table (1).

Table (1) Characteristics of Tested Filters

Filter number	Initial flow rate	Characteristics of filter and filter cartridge
1	1L/min.	Disposable cartridge with active carbon core. BRAUN AF-1
2	1.2L/min.	Disposable cartridge AP-217 consisting of 3 sections, prefilter, active carbon core and strainer.(Aquapure)
3	0.5L/min.	Simple and small unit which consists of transparent plastic column filled with granular active carbon [GAC]. (BARAKA)
4	4L/min.	Disposable cartridge of bonded cellulosic fiber (string media) (ATLAS)
5	2L/min.	Small unit of ceramic material as a strainer with pore size up to 100 μm (Curi-pet)
6	2L/min.	Simple unit which acts as a strainer (Foam Type)

Table (2) Summary of Analytical Procedures

Parameter	Method
Turbidity	Nepheometry
Odor	Threshold odor number
Iron	Phenanthroline method
Manganese	Persulphate method
Hardness	Titrimetric with EDTA
Sulphate	Turbidimetry
Total Plate Count	Pour Plate technique using nutrient agar
MPN of Coliform	Multiple tube technique using McConkey broth
Plankton Count	S.R. Count cell
Ammonia	Direct Nesslerization
Residual Chlorine	O.T. method

Bacterial enumeration and identification using plates for standard plate count were incubated at 35°c for 96 hours to give optimum colony size and numbers as stated by Geldreich *et al* (1972)

The positive tubes in presumptive test of coliform bacteria were inoculated in E.C.media and incubated at 45.5°c for about 48 hours to identify the coliforms (faecal or non-faecal). Samples were taken twice a month for physical, chemical and biological analysis. The influent and filtered samples were taken at the same time to give a full picture of the influent and effluent water quality. Samples for bacteriological analysis were collected after about six "ON" cycles performance at the day of sampling to allow a suitable flushing from the filters (this sample represents the normal usage). The samples were collected in sterile 200 ml. flasks, containing 0.1 ml. of 10% (wt./vol.) sterile sodium thiosulfate to remove the residual chlorine effect if present as recommended by Tobin *et al* (1981).

A sample of one liter was collected and concentrated using 0.45 µm membrane filter for planktonic organisms examination and enumeration. The analysis of samples started immediately after sampling.

The flow rate from each filter was measured weekly to estimate the volume of water treated by the filter at the end of the study, as it varies by plugging of the filtering media during the course of use. Every month 10l. sample of influent and filtered water was concentrated for detection of parasites.

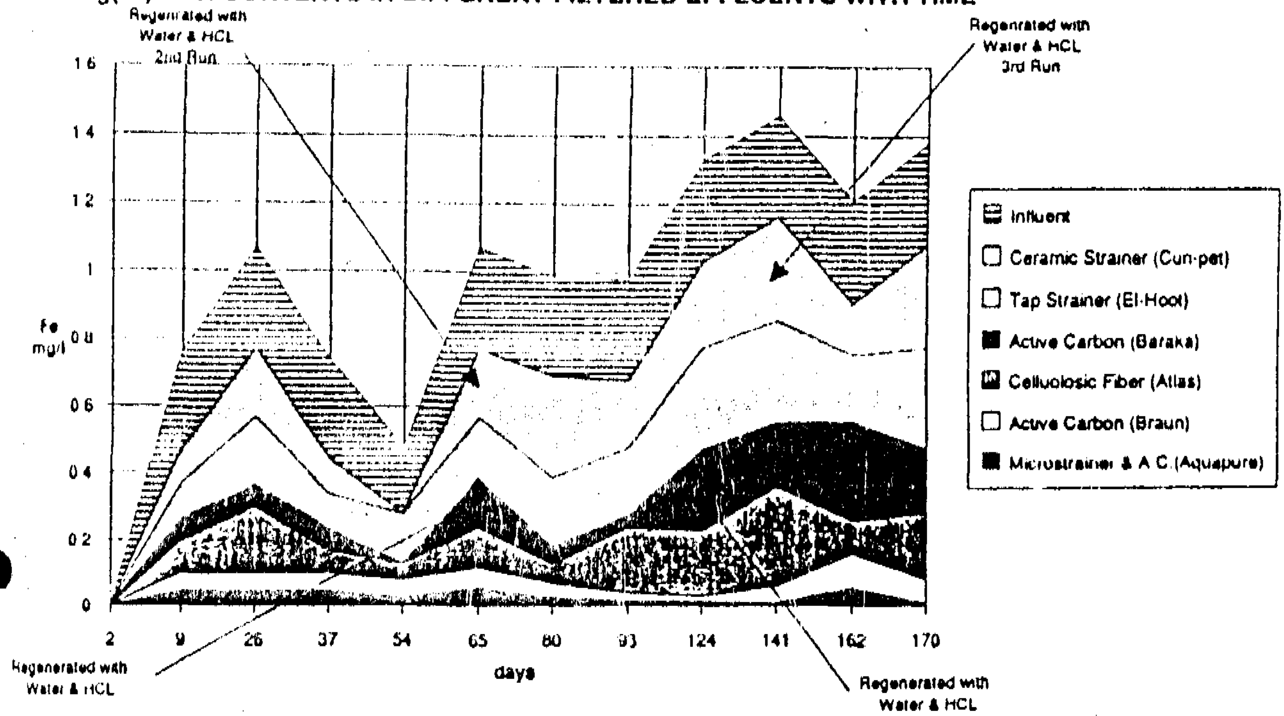
RESULTS

All tested filters did not affect the hardness, manganese, sulphate, ammonia and inorganics except iron which was influenced by the type of filter.

IRON REMOVAL

Changes in iron content through the period of the study from March to September 1991 in both the influent (Tap water) and the effluent from the various six filters are shown in Fig.(2). Filter (3) and filter (5) became completely clogged after 37 days of use. They were washed and installed again for a second use. Filter (3) was clogged again after 29 days and filter (5) was plugged after 60 days. They were both rewashed and installed to perform a 3rd run. Both filters were plugged, after 37 days and 30 days for filter (3) & (5) consecutively. The efficiency of iron removal dramatically decreased by the washed filters.

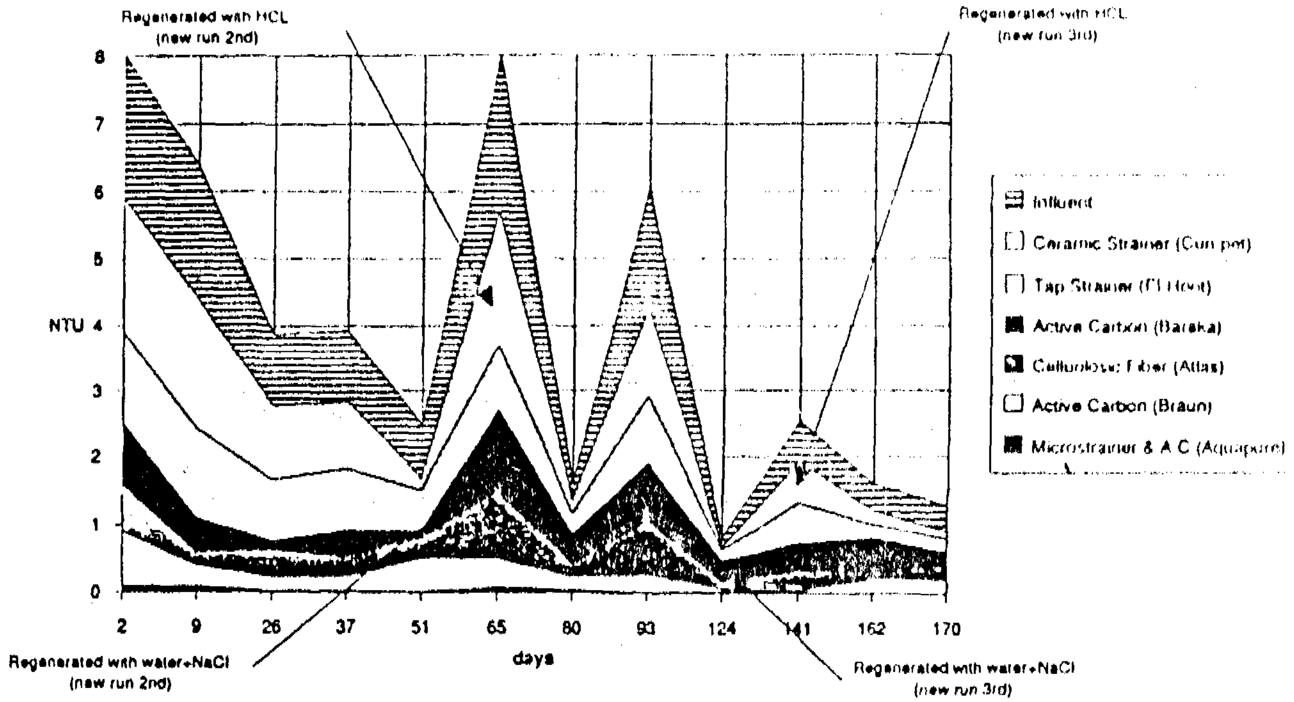
Fig(2)IRON CONTENTS IN DIFFERENT FILTERED EFFLUENTS WITH TIME



TURBIDITY REDUCTION

The turbidity of the effluent from each filter versus the turbidity of unfiltered tap water is shown in figure (3). It is clear that as the turbidity of influent water varies, the turbidity of the effluent from each filter varies accordingly, except filter (2) (Aquapure) which generally produced water with around zero turbidity and filter (5) (Curi-pet) which more or less did not affect the turbidity unless it became nearly plugged and minimum flow rate was produced. At the beginning of the second and third run of filter (3) after washing according to the manufacturer recommendations, the turbidity of the water was higher than the turbidity of the influent.

Fig(3)TURBIDITY CHANGES IN DIFFERENT FILTERED EFFLUENTS WITH TIME



BACTERIAL CHANGES

The results presented here are the Standard Plate Count (SPC) and MPN of Coliform bacteria after thoroughly flushing the tap and all the filters before sampling, this means that water stagnation effect in the filter is minimized.

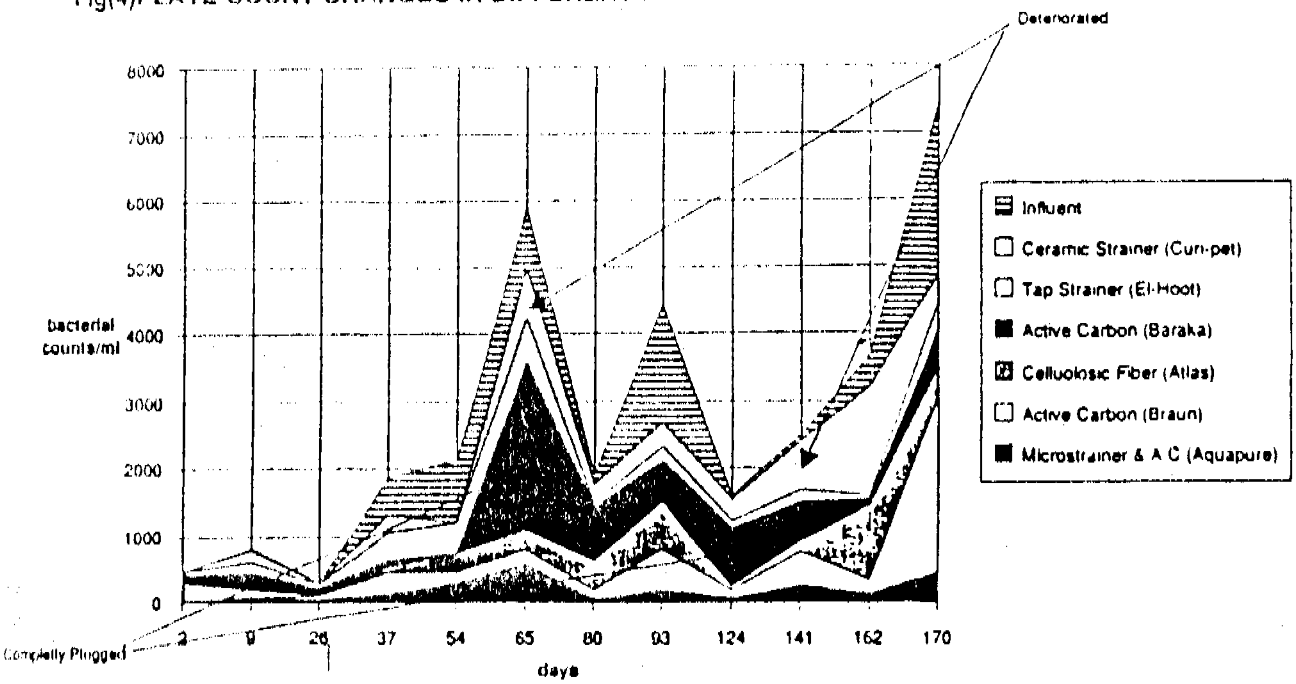
The plate count presented in logarithmic form for the effluent from each of the six filters versus influent is shown in Fig.(4).

It was observed that the first sample, all filters except #1 and #5 produced effluent with a greater bacterial count than those recorded in the influent. During the period of study there were fluctuations in the standard plate count (SPC) in terms of Cfu/ml. Filters effluents sometimes recorded higher values than the influents and no explanation could be given to this pattern.

Filters can act as a concentrator for coliform bacteria. As a result faecal coliforms may not be observed in the influent water analysis as their number is very small and can be missed in the initial bacterial testing. As their number increases in the filter they can surge with the effluent at a larger detectable number during the faecal coliform test. This pattern was noticed in the performance of filters #3,5 and 6 indicating the importance of the influent water bacterial quality on the performance of certain filters as shown in Fig(4).

The same behavior was also observed with respect to total coliform counts surging from filters #4,5,6 after 51 and 80 days of operation.

Fig(4)PLATE COUNT CHANGES IN DIFFERENT FILTERED EFFLUENTS WITH TIME



Planktonic Reduction

Ground water is normally free of phytoplankton and zooplankton and it is not expected to find these in either influent or filtered water. Though at four occasions phytoplankton and zooplanktonic micro-organisms were observed as shown in table (3). This concentration action by filter media in certain filters was basically dependant on their feed water quality. Thus all filters reduced the amount of these organisms by various percentages especially filter (2) which completely removed these organisms.

In one occasion, filter (3) increased the number of zooplankton higher than its number in the influent.

Table (3) Filters performance in removing Planktonic organisms

Occasion	Planktonic organism	Influent Count	Filter (1)		Filter (2)		Filter (3)		Filter (4)		Filter (5)		Filter (6)	
			Count	Removal percent	Count	Removal percent	Count	Removal percent	Count	Removal percent	Count	Removal percent	Count	Removal percent
1	phyto	[illegible]	[illegible]	[illegible]		100%	3,134	[illegible]	[illegible]	[illegible]	1,600	[illegible]	-	100%
17.8	zoo	-	-		-		-		-		-			
2	phyto	[illegible]	[illegible]	[illegible]	-	100%	-	100%	[illegible]	[illegible]	[illegible]	[illegible]	-	100%
24.4	zoo								.		.		.	
3	phyto	[illegible]		100%		100%	.	100%	7,111	[illegible]	[illegible]	[illegible]	4,444	[illegible]
10.4	zoo	[illegible]	.	100%	-	100%	-	100%	[illegible]	[illegible]	8,000	[illegible]	[illegible]	[illegible]
4	phyto	4,978	711	85.7%	-	100%	2,844	42.8%	1,422	71.4%	1,422	71.4%	1,422	71.4%
17.7	zoo	2,133		100%	.	100%	3,556	66.7%	2,133	0%	2,133	0%	711	66.7%

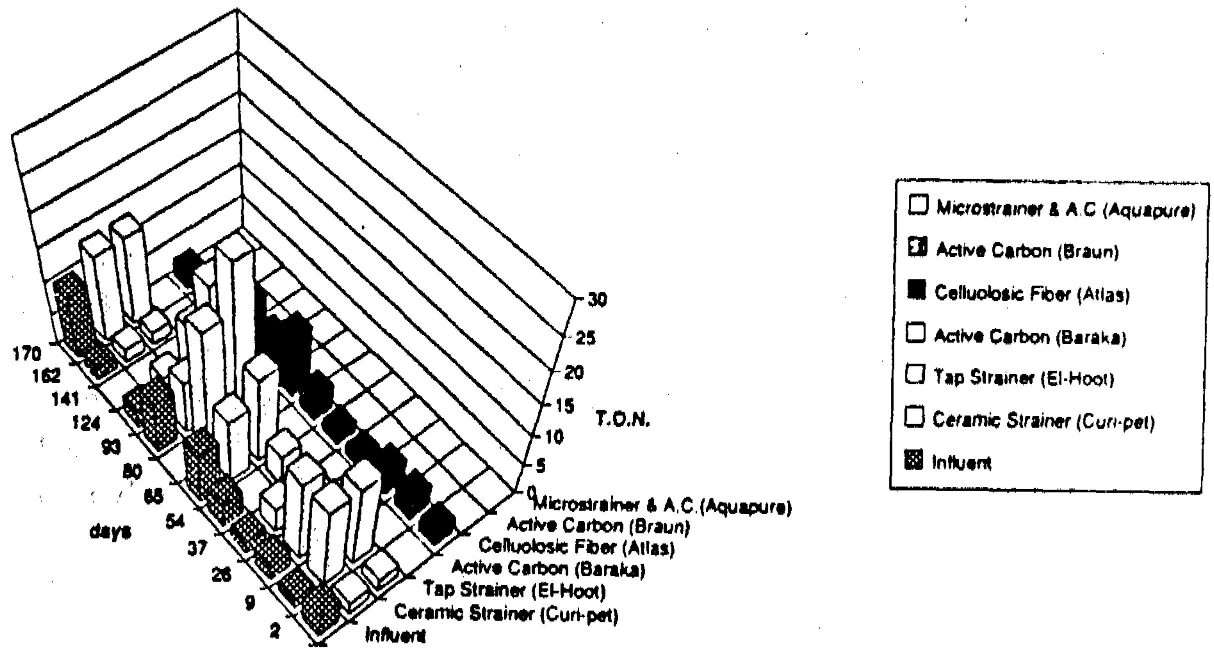
PARASITIC REMOVALS

In two occasions upon parasitic examination of the influent and filtered water samples, the influent contained cysts of Entamaeba histolylica, Entamaeba Coli, and Ascaris eggs, which filters #1,2 and 4 succeeded in removing, while filters #3,5 and 6 failed. The examination of the wash water of filter (5) after its first use showed E. histolylica, E. Coli, and Ascaris eggs.

ODOR REMOVAL BY FILTERS

The odor removal was very efficient as expected by active carbon filters. Other filters increased the odor in the filtered water specially after stagnation of water during the night Fig(5).

Fig(5)T.O.N. CHANGES IN DIFFERENT FILTERED EFFLUENTS WITH TIME



T.O.N. = Threshold Odor Number

DISCUSSION

The tested filters as available in the local market were of the particulate, active carbon or both, proved to be incapable of removing dissolved inorganic constituents present in the feed water.

As quoted by DeFillipi *et al*(1987) contamination of drinking water can be grouped into two major categories : organic and inorganic. The selection of an appropriate treatment technology depends on the contamination category. No available single treatment technology is capable of removing both types of contaminants.

Iron removal by different filters was basically due to its ellimination by enmeshment of the colloidal forms of iron present in the feed water. The soluble iron usually passes the filter media specially these having no active carbon where soluble iron can be adsorbed. In certain cases part of the colloidal iron was trapped as absorbed on the cellulosic filter media.

Removal of turbidity was synonymous to the removal of iron in case of filter #2 (Aquapure filter). The concentration of iron increased in the filters during their use as the influent water usually contain 0.27 mg/l of iron. This was supported by the high concentration of iron reaching 15.0, 12.5 and 7.0 mg/l in the hydrochloric acid wash of filter #5 after the first, second and third runs. This filter was plugged basically because of the high iron precipitation in addition to calcium, magnesium and sulphate salts present in the water forming scales on the filter media.

Turbidity reduction with new filters was generally lower than expected. As a residue of materials built up on the surface of the filter media, turbidity removal improved. This result agrees with the findings of Greve *et al*(1987). This buildup of filtered material also dramatically reduced the flow rates of the filters. Filters #3 & 5 became completely plugged after few weeks.

The performance of each of the six filters tested is illustrated in Fig(2). It is clear that filters (1) & (2) are more effective in turbidity reduction especially filter (2) which has a cartridge containing a microstrainer prefilter and active carbon core. The turbidity produced from filter (3) after washing was greater than the influent turbidity, this is due to the pressure of the influent which helped releasing and pushing out some particles which were previously deposited into the filter media.

All six filters after thoroughly flushing showed a fluctuation by time in the standard plate count (SPC) versus the influent. This result agrees with the results published by the EPA(1986) testing home adsorption units which showed moderate and variable effect of activated carbon units on bacterial levels of removals, however, no consistent pattern was demonstrated in these tests. Consecutive samples could produce filtered water with bacterial populations lower or higher than the control, non-filtered samples.

Bellen (1987) using GAC point-of-use filters found the pour plate count in the effluent after 2 minutes flush to be equivalent to that of the distribution system as present in few incidents.

Coliforms bacteria were present while it was undetectable in the effluent from filters (3), (4), (5) and (6). This indicates that colonization occur in these filters as supported by findings of Geldreich *et al* (1985) although it is undetectable in the influent.

For odor removal, the filters with activated carbon were the only devices successful in removing it, Frank *et al* (1984) stated that many of the units were tested beyond the manufacturer's claims, which in most cases were limited to improved taste or odor.

RECOMMENDATIONS

Household filters should be chosen based on their removal capacities and the type of pollutants needed to be removed. High salinity drinking or ground water should be analyzed carefully in order to know the influent water quality and proper point-of-use device can be chosen accordingly.

Point-of-use filters marketed in developing countries should be manufactured in a different format to suit the extra requirements mandated by the lower quality of influent water. In the brochure explaining the mode of use there should be a clear statement indicating the essentiality of letting the water flush. The filter ahead of its use for drinking in order to reduce the effect of bacterial excess growth during stagnation periods while the filters are not in use.

Proper chlorination or disinfection of the influent water will help drastically in improving the quality of the filtered water.

Active carbon filters proved to be successful in removing odor and taste as well as turbidity.

ACKNOWLEDGEMENT

Typography, computer charting & cover design by Arch/Mohamed H. Elwan

REFERENCES

Bellen G.;Anderson M. & R. Gottler, (1985), (1987), "Point-of-use Reduction of Volatile Halogenated Organics in Drinking Water"Final Rept. NSF, Ann Arbor, Mich. as quoted by Rozelle, Lee.T. in JAWWA vol.79, No.10

DeFillipi John A., and Joseph H. Baier, (1987) "Point-of-use and Point-of-entry Treatment on Long Island" JAWWA vol.79,No.10,76-81

Taylor E.W. , (1949), "The Examination of Springs and Wells Underground Waters", chapter VII, p.71 in the "Examination of Waters and Water Supplies", sixth edition published in London by J&A Churchil Ltd.

Environmental science and engineering Inc., (1986), "Additional Treatment Technologies for the removal of VOCs from Drinking Water"p.68 "Removal of Volatile Organic Chemicals from Potable Water", Noyes Data corporation U.S.A.

Frank B. Jr.;Donald P.L.; James S.K.; and L.C. Stephen, (1984), "Studies on home water treatment systems" JAWWA vol.76,No.4, p.126-130

Geldreich E.E.;Taylor R.H.; Blannon J.C. and D.J. Reasoner, (1985), "Bacterial Colonization of Point-of-use Water Treatment Devices" JAWWA vol.77,No.2,p.72-80

Geldreich E.E., Nash H.D., Reasoner D.J.; and R.H. Taylor, (1972) "The Necessity of Controlling Bacterial Populations in Potable Waters", Community water supply JAWWA 64:596-602

Greve D.F., and Randy L. Fultz, (1987), "Point-of-use Treatment for Turbidity Removal in a Muncipial System" Jour.AWWA,Vol.79, No.10,pp.46-52

Journal of Water Quality International, (1988), No.1, p.25

Martin R.J. and R.C. Shackleton, (1990), "Comparison of Two Partially Activated Carbon Fabrics For The Removal Of Chlorine And Other Impurities From Water" Wat.Res. vol.24, No.4, pp.477-484

Standard methods for the examination of Water and Wastewater, (1985), APHA, AWWA and WPCF, Washington D.C., 16th ed.

Taylor R.H., Allen M.J. and E.E. Geldreich, (1979), "Testing of Home Use carbon Filters" Jour. AWWA Vol.71, No.10

Tobin R.S.; Smith D.K.; and J.A. Lindsay, (1981) "Effects of Activated Carbon and Bacteriostatic filters on microbiological quality of drinking water". Applied and Environmental Microbiology, Vol41., No.3, p.646-651

THE DEVELOPMENT OF RURAL WATER SUPPLY IN THE PROVINCE OF FAYOUM, EGYPT

Abdel Rahman Abu Hamed* and A.M.H. Sannen**

*El Azab Water Works Fayoum, Egypt
**IWACO, Consultants for Water and Environment, P.O.Box 8520, 3009 AM Rotterdam, The Netherlands

ABSTRACT

The paper provides a case study of rural water supply in Fayoum. First, the present state-of-affairs is described and analyzed with respect to production, consumption and coverage. A water balance is drawn up and the projected trends up to the year 2000 are indicated. Nearly full coverage has been achieved already but still more than 50% of the population is served by public standposts. Considerable demand for house connections is apparent. Based on the present trend it is expected that by the year 2000, 75% of the population could be served by private connections, provided sufficient production capacity becomes available.

Secondly, the focus is on organization and finance with special attention to cost recovery. Estimates for present billing efficiency and the Unaccounted For Water (UFW) percentages are provided. With the perceived trend in the growth of house connections and decline of public taps there is ample potential to reduce UFW, provided an efficient billing and fee collection system is introduced and leakage is controlled. With the reduction of UFW by "technical" measures half of the cost recovery target can be achieved. The other half has to come from tariff increases.

Experience is drawn from the Netherlands supported Fayoum Drinking Water and Sanitation Project (FADWS) which started in 1990.

KEYWORDS

Rural water supply, Fayoum Egypt, production and demand, billing efficiency, Unaccounted For Water, future trends, development priorities

INTRODUCTION

In the past, Egypt has made it a priority to provide its population with basic services at a very low cost; this included the supply of clean and safe drinking water.

As a result of this policy rural Fayoum enjoys a relatively well established and rather developed regional water supply system, providing piped water of a fairly constant quality to a present population of about 1.5 million people. The service degree varies between house connections and public taps, between the central area of the Governorate and the fringes, between those receiving water from the central plant and those supplied by compact units, between inhabitants of main villages and hamlets, but still: piped water is accessible by nearly everybody.

This is to be considered an outstanding achievement for a developing country. Few countries with a similar level of development nowadays enjoy such a service level.

The other side of the coin however is, that the concept of "water for all" can only exist by virtue of extensive Government subsidies. User fees are to be paid by private connections only, while public standposts supply water free of charge. In Fayoum the consequence of this policy is that only about 25% of the operation and maintenance costs are recovered, hence 75% of the recurrent costs have to be subsidized from public financial means. Investments for extension and replacements are full Government responsibility.

In view of the required structural change in the public sector in general, the situation in the drinking water sector should also urgently change. This change will have to be brought about in the first place from the organization and management point of view. Water Authorities will gradually become Public Sector Companies, subsidies are expected to be cut and therefore water has to be sold instead of being simply provided in order to recover costs. To accomplish this, dramatic organizational transformation processes are required.

The extensive study carried out in Egypt ten years ago by Binnie & Tailor (1980) paid specific attention to the financial, organizational and management aspects of the drinking water sector, and laid down a concept and approach for the required transformation process. An integrated strategy of structural reforms including (limited) privatization, gradual tariff increase and institutional development was called for, but the subsequent development was rather slow. Much of the conclusions presented ten years ago are still valid today, as is also illustrated by this paper.

FAYOUM GOVERNORATE, A BRIEF DESCRIPTION

The governorate of Fayoum is of all the Egyptian governorates a relatively small region and comprises 3.2% of Egypt's population. It is an important area with regard to its natural and human resources. Fayoum is a fertile depression of 427,000 feddan, about 100 km southwest of Cairo, surrounded by desert (see figure 1). The altitude ranges from 25 m above sea level in the south and east sloping downwards to 44 m below sea level north-westwards to Lake Qarun.

The Fayoum oasis is watered from the Nile by the Bahr Youssef Canal, a remnant of the ancient link canal between Fayoum and the Nile. All water needs in the Governorate (irrigation and drinking water) are covered from this source. As for drinking water, the raw water from the canals is purified by a process involving sedimentation, filtration and chlorination. Groundwater, mainly being the result of excess irrigation water, is not used for either purpose because of its salinity. Deep artesian groundwater is not available. Excess water is discharged through drainage canals into either lake Qarun or into the Wadi Rayan lakes south-west of the Fayoum depression (since 1973).

In the 1986 census the population in Fayoum was established at 1,544,047. The compounded growth since the 1976 census, which estimated the population at 1,141,879, is 35.2% in ten years, or 3.07 % average per year. The average family size is 5.4.

Fayoum's population was 76.8% rural and 23.2% urban in 1986. Urban is defined as the capital and the district centres, while the other settlements are rural. The governorate is divided into five districts (Markaz). There are a total of 39 municipalities, 157 mother villages and around 1400 hamlets. Table 1 provides a summary of the 1986 population data, and based on the growth rate 1976-1986, a projection is made for the year 1990.

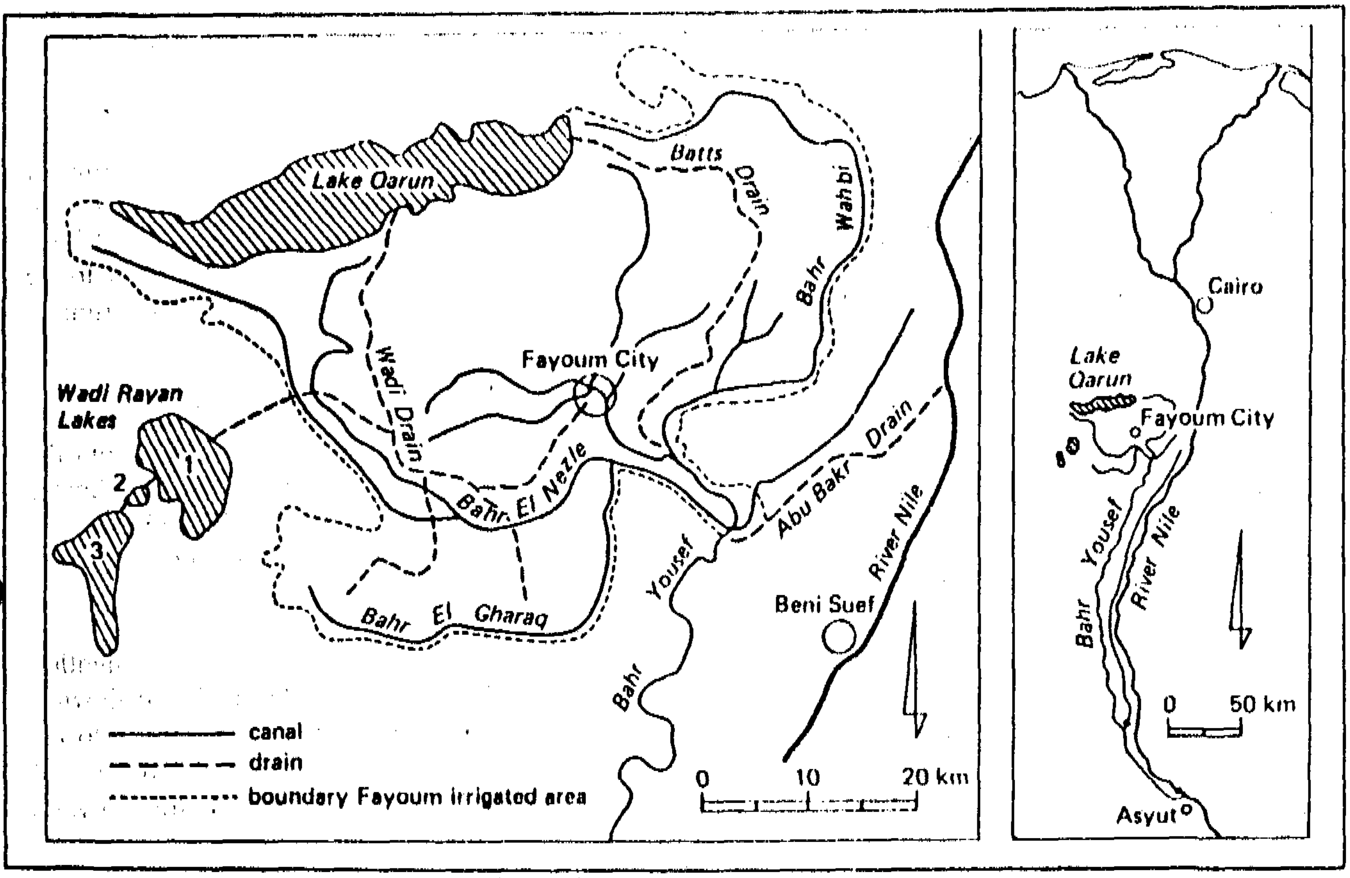


Figure 1. Fayoum Governorate

Rural water supply in the Governorate includes the entire population of the Governorate, but excluding Fayoum city. The population supplied amounts presently to about 1.5 million people.

DRINKING WATER SUPPLY IN FAYOUM

General

The responsibility for piped water supply in the Governorate belongs to two Water Authorities; Fayoum Municipality and El Azab Water Works (see table 2). The first manages drinking water supply in Fayoum city only (235,000 inhabitants); the second supplies the remainder of the Governorate (1.5 million population).

Drinking water in Fayoum basically means piped water. Groundwater is not suitable for human consumption. Washing clothes and dishes in canals is still widespread in the rural areas.

Water Production

The total production capacity of El Azab amounts to 2010 litres/second (see table 2). The actual production of the central plant is 1350 l/sec. The 17 compact units which are located scattered over the Governorate, are operated 16 hours per day at 25 l/s, during 11 months per year. From the actual production of 1605 l/s, about 1295 l/s has to cover the needs of rural Fayoum. Part of the Fayoum city demand (average 150 l/s), part of the demand of the adjacent Governorate of Beni Suef (100 l/s) and other Governmental demand (about 60 l/s) is also supplied from El Azab.

TABLE 1. Fayoum population 1986 and 1990 (projected)

Location	Population 1986	Average Annual Growth rate 1976-1986 (%)	Projection 1990
Fayoum city	212,523	2.47	234,930
Rural Fayoum	233,119	3.28	266,540
Total Markaz Fayoum	445.642	2.88	501,470
Ibshway city	34,430	2.67	38,485
Rural Ibshway	316,550	3.29	362,344
Total Ibshway Markaz	350,980	3.22	400,829
Itsa city	27,507	3.21	31,390
Rural Itsa	272,412	3.38	301,659
Total Itsa Markaz	299,919	3.36	333,049
Senoures city	55,323	2.77	61,550
Rural Senoures	205,366	3.01	232,055
Total Senoures Markaz	260,689	2.96	293,605
Tamiya city	28,930	4.04	34,261
Rural Tamiya	157,887	3.08	179,445
Total Tamiya Markaz	186,817	3.23	213,706
Urban total	358,713	2.80	400,616
Rural total	1,185,334	3.15	1,342,043
Grand total	1,544,047	3.07	1,742,659

Source: 1986 data, CAPMAS 1990

The total water production of El Azab in 1990 was estimated at 50.6 mln m^3/year. Of this quantity 40.8 mln m^3/year is available for the Governorate's population outside the capital. It should be noted that exact figures based on flow measurements are not available.

TABLE 2. Drinking water supply capacity in the Governorate of Fayoum

Location/type	Capacity (l/sec)	Production (l/sec)	Production (mm^3/year)
El Azab			
1 Central plant	1500	1350	42.6
17 Compact units	510	255	8.0
Total El Azab	2010	1605	50.6
Fayoum city	300	n.a	
1 Central plant	60	n.a	
2 compact units			
Under construction	300		

Source: El Azab (1990)/Fayoum city drinking water master plan (1986)

Population coverage

Since other drinking water supply alternatives not being available it can be stated that nearly 100% of the population should have access to the system in one way or another. The population is mainly served by house connections and public taps, as indicated in table 3. Total coverage is estimated at 97%.

TABLE 3. Water supply service connections in Fayoum Governorate

Location	House connections (HC)	Public taps (PT)
Fayoum city		
Municipal water supply	40,000	n.a.
El Azab	13,964	44
Urban connections	69,231	942
Rural connections		
Total El Azab	83,195	986
Av.users/connection	8	800
Coverage percentage	44.4 %	52.6 %

Source: El Azab, 1990

Notes:

a) The number of unregistered or illegal connections is not known. Shared use of HC's by more than one family is common.

b) The number of public taps reflects the registered ones only. El Azab estimates that there are around 2000 public taps in the Governorate, but this is not on record.

c) Coverage percentage is calculated with respect to 1.5 million population.

The average number of users per connection (8 for a HC and 800 for a PT) are estimates. Given an average family size of 5.4, it means that on average one HC serves 1.5 family, and one PT serves up to 150 families. These figures are comparable to other rural areas in Egypt.

Two other important categories of water use remain to be mentioned. These are non-domestic water use (industries, shops, mosques, clubs etc), and system losses. Non-domestic use is estimated at 10% of domestic consumption. System losses which include leakage and spillage are estimated at 30% of total production. Consequently a water balance can be drawn up as summarized in table 4.

Trends in water demand and production

The transformation in coverage over the last ten years has been substantial, as is shown in table 5. A strong increase in the availability of private connections is visable. If the trend continues it can be expected that towards the year 2000 around 75% of the population may have a private connection.

When more private connections become available, the number of users per connection will likely decrease. If in the year 2000 the average number of users for a HC is 7, there will be nearly 215,000 HC connected, which equals an increase of 132,000 connections in ten years from now. This perspective shows the potential of a substantial increase of revenues.

TABLE 4. Water balance El Azab 1990

Category	Rate	Volume in 1000 m³ per year
Production	1295 l/sec	40,800
Consumption		
House connections	60 lcd	14,454
Public taps	40 lcd	11,607
Total domestic		26,061
Non-domestic	10%	2,606
Total consumption		28,667
Estimated system loss	30%	12,133
GRAND TOTAL		40,800

Note: lcd means litres per capita per day. The figures of 60 and 40 lcd for HC's and PT's are based on Binnie & Tailor (1980) and El Azab estimates.

TABLE 5. Development of water supply coverage 1979-1990 (as % of total population)

Connection type	1979	1990	2000 (projected)
House connection	12	44.4	75
Public tap	81	52.6	25
TOTAL	93	97.0	100

Source: 1979 figures, Binnie & Tailor (1980); 1990 figures, El Azab

If it is assumed that per capita use of water from house connections moderately increases from 60 lcd to 70 lcd, per capita demand from public standposts remains constant at 40 lcd, non-domestic use remains at 10% and sytem losses are reduced to 20%, then the change in the water balance may be represented as in figure 2. Total demand is expected to increase by 22 mln m³/year, an increase which mainly originates from house connections.

To accommodate for the higher per capita consumption of water of an increased population, it is estimated that by the year 2000, water production capacity will have to increase by a minimum of 22 mln m³/year (700 l/sec). To allow for sufficient reserve capacity however, an extension of 1000 l/sec should be planned for.

The present trend in Fayoum is to install compact water treatment units in locations where the water supply is insufficient (mainly the fringes of the Governorate). There are at present 17 compact units which together produce 255 l/sec, or about 15 % of the total production. Temporarily these compact units serve a good purpose, but it is not the way in which the substantial future water demand can be met. Water production through compact units is relatively inefficient and costly. It is therefore recommended that after 1995 no additional compact units should be planned.

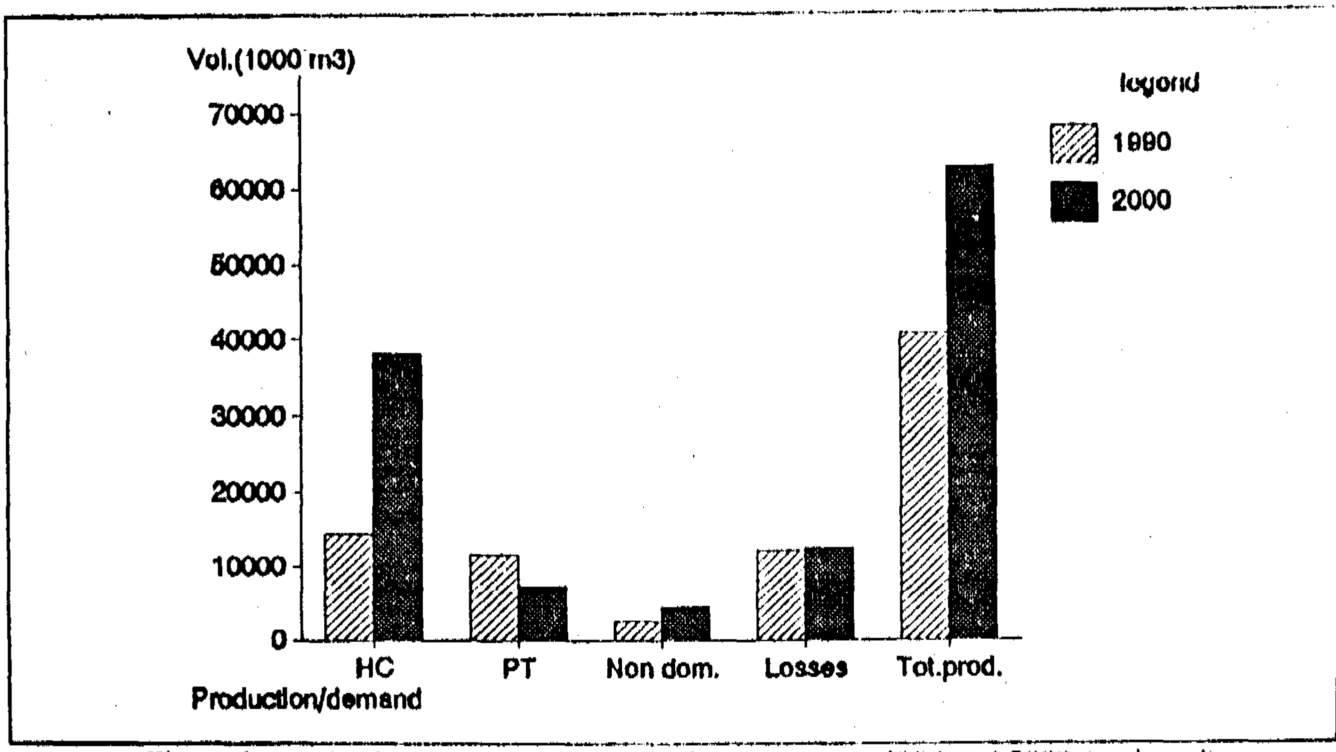


Figure 2. Production and demand of drinking water year 1990 and 2000 (projected)

It is required that plans are made to install additional capacity of 1000 l/sec, either centrally in El Azab, or if possible, decentralized units of 500 l/sec in the north-east (Tamiyah) and north-west (Ibshway) in order to reduce pumping costs and investments in large diameter trunk mains. The new capacity should become operational after 1995.

Organization

El Azab is not an independent water company which is run on a commercial basis, but it functions as a Governmental department, a state of affairs which is reflected in such fields as Finance and Accounting, budgeting, personnel management, tariff setting etc. There is limited room for an independent company policy or strategy. The General Manager is subordinate to the Directot of Housing of the Governorate, while the Finance Department is subordinate to the Ministry of Finance.

The organization is managed from a central office with supporting maintenance centres in each district (5 centres), and has a total of 751 employees of which 344 are employed in plant operation, 225 in maintenance and 182 in administration.

The following additional characteristics may be mentioned:

- More than 50% of the staff in water production are in the compact units, which only produce 15% of the total volume of water. This shows the relative inefficiency of producing water in small units.

- There are 61 staff in the private billing section, to cope with the administrative processing of over 80,000 accounts. On the other hand there are only 18 meter readers and 12 fee collectors in the whole area. This situation seems rather out of balance.

- The major part of the staff is low to semi-skilled; design capacity is limited.

Costs and revenues

The yearly expenditures of El Azab amount to approximately LE 3.6 mln. Revenues from water sold are LE 770,000, so 21.4 % of production costs are recovered. The deficit is supplemented through the Ministry of Finance, which provides the annual operating budget (see table 6). Table 6 also shows the revenues if all water from house connections would be sold at Pt 8.5/m^3, which is the present basic price, and if the supply to Fayoum city (average 150 l/sec) would have been fully paid for. The resulting overall billing efficiency of water sold is 53.3%.

The production costs of the water can be calculated by dividing the LE 3.6 mln annual costs by 50.6 mln m^3 annual production, being equal to LE 0.07 per m^3. The present basic water price is LE 0.085 per m^3, so sufficient to cover the costs if 85 % of the water produced would be paid for. There is however a high percentage of unaccounted for water (UFW), which is estimated at 78 % (see figure 3). UFW consists of 28% free water from public taps, 20% billing inefficiency and 30% system losses.

TABLE 6. El Azab annual costs, revenues and subsidies (LE 1000) year 1989

Cost, revenues and subsidies	Actual amounts	Potential max. revenue	Billing efficiency
Recurrent costs			
Operation	2450		
Maintenance	750		
Administration	447		
Total costs	3647		
Revenues			
House connections	716	1228	58.3 %
Fayoum city	54	216	25.0 %
Total revenues	770	1444	53.3 %
Subsidies			
Ministry of Finance	2796		

Source: El Azab, 1990

Concerning tariffs and water billing the following additional observations were made:

- the present basic tariff of Pt 8.5 would allow for an unaccounted for water (UFW) percentage of maximum 15%. However UFW is as high as 78%;
- the present national recommended basic tariff is 10 Pt. In Fayoum the previous lower tariff is still applied because the Governorate's People's Council didn't approve an increase of tariff yet;
- water from public taps is free, which means that nearly 30% of the water produced is officially not being paid for anyway;
- meter reading and billing pose many difficulties because of the many scattered and remote villages and the limited manpower and means of transportation. Fee collectors cannot exert authority or sanctions for non-payers;
- nearly 50% of water meters are out of order, so consumption has to be based on estimates, related to previous years consumption before the defect. Even working meters may have recording errors because

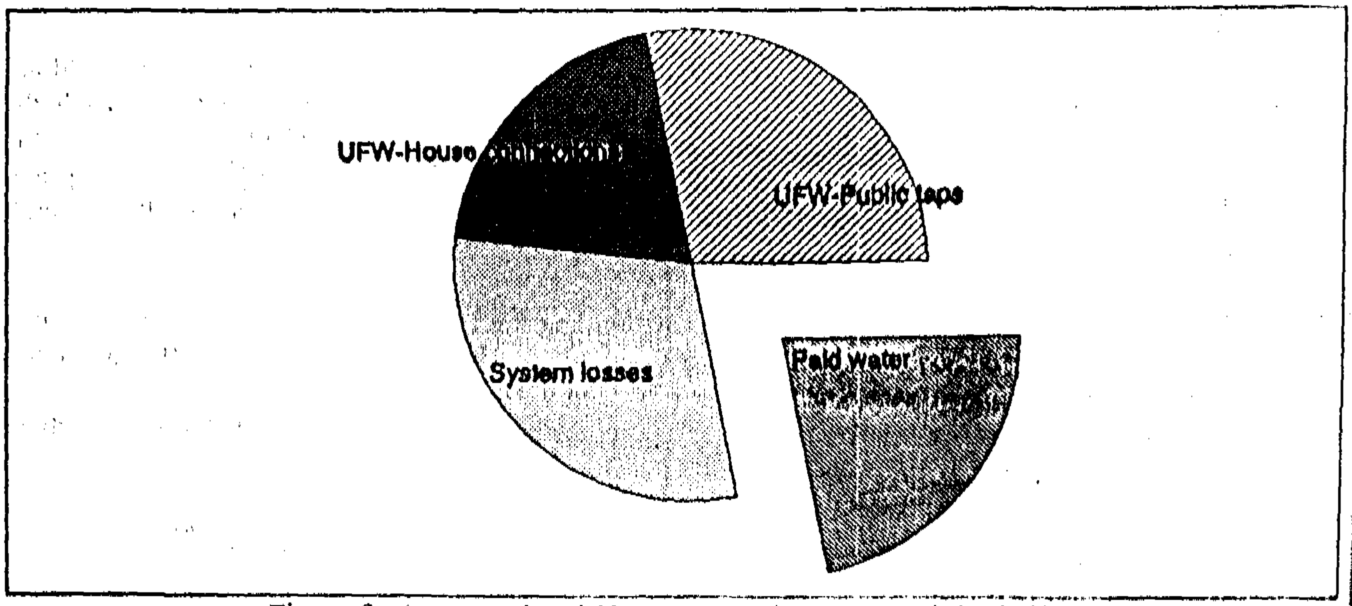


Figure 3. Accounted and Unaccounted for Water, El Azab 1990

no maintenance or calibration is carried out. As a result registered consumption does not reflect real consumption and the billing efficiency is 58% (with respect to house connections).

PRIORITIES FOR FUTURE DEVELOPMENT

The objectives for El Azab in the year 2000 may be formulated as follows:

a) achieving full cost recovery for recurrent costs;
b) installing additional production capacity of 1000 l/sec;
c) achieving increased organizational efficiency in key functions such as network management, maintenance and billing.

Cost recovery is the most difficult target to achieve, because it requires an integrated effort from the technical and the organizational side. Some operational targets may be formulated as follows:

1) Reduction of UFW, from the present 78% to 50%. This could be achieved as follows:

- reduction of system losses from 30% to 20% of production;
- reduction of free water from public taps from 28% down to 12%. Due to the "natural" increase in the number of HC's, demand from PT's will drop (see figure 2);
- improvement of billing efficiency with respect to HC's from 58% to 70%. As a result the percentage of unpaid water from HC's drops slightly from 20% to 18%. If no measures are taken unpaid water from HC's will increase substantially.

The following development activities are required in order to achieve the target:

- leak detection and leak reduction programme for transmission lines and reticulation systems;
- installation of new house connections at a rate of 1000-1200 connections per month in order to meet the real demand for water;
- establishment of an efficient watermeter workshop for repairing and calibrating water meters;
- reorganization of the present billing system;
- establishment of customer relations (promotion, information).

2) Doubling of the basic water tariff (at 1990 prices), from the present Pt 8.5 to Pt 16. Of the production costs, 90% should be recovered from sale of water to private connections. Future costs cannot be fully recovered from stagnant prices.

The tariff is a variable which cannot be controlled by the water company, since it is established at national level, and subject to approval from the Provincial People's Council.

The second objective of installing the required additional production capacity needs to be shared by the Governorate and the National Government. The masterplan for drinking water supply for Fayoum, which will be prepared through the Fayoum Drinking Water and Sanitation Project in 1992, will identify the need for this extension in more detail. Based upon the presented planning, financing options for the extensions can be investigated, whereafter the plants may be commissioned. If this takes place around 1993/94, the new capacity may become operational before the end of the decade.

In order to realize especially the cost recovery objective, organizational development with respect to El Azab is quite essential. Basic functions like distribution network management, cost accounting, financial analysis, billing and customer relations have to be developed.

The proposed establishment of a regional Public Sector Water Supply Company in Fayoum, with more delegated responsibility and independent policy making may be a good step forward in the right direction. Meanwhile development projects such as the presently ongoing Egyptian-Netherlands cooperation can create the necessary awareness with respect to the needed transformation. Some of the new approaches and techniques can be introduced already at pilot scale and staff can be trained to become familiar with them.

REFERENCES

Binnie & Partners, John Taylor & sons et.al, February 1980. Provincial Water Supplies Project, Final Report. Prepared for the ARE, Ministry of Housing, General Organization for Potable Water. Cairo, Egypt.

IWACO, DHV, ECG, El Azab Water Works. February 1991. Fayoum Drinking Water and Sanitation Project; Inception Report Volume II: Review of existing situation. Cairo, Egypt.

CAPMAS, 1986. Census data Fayoum.

SUSTAINABILITY OF WATER SUPPLIES
IN PROVINCIAL EGYPT

N F Nicholson

Camp Dresser & McKee International Incorporated
One Cambridge Center, Cambridge, Massachusetts, MA 02142.
U. S. A.

ABSTRACT

Life, health and hygiene all depend on access to a plentiful supply of safe drinking water. Piped water supplies in rural Egypt are insufficient to meet the demands of the existing population. This situation is worsening due to the rapid population growth and failure of existing water supply systems.

There are already areas of the country with severe piped water shortages. If corrective action is not taken soon densely populated villages will become vulnerable to outbreaks of waterborne diseases. Immediate action is need to reverse the deterioration of water supply systems and to improve the benefits gained from capital works investments in the sector.

This paper promotes the concept that sustainable water systems in rural Egypt depends on a central government and local unit partnership. Also needed are consumer bodies to determine user needs; local units to be given powers to managed the revenue and expenditure accounts; and, the central government to concentrate on setting policies and guidelines, and assisting with the implementation of major capital works.

KEYWORDS

Rural water supply; capacity building; community management; women in water supply; Egypt.

BACKGROUND

Lack of a plentiful supply of safe drinking water has serious consequences in many disadvantaged communities of less developed countries. Shortage of water has not been a problem for rural communities in the Nile Valley since the commissioning of the Aswan High Dam in 1957. However the quality and quantity of drinking water is deficient in many rural areas of the country.

The development of small water supply systems occurred in many rural communities of Egypt through to mid-1950. Thereafter funds for capital works in rural areas became scarce and the increase in demand fast outgrew the supply capacity. Consequently provincial residents placed reliance on private shallow wells for drinking water. Whilst the water in canals and the river was used for washing of dishes and clothes.

As the population continued to expand through 1960 and 1970 the problem of pollution in rural communities grew. Groundwater tables started rising and there were no adequate facilities to dispose of foul or grey wastewater. The disposal of solid waste also became a major problem.

Build up of these environmental pollution problems are contaminating the shallow groundwater aquifers supplying private wells. Pollution levels are rising also in canals and other water courses.

Health indicates show that despite intensive oral re-hydration programs and public health programs by UNICEF and external aid agencies, child mortality in Egypt is still around 100 per 1,000 live births. Also the local press reported recently that in Egypt each year 15,000 to 20,000 people die from typhoid or paratyphoid and a further 20,000 to 25,000 die from infectious viral hepatitis.

In more recent years there has been a surge of funds available for expanding drinking water supply systems in less developed countries including Egypt. Much of this increase in interest was promoted by the International Drinking Water Supply and Sanitation Decade sponsored by United Nations. In Egypt programs like the USAID funded Local Development program has done much to expand water supply systems. Unfortunately the impact of the new facilities is lost as the water systems are not operated efficiently.

Traditionally the people regard water available in the ground and water courses is free and feel they should not be charged for privilege of piped water. The Government recognises water is a finite resource yet has difficulty increasing water charges because of political sensitivity. Even so the fact should not be overlooked that a high capital investment is required to supply water to the consumer tap. Then electricity, materials and manpower are required on a recurrent basis to maintain the water service. This situation is no different from providing electricity to consumers, where metering and charging to meet the costs is fully accepted from the outset.

INVESTMENT/POPULATION

At the present growth rate the population of Egypt will double every 25 years. Although the trend has been for people to migrate to urban areas there is still a significant growth in rural populations. The 1986 census found 25 million people lived in rural areas representing 56 % of the total population.

Some Egyptian villages have populations of 30,000 or more. The population density is increasing with the construction of multi-story residential buildings. Demand for water is ever increasing and often exceeds supply capacity.

Considerable amounts of money have been invested in the water sector over the last 10 years. Table 1 shows an almost constant investment in the water sector each year. No adjustments are made for either increases in the number of people requiring a supply or the decline in real terms in the value of money.

Economy of scale is a factor that has to be considered where communities can be supplied by large regional water supply systems. However the type of water supply system supplying most Egyptian rural communities are small scale groundwater systems. The unit water costs (capital and recurrent cost) tends to be higher for these small systems compared to the regional systems.

TABLE 1: Investment in Egyptian Rural Water Systems

Years	Investment Water Sector ($ million)	Rural Population* (million)
1980-86	55	25
1987	16	26
1988-89	25	27
1990-91	26	29
1991	14	30

* Based on 1986 census, increased by 2.8 % per year.

CAUSES OF FAILURE OF EXISTING WATER SUPPLY SYSTEMS

Generally installing new capital works projects does not help sustain the operation and reliability of water supply systems. This fact is evident in many areas of rural Egypt where three indicators show that water supply systems are below the internationally recognized norms. These indicators are -

- o the hours per day water is available
- o the high water losses
- o the quality of water delivered

Some communities receive water from the public piped system only a few hours a week. Very few receive water more than 12 hours a day. Indeed there are known instances where consumers are so dissatisfied with the public service they voluntarily disconnect. Preferring instead to rely on private water sources which sometimes includes buying water from a water vendor tanker service at a cost very much higher than the government tariff.

High rates of unaccounted for water is another indicator of the poor standard of water service. Measurements made by various consultants in the recent past show water losses fall within the range of 20 to 70 per cent of production, with an average close to 50 per cent. The reasons for these high losses include high rates of leakage; wasteful operating practices, such as water towers frequently overflowing; lack of source works meters to measure supplies; and, a high percentage of out of service consumer meters, particularly large meters.

Poor quality water is a prevalent. Much of this is brought about by leaking pipe networks that are not continuously under pressure. Frequently these pipelines are laid in ground that is saturated with polluted water. When the consumers drain the pipelines, polluted water drawn into the pipelines contaminates the restored water supply.

The present operating management disencourages any sense of ownership at the local level. The USAID funded Local Development project, discussed later, involves local communities in the selection of capital works projects. Cost recovery from water sales and funding for recurrent expenditure is controlled by central government in all governorates except three with water companies. This situation destroys any sense of ownership by the local units that may have been generated by the implementation of new capital works.

Lack of recurrent operating funds results in poor maintenance of electrical and mechanical equipment, and lack of repair to defective pipelines. This leads to reducing the useful working life of capital works and a rapid decline in the standard of service provided to consumers.

USAID FUNDED LD II DECENTRALIZATION PROGRAM

New water projects

The USAID Local Development II (Provincial) Project (LD II-P) is the second stage of a program that started in 1980. The purpose of the program is to raise the standard of living of the rural poor through funding the construction of facilities for basic services. USAID funding has supported the process where local administrations increase their capacity to define, plan, organize, finance, implement and maintain projects that enhance their economic development at the local level. The primary success of the program is the decentralizing of capital works development. On the contrary the building of capacity to maintain the systems has not succeeded to keep pace with the rate of constructing new works.

During the life of the two Local Development programs 35 % of the block grant investment amounting to about US$ 125 million has been spent on extending piped water supply systems in rural communities. Projects range from constructing new wells and pump stations to extending and replacing network pipelines.

It is difficult to measure the overall impact of the program but a study conducted in 1988 by the USAID funded Water and Sanitation for Health (WASH) project made some conclusions about the first stage of the LD program. WASH found the percentage of buildings in rural communities connected to piped water systems had increased from about 5 % in 1980 to 35 % in 1986. The funds from the Local Development program was deemed to be a major contributor to this improvement.

Over the same period there was a sharp increase in population. In 1980 the estimated number of rural people not connected to piped water systems was 19 million. By 1986 despite the large increase in service connections the number of rural people not connected was still 19 million.

Operation of water systems

The construction of new capital works projects does not help to sustain water systems. USAID supports recurrent expenditure by allocating funds annually to sustain the operation of newly commissioned works installed under the local development program. Even so there is still a shortfall between actual costs and available recurrent funds. The result being a gradual deterioration of the standard of service and shortened working life of capital assets.

During the last cycle of the LD II-P program, governorates were encouraged to identify at least one cost recovery program. Often the selected pilot invloved the collection of a local service development fund. This is a special charge levied in addition to the normal water charges that are transferred to central government. The accounts of the local service development fund are controlled by the Governor who can authorize the distribution of the money for development or maintenance purposes.

MANAGING THE OPERATION OF RURAL WATER SUPPLY SYSTEMS

The responsibility of managing rural water supply systems in Egypt is ultimately that of central government. Central government currently controls the revenue and expenditure funds for operating water systems.

The management role of local units.

Local units are given limited resources to maintain the village level water supply systems. Even in areas supplied by regional treatment works, local units maintain the village networks and install new consumer connections. However operation control is lost when pipe networks cross administration boundaries. In these instances the village producing the water supply has no control over network losses or demand by the neighbouring village.

The local units employ staff to operate local water stations, maintain pipe networks including the installation of new connections, and reading the consumer meters and collecting revenues. Staff wages and salaries is paid from the government budget. Funds for the operating costs and cost of maintaining and repairing capital works are allocated from a second and separate government account. These funds, despite an injection of money from USAID to maintain Local Development works, are insufficient to pay the full operation and maintenance costs.

The problem of maintenance is further exacerbated by the fact that there is a shortage of skilled labor, spare parts and transport to regularly visit all the water stations. Further difficulty arises because of poor telephone services in many rural areas.

Some local units are very capable of maintaining water systems even with all the administrative and funding difficulties confronting them. Their success is attributed to good leadership by the village chief, who motivates skilled staff and makes maximum use of the village workshops. 800 of these units were built and equipped throughout the country.

The role of women in water supply.

Woman are the main water users in Egyptian provincial areas, yet at the moment they have little impact in the planning, design or management of the piped water systems. Indeed the women are usually by-passed in any decision making process although they are the sector of the community most affected by inadequate water services.

The chore of collecting water from public standposts it is left to woman and children. The current trend is that women use piped water in the homes for drinking and cooking, but wash clothes and cooking utensils in the nearest watercourse.

The use of open channel watercourse for washing purposes is far from hygienic. But it is a tradition that can probably be broken only by providing an alternative and equally convenient communal washing facility and introducing an intensive public training campaign.

SPONSORSHIP TO CAPACITY BUILDING IN THE WATER SECTOR

International organizations such as United Nations, World Bank, and World Health Organization all recognize the urgent need to introduce a quantum step to make water systems sustainable. In June 1991 Egypt was represented at the UNDP

Symposium in the Netherlands which developed the Delft Declaration. This declaration focuses on the global need for a new strategy for water resources capacity building in the next century.

The key statement from this symposium is "Experience shows that institutional weaknesses and malfunctions are a major cause of ineffective and unsustainable water services."

The International Water Supply Association recently launched an initiative through sponsoring a Foundation for the Transfer of Knowledge. The purpose is to focus on operation and maintenance, and institutional capacity in the water and wastewater sector. To date details of experts have been registered and these experts can be called on to assist less-developed countries such as Egypt. The Foundation is working very closely with the Community Water Supply section of WHO.

Capacity building

Capacity building depends on two interrelated concepts: Firstly strengthening of institutions at all levels to deal more effectively and efficiently with all aspects of sustaining water supply systems; and second developing the human resources needed to operate and manage the water systems. It is with this course of action that the future success of sustainable water systems is expected.

CONCLUSIONS

In Egypt unless something is done to improve the standard of water service within the rural areas systems will deteriorate and service standard will worsen. Densely populated villages will become vulnerable to outbreaks of epidemics of waterborne diseases.

A partnership involving central government and local units is worth exploring. Central government could set policies and guidelines to be followed by local levels. Also the government can assist with financing of major capital works programs such as constructing regional water treatment works.

At the other extreme the local communities should be given the resources and powers to manage the daily operation of water systems. Paramount to the success of the local level management is control over the financial aspects of operating water systems. This means revenues collected from water sales should be retained at the local level and used to fund recurrent operating costs.

The advantage of this rearrangement is there will be a close linkage between the consumers and the management authority. The local authority would have the resources and powers to swiftly deal with any complaints or operating problems. Furthermore the local authorities would have a strong incentive to -

- reduce operating costs by minimizing water losses
- ensuring water meters, particularly the large consumer meters, are kept in good working order
- ensuring revenues due are collected promptly and that prompt action is taken against consumers who are delinquent about paying their accounts.

Some will argue that the local units have not the capability to manage the water systems. However time has proved that management by the central government is not successful and new ideas have to be explored.

As an initial step towards changing the management of water systems, it is proposed a pilot program be formulated and introduced in a selection of governorates. This program should be supported by the government who authorise governors of governorates to delegate responsibilities to selected local units.

The powers given to the local units include -

- retaining revenues collected from water sales to finance the cost of operating water systems
- determining consumer needs within the users capacity to pay. It may be low income consumers would prefer an increase in public standposts and communal services.
- charging economic rates for supplying water and installing service connection
- taking positive action to monitor water supply and consumption. Thus ensuring unaccounted for water is minimised.
- setting up a consumer body where women can voice their requirements.

REFERENCES

McCommon, C., Warner, D., and Yohalem, D. (1990). *Community Management of Rural Water Supply and Sanitation Services.* The World Bank.

Okun, D.A., and Lauria, D.T. (1991). *Capacity Building for Water Resources Management.* United Nations Development Program.

Water: Save Now or Pay Later. The Urban Edge, Vol 15 No 3 April 1991 published by the World Bank.

SLOW SAND FILTRATION, A SOLUTION FOR WATER TREATMENT IN RURAL EGYPT

Ahmed Fadel *

* Associate Prof. of Sanitary Eng.
And Head of Public Works Dept.
Faculty of Eng. EL Mansoura Univ.

ABSTRACT

A Pilot Plant was constructed at Sandoup Rapid Sand Filter Compact Units Station, EL-Mansoura City, in order to develop a simple, cost effective, easy to operate and maintain technology for water treatment in rural Egypt. The pilot plant consists of an Intake, Up-Flow Roughing Filter (URF) 2.25 m diameter and four circular Slow Sand Filters 2.25 m diameter. The use of 4 filters in parallel facilitates studying several parameters, and modes of operation for the same raw water characteristics. The URF was employed as an effective pre-treatment to reduce the pollution loads on the slow sand filters. With the pilot plant in operation and because of the many objectives of this study, only the preliminary finding will be discussed in this paper. The results of runs, conducted during the period April,1st till July 1st,1991 indicated the following:
1- Slow sand filters receiving water directly, i.e., without pre-treatment, clogged within a few days. The Schmetzdeck was all algae. 2- The use of URF (pre -treatment) extended the run length to two months during this period. 3- The URF reduced the turbidity, and the algae load up to 80% 4- With the use of URF the Schmetzdeck on the sand filter functioned normally. 5- The filter, effluent turbidity was in the range of 1 to 2 NTU. 6- The performance of the existing rapid sand filters compact units, on the site, was very poor with regard to effluent turbidity and run length (time between filter back-washing);and 7- Covering the sand of one of the slow sand filters with either woven or non-woven fabric materials improved the over all performance of the covered filter.

KEYWORDS

Rapid Sand Filter, Slow Sand Filter, Upflow Raughing Filter, Schmutzdecke, Algae, Woven and Non Woven Fabric.

INTRODUCTION

The importance of water and water-related projects to the Government of Egypt is underscored in the 1982-1987 five year plan. Its approval marked a 250 percent increase in spending over the 1977-1982 investment program in such projects with a total investment of LE 3.4 billion, which is 2.7 percent of the total estimated GDP generated through 1987. The greatest portion of the investment was designated for capital projects for the large metropolitan systems.

There have been several comprehensive reports on water supply in Egypt. A 1984 report by the Japan International Cooperation Agency on the Sharqiya Govornorate water supply system and the several volume report of 1986 by SOGREAH, ECTO and C.G. Eaux on the water supply and sewerage development projects in Daqahliya, Damietta, and Behaira Governorates are examples. They, in general, show that the respective governorates have constructed treatment plants, wells and distribution systems to serve the entire governorate, not simply the major cities. The services can best be described as regional. In a study conduct by Fadel and Kamal (Fadel 1990) regional water treatment plant cost-effectiveness, it was shown that supplying water for villages and cities separately is more cost-effective than the construction of regional water treatment plants, (Fadel 1989).

Package rapid sand filtration plants have become the standard solution to tackle the problems of quantity and low pressure, especially at great distances from major plants. The rapid sand filtration plants imported for the Egyptian villages from various contries are, however, not without problems. The plant operation invoices judicious chemical dosing of alum, polymers and chlorine, periodic backwashing of filters, and maintenance of filter pumps, metering pumps, mixers, air compressors, chlorinators, electrical control systems, flow meters, gauges, and other sundry devices. Where raw water quality is poor, operators have not always been able to produce acceptable drinking water consistantly.

However, there are still many rural communities in Egypt that are faced with the need to construct and operate water treatment facilities. Greatly needed are simplified treatment systems that require a minimum level of operator skill, yet provide acceptable levels of treated water quality. The slow sand filter is such an unsophisticated water treatment process, requiring minimal attention from the plant operator and relatively unskilled personnel.

The major objective of this study is to evaluate the SSF as an efficient. Treatment system with low operation and maintenance cost, capable in removing cercariae, algae, and other water pollutants under Egyptian village conditions.

MATERIAL AND METHOD

Pilot Plant Description:

The pilot plant was constructed and installed in Sandoob compact water treatment plants in El-Mansoura City - Daqahlya Governorate. Three compact Rapid sand filters are located on the site. Figure 1. illustrates the layout of the pilot plant, which is consisted of:

A. Intake:

The pilot plant receives the raw water from Sandoob sump. The raw water is pumped to the distribution chamber by means of two pumps that are operated alternatively (each pump runs for 45 min.).

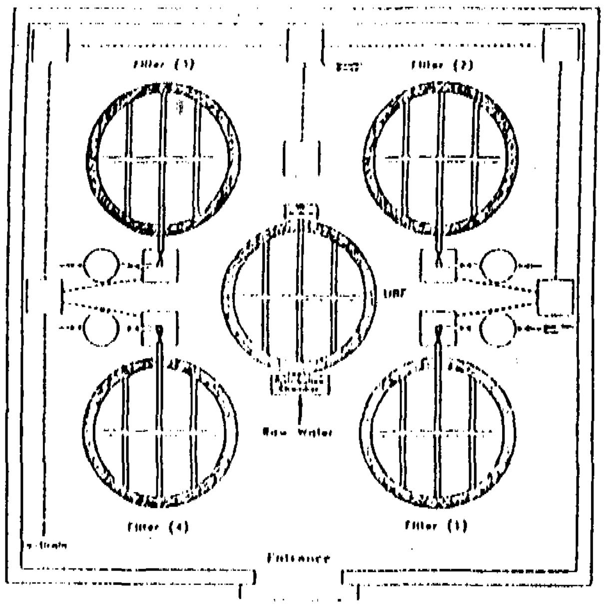


Fig. 1. Layout of Pilot Plant

B. Upflow Roughing Filter:

The upflow roughing filter is a reinforced concrete pipe with 3.50 m. height and 2.25 m. diameter. The upflow filter is employed as an effective slow sand filters pre-treatment.

The filter media is a graded gravel layer 1.75 m thichness that is classified into various sizes from 0.4 to 25 mm. as shown in Fig. 2

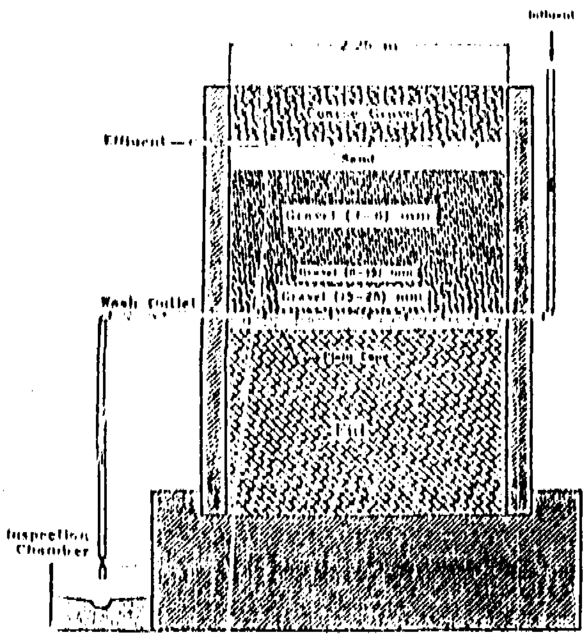


Fig. 2 Upflow Roughing Filter

The inlet system was designed to allow fast draining of the water for filter washing. The outlet system of the filter is placed at the filter top. It consists of PVC perforated pipes to collect the filtered water. The outlet system is covered by a gravel layer in order to prevent algal growth on the water surface. This layer depth is larger than the water depth above the filter outlet system to prevent sun light penetration in the water.

During operation raw water flows upward through the filter bed while filter cleaning is conducted by rapid downward flow of water.

C. Slow Sand Filters:

Four concrete pipes, each with 3.50 m in height and 2.25m in diameter, are used as slow sand filters. The filter media consists of a graded granular sand layer 50 to 140 cm thick, laying over gravel layer of 30 to 45 cm depth. Raw water is distributed to sand filters from the distribution chamber.

Each filter, is provided with an outlet flow control tank. These tanks are provided with float valves at the inlet and sluice valves at the outlet to control the flow and accordingly the rate of filtration of the slow sand filters. The dimensions of these tanks are 40 cm diameter and 60 cm for the depth. Piezometer tubes located from the gravel level up to above the top level of the sand at 10 cm intervals, were installed for sampling and head loss measurement. Figure (3) presents the filters configurations.

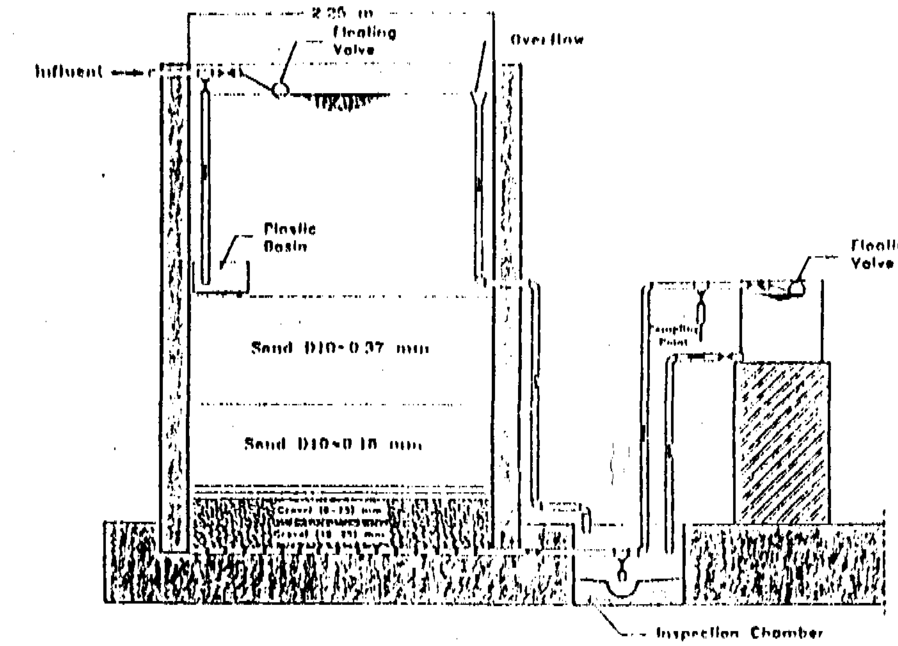


Fig. 3. Filters Configurations

Each filter is provided with an under drainage system which consists of holed P.V.C pipes placed at the filter bottom. The filter is also provided with sluice and float valves at both the inlet and outlet, in order to regulate and control the filters flow rate and adjusting the water head on the filter bed. The filter head loss is monitored through the plastic pizometers fixed on the filter external wall.

D. Pilot plant drainage system:

The filter overflow water plus treated water are discharged to inspection chambers and flow by gravity through P.V.C. sewers 6 "in diameter to the wastewater pump station of Sandoob compact water treatment plants.

Experimental procedure

After construction, a check up for detecting deficiencies such as leakage, bad connections and valves were conducted.Following the check up, two sets of runs were conducted with the variables illustrated in table 1.

Table I: Variables monitored during the two run sets.

FILTER NUMBER	RUN #	MEDIA: DEPTH cm	MEDIA: EFF. SIZE mm	MEDIA: UNIF. COEFF. "U"	RATE OF FILIATION	SOURCE	HEAD (m)	RUN DURATION (day)	NOTES
1	I	70.00	0.180	1.600	6.500	INTAKE	1.40	5	UNCOVERED FILTER
		---	---	---					
	II	80.00	0.370	2.000	4.350	URF	1.40	56	UNCOVERED FILTER
		60.00	0.180	1.600					
2	I	70.00	0.180	1.600	6.500	URF	1.40	28	UNCOVERED FILTER
		---	---	---					
	II	20.00	0.370	2.000	6.500	URF	1.40	54	UNCOVERED FILTER
		60.00	0.180	1.600					
3	I	50.00	0.180	1.600	4.350	URF	1.40	29	UNCOVERED FILTER
		---	---	---					
	II	20.00	0.370	2.000	4.350	URF	1.40	36	UNCOVERED FILTER
		60.00	0.180	1.600					
4	I	50.00	0.180	1.600	4.350	INTAKE	1.40	5	UNCOVERED FILTER
		---	---	---					
		---	---	---					
	II	WOVEN FABRIC			4.350	INTAKE	1.40	3	UNCOVERED FILTER ONE LAYER OF WOVEN FABRIC IS USEC ABOVE SAND LAYERS
		20.00	0.370	2.000					
		60.00	0.180	1.600					
URF*		20.00	0.180	1.600	26.00	INTAKE	0.70	70	ENDING FILTER RUN DEPENDS ON THE EFFICIENCY OF TURBIDITY REDCUTION
		80 cmm (gravel 4 - 6 mm)							
		15 cmm (gravel 6 - 15 mm)							
		30 cmm (gravel 15 - 25 mm)							

* UPFLOW ROUGHING FILTER

Turbidity, PH, suspended solids concentrations and Algae and Bacteria count, were monitored during those two sets of runs.

RESULTS AND DISCUSSION

Figure 4, shows the results obtained with regard to turbidity removal in the first set of runs. Filters 1 and 4 operated without pretreatment and clogged within 5 days while filters 2 and 3 (with pretreatment) run length was 29 days.

The URF removed over 80% of all the pollutants measured. Even though the influent to filters 2 and 3 was pretreated, by the URF, the four slow sand filters effluent characteristics were the same. It is noteworthy that despite the small depth of sand used in the filters, the effluent characteristics were reasonably acceptable. The compact units effluent turbidities were in the range of 3 to 8 NTU.

Analysis for the types of Algae found in the raw water, the compact units outlet, the URF, and at the slow sand filters effluent, were carried out during the run period. The results, showed that the compact unit efficiency in removing algae were very poor (20 to 60 %). On the other hand, the slow sand filters removed over 95 % of the algae.

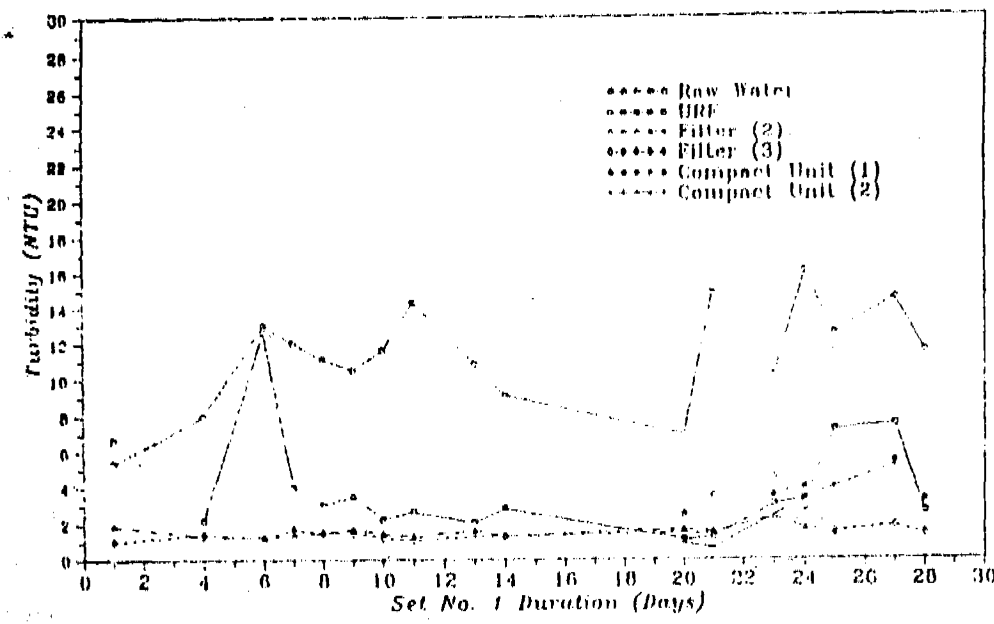


Fig. 4. Turbidity Removal For The Pilot Plant Filters and The Compact Units.

In Run set # 2, filters 1,2 and 3 were preceded by the URF, while filter 4 was left without pretreatment, but was covered by woven fabrics. The sand depth increased in all the four filters. The run lengths till headloss breakthrough were increased significantly for filters 1,2 and 3 to two months of continuous operation. Figure 5. a and b presents the turbidity removal in run set # 2. Figure 6. illustrates the algae removal during the experimental work. Filter # 4 clogged in 3 days only, because of the fast clogging of the filter media. It was decided to have the filter preceded by the URF.

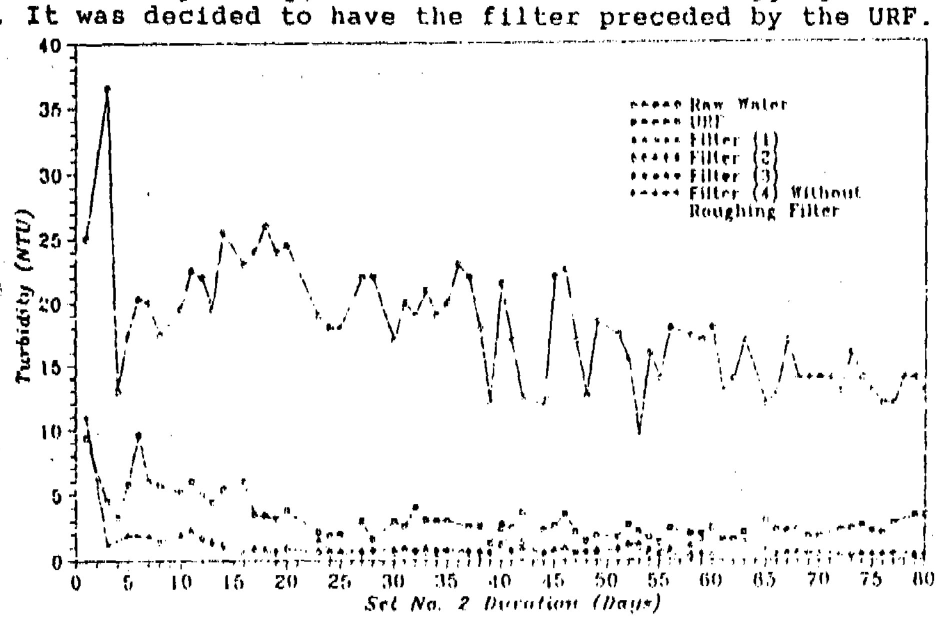


Fig. 5-a. Turbidity Removal For The Pilot Plant Filters

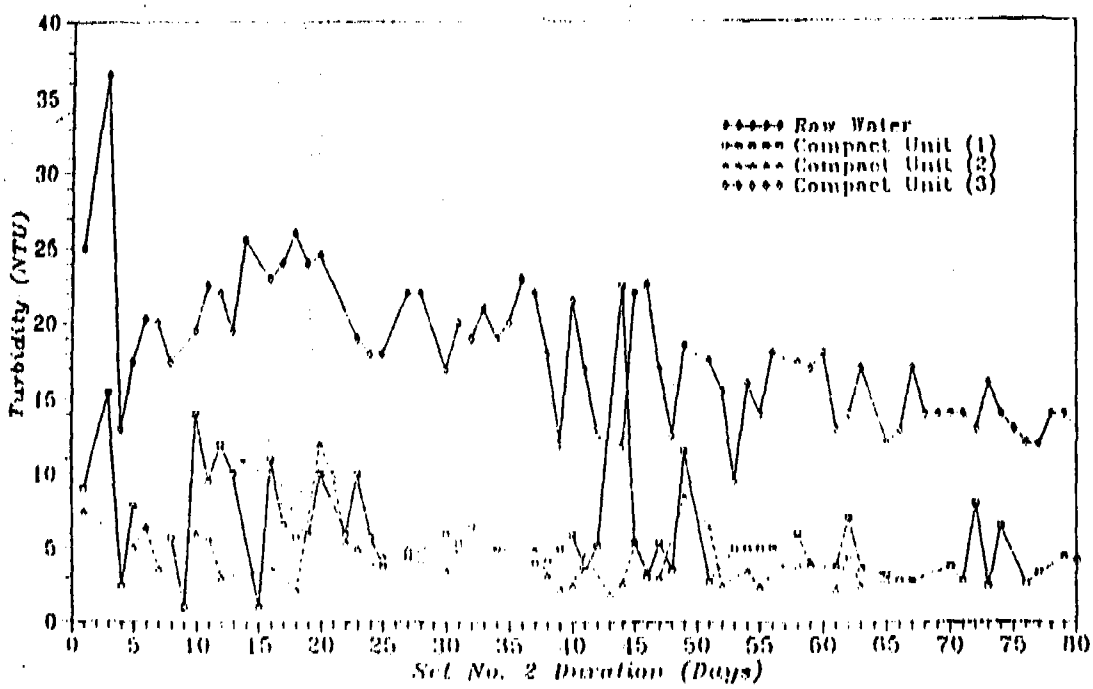


Fig. 5-b. Turbidity Removal For The compact Units

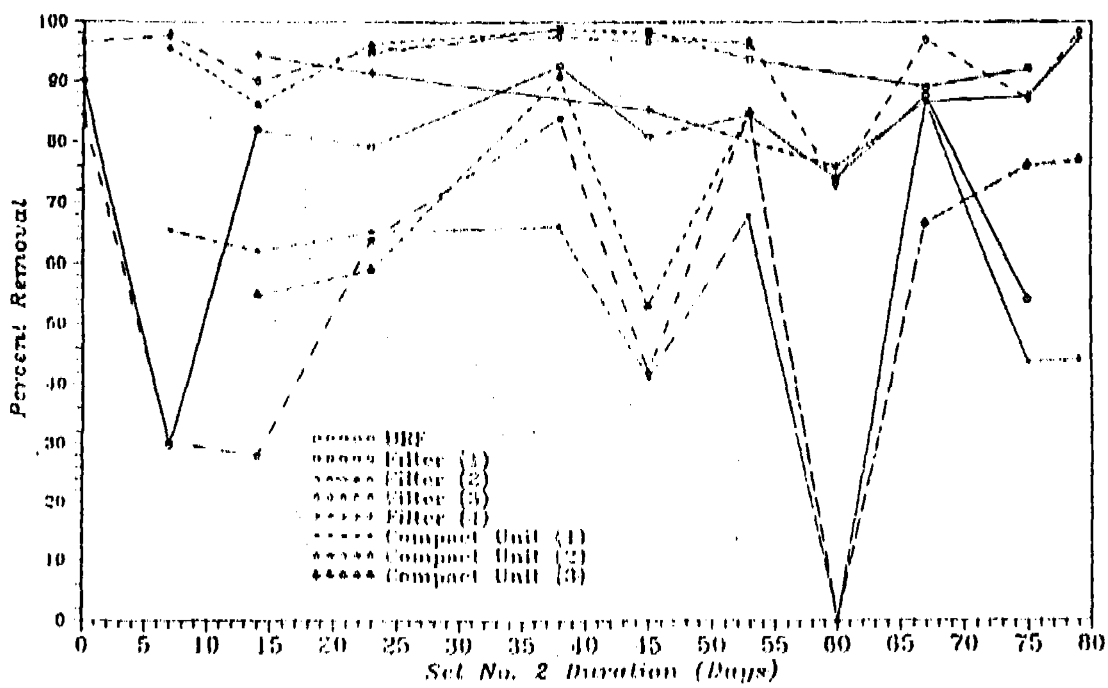


Fig 6. Algae Removal Efficiency For Run Set No. 2

CONCLUSION

In recent years, there has been a notion on the part of some engineers to assume that slow sand filtration is an old fashioned method of water treatment that has been completely superseded by the rapid sand filtration. This idea has definitely been shown to be mistaken. The experimental work conducted at Sandoup, El-Mansoura, city Egypt showed th slow sand filters perform much better than rapid sand filter, when treating the Nile River water. The results of the two Run sets conducted during the period of April 1st to July 1st showed that:

1. Slow sand filters receiving water directly, i.e., without pre-treatment, clogged within a few days. The Schmetzdeck was all algae.
2. The use of URF (pre -treatment) extended the run length to two months during this period.
3. The URF reduced the turbidity, and the algae load up to 80% .
4. With the use of URF the Schmotzdeck on the sand filter functioned normally.
5. The filter, effluent turbidity was in the range of 1 to 2 NTU.
6. The performance of the existing rapid sand filters compact units, on the site, was very poor with regard to effluent turbidity and run length (time between filter backwashing).
7. Covering the sand of one of the slow sand filters with either woven or non-woven fabric materials improved the over all performance of the covered filter.

ACKNOWLEDGEMENTS:-

"This work was carried out with the aid of a grant from the International Development Research Centre, Ottawa, Canada."

REFERENCES:-

Fadel, A.A. and Hassanin, K. (1990) water supply for rural areas. International Conference on Environmental Planning and Management. University of Roorkee, Roorkee, INDIA.

Fadel, A.A. (1989) "slow sand filtration for surface water treatment and cercarial removal in Egyptian villages." An approved proposal to IDRC, Canada.

SUPPLYING RURAL AREAS SURROUNDING ALEXANDRIA WITH POTABLE WATER

Engineer Mohamed Ahmed Marzouk
CHAIRMAN

Alexandria Water General Authority

ABSTRACT

As the production of Alexandria Water General Authority (AWGA) reached the point of covering the Alexandria requirements, great efforts were increased to cover the requirements of the villages in the new land reclamation projects in Dehera Governorate, the new communities in Noubaria and Borg El Arab and the extension in western part of North coast till Marsa Matrouh.
Stopping and cancelling the plan of installing many compact units in this area is the result of extending AWGA network to all these areas.
The area fed from Mariout and Borg El Arab water treatment plants suffers from the quality of the raw water in Noubaria Canal and consequantly the potable water which is extremely loaded with different sorts of agriculture, industrial and sewage waste from irrigation drainage canals connected to Noubaria canal.
Therefore to secure the raw water resources in Mariout and Borg El Arab treatment plants great efforts must be taken for the construction of a new canal specially for drinking water starting from a point just before km 46 along Noubaria Canal.

KEYWORDS

Water, Noubaria canal, pollution, total dissolved solids, chloride, total hardness, sulphate.

INTRODUCTION

In 1860 a water supply system including filters, reservoirs and pumps started in Alexandria. In 1954 the water supply was taken over by the Egyptian Government from the British company. In 1968 the Alexandria Water General Authority (AWGA) was established by Presidential Decree and in 1973 AWGA was assigned to the Alexandria Governorate.

Alexandria Population

From the beginning of the century Alexandria's population has steadily increased with a rate 2-3% per annum. By 1976 the total population is nearly 2.5 million. Presently about 3.5 million people are served normally. In the period June-September an additional 1-1.5 million visitors have to be supplied. By 2000 the normal population to be served is put at about 5 million.

Alexandria Water General Authority (AWGA)

AWGA obtains its raw water supply from the Mahmoudia and Noubaria canals fed from the Rosetta and Beherey branches from the River Nile.
Five water treatment plants obtain its raw water from Mahmoudia Canal.
Two water treatment plants obtain its raw water from Noubaria Canal.
The following table gives the actual capacity of the treatment plants respectively and the average daily production of AWGA in 1991.

	Actual Capacity Thousand M3/day
Rond Point	320
Siouf	560
Manchia	500
Mamoura	100
Forn El Guraya	50
Mariout	140
Borg El Arab	130
Total	1800

The (AWGA) distribution system includes 4092 km of pipeline ranging in diameter from 56mm to 1100mm, 23 booster pumping stations, 63 ground storage reservoirs and elevated storage tanks; As a part of the distribution system services AWGA supplies treated water to ships in the harbour.
The water treatment process in Alexandria water General Authority essentialy depends on metal salts aluminum sulphate in coagulation, then flocculation, precipitation, rapid filtration through sand and gravel filters and it depends on chlorine gas for disinfiction.

AWGA PLANNING CONSIDERATION

During the first developing five your plan 1982 - 1987, It was planned to double the production capacity of the water treatment plants to reach 1.5 million m3/day to cover mainly the needs of about 3 million inhabitants, putting into consideration that the increase of one million visitors more during the summer vacations.
After ensuring the covering of all needs of Alexandria city with all its requirements of potable water, great efforts were made to feed new areas surrounding Alexandria in the directions towards the east, the south and finally along the western part of the North Coast till Marsa Matrouh.
During the second developing five year plan 1987-1992, it was planned to increase the production capacity to reach 2.4 million m3/day while the expected population will reach 3.5 millions in addition 1-1.5 million visitors during summer vacations.
As the production of AWGA reached the point of covering the Alexandria requirements, efforts were increased to cover the requirements of new land reclamation projects in Behera Governorate, the new communities in Noubariah and Borg El Arab and the extension in western part of the North Coast till Marsa Matrouh which can be specified as follows:

Areas Fed from Treatment Plants in Alexandria City

(Manchia-Siouf-Maamoura)

The new reclamation areas of Khorshed and Abis, where we layed a new network of nearly 100 km for feeding about 20,000 inhabitants in more than 50 villages.
The areas on the borders of Behera Governorate such as Kom El Tarfaia, El meaddia in the east and about 30 more villages of nearly 30,000 inhabitants.

Areas Fed from Borg El Arab and Mariout Treatment Plants

Areas on the borders of Behera Governorate. Such as Kom El Farag, Abou El Matameer and other areas.

Areas in the western part of Alexandria Governorate. Such as Sidi Abdel Kader, El Nasseria, El Hawariah, King Mariout, Baheig, Borg El Arab, El Hammam and more than twenty new communities.

Areas East and West Noubaria. Feeding the areas of east and west Noubaria with potable water through new network which covers the following villages:

14 in sugar beet project
Mostafa Kamel
El Nabawi El Mohandis
Abdel Assem Abo El Ata
Osman Moharem
El Noor
El Adle
Ahmed Shawky
Abo Baker El Sadeek
Saad Zaghloul
Taha Hossein
Aly Abn Abo Taleb
Abas El Akad
Tawfeek El Hakeem
El Sheekh El Shaarawy
Hafiz Ebrahim
Abdel Meneem Road
Ahmed Refaat
El Sheekh El Ghassaly
Ahmed Ramy
El Hossein
Osman Ebn Afan
El Wafaa
El Mouroua
El Wasam
El Tadamon
El Shahama
Abd El Haleem Mahmoud
El Wehda
Ahmed Badawy
Mohamed Azaam
Mohamed Abd El Rakeep
El Shagaa.

Some of these villages were fed from compact units. These compact units were used at the early start of the reclamation projects as the only source for drinking water.
Therefore extending new networks for feeding these areas gave the following results:

Feeding inhabitants with drinking water according to the standards.
Stopping about 17 compact units with the tendency of increasing this number in the near future as soon as the new network covers the whole area.
Cancelling the plan of installing any more compact units in this area.
Stopping the side effects of using water out of standards and its positive reaction on human activities.

To give an idea about the length of the networks which covers all such rural areas.
Main network diameter 350-1500mm = 334 km.
Secondary network for the same area 100-300mm = 856 km.

Areas along the North Coast. Due to the bad quality of underground water along the North Coast because of high salinity, and due to the limited capacity of the desalination plants installed at Marsa Matrouh and the lack of experience of operation and maintenance of these plants in addition to the high expenses of running costs, therefore great efforts were made to feed the following touristic villages along the North Coast till Marsa Matrouh through a new network

Madam Nazla
Teachers
Abou Youssef
El Zohour
Six of october
El Shate El Akhdar
East Abou Talat
West Abou Talat
Silver Beach
Engineers Beach
Sidi Krir. Electric Power Station
El Dekhela Air Port
Marine forces
Sidi Krir
Kuwait Beach
Alexandria Lawyers
Education staff
Ministry of Foreign Affairs
Ramsees Beach
Republic Presedency
Borg El Arab
Marakia
Cement Factory
El Hamam
El Ballah
Marabella
Rowad touristic village
Misr El Gedida
Omayed
Gypsum Factory
Mena touristic village
Green Beach
Policemen Beach
Hodhod Beach
Marina
El Alamen
Sidi Abd El Rahman
Neuclear energy
El Dabaa
Galal
Fouka
Ras El Hekma
Grawla
Samala

The length of the network which covers this area is as follows:
Main network 350-1000mm = 394 km.
Secondary network 100-300mm = 610 km.

WATER QUALITY OF MARIOUT AND BORG EL ARAB TREATMENT PLANTS

The raw water source for these treatment plants is Noubaria canal at km 81 and km 96 respectivity.
There are several drainage canals connected to Noubaria canal as extra source for irrigation water.
The water in these drainage canals are extremely loaded with different sorts of agriculture, industrial and sewage waste which affects the quality of raw water and consequantly the quality of treated water.
These drainage canals which discharge their waste along Noubaria Canal at Kilometers 29,51.7, 62.5, 72.5, 85 respectively from the intake increase the total dissolved salids as shown in Fig. 1.
Also increase other pollutants in the raw water and consequantly in the potable water either before or after chlorination.

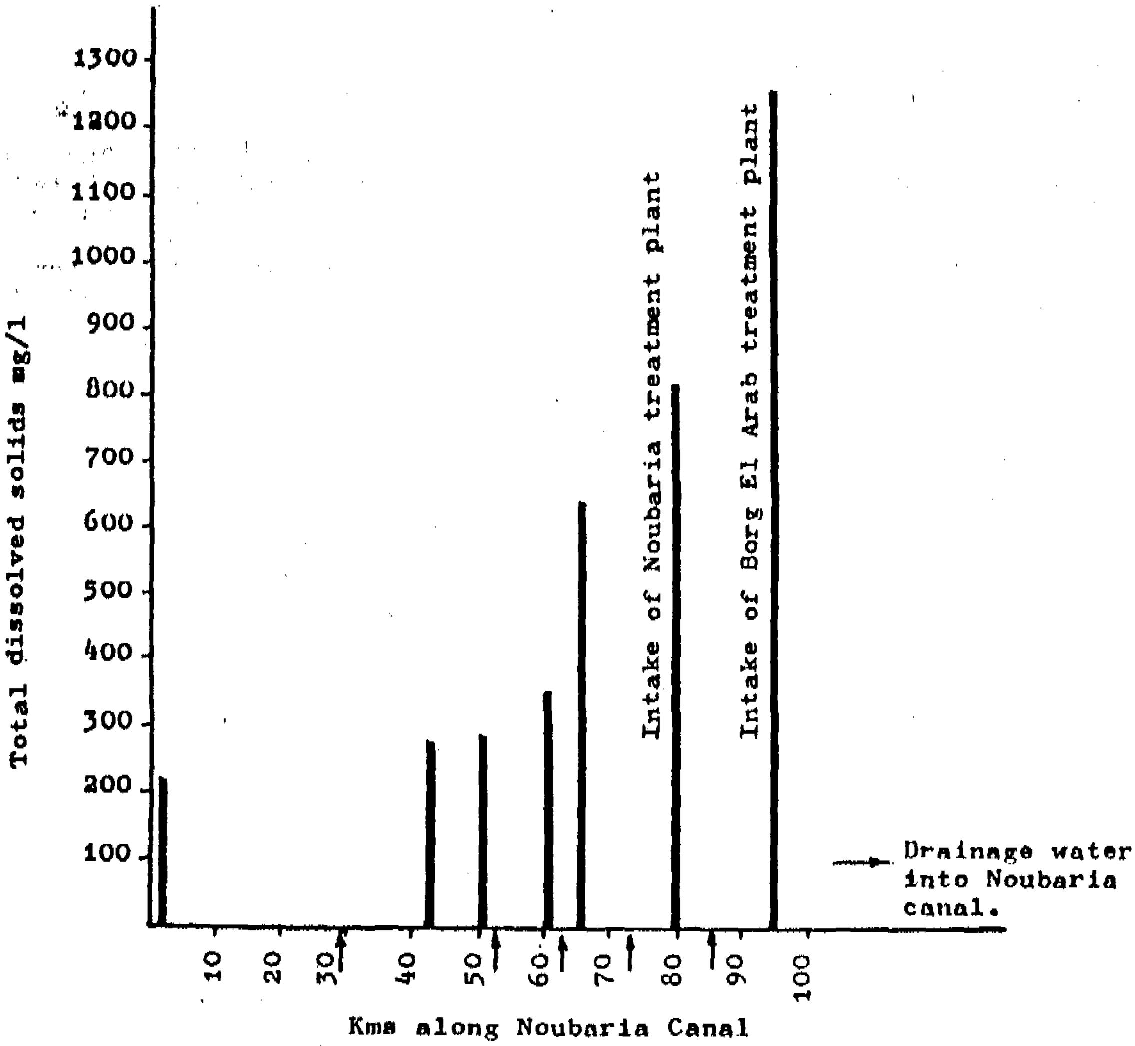


Fig. 1. Increase in total dissolved solids due to the discharge of drainage water into Noubaria canal.

Total dissolved solids (TDS) of potable water in Alexandria Water treatment plants (Rond Point, Siouf, Manchia, Maamoura, Forn El Guraya) ranging from 220 to 400 mg/1.
Total dissolved solids of potable water in Mariout treatment plant ranging from 400 to 800 mg/1 along the whole year except the time of January and the first half of February where the feeding of raw water stops for maintenance of irrigation network where the TDS increase to reach more than 1000 gm/1.
Total dissolved solids of potable water in Borg El Arab treatment plant ranging from 700-1100 mg/1 along the whole year except the time of January and first half of February where the TDS increase to reach more than 1500 mg/1 as shown in Fig. 2.

Th
of

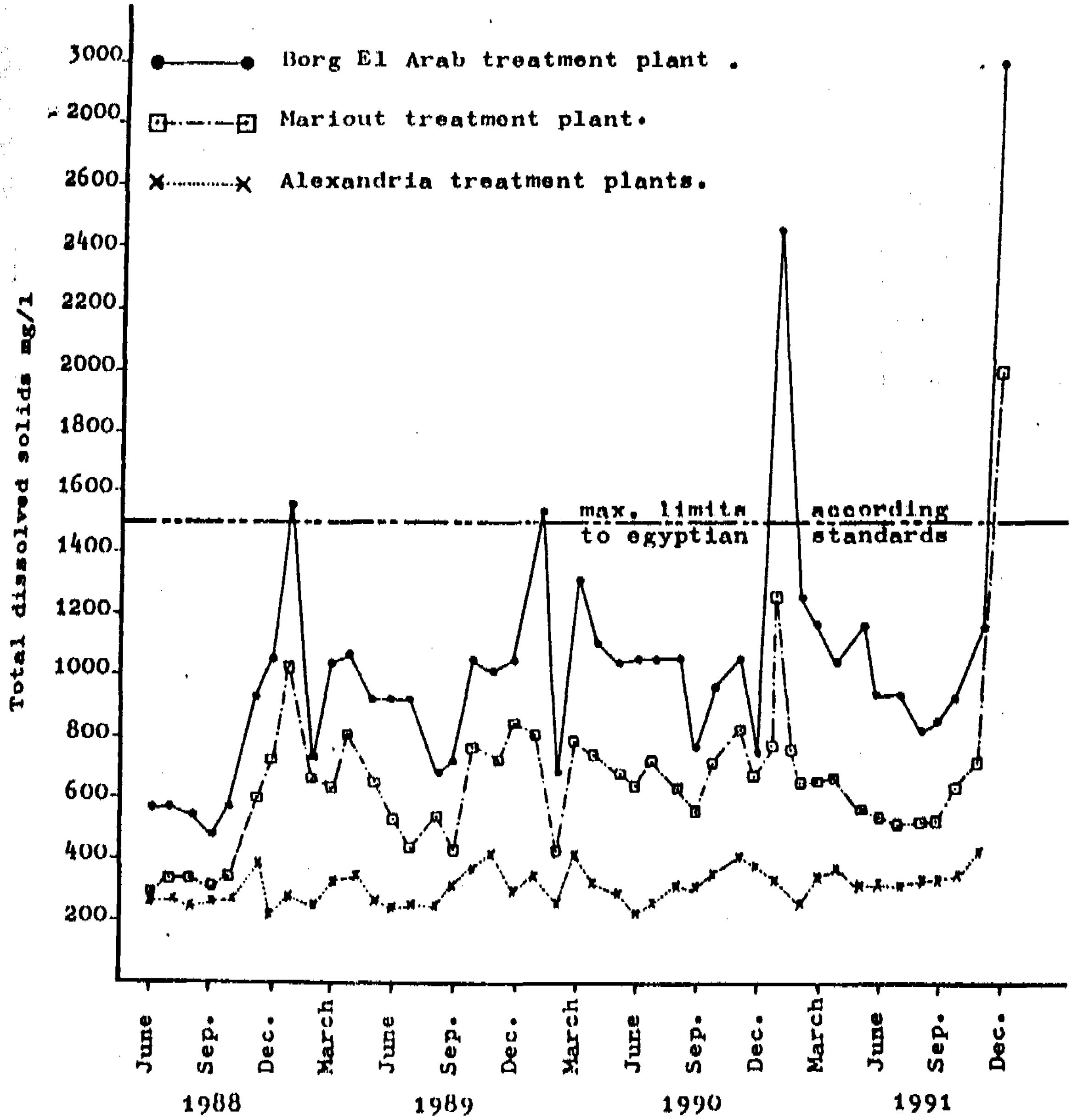


Fig. 2. Comparison of total dissolved solids of potable water at Borg El Arab, Mariout and Alexandria treatment plants during the period 1988 - 1991.

The level of total hardness, chloride and sulphate in the potable water of Borg El Arab treatment plant is shown in Fig. 3.

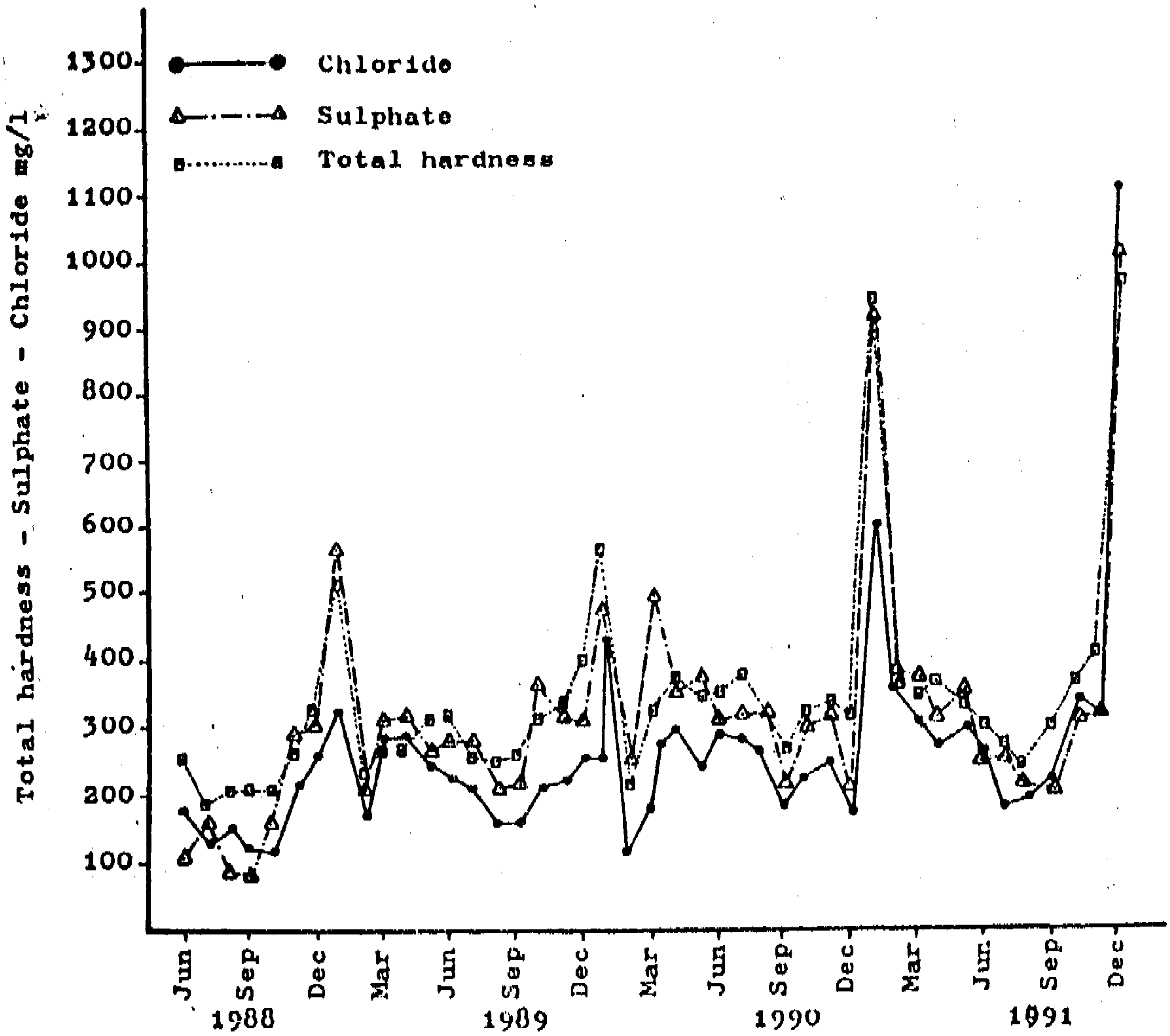


Fig. 3. Levels of total hardness, Chloride and Sulphate in potable water of Borg El Arab treatment plant.

Also Fig. 4. shows the increase of chemical oxygen demand COD (dichromate reflux method) in the raw water feeding Borg El Arab treatment plant.

Due to the increase of all these parameters in the raw and treated water of Borg El Arab treatment plant compared with raw and treated water of Alexandria treatment plants.

Changes in taste and odour become a major problem which required the use of activated carbon at some intervals leading to the increase of treatment expenses.

Increase of total dissolved solids which affects to a large extent the quality of the water feeding the industrial area, leading to enormous production problems.

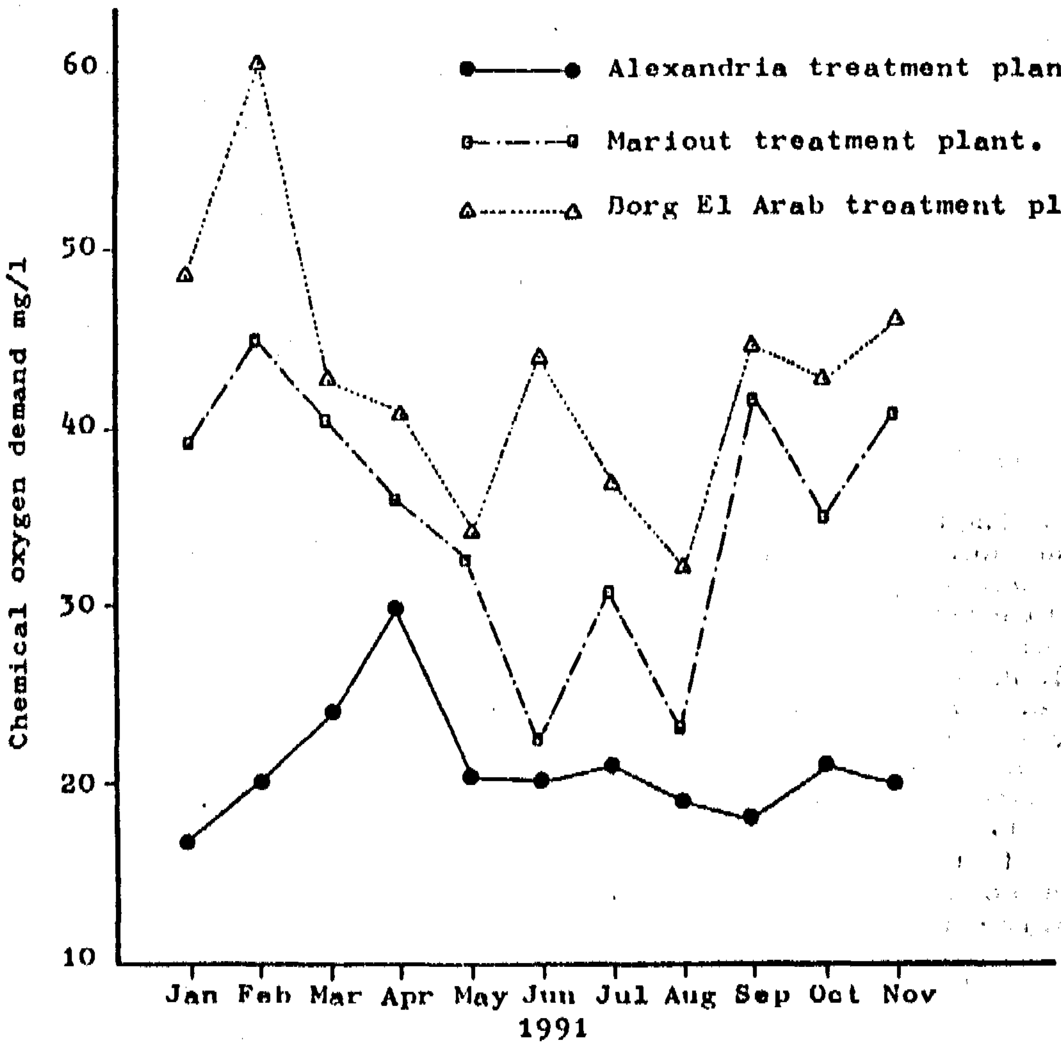


Fig.4. Comparison of mg COD/L of raw water feeding Borg El Arab, Mariout and Alexandria treatment plants.

Because of the increase of irrigation requirements to cover the great extension in reclamation projects, the planned scheme is aiming to use more drainage water in Noubaria Canal with a quantity ranging from 3 to 4.2 million m3/day by transferring all the drainage water of Behera Governorate from Al-Omoum drainage canal to Noubaria Irrigation Canal, which affects to a large extent the quality of the raw water in Noubaria Canal.

CONCLUSION

The continuation of adding more drainage water to Noubaria Canal will affect the quality of the raw water to such an extent which goes beyond the limits of the standard specifications.

RECOMENDATION

Therefore, to secure the raw water resources in Mariout and Borg El Arab plants great efforts must be taken for the construction of a new Canal specially for drinking water starting from a point just before km 46 along Noubaria Canal with assurances from Ministry of irrigation not to connect any drainage canals before such new intake.

A REVIEW OF A NEW PROSPECTIVE OF WATER SUPPLY FOR SMALL COMMUNITIES BY DESALINATION

S.H. Eissa and M.A. Khedr

Chemical Engineering and Pilot Plant Dept.,
National Research Center, Cairo, Egypt

ABSTRACT

In Egypt, thousands of small communities are scattered in rural areas where conventional water sources are rare. Means for continuous supply of clean water are vital. Desalination of local saline water supplies such as brackish and sea water, appears to be a promising supplementary source for natural fresh water. Conventional plants of either multi-stage flash evaporation or reverse osmosis are not recommended for rural areas. As an alternative for small capacities, a new prospective method for water desalination is nowadays under investigation which consists of humidification followed by dehumidification of an air stream. Owing to the use of below-boiling temperatures and ambient pressure the process device is of simple construction and may be made entirely of inexpensive materials. The object of this article is to summarize some developments in desalination by this technique in order to emphasize the merits of its application for water supply in rural areas.

KEYWORDS

Humidification-dehumidification desalination process; water desalination using waste heat; solar-powered desalination process; non-conventional desalination process; evaporation process for water-desalination.

INTRODUCTION

Water demand in Egypt is growing in accordance with the vast population growth and the implementation of industrial and agricultural projects. Hence, there is an urgent need to increase the rate of development of water resources.

A considerable fraction of the population, however, still remains in villages which are nearly scattered, and many of them had either no nearby source or had depleting sources of potable water. The basic requirements of fresh water for domestic needs in these small communities could be estimated fairly well around 2-20 m^3/day. The basic problem in getting low-cost Nile River water is the limited capacity and necessity of a long transmission line which would require a large investment in capital.

Desalination of a local saline source, such as brackish or sea water has imposed itself as a viable alternative water resource, and existing small capacity units would match the increasing demand on the supply. Currently desalination plants, such as MSF and RO could not be in agreement with rural areas as the cost would be exorbitant. The philosophy of the present paper is to offer a view to a new issue for desalinated water supply to those communities.

THE PROPOSED SOLUTION

Research carried out over the last 25 years has increased in the study of a new concept that appears suitable for this typical case. This new technology is basically a unique and innovation distillation process operating at temperature below-boiling and ambient pressure. The process, which is well founded on basic thermodynamic principles, involves a series of highly efficient energy conserving heat and mass transfer steps that occur simultaneously to cause evaporation and condensation of water feed stream. The humidification-dehumidification (H-D) desalination process can be visualised simply as a process of bringing unsaturated air into contact with warm salt water, under such conditions that a desired humidity is reached. Fresh water is then obtained by cooling the saturated air-vapor mixture to a temperature below its dew point. The process loop may be represented diagrammatically as in Fig. (1). it consists of a heating source, simulating solar collectors or any auxiliary heat addition, to heat the salt water, and the humidifier-dehumidifier assembly. The remainder water in the humidifier is recirculated and portion of it should be blown down due to excessive concentration and make up of salty water should be introduced.

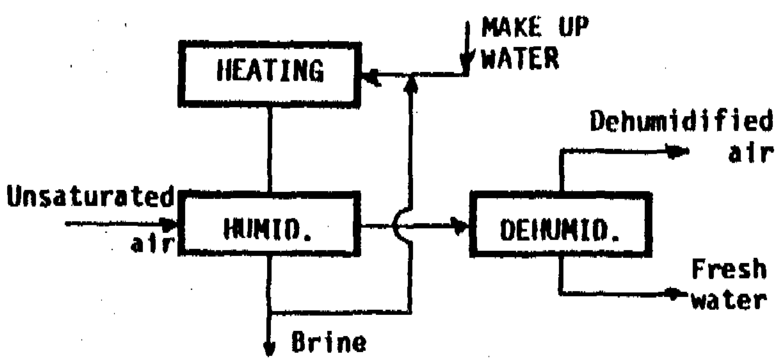


Fig. 1. A block diagram for (H-D) desalination process.

OPERATION PARAMETERS

Preliminary studies (Garg et al., 1967a,b; Gahin et al., 1980) has been undertaken in the early stages of the development and operation of the H-D desalination technique. The studies concentrated on the evaluation of different operation parameters to obtain sufficient informations for the performance of the combination of different components in such a loop. The principal variable parameters are temperature gradient in humidifying and dehumidifying columns, water to air ratio in the humidifier, and of course the heat input. These parameters have major effects on the recovery heat ratio (condensed energy/input energy), and consequently on the water productivity and the performance ratio.

As expected, the water productivity increases with the increase of heat input for all water to air ratio. Also, it was reported that for the same heat input higher water to air ratio increases the water productivity. However, it should be noticed that the water to air ratio has to be carefully choosen to get optimum productivity without increasing the air velocity to the extent of carrying over saline water with it, resulting in the contamination of fresh water with salts. In most experiments, it was noticed that the water evaporated is almost double the water condensed. This leads to consideration of the use of more than one effect, or recirculation of the air in the humidifier.

As mentioned above, the process operates at a temperature below-boiling (40-80°C max.) which are typical values of heated water using solar collectors. The current state-of-the art of desalting water with solar energy was presented by several investigators (Grune, 1970; Hanada, 1977; Taylor, 1977; Takeushi, 1978a,b and Yanagii, 1978). It was reported that the system can produce as much as 5 times the water produced by solar still of the same solar collecting area. Yet, further work is necessary to prove the applicability and the economy of using solar collectors with or without heat storage tanks. Using a heat pump (Busweiler et al., 1983) as energy supply was not well adapted to the conditions of desalination process, unless a better design of the heat pump might effect a further reduction of the energy reduction.

SELECTED PROCESS DESIGN IMPROVEMENTS

The main object for developments is to lower the cost of desalted water through:

- Investment costs by:
  a) Reduction of total heat transfer area.
  b) Reduction of the required equipment of a total unit.

- Energy costs by:
  a) Lower energy consumption due to the possibility of a higher gain ratio.
  b) Reduction of heat transfer area fouling.
  c) Applying low temperature external heat.

A brief description of recent developments in H-D desalination is given below, and the different items of the developments are summarised in Table (1),

TABLE 1 Summary of the Different Items of Improvements

Main features of improvements	Systems as described: Mehta	Madani	El-Dessouki	Larson
- Investment costs:				
a) Reduction of total heat transfer area	X	X		X
b) Reduction of the required equipment for total units	X		X	
- Energy costs:				
a) Lower energy consumption		X		X
b) Reduction of heat transfer fouling		X	X	X
c) Applying low temperature external heat	X	X	X	X

Improvements have been brought about by Mehta (1972) by making use of an air recycling system in which air coming out from the dehumidifier is recycled to the humidifier (Fig. 2). The advantages obtainable by this system consist of a more than 20% reduction in the packed height of the humidifier and more stable operation of the plant. Cost calculations show that the use of air recycling gives a cost reduction of nearly 7% in capital investment.

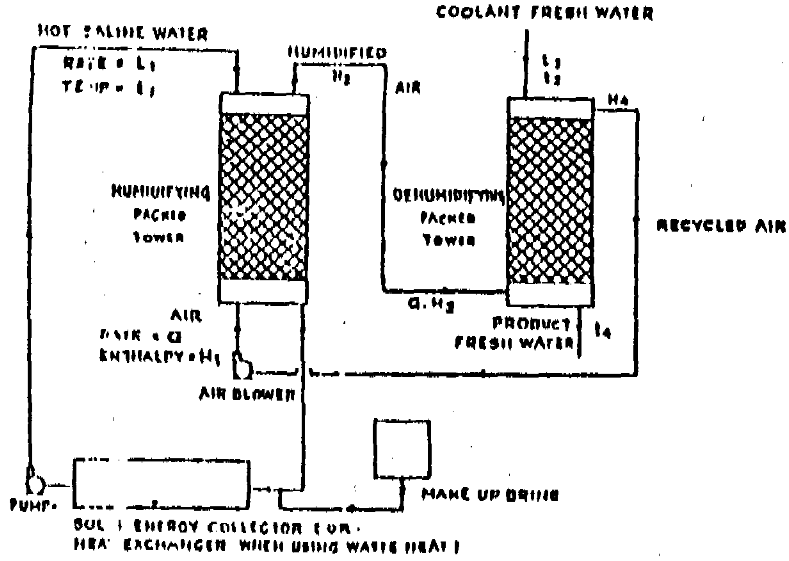


Fig. 2. Diagram of the H-D technique (closed system).

Small scale water producing unit was also suggested by Madani et al. (1989) and was investigated on the basis of experimental data generated by testing a pilot unit, shown in Fig. (3). Modifications to the dehumidification section have been proposed which consist of two gravity assisted heat pipes and a double pipe heat exchanger. The heat pipes were integrated to the system to benefit from their high values of heat transfer coefficient (Dunn et al., 1978). However, experimental results showed that they did not contribute much to the dehumidification process which was attributed to the unsufficient contact between air and heat pipe's evaporating section fins. A design for a practical unit, producing 1.5 m³/day to 5 m³/day according to the variation in climatic conditions - throughout the year - was performed and the calculated water cost ranged from 1.9 to 6.9 $/m³ fresh water.

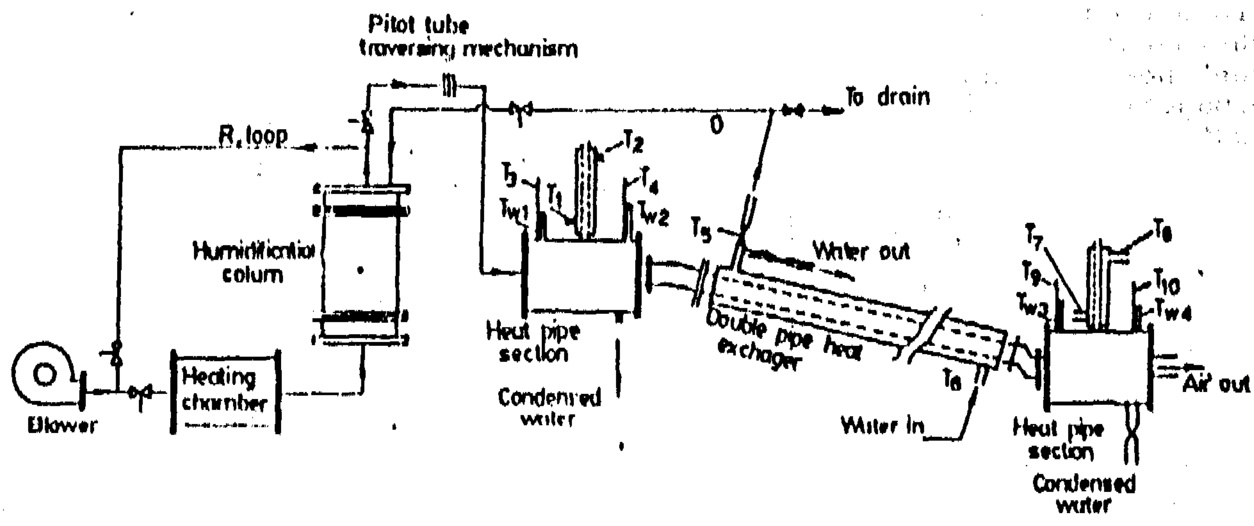


Fig. 3. Dehumidification using heat pipes.

The use of gas turbine waste heat in water desalination reduces approximately 30% of water production costs (Tadross, 1982 and Shawly et al., 1983). Initiated by this result, another possible installation, shown in Fig. (4), presented a multi-effect H-D process coupled with a gas turbine power plant (El-Dessouki, 1989). Air is used as operating fluid instead of water by directly heating when mixed with the flue gases. The desalination unit is composed of three main components:

- The cooling tower, where fresh water is cooled by furnishing part of the latent heat required to vaporize some of the water into incoming air, thus reducing the load on the humidifier.
- The humidification units where the air-flue gas mixture of high temperature is cooled and humidified by contact with recirculated salt water.
- The dehumidification tower where fresh water is obtained by cooling the water vapor-gas mixture as it comes in contact with the cold and fresh water coming from the cooling tower.

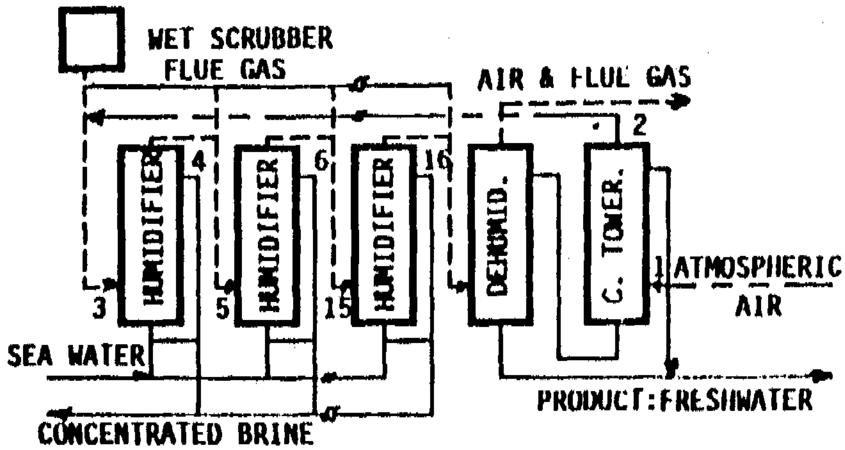


Fig. 4. H-D desalination using waste heat.

A carrier-gas process (Larson *et al.*, 1989) was recently proposed by Evcon Corporation in U.S.A. Basically, the device consists of two chambers - one for evaporation and one for condensation - separated by a common heat transfer wall. Saline water is introduced into the evaporation chamber, one surface of which is the heated wall, causing pure water to evaporate and be carried by a circulating carrier gas, usually air. The air-vapor mixture is then directed to the condensation chamber, after being slightly heated by an outside heat source, where it cools by heat transfer through the common wall, resulting in condensation of the vapor and giving up its heat of condensation to the evaporation chamber causing further evaporation. In a proposed production device (Fig. 5), multiple evaporation and condensation chambers are connected alternatively. This arrangement allows doubling the heat transfer surface available within a chamber (increasing production and improving the efficiency) with little increase in capital cost.

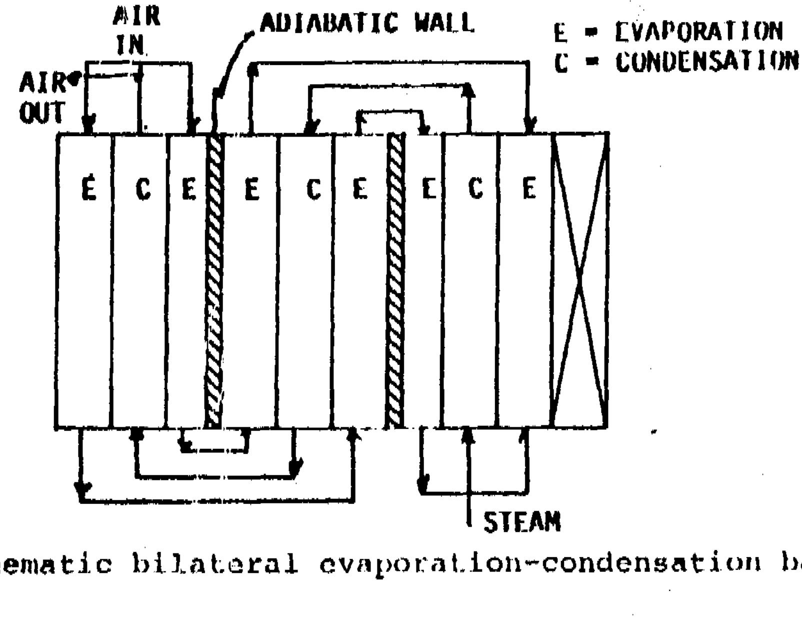


Fig. 5. Shematic bilateral evaporation-condensation battery.

ATTRACTIVE FEATURES OF H-D PLANTS FOR RURAL AREAS

New cost effective and environmentally acceptable technology is required to satisfy the water supply requirements. The H-D desalination process, now under development, appears to have significant potential in this regard, especially for remote and rural areas.

Based on extensive research and work as discussed earlier, the attractive features of such technique may be summarized as follows:

1. The process is simple and flexible operating without sophisticated parts which makes this concept so outstanding. This simplicity implies ease of service and improved chances of successful operation without expert training.
2. Temperature and pressure are so low that simple materials can be used and the unit can be locally produced, easily and economically without call for foreign aids.
3. Most of the feed water pretreatment operations is not required since there is no corrosion of metallic heat transfer surfaces as direct contact is used in all units.
4. The system can operate over a wide range of temperatures, which allows utilization of many waste and conventional heat supplies which may be the only significant source of energy at reasonable costs.
5. A simple construction might be integrated into a greenhouse for space conditioning. The exit air has a dry bulb temperature near that of atmospheric air, and still relatively higher in humidity. This would result in the production of high quality food in addition to water.

REFERENCES

Busweiler, U. and Kast, W. (1983). Theoretical and experimental investigation of an evaporation process for desalination of sea water. Ger. Chem. Eng., 6(4), 256-263.

Dunn, P.D. and Reay, D.A. (1978). Heat Pipes, 2nd ed., A Wheaton and Co., GB.

El-Dessouki, H.T.A. (1989). Humidification-dehumidification desalination process using waste heat from gas turbine. Desalination, 71, 19-33.

Gahin, S., Darwish, M.A. and Ghazi, M.A. (1980). Solar-powered H-D desalination process. Proc. Int. Symp. Fresh Water Sea, 7th, 2, 399-406.

Garg, S.K., Mehta, M.H. and Datta, R.L. (1967). Conversion of sea water into pure water for boilers and other industrial purposes. Seminar on Water Treatment for Industries, Ind. Chem. Manuf., Bombay.

Garg, S.K., Mehta, M.h., Gomkabe, S.D. and Datta, R.L. (1967). Experience in the operation of H-D technique of water desalination. Conference on Water Desalination, Bhavnagar.

Grune, W.N. (1970). Multiple Effect Humidity Process. 3rd Int. Symp. Fresh Water Sea, 1, 655-668.

Hanada, K. (1977). Jap. 77,129,674, C.A. 89, 1978, 48752.

Larson, R., Albers, W., Beckman, J. and Freeman, S. (1989). The carrier-gas process - a new desalination and concentration technology. Proc. of 4th World Congress on Desalination and Water Reuse, 1, 119-138.

Madani, A.A. and Zaki, G.A. (1989). Prospective of two small water production units. Proc. of 4th World Congress on Desalination and Water Reuse, 1, 167-180.

Mehta, M.H. (1972). Humidification-dehumidification with air recycling for water desalination. Indian Chem. Eng., 14, 3-7.

Shawly, A., Girgis, F., Kreuzer, A. and van Loebbecke, D. (1983). Gas turbine a major factor to reduce capital and operating costs for dual process desalination plant. Desalination, 44, 17-27.

Tadross, S.K. (1982). The efficient production of electricity and water in cogeneration systems. Desalination, 38, 99-108.
Takeushi, T. (1978). Jap. 78,32,876, C.A. 89, 1978, 185870.
Takeushi, T. (1978). Jap. 78,32,877, C.A. 89, 1978, 185871.
Taylor-Floyd, B. (1977). Plumbing Eng., 5(3), 34-35, 37-38.
Yanagii, H. (1978). Jap. 78,02,385, C.A. 89, 1978, 48757.

ASSESSMENT OF WATER QUALITY IN RURAL AREAS (ATTRICE, GIZA)

S. EL-Hawaary, M.M. Kamel, M.A. Ali
and Gamila E. Mohamed
Water Pollution Control Dept. N.R.C. Dokki, Cairo Egypt.

ABSTRACT

A total of 58 water samples were collected from 15 hand pumps and one public drinking water supply from one of Giza villages, in an attempt to evaluate the microbiological quality of these water sources. Samples were tested for total bacterial counts, total and faecal coliforms (TC & FC), faecal streptococci and coliphages. In addition, Salmonellae, Staphylococci and yeasts were also enumerated by the membrane filter technique. Samples showed cytopathic effect (CPE) in the third passage were considered virus bearing samples. With the exception of the public water system, after flushing the storage tank and the main pipe line and regular operation of the system, all tested water sources contained some hazardous microorganisms. Pollution control measures, to protect water resources must be condsidered.

KEYWORDS

Biological indicators, coliforms , faecal streptococci, coliphage, pathogenic microorganisms, ground water.

INTRODUCTION

The most common and widespread hazard associated with drinking- water is the contamination; either directly or indirectly by sewage and /or animal excrements. The drinking of water so contaminated or its use in the preparation of certain foods may result in dangerous cases of infections (Geldreich, et al; 1972; Benarde, 1973 and Crane, et al. 1983).

Faecal pollution of drinking water may introduce a variety of intestinal pathogens as bacteria, viruses and parasites (Pierce and Hirschhron, 1977 and Blake, et al., 1980). The density and widespread of these pathogens reflect the nature of microbial diseases prevailing in the community. Consequently, the primary prevention measure to control gastrointeritis and other waterborne diseases in the community is the establishment of water supplies free of contamination and easily available as the sole source for drinking and other municipal uses.

Interruptions in safe water supplies, as a result of frequent practice of rotating or intermitent service, often result in contamination of drinking-water supplied to consumers. Furthermore, when piped safe water is not available, the population mostly resort to use other water sources which may not be bacteriological safe.

In rural areas especially villages, the situation is further complicated, since water sources are continuously subjected to hazardous contaminants derived from pollution of water resources by agricultural wastes, sewage disposal manners and manure applications (Crane, et al., 1983 and EL-Hawaary, 1983).

This investigation is an attempt to assess the bacteriological characters of drinking water sources in one of Giza villages, as a part of the Integrated Rural Development program sponsored by the National Research Centre, Cairo,Egpyt.

MATERIALS AND METHODS

The area of study is about 50 Km. North-west EL-Giza city. The village is located in-between Rosetta branch of Nile River and Riah EL-behori about 10 Km from the latter. The economy of this village is based on agriculture.

Water samples were collected on a monthly basis (late summer and autumn 1990) under aseptic conditions from the sources of drinking water used by the village residents (about 2000 or more). The most important source is a small governmental public water supply system, where ground-water (below 50 meters) is pumped into 25 cubic meter storage tank, connected to the distribution system without any treatment. The second water source is the hand pumps (20 meters depth) which are distributed within and arround the village. For bacteriological analysis water samples, were collected in 1 liter sterilized glass bottles. For virus examination, samples were collected by using the continuous flow swab sampler (CSS) (EL-Hawaary et al.,1987), where fifty liters of each sample were passed through a sterile cotton swab (4m x 15 cm). The CSS and the inside guaze were returned undrained to the laboratory for further processing. All the collected samples were transported to the laboratory under chilled conditions wihin 3-4 hours from collection.

Bacteriological Analysis

Poured plate counts were carried and incubated at 37°C and 22°C in duplicate plates for 24 and 48 hours respectively, for total bacterial counts. Total coliforms (TC), faecal coliforms (FC) as well as faecal streptococci MPN per 100ml were conducted according to APHA (1985), using 10-replicates fermentation tubes (FT10) procedure. Salmonellae, staphylococci and yeasts were enumerated using the membrane filter technique and their specific media as described by EL-Hawaary and Khairallah (1987).

Coliphage Assay

Coliphages were enumerated using the procedure described in Section 919C of the Standard Methods (APHA, 1985).

Enteroviruses Assay

Gauze and associated water concentrate, inside the CSS, were transferred into a sterile wide mouth bottle (2 liters) containing 100 ml alkaline eluent (3% beef extract PH 9). Gauze was squeezed twice after rewetting in the squeeze. Extracted squeeze was aspirated into a sterile graduated container. Another extraction in 100 ml alkaline eluent was carried out and added to the first extract, mixed, neutralize to pH 7-7.2 by 1N HCl, as soon as possible and completed to 300 ml with sterile tap water. Samples concentrates were filter sterilized and stored at -20° C for cell inoculation within 48 hours. Concentrates were inoculated into 25 cm^2 flasks (1 ml per flask) of African Green Monkey Kidney (AGMK) cell line (Vero), three flasks for each sample.

All samples were subjected to three "blind" passages on the same cell line and observed daily for 10 days for *cytopathic effect* (CPE). *Positive results were considered for samples which showed CPE in the third passage*, and for source when showed at least 2 CPE positive samples.

RESULTS

All of the tested water samples (58) showed an average value of 10^2 per 1ml for total bacterial counts either at 22°C or 37°C. In some cases, total bacterial counts reached more than 10^3 at its highest levels or reduced to undetectable numbers per one ml in other cases. Biological indicators, i.e total and faecal coliforms, faecal streptococci [MPN / 100 ml] and coliphages [PFU /100 ml], ranged between undetectable numbers and 10^2 per 100 ml (Table 1).

Salmonellae, total staphylococci and yeasts were commonly detected in all the tested water samples, with one or two exceptions for each parameter, as the counts reached 10^2 per 100 ml, on the average (Table 1 & Table 2). Great reduction in total bactorial counts and in all the tested parameters were noticed after *flushing of the public water system* (Table 2). *According to WHO recommendations* (1984), *the frequency of acceptability* of untreated ground water based on the analysis of 3 successive samples are indicated in Table (3) for all tested sources. Acceptable source must show, at least, two successive satisfactory results. According to this table, sources no. 1, 5, 14 and 16 in addition to the public system are considered safe sources for drinking.

Detailed results of these water sources (Table1) indicate the presence of Salmonellae, staphylococci, yeasts and coliphages in source no.1, Sources no. 14 &16 are free from viruses by using 50 liters samples and the available technique, meanwhile other organisms were detected. Furthermore,Salmonellae and viruses were undetectable in source no. 5.

DISCUSSION

Drinking water can act as a vehicle of transmission of number of serious diseases (Robeck, 1969; Payment & ELLis, 1985 and Sim & Dutka, 1987). Consequently, bacteriological quality of water, as controlled by the Egyptian standard or according WHO guidelines, is of paramont importance.

In addition to the parameters recommended by the previously given standards as indicators of faecal pollution, other criteria such as streptococci and coliphages have to be considered. Other microorganisms

Table 1. Microbiological quality of the tested hand pumps*.

Source	Total viable count/1ml at 22°C	Total viable count/1ml at 37°C	Indicators of pollution MPN /100ml: Total Coliform	Faecal Coliform	Faecal Strep.	Coliphage PFU per 100ml	Pathogenic organisms/100 ml: Total Staphylococci	Salmonellae	Total yeasts	Virus Incidence
1	108	91	9.7	7.7	BD	20	6.7	2.0	530	+
2	119	99	15	15	BD	45	170	1.0	32	+
3	160	97	15	15	BD	150	406	4.0	190	-
4	130	120	18	14	0.3	230	29	2.0	900	-
5	14	10	2.0	BD	BD	22	21	BD	590	-
6	110	64	16	5.7	0.6	370	89	26	430	-
7	27	17	23	23	15	1.0	550	1.0	980	+
8	130	102	23	13	2.7	213	35	2.0	12	+
9	180	51	21	14	BD	47	m	m	m	-
10	120	102	23	21	BD	350	580	10	84	+
11	210	74	23	23	8.0	81	BD	1.0	280	-
14	39	27	9.3	1.8	2.0	m	18	0.3	42	-
15	880	490	2.3	4.7	1.0	m	16	1.0	670	-
16	38	65	1.0	BD	0.3	m	15	0.3	210	-
17	940	890	23	19	0.7	m	140	1.3	620	-

* Average Values of three Successive Samples
m Missed result
BD Below detection limits

Table 2 Bacteriological quality of the governmental public water system befor and after flushing*

Treatment	No. of Samples	Total viable count/1 ml at:- 22°C	37°C	Indicators of Pollution MPN / 100ml TC	FC	FS	Coli-phage PFU per 100 ml	Total staphylococci per 100 ml	Total yeasts per 100 ml
Befor flushing	2	4.7×10^2	4.9×10^2	2x10	5	3	2.7×10^2	0	1.5x10
After flushing	5	1.2x10	1.4X 10	BD	BD	0.4	1.2x10	0	0
Distribution system	6	BD	BD	0.2	BD	0.2	3	0	0

* Average values of three successive samples.

BD bellow detection limits

Table 3 Frequency of acceptability of Public water System and Private hand pumps according to WHO guidlines (1984)

Source / Acceptability	Public System	Private hand Pump. No. 1	2	3	4	5	6	7	8	9	10	11	14	15	16	17
Satisfactory	11	2	1	1	0	3	1	0	0	0	0	0	2	0	3	0
unsatisfactory	2*	1	2	2	3	0	2	3	3	3	3	3	1	3	0	3

* the two Samples were collected before flushing the Public water Subbly System.

such as Salmonellae staphylococci and yeasts are also of special significance. Moreover, virus detection was attempted using a rather simple and efficient technique; which revealed the presence of enteric viruses in five sources representing 33.3% of the tested hand pumps.

The significance of virus detection was varified by its presence in water derived from hand pump. No.1. whereas the same sample was free from faecal streptococci which is considered a good indicator of faecal pollution (Geldreich and Kenner, 1969; Slade, 1985 and EL-Hawaary and Khalafalla, 1987). However, total coliforms (TC) and faecal coliforms (FC) were detected only once during the three successive water samples from that source. In addition most of the samples showed high densities of several pathogenic forms such as Salmonellae yeasts and/or staphylococci even in water samples recorded as bacteriological safe according to the conventional standards. Consequently, microbiological examination of drinking water should be extended to include microorganisms liable to affect public heath.

CONCLUSION

Bacteriological analysis of water sources should be based on a battary of bioindicator, and not only on the classical indicators of pollution. In addition, pollution control measures must be taken to protect water resources especially in case of ground water which represent an important source in rural areas.

ACKNOWLEDGEMENTS

The authors are greatly indepted to prof. Dr. F.EL-Gohary, prof. of water pollution, Water Pollution Control labs. for her valuable support and help.

REFERENCES

APHA (1985). Standard methods for the examination of water and wastewater. 16 th ed. American Public Health Association , Washington D.C.

Benarde, M.A. (1973). Land disposal of sewage effluents: appraisal of health effects of pathogenic organism. J. Amer. Water Works Ass., 65, 432-440

Blake, P.A., Weaver, R.E. and Hollis, D.C. (1980). Diseases of humans (other than cholera) caused by vibrios. Annual Review of Microbiology, 34, 341-367.

Crane, S.R., Moore, J.A., Grismer, M.E. and Miner,J.R. (1983). Bacterial Pollution from agricultural sources. A review Transection of the Amer. Soc. Agr. Eng., 26 (3); 858-866

EL- Hawaary, S.E. (1983). Determination of water quality at Damiotta Province. Final Report PR 5-1-4-1981, N.R.C. Wat. Poll. Control lab. Ciro Egypt.

EL- Hawaary, S.E. and Khalafalla, G.M. (1987). Resistance of bioindicators to chlorination during wastewater treatment. Assult Vet. Med. J., 18; 166-171.

EL- Hawaary, S.E Sokkar, I.M., Ali, M.A. and Khalafalla (1987). Viruses in treated effluents. I.Drinking water. J. Egypt. Pub. Health Asso., LXII; (5,6), 301-314.

ELLis, J.B. (1985). Water and sediment microbiology of Urban Rivers and their public health implications. Public Health Engineer 13,(2), 95-98.

Geldreich, E.E. and Kenner, B.A. (1969). Concepts of faecal streptococci in stream pollution. J. Water Poll. Control Fed. 41, 336-352.

Geldreich, E.E. Nash, H.D, Reasoner, D.J. and Taylor, R.H. (1972). The necessity of controlling bacterial populations in potable waters, community water supply. J. Am. Water Works Assoc., 64, 596-602.

Kittrell, F.W. and Furfari, S.A. (1963). Observation of coliform bacteria in streams. J. Water Poll. Control Fed., 35, 1361-1365.

Payment, P. (1981). Isolation of viruses from drinking water at the Pont-Viau water treatment plant Can. J. Microbiol 27 , 417-420

Pierce, N.F. and Hirschhorn, N. (1977). Oral fluid : a simple weapon against dehydration in diarrhea. WHO Chron., 31, 87-93.

Robeck, G.G. (1969). Microbial problems in groundwater. Ground water 7, 33-39.

Sim, T.S. , and Dutka, B.J. (1987). Coliphage counts: are they necessary to maintain drinking water safety. Mircen J. Appl. Microbiol. Biotechnol., 3, 223-226.

Slade, J.S. (1985). Viruses and bacteria in a Chalk well. Wat. Sci. Tech., 17, 111-125.

WHO (1984). Guidelines for drinking-water Quality. Vol.1 Recommendations. World Health Organization, Geneva.

PATTERNS OF WATER QUALITY IN RURAL AREAS OF ASSYUT GOVERNORATE

Ruud J.P.M. Platenburg*, Magdi Zaki **

** IWACO B.V., Dutch Consultants for Water and Environment,
P.O. Box 8520, 3009 AM Rotterdam, The Netherlands
** United Nations Children's Fund (UNICEF),
8 Adnen Omar Sidky St, Dokki, Cairo, Egypt

ABSTRACT

In 1990-1991 an action-research programme in the field of rural water supply and sanitation was implemented with the objective "To assess to what extent childhood diarrhoea is reduced by the delivery of hardware facilities which improve water quality, water availability and excreta disposal, and also including an intensive educational package directed toward improving behaviours concerning water use and personal and domestic hygiene".

The intervention in Assyut Governorate comprising the construction of handpumps and latrines and a health education programme, was implemented during the second half of 1990. The data collection and data evaluation have been carried out during the period 1990-1991. Data were collected from the villages served with a complete intervention package as well as in control villages.

This paper deals mainly with the water quality issues which were part of the research programme. A comparison is presented for the water quality from both traditional and new handpumps. This comparison is supported by data collection throughout the research period within certain intervals, and by data collected from other handpumps installed at earlier times in areas within Upper Egypt. Findings concerning the actual drinking water quality, and the quality control of intervention and monitoring procedures are also discussed.

Major conclusions drawn from the results of the monitoring programme are:

- The design, the drilling method and a proper development of handpump wells play an important role in the quality control of its water.
- The bacteriological water quality improves only gradually after construction and eventually reaches acceptable levels. However, deep groundwater is thought to be of bacteriologically excellent quality. The most probable explanation for this gradual improvement is therefore the relatively long survival times of bacteria that entered the wells during construction.
- Although it is not the intention of this paper to discuss the behavioural changes in the village communities during the research period, it was observed that, while water quality from handpumps are improving with time, the water quality from in house zirs (storage reservoirs for drinking water) remained poor.

KEYWORDS:

Public health, rural water supply, handpump, water quality, faecal coliform, contamination

INTRODUCTION

Diarrhoeal illness is a major cause of both morbidity and mortality among young children in Egypt. Preventive actions to reduce the incidence of diarrhoea in young children have been carried out by UNICEF in conjunction with the National Diarrhoeal Disease Control Project, implemented by the Egyptian government. UNICEF has, for nearly ten years, conducted a programme for provision of safe water and family latrines to remote populations of Upper Egypt. During the next two years UNICEF plans to intensify this effort and will integrate an intensive programme of water hygiene education with the provision of India *Mark II handpumps* and family pit latrines to other remote areas of Upper Egypt not yet served by the UNICEF programme.

Within the 1990-1994 Plan of Action for the Village Water Supply and Sanitation Programme of Upper Egypt, a large scale combined intervention/research programme was planned aimed at evaluating the impact of UNICEF water supply and sanitation programmes in two districts of Assyut governorate (figure 1). The main objective of the action-research programme is: "To assess to what extent childhood diarrhoea is reduced by the delivery of hardware facilities which improve water quality, water availability and excreta disposal, and also including an intensive educational package directed toward improving behaviours concerning water use and personal and domestic hygiene".

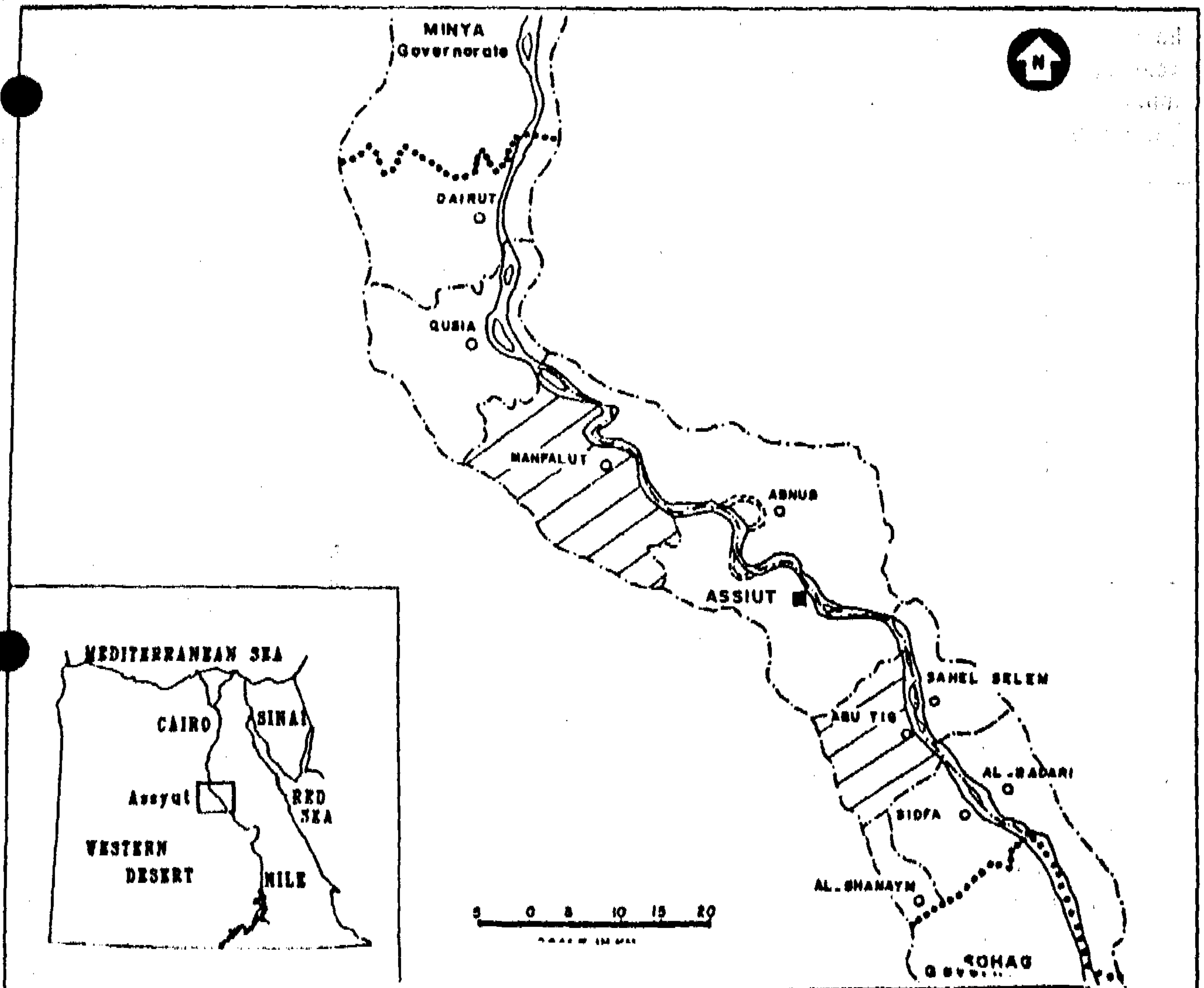


Figure 1. General location map

PATTERNS OF WATER QUALITY IN RURAL AREAS OF ASSYUT GOVERNORATE

Ruud J.P.M. Platenburg*, Magdi Zaki **

** IWACO B.V., Dutch Consultants for Water and Environment,
P.O. Box 8520, 3009 AM Rotterdam, The Netherlands
** United Nations Children's Fund (UNICEF),
8 Adnen Omar Sidky St, Dokki, Cairo, Egypt

ABSTRACT

In 1990-1991 an action-research programme in the field of rural water supply and sanitation was implemented with the objective "To assess to what extent childhood diarrhoea is reduced by the delivery of hardware facilities which improve water quality, water availability and excreta disposal, and also including an intensive educational package directed toward improving behaviours concerning water use and personal and domestic hygiene".

The intervention in Assyut Governorate comprising the construction of handpumps and latrines and a health education programme, was implemented during the second half of 1990. The data collection and data evaluation have been carried out during the period 1990-1991. Data were collected from the villages served with a complete intervention package as well as in control villages.

This paper deals mainly with the water quality issues which were part of the research programme. A comparison is presented for the water quality from both traditional and new handpumps. This comparison is supported by data collection throughout the research period within certain intervals, and by data collected from other handpumps installed at earlier times in areas within Upper Egypt. Findings concerning the actual drinking water quality, and the quality control of intervention and monitoring procedures are also discussed.

Major conclusions drawn from the results of the monitoring programme are:

- The design, the drilling method and a proper development of handpump wells play an important role in the quality control of its water.
- The bacteriological water quality improves only gradually after construction and eventually reaches acceptable levels. However, deep groundwater is thought to be of bacteriologically excellent quality. The most probable explanation for this gradual improvement is therefore the relatively long survival times of bacteria that entered the wells during construction.
- Although it is not the intention of this paper to discuss the behavioural changes in the village communities during the research period, it was observed that, while water quality from handpumps are improving with time, the water quality from in house zirs (storage reservoirs for drinking water) remained poor.

KEYWORDS:

Public health, rural water supply, handpump, water quality, faecal coliform, contamination

The intervention activities were implemented by UNICEF. The research activities were carried out by SPAAC, Consultants for Social Planning, Analysis and Administration and IWACO, Consultants for Water and Environment.

GENERAL RESEARCH PROGRAMME

Twenty (20) satellite villages were selected for the research programme. Ten (10) villages received an intervention and ten other villages functioned as control villages. The intervention aimed at providing each household with a pit latrine and each 8-10 households with one India Mark II handpump. Moreover an educational programme was implemented, focussing on various hygiene aspects. The data collection of the research programme was split up into three main parts:

- The social cultural part, comprising on-site observations of target behaviour and the assessment of knowledge and beliefs:
- The environmental part, comprising environmental conditions in house, water use and conditions at the handpump sites and water quality;
- Aspects related to the health of children under 3 years comprising diarrhoea and diarrhoea risk factors.

The environmental part was monitored through four surveys; one baseline survey before intervention and three outcome surveys at 3, 6 and 11 months after the intervention. The intervention and control communities were surveyed in pairs, principally distributed over a period of 3 to 4 months for each survey. Figure 2 illustrates this with an indicative barchart of activities.

```
| activity                     | second half 1990 | first half 1991  | second half 1991 |
|------------------------------|------------------|------------------|------------------|
|                              |                  |                  |                  |
| Data collection:             |  B            3  |       6          |    11            |
|        first set of villages |  ===  - - - - ===| - - -===  - - - -|- -===            |
|                              |     B            | 3       6        |        11        |
|        second set of villages|    ===  - - - -  |=== - - -===  - - |- - -===          |
|                              |       B          |    3       6     |           11     |
|        third set of villages |      ===  - - -  | - === - - -=== - |- - - - -===      |
|                              |                  |                  |                  |
|                              |     f  s  t      |                  |                  |
| Intervention:                |    =========     |                  |                  |
|        first, second, third |                  |                  |                  |
```

Figure 2. Indicative barchart of activities

DATA COLLECTION FOR WATER QUALITY ASSESSMENT

One of the main blocks of data collection within the environmental surveys concerned the water quality assessment. Water samples were taken during all four surveys from the following sources:

- All handpumps, used by ten (10) selected households in each intervention and control village. Part of the handpumps used by the selected households after intervention concern new India Mark II handpumps.
- All zirs (storage reservoirs for drinking water), used by the same ten (10) selected households in each intervention and control village.

All samples were bacteriologically analysed on the contents of faecal coliform. Faecal coliforms are supposed to be a tracer for the possible presence of pathogenic organisms, which may cause diarrhoea. All first samples taken from both the traditional and new handpumps were also analysed on the presence of chloride, manganese and iron on the total hardness.

It was anticipated that the average bacteriological water quality in intervention villages would improve due to the installation of India Mark II handpumps. However, the water quality improved only very slowly. Consequently the following steps were initiated.

- Sampling of all new handpumps during each survey in the intervention villages
- Implementation of specific water quality investigations
- Checking the procedures used during sampling and analysis and the programme for laboratory quality control.

This paper further reports on the findings of faecal coliform analyses of samples from handpumps and zirs.

HYDROGEOLOGY AND MIGRATION OF BACTERIA

The top soil of the traditionally occupied land of Assyut Governorate is usually clayey. This clay layer is underlain by sand and gravels from which groundwater can be tapped. The traditional handpumps usually extract water from the top of the aquifer, which depth is in the order of magnitude of 5 to 10 m below the ground level. The new India Mark II handpumps were installed at a depth of approximately 35 m below the ground level (g.l.). Figure 3 schematically shows the situation.

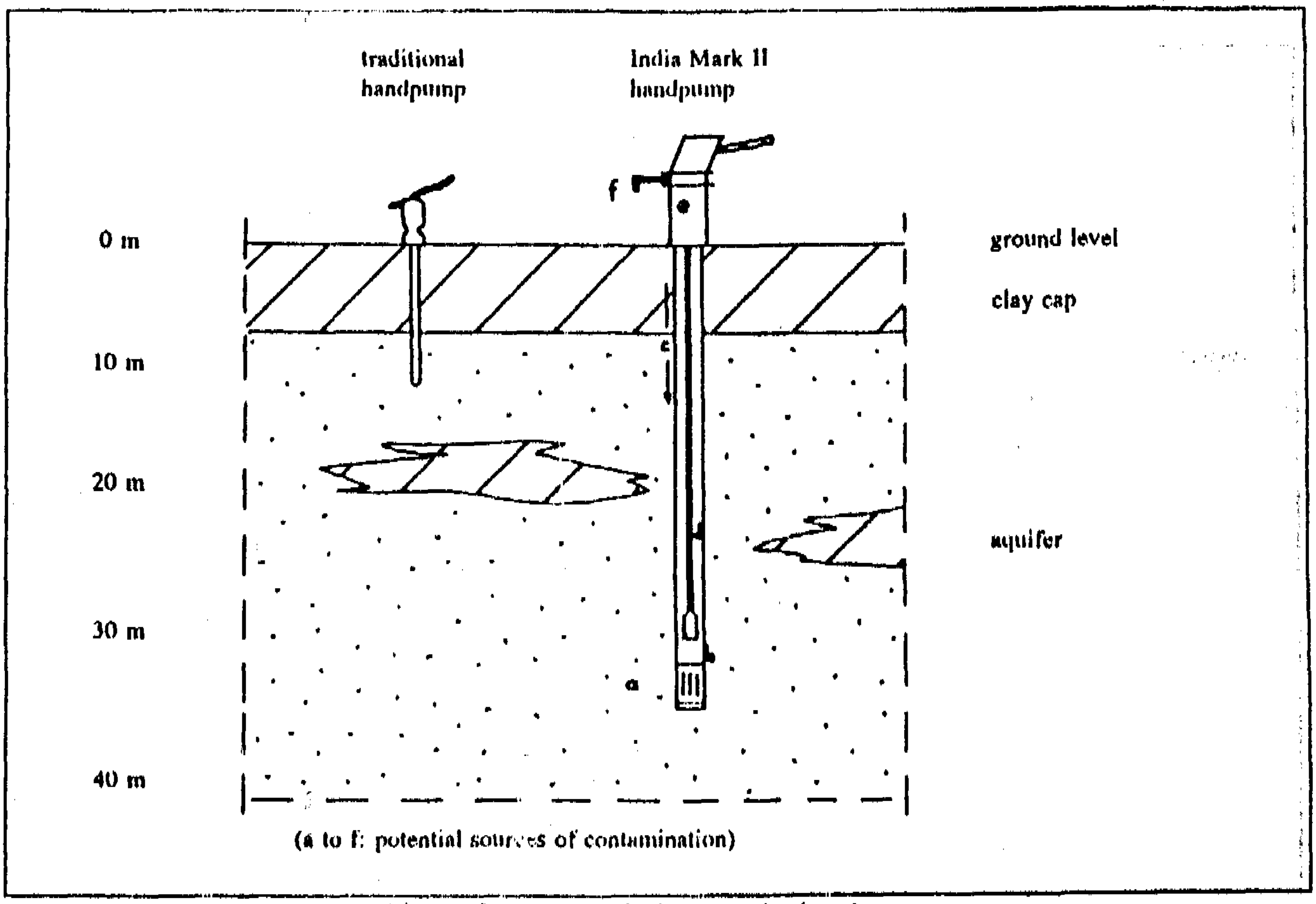


Figure 3. Schematic layout of a handpump

Contamination of the extracted water can be caused in various ways. Theoretically, the potential sources of pollution as indicated in figure 3, should be distinguished:

a. Groundwater at a depth of 35 m below the ground surface, which infiltrated many years ago cannot be contaminated with faecal coliforms, since survival times of these bacteria are much less. Literature provides survival times in groundwater ranging from a few hours upto about half a year (Bitton 1984).

b. Contamination of the borehole likely occurs during the drilling of the borehole; the drilling method applied for the intervention concerns the cable tool technique with bailer.

c. The borehole was probably refilled by collapsing soil around. Therefore, the hydraulic conductivity of the borehole material is probably much higher than of the surrounding soil. However, the pressure difference between top of the aquifer and a depth of 35 m - g.l. is probably so small that contamination by infiltration through the borehole may be considered as negligible.

d. The pipes and screens of the well may likely be contaminated by storage at dirty locations prior to the well construction.

e. Handpumps may also be contaminated at the storage locations before construction.

f. The spout of the India Mark II handpump (figure 4) is directed downward. This avoids a return flow of water back into the well. Contrary to this, traditional handpumps are partly initiated by pouring water into the well. Moreover, the spouts of handpumps are often touched particularly by children, facilitating the transfer of faecal coliform to a well.

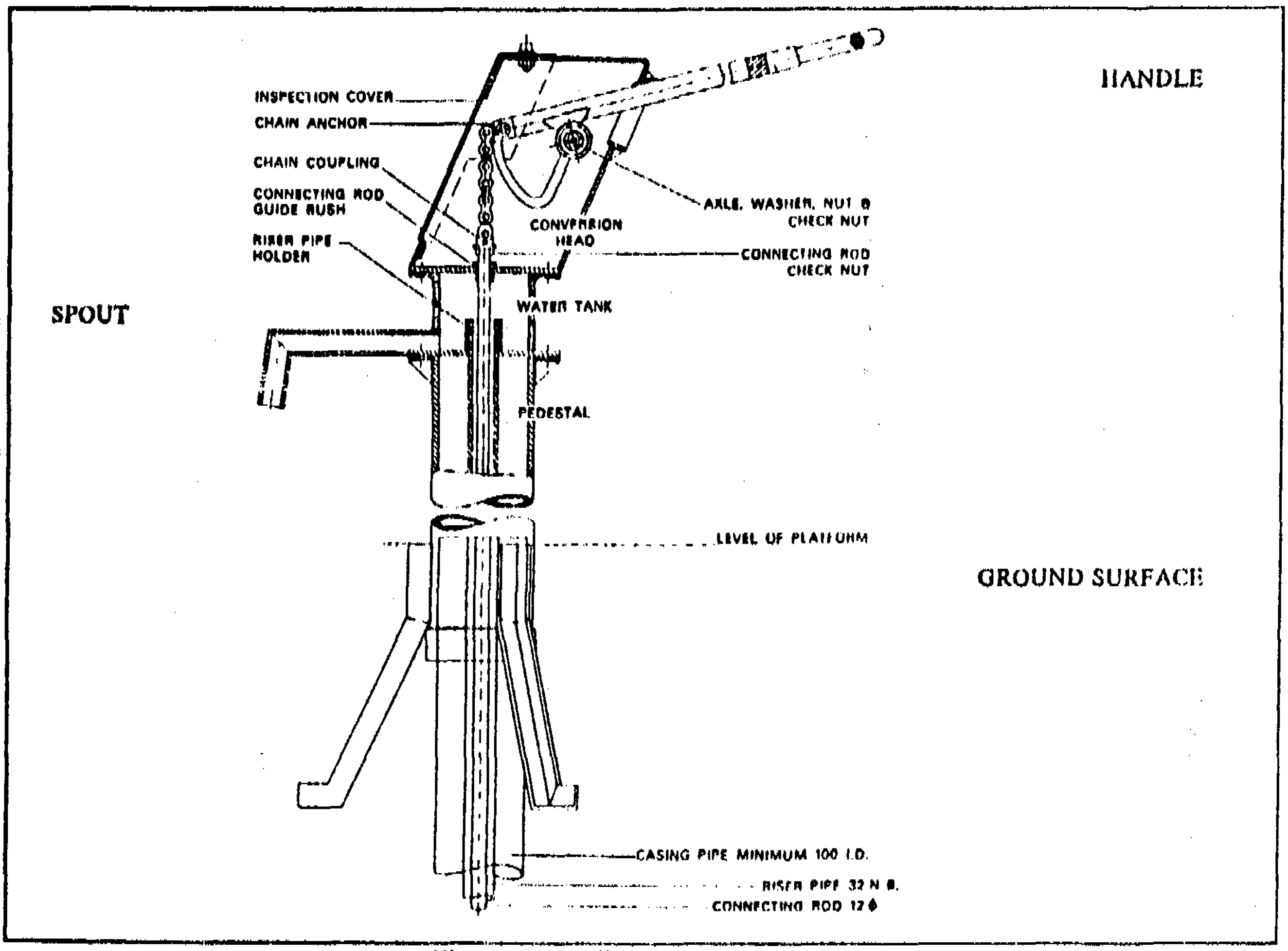


Figure 4. India Mark II handpump

The new handpump wells were disinfected upon completion of the well. Due to the observed contamination with faecal coliforms, some wells have been disinfected twice. Disinfection was carried out by using tablets (sodium-dichloro-isocyanurate) and powder (calcium-hypochlorite). The tablets were dropped from the well top and the powder was poured into the well. This method would assure disinfection from two directions. Table 1 presents a schedule with the dates of installation and disinfections for each village (UNICEF 1991).

TABLE 1. Installation and disinfection of wells

Village	District in Assyut	Construction and Initial disinfection	Second disinfection
Helba	Manfalut	21 to 23 September	10 October
El Mazani	Manfalut	23 to 26 September	27 October
Omran	Manfalut	15 to 19 October	28 October
Eliwah	Manfalut	25 to 28 October	-
Ammar	Manfalut	9 to 15 October	28 October
El Tahrir	Manfalut	19 to 25 October	-
Hebish	Abutig	17 to 22 December	-
Khalil Salim	Abutig	20 to 22 November	-
El Sheikh Erian	Abutig	22 to 27 November	-
Hashim	Abutig	12 to 22 December	-

PRESENTATION OF RESULTS FOR NEW WELLS IN THE INTERVENTION VILLAGES

The water quality from all new handpump wells has been extensively monitored on faecal coliforms. Analyses were performed after the first disinfection and during the outcome surveys (3, 6, 11 months). Table 3 shows all average values of individual results.

The multiple tube method (APHA, 1985) was applied to obtain the most probable number of faecal coliform in 100 ml (MPN/100 ml). Five tubes are incubated in which faecal coliform may develop. More positive tubes indicate a statistically larger number of faecal coliforms. All results are expressed as the numbers of positive tubes in order to facilitate statistical calculations. The relationship between the number of positive tubes and the MPN index is indicated in table 2.

TABLE 2. Relationship nr. positive tubes and MPN index

Nr. of positive tubes	MPN of faecal coliforms per 100 ml	Nr. of positive tubes	MPN of faecal coliforms per 100 ml
0	< 2.2	3	9.2
1	2.2	4	16.0
2	5.1	5	>16.0

At first, samples taken from most newly constructed handpumps show heavy contamination levels. Water from more than 90% of the handpump wells in four villages contains more than 2.2 faecal coliforms/100 ml. A minimum of 50% of the handpumps contaminated at this level, was observed in two villages. Subsequent to the second disinfection, some of the wells clearly improved, but in general the results of water analysis were still at unacceptable levels of contamination. However, when the second round (3 month survey) of data analysis became available most of the water samples from different wells showed significant improvements. After the subsequent data collection surveys (6 and 11 months survey), it was clear that a major trend can be recognised in almost all villages that the quality of water is improving by time (table 3).

TABLE 3. Faecal coliform analyses for new wells

Intervention village (Nr. of new wells)	Date	Faecal coliform average (*)	Faecal coliform exceedance (**)	Intervention village (Nr. of new wells)	Date	Faecal coliform average (*)	Faecal coliform exceedance (**)
Helba (10)	07/10/90	4 tubes	90 %	El Tahrir (10)	13/12/90	2 tubes	50 %
	11/11/90	1 tube	40 %		23/01/91	2 tubes	40 %
	24/12/90	1 tube	40 %		24/04/91	2 tubes	50 %
	09/03/91	0 tube	10 %		23/09/91	1 tubes	30 %
	10/08/91	2 tubes	50 %				
Mazani (11)	12/10/90	5 tubes	100 %	Hebish (12)	22/01/91	5 tubes	91 %
	30/11/90	3 tubes	73 %		02/03/91	3 tubes	66 %
	19/11/90	1 tube	36 %		13/05/91	3 tubes	66 %
	01/03/91	1 tube	18 %		03/11/91	1 tube	16 %
	26/08/91	1 tube	18 %				
Omran (9)	09/11/90	2 tubes	78 %	Khalil Salim (8)	22/01/91	3 tubes	87 %
	31/12/90	3 tubes	67 %		02/02/91	3 tubes	62 %
	26/03/91	1 tubes	32 %		03/05/91	2 tubes	50 %
	01/09/91	1 tube	11 %		01/10/91	3 tubes	62 %
Eliwah (8)	09/11/90	3 tubes	50 %	Erian (8)	22/01/91	3 tubes	62 %
	06/01/91	3 tubes	62 %		16/02/91	2 tubes	50 %
	31/03/91	0 tube	12 %		19/05/91	1 tube	13 %
	06/09/91	1 tube	12 %		15/10/91	1 tube	37 %
	06/09/91	1 tube	12 %				
Ammar (8)	07/11/90	3 tubes	62 %	Hashim (12)	11/01/91	4 tubes	91 %
	14/01/91	4 tubes	75 %		07/02/91	3 tubes	67 %
	04/04/91	2 tubes	37 %		11/05/91	2 tubes	67 %
	16/09/91	1 tube	37 %		06/10/91	1 tubes	33 %

(*): average number of positive tubes (see table 2)
(**): percentage of samples with > 1 positive tubes (MPN > 2,2 faecal coliform per 100 ml)

Most probable explanation for the slow improvement of the water quality concerns the survival times of bacteria, which appears longer than previously anticipated. The bacteria must have entered the well during construction (source b in figure 2) and have not fully been reached by the disinfectants.

PRESENTATION OF RESULTS FROM THE OUTCOME SURVEYS IN THE INTERVENTION AND CONTROL VILLAGES

During the baseline, 3, 6, and 11 months surveys, handpump wells from selected households were sampled for faecal coliform analyses. Only traditional handpump wells were sampled during the baseline survey. At 3, 6, and 11 months after intervention, part of the handpump wells sampled in the intervention villages concerns newly constructed India Mark II handpumps.

In addition, also zirs were sampled in the same selection of households. Zirs are extensively used in rural Egypt for the storage of drinking water, particularly in summer. Table 4 includes the average results.

TABLE 4. Results from faecal coliform analyses

Type of sample	Survey	Villages (Number of samples)	Faecal coliforms average (*)	Faecal coliforms exceedance (**)
All selected handpumps	Baseline	inter. (96)	2,8 tubes	63 %
		control (93)	2,9 tubes	66 %
	3 months	inter. (144)	2,8 tubes	64 %
		control (110)	2,5 tubes	61 %
	6-months	inter. (138)	2,0 tubes	46 %
		control (121)	2,9 tubes	67 %
	11-months	inter. (139)	1,9 tubes	46 %
		control (111)	2,8 tubes	60 %
All selected zirs	baseline	inter. (89)	4,8 tubes	96 %
		control (94)	4,9 tubes	99 %
	3-months	interv. (66)	4,5 tubes	100 %
		control (79)	4,4 tubes	95 %
	6-months	interv. (77)	4,7 tubes	99 %
		control (89)	4,9 tubes	99 %
	11-months	interv. (78)	5,0 tubes	100 %
		control (89)	5,0 tubes	100 %

(*) : average number of positive tubes (see table 2)
(**): percentage of samples with > 1 positive tube (MPN > 2,2 faecal coliform per 100 ml)

The result of the various surveys reveal the following:

- Some 60 to 70% of the traditional handpump wells are continuously contaminated with faecal coliform. From the 6-month survey onwards, a significant decrease occurs in the faecal coliform content of handpump wells in the intervention villages. The decrease is due to the installation of India Mark II wells.

- Nearly all zirs are severely contaminated with faecal coliforms, despite the supply of water with a significant better quality. Contamination of water apparently occurs during the transport and storage of the water in the zir.

SPECIAL WATER QUALITY INVESTIGATIONS

Upto the six months outcome survey, the water quality from the new handpump wells remained poor. Special water quality investigations were subsequently carried out in order to:
- study the precise source of bacteriological contamination;
- check the procedures for sampling and laboratory analyses.

Presentation of these data is beyond the purpose of this paper. However, the main findings are highly relevant and are mentioned below.

- The presence of faecal coliforms in newly constructed India Mark II handpump wells is probably due to bacteria which entered the borehole of the wells during construction.

- Handpump wells were sampled after 5 minutes of pumping. Zirs were sampled with a spoon disinfected with alcohol and flame. The bottles used for sampling were properly sterilized in the laboratory. No contamination source could be assessed during the sampling procedure.
- The laboratory analyses for faecal coliform were strictly carried out according to the "multiple tube method" (APHA 1985). Blanks and duplicate samples have been analysed each day. Moreover, the results show a high consistence through time. These check ups reveal a proper execution of laboratory procedures.

EVALUATION AND CONCLUSIONS

Monitoring programme:

Other water quality surveys were previously carried out by a team from the National Organisation for Potable Water and Sanitary Drainage (NOPWASD) in the Nile Valley Region. Forty one (41) handpump wells were checked in Sohag Governorate and 85% found to be with <2.2 MPN faecal coliforms per 100 ml, which can generally be regarded as free of contamination. Another 68 pumps were checked in Assyut and 82% were free of faecal coliforms. Another 90 pumps were checked in Qus district (Qena) and 88% were found to be free of contamination. The above mentioned results were obtained 2 to 6 years after construction of the handpumps (all India Mark II). The installation dates and average results are included in table 4.

TABLE 4. Results from other monitoring programmes

Governorate	No. of pumps	% of handpumps <2.2 faecal coliforms	date of installation
Assyut	41	85	84-88
Sohag	68	82	88-90
Qena	90	88	87

Source: NOPWASD 1990, 1991

From the table above one can also conclude that time alone is a significant factor for improving the water quality, since control measures have not been taken. When applying disinfection on the contaminated handpump wells, the remaining contaminated wells comprised 2-3% of the total number, which really represents bottleneck cases.

Figure 5 illustrates the gradual water quality improvements in the current surveys and combines this with results from the previous monitoring programmes. Newly constructed handpump wells may remain bacteriologically contaminated for about half a year and more. Contamination of the original groundwater at 35 m below ground level is very unlikely due to the long travel times from the ground surface. Bacteria likely entered the boreholes during construction. Disinfection of handpump wells urged the improvement of the bacteriological water quality in part of the wells. Bacteria from human origin have limited survival times in the soil environment which may be up to 0.5 to 1 year pending the soil conditions (RIGW/IWACO 1989; Bitton 1984). The outcomes of the water quality survey reveal the possibility of even longer survival times of bacteria in groundwater.

The continuous contamination of many traditional handpumps may be regarded as recent. New handpump wells are thought to be initially contaminated during the construction. Contamination observed some time after construction cannot be considered as recent anymore. This seriously decreases the risk of the presence of pathogenic bacteria in the water abstracted from these new India Mark II handpumps.

Future monitoring programmes for the bacteriological quality of water should be based on the potential survival time of bacteria. The travel time of groundwater from the ground surface is very important in this respect. Further study should be carried out on the process behind these water quality improvements. Knowledge should be obtained about the type of faecal coliform , which is responsible for their persistence. Finally initial contamination during construction of handpumps should be minimised as much as possible. Drilling methods and proper well development should be further evaluated in this respect.

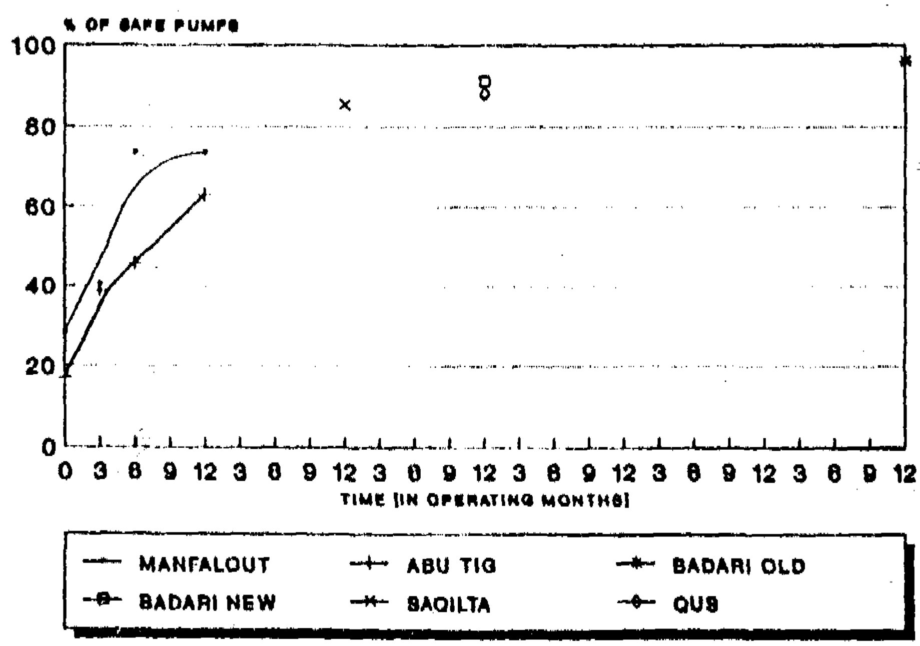


Figure 5. Average water quality improvement of new handpump wells

Improvement of drinking water quality

Despite a better quality of water from handpumps in general, the bacteriological water quality in zirs is poor. Nearly all zirs remained contaminated despite the implementation of new handpump wells and consequently a significant improvement of the water quality of wells. Apparently contamination occurs during the transport or storage of water. The health education intervention focussed amongst others, on messages related to water use. Various significant improvements in the behaviour of people regarding water use, were noticed. However, a relation with water quality improvements could not be assessed yet.

The World Health Organization prescribes an absence of faecal coliforms for drinking water (WHO, 1985). The necessity of a continuous supply of bacteriologically safe water from wells is therefore inevitable for rural areas. However, the hygienic practices during transport and storage of drinking water greatly determines its quality before consumption. Intervention programmes should therefore particularly focus on health education in order to improve the hygienic practices.

REFERENCES

American Public Health Association (APHA), 1985. Standard Methods for the Examination of Water and Wastewater. New York, USA.

Bitton, B. and C.P. Gerba, 1984. Groundwater Pollution Microbiology. John Wiley and Sons, New York, USA.

IWACO/SPAAC, 1991a. Assessment of the Impact of a combined water and sanitation programme in Upper Egypt; Data management report. Cairo, Egypt.

IWACO/SPAAC, 1991b. Assessment of the Impact of a combined water and sanitation programme in Upper Egypt; Proximate Impact Analyses, Environmental Sanitation Survey. Cairo, Egypt.

NOPWASD, 1990. Water Quality Survey, Cairo, Egypt.

NOPWASD, 1991. Water Quality Survey, Cairo, Egypt.

RIGW/IWACO, 1989. Development and Management of Groundwater Resources in the Nile Valley and Delta, Monitoring and Control of Groundwater Pollution, Assessment of groundwater pollution from domestic activities. El Kanater El Khairiya, Egypt.

SPAAC, 1991. Assessment of the Impact of a Combined Water and Sanitation Programme in Upper Egypt, Interim report. Cairo, Egypt.

UNICEF, 1991. A research design for assessment of the impact of a combined water-sanitation programme in Upper Egypt. Cairo, Egypt.

World Health Organization (WHO), 1984. Guidelines for drinking water quality. Geneva, Switserland.

WATER COURSE POLLUTION CONTROL: AN ENGINEERING ECONOMIC MODEL FOR DOMESTIC WASTE DISPOSAL

A.H.Gaber*, A.H. El Ahwany*, Kh.H. El Ahwany**, and A. Zaki*

*Chemical Engineering Dept. Cairo University, Giza, Cairo.
**Enppi Co., Nasr City, Cairo.

ABSTRACT

A georgraphical model representing a water course in rural Egypt has been considered to analyze its multiple point-source pollution from adjacent villages and to investigate possible pollution control strategies. An array of 50 villages, 5000 population each, located along a 100 km canal or drain was considered. An engineering-economic model is developed to predict BOD-DO profiles along the water course. Techno-economic assessment of three proposed alternatives shows that phased implementation of wastewater treatment and collection projects is more suitable and appropriate for Egyptian situation due to limited financial resources and the critical levels of pollution. An optimization study has investigated the most appropriate cluster size which should be served with one treatment plant.

KEYWORDS

Multiple point-source pollution; BOD-DO simulation model; techno-economic assessment; clustering; optimization.

INTRODUCTION

Water courses are continuously receiving certain pollution loads from the surrounding villages. In Egypt, a major source of pollution in rural areas is the domestic sewage. This special nature of the pollution problem for irrigation drains and canals comes from the high domestic pollution loads of the densely populated villages located along the water course. Therefore, certain stretches of the Nile and its canals exhibit serious pollution problems and ecological perturbations. Also, the poor sanitation of these areas leads to serious health hazards. These problems are constantly and consistently manifested due to the expanding population and urbanization while the financial resources are limited (Gaber et.al, 1982, Frankel, 1965; Anderson and Day, 1968).

To help analyze this problem, a hypothetical case of 50 villages 5000 persons each, located along 100 km canal or drain has been considered. The distance between each two villages is the same and the sewage is disposed to the neighboring canal and/or drain. A mathematical model that describes this situation of multiple point-source pollution of a canal or drain is a predictive tool to investigate degrees of pollution assuming different situations. The simulation model helps also to investigate the possible control strategies that maintain water quality standards.

MODEL DEVELOPMENT

The water course is divided into a number of reaches. The reach is defined as the distance between two consecutive discharges, i.e. villages. At the beginning of the reach, it is assumed that the stream and the wastes are perfectly mixed at the point of discharge.

The BOD and DO balances are made according to the simplified conceptual model shown in Fig. 1 representing the physical situation.

Waste effluents are assumed to be identical for all villages. The diffused organic load discharged from agricultural land is neglected. The only source of pollution is assumed to be domestic sewage for simplification purposes. The daily organic load per capita is taken as 55 gram BOD, and the daily average water consumption may be varied to be 50, 80, 150 liter/capita/day. Initial conditions for the water course (canal or drain) are zero BOD and 95% saturation of the dissolved oxygen at 20°C, i.e. 9.17 mg O_2/liter.

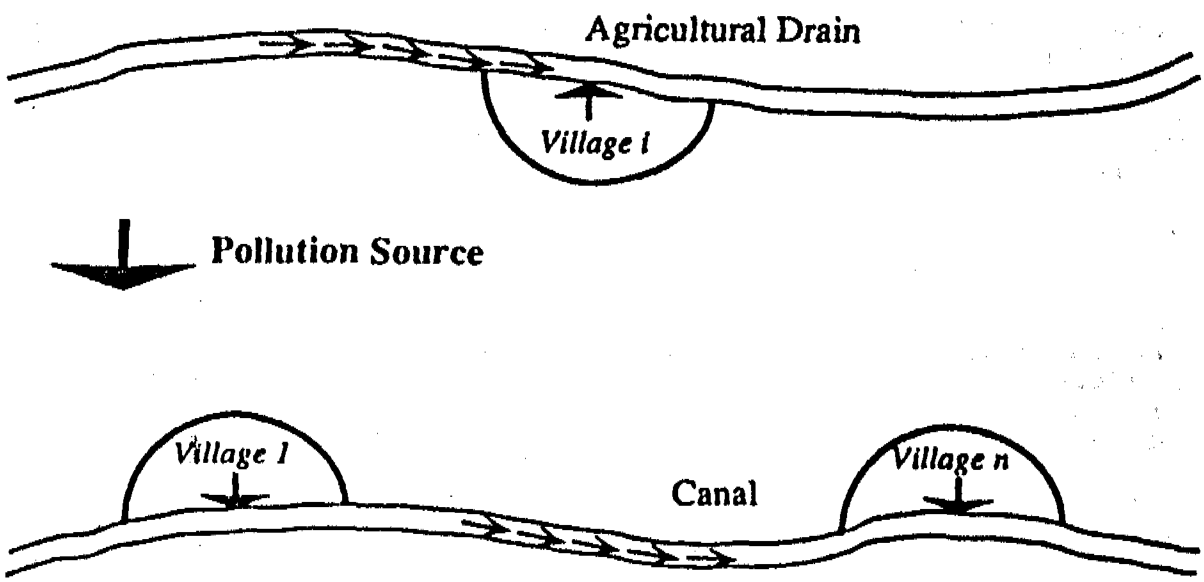


Fig. 1 The Geographical Model

The change in BOD and DO in the reach is modeled by assuming that this reach is essentially a plug-flow reactor. At steady state conditions, BOD and DO concentration at any intermediate point or at the end of the reach are calculated by the following equations:

$$Lim = (L_{i-1}\, Q_{i-1} + X_i\, (1-E)\, Q_{Di}\, L_{Di} + Q_{Ai}\, L_{Ai})/Q_i$$
$$Dim = (D_{i-1}\, Q_{i-1} + X_i\, Q_{Di}\, D_{Di} + Q_{Ai}\, D_{Ai})/Q_i$$

where:

Q = flow rate, m3/d
L= biological Oxygen Demand (BOD), mg/L
D= Cs-C = Oxygen Deficit, mg/L
Cs = Oxygen saturation concentration, mg/L
C = Oxygen concentration, mg/L
i = subscript denoting stream reach number
im = subscript denoting the mixture conditions
i-1 = subscript denoting the end of the reach before the reach number (i)
X= ratio of wastewater discharged into the watercourse.
E= treatment unit efficiency D,A = subscripts denoting wastewater drain and agricultural drain

Oxygen - Sag Equation:

$$D_{i,ip} = K_1\, L_{im}/(K_2-k_1)\, (\exp(-k_1 t_{i,ip}) - \exp(-k_2\, t_{i,ip})) + D_{im}\, (\exp(-k_2 t_{i,ip}))$$

where

i,ip subscript denoting the conditions of an intermediate point of the reach

k1 Deoxygenation rate constant, day-1
K2 Reaeration rate constant, day-1
ti,ip Time of flow passed from the top of the reach up to point ip.

RESULTS AND DISCUSSION

The validation of the simulation model as well as the application of the model in the techno-economic assessment of the different disposal and treatment policies will be discussed in this section. There is also a discussion of the optimization case-study to find the optimal number of treatment plants.

Model Validation

The simulation model has been validated by comparing its BOD and DO predictions to actual measurements drawn from literature (Younis et al.1983). The model, in spite of its simplicity, proves to simulate the water course conditions with an acceptable degree of accuracy. The discrepancies are less than 20% in BOD, and about 8% for the DO values.

Table 1 shows the calculated and measured values of BOD and DO concentration of the 300-km reach from Aswan Dam to Naga Hamadi Barrage. This difference in DO values is due to neglecting the other oxygen demands as for nitrification and the benthic demand. This difference is expected to be minor when applying the model to a stream of multipoint pollution sources with relatively higher values of BOD.

Table 1 Calculated and Measured Values of BOD and DO concentration for Model Validation.

Location	Distance from Aswan Dam (km)	BOD (mg/L) measured	BOD (mg/L) calculated	DO (mg/L) measured	DO (mg/L) calculated
Aswan Dam	-	1.30	1.30	9.30	9.30
Dishna	221	2.50	2.52	10.00	10.67
Naga Hamadi	301	1.95	1.98	10.00	10.80

Techno-Economic Assessment of Different Alternatives for Waste Collection and Treatment

The model can be used to generate control strategies to maintain water quality standards in polluted streams within certain required limits. Three alternatives are proposed to satisfy the requirements of law 48, 1982. Law 48 does not permit any waste disposal into canals and puts the limits of disposed wastes into other water courses to be 6.0 mg/L as maximum BOD, and 4.0 mg/L as minimum DO concentration.

The Three alternatives are:

Alternative I

Phase 1 : Construction of sewerage networks for each village, over a number of years.

Phase 2: Construction of complete treatment plants.

Alternative II

Phase 1: Construction of sewerage network plus primary treatment unit for each village.

Phase 2: Adding a secondary treatment plant for each primary unit.

Alternative III:

Construction of sewerage networks plus complete treatment unit for each village.

The following total costs are assumed for constructing each item:

Sewerage network	150	LE/Capita
Primary Treatment Unit	50	LE/Capita
Secondary treatment unit	150	LE/Capita

It is assumed that the limited financial resources for these fifty villages are LE 5 millions per year.

Figure 2 represents the BOD profiles for the three alternatives, and the following remarks can be concluded:

- The phased implementation alternative II can be considered most appropriate in this particular case. It will solve the problem of pollution in the canal in a relatively acceptable period. It takes only two years longer than alternative I, but it will not increase the drain pollution very much as in alternative I.

- Assuming population growth rate of 2.8% per year, and making the designs for twenty years. It has been found that it will take 31 years to accomplish the projects of any alternative. Therefore, the annual budget for financing the LE 10 millions plan should be increased. If LE 10 millions are assigned per year for this plan, it will be completed in about 15 years.

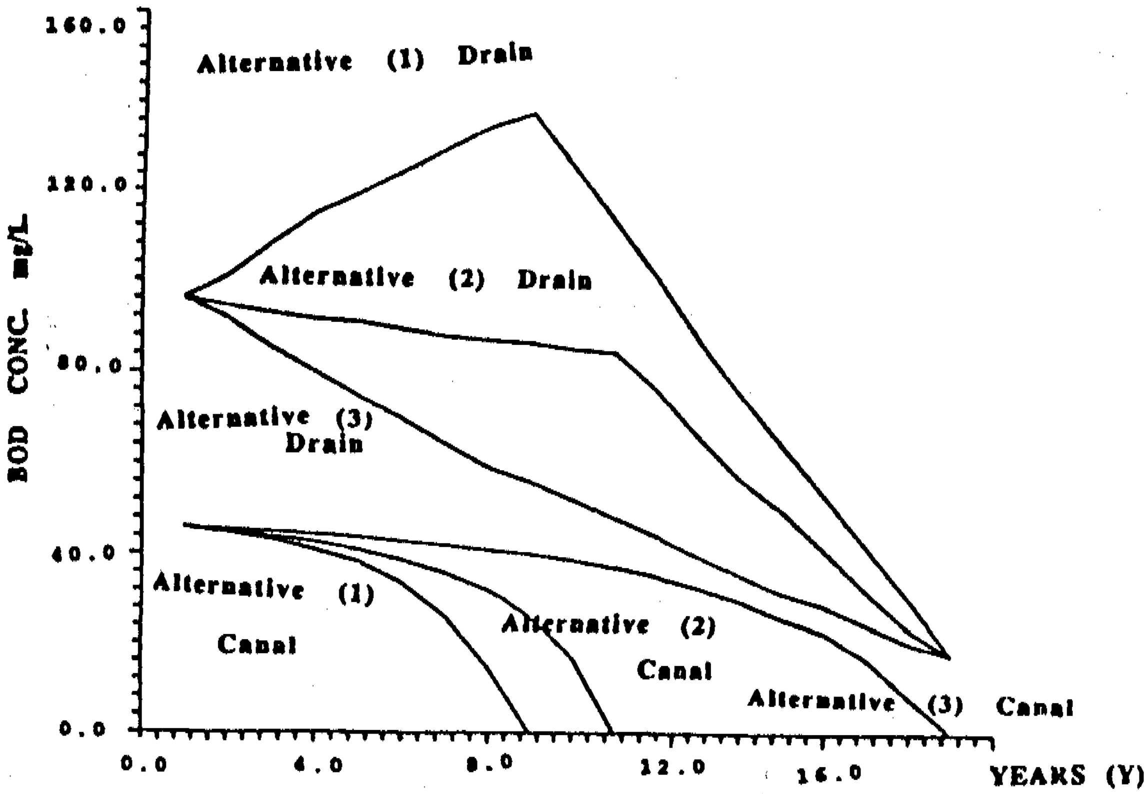


Fig. 2 BOD levels in both the canal and drain for the three proposed alternatives.

Optimization Study for Optimal Number of Treatment Plants

In this optimization case study wastes of a cluster of villages are to be collected in one treatment plant to minimize the cost of treatment. Four cases are considered in this study:

Case I. One treatment plant serving 50 villages.

Case II. Two treatment plants (each serving a cluster of 25 villages)

Case III. Four treatment plants (each serving a cluster of about 12 villages.

Case IV. Twenty five treatment plants (each serving a cluster of 2 villages.

Cost Estimation for the Five Optimization Cases

The total costs of construction and operation of a treatment plant decreases as the plant capacity increases. But, at the same time, as the number of villages collecting their wastes in one treatment plant increases, the cost of piping and pumping will also increase. Thus, there is an optimum number of treatment plant that can be determined.

Table 2 summarizes the results of total costs for the five optimization cases of village clusters. Plotting these values of total costs versus the number of treatment plants, it can be shown from Fig. 3 that the optimal number of treatment plants is 4 which gives minimum total cost.

TABLE 2 Total Cost for the Five Optimization Cases (Million LE)

Item	Year 1991 Population					Year 2011 Population				
	Case I	Case II	Case III	Case IV	Case V	Case I	Case II	Case III	Case IV	Case V
Piping (Iron Pipes)	34.35	25.51	19.3	6.00	-	45.8	34.34	20.89	16.22	-
Pumpg. Stations	30.25	25.45	20.0	27.26	23.19	30.2	25.45	19.98	27.26	23.2
WWTP	26.9	33.19	42.1	70.24	85.76	45.1	57.6	70.16	117.7	145.3
Total	91.5	84.15	81.4	103.5	109.9	121.1	117.4	113.03	161.18	168.5

The same design and costing calculations are performed for the capacity after 20 years considering 2.8% population growth per year.

The optimal number of treatment plants is still 4; but the total cost is increased. The cost of each item at different capacities are taken from actual plant data in Egypt at their present worth values. The design velocity of wastes is 1- 1.5 m/s, and pressure drop calculations are based on Hazem-Williams formula according to the Egyptian Standards.

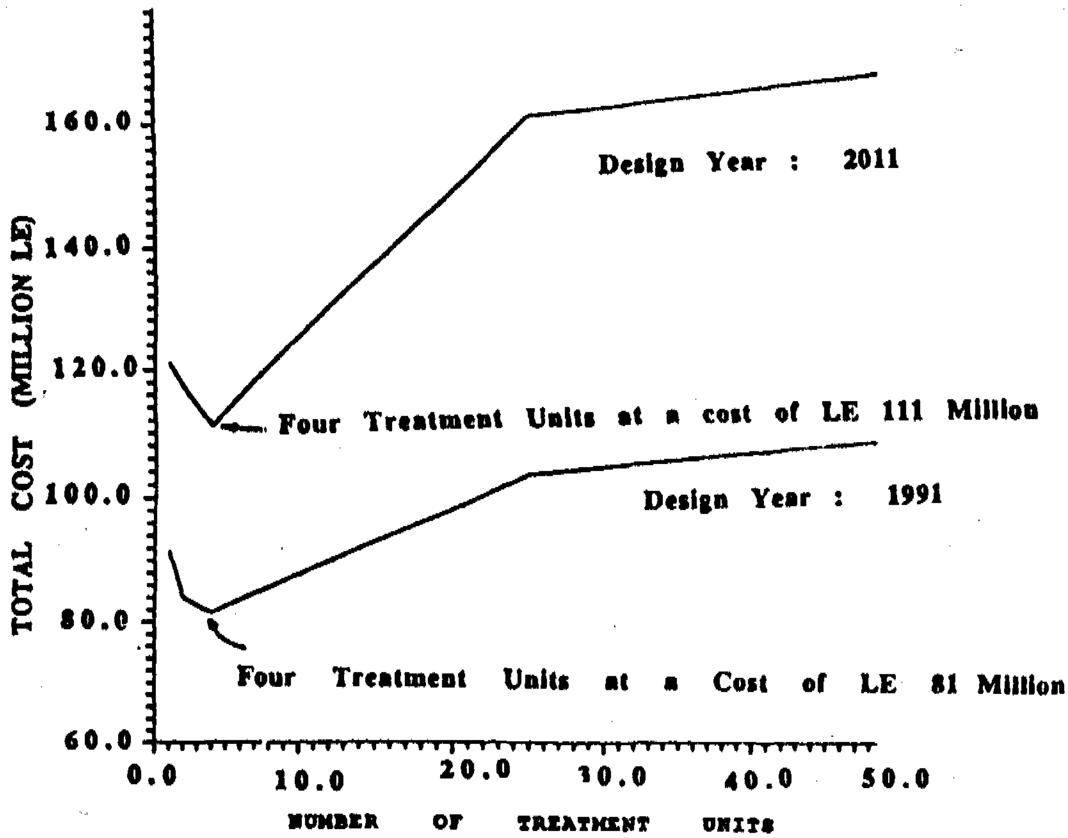


Fig. 3 Total cost of treatment and collection versus number of treatment units for 1991, 2011 Design year.

After deciding the requird treatment efficiency from DO and BOD cuves, the total cost is calculated for each case. Figure 4 shows the DO concentration profiles for the optimization case III for different treatment efficiencies. The required efficiency satisfying the standards is about 75%. The DO concentration profiles at year 2011 show that the required efficiency should be 85% to have DO levels of 4.0 mg/L or higher.

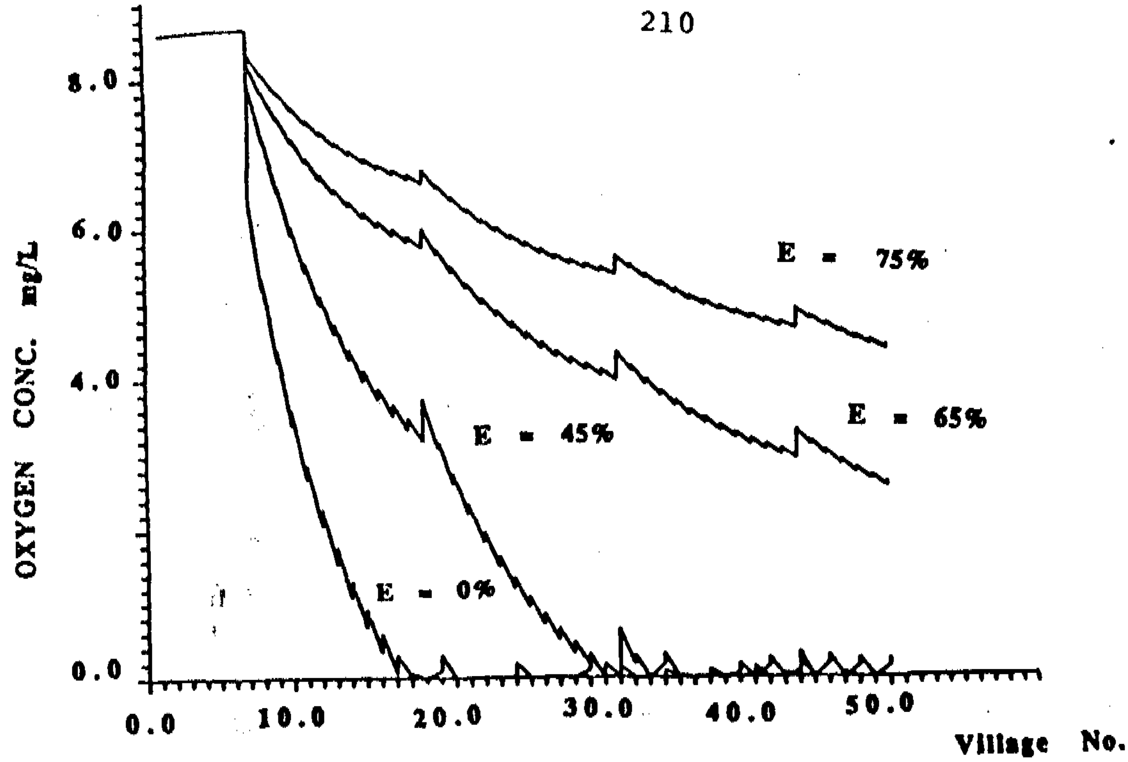


Fig. 4 DO profiles using different treatment efficiencies for the 4 WWTPs solution (Case III)

CONCLUSIONS

The BOD-DO simulation models help in taking decisions and techno-economic assessment for different alternatives of treatment and/or disposal policies. The application of this engineering-economic model on the proposed treatment alternatives, showed that the phased implementation of Law 48 can solve the problems of pollution in a relatively acceptable period. The optimization study can be extended to investigate other topological or regional clustering of villages. Enhanced primary treatment, as an intermediate pollution control policy, may be considered instead of conventional primary treatment.

REFERENCES

Anderson, M.W. and Day, H.J (1968). Regional management of water quality - a systems approach. Journal WPCF, Vol.40, No 10, Oct. 1968, 1679-1687.

Frankel, R.J. (1965). Water Quality Management; an Engineering-Economic model for domestic waste disposal. PH.D Thesis, Univ. of California, Berkeley.

Gaber, A., El Rifaie, M., and Zaki, A. (1982). Small Rural Communities Domestic Wastewater Management Project. Joint Egyptian-German Seminar on "Waste Reuse in Urban and Rural Areas", Cairo, February, 1982.

Younis, M.I., Hassan, M.F., Darwish, G.D., Dorhan, M.A., and Mancy, K.H. (1983). Water quality studies on the River Nile and the Aswan reservoir. The Egyptian Academy of Scientific Research and Technology and University of Mitchigan.

ASSESSMENT OF THE PERFORMANCE OF OXIDATION POND SYSTEM FOR WASTEWATER REUSE

F. El-Gohary, R. Abdel Wahaab,
S. El-Hawary, S. Shehata, S. Badr and
S. Shalaby

Water Pollution Control Dept.,
National Research Centre, Dokki,
Cairo, Egypt

ABSTRACT

A study has been conducted to evaluate the performance of an aerated oxidation pond system in a village in Egypt. It comprises an anaerobic pond (AP), an aerated facultative pond (AeP) and a maturation pond(MP). The assessment involved an intensive programme of sampling and analysis of raw wastewater, unit process contents and unit process effluents.

Field studies indicated a wide fluctuation in the BOD_5 load applied to the STP. It ranged from 64 to 290 g BOD_5/m^3 d, with an average value of 146 g BOD_5/m^3.d. This however, did not affect physico-chemical characteristics of the final effluent. Residual COD, BOD & SS were around 99 mg/l, 32 mg/l & 66 mg/l, respectively. Although faecal coliform removal was around 98.9%, yet residual count was still high. Also, significant decline in both parasitic eggs and protozoal stages has been recorded.

KEYWORDS

Wastewater treatment, aerated oxidation ponds, design performance assessment, pathogen removal.

INTRODUCTION

Stabilization ponds are now a well established method of biological wastewater treatment. Wherever suitable land is available at reasonable cost, they are usually significantly cheaper than other processes, and maintenance requirements are very simple (Mara, 1976; Arthur, 1983).

The wide acceptance of waste stabilization ponds in tropical countries, is due to the fact that the public health authorities are becoming more aware of the need for implementing regulations to limit concentrations of pathogen organisms in sewage discharges, particularly in countries practicing agricultural reuse of treated sewage. It is well established that conventional sewage treatment processes cannot compete with ponds unless they incorporate disinfection(Feachem et al., 1981).

Research carried out in northeastern Brazil (Mara & Silva, 1986) has shown that the Engelberg guidelines for helminths would normaly be ach - ieved by a series of three ponds - a 1-day anaerobic pond followed by a 5-day facultative pond and 5-day maturation pond. Such a series would, depending on temperature, reduce the faecal coliform concentration by only 2-3 log units, so that further maturation ponds would be necessary in order to achieve the Engelberg guideline of < 1000 per 100 ml(Mara & Cairncross, 1989).

As already indicated, the one disadvantage of stabilization ponds is that they require large areas of relatively flat land. A number of options exist to reduce the pond area required. Increasing pond depth is one example. Recent research has shown that ponds 2-3m deep can achieve degrees of bacterial and viral removal comparable to those in ponds of conventional depth (1-1.5m), (Oragui et al.,1987; Mara et al., 1987). Another alternative is to aerate the facultative pond.

Purpose And Scope

The present study has been conducted by the Water Pollution Control Department at the National Research Centre for the WHO/EMRO to evaluate the performance of an aerated oxidation pond which has been constructed in a village in Egypt. The main objective is replication in rural Egypt on successful testing. The layout of the sewage Treatment Plant (STP) is shown in Figure (1). It comprises an inlet screen (S), flow measurement device (FM), an anaerobic pond (AP), an aerated facultative pond (AeP), and a maturation pond (MP).

The AP was designed to receive a volumetric organic loading of 100 g BOD_5/m^3.d. The hydraulic retention time is 4.3 days. Effluent from the AP overflow into the AeP where two mechanical aerators are located on floats. The hydraulic retention time in the AeP is 2.5 days. The MP depth is 1.5 m.

MATERIALS AND METHODS

The STP evaluation,involved an intensive programme of sampling and analysis of raw wastewater,unit process contents and unit process effluents (Figure 1).

Physico-chemical analysis and biological examinations were carried out according to Standard Methods(APHA,1989). The only exception was helminths and protozoa,the examination of which was according to the method recommended by WHO (1989).

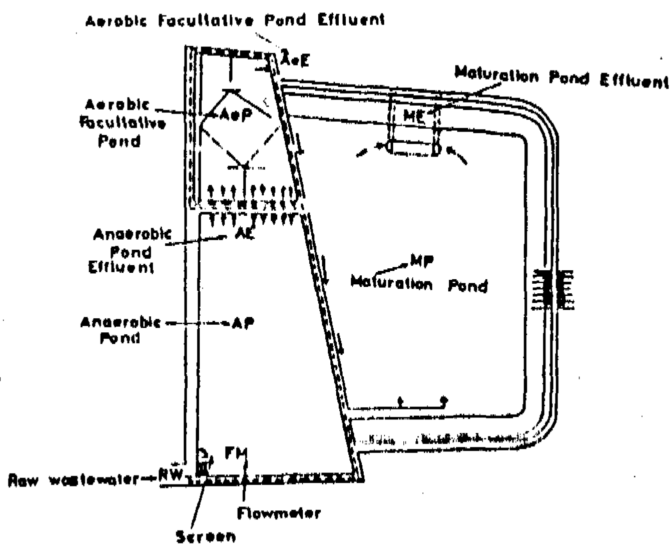


Fig. 1 : GENERAL LAYOUT FOR SEWAGE TREATMENT PLANT "MIT MAZAH DESIGN"

RESULTS AND DISCUSSION

Raw Sewage Characteristics

Results of the analysis of thirty nine samples collected weekly over a period of ten months, indicated that crude sewage characteristics are consistent with a sewage above average strength. The COD ranged from 316 to 2661 mg/l, with an average value of 1045 mg/l.

Corresponding BOD_5 ranged from 180 to 1110 with an average value of 418 mg/l. It is worth mentioning that the soluble fraction of the BOD_5 is only 34.5%, on the average. The rest is in a particulate form. Suspended solids concentrations are relatively high, ranging from 168 to 2058 mg/l with an average value of 632 mg/l (Table 1).

The density of total coliform (TC) and faecal coliforms (FC), presented as most probable numbers (MPN) per 100 ml, ranged from $2.4x10^9$ to $2.4x10^{11}$ and from $1.6x10^9$ to $2.4x10^{11}$, respectively.

Performance Of The Different Units

Physico-Chemical characteristics

A summary of the most relevant physico-chemical characteristics of effluents from the Ap, AeP and MP are given in Table (1) and presented graphically in Figures (2,3&4).

Although the measured BOD_5 load applied to the AP was 146 $g/m^3.d$, on the average, the efficiency was not affected. COD, BOD_5 & suspended solids percentage removal values were 65, 68 and 67, respectively.

During the study period, mixed liquor suspended solids (MLSS) content of the AeP was around 192 mg/l. Such a level of MLSS achieved 71.39% removal of the soluble BOD_5 remaining in the anaerobic pond effluent. Corresponding COD removal was 49.78%, on the average. Dissolved oxygen content varied from 0.3 to 1.5 mg/l, with an average value of 0.45 mg/l.

Physico-chemical analysis of the MP effluent indicates effective biodegradation of suspended and dissolved organic fraction remaining in the facultative aerobic pond effluent. Average total COD and BOD_5 removal values were 56% and 50.9%, respectively. Suspended solids removal was 67.85%, on the average.

The overall efficiency of STP for removing the carbonacious fraction is considered good. Average residual COD, BOD_5 & SS were 99,32 & 65 mg/l, respectively. However, no nitrification has been recorded. Average residual total phosphorus in the MP effluent was 7.7 mg p/l. This corresponds to an overall removal of only 16.3%.

Algal Population

Nutrient removal through the algal pond is principally a function of assimilation into algal-bacterial biomass. The amount of nitrogen and phosphorus which may be removed from the effluent by algal assimilation mechanism is dependent upon the intracellular content of algal biomass and the amount of biomass which may be abstracted daily as productivity or yield (Hensman, 1986). Figure (5) shows the relationship between total algal count and chlorophyll "a" concentration during the study period.

Examination of the algal population in the MP indicates the presence of

Table (1) The efficiency of the different treatment unit processes

Parameters	RW	AP Eff.	AeP Eff.	MP Eff.	Overall %R.
COD(unfil.)	1045.00	356.53	230.00	99.10	
S.D.	564.61	109.76	58.39	33.62	
% R.	–	65.88	35.49	56.91	90.52
COD(fil.)	262.59	97.52	48.97	43.38	
S.D.	72.84	30.28	15.97	12.50	
% R.	–	62.86	49.78	11.42	83.48
BOD(unfil.)	418.41	133.69	65.46	32.21	
S.D.	184.99	42.51	20.94	11.40	
% R.	–	68.05	51.04	50.79	92.30
BOD(fil.)	137.31	56.67	16.21	11.72	
S.D.	42.44	20.46	8.44	7.15	
% R.	–	58.73	71.39	27.69	91.46
TSS	632.21	204.83	184.64	65.66	
S.D.	448.08	70.36	51.03	23.05	
% R.	–	67.60	9.86	64.44	89.61

The results are the mean values of thirty nine samples.

Fig.(2)

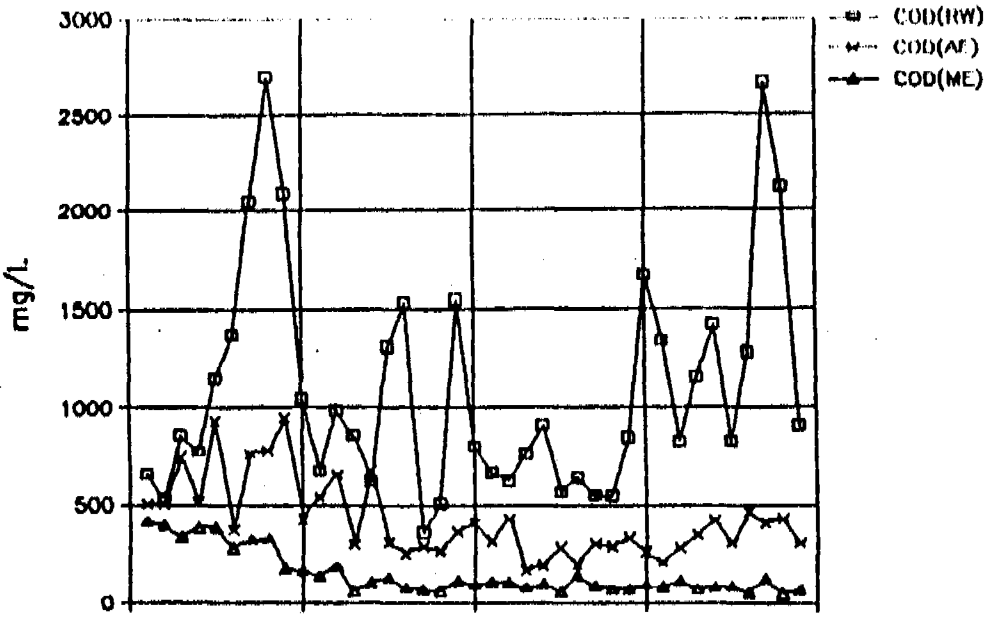


Fig.(3)

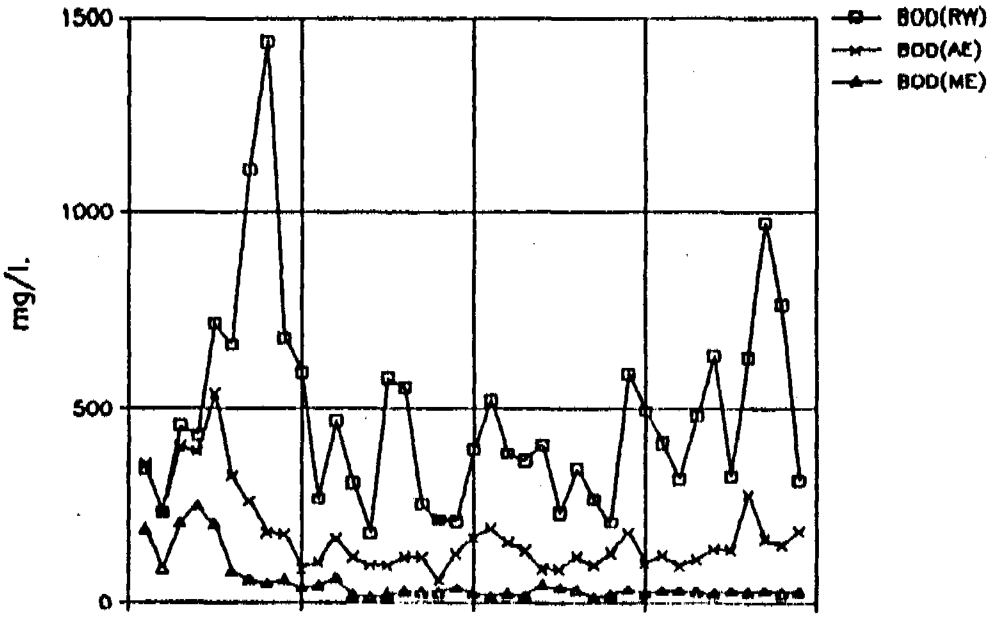
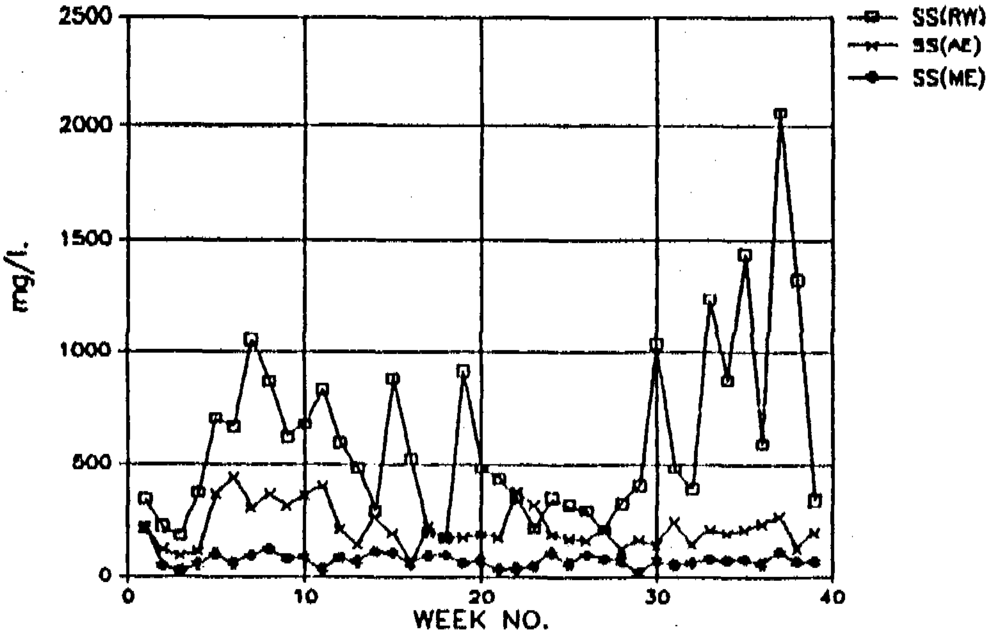


Fig.(4)



Variation in selected parameters along the treatment unit processes.

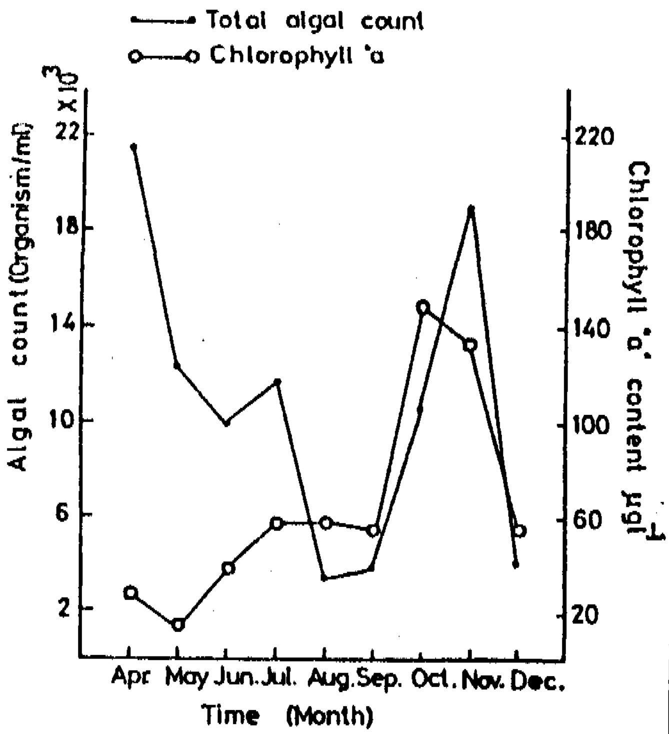


Fig. 5 : Correlation between total algal count and chlorophyll "a" concentration in the Maturation Pond

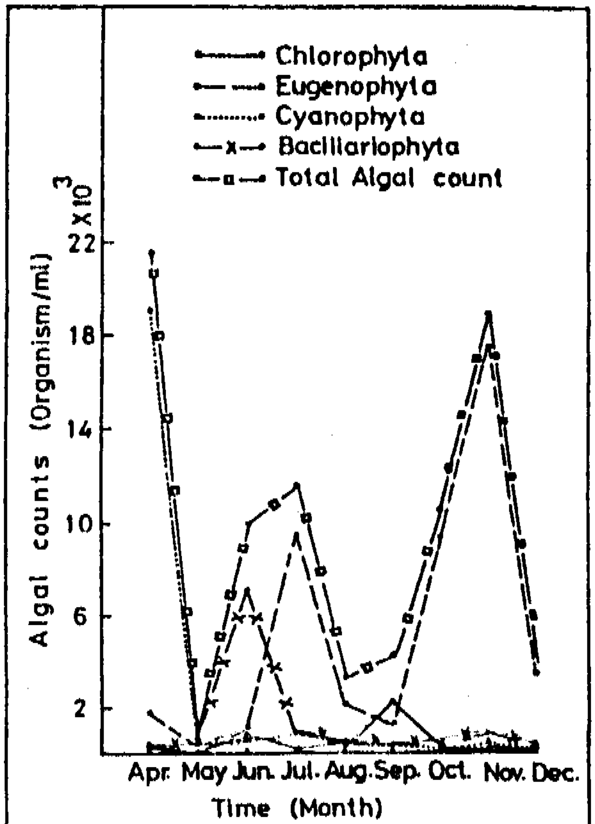


Fig. 6 : Monthly changes in Algal Groups of Maturation Pond

various algal species belonging to four groups, namely, chlorophyta (green algae), Euglenophyta (motile green algae), Cyanophyta(blue-green algae) and Bacillariophyta (diatoms). Clear variation in the diversity and redundancy between the different months has been detected (Figure 6).

Euglenophyta represent the most abundant group always present in good number during the investigation period. The most dominant species may be Euglena pissiformis and its number reached $5.5x10^6$ organism/l during July.

A good diversity of diatoms was present in all investigated samples and their highest numbers were detected during June. Diatoma elongatum, Melosira granulata, Nitzchia linearis and Cyclotella elongatum, were the most dominant species. Typical example of genera representative of diatoms in stabilization ponds are cyclotella, Gomphonema, Nitzschia, Synedra and Melosira (Palmer,1969 & 1975).

Green algae reported as being less predominant group. During May, green algae, disappeared completely while it dominated all algal groups during September.

Pathogen Removal

Determination of total and faecal coliform density in the effluent of the different treatment units indicates, 96.3% removal for T.C. and 98.6% removal for F.C. in the AP. Further reduction of 52% in the TC & 20% in the F.C. took place in AeP. Overall percentage removal values were 98% and 98.9% for T.C. & F.C., respectively. Residual count however is still very high (Figure 7).
No change in the incidence of salmonella was recorded after anaerobic treatment (44.4% of the total examined samples). This value was reduced to 22.2% in the AeP effluent. Further reduction to 11% has been recorded in the maturation pond effluent (Figure 7).

The frequency existance of total helminthic eggs and protozoal stages along the STP are recorded in Tables (2&3). Available data indicates a significant decline in both parasitic eggs and protozoal stages.

From the available data, it is became clear that the effluent cannot be used for unrestricted irrigation. To improve the biological quality of the wastewater, the detention time should be increased by adding one or two cells to the maturation pond.

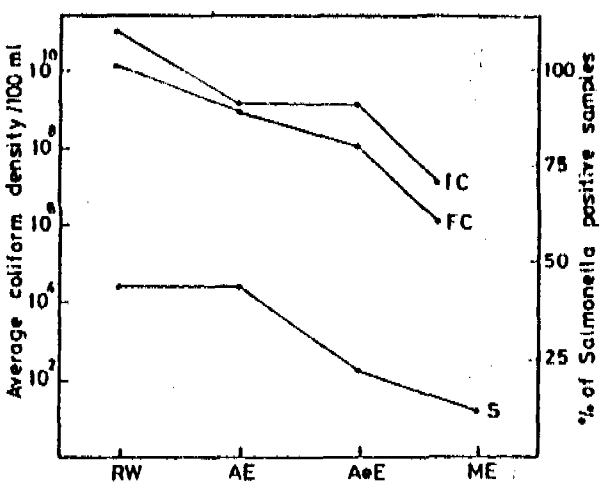


Fig. 7 : Monthly changes of total coliform (TC), Faecal coliform (FC) and Salmonella (S) along the treatment unit processes

Table (2) : Monthly frequency of parasitic eggs along the treatment unit processes

Parasite	Samples			
	RW	AE	AeE	ME
Schistosoma haematobium	1	3	1*	1*
Fasciola hepatica	1	2	nd**	nd
Anchylostoma spp.	1	1	nd	nd
Ascaris lumbricoides	4	3	1	1
Trichostrongylidae	3	3	2	2
Enterobius vermicularis	2	nd	nd	nd
Taenia spp.	3	1	2	nd

* Dead eggs
** Not detected

Table (3): Monthly frequency of protozoal cysts along the treatment unit processes

Parasite	Samples			
	RW	AE	AeE	ME
Entamoeba coli	nd*	1	nd	nd
Balantidium coli	nd	2	1	2
Eimeria oocyst	4	3	1	2
Trichomonas spp. (Vegetative form)	nd	2	1	nd

* Not detected.

REFERENCES

Arther,J.P. (1983) Notes on the design and operation of waste stabilization ponds in warm climates of developing countries. Washington,DC, World Bank, (Technical Paper No.7)

Feachem,R.P. et al.,(1981). Health Aspects of excreta and sullage Management A state of the art review. Appropriate Technology for Water Supply & Sanitation,Vol. 3 The World Bank.

Hensman,L.C.(1986) The use of algae for removal of phosphorus from Secondary wastewater effluents. Ph.D.Thesis University of Pretoria.

Mara,D.D. (1976) Sewage Treatment in hot climates. Chichester,John Wiley,

Mara,D.D. & Silva,S.A. (1986) Removal of intestinal nematodes eggs in tropical waste stabilization ponds. Journal of tropical medicine and hygiene, 89 (2): 71-74.

Mara,D.D. et al·(1987) The performance of a series of five deep ponds in northeast Brazil. Water Science and Technology,19 (12):61-64.

Mara,D. & Cairncross,S. (1989) Guidelines for the safe use of Wastewater and excreta in agriculture and aquaculture. WHO,Geneva,

Oragui,J.I. et al. (1987) The removal of excreted bacteria and viruses in deep waste stabilization ponds in northeast Brazil. Water Science and Technology; 19 (12): 569-573.

Palmer,C.M. (1969) Algal records for three Indiana sewage stablization ponds. Proc.Indiana Acad. Sci. 78: 139-145.

Palmer,C.M. (1975) Algae in American sewage stabilization ponds. Rev. Microbiol. (Sao Paulo, Brazil) 5(4): 15-80.

Standard Methods for the examination of water and wastewater,(1989), APHA AWWA,WPCF. 17th ED. Washington.

WHO (1989) Health guidelines for the use of wastewater in agriculture and aquaculture. Technical Report Series 28.

WASTEWATER TREATMENT/REUSE IN RURAL AREAS

ATALLAH S. KUTTAB

Program Manager/Consultant, Save the Children/USA,
1 Latin America St., Garden City,
P.O.Box 580, Cairo, Egypt

Assistant Professor, Department of Civil Engineering
Birzeit University, P.O.Box 14, Birzeit, Palestine.

ABSTRACT

Proper hygiene leading to good health, in urban as well as rural communities, require that the consumption of drinking water is raised to acceptable levels (UN organizations put it at 40 liters/cap/day). The increase of water availability necessitates the provision of sewage drainage facilities. Urban areas are normally provided with sewerage schemes (sewer lines, treatment plants, etc.). However, it is unrealistic and not cost feasible to construct such sophisticated systems in villages. This is due to limited resources of public funds available to the responsible government agencies.

In rural areas, the provision of utilities to drain sewage in a safe way lags behind the provision of water for household activities, including drinking water. This creates severe contamination to the environment of the various villages and reduces the impact of water on the improvement of health.

An appropriate wastewater treatment/reuse system, called the Subsurface Drainage Technique (SDT), is described here which was successfully applied, by Save the Children/USA, in several villages on the Israeli Occupied West Bank and Gaza Strip. The system is applicable for individual households with land available in their immediate vicinity. It consists of a watertight septic tank, where primary treatment occured, followed by a subsurface drainage field in which the secondary treatment took place. The treated wastewater in the drainage field allowed indirect irrigation (below ground level) for surface plants. Local materials were adopted for the construction of the SDT. Villagers themselves were trained to build the various units and therefore were able to maintain their efficient performance. Ongoing monitoring of the plants grown in the drainage field and the testing for bacteriological contamination ensures the safe performance of the technology.

KEYWORDS

Appropriate; wastewater; treatment; rural

INTRODUCTION

It is the practice that the provision of water precedes the introduction of sewage drainage facilities. This is understandable since prior to the existence of easily accessible water, there is hardly any water to drain and therefore the need for drainage facilities hardly exists. Unfortunately, the investment to make water available is rarely coupled with similar investment to provide sewage drainage/treatment facilities. This later stage is implemented normally after the wastewater problems start surfacing and possibly offset any improvement in the health of the community being serviced.

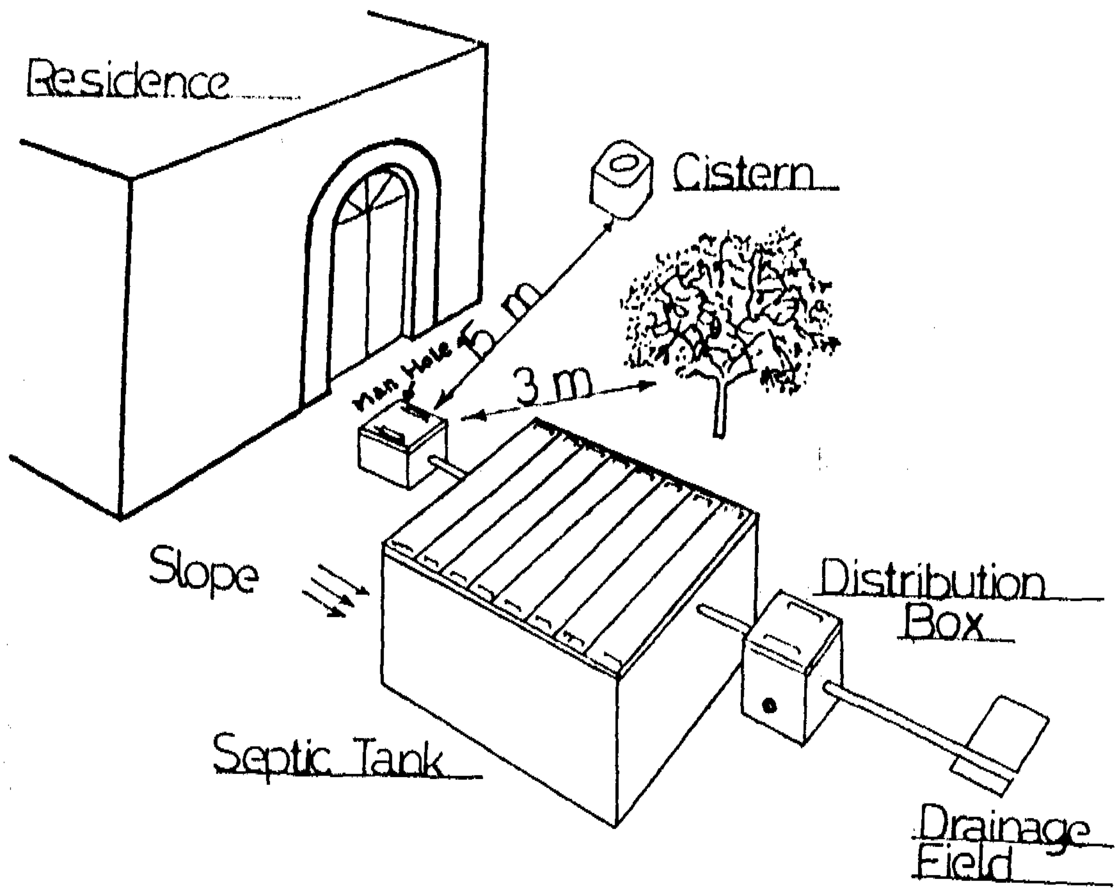
Proper hygiene leading to good health, in urban as well as rural communities, require that the consumption of drinking water is raised to acceptable levels (UN organizations put it at 40 liters/cap/day). The increase of water availability necessitates the provision of sewage drainage facilities. Urban areas are normally provided with sewerage schemes (sewer lines, treatment plants, etc.). However, it is unrealistic and not cost feasible to construct such sophisticated systems in villages. This is due to limited resources of public funds available to the responsible government agencies.

An appropriate wastewater treatment/reuse system, called the Subsurface Drainage Technique (SDT), is described here which was successfully applied, by Save the Children/USA, in several villages on the Israeli Occupied West Bank and Gaza Strip. The system is applicable for individual households with land available in their immediate vicinity. The paper discusses the SDT system, materials used in the construction plus costs and its implementation.

DESCRIPTION OF THE TECHNOLOGY

The technology proposed here is not new but was adapted to suit the local conditions in the Isreali Occupied West bank and Gaza Strip. The wastewater is drained from the house in sewer lines to a water tight septic tank where it undergoes primary treatment consisting of sedimentation and stabilization by anaerobic bacteria. The size of the septic tank depends on the quantity of disposed water and a minimum retention period of three days. The secondary treatment occurs in a drainage field. The drainage field, which consists of a series of subsurface perforated pipes, should be located at least 15 meters downslope from the water catchment area of a cistern. Figures 1 and 2 give typical details for the site plan, SDT and the septic tank. The details of the system presented in this paper (sizing of the septic tank and drainage field) is based on a daily disposal of 1 cubic meter of wastewater per day, which is typical for a single household (consisting on average of 10 individuals).

The overflow from the septic tank drains into a distribution box which leads to the subsurface perforated pipes embedded in a layer of coarse aggregates (filter). The distribution box is essentially a regular manhole with several outlets. The base of the distribution box should be designed such that the flow in all the perforated pipes is equal. The wastewater trickles through the perforations in the pipe to the filter media surrounding the pipes. The pipes, which should have a slope of at least 1%, are embedded in trenches. The dimensions of these trenches are interrelated and depend on the permeability of the soil in the drainage field as outlined in Table 1. Also, Figure 3 gives details of the drainage trench.



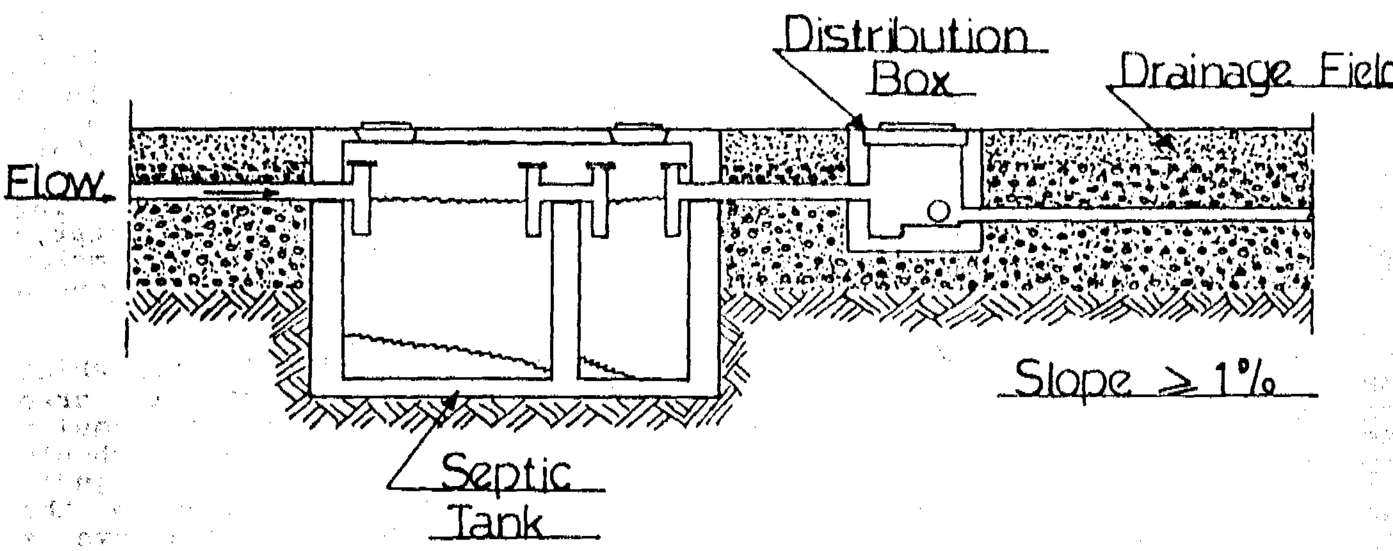


Figure 1 TYPICAL DETAILS OF THE SUBSURFACE DRAINAGE TECHNIQUE

Dimensions of Trenches in the Drainage Field (meters)

Width	Depth	Clear Space Between Pipes	Total Drainage Length*
0.45	0.45-0.75	1.80	20-100
0.60	0.45-0.75	1.80	15-75
0.75	0.45-0.90	2.30	12.5-60
0.90	0.60-0.90	2.70	10-50

(* Depends on soil permeability in the drainage field)

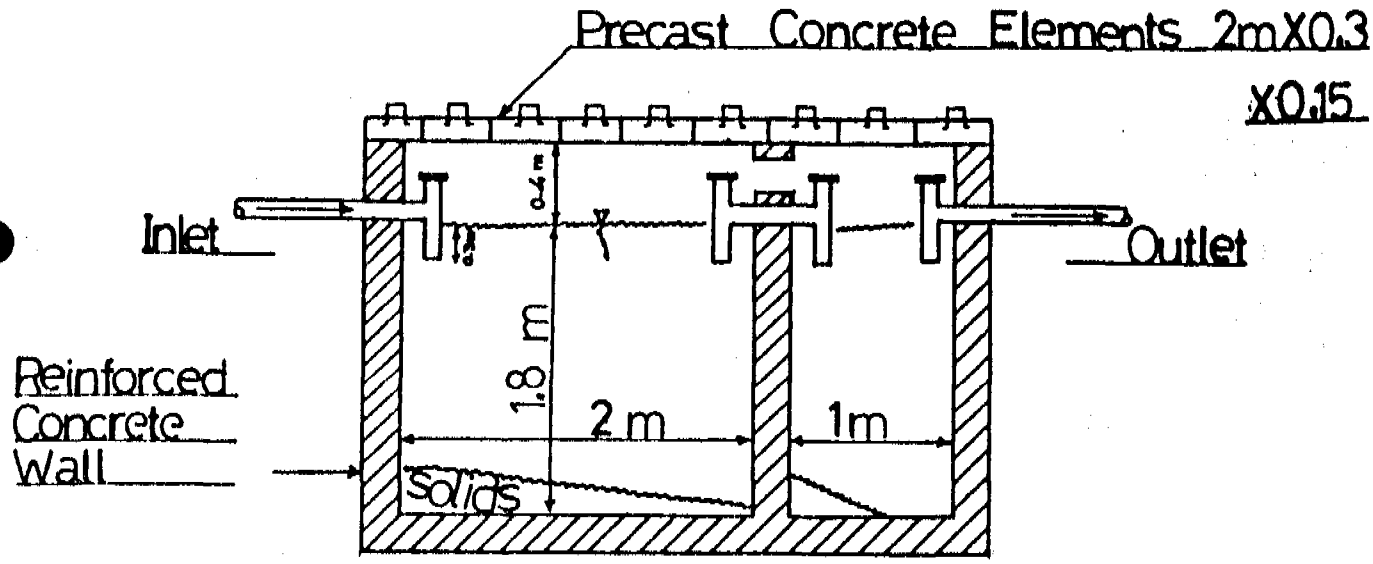


Figure 2 DETAILS OF THE SEPTIC TANK

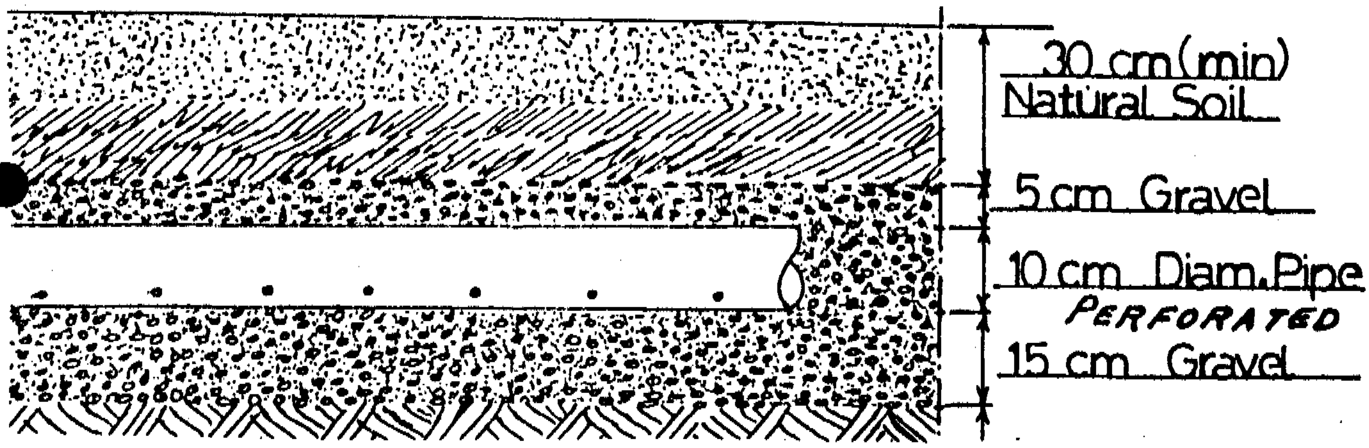


Figure 3 DETAILS OF THE DRAINAGE TRENCH

CONSTRUCTION, MAINTENANCE AND COST

Local materials were adopted for the construction of the SDT. Concrete ingredients, cement and various gradation of stone aggregates, were readily available. In some places, concrete blocks were produced locally in the village. Therefore, villagers were encouraged to mix concrete themselves and build the septic tank using in situ mixed concrete. Alternatively, and depending on the preference of the villagers, concrete blocks were used in the construction of the walls of the septic tank which resulted with saving in the cost of formwork. The difficult part of the construction was the roof of the septic tank. To eliminate this difficulty, precast units with dimensions 2 meters long by 0.3 wide by 0.15 deep were produced in the backyard of the individual households. The units were cast on the ground which was smoothened and covered with a plastic sheeting for that purpose. A simple rectangular frame was used as the main formwork. The size of the precast unit was dictated by the lifting capacity of four adults (approximately 200 kilograms). All the excavation needed for the septic tank and the drainage field was done by the family members themselves.

Villagers were trained to build the various units and therefore were able to maintain their efficient performance. The evaluation of this process is ongoing at this stage since no problems were speculated in the function of the system in the first couple of years. However, samples of the surface soil and the plants cultivated are taken on regular basis to check for any bacteriological contamination.

The cost benefits of the proposed system include the saving in the emptying of seeping pits which got clogged with time plus the water made available in the drainage field which is indirectly recycled for irrigation of home gardens. The cost of materials for a typical household unit is detailed in Table 2. The cost of labor was estimated to be roughly of the same magnitude as the cost of materials.

TABLE 2

Cost of Materials for a Typical Household Unit (US Dollars)

Item	Cost
Cement, Aggregates and Blocks	180
100mm Diameter Plastic Pipes	50
Steel Reinforcement	20
TOTAL	250 US Dollars

(Note that the costing is based on 1990 prices)

CONCLUSION

A wastewater treatment/reuse system suitable for rural areas was presented here which capitalised on locally available materials. The technology was simple to be comprehended by villagers who did all the construction work themselves. The proposed system converted the wastewater to an asset by making it available to subsurface irrigation of house gardens.

The main thrust behind the subsurface drainage technique described in this paper, is the fact that it is preferable not to use centralized systems for drainage of sewage in rural areas because the initial and maintenance costs are prohibitive. The choice of a technology which deals with wastewater in the direct vicinity of the household in a safe way means that more interaction of the community is achieved in the construction and maintenance which results with a reliable and sustainable technology.

REFERENCES

Baya', Majed (1986). Sewage treatment systems for rural areas. Unpublished Dissertation. Birzeit University. Birzeit, West Bank.

Khaled, Mohammad (1990). Wastewater/reuse system in rural areas. First Water and Sanitation Conference. Notre Dame Centre in Jerusalem. March 1990, Jerusalem.

Tamer Institute (1990). Treatment of sewage water. Special Publication by Tamer Institute for Community Education. Jerusalem. (in Arabic).

AN APPROPERIATE SLUDGE HANDLING APPROACH FOR RURAL AREAS.

KAMAL.T.EWIDA

Environmental sciences Dpt,Faculty of Engineering

Zagazig University,ZAGAZIG,EGTYPT.

ABSTRACT

The development of water supply and wastewater disposal facilities in rural areas specially those of developing countries depends to a high degree on the identification and application of approperiate techincal methods.

The much-used phrase approperiate technology of systems used must suit the size, nature,cost,culture,history, and capabilities of local people. The choices therefore cover a wide spectrum of methods, materials, systems and operations.

As has so frequently been stressed, generalized formulas or packaged systems are ill-adapted to dealing with the disparate conditions of rural areas in the developing countries. One should seek out and apply that technology most applicable to that segment of society for which it is being provided.

The purpose of this paper is to examine traditional as well as innovative systems for on site disposal and handling of excreta and organic residues sludges that are most suitable for rural areas in developing countries.

The suggested approach investigates the designs,functions and performaces of pit and composting latrines that can handle sludge disposal mainly excreta. For the vast majority of people in developing countries where it is expensive to install,uses large amounts of clean water and pollutes the receipient. For all those without access to piped water, a flush toielet is not even an alternative to consider.Analytical techniques were also used to evaluate the nutrient value of compost produced by the compost latrine.

KEYWORDS

Sludge disposal,sludge handling, Rural saniteation, Latrine, composting.

INTRODUCTION

Wastewater technologies developed in the industrial world over the past one hundred years or so can only to a limited extent be used in developing countries due to the following reasons:

- The capital requirements for conventional sewerage exceeded resources available to most developing countries. Where such systems are introduced they serve only a selected portion of the population. Most households have to solve their disposal problems themselves, specially at rural areas.

- Water is in many developing countries a much too precious commodity to be flushed away in sewers.

- Unplanned rural areas expansions makes it impossible to serve existing built up areas with gravity fall sewers.

- The techincal and administrative skills required to built, operate and maintain complex technological systems are short supply in most developing countries.

Alternatives to conventional wastewater technologies do exist and have over the past three decades received increasing attention. There are basically two approaches of handling human excreta: they can either be transported away for treatment and discharge, or disposed on site.

Whichever way is used,the excreta can either be mixed or not mixed with water. This gives four possibilities :

	TRANSPORT	NO TRANSPORT
WTERR	1- Flush toilet connected to sewer. - Aqua privy connected to sewer	2- Flush toilet connected to septic tank Aqua Privy cesspool Biogas tank
NO WATER	3- Bucket latrin Long drop latrin	4- Pit latrine compost latrine

The concerne of this paper is mainly group 4, where the classical pit latrine, the improved pit latrine and the compost latrine are to be examined as an approperiate approach for slulge handling and compost production at the rural areas of developing countries

The Classical Pit Latrine.

Classical pit latrine has been used for a quite long time allover the world. In its simplest form it consists of a large hand.dug pit coverd with a squatting slab made of timber and soil. This simple form of latrine has the advantages of being easily understood by the user, and where soil and ground water conditions are right it is easy to construct entirely using local resources.However this type of latrine has serious disadvantages: it is only feasible under special ground conditions. The soil must be deep, stable and permeable, and the ground water table must be lower than the depth of the pit. These restrictions are often overlooked resulting in pit collapse, especially when heavy rains have destabilized the soil, and in large scale insects breeding when liquid matter accumulates in the pit because of impermeable soil or high ground water table.The pit provides a protecting breeding ground for filth flies and mosquitoes and the soil on the platform a hatching place for hookwarms. The odours may be extrmely offensive. The lifetime of the pit is therefore very limited (Cepheri).

Improved Pit Latrines

Traditional pit latrines short comings can be overcome through some design modifications:the pit can be provided with a screened vent, the squatting slab can be made from cement or reinforced concrete and provided with a flush-bowl, the pit can be lined, partially displaced or placed above the ground pit vantelation is very imporant, this may be carried out through a ventpipe which helps in ventilating odours away and trapping filth flies. The ventpipe can be made from bamboo, timber, masonry, ferocemrnt or plastic.If the walls of the latrin's shelter are of massonry construction, ventelation can be via flue shapped by the the building blocks. The ventpipe opening at the top must be screened to prevent insects from getting in and out of the pit that way. Pit ventilation makes the latrine virtually odour free :the updraught through the pipe creates a downdraught through the hole in the squatting slab. Filth flies breeding in the pit will try to escape up the vent pipe but are prevented by the screen or gauze. Figure 1, shows a latrine of this type developed by Blair Research Laboratories in Harare, Zimbabwe during the mide 70s(Morgan 1979).

Another type of latrine with an off-set pit has been used in southern Africa for over 30 years. This is the so called R.O.E.C. (Reid's Odourless Earth Closet), Figure 2.The pit is 1m wide, 2m long, and at least 3m deep. It is covered with a reinforced concrete or feroccment slab and fitted with a ventpipe.

The squatting slab is on the side of the pit and the excreta are deposited in it via chute. This type of latrine should be used only where the soil is stable and permeable and where the ground water table never comes with in 3m of the ground surface.

Compost Latrine.

This is the most favourable and reliable latrine for rural areas in developing countries.It has dual advantages,(a)advanced design criteria for sludge handling,(b)production of sludge compost most suitable as soil conditioner.

It is estimated that a total weight of excrement of 790 kg (feces 90 kg, and urine 700 kg) is exerted by an adult per year. The excrement contains 4.4 kg of nitrogen, 1.96 kg of phosphorus, and 1.67 kg of ammonium sulphate, and 3.74 kg of potasium sulphate, there are other nutrative elements which are essential for sound soil fertility.

Composting is a biological process in which various types of organisms under controlled conditions break down organic substances to humus end product (mature compost). It is the" controlled conditions" which distinguish a composting operation from a garbage heap or manure pile.

As a biological process composting is influenced by a number of environmental variables such as aeration, temperature, moisture, PH value and the ratio of carbon to nitrogen.

An immense varielty of organisms are living in and contributing to the break down of compost heap. They range in size from viruses, bacteria, fungi, and alage to earthworms, arthropods and redents. It is this rich flora and funa that is responsible for the rapid decomposition taking place in a well functioning compost latrine. Compost latrines of different sizes and design approaches are used now at different places in the world such as

India,Vietnam and Tanzaneia.

EXPERIMENTAL PROCEDURE

An experimental composting latrine has been bulit at a rural comunity of about 2000 inhabitants near the city of Belbeis at the Sharqeia governerate,Egypt. The latrine had two chambers, each holding 700 liters.Both chambers were covered with squatting slabs.Only one chamber at a time was used.The hole leading to the other chamber was covered with a pile of bricks. A screened ventpipe was serving both chambers as shown in Figure (3,4). The latrine was serving a household of six people.

Before the latrine was used for the first time, the chamber was filled with loosely packed grass, leavs, straw, husks, sawdust,and yard sweepings. It was then used as an ordinary pit latrine with no water allowed to be poured into it. Several times a week more grass clippings, sweepings,etc were put into the chamber, and preferably after each use. They reduce odours, absorb moisture and make the contents of the receptable less atractive to flies. When the first chamber was used until it was 3/4 full, after four months, a sandy soil was added to fill the rest of the chamber and the pile of bricks shifted from the hole over the full chamber. The purpose of covering the hole with bricks is to creat a suitably contained aeration path (through vent) for microbial digestion and prevent further use of this chamber until the contents were removed.

When the second chamber was nearly full the contents of the first one was removed after stirring with a wooden stick for analysis.

The whole experimental procedure lasted for eight months (April to November) and the ambient temperature was weekly recorded during that period and averaged to be 24 C.

ANALYTICAL TECHNIQUES

The analysed sample of compost was fairly dry, soil like and almost odour free.

Ash content was determined by weight loss after ignition at 550 C. Organic carbon was determined by oxidation in the presence of 1.ON KCrO and concentrated sulpuric acid at room temperature. A factor of 1.3 was used for unoxidized carbon (Nelson & Sommers). Total nitrogen was measured as kjeldahl nitrogen. Hydrolysable nitrogen was determined by boilling under reflux for 16h in 6N HCI(Bremner). Mineral nitrogen (ammonia and nitrate) was extracted from the compost using a saturated calcium sulphate solution which proved equally effective as 2N KCL for this material

Nitrate was determined by the phenoldisulphonic acid method (Welcher), ammonia was determined colorimetrically. Cation exchange capacity (CEC) of the compost was measured with 1N ammonium acetate (PH 7.0) as extractant of exchangable ions.

RESULTS AND DISCUSSION

The compost analysis resulting from the experimental compost latrine is shown at Table .1. It represents the composition of the compost at the end of eight months period chosen for the composting process.

Table - 1 -

Analytical Details of compost produced after eight months of composting by the compost latrin :

Analysis	Value In Compost sample
Moisture (%)	5.4
Ph	7.4
Volatile Solids (%)	19.3
Organic carbon (%)	17.7
C/N	14.4
Total nitrogen (%)	3.1
NH _ N (PPM)	6.3
NO _ N (PPM)	80.7
C E C (meq per 100 g)	45.9
Exchangable Cations	
Ca (meq per 100 g)	47.3
Mg (meq per 100 g)	1.1
K (meq per 100 g)	7.0
Na (meq per 100 g)	2.4

It can be clearly seen from the analytical results that the compost produced is of a reasonable nutrient value, although the low value of total nitrogen may be attributed to amonia volatilization during the composting process, however we can use the compost produced by the composting lattrin for sandy soil in rural areas.

The produced compost is certinly not sterile but is no more to handle than the soil in the garden. However any recomended latrine building programme must include intensive health education scheme and follow up.

CONCLUSION

The flush toilet cannot solve the problems of excreta and sludge handling for the vast majority of people living at the rural areas of developing countries. It is expensive to install, uses, large amounts of clean water and pollutes the receipient. For all those without access to piped water, a flush toilete is not even an alternative to consider for the vast majority of households living at the rural areas of developing countries, sanitary excreta and sludge disposal must be based on *simple insite*,water conserivng systems like latrines. The compost latrine system proved to be most suitable, where due to its simple design and in expensive cost can produce soil conditioning composts necessary for land developiment at rural areas.

REFERANCES

Bremner,J.M.,"Organic forms of soil nitrogen". In Methods of soil analysis, Part 2. Agronomy (Black, C.A.CEds), 93-159 (1965).

Cepheri,T.,"Evaluation of rural latrine desigens", Proceedings of the symposium, Nagpur, India. (1964).

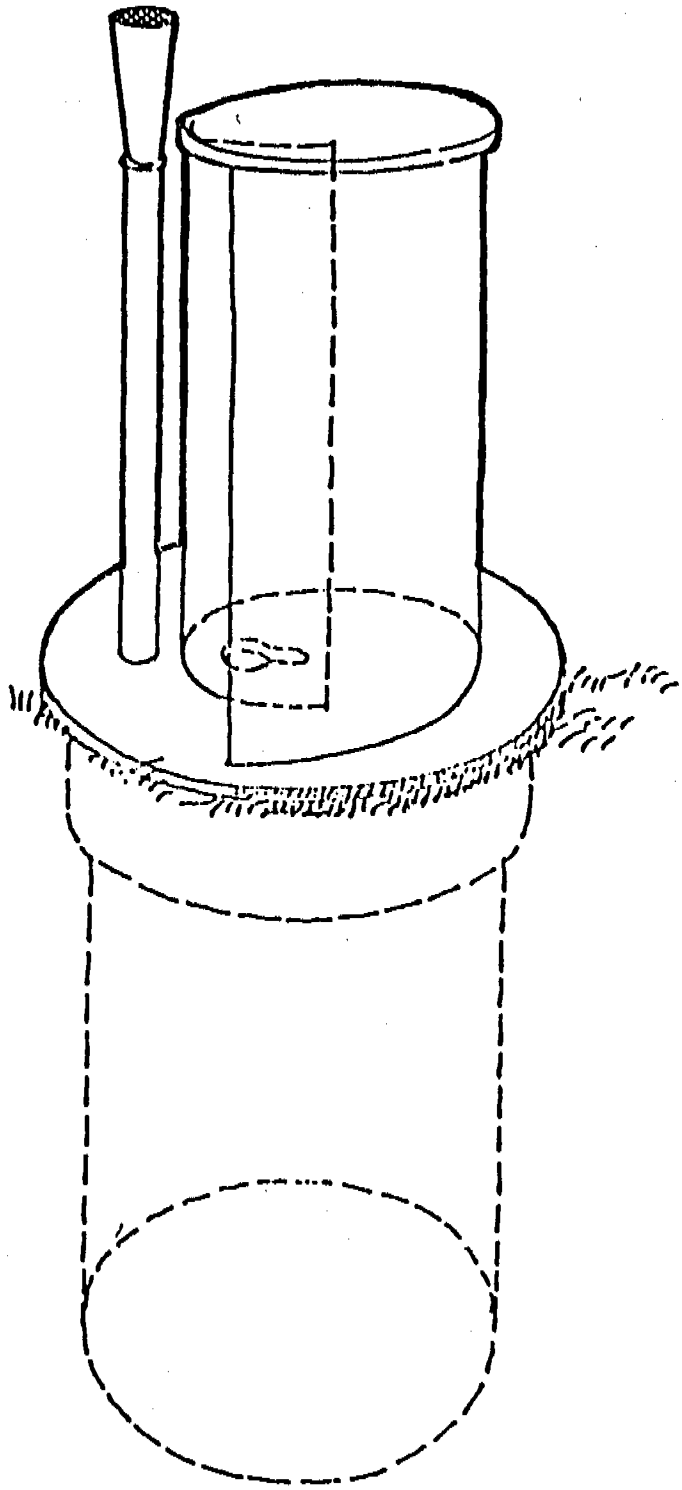


Figure 1

Ventilated pit latrine with ventpipe acting as flytrap. Blair Research Laboratories, Zimbabwe.

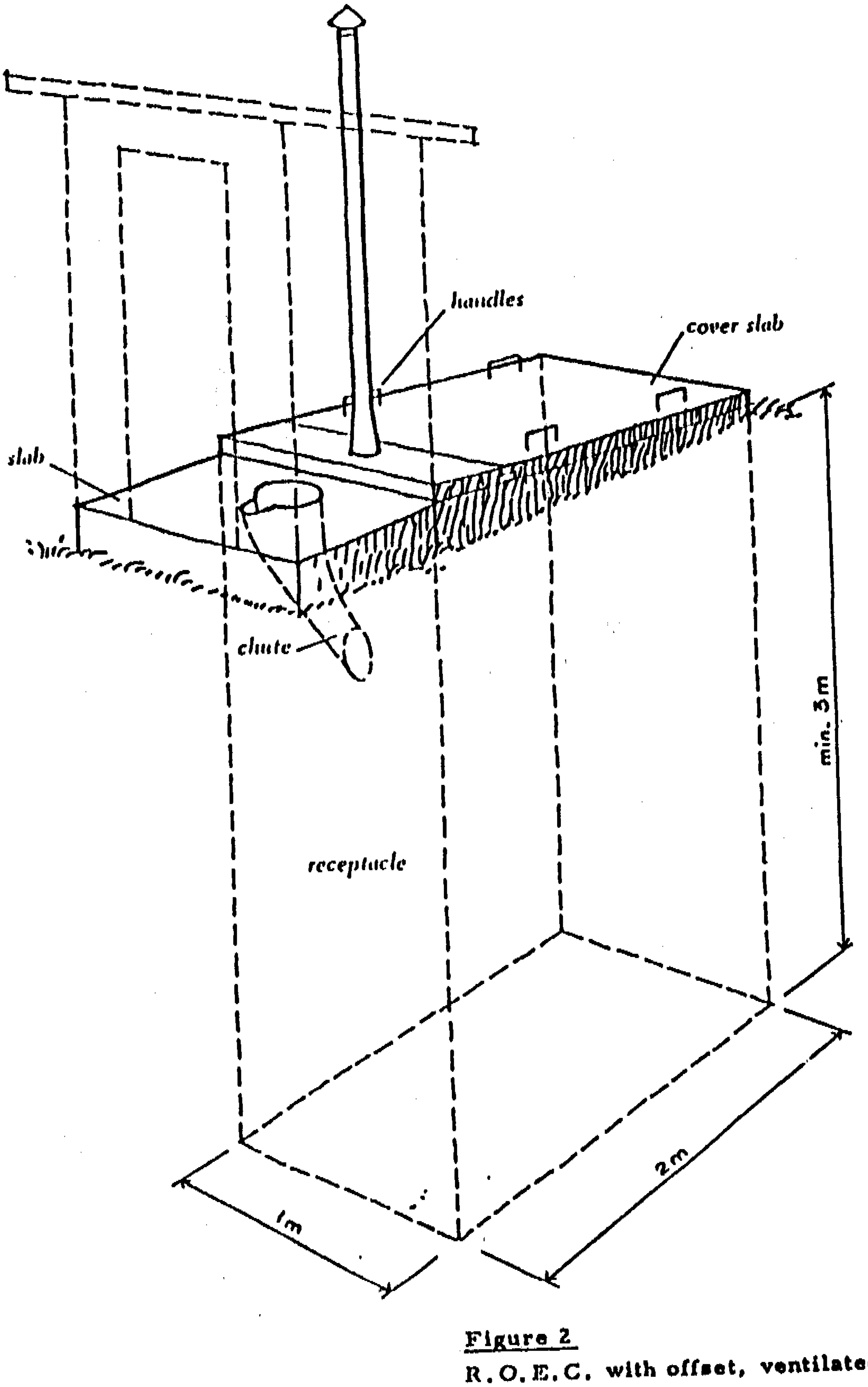


Figure 2

R.O.E.C. with offset, ventilated pit.

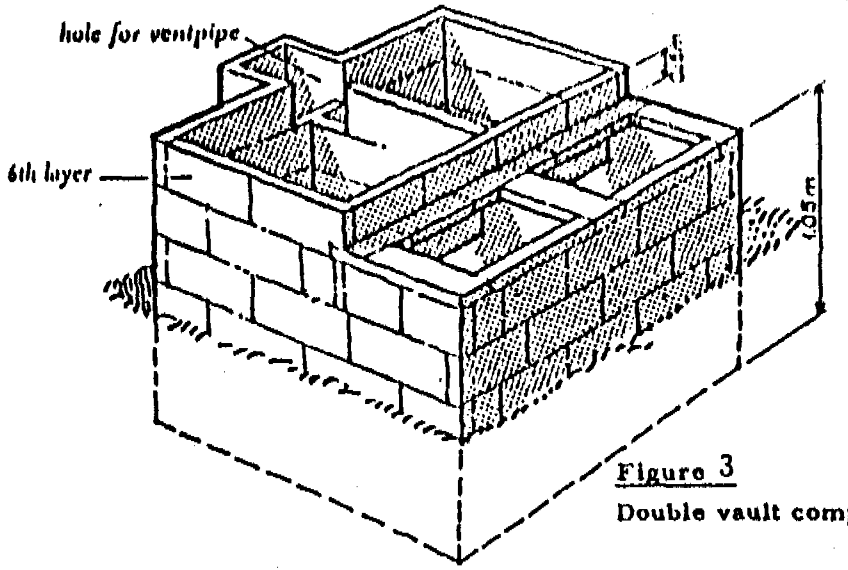


Figure 3
Double vault compost latrine developed

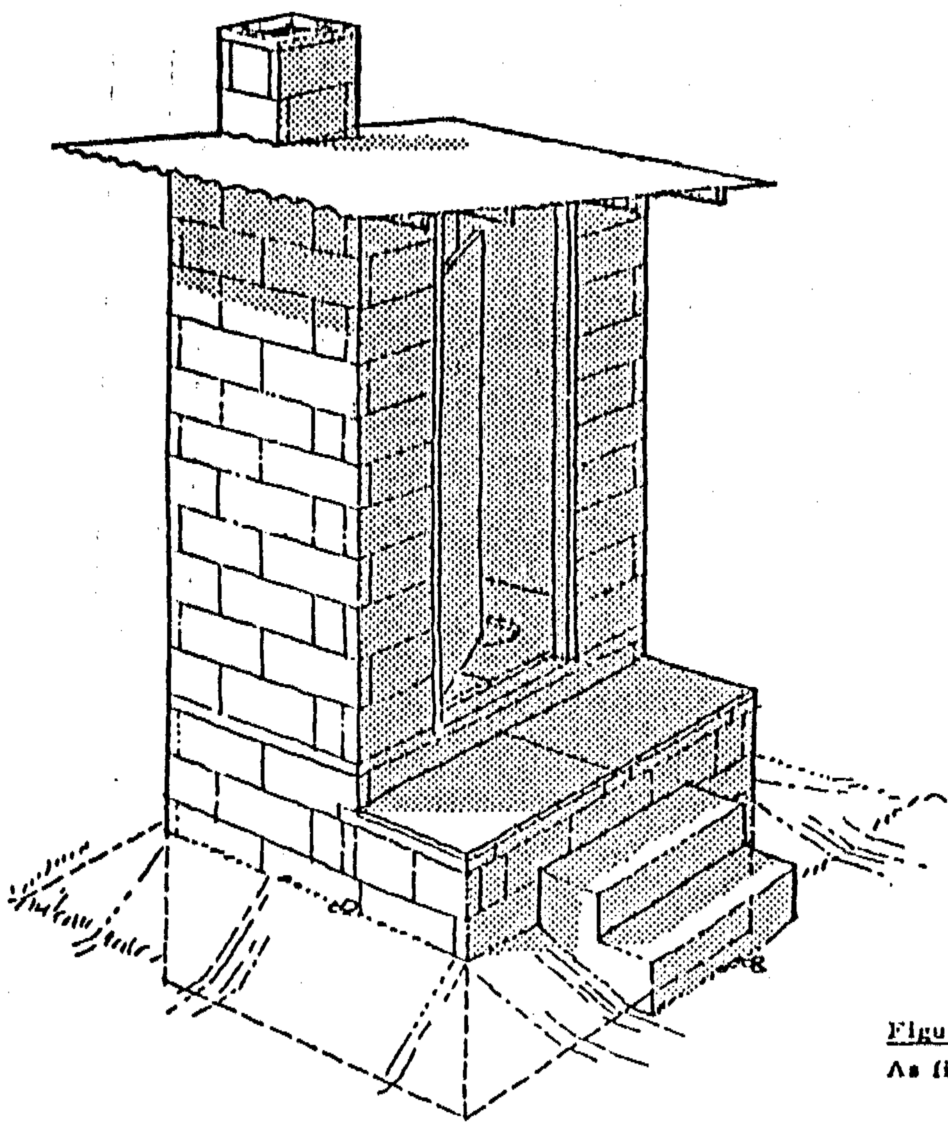


Figure 4
As fig 3 completed.