INTERNATIONAL REFERENCE CENTER
FOR COMMUNITY WATER SUPPLY
AND SANITATION

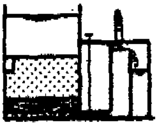
REPUBLIC OF KENYA

MINISTRY OF HEALTH

SLOW SAND FILTRATION
COMMUNITY EDUCATION AND PARTICIPATION

REPORT OF A SEMINAR HELD IN NAIROBI, KENYA

NOVEMBER 6 - 9, 1983



IRC Research and Demonstration
Project on Slow Sand Filtration

April 1984

INTERNATIONAL REFERENCE CENTRE FOR COMMUNITY WATER SUPPLY AND SANITATION

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GOVERNMENT OF KENYA

MINISTRY OF HEALTH

SLOW SAND FILTRATION
COMMUNITY EDUCATION AND PARTICIPATION

Report of a Seminar held in Nairobi

6th. to 9th. November, 1983

Organised by the Division of Environmental Health
Ministry of Health
in collaboration with IRC

Participating Agencies: Ministries of Health, Water Development, and Culture and Social Services, Kenya; University of Nairobi; and Kenya NGOs; and the International Reference Centre (IRC) for Community Water Supply and Sanitation, the Netherlands

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PAPERS

The papers here presented have been abstracted from larger documents to make this report more compact. (Editor)

List of abbreviations

GOH = Government of Kenya
MOWD = Ministry of Water Development
RWS = Rural Water Supply
IC = Individual Connections
Shs = Kenyan Shilling (1 US $ =
DDC = District Development Committee
KWAHO = Kenya Water for Health Organisation
HRF = Horizontal Roughing Filtration
VRF = Vertical Roughing Filtration
SSF = Slow Sand Filtration
UDSM = University of Dar es Salaam

NATIONAL SEMINAR ON SLOW SAND FILTRATION AND COMMUNITY EDUCATION AND PARTICIPATION

NAIROBI, KENYA

NOVEMBER 7 - 9, 1983

PREAMBLE

A national seminar organized jointly by the Ministry of Health, Nairobi Kenya, and the International Reference Centre (IRC) for Community Water Supply and Sanitation, the Netherlands, discussed the findings of the integrated research and demonstration project on Slow Sand Filtration and Community Education Participation. The participants consisted of representatives of Ministries, and non governmental agencies involved in water provision.

The seminar stressed that slow sand filtration due to its effectiveness and simplicity should receive due attention in the choice of water treatment technology, particularly for small community water supplies.

At present slow sand filters are being used to a limited extent in Kenya mainly because emphasis has been on large supplies, lack of expertise and information on the cost effectiveness of the methods, and a bias towards sophisticated technology encouraged by overseas donors.

Except for the North East Province, and some parts of Rift Valley Province, surface water is widely available, though often in limited quantities. Frequently, though, groundwater is scarce and groundwater quality not acceptable to the population. Because pollution is increasing with increasing population densities, surface water has to be treated to be suitable for drinking purposes. A simple and reliable treatment system such as slow sand filtration is essential.

The provision of water supply alone will not improve the quality of life of the community. An integrated approach involving health education and community participation is needed to ensure proper operation and maintenance as well as to create an awareness leading to safe water use. The participants agreed that the dialogue between the Ministry of Health, the Ministry of Water Development and the University and N.G.O.s initiated in the seminar is very important and needs to be maintained.

CONCLUSIONS AND RECOMMENDATIONS
OF PARTICIPANTS

1. Slow sand filtration is a suitable method to treat surface and spring water and therefore it should be further promoted by the Ministries of Water Development and Health and the other agencies active in water provision in Kenya for those communities where the local situation is appropriate.

2. It is recommended that more research work be carried out to develop appropriate design standards for Kenya by
   - rehabilitation of existing schemes,
   - construction of demonstration plants, and
   - encouragement of community participation.

3. Interaction among various organisations dealing with water supply and sanitation is necessary and can be stimulated by seminars, meetings and inter-ministerial discussions.

4. It is desirable that more information on appropriate methods of treatment such as Slow Sand Filtration is included in the basic training courses for all levels of staff. Although the curricula at the Ministry of Water Development Training School, the Medical Training Centre and the University-in the Department of Civil Engineering-do include SSF, more emphasis is definitely required.

5. Library and information sections should be strengthened and practical methods developed to disseminate information from the central level to the provincial and district levels and vice versa.

   Donor agencies, e.g. U.N. agencies, should be encouraged to participate in the programmes to support information exchange in Kenya in close collaboration with agencies such as the International Reference Centre for Community Water Supply and Sanitation.

6. Local communities in Kenya should be able to operate and maintain slow sand filters provided,proper training and regular supervision is given to caretakers coming from the community.

7. There is a pressing need to start dialogues with interested communities on their existing health practices and needs prior to the planning and construction of a water supply system. Sufficient time should be allowed to establish this dialogue and for it to be effective. These discussions can then also form the basis for plans to start improving the health conditions and should therefore be continued after completion of the water supply system.

8. The community should be encouraged to participate in the provision of their own water supply as well as to make regular contributions in cash or kind to ensure proper operation and maintenance of the schemes.

OPENING THE PROCEEDINGS

Mr R.W. Walukano of the Ministry of Health explained the background to the Seminar emphasising the importance of low cost technology in the provision of water supply and of community participation. He then introduced the Chairman for the session, the Chief Public Health Officer Mr N.M. Masai.

Mr Masai firstly congratulated the Ministries of Health and Water Development and the University of Nairobi on being involved in research and demonstration project in slow sand filtration. He welcomed those participating in the Seminar and thanked the International Reference Centre for generously supporting this programme and then called upon the Assistant Minister for Health, the Honourable Ochola Mak' Anyengo to speak.

Mr Mak'Anyengo explained that pressure of work had prevented the Minister being present and read the Minister's speech. The need for discussion, review, and dissemination of information on slow sand filtration with related issues such as community education and participation was widely recognised and in line with the goals of the International Decade on the utilisation of resources. Public information to increase awareness was urgently needed. The Assistant Minister expressed his pleasure at being present and formally declared the seminar open.

The Chairman called upon the Ambassador of the Government of the Netherlands His Excellency E. G. Tydeman, who mentioned Dutch involvement in the shallow wells programme in Nyanza Province and numerous other water projects, and said he expected the seminar to be both fruitful and stimulating and wished participants every success.

Finally Mr Masai called upon Mr J T Visscher of the IRC, Technical Director of the Seminar, who said how pleased he was with the response of the Ministries and of those invited to participate. He mentioned that he expected the three days to be demanding for the participants - the programme was a heavy one - but also valuable to them, and he hoped, to the Government and people of Kenya.

PLANNING AND IMPLEMENTATION OF RURAL WATER SUPPLIES IN KENYA

W.M. Ndegwa, Ministry of Water Development, (Nairobi).

The rural population in this country has traditionally relied on natural springs, streams, rivers, wells and lakes. These resources are the main ones that have been used in the rural water supply systems. The water needs in both rural and urban areas in this country are enormous. There are hundreds of people who lack reasonable access to an adequate supply of safe drinking water especially in the arid and semi-arid areas which comprise approximately two-thirds of this country. Good planning and implementation are required in order to meet the goals of the International Drinking Water Supply and Sanitation Decade (1981 -1990). The declared targets to be achieved by 1990 are water supply coverage of 100% in urban areas and 75% in rural areas. The Kenya Government's endeavour to provide the people of this country with clean drinking water by the turn of this century is therefore a big task.

The two main parties in rural water supplies are the G.O.K. and Donor Agencies. Each has its objectives in planning. The two overriding objectives of Swedish Development Assistance in the water sector are resource growth and the reduction of social inequalities. By resource growth is meant the increase or improvement of the nations development resources; these include overall economic growth as well as improvement in basic education, research, health standards etc. The second objective is that of narrowing of the gap between the rich and poor, as measured in terms of income and wealth.

The main objective of G.O.K. has been to provide all people of this country with clean water by the turn of the century.

The development of the rural water supplies over the past decade has been administered within the M.O.W.D. under the various programmes of which the most important are:

(i) Rural Water Supply Programme I - IV (RWS)
(ii) Self-Help Programme
(iii) Rehabilitation Programme.

The rural water supply programmes started in 1970's and have been by far the most substantial component in the development of rural water supply in Kenya. Various international agencies and bilateral donors have, over the years, assisted the RWS programmes financially. Noteworthy are the contributions from the Government of Sweden, (through SIDA), and the World Bank (IBRD).

As of 1977, 13% of the rural population had access to an improved water supply provided by projects extended by several Ministries. Expenditure of K£ 20.1 million at 1976 prices had brought water to 1.46 million rural people. An expenditure of K£ 238 million at 1978 prices was foreseen as the minimum investment requirement to serve an additional 13.6 million people by the year 2000.

Approximately 800 water schemes pre-existed or had been completed by 1973 at which time some 600 were not functioning properly. Originally design and construction defects caused part of the problems, but operation and maintenance shortfalls were the main deficiencies. As a result the M.O.W.D. now has multiple roles to fulfill.

- the design, supervision and construction of new schemes.
- the rehabilitation of schemes
- the operation, or supervision and training, for operation and maintenance of existing schemes.

At present it is estimated that 20% of the rural population is supplied with water, and actually 35% of this sector receive water. It has been argued that an increase in individual connections has tended to deprive of water that part of the population that cannot afford to pay for I.Cs. The rate of recovery of the cost of running these water supplies has been very low. The recovery of operation and maintenance costs of producing 1m^3 of water is around Shs 1.00. The M.O.W.D. overhead for producing this 1m^3 is Shs 4.50. Additionally in 1981-82 the M.O.W.D produced 22.4 million m^3 of water and 50% of that amount was billed. This information has significance for the future planning of water systems.

There has been a very sharp increase in the cost of new water schemes due to global inflation in the cost of materials. This calls for more detail in planning of water supply systems. Also local communities should be involved, and the selection of a suitable technology remains important since other problems are compounded when techniques, methods and equipment used are not compatible with the situation of the rural community. Slow sand filtration has been mentioned as suitable technique for rural communities. In Kenya slow sand filtration dates back to 1954, but up to now there has been little impact in the rural areas.

Project selection in the RWS Programme follows a systematic procedure during the initial formulation but subsequent adjustments in programme and project scope are pragmatic and do not follow any well defined process. The selection of projects is basically carried out by the District Development Committee with the technical advice of the District Water Officer.

The outcome of the DDC meetings is a list of priority projects submitted to the Ministry of Water Development for inclusion in the rural water supply programme planning. Other funds are available to the DDC for the smaller water supply projects, and Rural Water Supply planning is now focussed on larger projects.

Projects are selected in various districts to equate expenditures in unserved rural population areas. The present information on cost and population served is however, very uncertain. Special attention is paid to the poorer areas of the country which receive favoured treatment.

Following the preparation of a list of projects with the limits of supply tentatively established, the Ministry starts the cycle of project identification, feasibility study, preliminary design, including marketing study, final design, tendering and construction.

The M.O.W.D. has involved the local community in the laying of pipes, trenching and carrying out of semi-skilled works. This has been the basis of self-help projects. Experience over several years has shown that in the early stages of planning the local community can be involved in the choice of level of service, the source of water, and the siting of supply facilities. This actually stimulates a feeling of local pride and commitment.

From information gathered, it has been found that consumers are in most cases, using more water than they can pay for. So, cheaper water systems such as hand-pumps, gravity systems, furrows, canals, and slow-sand filters are to be encouraged. Also the use of windpumps and solar pumps.

In our evaluation work we ask to what extent each individual scheme is realising its objective of providing the resident population with safe and reliable water? The only justification for the entire programme is supplying the households with safe and reliable water for domestic and livestock use.

PLANNING, DESIGN AND IMPLEMENTATION OF SELF HELP WATER PROJECTS

P G Munoru, Ministry of Water Development, Kenya.

Self help water projects in Kenya date back to the 1950's when they were generally funded by County Councils. The Public Health Department of the Ministry of Health became involved especially in wells and the protection of springs.
Now the Ministry of Water Development is directly involved in about 300 water supply projects but currently projects are estimated to number about 800. Some are incorporated into national planning, and all are receiving inputs in planning and design and assistance in construction from Ministry of Water Development staff.

Self help water projects are initiated locally and then registered with District Development Committees. Members of the Management Committee are listed and the Committee is then free to approach potential donors, and also the M. O. W.D. for technical assistance and a water permit. The permit is granted after the Water Board has approved the rules of association.

Project planning and design are usually undertaken by District level staff though some Districts rely on Provincial or National level technical staff and consultants may be called in for large projects. The first priority is to give people access to water emphasising quantity rather than high quality because more disease is believed to be associated with inadequate supply and also capital costs are lower. In future more slow sand filtration plants will be installed reducing costs but requiring experienced operational staff.

Project implementation is increasingly being directed to self help projects. In the fiscal year 1983-4 about K£5 m has been voted. People locally are raising more money and the Government is assisting at the District level through the Rural Development Fund of the Department of Economic Planning. Unskilled labour provided by the community can reduce costs by 30 to 40 per cent.

Operation and maintenance is financed by water tariffs set up by the Management Committee, usually a flat monthly rate per family. Machinery breakdowns and fuel costs can make problems. Operators receive training at an annual programme in which the Ministry of Culture and Social Services participates.

Finance provided by the Government and the community is often supplemented by NGO's. The Government is assisted by funding from, in particular, the Netherlands, Denmark and the EEC. Some finance and labour from the community is essential for Government assistance.

Constraints impeding development are many including inadequate capital, lack of community motivation, lack of sufficient technically qualified manpower leading to delays, poor designs, and poor supervision. Transport at District level is usually inadequate, institutions involved do not co-ordinate activities, water resources are often inadequate or difficult to utilise and so involve high cost solutions.

SLOW SAND FILTRATION PROGRAMME

Slow sand filters have been used for water treatment in many European countries for over 150 years and are now seen as very significant in the implementation of water decade goals. The first SSF plant in Kenya was built about 1954, but the standard designs used were unsatisfactory leading to poor operation so that these plants now need rehabilitation.

Two pilot plants are now being built under the IRC-WHO programme at Kisekine - Machakos District, and Giaithieko - Kiambu District, but are not yet in operation. At Kisekine problems of rock excavation at the intake site led to a change of site. Then claims for compensation for land led to a further change of site. The construction work has progressed slowly but with additional funds the target date for completion is now mid-1984. The SSF is designed to provide adequate clean water for the project.

At Giaithieko the water project has been in operation for some time and the SSFs are designed to improve water quality. Construction should commence in the current financial year.

FUTURE STRATEGIES

Self help projects will play a big role in the realisation of the decade goals. More community involvement at all stages of the project cycle is needed. 'Appropriate technology' and 'proper technology mix' should be emphasized. Slow sand filters are appropriate for village use both by reason of volume of water required and ease of operation. .Good cost saving designs, use of locally available materials, active community participation with health education and training of water supply operators at village level are essential. Then community water supplies can be ensured through SSF.

THE ROLE OF WOMEN IN RURAL WATER SUPPLY IN KENYA

Margaret Mwangola, Director, Kenya Water for Health Organization.

Easy access to safe drinking water supply is not only an indication of development, but also a reflection of quality of life. In Kenya most rural people, have no easy access to safe drinking water. In 1976 only about 15% of Kenya house-holds had access to piped water. Poverty and availability of water are closely related, lack of water within reasonable distance is an aspect of being poor. But willingness to do something about it has recently been clearly seen in rural Kenya.

Since 1967 people increasingly have contributed cash, labour and material to rural self-help water projects. In 1967 contribution was as little as £77,000 but rose to £800,000 by 1979. The Kenya Government has also responded eagerly to this Harambee effort.

Thus a lot of resources are coming into this programme but for some time inadequate attention has been given to maintenance. Many rural self-help water projects are not functioning and need rehabilitation Self-help water schemes are especially unreliable.

Ministry of Water Development, Ministry of Health and Ministry of Culture and Social Services with overseas donors hold annually a training programme for rural water operations, teaching simple skills in maintaining supplies. Initially, several water schemes were rehabilitated. Later some of those who had been trained left rural areas for better jobs. The women who carry water, are once again forced to bear the same burden as the schemes become inoperational.

The time has come for women themselves to be involved in motivating and mobilising the community to plan and implement water schemes and, especially, to ensure these schemes continue to fulfil their original objectives.

EXISTING SITUATION - Women suffer particular hardships.
Hours and calories that could be devoted to essential development tasks are lost. The time and energy consumed in fetching water from long distances might otherwise be devoted to caring for their

families, or to educational or income earning pursuits.

When a man decides his family must move and cultivate in a new area it is the potential fertility of the land that determines where the new house will be sited. Often women and children have to go great distances daily for the essential water and fuel wood. Some of the journeys women make to secure water in the dry, areas of Kenya are almost unbelievable. To spend half of all the daylight hours gathering water is not unusual. Water in swamps, and pools which is contaminated most of the time, is the only alternative.

SOME RECENT TRENDS

For a long time the potential contribution of women to development in Kenya was largely ignored. When 1975 was declared by the UN to be "International Women's Year",and the period 1975 - '85 the UN "Decade for Women" a new stimulus was provided. Rural women have since become more involved in income-generating activities seeking to improve their livelihood.

Small commercial projects, including chicken-keeping, goat-keeping, pig-keeping, communual farms, mabati groups (for home improvement) have sprung up in many areas. Water projects have been particularly important in this development process.

Safe water is needed for drinking, sanitation, food preparation, live-stock maintenance and crop production. Most of Kenya lies in low rain-fall zones. With such competing needs water is often scarce. Though recently we have begun to see men carrying water for sale using bicycles or donkeys water collecting is a female's job and frequently a neck and back-breaking labour. Women must also collect firewood, rear and socialise their children, care for the old, deal with all family sicknesses, participate in communal labour in villages, etc... When there are nutritional deficiencies women and their children are normally the worst hit.

Women in Kenya are not privileged. With low rainfall, small plots of land and the increasing demands of their situation, their status is always pre-carious. To release them from unnecessary toil is to release a potent force for social, human, and in particular, family development.

AREAS OF IMPORTANCE FOR WOMEN'S PARTICIPATION IN WATER DEVELOPMENT.

Little is being done to involve women as maintainers of water projects, or trainers of trainees, or trainers of trainers or as sanitary engineers or water engineers. There is great need of efforts directed to this end to make women full participants in water development.

In Kenya Water for Health Organization we know that most women of this country want more and better quality of water and, especially, water close to their houses. KWAHO is also very concerned about "Community Education ". We conduct workshops to teach the community safeguarding water quality. KWAHO also addresses itself to water scheme maintenance and simple village technologies for women. We are going to involve the community for the first time in the Ministry of Water Development, and UNDP "Hand Pump Testing Project".

So KWAHO whole heartedly welcomes this workshop and congratulates Ministry of Health International Water Reference Centre and all those involved. Speaking not for KWAHO but for several millions of Kenyan women whom KWAHO is committed to serve as funds become available, we want more, better, and readily available water to use in our homes; more of the water that becomes available when it rains.

Farming as a means of life makes most of us live in scattered settlements and we want water nearby. We know that water engineers prefer either to catch water high in the forests or to pump it from the ground. Surface water in pools, ponds and small streams, they think is likely to be contaminated. But if women can get this water and, using the methods of Slow Sand Filtration, make sure it is made fit to drink, then some thousands of villages can benefit.

CONCLUSION

I wish to emphasise effective planning, monitoring and evaluation for programmes that affect the lives of women, water included. Already health improvement has begun where water is accessible to people. More programmes geared to community education on this subject are urgently needed KWAHO is very gratified to find technical people such as yourselfs getting into community oriented workshops such as this one. We, in the fabric of non-governmental organizations, feel very grateful, when you work with us and we particularly thank Kenya Government for giving us every support each time we are in need.

THE INTERNATIONAL RESEARCH AND DEMONSTRATION PROJECT ON SLOW SAND FILTRATION

Jan Teun Visscher, International Reference Centre for
Community Water Supply and Sanitation (IRC). The Netherlands.

Slow sand filtration is a very appropriate method for making surface water safe to drink. This may be illustrated by a brief description of the process.

In the slow sand filter the water percolates slowly through a porous sand bed. During this passage the physical and biological quality of the raw water improves considerably. In a mature bed a thin layer forms on the surface of the bed. This filter skin consists of a great variety of biologically active micro-organisms which break down organic matter while also straining out a great deal of suspended inorganic substances. When after some months the filter skin gets clogged, the filtration capacity can be restored by cleaning the filter, i.e. by scraping off the top layer of the filter including the filter skin.

Slow sand filters are an essential element of water treatment works in various European cities, e.g. London and Amsterdam, but little was known until recently about their merits for application in tropical areas. In order to assist developing countries in generating this knowledge and experience on SSF, the integrated research and demonstration project on slow sand filtration (SSF Project) was initiated in 1976. This project embraces applied research, demonstration programmes and the transfer of information.

The applied research on the engineering aspects of SSF has been done by institutes in India, Thailand, Kenya, Sudan, Ghana and Colombia. After the reliability of the process was proven for tropical conditions, the second phase was initiated to demonstrate at village level the effectiveness of SSF as a simple purification technique. This has been accomplished by the installation of a number of village demonstration plants in selected villages. The communities in the villages were involved in the planning, construction and operation of the schemes. This integrated approach in which the community, the public health department and the water supply agency closely collaborated together was chosen in order to increase the commitment of the community to the water supply system and to enlarge its impact on the health situation. We have now arrived at the stage of dissemination of information. Therefore I would like to present some of the major findings of the project.

When surface water is readily available, whilst groundwater is not, slow sand filtration will frequently prove to be the simplest, most economical and reliable method to prepare safe drinking water.

- No other single process can effect such an improvement in the water quality.
- If well operated, it provides water that is virtually free from disease carrying organisms.
- The simple design permits construction wholly with locally available material and avoids costly imported machinery and highly skilled professionals.
- Operation and maintenance of the process is cheap and simple. After a period of training, local people can perform these tasks.
- Safety chlorination of slow sand filter effluent, although desirable, is not essential. Where safety chlorination cannot be guaranteed, SSF still provides a safety barrier because of its efficiency in retaining harmful organisms while other treatment techniques do not. Therefore SSF comes into special prominence for rural water supply.
- For smaller size plants, the cost of construction and operation and maintenance is lower than that of other purification systems. In India it was found that SSF- in comparison to RSF-was cost efficience up to 8 mld. With the rising costs of energy and chemicals, the balance will continuously become more favourable for SSF.

Based on the findings in the SSF Project, the following design criteria for SSF were developed:

design period	10-15 years
period of operation	24 hrs per day
rate of filtration	0.1 m/h (0.1-0.2 m/h)
area per filter bed	10-100 m^2
number of filter beds	minimum of 2
height of supernatant water	1 m (1-1.5 m)

initial depth of filter bed	1 m (1-1.4 m)
minimal depth before resanding	0.5 m
depth of underdrains	0.4 m (0.3-0.5 m)
specification of filter sand	$d_{eff.}$ = 0.15-0.35 mm Uniformity coef. = 2.5

The implementation of a community education and participation programme prior to the introduction of the water supply system is essential. This can help to ensure that the needs of the population are indeed fulfilled by the programme. Local resources will be mobilized and can ensure that the facilities are both used and maintained properly, and thus enhance its length of operation. In countries where the recurrent budget available for maintenance activities is low, the need for community involvement in maintenance comes into special prominence.

Health education is a key element in initiating discussion and in changing community practices detrimental to hygiene and sanitation. This concerns specifically topics such as maintaining the purity of water from delivery point to ingestion by clean receptacles, clean hands: also avoiding waste of water and nuisance around delivery point.

These are the essential major findings of the project. During this present meeting more detailed information will be presented on slow sand filtration and community education and participation.

OPERATION AND MAINTENANCE OF SLOW SAND FILTERS

Jan Teun Visscher, International Reference Centre for Community
Water Supply and Sanitation (IRC)

One of the most attractive aspects of Slow Sand Filtration is its simplicity of operation. This simplicity makes its application particularly appropriate in rural areas where local people can do the job including normal maintenance. Provided that the plant has been well designed and constructed, the performance of the filter will depend on the conscientiousness of the operator carrying out the daily routine. Proper training is essential as the caretaker will have responsibility of ensuring that the water supplied to the community is safe and attractive in appearance. The caretaker should not only understand the technical aspects but also the concept of community participation and his role in health education.

Mode of operation

The most effective way to operate a slow sand filter is to run it continously for 24 hours each day at a constant rate. This ensures proper functioning of the biological process and provides the best effluent quality. It has become common engineering practice to choose a constant design rate of filtration between 0.1 - 0.2 m/h. Higher design rates are in some cases possible but are not recommended for use in rural areas as these will lead to a more complicated operational process due to more frequent clogging of the filter. The filtration rate in a filter is generally determined by measuring the discharge of the filter out let. A practical measurement device is required to enable the operator to operate the filter properly. If continuous operation is not possible, declining rate filtration is the only acceptable alternative-to bridge the gap between shifts-to full scale operation.

If at the end of a shift the operator closes the inlet valve the top water level will slowly drop and so the head of filtration will decrease and the filtration rate will decrease as well. Operating the filters at declining rate requires a larger filter bed area than continuous operation but is sometimes necessary if the power supply is intermittent or to reduce the cost of fuel and operation wages. The effluent quality of filters which are operated at declining rate is quite acceptable. Only a slight deterioration of the overall bacteriological performance of the filters can be expected.

Intermittent operation should not be allowed since it has been shown conclusively that an unacceptable breakthrough of bacteriological pollution occurs 4-5 hours after restarting the filters.

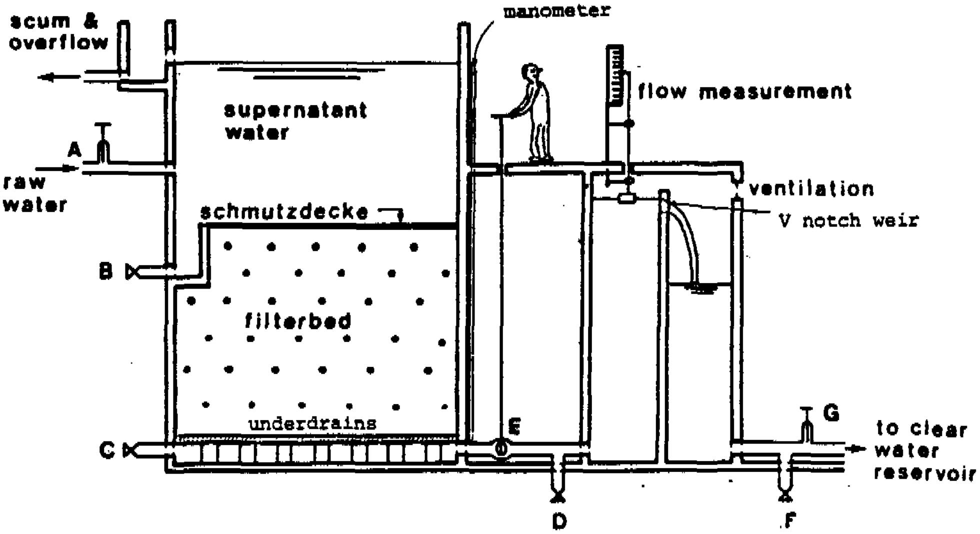

FIGURE 1. Basic elements of a slow sand filter

Operational Procedures: Initial commissioning of the filter

When the filter box has been completed and the filter material has been cleaned and inserted to the designed initial thickness of 1.0 or 1.2 m, the filter can be charged with water.

With all outlet valves closed filtered water is admitted from the bottom (valve C) to flow upwards through the drainage system and the gravel and sand bed until it reaches 10 - 15 centimetres above the sand bed. Valve C is then closed. This method of charging ensures that air accumulated in the system, especially in the pores of the sand bed, is driven out.

When no filtered water is available for backfilling, a temporary connection can be made with the raw water.

Next, valve A is gradually opened and water is allowed to flow on top of the bed. The rate of filling is initially low to prevent scouring of the sand around the inlet. With the increasing layer of supernatant water the rate of filling can be increased. When the normal working depth of the supernatant is reached the outlet valve C is opened and the effluent is run to waste at the design rate of the filter.

The filter must now be run continuously for a few weeks to allow for so-called "ripening". The ripening period has ended when bacteriological analysis indicates that the effluent quality reaches local water quality standards. From then on water can be passed into the water supply system. Often it is not possible to wait so long; in that case the water can be supplied after a few days provided there is adequate chlorination of the effluent during the ripening period.

Daily operation

As shown in figure 1 valves A and E are the two most important control devices of the filter. Valve A is meant to keep the supernatant water at a constant level. Valve E is the valve actually regulating the filtration rate. Under normal operating conditions, the filtration rate will be kept as constant as possible. However, due to clogging, the resistance of the filter bed gradually increases and therefore the operator has to compensate for that by opening the regulating valve E a little bit every day. When large adjustments of valve E become necessary this is an indication that the filter will soon need cleaning.

Depending on the seasonal variation of the raw water quality, especially, the turbidity, the interval between consecutive cleaning operation may vary between 60 and 90 days.

A simple and effective way of setting the correct rate of filtration is shown in figure 2. In the outlet chamber a V-notch measuring weir is installed. Just upstream of the weir a float is placed which indicates the actual filtration rate by a pointer, which moves up or down in front of a scale calibrated from 0 - 0.4 m/h. When the operator manipulates valve E he can easily see by reading this pointer whether he has set the correct rate of filtration.

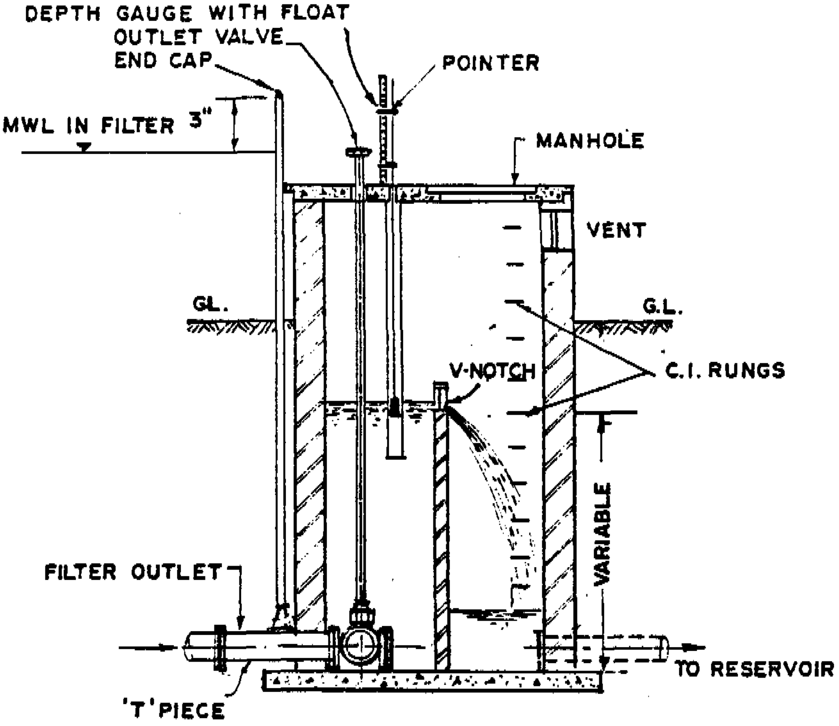

Figure 2: Measurement device (NEERI)

Cleaning

To clean the filter it is necessary to lower the water level in the bed to about 0.1 - 0.2 metres below the top of the sand. The inlet valve should be closed so that the top water level will gradually reduce through normal filtration until it reaches the level of the weir. The top water drainage valve (B) and the emptying valve (C) may then be opened so as to drain off the remainder of the water to a level of about 0.1 - 0.2 metres below the surface of the sand. Valve B may be opened at an earlier stage to drain off the top water more quickly.

When the water has reached the required level below the sand, as can be observed in the weir chamber, the emptying valve should be closed. The bed is then ready for cleaning.

Cleaning of the filter bed is accomplished by scraping the top 1-2 centimetres of the bed. The cleaning operation must be completed as quickly as possible in order to reduce to a minimum the inter-ference with the life of the micro-organisms in the remaining part of the filter bed.

Floating matter such as leaves or algae should be discharged over the scum weir by first raising the level of water in the bed and thus causing a surface flow across the bed, which carries the floating matter over the weir. If this floating matter is not removed it becomes a nuisance when cleaning takes place and may make it difficult to drain the bed.

When one bed is shut down, to maintain the output of the treatment plant the remaining bed or beds have to work at a higher rate. The filtered water valve on each of the other beds must therefore be opened slightly in two or three stages until the required total output has been reached, but the maximum permissible filtration rate must not be exceeded. This rate, laid down at the design stage, is arrived at from experience and quality considerations - a guide figure might be 0.3 m/h. After cleaning, the filter has to be refilled with water. This process, called backfilling, has to be done from the bottom up in order to drive out the air bubbles. In the absence of an overhead storage tank, backfilling may be effected by using filtered water from an adjacent filter. If this method of operation leads to a temporarily reduced output of the plant, the population should be informed in advance.

When the filter is put back into service a period of at least 24 hours is required to allow for re-ripening of the bed. After that period, the bacteriological flora has been sufficiently re-established to be able to produce a safe effluent which can then be put back into the supply. In cooler areas this ripening period may, though, have to be extended to a few days.

Re-sanding a filter

Re-sanding becomes necessary when successive scrapings have reduced the thickness of the sand bed to 50 centimetres, in the case of builder grade sand. Fortunately this rather lengthy operation only has to be done at two or three years intervals. Assuming, for example, an initial thickness of the filter medium of 80 cm and an average of 6 scrapings a year (or 6 x 2 = 12 cm total scraping a year) then re-sanding would only be necessary after 2½ years of operation.

The method of handling the sand is as follows: The old sand which has to be replaced is moved to one side, the new sand is placed and the old sand replaced on the top of the new (fig 3). This"throwing over" process is carried out in strips.

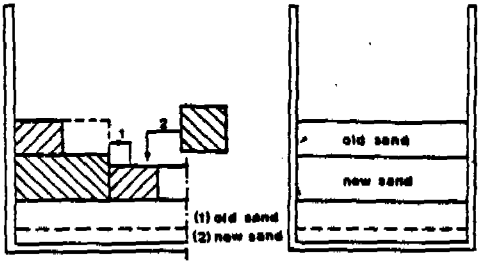

Figure 3 Throwing over practice

Excavation is carried out on each strip in turn. The removed material from the first strip is stacked to one side in a long ridge, the excavated trench is filled with washed or new sand and the adjacent strip is excavated, throwing over the removed material from the second trench to cover the new sand in the first. When the whole of the bed has been re-sanded, then the material from the first trench is used to cover the new sand in the last strip. By doing so, the layer of "old" sand (which is rich in microbilogical life) is replaced at the top of the filter bed which will enable the re-sanded filter to become operational within a minimum re-ripening period.

It is also possible to remove completely the old sand layer and spread it over the new sand after this is placed. This is especially appropriate for small slow sand filters.

Sandwashing

Sandwashing has to be carried out to separate the dirt from the sand after scraping, and sometimes to clean new sand before it is placed in the filter during construction of the filter, or during re-sanding. Usually it is cheaper to wash and store the scraped sand than to use fresh sand for re-sanding purposes. However, while washing, some 20-30% of the sand is lost.

A simple method for sandwashing is hose washing.

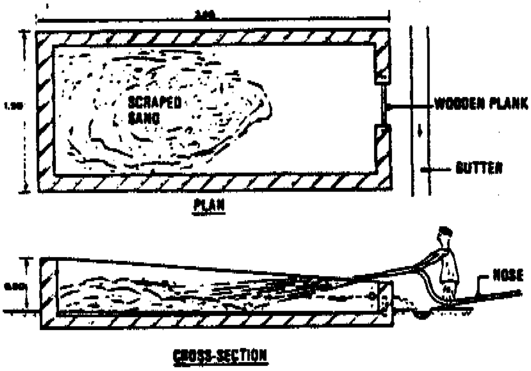

Figure 4. Sandwashing platform.

For this, a platform is constructed about 2.5 m long by 1.5 m wide with a ditch lengthwise of 15-20 cm. The platform is surrounded by a wall rising from 30cm at the bottom to 60 cm high at the top, except the lower end, which is closed by a removable plank weir 15-18 cm high. 1.0 cubic metres of the sand are placed upon this platform and a jet of water from a hose is played upon it, moving it about from place to place. It is essential to stir the sand in such a way that the dirt is washed out To check whether the sand is clean, take a handful and rub it between the hands; if there is any sign of dirt on the hands, the sand is not yet clean enough. Washing the sand scraped from the filters should be done immediately before it dries. After cleaning, the sand should be properly stored.

Records

Records are to be maintained to provide information on the performance of the filters, a check on the work of the operating staff, and also to provide data for planning future improvements. In village SSF plants which have limited staff only essential records should be kept, including data on daily hours of operation of raw water and clear water pumps, results of quality control and dates of cleaning operations, quantities of chemicals used and daily output from the plant. To record the daily production of water, a water meter included in the effluent main of the water works is helpful.

Quality control

In rural areas constraints to the adoption of a proper water quality monitoring programme can include lack of adequate laboratory facilities and trained personnel, and long distances, which may involve unacceptable delays between sample collection and testing. The cost of testing may also be high. Therefore, daily testing of important water quality parameters will not be possible for many rural water supply schemes. However, simple routine tests for turbidity and residual chlorine can be performed after some training by the operator himself. Regular supervision is necessary to check and ensure the reliability of the results of these tests.

Complete physico-chemical and bacteriological tests of the raw and treated water should be carried out periodically by a higher level agency. However, because there is a lack of laboratory facilities, especially in the rural areas, that national and local governments must assist the agencies responsible for water quality testing with the establishment of regional laboratories to monitor the water works.

PLANNING, DESIGN AND CONSTRUCTION OF SLOW SAND FILTERS

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A slow sand filter is essentially an open box about 3 m deep, circular or rectangular in shape and usually made of concrete or masonry. It contains a bed of fine sand supported by layers of graded gravel. A simple system of drains at the bottom collects the filtered water. The water to be treated stands over the filter bed to a depth of about 1.0 metre and provides the driving force for the water to flow through the sand bed. During its downward passage purification is brought about by a combination of complex physico-chemical and biological mechanisms. Turbidity is removed, organic matter is converted into simple, harmless substances, disease causing bacteria and viruses are destroyed and a clear, safe water is produced. When the filter is clogged with impurities, it is cleaned by removing the top 1 - 2 cm of sand along with the 'Schmutzdecke', the filter skin, which is an active biological layer. The frequency of cleaning is once in 2 - 3 months and can be done with manual labour.

Technology for community water supplies for developing countries should have the following characteristics:

- Simple, robust and reliable
- Relatively labour intensive with low capital cost and little input of foreign materials and skills.
- Acceptance and support of the local community with minimum change to the social fabric

  and

- Capable of organisation at local level with relatively simple training.

Slow sand filtration can fulfil these requirements and is an appropriate treatment method when:

- Raw waters of low turbidity (50 NTU) such as from canals, lakes and impounded reservoirs, are to be treated.
- Land, labour and filter sand are readily available and at reasonable cost.
- Chemicals and equipment need to be imported.

The other advantages are: No other single process can bring about a simultaneous improvement in the physical, chemical and biological quality of water being treated as can slow sand filtration. Further the problems of sludge disposal associated with conventional treatment methods is non-existent or minimal.

Elements of Slow Sand Filter: The basic elements of a slow sand filter are as follows:

a. Filter box: Usually rectangular in shape and about 3 m in depth. The materials most commonly used for construction are concrete, stone or brick. The box contains a supernatant water reservoir, a bed of filter medium, and underdrainage system and a system of control valves and other appurtenances.

b. The top water layer (Supernatant): The depth of water over the filter-bed is usually about 1 metre. The supernatant serves two purposes; It provides the pressure to drive the water through the sand bed and to overcome resistance in other parts of the system. It provides storage of several hours for the incoming water before it reaches the sand surface. During this period, suspended particles begin to settle and biochemical processes improve the water quality.

c. Filter-bed: Usually made of clean natural sand free from clay and silt. The sand does not require careful grading but particles which are too small or too large are removed by sieving. For efficiency, the minimum thickness of filter bed should be not less than 40 - 50 cm. As a layer of 1 - 2 cm of sand will be removed every time the filter is cleaned a new filter should be provided with an initial sand bed thickness of about one metre. Resanding will then become necessary only once in 2 - 3 years.

d. Underdrainage system: Provides an unobstructed passage way for the treated water to leave the underside of the filter. The underdrains may be made of unjointed bricks laid to form channels, perforated pipes and porous tiles laid over drains. A gravel layer of 10 - 30 cm, properly graded, is placed on the underdrains. This prevents sand from entering and ensures uniform abstraction of filtered water over the entire bed area.

Implementation of Slow Sand Filter System

i) Preparatory activities: Before construction of water supply project can begin,preparatory activities by way of consultation with the community and comprehensive survey of local conditions are essential. The local people must be apprised of the various options available for water supply, and their relative merits and implications. They should be involved in the decision making process so that there is no doubt that the scheme is acceptable to them. Their assistance and cooperation will ensure successful implementation of the scheme. Women who are the main users of water, can play an important role in the educative process to ensure that the water supply is fully and properly used. The important points to be investigated in the preliminary surveys are:

- Available and potential water sources, their quality, adequacy and reliability of yield.
- Examination of patterns of water use, climatic conditions and socio-economic factors.
- Health problems which may show particular requirements for water supply.
- Availability of local skills and materials for construction, operation and maintenance of the water supply system.
- Institutional infrastructure for management.

ii) Design Considerations

General: Water supply is a capital intensive utility and the meagre resources available for it must not be wasted on overdesigned facilities. The design period, the trend in population growth and its forecast size, intended level of services, etc., determine the size of the facility and thereby the capital investment required for it.

Design Period: In slow sand filter construction, there is no economic advantage in building large plants to serve long years into future. Therefore, the design period should be short, say 10 years. This will help to optimize the long term investment in water supply and will allow the available money to finance more new projects immediately.

Service Levels: Norms for level of service such as per-capita supply and method of water distribution are generally laid down by water supply agencies at national/state level. The most commonly recommended per-capita value for rur al water supply in developing countries is 40-90 l/d depending upon whether the supply is through public stand posts or through individual house-connections.

Design Demand: The per-capita supply multiplied by the projected future population gives the design demand. It would be convenient to convert the daily required volume to a design flow 'Q', the quantity of water to be treated per hour rather than per day. This is because the daily requirement of water may be treated over a period of 24 hours or just in a few hours as is done in small plants. Thus, for a given daily output, the size of the plant depends on duration of filter operation.

Filtration rate and number of filters: To provide for changes in raw water quality and uncertainties in operation and maintenance, it is desirable to maintain a normal filtration rate of 0.1 m/hr. A minimum of two filter units should be provided. This will restrict the overload rate to 0.2 m/hr when one unit is taken out for cleaning and would ensure uninterrrupted production. There is then no need to provide for any standby unit. The number of filter units for a given area can be increased to gain higher flexibility and reliability. For a given area, the optimum number and size of filters (which will be only 3 per cent more expensive than the minimum 2 bed unit) are given in Table 1. This can be used as a ready reckoner for design purposes.

Filtration and Layout: Rectangular filters offer the advantage of common wall construction and may be preferred except for very small installations where circular shape may be economical. Arranging filters in a row maximizes the number of common walls and facilitates construction, operation and maintenance. Filters can also be arranged symmetrically on either side of a central pipe gallery. The layout will be determined by local topography and the placement of pump houses, storage and other facilities.

TABLE 1 - OPTIMAL NUMBER AND SIZE OF FILTERS FOR A GIVEN AREA

Area (c2)	Capacity+ m/hr	No. of units	L	B	P
50	5	2	5.77	4.33	34.64
100	10	2	8.18	6.12	48.98
150	15	2	10.00	7.50	60.00
200	20	2	11.54	8.66	69.28
250	25	2	12.00	9.68	77.45
300	30	2	14.14	10.60	84.85
400	40	3	14.14	9.42	113.13
500	50	3	15.81	10.54	126.49
600	60	3	17.32	11.54	138.56
700	70	3	18.70	12.47	149.66
800	80	3	20.00	13.33	160.00
900	90	3	21.21	14.14	169.70
1000	100	3	22.36	14.90	178.88
1200	120	3	24.49	16.32	195.95
1400	140	3	26.45	17.63	211.66
1600	160	4	25.29	15.81	252.98
1800	180	4	26.83	16.77	268.32
2000	200	4	28.28	17.67	262.84

+ At a filtration rate of 0.1 m/hr.

L Length in metres

B Breadth in metres

P Perimeter in metres

Pre-treatment: An important limitation of slow sand filtration process is its vulnerability to high turbidity. Raw waters with a turbidity of 50 NTC or more for long periods cause rapid clogging of filters. From an operational point of view this requires frequent cleaning which is not practical. Pre-treatment can then offer a solution. Various types of pre-treatment have been advantageously used in small community water supply system.

River-bed filtration: When the river-bed is composed of sand or gravel extending to sufficient depth, raw water intake and pre-treatment can be combined by means of river-bed filtration system. The river water percolates through the bed into the perforated pipes laid below. The silt is screened out at the top of the river-bed from where it is scoured by the river flow.

Sedimentation: This can be applied when raw water contains a large amount of settleable material which can rapidly clog the filter. By passing the water through a properly designed sedimentation tank, a large proportion of the suspended matter can be removed. Provision must be made for periodically emptying the tank of silt.

Horizontal flow pre-filtration: May be applied for raw water turbidites up to 150 NTU. The process is a combination of sedimentation and filtration. The pre-filter is a rectangular box usually of 1 m depth. Horizontal flow velocity should be in the range of 0.5 - 1.0 m/h. The total length of the filter-bed may vary between 5 and 10 metres or more.

The box is divided into a number of compartments packed with crushed stones of graded sizes from coarse to fine. Clogging of the pre-filter will take place slowly so that cleaning will be needed only after a long period of use.

iii) Construction aspects: The construction of slow sand filters should be based on sound engineering principles. The structural design, the construction materials and methods are governed by local requirements and conditions. Some of the important considerationsthat need attention are (i) the type of soil and its bearing capacity; (ii) the ground water table and its fluctuation and (iii) the availability and cost of construction materials and labour. Water tight construction of the filter box should be guaranteed, especially when the ground water table is high. This will prevent loss of water through leakage and contamination by ground water. The top of the filter should be at least 0.5 m above the ground level in order to keep away dust, animals and children. The danger of short-circuiting of raw water may be prevented by roughening the inside of the walls. The drainage system should be carefully laid as it can not be inspected cleaned or repaired without the complete removal of the filter bed material.

The inlet structure is an important component of a slow sand filter and should be so designed and constructed as to cause minimum disturbance to the filter bed, while admitting raw water and to facilitate routine operation and maintenance. A filter needs to be cleaned periodically and this is done by lowering the water level a few centimeters below the sand bed and scraping the top layer of 1-2 cms of sand. It is found in practice that draining the water through the filter bottom takes several hours, at times 1 - 2 days. In order to obviate this difficulty, a supernatant drain out chamber with its top just above the sand level, has to be provided. By a proper design, the filter inlet and the supernatant drain out could be suitably combined in a single chamber.

The outlet structure incorporates means for measuring the filter flow, and back filling with clean water after sand scraping and recommissioning of the filter.

In small filters, the outlet chamber is usually constructed in two parts separated by a wall with a weir. The sill of the weir is fixed above the highest sand level in the filter-bed. This makes filter operation independent of fluctuations in the clear water storage level and prevents occurrence of negative head in filter. It also aerates the filtered water thus raising its oxygen content. To facilitate aeration, a ventilation opening properly screened is provided in the chamber.

The filter discharge can be measured by installing a "V" notch weir in the outlet chamber and noting the water level above the weir with the help of a float-controlled pointer and a pre-calibrated scale. The pointer moves up or down depending on the water level over the weir. The operator sets the required filtration rate by regulating the outlet valve until the pointer indicates the desired rate on the scale.

To facilitate drainage of surplus water entering the filter and scum that may accumulate on the supernatant water, an overflow pipe/weir should be provided in the filter.

Cost Aspects

Minimum filter cost: The cost of a filter excluding pipes and valves is made up of two components: the total cost for floor, underdrains, and gravel; and the cost of walls of the filter box.

This cost in general is

$$f = K_A A + K_P P \qquad \ldots.(1)$$

Where A is the total filter bed area in m^2, P the total wall length in m, K_A the cost per unit area of filter bed, and K_P the cost per unit length of wall. For rectangular filters with common walls, the practice is to minimise C subject to:

$$A = nlb \text{ and } P = 2\ nb + l\ (n + 1) \qquad \ldots.(2)$$

Where n is the number of filters, b is the breadth, and l is the filter length.

The term $K_A A$ is constant for any value of A and any filter shape. Hence, the minimum cost solution is the solution that minimises N, which is

$$l^2 = \frac{2 A}{n + 1} \quad .... \quad (3)$$

and

$$b = \frac{(n + 1) l}{2 n} \quad .... \quad (4)$$

The equation for b, when re-arranged, shows that $2nb = (n+1) l$ or, the conditions for minimum filter cost is to have the sum of the lengths equal to the sum of the breadths. It can be shown that this is true whether filter units are arranged in a single row or as blocks on each side of a central gallery. The general expression for the minimum cost is found by substituting Equations 3 and 4 for Equation 1:

$$C = K_A A + 2 K_p (24 (n+1) \quad .... \quad (5)$$

The value of K_A and K_p an be worked out for any place based on prevailing prices for construction materials; eg. $C = 500A + 1660 (24 (n + 1))$ for Nagpur, India, 1983. .... (6)

<u>Economy of scale:</u> A general cost model for the filter beds can be written as :

$$C = K(A)^a \quad .... \quad (7)$$

Where 'A' is the total area of the filter beds, K(A) is the cost per unit area of filter bed construction including walls, and 'a' is the exponent that represents the economy of scale factor. The cost data obtained from Equation 6 for various values of A can be used to determine the parameters K and a of the function by the method of least squares. The resulting equation for Nagpur 1983 is given by:

$$C = 1617 A^{0.869} \quad .... \quad (8)$$

Large economies of scale are associated with small values of the exponent. Until the exponent decreases to about 0.6 or 0.7, there is no economic incentive to overdesign. Thus, very little saving is accomplished by increasing the size of the project in order to provide service over a long time into the future.

Cost of Slow Vs Rapid Sand Filters: There is a general misconception even among professional engineers that slow sand filters are expensive. This is not, however, always true and for many small water supplies slow sand filters are cost effective. A comprehensive study of the cost of slow Vs rapid sand filters was made in India recently. The costs (1982 prices) obtained for both the types of plant are shown in Table 2. It can be seen from the Table that capital cost of slow sand filters is less than that of a conventional plant up to a capacity of 3.0 mld. When compared on total annual cost basis, which provides a true comparison, it is found that slow sand filters are economical up to 8.0 mld capacity. However, these limits have to be determined for specific situations using local cost data.

TABLE 2 COST OF SLOW Vs RAPID SAND FILTERS

Capacity mld	Cost in lacs (Rs. = US $10,000)	
	S.S.F.	R.S.F.*
1.0	4.6	6.3
1.5	6.5	7.9
2.0	8.4	9.2
2.5	10.2	10.5
3.0	11.9	11.7
4.0	15.3	13.8
5.0	18.6	15.7
7.0	24.9	19.0
10.0	34.0	23.1
15.0	48.4	29.3
20.0	62.1	34.5

* Based on regression model

SUMMARY.

Slow sand filters because of their advantages of simplicity, efficiency and economy are appropriate means of water treatment for community water supplies in developing countries. The basic elements of a slow sand filter have been briefly described. Planning, design and construction aspects of water supply systems with special reference to slow sand filters have been presented. Cost comparison between rapid and slow sand filters has been indicated.

SLOW SAND FILTRATION - PILOT PLANT CONSTRUCTION

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1. INTRODUCTION

The Department of Civil Engineering of the University of Nairobi was one of the participating institutions in the WHO/IRC Project on slow sand filtration. Here we highlight the pertinent features of the Pilot Plant construction, its operation, maintenance and performance, from the experience obtained in the limited research work at the Department of Civil Engineering. In Kenya, as elsewhere, designers have traditionally preferred using rapid sand filters instead of slow sand filters, and until recently developing and utilizing slow filtration in public water supplies in Kenya was very limited. Most designers have been trained to prescribe chemical coagulation followed by sedimentation and rapid sand filtration as a standard form of water treatment for public water supplies.

Slow sand filtration has many advantages, especially to the rural communities in developing countries, in that it is easily adapted to the local situation, relatively cheap and the required skills for design, construction, operation and maintenance are generally available in such communities.

The Department of Civil Engineering undertook to study the performance of laboratory scale pilot plants of slow sand filters in terms of removal of turbidity, colour, iron and bacteria.

2. NEED FOR PILOT FILTERS

By filtration water is separated from suspended and colloidal impurities, and the number of bacteria reduced and chemical characteristics changed. Filtration provides insurance that particulate matter which might interfere with disinfection is consistently removed.

The process of obtaining purified water by filtration utilises:

1. Physico-chemical removal mechanism
2. Biochemical removal mechanism

The physico-chemical removal mechanism relates to the transport and attachment phenomena whereby suspended particles are first moved from the flow streamlines and brought to the vicinity of the filter grains, and subsequently absorbed.

In the biochemical removal mechanisms, chemical and micro-biological reactions go on in the filter bed. Some of the organic matter from raw water is converted into cell material by bacteria, while other organic matter is converted into metabolic energy.

Studies on pilot filters should ensure that all necessary factors have been incorporated in the full-scale design to meet the desired goal of effluent quality, while at the same time maximizing the net water production per unit filter area. Maximum water output is desirable because it minimizes the capital cost per capita of a project.

The water production of a filter is influenced by the filtration rate and also the length of the filter run. Change in raw water quality leads to change in filterate quality. Thus slow sand filters are designed to operate under uniform condition.

3. CONSTRUCTION

Generally the number of filters in a given pilot study is related to the budget, but it is always desirable to use several filters, which reduces the time spent in running a particular test and also enables the simultaneous evaluation of various treatment options even with a variable effluent quality. When different treatment modes are tested over different time periods variations in influent quality often present difficulties in obtaining reasonable comparisons.

The construction material for filter boxes should meet the following criteria. It should:

(i) Have structural strength to withstand the loading of sand and water.
(ii) Not affect the quality of the water.
(iii) Have a durability of more than two years to facilitate proper monitoring of the various parameters.

The filter medium should consist of inert and durable grains. The most common filter medium is washed sand which should be free from organic matter and preferably disinfected before use.

The filter medium is defined by its effective size and uniformity coefficient. The effective size is defined as the particle size corresponding to 10% passing (d_{10}) while the ratio d_{60}/d_{10} defines the coefficient of uniformity.

Below the filter media is the underdrain system which provides an unobstructed passage for the collection of treated water and also supports the bed of filter media. A layer of coarse gravel or broken durable stones, or structures of main and lateral drains built up from perforated or non-jointed pipes, concrete blocks or bricks, can provide the drainage system. This is covered by a layer of variable size gravel, the largest at the bottom and the smallest size on the sand-gravel interface.

4. DESCRIPTION OF THE PILOT PLANT AT KABETE

Three pilot slow sand filters were installed at Kabete Water Treat ment Works and operated during the period June 1976 to September 1977.

The filter boxes were made of circular corrugated galvanized iron sheets. Each filter tank measured approximately 1.3 m internal diameter and 1.8 m deep.

The filter tanks for the downward flow were made up of (starting from the bottom):

Concrete blocks underdrainage	153 mm
Perforated galvanized iron sheet (approx.)	1 mm
19 mm Ø crushed stone aggregate	120 mm
9.5 mm Ø crushed stone aggregate	120 mm
Filter sand	800 mm
Supernatant water reservoir	800 mm
Freeboard	100 mm

Each filter tank was fitted with a 15mm diameter overflow pipe to help in maintaining constant the supernatant water level (head causing flow). In order to investigate the effectiveness of using a pre-treatment unit a trapezoidal unit made of fiberglass was fitted with the necessary pipework.

Air influent and effluent temperatures were recorded. Samples of raw and treated water were subjected to physical chemical and bacteriological analysis.

5. CONCLUSIONS

(i) A filter medium having an effective size of 0.68 mm and a coefficient of uniformity of 1.4 did not give satisfactory effluents. A filters medium of 0.22 mm gave better results. Recommended values are effective size ranging from 0.15 to 0.35 mm, and coefficient of uniformity ranging from 2 to 5.

(ii) During the test runs removal of colour and E.coli was not too good. This was most likely caused by the filter material being too coarse (0.68 mm) and short circuiting along the walls of the filter. Experiments in other countries demonstrate clearly the effectiveness of slow sand filters in removing E. coli and colour.

(iii) Slow sand filters get clogged by silty water and therefore pre-trement is required if the water is high in turbidity.

(iv) The provision of a pretreatment unit increases the length of a filter run.

6. REFERENCES

(1) Runji, C G (1978)"Performance of Slow Sand Filters in Kenya." M.Sc thesis. University of Nairobi.

(2) Runji, C G "Slow Sand Filtration in Kenya. Report on Phase I Activities." Department of Civil Engineering, University of Nairobi.

(3) Van Dijk, J C and Oomen, J. H. C. M. (1978) "Slow sand filtration for Community Water Supply in Developing Countries. A Design and Construction Manual." Technical Paper No.II. WHO/IRC. The Hague. Netherlands

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PRE-TREATMENT AND S.S.F IN TANZANIA

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INTRODUCTION

Slow Sand Filtration (SSF), if properly applied, is one of the most appropriate processes for treatment of surface waters in developing countries. However, the quality of most tropical surface waters limits the applicability of SSF alone and often some form of pre-treatment has to be applied to raw water.

The suitability of water for SSF is often distinguished by turbidity, but in actual fact, the clogging of the filters is brought about by such impurities as solid matters and algae which are responsible for physical blocking of pores between the sand grains. Turbidity is usually measured by photo-metric principles which allow the determination of the intensity of light scattered and absorbed by suspended matter in water, which is related to finely dispersed matter. In fact total suspended solids concentration and filtrability are parameters which can characterize more accurately the suitability of water for SSF. But in practice, the determination of suspended solids concentration is too involved so that turbidity is preferred as an indirect measure of the levels of suspended solids in water. Using this approach a better assessment can be ensured by establishing a correlation between turbidity and suspended solids concentration so that for any turbidity value measured, one is able to get the corresponding suspended solids concentration.

HISTORY OF THE APPLICATION OF SSF IN TANZANIA

The initial application of Slow Sand Filtration (SSF) as a water treatment process in Tanzania during the early seventies has had an unpleasant history. At that time, due to shortage of local engineers, many rural water supply (W/S) schemes were designed by expatriates who came for short official visits (as consultants) or worked for only a few years with the Ministry of Water. Most of the schemes which were designed to apply SSF had serious operational difficulties due to the extremely short filter runs experienced with them. For example, Ref. 1 reports that SSF constructed in about five villages in Tabora region of Tanzania were already inoperational in 1977 hardly two years after being commissioned. In Ref. 2 similar operational problems with SSF were reported in a number of provinces in Kenya. These short filter runs often led to abandonment of the SSF treatment plants due to the heavy burden of having to clean the filter beds frequently. There were two most likely causes of these problems, improper operation of pretreatement units (or indeed the treatment plant as a whole) say by application of very high overflow and/or filtration rates, and secondly - which was valid for most of the schemes which failed - feeding of raw waters with high content of impurities directly into the SSF.

RESEARCH IN PRETREATMENT OF SSF WITH HORIZONTAL FLOW ROUGHING FILTERS (HRF)

Research work aimed at the ultimate development of an appropriate biophysical pretreatment process for SSF in developing countries was intitated at the University of Dar es Salaam (UDSM) in early 1979 and is now known as "The SSF Research Project".

1. Water quality survey

   The survey and statistical analysis carried out on the water quality data of surface waters in Tanzania showed that there is a need to pretreat raw water prior to SSF. The prevalence of high average turbidity and suspended solids concentration coupled with remarkable seasonal fluctuations proved the necessity of pretreatment of almost all SSF influents.

2. Laboratory tests at UDSM

   The following four biophysical pretreatment methods were tested for suitability of application to SSF influents:

   - Plain sedimentation aided with lamella plate settlers.
   - Plain sedimentation alone.
   - Vertical Flow Roughing Filters (VRF)
   - Horizontal Flow Roughing Filters (HRF)

   The best pretreatment efficiency we found could be obtained with VRF and HRF. However, although their treatment efficiencies were similar, the advantage of providing an almost unlimited silt storage capacity (which is a function of length and porosity when the height and width are limited for maintenance reasons) is with HRF. Moreover, the design and construction of HRF needs less skilled personel and equipment than VRF.

3. Field tests.

(i) Short-term field tests (1980/81):-

In order to check the validity of laboratory experiments in the field, tests were carried out at the water treatment plant sites of Handeni, Wanging'ombe and Iringa. At the first two treatment plant sites, portable UPVC pipe models of 250mm diameter were used as SSF and HRF units whereas at the pilot plant site (i.e. Iringa), a large scale pilot plant was constructed with one HRF and SSF unit. At Wanging'ombe, besides installing the pipe conduit models, a bigger SSF with an inner diameter of about 2.4m was constructed and tested along with the others.

(ii) Longterm field tests, (Jan to Aug 1983):-

At the Iringa pilot plant additional reference models were installed after making a few modifications to the HRF unit constructed there. The tests were carried out in order to enable us to generalize the design guidelines for HRF and to establish its longterm behaviour with respect to such aspects as clogging of the filters and improvement of chemical parameters.

4. A companion research programme in HRF has been undertaken by the International Reference Centre for Wastes Disposal (IRCWD) in Switzerland. The aim is to produce detailed theoretical explanations about the prime factors/processes responsible for purification in HRF. In order to enable a comparison of the field tests (from Iringa) and laboratory tests (IRCWD) especially concerning the physical aspects of removal, the raw water of Little Ruaha in Tazania (from which the pilot plant of Iringa draws its raw water) is continuously simulated at IRCWD by mixing some groundwater with Kaolin in specific proportions.

5. Results of research carried out by UDSM

1. The field tests were in very close conformity with the laboratory investigations in terms of treatment efficiency of HRF, but the results from the three field tests sites were not directly comparable. The differences might have stemmed from variation in characteristics of the raw water sources and the pattern of operation of the HRF units (i.e) whether continous or intermittent).

2. Pretreatment of raw water with HRF prolongs the filter runs to acceptable durations (i.e. more than 3 to 4 weeks) so reducing maintenance costs and allowance for development of biological activities in the filter bed.

3. HRF have no or little influence on chemical quality parameters of water.

4. Average turbidity removals of 50% and maximum removals of about 80% were observed during the research period. The maximum removals were attained only at relatively low filtration rates.

5. After a ripening period of about three weeks, the HRD can remove 50 - 80% of E. Coli organisms and 50 - 75% of the total coliform bacteria from a raw water with less than 1000 total coliform counts per 100ml. after 24 hours of incubation

6. The following design guidelines should be observed for HRF:
   (i) In general, the filtration rates should be kept less than or equal to 2.0 m/hr, The best way of establishing the optimum values is by carrying out pilot tests with the raw water to be treated.
   (ii) The diameter of filter media to be used (usually gravel) should range from 50 to 1mm and only 3 or 4 fractions should be provided.
   (iii) HRF should be designed with filter runs of at least six months and at most three years.
   (iv) The net total length of the filter media should lie in the range of 10 to 20 metres.

7. Although the investment costs of HRF are slightly higher than for chemically assisted sedimentation, its running costs are about one tenth of the latter. A comparison of annual discounted costs shows that HRF are cheaper than chemically assisted sedimentation.

6. Conclusions

With reference to rural water supply schemes in Tazania, the following general conclusions can be drawn:-

(i) HRF alone (with fine fractions) can be applied as sole treatment of raw waters having low bacterial pollution loads and average concentrations of settleable suspended matter.

(ii) Application of the combination of plain sedimentation and HRF (with relatively fine fractions) should be considered for overall treatment of raw water sources having high settleable suspended matter and low bacterial pollution loads.

(iii) HRF can be very conveniently applied as a pretreatment before SSF in schemes which have high bacterial pollution loads and considerable amounts of settleable suspended matter.

WORKING CONDITIONS OF W/S SCHEMES WITH SSF IN TANZANIA

The following observations were made during the site visits to W/S schemes having SSF in different areas in Tanzania during this year.

1. Operation of pretreatment units

In many cases, improper operation of pretreatment units result in very short filter runs of SSF. For example, the poor settling efficiencies of sedimentation tanks are usually a result of application of high overflow rates. This can be controlled however, by installation of weirs which indicate the maximum allowable height of flow over their crests or simply by constructing additional units thus automatically reducing overflow rates in the existing ones.

For some chemically assisted pretreatment units, shortage of chemicals, lack of proper rapid mixing at the dosing points, lack of reliable analyses of optimal doses of Aluminium Sulphate (alum) and sometimes improper planning of sludge flushing from the small settling tanks provided, contribute to poor settling efficiencies experienced. These problems can be solved by improving the dosing facilities and establishing optimal doses of coagulants by carrying out the jar test experiments frequently. The pattern of sludge flushing from settling tanks must not interfere excessively with the daily water demand pattern especially during the peak hours periods.

2. Cleaning of the filter beds of SSF

The most common practise is to scrape off the top one to three centimetres of sand from the SSF bed after clogging and to refill it to the original level after washing. The application of this technique should have some technical and economic justification. The cost of refilling with fresh sand stored at the site or brought in from nearby quarries may not be much higher than the costs of washing after scraping if unsieved sand is used.

Usually, the refilling of sand has to be done once in two or more years if scraping without refilling is used. But it is essential that repeated washing and refilling of the top sand does not result in considerable changes of the particle size distribution of the sand beds. Blending of the washed and unused sand should be carried out before refilling the sand in the SSF.

In extreme cases, the filter bed is washed within the SSF box by filling it with water and, after a thorough mixing up of the contents, the dirt is flushed off through the overflow pipe. However, such a practice is not recommended because it seriously disturbs the purification mechanism of the SSF and allows penetration of impurities deep into the sand bed.

3. Background knowledge of the plant operators

In order to ensure that plant attendants at least have the miminum knowledge, some theoretical and practical instruction must be given preferably in the official language which they are most conversant with (e.g. Swahili). However, imparting this knowledge to the operators is best done by training them during construction of the new treatment plants and to give them on site training before or immediately after commissioning of the schemes.

4. Control of filtration rates of SSF

Without good basic education, most of the attendants are not even able to check the filtration rates of the SSF at any time during normal operation of the plants. For more reliable control of filtration rates, devices which indicate the rates visually should be used. Such devices can be installed in the outlet box of the SSF as a floating structure just before the effluent weir itself. (see Ref. 3)

5. Design of the SSF

Design of the inlet and outlet structures of some of the SSFs are completely unacceptable. Frequently the latter is not properly provided for, thus allowing occurence of negative pressures in the filter beds and thus premature filter runs due to the subsequent airbinding. Poor design can be checked by charging a few competent engineers in the field of SSF with the task of examining and approving the designs of SSF before the commencement of any construction work.

6. Rain water impoundments as raw water sources for SSF

Most of the SSFs treating impounded rain water have shorter filter runs during dry seasons than wet seasons; contrary to those treating surface waters in the tropics. The quality of rainwater impoundments deteriorates during the dry seasons because the settling process is easily disturbed by the prevailing winds blowing across these shallow reservoirs.

During the dry seasons when the depth of small reservoirs becomes very shallow, cattle can further disturb the settling process whilst drinking water. During the wet seasons rainwater contributes to the increase of the volume of water without increasing the impurities, resulting in better raw water qualities.

7. Use of sieved or unsieved sand

Only a few SSF schemes, we found, use sand which was sieved prior to filling in the filter boxes. Most use natural sand whose sieve curves we found not to comply closely with the specifications recommended in the literature, that is a specific diameter, $d_s = 0.15 - 0.35$ mm and a uniformity coefficient (U_c) of between 2.0 and 3.0 to ensure sufficient permeability. To blend sand from two different quarries in order to form a sand mixture which meets the above mentioned specifications may be necessary.

FOR SSF PLANNED AT UDSM

1. To check whether or not refilling of washed or unused sand on top of the SSF bed after every scraping, has any effect on rejuvenation of biological activity on the filter bed (e.g. delay of effectiveness of bacteriological quality improvement of the effluent).

2. Investigations on penetration depth of impurities in the SSF bed as a function of the size of sand grains and the filtration rate applied.
3. Comparison of treatment efficiency of SSF with sieved sand beds and with unsieved sand complying with SSF beds specifications recommended in the literature.
4. Continuation of research with HRF-SSF systems at the Iringa pilot plant.

THE FUTURE OF HRF-SSF SYSTEMS FOR RURAL AREAS IN TANZANIA

We plan to verify the technical and economic suitability of HRF in Tanzania combining our research results with laboratory tests at IRCWD. The 'SSF Reseach Prohect' will then involve implementation of a number of village w/s schemes. Aspect which cannot easily be simulated in research centres like community participation, acceptability, reliability and operational simplicity will be studied through construction of about five demonstration village w/s schemes. The co-operation agreement involving DANIDA, NORAD, IRCWD and UDSM is expected to be signed soon. The Civil Engineering Department will both offer its consultancy services and help to conduct workshops and training of the recruited plant operators.

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REFERENCES:

1. BROCONSULT AB (August 1978) 'Rural Water Quality Programme in Tanzania'. Final report, Taby/Sweden.
2. CHESEREM, E.K.A. (1980), 'A Study of upward flow pilot plant filters'. M.Sc. Thesis - University of Nairobi, Kenya.
3. IRC Occasional paper series, (Jan 1983), 'Guidelines for operation and maintenance of Slow Sand Filtration Plants in rural areas of developing countries'. The Hague - The Netherlands.
4. WEGELIN, M. and MBWETTE,T.S.A.(July 1982), 'Slow sand filter research project - report 3': Research Report CWS 82.3, University of Dar es Salaam - Tanzania.
5. WEGELIN, M. (July 1980) 'Slow Sand Filter Research Project report 2'. Research Report CWS 80.2 University of Dar es Salaam - Tanzania.

RESEARCH AND DEMONSTRATION PROJECT ON SLOW SAND FILTRATION - INDIA

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Introduction

The National Environmental Engineering Research Institute (NEERI) works in active collaboration with the International Reference Centre (IRC) for Community Water Supply and Sanitation. The Netherlands which has been engaged in the last few years in an integrated research and demonstration project on Slow Sand Filtration.

Phase 1 - Applied Research

In the first phase the following activities were undertaken:

i) A questionnaire survey was made on existing slow sand filters in India. It was found that more than 60 per cent of the plants serve populations in the range of 2000 - 10,000. The raw water sources comprise canals, rivers, tanks and impounded reservoirs. Sedimentation/extended settling is the most common form of pre-treatment adopted. Almost all the plants are of traditional design with 0.1 m/hr. filtration rate and one or two standby units. Underdrains made of bricks or pre-cast concrete slabs are commonly used.

As for operation and maintenance, short filter runs due to algal growth on filter or high turbidity during the monsoon is reported in a few cases. Field visits have shown that scouring of sand at the inlet to the filter was a common phenomenon. Methods of filter cleaning were often old and unscientific.

ii) Extensive applied research was carried out on the following aspects which have a bearing on the performance efficiency as well as the cost of slow sand filters.

- Effect of filtration rates higher than traditional 0.1 m/hr.
- Influence of shading the filter.
- Effect of interminent and declining rate operation.
- Effect of high organic pollution in raw water.
- Performance of filters with builder-grade sand.

Experiments were conducted on 3 pilot filters made of pre-cast RCC pipes of 1.65 m diam. and 2.5 m length, and provided with all accessories for operation and control. Natural surface water from Lake Ambezari was used for the studies so as to represent field conditions. Data on the performance of filters under various operating conditions and influent water quality were collected and analysed.

iii) Field study of a full scale slow sand filter installation near Nagpur, treating canal water and designed to serve a population of about 20,000, was undertaken. This resulted not only in the generation of performance data under prevailing local conditions but also provided insight into the operational and maintenance aspect of the plant.

Conclusions

The following conclusions have been drawn from the studies carried out on different aspects of slow sand filtration:

- Slow sand filters treating surface waters of turbidity up to 30 NTU produced good quality filtrate with turbidity less than 1 NTU at filtration rates of 0.1, 0.2 and 0.3 m/hr. At higher filtration rates, the filtered water output increased, but the length of filter run decreased. The increase in output was however, not directly propotional to the filtration rate.
- Under varying conditions of raw water quality and filter operating, more than 85 per cent of filtrate samples were free from E.coli.. thereby meeting the drinking water quality standards.
- When raw water containing 8-12 mg/1 COD was treated at filtration rates up to 0.3-m/hr., the COD removal efficiency was 55 to 75 per cent. The efficiency was higher with higher initial COD concentration. No significant difference in efficiency was observed with respect to rate of filtration.
- The chemical characteristics of raw water such as alkalinity, hardness, chlorides and sulphates, remained unaltered during slow sand filtration. There was considerable reduction in the total iron content of raw water.

- Under tropical conditions covering the filters to exclude sunlight did not materially influence the filter performance, but retarded the development and proliferation of algae.

- Interminent operation of slow sand filters resulted in the deterioration of bacteriological quality of filtered water shortly after the startup. However, a satisfactory filtrate was ensured when the filter was run with a falling supernatant (i.e.) declining rate filtration.

- Higher levels of organic pollution (COD 20 mg/1) in raw water adversely affected the filter performance resulting in deterioration of filtrate quality. The filters recovered gradually and gave a satisfactory performance when the pollution level was reduced.

- Slow sand filters with builder grade sand were also effective and gave a filtrate of satisfactory quality.

Arising out of the laboratory and field investigations and a critical review of slow sand filtration practice in India, guidelines were formulated for cost effective design of slow sand filters, their construction, operation and maintenance.

Phase II - Field Demonstration

In the field of water supply, four village demonstration plants (VDPs) were constructed (Table 1). These plants, designed to cover a wide variety of local conditions, both technical and socio-economic, were evaluated for their performance over a period of 2 years.

TABLE I - DEMONSTRATION SLOW SAND FILTER PLANTS IN INDIA

SALIENT FEATURES

	Plant I	Plant II	Plant III	Plant IV
State	Andhra Pradesh	Naryana	Maharashtra	Tamil Nadu
Village Pothunuru		Abub Shanar (group of villages)	Borujwada	Kayayagoundanpatti
Date completed	April 1980	March 1979	November 1979	March 1979
Population Design	1971:3250 2001:6250	1971:8700 1991:12700	1976:700 2006:1300	1976:8500 1986:10000
Design Water supply	45 lpcd	45 lpcd	70 lpcd	45 lpcd
Plant capacity	17.5 m^3/hr	24.0 m^3/hr	5.7 m^3/hr	22.6 m^3/hr
Raw water Source	Eluru canal	Shakra Irrigation canal	River Kolar	River Suruliar
Pre-treatment	Stroage 3½ months	Storage 1 month	Infiltration Gallery	Plant Sedimentation + horizontal pre-filtration
Slow Sand Filters	11x7.9 m^2 (x2)	10 m dia. (x4)	5 x 3.8 m2 (x2)	12 m dia. (x2)
High level Stroage	91 m3	135 m3	35 m3	90 m3
Distribution	Stand posts	Stand posts	Stand-posts	Standposts and houseconnections
Estimates cost-Rupees *	368,000	1,668,000	270,000	410,000

* Indian Rs. 9/- = 1 US $

The demonstration programme had, in addition, two important objectives:

i) to identify possible operation and maintenance problems of village level slow sand filter plants, and the appropriate remedial measures and

ii) to impart in-plant training to the local operator and equip him with necessary knowledge and skill for eventual taking-over of the plant for future routine operation and maintenance.

The field evaluation of village demonstration plants has established the efficacy of slow sand filters as a reliable and effective means of water purification and confirmed the results of applied research carried out in the first phase of the programme.

An extensive community education and participation programme was concurrently implemented in the project villages. The community the public health department and the water supply agency closely collaborated together. The aim was to increase the involvement and commitment of the community to the project.

As part of Phase II activities, an International Workshop of representatives of participating institutions from Thailand, Sudan, Kenya, Ghana and India was organised at Nagpur to review the findings and devleop guidelines for future large scale implementation of slow sand filters. Extensive discussions and the exchange of experience between engineers, scientists and public health agencies resulted in a set of recommendations (IRC Bulletin No. 16). Further areas of research and development were also identified.

For effective implementation of the project and to promote and strengthen collaboration between various agencies, a Project Managing Committee (PMC) was established consisting of these members:

- Adviser (PHEE), Ministry of Works and Housing Government of India.
- Director, NEERI
- Chief Engineers of participating states
- Director, Central Health Education Bureau, Govt. of India.

The PMC met periodically formulated policy decisions, reviewed and discussed the progress of the project, and provided general guidelines for implementation.

Phase III - Information Dissemination

A Workshop was organised jointly by NEERI and IRC in April 1983 at Nagpur to review and discuss in detail the results and experiences of the project. The participants comprised of an expert group of research scientists/engineers, public health specialists from government departments and NGOs. The Workshop resulted in a number of recommendations with special reference to slow sand filtration, community education participation and information support. Next a National Seminar was organised by NEERI and IRC during June-July 1983 at Nagpur. The seminar provided a unique opportunity for wider dissemination of information and the exchange of experience between Chief Engineers (PH) from different states of India, policy makers, professional engineers and public health agencies involved in the provision and promotion of water supplies from India and some neighbouring countries.

Applied research continued during Phase III of the project. Specifically, the performance of slow sand filters with smaller (25 - 50 cm) depth of sand, design, and operational aspects of declining rate filtration, and efficiency of virus removal, have been investigated.

Conclusion

The strategy followed for the development, implementation and evaluation of the various technical, organisational and social aspects of the integrated research and demonstration project has served as a model for future large scale implementation of rural water supply programmes. The project is also an example of how TCDC can play a vital role in evolving appropriate technologies for water supply for mutual benefits.

COMMUNITY HEALTH EDUCATION ON WATER SUPPLY AND SANITATION WITH EMPHASIS ON SLOW SAND FILTRATION

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Community Health Education is most important to ensure that the community takes all possible practical steps to protect themselves against health hazards associated with water. A slow sand filtration project is aimed to provide the community with clean and wholesome water. Community Health Education is an essential component to make the scheme a valued community asset which the community will maintain and use intelligently.

Past experience has shown that projects provided without the community being consulted, educated and involved are not valued by the community. We must break away fromtraditionalism and adapt and adopt innovations. Community health education, community involvement, and appropriate technology must dominate the minds of those involved in planning and implementing slow sand filtration projects and other community water and sanitation projects.

To encourage the community to change attitudes and behaviours positively, we too must accept innovations which have been tried and found effective and efficient. Regular meetings and exchanges of experiences among professional and technical personnel are essential.

THE PROBLEMS we face can be identified as:

1. Inadequate community education and involvement.
2. Frustration of the felt needs of the community.
3. Inadequate preparation of personnel in community health, education methods, and in eliciting popular participation.

OUR OBJECTIVES can be stated as follows:

1. To inform and educate the community on Slow Sand Filtration so that by the end of the project they will understand the usefulness of the project.
2. To create a climate conducive to popular participation leading to the generation of ideas and contributions to the project in labour and other project requirements.

The Target Groups to be convinced are:

1. Project implementers who should know the strategy and procedures to be followed in carrying out effective Community Health Education. The roles to be played by each at each stage of project

implementation should be agreed. Community Health Education should be implemented systematically to ensure that all are reached with clear and simple messages. Seminars are needed for implementing personnel to improve their communication skills and their understanding of their roles.

2. Formal community leaders such as members of Provincial Administrations should be involved immediately to be responsible for community mobilization. Understanding the hopes and worries, beliefs and life styles of people, they will influence the direction the project will take. Implementing personnel should treat them as collaborators, and discuss regularly with them, implementation.

3. Womens groups are very important. Making water available in their homes is one of their basic roles, as is responsibility for ensuring that drinking water is wholesome and kept clean. Efforts to purify water will win women's confidence and approval. Men, though, provide social reinforcement and moral support and also areimportant as forming the labour force for project implementation.

4. School pupils are not normally given prominence in project implementation but their knowledge and behaviours can be shaped positively because they have not developed rigid attitudes. In short-term implementation they can take messages home, interpret them to their parents because they understand biological processes including the 'germ theory' of disease transmission. They can also assist as a labour force.

METHODS OF COMMUNICATION to be utilised are:
- Interpersonal (face to face) communication.
- Mass media.
- Educational materials.

1. Interpersonal communication should form the main channel of communication in Slow Sand Filtration projects so that community participation can be generated. Project personnel should exchange ideas with people in the villages to strengthen the project. Personnel involved, observing the community learning and behaviour patterns, can assess the areas which require reinforcement.

2. Mass media. Use of radio has been effective in creating awareness in Kenya. Discussions can be transmitted, also interviews with leaders in the project area so that people identify with the project and feel that what they are doing is important.

3. Educational materials. These help to stimulate the five senses

and improve perception by target groups of the project and the roles to be played by them. Pictures which can be understood by illiterates and semi-literates, posters and handouts remind people of details they might forget.

MESSAGE (CONTENT). Community Health Education does not take place in a vacuum. It has to be based on selected topics, organized and sequenced so that specific messages are conveyed leading to practical conclusions. For Slow Sand Filtration important topics are: Sources of water and possibilities of pollution: Utilization of water at home: Methods of purification with emphasis on SSF: Waterborne diseases and prevention procedures: Maintenance of SSF plant to ensure its effectiveness.

COMMUNITY PARTICIPATION. Eliciting effective popular participation is not easy. Each situation requires a 'home-made' approach. A person leading a discussion must identify community needs, set a participatory climate, encourage resource persons to listen, organize small groups and make sure topics are clearly understood.

MANAGEMENT is difficult when all the participating agencies are equal partners and each has its distinct objectives and would like to get some credit. A prime mover - a person or agency responsible for ensuring that the multi-agency collaboration works satisfactorily - is essential to ensure full participation.

EVALUATION OF THE PROJECT should be based on the objectives and take place at various stages of implementation, and at the end. To leave out evaluation or to do it in a disorganized way, or to make unsubstantiated statements, reduces project impact

APPROPRIATE TECHNOLOGY must be utilised with community health education. The technology used should be simple and practical, cheap and understandable by the community, and of course it should be acceptable. Slow Sand Filtration meets all these requirements.

SUMMARY. Community Education should always be in the minds of those designing and developing projects for the community. Education is often forgotten or is last in the list of activities, gets least funding and least support. But to succeed projects must fit the sociological realities of the community concerned.

THE PARTICIPATORY APPROACH TO VILLAGE WATER SUPPLY

Jan Teun Visscher, International Reference Centre for Community Water Supply and Sanitation (IRC).

Analysis of existing small community water supplies has shown that essential preprequisites for a successful supply are:

1. Provision of enough safe water for the various purposes for which it is needed. The supply should be convenient, acceptable and available to all potential users. For example everyone must be able to easily operate the taps and not have to walk very far or wait a long time. Water must have a good taste and be equally available to all.
2. Design and construction must ensure that the cost of operation and maintenance can be covered by the water charges paid by the consumers.
3. Proper operation and prompt, adequate maintenance must be possible at the local level.
4. Correct use of the system arising from a positive attitude of the community towards the water supply.

Fulfilling the prerequisites implies full community participation in the planning, construction and management of the supplies, together with supporting activities in sanitation and health education.

Current community participation in rural water supply

Agreement is easily reached on the need for community involvement but in practice few existing water programmes actually foster community education and participation (CEP).

Latin America has the longest experience in CEP programmes for rural water supply. These are generally village programmes providing piped water supply with yard or house connection. The households provide labour in construction inlieu of connection fees. But the value of this contribution is generally not more than 20 percent. A community water board administers the installed supply under agency supervision, including collection of water tariffs from consumers and the use of this income to pay recurrent costs including the employment of a local caretaker to operate and maintain the supply. This is probably made possible because people can afford to buy household connections rather than by cultural features specific to the region.

In Africa village systems with piped yard connections are very unusual. Communal wells, water reservoirs and piped supplies with public standposts are usual and voluntary labour is used to dig the wells and trenches.

To assist the community in maintenance there are water committees and also training of local caretakers, but progress is limited and attempts to obtain regular payment for fuel for pumped systems have proved unsuccessful.

Many agencies involved consider community participation as a tool to achieve the agency's objectives, that is rapid construction without obstruction by local people, lower construction and recurrent costs, etc. Where more than one agency is involved different goals for community participation may lead to conflict situations. Progress ceases when there are conflict situations. Yet community participation begins with acknowledging that people in the villages can change their own lives provided some resources and specific expertise can be provided. Voices from outside the community - engineers, health specialists, - must listen to the voices within the community.

INVOLVEMENT OF THE COMMUNITY

Community participation in a water supplyproject involves firstly identification of community priorities, secondly collective decision making and thirdly co-operative action.

This means that at least some members of all sections have to be informed at an early stage and consulted about:

1. The need for and possibility ofsecuring a safe water supply,
2. their preferences, and the technical and financial consequences of their choices.
3. the preparations and contributions which are expected from them;
4. the project approach.

Women are usually the main users and therefore should certainly be included in these processes.

Health Education

Provision of the safe water, by itself, has only a limited impact on the improvement of health. To increase the health impact there must be general acceptance of the water supply; proper use of facilities including good drainage; increased use of water for hygiene; cutting of alternative routes of infections.

Parents will not automatically change that part of their behaviour that is infecting and reinfecting their infants and small children with diarrhoeal disease, simply because of easy access to water.

Health education and often an improvement of sanitation facilties are needed to break the transmission cycles of various diseases. Passing down health information using mass communication activities is not proving satisfactory.

It is not so much knowledge which has to be imparted; rather it is the creation of awareness and understanding that should be the major aim. In rural communities this can often be done by approaching the women at their work site. A project in West Africa revised its programme from information visits and mass meetings to working together with the population, helping them to preserve good practices and improve the bad ones.

Educational materials used for discussions and training are best developed during the discussions and can be based onlocal stories. In the discussions an atmosphere of dialogue is important. Community members should discuss the difficulties and constraints in changing their practices and find ways in which the changes can be facilitated.

An integrated approach

Rural water supply is best considered in a broader development perspective with community participation a prerequiste. Then the following steps can be identified:

Approach the community. Contact the village leaders to find out how to reach the different groups in the community. Touring the village with the leaders may help to identify problems and create awareness among the leaders.

Training the village health worker/community development worker should be discussed during the visit. Involvement of women should be strongly encouraged. Once selected, the VHW/CDW should receive training to enable her/him to discuss the locally possible routes of transmission of water and sanitation related diseases, and the ways in which the environmental conditions and behaviour can be improved with the locally available resources. Also a village environmental committe responsible for CEP in water and other development project should be established.

Advice on appropriate water supply systems should include discussion of payment for maintenance and advice on the possibilities and consequences. Both a socio-economic and a technical survey are required. In surveys the community participate as they have the best knowledge of their country.

From the surveys a number of options should be identified and cost calculations made. Then the communityshould select the facility which is physically and financially acceptable to them.

Participation in construction may increase the skills of the villagers and also begin adoptionofan active role in operation and maintenance.

Operation and maintenance should be a community responsibility. This may lead to social control on waste disposal, clothes laundering and avoiding spillage at the standposts. For operation and maintenance, funds have to be secured. Often it will be necessary to employ a paid caretaker and some assistants. Salary and costs involved will have to be paid by the community through water rates or taxation. Preferably the caretaker should come from and be selected by the community. He or she should receive sufficient training to manage the scheme and given enough background information on community participation and health education.

Evaluation through feedback from users (through the caretaker or the village environmental committee) may lead to further improvements and provide agencies involved with necessary informationto enable adjustments.

Constraints identified can include the multitude of agencies involved in drinking water supply and sanitation, each with a limited sphere of responsibility, making it difficult to respond to particular village needs. Another constraint is an adminstrative system which includes detailed targets. Managers are rewarded according to the number of systems built rather than on the number which remain in operation. Then a review of the support provided by donor agencies is required.

Often sufficient time and manpower are lacking for community consultation and motivation before technical implementation is begun. Information is lacking on the potential benefits and cost savings of adopting community participation. The managers of water supply and sanitation services may not be willing to spend the funds.

The information material which the water agency needs, if it is placed in the position of advisor to the community, is often not available. Specific training programmes for community development workers and caretakers aiming at developing the skills required for implementing an integrated approach have to be organized. Skilled senior professionals in this area are needed.

It is not easy to overcome these constraints but by initiating a more integrated approach based on community participation in some pilot villages, the data and enthusiasm essential for wider application in government programmes may be provided. A project management committee with representatives of the various government agencies involved should co-ordinate such a project. To agree to the adopted approach they must understand and appreciate each other's views. It is my sincere hope that the discussions of today may contribute to that understanding.

COMMUNITY EDUCATION AND PARTICIPATION

Norman Scotney, Consultant, Nairobi and London.

The widespread publicity given to the slogan "Water for all by the year 2000", since the Mar del Plata Conference is creating serious problems. The slogan implies that people in decision making positions, are going to provide everybody with sufficient, good quality water within twenty years. We know that this is not possible!

Why do so many billions of people in the developing world not today have sufficient good water? In general terms we know the answer. People, firstly, are too poor, do not produce enough cash or revenue to pay for water provided for them by the methods we have been using. Secondly, they do not understand what makes good quality water and how it becomes contaminated. They can even collect good water and then themselves contaminate it. But, thirdly, and perhaps most significantly, they have no idea how they can help themselves out of their miserable, depressing and exhausting situation.

Firstly, lack of cash and ability to pay water charges does not mean that people have no resources. They have skills and energy that enable them - with so many difficulties facing them - to survive where many of us could not. They also have the capacity to think through problems. Working closely with and learning from the people of Kenya's dry north-west, the huge Turkana district I found that they can weave baskets that hold water. They have such capacity in discussion with you for thinking through their problem that continually you learn from them. In cash terms they are poor but they have very valuable resources.

The essential problem confronting us is helping people to overcome their difficulties by using the resources they already have. We must provide "know how" and perhaps a little seed money so that progress can be faster. Our resources must fit their resources-and their needs-to help them get out of the pit. The trouble is that we do not have the relevant resources and with slogans like "Water for all by the year 2000"., we have led the more simple minded to think they have only to wait until we put taps outside every house and in every shamba.

Why do our resources not fit the needs of poor people? Where is the gap? Substantially we have learnt about water provision from the water engineers of the developed, high income countries and from their books. They have not told us about all the farmers and village people in Europe and North America who today get water from a stream or well because that is not the water provision they are involved in. Trained to produce urban water systems - financed by water rates - they have spread this approach, and backed it with funding and high level technical resources from their own countries. How we have to change gear and move towards developing the existing resources of our people by helping people to help themselves. I am going to concentrate on just two matters that seem to me important:

Firstly, recognition by people of water quality,
Secondly, community water management.

In a village in West Nile Uganda I was asked by the headmaster and school committee to look at their water supply. They were taking water from a seepage on the side of a hill. Just above, on the hill, were a number of houses with no latrines. I said I thought there must be contamination, that it was likely to increase and that they could have an epidemic of diarrhoeas. A woman did not agree with me. She held up a glass bottle of water and said in Lugbara. "See this water is clear, it flows, and it tastes all right. You show me there is disease in this water?" A long discussion - it was a village baraza - followed but of course many people were unconvinced and I left the school committee with their problem.

Since then I have found that there is resistance to the idea that people can contaminate water. In cholera areas the resistance is less but in manyattas and small traditional settlements people often do not believe they can contaminate their water. Historically this was true! Because their hygiene was so limited and they were living close together they already shared the same pathogens. Contamination for them, then, began only with the visiting stranger or the family member who returned from a visit.

To show people the chain of transmission of disease through water is not easy, though experience of cholera in some areas has simplified the problem. Elsewhere I think that the diarrhoeas of children - especially when several suffer at the same time - may open a way. In another village of West Nile a woman invited me and my group into her hut to talk, without the neighbours hearing, about the deaths of three of her children. One had died of diarrhoea. I asked her whether at that time she had done something she did not normally do. She said it was the rain season and she remembered that there was water in the pools. I had noticed there were no latrines and people defecated in hollows where they were less easily seen. So, she did not bother to go for water all the way to the borehole. Although I did not want to burden her with shame I think that she understood from our conversation that it was contaminated water that had killed her daughter.

For success in water schemes, people must understand water quality. To succeed we must help people to understand contamination. There is now great interest in oral rehydration therapy for diarrhoeas. ORT can save the lives of many children with diarrhoeas, but spreading understanding of water quality - which should be linked with ORT because the water used must be safe-can save even more.

Water management and water provision is inevitably a community affair. All sources except roof catchments and single family wells are communal sources. Because lack of cash money draws the people together, they have to rely more on exchange of goods and produce and exchange of ideas and on working together. Many thousands of schools in Kenya have been built by community effort, financed by community (harambee) collections. In the sameway community co-operation is helping people to improve water provision through protecting and improving streams, through well digging, and can help through slow sand filtration.

We know the technical problems can be overcome. Then the crucial issue will be whether we can work with the community, provide the "know-how", and sometimes seed money, to ensure that the community completes a project in a reasonable amount of time. But the initiative must be with the community; the project must be theirs.

"Community participation", as a phrase does not show clearly the key role of the community. From the beginning there must be an effective community organisation, a strong community will (or "motivation") with readiness to seek a feasible plan of action. to make the necessary effort and to work regularly for the completion of the project. From the beginning, too, it must be clear to all that this is a community project and that the assets when it is completed, will be the community's to control, maintain and renew. Promoting "Community Management" must be our aim.

CLOSING OF PROCEEDINGS

On Tuesday 8 November, and again on 9 November, participants working in groups produced group answers to questions arising from the Seminar. These answers were then embodied in draft"Conclusions and Recommendations". After discussion in plenary sessions and significant revisions these were adopted by participants and in the final form they appear in the introductory pages of this report.

Finally, on Wednesday 9 November, the Seminar was honoured by the presence of the Honourable Jeremiah Nyagah, Minister for Water Development, Honourable Odupoy, Assistant Minister—M.O.W.D., Mr Y F O Masakhalia, Permanent Secretary, and Mr C N Mutitu, Chief Water Engineer, for the closing ceremony. Mr Benson Murigo, Ministry of Water Development, as Chairman for the session, introduced the Ministers explaining how participants had welcomed this opportunity to discuss in depth slow sand filtration and its utilisation in the development of Kenya.

The Minister emphasized the need for simple low cost, technology and the involvement of Wanurchito secure rapid and effective expansion of water provision. The people were ready to help themselves but needed the skilled and patient guidance that we could and should be able to give. The Honourable Minister expressed his pleasure at the spirit of collaboration evidenced by the Seminar and hoped this would continue in further meetings and joint activities. Finally the Minister expressed the thanks of Government to the International Reference Centre for Water Supply and Sanitation, and especially its representative Mr J T Visscher, and declared the Seminar officially closed.

COLOPHON

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