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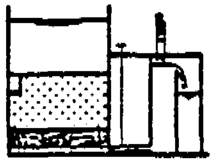
INTERNATIONAL REFERENCE CENTRE
FOR COMMUNITY WATER SUPPLY
AND SANITATION

NATIONAL ADMINISTRATION
FOR WATER

REPORT OF A SEMINAR ON SLOW SAND FILTRATION AND COMMUNITY EDUCATION AND PARTICIPATION

KHARTOUM, SUDAN

NOVEMBER 13-17, 1983



IRC Research and Demonstration
Project on Slow Sand Filtration

June 1984

INTERNATIONAL REFERENCE CENTRE FOR COMMUNITY WATER SUPPLY AND SANITATION

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ACKNOWLEDGEMENTS

This publication gives a summary of the papers presented in the seminar on slow sand filtration and community participation. It also provides useful recommendations which hopefully will be implemented and lead to better functioning of slow sand filters and their construction at lower costs.

Many people have contributed to the success of the seminar and have helped in its preparation. We are indebted to the staff of the National Administration for Water, the Schoool of Hygiene, the University of Khartoum and the Royal Netherlands Embassy for making the seminar a success. Particularly we are indebted to Dr. Beshir M. El Hassan, Dr. Isam M. Abdel Magid and Mohmed El Mahdi. They have not only organized the seminar but have also evaluated 10 existing slow sand filters in Sudan. The results of this evaluation clearly indicated the need for improvement in operation and maintenance practices. They therefore also undertook the tasks of translating the IRC Manual on Operation and Maintenance of Slow Sand Filtration Plants into Arabic and preparing a separate manual on Slow Sand Filtration in Sudan.

We are indebted to Mr. Peter Heeres for assisting in the seminar preparations and the compilation of this document, to Mrs. West for editing and to IRC staff for preparing the layout and processing the text.

1. INTRODUCTION

Water is essential for life: without it people die within a few days. Unfortunately at present even people having access to water get sick and die because the water they use is contaminated. These two sentences expressing the need for improved water supply were expounded by Mr. I.M. de Jong, Chargé d'Affaires, the Embassy of the Kingdom of the Netherlands, in his opening address to the combined seminar on slow sand filtration and community education and participation held in Khartoum, Sudan, from 13 to 16 November 1983.

This seminar was organized jointly by the National Administration for Water, University of Khartoum, and School of Hygiene in the Sudan and IRC in The Netherlands, in order to disseminate the experience gained in the Integrated Research and Demonstration Project on Slow Sand Filtration. This project was initiated by IRC in 1976 to assist developing countries to generate knowledge and experience on the use of slow sand filtration (SSF). The project embraces applied research, demonstration programmes and the transfer of information. In phase I of the project, the reliability of the SSF process under tropical conditions was demonstrated by a number of institutes in India, Thailand, Kenya, Sudan, Ghana, and Colombia. The application of SSF at the village level as a simple water purification method was demonstrated in phase II.
Where surface water is readily available, but not groundwater, slow sand filtration has frequently been shown to be the simplest, most economic, and most reliable method to prepare safe drinking water.

The major findings of this project are summarized as follows:
- No other single process can effect such an improvement in water quality.
- When well operated, SSF plants provide water that is virtually free from disease-carrying organisms.
- The simple design enables construction with locally available material and does not require costly imported machinery and highly skilled professional staff.
- Operation and maintenance of the process is cheap and simple; and after a period of training, local people can carry out these tasks.

- Safety chlorination of slow sand filter effluent, although desirable, is not essential. Where chlorination cannot be guaranteed, SSF provides a safety barrier because of its efficiency in retaining harmful organisms which other treatment techniques do not. Therefore, SSF is particularly appropriate for rural water supply systems.
- Especially for smaller plants, the cost of construction and operation and maintenance is lower than that of other purification systems. In India, SSF in comparison with RSF was found to be cost effective up to 8 bln. With the rising cost of energy and of chemicals, SSF will become more economically favourable.

The activities of phase III of the SSF project in Sudan include the following:
- translation of guidelines for operation and maintenance of SSF plants into the Arabic language;
- evaluation of various design features and performance of existing SSF plants;
- a seminar on SSF with emphasis on health education and community participation.

The institutes in Sudan which participated in the SSF project are:
- National Administration for Water (NAW)
- School of Hygiene
- University of Khartoum.

NAW, which is within the Ministry of Energy and Mining, is responsible for providing adequate and safe water supply for domestic use and for animals in rural areas throughout the country. The School of Hygiene conducts training courses of four-year duration for public health inspectors. Engineers are trained to the BSc and Msc level at the University of Khartoum.

The first SSF schemes were constructed in the late 1950s and at present there are approximately 250 throughout the country (see Table 1).

Table 1. Number of SSF plants in Sudan

Location	Number	Date of installation
Gezira and Manager	130	late 1950s
New Halfa	70	about 1968
Rahad	37	1978 - 1983
Northern Sudan	max. 3	
South Kordofan	2	1961 - 1983
Other areas	5	

One drawback to SSF in Sudan is that, because of its simple operation and maintenance, an attitude has developed that these filters do not require attention and hence many have been neglected. Frequently, untrained personnel are entrusted to operate and maintain them with the result that many filters do not function properly.

Another problem is the supply of treated water to the consumer. The area surrounding water taps is often muddy and dirty, and frequently the clean water is not properly handled and stored. This problem can only be solved by informing and involving the community. For this, the support of external agencies is required; not only technically support, but also support in health education and proper sanitation.

To reduce the incidence of diseases and to improve the well-being of the people, reliable water supply and adequate sanitation are essential. Therefore, the objectives of this seminar were:

- dissemination of technical information on SSF;
- promotion of an integrated approach to water supply planning, including non-technical aspects, such as, health education and community participation.

In the plenary sessions on the first two days of the seminar, papers were presented on both technical and non-technical aspects of slow sand filtration (see Appendix 2).
On the third day, several SSF plants in the Rahad and Gezira schemes were visited in order to observe the practical problems of SSF in Sudan. On the final two days, participants worked on a planning and design exercise for rural water supply systems (see Appendix 4).

2. RECOMMENDATIONS AND CONCLUSIONS

Slow sand filtration (SSF) is a very suitable method for the treatment of surface and spring water, and, therefore, should be further promoted by the Ministries of Energy and Mining, Irrigation, and Health and also by other agencies involved in the provision and treatment of water, for example, the Rahad Gezira and New Halfa schemes. A first step could be the rehabilitation of existing slow sand filter plants.

In planning new hafirs, SSF and, if necessary pre-treatment of water, should be included. Further investigation of pre-treatment methods suitable for use in combination with SSF, for example, extended sedimentation and roughing filtration, should be encouraged, because of the high seasonal turbidity of surface water in Sudan.

At the regional level, bodies should be set up to coordinate the activities of the various agencies involved in water supply, sanitation, and rural development, and to prepare plans for a more integrated approach. Seminars and workshops are useful tools to support such development.

Community participation is essential to ensure proper installation, and operation and maintenance of water supply systems. This should be encouraged from the beginning of the feasibility stage by making existing or newly established village committees responsible for their own water supply schemes.

Health education is vital to ensure the health impact of the water supply system. Therefore, a dialogue with the community about existing health practices and needs is essential and should commence prior to the implementation of the water supply system. Sufficient time should be allowed to establish this dialogue and to allow it be effective. Such agencies should be strengthened and provided with sufficient means to carry out this task.

The ministries of services in the regional governments should be fully equipped and staffed, so that they can plan a role in the design, and operation and maintenance of rural water supply systems assigned to them.

Villagers should be mobilized to participate in operation and maintenance under the supervision of these ministries. The cost involved should be met preferably from the revenue collected by the users.

Training programmes should be prepared for caretakers and supervisors of the existing schemes. Caretakers should be trained on-the-job and should also receive some theoretical training at regional centres. Their conditions of service should be carefully investigated, and, if necessary, improved to create job satisfaction and to ensure continuity of operation, and hence to safeguard of the investment in the water facilities.

It is desirable that more information on appropriate methods of water treatment and sanitation be included in the curricula of the various institutions involved. Some information on methods, such as SSF, is included in the curricula of the University of Khartoum and the School of Hygiene, but more emphasis should be given.

Library and information sections of institutions at both the central and regional level involved in water supply and sanitation programmes should be developed further.

Regional laboratories should be fully equipped and adequately staffed to monitor the water quality of supply systems.

3. SUMMARY OF INFORMATION PRESENTED IN THE SEMINAR

The information given in this chapter is based on the papers presented during the plenary sessions. A list of these papers is given in Appendix 2.

3.1 WATER RESOURCES IN SUDAN, WITH EMPHASIS ON RURAL AREAS

Although located in the arid zone of Africa Sudan is considered to be rich in water resources which are, in order of importance:

- Nile River and its tributaries;
- groundwater;
- seasonal streams.

Nile River and its tributaries

As a result of an agreement with Egypt, Sudan is entitled to abstract only 8.5 billion m^3 annually. However, 35 billion m^3 of water are lost through evaporation in the swamps of southern Sudan, it is estimated that a maximum of 24 billion m^3 of that lost could be reclaimed. Plans are now under way to reclaim an estimated 18.5 billion m^3 of that lost through evaporation. Water from the Nile is used extensively in a number of irrigation schemes. It is also used for human consumption, but treatment is required because of:

- faecal contamination;
- high turbidity in the rainy season.

Groundwater

Groundwater is a source for drinking water. Approximately 150 billion m^3 water per year is supplied for domestic use from 4200 wells in the Sudan. Studies have indicated that water from this source could also be used to irrigate about 250,000 ha.

Seasonal streams

The most important of these streams, the Gash River with an annual flow of approximately 560 million m^3 and the Atbra River with an annual flow of 12 million m^3, both of which originate in the Eritrean Highlands.

During the period 1947 to 1983, the following have been constructed to store water from seasonal streams in rural areas:

- 916 hafirs (ponds) with a total storage capacity of 19.12 billion m^3;
- 48 small embankments with a total storage capacity of 71.8 billion m^3.

However, losses due to evaporation (40%) and seepage (10%) reduce the quantity of water available to approximately 45.5 billion m^3.

3.2 WATER TREATMENT IN RURAL AREAS

The supply of drinking water is a serious problem in the Sudan: in the north and west desertification is a problem; in the east salination is a problem; and in the south, there are extensive swamps. The three main resources for drinking water in the Sudan are:

- surface water (rivers, ponds, lakes, small upland and seasonal streams, etc.);
- groundwater, which can be found in good quality in most places in the Sudan, except the Umm Ruwaba reservoirs where the range of dissolved solids is high;
- rainfall, rain water harvesting is a good alternative for the collection of drinking water when other sources are remote, expensive, or extremely polluted. The annual rainfall distribution exceeds 1500 mm in the south and decreases nothward to an average of 3 mm in the north.

In rural areas, water treatment methods should be selected which are relatively simple and which produce safe water at a low cost. Introduced technology must be acceptable to the community concerned, and their involvement is essential for the maintenance and operation of the water treatment scheme. Simple methods to improve water quality include:

- boiling of water, before use in order to make it bacteriologically safe for human consumption, and before storage, to destroy cercaria responsible for bilharzia;
- the use of both plant and soil materials for domestic treatment of very turbid water;
- slow sand filters built with local materials, skills, and labour.

However, when these simple methods cannot be applied, other more complicated water treatment systems are required, such as:

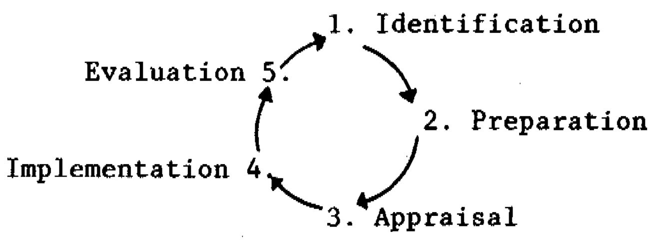
- disinfection
- sedimentation
- coagulation and flocculation
- rapid filtration.

Once clean and safe water is available, care should be taken not to contaminate it again before use. In the Sudan, water for domestic use is commonly stored in baked clay jars called zeers. The water is easily contaminated because these jars are not always cleaned regularly; and because dirty and stained utensils are used to withdraw water. It is therefore essential that zeers be properly constructed and conveniently located, and that adequate information on hygiene be provided.

3.3 PLANNING AND MANAGEMENT OF A RURAL WATER SUPPLY

Five phases can be identified in planning a rural water supply system. These, when put in a logical sequence, result in a project cycle (see Figure 1). During each phase the following aspects must be considered: finance, organization, and technique.

Project cycle



Time schedule:

1. Identification	1
2. Preparation	1
3. Appraisal	.25
4. Implementation	2
5. Evaluation	.25
Total	4.5 years

Figure 1. Project cycle and time schedule for a rural water supply system.

Ministry of Finance in Sudan has a twofold role. Firstly, it has the task of securing funds, either local, foreign, or both, to finance projects. Secondly the ministry, through an economist or financial analyst, has the task to evaluate projects in terms of: time, cost-benefit analysis, least cost analysis, internal rate of return, and the net present value.

The engineers are responsible for the technical design of a water supply system. Such systems can be managed in one of five ways:
- directly by a water authority;
- the water authority may delegate responsibility to village level;
- private individuals or institutions;
- association of water users;
- communal ownership.

The main difference is the level of community involvement. The consequences for each type of management on the various aspects of the system are given in Table 2.

Table 2. Variations of village level organization

Type of organization	Key requirements				Cost	
	Construction	Maintenance	Access	Motivation of manager	To authority	To user
Water authority with water rate	Direct employment or contract: construction may be efficient, but expensive	Routine maintenance possible at a cost	Open to the public by right	Bureaucratic	High cost, but offset against the prospect of recurrent income	User faces recurrent charge that will be substantial in the case of small supplies
Water authority with some management delegated to local individual or committee	Community participation in fund raising and in construction can be organized	Some local maintenance or first-aid repair can be institutionalized but responsibility rests with water authority	Open to the public by right	Local 'managers' receive some kind of reward	Initial cost may be reduced but recurrent costs must be met	User pays through participation, thereafter only indirectly through taxation
Private supply or institution supply with access to public	Private; no administrative involvement	Private; no administrative involvement	Access by payment (per container or per month)	Interests of owner/user plus possible profit in some cases	Some subsidy may be necessary to secure standards and to secure access for the public	Commercial fee unless there is private or public subsidy
Association of water users	Association constructs with some technical assistance	Association responsible for maintenance	Access to members only	Corporate interests members plus taken share of dues	Initial capital grants and supervision costs	Routine payments of dues to cover maintenance costs
Very local Authority or commune	Water supplies constructed as a communal facility	A routine activity for a work team or department	By right of community membership	Water management one of several functions	Grants and supervision costs	Costs met out of local tax or in a commune, production profits

3.4 SLOW SAND FILTRATION

Description of the process

Slow sand filtration is an appropriate method for making surface water safe for human consumption as illustrated by the following brief description of the process. In the slow sand filter, water percolates slowly through a porous sand bed. During its passage, the physical and biological quality of the raw water is improved considerably. In a mature bed, a thin layer forms on the surface which is referred to as the skin consisting of a variety of biologically active micro organisms which break down organic matter. At the same time many of the suspended inorganic substances are filtered out. After several months, the filter skin becomes clogged. The filteration capacity can be restored by cleaning the filter, by scraping away the top layer of the filter, including the filter skin.

Elements of an SSF plant

An SSF plant consists of:
- filter box;
- supernatant water;
- filter bed;
- underdrain system;
- valves and flow measurement devires.

Design criteria

On the basis of the findings of the SSF project, the design criteria for an SSF plant can be summarized as follows:

design period: 10 - 15 years;
period of operation: 24 hours per day;
rate of filteration: 0.1 m/h (0.11 - 0.2 m/h);
area per filter bed: 10 - 100 m^2;
number of filter beds: minimum of 2;
height of supernatant water: 1m (1-1.5 m);
initial depth of filter bed: 1m (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 coeff. 2-5.

The actual design of an SSF will depend on:

- the quantity of water required, which is a function of the size and growth rate of the population, design period, water consumption per head, etc.;
- availability and quality of raw water, in the Sudan, an important drawback is the high turbidity (50 NTU) of raw water, which leads to rapid clogging and hence poor performance of the SSF process.
  Testing of a SSF in a pilot plant is advisable to determine whether pre-treatment is required, such as:
  . riverbed filtration;
  . sedimentation;
  . horizontal flow pre-filtration.

Mode of operation

There are two possible modes of operation of a SSF plant:

- continuous flow, 24 hours a day, with the rate of filtration preferably 0.1 m/h; this is most suitable because it produces the best effluent and requires the smallest filter area;
- declining rate filtration, whereby after a certain period of operation (e.g., 8 or 16 hours), the inlet valve is closed but the outlet valve remains open, resulting in a fall in the top water level and hence a declining rate filtration.

The common practice in some countries of intermittent operation should not be adopted in Sudan. It has been shown conclusively that an unacceptable breakthrough of bacteriological pollution occurs approximately four to five hours after filtration has resumed.

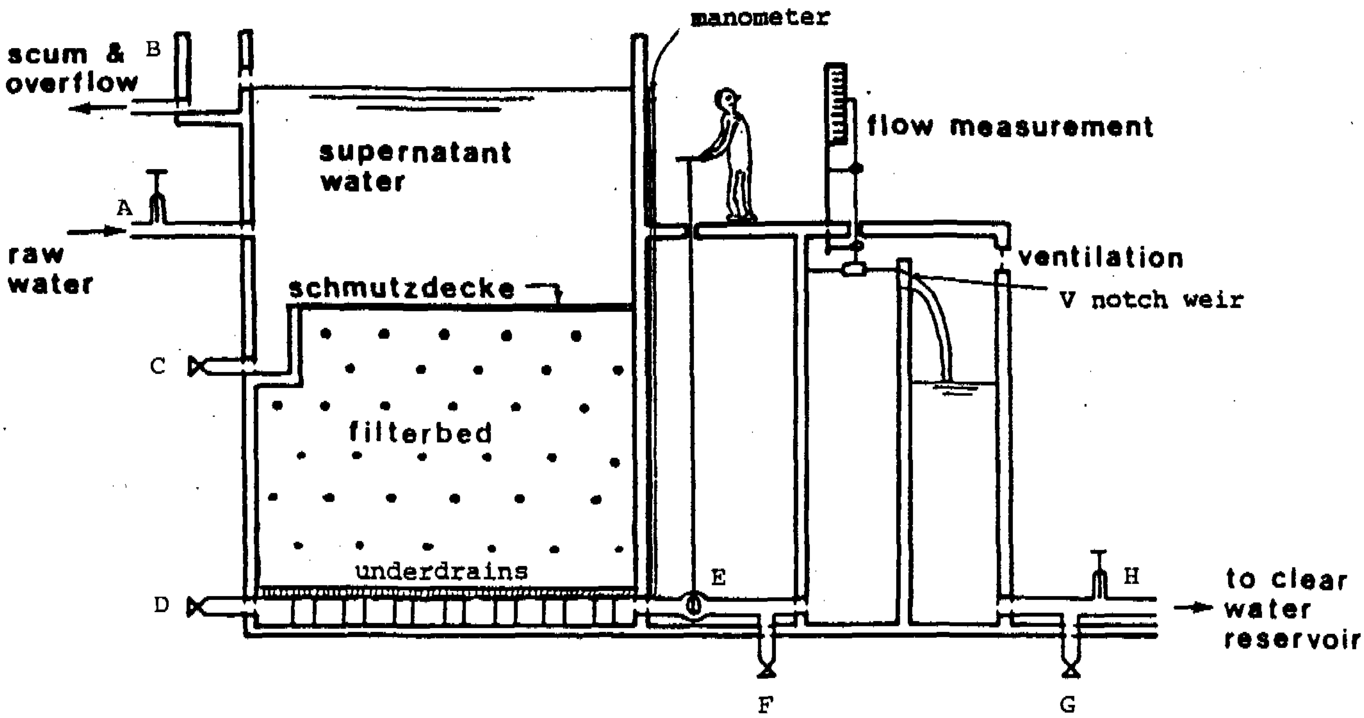


Figure 2. Basic elements of a slow sand filter.

Initial commissioning of the filters. Filtration media should be added to the design level. Clean water should then be introduced through inlet valve D (Figure 2) so that the water is admitted from the base to flow upwards through the drainage system and the sandbed until it reaches a level of 10-15 centimeters above the sand bed. This method of charging ensures that air accumulating in the system is driven out.

Inlet valve A (Figure 2) for raw water is opened and valve H remains closed. The quality of the treated water is checked at valve G. The quality of the effluent will improve during the ripening period (increasing biological activity). When tests of the quality of the treated water are satisfactory, valve G is closed and valve H opened. The water is then ready for use. However, if correct testing is not possible, the effluent can be permitted to flow into the clear well after a period of four to five days, or even earlier, if the effluent is chlorinated.

Daily operation. Filter bed resistance increases due to clogging. The flow must be checked every day, and, if necessary, valve E (Figure 2) should be opened. Further, the flow rate should be kept at 0.1 m/h.
Other activites to be carried out by the operator include:

- cleaning of the inlet, surroundings and plant, and maintaining the fence;
- operation and maintenance of pumps;
- simple quality control of raw and treated water, for example, for turbidity and residual chlorine;
- removing algae and floating matter from the filter;
- maintenance of records as to cleaning of the filter bed, daily hours of operation of raw and clear water pumps, results of quality control etc.

Cleaning (approximately once every two months). When filter flow is reduced to less than 0.1 m/h, while the outlet value E (Figure 2) is completely open, the filter bed will require cleaning. To restore the filtration capacity the first two or three centimeters of the sand bed must be scraped away. Therefore, the water level must be lowered to about 10-20 centimeters below sand level. This can be accomplished by continuing the filtration process after closing the inlet valve. However, this may take some time and, therefore, drainage valve C (Figure 2) may be used to draw off the top water level quickly. Subsequently, valve E and F (Figure 2) may be opened to drain the remaining water.

The bed is then ready for scraping. This must be done as quickly as possible, preferably within a day, to prevent the microorganisms in the lower layers of the filter from starving. After cleaning, the filter has to be refilled with water following the procedure indicated under initial commissioning (page 14). During the cleaning of one filter, the rate of filtration in the other filters must be increased (maximum allowable, 0.3 m/h) to maintain the total output of the plant.

When the filter is returned to service, a period of at least 24 hours is required for the bed to reripen.

Resanding (approximately once every two or three years). This becomes necessary when successive scrapings have reduced the thickness of the bed to 50 centimeters. The method of handling the sand is basically as follows.

The old sand is moved to one side, and new sand is placed in position. The old sand is then placed on the top of the new. In small filters it is preferable to remove the old sand completely from the filter and then to spread it over the new sand, once the latter has been placed.

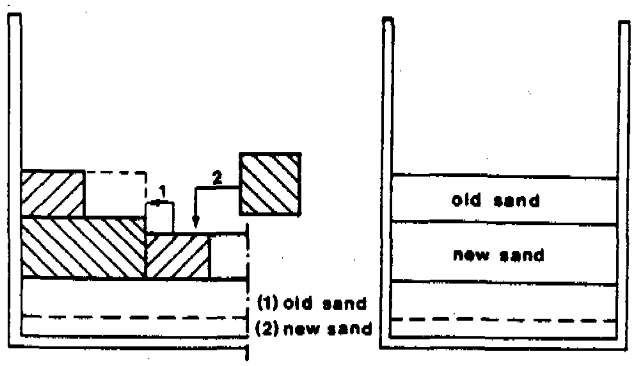


Figure 3. Throwing over practice.

3.5 COMMUNITY EDUCATION AND PARTICIPATION (CEP)

Water supply and sanitation facilities can be improved considerably by reducing the incidence of diseases associated to some degree with water. Such diseases may be classified as follows:

1. Water-related diseases
- diseases contracted when shortage of water is the main contributing factor, results in cessation of bodily cleanliness e.g., skin diseases;
- diseases due to water in which there is a surplus or shortage of certain trace elements, e.g. fluorisis (too much fluorine), goitre (lack of iodine);

2. Water-borne diseases
- diseases due to infected water; water acts as a medium for pathogens development and multipication, in addition to being a prime agent for, e.g. cholera, typhoid and guinea worms;

3. Water-associated diseases

- diseases transmitted from person to person via a vector having aquatic stages or an aquatic phase in its life cycle, e.g., malaria, schistosomiasis, and river blindness.

Health education, an indispensible tool:

- to help villagers indentify hygiene risks;
- to establish the relation between unhygienic practices and water - also excreta-related diseases;
- to develop social norms and values that would lead to the adoption of improved health practices, improved water supply and sanitation;
- to discuss possible improvements to health conditions in the villages.

Several methods of communication are used in health education:

- mass media, e.g., television and radio;
- health education in schools;
- at village level, health workers, group discussions, meetings, conducted by village health workers and by posters, etc.
- parents instruction of children.

Participatory approach

Experience has shown that the likelihood of water supply and sanitation schemes being implemented and properly applied is when the community is involved at an early stage. The community should be invloved:

- within the project, in planning and design, provision of labour and finance;
- in organization of operation and maintenance, e.g., collection of revenue to meet unavoidable expenses such as payment of cartakers;
- proper storage and handling of water.

Important factors are the involvement of the community, and stimulation of changes in behaviour. These matters depend heavily on the individual community concerned; its organizational structures, the level of education, etc. There is no pre-determined formula for community participation.

Involvement of the community

Full community participation in a water supply project involves:

- identification of community priorities;
- collective decision making;
- cooperative action.

This means that all villagers, or at least representatives of all sections, should be informed and consulted at an early stage about:

- the need for and the feasibility of providing a safe water supply;
- their preferences and the technical and financial consequences of their choice;
- the preparations and contributions which are expected from the villagers;
- the project approach.

It is not an easy matter to reach all sections of the community. Women, for example, often are not involved in the information and decision-making process. Yet, since women are usually the main users and have the main responsibility to train children, they should be included.

An integrated approach

It is very difficult to generalize, but if rural water supply is considered in a developmental perspective, and community participation as a prerequisite, then the following steps can be identified in setting up a water project.

1. Approaching the community. Initially, communities can be contacted through local leaders (religious, political, etc.). Lack of cooperation by such people can be almost as harmful to the success of a project as their open opposition. In this way, support by the leaders and contacts with different groups within the community may be achieved.

2. Training the village health worker/community development worker. The function and selection of a village health worker/community development worker (VHW/CDW) should be discussed during the initial visit. At this stage particularly, the involvement of women should be strongly encouraged. The selected VHW/CDW should receive training to enable her, or him, to

start a dialogue on the possible local routes of transmission of water-and excreta-related diseases and ways to improve environmental conditions and behaviour of the community within the resources available locally. Also, in cooperation with the village authorities, a village environmental committee, responsible for CEP in water and other development projects, should be established. If the lack of safe water supply is shown to be a problem, then an official request for assistance should be made to the agency responsible for its provision.

3. Advice on appropriate water supply system. If the community wants a water supply, its terms, including payment for maintenance, must be negotiated. Firstly, they need advice on various water supply systems and their consequences. Both a socio-economic and a technical survey are required. The community should play an active role in these surveys, since they have the best knowledge of the local area. On the basis of the outcome, a number of options should be identified and cost calculations made.

4. Construction. Encouragement of community responsibility for the water supply is very important. This should lead to community control on waste disposal, which includes laundering of clothes, and the prevention of spillage at standposts. Funds must be secured for operation and maintenance. The level of community participation will depend on the type of water supply and treatment.
Often it will be necessary to employ a paid caretaker and a number of assistants. Salaries and costs involved will have to be paid by the community through water rates and other forms of taxation. Preferably, the caretaker should come from and be selected by the community. He or she should receive sufficient training to enable him or her to manage the scheme, and should be given adequate background information on community participation and health education. In close collaboration with the village health worker and the subcommittee for CEP, the caretaker has an important role to improve the village environment.
In some cases, it may be possible to combine the functions of the caretaker and VHW. Consultation between the community and the caretaker should also aim at developing regulations for the water supply, such as protection of the water intake.

5. Evaluation. Occasional checks on user satisfaction are essential. Feedback from users through the caretaker or the village environmental committee may lead to further improvements and may provide the agencies involved with necessary information to enable adjustments to be made for the selected approach.

Identification of the constraints

A number of constraints must be overcome to achieve an integrated approach. These include:

- the multitude of agencies involved in drinking water supply and sanitation;
- lack of information on the potential benefits and cost savings of community participation;
- administrative systems which provide detailed targets and hence view community participation as a long tiresome process for which there is no time;
- the lack of specific training programmes for community development workers and caretakers.

4. FIELD VISIT

During the seminar, participants and several observers made fields visits to:

. Blue Nile Health Project;

. several SSF plants in the Rahad and Gezira Schemes, approximately 300 km south of Khartoum.

4.1 BLUE NILE HEALTH PROJECT

Blue Nile Health Project (BNHP), which is sponsored by WHO, is a research project on water-borne diseases. A simple household water supply system was demonstrated at their local headquarters. This system consists of a box filled with sand which is placed in a canal or pond. Water is extracted from the box by means of a hand pump. The volume of the box is 18 litres, the cost of the pump ± 250 S.P. and the total cost of the system ± 300 S.P. Although this system only partially eliminates the bacteriological contamination of the water, it effectively prevents the water gatherer from coming into contact with bilharzia since entering the water is no longer necessary.

A latrine project has been incorporated in BNHP. The type of latrine promoted is equipped with a flap trap, a ventilation pipe and a concrete squatting slab. The cost of this slab per household is 36 Sudan pounds. Usually the transportation of the slab is financed by the local government. Villagers are required to build their own latrines. Construction of the slab takes place at a central unit with a production capacity of 70 slabs per week. Because of a rapid increase in production, the production unit was expanded. However only the original unit has a roof. The expanded area is in the open and during the setting process the slabs are exposed to direct sunlight which reduces the strength of the slabs significantly.

4.2 RAHAD AND GEZIRA SCHEMES

During the field trip, three filter plants were visited in villages number 25, 40, and 75 in the Rahad Scheme, and a fourth at El Fau.
The two filter plants in villages numbers 40 and 75 consist of one sedimentation tank, two slow sand filter tanks (diameter approximately 8 m, design capacity 10 m^3/h), and a storage tank. The clear water is pumped to an elevated reservoir.

	SEDIMENTATION	SLOW	CLEAR	ELEVATED
RAW WATER		SAND	WATER	RESERVOIR
		FILTRATION		WELL

Figure 4. Scheme of the water filtration plants in villages number 40 and 75 in The Rahad Scheme

The source of raw water for village 75 is a hafir (pond) and for village 40, a canal. It is intended that the raw water flow by gravity from the inlet to the clear water well. Water is pumped twice daily from the clear well to the elevated reservoir. No valves or flow devices have been installed. Operation of the plants is limited to the operation of the pump, that is twice per day.

The filter plants in village 25 and in El Fau are of identical design, but the plant at El Fau is twice the size, the design capacities being 1350 and 2700 m^3/d, respectively. The micro strainers are used during the rainy season only. There are no flow control devices. The only pumps in operation are those which pumped water from the clear water well to the elevated reservoir.

MICRO	COAGULATION	SLOW	Chl.	CLEAR	ELEVATED
STRAINERS	FLOCCULATION	SAND		WATER	RESERVOIR
	SEDIMENTATION	FILTRATION		WELL	

Figure 5. Scheme of water filtration plants in village 25 in the Rahad Scheme and at El Fau, using water from the irrigation canals

To improve the site conditions and the functioning of the water supply systems it is essential that:

- operators are so trained that they understand and appreciate the purification process, and the responsibility of their position;
- existing designs be improved; in particular, valves for control of the rate of filtration and monitoring devices should be installed;
- the operator be required to record daily events at the plant site.

Appendix 1: PROGRAMME OF THE SEMINAR

13 November	-	Official Opening by Mr. I.M. de Jong, Chargé d'Affaires of the Netherlands Embassy
	-	Presentation of Key-notes on behalf of the NAW and IRC
	-	Presentation of papers on technological aspects of slow sand filtration
14 November	-	Presentation of papers on socio-economic aspects of SSF projects
	-	Laboratory demonstrations
	-	Slide presentation: Water for Rural Colombia
15 November	-	Field visit to slow sand filtration plants at Rahad and Gezira schemes
16 November	-	Planning and design exercise
17 November	-	Presentation of findings of planning and design exercise.
	-	Presentation of the findings, conclusions and recommendations by the project committee and IRC.

Appendix 2: LIST OF PAPERS PRESENTED

1. Opening Address
   Mr. I.M. de Jong, Chargé d'Affaires of the Embassy of the Kingdom of the Netherlands.

2. Keynote, introducing participants to IRC and SSF project.
   Mr. Kheiralla, General Director National Administration for Water.

3. Keynote: The International Research and Demonstration Project on Slow Sand Filtration.
   Mr J.T. Visscher, IRC.

4. Water Resources in Sudan with emphasis on Rural Areas.
   Mr. Mohammed El Mahdi, NAW.

5. Planning and Management of Rural Water Supply.
   Mr. El Hag El Tayeb, Director, Grant and Loan Project, NAW.

6. Water Treatment for Rural Areas, with emphasis on Sudan.
   Dr. Isam Mohamed Abdel Magid, Faculty of Engineering and Architecture, University of Khartoum.

7. Planning, Design and Construction of Slow Sand Filter.
   Mr. V.A. Mhaisalkar, National Environmental Engineering Research Institute, Nagpur, India.

8. Operation and Maintenance of Slow Sand Filters.
   Dr. Bashir Mohamed Elhassan, Dean, School of Hygiene.

9. Water and Disease.
   Dr. Kamal Kheiralla, Fac. of Med.

10. Community Participation: objectives, techniques, and methodology.
    Mrs Nimat Wagialla, Min. of Agr.

11. Health Education: objectives, techniques, and impact.
Mr. Abdel Wahab Mohamed Makki, Deputy Dean, School of Hygiene.

12. Participatory Approach to Village Water Supply.
Mr J.T. Visscher, IRC.

Appendix 3: LIST OF PARTICIPANTS AND OBSERVERS

Participants	Address	
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Appendix 4: PLANNING AND DESIGN EXERCISE

4.1 Introduction

A reliable water supply in both quantity and quality, is still not available in many places in the Sudan. Improvement of the existing situation is not a simple task, as evidenced by the papers presented during the seminar. Many aspects have to be dealt with in planning reliable and durable water supply systems. A technical solution for a problem does not necessarily mean it is financially or socio-economically feasible.

4.2 Objective

The prime objective to improve a water supply system, is not necessarily accomplished by following a standard pattern. The aim of this exercise is to demonstrate how and where basic information for design can be treated systematically to produce an appropriate design for a particular water treatment plant. The first guidelines to follow may be set out as follows:

- to establish the precise information required in each phase of planning the water supply;
- to ensure that planning and design are closely related to factors, such as, economy, finance, health education, and social structures;
- to find a technical solution, taking into account above mentioned aspects.

4.3 Exercise

The seminar participants are to be divided into six groups. Each group will plan and design a water supply system, whenever feasible, incorporating slow sand filteration. The exercise consists of two parts: I Planning; and II Design.

In part I Planning, the following phases can be identified:

- identification
- design
- construction
- operation and maintenance

Within each phase, the following should be considered:

- organization (institutional requirements, community participation, supervision, etc,)
- economics and finance (provision of capital, cost recovery, etc.);
- technique (what type of system is required, dimensions, etc.).

Examples of questions which may arise during the group discussion:

1. Who should decide that the community requires a water supply?
2. Who should make the request for a water supply and how does it reach the water agency?
3. Should there be close working relationships with other organizations, such as, health and educational institutions?
4. What type of preliminary survey of community and site should be undertaken, who should be involved, and what topics should be covered?
5. Who should provide the funds, how should they be allocated, and how should a project approved?
6. Who should produce the design? What number of staff should the design unit comprise, who should approve the design?
7. Who should formulate the terms of reference for the contractors, if contractors are to be used?
8. Who should be involved in construction, and who should supervise?
9. Who should recruit the operators, and what general criteria are applied?
10. Who should train the operators, and where?
11. Who should be in charge of operation and maintenance?
12. How should payment for the supply be organized, and what should the tariff be, if any?

Additional information on the assignment will be distributed on the day of the exercise. One of the three cases will be allocated to each group of participants.
On the final day of the seminar each group will present their findings.

Additional information

A. Fasha-shogia village is located on the west bank of the White Nile. This village should be supplied with water treated by slow sand filtration. Indicate how you would solve the problem for this village.

B. A new settlement is envisaged in a new irrigation scheme, and the provision of safe water supply is considered to be of paramount importance. How would you ensure this?

C. A small town collects its water from a borehole, but unfortunately the borehole has become dry. The nearby hafir is considered to be the only hope for a water supply for this growing town. How would you solve the water supply problem for this town, on the basis of available source?

Table 4.1 Additional data on the three case studies

Case Study	Population Total	Population Growth rate (%)	Lit C.D	Turbidity	Suspended solids	COD	BOD	MPN. E.Coli per 100 ml.
A	5000	2.5	30	24	400	4	2	10
B	2000	7	80	15	120	6	5	154
C	7000	1	50	120	900	10	8	3000