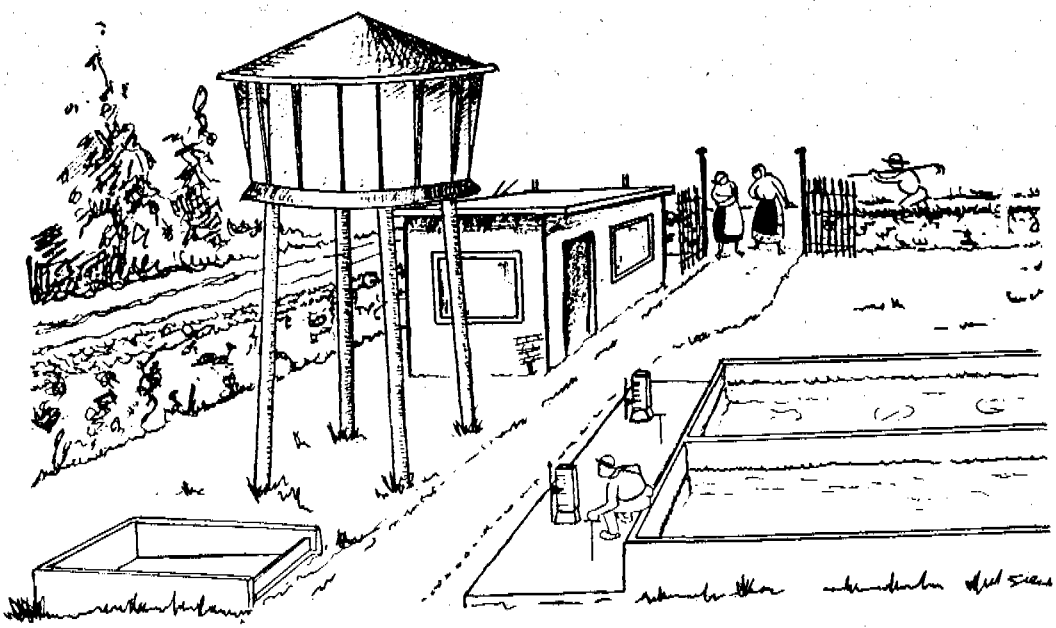
OW SAND FILTRATION

Manual for caretakers



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SLOW SAND FILTRATION

Manual for Caretakers

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with illustrations by
A. Figee

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CONTENTS

PREFACE

The objective of this manual is to provide caretakers of slow sand filtration plants in rural areas of developing countries with the information they require to carry out their job. The caretaker is responsible for ensuring that water is supplied to the community in sufficient quantities and that it is safe for drinking and domestic use, and attractive in appearance. The caretaker should not only understand the technical aspects, but also know how to involve the community because this will improve correct use of the water supply system. This will be more easily done if the community has already been involved in planning the system.

The caretaker's awareness of the importance of safeguarding the plant and the distribution network may be increased by the provision of basic knowledge on sanitation and health, some of which is therefore included.

Under normal conditions, a trained caretaker can cope with the day-to-day work and solve the problems. However, sometimes major problems may occur, such as excessive growth of algae. Then the caretaker may need to consult the supervisor who should be in a position to send more qualified technicians, equipment and spare parts to restore the performance of the slow sand filter system.

Although this manual provides basic information for caretakers, adequate training and support will also be needed. To facilitate the preparation of training programmes, a guide for training caretakers of slow sand filters has been prepared to be used together with this booklet. Also, IRC has published a manual for design, construction and operation and maintenance; sound design and construction are pre-requisites for the caretaker to do a good job.

This manual draws heavily on the "Guidelines for operation and maintenance of slow sand filtration plants in rural areas of developing countries" which was developed at IRC from contributions by particularly Mr. R. Paramasivam and Mr. A. Raman of the National Environmental Engineering Research Institute, Nagpur, India; Mr. Mugele, formerly senior engineer, Thames Water Authority, London; and

Mr. J.K. Densham, Industrial Training Services Ltd., London. Comments received endorse the usefulness of guidelines for higher level staff, but also indicated the need to address caretakers. This earlier publication together with the comments received were very useful in preparing this manual. The authors are grateful to Ms M. Boot, Mr R. Brasseur, Mr E. Hofkes and Ms. C. van Wijk-Sijbesma for reviewing the draft manual.

1. INTRODUCTION

The caretaker of a slow sand filtration plant has a great responsiblity to guarantee the regular supply of good quality drinking water in sufficient quantities to the villagers. Therefore, adequate operation and maintenance of the system is essential. Water supply agencies may not always realize the importance of the caretaker's job, and thus may not provide sufficient training and adequate tools. Fortunately, a little training and only simple tools which often can be made locally are required for operation and maintenance of slow sand filters.

The caretakers job includes a range of tasks which are described in detail in Chapters 4 to 8. Some of these need to be done daily, and others weekly, monthly or even less frequently. Often, adequate operation of the plant is not the only task. Upkeep of the distribution system is also important, because precious purified water is lost through leaking pipes and broken taps.

In addition to these technical tasks, there is also the promotional side to the job. If the purified water is collected in a dirty bucket or contaminated in another way, then the caretakers effort will be in vain.

The community can help greatly in the operation and maintenance of the water supply system. They can handle the system with care and they can report leakages. Good communication between caretaker and community is necessary so that the community can be informed in advance of breakdowns and repairs, so that they can store water for these periods.

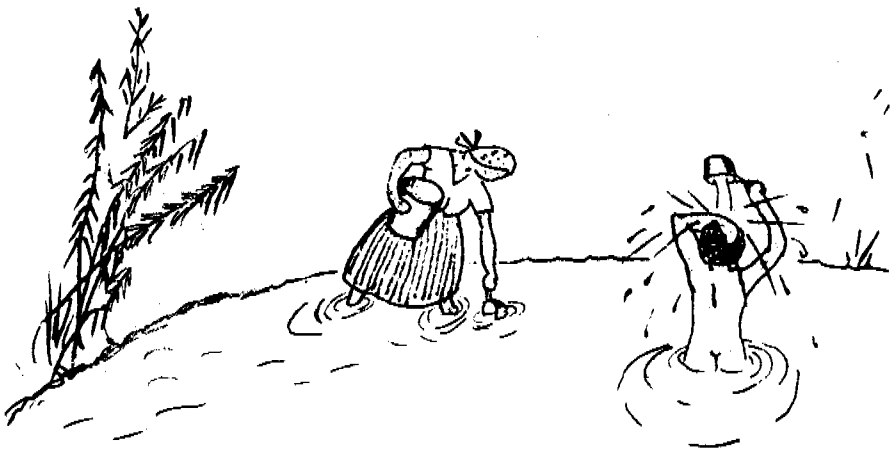
Therefore, the manual also includes suggestions on how to communicate with and involve the community. When the community appreciates the caretakers responsibilities they may also seek advice on other points. Therefore, some information on sanitation and hygiene education is given in Appendices I and II.

2. THE WATER SYSTEM

2.1. The source: surface water

Surface water often contains impurities and therefore is generally not safe to drink. In rainy periods, the water may look very dirty, but even if the water looks clean, it may still contain many disease-causing organisms. Many of these organisms, which cannot be seen because they are very, very small, are brought into the river, for example, by:

- discharging waste and wastewater;
- bathing and washing clothes;
- defaecating children;
- defaecating animals.



Usually surface water is not safe to drink because it is contaminated in many ways.

2.2. Need for purification

Water that contains disease-causing organisms is not fit for human consumption. These organisms can be destroyed by boiling the water for ten minutes, but this requires much fuel and is also a cumbersome task. Instead of boiling the water, it could be purified by the process of slow sand filtration. This can be done either at household level, or at community level which has the advantage that all households receive safe water. This method not only destroys disease-causing organisms but also effectively removes other impurities.

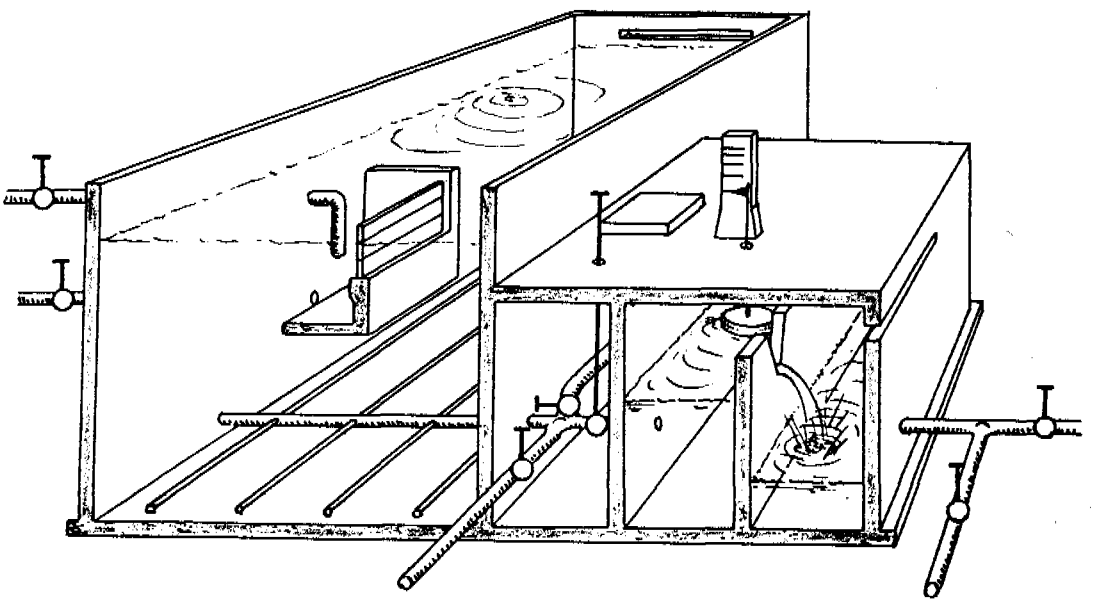
Surface water should be treated: boiling is a good but cumbersome method; slow sand filtration is often more practical.

2.3. Slow sand filtration plant

A slow sand filter consists of a box, often made of concrete in which a bed of sand is placed over a layer of gravel and perforated pipes. These pipes collect the treated water. A drawing of a slow sand filter is presented below.

Other important parts of a slow sand filter plant are:

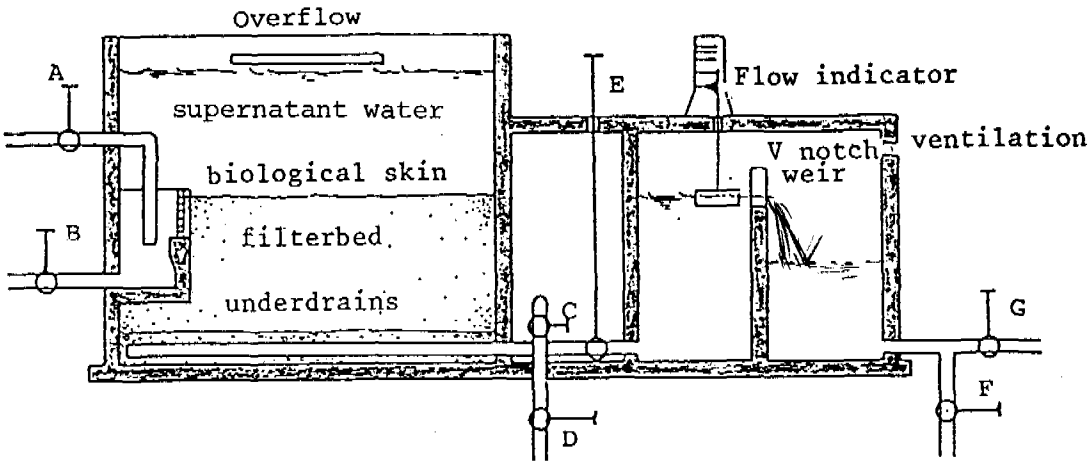
- the raw water intake, the structure through which the water is drawn from the river;
- the water outlet chamber, the place where the treated water is collected from the perforated pipes and flows out of the filter into the clear water well;
- the clear water well, the tank in which the treated water is stored;
- the overhead storage tank, an elevated tank to which the water is pumped from the clear well and from which it flows into the distribution system.



Slow sand filtration has been proven to be a very effective way to purify polluted surface water.

2.3.1. Main valves of the slow sand filter

For daily operation and control, the caretaker needs to understand the functions of the various valves in order to operate the slow sand filtration plant. An overview of the main valves is given below.



- inlet valve (A), to admit raw water into the filter;
- drain valve (B), to drain the supernatant water quickly;
- recharge valve (C), to undercharge the filter with water initially and after cleaning;
- waste valve (D), to run water to waste;
- filtered water valve (E), to control the rate of filtration;
- waste valve (F), to run water from the outlet box to waste;
- distribution valve (G), to pass the purified water into the supply.

Some plants do not have all these valves. Sometimes there is a simple plug instead of valves B, C, D and F.

2.4. The purification process in a slow and filter

In a slow sand filter, the water percolates slowly through a sand bed. During this passage impurities are removed from the water by a combination of processes.

Particles present in the raw water settle on the sand surface. After one or two days these particles form a thin layer on top of the sand bed. This layer, which is also called the filter skin, retains even very small particles and also tiny micro-organisms present in the river water. As long as the water continues to flow, these micro-organisms will not die but flourish in the filter skin.

These micro-organisms are the most important element of the slow sand filter, because they consume disease-causing organisms and other impurities.

The micro-organisms grow in number, this is called the ripening process. After some time there will be so many micro-organisms that almost all disease-causing organisms will be consumed by them and therefore virtually none will pass through the biological skin. This ripening process may take up to two weeks in new filters and only a few days in filters that have been used before.

The best way to assist the micro-organisms with their important task is to keep the filtration rate (that is the rate at which the water passes through the filter) as constant as possible. It is most important to avoid rapid changes in this rate and in the quality of influent water.

The continuous settling of particles on top of the sand bed will lead to gradual clogging of the filter skin and this in turn will reduce the filtration rate. This can be compensated for by opening the outlet valve a little more each time. When after one or two months the valve cannot be opened further, the decrease of the filtration rate cannot be corrected, then the filter needs to be cleaned by removing the clogged layer of sand. This can be done by draining the water below the sand surface and scraping off about two centimetres of the sand bed, and then it can be refilled with water. About two days after filtration has begun again, the water will be safe to drink.

3. OPERATION AND MAINTENANCE BY CARETAKER AND COMMUNITY

3.1 The Caretaker

Every water supply system has to be operated and maintained properly. Often one or a few persons will be responsible for operation and maintenance. These persons, who are also called caretakers, have a very important task.

First of all they have to ensure that the treatment plant functions properly. This means that the caretaker needs to know and understand all the tasks involved in routine operation and maintenance. In most cases, the caretaker will also have to look after the distribution system and repair the taps. A good relationship with the community will help to increase their appreciation and willingness to support the caretaker. The attitude to the job is a key to building this relationship. Ideally the work needs to be seen as an important service to the community and especially to the women. Good communication can help to improve this service. The caretaker, for example, can ask the women if they are satisfied with the service or inform them of possible interruptions in the supply. Demonstration visits to the plant can be organized for, groups of women or school children.

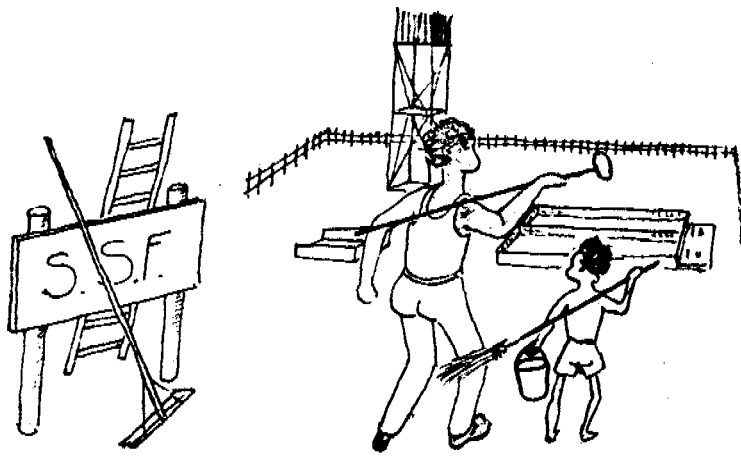
The caretaker may also need to have formal discussions, for example on water use and health risks or supply of spare parts, with local leaders and the village water committee. Village meetings preferably are organized together with the village health worker.

Some of the more general tasks are described in this chapter. The jobs directly involved in the upkeep of the plant are described step-by-step in Chapters 4, 5, 6 and 7.

3.1.1 Safeguarding adequate functioning of the entire system

Adequate maintenance and regular inspections of the entire water supply system including the intake, the pumps, the treatment plant, the distribution system and the taps are required to ensure that the community has a safe water supply.

Immediate repair of leaking pipes and taps is essential. Leakages lead to waste of precious water and also to a drop in water pressure. When the water pressure is low, disease-causing organisms may enter the distribution system and pollute the water again. Stagnant water by taps leads to unhygienic conditions and the breeding of insects. In dry areas, puddles around taps can lead to an increase in the incidence of malaria and filariasis, as mosquitoes which transmit these diseases breed in stagnant water.

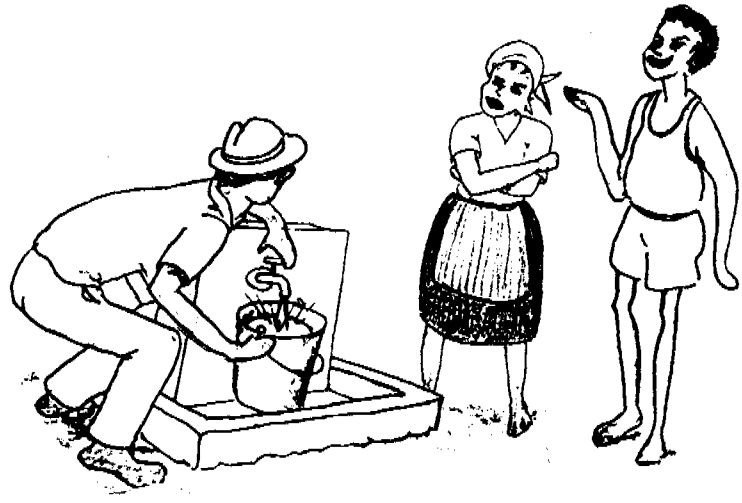


Conscientious operation and maintenance of the slow sand filters and the other parts of the water supply system is essential.

3.1.2. Ensuring proper use of taps

Often when taps are not used properly, they start to leak and purified water is wasted. Therefore, it is important to find out why the community does not use the taps properly. If necessary a meeting can be organized with the users to discuss the problem and identify possible solutions. For example, with public taps, a tap committee or tap caretakers can be elected.

Also, it is important to ask the users regularly whether they are satisfied with the supply. If they are not satisfied, it is important to discuss with the community how improvements can be made.



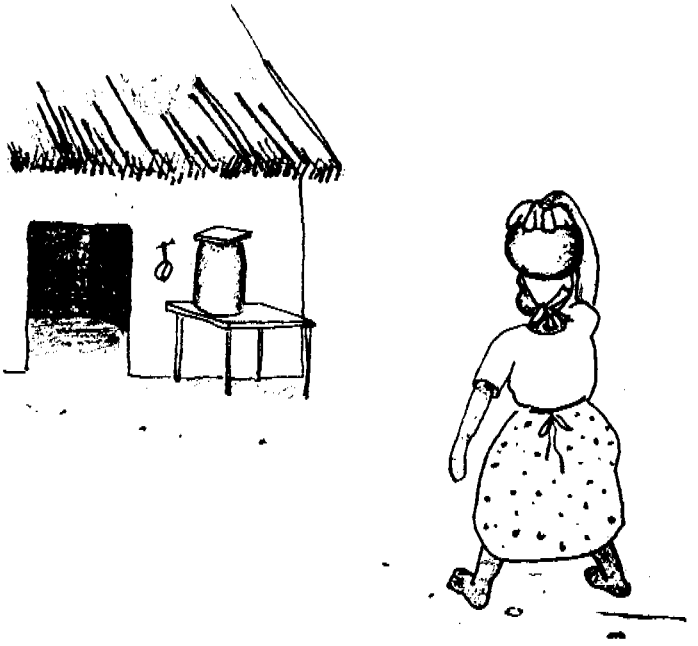
If taps are not used properly try to find out why not, and try to find a solution together with the users.

3.1.3. Keeping the water safe to drink

Containers used for collection and storage of water should be cleaned thoroughly before use because they may contain dirt and disease-causing organisms.

Dust and dirt may enter open containers, therefore water should be stored in containers covered with a lid. Take a clean bowl to draw water from a container and prevent hands from coming into direct contact with the water.

Efforts to purify the water will be in vain if it becomes polluted again between collection and consumption. The village water committee and village health worker can help to develop good water use practices through informal discussions especially with women and school children.

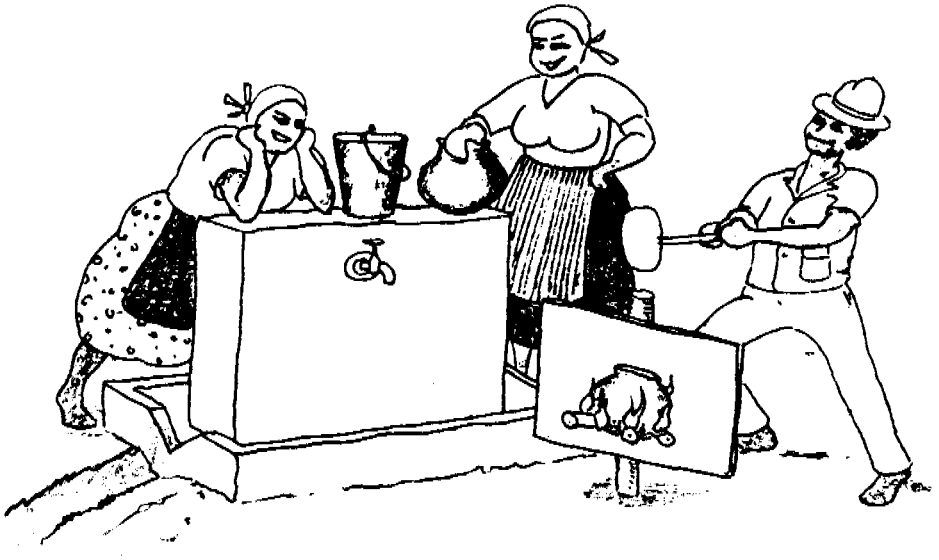


Discussions with users on how water can best be collected and stored helps to prevent it becoming polluted again.

3.1.4. Providing information on breakdowns

If the treatment system fails, the community must be informed that they have to boil water before drinking or only drink tea, until the treatment system is repaired.

Also, it is very important to inform the community beforehand, and particularly the women, when an interruption to the supply may be expected. This will enable them to store some purified water.



Warn the community immediately when the treatment process fails, so that they can purify the water by boiling.

3.2. Community support for the caretaker

The community also has a responsibility to assist the caretaker by:

- not polluting the river upstream of the raw water intake;
- handling the standposts or yard connections with care and reporting leakages of taps and pipes immediately to the caretaker;
- informing the caretaker immediately when sudden changes in raw water quality are observed, for example when it becomes very turbid or contains dead fish;
- helping the caretaker with simple maintenance tasks;
- informing the caretaker when they are not satisfied with the supply.

A caretaker who listens and reports to the community will be better appreciated and receive more support.

3.2.1. Prevention of pollution

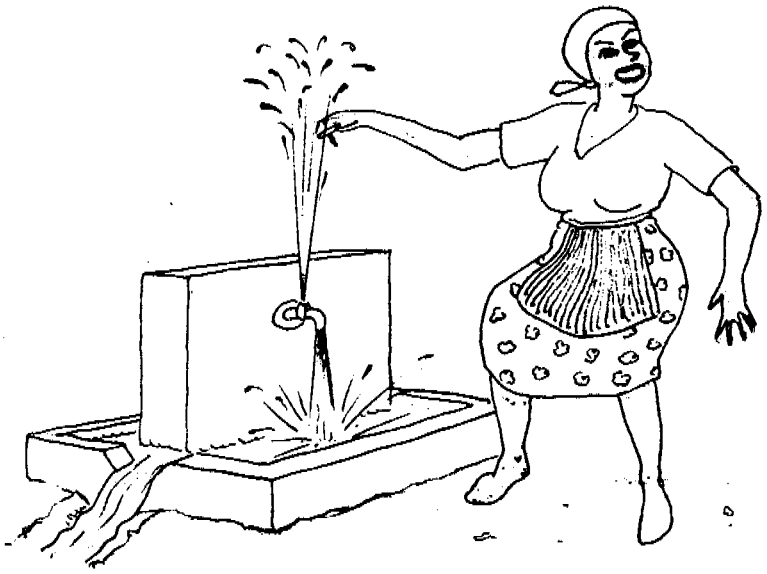
Washing, bathing, cattle watering, and human excreta will pollute the river water and make it more difficult to purify. Therefore, such activities should be avoided upstream of the raw water intake.

Prevent pollution of the river water upstream of the raw water intake to facilitate treatment.

3.2.2. Reporting of leakages

Immediate repair of leaking pipes and taps prevents wastage of large quantities of precious water.

The community can help greatly by reporting leakages in pipes and taps immediately to the caretaker. The caretaker will gain more support from the community if complaints about quality are followed up by action or explanation.



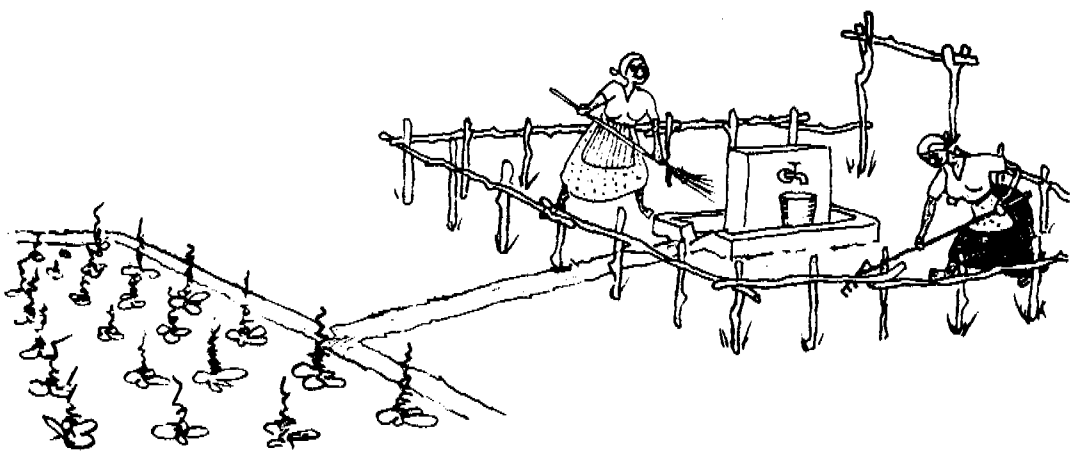
Villagers can help to prevent waste of precious purified water by reporting leaking pipes and taps immediately.

3.2.3 Reducing the risk of re-pollution

An unclean and muddy area around the water collection point increases the risk of re-pollution and may make people return to their original sources.

Spillage of small amounts of water at the taps is unavoidable, but it should not lead to a muddy area at the water collection point. Proper drainage of spilled water to a soakage pit or a vegetable garden is required.

The person responsible for keeping the area and the standpost clean can benefit from the spilled water, for example, by using the water to grow vegetables.



Villagers can reduce the risk of re-pollution of their water by regular cleaning of the site and proper drainage of spilled water.

3.3. How to organize the caretaker's job

To help in planning the work of a caretaker, the most important tasks to be done and their frequency have been listed on page 17. However, with the help of the supervisor, this list will need to be adapted to the particular situation.

Daily tasks. Regular visits, once or twice a day, are required to the plant to ensure that it is functioning properly and that the raw water intake is not blocked. On each visit the rate of filtration needs to be checked and possibly adjusted to ensure that the biological process is working as well as possible. Take advantage of being at the plant and check the pumps and other moving parts. It is important to keep the log book because this will help to predict forthcoming jobs, such as cleaning the filters.

Weekly tasks. Once a week, pumps and engines, if any, and other moving parts need to be checked. Tightening loosened nuts and bolts and lubrication of machinery will make these parts last much longer. The plant site should be kept clean and readily accessible. Leaking taps and pipes mean loss of water. The best way to reduce this is to inspect the distribution network regularly, and to repair leaking taps immediately. At these inspections community members can be asked whether they are satisfied. Also, important matters, such as the cleaning of standposts and water storage, can be discussed.

Monthly or less frequently. If the resistance of the filter becomes too high, the filter needs to be cleaned. How often this needs to be done depends on the quality of the raw water and the time of the year. Cleaning is done by scraping off the top two centimetres of the sand bed. Washing the removed sand immediately will prevent odour problems.

Yearly or less frequently. Once a year, check whether water is seeping into the ground through cracks in the filter box, the outlet box and the clear water tank. If so, this must be remedied.

After one year a deposit may have been formed in the clear well which has to be removed before it becomes too thick. About every two years, so much sand will have been removed from the filters that the layer has become too thin. New sand has to be placed in the filter underneath the remaining sand. This is a laborious task, which fortunately does not need to be done frequently.

Caretakers work schedule*

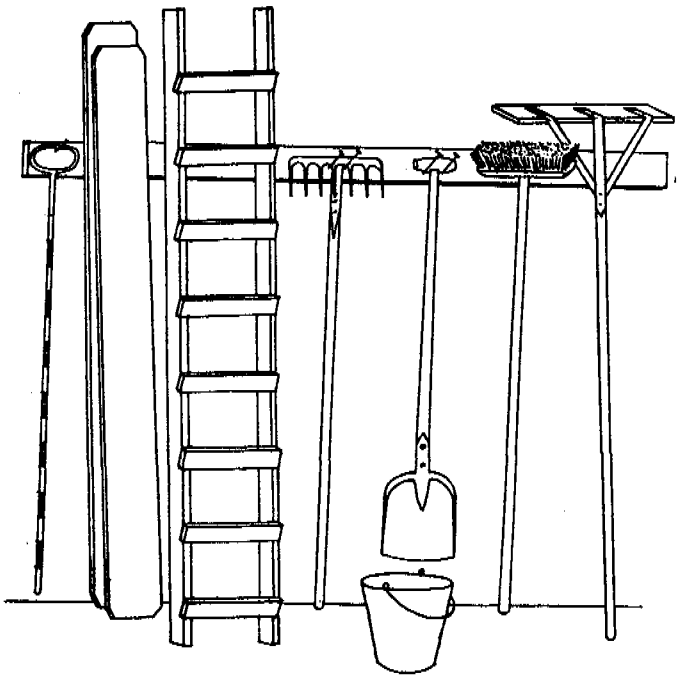
	For information, see Section
Daily	
- check the raw water intake (some intakes can be visited less frequently)	4
- visit the slow sand filter	6.2
. to check and adjust the rate of filtration	6.2
. to check the water level in the filter	6.2
. to check the water level in the clear well	
. to sample and check the water quality	6.3
- check all pumps	8
- keep the logbook of the plant	6.4
Weekly	
- check and grease all pumps and moving parts	8
- check the stock of fuel and order more if necessary	8
- control the distribution network, check the taps, and repair them if necessary	3.1
- communicate with users	3.2
- clean the site of the plant	
Monthly or less frequently	
- clean the filter bed(s)	7.2
- wash the sand removed	7.3
Yearly or less frequently	
- clean the clear water well	
- control the filter, the outlet box and the clear well for watertightness	5
Every two years or less frequently	
- resand the filter unit(s)	7.4

* This schedule is indicative only and will need to be adjusted to your situation with the help of your supervisor.

3.4. Tools for the caretaker

Proper tools and equipment help to make the job of the caretaker easier. It is better to repair damaged tools at once, so that they are ready when needed.

Only simple tools are needed and often these can be made locally. The following tools are required: measuring stick wooden planks, ladder, rake, spade, bucket, long handled brush, and levelling tool.

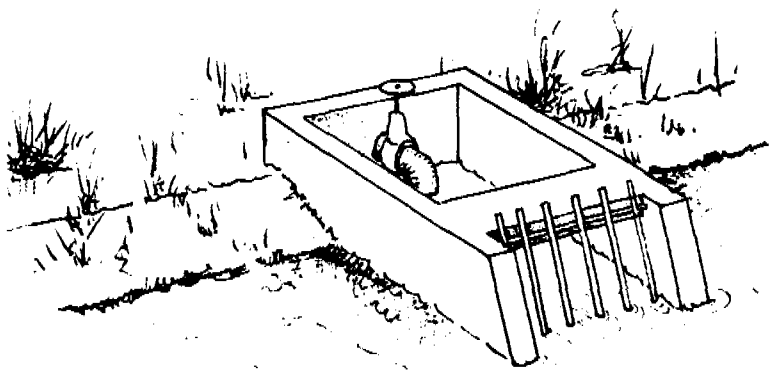


A good job can only be done with proper tools.

4. OPERATION AND MAINTENANCE OF THE RAW WATER INTAKE

The raw water intake is an essential part of the treatment plant. When carefully operated, it contributes greatly to the proper functioning of the plant. If the intake is far away, someone living close to it could be appointed as assistant caretaker to maintain the raw water intake.

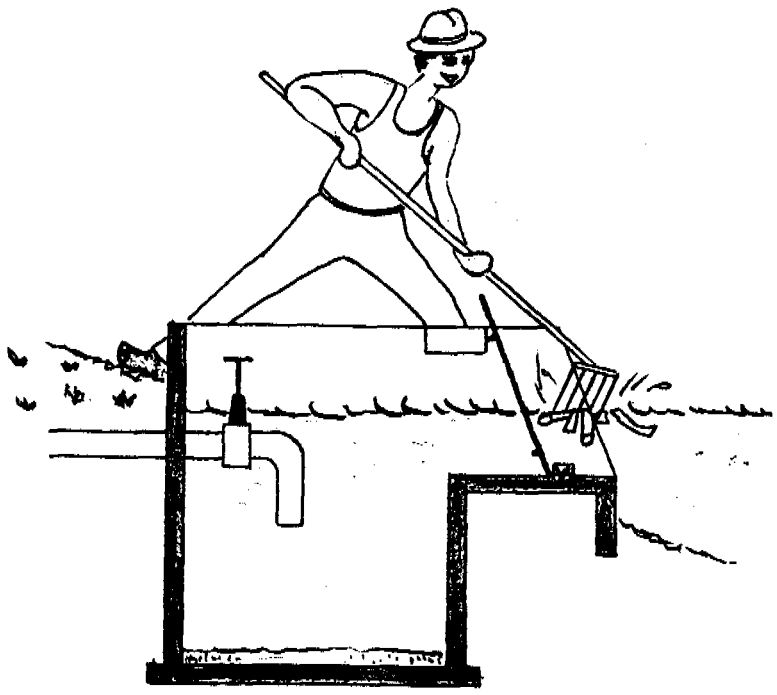
The raw water intake usually consists of a sump in which sand and silt settle. This sump is protected by a screen which prevents floating material entering it.



For adequate functioning of the raw water intake:

- clean the screen of the intake daily;
- check the depth of the sump daily;
- remove the deposit from the sump if it is more than 50 cm;
- close the intake when the quality of the river is poor;
- maintain the intake pump properly, if there is one (see Chapter 8).

Clean the screen of the intake daily.

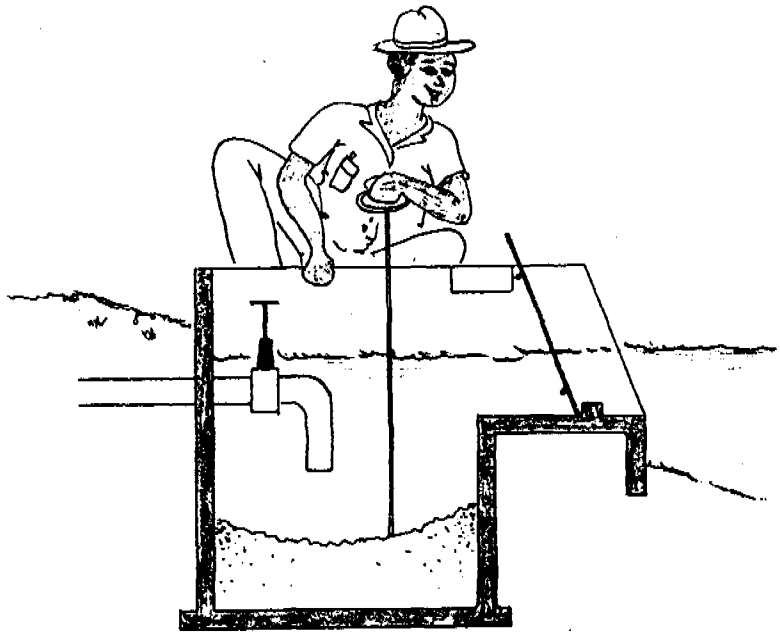


If the screen is not cleaned daily, the intake may become blocked, too little water will flow to the plant and the pumps may run dry and become damaged.

To prevent the intake from becoming blocked, the material retained by the screen must be removed daily, or more often if there is a lot of floating material on the river.

The material removed from the screen is best dried in the sun and then burned. Otherwise, it may start rotting, cause an unpleasant smell and attrack flies and rats.

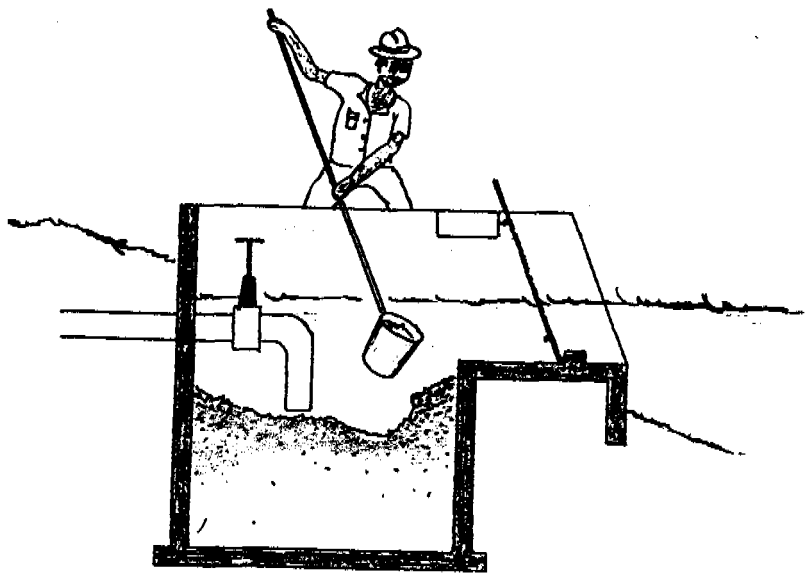
Check the depth of the sump daily.



Sand and silt will settle in the sump. Each time the sump is visited, the level of the deposit in the sump should be checked with a measuring stick.

Particularly during the monsoon, frequent checks of the height of the deposit are required.

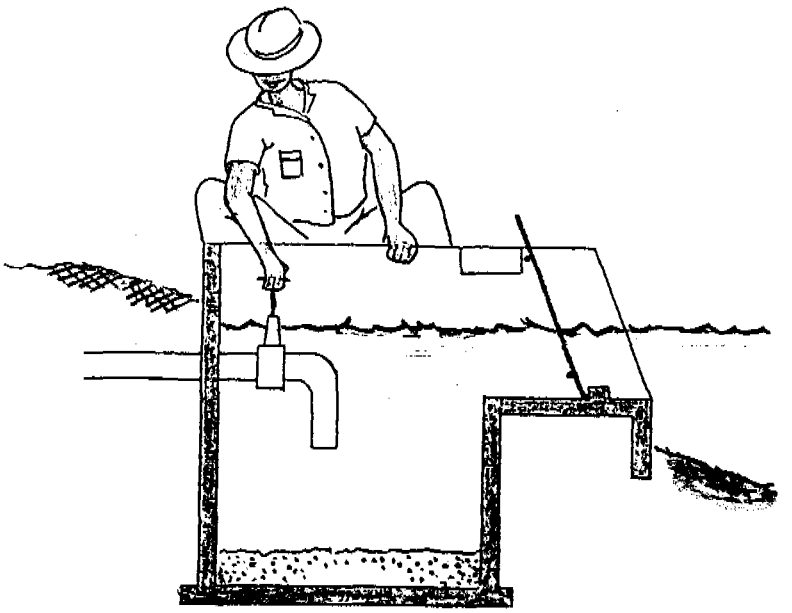
Remove the deposit from the sump when it is more than 50 cm deep.



If the deposit is not removed in time, the pumps will get damaged. To clean out the sump:

- close the intake valve (A)
- remove the deposit with a bucket attached to a pole
- allow the particles left behind to settle
- open the intake valve (A).

Close the intake temporarily when the river water becomes very turbid or contains dead fish.



When the river water becomes very turbid, the filters clog up rapidly and frequent cleaning will be required. Therefore, it may be useful to stop the intake of raw water temporarily in periods of excessive turbidity, such as during the monsoon.

Sometimes by accident toxic chemicals, such as pesticides, and insecticides enter the river. These are harmful to human beings and often they also kill fish. Therefore, the presence of a large number of dead fish may mean that the river water has been poisoned. If this happens, it is better to stop the intake of raw water temporarily.

Maintain the raw water pump (Chapter 8).

5. PREPARATION OF A NEW FILTER

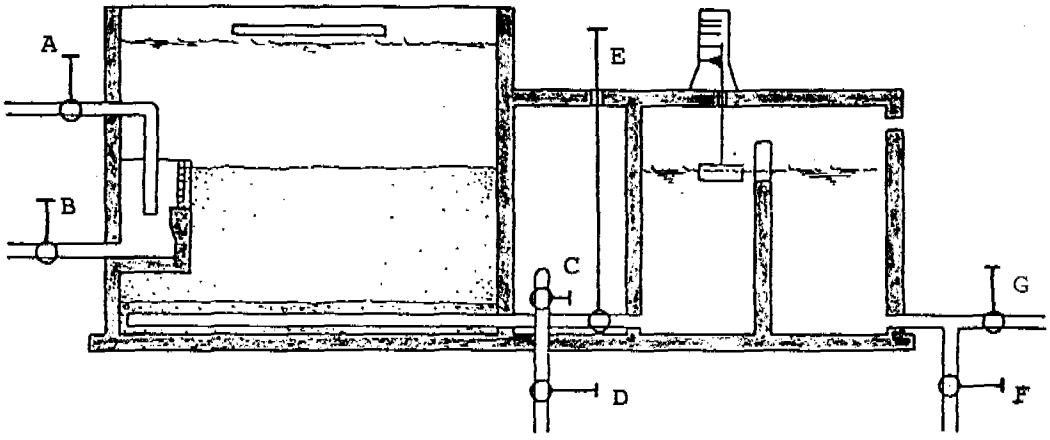
When the slow sand filter is constructed it needs to be checked to see whether the filter box is watertight. Also, it must be cleaned and washed thoroughly before the filter is used. Otherwise impurities attached to the floor and walls may reduce the quality of the filtered water during the first months of the working of the filter. After cleaning the box, washed gravel and sand can be placed in it.

Steps in preparing a new filter are:

1. check for watertightness of the filter by filling it with water and check whether the water level drops overnight
2. clean the filter box by brushing and washing its walls and floor
3. Clean the filtered water outlet box by brushing and washing walls and floor
4. wash the filter gravel
5. place the washed gravel on the drainage system
6. wash and sieve filter sand
7. spread the sand evenly on top of the gravel to the required height.

Step 1: check for watertightness.

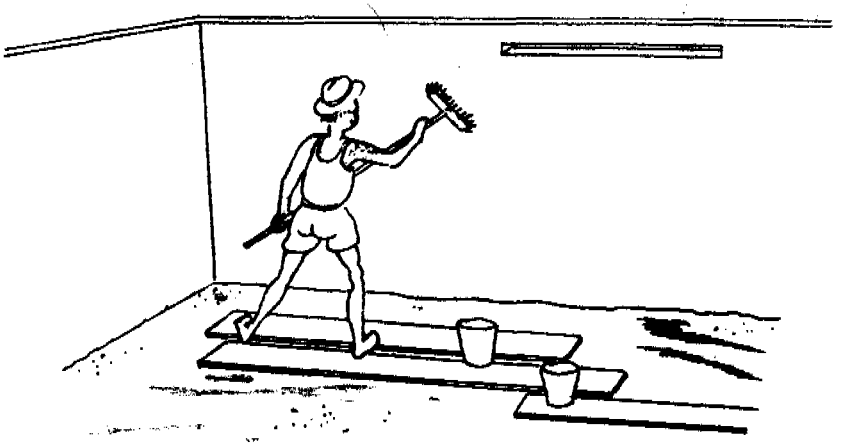
The filter box has to be checked for watertightness before the gravel and sand can be placed in it. It is easier to repair possible leaks in an empty filter box.



To check the watertightness of the filter box:

- remove all equipment and loose material from the filter;
- make sure that all valves are closed;
- open valve (A) and fill the filter box until it overflows;
- close valve (A);
- if the water level does not drop noticeably after 24 hours, the filter box is not leaking;
- open valve (E) to fill the outlet chamber;
- close valve (E);
- if the water level in the outlet chamber does not drop noticeably after one day, this section is not leaking;
- empty the filter box by opening valve (D) and (E).

Step 2: clean the filter box.



To clean the filter box:

- brush the floor and walls of the empty filter box, and drain the water through valve (D);
- be careful not to damage the underdrainage system.

Step 3: clean the filtered water outlet box.

To clean the filtered water outlet box:

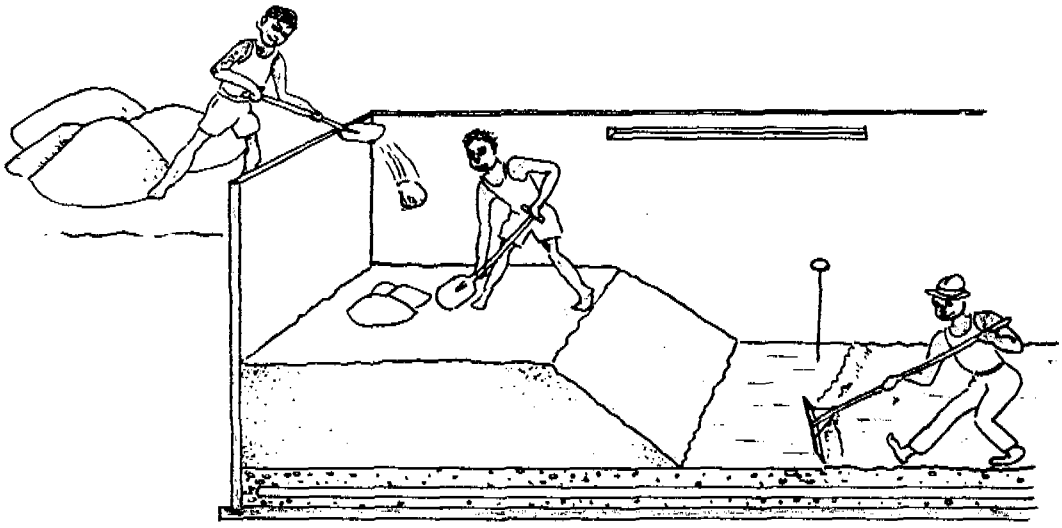
- enter the water outlet box through the man hole;
- brush the walls and floor;
- drain the wash water by opening valves (D) and (E).

Step 4: wash the gravel on the washing platform (see Section 7.3).

Step 5: place the gravel on top of the underdrains and spread it evenly to the required depth.

Step 6: wash sand on the washing platform (see Section 7.3).

Step 7: place clean sand in the filter.



Throw clean sand in the filter and spread it evenly on top of the gravel to a depth of at least 80 cm.

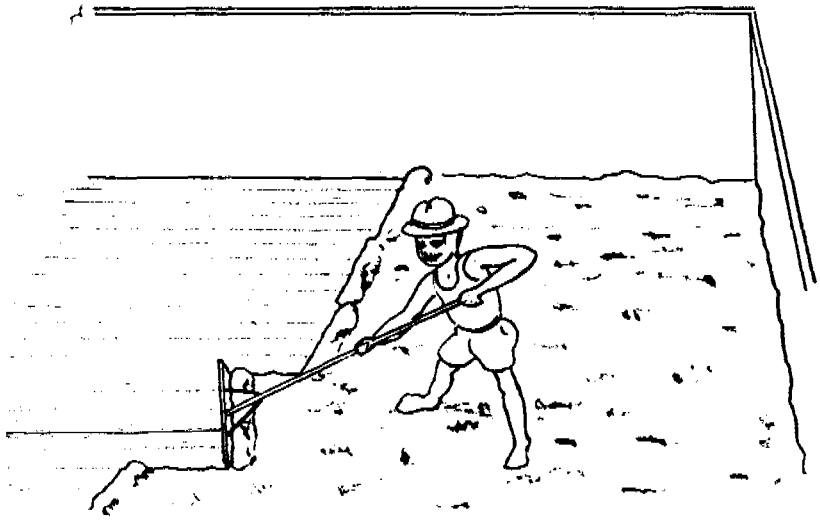
6. SLOW SAND FILTER OPERATIONS

6.1. Starting up a filter

A filter needs to be started up with care if it is to work properly. The following steps need to be taken:

1. level the sand surface
2. undercharge the filter with water by opening recharge valve (C)
3. level the sand surface again if required
4. fill the filter with water by opening recharge valve (C) until the water level is 20 cm above the sand surface, then the inlet valve (A) must be opened
5. start the filtration process by opening filtered water valve (E) slightly; stop turning the valve when the filtration rate is 0.02 m/h, and then open waste valve (F) to remove the water to waste
6. increase the filtration rate every hour by 0.02 m/h by turning valve (E), continue until design rate is reached (usually this is 0.1 m/h)
7. adjust the flow rate daily
8. check daily whether the filtered water is safe to drink
9. when the quality is acceptable, pass the filtered water into supply by closing waste valve (F) and then open the distribution valve (G).

Step 1: level sand surface.



Be careful not to pollute the sand, therefore do not enter the filter box with dirty shoes, and clean the levelling tool beforehand.

Step 2: undercharge the filter with water.

To undercharge the filter:

- make sure that all valves are closed;
- open the recharge valve (C) slowly and only partially.

The water will enter the filter bed through the drainage system. The water level in the sand bed will rise very slowly for several hours until it reaches the sand surface.

Step 3: level sand surface again, if it is not even.

When the water level reaches the surface of the sand this may be disturbed. Then it has to be levelled again in order not to disturb the performance of the filter. In that case:

- close the recharge valve (C);
- open the drain valve (B) to drain the water level to 10 cm below the sand surface, then close it again;
- even out the sand surface (as indicated in step 1).

Step 4: carefully fill the filter with water.

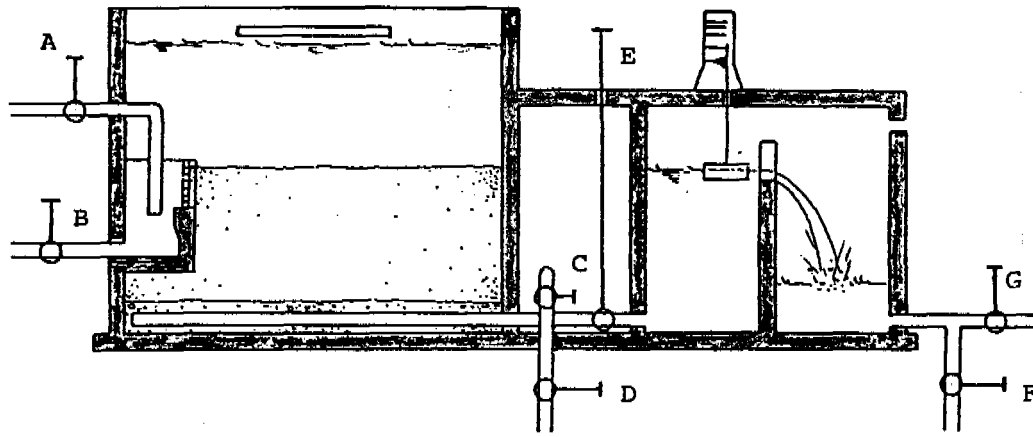
When the sand surface is level, the filter can be filled with water:

- make sure that all valves are closed;
- open recharge valve (C) gradually to undercharge the filter bed again;
- when the water level has reached 10 to 20 cm above the sand surface, close valve (C);
- open the inlet valve (A) very slowly and gradually, otherwise the sand surface near the inlet system will be disturbed. The water level in the filter will now slowly rise until it reaches the level of the overflow.

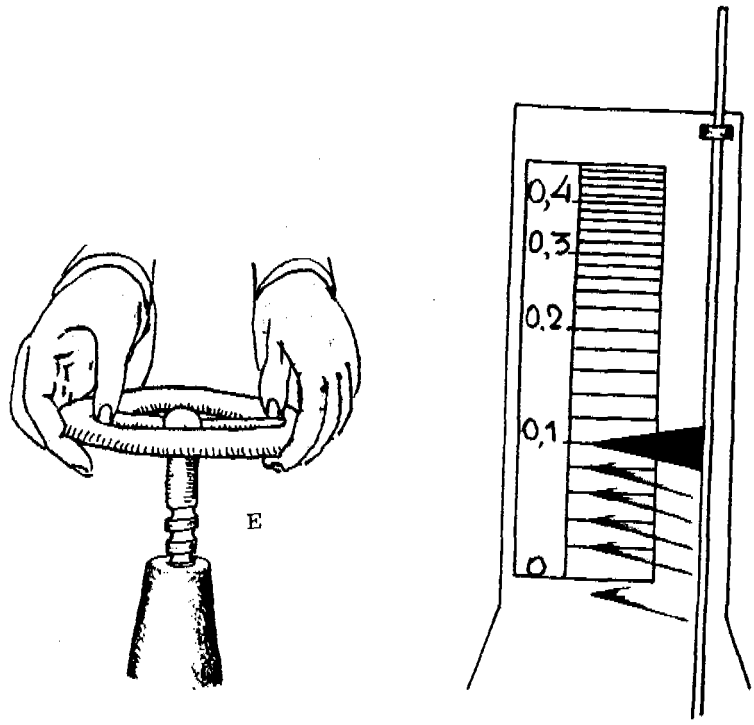
Step 5: start the filtration process.

When the water reaches the overflow level, the filtration process can be started:

- open waste valve (F), at first the water passing through the filter will not be safe and has to be discharged or passed on to another working filter;
- open the filtered water valve (E) gradually, stop turning the valve when the flow indicator shows a filtration rate of 0.02 m/h.



Step 6: increase filtration rate every half hour by 0.02 m/h and continue until design flow is reached.

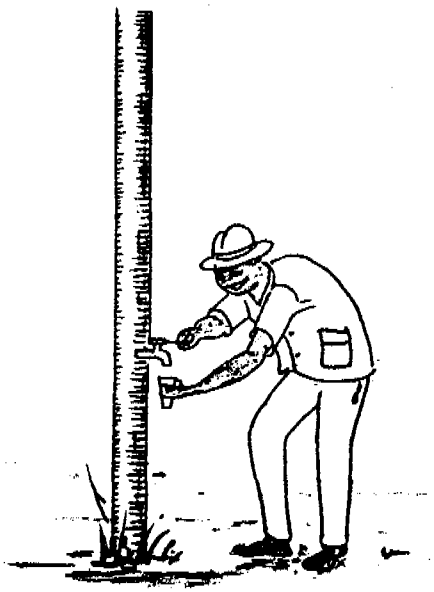


The filtration rate needs to be increased gradually to facilitate the initial removal of impurities from the raw water. When adjusting the rate it must be remembered that it will take at least five minutes before the flow indicator shows the new rate of filtration.

Step 7: adjust the flow rate daily.

One or two days after filtration has started, a thin layer will form on the sand surface and each day it will continue to grow and contain more micro-organisms. Thus the resistance of this layer increases slightly. Therefore, the filtered water valve (E) needs to be opened a little more each day to maintain the filtration rate.

Step 8: check daily whether the water is safe to drink.



Gradually the quality of the purified water will improve until it becomes safe to drink. A good indication of the quality can be obtained by checking the turbidity and the bacterial count. (see Section 6.3).

- For a new filter, both the turbidity and bacterial counts have to be checked once a week for the first two weeks, and thereafter daily.
- For a filter which has been cleaned the ripening process goes on quite quickly and therefore daily checks are required.

Step 9: pass the water into supply.

When the turbidity of the filtered water and the bacterial counts meet the local standards, the water can be passed into the clear well or the distribution system. Some exceptions to this rule are set out on the next page.

To pass the water into the clear well:
- close the waste valve (F);
- open the distribution valve (G).

Exceptions to the standard procedure of passing water into supply indicated in step 9 are:

Exception 1: When there is water shortage.

When there is a water shortage, water may have to be distributed even though the ripening process has not been completed. This can be done provided the community is informed that the water is not safe and needs to be boiled.

Exception 2: When bacteriological testing cannot be made.

When bacterial counts cannot be made, checks on turbidity should be made daily. Distribution of water from a new filter can usually start about two weeks after the first day turbidity has met local standards. For filters which have been cleaned (Section 7.2), this period is only about one or two days. The amount of time required should be discussed with the supervisor.

Exception 3: When safety chlorination is provided.

If safety chlorination is provided, the water can be passed into supply when the turbidity level and the chlorine level are acceptable (see Appendix III).

6.2. Daily operation of the filter

The daily operation of a slow sand filter needs regular attention. Slow sand filtration is a biological process. Therefore it is essential to keep the flow of water as constant as possible and to avoid sudden changes in the filtration rate.

To control the filtration process:

1. keep the water level in the filter box constant by adjusting the inlet valve (A) when required;

2. remove scum and floating material by opening the inlet valve (A) further for a short time;

3. check the rate of filtration on the flow indicator;

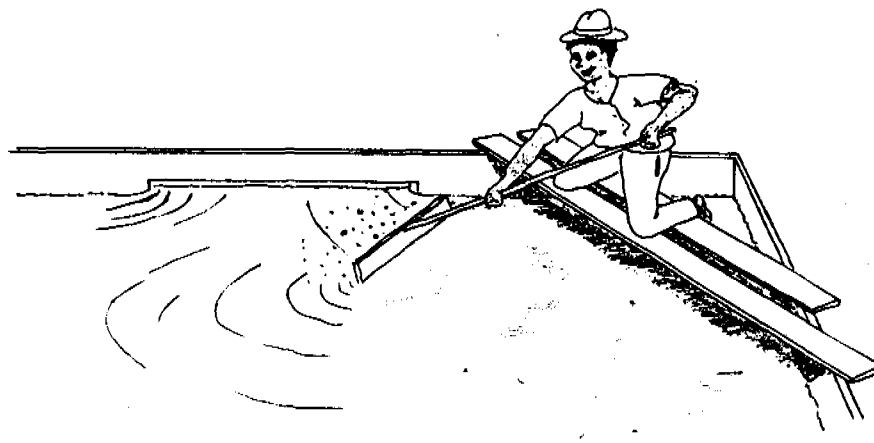
4. adjust the rate of filtration by manipulating the filtered water valve (E);

5. check whether the filter needs to be cleaned.

Step 1: check the water level in the filter box and keep it at the required level.

The top level of the water can be kept at the designed level. This can be done by manipulating the inlet valve (A). Care should be taken not to disturb the filter skin by increasing the water flow by opening inlet valve (A) too quickly.

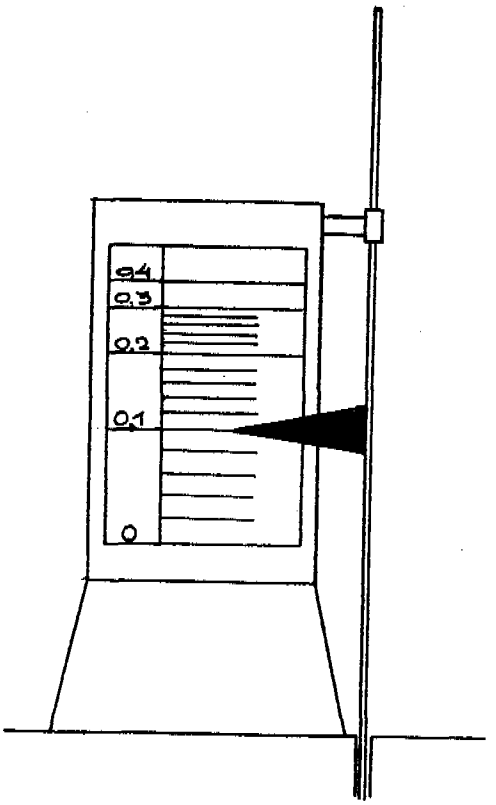
Step 2: remove scum and floating dirt.



Scum floating on the surface of the water and filamentous algae must be removed because this may interfere with the purification process. To remove this material:

- open inlet valve (A) a little further, so that the water level will rise and start to overflow through the overflow outlet;
- brush the walls of the filter box to remove algea; take care not to disturb the sand surface;
- remove scum and other dirt via the overflow;
- close the inlet valve (A) a little until no more water flows through the overflow.

Step 3: check daily the rate of filtration.



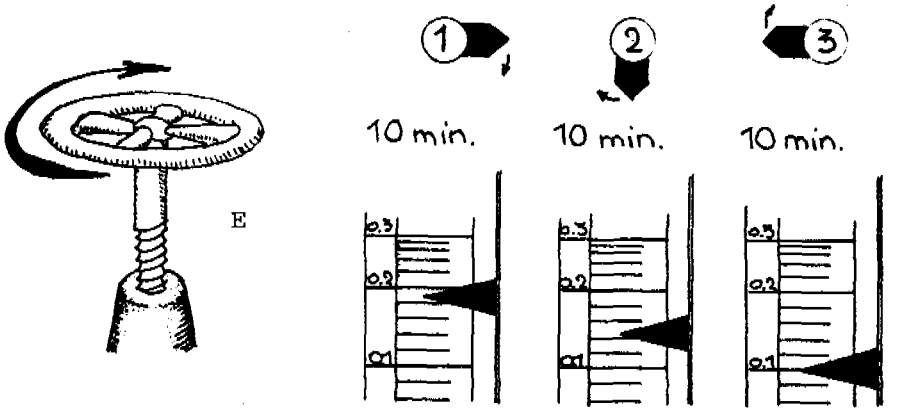
Once or twice a day, the filtration rate should be checked by looking at the position of the pointer on the scale.

Step 4: adjust the rate of filtration.

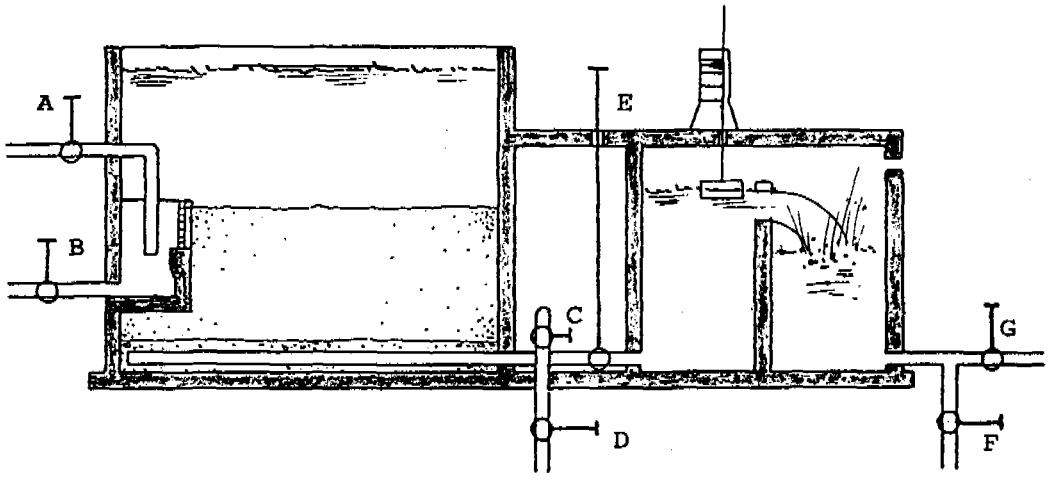
A constant filtration rate is very important in slow sand filtration. When kept at the designed rate (usually 0.1 m/h), sufficient safe water is produced for the community because these are the best conditions for the biological process. Adjustments can be made by manipulating the filtered water valve (E), as explained on pages 37 and 38.

How to decrease the filtration rate.

If the rate of filtration is too high, the filter will clog up rapidly and frequent cleaning will be necessary. Close filtered water valve (E) a little to adjust the filtration rate to its designed rate.



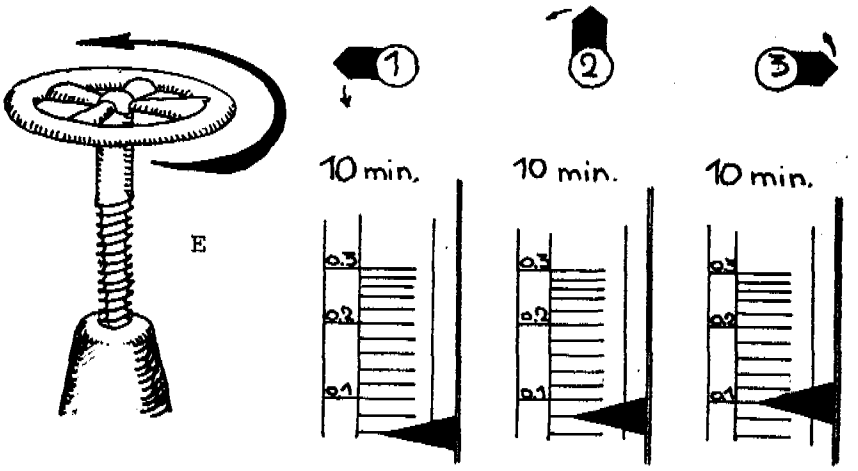
Turn valve (E) clockwise to decrease the filtration rate.



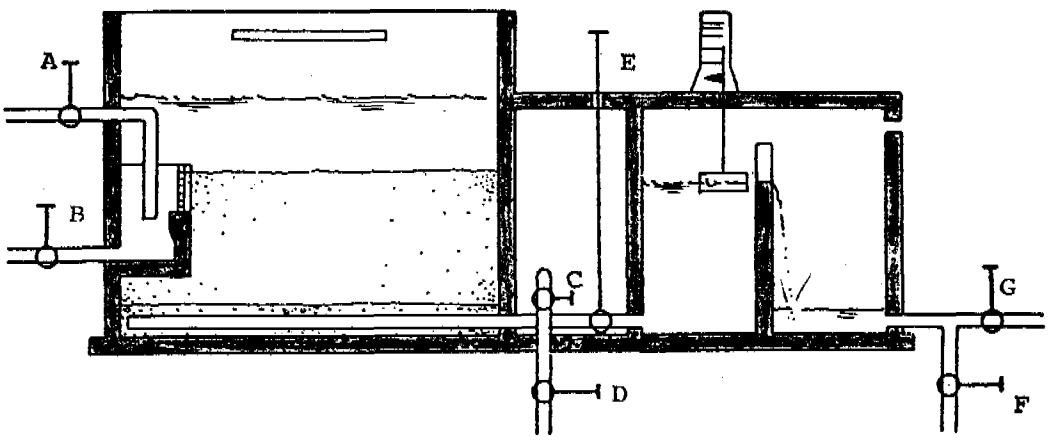
Prevent the rate of filtration becoming too high.

How to increase the filtration rate.

If the rate of filtration is too low, not enough purified water will be produced. To increase the rate of filtration, open the filtered water valve (E) further.



Turn valve (E) counterclockwise to increase the filtration rate.



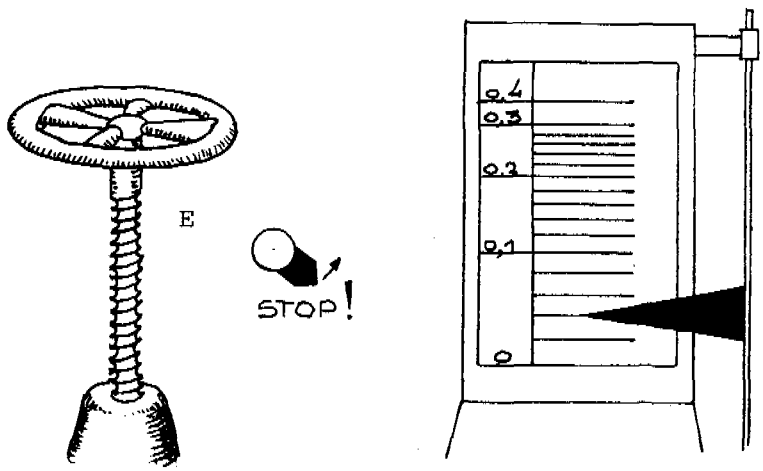
Adjust the filtration rate when it becomes too low.

Step 5: decide to clean the filter when the filtration rate cannot be brought back to the designed rate by opening valve (E) further.

During the filter run, the filter skin will gradually become clogged. This will result in an increase in the resistance in the filter which will need to be compensated for by opening valve (E) further to keep the filtration at the designed rate. Generally, very little adjustment of valve (E) is necessary in the first two or three weeks after a filter bed has been cleaned. When large adjustments of the filtered water valve become necessary, this is an indication that the bed soon needs to be cleaned. Record keeping helps to predict when cleaning will be needed.

When valve (E) is opened fully and the filtration rate drops slowly, the rate can only be restored by cleaning the filter (that is, scraping off the top 2-3 cm of the filter bed).

Cleaning needs to be planned because the filter will be out of service for a few days.



The resistance of filter skin gradually increases. When it becomes too high, that is when valve E is fully open and the filtration rate cannot be maintained, the filter needs to be cleaned.

6.3. Water quality control

Daily monitoring and recording of water quality provides essential information on how to run the plant.

Two measures which give a good indication of how the plant is functioning and also of the quality of the purified water are turbidity level and bacterial counts.

6.3.1. Bacterial counts

Bacterial counts indicate the presence of disease-causing organisms. Unfortunately, often these counts cannot be carried out in rural areas because laboratory facilities and trained staff are not available. Occasionally, the caretaker may have to collect samples for such tests, but this must always be done under the guidance of trained staff.

6.3.2. Turbidity testing

The turbidity level indicates the amount of impurities suspended in the water. Turbidity testing requires special equipment. If this equipment is not available, a comparison of the turbidity of the raw water and the filtered water will provide useful information about the functioning of the plant. A caretaker will require training before he will be able to make a reasonable estimate of the turbidity.

To measure the turbidity of the water:

1. clean the sampling device before taking the sample;
2. collect a sample of
   * the raw water at the intake (if possible)
   * the water on top of the filter bed
   * the filtered water from each filter;
3. measure and/or compare the turbidity of the three samples;
4. record the findings and take action if required.

Step 1: clean the sampling device.

Use of an unclean sampling device will mean that the quality of the sample is different from that of the source. Also, a dirty sampling device may contaminate the purified water.

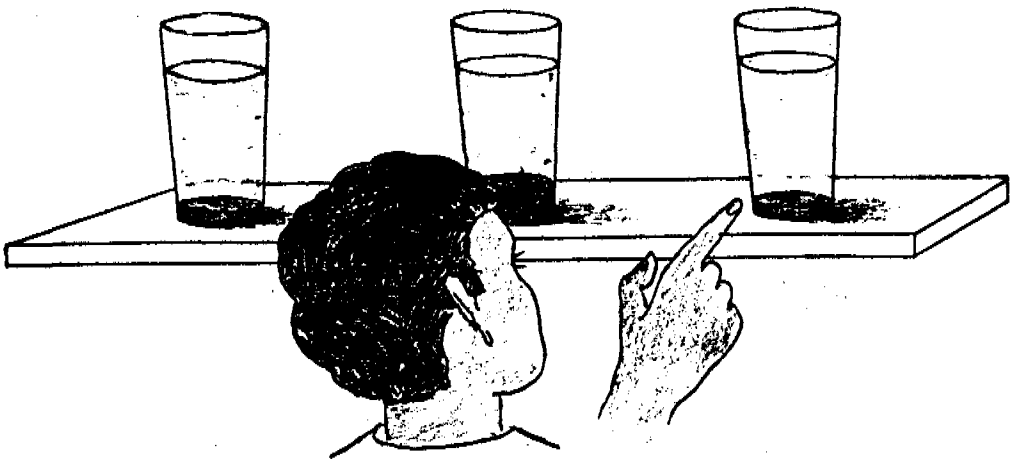
Step 2: collect a sample of:

- raw water at the intake if possible
- water on top of the filter bed
- filtered water from each filter.

Take three samples at the intake with a short interval between each of about two minutes. Mix the three samples in a clean bucket and take one sample from the bucket. This will increase the reliability of the method. Do the same at the other two sites.

Step 3: measure and compare the turbidity of the three samples.

Measure the turbidity of each sample with a turbidity meter. If a turbidity meter is not available, the level will need to be estimated. Therefore, pour the three samples into three separate glasses of the same size and shape. Compare the turbidity of the water in the glasses. More information may be obtained by allowing the material to settle for half an hour and then measuring the layer of sediment.



Step 4: record the findings and take action.

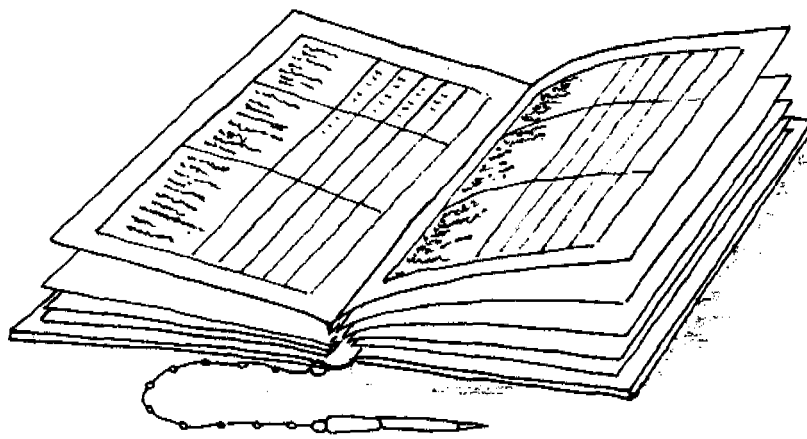
Record the found or estimated values in the logbook.

- If the raw water is very turbid, then it is recommended that the raw water intake be closed for a short period.

- If the filtered water is turbid and leaves a deposit, the rate of filtration may be too high, possibly because the flow measurement device is not working. If the rate is normal and the filtered water remains turbid, then the unit must be stopped and the supervisor called in immediately. Also, the community needs to be requested to reduce water use until the filter unit is back in service.

6.4. Record keeping

A record must be kept of day-to-day events including filter performance and change in water quality. This record helps to plan events, such as cleaning of a filter. An example record is shown on the next page.



Keeping a logbook is essential for good operation and maintenance.

Example record for slow sand filter plant

day	1	2	3	4	5	6	7
Interruptions in raw water intake	-	-	-	-	-	-	-
Cleaning of inlet	x	x	x	x	x	x	x
Cleaning of sump	-	-	-	-	-	x	-
Turbidity of raw water (NTU)	5	15	10	5	20	5	5
Filter 1*							
Removal of scum	-	-	-	-	-	x	-
Filtration rate before adjustment (m/h)	0.1	0.2	0.2	0.2	0.19	0.1	0.1
Filter cleaning	-	-	-	-	-	-	-
Sand level after cleaning (cm)	-	-	-	-	-	-	-
Daily water production (m^3)	20	40	40	40	39	20	20
Turbidity filtered water (NTU)	1	1	2	1	1	1	1
Filter 2*							
Removal of scum	x	-	-	-	-	-	-
Filtration rate before adjustment (m/h)	0.07	Filter out for cleaning			0.1	0.1	0.1
Filter cleaning	-	x	x	-	-	-	-
Sand level after cleaning (cm)	-	-	80	-	-	-	-
Daily water production (m^3)	17	-	-	-	-	20	20
Turbidity filtered water (NTU)	1	-	-	5	1	1	1

x : carried out; - : no action taken

* : from day 2 filter 2 is out of operation for cleaning, and therefore the daily water production of filter 1 must be doubled.

7. CLEANING OR RE-SANDING A FILTER

After a filter has been working for several weeks or months, the time will come when the filtered water valve (E) is fully open. Then the filter needs to be cleaned.

Cleaning means that the filter unit has to be shut down and is out of service for at least three days. One day for cleaning and two days to restore the filter skin.

When the logbook indicates that two filter units will need to be cleaned at the same time, take one filter out of service for cleaning even before the filtered water valve (E) is fully open. This is done to avoid the two filters being out of operation at the same time.

7.1. Shutting down procedure

To clean the filter:

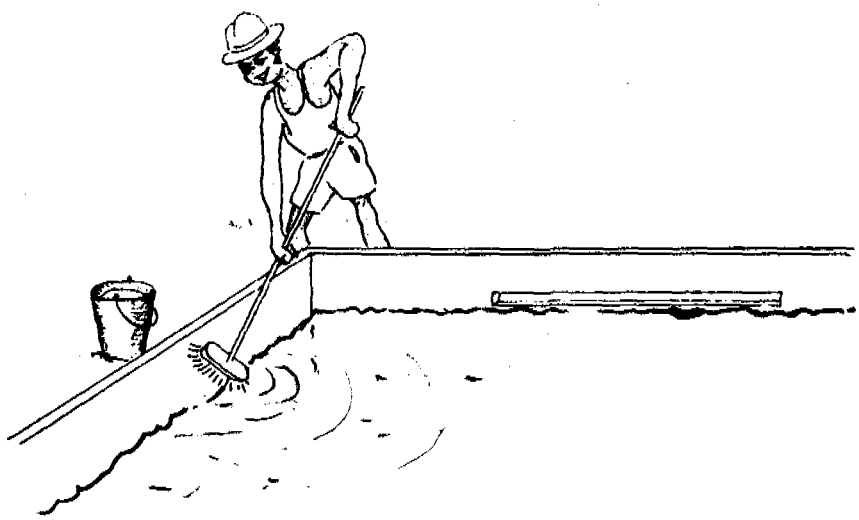
1. remove material floating on the water through the overflow by opening the water inlet valve (A) fully;
2. clean the filter walls with a long brush;
3. drain the water to the required level by closing the water inlet valve (A) and opening drain valve (B); and close valve (E) and open valve (D) when the water reaches the sand surface;
4. when the water level has fallen 20 cm below the sand surface stop the draining by closing valves (B), and (D);
5. maintain the water output of the plant by gradually increasing the filtration rate in the other units.

Step 1: remove floating material.

If scum, leaves or algae are floating on the surface of the water, these have to be removed by raising the top water level. If this is not done, the floating matter will settle on the filter bed and make scraping more difficult.

Remove the floating material by opening the water inlet valve (A) fully. As the water level in the filter box rises, all scum and floating dirt will be carried by the water through the overflow.

Step 2: brush the filter walls.



Brush the walls and continue to discharge water through the overflow until all floating dirt is removed.

Step 3: drain the water from the filter.

Close the raw water valve (A) and open the drain valve (B), and then the level of the water above the sand will fall. Because the filtered water valve (E) is also open, the filter will still produce some filtered water, but most of the water will flow through valve (B).

While the water is draining, continue to clean the walls of the filter using a long-handled brush.

Open valve (D) and close valve (B) when the water level has reached the sand surface.

Step 4: stop draining the water when the level has fallen 20 cm below the sand surface.

Close waste valve (D) when the water has fallen 10 to 20 cm below the sand surface. In most filters the water level in the inlet box will be the same as the level in the sand bed.

Step 5: maintain the water output of the plant.

Even though one filter unit is shut down, the output of the filtration plant needs to be maintained. The remaining bed(s) have to work at a higher filtration rate. Therefore, the filtered water valve on each of the other beds must be opened slightly in two or three steps to maintain the output of the filtration plant. However, do not increase the rate beyond the permissible maximum set in the design stage (often this will be 0.3 m/h).

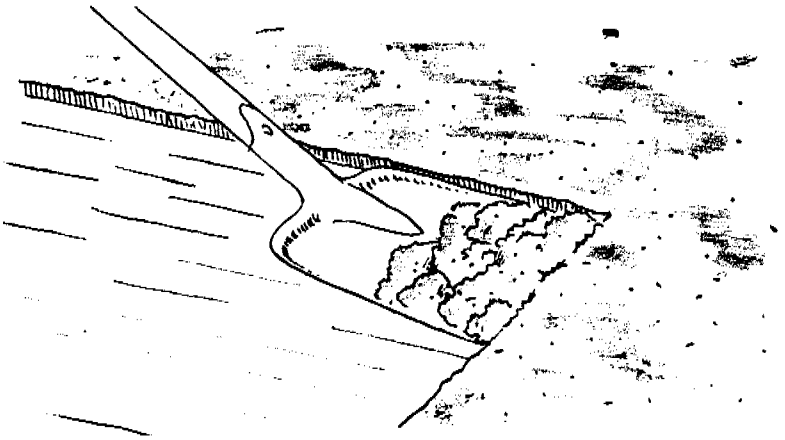
7.2. Cleaning a filter bed

Cleaning a filter bed means that about one to three centimetres of sand has to be scraped off the filter bed. How often this is done very much depends on the quality of the raw water and may vary from once every three to ten weeks. If the cleaning procedure is carried out quickly, some of the micro-organisms will survive and the purification process will become effective again within one or two days.

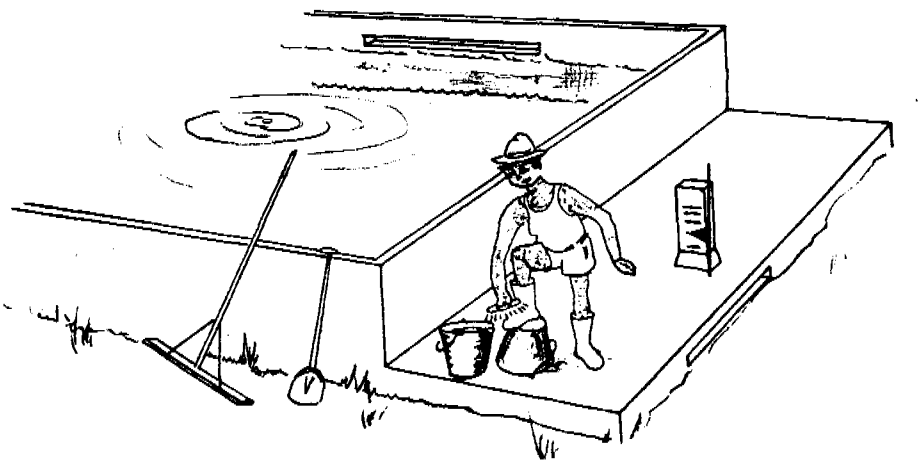
To clean a filter bed:

1. wash the equipment and your boots before entering the filter box
2. place the boards at the foot of the ladder, possibly after scraping the area on which they are placed
3. place equipment on these boards
4. mark out areas by scraping narrow strips, and place boards on these strips
5. scrape the upper 2-3 cm of each area, and remove the scrapings from the filter
6. check the inlet valve (A) and drain valve (B)
7. remove all equipment and then level the sand surface
8. Check and record the depth of the sand bed. This information will help in working out in advance when the filter bed will become too thin and therefore will need to be re-sanded
9. adjust the inlet box to the level of the sand
10. start up the filter again
11. allow the filter skin to develop
12. pass the filtered water into supply and adjust the rate of filtration in the other filter unit(s).

The filter is scraped to remove the clogged layer of sand. Only the first 2-3 cm of the sand bed will contain silt; the other part will still be clean. The layer to be removed will be indicated by the colour. Scraping can best be done with a square-nosed shovel.

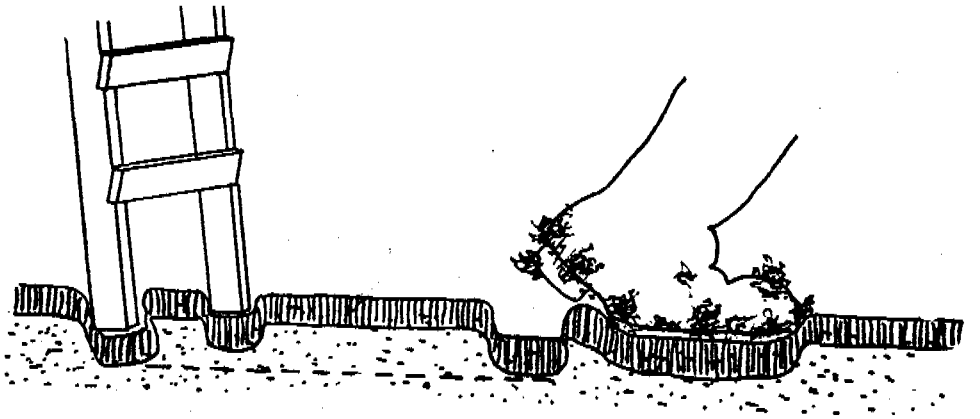


Step 1: wash equipment and boots before entering the filter box.



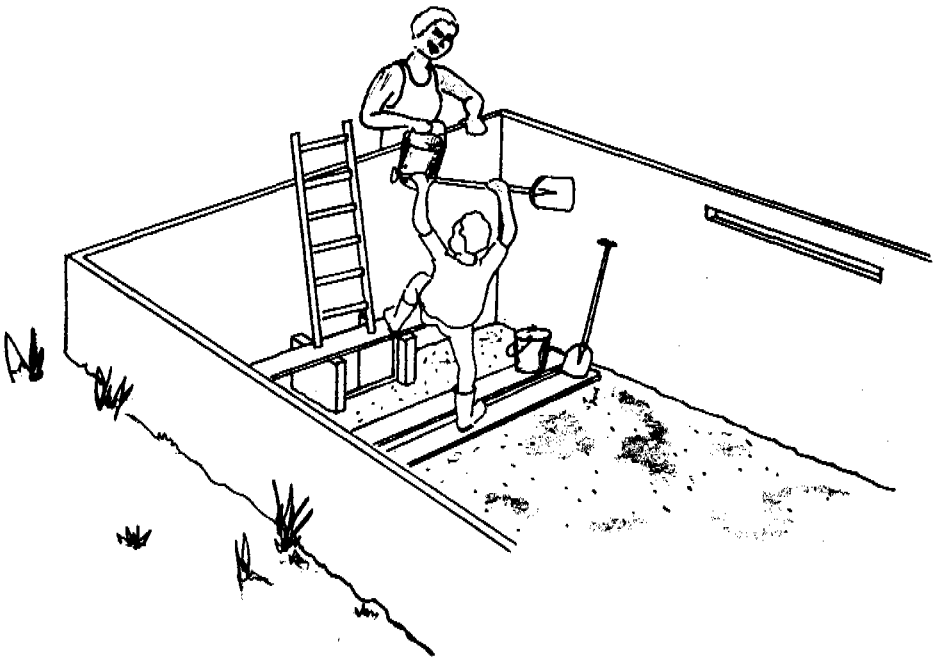
Dirt on equipment or on boots may be carried into the filter unit and be pressed into the filter bed. This will contaminate the filtered water after re-starting the filtration process, or will require the removal of a thicker layer.

Step 2: place boards on the scraped area.



If boards are not placed on the sand, workers entering the filter unit will press the filter skin into the sand bed. This will make scraping much more difficult because a much thicker layer will have to be removed.

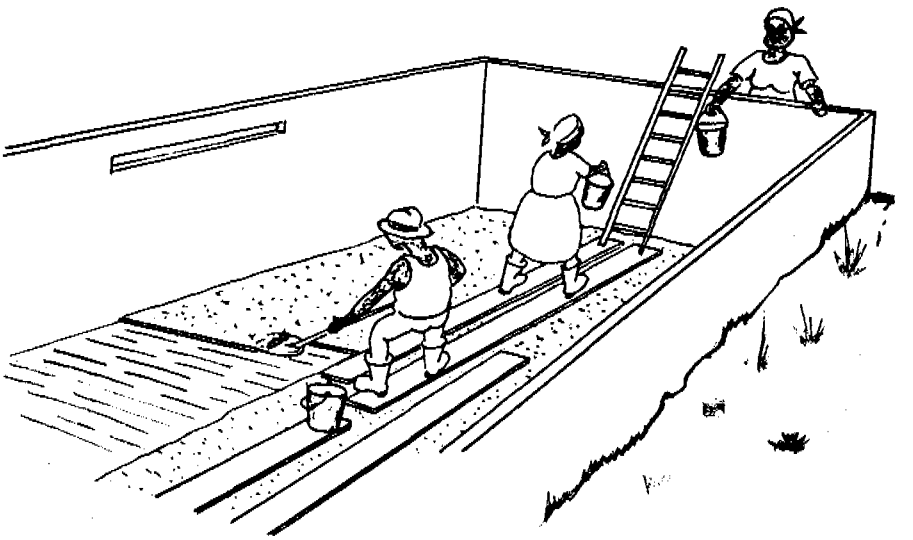
Step 3: place equipment on the boards.



Step 4: mark out areas of about 3x3 m by scraping narrow strips, and place boards on these strips.

It is much easier to scrape small sections at the time. Therefore, the total surface area can best be divided into smaller areas.

Step 5: scrape the upper 2-3 cm of each area and remove the scrapings from the filter.



Usually the scrapings cannot be thrown over the side of the filter. They must be loaded into some type of bucket which can be used to carry or lift the scrapings out of the filter bed to the sand washing area.

Step 6: check inlet valve (A) and drain valve (B).

The inlet valve (A) and the drain valve (B) are exposed, and therefore they can be easily checked and maintained.

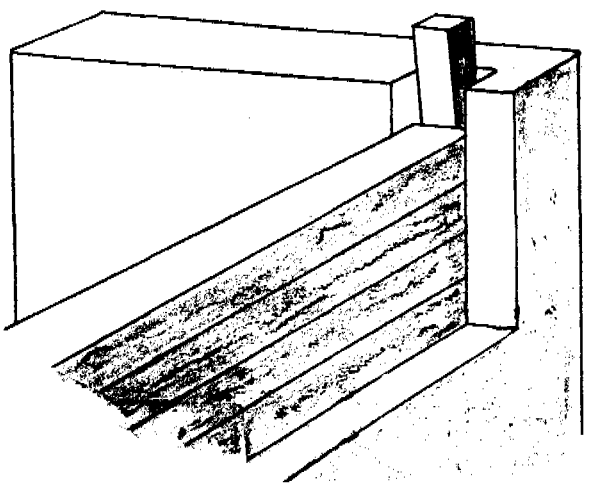
Step 7: remove all equipment and then level the surface of the sand.

When all the scrapings have been removed from the filter unit, remove all the equipment. Then level the surface of the sand, removing the boards one by one as this is done.

Step 8: check and record the depth of the sand bed which should not be less than 50 cm.

If the depth of the sand bed is less than 50 cm it needs to be re-sanded. A mark can be drawn on the wall to indicate the minimum allowable sand level. It is necessary to know in advance when the bed has to be re-sanded because the filter will be out of operation for a longer period. Therefore, it is necessary to keep careful records of the depth of the sand.

Step 9: adjust the inlet box to the new sand level.



If necessary, adjust the inlet box to the new sand level. The height of the timbers should be just a little over the level of sand in the filter, so that the supernatant water can be drained without washing out filter sand. When the timbers have been adjusted, the upper timber needs to be pinned in place to prevent it floating away.

Step 10: start up the filter again.

Re-starting the filter as quickly as possible prevents starvation of the micro-organisms in the deeper layers of the filter bed. The purification process then will become effective in the shortest possible time.

The procedure for starting up the filter is outlined in (Section 6.1.)

Step 11: allow the filter skin to develop.

Until the filter skin has been fully developed, the filtered water of a re-started filter must be pumped to waste or to another filter. If the whole cleaning procedure is completed within one day, this may only be necessary for one or two days. However, a long cleaning procedure (several days) will lead to a much lower development of the filter skin and this should be avoided.

Step 12: pass the filtered water into the supply and adjust the rate of filtration in the other filter unit(s).

When the filter skin has been fully developed, the filtered water of the cleaned filter can be passed into supply. Consequently, the filtration rate of the other filters can be gradually decreased to the normal design level (usually 0.1 m/h filtration rate).

7.3. Sand washing by hose

The scrapings of sand and dirth removed from the filter are brought to the sand-washing platform. These scrapings contain valuable sand which can be re-used when the filter needs to be re-sanded. If not washed directly after removal, they will become smelly and attrack flies.

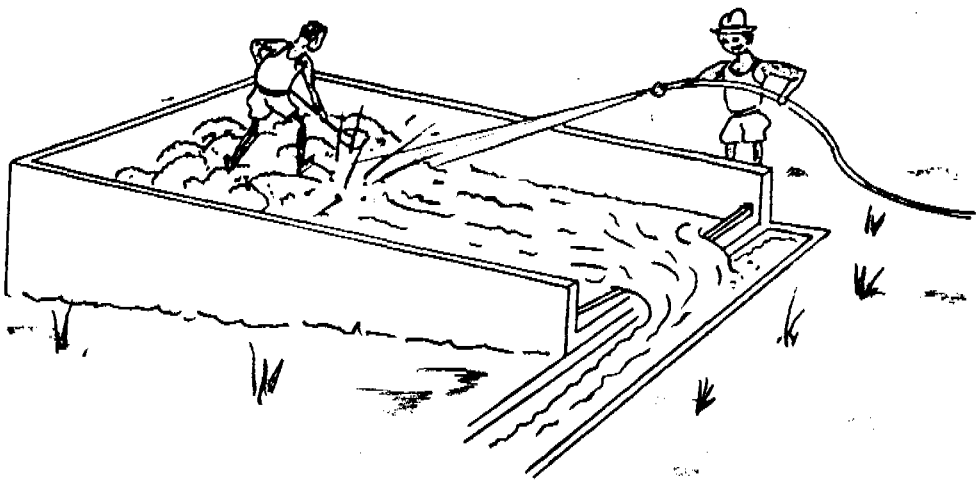
To wash the scrapings:

1. place the sand scrapings on the washing platform
2. spray water on the scrapings while stirring them with a stick
3. check whether the sand is clean
4. drain the water from the platform
5. dry the sand
6. remove coarse material from the sand
7. store washed and dried sand
8. clean washing equipment and platform.

Step 1: place sand scrapings on the washing platform.

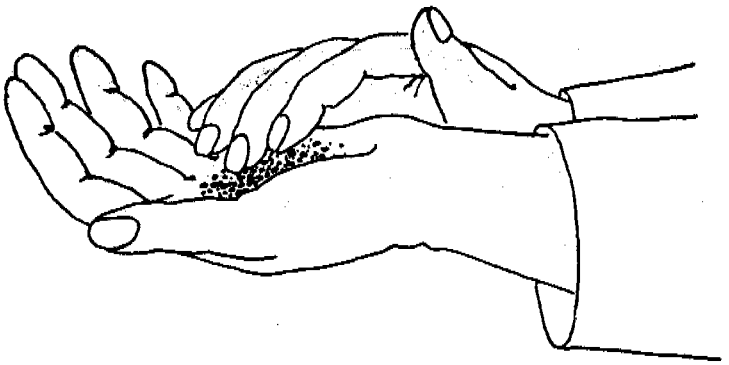
Do not place more than one cubic metre of scrapings from the filter, that is the contents of 100 buckets, on the platform at the same time. A larger quantity is more difficult to wash.

Step 2: spray water on scrapings while stirring them with a stick.



Direct a hose on the scrapings, and move them about. Sand will settle, and the water containing the impurities will overflow the weir and will be removed. Stir the sand while washing to help wash out the dirt.

Step 3: check whether the sand is clean.



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 hand, the sand is not clean enough.

Another method is to put a small quantity of the sand into a glass bottle, add clean water and shake well, and then let it stand for a short time. If there is virtually no sediment on the sand surface, it is sufficiently clean and washing can stop.

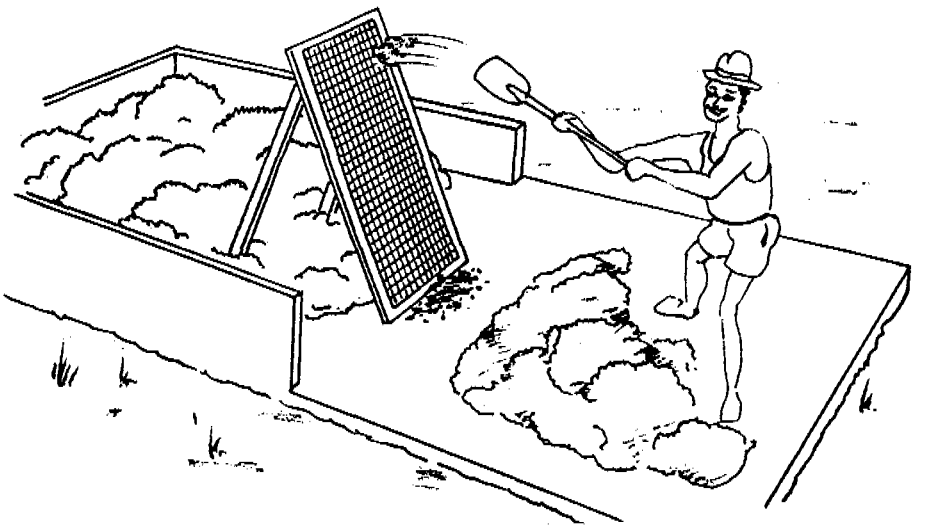
Step 4: drain the water from the platform.

Usually after an hour the sand has been washed sufficiently. Remove the weir and drain all the water from the platform.

Step 5: dry the sand.

Spread the washed sand out on the platform and let it dry in the sun. Turn the sand from time to time to improve drying.

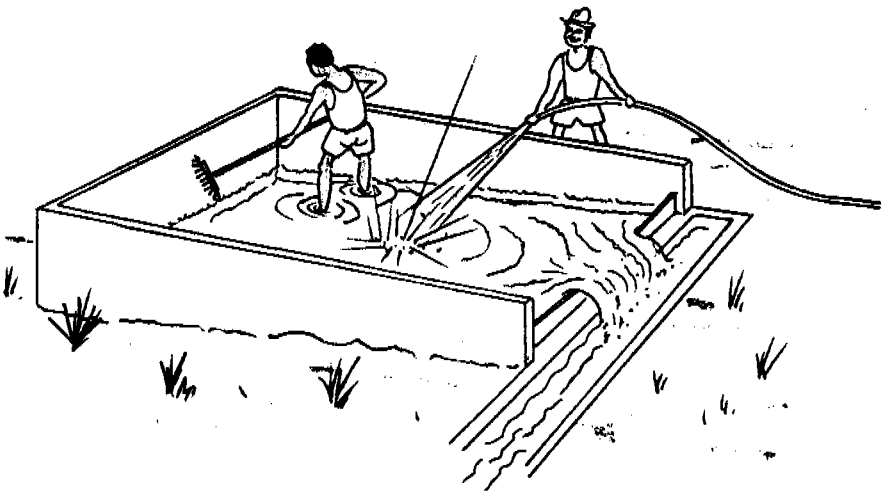
Step 6: remove coarse material from sand, as required.



After drying the sand in the sun, pass it through a sieve of 6 mm mess to remove gravel, wooden chips and other coarse material.

Step 7: store washed and dried sand in a place where dirt and dust cannot enter.

Step 8: clean washing equipment and platform.



When sand washing is finished, brush firmly and wash the platform and equipment with water.

7.4. Re-sanding

Re-sanding becomes necessary when successive scrapings have reduced the thickness of the sand bed to 50 centimetres. Re-sanding means that a new layer of sand has to be placed in the filter under the existing layer because the latter may contain some silt. This is done because if the existing layer contains some silt, the filter will not function properly.

The sand can be removed from small filters by throwing or carrying it out of the filter. It is more convenient to re-sand large filters in strips. Then only sand in the first strip will have to be stacked up against the wall or thrown out of the filter. Sand in the following strips can be removed and placed directly on top of the new sand in the previous strip.

The decision to re-sand should be made well in advance because it will be a week or more before the bed can be put back into service. The work must be planned, if possible, in a period of low water demand. Avoid the need to re-sand one filter while the other filter is being cleaned. Fortunately, re-sanding is only required every two or three years.

To re-sand a filter:

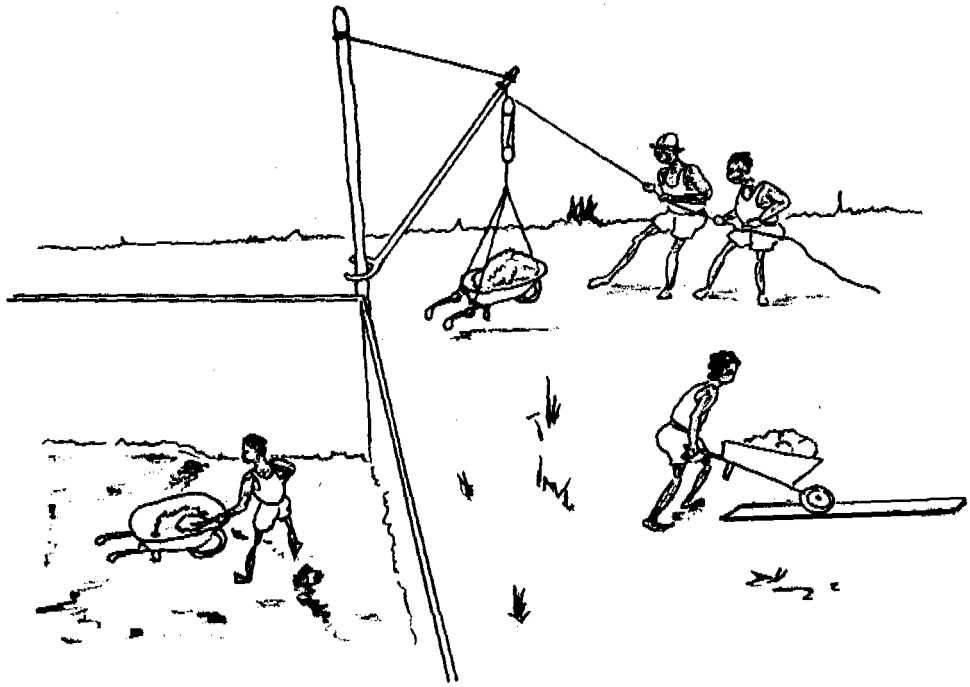
1. shut down and clean the filter
2. drain the water from the sand bed
3. remove the sand and place it beside filter or to one side
4. place a layer of clean sand on top of the gravel pack
5. level the surface of the new sand layer
6. replace the old sand on top of the clean sand
7. level the surface of the sand
8. adjust the inlet box
9. re-start the filter process
10. allow the filter skin to develop
11. pass the filtered water into the supply and adjust the rate of filtration in the other filters.

Step 1: Shut down and clean the filter (see Sections 7.1 and 7.2).

Because the remaining sand will be used again immediately the filter must be scraped first (Section 7.2).

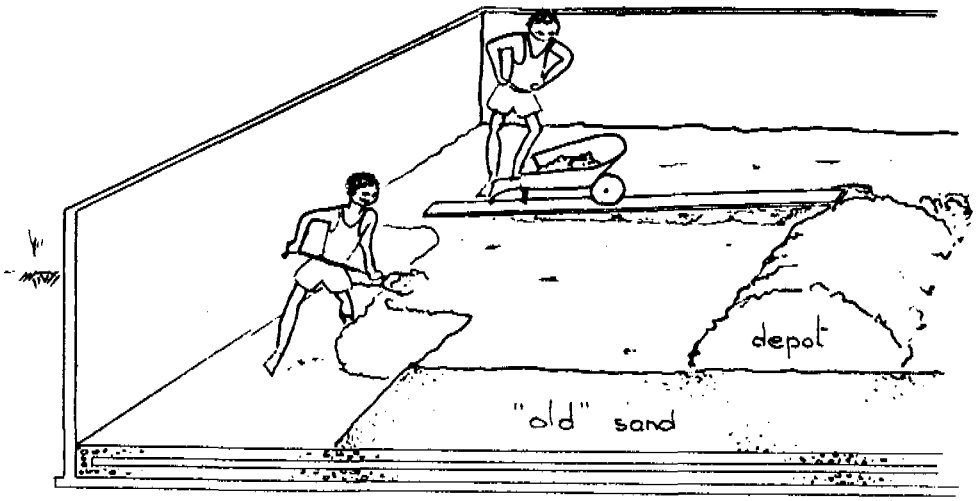
Step 2: drain the water from the sand bed and reduce the level of the water in the box to the level of the gravel. Open the waste valve (D).

Step 3: remove the sand and place it beside the filter.

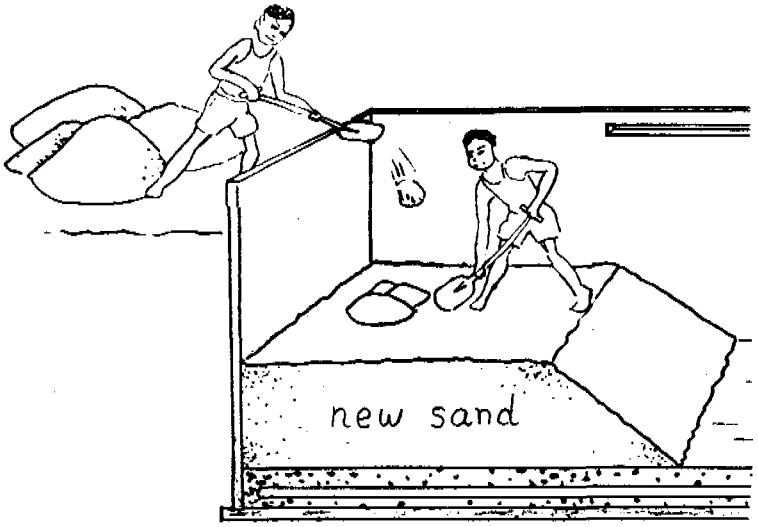


Remove the sand from the filter or the first strip and place it on a clean area beside the filter. Take care not to disturb the layer of gravel. The sand can be thrown out of the filter or carried out in a wheel barrow and a gantry.

Instead of removing the sand from the filters, sand from the first strip can be stored temporarily at the opposite end of the filter box.



Step 4: place a layer of clean sand on top of the gravel pack.

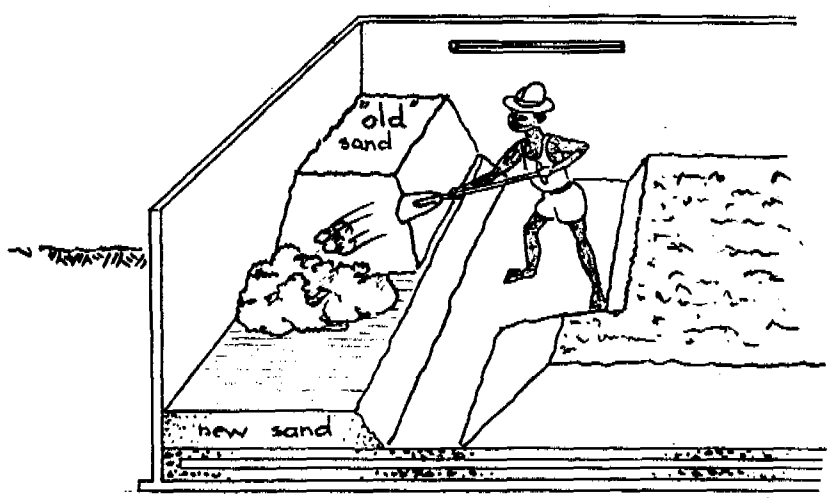


Place the washed and cleaned new sand in the emptied filter or on a strip on top of the gravel layer from which the sand has been removed. Usually, only about 30 cm has to be placed, because the "old" sand layer of 50 cm will be replaced on top.

Step 5: level the surface of new sand layer.

Level the surface of the new sand layer and check the thickness of the bed.

Step 6: Replace the sand on top of the clean sand.



Replace the sand, which contains many micro-organisms, on top of the new sand. Here the advantage of working in strips for large units becomes obvious. The "old" sand in the second strip can be removed and placed directly on top of the "new" sand in the first strip, and the "old" sand in the third strip onto the second and so on.

Step 7: level the surface of the sand.

When re-sanding has been completed, the surface of the sand must be levelled.

Step 8: adjust the inlet box.

Place timbers in the inlet box to the required level, this means one timber more than the upper sand level.

Step 9: re-start the filter process.

Re-start the filter as quickly as possible following the procedure outlined in Section 6.1.

Step 10: allow the filter skin to develop.

Because the old sand, which contains many micro-organisms, is replaced at the top of the filter bed, ripening will take less time than in a completely new filter, provided re-sanding has been completed within a short period. Ripening of a re-sanded filter will take 3-7 days under tropical conditions and about two weeks in more temperate areas.

Step 11: pass the filtered water into the supply and adjust the rate of filtration in the other filters.

When the filter skin has developed fully, the filtered water can be passed into the supply. The rate of filtration in the other filters may be decreased gradually to their normal level.

8. MAINTENANCE OF PUMPS, ENGINES AND VALVES

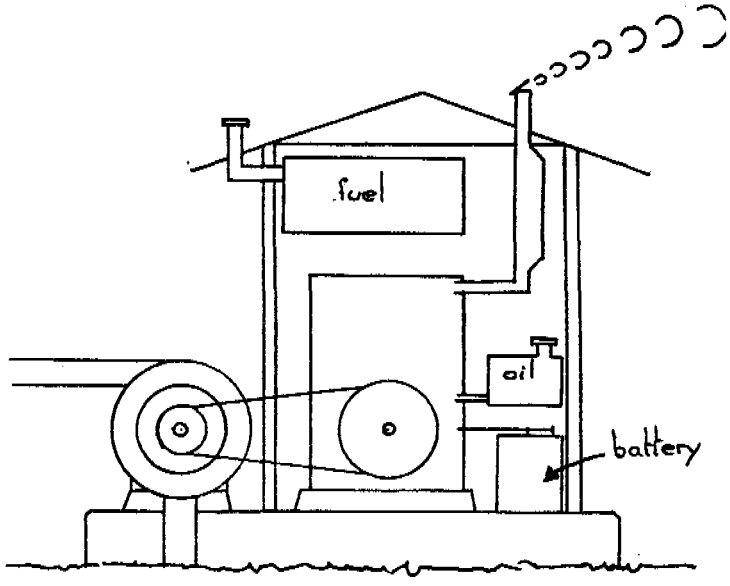
Pumps, engines and valves require regular maintenance. Therefore, check and grease all moving parts once a week.

When a diesel pump is included in the system, the following needs to be checked before starting the engine:

* the water level in the sump
* the engine
  - oil level in the engine
  - water level in the radiator
  - water level in the battery
  - level of diesel fuel in the tank.

Once a week, all nuts and bolts need to checked and tightened if necessary.

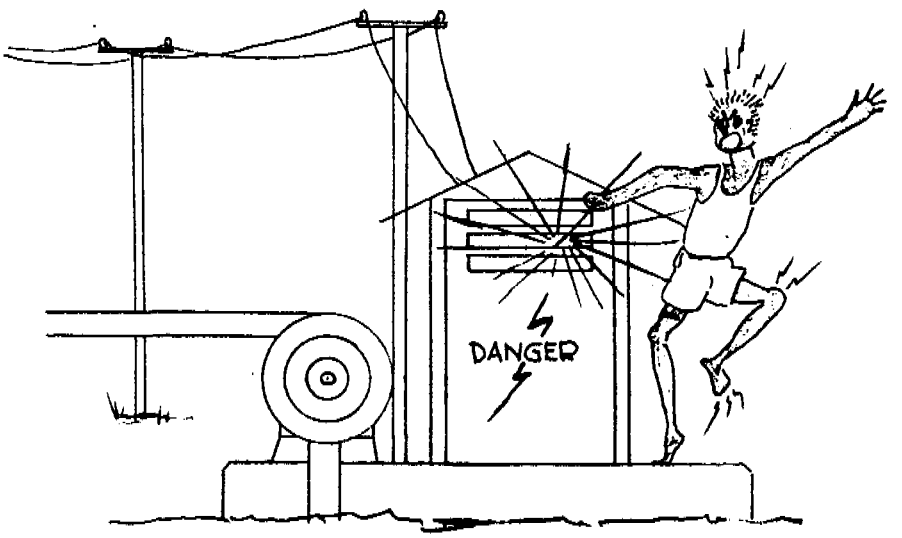
Operation and maintenance of the engine should be done according to the instruction manual for the engine (changing air filter and renewing motor oil, for example).



Proper operation and maintenance of pumps and valves ensures longer life and reduces breakdowns.

If there is an electrical pump system, protection of the site is very important. Many accidents may occur because unexperienced persons are not aware of the dangers of electricity.

Every six months, an electrician should check the electrical system to keep it fully operational and in a safe condition.



Electricity can be fatal to unexperienced persons, therefore do not allow villagers to interfere with electrical systems.

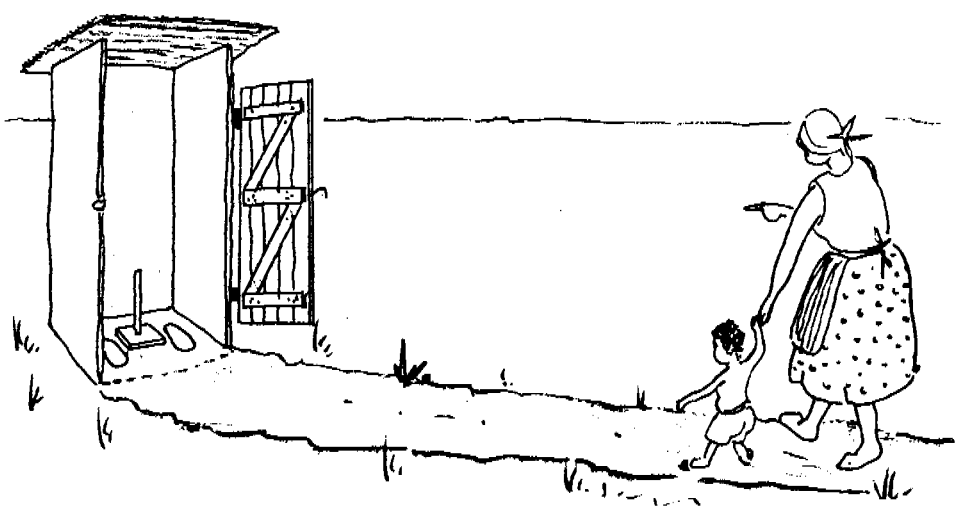
APPENDIX I
HYGIENE AND SANITATION FOR SAFE WATER SUPPLY

When the community appreciates the importance of safe water and accepts the caretaker's responsibility, they may also seek advice on other topics. Then it is important to know that provision of a safe water supply needs to be combined with proper personal and domestic hygiene practices. Sanitary removal and disposal of human waste is also essential to reduce or prevent the transmission of disease.

Disease transmission routes can be broken, only if ALL people in the community have easy access to the new water supply and properly use adequate sanitation facilities.

Latrines are quite common in many villages. Some are more hygienic than others because they have been constructed properly, are cleaned every day, and have a lid to cover the hole.

A dirty and smelly latrine not only creates a risk for public health, but also people will not like to use it. Simple improvements to existing latrines can contribute greatly to better use.



Adequate sanitary facilities which are used properly together with improved water supply create better health conditions in the village.

APPENDIX II
HYGIENE PRACTICES

Many hygiene practices which are passed on from parents to their children protect them from becoming sick. However. other practices carry a risk and need to be changed.

Regular washing of the body is important and washing of the hands after defaecation is essential. Children should be taught to use latrines and to wash their hands afterwards. Just pouring water over the hands is not sufficient. Hands should be washed preferably with soap. But when soap is in short supply or too expensive, other solutions could be discussed and promoted, for example the use of clean sand or ash.

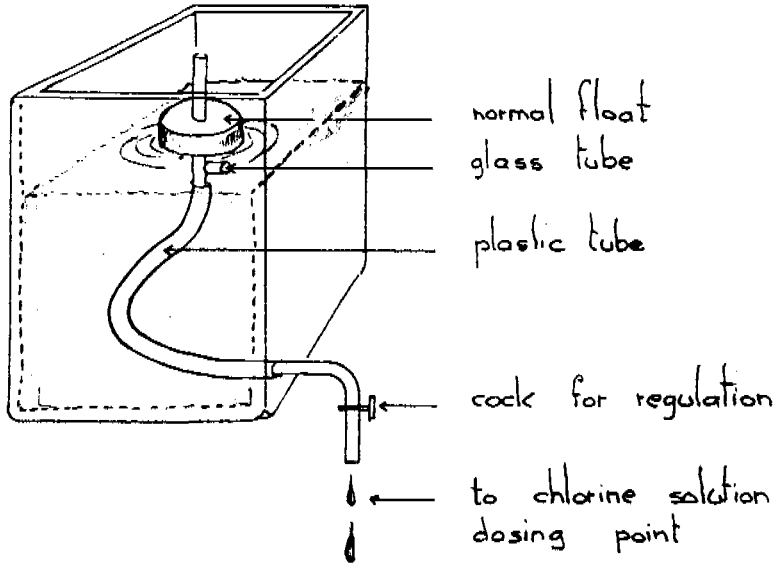
Together with the village health worker, a hygiene education programme can be set up to create community awareness and support for the water supply and to discuss the need for using or improving sanitation facilities. Particularly children should be accustomed to proper hygiene practice because they run the highest risk.

Adequate personal hygiene is essential for improving the health conditions.

APPENDIX III
SAFETY CHLORINATION

Although a slow sand filter which is properly operated and maintained produces water virtually free of disease-causing organisms, chlorination of the filtered water may be applied. Chlorine kills micro-organisms and therefore chlorination provides an extra safety barrier in the production and supply of drinking water. The quantity of chlorine required is very small and needs to be carefully controlled. Too little chlorine will not kill the organisms effectively, and too much leads to a bad taste in the water so that people refuse to drink it.

In most slow sand filtration plants, the chlorine solution is dosed into the water just after the overflow weir in the outlet chamber. This guarantees simultaneous mixing and provides for sufficient retention time to be effective in killing disease-causing organisms. The purified and chlorinated water is perfectly safe when it reaches the users.



A drip chlorinator is often used for dosing the chlorine solution.

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