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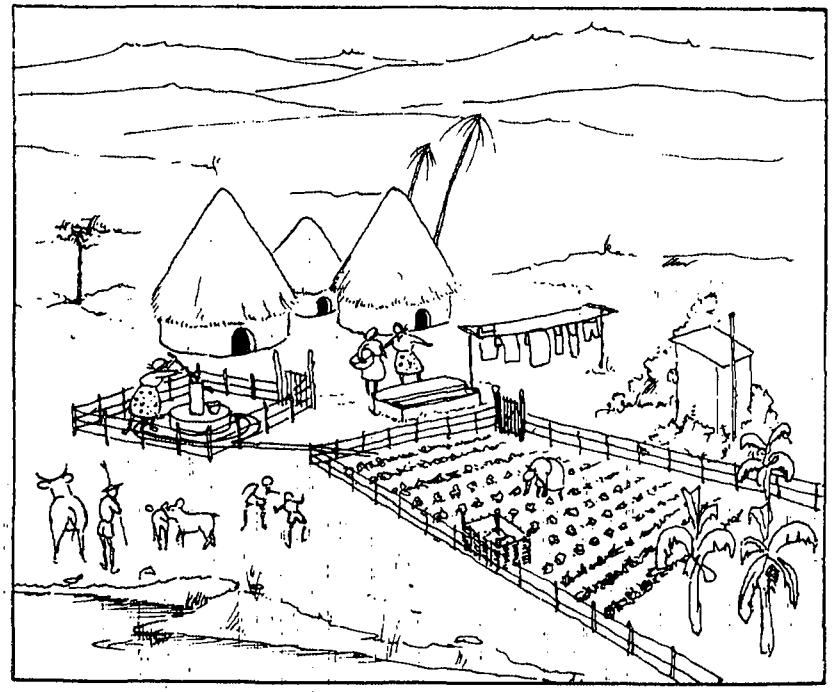
The Hague, The Netherlands

Community Self-Improvement in Water Supply and Sanitation



5 Training Series

IRC, INTERNATIONAL WATER AND SANITATION CENTRE

IRC is concerned with knowledge generation and transfer and technical information exchange for water supply and sanitation improvement in developing countries. The emphasis is on innovative approaches to prevailing problems. The target groups are management and technical staff concerned with planning implementation and utilization and technical staff concerned with planning, implementation and use of water supply and sanitation facilities in rural and urban fringe areas.

The centre works together with partners in developing countries, United Nations organizations, bilateral donors and non-governmental organizations. Its multidisciplinary staff provides support through training and education, publications, and general information exchange.

Activities integrate technical and non-technical issues in water supply and sanitation and include community participation particularly the role of women, hygiene education, appropriate technology, operation and maintenance, community-based financial management, and development of technical information exchange.

IRC is an independent, non-profit organization. It is supported by and linked with the Netherlands Government, UNDP, UNICEF, the World Bank, and WHO for whom it acts as a Collaborating Centre for Community Water Supply and Sanitation.

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COMMUNITY SELF-IMPROVEMENTS IN WATER SUPPLY AND SANITATION

A training and reference manual for Community Health Workers, Community Development Workers and other community-based workers.

Training Series no. 5

IRC, International Water and Sanitation Centre
The Hague, The Netherlands

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CONTENT

PREFACE

In many developing countries national objectives have been set and resources directed to providing adequate and safe water supply and sanitation provisions. Yet many people in rural and urban fringe areas still do not have access to adequate facilities. Very often scattered communities in remote areas are not included in national programmes and initiatives. For small communities national funds are not available and financial and labour inputs for water supply and sanitation facilities must come from the communities themselves. Stimulation of communities to make an effort to improve local conditions and some expert knowledge on possible improvements is often required. Community development workers and community-based health workers already having these contacts with communities can become this change-agent.

Improved water supply and sanitation provisions will not on their own bring significant improvements in community health. Functioning, adequate use of the provisions and safe hygiene behaviour are key issues at stake.

This manual is designed to provide community development workers, community health workers, and other community-based workers with ideas and information to work with the community in order to implement self-help improvements. The manual is to be translated in the local language of the community workers and adapted to the local cultural and socio-economic condition. It is for use in training courses and for distribution as a reference for community-based workers in the field. In the outlined approach community-based workers act as a catalyst for the community to identify problems and felt needs related to water supply and sanitation. Consequently they assist communities to set their own priorities for improvement and to select and implement the most appropriate technical option.

To support the community decision making process the terms "burdens" and "health risks" in water and sanitation practices are introduced. Burdens are problems perceived by the community as needing improvement. For example, waiting time resulting from sharing a water pump with a large number of families may be perceived as a burden, whereas in other communities a reduced number of families using a pump may effect the social contacts, which may be felt as a disadvantage. Health risks relate to local practices which may result in water and sanitation related diseases. Existing health risks may not be perceived by the communities and therefore the community-based worker needs to have adequate training to be able to identify and explain these risks.

The manual gives a number of relatively simple self-help solutions. These technologies are relatively easy to construct, operate and maintain with mainly inputs from the community and minor or no outside support. The manual gives information about the skills and materials required for several options and the appropriateness and limiting conditions for application. General building practices are being discussed but detailed construction drawings and guidelines are not included. An information network through local channels for the distribution of more detailed technical information have to be established or if present, to be used, to provide the training centres and the community based workers with this information.

The training in which the manual may be used should include a major practical component on building practices applied to given self-improvements.

The development of this document has been made possible through financial support from the Netherlands Ministry of Housing, Physical Planning and Environment, Department of International Environmental Affairs.

Towards the realization of this present document contributions were made by Jo Smet, Jan Teun Visscher, Dick van Ginhoven en Willem Ankersmit. The illustrations have been made by Mr. A. Figee, who used his broad working experience in the civil engineering sector. Valuable comments on the draft manual were given by the reviewers Dr. Sandy Cairncross, Han Heynen, Jan Willem Harnmeijer, Marieke Boot (IRC) and Teun Bastemeijer (IRC) for which IRC is thankful.

Special thanks go to Lauren Wolvers and Carmen Sloot who did the final text processing.

PART I: INTRODUCTION

1. INTRODUCTION

Access to sufficient and safe water and adequate sanitation facilities are essential for community health, but having these facilities does not automatically guarantee improvement in community health. Health benefits of clean water supply and adequate sanitation come only through proper functioning and use of the facilities and often it requires improved hygiene behaviour.

Community development workers, community health workers and other community-based workers can be of great help to communities when it comes to improving their water supply and sanitation provisions. This can be done using relatively simple self-help options. They can assist the community to develop an understanding of the linkage between water supply, sanitation and hygiene education and improved health. The identification of existing health risks and burdens helps the community in defining their own problems. The community with assistance from the community workers can look for the best feasible solutions considering technical, financial, cultural and social conditions.

This manual has been written to guide and help community-based workers with this task. Divided in three main parts the manual gives information on the following aspects:

- Part I: working with the community
- Part II: introduction to water, sanitation and health and the related burdens and health risks
- Part III: options for simple self-help improvements including organizational guidelines.

Working with the community

This part of the manual gives ideas and suggestions on how to stimulate and guide the community:

- to identify their problems and felt needs in water supply, sanitation and health
- to work out their priorities for improvements
- to examine feasibility of the options for self-help improvements
- to apply for minor financial and/or technical external support
- to implement the improvements
- to operate and maintain these improvements.

If the community worker is not living in the community, regular visits to the place are important.

Burdens and health risks in water supply and sanitation practices

The important linkage between water, sanitation, and hygiene and health is outlined in the manual. The burdens and health risks in water and sanitation practices are discussed.

The burdens are the community's perceived problems which require a solution, for example the burden of carrying heavy water containers for long distances.

Health risks are related to local practices which may result in water and sanitation related diseases, such as diarrhoea and worm infestation.

Options for simple technical self-help improvements

A number of technical options for self-help improvements are given. To implement these, inputs from both the community-based worker and the community are required. Most are simple to construct, operate and maintain and may require minor or no inputs from outside the community.

The introductory aspects and general information of Part I and II form the basis of the activities of the community worker in the field of water supply and sanitation. This information could be used to explain the types of feasible technical solutions and the organizational requirements which are needed for the solution-selection process. Part III could be used as a guide for demonstration and practical sessions in the training of the community-based workers.

The following subjects are described in part III:

water quality at the source 

water quantity 

water lifting 

water transport 

water storage 

water treatment 

sanitation 

waste disposal 

household practices 

general construction guidelines 

2. WORKING WITH THE COMMUNITY

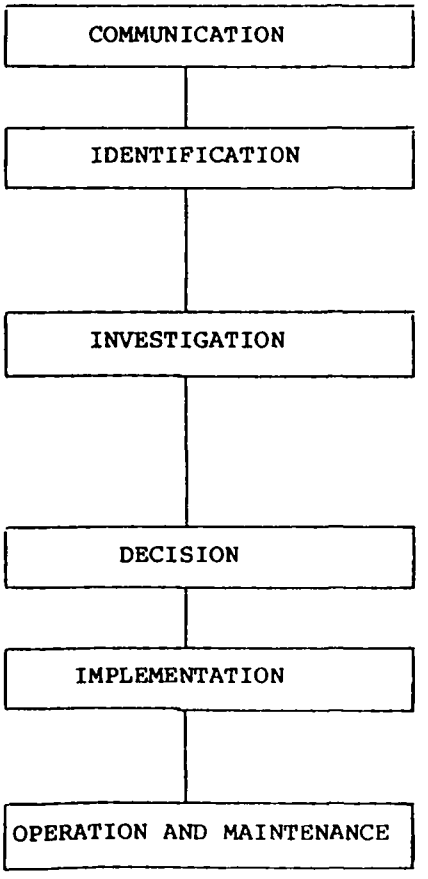
This chapter describes the process of communicating with the community. It deals with ways in which community workers could work with communities and how they could seek people's views and opinions on burdens, health risks, needs and possible solutions. Also, community workers who are already active in a community and who have already established contacts with communities may find some useful hints in this chapter. Suggested activities are not always relevant for community workers who live in and are therefore part of the community.

Community workers should learn during their training how to approach and work with the different groups and individuals in the community. In their training location they can learn, apply and evaluate the process outlined below.

2.1 THE SELF-IMPROVEMENT PROCESS

How this manual can be used in community self-improvements

The steps a community assisted by the community worker could follow in the process of community self-improvement are given in the following diagram. This training manual gives the information for each step in this process.



Communication is working with and through individual members, groups and leaders in the community.

Identification of the burdens, health risks and needs in water supply and sanitation is done by the community with assistance of the community worker.

Investigation of the environmental circumstances and natural resources of the area, but also the existing practices and habits, and the financial, organizational and technical limitations.

The decision is made by the community about the technically and financially most feasible option for improvement.

The implementation of the technical improvement is done by the community, assisted by artisans and the community worker.

Operation and maintenance procedures are developed with the community and implemented by the community.

Problems in the process

The community, the leaders and the community workers should allow sufficient time for each of the steps in the process of community self-improvements, from communication up to implementation. For example, if serious health risks are present in the community which are not perceived as such, it will take some time before the people actually see that the situations are harmful. In such situations hygiene education is planned and people are sensitively approached by the community workers and the leaders. They could set examples of improved sanitation, water-related practices and home and yard cleanliness, in their own environment and at places such as the health unit, school, mosque, offices, market and bazaar. These examples may increase the community health awareness and may even be followed. The identification of the existing serious health risks by the community comes then as a result of increased health and hygiene awareness.

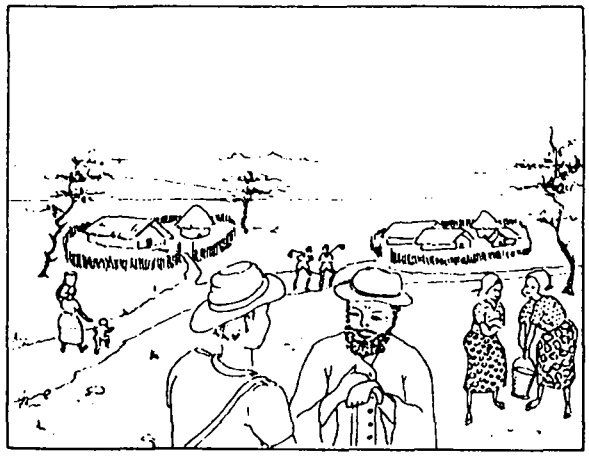
Constraints such as shortage of materials which delay the improvement of the process may demotivate the community to improve the situation. Proper communication with the community by the leaders and the community worker is then needed and perhaps interim solutions are to be discussed and implemented.

2.2 MEETING THE LEADERS

For community workers who do not live in the community, the usual approach is to formally contact the 'leaders' first. There may be a community council or committee, a group of elders, one or more government or party representatives, or an important organization such as an agricultural co-operative of which most of the people are members.

Formal and informal leaders

Apart from meeting the formal administrative leaders in the community, other generally recognized people such as religious leaders, traditional practitioners, midwives, teachers etc. should also be approached. Good contact with these key people may make work in the community easier. However, it should be avoided that problems and solutions are only discussed with them and presented to the community, otherwise people will feel that plans are being imposed on them. Involvement of the entire community is crucial and should be carefully planned.



Meeting the community elders

Even though leaders generally know a lot about their community and its inhabitants, they may not know all there is to know about the water and sanitation situation. Moreover, they have vested interest that could make their views and ideas differ from those of the other members of the community.

Informal talks with members of the community

Introductory meetings

The main objective of one or two introductory meetings with leaders is to get an entry into the community and to pave the way for further contacts with leaders and other people. For these first meetings a number of "do's and do nots" are listed on the next page . If the community worker is actually a member of the community, some points are not relevant.

Community meetings

The findings of the informal talks the community workers had with the different community groups and individuals are first discussed with the leaders. A public community meeting is then called for in which people are encouraged to participate. For each step in the entire process, from communication up to operation and maintenance, such a public community meeting could be organized to report on the findings, the progress and to get a general concensus on conclusions and actions (see also 2.4).

Discussions and meetings are carefully planned in view of the activities of the community members such as farming, daily duties, ceremonies, funerals etc.

POINTS TO REMEMBER FOR A FIRST MEETING WITH LEADERS

DO

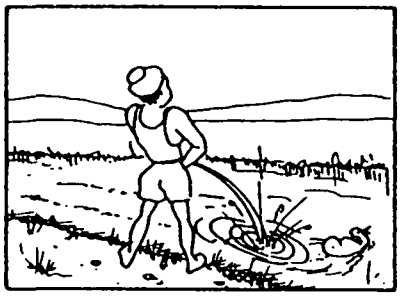
* introduce yourself and your organization;
* allow the leaders to introduce themselves and their roles in the community;
* emphasize that you have not come to impose changes, but to assist the community in carrying out its own improvements;
* explain the approach of identifying burdens, health risks and needs, and selecting options for improvements;
* ask the leaders about burdens, diseases and needs in the community and ask them what solutions are already applied;
* ask them if they have suggestions for improvement of the situations which have been discussed with the community;
* try to find out how much they know about the links between water, sanitation practices and diseases;
* ask them to introduce you to the school, co-operatives, organizations such as women's groups, welfare societies, saving groups etc. in the near future;
* ask them to show you around the community one day and to introduce you to people you might meet.

DO NOT

* don't use a first meeting to give hygiene education;
* don't tell the leaders that practices in their community are wrong;
* don't make promises that you may not be able to keep;
* don't consider a list of burdens and needs brought forward by the leaders as final;
* don't make decisions yet about options for improvements.

2.3 WALKS IN THE COMMUNITY TO OBSERVE THE SITUATION

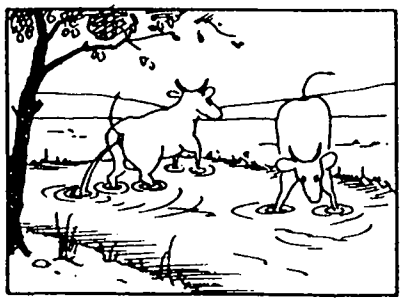
Several walks through a community are necessary to get to know the situation and to get an impression of burdens and health risks, as well as to allow people get to know the community worker. Both community worker and community leaders may benefit from the information obtained through such community walks. Often community leaders cannot spare several days for walks in the community, and people may not feel free to talk when community leaders are present. Therefore, appointments could be made to see the people later on, without the community leaders. People tend to be more relaxed and more open in expressing their views when these talks are held in their homes. It is better not to invite them for personal talks in communal buildings such as offices and schools, though this is much easier for the community workers.



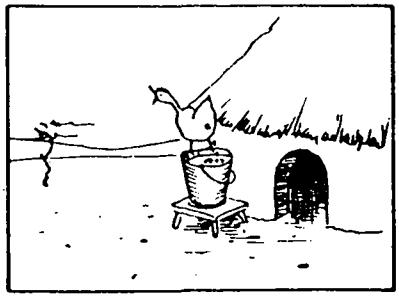
Water contamination

Improper waste disposal

Informal talks with the people met during such community walks will provide useful information. The views of all community members are important but especially the views of women, who are usually primarily responsible for matters regarding water in most communities. Key informants such as teachers and informal leaders can give additional information on the situation placed in the social and economic context of the community. Again a few "do's" and "do nots" for the first walks in the community are listed.



Water contamination
by animals



Drinking water
contamination

POINTS TO REMEMBER FOR THE FIRST WALKS IN THE COMMUNITY

DO

* pay special attention in your observation to the occurrence of any of the burdens and health risks listed in Chapter 4;
* visit the water source(s) whatever the distance is;
* follow the common water transport routes from the source(s) to the homes;
* visit a few houses;
* be honest and open about the purpose of your visit;
* talk with people you meet outside and in their homes;
* talk with the people about their perceived burdens and needs;
* ask whether problems with health and water are different during different times of the year;
* try to find out how much people know about the links between water, sanitation and disease.

DO NOT

* try to get an impression of the whole community, but don't force leaders to show you the poorer or bad sections of the place; if they do not want to, this can wait until later when the contacts have become less formal;
* don't insist on having a look at latrines and places where people defecate if people are reluctant or shy; it may be wise to postpone this subject;
* don't tell the people that their practices are wrong, even if you think they are;
* try to see more than problems and negative aspects: don't overlook correct, intentional and innovative practices, because they can be a basis for further improvements.
* don't write notes when talking with people; listen carefully and write your findings later;
* don't make the people any promises you can perhaps not keep.

Perceived burdens

Sometimes it may be difficult for people to mention "burdens". What might seem a heavy burden to an outsider may be just a fact of life for the people in the community. Heavy waterlifting and carrying water over a long distance may be a very normal task for women. Their mothers and grandmothers did it before them, and their children are already helping them now. Women may start perceiving this task as a burden only if they realize that improvement could result in fewer aching backs, more time for rest or other activities, and time for their children to receive a better education than they did.

Sometimes, a situation that appears burdensome to the community worker may be advantageous or pleasant in the eyes of some people. The long queues and waiting times at a water collection point may be the only opportunity for women in "closed" societies to exchange news and to relax for a while. In such situations there is no point in emphasizing the burden of long queues.

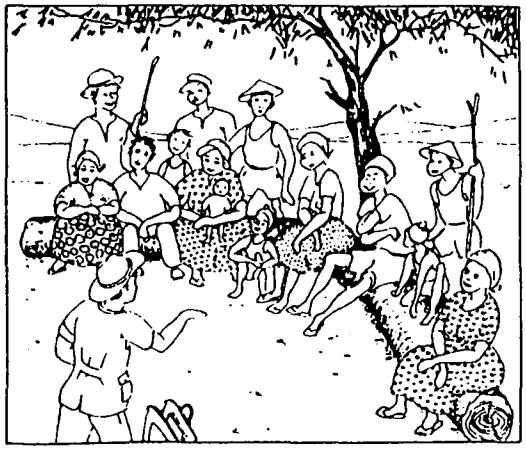
2.4 COMMUNITY MEETINGS

The approach used in this manual is based on a continuous dialogue between the community and the community worker, about burdens, health risks and needs for improvement and how to improve. Community meetings are the most unsuitable way to have a dialogue. People who could give useful information may be too shy to speak up in a meeting. In many cultures women are not used to or expected to play a prominent role in meetings, while they do play a major role in matters regarding water and sanitation. Walks in the community, home visits and discussions with women's groups will provide a better insight in the situation than general meetings.

When to plan public community meetings

There are some purposes for which general public community meetings can be appropriate. A public community meeting could be held to introduce the community worker and his or her organization. Such a meeting is also necessary to get the community concensus on conclusions of surveys on the water supply and sanitation situation, i.e. after the first investigations and discussions with people and groups. Concensus on actions to improve the situation in the community, on the coming activities and on the approach can also result from the meetings.

When planning the community meeting, make sure that all people can attend. Do not, for example, plan the meeting during harvesting days or when the women have to prepare meals at home.



Community meeting

Topics for a community meeting

The results of investigations and informal talks are discussed with the community, perhaps first in the community groups but also in a public community meeting.

The possible options for improvement will be discussed, particularly the organizational, financial and material implications of the options in view of the community capacities both at that moment and in the future to cover maintenance, replacement and extension costs. Options for improvement could be presented to the meeting and discussed.

Community meetings are also useful if voting is required, for instance, if a community health committee is to be elected.

As an introduction to the topic of the public meeting and to make attending the meeting extra attractive, a film or slides on water, sanitation and health could be shown or a play could be performed. Inviting a health authority who emphasizes the water, sanitation and health relation in view of the prevention of diseases could be considered. However, such events are just attractive "extras". They should never come in place of dialogues with small groups and individuals or shorten the public meeting, which might mean that not all people could give their views.

POINTS TO REMEMBER FOR A COMMUNITY MEETING

DO

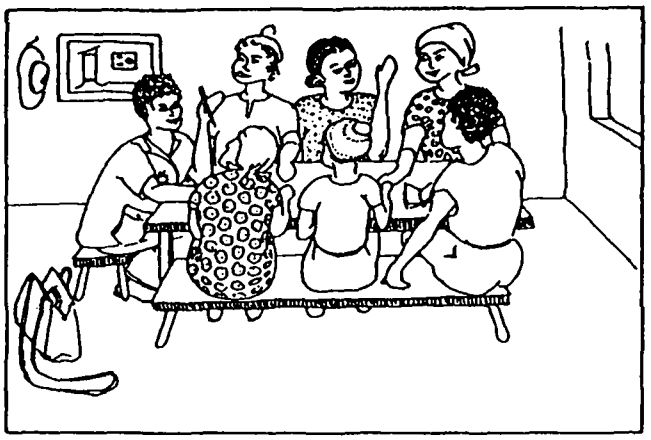
* get agreement on the purpose and the content with the community leaders;
* announce the meeting and its purpose well in advance, so that the whole community knows about it;
* make the meeting extra attractive by showing slides etc. as introduction;
* ensure that place and time of the meeting are suitable for men and women to attend;
* encourage all community members to speak up in discussions during meetings;
* come to general concensus on the meeting issues.

DO NOT

* don't dominate the meeting or strongly disagree with points raised by the participants.

2.5 WORKING WITH COMMUNITY GROUPS

If a community has a water or health committee, the community worker will of course meet, plan, work and discuss with them. Community health workers may be members of this committee. Burdens and health risks will be discussed with the committee, which must later be strongly involved in carrying out improvements and making maintenance arrangements.



Meeting a women's club

There may be other formal or informal groups and individuals that could play specific roles in the process of improvement of health, water supply and sanitation. They could be of great help in the early stages of identification of burdens, risks and needs. Many of them could also be active later, in implementation, financing and maintenance of facilities, and in the introduction and carrying out of new practices.

The list on the next page gives a number of possible contributions from various groups and people that a community worker may find in a community. Of course the exact roles must be determined by the people and the community worker together.

Possible contributions from community groups in the process of community self-improvement:

* women's club:
  - personal experiences with burdens and health risks;
  - perceived needs for improvements;
  - judging feasibility of improvement options;
  - co-operation in implementation and maintenance;
  - communication to other women, men and children;

* co-operative:
  - organization;
  - financial management;
  - fund raising;

* schoolteachers:
  - education on health, hygiene and new practices to children and grown-ups;

* midwives:
  - communication on health, hygiene and new practices;

* youth club and schoolchildren:
  - clean-up campaigns;
  - assistance in implementation and maintenance;
  - indirect communication on health;

* pupils of technical schools:
  - assistance in implementation and maintenance;
  - fabrication of spare parts;

* theatre group/community performers:
  - perfomances in the framework of the process of change and improvement;

* Local story tellers:
  - communication.

PART II: WATER, SANITATION AND HEALTH

3. INTRODUCTION TO WATER, SANITATION AND HEALTH

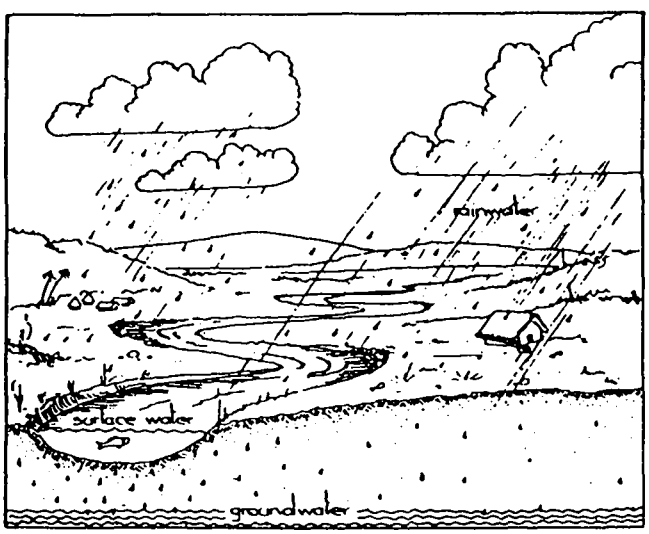
This chapter gives background information on the various sources of water supply and on the links between water, sanitation, hygiene and health. This information can be used in discussions with the community about health risks.

3.1 WATER SOURCES

There are three major sources of water available:

- rainwater
- surface water
- groundwater

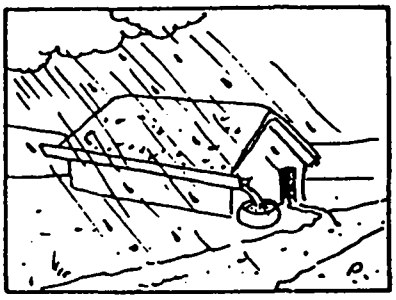
Often, communities depend on more than one of these sources for their water supply. Sometimes there are alternating periods of drought and abundant supply of water.



The three water sources

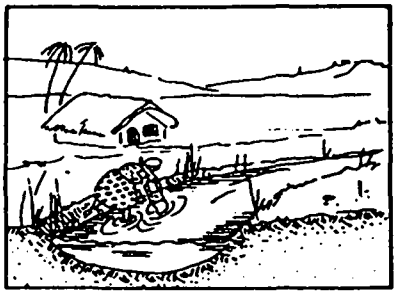
Rainwater can be collected from roofs or ground surfaces such as roads or school playgrounds.

If rainwater collected during the rainy season is meant to be stored for use during the dry season, large storage basins or containers are required.



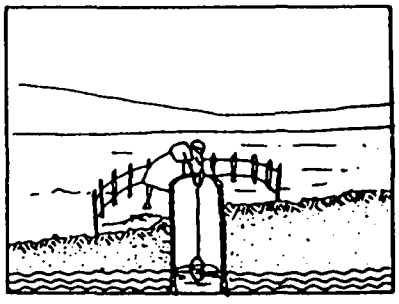
Roof catchment of rain water

Surface water can be collected from rivers, streams, lakes and canals, and from man-made open water sources.



A stream as water source

Groundwater is the rain and surface water that infiltrates into the ground and is stored in "water-bearing layers". It can be collected from natural springs where the water bearing layers reach the surface, or by digging wells or drilling boreholes to reach the water bearing layers.



Groundwater collection via a well

3.2 WATER QUALITY

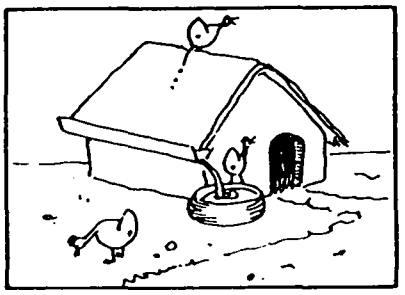
Not all water is fit for human consumption

Rainwater

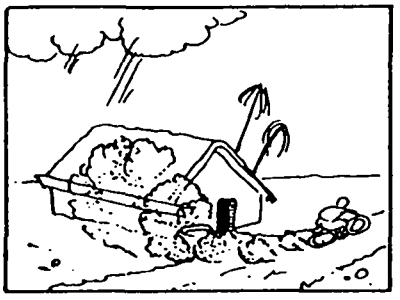
Rainwater in itself is pure.

When it is collected from roofs or from any other surface, it may be contaminated and polluted by:

- bird droppings and dust containing harmful organisms;
- dust from factories containing hazardous chemicals;
- dust from fields and roads containing pesticides and other toxic chemicals.



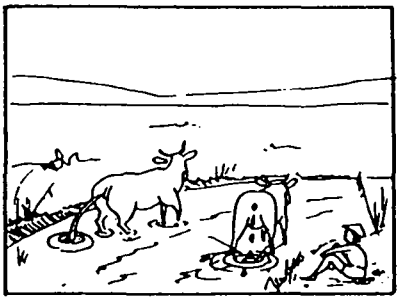
Animals contaminate rainwater



Dust pollutes the collected rainwater

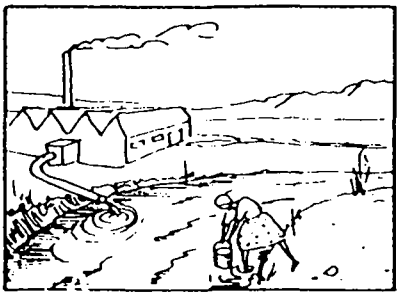
Surface water

Surface waters are almost always contaminated by people and animals who defecate in or nearby the water. Disease-causing organisms may be present in the water.



Animals contaminate surface water

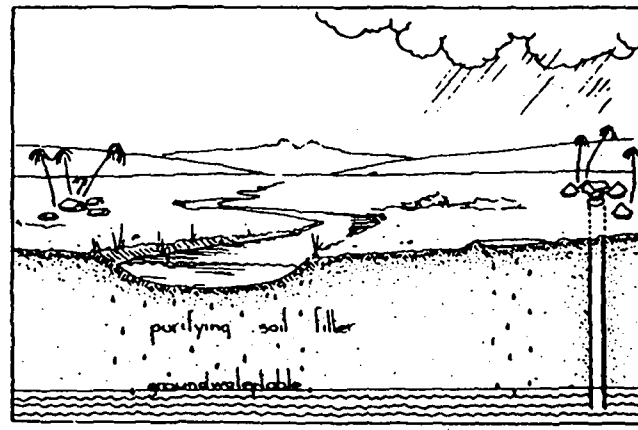
Surface waters are also often polluted with dangerous and toxic chemicals used in fertilizers and pesticides, or coming from factories that dump their wastes in the water.



Industrial pollution of surface water

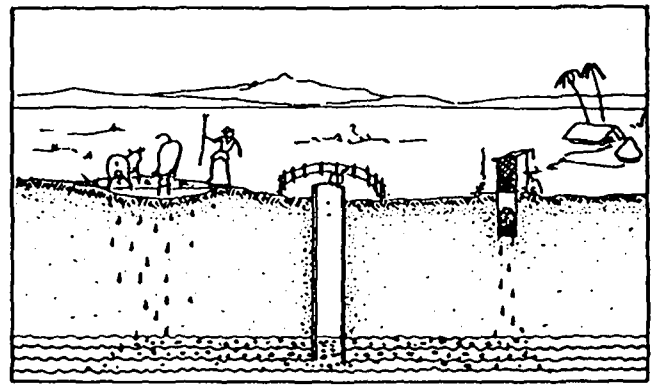
Groundwater

Groundwater is mostly free of contaminating organisms. The soil acts as a purifying filter retaining many harmful organisms as the water passes through. Chemicals from factories and farming may remain in the water. When the water passes through the soil it may pick up minerals from the soil which may give it an unpleasant taste, or which may even be harmful to humans.



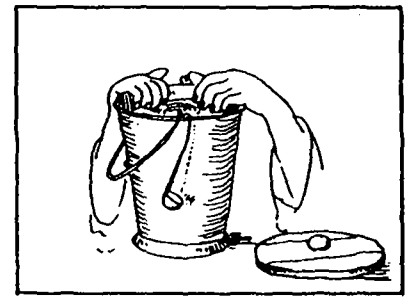
The soil acts as a purifying filter

Groundwater can become contaminated from deep waste pits and latrines located too close to the well or spring. Dust and dirt may enter an uncovered well and contaminate the water in that way.



Contamination sources for groundwater

Clean water can become contaminated during transport from source to home, and during storage. Holding the rim of the container with unwashed hands may easily lead to contamination of the water. Water stored in open containers is also easily contaminated.



Hands contaminate clean water

Immunity and resistance

Fortunately many people have built up a natural immunity to water-related diseases. This means that they do not become ill with these diseases unless the water is very badly contaminated. Young children and old people have less resistance than others and they are most likely to suffer from water related diseases. The most common of these diseases is diarrhoea, which is caused by either drinking contaminated water or eating contaminated food. Diarrhoea occurs more often in families where insufficient water is used for personal and home cleanliness. Cholera and typhoid are two of such serious diarrhoeal diseases which may be caused by drinking contaminated water.

Measuring levels of water contamination

In many rural areas equipment for accurate measurement of levels of water contamination is not available. Careful observation of activities at and around the source will give an indication whether water may be contaminated. For example, surface runoff and spilt water flows into the well or animals get too close to an unprotected source.

But the way water is transported and stored in the house are also points where contamination might take place, and if water is drawn from the storage jar using a dirty mug or hands, the perhaps clean, safe well water may become heavily contaminated. Just boiling the unsafe water will not ensure that the people drink safe water. Hygiene education should deal with all these aspects to correct possible behaviour in the community which is a risk to health.

3.3 WATER QUANTITY

Water quantities sufficient just for drinking and cooking are not enough for a healthy life. Water is also needed for washing and cleaning. Many diseases result from lack of water for bathing, clothes washing and home cleanliness.

The occurrence of skin diseases, louse-borne fever, eye infections and diarrhoeas can be reduced by improved hygiene behaviour using soap and more water.

Regular bathing using soap

Water consumption

The amount of water that is used per household could be measured at the water collection point. It is then still important to find out for which purposes the water is used, such as washing, bathing and cooking, and how housecleaning is done. Using a lot of water does not automatically mean that the water is used properly to reduce the mentioned diseases.

Incidence of diseases

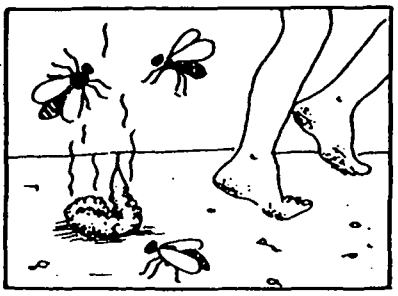
The incidence of diseases, which are due to insufficient water and therefore due to poor hygiene, is a good first indicator for insufficient water use. (The incidence of a disease is the number of people who get ill with a certain disease in a certain time period, say one month). Particularly, a high incidence of skin diseases or eye infections provides an argument to investigate whether people have and use enough water.

How to improve this situation

If people have, but do not use sufficient water, and water quantity related diseases are very common, something must be done to improve the situation. This will often include the adoption of new habits, such as washing hands, body and clothes more frequently. In some areas it may also mean that the yield of existing water sources must be improved, or that new sources must be created.

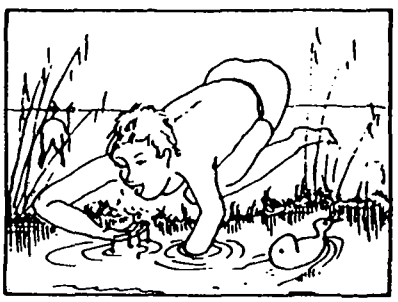
3.4 SANITATION

Faeces or "human waste" is the major contaminator of water and food. Faeces of sick people or animals contain the micro-organisms (such as bacteria, viruses, worms etc.) that cause their disease. Even a tiny quantity of it, consumed by a healthy person, could make that person sick. The faeces of babies and of people who look and feel perfectly healthy but carry diseases, may also contain disease-causing organisms. People will probably say that it is not their habit to eat faeces, but many people do, without even knowing it, though in very small, invisible quantities present in water or food.



Human waste may cause serious health risks

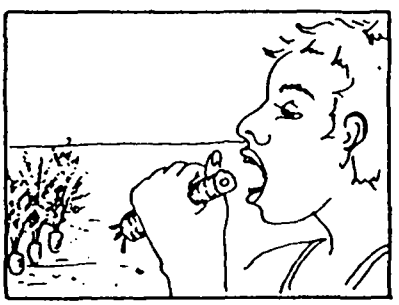
When people drink the water from polluted surface or groundwater sources the situation is clear, even though it is difficult to understand and realize that the tiny quantities of faeces in the water can be dangerous.



Drinking contaminated surface water

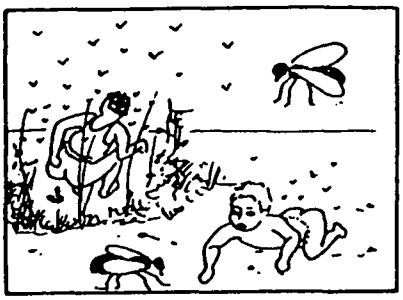
Sometimes it is difficult to understand how contamination of water and food by faeces has taken place.

If animal or human waste is used as fertilizer, tiny bits of it will stick on the vegetables. If these are eaten raw, without having been thoroughly washed with clean water and clean hands, faeces are actually eaten.

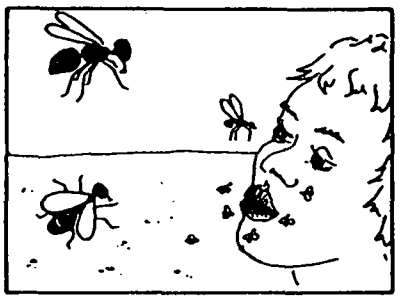


Eating raw, contaminated vegetables

When open defecation is practiced, people will carry tiny particles around on their feet and spread it around. Children playing on the ground will get it on their hands and may eat small particles of faeces when they put their fingers in their mouths. And then there are flies, who like food and faeces, and always fly or walk around, spreading minute quantities of faeces over food, cups, plates, spoons and eyes, thus spreading diseases.



Hands become contaminated



Flies spread diseases

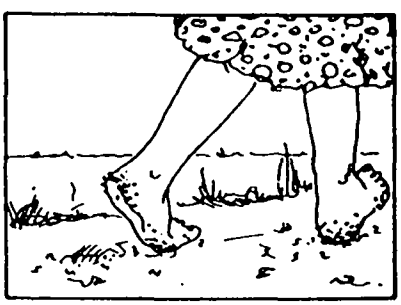
Flies contaminate food

Flies transfer diseases

Some worm diseases have a more complicated "transmission route" than the simple faeces-to-mouth route.

Hookworm can enter the body of a person who walks barefoot on soil that is contaminated with faeces.

Hookworm eggs may be present in faeces.



Hookworm larvae penetrate skin

Roundworm (ascaris) eggs causing worm infections may be ingested via contaminated hands or food that has been in contact with contaminated soil. Roundworm eggs need soil for their development.

Toys and hands become contaminated with roundworm larvae

Bilharzia or schistomiasis is the result of swimming, bathing or walking in water contaminated with faeces or urine from people who carry that disease. The disease-causing organisms need water-snails for development.

Contamination and transmission!

Water and sanitation improvements

Whether the route of transmission is simple or complicated, whether the disease is caused by germs or worms, the basic cause is faeces and in some cases urine. Therefore, water supply improvements aiming at better water quality or quantity, or both, must be carried out in combination with sanitary improvements to improve the health in the community. [1]

[1] Safe and adequate water and improved sanitation contribute to the prevention of the mentioned diseases. If people suffer of diseases, such as worm diseases, they need a medical treatment from either the health unit or from using the local medications that have proven to be effective. See also "Where there is no doctor" by Werner (1977); this book is translated into many local languages.

4. BURDENS AND HEALTH RISKS

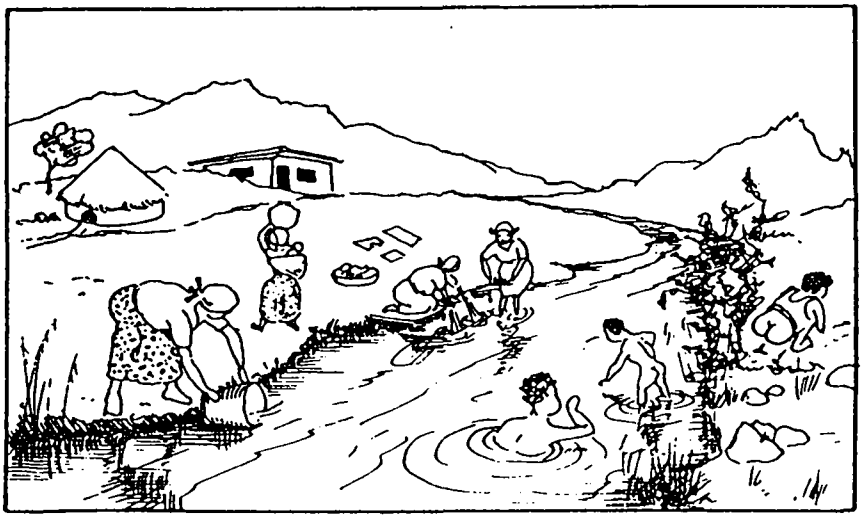
This chapter gives some information on various common burdens and health risks related to water and sanitation.

> BURDENS: problems or heavy tasks perceived by the community which require a solution.

> HEALTH RISKS: dangers for the community due to local circumstances and practices related to water and sanitation and which result in diseases such as diarrhoea and worm infestation.

The perception of "burdens" varies from place to place except for common burdens.

The description of the burdens and risks in this chapter follows the usual sequence, from water collection through water storage to water use.
The subjects sanitation, waste disposal and household practices are also screened for burdens and health risks.



Burdens and health risks at the water source

Checklists

Apart from the general information, lists with the basic check-points for each subject are added. These could be used when exploring the situation in the community and in meetings with the people and community leaders.

Solutions

After the identification of the burdens and risks, the people of the community will be informed and possible solutions discussed in general community meetings. Each problem is followed by a reference to Part III for more technical information on the solution.

Posters

The illustrations on the burdens and risks could be used in the explanation of the findings and the discussion on alternative solutions to the community by copying them on flipcharts.

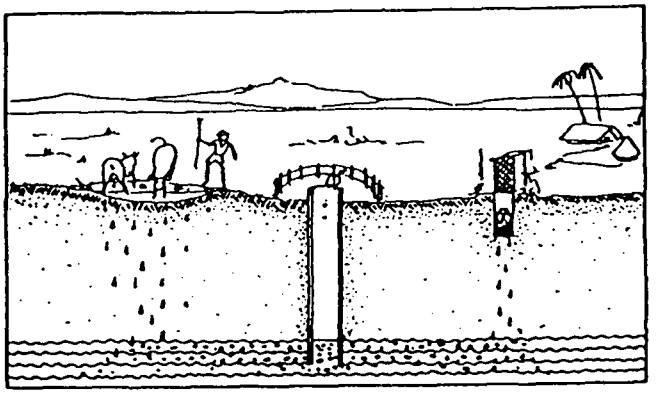
4.1 WATER QUALITY AT THE SOURCE

Groundwater

Well or springwater is dirty with dust, leaves, bird droppings, and spilt water and surface runoff flow into the source.

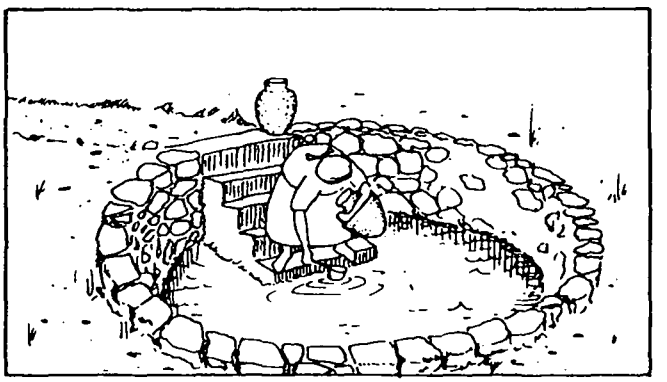
Unsafe springwater needs protection

Well or springwater is contaminated as a result of seepage of polluted groundwater from latrines or cattle puddles.



Groundwater contamination could be prevented

Guinea worm is endemic: the well gets contaminated because infected people can come too close to the water of the well, such as in case of traditional open wells, step-wells and small ponds.

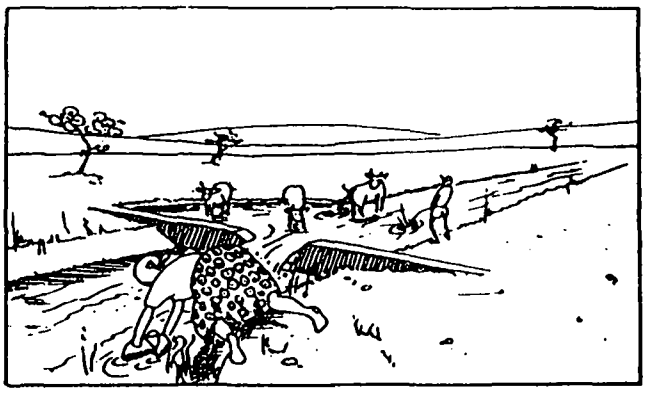


Sealing the step-well with a cover stops the transmission of Guinea worm

For measures to protect wells and springs → Chapter 6

Surface water

Riverwater or other surface water is polluted at the collection point as a result of contamination upstream from human settlements, agricultural or industrial activities.
If industries dump their waste in surface waters or farmers use pesticides/insecticides near surface waters, special protection measures should be taken.



Surface water pollution gives health risks

For measures to protect surface water → Chapter 6

All waters

* The water has an unpleasant taste, or smell or colour.
* There are mud particles in the water.
* The water is brackish.

Unpleasant taste, smell and colour may be caused by algae, i.e. very small plants that grow in the water, especially when the water is polluted with fertilizers.

For boiling, filtering and other treatment methods at home → Chapter 11

Contamination of piped water

Piped water supplies may face leakages in the pipes. A lot of water will be wasted then. When there is no pressure in the water pipes, dirty and contaminated water may enter the pipes through the leaks. The water quality at the tap will then also be poor.

Fluoride

Some diseases are the result of micro-organisms in the water, others the result of certain chemicals present in the water. If there is a lot of fluoride in the water, the teeth of the people get a brownish colour and when the fluoride content is very high, people may get deformations of the skeleton.

MINIMUM CHECK-POINTS

WATER QUALITY

GROUNDWATER

* Can spilt water or surface runoff flow into the well because:

  - well apron is broken
  - well lining is poor
  - headwall of the well is too low
  - subsoil is fractured or has fissures

* Are there pollution sources near the source such as:

  - latrines (within 30 metres)
  - cattle puddles (within 10 metres)
  - industrial dumpsites (within 200 metres)

* Can animals (cattle,sheep, dogs) reach the well site?

* Is the well, when not used, covered, and with a proper lid?

* Does the water from some or all sources taste salty?

SPRING WATER

* Is the surface runoff water directed away from the spring?

* Is the spring protected from animals?

SURFACE WATER

* Are there by-laws that forbid human activities such as bathing and laundry, and that torbid animals to come in contact with the water near the point of collection or intake?

* Are there many sites upstream of the intake or collection point where human activities take place or where animals come in contact with the water?

* Are there industrial activities, dumpsites, or agricultural activities using pesticides upstream?

  (It is important to know which materials, chemicals etc. are dumped in the water, so that this can be reported and the possible health effects be determined).

MINIMUM CHECK-POINTS

WATER QUALITY (continued)

PIPED WATER

* Is there a constant supply of water or is the supply intermittent?
* Are there leakages in the water pipes?

RAINWATER

* Are the roofs and gutters free of dirt (leaves, bird droppings etc.)
* Do people collect water immediately after it starts to rain or do they wait for a short time?

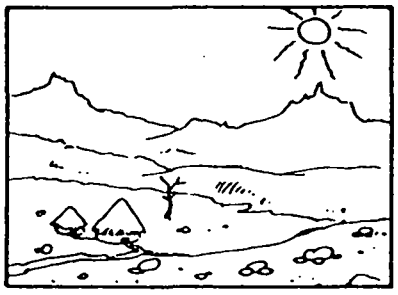
HEALTH

* During which season is diarrhoea most common?
* Have there been outbreaks of cholera, typhoid or diarrhoeal diseases in the last few years and did many people die during these outbreaks?
* Are there many people in the community with brownish, mottled teeth?

4.2 WATER QUANTITY

Water shortage

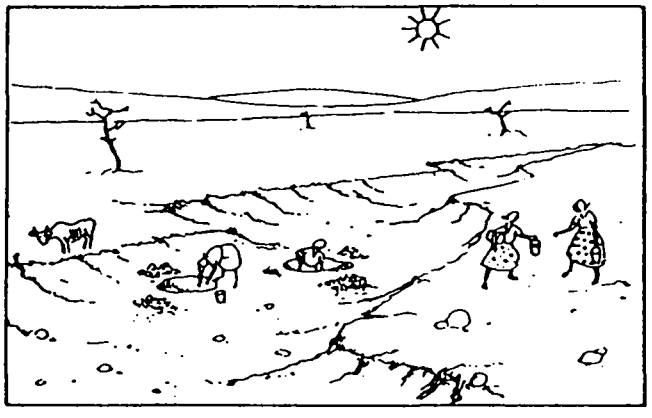
There are no water sources in the community that can provide sufficient water for drinking, bathing, washing and cleaning.



Dry areas face shortage of water

For the creation of new or additional sources	→	Chapter 7

The sources that are available frequently run dry, and then there is not enough water for the common purposes.



Water is scarce in the dry season

For the improvement of the yield of existing sources and the creating of new or additional sources	→	Chapter 7

Occurrence of diseases

Skin and eye diseases are endemic: this is a burden to the people and an indication of insufficient water use and sometimes it may reveal that insufficient water is available.

Child having skin infections and rashes

For the improvement of the yield of existing sources and for the creation of new or additional sources → Chapter 7

Lack of water storage

Water storage containers are not suitable (for instance too small) to store water from the rainy season for use in the dry season.

For large storage facilities → Section 10.3

MINIMUM CHECK-POINTS

WATER QUANTITY

* Is the common water source supplying sufficient water throughout the year?

* What is the nearest source supplying water (distance) in case the usual water sources run dry?

* How much water is collected per household? Is the water for bathing and laundry included? Ask at least 20 families randomly chosen in the community.
(Best to ask for the number of trips that is usually made per day, and the type of container (volume) used).

* Are skin problems among children very common in the community?

* Are there many people with eye infections in the community?

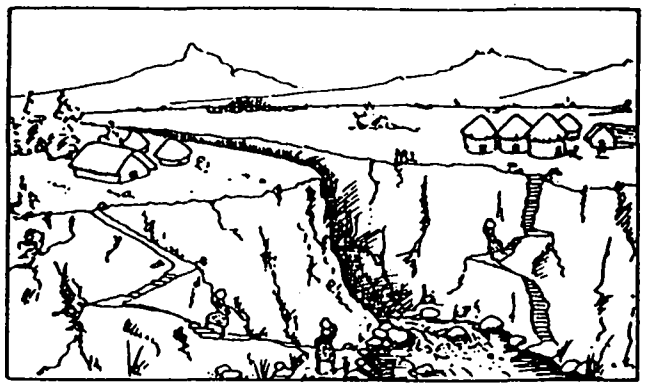
* In case rainwater is used: is the volume of containers or tanks usually sufficient to provide water during the dry season?

4.3 WATER COLLECTION

Burdens in water collection

* Drawing water from the sources is a heavy and tiresome job.

* The muddy surroundings at the source make water collection difficult and dangerous for old people.



Water collection is a tiresome job

For improvements of source and surroundings → Chapter 6

* A water lifting device (e.g. a pump) is present but people are not satisfied with its operation.

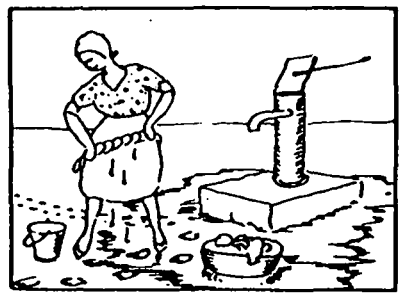
For improved bucket lifting and pumping → Chapter 8

* There are long queues at the source and therefore people have to wait a long time.

Long queues at the source

For reduction of waiting times at springs → Section 6.2

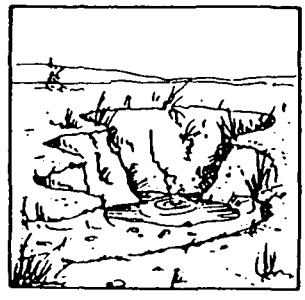
Facilities for bathing and/or laundry are missing at the water collection point.



No laundry facilities

For bathing and laundry facilities → Section 6.1

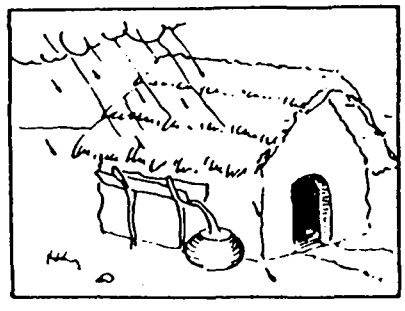
The inner sides of the well frequently cave in (collapse), making water collection difficult.



Water hole with caved in walls

For well lining → Section 7.4

Collection of rainwater is difficult; collection methods and storage facilities are missing.



Poor rainwater catchment

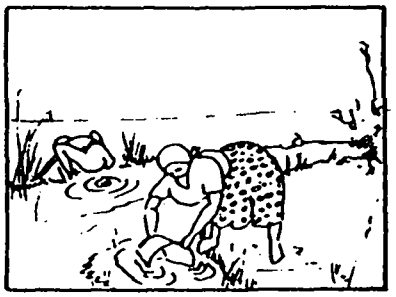
For rainwater catchment → Section 7.1

For large water containers → Section 10.3

Health risks in water collection

* People get infected with bilharzia or schistosoma because they come in contact with the water sources that contains bilharzia larvae. The longer the contact (e.g. in bathing) the higher the risks of getting the infection.

* Drawing buckets are dirty and contaminate the water



Transmission of schistosomiasis

For reduction of the number of schistosoma larvae	→ Section 6.3
For improvements of source and surroundings	→ Chapter 6

Surroundings of houses and water sources become muddy because of inadequate drainage. Pools and puddles are ideal breeding places for mosquitos.

For drains	→ Section 6.1
For gutters and roof catchment of rainwater	→ Section 7.1

MINIMUM CHECK-POINTS

WATER COLLECTION

ALL WATER SOURCES

* Are the surroundings of the source muddy with stagnant water giving a suitable environment for snails (responsible for schistosomiasis transmission)?
  (Ask also at the health centre or dispensary whether schistosomiasis is a problem)

* Are proper laundry and/or bathing facilities available at the source?

OPEN WELL

* Is the well properly lined and does it have a headwall?

* Is the drawing bucket properly placed to avoid contamination?

HAND-PUMPED WELL

* Does the handpump function properly?

* Are the people satisfied with the operation of the handpump?
  (Can children operate the pump?)
  (Ask 20 randomly selected persons)*

* Are there considerably long waiting times at the hand-pumped well?

RAINWATER COLLECTION

* Is the rainwater collected from a roof made of a hard, smooth material?

* Is the gutter system well designed and made of proper material (not too much spillage)?

* Is the spilt water surface runoff properly drained away from the source?

* Do not raise the expectation that all the operational problems of handpumps will be solved. Sometimes the solution is simple but often beyond the community's capacity.

4.4 WATER TRANSPORT

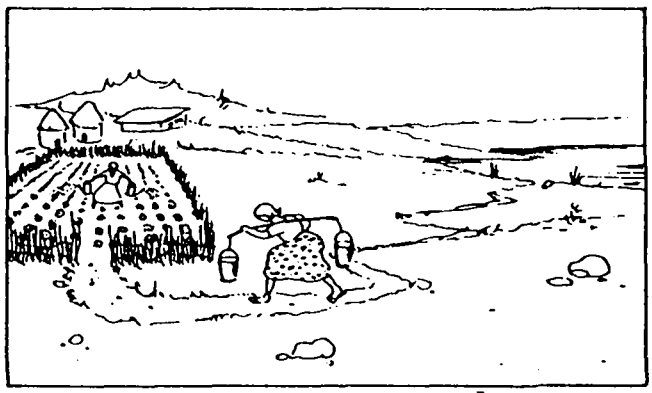
Burdens in water transport

* The source is far away; a lot of time and energy is spent on water collection.
* The source is difficult to reach; the track or path is steep, slippery or rocky.
* Some of the collected water spills during transport and more trips must be made.

A lot of water is spilt

For improvements in water transport by people, carts and animals → Chapter 9

* Carrying water to vegetable plots is an additional heavy job.



Garden watering is a heavy job

For drains to divert spilt water to vegetable plots → Section 6.1

For water lifting from wells and surface water → Chapter 8

Health risks in water transport

* Water carrying is a heavy job and leads to back-pains and headaches.

* The water gets contaminated during transport; dirt gets into the open containers.

* Transport containers are dirty and are not cleaned before use; the water gets contaminated.

For improvements in water transport by people, carts and animals and for improvements in transport containers.	→ Chapter 9

* Animals used for water transport get too close to the source and contaminate the water.

For source protection (fence and and gate)	→ Section 6.1

MINIMUM CHECK-POINTS

WATER TRANSPORT

* What is the distance from the community to the common source?
* Is it difficult to reach the source?
* By what means is the water transported to the homesteads?
* Is water carried to neighbouring vegetable plots?
* Do the people prevent the water from getting contaminated and spilt during the collection trip? How?
* Do the water drawers clean the containers before filling them?
* Does this rinsing water pollute the source?

4.5 WATER STORAGE

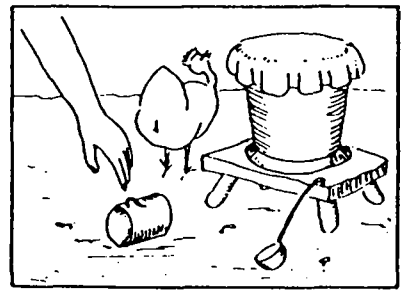
Burdens in water storage

* Water is not stored at all because people do not use storage containers; whenever water is needed it is fetched.
* Large storage containers are costly or not available.
* Drawing water from the storage containers without spilling water is difficult.
* Cleaning of the containers is difficult because of their size or shape.

For small and large storage containers and for safe drawing methods → Chapter 10

Health risks in water storage

* Water is stored in open, uncleaned containers.
* Water is drawn from storage containers with dirty ladles, dippers and mugs.



Mug and ladle become contaminated

For small and large storage containers and for safe drawing methods → Chapter 10

MINIMUM CHECK-POINTS

WATER STORAGE

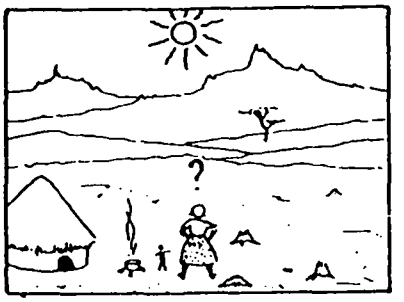
(If information is needed from the people, check with at least 20 randomly selected families)

* Are storage containers available or for sale in the community?
* Is water stored at household level?
* What kind of containers are commonly used (materials, volume)?
* Are the containers covered?
* How is the water drawn from the container?
* Is the drawing device kept in a proper place?
* Can the container easily be cleaned?

4.6 WATER TREATMENT

Burdens in water treatment

* People boil or would like to boil water, but boiling is expensive (cost of fuel) or makes the collection of more firewood necessary. Often they dislike the taste and temperature of boiled water.



Where to find firewood?

For improved fireplaces → Section 14.4

Health risks in water treatment

* The drinking water is not-treated at all: a health risk if source, collection and transport improvements are not (fully) effective.

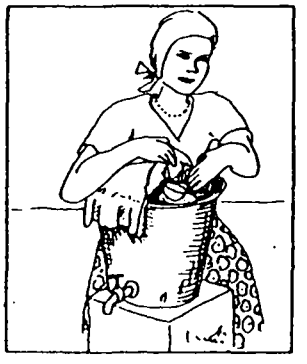
* The water is not properly and effectively treated.

* The water tastes of the chemicals used for treatment; people dislike the taste and therefore they go back to traditional sources.

For boiling, filtering and other proper treatment methods → Chapter 11

* Boiled water is cooled down to 40-60°C before it is poured into dirty storage vessels; then the effect of boiling water is entirely gone.

* The efforts of treatment are wasted, because the water gets contaminated afterwards during storage or use.



Why not using the tap?

For improved water storage → Chapter 10

MINIMUM CHECK-POINTS

WATER TREATMENT

* Is the piped water treated for before distribution?

* Has the water regularly been checked for the presence of bacteria?

* Is the water chlorinated?

* Has the water regularly been checked for the presence of chlorine at the tap?

* Do the people drink the chlorinated water or do they go for untreated drinking water?

* Do people treat the drinking water at home by:
  - boiling
  - filtering
  - adding chemicals
  - prolonged storage
  (ask at least 20 families)

* In case of home treatment, is it done properly and what are the problems related to the home treatment?

* Are proper containers (clean and with cover) used after home treatment of the water?

4.7 SANITATION

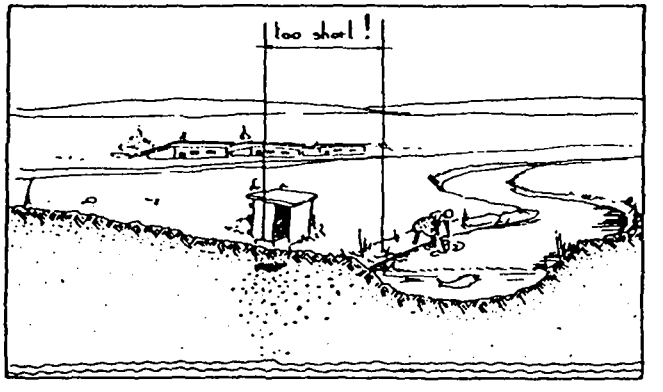
Health risks in sanitation

* People use the open field for defecating
* Some people have latrines, but others and children use the open field.

Health risks for all people

For correct defecation-practices in the open field → Section 12.1

* Some of the latrines are located too close to a water source.



Water source is contaminated.

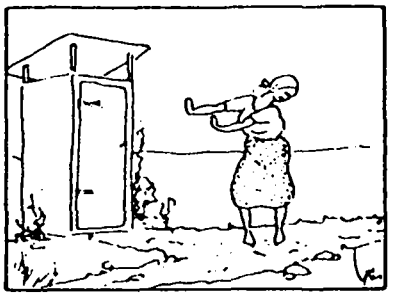
For correct location of latrines → Section 12.2

* Many flies and mosquitoes feed and breed in the latrines
* Latrines are fouled

For suggestions to reduce the insect problems and to keep latrines clean → Section 12.2

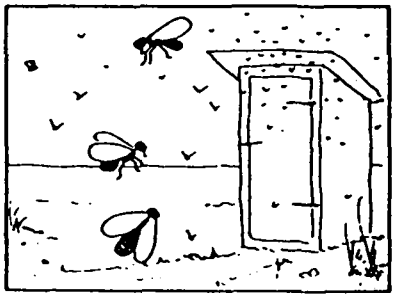
Burdens in sanitation

* There are many pit latrines and these are used. But the people strongly dislike the smell.



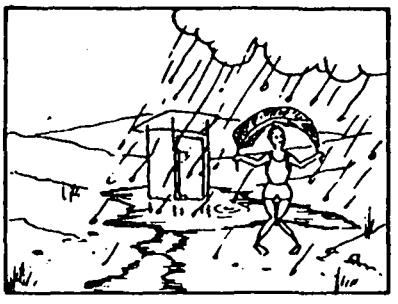
People dislike the bad smells

* There are many flies in and around the latrines.
Therefore, people may be discouraged to use the latrine. The flies may transmit diseases.



People find flies a nuisance

* The pits of latrines overflow during rainy periods or the surroundings are flooded, making it difficult for the people to use is. The environment will be contaminated causing a serious health risk.



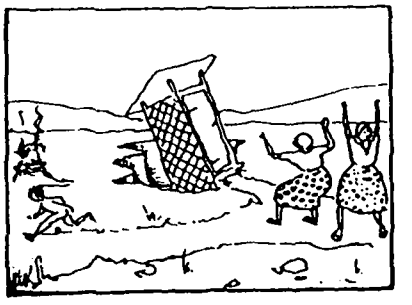
Overflowing pit make use of latrine difficult

* The capacity of pits is not sufficient.

* The latrines are difficult to clean.

* The floors of the latrines are broken or have cracks and small children therefore have fear to use the latrines.

* The sides of pits cave in. People can not use the latrine anymore and will either go to their neighbour's latrine or to the bush.



Collapsed latrine

For different types of latrines and pits for different circumstances, including suggestions for super-structures, slabs, and guidelines for location → Section 12.2

MINIMUM CHECK-POINTS

SANITATION

(Observe and/or ask at least 20 randomly selected families)

* Does the family have a latrine? If no, why not?
* What are the complaints related to latrines?

  e.g. - flies, mosquito nuisance

  - bad smell

  - overflowing pit during rainy season

  - caving in of pit during rainy season

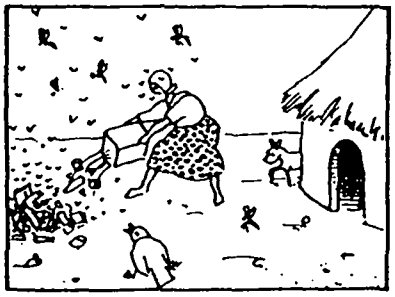
  - unreliable slab

* Do adults go to the latrine? If no, why not?
* Do children above 3 years go to the latrines? If no, why not?

4.8 HOUSEHOLD PRACTICES

Combined burdens and health risks

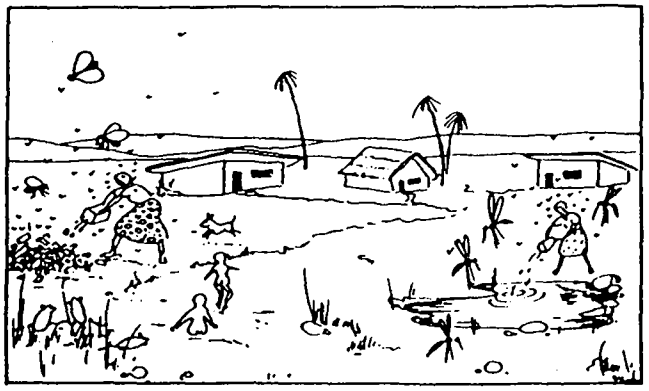
* Solid household waste is not collected and/or disposed of safely; where it is thrown it attracts dogs, rats, mice, crows and flies.



Improper waste disposal

* Household wastewater is not drained away properly; there are muddy pools around the houses.

* Stagnant water in wastewater pools and in clogged drains attractsmosquitoes for breeding



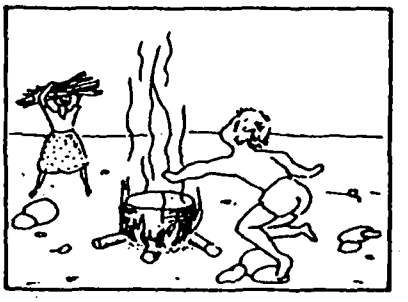
Unhygienic environment

For various solutions for waste disposal, including burying, composting, incineration and drainage → Chapter 13

* Even though the houses are kept clean there are flies, contaminating stored food, water and utensils.

For methods to keep flies away → Chapter 14

* Open fires are used: (i) children may fall into the fire, (ii) a lot of firewoord is required, and (iii) the house becomes very smoky.



Open fires cause accidents

For improved open fires and closed fire → Section 14.2

* There are many more problems that occur frequently at the household level. Visits to homes and extensive talks with housewives will clarify these problems.

For some improvements at house hold level → Chapter 14

MINIMUM CHECK-POINTS

HOUSEHOLD PRACTICES

(check per family)

HOUSEHOLD WASTE AND WASTEWATER

* Where is the solid waste disposed of?

* What is done with it after disposal?
  e.g. buried, covered with soil, burned etc.

* Is the disposal of household wastewater giving pools in the community?

INSECTS

* Are there many flies and mosquitoes around the house?

* Is the food protected against flies?

* Do the people in the family use mosquito netting for the beds?

OTHERS ISSUES

* Do the family have an open fire?

* Is there sufficient ventilation in the house?

* What kind of roofing material is used?

* Where are the kerosine, the pesticides etc. (safely?) stored?

PART III: TECHNICAL OPTIONS FOR SELF IMPROVEMENT

5. GENERAL REMARKS

5.1 AREAS IN WATER, SANITATION AND HYGIENE

The following subjects are described in this part:

- water quality
- water quantity
- water transport
- water storage
- water treatment
- sanitation
- waste disposal
- household practices
- general construction guidelines

Each subject has its own logo or symbol, which appears at the right top corner of each page.
The symbols have been summarized in the Introduction (Chapter 1).

5.2 MATERIALS AND LABOUR REQUIRED

Before deciding on the type of improvement and the technical options, the community should know what it will cost to build the new asset and also to operate and maintain it.

For example, a community may have enough money for the installation of a handpump but not for the necessary short and long term maintenance. In such a case it is better to look for and discuss other more feasible options such as a dug well with windlass.

When it concerns improvements for the individual household such as improved pit latrines or other sanitation or house hygiene improvements, the household should know how much it will cost. The promoted improvement will be copied only if the costs involved in the improvement are not too high in view of the income of the average household, otherwise other more feasible options should be introduced and promoted. Discussions with community groups on technology and finance may help in the selection of options.

In some communities it is difficult to mobilize the people to contribute free labour in the construction of water supply improvements, but instead people prefer to give extra money so that hired labour can do the job. Where the community members provide free labour it must be known how long the work will take; how many working days are needed for unskilled and skilled labour. This information is also needed to make a good work plan.

Required Materials

The descriptions of the technologies in part III are done in a way that a carpenter or a mason easily can list the required materials. Using the local market prices, they can then calculate the total estimated costs.
It is better not to underestimate these costs. Material prices always go up and the people may not agree to give more money for the improvements afterwards.
Best is to use realistic market prices and to add a certain percentage (10-30%) for inflation per year.

The costs depend on the availability of construction materials in the community or district. Therefore, the use of local construction materials whenever possible is a great advantage in availability and costs.

Example

The following table is an example of an estimated calculation on construction materials and costs for the improvement "Comprehensive Well Protection" (Section 6.1.2).

EXAMPLE

MATERIAL REQUIREMENTS AND ESTIMATED COST

For comprehensive well protection
well depth 12.0 metres
well diameter 1.0 metre

Compiled by: G. Ismael
Date: 12-08-88

item	no.	unit cost	cost
* bricks, stones or concrete blocks (0.2 x 0.1 x 1m) for headwall and foundation (depending upon height of lining)	60-100	....	....
* bags of cement for mortar, plastering	2-4	....	....
* sand (m^3)	2	....	....
* gravel (m^3)	2	....	....
* material for cover (wood, metal, sheets)	....	....	....
* hinges for cover	2	....	....
for fencing			
* wooden planks for gate	5	....	....
* wooden posts for gate	4	....	....
* hinges or pieces of car tyre	2	....	....
* fencing material (branches, poles and wire, bushes)		....	....
	Total cost		

(if materials cannot be bought in the year in which the cost were estimated, add 30% per year for inflation)

Estimate of required labour

For the organization of the work and the mobilization of the people who will be asked to contribute to the construction of the improvement, it is necessary to estimate the necessary labour days. If special skills are required this should be noted. The costs will rise if the skilled people are not available in the community but have to come from town or distant communities.

An example of an estimate of required labour is given below.

EXAMPLE

ESTIMATE OF REQUIRED LABOUR

For construction of a dug well
diameter: 1.0 metre
estimated depth: 12 metres

Made by: Peter Mahuru
Date: 03-01-88

Activity	Labour expressed in man-days				
	supervisor	unskilled labour	mason	carpenter	transp. +driver
0. site preparation	1	4	1		
1. digging the well	10	30			
2. collection of sand and gravel		6			2
3. production of concrete blocks (800)		24	8		
4. carpentry work including moulds				3	
5. construction of the lining	5	10	5		
6. construction headwall, platform and drainage	1	5	1		
7. construction of fencing	1	2		1	
Total	18	81	15	4	2

5.3 ORGANIZATION

People who contribute to the work are not available any time of the year. Farmers will give priority to working in their fields when they have to prepare their field for planting or when they have to weed or harvest. For other groups in the community other limitations regarding available time periods may exist. When planning and timing the community self-improvement, traditional ceremonies and funerals should be considered.

Skilled people such as masons and carpenters are often asked to assist in community improvements. Schools, dispensaries, etc. are built with their assistance. The community government should keep these very valuable persons enthusiastic by giving them a compensation either in money or kind, or by exempting them from other communal duties.

It is necessary to make a time planning and a workplan. Examples of these plans are shown on the following pages.
The time planning indicates what the sequence of the activities is and which activities cannot start before another activity is finished. If for instance, the gravel cannot be collected because there is no transport available, the concrete blocks can not be produced and the lining not constructed.

The workplan indicates the labour inputs that are needed at a certain moment in the time planning; who is needed when to do what. The workplan lists the different activities with the names of the people who will do the jobs. If people do not show up, the reason of absence should be recorded. Also the progress of the work, for example the digging of the well, could be monitored and recorded.
The workplan could be made and filled out by a person who is technically capable to supervise the work and on the other hand has a certain authority in the community, like a member of the Community Health or Water Committee. The community worker might also be a good person.

If for a particular reason the work can not continue, for instance due to shortage of materials, then the people who are supposed to report to provide free labour and the artisans must be timely informed so that they do not waste time and loose motivation by staying idle at the site until sombody comes to say that they can go back home.

Community Health or Water Committee

The Community Health Committee or the special Water Committee could take the responsibility of many of the organizational aspects. The committee should report to the community and community leaders.

Some points to remember in the organization of water supply and sanitation improvements:

- needed materials
- need for transport
- required skills
- required labour
- foreman/supervisor
- timeplan
- workplan with time schedule and needed people
- estimated cost
- financial control
- reporting to the community
- opening ceremony of improvement

EXAMPLE

TIME PLANNING

For construction of a dug well — Made by: Krishna Patel
location: Off-Mainstreet, near Health Unit — Date: 12-01-88
diameter: 1.0 metre
estimated depth: 12 metres

Acivity	Days	Week no's 1	2	3	4	5	6	7	8
0. site preparation	1	—							
1. digging the well	10			—	—	—			
2. collection of sand and gravel	2	—							
3. production of concrete blocks (800) and curing	8	—	—	—	—				
4. carpentry work including:									
- moulds	2	—		—					
- cover	1							—	
5. construction lining	5					—	—		
6. construction head-wall, platform and drainage	1							—	
7. construction of fencing	1							—	
8. opening ceremony									—

EXAMPLE

WORKPLAN

Made by: Krishna Patel
Date: 13-01-88

For construction of a dug well
location: Off-Mainstreet, near Health Unit
diameter: 1.0 metre
estimated depth: 12 metres

Activity 0: Preparation of the site

* cutting shrubs and trees
* removing roots
* levelling ground surface
* casting workfloor for production of blocks
* constructing small provisional shed

Time required: 1 day
Labour required: 1 supervisor
1 mason
4 labourers

Date: 01-02-88

Name	present 08.00 12.00	present 14.00 18.00	reason for absence	progress
1. Supervisor Mr.				
2. Mason Mr.				
3. Labourers a. Mr.				
b. Mr.				
c. Mr.				
d. reserve Mr.				

Activity 1: Digging of the well

Teams of 3 people will be formed: 1 digger, 1 puller and 1 for other jobs and who can rest. The people in the team rotate.

Time required: 10 days
Labour required: 1 supervisor
30 labourers

Date: from 15-02-88 to 27-02-88

	Name	present 08.00/ 12.00	present 16.00/ 18.00	reason for absence	progress (depth in m)
Day 1	1. Supervisor Mr.				
	Labourers a. Mr.				
	b. Mr.				
	c. Mr.				
	d. reserve Mr.				
Day 2	1. Supervisor Mr.				
	Labourers a. Mr.				
	b. Mr.				
	c. Mr.				
	d. reserve Mr.				
Day 3	1. Supervisor Mr.				
	Labourers a. Mr.				
	b. Mr.				
	c. Mr.				
	d. reserve Mr.				

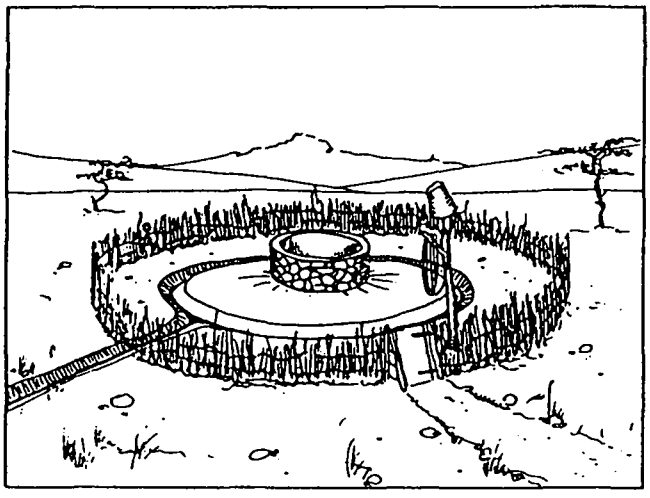
6. WATER QUALITY IMPROVEMENTS

6.1 GROUNDWATER PROTECTION

6.1.1 BASIC WELL IMPROVEMENT

This improvement option for wells is suitable for any kind of well, regardless of the diameter or depth. The protective measures described here should be considered as an absolute minimum:

* a drain, to drain off spilt water away from the well to a soak pit or to a vegetable garden;
* a rim around the well to avoid the inflow of spilt water and surface runoff;
* a fence with a gate to keep animals away from the well; local construction techniques may avoid the use of a gate. A live fencing of thorn bush suits very well;
* a post with hooks to hang drawing containers so that they do not get dirty when not in use.



Basic well protection

NOTE:

* Even with these improvements the well water may still become contaminated by the drawing container (e.g. from dirty hands), by dust and dirt falling into the well, and by seepage of polluted groundwater, therefore further improvements will be useful.

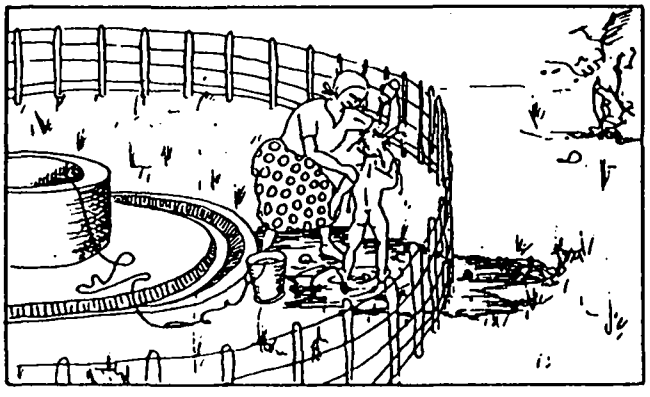
For estimates of materials and labour required	→ Chapter 5
For lining of wells	→ Section 7.4
For improved water lifting	→ Chapter 8

Maintenance:

* daily sweeping of the well surroundings;
* daily cleaning of the drain;
* regular checking of fence and gate;
* daily thorough scrubbing of drawing containers (with soap or clean sand).

Correct use:

* hanging the containers on the hook after use;
* body and clothes washing is not allowed within the fenced area.



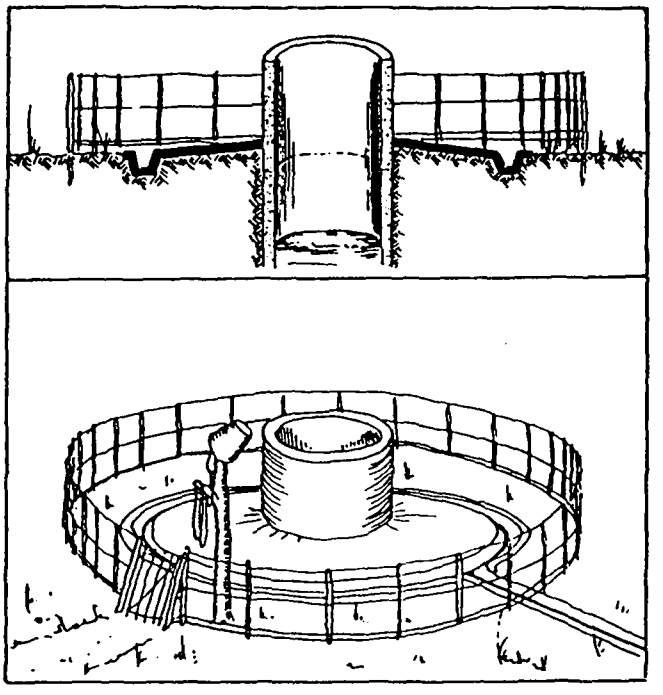
No bathing within the fenced area

For bathing and laundry facilities	→ Section 6.1

6.1.2 COMPREHENSIVE WELL PROTECTION

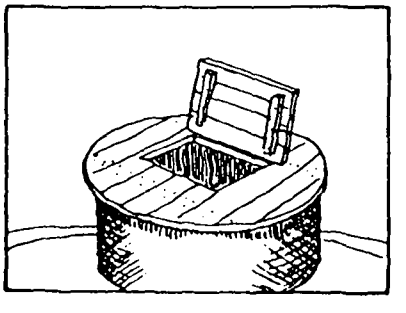
This improvement option for wells provides better and more comprehensive protection than the 'basic well protection'. It is more expensive and requires more maintenance. The protective measures are:

* an apron around the well to improve drainage of spilt water, to avoid seepage and to create a clean working space;
* a circular drain around the apron to improve drainage;
* a low wall or 'headwall' of 75 cm high around the well to avoid inflow of spilt water and to minimize the risk of children and animals falling into the well;
* a fence, a spilt water drain and a post with hooks as described with the previous option, 'simple well protection'.



Well protection

* a cover over the well to avoid dust, leaves etc. from falling into the well when it is not in use;



Well cover

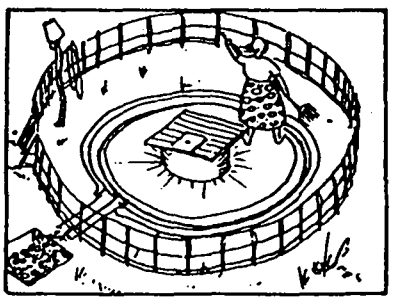
NOTE:

* The well water may still be contaminated by the drawing container (dirty hands).

For estimate of material and labour requirements	→ Chapter 5
For lining of wells	→ Section 7.4
For improved water lifting	→ Chapter 8

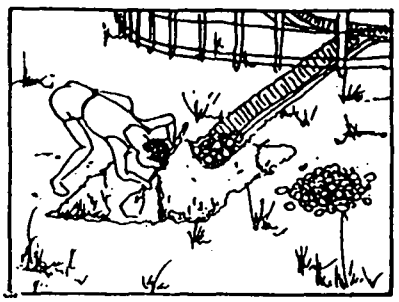
Maintenance:

* daily cleaning of apron and drains;
* regular checking of apron and drains for cracks and damage;



Keep drains clear

* regular cleaning of soak pit, if this is present;

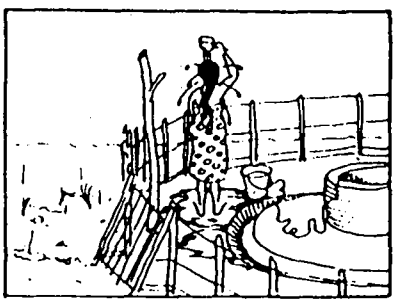


Remove silt and dirt from soakpit

* daily scrubbing of drawing containers and cover handles;

Correct use:

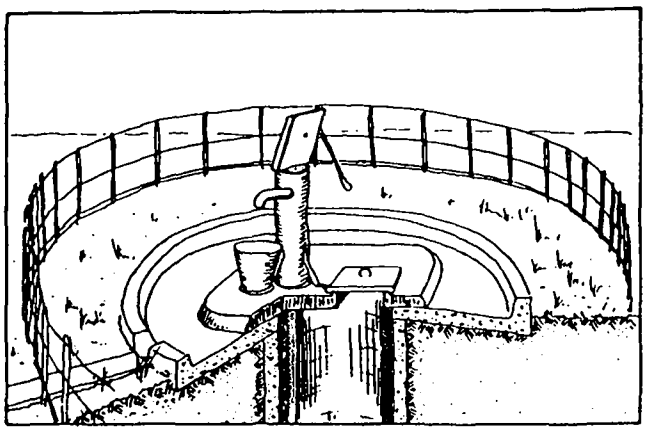
* hanging the containers on the hook after use;
* closing the cover after use;
* body and clothes washing within the fenced area is not allowed.



Incorrect use of well site

APRON OR WELL PLATFORM

The apron helps to keep the direct well environment clean and dry. It prevents spilt water from entering the well in case there are cracks in the lining. The apron drains the spilt water to a drainage channel because it slants slightly to that side.
The rim of the apron can be made of burnt bricks or cement blocks. The rest is made of a foundation of coarse gravel and rocks covered with a layer of mortar. The well-covering concrete block is also covered with some mortar to make it one part with the platform.

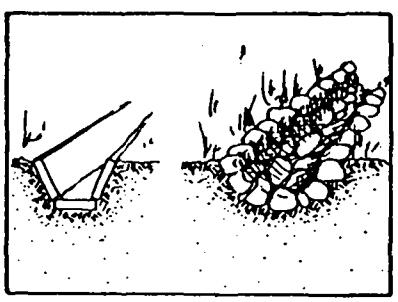


Concrete platform gives extra protection

DRAIN AND SOAK-PIT

Drains

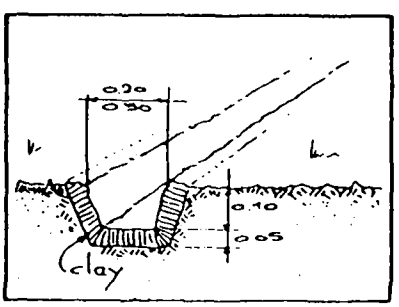
Drains can vary from simple trenches to concrete pipes. The choice of a particular type of drain will depend on the available financial and material resources. It must be realized that, where there is hardly any money to spend on materials, a simple system of dug spilt and wastewater drains, preferably plastered with clay, can already mean a great improvement.



Drain construction

Size

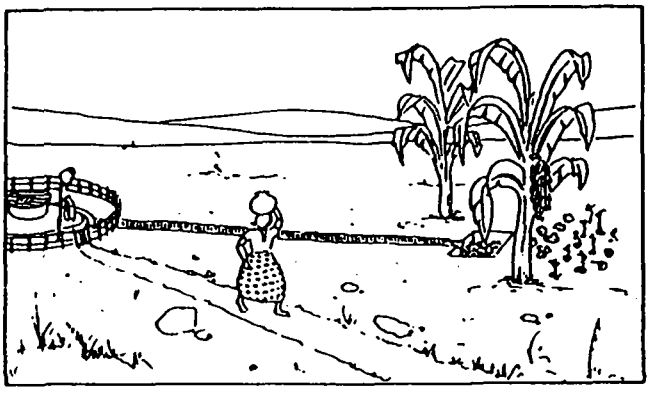
The size of drains will depend on the quantities of water flowing through them. Generally, a depth of 0.1 m and a width of 0.2 to 0.3 m will be sufficient.



Size of drains

Length

A drain that leads spilt water away from the well should be at least 10 m long, to minimize the risk of contamination of groundwater. Where the drain ends the water flows freely or flows into a soak-pit and seeps into the ground.

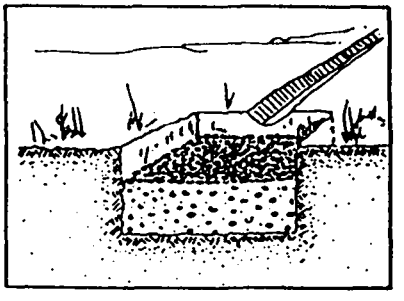


Length of drainage channel

Soak-pits

At the end of a drain the soil will be muddy, and especially if the soil is not permeable, pools with stagnant water are formed. This may pose a health risk. A soak-pit can solve these problems.

A soak-pit is a pit dug at the end of a drain which is filled with coarse gravel of more than 20 mm diameter. Generally, a soak-pit of 1 m^2 and 0.75 m deep will be sufficient. The water drains into the pit and seeps into the ground through the sides and the bottom. The size of a soak-pit will depend on the permeability of the soil and the quantities of water being drained. If the area around the pit becomes muddy or if pools start appearing, the pit should be enlarged.



Soak-pit

Regular cleaning of the pit is needed because mud and dirt may block the seepage. Additionally banana trees or trees like eucalyptus could be planted at the end of the drain. These will use up much of the water.

BATHING AND LAUNDRY FACILITIES

Where bathing and/or laundering takes place at or close to the well or any other source, proper facilities must be provided to prevent contamination of the water source.

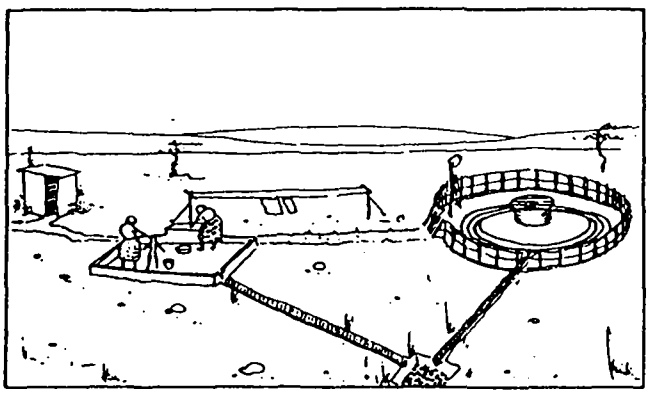
Having that purpose in mind, bathing and laundry facilities must always be provided with the following:

Drains

Drains lead wastewater away from the well to prevent dirty, used and sometimes soapy water from flowing into the well or the water collection point.

Apron

A hard, smooth surface (apron or working place) to facilitate drainage and to prevent wastewater seeping into the ground, close to the well or other water source.

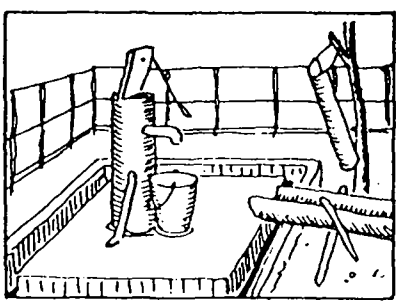


Location of bathing and laundry facilities

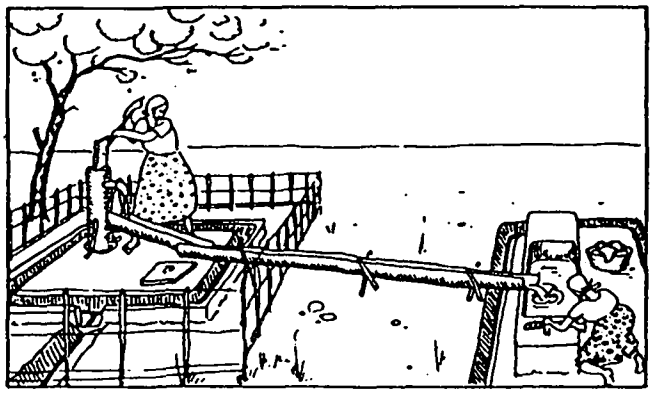
The location of bathing and laundry facilities must suit the users, while at the same time minimizing the risk of polluting the water source.

Apart from these basic requirements for bathing and laundry facilities, the users may need additional equipment or facilities such as water storage tanks, raised platforms or "washing stones" for laundry.

If bathing or laundry facilities are located at some distance from the source, sometimes a small pipe or gutter could lead the water to a basin.



Gutter system



Water is led to washing site.

For bamboo water pipe system → Section 9.5

For drains → Section 6.1

6.2 SPRING IMPROVEMENT

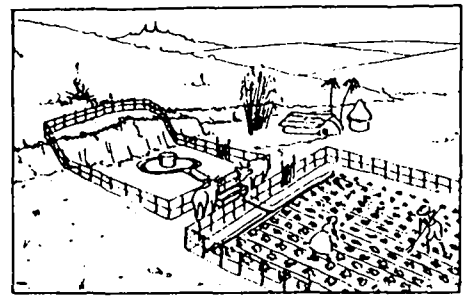
6.2.1 SPRING PROTECTION 1

This option for spring improvement is meant for springs in flat areas. In such circumstances the water is generally collected from a small pool formed by the spring. If the spring is located at an even slightly elevated location, it is better to build a small springbox or an improvement like the "spring protection 2" and have the tap at some distance to avoid contamination of the source.

The measures for "Spring protection 1" are simple:

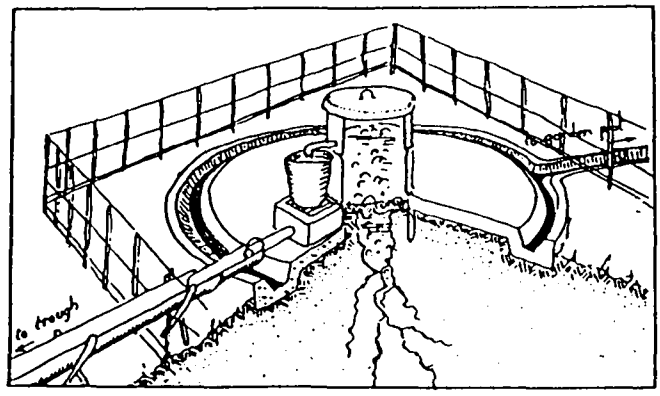
* a fence (e.g. thorn bush) around the spring area to keep animals away;

* a channel to drain off spilt water to a vegetable/fruit garden or to a soak-pit;



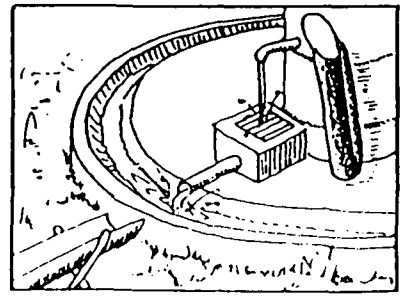
Proper fencing

* a large diameter pipe or a small diameter (0.6 m) concrete ring placed vertically in the soil at the eye of the spring, to avoid contamination of the water. The water is drawn from the topside of the pipe.
An overflow must be provided to allow excess water to flow from the spring. If the waterflow is obstructed it may seek other ways into the subsoil and develop a new spring elsewhere. The overflow may feed a trough.



Spring water protection

* a circular concrete apron around the spring.



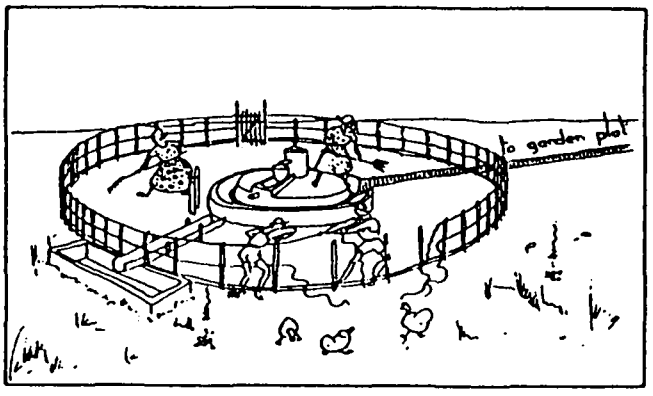
Drainage of excess water

* If the water level drops, the cover can be removed and the spring acts as a well. A bucket should then be used.

For estimate of materials and labour required	→ Chapter 5
For drains and fencing	→ Section 6.1
For apron	→ Section 6.1

Maintenance:

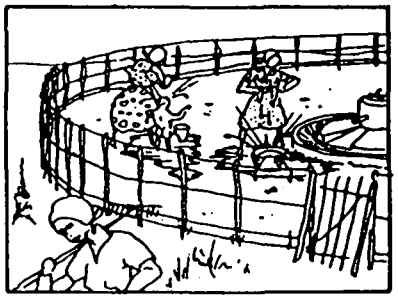
* regular cleaning (daily) of the apron and the area within the fence.
* daily cleaning of the drain
* checking of the fence
* daily cleaning of the drawing container



Proper maintenance

Correct Use

* no body and clothes washing within the fenced area

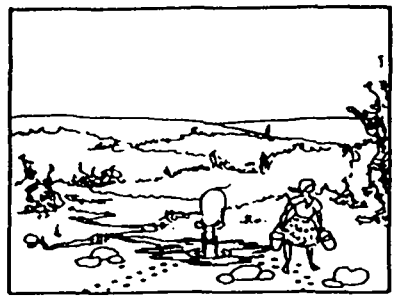


Incorrect use

6.2.2 SPRING PROTECTION 2

This option for spring improvement is meant for springs in sloping sites.
The improvements are fourfold:

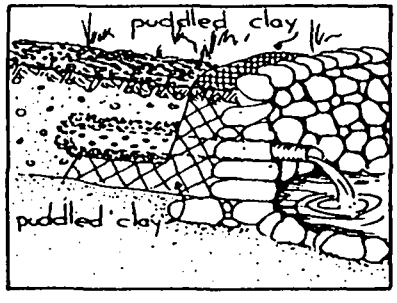
* avoiding contamination of the spring water;
* improvement of muddy unhygienic spring surroundings;
* improvements of the yield of the spring;
* stopping or avoiding erosion.



Unprotected spring

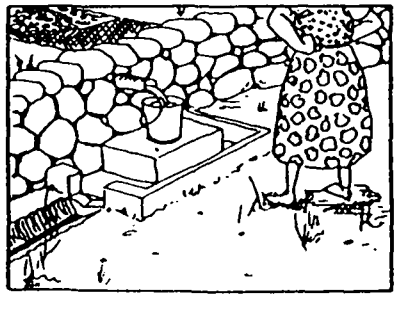
The measures, in order of construction are:

* a small trench of 2 to 5 m from the eye of the spring downhill; a pipe with small holes is placed in this trench inbedded in a layer of coarse gravel (8-20 mm) and covered with fine gravel and puddled clay. The depth will depend on the nature of the spring and subsoil.



Spring-filter construction

* a 5 cm thick layer of clay behind the retaining wall to avoid leakage;
* a retaining wall with a hole for the pipe and a platform where people can collect the water. The size of the wall (depth and width) depends on the state of the spring and the subsoil; it should reach until stable soil. It is even better to construct the collection pipe and platform at a larger distance from the spring.

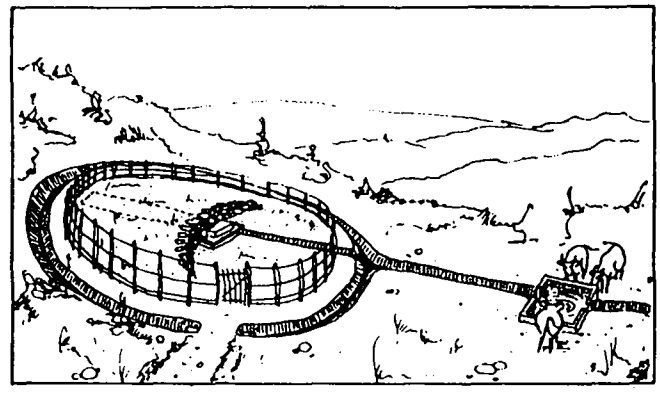


Wall with platform

* a drain uphill from the spring, to avoid erosion and seepage of contaminated water;

* a drain, to drain off excess and spilt water, for instance to a vegetable garden or a place for watering cattle;

* a fence with gate to keep animals out. If possible the fencing could be extended to better protect the groundwater.



Fenced spring site

For estimate of materials and labour required	→ Chapter 5
For drains and fencing	→ Section 6.1

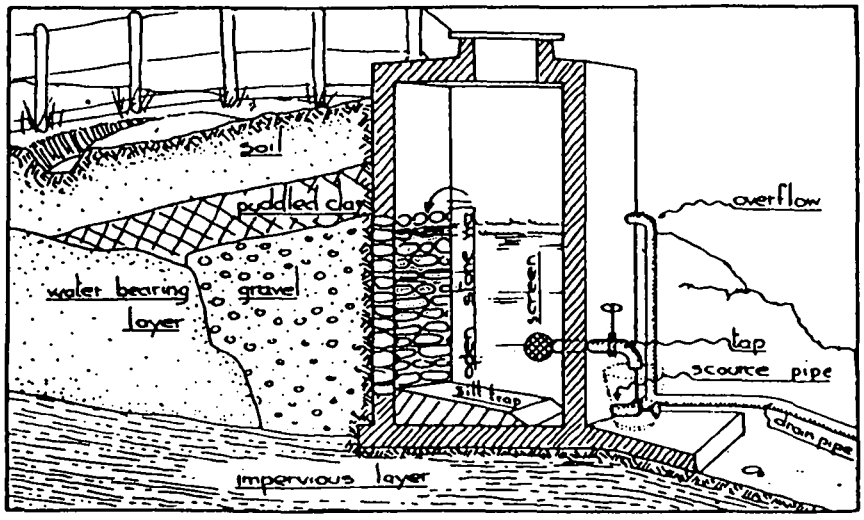
Maintenance:

* a daily cleaning of drain, storm water drain and platform

* occasional check of the retaining wall for cracks which need to be repaired.

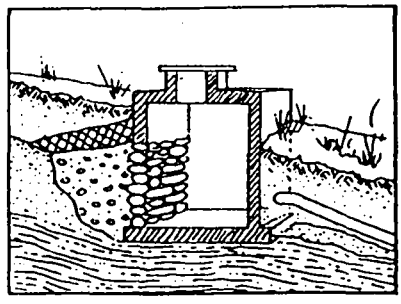
6.2.3 SPRING BOX

A spring box or reservoir can serve various purposes. When a spring has a limited capacity it takes a long time for containers to fill up, resulting in long waiting times. Moreover, people may not bother to clean their containers to limit wastage of water, which may cause health risks. A spring box will collect water during the times that the spring is not used. The spring box can serve as a 'silt trap' at the same time: particles present in the water will settle at the bottom of the reservoir.

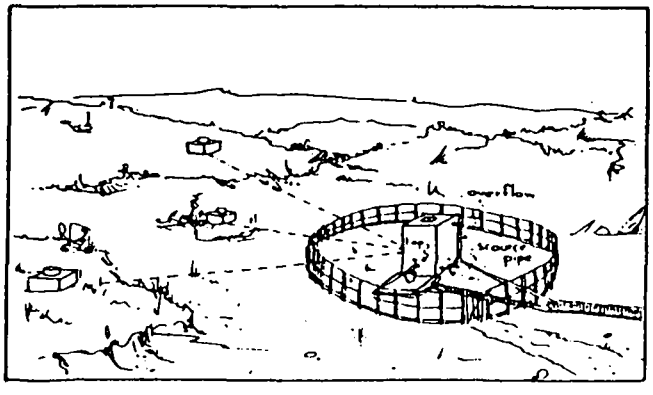


Spring box gives good protection of safe spring water

In case there are several springs in an area, each could be provided with a small spring box. From these small spring boxes, pipes could lead the water to a central, larger reservoir from which the water can be collected. Preferably each spring should have its own inlet into the central reservoir.



Small spring box



Several spring boxes with central reservoir

If the central reservoir is far away from the community, the water can be piped to a storage tank constructed at a more convenient location in the community.

At the collection point the protective measures described in the previous option for spring improvement must be provided: platform, drains, fence and gate, and a storm water drain above the spring.

In case more springs are connected a storm water drain must be dug around each of them. The area can be further protected with a bund (using the material from the ditch) planted with hedge.

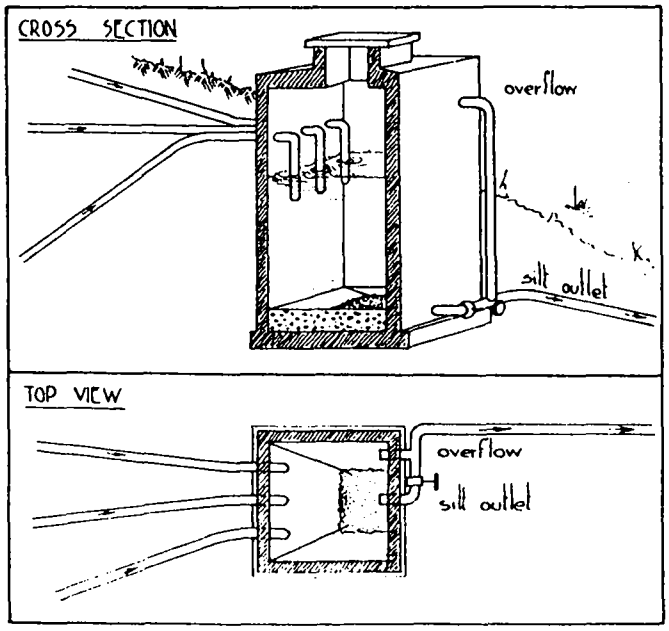
Construction:

Advice on design and construction is needed.

For estimate of material and labour requirements	→ Chapter 5

Maintenance:

* regular inspection of the outside of the spring box, for leaks;
* regular inspection of the inside;
* regular cleaning of mosquito screens;
* yearly removal of silt, collected at the bottom;
* daily cleaning of platform and drains.



Detail of central reservoir

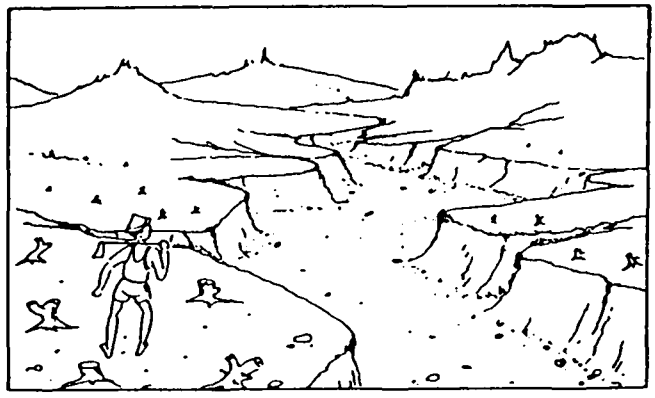
6.3 SURFACE WATER PROTECTION

Often the surface water is polluted upstream because people use the water for all kinds of activity such as bathing and washing. Defecation is also often done in or nearby the stream. The water does not only become dirty, but drinking this water is also a health risk. There are several solutions, such as infiltration wells, to avoid contamination and pollution by people.

For infiltration wells → Section 6.4

The surface water may also become unsafe for drinking because farmers use pesticides and insecticides that get into the water, or factories dump chemical waste in the stream or lake or at a site from where it may leach into the ground or surface water. It may occur that suddenly many dead fish float on the surface of the water. This indicates that the water contains toxic parts, and that the water should not be used for drinking anymore.
The incident must be reported immediately to the district health authorities for action. Measures are beyond the capabilities of the community. A community by-law could forbid use of the lands close to the surface water for agriculture or at least forbid use of chemicals in agriculturing these lands.

When the quality of the riverwater is poor and the water is turbid, improvements could be made by prohibiting or reducing the cutting of trees. This becomes more difficult if the river water comes from far away, because then many other communities should be involved.
Measures to reduce the amount of firewood needed help to solve the problem.



Deforestated land

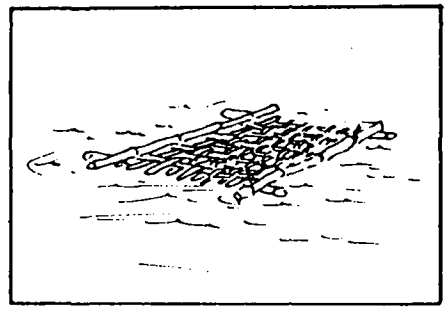
For improved fireplaces → Section 14.4

Planting more trees also helps also to overcome the problem. The department of forestry could be contacted for advice and assistance.

Community efforts in reafforestation

Schistosomiasis or bilharzia

The life cycle of the schistosoma depends on the presence of specific snails in the surface water. If the number of these snails is reduced, the spread of the disease will also be less. The snails can easily be trapped on mats woven from palm leaves, size 1 x 1 m, placed in surface water. The mats are regularly checked for snails. The attached snails are removed and killed. This exercise could be part of a school hygiene programme. The schistosoma larvae can be made visible to show that the snails are infected.



Palm leave mats help to reduce the snails

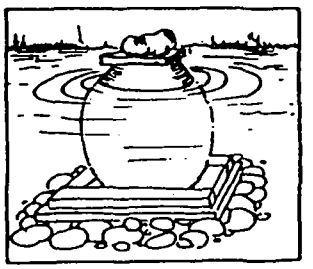
If people have to come in contact (e.g. when collecting water or laundering) with schistosoma-infected surface water, the water contact period should be as short as possible to reduce the risk for infection.

If schistosoma-infected surface water is used as drinking water source, prolonged storage of at least 24 hours should be used to let the larvae die off and so to cut the transfer of the disease.

6.4 SURFACE WATER INFILTRATION

6.4.1 SURFACE WATER JAR-FILTER

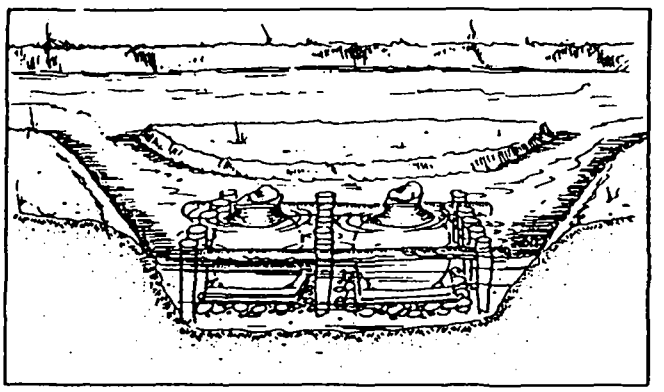
This filtering option provides a way to obtain clear water from muddy surface water sources such as rivers, irrigation channels, ponds etc. The muddy water is filtered through the (unglazed!) sides of a porous ceramic or clay jar.
This could be a simple small household jar, with a tightly fitting cover, made heavier with stones to keep it from floating or being carried away. Also a bigger jar could be permanently placed for use by a larger number of people.



Clay jar water-filter

Location of jar-filters

The location of the jars should be where the force of the current is low. It is also possible to dig a diversion channel by the side of the river or channel, in which the jars are placed.
The time it takes for the jar to fill up will depend on its size, the permeability of the material and the turbidity of the water.



Diversion channel with clay jars

NOTE:

* This option is not meant to purify contaminated water. Though some disease-carrying organisms may be stopped by the filter, the water cannot be considered 100% safe.

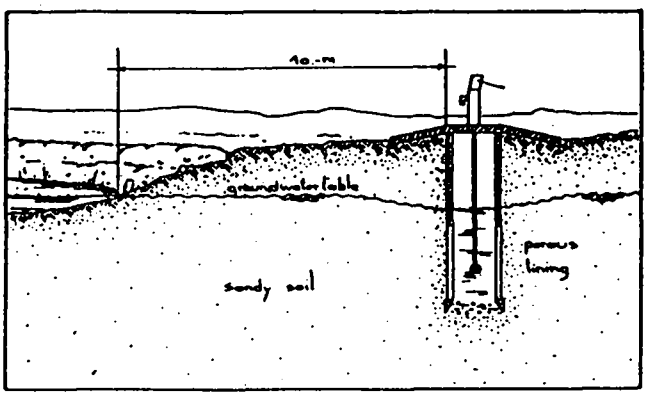
For water treatment at home → Chapter 11

Correct use:

* replacing cover after use;
* using clean hands and containers when drawing water from the jar;
* weekly cleaning of the outside and the inside of the jar using a brush and clean water.

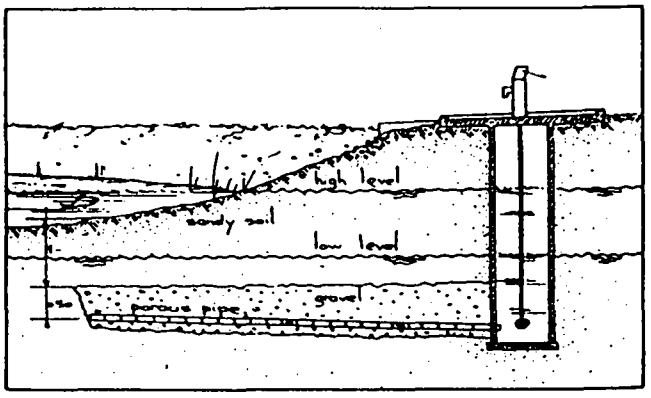
6.4.2 INFILTRATION WELL

Infiltration wells can be constructed along the banks of rivers, lakes, ponds and other sources of surface water. The soil and gravel of the riverbed between river and well acts as a filter. The water from the well will be safe for drinking provided the soil is not too coarse and the well is placed at same distance from the river (some 10 m). If the well is dug deeper than the bottom of the riverbed it may supply water even when the river runs dry.



Infiltration well

If the soil between the surface water source and the well is not sufficiently permeable, the yield of the well can be improved by the use of galleries. Galleries are perforated or slotted pipes (pvc or metal) that are laid underneath the river bottom to collect water. The pipes end in the well.



Infiltration well

Infiltration wells are only feasible if the soil is permeable. The permeability can be determinded by digging a test hole. Infiltration wells are of course not feasible by the sides of lined irrigation channels.

Digging, construction and protection of infiltration wells are the same as for ordinary hand dug wells. However, the walls of infiltration wells should be made of porous lining. This lining can be made out of honeycomb brickwork, quarry stones or porous concrete.

For wells and well-lining → Section 7.4

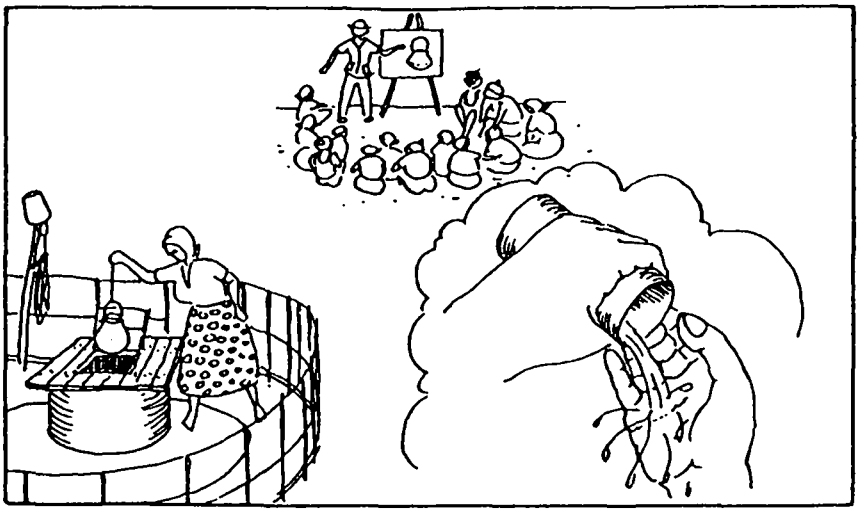
For well protection and maintenance → Section 6.1

6.5 CHEMICAL WATER TREATMENT AT THE SOURCE

Disinfection of the water at the source should only be considered as a temporary measure in case of emergency e.g. diarrhoeal disease outbreaks (cholera/typhoid). Pot chlorination may be an appropriate solution under such circumstances.

For chemical water treatment → Section 11.2

Chlorination could be additional but should never replace source protection and efforts to improve hygiene practices.



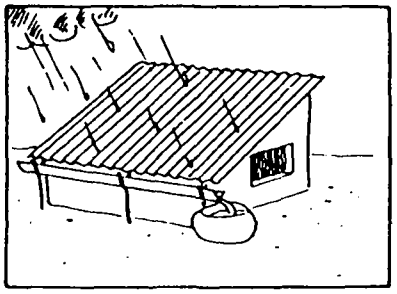
Combined measures for health effects

7. WATER QUANTITY

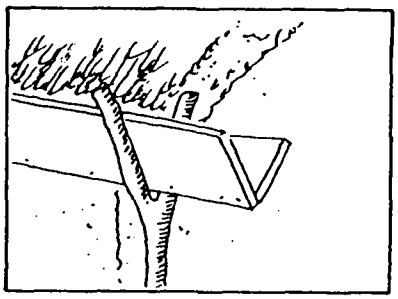
7.1 RAINWATER

7.1.1 ROOF CATCHMENT

In areas with frequent or seasonal rainfall, rainwater can be collected from roofs of houses, schools and other buildings. When properly stored, water collected in the rainy season can be used in the dry season. Roofs covered with tiles, corrugated asbestos cement or galvanized iron sheets are most suitable for roof catchment. Thatched roofs (palmleaves, straw, grass) are less suitable as they will retain about half of the rainfall.



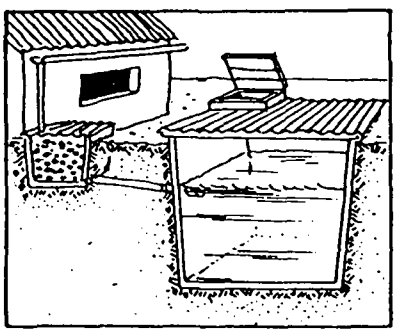
Rainwater catchment from hard roof



Rainwater catchment from thatched roof

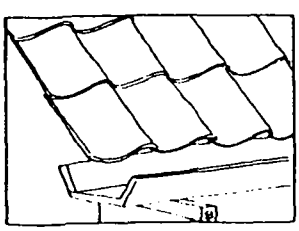
There are two methods to "catch" the rainwater.

* The first method is by way of a gutter attached to the roof with a downpipe that leads to a storage container or underground tank.

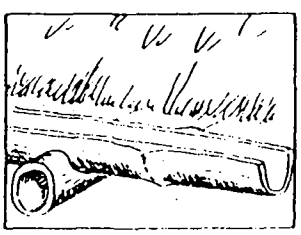


Gravel filter and underground storage

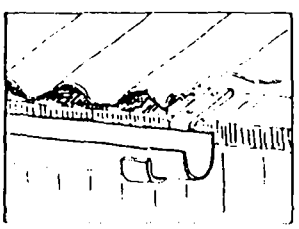
Gutter systems



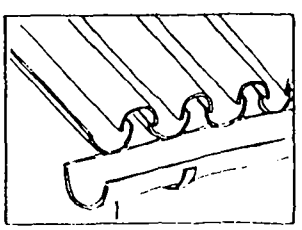
Timber



Bamboo

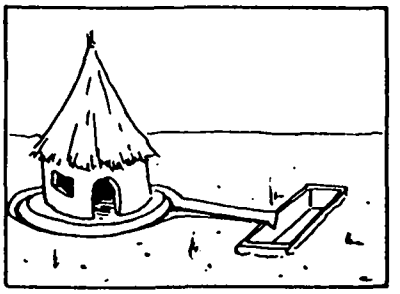


Metal



Asbestos cement

* Another method is to construct drains around the house or building, leading to a storage tank. However, the rainwater caught on the roof still comes in contact with the ground. The collected water will always be highly contaminated, and also dust and other dirt from the roof and the drain will be picked up by the water flow. To avoid too much evaporation the storage tank could be covered.



Indirect roof catchment

Rainwater directly collected from a clean roof and stored in a clean container is quite safe for consumption.

Have the roof and gutters cleaned before the rain starts.

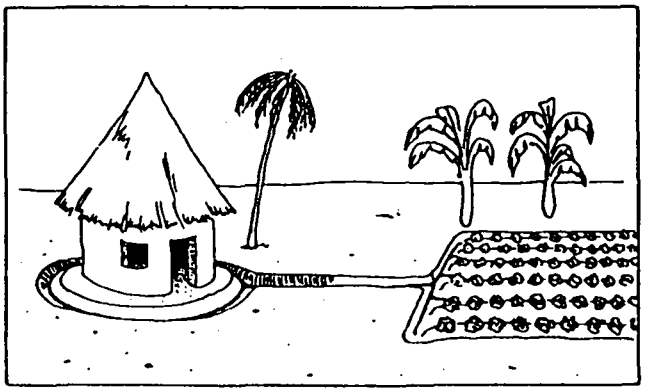
It is advisable to let the first rain wash roofs, gutters or drains (first 5-10 litres, also called "foul-flush" is sufficient) before starting to collect the water.

For rainwater storage containers → Chapter 10

For drains → Section 6.1

NOTE:

Even if storage of rainwater is not necessary or feasible, there are good reasons to construct gutters and/or drains. When rain is allowed to run freely from the roofs, the area around the houses can become muddy (a health hazard and a nuisance) and walls and foundation of the house may be damaged. If rainwater from roofs is not stored, it can be drained off to a (vegetable) garden, to a soak-pit, or to a river or stream nearby.

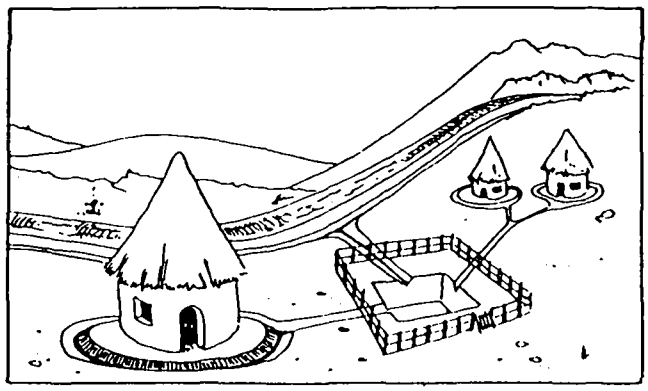


Drainage of rainwater from the house

7.1.2 SURFACE RUNOFF WATER

Roads and other hard ground surfaces such as school playgrounds, generally collect a lot of water during heavy rainfall. In areas with water shortage during part of the year, this water could be stored for dry periods.

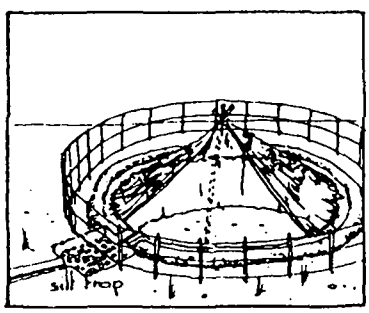
Ditches along the road or around the playground can lead the water to one or more collection basins. These basins could be simple pits plastered with a layer of clay or cement mortar on the bottom and walls to avoid seepage of the collected water.



Runoff water collection

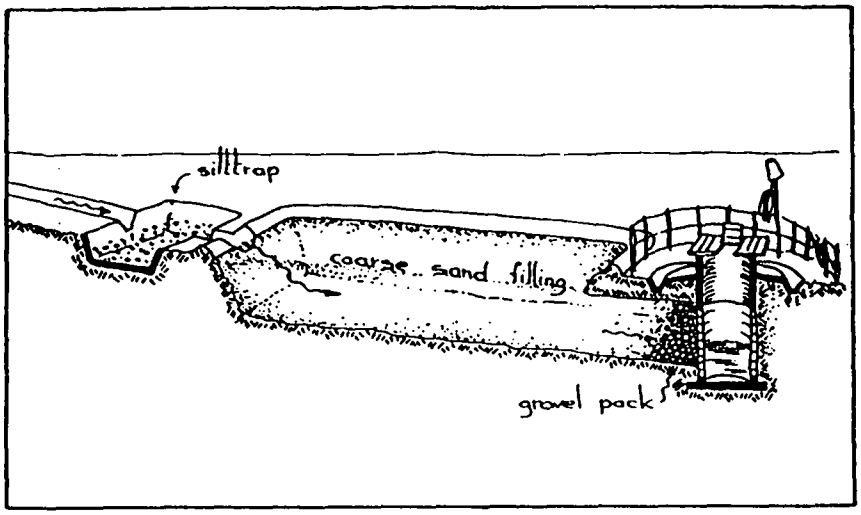
The quality of the water stored in the tank improves as time passes. However, the water in such an open tank will again become polluted. Moreover, a considerable quantity of the stored rainwater will disappear through evaporation.

A considerable improvement can be obtained by passing the collected water through a simple roughing filter (filled with gravel and coarse sand) and covering the tank. The silt trap must be cleaned regularly.



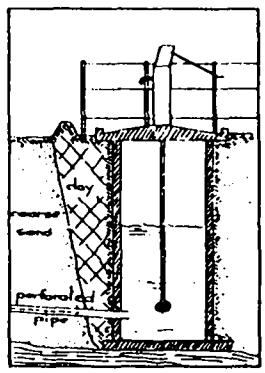
Gravel filter and covered storage tank

The collection basin can also be filled with coarse sand and be equipped with an extraction well at one side. The sand acts as a purifying filter and will limit evaporation. The storage capacity of a basin filled with sand is about 30% of the basin volume. The basin is then called an infiltration basin.



An infiltration basin stores and treats the water

An abstraction system must be constructed before the pit is filled. It may consist of one or more perforated PVC or metal pipes which are placed in the infiltration basin and end in the abstraction well itself, in which a pump can be installed. Another option is to construct the abstraction well as a lined dug well.



Abstraction well with perforated gallery

The total area of the basin needs to be protected and spilt water must be drained outside the basin area. This requires careful construction of the abstraction well, the apron, the drain and the fence, as well as careful consultation with the community.

For infiltration wells → Section 6.4

For porous lining of the wells → Section 7.4

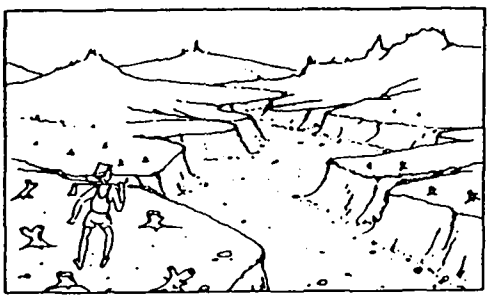
For well protection → Section 6.1

7.2 SURFACE WATER PROTECTION

The amount of water that flows in a river or stream varies during the year. In the dry season the river may become completely dry. It does not rain and the groundwater sources that feed the river run dry.

Erosion

If there are no grasses, shrubs, trees etc. that cover and hold the soil, during heavy rains the topsoil may be removed by the surface runoff. The result is that rainwater does not infiltrate into the soil during rains but almost entirely runs off. This erosion problem is shown by the rivers and streams that have very turbid water during the rainy season.



Cutting of trees results in high runoff flow and topsoil and vegetation is removed.

Re-afforestation

The big variation between the amount of water that flows in the river during rainy season (much water) and during dry season (river is dry or almost dry) may be improved by planting more trees and shrubs upstream of the intake. The vegetation and the topsoil help to retain the groundwater and release it slowly over a long time. Several types of trees are known to grow fast and are therefore very suitable. For information and support on re-afforestation (planting trees) the Department of Forestry could be contacted.

Tree planting is encouraged because trees help retain the groundwater

The need for firewood is mostly the reason for cutting the trees.

For improved fireplaces → Section 14.4

Planting more fast-growing trees around the house may help in the supply of firewood.

7.3 SURFACE WATER

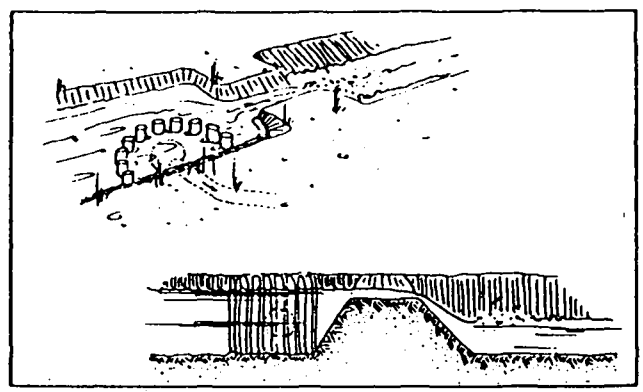
Water can be abstracted from a river or stream and stored in a natural or man-made infiltration basin. This process serves two purposes: the water stored in periods of high flow can be used in periods when the river runs dry, and the river quality will be greatly improved by the filtration process. Thus, the infiltration basin may be a good option to provide safer water throughout the year.

Intake by gravity or pump

The water may be abstracted from the river via a pipe or a channel and flow to the infiltration basin by gravity flow. In other cases a pump may be required.

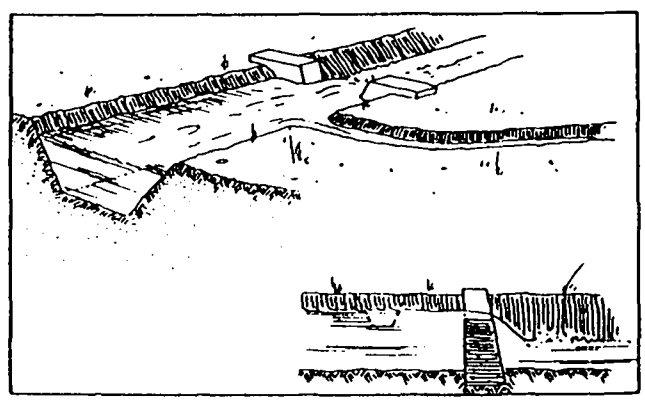
Weir to improve abstraction

Construction of a small weir in the stream or river will make the water flow more easily into the pipe or channel.



Small weir downstream of intake

The weir may be constructed in rock and quarry stone but particularly in rivers with a strong current a concrete structure will be needed, for which engineering advice is required.



Concrete weir with side channel

Pretreatment

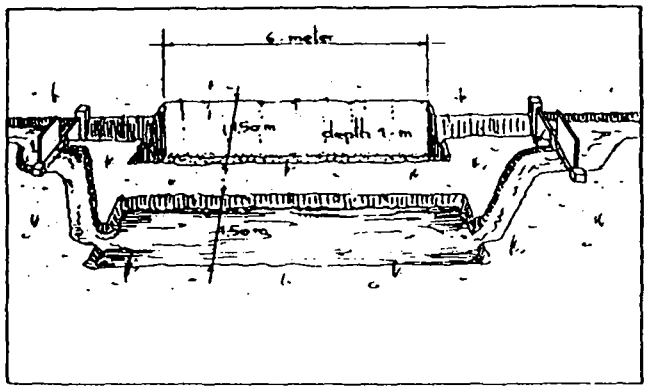
Very muddy river water will quickly clog the surface of the infiltration basin. This problem can be solved in two ways:

1. sedimentation basin

2. horizontal roughing filter

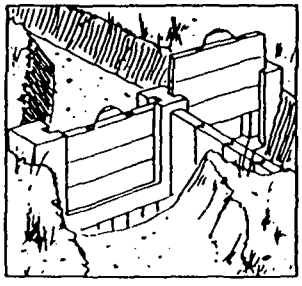
1. Sedimentation basin

The size of a sedimentation basin depends on the volume of water that passes through and the amount of silt present in the surface water. The more silt, the longer the water should remain in the basin, and therefore the larger the basin. The surface area (m^2) should be about 5% of the amount of water (m^3/day) to be treated.



Typical rural sedimentation basin

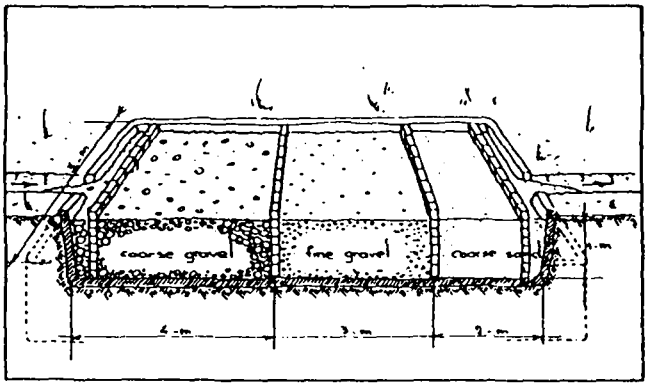
Best is to build two similar basins. Whilst water is passed onto one section, the other section is allowed to dry. After removing the dried silt, which can be done manually, water is passed to the cleaned section and the other is allowed to dry. Depending on raw water quality, cleaning will be needed every few days, weeks or months.
An open brickwork wall on the inlet side of the filter will equally distribute the water over the full width.



Construction detail

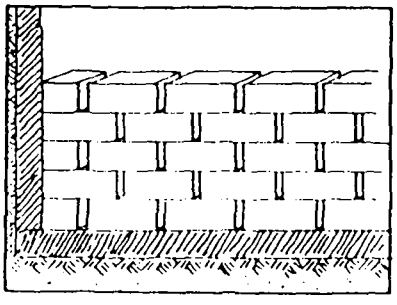
2. Horizontal roughing filter

Before the water reaches the infilration area it can be passed through a roughing filter. That is a basin filled with two or three types of gravel placed after each other, decreasing in size. Most of the mud present in the raw water will deposit on the gravel. The out-flowing water will be much cleaner and clogging of the infiltration surface will occur at a much lower rate.



Typical rural horizontal roughing filter

The disadvantage is that the gravel needs to be taken out at regular intervals (per half year to one year, depending on silt load of surface water) to be washed to remove the deposits.

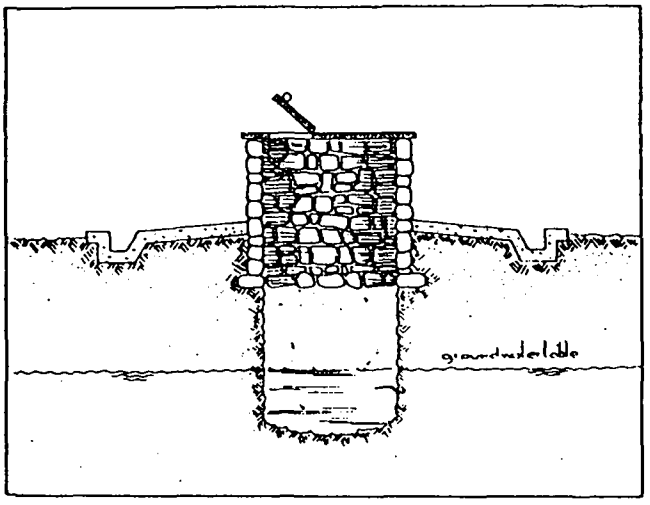


Open brickwork as separation wall

7.4 GROUNDWATER

7.4.1 HAND-DUG WELL

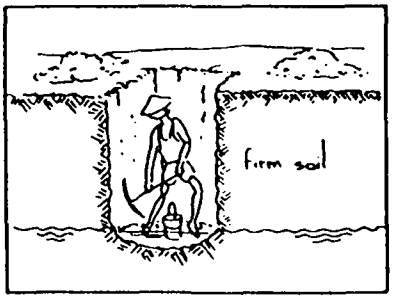
Hand-dug wells can be constructed in areas where the water-bearing layer is not too deep. Generally no sophisticated equipment is needed for construction. Access to the well is very simple. Water lifting devices can be used. Dug wells, because of their large diameter, may act as water reservoirs. This is particularly useful in areas where the inflow to the well is low, and therefore boreholes (or drilled small diameter water-holes, see section 7.4.2) cannot meet the demand of water.



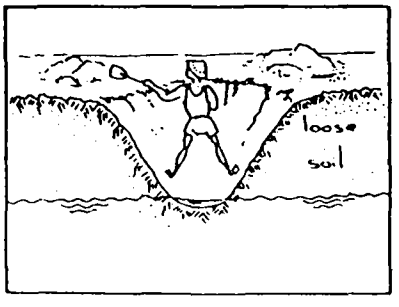
Shallow dug well partly lined with stones

Digging of wells

Wells in loose and sandy soils tend to cave in and may need a lining made out of bricks, stones or concrete. The easiest way to determine the need for lining and the required depth, is to look at other wells in the area. If there are no wells in the area, test digging/drilling will be necessary. The water can then also be tested for taste.



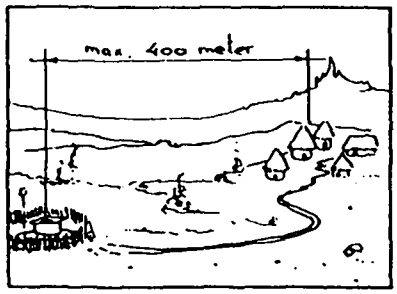
Stable soil



Loose soil

Location of wells

The community should be asked where it would prefer to have the wells located. The people may have different reasons for their choice. The selected sites may not all be suitable for a well-location. If the test for availability and depth of groundwater gives negative or poor results, or pollution sources are nearby, the selected well-site should be left out and another more suitable site be looked for and checked for suitability. Perhaps external expertise could assist in assessing whether the selected site would ensure qualitative and quantitative reliability of water supply. The final decisions are to be taken by a general community meeting.



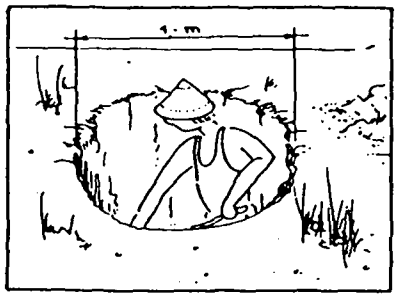
Distance between well and users

Number of wells

The number of wells to be constructed in a community largely depends on the quantity of water that can be safely withdrawn from a well, resulting in numbers of people that can use the well, and the longest distance that is convenient for people to collect water. One well per 250 to 400 people is a general guideline. A reasonable maximum distance is 500 m.

Diameter

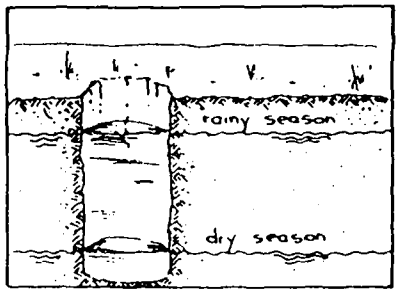
The minimum diameter of a hand-dug well is 0.8-1.00 m. This is the minimum space required for one person to be able to dig. A standard diameter should be adopted if more wells are dug to allow for standardization or reuse of equipment such as well covers and moulds for concrete well-rings.
Larger well-diameters may be required if the flow of water towards the well is low and the well acts as a water storage tank.



The well diameter should be large enough to work in.

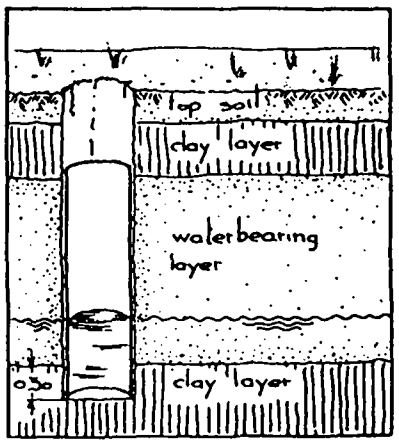
Depth

The required depth of a well depends particularly on the depth of the water-bearing layer at the end of the dry season. The well should reach sufficiently deep into the layer to prevent it from running dry in the dry season.



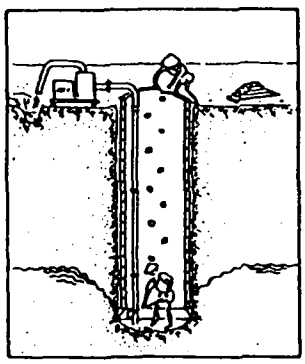
The dry season water-table determines the depth of the well.

When the water-bearing layer consists of fine sand, digging should be continued to at least 30 cm into the underlying clay or solid layer. Otherwise the mixture of fine sand and water will enter the well through the open bottom and slowly fill it up.



Well dug into clay layer

Sometimes a hand- or engine-driven pump is needed to withdraw water from the well that is being constructed. Without such a pump it may not be possible to dig sufficiently deep.
The lining at the height of the water-bearing layer should be porous.



Digging under the groundwater level

Labour

The time required for well digging will depend on the soil, and the diameter and depth of the well. It is most efficient to work with at least three people who rotate in their tasks: one digging in the well, one lifting soil and one removing the lifted soil. Total construction may take a team of 3 to 4 persons 2 to 5 weeks.

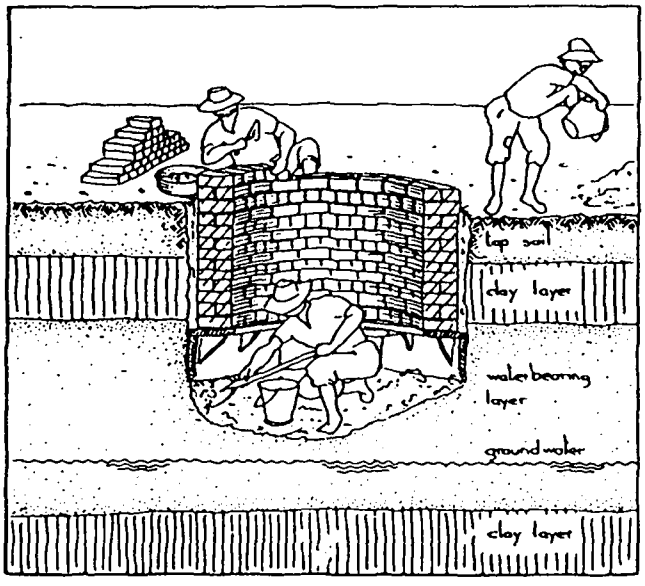
For well protection, construction of rim, apron, drains etc. → Chapter 6

BRICK LINING

In loose soil lining of the well is necessary to avoid caving in of the walls.
Burnt bricks are a suitable material for well lining. Though the building technology is not difficult, masons should be trained by an experienced well-constructor. Construction faults may result in very dangerous situations during and after the construction.

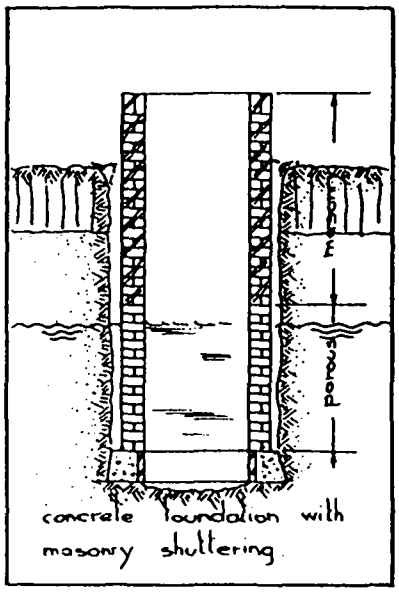
A cutting ring can be made of timber. Eight pieces are connected to form one big ring. Reinforced concrete is also a very suitable material for making a cutting ring.
First a pit with a depth of about 50 cm is dug in which the cutting ring is placed. The first three courses are cemented with mortar. Then bricks are arranged in such a way that an open brickwork is obtained to allow for the inflow of groundwater when the well is finished. The open brickwork is usually done over a height of 1 metre depending on the thickness of the water-bearing layer. The digging under the cutting ring is equally and carefully done to ensure straight sinking of the lining. Each brick course has to be finished before starting a new course in order to maintain a uniform weight.

Detailed construction guidelines are available through the training institute.



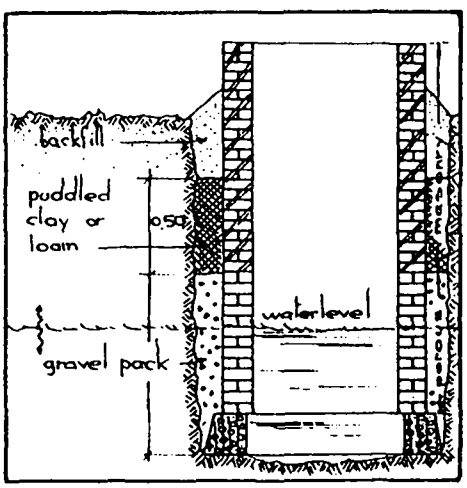
Construction of brick-lined well

If the soil is stable, it may be possible to dig the pit up to groundwater level. This is best done at the end of the dry season when the groundwater table is lowest. The concrete foundation can then be cast at the bottom of the well using a masonry or timber shuttering. The lining is built as described in the previous section. The lower part of the lining should be porous.



Brick-lined well built in stable soil with high groundwater table

Space between the water-bearing layer and the brickwork is filled up with fine gravel to prevent clogging of the open brickwork by the fine sand and silt. Above the highest water level or above the water-bearing layer the space is filled with very fine clay which will form a seal that prevents seepage of spilt water and surface runoff down along the lining.

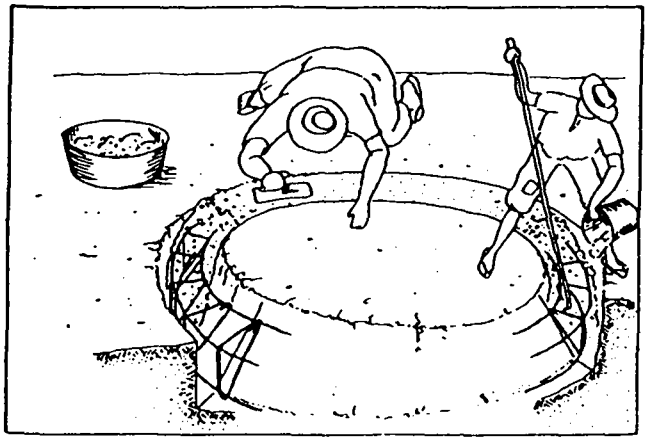


Gravel pack, clay seal and backfill complete the well construction

CONCRETE BLOCK LINING

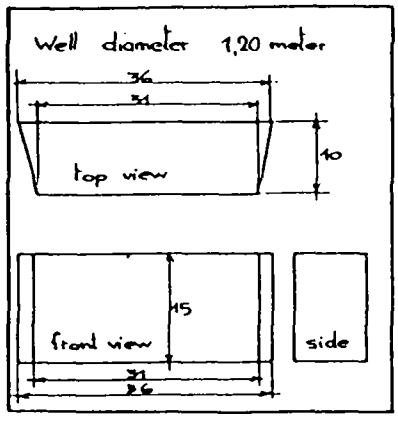
Concrete blocks can also be suitably used for such a lining when combined with a cutting ring. The following steps are required.

1. Prepare an earth mould for the cutting ring by digging a circular ditch 30 cm deep and 20 cm wide with a wedge-shaped bottom, and a diameter of 100 cm. Place reinforcement bars and pour the concrete into the ditch. Cure the ring for about a week by pouring water on it twice a day and covering it with leaves.



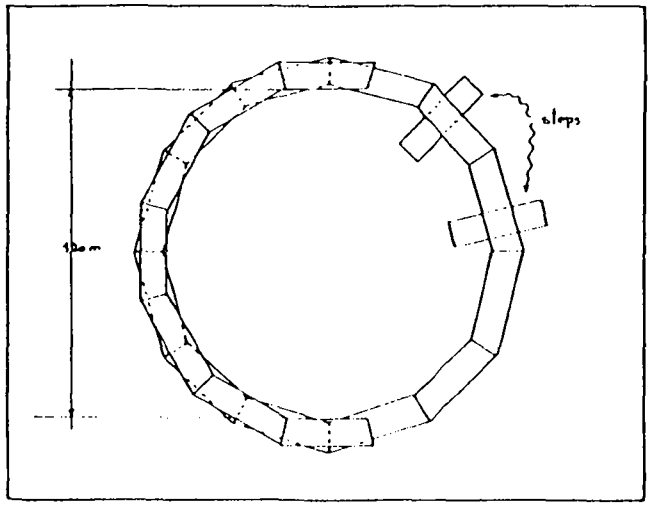
Making the cutting ring

2. Prepare curved concrete blocks using a metal or timber mould and cure the blocks for 2 weeks before using them.



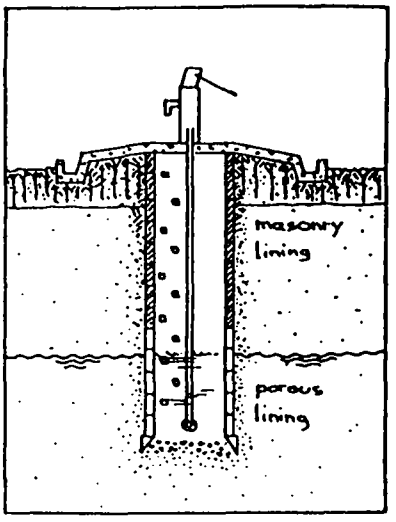
Concrete block dimensions

3. Excavate the well as far as can be done safely and lower the cutting ring into the excavation. Place mortar concrete blocks on top of the ring. In the first meter, porous blocks may be used to ensure that water can flow into the well through this part of the lining. At every fifth layer steps are provided.



Building the lining

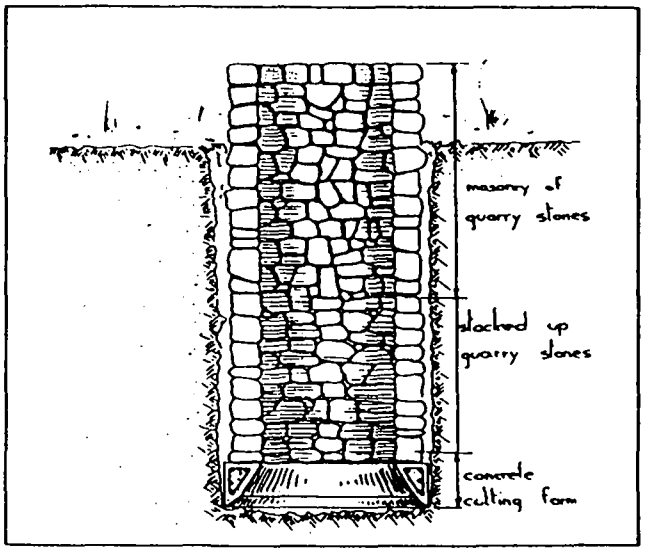
When the lining is about 1 m high, digging can be re-started. Digging under the cutting ring is carefully and equally done to ensure slow and straight sinking of the lining.
This process continues until the well has reached its final depth or until too much water flows into the well, more than can be pumped out.



Block- or brick lined dug well

Quarry stones

Instead of using concrete blocks, also quarry stones could be used. Particularly quarry stones require experienced workers to avoid uneven distribution of the load, which might lead to uneven sinkage of the well.



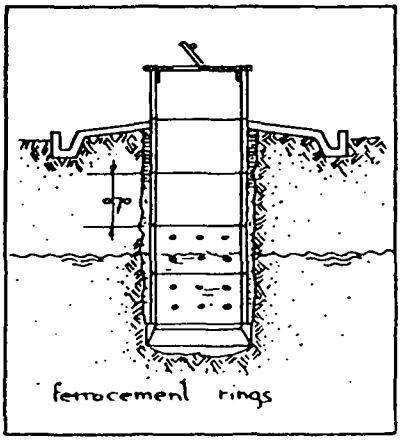
Quarry stone-lined dug well

The space around the well lining is filled up with gravel and clay as explained under "brick lining".

PRECAST RING LINING

Instead of using blocks, precast rings can be used for lining. The concrete rings are quite heavy. Sufficient manpower and/or equipment must be available to transport the rings to the well and to lower them into position. A concrete ring of 100 cm diameter, 10 cm thick and 50 cm high weighs some 350 kg.

The concrete rings can be manufactured at the well construction site or at a central place. In the latter case transport must be available for ferrying the rings to the well site.
The best method is to make use of metal moulds. Ferro-cement rings can also be used. For both techniques experienced masons must supervise the manufacturing to get good results.



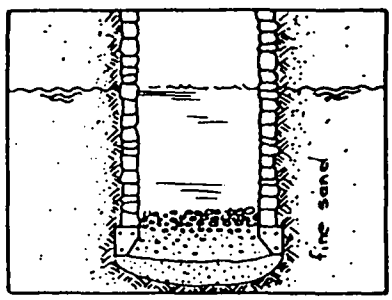
Dug well lined with precast concrete rings

BOTTOM SECTION

The lower section of the well needs to be porous to allow the water from the water-bearing layer to penetrate into the well. Water may enter into a lined well from the bottom only or from the sides.

Inflow through bottom only

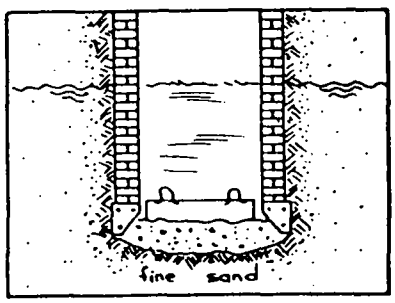
Water will enter into a well through the open bottom if the bottom of the well is situated in the water-bearing layer. The bottom of the well may be finished off with layers of gravel and coarse sand, each with a thickness of 10 cm.



Gravel pack bottom allows for inflow of groundwater.

Inflow through walls only

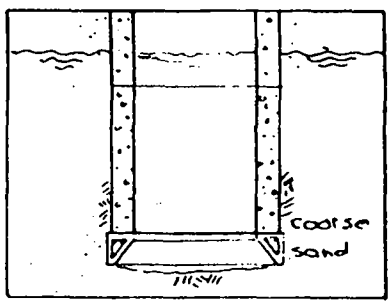
If the water-bearing layer consists of fine sand this sand may enter the well through the open bottom and slowly fill it up. Then the water-bearing layer should be paned and the water inflow should be guaranteed by applying a porous lining.



Bottom plate prevents fine sand entering the well.

Porous rings

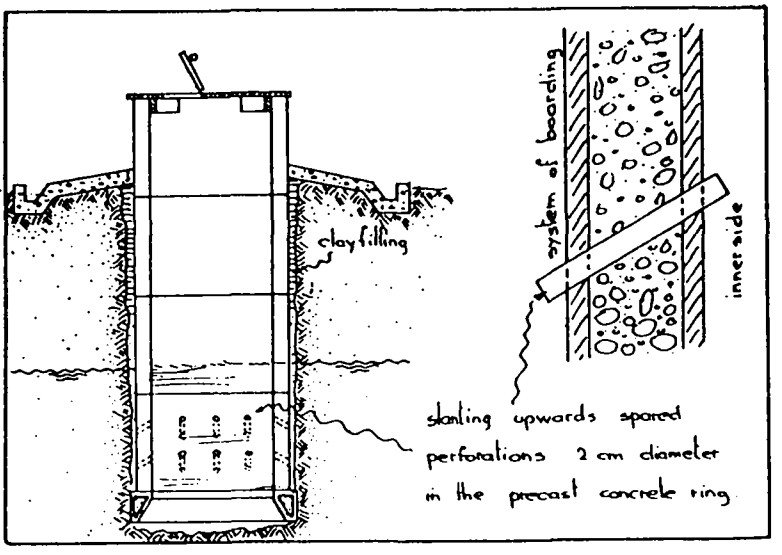
Lining rings situated in the water-bearing layer could be made of porous concrete to allow the water to enter the well. Porous concrete can be made using a mixture of gravel and cement and very little sand: 1 part cement, 1 part sand and 4 parts gravel.



Lining with porous rings

Perforated rings

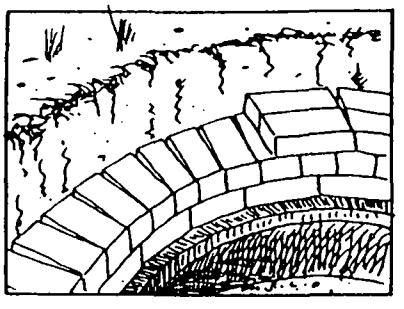
Lining rings can be manufactured with small holes that allow groundwater to enter the well. The holes are obtained by putting short pvc pipes in the mould during the casting of the ring. The holes must slant upwards, towards the inside of the ring.



Upward perforations in concrete rings

Open brickwork

Bricks can also be used for a porous lining, either in the form of loosely stacked bricks or in masonry with open vertical joints.



Loosely stacked bricks allow water to enter well.

7.4.2 HAND-DRILLED WELL

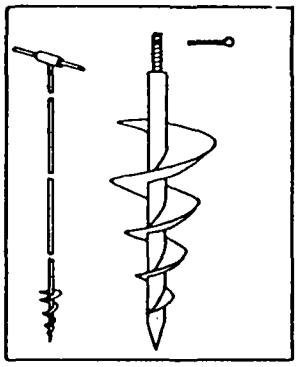
Hand-drilling of wells is feasible in unconsolidated soil to a depth of 20 metres. Drilling a borehole is easier than digging. Much less soil is removed and drilling below the groundwater level is easy because of the casing that prevents the walls from collapsing. The installation of the lining (pvc pipe) is quite simple and requires only light equipment.

A drilled well is only feasible when the community can afford the installation and operation of a pump. Moreover, special equipment and tools are required for hand-drilling. It is not worthwhile to buy this equipment for just one or two wells.

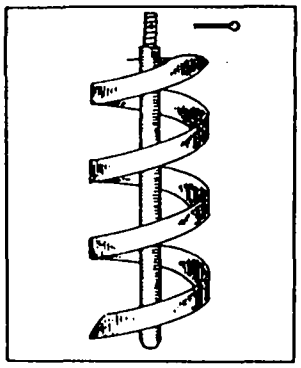
Hand-drilling must be supervised by an experienced drilling team.

Equipment required

- tripod (wood, bamboo, metal) to be erected over the well site
- spiral auger
- 20 m extension rods
- pulley with rope
- hand-auger
- bailer



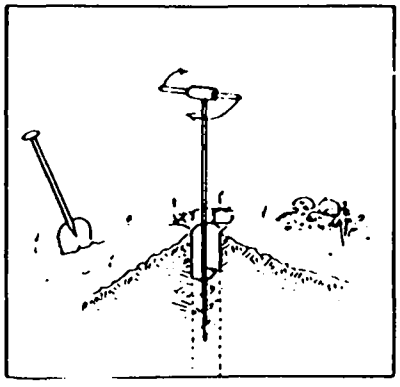
Conical hand-auger



Spiral auger

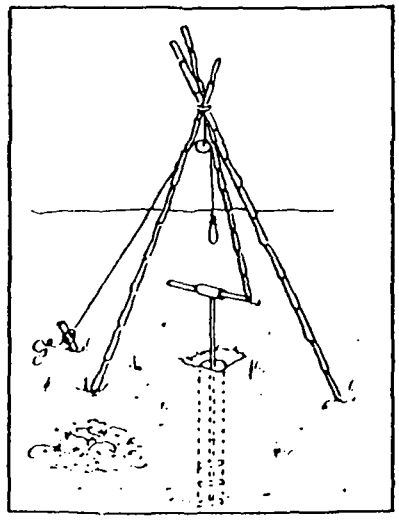
Hand-drilling procedures

1. Place a tripod over the selected site.
2. Drill the first meter of the well with a hand-auger.



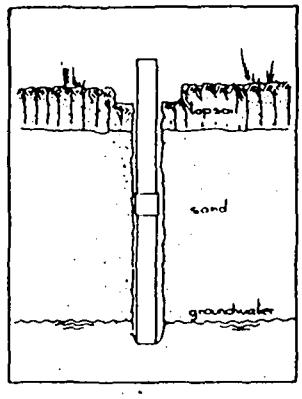
Drilling with a hand-auger

3. Mount the spiral auger and the cross bar and continue drilling. Every time drilling has proceeded over some 50 cm the auger has to be pulled out from the hole with the pulley and the earth collected in the auger must be removed. Replace the cleaned auger in the hole, add extension rods when needed, and continue drilling.



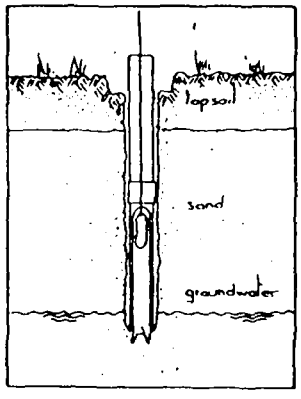
Tripod construction

4. When the water table or loose soil is reached, a casing of pvc or metal pipes will have to be placed.



Casing of pvc or metal is placed

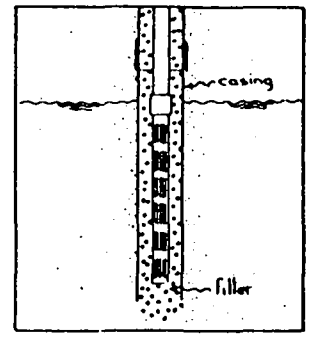
5. Drilling is now continued with a bailer, a cylinder with a flap valve at the bottom. This bailer falls freely in the casing and collects soil when it hits the bottom of the well. At regular intervals the bailer is emptied and the casing turned around and forced down.



Drilling with a bailer in the casing

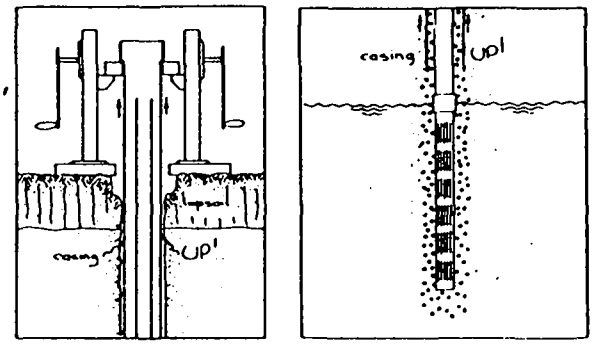
6. When the final depth has been reached, that is when the water-bearing layer has been paned, the well can be installed.

7. A smaller diameter (pvc) pipe is lowered into the borehole. The pipe section which reaches into the water-bearing layer has to be perforated (slotted) to allow water to enter into the well. This section needs to be surrounded by a gravel pack. Fine gravel is therefore poured into the spacing between the borehole casing and the pvc pipe. This needs careful supervision otherwise fine particles present in the aquifer will enter into the well.



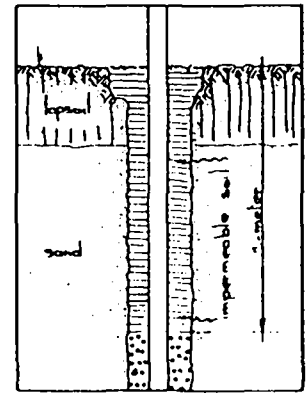
Permanent well casing-pipe

8. The temporary casing is now being withdrawn, often by using hydraulic jacks.



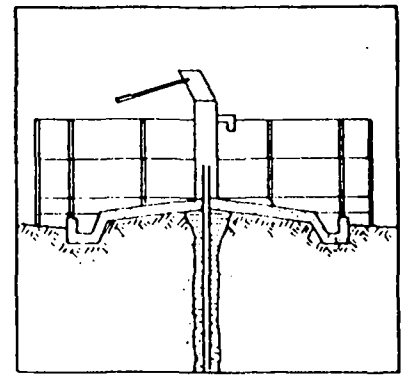
Temporary casing is removed

9. Above the gravel pack the space between the pvc pipe and the borehole needs to be filled with impermeable soil material to avoid the possibility of seepage of spilt water along the side of the well.



Borehole is sealed

10. Now the apron can be constructed, the well developed and a pump put in place if the well produces enough water.



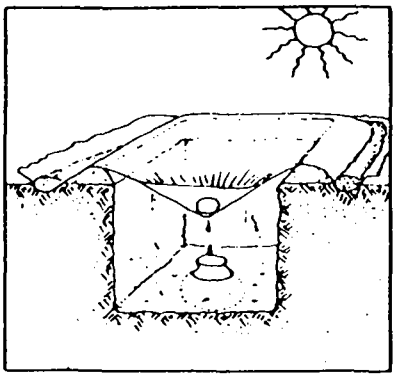
Completed handpump well

7.5 CONDENSATION OF WATER

Where and when there is no water or only brackish water available from normal sources, small quantities of water for household use can be obtained by collecting condensed water. Although most people do not like condensed water because it has a flat taste, it may be a potential option to get fresh drinking water. Two methods to obtain it are described here.

Groundwater evaporation

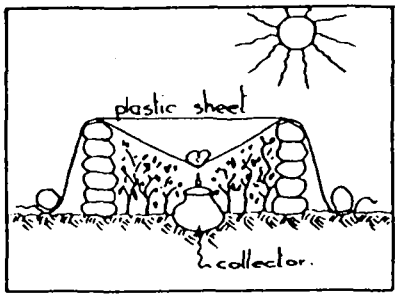
Dig a hole in a spot that receives continuous sunshine. The hole should be at least 100x100x50 cm. Place a clean jar in the middle of the hole. Cover the hole with a plastic sheet, fixed around the hole with earth and stones. Place a stone in the middle of the sheet so that it slopes down towards the middle. During the daytime groundwater will evaporate from the soil under the influence of the heat of the sun. This vapour will condense on the bottom side of the plastic sheet and part of it will seep to the middle and drip into the jar. Evaporation can be increased by placing jars with brackish water in the hole.



Groundwater evaporation

Plant transpiration

Cover a number of plants with a plastic sheet after placing a clean jar. Put a stone on the sheet above the jar. A similar process as described above will take place. Here the water evaporates or "transpires" from the leaves of the plants.



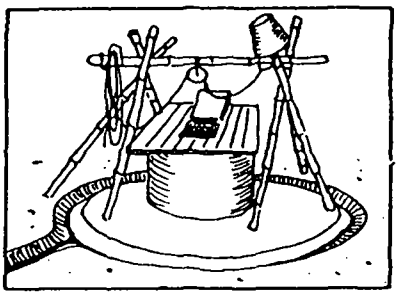
Plant transpiration

8. WATERLIFTING

8.1 BUCKET LIFTING

8.1.1 PULLEY

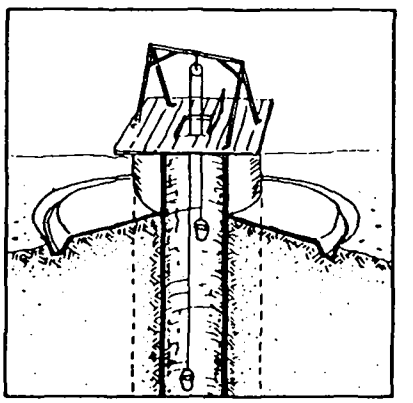
A pulley makes drawing water from a well easier. Rope and bucket are permanently fixed to the pulley. After use, the well is properly covered and the bucket should not remain hanging in the water. A hook fixed to one of the supporting posts must be provided on which to hang the rope and the bucket.



Protected well with pulley system

Double bucket rope system

Only one person at the time can draw water using the pulley. This may increase waiting times if people are used to drawing water from the well with more than one person at the same time. This drawback can be partly solved by attaching a bucket at both ends of the rope. While one bucket is lifted, the other one goes down. Rope and buckets are permanently fixed and cannot pick up dirt from the ground. If the well diameter is large, two or three pulleys could be fixed to the beam.



Protected well with double bucket system

NOTE:

* Bucket and rope can become contaminated during use e.g. by dirty hands or by placing them in muddy surroundings.

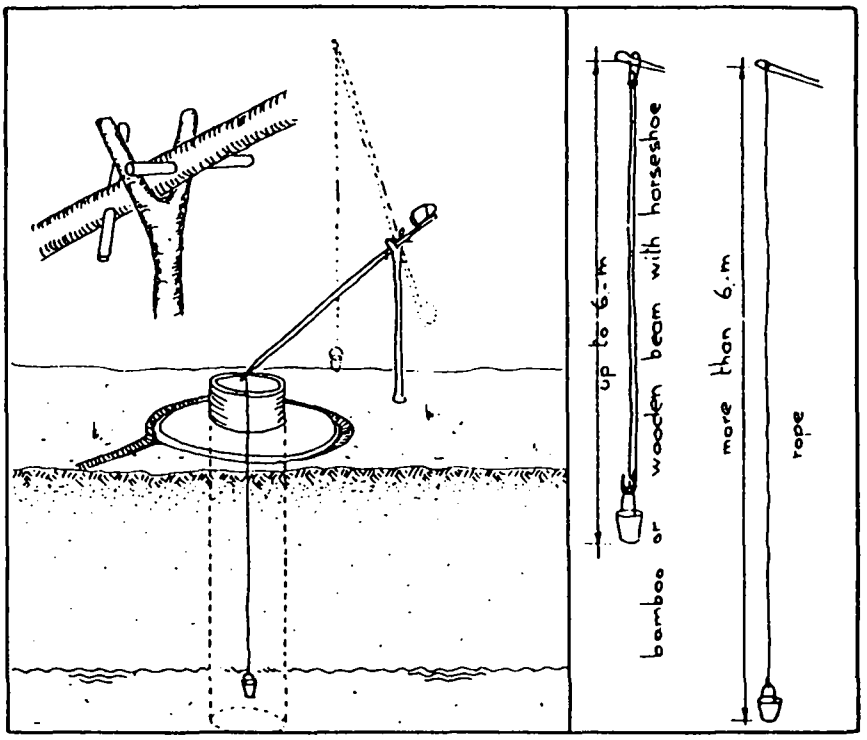
For material and labour requirements → Chapter 5

Maintenance:

* daily scrubbing of the bucket
* regular lubrication of the pulley

8.1.2 SHADUF

Water lifting is made considerably lighter with a "shaduf". A counter-weight at the end of a pole that acts as a lever, reduces the weight of the full bucket. The shaduf can be constructed of bamboo or wood and used for any kind of well, covered or uncovered. More than one shaduf can be constructed around larger wells. The well should be closed with a cover.



Shaduf can be used for any well-depth.

NOTE:

* Bucket and rope can become contaminated during use e.g. by dirty hands or muddy surroundings.

For material and labour requirements → Chapter 5

Maintenance:

* daily scrubbing of the bucket
* regular checking of the condition of the construction

8.2 PUMPING

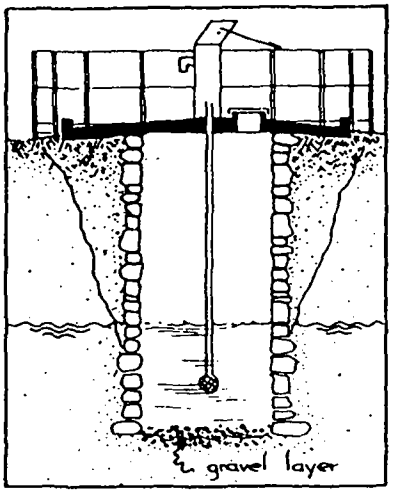
8.2.1 INDUSTRIAL PUMP

Whether a pump can be bought to lift water from a well will depend on the financial situation and on the availability of pumps in the area. Moreover, industrially produced pumps require regular maintenance for which skills, tools and spare parts are necessary that may not yet be available in a community or even in the provincial capital. Proper operation and maintenance requires thorough training of female or male pump attendants and the set-up of a maintenance system before installing an industrial pump in the community.

When making a choice between the pumps available, a number of points should be considered:

* ease of operation for women and children;
* acceptability of the mode of operation to the users;
* required frequency and ease of maintenance and repairs;
* availability of spare parts or the possibility to produce spare parts locally;
* cost of a new pump, installation and spare parts;
* the lifting capacity.

If the water level is high (less than 7 metres below ground level) a suction pump could be used. These pumps are much cheaper and easier to maintain than the deep well pumps. Pumps can be fitted on new boreholes and in existing dug wells. The main advantages are the ease of water lifting and the limitation of the risk of water contamination. Some of the protective measures described in section 6.1 still need to be provided, such as an apron, spilt water drains, and a fence with a gate.



Protected dug well with handpump

For well protection → Section 6.1

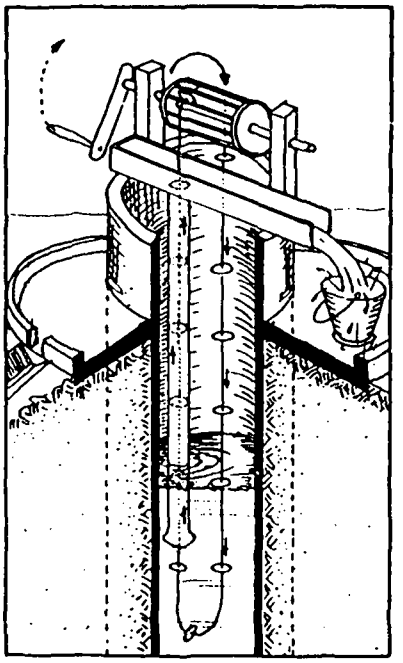
For hand drilled wells → Section 7.4.2

NOTE:

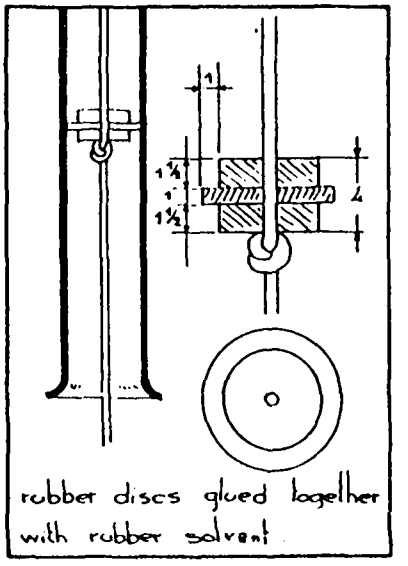
* Do not install pumps without the assistance of technically skilled people.

8.2.2 CHAIN WASHER/ROPE PUMP

The chain washer/rope pump is a water lifting system that can be made locally or by a national industry and does not require very sophisticated production and maintenance equipment, moreover it can be easily maintained locally.



Chain washer/rope pump



Detail of washer attachment

The principle is simple: a chain made of rope with washers at regular intervals is pulled through a pipe that reaches into the well water. On its way up through the pipe the washers lift water: the water is "caught" between the washers. The chain washer/rope pump is suitable for any kind of dug well. New models are even used on drilled wells; the water production is better in shallow wells.

Of course protective measures described in section 6.1 also need to be provided, such as apron, spilt water drain, well cover and fence with gate.

For material and labour requirements → Chapter 5

Maintenance:

* daily cleaning of collection gutter;
* regular checking of rope, washers and bearing for signs of wear and tear;
* replacing all washers when some are worn;
* regular checking and tightening of the knot that joins the two ends of the rope;
* regular checking of the raise wheel.

For well protection → Section 6.1

9. WATER TRANSPORT IMPROVEMENT

9.1 TRANSPORT CONTAINERS

There is no reason to change the type of transport containers if the users are satisfied with them. However, often containers have no lids or other types of cover. Covering containers during transport is an important necessity to prevent contamination.

Covers for containers

The cheapest covers that provide at least some protection are leaves from trees, for example banana leaves, but these may be contaminated and difficult to clean.
There are many alternatives for making lids or covers. The type of transport container used and the materials available will determine the choice:

* earthenware
* wood
* cork
* tin (from old cans)
* plastic
* cloth

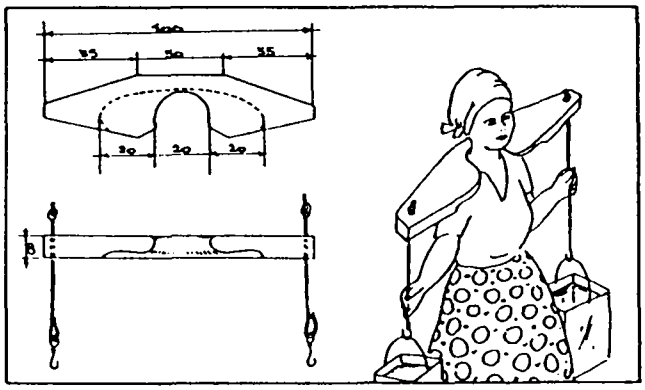
Maintenance

* Cleaning of containers and covers/lids every time before use.

9.2 CARRYING AIDS

YOKE OR SHOULDER CARRIER

A yoke or shoulder carrier facilitates water carrying and causes less physical discomfort than carrying containers on one's head or back. When the introduction of yokes is considered, it would be a good idea to make only one yoke first. This "model" could be tried out by several users before a final decision is made.
A yoke can be used for most types of transport containers, though sometimes the containers may have to be adapted, for instance by providing handles.



The use of a yoke makes water carrying easier.

A light tree pole is less comfortable than the yoke but could be introduced as a first step. It makes water carrying much easier.

Improved water carrying

Improvement of path to water source

Sometimes simple improvements to the road or path leading from the water source to the houses could contribute to the ease of water transport.

The measures to be taken will depend on the circumstances:

* if the paths are steep: cut steps, construct stone or concrete steps, provide rail of rope, bamboo or wood;

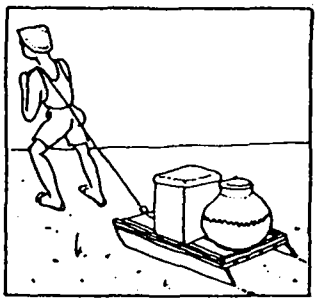
* if the paths are slippery: construct simple pavement.

For simple sandals → Chapter 14

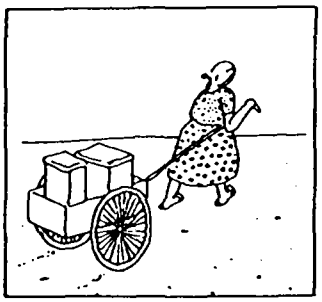
9.3 WATER TRANSPORT WITH CARTS

9.3.1 WOODEN CART

If the water transport route is flat, the construction of carts could be considered. Several water containers could be transported per cart, the number depending on the size of containers and cart. A cart not only makes water transport less strenuous, it can also make transport of more water per trip possible. It is then perhaps possible for users, in most cases women, to take turns in collecting water for several households, thus gaining time for other activities or rest.



A sledge is possible if the surface is smooth.



A cart with bicycle wheels makes water collection much easier.

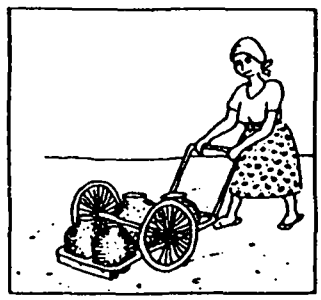
For material and labour requirements → Chapter 5

NOTE:

* These carts can be used for other purposes as well, for instance transporting firewood.

9.3.2 CART OF STEEL PIPES

When steel pipes are available and a blacksmith is present in the community, this cart could be constructed. The cart is especially designed to transport four round water pots.



Steel cart for water pots

For material and labour requirements → Chapter 5

Construction:

* Make the outer frame by bending a long piece of pipe.
* Fix 3 short pieces of pipe and 4 circular-bent pipes, by welding them to the frame.
* Fix the wheels.
* Fix 2 pieces of V-shaped pipe or a wooden beam under the front side of the cart.

The steel pipe can be bent by taking the following steps:

* fill the pipe with sand;
* heat the pipe and bend it while it is hot.

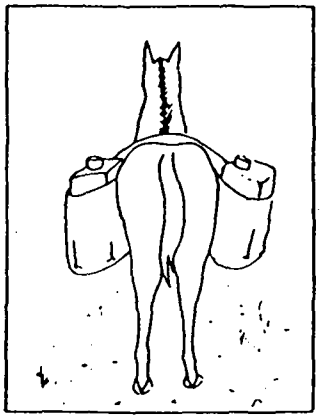
NOTE:

* Do not attempt to make this cart if there is no experienced blacksmith in the community.

9.4 WATER TRANSPORT BY ANIMALS

SADDLE-BAGS AND CARTS

In some communities there are horses, donkeys or cattle that could be used to transport water. All that is needed to make water transport by animals possible are saddle-bags.
These could be made of leather, canvas, or any other suitable material available.



Saddle-bags for a horse

Animals could also be used to pull carts for water transport.

NOTE:

* Animals used for water transport should not be allowed to get close to the water source. They should stay outside the fencing.

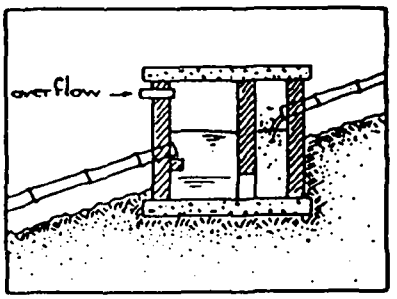
9.5 PIPED SYSTEM

BAMBOO WATER PIPES

In areas where bamboo is abundant and cheap, a bamboo pipe system could bring water from springs and streams to the village. Such a system will be only advisable for smaller systems because bamboo pipes need to be replaced after a few years.

If the slope of the system is more than 1:15 (1 metre height difference over a distance of 15 metres) or less than 1:50, expert advice is needed before constructing the system.

If the lower part of the system is situated more than 20 m below the water source, the pressure in the pipes becomes too high for bamboo to withstand. In that case, one or more pressure relief chambers must be provided.

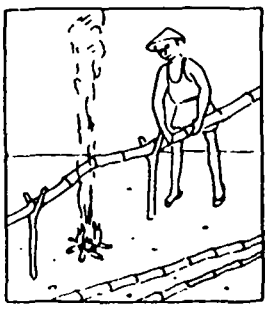


Pressure relief chamber

In most areas where bamboo is available, the people are familiar with its properties and potentials. The following information gives a summary of the most important points:

Straightening of bamboo

Bamboo pipes can be straightened by heating them over a fire, until they are flexible enough to bend.



Straightening bamboo over a fire

Treatment of bamboo

The durability of bamboo can be extended by soaking the green bamboo in a solution of equal weight parts of boric acid and borax for several hours.
Twenty buckets of water should be added to one bucket of the boric acid/borax mixture. The bad smell and taste of water transported through treated pipes will disappear after a few weeks of use.

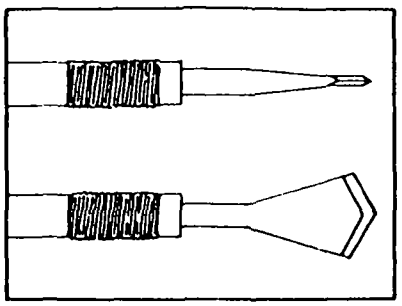
The use of chemicals for preservation of the bamboo is not advisable because these chemicals may then remain present in the drinking water and cause serious health problems with the water users.

Removing membranes

The membranes in the bamboo pipe must be removed carefully and completely because remnants will hinder the waterflow. Membranes can easily be removed with chisels.

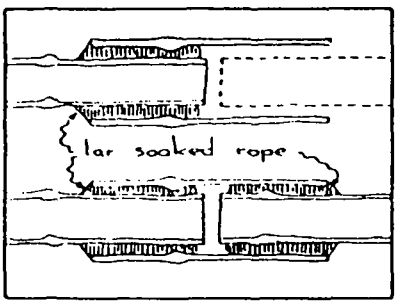
Chisels can be made in several ways by local blacksmiths.

Using a bolt with a diameter of 12 mm. The bolt is heated in a fire till glowing temperature and then flattened by hammering into the required shape. When cooled down it is sharpened using a file.



The chisel is used to remove the membranes.

Using galvanized iron pipes of different diameters.
Suitable diameters are 1/2, 1 and 1 1/2 inch. A piece of the pipe is cut off using a metal saw. The edges are sharpened with a file.

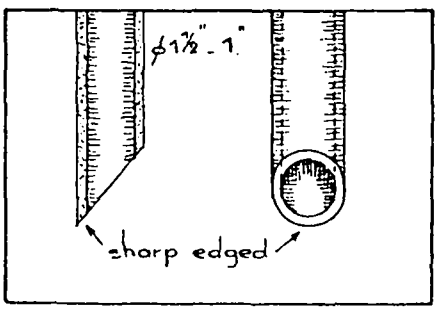


Chisels can be made of GI pipes.

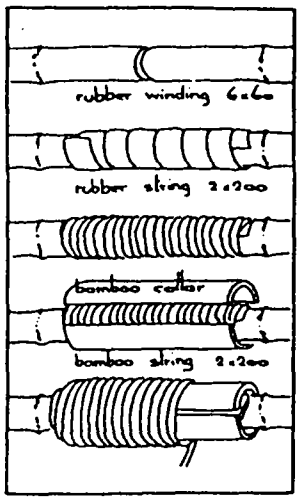
The membranes are drilled out starting with the small diameter pipe.

Joints

A joint between bamboo pipes can be closed by fixing a piece of bamboo of a larger diameter over the joint.
The joint can be made watertight by winding strips of rubber, cowhide or tar-soaked rope between and around the two layers of bamboo.



Joint of bamboo pipes



Connection of bamboo pipes

Maintenance:

* Regular checking of the system and replacement of rotting or leaking pipes and joints.

For apron and spilt water drains at collection point	→ Section 6.1
For spring box and reservoir	→ Section 6.2

10. WATER STORAGE IMPROVEMENTS

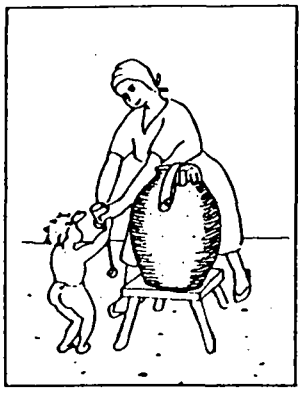
10.1 SMALL STORAGE CONTAINERS

Small containers can be used for water storage at home. The storage time will depend on the size of the container and the water use. The longer the storage time, the greater the risk of contamination. Though all stored water should be kept as clean as possible, it is most important for drinking water and less important for water for cooking as this will be boiled during cooking.

Protection during storage

To limit the contamination, the following measures are essential:

* containers should be placed out of direct reach of small children. Children must be taught to hygienically draw water from the containers;

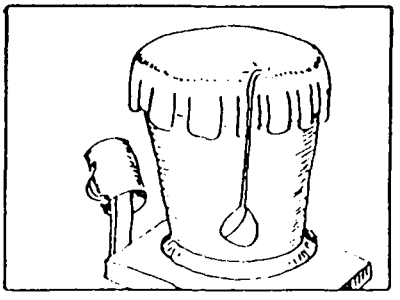


The water is kept out of reach of small children

* containers should have covers to prevent dirt, insects and small animals from entering the water. Covers may be made of pieces of cloth or plastic sheets, leaves, stones or wood;

Different types of containers and covers

* a fixed ladle should be used to draw water from the containers and it should be returned at a clean place after use;



Covered container with ladle and mug

* containers and covers should be cleaned regularly, preferably each time new water is poured into them. If large containers are filled up when they are not yet empty, the sediment settled at the bottom should regularly be removed.

Different types of containers

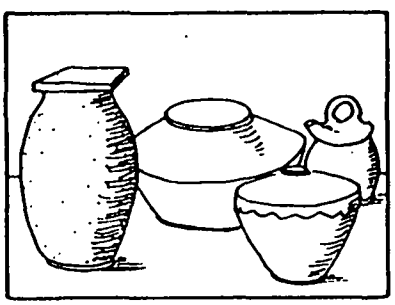
If people are satisfied with their storage containers, there is no reason to introduce new types, though changing drawing methods and cleaning habits, and the promotion of use of covers may be necessary. Where no storage containers are used, they could be introduced. The types and materials will depend on the local circumstances.

A few possibilities:

1. Bottles and glassware pots are excellent storage containers, especially those with tight fitting lids. They can be easily cleaned with hot water and possibly soda. Bottles that were used for chemicals of any kind, including medicine, are better not used.

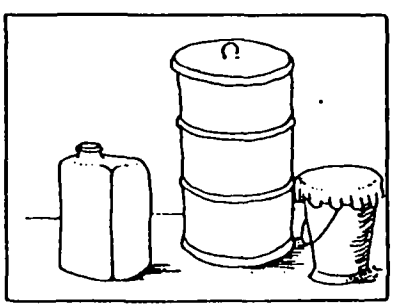
Glass bottles and pots

2. Earthenware pots have the advantage of cooling the water during storage due to evaporation through the porous walls. Moreover, earthenware gives water a specific taste that sometimes is appreciated by the people. A disadvantage is the difficulty of cleaning due to the rough surface. Glazing the pottery would solve this problem, but would at the same time prevent evaporation.
In some countries calebases are commonly and satisfactorily used.



Earthenware

3. Petrol drums, when thoroughly cleaned and scoured, make big, strong containers. Rusting can be partly prevented by painting the inside with bituminous paint.



Large containers

4. Where containers are not easily available they could be made from available materials. Baskets can be made suitable as containers by lining them with strong plastic or rubber. Also leather can be used to make storage containers. Ensure that no sharp parts will make the container leak. Lining the inside with clay may help then.

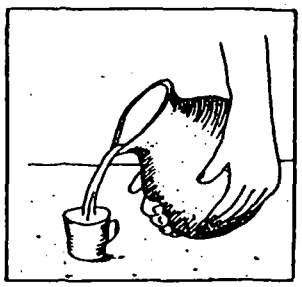
NOTE:

* Plastic containers may have contained chemicals or poison and should only be used if they have contained harmless products.

10.2 SAFE DRAWING METHODS

Pouring water

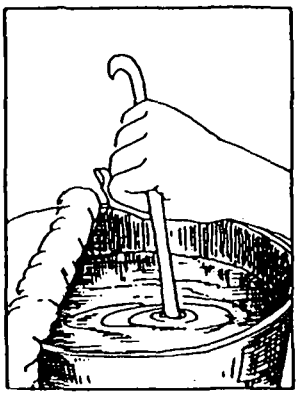
Pouring water from the storage container is the simplest drawing method that does not involve a risk of water contamination: the water is not touched with hands or a ladle. A spout on the jar or pot will facilitate pouring without spilling.



Pouring water is a safe method

Drawing devices

When ladles, cups and spoons are used to dip water from the container they should have long handles, so that the hand holding the dipper never touches the water. Cups or mugs used by people can be easily improved by fixing a handle using for instance wood or steel. Ladles should never lie around: a hook could be fixed to hang the ladle out of reach of children and animals.

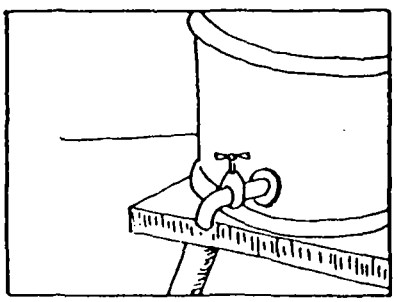


The cover is partly removed and the water is scooped with a ladle

The handle of a ladle should have an eye, a hook or a round piece of string at the end. Another way to keep the ladle safe is to keep it in the water.

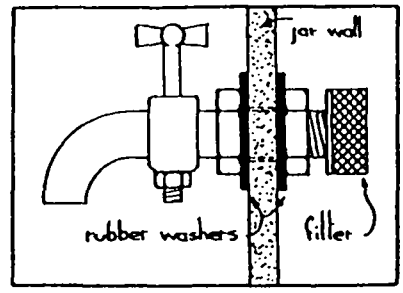
Tap

An expensive but effective way of preventing water contamination is fixing a tap to the storage container. The hole in the container on which the tap is fixed could be carefully drilled. Any kind of small tap is suitable, provided it can be properly fixed on the container using nuts.



Container with a tap

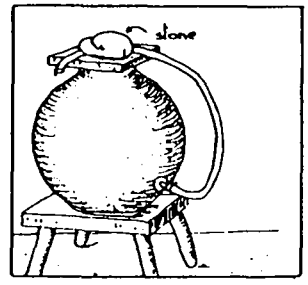
Rubber washers should be placed between pot and nuts, both on the inside and outside of the pot, to prevent leakage.



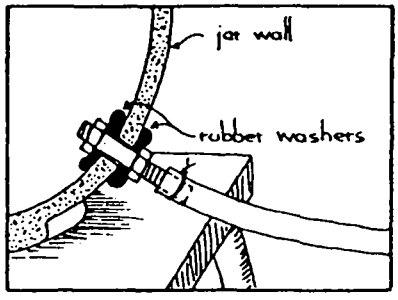
Detail of tap

Hose

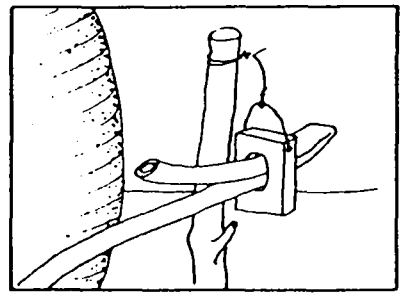
Instead of fixing a tap, a short piece of a metal or hard plastic pipe could be fitted in the drilled hole of the container. A flexible plastic or rubber tube preferably with a clamp can be attached to it.



Hose attached to container



Detail of hose attachment



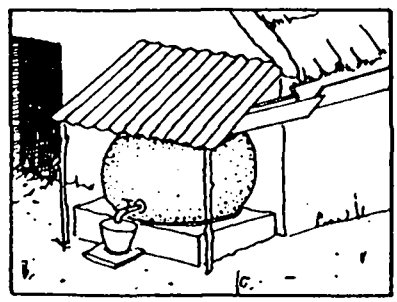
Closing the waterflow

10.3 LARGE STORAGE CONTAINERS

10.3.1 GENERAL

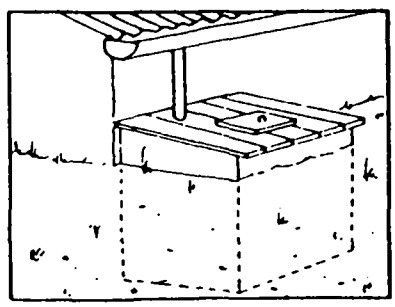
Large storage containers are mostly meant for seasonal storage of water. Generally the containers are located outside the homes. The site must be stable to ensure that the container remains in position. At unstable sites a foundation has to be made. The containers can be made of several materials as indicated in the following options. They may range in size from 1 to 10 m^3 and can be used by one or more households. The size will depend on the available sources of water, for example if rainwater is the only source, the storage capacity needs to be sufficient to supply water at the end of the dry period.

To protect the containers from the sun a simple roof could be built from local materials or the roof of the house could be extended to create shade. A fence should be built around the container if children and animals could come near the container and could lift the cover.



Home rainwater storage container

If large containers are used to collect rainwater from the roof, a round hole should be made in the cover for the inlet pipe, and a small screened ventilation pipe should be placed.



Underground rainwater storage container

Maintenance of large containers:

* once a year the container needs to be cleaned and washed out;
* a check for water tightness needs to be made and cracks must be repaired;
* covers and tubings have to be checked and if necessary repaired;
* if a filter is provided this needs to be cleaned as well.

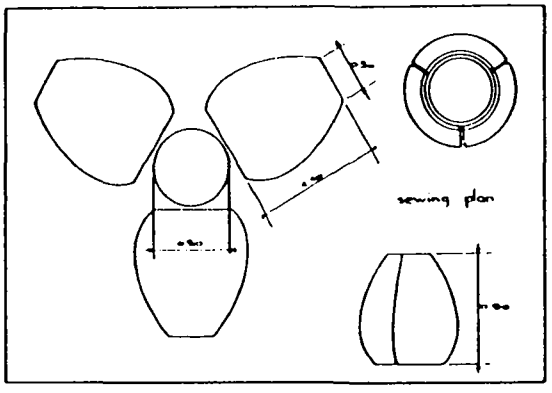
10.3.2 CEMENT MORTAR WATER-JAR

The spherical shape of this concrete container creates the advantage that only a thin layer of concrete is required, for which relatively little cement is needed. Therefore, the cost of this container is low. Instead of a solid mould, a sack made of strong textile or jute is used. The sack can be used for the production of several containers.

For a 250 litres jar, 1/2 bag of cement and 1 bag of sand is needed. Use as little water as possible but enough that the mixture just stays together.
This type of containers can hold upto 1000 litres of water.

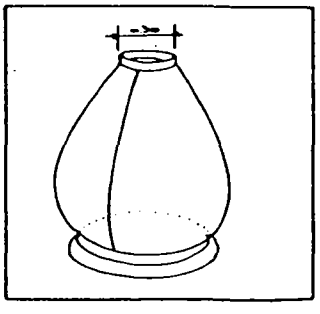
Construction

1. Sew a big sack, of a size and shape desired for the container. The best results will be obtained when several (3-5) pieces of material are sewn together as indicated. Leave the top part of the sack open, turn it inside out, so that the cement mortar will be applied to the sides with smooth seams.

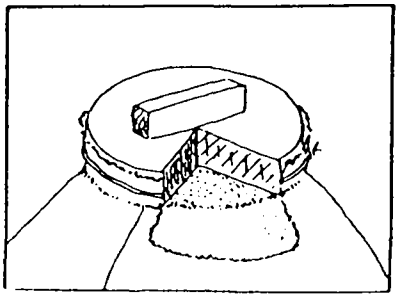


Pieces of cloth or hessian to be sewn together

2. Construct a circular concrete base plate of 15 cm thick and a diameter of 60 cm. Place the bag on this base which is cast the day before, and fill it with wet saw dust, rice husk or a mixture. When the sack is full, fold the top together. Shape the filled up sack to the desired belly shape. Spray it with water and place a thick round piece of wood or a metal ring on top. This will shape the top opening of the jar.

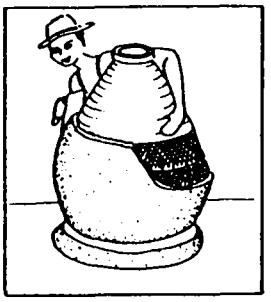


Bottom plate with bag

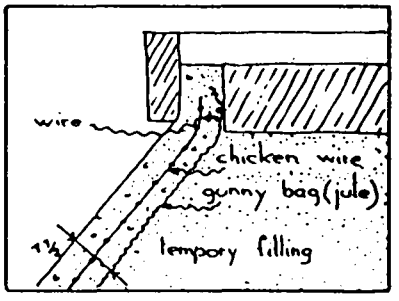


Bag filled with wet material and closed with wooden disc

3. Apply a layer of 5 mm cement mortar on the filled up sack. Work from the bottom upwards. Apply a second layer of 5 mm. The total thickness should be 1 cm. Check the thickness with a nail. If a tap is to be fixed in the jar, a hole could be made for it at this stage. Use a flat piece of wood to smooth the surface. The jar could be reinforced by applying chicken wire if it has to be moved from the place where it was constructed.

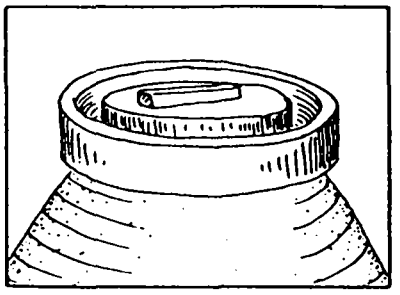


Applying the mortar layers



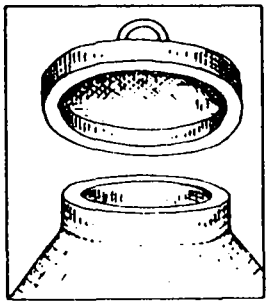
Detail of top of jar

4. Place a second metal or wooden ring over the neck, leaving a space of about 3 cm, and fill this with the mortar. The collar must be sturdy.



The second ring helps to make the collar

5. Cover the jar with a damp cloth or a plastic sheet for four days to prevent the mortar from drying too quickly. Sprinkle some water over the mortar. Remove the rings of the neck, the filling and the sack carefully after two days.
   Check the jar for faults and apply mortar on them. Make a cover for the jar.



A fitting cover is separately made

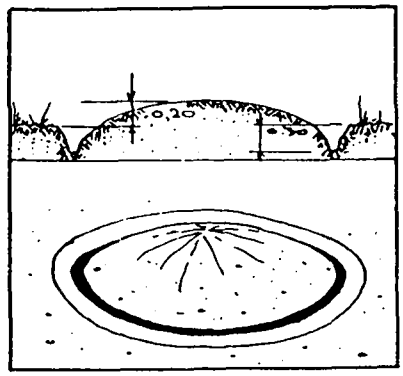
For general construction guidelines → Chapter 15

10.3.3 FERROCEMENT WATERTANK

A ferrocement container can hold up to 6000 litres of water. It could be shared by a few households. When calculating its cost, the cost of a waterlifting device should be included, for instance a low lift suction pump or a simple bucket and rope system. A fence must be constructed around the tank.

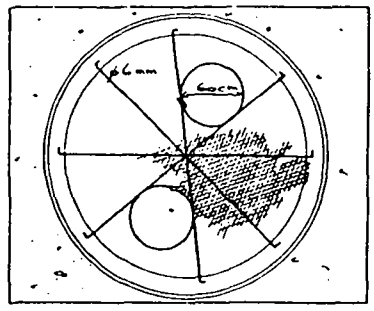
Construction

1. Dig a circular trench with a diameter of 2 m, and a width and depth of 30 cm. Put the removed soil inside the circle, compress it and shape it into a dome. The top of the dome will be around 20 cm above ground level.



The removed soil is shaped into a dome

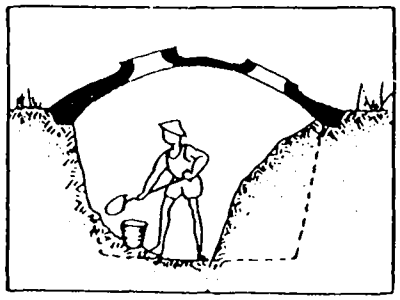
2. Place 4 bent steel reinforcement rods of ø 6 mm diagonally over the dome. Place two rings of reinforcement wire with ø 60 cm in two sections formed by the diagonals, and put two layers of chicken wire mesh over the dome, leaving the space within the two rings open. Place 4 circular reinforcement rods in the trench. Cast concrete in the trench and apply two 6 mm thick layers of sand-cement mortar on the dome, leaving the two holes open.



The reinforcement is placed on the dome

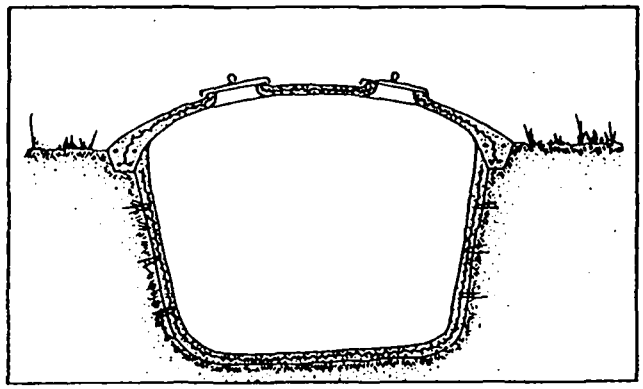
After two days the two covers of the tank may be cast in those two circular openings. They can be reinforced with chicken wire. Do not forget to provide (steel) handles.

3. Remove the covers after three or four days and dig out the soil under the dome, removing earth through the two holes. Dig as deep as 2 metres. Do not dig under the circular concrete beam.



Digging out the soil should be done carefully

4. Apply one layer of mortar on the bottomside of the dome, and on the bottom and sidewalls of the tank. Fix wiremesh over the fresh mortar of sidewalls and bottom using wire pins, bent as a hairpin. Apply a second layer of mortar, and seal the tank with a final layer of waterproof cement or strong mortar, 1 cement: 1 sand. Allow for proper curing.



Completed storage tank

For material and labour requirements → Chapter 5

Maintenance:

* cleaning the tank every time before filling it up;
* regular checking for cracks and leaks.

For fence and gate → Section 6.1

For bucket-hygiene and pumps → Chapter 8

10.3.4 BAMBOO CEMENT CONTAINERS

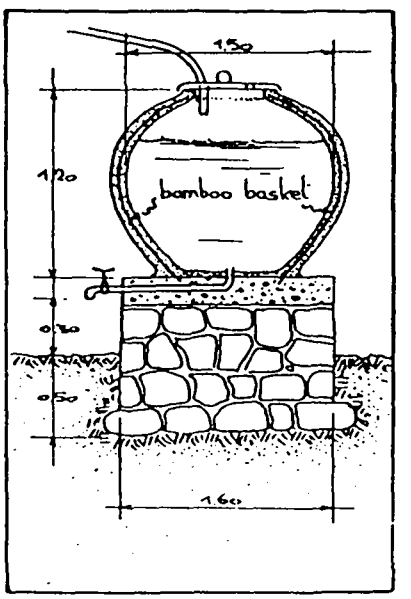
The bamboo cement container is of considerable size. It can hold approximately 1500 litres of water, sufficient to provide drinking water for a household of five members for a period of around four months. Since the container can hold a lot of water it will be very heavy when full, therefore, a sound foundation is required.
Bamboo is used as reinforcement material. Alternatives are several layers of chicken wire, reinforcement bars or wire mesh.

Construction

1. Make a bamboo basket of 120 cm high, with bottom and top diameter of 60 cm, and middle diameter of 150 cm.

2. Make a circular foundation of stones and mortar, with a diameter of 160 cm. About 50 cm of the foundation should be below and 30 cm above groundlevel.

3. Cast a concrete slab over this concrete, with a metal pipe bent upwards in the middle of the circular slab. A tap will be fixed on the end of this pipe. Ensure that the total height of foundation and slab is sufficient to place a water pot or bottle under the tap.



Construction of the bamboo cement container is done by skilled people

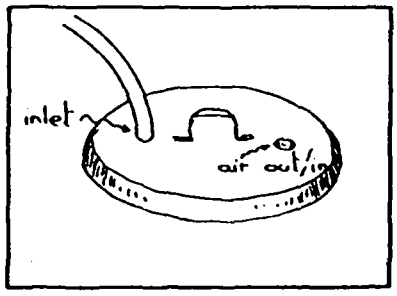
4. Cut out the bottom from the basket and place the basket on the one-day old foundation.

5. Cover the basket with a 2 cm thick layer of mortar (1 cement: 2 sand). Keep the fresh mortar damp.

6. Add a second layer the next day and a third layer one day later. The total thickness will be 6-8 cm.
Cover the tank with wet hessian or plastic sheets.

7. Smoothen the inside of the cistern with cement and water to facilitate cleaning.

8. Make a cover (ø 60 cm) with two holes: one for (rain)water and a small one for air in/outlet. This air in/outlet should be covered with gauze to prevent mosquitoes from entering the tank.



Rainwater and air in/ outlet

10.4 PROLONGED PROTECTED STORAGE

Generally, water that is collected from the source is drunk or used for cooking the same day. Sometimes it would be wise to store water a bit longer, especially if it is meant for drinking.
There is evidence that prolonged storage improves water quality. If water is stored in a clean, closed container and left untouched in a cool place for a period of 24-48 hours, a process of purification takes place. Suspended matter settles on the bottom of the storage container and a lot of the organisms that may cause diseases actually die. This improvement in quality does not mean that disease causing organisms will not be present anymore.

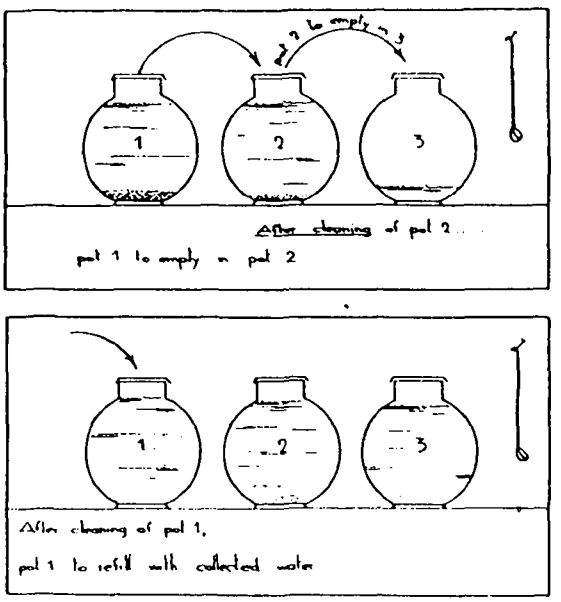
The 3-pot system

The 3 pot system is an effective means of purification. Any type of storage container can be used, but earthen pottery is preferred because of its cooling effect. The size of the containers depends upon the number of household members. The consumption of drinking water is 2-3 litres per day per person.

Day 1:
Water is used from pot 3 until water has been collected, then:
- pot 2 is slowly emptied in pot 3 and sediments are removed;
- pot 1 is slowly emptied in pot 2 and sediments are removed;
- pot 1 is now filled with the collected water.

Day 2:
Pot 3 may be empty; water is collected and the same procedure as for day 1 is followed.

Day 3:
Water collected on day 1 will now be used after a storage period of at least 48 hours.



Prolonged storage is carefully done

NOTE:

* Stored water that is not properly protected with a closely fitting cover may become contaminated and is therefore dangerous for health.

* The pots are thoroughly cleaned before refilling.

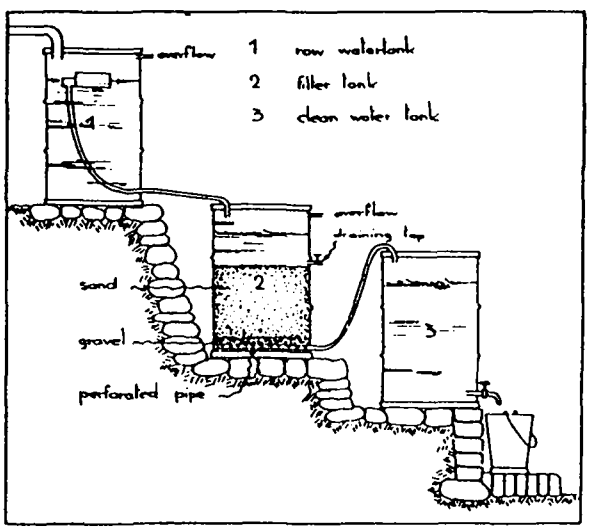
* Emptying from one pot into the other can also be done by siphoning.

11. WATER TREATMENT OPTIONS

11.1 BIOLOGICAL TREATMENT

SMALL-SCALE SLOW SAND FILTER

In a slow sand filter, water is passed through a bed of sand. Impurities in the water will be retained on top of the sand bed. After some days a slime layer will develop on the sand surface which will contain many organisms which will feed on harmful bacteria and viruses that enter the filter. A properly operated slow sand filter with a continuous water flow will produce water that is virtually free from disease causing organisms. A small-sized unit can be made out of three empty oil drums.



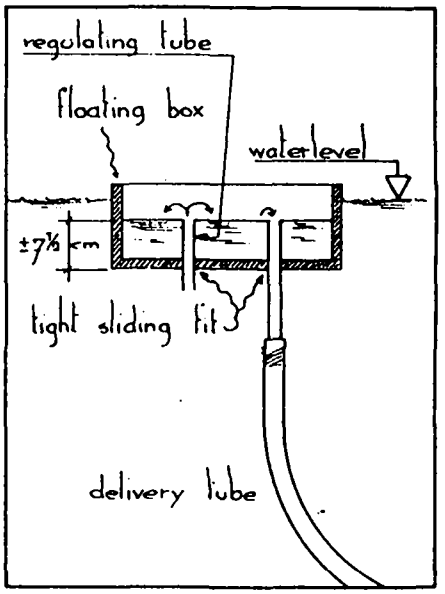
Slow sand filter system

The raw water tank

The first drum serves as a raw water storage reservoir. It is also a balancing tank: if too much water flows in it overflows and if not enough water comes in, the stored water is used for filtration.

The floating weir

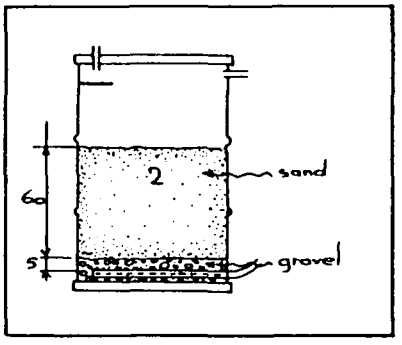
The slow sand filter is operated with a constant filtration rate of 0.1 m/h. This rate is obtained through the adjustment of the inlet tube of the floating bowl. This inlet tube has a very small diameter of about 5 mm and can be moved up and down. The discharge increases when the tube is moved down. The outlet delivery tube is put at the same level as the inlet tube. The amount of water discharged is measured at the outlet of the delivery tube. The required amount of water is equal to the sand surface area times the rate of 0.1 m/h (For an oil drum with a diameter of 0.45 m, the amount is 16 l/h or 0.26 l/min).



Floating bowl in raw water tank

The filter tank

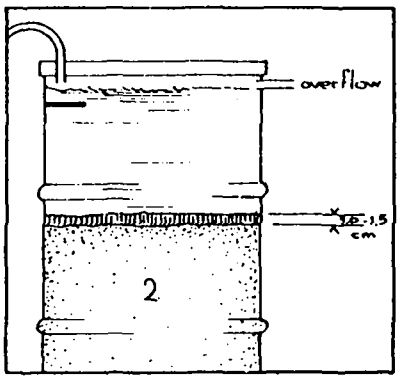
In the second drum, a layer of 60 cm of fine sand (diameter 0.15-0.30 mm) is placed over a perforated pipe covered with a thin layer of gravel (5 cm). The water outlet should be kept a bit higher than the sand level otherwise the filter does not function well. When the filter works, all kind of dirt present in the raw water is retained by the biological layer and the filter sand. That means that the raw water cannot pass easily through the filter sand. After some time the filter starts delivering less water and also the water level in the filter drum rises. When the drum starts overflowing, the sand filter has become dirty and needs to be cleaned. The inflow is then stopped.



Filter components

Scraping biological layer

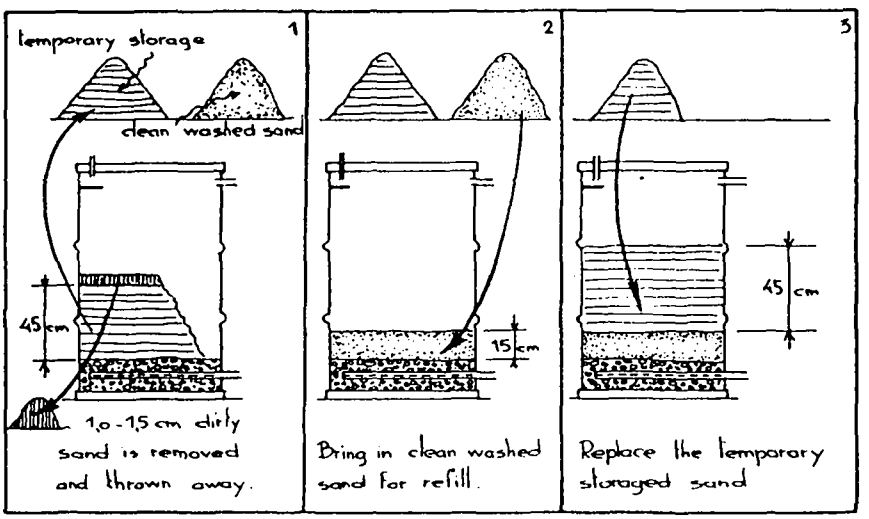
The biological layer is mainly responsible for the blocking of the filter. Therefore, the raw water above the sand is drained away through the special drainage outlet or simply scooped out using a mug or small container. More water is drained through the filter until the water level in the filter-bed is about 10 cm under the sand surface. Then 1.0-1.5 cm (one finger) sand is scraped. The filter is ready to re-start the filtration process. The filter must be covered with water before the filtration rate is set at 0.1 m/s.



Scraping of biological layers

Re-sanding of filter

When after many scrapings of sand the filter-bed reaches its minimal thickness (i.e. 45 cm), it is time for resanding. Most of the sand is then removed. On top of the gravel a 15 cm layer of fresh sand (old well-washed sand plus new sand) is placed covered with the removed 45 cm of old sand.



Re-sanding of the filter

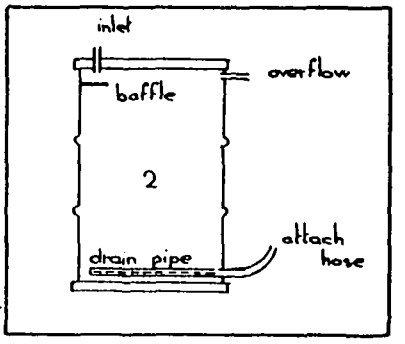
Construction

Drums

Clean three oil drums of 200 litres, and if possible disinfect them with bleaching powder. Do not use drums that have contained chemicals. Make covers for these drums.

Inlet/outlet

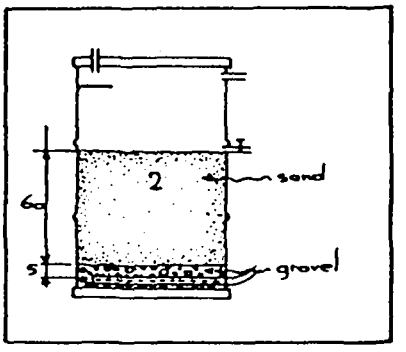
Fix pieces of pipe with a diameter of 10 to 15 mm to the raw water drum, filter drum and clean water drum for overflows, inlets and outlets. The drain/outlet pipe (1 inch pipe) should be perforated where it is inside the drum and bent upwards as indicated.



Construction of filter tank

Filter-bed

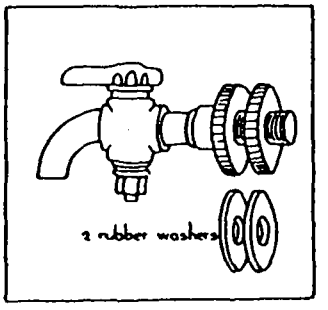
Wash fine gravel and sand thoroughly. Put a layer of fine gravel in the drum, up to 5 cm above the drain-pipe. Fill the drum with a sand layer of 60 cm.



Filter-bed composition

Clean water drum

Fix a supply tap to the collection drum, and place the drum below the outlet of the filter drum. The outlet enters the collection drum through a hole in its cover. The top of the clean water tank should be at the same level as the top of the sand bed.



Clean water tank-tap

Let the process continue even when the collection tank is filled and starts to overflow. Then the biological layer on the sand surface will continue to function. If the process is interrupted, the biological layer does not function anymore and the water will not be safe for drinking purposes.

Maintenance:

* ensure that there is always water in the raw water storage reservoir;

* check floating bowl discharge regularly and adjust tube position to maintain a filtration rate of 0.1 m/h;

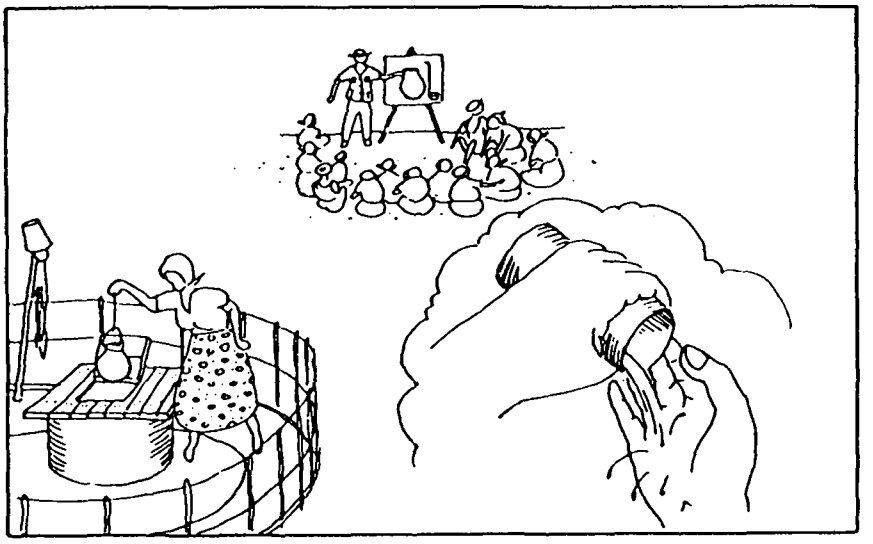
* clean filter by removing 1.0 to 1.5 cm of the sand bed when filter drum starts to overflow;

* when the minimum thickness of 45 cm has been reached, a new layer of sand has to be placed underneath the existing layer (re-sanding).

11.2 CHEMICAL WATER TREATMENT

11.2.1 POT CHLORINATION

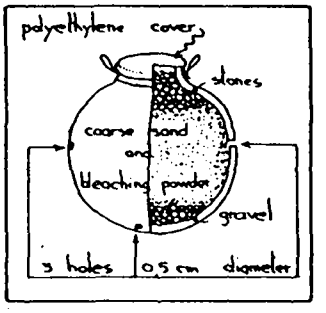
Disinfection of the water at the source should be considered as a temporary emergency measure, for instance in case of a disaster. If disinfectants are readily available on the local market permanent water treatment using disinfectants could be considered. It may be necessary when the water is known to be contaminated with cholera bacteria or bilharzia larvae. Chlorination could be additional, but should never come instead of source protection and efforts to improve hygiene practices. Chlorination will give the water a distinct taste which the consumers sometimes dislike or reject entirely.



Joint efforts to improve health

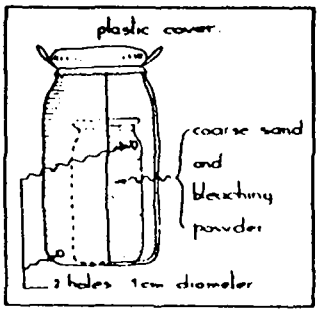
Pot chlorinators

The pot chlorinator is to be placed in a source with unsafe water, for instance a well, a spring box or a storage tank. A pot that holds 1 kg bleaching powder and 3 kg sand, plus the required stones and gravel, is sufficient for a water source that serves some 60 people. It takes at least one hour after hanging the pot in the water for the chlorine to disinfect it.



Pot chlorinator

Because the bleaching powder is mixed with sand, chlorine will be released slowly and disinfection will be effective for a longer period, say two weeks.



Pot chlorinator

NOTE:

* Replacement of bleaching powder and sand will return every two weeks; the costs may therefore be considerable.

* When bleaching powder is stored in a cool dark place it loses half its strength in about a year. Improper storage causes the strength to reduce much quicker.

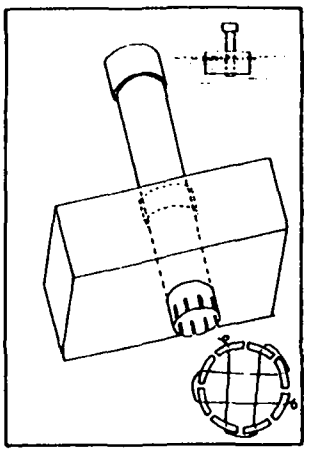
Maintenance

* replacement of the sand/bleach mixture every two weeks;

* thorough scrubbing of pot, stones and gravel at that occasion.

11.2.2 FLOATING CHLORINATOR

The floating chlorinator is made of a floating body in which a plastic tube is placed containing chlorine tablets. The chlorinator floats on the water in the water storage tank, spring box or pumped well. The chlorine tablets in the tube slowly dissolve in the water. By pushing the tube more through the float, more chlorine will dissolve.



Floating chlorinator

The floating body measures 400 x 200 x 250 mm and can be made of polystyrene or wood. For the tube PVC or bamboo are suitable materials. The tablets rest on a copper wire at the base of the tube.

NOTE:

* The position of the tube determines the amount of chlorine that enters the water. This position should be given by a specialized public health laboratory.

* Cost of chlorine tablets may be high. The use of chlorinators is best restricted for emergency situations. Improved source protection and better hygiene practices are more effective in the long run.

Maintenance

* Addition of new chlorine tablets after several weeks;

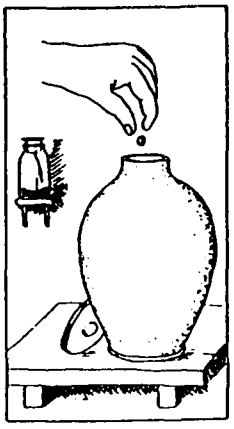
* Careful cleaning of base of the tube.

11.2.3 CHLORINE TABLETS AND BLEACHING POWDER

If water is filtered and disinfected, disinfection should always be the last step.

Chlorine tablets

The easiest way to disinfect drinking water is to add chlorine tablets to it. These tablets can be bought in a chemist's or pharmacy. The tablets are quite cheap, but to use them continually will turn out to be very expensive. Therefore, their use could be limited to periods with increased risks, for instance during epidemics. Always follow the instructions on the packet when using the tablets.



The use of chlorine tablets

Bleaching powder

Another method to disinfect contaminated water is to add a bleaching powder solution. Sometimes liquid bleach (hypochlorite) is available at the market. The volume of the bleach to be added should be given by a specialized institution, like a public health laboratory. It takes about one hour for the chlorine in this solution to destroy the bacteria in the water. Application of this method requires some training and some specialized tools.

Both methods may give a distinct taste of chlorine to the water.

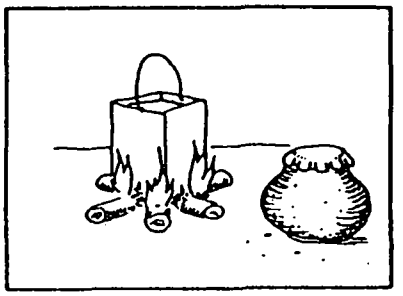
NOTE

* Bleaching powder loses half of its strength within a period of one year, even when stored in a cool dark place.

11.3 HEATING

BOILING

Boiling kills the disease-carrying organisms in water. Just bringing water to the boiling point is not sufficient to kill all micro-organisms that may be present in the water. To be totally safe for consumption, water must boil for twenty minutes! This is quite long and expenditures on firewood or other fuel will be high in the long run. To boil water for a few minutes is in any case better than not boiling it at all.



Boiling water

For improved fireplaces → Chapter 14

Of course boiled water must cool down before it can be drunk. It is important to avoid re-contamination. The safest method is to let the water cool in the same pot in which it was boiled, and use this as a storage container. Second best is to pour the water into a clean storage container immediately after boiling. Earthenware containers are the best.

For safe storage → Chapter 10

NOTE

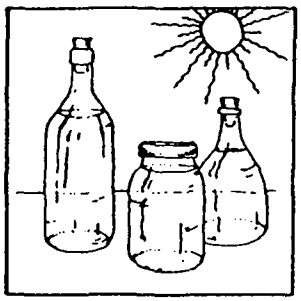
* Do not allow the water to cool, not even to a hand-warm temperature, before pouring it in a storage container. Most bacteria that might be left in the storage container will be killed by the hot water.

11.4 RADIATION

SOLAR TREATMENT

The rays of the sun have a purifying effect: they can kill all or most micro-organisms present in the water.

The rays of the sun can only get to the water if it is stored in non-coloured glass or transparent plastic containers. These should be covered or closed, and placed on a sunny spot, in such a way that they do not cast shadows on each other.



The sun-rays kill most of the bacteria and viruses.

When the bottles are left in the sun from morning till late afternoon, the water is safe for consumption. Of course the water will then be warm. It can be left to cool overnight, as long as it is not re-contaminated: the cover or stopper of the glass or plastic container should not be removed during cooling.

NOTE

* Solar treatment is not possible during periods with cloud cover because the radiation of the sun is insufficient then.

* If the water contains many suspended or organic particles and is turbid, it needs to be filtered before solar treatment.

For filtering → Section 11.1

NOTE

* Solar treatment should not be attempted with water in earthenware, non-transparent or any other containers that do not let the sun-rays through. Without the effect of the purifying sun-rays, the only thing happening is the increase of the water temperature.

12. SANITATION

12.1 OPEN FIELD SANITATION

BURYING FAECES

In many communities, not all people have a latrine, so they use the forest, bush, beach, river etc. In some cases, grown-ups use latrines while children do not. People who have latrines at home may use the open field when they are at work, travelling or far away from the facilities.
With the introduction of latrines, the extent of open field defecation will decrease, but it will be difficult to entirely eradicate it. Therefore, it is advisable to discuss correct habits regarding open field defecation in any case, whether or not latrines are or will be available.

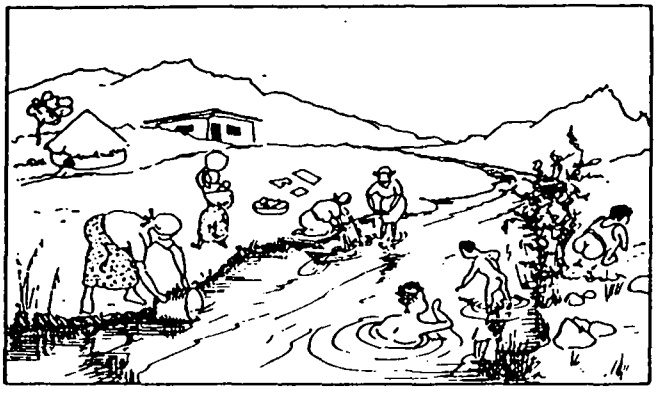
For health risks related to faeces → Chapters 3 and 4

SOME POINTS FOR DISCUSSION

Water source contamination

* Defecation in or nearby rivers, streams and ponds causes contamination and may spread diseases.

* Defecation close to any water collection point such as springs, wells and surface water sources may endanger the health of the community.



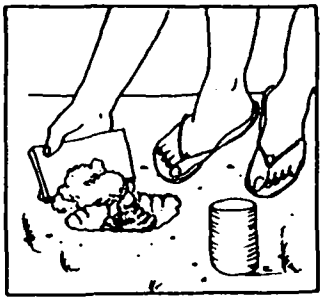
Contamination of water source

Field contamination

Defecation in or close to vegetable gardens, rice fields or other fields may pollute the food crops and may thus cause diseases, or may contribute to the spread of diseases such as schistosomiasis and worm diseases.

Burying faeces

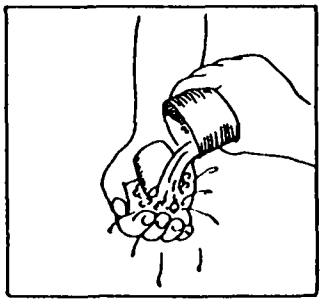
When faeces is buried, people or animals will not get it on their feet, so spreading it over a larger area and into houses is prevented. Moreover, flies cannot get to the faeces. Burying faeces is a matter of digging a small hole and closing the hole again after "use". However, it will not fully prevent the spread of diseases such as hookworm and roundworm which need soil for development.



Cover the faeces with enough soil.

Hand-washing

Washing hands after defecation is preferably done with water and soap to remove the germs which otherwise may cause diseases. If soap is not available, sand and ash may be used. If there is no water available, hands should be washed at the earliest opportunity, for instance when coming home or when passing a river, stream or other water sources.



Regular hand-washing is important.

12.2 LATRINES

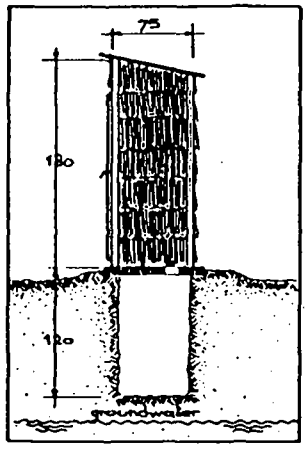
12.2.1 DIFFERENT TYPES OF LATRINES

If an area is more densely populated, open field defecation will become less suitable and pose a greater health risk. Then latrines will be required. There are various types of latrines. The choice of a particular kind of latrine will depend on the type of soil, the level of the water table, the cost, and of course, the people's preference and local practices.
The four basic types of latrines are dealt with here.

Type of latrine

1. Simple pit latrine

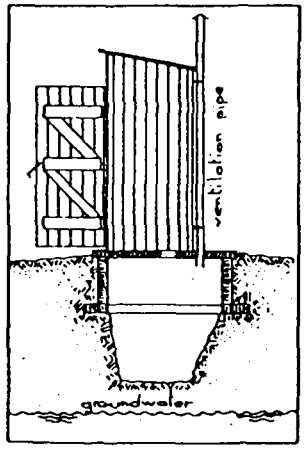
A simple pit latrine consists of a pit, slab and superstructure. When the pit is full it is emptied or a new pit is dug and the slab and superstructure may be moved to the new location. The disadvantages of a simple pit latrine are the smell and the attraction of flies and perhaps mosquitoes. Both can be partly solved by covering the hole with a lid after use. Emptying the pit is a health-hazardous job which can better not be done if enough space for a new pit is available.



Simple pit latrine

2. Ventilated improved pit latrine

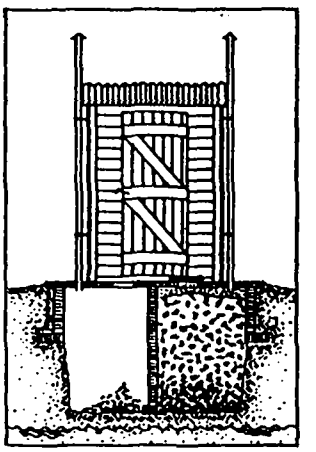
To overcome the smell and the nuisance of flies, the ventilated improved pit latrine, or VIP, has been developed. This pit latrine has a vent pipe of which the open end is covered with a fly screen. If the people dislike the smell of latrines, the VIP offers a good solution. The vent pipe can be made of different types of materials such as PVC, burnt clay pipes, bamboo, ferrocement etc.



Ventilated improved pit latrine

3. Double pit latrine

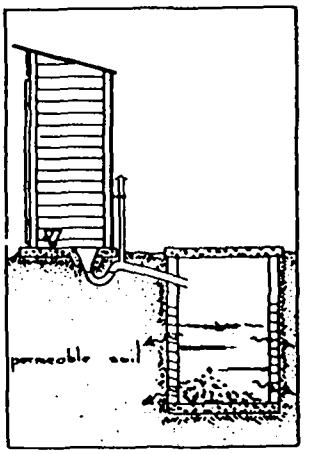
In a double pit latrine, or DPL, one pit is used, while the other one is sealed off. By the time the pit in use is full, the contents of the other pit have decomposed, and the pit can be emptied without a health risk. All the disease-causing micro-organisms that were present in the faeces will have died off. The pit volume should therefore be sufficient for at least one year use. This process is repeated again and again. The decomposed pit contents can be used as fertilizer. Since there are two pits instead of one, they can be less deep than a single pit with similar capacity. This makes the DPL particularly suitable for areas with a rather high water table. The pits of the double pit latrine can be ventilated by providing one vent pipe for each pit.



Double pit latrine

4. Pour-flush latrine

A pour-flush latrine is feasible where there is enough water near the latrine the whole year round and where the soil is sufficiently permeable. A waterseal prevents flies and mosquitoes from entering the pit and smell from escaping. A waterseal can easily get clogged. It is therefore not suitable if people use corncobs, stones or other large objects for anal cleansing. A pour-flush latrine can be constructed with one or two pits.



Pour-flush latrine

NOTES:

* Drainage

For each type of latrine, drainage around the superstructure and pit must be provided. If the latrine is built slightly above ground level, flooding will be prevented.

* Bad smells

To avoid bad smells coming from the pit, ashes (preferably still hot) could be thrown in the pit daily in case ventilation is not a feasible solution.

* Mosquito breeding

In areas with a high groundwater table latrines pits contain a lot of water (wet pits) and may become breeding sites for mosquitoes.

Several measures can be applied to reduce the breeding:

- place a tight lid over the hole; always put it back in place after use;
- install a ventilation pipe; the upflow of air and the screened open end of the pipe reduce the breeding of mosquitoes in the pit;
- add oil or kerosene to the water in the pit; however, this may cause groundwater pollution;
- add a lot of small polystyrene balls that form a floating layer which prevents the mosquitoes from laying eggs in the water.

* Fly nuisance

Flies like faeces: to eat it and breed in it. They are attracted to the pit by the foul smell. They will come into the pit through the squatting hole or through the ventilation pipe if the open top end is not well screened.
For laying their eggs they prefer pits that do not contain a lot of water (dry pits).

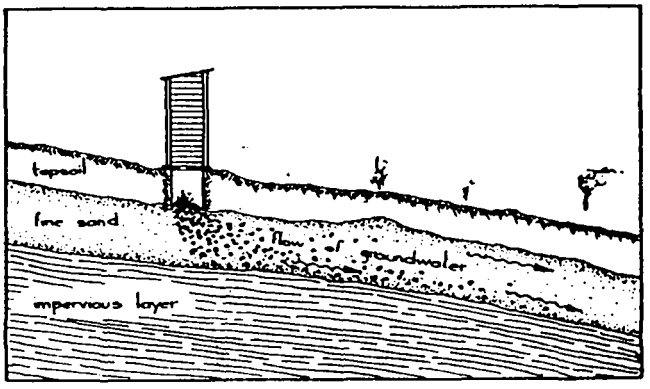
The best measures to reduce this health hazardous situation, since flies spread diseases, are:

- place a tight lid over the squatting hole and always put it back after use;
- screen the ventilation pipe properly;
- put hot ashes over the dry faeces in the pit daily.

12.2.2 LOCATION OF LATRINES

Soil pollution

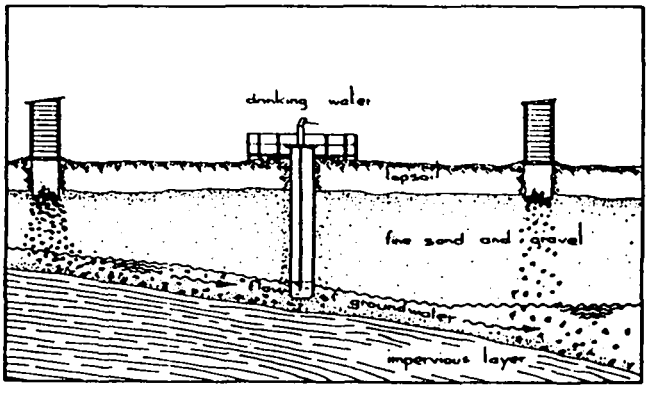
The content of the pits of single or double, wet or dry pit latrines leaches out and pollutes the soil around the latrine. Bacterial soil pollution can extend to a considerable distance from the latrine.



Bacterial movement due to groundwater flow

Water source contamination

The polluted groundwater can contaminate well, spring and surface water. When deciding about the location of a latrine, it is important to determine the direction of the groundwater flow. This is easy in the case of sloping ground: the direction of the groundwater flow is towards the lower areas.

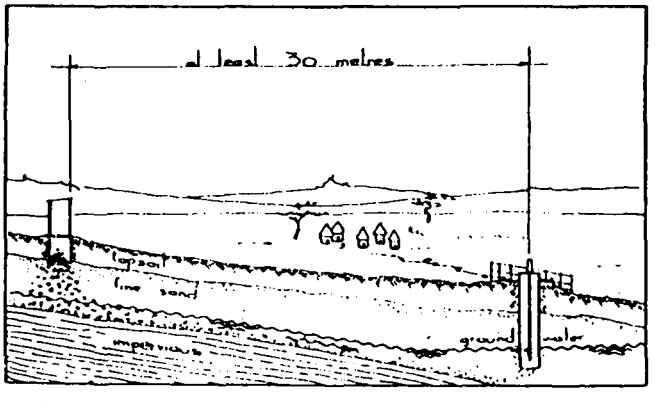


Well water contamination from latrine

If the area is flat, the direction of groundwater flow is sometimes difficult to determine and sufficient distance is required between water points and latrines.

Distance between latrine and water source

To be on the safe side, latrines should be constructed at a distance of at least 30 metres from wells, springs and the water distribution network.



Safe distance between latrine and water source

In case a latrine is constructed anywhere near a surface water source, it should be constructed downstream of the water collection point.

12.2.3 PITS

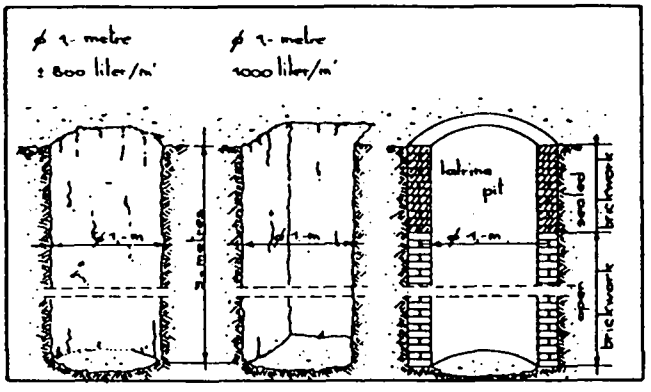
Pits are meant to collect and to a certain extent also to decompose the excreta. The water that is contained in excreta soaks into the soil through the sides and bottom of the pit.

Defining type and size of pit

The choice of a particular kind and size of pit will depend on:

- the stability and permeability of the soil;
- the highest level of the groundwater table;
- the number of users of the latrine;
- the availability of digging or drilling equipment;
- materials thrown in the pit such as cleansing materials and household waste.

The size of the pit also determines the time period before it is filled up and when it has to be emptied or a new pit has to be dug. Pits can be square or circular. In unstable soils, it is advisable to dig circular pits, to minimize the risk of collapse.



Types and sizes of pits

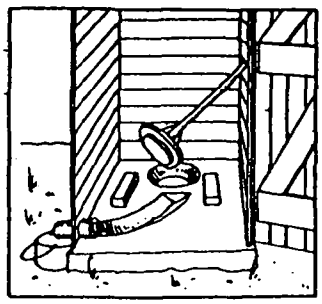
Size

To determine the required pit volume, the excreta volume of a family of 6 members is estimated to be 0.5 m^3 per year. If voluminous cleansing materials are used and if household waste is thrown into the pit, the waste volume will be higher, up to approximately 0.75 m^3 per year.
If emptying is to be done only once in 4 years, the pit must be four times as big, i.e. 2 and 3 m^3 respectively. If more than 6 people will be using the latrine, then the pit should also be larger.

These exemplary figures are meant for dry pits and when no water is used for cleansing. When water is used for anal cleansing and for wet pits, the pit can be slightly smaller, or emptyied less frequently because the water speeds up the process of decomposition and soaking away.

Hard or impermeable soil

However, if the soil is very hard or impermeable, water and also urine will not soak away into the soil and the pits will fill up very quickly. In that case, it is advisable to drain urine into a separate container that can be emptied frequently.



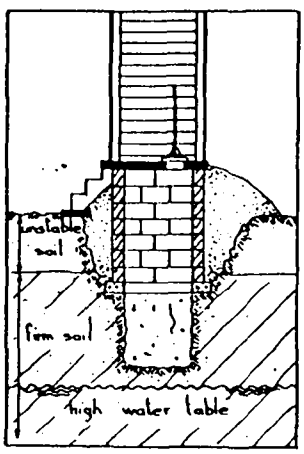
Separate urine collection

Depth

The bottom of the pit should be preferably at least 1 metre above the level of the groundwater table in the wet season. Groundwater below and around pits is bound to get contaminated in any case, but if the bottom of the pit is very close to the groundwater, contamination will be extremely serious. The chances of the pit collapsing are much higher when the pit is extended below groundwater level.

Mound or elevated latrine

If the water table is very high, the latrine could be built on a small mound. Deep pits are easy to dig in stable soils.
In unstable soils, pits could be made shallow and/or they could be lined.

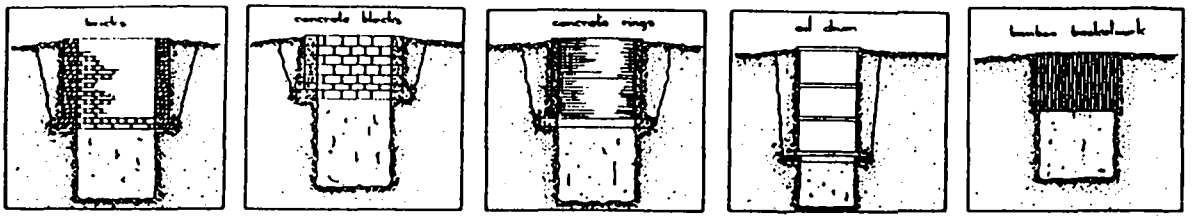


Mound latrine

Lining

In unstable soils, lining of the pits will be necessary. However, the sides of the pit must be permeable. Therefore, the lining should be of permeable material such as honeycomb brickwork, porous concrete or concrete with holes. The upper 40 cm of the lining must be impermeable to prevent inflow from surface runoff.

For porous lining (lining of bottom part of well) → Section 7.4



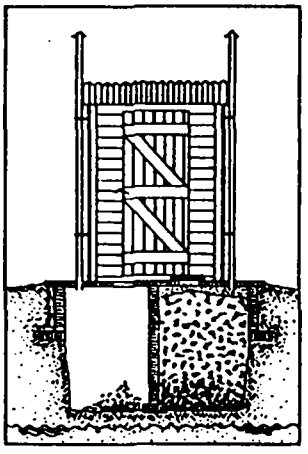
Brick lining Concrete blocks Concrete rings Oildrum(s) Bamboo/basket work

In very loose soil, such as fine sand, it will be difficult to construct honeycomb brickwork. The sand will flow through the holes into the pit. In such soil, brickwork or any other lining material should not be open. The open bottom of the pit will allow for sufficient soakage.

The bottom of a pit should never be entirely sealed.

Double pits

The two pits of a double latrine should be properly separated. If the seriously contaminated water of the pit in use soaks into the other pit, the process of composting and eradication of disease-causing organisms will not be optimal. The two pits could be dug as illustrated, and rendered with a waterproof mortar.



Double pit latrine

Material and costs

The required material and labour for the construction of pits will vary widely, depending on diameter, depth, need for lining and the material used for lining.

Maintenance

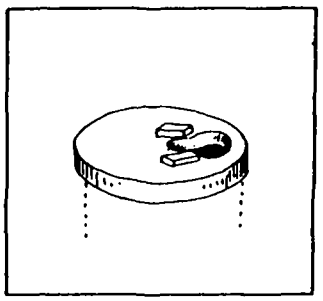
* When the pit content has reached a level of about 50 cm below the slab, the pit must be sealed with soil and a new one dug.
  If there is not enough space for a new pit, dig out the contents of the pit using buckets. Take precautions to avoid caving-in.
  Dispose of the contents at a safe place, for instance in small pits that will be sealed off at some distance from the community, but not near a water source.
  Avoid contamination of the ground and direct environment in the emptying process. Clean used equipment thoroughly, as well as clothes and footwear worn, and use soap for personal hygiene.

12.2.4 LATRINE SLABS

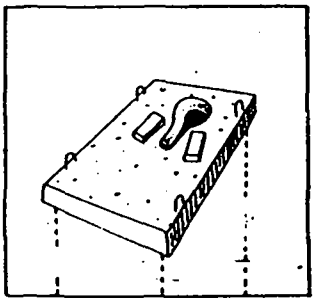
In most cases the squatting slab with the hole will be located directly over the pit. It will have to span the diameter of the pit and must therefore be quite strong.

Slab types

1. A circular or square concrete slab, 5 cm thick and reinforced with wire mesh. A hole should be kept open in the middle, for instance by placing an old bucket before pouring the concrete. Two bricks placed in the wet concrete can serve as footrests. Leave enough space for the cover between the squatting hole edge and the footrests. Reinforcement with two layers of chicken wire gives another option. This ferrocement slab could be 30 mm thick.

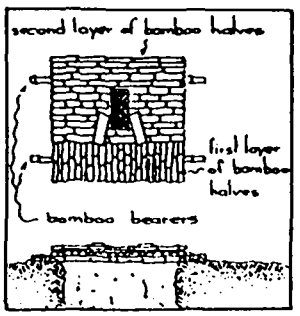


Circular concrete slab



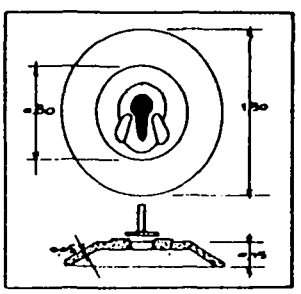
Square concrete slab

2. A wooden or bamboo slab can be made by constructing a supporting grid of small beams over the pit. Two layers of split bamboo are nailed onto the grid. In the case of wooden boards, one layer is sufficient. A rectangular hole is kept open. If required, two footrests can be made of wood.
To get a smooth surface the slab is plastered with clay. This makes cleaning possible. Bamboo and wood may be easily attacked by insects and micro-organisms and may then not be strong enough and therefore unsafe.



Bamboo slab

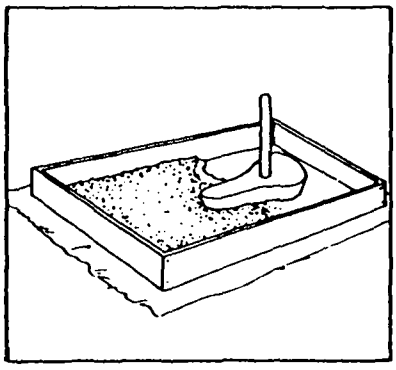
3. A circular concrete slab can be made using a "shell-type design". This slab-type does not require reinforcement that may not be readily available in the rural areas. This lightweight slab is particularly suitable if many slabs have to be produced.
Transport is to be done very carefully.



Shell-type slab

Construction of a reinforced square slab

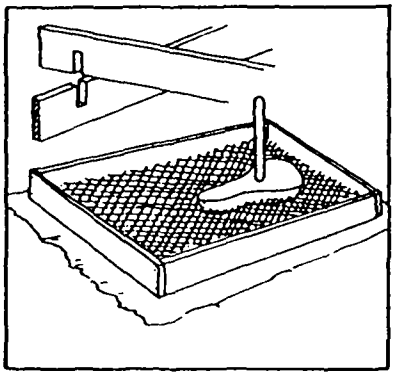
1. Make a framework of timber, 30 mm thick and for instance 1.25 m x 1.25 m in size, depending on the pit. Also make a timber mould for the hole. This mould will be the well-fitting cover with handle for the squatting hole.



The first layer of mortar is poured in the mould

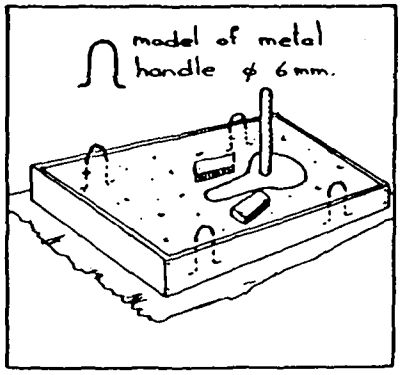
2. Place paper or plastic on the leveled ground surface and place the mould for the squatting hole (and vent pipe if required). First put a layer of sand/cement (ratio 3:1) mortar of 10 mm.

3. Put the two layers of chicken wire with a cut hole for the squatting hole on the mortar. Place the two bricks for the footrests in the right position slightly directing outwards.



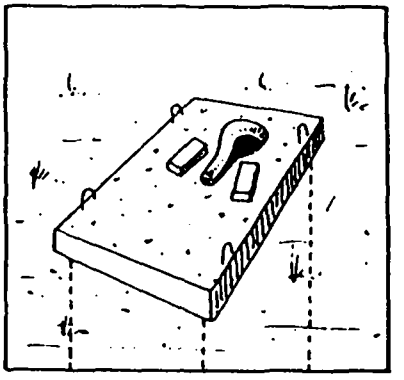
Two layers of chicken wire are put over the first layer of mortar

4. Pour sand/cement mixture until framework is full and level the surface. Cast four metal handles in the fresh concrete.



The mould is filled up with mortar

5. Cure the concrete slab for four days by placing wet hessians or a plastic sheet after wetting. After two days the moulds can be removed. Leave the slab for 10 days to harden before it is removed.



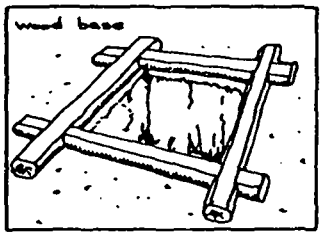
After 10 days the slab can be removed

Preserved bamboo or termite-resistant wood may be used as alternative reinforcement materials but then concrete should be used and the slab should be at least 60 mm thick.
To allow for removal to a new pit, the squatting slab could have four metal handles cast in the slab.

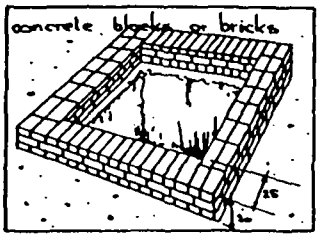
For an estimate of material and labour requirements → Chapter 5

12.2.5 SLAB BASES

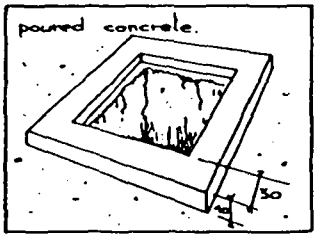
The concrete or ferrocement slab will be put on a base. The base will support the slab all around, so that the slab will not crash. If a lining is built, the slab is put on it. In case of stable soil it is still necessary to construct a base. The following options are possible depending on availability of materials.



Wooden base



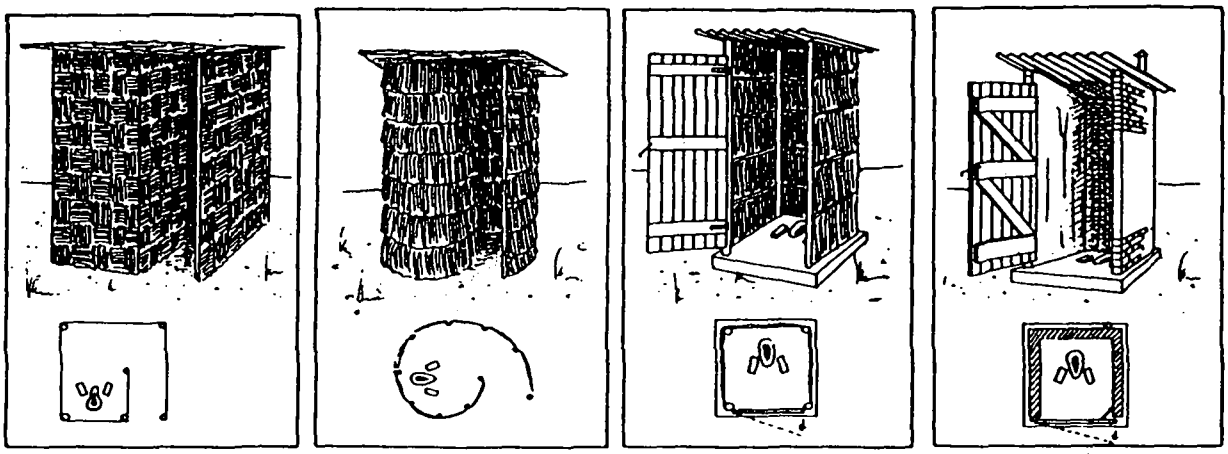
Base of blocks or bricks



Poured concrete base

12.2.6 LATRINE SHELTERS

The main purpose of a shelter, or superstructure, is to create privacy for the user. The need for privacy depends on the local situation and location. A roof can protect the user and slab against rain. A cover on the drop hole and a drain around the pit, or a slightly raised slab and superstructure can also avoid the rainwater entering the pits. A latrine shelter can be anything, from a three-walled cubicle without a roof or one made of woven bamboo, leaves or wood, to a miniature house of bricks and tiles, with a lockable door. An L-shape construction provides sufficient privacy.



L-shape square type L-shape spiral type Palm leave walls Brick walls

When constructing latrine shelters ensure that:

* the space is easy to clean;
* the overhang of the roof, if any, is large enough to protect the walls and foundation of the superstructure against heavy rains;
* provision is made to place or hang a container with water and to store soap or ashes for hand-washing outside the shelter;
* provision is made to store cleansing materials and a brush or broom inside the shelter;
* openings are kept small and fly screens are placed to increase the convenience of using the latrine.

For estimate of material and labour requirements	→ Chapter 5

Maintenance:

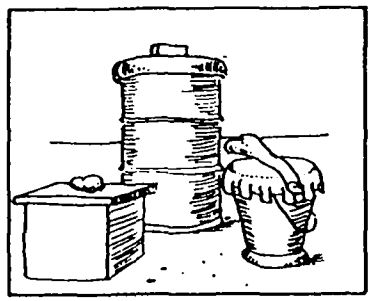
* daily cleaning of slab, doorhandles (if any) and water container;
* weekly or more frequent thorough cleaning of the slab, for instance with ashes;
* regular cleaning of the drain;
* repair of cracks in the slab when necessary.

13. WASTE DISPOSAL

13.1 GARBAGE STORAGE

Garbage disposal sites such as compost pits or community garbage pits are best not located nearby the houses because of health reasons. Therefore, waste disposal should start with safe, temporary storage in or just outside the house.

Anything will do as a waste or garbage container, as long as it is easy to clean and has a cover. Old tins, oil drums, buckets or bowls, all with covers, can be used for temporary collection of garbage at home. Emptying and cleaning will be easier if a piece of paper, plastic or some dry leaves are put on the bottom of the garbage container.



Household garbage containers

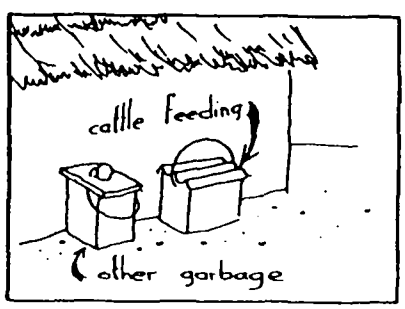
Garbage containers must be kept out of reach of small children, animals and vermin and covers should fir tightly.

Correct use and maintenance

* replace the cover after use;
* empty the container daily, even if it is not yet full;
* clean container and cover frequently;
* wash hands after emptying the container;
* repair container when there are cracks or holes.

NOTES:

* If garbage is used for cattle feeding or composting, non-organic waste such as glass, plastic and tins should be kept separate.



Separation of household garbage

* If garbage is eventually to be burnt, it is advisable to keep wet or humid garbage apart and to deal with it separately.

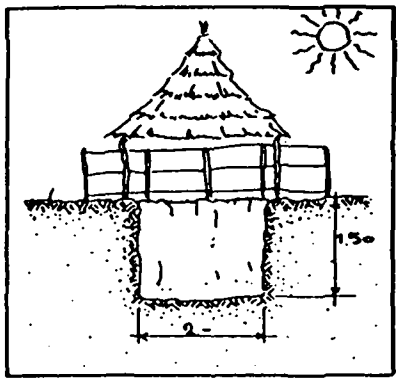
13.2 COMPOSTING

Compost pit

In a compost pit, organic waste is left to decompose for a period of 2-3 months. The result is a compost that can be used to enrich the soil of agricultural fields or gardens. Generally, one household does not produce sufficient organic garbage to fill up a compost pit quickly. One pit could be shared by several households. Moreover, organic waste material other than just household garbage such as dry grass, weeds, leaves and animal droppings can be put in the pit.

Construction

* dig a pit of 2x2 m, and 1-1.5 m deep;
* construct a simple shelter over the pit that creates shade;
* construct a fence to keep animals out.

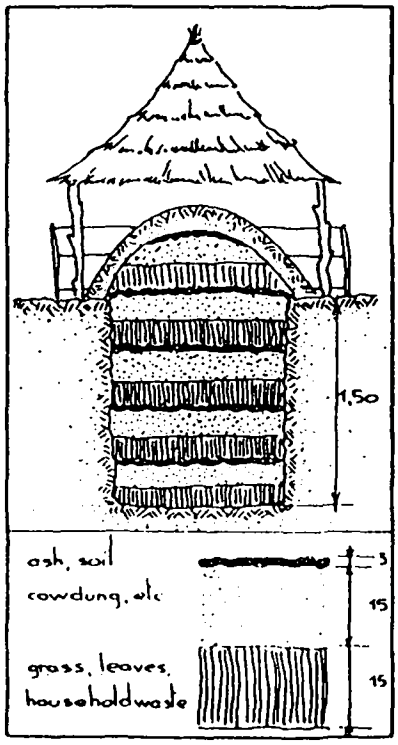


Dimensions of a compost pit

Building up of compost pit

The best results will be achieved when the pit is filled up in layers as illustrated:

* first, a 15 cm thick layer of grass, leaves, straw and household waste;
* a second layer of animal dung and/or poultry manure;
* a third, 3 cm thick layer of ashes and/or soil.



Different layers of compost pit

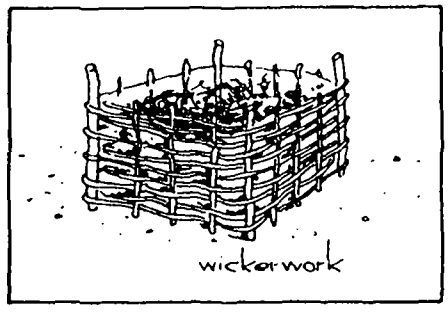
Composting procedures

* fill up the pit by repeating the three layer system;
* stir the contents of the pit every now and then;
* sprinkle a little water on the contents during dry weather to stimulate the composting process;
* fill up the pit a bit higher than ground level, to allow for shrinkage;
* close and seal the pit with a layer of animal dung and mud;
* leave the pit for 2-3 months before opening it;
* use the decomposed material as fertilizer.

NOTE:

* Do not put plastic, tins, glass or earthenware in the compost pit: these materials do not decompose.
* Food left-overs can be put in the compost pit, but they have to be covered with soil otherwise they will attract rats and mice.

When the groundwater level is high during the rainy season or generally, composting is done above ground level.
Four poles are placed in the ground making a square of say 1.2 x 1.2 m. Tree branches are placed behind the poles to keep the compost material together.
During rains nutrients will leach from the compost into the soil, rendering this very fertile. New heaps could therefore best be made at fresh places in the garden.
The process is similar as for the compost pit.



The compost heap

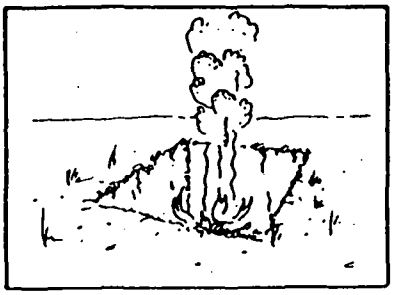
13.3 LAND-FILLING

GARBAGE DISPOSAL PITS

Some garbage cannot be used for composting. Empty tins, broken glass and pottery, packing materials, plastic containers and bags, old rubber tyres, etc. must be disposed of properly.

Burning

Some of this kind of garbage could be burnt. However, especially rubber and plastic will cause a very bad smell.



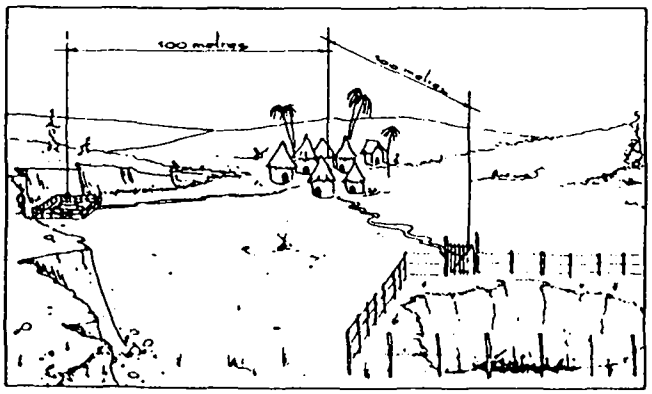
Burning of non-organic waste in a pit

Burying

The easiest way to get rid of non-organic waste is burying. Burying could take place at household level, in a small pit dug in the private yard or garden. Burying could also take place in a common pit for the whole community. A garbage pit is not a very attractive sight. Therefore, the location of a community garbage pit should be at a safe distance (100 metres) from the community.

Location of garbage pits

Moreover, some organic waste may also end up in the pit, attracting flies and vermin, and polluting the groundwater. From a health point of view, community garbage pits must be located at least 100 m away from rivers, streams, ponds and any other water sources, such as springs and wells.



Community garbage pit at safe distance from water source and community.

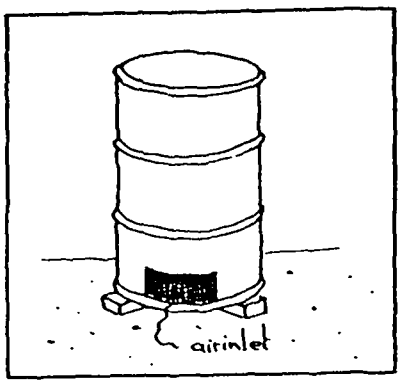
NOTE:

* If pits are used to dispose of all garbage, including organic waste, the contents of the pit should be covered frequently with a layer of soil and it should be fenced off to keep out animals.

13.4 INCINERATION

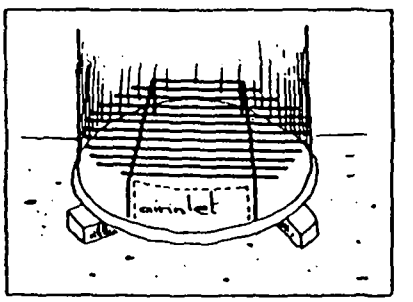
Some households waste can not be composted. Plastic, rubber, paper etc. can best be disposed of by burning. Hospital waste should be burnt to prevent that the infected and therefore dangerous waste may be picked up by children.

An incinerator can be made from an oil drum in which an opening is cut near to the bottom. The opening allows the removal of the ash and the inflow of air needed for the combustion.



Simple incinerator

Iron bars are placed inside to provide a suitable fireplace.



Iron bars inside the incinerator

13.5 WASTEWATER REMOVAL

DRAINS AND SOAK-PIT

Waste water

Each household produces wastewater. Dirty water from cooking, washing up, cleaning floors, hand-washing and bathing, and laundry must be drained away properly. The construction of a wastewater drain could take care of this. The drain should lead to a soak-pit. From this soak-pit the water will seep into the soil.

Rainwater

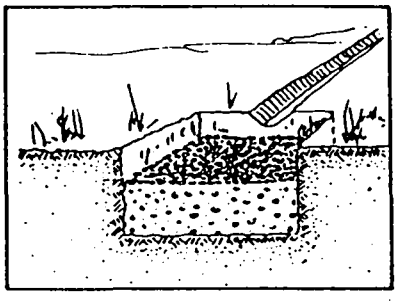
Rainwater could be led to vegetable gardens or to a soak-pit.
A drain around the house, which will also drain away rainwater from the roof is a necessity.

NOTE:

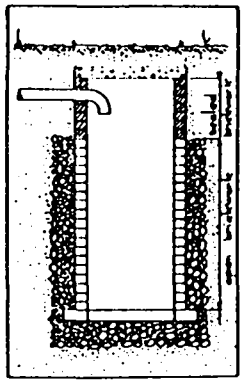
* Wastewater drain and soak-pit must be located at least 30 m from any water source, such as wells and springs.

Types of soak-pits

Drains and soak-pits can vary from simply dug trenches, which are a considerable improvement compared to a situation without any drainage, to well constructed stone or concrete systems. Material requirements and costs will vary accordingly.



Simple soak-pit



Soak away

For drains and soak-pits → Section 6.1

Maintenance:

* sweep and clean the drains regularly;
* immediately remove anything that could cause a blockage in a drain;
* clean the soak-pit regularly.

14. HOUSEHOLD HYGIENE IMPROVEMENTS

14.1 FLOOR, WALLS AND CEILING

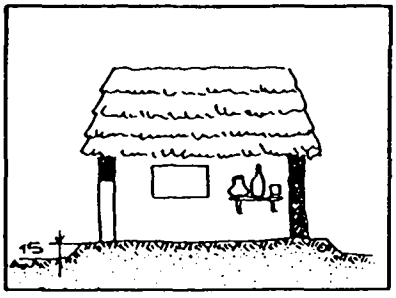
A first prerequisite for a hygienic home is a good floor. It makes its cleaning easy.

A few characteristics of a good floor are:

* the floor is raised at least 10 and preferably 15 cm above the outside ground level, to prevent flooding in the house and to facilitate sweeping and cleaning of the floor;

* the floor should be hard and smooth, to facilitate cleaning and to prevent dirt from getting into cracks;

* the floor should have a waterproof top layer of clay, tiles, bricks, cement or dung to facilitate the use of water in cleaning.



Raised floor prevents inside flooding

The walls and the ceiling in the house should be as smooth as possible. This prevents dust from falling down and insects from hiding in cracks. It will also prevent vermin from entering the rooms. Smoothing can be done with cement, gypsum or clay plastering. The use of lime for whitewashing the walls and ceiling is advisable because lime kills micro-organisms and given the interior of the house an hygienic appearance.

NOTE:

* Indigenous methods used for wall construction such as "poles and mud" construction can also be used for ceilings.

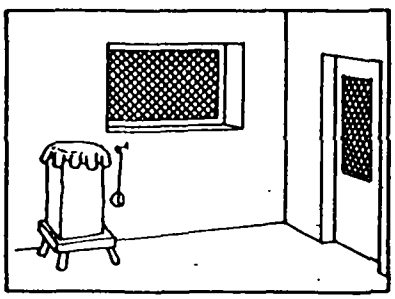
14.2 INSECT PROOFING

It will be difficult to keep insects such as flies and mosquitoes completely out of the house. Measures must be taken to minimize the number of insects getting into the house and to prevent those that come in from contaminating food and water.

A few options are illustrated. Solutions and designs must be adapted to the prevailing problems and needs.

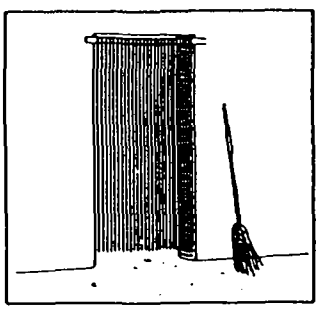
Insect screens

Screens for doors and window openings will let in light and fresh air, and keep insects out. Wire netting or mosquito netting can be bought if available.



Mosquito screens

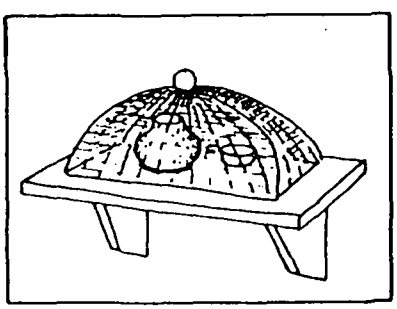
String curtains can be made of plastic ribbons or sisal rope hanging close together.



String curtain in door opening

Food protection against insects

Utensils holding food and water can be protected by pieces of screening material. A proper cover can be made of wire netting or woven reed, like an upside down basket.

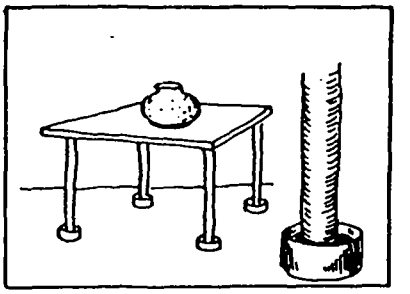


Screened food cover

For improved water storage → Chapter 10

Ant protection

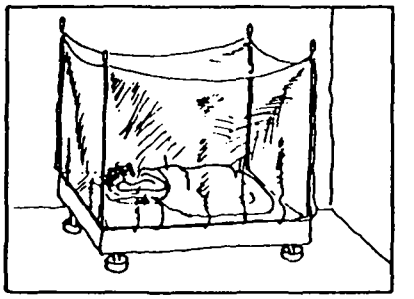
Crawling insects such as ants can also be a nuisance. An easy way to stop them from getting on tables and in cupboards and beds, is to put saucers or tins containing kerosene or oil under the legs of the furniture. Water will also be effective in case kerosene or oil is too expensive. However, water may speed up the rot of wooden furniture.



Tins filled with oil prevent the climbing of ants

Mosquito netting

Mosquitoes do not contaminate water or food, but their bites can be dangerous. Malaria and dengue fever are a result of mosquito bites. Sleeping under a mosquito net gives some protection, but screening the house will also reduce the number of mosquitoes that get in.



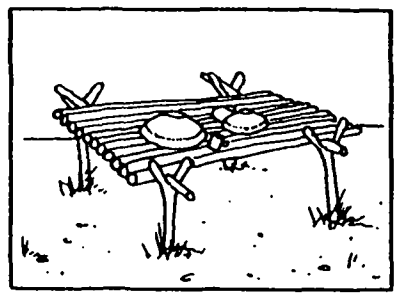
Mosquito net for a bed

Because most people stay outside in the evening, proper clothing may help protect the body against mosquitoes.

14.3 DRYING RACK AND CLOTHES-LINES

Drying rack

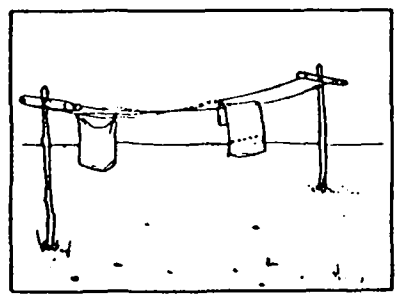
A drying rack provides a good solution if the household lacks a facility to safely and efficiently dry household utensils. The size of the rack will depend on the number and size of the utensils, and on the space available. A rack can be made from wood or bamboo.



Drying rack made of bamboo

Clothes-lines

When freshly washed clothes and bedding etc. are hung to dry on a clothes-line, worm-eggs, bacteria and dirt from the ground cannot get onto them. Therefore, the clothes do not transmit the related diseases to the skin. However, some flying insects may lay eggs in the laundry, which may result in skin rashes. Another advantage of a clothes-line is that the laundry dries quickly, especially when there is some wind.



Clothes-lines

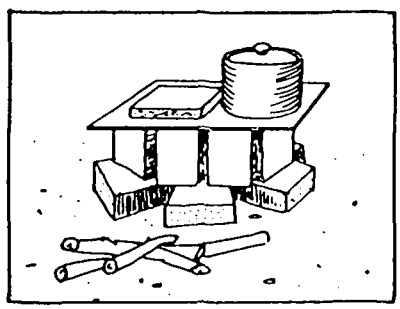
14.4 FIREPLACES

A shield built on one side of an open fire offers a number of advantages:

* the fire burns better and gives more heat;
* the shield provides some protection against fire sparks;
* at least on one side of the fire there is no risk of children burning themselves or falling into the fire.

Shielded fireplace

A shield can be easily made from mud blocks or bricks. Sheet metal can also be used, but it will get very hot, which is risky when there are children around.



Shielded fireplace

Smoke problem

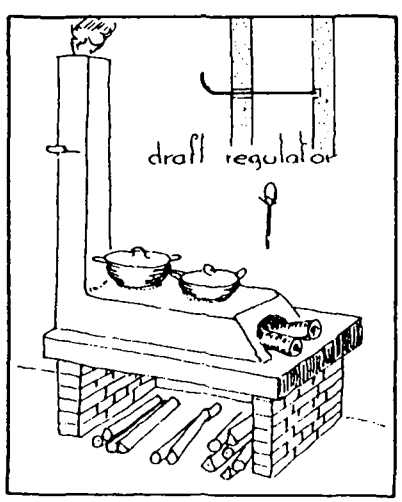
One disadvantage of an open fire will not be solved by a shield: the room will still be smokey. Smoke may cause lung and eye problems. Part of the smoke can be got rid of by making an opening in the roof.

If the smoke of the fire is also meant to fight the insects in the house, it would be advisable to look for different methods.

Advantages of closed fireplaces

When a closed fire is constructed, a number of problems can be solved at the same time:

* a closed fire is much safer, especially for children;
* the cooking place could be raised so that one does not have to bend when cooking;
* the elevated fire creates space to store firewood;
* a chimney connected to the fireplace will remove the smoke;
* less wood will be required for cooking because the efficiency of a closed stove is higher.



Improved stove with draft regulator

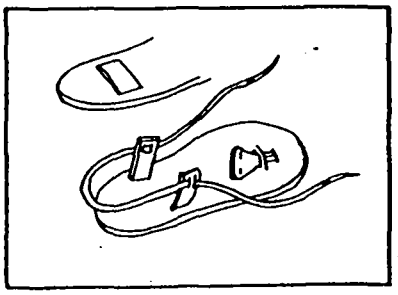
The details of the design should be discussed with the users, generally the housewives.

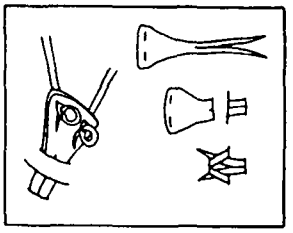
14.5 FOOTWEAR

Footwear can protect the feet against small wounds which often get infected if one does not wear shoes. In areas where hookworm is present footwear is indispensable. Hookworm is a worm that enters the body through penetration of the skin.

Sandals

Shoes and sandals are sometimes too expensive to buy. Simple sandals and flip-flops can be self-made, from used car tyres or scrap pieces of leather.

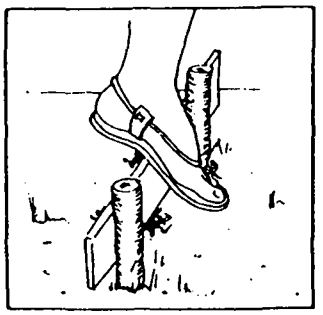




Simple sandals

NOTE:

* Dirt, small bits of faeces and clay tend to stick to the soles of footwear. Therefore, shoes and sandals should be regularly cleaned and people should wipe their shoes or take their shoes off before entering the house.



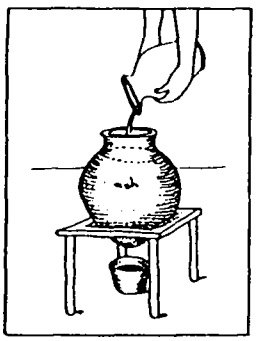
Cleaning the shoes before entering the house

14.6 SOAP MAKING

Soap is an important item to control the spread of diseases. It helps the people in personal hygiene and washing their clothes. Soap may be expensive or not available at all.
For making soap you need fats, oils and lye. Both animal fat (e.g. mutton, lamb) or vegetable oil (coconut, palm nut, maize, olives, ground nut etc.) can be used.
The lye can be made from leaf or wood ashes, but the commonly used alkali, caustic soda, may be available in town shops as well.

Making lye

To make lye, slowly add 7.6 litres of water to 19 litres of ashes, preferably from hardwood and not from paper. After some time, brown lye will drip from the bottom of the jar. When no more lye drips out, pour the lye water through the ashes again to increase its strength. This will make about 1.8 litres of lye.



Adding water to ashes gives lye.

The strength of the lye is right when a fresh egg can float on top. Boiling may concentrate the lye if necessary.

Rainwater is the best type of water for making soap.

Precautions

* Caustic soda will burn the skin and eyes, so protect your eyes and hands if working with it.

* Add alkali to water and never the other way around.

Basic recipe

To make 4 kg of soap you need:

* 3 litres or 2.75 kg oil or fat
* 370 g caustic soda or lye
* 1.2 litres water.

Choosing oils and fats

Different oils and fats bring their specific properties to the soap, and the best mixture can only be obtained by experimentation.

Coconut or palm nut oil : caustic soda = 6:1

Olive, corn, ground nut oil: caustic soda = 8:1

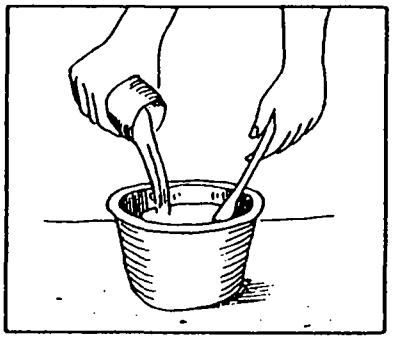
Perfume can be added at the same time as the alkali.

Production procedure

* add the alkali to the water; the alkali solution should be at body temperature;

* melt (any) fat in the oil/fat mixture;

* pour the alkali slowly in the oil/fat mixture, stirring it continuously in one direction only; continue stirring for at least half an hour; the mixture should become thicker;

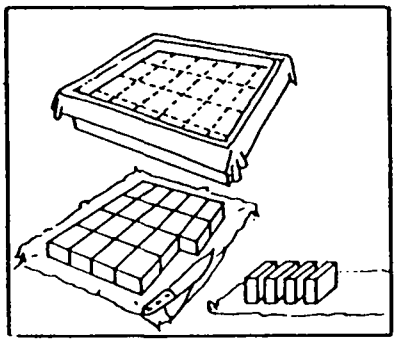


Mix water, alkali and oil/fat

* pour the mixture into moulds lined with cloth or waxed paper and leave it to set for two days or longer in a dry place;

* when the soap has set, remove it from the moulds and cut into bars;

* stack the bars and leave them for 4-6 weeks to allow the chemical reaction to finish completely.



Soap has set but must still be dried.

15. GENERAL CONSTRUCTION GUIDELINES

15.1 WORKING WITH CONCRETE

Concrete is an ideal material used in many constructions. The ingredients of concrete are cement, fine aggregate, coarse aggregate and water. To obtain a strong construction, the concrete must be made with ingredients of good quality. Certain simple rules to make good concrete must be followed.

15.1.1 BASIC PRINCIPLES

Cement

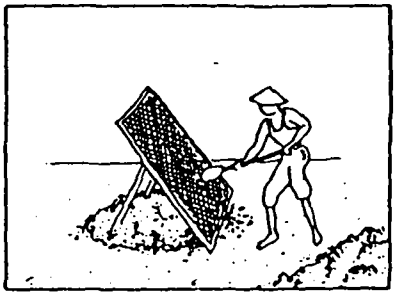
The cement should be a free-flowing powder. To avoid lumps due to moisture, it should be stored in a dry place, not for too long and not directly on the ground, but for instance on logs or planks.

Sand

The sand should be free from clay and organic matter, otherwise these should be washed out. The sand should not be too fine or too coarse.

Gravel

The size should be between 5 and 35 mm, hard and durable. It should also be free from clay and organic matter, otherwise these should be washed out. It may be necessary to screen the gravel to separate the very fine and very coarse material from the suitable size.



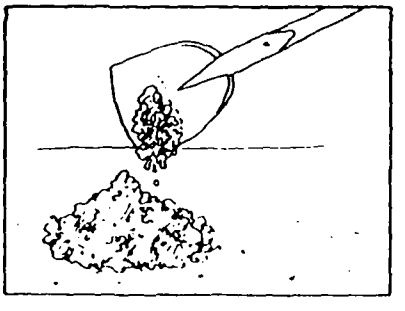
Sieving of gravel

Water

The water to be used should be clean, fresh and clear. In general, drinking water is suitable for making concrete.

Amount of water

The strength and durability of the final construction depends also on the amount of water used. In general, the less water used, the better the quality of the concrete, but the mixture should be workable.



The mixture should not flow out.

Mixture ratio

The commonly used proportions for a workable mixture are:

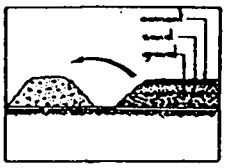
1 part of cement
2 parts of sand
3 parts of gravel

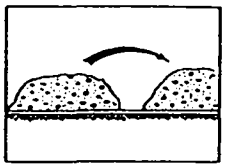
If these proportions doe not make a nice workable mixture, change the sand-gravel ratios.
Should the concrete be watertight, the mixture ratios should be:

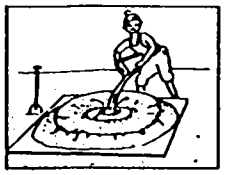
1 part cement
1 part fine sand
1.5 parts gravel

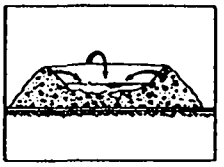
Mixing

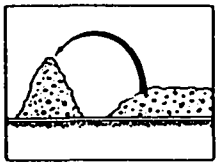
Put the gravel on a watertight surface, spread the sand and cement over it and mix until an uniform colour appears. Make a hollow in the dry material and slowly add the water.
The ingredients should be mixed thoroughly until the cement paste (cement plus water) covers every particle of sand and gravel.


Dry mixing


Dry mixing


Add water


Wet mixing


Wet mixing

Casting

The concrete mixture should be used as soon as possible after mixing.
The material should be properly worked in the corners.
If thick layers of concrete are applied, it should be compacted by poking with a stick.
To prevent the concrete from sticking to the moulds, the moulds should be pre-treated with used engine oil.

Curing

Proper curing of concrete gives it the final strength and durability.

Curing should continue for at least seven days by covering the concrete with wet materials, such as hessians or clothes; even sand or straw will do.
Keep the covering permanently wet.
The moulds can be removed two days after casting.

Reinforcement

Usually steel is used as reinforcement. If a wire mesh is used, the technique is called "ferrocement".
If these materials are not available, split bamboo or hardwood can be used. The strength of the material and the final strength of the product, for instance a latrine squatting slab, must be checked before use.

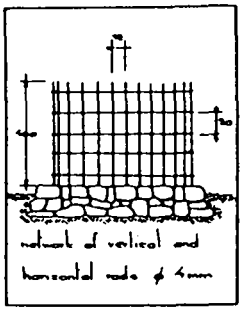
15.1.2 FERROCEMENT

Ferrocement consists of a sand-cement mortar which is heavily reinforced with rods and chicken wire. The reinforcement consists of a network of vertical and horizontal rods of small diameter (4-5 mm), spaced at a distance ranging from 50 to 120 mm. A layer of chicken wire (mesh size 20 mm) is placed on both sides of this network, which is then embedded in mortar made of one part cement and two parts sand. The sand content should not contain silt and should be well graded. Coarse sand has the advantage over fine sand that shrinkage will be lower, but the workability of the mortar will be less. Fresh cement should preferably be used for the mortar, but if it is not available, the cement should be sieved before it is put into the mixture.

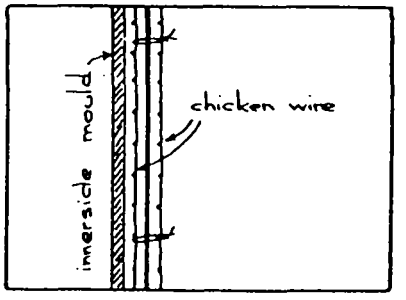
Building procedure

An inside or outside mould is usually used when constructing ferrocement reservoirs. When an inside mould is used, the building process is as follows:

* The network of horizontal and vertical rods of a small diameter and a layer of chicken wire is placed against the mould.

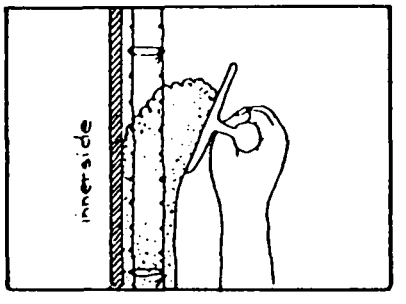


Network of reinforcement bars



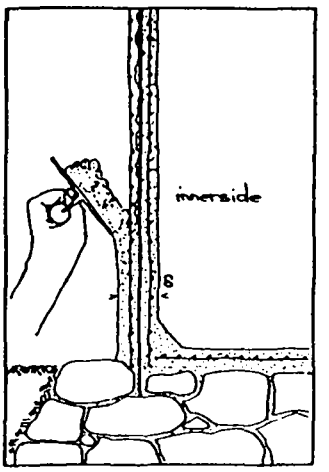
Chicken wire bound to the network

* The mortar is spread onto the reinforcement with a trowel, up to the inside mould.



First mortar layer

* As soon as possible (normally within 2 hours), successive layers are added in the same way until the required wall thickness is attained, which is usually 40-80 mm. In case of thick walls extra layers of chickenwire are applied



Final layer of mortar

Quality check

To ensure satisfactory adherence of the successive layers, careful curing (10-14 days) is necessary, especially in warm, dry weather. And a simple check can be made by rubbing a stone over the surface of the tank. A rather high sound indicates good construction, whereas a low sound in a section suggests that the successive layers are not well bonded. To correct this, the weak part of the top layer can be cut away, the last but one layer roughened, and an extra layer of chicken wire placed on the damaged spot. A layer of mortar should then be applied and cured properly.

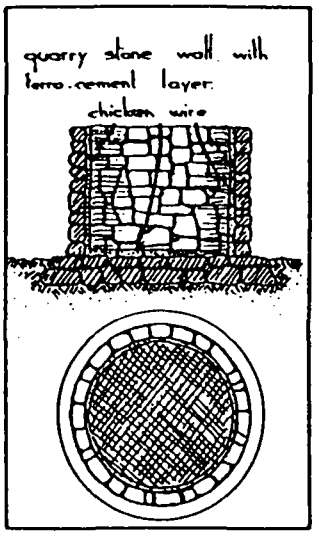
Repairs

Leaking tanks can be repaired in a similar way, but if the mortar is well cured and clean sand and fresh cement are used, weak sections are very rare.

15.2 MASONRY OF QUARRY STONES

Tank construction

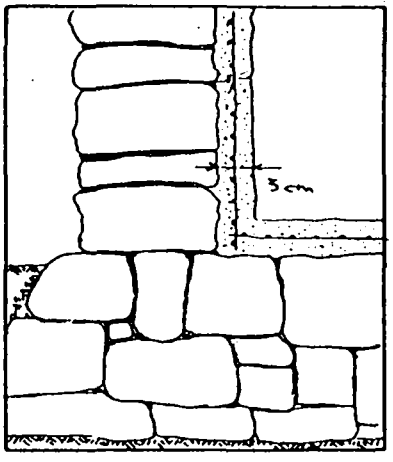
Quarry stone masonry may use a large quantity of mortar, particularly if the stones are irregular in shape and the spaces in between are not filled with smaller stones. If this is the case, consideration should be given to whether construction in ferrocement would be more efficient.



Tank built with quarry stone

Combination of quarry stone or bricks and ferrocement

In several locations, a combination of masonry and ferrocement is used. A 5-10 cm masonry wall is constructed and used as an outside mould, on which a 2-3 cm layer of ferrocement is placed on the inside. This structure combines ferrocement's advantageous feature of good watertightness with the higher compression resistance and easy framework of masonry.



Ferrocement with quarry stone

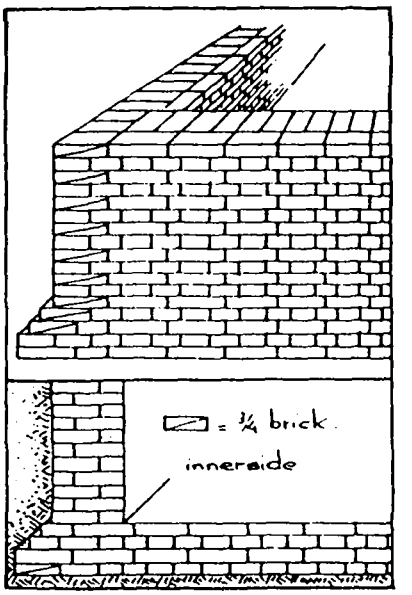
15.3 MASONRY

Masonry and mortar should be of a high quality to obtain a watertight structure. The wall thickness of circular reservoirs with a diameter of 5-10 m, constructed below ground level, should be about 0.2-0.3 m and should be carefully checked for leakages.

Construction in masonry

Important points in their preparation are:

* vertical joints should never be placed above each other;
* the bricks should not be split in pieces smaller than half the standard size available locally;
* bricks which have been close to the oven fire should be used because they are stronger;
* the bricks or stones to be used should not take up more than 25% water.



Storage tank in masonry

Mortar

Mortars for masonry consist of cement, sand and water. A mixture of one part cement and 2-2.5 parts sand is suitable. If the bricks are of low strength then the strength of the mortar should also be reduced, for instance to 1:4, to prevent differences in shrinkage between brickwork and mortar. This will lead to a less rigid, watertight construction, so the walls should be rubbed with a brush dipped in a mixture of one part cement and one part sand to improve watertightness.