Water technology Water-tegnologie
CSIR WNNR

RAINWATER HARVESTING

A TECHNICAL GUIDE

Compiled by M C Chibi
Edited by dr F A van Duuren

Rainwater harvesting has been practised successfully in some parts of the world for more than 4000 years. Yet despite the pressing need for adequate drinking water supplies in arid and semi-arid areas, this water supply technique is still not as widely used as it could be.

Rainwater collection has many advantages:

- it is renewable
- it is available at the point of consumption
- it is generally of very good quality
- it may usually be used as drinking water without any treatment

There are various methods of harvesting rainwater before it enters the soil or flows into streams as runoff:

These include:

- intercepting the rainfall before it strikes the ground by placing an impervious cover on or above the ground,
- landscaping to concentrate the rainfall-runoff to a storage structure with a minimum of delay,
- treatment (e.g. chemical) of the catchment surface to reduce filtration.

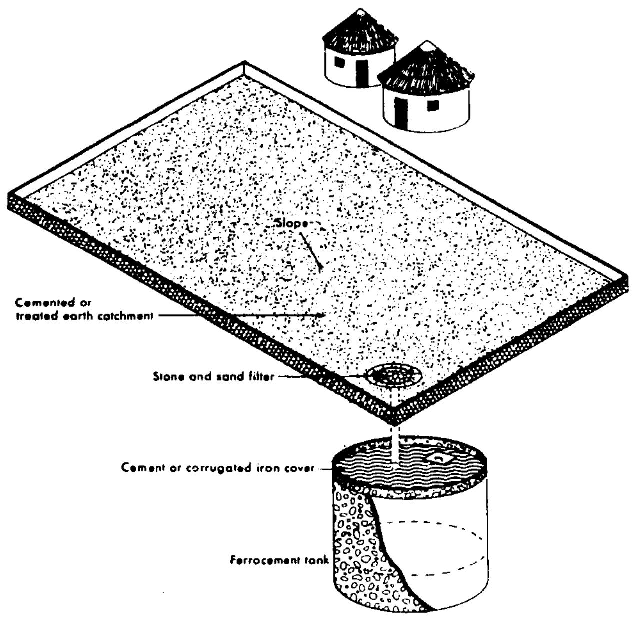

Fig. 3. Ground catchment system

Some Definitions

1. Roof catchment systems - where a roof, normally of corrugated iron or some other impervious material is used for the collection of rainwater. This is normally fed via gutters into an above ground storage container (see Fig. 2).
2. Ground catchment systems - where a natural or treated ground surface is used as a catchment apron to collect rainwater, which is normally stored in a sub-surface container (see Fig. 3).

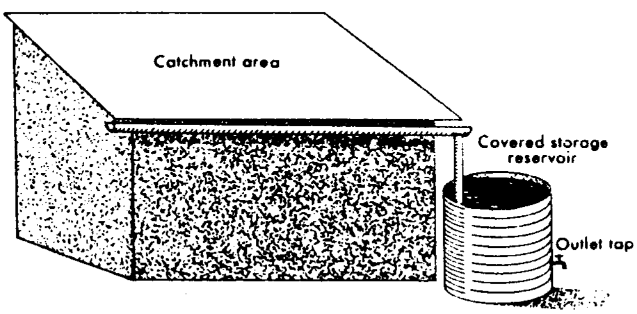

Fig. 2. Roof catchment system

Various systems which can be used in water collecting will be explained, and advice will be given on how to make the most efficient use of the catchment areas and resources available through the construction of technically and economically appropriate storage tanks.

The value of an additional potable supply is obvious in the many parts of South Africa that do not have piped water, or where the only supply is either saline, contaminated or unreliable. It should also be remembered that the storage tanks can be used to store water supplied from other sources.

Fig. 4. Well water could also be used in a rainwater storage tank

Storage tank capacity

The capacity of the storage depends on the maximum amount of water that must be stored to meet individual family needs. To find the ideal capacity, one needs to determine:

- Average annual and monthly quantities of rainfall
- Amount of water available from the catchment area
- Number of people who must use the water
- Average daily water use per family

Regional data on average monthly rainfall may be available from the Ministry of Agriculture and Water Supply, some universities, the Weather Bureau, Department of Water Affairs, or a nearby weather station. Figure 5 shows the mean annual rainfall distribution in South Africa. Using these rainfall maps, it is easy to estimate roughly the mean annual rainfall in your area. It should be remembered that these are mean values, and there will be considerable variation from year to year.

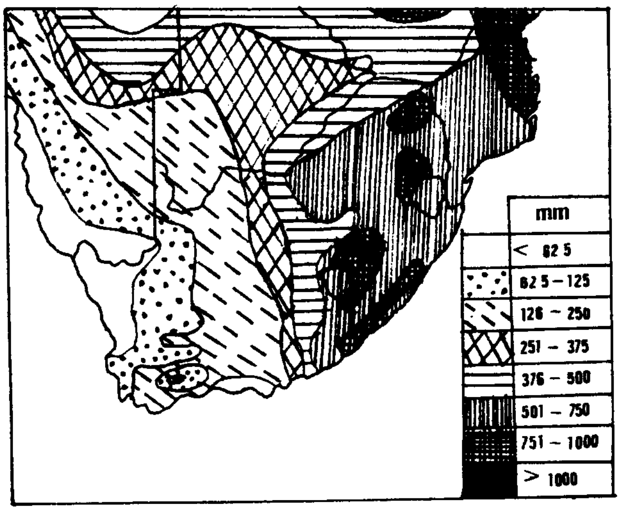

Fig. 5a. Summer rainfall distribution

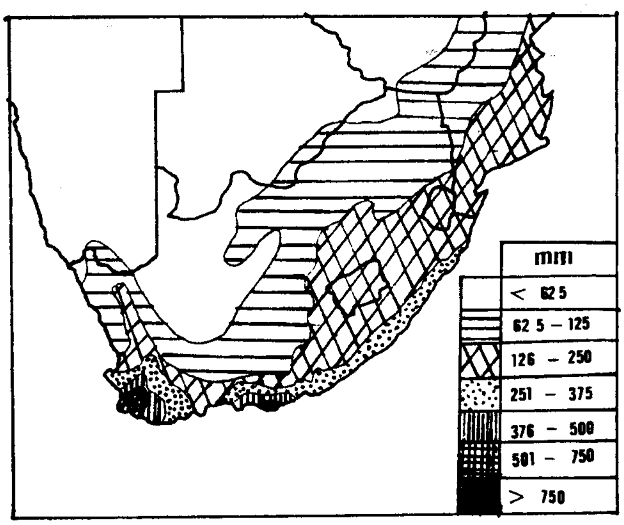

Fig. 5b. Winter rainfall distribution

Note: Annual rainfall is the sum of both Summer and Winter rains.

The amount of water in litres each month from a catchment area is found by multiplying the average monthly rainfall by the catchment area and then by 0,8 to take into account losses, i.e.

Available water (litres) =
Catchment area(m^2) xRainfall (mm) x 0.8

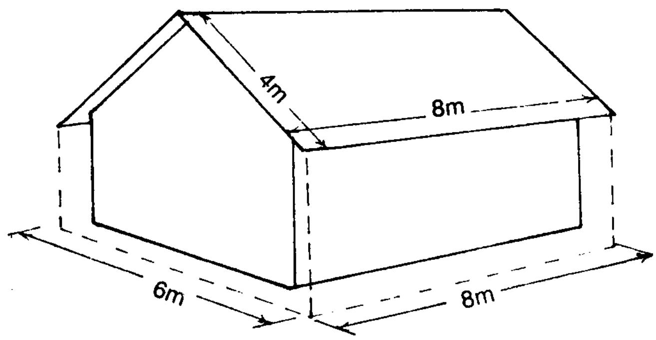

Fig. 6. Roof catchment area

The catchment area is the PLAN area of the roof and not the surface area of the roof. It is the length of the roof by the width of the roof base. Figure 6 shows the dimensions of a 48 m^2 catchment area.

Since rainfall events in Southern Africa are highly seasonal, it will usually be necessary to obtain or construct a fairly large tank to obtain water for the dry months. Increasing the storage capacity will result in a more reliable supply, that is, being able to capture and utilize more of the available supply. Users should, however, be educated in wise water use practices so that they can count on a year-long supply. Where possible, alternative supplies should be used for washing clothes and for watering of gardens or animals (see Figure 7).

A crude but effective means of determining the storage capacity required for any particular rainwater storage system is to determine the average maximum length of the dry season (or mean maximum period without rain) and calculate the volume of water needed over this period. The volume needed is equivalent to the required storage.

Fig. 7. Alternative water supplies to be used for low-quality water requirements.

Design Example: Volume of water available from a roof catchment

From Figures 6 and 7 we get the annual rainfall of 1033 mm and the catchment area of 48 m^2 for a house located in a certain area.

Step 1. Multiply catchment area by the annual rainfall

48 m^2 x 1033 = 49 584 litres/year

Step 2. Multiply this total by 80 per cent. Not all water will be available because of losses due to evaporation and run-off that does not flow into the gutters. To be safe, assume a 20 per cent loss for a rain catchment.

49 584 x 0,8 = 39 667 litres/year

Step 3. Divide the total by 12 to get monthly rainfall

39 667 litres/year + 12 months/year = 3305 litres/month

Step 4. Divide again by 30 to determine litres per day

3305 litres/month + 30 days/month = 110 litres/day

A second method determines the storage capacity needed using the example given in Figure 8. The average monthly rainfall figures are in the table at the top row, and the second row gives the available water from a catchment of 48 m^2. Note that these rainfall figures are only an example. The rainfall may be high during several months but in June and July no rain falls at all. Design of storage tanks as structures should take these variations into account.

Month	Jan.	Feb	Mar	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Rainfall (mm)	226	188	173	46	2.5	0	0	5	5	41	130	216	1,032,5
Available Water (in liters)	8,678	7,219	6,643	1,766	96	0	0	192	192	1,574	4,992	8,294	39,646

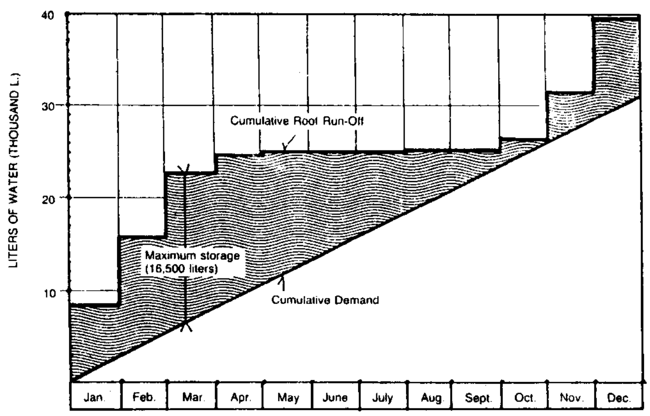

Fig. 8. Determining maximum storage capacity

Using the information on annual rainfall for a specific region (as given in Figure 5, for example), together with the effective roof area from which water is to be collected, it is possible to determine how much water will be available on a daily basis. A design example is given to illustrate how to make this calculation.

In the example, an average of 110 litres of water per day would be available to a family. For a family of six, each person would be able to use 18 litres per day. This of course, is an average amount. During some months, more than 3305 litres would be available, while during the dry months, no rain may fall at all. A storage tank will be needed to ensure adequate supply during the dry months.

TYPE OF TANK	ADVANTAGES	DISADVANTAGES	ESTIMATED LIFE EXPECTANCY
Corrugated iron	1. Readily available 2. Ready to install 3. Low labour costs	1. Short life expectancy 2. Rusts easily 3. Needs to be transported to site 4. Max. size 9m³	2-10 years
Ferro-cement	1. long life expectancy 2. can be built much larger than corrugated tanks 3. Uses local labour and	1. Requires special constrution moulds 2. Requires trained builders 3. Danger of cracking if material allowed to dry out	15-20 years
Brick and cement	1. Can be built to any size 2. Can be built above or below ground	1. More expensive than equivalent sub-surface tank	20+ years
Plastic	1. Relatively cheaper 2. Low labour costs	1. Short life expectancy 2. Difficult to fix in specified location 3. Punctures easily	1-5 years
Masonry	1. Long lifetime 2. Can be built to any size	1. Requires skilled stone mason 2. Restricted to areas with abundance of rock 3. Uses local labour and materials	20+ years

Table 1: Advantages and disadvantages of different types of rainwater catchment tanks

Storage tank design

Concrete, ferro-cement, galvanized iron, masonry, asbestos cement, fibre glass or plastic storage tanks are all useful and practical for storing rainwater. Reinforced concrete storage tanks are usually either rectangular or circular in shape and are located adjacent to the house. They can either be built at ground level as shown in Figure 9 or underground as in Figure 10.

Choosing the appropriate type of tank

Once the appropriate storage volume has been calculated, it is necessary to decide how best to provide this. Several types of surface and sub-surface tanks may be considered to do the job. Each has its own advantages and disadvantages and these are summarised in the above table. Clearly, where ground catchments are involved, subsurface tanks are the only option (unless the topography of the catchment area permits by sloping suitably where the tank is to be sited). Subsurface tanks require some means of extracting the water. As pumps are too expensive in the case of small sub-surface

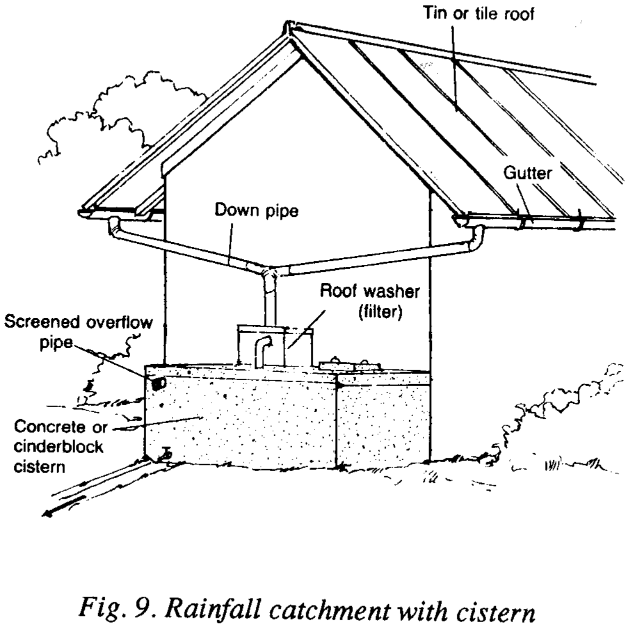

Fig. 9. Rainfall catchment with cistern

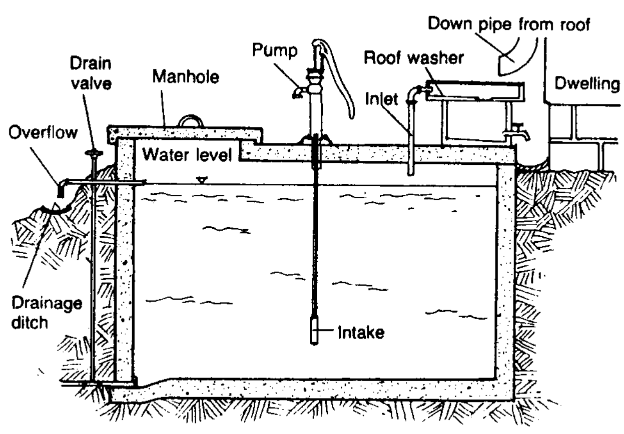

Fig.10. Underground storage for roof catchment

tanks, tins or buckets are usually lowered into the tanks directly (see Fig. 11). Very often this results in contamination of the supply.

Simple modifications of the bucket can be made to ensure that no contamination occurs as shown in Figure 12.

Fig. 11. This well is contaminated by buckets being lowered into it.

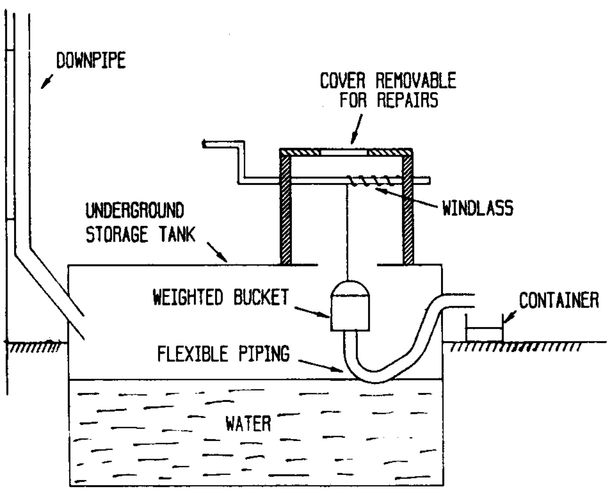

Fig. 12. One method of protecting a well from pollution.

In designing a storage tank, the following guidelines should be kept in mind:

1. Choose the best site for the cistern or tank and decide whether to build it underground. Advantages with underground tanks are an improved structural strength as well as cooler water temperatures. The disadvantage is that water must be taken up through a pump. It is important that the storage tank be on higher ground than excreta disposal systems and is separated from them by at least 20 m.
2. Above ground tanks should have a small foundation of at least 300 mm in the ground. Underground tanks should extend about 200 - 300 mm above the ground's surface to provide for the installation of an overflow and to prevent any difficulties in maintenance.
3. Use a thick concrete mix to ensure that the walls are watertight. Use a mixture of one part cement to 2 parts sand and 3 parts gravel (1:2:3).
4. Each tank should have a manhole that enables access for maintenance. Manhole openings should be covered to prevent entrance of light, dust or other substances that could contaminate the water.
5. Install a screened overflow pipe at the top of the tank as shown in Figure 9.

   Slightly above the bottom of the tank, place an outlet pipe or tap. The tap should be high enough so that a container used for collecting the water can be placed underneath it. For an underground tank the outlet will probably be a handpump installed on the top cover. The pump's intake pipe should extend to near the bottom of the tank.
6. On top of the tank install a device for diverting the run-off from the roof.

   The first run-off is likely to be contaminated. Several designs of run-off diversion devices are discussed later.
7. Adequate drainage should be provided at the overflow pipe so that standing water does not accumulate around the cistern. Standing watêr is a breeding place for mosquitoes.
8. Brick and masonry tanks can be constructed and are recommended when locally available at comparatively low prices. They are built in the same way as reinforced concrete tanks but special care should be taken to ensure their impermeability.

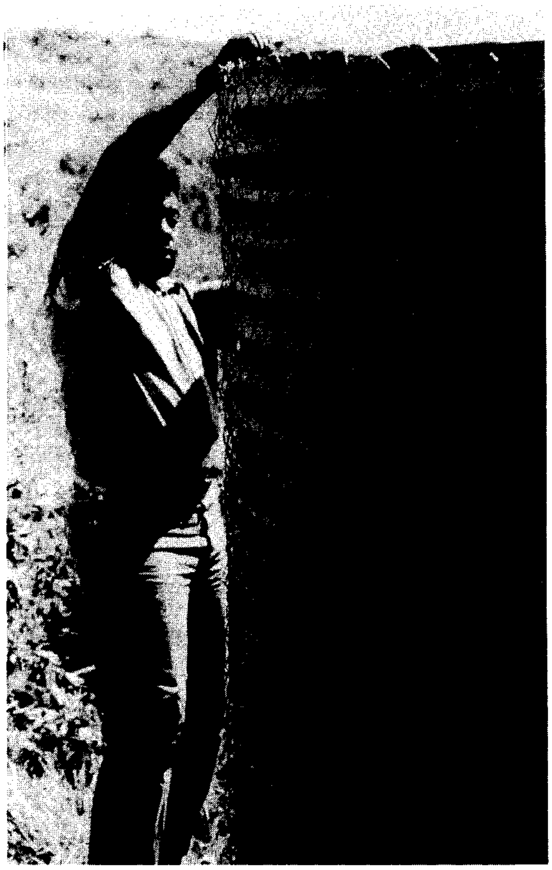

Fig. 13a. Building a ferro-cement tank

Fig. 13b Building a ferro-cement tank

Ferro-cement tanks

Ferro-cement tanks are fast gaining popularity over galvanized iron tanks because of their relatively cheaper costs as well as the fact that they are built on site. They can be built by hand. Cement mortar (one part cement to three parts of sand) is trowelled into a mesh of wire reinforcement (Fig. 13). A 5000 litre ferro-cement tank similar to the one shown in Figure 13 can be made by one skilled builder with the help of several inexperienced hands.

The tank illustrated in Figure 13 has a diameter of 1,9 m and a height of 1,8 m. For best results in building the ferro-cement tank, use sheets of standard galvanized corrugated iron. The forms are joined as shown in figure 13 a. The tank sits on a foundation slab made of concrete. The tank needs a roof to protect the water from contamination and evaporation. The roof is cast in the same method as the walls. This is best done on flat ground and the dried structure later lifted onto the top of the walls to complete the tank. Painting the roof white may help to protect the water from heat.

For more detailed instructions on the construction of ferro-cement tanks, see "How to construct a 5000 litre ferro-cement tank", also available from the Division of Water Technology, CSIR.

The gutter

Three main types of guttering are used in South Africa.

- galvanized iron
- PVC
- asbestos cement

Common problems with all three are that:

1. The gutter is often too small for the roof area from which rainwater is being collected. Therefore the gutter overflows during heavy rains.
2. The brackets holding the gutter to the building are often too weak or too far apart to firmly support the gutter. As a result the gutter either sags or pulls away from the building.

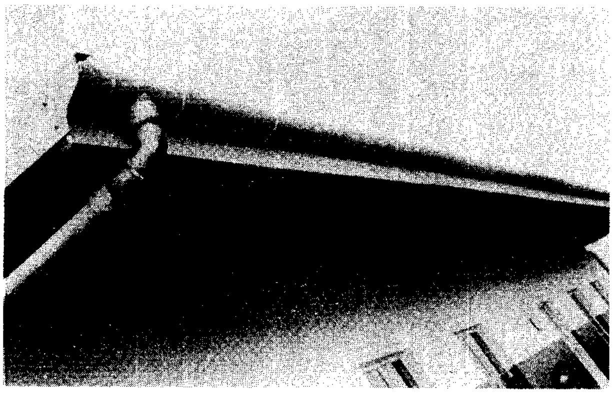

Fig. 14. Gutters

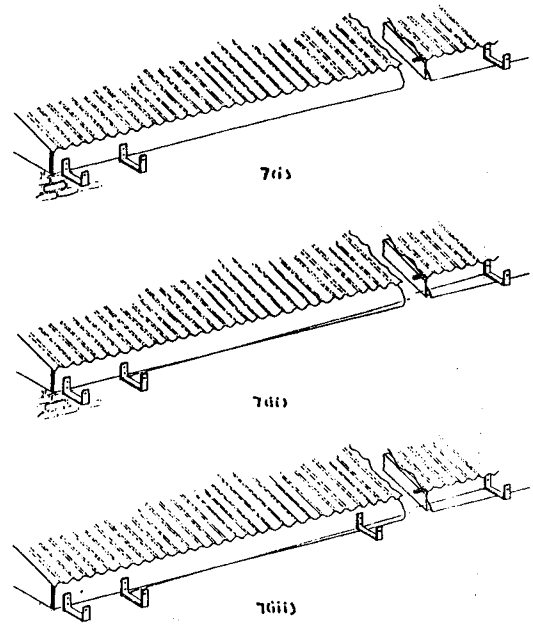

Fig. 16. Diagram showing method of gutter alignment

3. Often the rubbish which collects inside the gutter systems is not cleared out. The rubbish then blocks the gutter and downpipe or pollutes the water stored in the tank.

To efficiently catch water running off the roof, the gutter should not be too far below the roof, otherwise there is a danger that the water will overshoot (see Figure 15).

A good way to align gutters is to fix the brackets at either end of the gutter in the correct position (see Figure 16). The brackets at the far end of the downpipe should be as high as possible and the brackets near the downpipe'should be as low as possible (with due consideration to the point made in the last paragraph). This will give the maximum fall possible. A string line should then be run along the back corners of the end brackets (see Figure 16 ii). The rest of the brackets can then be positioned on the stringline to form a fall. Care must be taken that the brackets do not move the stringline out of position.

If there is more than one downpipe along the length of a gutter, then the brackets nearest the downpipe should be as low as possible and the bracket midway between the downpipes should be as high as possible.

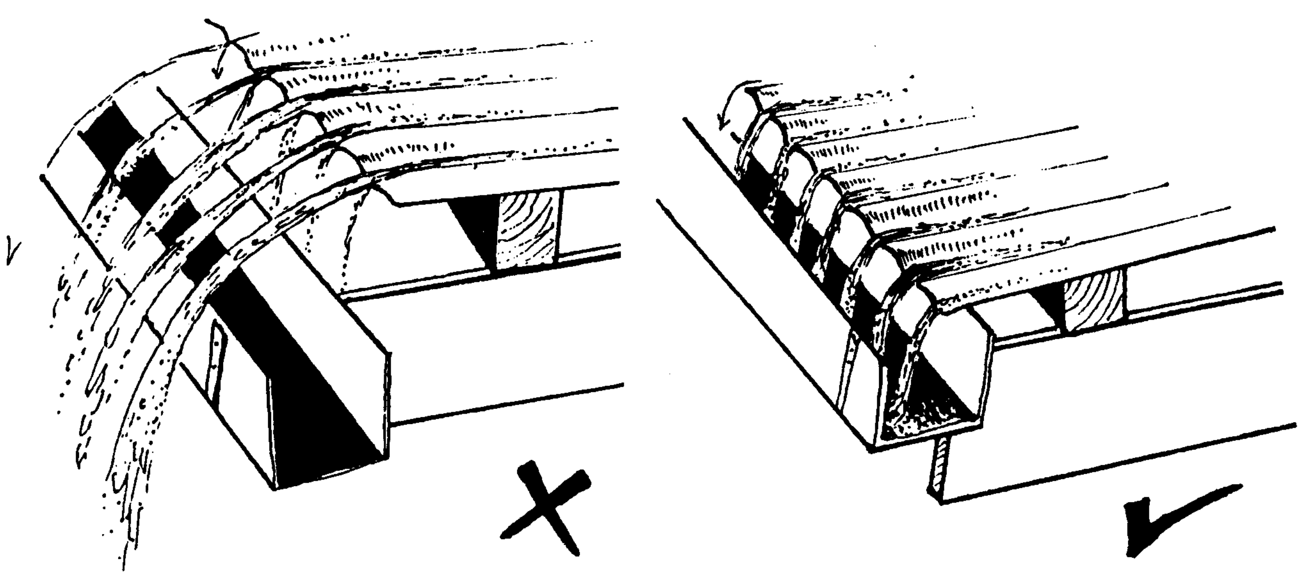

Fig. 15. Diagram showing correct gutter positioning with respect to roof

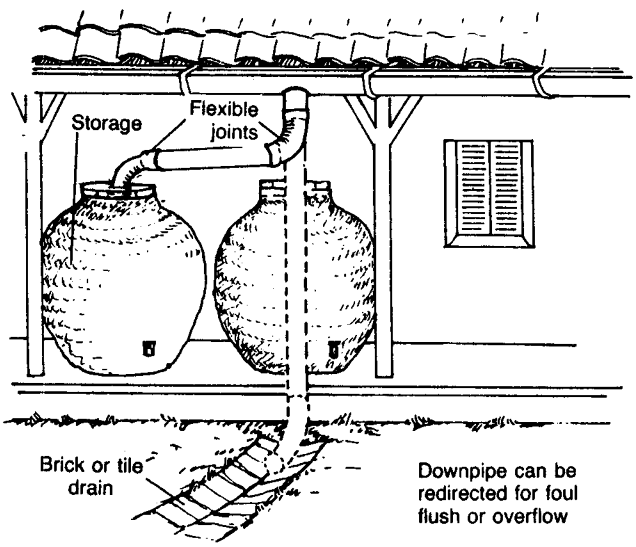

Fig. 17. Flexible downpipe for diverting dirt wash

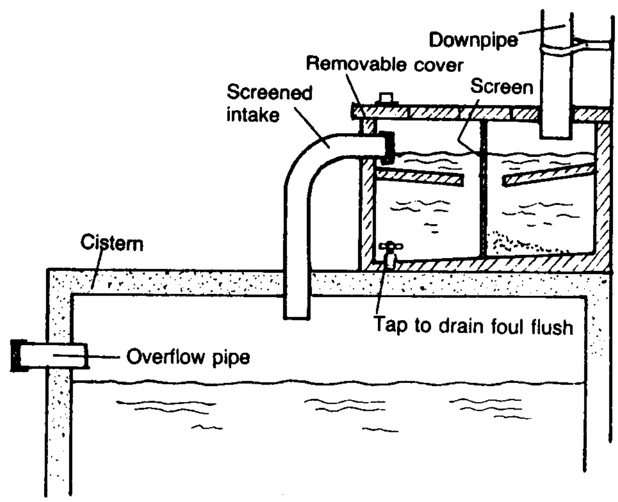

Fig. 18. Foul flush box

Maintenance

Maintenance of gutter systems ensures their correct functioning and long life.

The maintenance required is that:

- Once a year before the rains start, gutters should be cleaned of all debris.
- Trees should be cut back regularly to prevent leaves from blocking thegutters and birds from perching in the trees and thus fouling the roof or gutters especially if water is being collected for drinking.
- Brackets that come loose should be refixed or replaced immediately, to ensure that gutter slopes are maintained.
- Leaks should be fixed immediately.

Dirt wash disposal

During periods of no rain, dust, dead leaves and bird droppings will accumulate on the roof. These materials are washed off with the first rain and will enter the storage tank and contaminate the water if some basic steps are not taken.

To prevent leaves and other debris from entering the downpipe, a coarse mesh screen should be placed over the downpipe. The mesh will catch the large debris but let the water through. The screen must be cleaned periodically to prevent clogging.

A downpipe that can be moved manually away from the tank can be installed to divert the first flow of water from the roof.

An illustration appears in Figure 17.

Where the pipe is moved away from the tank, water simply runs to waste. For this method to be effective, someone must be at the house to move the pipe.

Several other techniques are available for diverting the first run-off from the storage tank. In Figure 18 water from the gutters runs through the downpipe and into a small box built on top of the tank. The first run-off is caught by this box.

When the box fills, water runs over the top of it into a channel that leads it to storage. A drain then empties the box of the dirty water. This small foul flush or first wash collection box can be made from concrete or from metal. It is most useful when permanent concrete tanks are built because of the extra cost.

A small charcoal sand filter box can also be installed as in Figure 19. As the rain passes through the filter, sediment and debris are filtered out and clear water flows to storage. The advantage of this design and the box for the foul flush is that no one has to be present to divert the water flow from the roof.

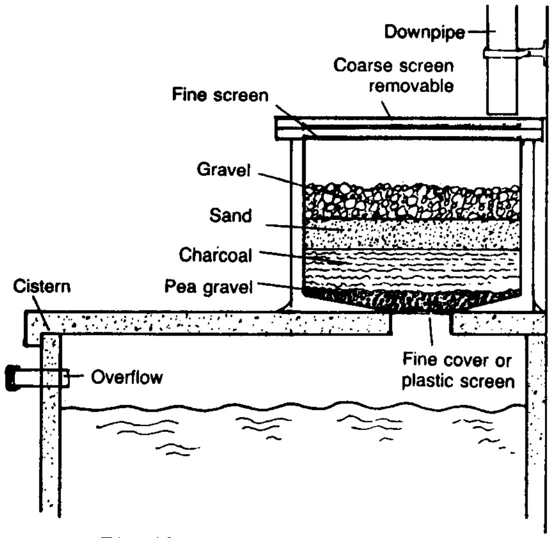

Fig. 19. Charcoal sand filter box

No matter which method is used to divert the first wash, the quality of water collected in the cistern must be checked. Water from roof catchments may need treatment before it can be consumed.

In the next several decades in the developing world, and especially in Africa we will be faced with an imense task of supplying water to `many millions of people. In order to meet this crisis, water will have to be provided as cheaply as possible from systems that are going to be largely maintained by the users.

In those efforts to provide water, rainwater should not be neglected. Because of its unique advantages of technical simplicity and convenience, rainwater catchment can make a major contribution to supplying the water needs of many people.

Further reading:

1. Select and install your gutters properly. *Botswana Technology Centre.* 1987

2.Designing Roof Catchments Technical Note No. RWS. 1.D.4 *Water for the world.*

3.Designing a Household Cistern Technical Note No. RWS.5.D.1 *Water for the world.*

Appropriate Technology Programme

Division of Water Technology
CSIR
Box 395
Pretoria
0001

Tel : (012) 841-2291 or 841-2254
Fax : (012) 841-4785
Telex : 3-21312 SA

The Appropriate Technology Programme produces technical guides and videos on water supplies for small communities which are available on request.

Presently available are:

- Healthy water for your family
- Water filter for your home
- How to protect a natural spring
- How to build a small ferro-cement water tank