40 Green World Actions

40 manuals to improve the environment in rural communities

Christian Fenger

Publication:

The GAIA-Movement Trust
Living Earth
Green World Action

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ISBN 978-2-9700470-2-5

Printing: Don Bosco Technical Institute,
Okhla Road, New Delhi - 110025, India

February 2006

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Call and Service Centre

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Wind rope pump being erected at Nhamatanda in Mozambique

1

Introduction

Children irrigating the vegetable garden at the Farmers Club in Bilibiza

1 • Why a Green World Action Manual

The value and importance of small "environmental actions"

The environment is a popular news item in the media. Often as as yet another alarming headline: Deforestation, an increase in desert land, melted glaciers and destroyed coral reefs.. This leaves many people with a feeling that there is not much one can do to change the course of man and nature.

Small actions, however, can have a great impact when many people implement them. This is why this book has been written.
The GAIA-Movement wishes to get many people to understand and implement simple systems such as the ones described in this manual. This will not only improve their own lives, but also contribute to preserve and improve their local environment.

To you - the user of the manual

This manual was written as part of the programme "GAIA Activities at Village Schools" - implemented in Central Mozambique and in Angola.

The idea is to give some practical examples of how one can improve living conditions and at the same time protect and improve the local environment. Most of the systems are simple and economical to construct or set up. This makes it possible to carry them out at village schools and in rural communities.
The manual consists of 40 concrete instructions on how to set up affordable systems related to the issues of water, soil, food, waste, energy and nature preservation.
They can be used by anybody interested in creating such systems.
With this manual, we hope to give you the possibility to acquire new skills and knowledge - and thus hopefully change your life and the lives of others to the better. Education can change lives - sometimes even the smallest things can change lives.
We hope that you enjoy using this book. Please let us know of your experiences as we would like to include more systems in future editions.

Contact us

It is a challenging task to describe technical systems on a limited space so that the user can implement them to function well.
Differences in local conditions might also make it necessary to adapt and change some of the elements.
Therefore, you are more than welcome to contact the GAIA-Movement at info@gaia-movement.org to get assistance with specific questions, or to be referred to people who can give you more information.

Acknowledgements

The GAIA-Movement is extremely grateful to the organisations that have assisted with material to this manual.
We are similarly grateful to the many volunteers in assisting us with the enormous task of bringing together this publication, we are thankful for their dedication. Most of the volunteers have replied to requests for assistance with translations, corrections, proofreading, layout work and production of illustrations posted on the UN Online volunteer website:
www.onlinevolunteering.org

Many thanks to all of you.
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For further information about the GAIA-Movement and our projects, please visit us at:
www.gaia-movement.org

2 • Case Stories of Green World Actions

GAIA Activities at Village Schools

We know there is a huge need for such GAIA activities.

In September 2005 we met some of the students from the teacher training college in Chimoio, run by ADPP Mozambique (Ajuda de Desenvolvimento de Povo para Povo).

They were part of the 60 students who started to implement the GAIA project in Central Mozambique. We met them in a village 40 kilometres from Chimoio. During one year of their education they work as teacher trainees at village schools. Besides teaching, each teacher trainee also chooses a line of community work - of which one is to implement GAIA activities.

Ana was one of the students we met, and she was making slabs for latrines with a group of village people. She told us that it is good to do community work because it improves people's lives in all aspects. When the latrine was finished, the family would not need to go to the bush and would at the same time improve their hygiene.

She also told how important education was to improve the level of hygiene and sanitation, and how they were doing this in the village school and campaigns.

Community development work is not an easy task, as one often faces a variety of challenges.The students we met told how they had overcome some of these difficulties. When there was only cement for a limited amount of latrine slabs, they mobilised 25 families to make latrines with local materials. The slabs were then made with short poles and good clay. Even though it will not last so long, it is fine for the kind of composting latrine the students were promoting. A new latrine pit will be made after one year, and a tree planted in the old pit.

Protecting the soil against evaporation with grass

Another group wanted to start production of tree seedlings, but did not yet have the seeds and plastic bags. They therefore mobilised the pupils to collect seeds at their homes. They went to the local market and agreed that the sugar sellers should keep the small plastic bags, when the sellers sell the sugar in smaller quantities. In this way they got many planting bags to produce the tree seedlings.

The students were also able to find other local organisations to assist them with seeds and materials.

Using sugar bags to produce tree seedlings

These examples show that it is possible to start the process of improving lives and conditions in the villages, even with very small means. The crucial elements are determination for change and knowledge.

This Green Action Manual is made to give such knowledge and ideas to people like Ana who have the determination to work on improving lives and environment in their local communities.

We want to see these GAIA activities spread to many more parts of Mozambique and Angola, as well as to many other countries. Hopefully many others will find it useful as a handbook to get ideas, assistance and inspiration.

Irrigating a tree that will supply firewood

Students at the Teacher Training Colleges, EPF Chimoio and Nhamatanda discussing the results achieved in 20 communities

Producing a slab for a latrine of the kind in which a tree will later be planted

Showing how to multiply vetiver grass to use against soil erosion

2

A locally made rope pump providing water in Zambia

Safe and Sufficient Water

3 • Introduction

Water is life! Without water there would be no life on the planet. We all use water every day; to drink, wash ourselves, to cook, to wash our clothes, flush our toilets and water our gardens. Animals and plants will die without water. Our daily existence depends on water. In rural areas of developing countries, a large portion of women's daily work is to secure an adequate amount of potable water for their families.

The world's economy also depends on water. Industries and especially agriculture spend enormous quantity of water in their production.

This manual introduces the two main water related problems that the human race has yet to solve:

- Resources of fresh water are coming to an end
- 1.2 billion people do not have access to potable water

Water resources are coming to an end

About 70% of the water that is taken from rivers or pumped from the water table is used for irrigation. In many regions of the world the use of water at this rate is unsustainable. The ground water is being used faster than it is being replaced by the rain water that filters through the earth to replenish the water tables. The result is that the water tables fall, and wells run dry.

Water tables are falling in many countries, including China, India, and the United States, which, put together, produce half of the world's grains. Under the northern plain of China, where half of the wheat and a third of the country's maize is produced, the annual fall of the water table has increased from 1.5 metres per year a decade ago to its current rate of 3 metres a year. In the areas surrounding Beijing, the capital of China, it is necessary to drill up to 1000 metres to reach water.

Recent data from India, from studies of Punjab and Haryana, indicates that the water tables are falling at a rate of one metre per year. It is estimated that the reduction of the water supply will reduce the grain crops of India by one fifth. (Information from Worldwatch Institute - www.wwiuma.org.br)

Water is life. For fishermen in Lochinvar, and everyone else

Today it is no longer enough to build more dams or drill more wells. The only option is to reduce the growing demand through stabilization of the population and to improve the efficiency of using water - in the same manner that agricultural productivity was improved in the second half of the 20th century. This means that water must be used more efficiently in agriculture and agricultural systems that promote better infiltration of the water into the ground must be adopted. It means we must promote water and water source preservation systems to raise the level of the water tables.

Lack of potable water

Many places in the world lack potable (drinkable) water and many people die because of this. An estimated two million people die each year because of water related diseases. One third of humanity lives in a constant state of sickness or disability as a result of unsafe water.

It is possible to avoid these diseases. Water can be treated with chlorine, but many people do not have the money to buy it, or it is not available for purchase in their area. Water can also be boiled before it is used, but many families do not have sufficient fire wood, and obtaining more would mean even more work for the women. For these reasons it is good to learn other methods of making water safe to drink.

This chapter

This chapter presents the following low cost solutions:

- making water potable (sections 4-6),
- economizing water resources (sections 7-8),
- providing water for domestic use and small scale irrigation (sections 9-14).

4 • Solar Disinfection

Idea

The idea is to spread a simple system for cleaning water which can be used when people cannot boil water.

Introduction

Access to clean water is a problem in many parts of the world. In many places people have to use water from rivers or lakes, or use rainwater collected in containers. This water is often full of microorganisms that spread diseases. The diseases are spread when people use the water for cleaning food or drinking. To avoid getting sick it is necessary to disinfect the water. This can be done in many ways:

- boiling - this will kill nearly all microorganisms
- disinfecting with chlorine - this is done in many larger cities
- treating with radiation - this will also kill the microorganisms

For many people in Africa getting enough firewood is a problem. It is a difficult task on which most rural women spend several hours a day, or, in the towns where there is no possibility of gathering firewood, firewood or charcoal must be purchased.
This means that even when people know that they should boil all water used for drinking or cleaning foods and eating utensils, it is often not done. Hence, it is good to promote other simple methods that could help people get safe drinking water and, therefore, avoid diseases.
Although the radiation method mentioned is used in many developed countries with special equipment, ultraviolet rays in sunlight are also capable of destroying microorganisms. These rays can go through glass or clear plastic bottles. The Swiss Federal Institute of Environmental Science and Technology (EAWAG) developed the SODIS method and showed that 6 hours of normal sunlight will disinfect surface water so that it is safe to drink.

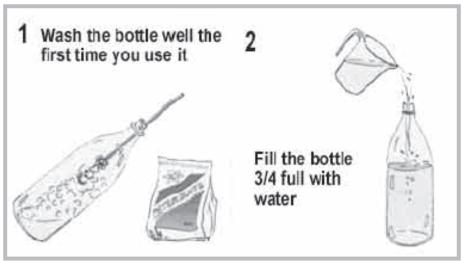
6 hours of exposure to the sun are enough to disinfect transparent water

Solar radiation does not kill all bacteria but it inactivates the bacteria causing diarrhoea, cholera and typhus. The system can be used even when the water contains many more microorganisms than normal.
If the temperature gets over 50 degrees for just one hour many other parasites like worms and amoebae are also killed. It is therefore good to place the bottles on a black surface. If the water used is fairly clear and the correct steps are followed it is possible to obtain safe drinking water.

How to disinfect water with sunlight

- Fill some clear plastic bottles (PET) with screw caps 3/4 with clear (transparent) water.
- Close and shake at least 20 times to get air into the water. The oxygen helps to kill the bacteria.
- Fill up the bottles completely with more water and close well (no air inside as the bubbles will reflect the sun).

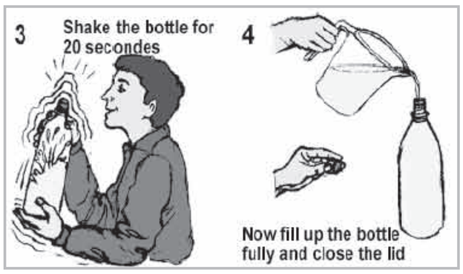
- Place the bottles lying down in a sunny place - for example on a roof or on some sheet metal.



• The warmer the better, so it is good to place them on a black surface - or paint half of the side black (and place the black side down!)

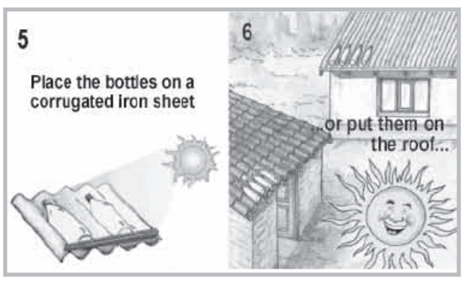
• After 6 hours of sunlight (do not place in shade!) the water is disinfected.

- If it is very cloudy, leave the bottles for 2 days. The system does not work if it rains during the 2 days.

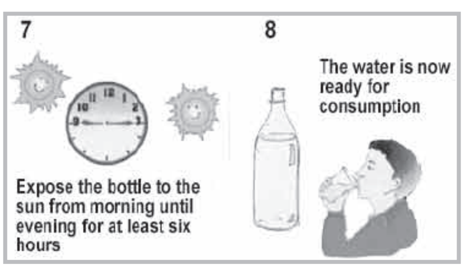


• Place the bottles in a cool place or in water to cool.

• Keep the water in the same bottles and use it. Do not fill it into other containers unless they have been disinfected.



To get a good result it is important that the bottles are PET bottles as they let more of the ultraviolet rays through. Clear Coca Cola plastic bottles are an example of PET bottles. Do not use coloured bottles (green, brown, etc.). The ultraviolet light does not go through.



PVC bottles are not so good. (PVC does not burn easily. PET burns easily and smells sweet when burned). Avoid using scratched bottles as less light will get in. Change them when they are not clear any more or after one year. Glass bottles can also be used.

To be sure that the water is clear enough to use perform the following test:

- Fill the bottle with water.
- Place it (normally - not lying down) on top of a piece of paper with some letters of 3 cm.
- Look through the opening from the top through the bottom of the bottle.
- If you can see the letters (read them) the water is clean enough for SODIS.
- If you cannot read the letters you have to clean the water through a fine filter (cloth) or use moringa seeds to clean it (see next section).

**** SODIS does not remove any chemical pollution from farms, factories, garbage dumps etc. from the water ****

Information and drawings adapted from www.sodis.ch, website of EAWAG, the Swiss Federal Institute of Environmental Science and Technology

5 • Water Clarification with Moringa

Idea

The idea is to promote a system where moringa seeds are used to purify turbid (unclear) water. This system is especially useful for cleaning river or lake water with many small dirt particles.

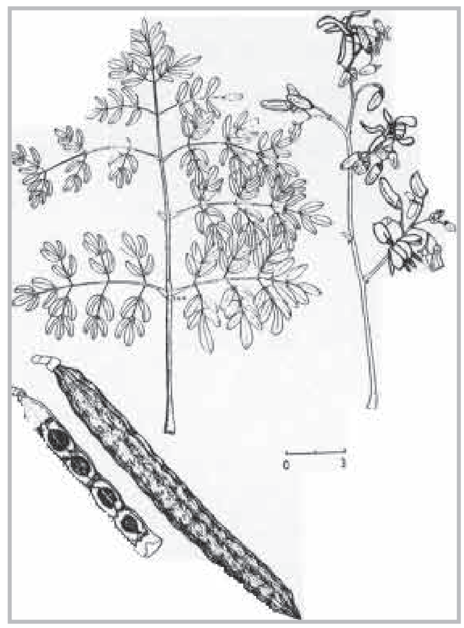
Introduction

As mentioned in the previous section, it is possible to disinfect water with the ultraviolet rays in the sunlight. If the water contains many very small particles this method is not good. The light cannot penetrate and ensure that all microorganisms are killed. This kind of water is often found in rivers carrying fine clay particles from erosion upstream. If it is not possible to filter the water and make it clear enough for solar disinfection, the solution is to use moringa seeds. Compounds in the seeds bind with the silt and clay so they settle at the bottom. With the particles many of the bacteria and other organisms will also settle. Moringa is also a very useful tree because the very nutritious leaves can be eaten. It is easy to grow and is found in many places in Asia and Africa.
Read more about how to grow moringa and use the leaves to improve nutrition in section 31.

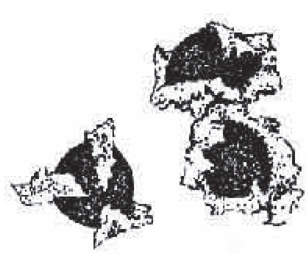
Instructions

How to clear water with moringa seeds:

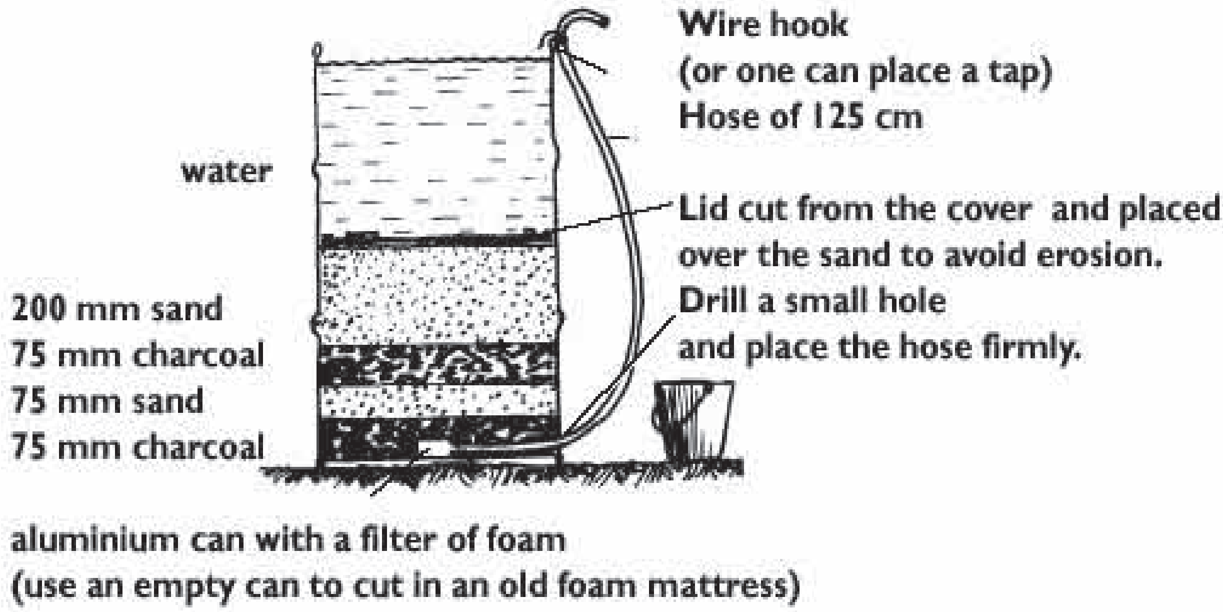
- Use one seed to clean 1 litre of turbid water.
- Take off the shell of the seeds.
- Grind the seeds to a powder inside some cloth on a stone.
- Mix the powder with a little water to free the active components, and mix this white solution for some minutes.
- Mix the water using a wooden tool.
- Leave the container without moving it for one hour so the particles can settle on the bottom.
- Pour the cleared water carefully into the PET bottles so they can be solar treated.
- Do not use the bottom part where the particles have settled.



Moringa - leaves, flowers and seeds



6 • The Drum Water Filter



7 • Simple Water Filters

Introduction

One of the options to make water safe for drinking are ceramic filters for family use. This technique is commonly used for instance in India and Brazil where candle filters of different qualities are produced. Because of transport costs these filters are expensive in Africa or not available at all. This section describes two systems - a clay filter that can be made at no cost, and a low-cost siphon filter made by combining a quality candle filter, a plastic tube and two containers.

The clay filter

This simple clay filter was developed by the Australian National University scientist Tony Flynn. The production of these filters is extremely simple.

Take a handful of dry, crushed clay, mix it with a handful of organic material, such as used tea leaves, coffee grounds or rice hull, add enough water to make a stiff biscuit-like mixture and form a cylindrical pot that has one end closed, then dry it in the sun. According to Mr. Flynn, used coffee grounds have given the best results to date.

Next, surround the pots with straw and put them in a mound of cow manure. Light the straw and then top up the burning manure as required. In less than an hour the filters are finished.

The properties of cow manure are vital as the fuel can reach a temperature of 700 C in half an hour and will be up to 950 C after another 20 to 30 minutes. The manure makes a good fuel because it is very high in organic material that burns readily and quickly. The manure has to be dry and is best used exactly as found in the field. There is no need to break it up or process it any further.
The filtration process is simple, but effective. The basic principle is that there are passages through the filter that are wide enough for water droplets to pass through, but too narrow for pathogens. Tests with the deadly E-coli bacterium have seen the filters remove 96.4 to 99.8 per cent of the pathogen - well within safe levels.
Each filter can process a litre of water in two hours.

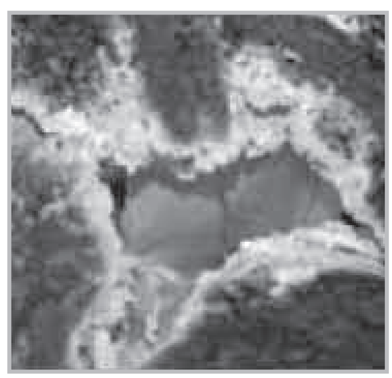
Step-by-step guide

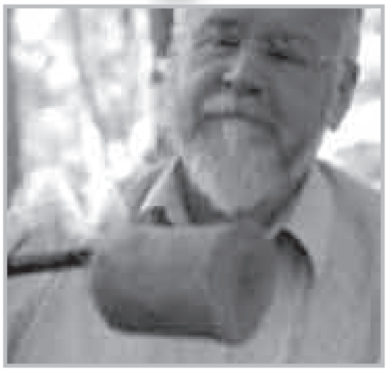
Make the clay mixture
Dig the red to brown coloured clay and dry it in the sun. Pound and crush the clay into a fine, powder consistency. Mix one handful of dried and crushed clay with one handful of dry organic material (used coffee grounds are ideal, rice hulls, sawdust or tea leaves may also be used), ensuring it is well distributed through the clay. Add a little water at a time, using just enough to produce a stiff mixture that is firm to handle, is not wet and will not lose its shape when moulded.

Shape into filter pots and place them in fire
Shape the clay mixture into a cylinder and leave it to dry in the sun. The walls of the finished pot should be about as thick as an adult's index finger. Do not break up or crush the lumps of cow manure, the best heat will come from lumps as they are found. Put the dried filter forms onto a layer of dry manure, surround them with dry straw or leaves and add another two or three layers of manure. The pots should be completely covered and not visible. Light the straw or leaves.

Fuel the fire with more manure
The fire will reach a temperature of 700 C in about half an hour and will reach 900-950 C after another 20 to 30 minutes.
To keep the fire at the required temperature, it will be necessary to add manure. To do so, place it over the holes in the sides and the top of the burning mound.
The temperature of the fire can be judged by its colour, when it is burning well the fire will be a bright orange-to-yellow colour. The filters should be in the fire at that colour for at least 30 minutes.

Bake the filters in the fire
It will take less than an hour to sinter the filters and burn away the organic material, leaving passages that are wide enough for water to pass through, but too small for bacteria and other microorganisms.





Remove the filters from the fire

After firing for 45-60 minutes, remove the pots from the fire. The pots will be red hot so should not be touched.

More unfired pots can be put into the fire at this point, and covered with more cow manure as before. You will need to repeat the process and wait until the fire is burning strongly and to see the same colour again for at least 30 minutes before removing the next filter.

See how to make a clay filter in the text

Filter water

Allow the filter to cool. Wash out any charcoal or rubbish and fill with water. Discard the first water to pass through the filter.

If there is heavy contamination, a series of two or more filters can be used in order to ensure decontamination.

Information and photos provided by Mr. Tony Flynn of the National University of Australia. www.anu.edu.au

The siphon filter

How the siphon filter works

The filter is placed in the upper container which is placed at a height of for instance 1.5 m high. The other end of the tube is put into the lower container that is placed 0.7 to 1 metre below the upper container. A vacuum is then created either by sucking with the mouth or with a suction device.

Once the water is flowing, this flow will go on because of the siphon (vacuum) effect. The flow of water depends on the height difference and the quality of the filter, but can be 2 - 5 litres/hour.

Filter element

The filtering element in the siphon filter is a ceramic candle filter that is sold as spare parts for water filtering systems. Water filters of a fair quality and accessible price are produced in India (around 30 million filters in use) and in Brazil by the companies Pozzani or Stefani.

The element consists of a ceramic piece in the shape of a cylinder (a thick candle). This ceramic has very small pores which retain fine particles and bacteria. The quality of candle filters is measured by the capacity to retain bacteria. This depends on the pore size of the filters. If the pores are small enough all bacteria are retained. The ceramic part is glued to a metal or plastic cover with an outlet nipple for the clean water.

How to make a siphon filter

Materials needed:

- 1 candle filter element,
- 1 metre of plastic tube, outside diameter 7 mm (or the size that fits into the outlet of the filter element),
- 1 container or bucket for the unsafe water (upper container),
- 1 container, bucket or bottle with a lid for the safe water (lower container),
- colloidal silver (optional - but recommended). 1 gram of powder for 20 filters.

In order to make the filters more efficient in eliminating harmful bacteria from unsafe water, it is recommended to impregnate the ceramic part with colloidal silver (if this is not done by the factory already). The silver is inexpensive and can be purchased in a powder form - for example from Argonol in

Spain. Twenty candle filters can be treated with one gram of this powder. Colloidal silver is perfectly safe and is approved for filters by the World Health Organisation, WHO.

Mounting of the siphon filter

- Cut a piece of one metre tube and make the cut with an angle of 45 degrees.
- Mount one side into the nipple of the filter and make sure it enters at least one cm.

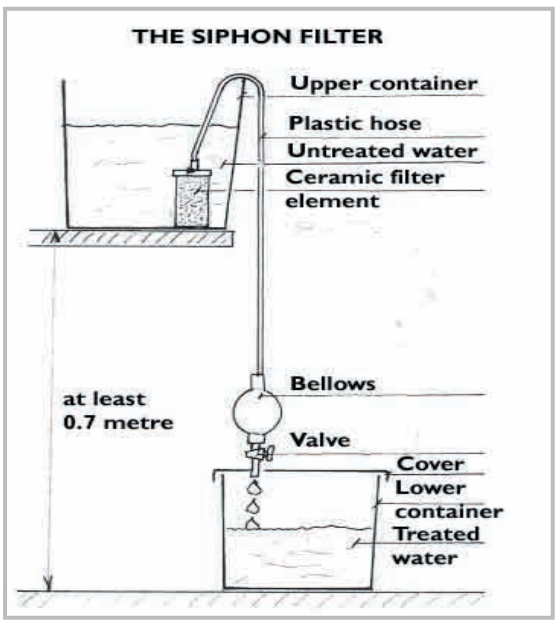
Bubble test
Before distributing the filters, check them for leaks with the so-called bubble test.
Fill up a bucket with water, join the plastic tube into the plastic nipple of the filter element, and place the filter under water.
Then blow through the plastic tube. If large bubbles come out, the filter must either be replaced or repaired. Leaks are normally found between the ceramic part and the plastic cap and can often be repaired with silicone or plastic glue.

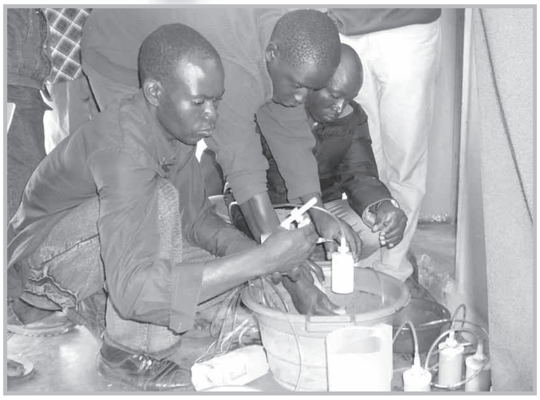
How to impregnate
Because one needs very little silver per filter, it is easiest first to make a concentrated solution, which can be used for many filters.
Mix 10 grams of colloidal silver powder (enough for 200 filters) into 500 ml demineralised or distilled water as used for batteries (NOT battery acid !!!). If you do not have access to this, then use boiled water. You can keep this solution for a long time. About 100 ml of water is needed to impregnate a filter. You must therefore calculate how much water you need to impregnate your filters.

Example: You want to impregnate 40 candle filters
- You will need 40 x 100 ml water = 4 litres of water.
- You will need 1/5 of the concentrated silver solution (40/200 = 1/5).
- Take 100 ml of the concentrated silver solution.
- Mix this into a bucket or basin with 4 litres of distilled or boiled water
- Submerge the filters for 5 minutes in this solution.
- Hold the filters so that the solution leaks out.
- Leave the filters to dry.

Use of the siphon filter

- Place the filter in the upper container and leave the tube hanging out.
- Fill water to be treated into the upper container. It must cover the filter and not be more than the amount you can have in the bottom container.
- Place it at least one metre over the ground.
- Place the lower container 0.5 to 0.8 metre below the upper container.





Treating the filters with colloidal silver

- Suck at the end of the tube until water comes out and place the end of the tube in the lower container/bottle.
- Finish the filtering by placing the end of the tube higher than the filter.
- Do not drink the first 10 litres that are filtered after treating with silver.

Maintenance

"Basic Water Needs" has developed this filter set

- Replace the candle if it gets cracked or every year (recommended).
- Clean the filter with a tooth brush or another strong brush, if the pores become clogged and the filter capacity therefore is reduced.
- Blow through the tube to press out the dirt from the pores.

If the water to be filtered is turbid (full of fine clay particles), it is recommended to first filter the water through a fine cloth, through a homemade clay filter or to use moringa seeds to get the dirt particles to settle (see Section 5).

Filter demonstration in an Indian village

Information and photos kindly supplied by:
Henk Holtslag, holtslag.dapper@planet.nl
"Basic Water Needs", India
Connect International,
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Jan de Jongh, Arrakis, www.arrakis.nl

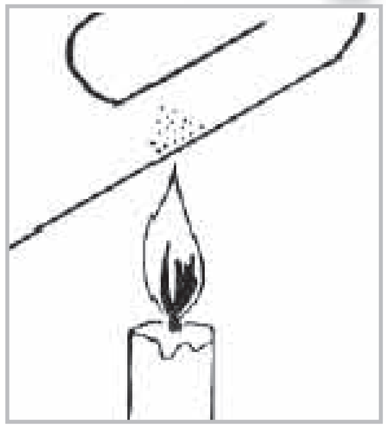
8 • The 'Tippy Tap'

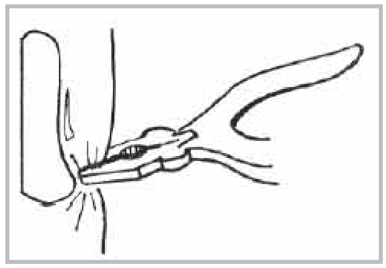
Idea

Lack of water is the principle reason for which people neglect to wash their hands regularly. Here is an idea that uses only about a tenth of the normal quantity of water per hand washing. The Tippy Tap is made of a used plastic bottle of the type with a handle and a string. It doesn't consume as much soap either because the soap is protected by a can from the rain so it doesn't get wet.

Instruction

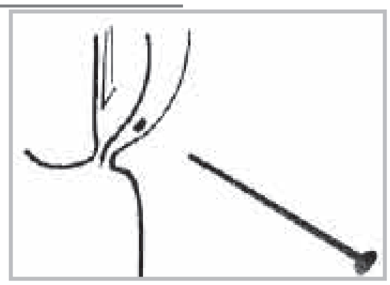
1. Heat the base of the handle of a plastic bottle slowly with a candle, turning the handle until all sides are evenly heated and have become shiny.
2. Remove the candle and pinch the base of the handle closed with a pair of pliers so that the water cannot pass through it. Hold the handle closed with the pliers until the plastic cools to ensure that the opening is completely closed.
3. Heat the point of a small nail over a candle. Use the hot nail to make a small hole on the outer side of the handle just above the place where it is sealed off.
4. Heat the nail again and make two smaller holes in the back part of the bottle. The holes should be in the middle of the bottle and about a finger width apart. A cord will be passed through these holes to hang the Tippy Tap.
5. Thread a cord through the two holes and tie the ends to a pole. Tie a bar of soap and an empty can on another piece of cord so that the can will protect the soap from the rain and sun. Connect this cord to one of the support cords.
6. Tie another piece of cord to the neck of the bottle and leave it hanging down. This cord is used to pull the bottle down so that the water comes out the hole in the handle.
7. Fill the Tippy Tap with water up to the holes in the back of the bottle. Tie the system to a pole or a branch and the Tippy Tap is ready to use.



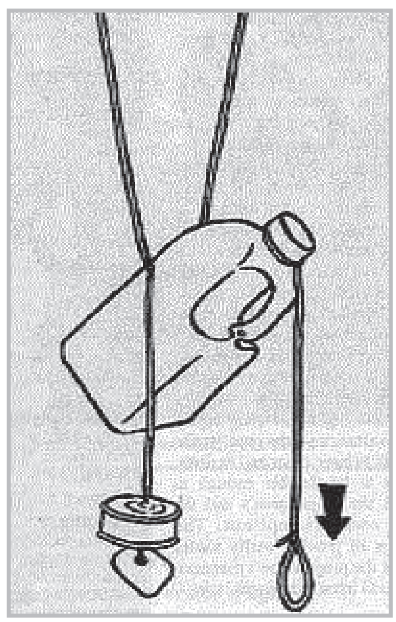


How to use the Tippy Tap:

- Let the water flow over your hands.
- Use the soap.
- Rinse your hands to remove the soap.
- Dry them with a clean cloth.
- Ensure that the Tippy Tap is tilted back so the water does not run out.



The Tippy Tap was originally made of a pivoting gourd and was designed by Dr. Jim Watt and Mr. Jackson Masawi at the Rural Centre of the University of Zimbabwe. The plastic version was designed by Mr. Ralph Gamet and Dr. Jim Watt in Canada.



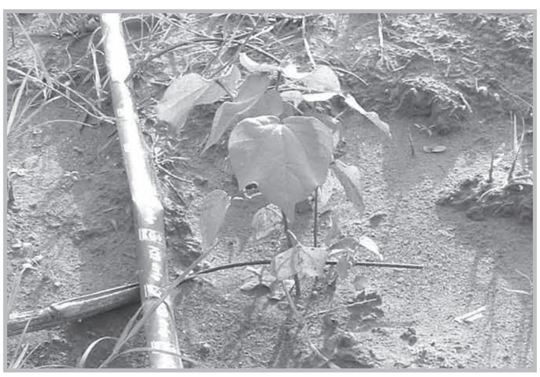
9 • Drip Irrigation

Introduction

An efficient way of using water for crop production is drip irrigation. Trials have shown that, depending on the crop, drip irrigation uses 10 times less water than flood irrigation. Another advantage of drip irrigation is that nutrients can be added to the water which then enters directly into the soil around the plants. A manure "tea" can be made from animal manure or green plants. This liquid should be thinned in order not to burn the plants. Correct irrigation avoids that nutrients are washed away by rains or transformed by microorganisms.

Drip irrigation system in Nicaragua

A simple drip irrigation system can be connected directly to the outlet of a pump (the outlet should be at least 0.7 m above the drip outlets). Or the system can consist of a storage tank. A main hose is connected to lateral hoses with small holes or inserted micro tubes.



Micro-tubes are cheap and easy to clean

The two systems described here are:

1. the Nica drip,
2. the Micro-tube drip.

How to design the lay-out

The lay-out of the system depends on several factors, such as:

- availability of manpower to pump and work on the land,
- the type of products to be grown,
- the soil and climate conditions,
- the slopes and differences in height of the soil surface.

If possible, then ask advice from local agricultural experts to design the optimal lay-out.
Ask them also how much water the various crops require and how often they need that amount.
The area that can be irrigated with a drip systems and a hand rope pump is between 1/8 to 1/2 ha.

Nica Drip

Materials and tools needed to set up a Nica drip:

- a filter (inside the tank), an outlet tube and a valve,
- a main hose of 30 to 50 mm (depending on size of plot),
- "T" pieces and extra valve in case 2 sections are desired,
- connectors to connect the laterals to the main hose,
- laterals (polypropylene hose, strong black plastic, of 14-19 mm diameter),
- a nail or piece of strong wire of 1.5 mm diameter,
- pliers to hold the nail and scissors or a knife.

How to install

1. Connect the laterals to the main, fold the other end and fix it with a stick in the ground.

2. Make holes (1.5 mm) with the nail on the topside of the pipe (distance between the holes depends on the plants to be irrigated, e.g. tomatoes 70 cm).
3. Make drippers of the lateral hose. Each dripper requires 2 "sleeves" of 5 cm. Cut the sleeves lengthwise and mount one sleeve over the lateral without covering the hole. Place the other "sleeve" over the first one, but the second one covering the hole.
4. Fill up the tank, test if equal water amounts come out from every dripper
5. Plant 4 plants around each dripper.
6. In case the area is sloping, differences in water flow from the drippers can be compensated by partly closing the laterals or main hose on the lowest sections.

"Micro-tube Drip"

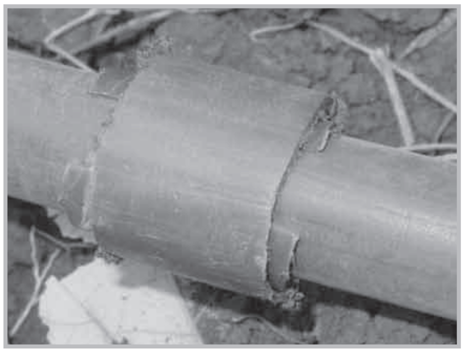
Complete systems are distributed as Drum Kits by the organisation IDE (International Development Enterprise). They use so-called "lay flat" hose for mains and laterals which reduce cost and transport volume compared to the Nica drip.

The complete systems require water pressure of about one metre. This means that there must be one metre difference between the outlet of the tank and where the water comes out of the micro-tubes. The micro-tube drippers inserted in the lay-flat hoses are in this system about 0.6 m long. It is possible to use the system with less water height (0.5 to 0.9 metre). The length of the drippers is then reduced to 0.3 to 0.5 metre.

This makes it possible to make a cheaper system connected to a tank made of bricks (see section 11), even though the water from a tank on the ground will have less pressure than if the water comes from a container placed one metre above the ground.

Water flow from the drippers can be altered by making the micro-tube longer or shorter.

The micro-tubes of the lowest placed laterals should be longer than those of the laterals placed higher up. To have an equal amount of water from the dripper, you will need to experiment with the tube lengths. If the land is sloping it is best to let the laterals run along the contours, so that the pressure is the same within the lateral.



Making a hole, cutting a sleeve and the finished Nica drip

Troubleshooting

No water comes out of the dripper:

This can be due to dirt in the water or an air bubble. Take out the air bubble by sucking on the micro-tube. To remove dirt, take out the dripper and blow or suck it.

Weekly maintenance

- Control regularly that equal amounts of water come out of all the micro-tubes
- Open the end of the laterals to flush out any dirt
- Check /clean the filter

Information: Henk Holtslag, holtslag.dapper@planet.nl

10 • Maintenance of Water Posts

Clean water is important for a good health

Clean drinking water is very important for the family to remain healthy. Many diseases are caused by unclean water. Safe water comes from a protected hand dug well or from a borehole with a hand pump. If the hygienic rules for the water points are well kept - all these systems are good. The safest are boreholes with hand pumps. However, boreholes cannot be installed everywhere because they are much more expensive. One borehole costs as much as 10 wells.

Water committees

Building a pole fence to protect the water point

In order to construct and maintain a water point - any of the above mentioned - it is important that the community forms a Water Committee. This committee consists of a chairman, a secretary, a treasurer and a few active members. The responsibility of the committee is to organise the community to assist with construction of the water points and hereafter maintain and safeguard them.

They must also protect them against vandalism and theft and keep the areas clean. Every year after harvest he committee must receive contributions from the families, in order to be able to buy spare parts, cement and so on for the maintenance and repair.

Main rules of well maintenance

- Slash grass around the well.
- Keep the drainage clear and sweep the area clean.
- Keep animals away from the well: construct a fence.
- Keep the bucket and rope/chain clean - they should never be on the ground.
- Put the lid on after use.
- Take in the windlass, chain and bucket at night or secure them.

Main rules of borehole maintenance

- Slash grass around the borehole
- Maintain the drain systems and keep the area clean by sweeping
- Fence the borehole - this is important, because cattle can destroy the pump
- Make sure children never play with the pump
- The handle must be operated smoothly
- The pump should be greased and bolts tightened monthly

The Water Committee shall call for professional assistance if the pump breaks down. Buy the spares and pay the technician for the work done. The government might have a system for the repair of hand pumps, but the community members must know that if it takes a long time to repair the pump they are the ones who will suffer. There are pumps in Zambia which have been in disrepair for 3 years. Therefore it is better for the welfare of the community to solve the problem locally.

Create a good environment around the water point

The community should make a nice environment around the water point. This can include:

- Live fencing - for example with finger euphorbia, jatropha or moringa. A live fence looks beautiful - and at the same time the community does not regularly need to renew a pole fence.
- Plant shade trees.
- Plant flowers.

User fee

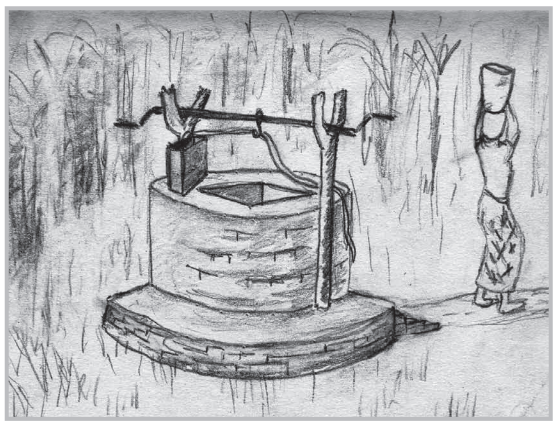
The committee should collect a small user fee annually of each member of the community (after the harvest).

Information and drawings courtesy of DAPP (Development Aid from People for People) Child Aid and Environment, Monze, Zambia.

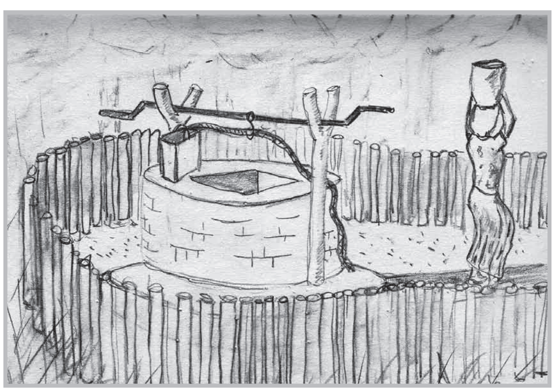
The "water ladder"

1.Open well with a bucket

2.Open well with a windlass



3. Protected well, but open



4. Protected well with a rope pump

11 • Low-cost Water Tanks

A water reservoir can store rainwater for domestic use or for irrigating a vegetable garden. Many already use fuel drums. This section also describes other inexpensive containers such as the straw mat tank and the brick tank. Little cement is needed because they are reinforced with steel wire.

The tank can be placed under a roof to collect rainwater or just beside a well with a rope pump to store irrigation water.

Straw mat tank

Low-cost water tank made of straw

1. Take the materials to the place where you will build the tank. It should be a place where it is easy to collect water. It should also be elevated so that the water can be drained out of the holes
2. A mat made of bamboo or strong grass is made into the shape of a cylinder or a drum. There should be a double layer. The mat can be cut into two long strips to make a small cylinder. Or use two mats to make a larger tank.
3. Reinforce the cylinder with three circles of steel wire.
4. Mix 1 part of cement with 5 parts of sand, small gravel (if available), and water to make the bottom of the cylinder.
5. Place a PVC pipe 20 cm long (8") in the lower part of the cylinder. This tube will remain closed and only be used to drain the tank after cleaning. Place another PVC pipe 20 cm (8 inch) over the bottom of the tank. This tube will be the water outlet.
6. Mix cement and water to form a thin solution and "paint" both the inside and the outside of the cylinder with a large brush. Let it dry for about half a day.
7. Mix 1 part of cement with 3 parts of sand and water. Place the mixture on both sides of the cylinder as thinly as possible - maximum 3 to 4 cm.
8. The area where the tubes are, need to be reinforced with a thicker layer - about 7 to 8 cm. The area where the wall ends meet the bottom should also be reinforced.
9. Let the tank dry for 10 days in a humid environment - covered with grass or leaves and watered everyday.
10. Place a sponge or a piece of cotton in the water outlet to filter impurities. This step is also important if the water is being used for drip irrigation. It will keep the little holes from getting blocked.

Using a fuel drum as a water reservoir

The following are the necessary steps to convert a fuel drum into a water tank:

- Cut the bottom of the drum.
- Smooth out the sharp edges.
- Buy a "T" shaped water pipe fitting and place it into the small threaded hole on the lid.
- Connect two hoses to the "T" joint. The hoses can be connected with bicycle tubes if fittings are not available.

Brick water tank

Materials for a 400 litre tank. 3 layers of bricks. Diameter 0.85 m. Height 0.70 m:

- 90 bricks (23 cm x 11cm),
- 30 m black steel wire (1.5 mm),
- ½ bag of cement,
- 2 bags of sand,
- 0.5 m of 1” PVC pipe or other pipe.

1. Clean a circular area with diameter of at least 1.3 m and make it horizontal and flat.
2. Draw a circle of 85 cm, for instance with a piece of wire and 2 sticks.
3. Place a first round of bricks outside this circle, with the long sides vertically. Clean the bricks to ensure that they are more or less even.
4. Secure a wire around the bricks at 3 cm from the top. Tighten the wire by making a loop at one end and pull through the other end.
5. Secure two other wires. One in the middle and one 3 cm from the bottom.
6. Place a second and a third round of bricks on top and also place wires as in steps 4 and 5.
7. Mix one part of cement (start with 1/3 bag of cement) with 4 parts of sand, small gravel (if available), and water.
8. Apply a thin layer on the outside and inside of the tank just to cover the bricks.
9. Cut a 25 cm long steel pipe or thick walled PVC pipe of 1” to make the water outlet.
10. If a steel pipe is used, weld pieces of round bar to it to fix it in the cement. If PVC is used, put PVC glue and sand to increase the grip of the pipe in the cement, or make the PVC pipe end a bit square by heating in a fire.
11. Place the pipe 3 cm from the bottom and make the wall thickness at the part of the outlet 15 cm thick.
12. Put a 3 cm thick cement layer on the floor of the tank.
13. Mix cement and water (no sand) to form a thin solution and “paint” on the inside of the tank with a tool or large brush. Let it dry for about half a day.
14. Let the cement cure. Cover the tank with plastic sheet or paper and KEEP IT WET during 10 days. Put water twice or more every day!!
15. Place a filter (Sponge or old sock) on the inside of the water outlet to filter impurities. This is important if the water is used for drip irrigation. It will keep the little holes from getting blocked.

Measure with a stick to ensue a circle is formed

Scrape the edges of the bricks so that they fit closely

Larger tanks can be made by making a bigger circle and increasing the number of bricks and cement accordingly.

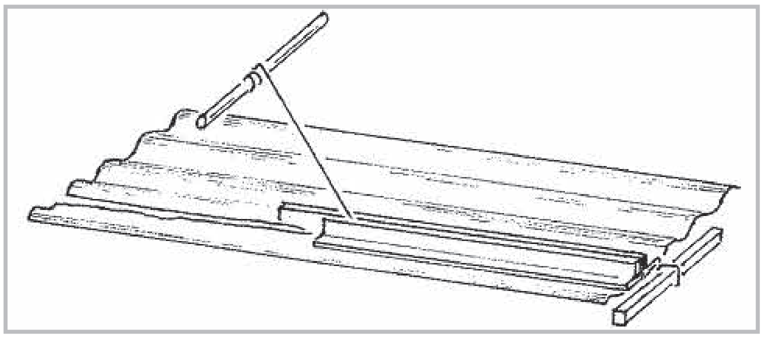
Make the bricks wet before applying cement

Text and photos kindly provided by Henk Holtslag, holtslag.dapper@planet.nl
Additional information from Jan de Jongh, Arrakis, www.arrakis.nl

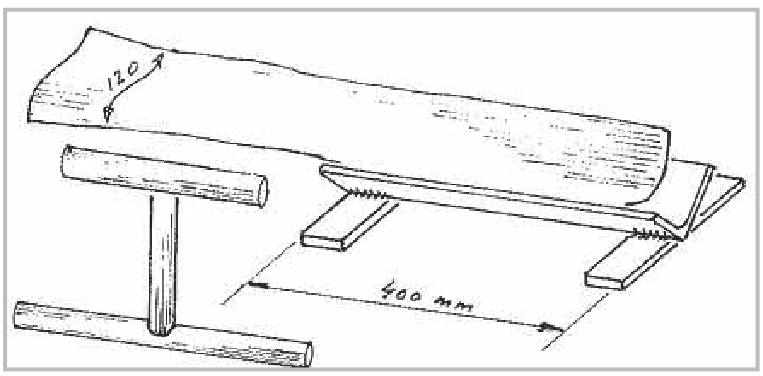
12 • Making Gutters

An efficient rainwater collection system needs gutters, and these can be expensive. However, it is possible to build low-cost gutters from corrugated galvanized metal sheets. In Ghana, it is possible to build gutters for US$ 0.7 per metre. This type of gutter should not be made very long since it is directly connected to the roof. If the gutters get filled with water, they may become too heavy and damage the roof.
(See this type of gutter on the photo at the end of this section)

1. Cut strips

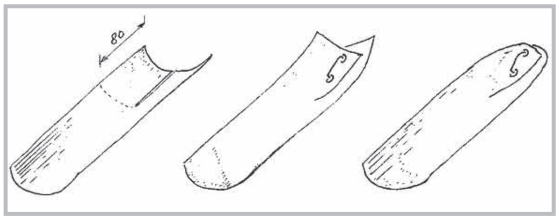


The first step is to cut the corrugated sheet into strips. A 120 cm sheet can be cut into ten 12 cm wide strips. Place your feet on the boards or angle iron and pull the thread.



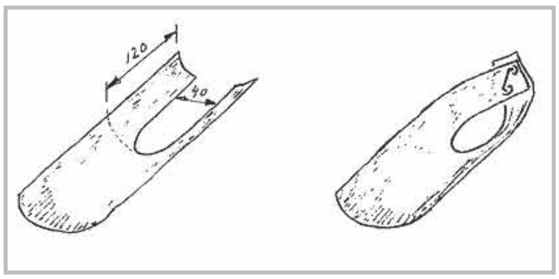
Alternative: Make a good scratch along the angle iron (ruler) and bend the sheet several times. The edges will be straighter.

2. Make the gutter into a round shape with a "gutter bender."



3. Close the edge

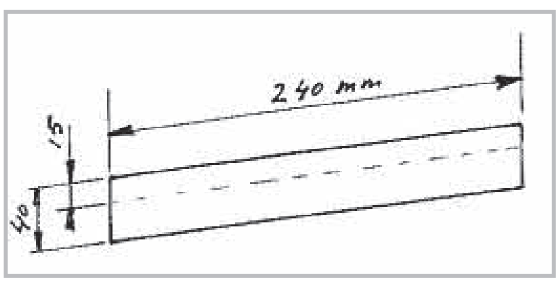
A: Make an 80 mm cut at the end of the gutter
B: Fold the two edges over each other
C: Punch two holes with a nail and tie them together with a galvanized wire
D: If desired, cut the edges to make them round



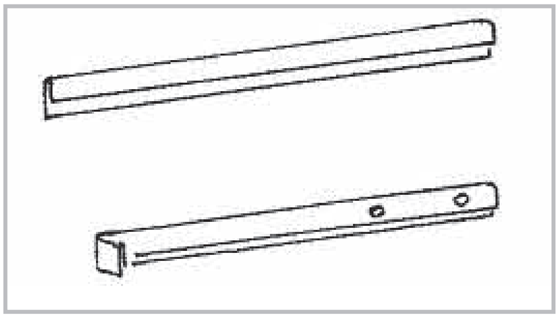
4. Closed edge with draining hole

A: Cut a strip in the middle of an edge to make two lips
B: Punch two holes
C: Tie the tongues together

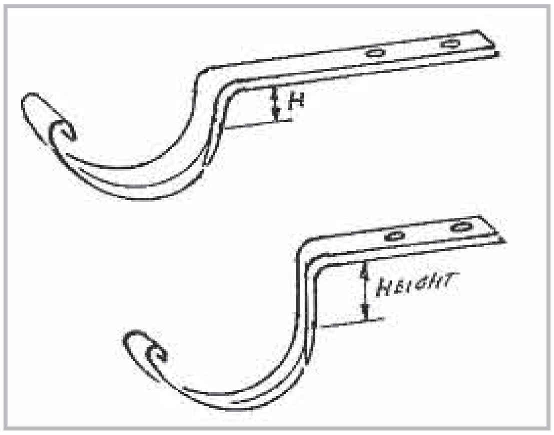
5. Gutter support



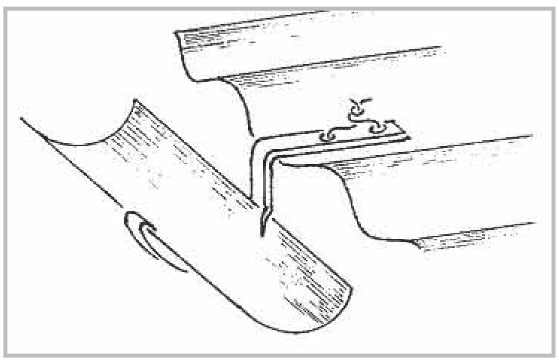
A: Cut a strip from the 1 mm metal sheet
B: Fold it, leaving one side longer than the other. This way, it is easier to cut a recess to support the gutter.



C: Bend the hook. Punch holes with a heavy nail. Use a heavy piece of steel with a 10 mm (approximately) hole. Place the gutter support on the steel piece in a way that allows you to punch a hole with a nail trough the gutter support and the steel piece.

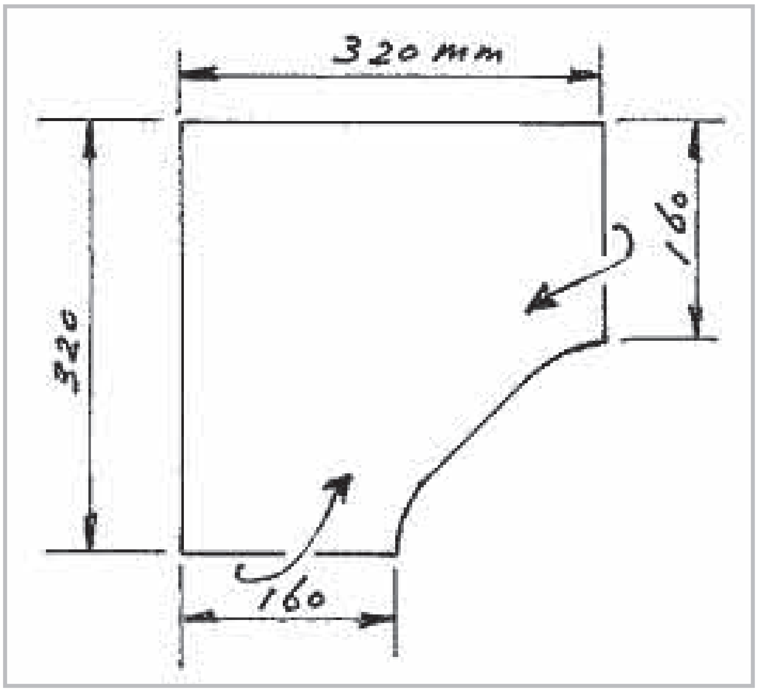


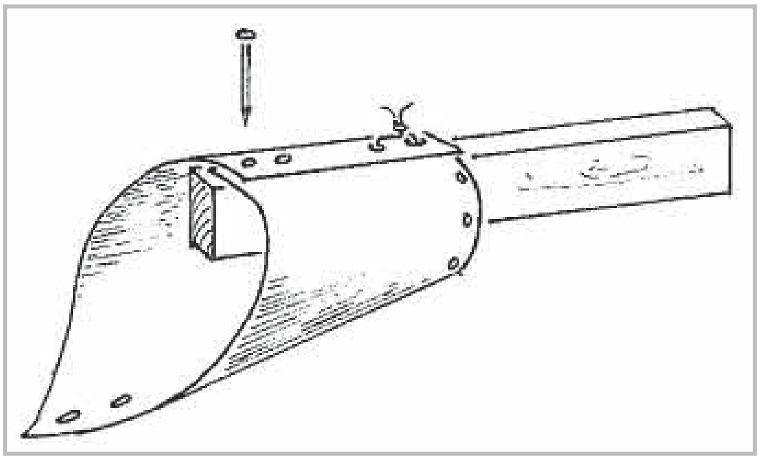
D: Curve the gutter seat. Cut a recess to hold the gutter in place.



E: The last bend gives the height of the support. Different heights give the desired inclination to the gutter.
F: Place the hook on the roof. Use the hook as a jig to punch holes. Support the roofing sheet with a piece of wood while punching. Tie the support. Place the gutter on the hook. Bend the recess piece that holds the gutter in place.

6. Receptacle
A: Cut a piece of the galvanized metal sheet. Straighten it using the gutter bender.

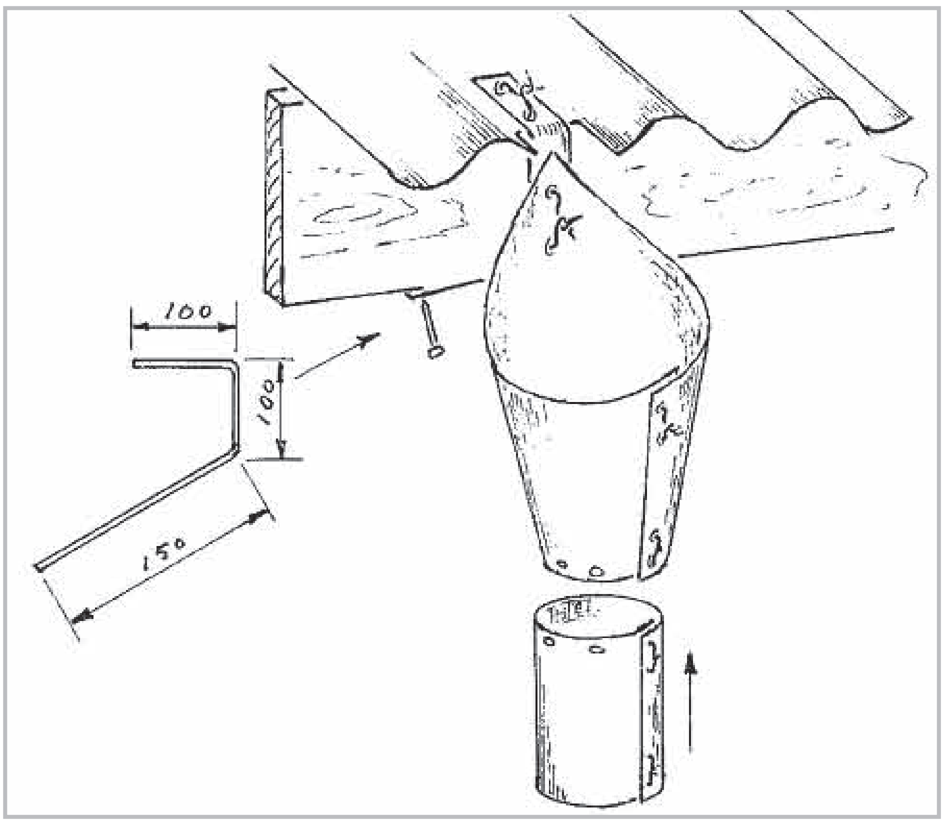




B: Bend the two short sides over each other. Punch holes over a piece of wood. Tie the receptacle with galvanized iron wire.
C: Cut a 40 mm strip from the 1 mm metal sheet and fold it to make the support.
D: Cut a recess on the roof to make room for the support. Mount the support on the roof and secure it to the board.
E: Tie the pipe to the receptacle and the support.

Text and photos kindly provided by Henk Holtslag, holtslag.dapper@planet.nl

Tank for storing water for irrigation



A complete system to collect rainwater with the gutter fixed directly to the roofing sheets

13 • The Rope Pump - Introduction

Low-cost solutions to address water scarcity

Drought spells and erratic rainfalls frequently affect Southern Africa. We thus urgently need low-cost solutions to improve food production and consequently improve living conditions

The rope pump is an efficient and low-cost solution for small-scale irrigation systems. The quantity of water depends on the depth of the well. The amount of water it provides depends mainly on the depth of the well. At 10 metres, it is possible to obtain 200 litres in 5 minutes.

Compared to treadle pumps, rope pumps can be used in much deeper wells. Treadle pumps can only extract water from wells up to 6-7 metres deep. Rope pumps can reach depths of at least 30 metres.

The rope pumps can be built locally with materials that can be acquired in the area - steel, PVC pipes and used car tyres. The only requirement is the existence of a workshop with machines for welding and cutting steel. The techniques are simple to understand and it is possible to train people in the villages to install and maintain the pumps.

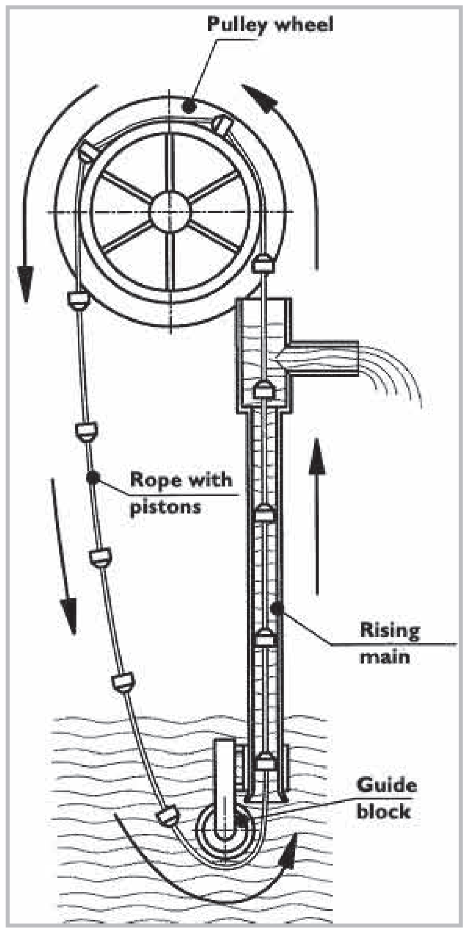
The promotion of pumps for small-scale irrigation can also be a way to improve the natural environment. Many communities establish irrigated gardens at the riverbanks in order to be able to produce food during the dry season. Deforestation of the riverbanks leads to increased erosion and over time reduces the amount of water in the river during the dry season. Rope pumps make it possible to irrigate gardens away from the riverbanks, thus providing an alternative to the destruction of the vegetation along the rivers.

What is the rope pump?

The rope pump is economical and easy to build. It is made of metal, PVC pipes and recycled tyres. It can be built and maintained by people with little technical training.

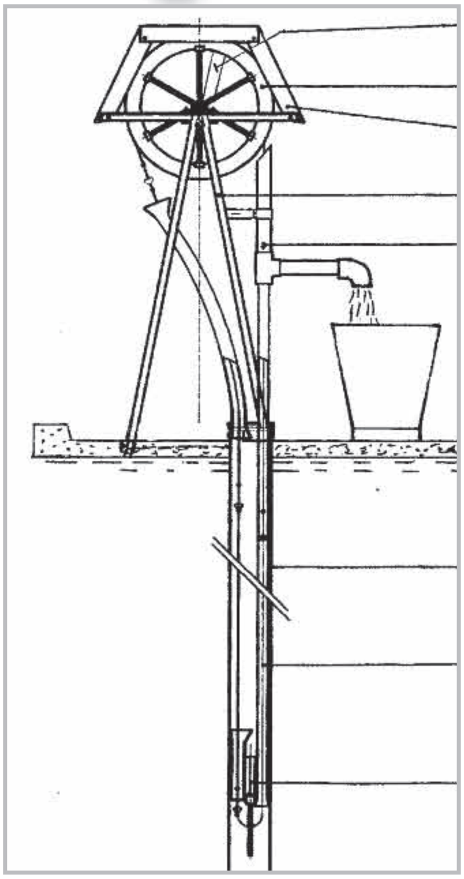
A rope pump uses a continuous rope with attached pistons. The rope runs up through a PVC tube (main ascending tube on the drawing). The low extremity of the tube reaches the ground water in the well. The top extremity is above ground. Pistons are attached to the rope at every metre and fits perfectly inside the tube. When the rope is pulled up through the tube, the water above each piston is pushed up.

Above ground, the rope works over a wheel, so that when the wheel handle is turned, the rope is pulled up through the tube and goes down into the well again. At the bottom there is a specially constructed guide block that makes the rope re-enter the PVC tube smoothly as soon as the rope is pulled.



The rope pump system

The rope pump can be used to a depth of about 30 metres. The deeper the water is, the smaller the diameter of the tube must



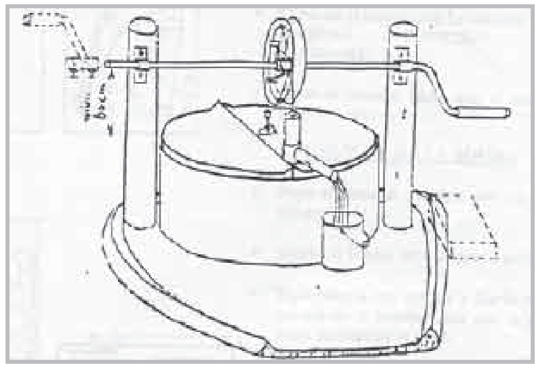
A rope pump installed in a borehole also below

be to avoid the water column becoming too heavy.
This means less water can be extracted from a deep well.

Two different models

The pole model
This system is built with a handle fixed to two poles - see the drawing.
Work can be made easier with handles at both sides of the well.
The pole model can be installed in an open well, when the water is only used for irrigation. If the water is also used for drinking, the well must be covered with a concrete lid to ensure that the well water is not contaminated.

The "A" model:
The A model has a metal frame that is fixed to a concrete lid (see the drawing above).
It can be installed over open wells or boreholes, and when the water is well protected from contamination it is safe to drink.



The pole model rope pump

Rope pumps around the world

50,000 pumps in Nicaragua,
20,000 in Mexico, Guatemala, Honduras, Ghana, Zimbabwe, Zambia, Tanzania, etc.
Rope pumps are produced by DAPP (Development Aid from People to People) in Shamva, Zimbabwe, by DAPP in Monze and Chibombo, Zambia, by ADPP in Chimoio and Bilibiza, Mozambique and soon by ADPP in Cabinda, Angola.

Information and illustrations kindly supplied by:
Henk Holtslag, holtslag.dapper@planet.nl
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Connect International,
www.connectinternational.nl
Jan de Jongh, Arrakis, www.arrakis.nl

A wooden rope pump has been developed and is now made by local carpenters in Northern Mozambique

14 • Well Drilling - Introduction

The Rota-sludge method

The manual excavation method, Rota-sludge, is based on the sludge method, which has been employed to drill millions of wells in soft ground in Asia. Recently this method has been improved to make it more effective on harder ground. By training local organizations and craftsmen it is successfully being used in Nicaragua, Tanzania, Ethiopia, Senegal, Zambia, Mozambique and Zimbabwe.

How it works

The drilling mechanism consists of a bamboo or wooden lever, a 1½ to 2-inch drill pipe and an auger (soil drilling bit) with hardened teeth. To begin drilling, a starter hole is dug. The hole is connected to a shallow pit.

This hole is then filled with drilling fluid, which consists of water and clay or cow dung (or bentonite if possible). The function is to make a thick fluid that can lift up the sand and clay. Another function is to plaster the sides of the well, so that the water does not disappear.

The lever creates up and down movements. During the upward movement, the top of the drilling tube must stay closed. You can use your hand to close the top and create a vacuum. During the downward movement, remove your hand to open the pipe and allow the drilling fluid to flow back into the pit. The heavy particles and sand settle on the bottom of the pit while the "clean" drilling fluid flows back into the drill hole. As the hole gets deeper, new pieces of threaded pipe are added.

Rota-sludge drilling in Northern Mozambique: 15-20 m in 3-4 days

The drilling becomes more efficient if the tube is rotated 45 degrees at the moment the drilling tube touches the bottom of the hole. This technique allows the drill bit to scrape compact layers of sand, clay, sand stone or tuff stone. It does not work with solid rocks.

"Baptist" drilling

"Baptist" drilling is another low-cost drilling method. It was developed by Terry Waller at the Human Needs Project in Bolivia. Families are here trained and assisted to drill their own boreholes. They drill up to 60 metres down through clay and sand with equipment made locally.

The differences from the Rota-sludge system are:

- the drilling bit has a valve
- a rope and pulley is used
- only bottom pipes are of steel. The rest are of thick walled PVC, making the system easier to transport.

See the photo next page.

Teeths of drill bit from steel from truck springs

Information kindly provided by Henk Holtslag

15 • Ground Water Recharge

Artificial and natural recharge of ground water

Drilling a borehole with the "Baptist" system in Mozambique

Many water wells in Africa, especially hand dug wells, dry up at the end of the dry season, because more water is taken out than is coming in by the natural recharge. Reasons for limited ground water recharge can be compact topsoil layers, loss of vegetation, increased erosion, etc. There are several ways to increase the recharge of ground water such as small dams or bunds, underground dams, using recharge holes or the planting of trees or vetiver grass that have long roots.

Testing the need for a recharge system

Using a step auger to make the recharge hole

Before starting to set up a groundwater recharge system, one needs to find out if it will increase ground water recharge and where it should be placed. The steps are:

1. Select a well that runs dry and where people know that water does not penetrate easily into the soil. For example places where water stays in puddles.
2. Find a location at least 10 metres from the well, where rainwater running on the surface can be collected. The distance should be at least 10 metres to ensure that the surface water is filtered before it reaches the well. If the area slopes, the place should be made at a location higher than the well ("up stream").
3. Dig a hole ½m round and 30 cm deep.
4. Fill the hole with water.
5. Check the hole after one hour. If there is still water after one hour, there is a good chance that a ground water recharge system will make it possible for more water to reach the ground water.

It is important that this test is carried out after the first heavy rains. If the soil is very dry, it will absorb much of the water, and therefore not show the actual flow of water into the ground.

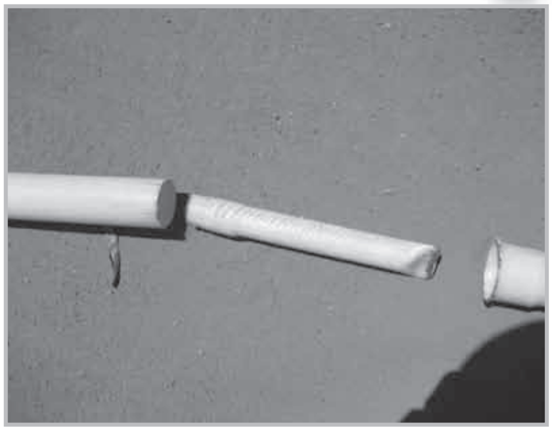
If the recharge test is positive the tube or vetiver recharge systems can be applied.

Tube Recharge

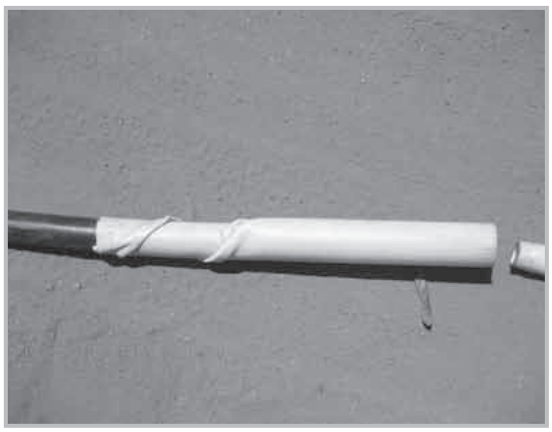
This low-cost option combines manually drilled holes with drainage tubes that pass through the compacted topsoil layer. Rainwater, that otherwise would run off to rivers or evaporate, can thus penetrate into the groundwater (aquifers). The recharge tubes are closed by a cover tube, which is only taken off after the collected water has settled for some time, allowing particles to settle down at the bottom of the hole and the water to become clear. After having taken off the cover, the collected water flows through the recharge tube and ends up as ground water.

How to install

- Drill a 2 inch recharge hole inside the test hole. Use an auger (soil drill) or manual drilling method such as the Baptist system. The hole should pass the compact soil layers and reach the permeable layers (that the water can pass through). The recharge hole should not reach the ground water layer (aquifer) to avoid contaminating the ground water with surface water.
- Test the recharge capacity of the hole after drilling 2 metres. Fill up the small hole with water (as above - about 100 l) and check after one hour. Continue this test for every metre until all water disappears within one hour.
- Cut the drainage tube (1" or ¾") as long as the depth of the hole. Make a filter at the bottom part by cutting slots with a hacksaw on one side for every 1.5 cm on a length of 3m.
- Connect the drainage tube (called pressure tube on the drawing) with a 0.3 m long tube of 1½".
- Make a 0.5 m cover tube of 1½". Expand one end of the cover tube (by heating), so that the two 1½" tubes can be joined.
- Place a filter in the 0.3 m 1½" tube. The filter is made of a slotted 1" tube with a cloth or sock inside. This cloth can be cleaned when dirty or be replaced.
- Place the set of tubes in the borehole in such a way that the top of the top filter part is just above the bottom level of the run off or pond.
- Fill up the space around the tube with fine gravel or coarse sand. Seal the top part with clay.
- Cover the drainage tube with the cover tube and dig a storage pit around the tube. The volume of this storage pit should be at least 3,000 litres (3 m3) - for example a pit with a diameter of 3 m and a depth of ½ m. Make sure that the tube is placed so that it can be reached when the pit is filled up with water.
- When it rains the storage pit fills with water. Leave it for some hours or longer until the dirt and sediments have settled.
- Take the cover tube off and the water in the pond will flow via the drainage tube into the ground.
- When the pond is empty, check the filter cloth first, put back the cover tube and wait for the next rain.



A complete system before installation



PVC pipe fitted to plastic pipe with heat

Materials:

- Drainage tubes made of polypropylene (black hard plastic) or PVC with diameters of 20 mm or more. Length of 3 m or more depending on the depth of the hole.
- Cover tube of 1½". 1 piece of 0.3 m and 1 piece of 0.5 m.
- Filter tube of 1". 1 piece of 0.3.

Using the tube recharge system

Add gravel along the tube and clay on top to seal the system

Every time it rains some ten cubic metres of water will flow back into the aquifer. If the pond is made bigger, more water can be recharged. Testing is needed to find out the maximum capacity of recharge. When the drainage tube becomes clogged , it may be opened again by swapping (moving a stick with a cloth up and down the drainage hole). Depending on capacity and flow patterns of the ground water, part of the recharged water can be pumped up during the dry season.

Cost

The dirt must settle before the plug is lifted

The cost of drilling depends on the materials and time needed and the time of drilling will depend on the geological situation. In many cases where there are no stones or boulders a 10 m hole can be made in one day with an auger or with a Baptist drill. If the holes are drilled by the families themselves labour cost can minimised. The equipment for Baptist drilling to 12 metres costs around US$ 75. This equipment can be used for many holes.

Depending on the materials used (black hose is normally the cheapest) and the depth of borehole, the cost of the materials for a complete tube recharge system will be between US$ 5 and US$ 25.

Vetiver Recharge system

Groundwater recharge is needed where there are hard soil layers or rocks in the soil, so that it is impossible to make a recharge hole. Other areas will not have the tools or the trained persons to drill recharge holes.

In such situations the vetiver recharge system can be used. The advantages are that it is cheap since the user only needs to acquire vetiver slips (planting material) and supply the labour (more on vetiver in Section 23).

The vetiver grass has roots of 2-3 metres length that can penetrate even very hard soil layers. The roots are also called "living nails". When vetiver slips are planted close - 15 or 20 cm from each other - they form a closed barrier that stops or slows down water running on the surface. The topsoil carried with the water then settles in front of the vetiver grass and gradually build up a small dyke or barrier.

Much of this water will penetrate into the ground because the water can flow along the vetiver roots.

The vetiver recharge system is established in the same location as one would make the tube recharge system. This means "upstream" and at least 10 metres from the well.

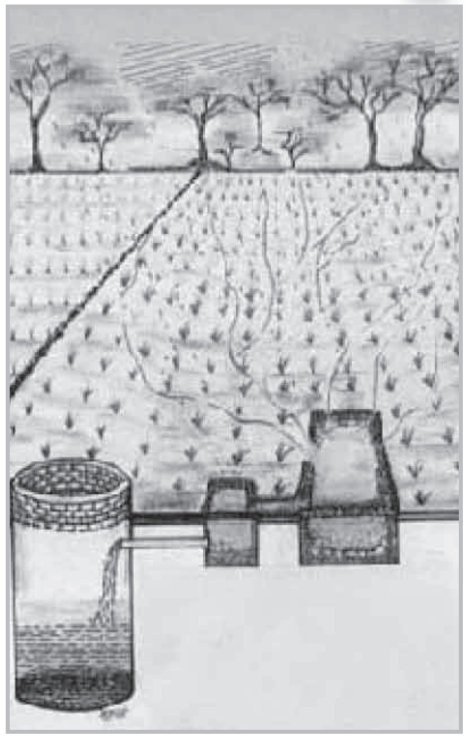
The idea is to get water to accumulate in storage pits and sink into the water along the vetiver roots. A storage pit is dug in the shape of a half circle with a diameter of at least 3-4 metres. The pit should be about 1 metre deep. It is OK to leave large stones

in the pit, if they are difficult to get out. The soil that is dug out is placed "downstream" of the pit to form a dyke or barrier.
The vetiver slips are planted in rows on the barriers that form half circles. The water then seeps through the soil of this barrier and when it reaches the vetiver roots, runs along the roots into the ground. It can occur that fine soil particles fill the pores in the barrier so that the water does not disappear from the storage pit. One solution is to remove the first 10-20 cm of the barrier and add new sandy or loamy soil so that it is porous again. One could also make an extra pit, as described next.

Double Pit Recharge

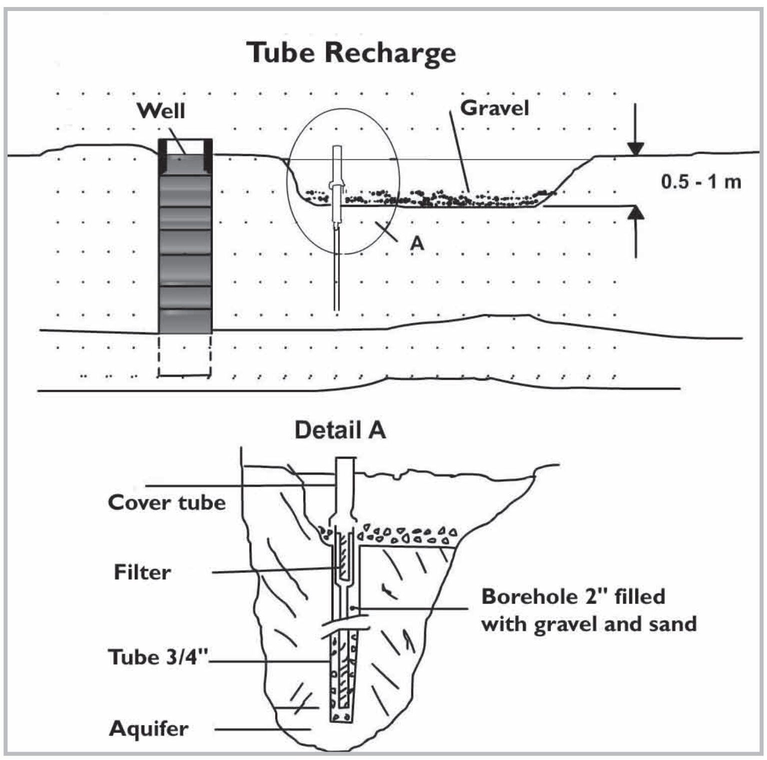
This is a simple system developed by a farmer in Aurangabad District, Maharashtra, India. It became very popular because it gave the farmers more water for irrigation at a very low cost - about USD 25-30 for labour (3-4 mandays) and a pipe. There is very little maintenance.
Two pits are dug next to a well. The large pit is approximately 2.4 x 1.8 x 1.8 metres and the small one is 1.2 x 1.2 x 2.4 metres and is built along the slope of the larger pit, about 3 metres away from the well. The smaller pit is filled with stones, gravel, and coal or charcoal, which act as a filter. A large pipe of cement or PVC (8" or two or more smaller ones) fitted with a wire mesh filter is fixed at the bottom of the smaller pit. This pipe opens into the well. Rainwater that collects in the larger pit, flows into the smaller pit and is filtered clean before it flows into the well through the pipe.
The silt that accumulates in the pits can be put back on the fields. In this way, soil is conserved as well.

The system can also be combined with Tube Recharge, so that the water from the large pit runs to the second pit into which the Tube Recharge is fitted. This is recommendable if the water in the well is used for human consumption.



Drawing and information on the last system from Agricultural Technology Management Agency (ATMA) recorded on www.farmingsolutions.org/successtories, where there are many other good examples to learn from.

Other information and photos in cooperation with Henk Holtslag, holtslag.dapper@planet.nl and Jan de Jongh, Arrakis, www.arrakis.nl



16 • Subsurface Dams

Introduction

Subsurface dams built of soil across riverbeds have proved to be the most reliable and inexpensive water source in arid and semi-arid areas.

Subsurface dams prevent floodwater, which has filled the spaces between the sand particles in riverbeds, from being drained downstream thereby drying up the sand in riverbeds.

Subsurface dams let rainwater pass without reducing the flow to people living downstream. Subsurface dams do not require any maintenance. They cannot be eroded or clogged with mud or sand. Evaporation loss is almost non-existent since the water is stored in the sand.

Where can it be placed?

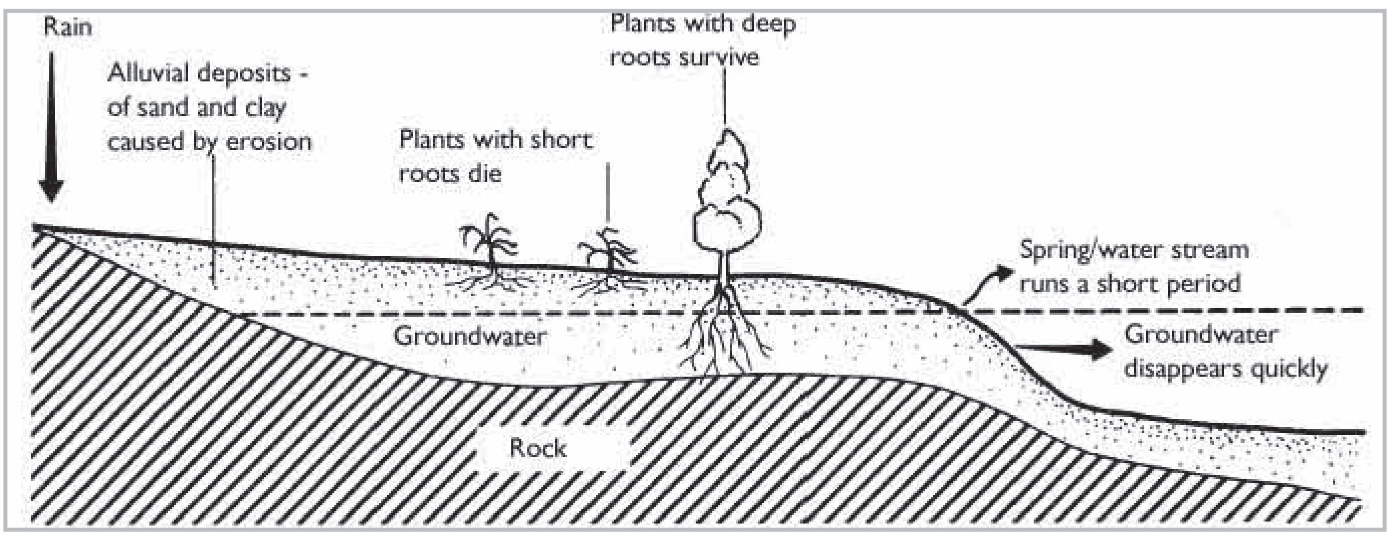
A subsurface dam should, preferably, be constructed on an underground dyke, because that provides a greater volume of water. A dyke is a hard layer under the sand, that already acts as a dam. Subsurface dams can be constructed in riverbeds with no dykes, but they might produce less water. It is also important to observe the following:

1) Coarse sand can store more water than fine-grained sand. Riverbeds containing coarse sand are therefore preferable.
2) Subsurface dams should not be located where waste from villages and other places can contaminate the water.
3) The area of the subsurface dam should not contain salty soil or salty rocks, because that will make the water salty.
4) The dam should not be built on boulders or fractured rocks, because they will cause leakage.

Identifying the presence of dykes

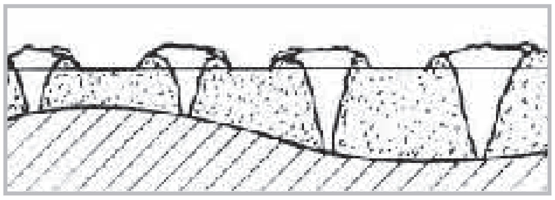
Underground dykes are easiest to locate a couple of months into the dry season by looking for the following:

a) Waterholes in an otherwise dry river -because there is always one or several dykes downstream of waterholes.
b) Dry stunted vegetation on riverbanks with taller evergreen trees just upstream. A dyke situated at the dry place



traps the water, which the green trees are using.

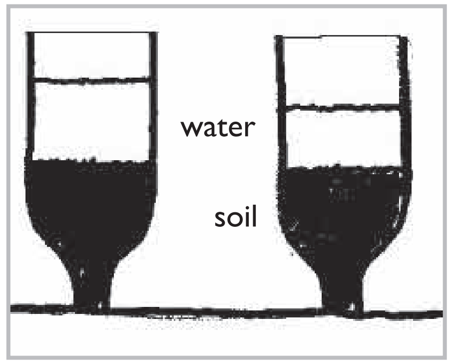
The dykes can also be located by digging trial pits and/or probing with an iron rod hammered into the sand and/or divining with brazing rods or sticks.



Design of the dam

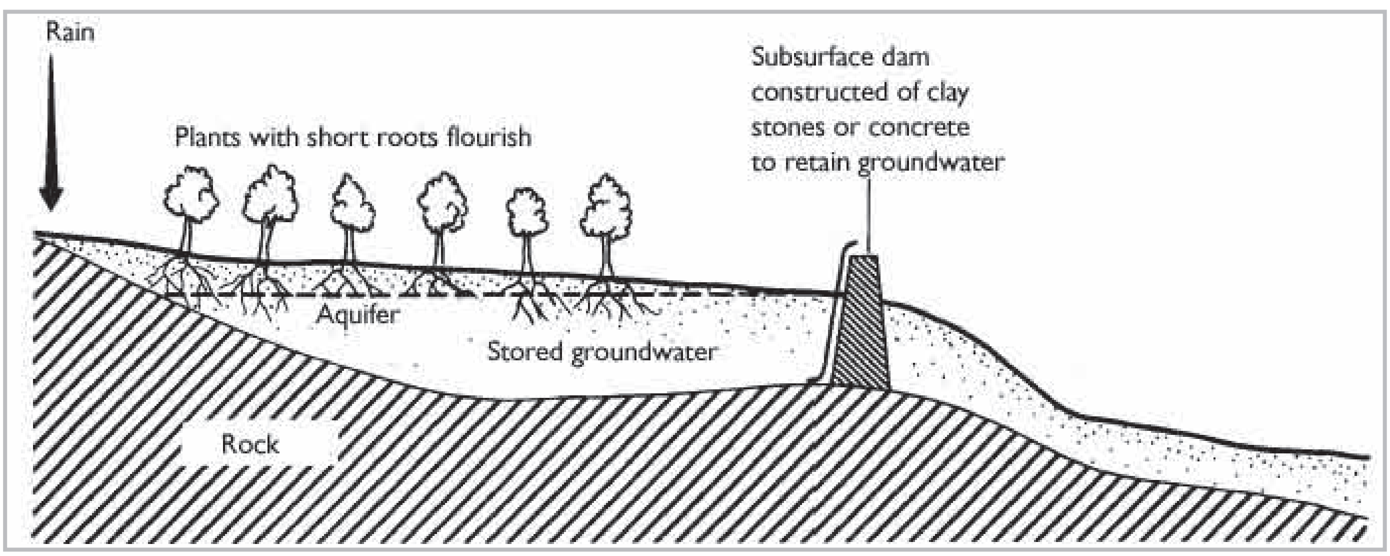
Dam wall

1. The dam wall must be well connected to firm soil at its complete length and at the two banks to prevent water from seeping through. This connecting area (key) should be at least 60 cm wide and 60 cm into the clay soil (the dyke). This key and the subsurface dam will be built with moist layers of the least porous soil that can be found in the area.
2. The porosity of soil can be found by observing the same amount of water seeping through samples of the various soil samples taken at a dam site. The soil samples are filled into transparent plastic bottles turned upside down with their caps and bottoms removed. The soil samples should measure 20 cm. They are saturated with water and 10 cm of water is added. The sample with the slowest infiltration rate is the most suitable soil for building a dam wall. This is the soil that will allow the least water to seep through (least porous).



The soil in the bottle at the left is best suited for dams since less water seeps through

3. The thickness of the dam is determined by the amount of time it takes 10 cm of water to seep through 20 cm of soil. If the infiltration time is 60 minutes, the minimum thickness (measured at the top) of the dam wall is 100 cm. If the water seeps through the soil faster, then the crest should be made 5 cm wider for every one minute it takes less than the 60 minutes. For example, if the infiltration time is 50 minutes, then the



thickness of the dam should be 150 cm, because 100 cm + (60 - 50) x 5 cm = 150 cm.4.

Construction

1. The sand overlaying an underground dyke is removed in a stretch that is 2 metres wider than the base of the dam wall.
2. The width of the base is excavated to a depth of 20 cm into the clay of the bottom of the riverbed.
3. A key at least 60 cm wide and 60 cm deep is excavated into the firm soil along the middle of the dam wall and reaching to the top of both ends of the dam wall in the two banks.
4. The key and dam wall are build of the least porous soil, which is moistened and compacted in layers of about 20 cm thickness until the top of the dam wall is reached.
5. The sides of the dam wall are cut so that they slope 45 degrees outward from the top and smoothened.
6. The upstream side of the dam wall is waterproofed by compacting a 5 cm layer of clay or cow-dung mixed with soil onto the dam wall.
7. Upon completion of the dam wall, sand is back-filled against both sides so that the top of the dam wall is equal with the level of sand in the riverbed.

Extraction of water

Water can be drawn from a subsurface dam through a well dug in the riverbed. It is also possible to connect a well dug in the riverbank to the dam reservoir with a tube, so that the water runs into the well. In this case the water must be treated before drinking.

Information and Illustrations by "Kenya Rain-water Association", Erik Nissen-Petersen, and the book by C. Burrow "Water Resources and Agricultural Development in the Tropics," 1987.