5

Recycling of Waste

38 • Introduction to Recycling

This chapter will address two types of recycling: recycling of nutrients through ecological sanitation, and recycling of domestic water.

Ecological sanitation

Ecological sanitation is a concept that is becoming more and more popular in many parts of the world. New programmes based on the principles of ecological sanitation are being implemented in many different countries.

Ecological sanitation is not a new idea. Centuries ago, many peoples learned the value of using urine and faeces in agriculture. Aspects of ecological sanitation have been used in Asia and parts of Africa since agriculture began.

More recently, ecological sanitation programmes have been implemented in Asia, Central America, Sweden, Ethiopia, Zimbabwe, and South Africa.

Principles of ecological sanitation

The guiding principles of ecological sanitation are the following:

- conservation of water
- protection of the environment from contamination by untreated urine and faeces (excreta)
- recognition of the fact that urine and faeces are resources which, appropriately developed, can contribute to the production of food and to development

This is an important change from conventional thinking about sanitation, which holds that urine and faeces have no value and should be transported far away using precious clean water resources.
Ecological sanitation helps to reduce the risk of spreading diseases by containing and treating excreta before collecting it. These systems recycle the nutrients found in excreta and return them to the soil, so that they may be used safely and productively.

Ecological sanitation has become popular in response to growing concerns about problems associated with waste water sewage systems. Although sewers are obviously very convenient and, when properly constructed, hygienic, there are concerns about the ability of many countries to treat sewage properly. In reality, more and more countries simply dump raw sewage, or "black water", in rivers, lakes, and other bodies of water. This causes serious environmental and health problems (loss of marine life, loss of available fish for food, loss of income from tourism, and contamination of canal waters). Many countries also face an urgent lack of water. Where water is scarce, it makes no sense to use water to move human excrement from one place to another.

In Malawi, the NGO Water Aid started a programme to promote ecological sanitation, using a "double pit latrine" system. After three years, a study of the area showed that many families had adopted the system, because they realised that the compost it produced was valuable and had reduced their expenditures on chemical fertilizer. Before the use of fertilizer from their composting latrine, it was common for families to buy 2-3 sacks of chemical fertilizer every year. Once they began using the fertilizer produced in the composting latrine, the same families only bought one sack of chemical fertilizer yet obtained the same amount of crops.
Ecological sanitation systems can bring important agricultural benefits to people living in areas where land resources are scarce, or where soil fertility is low. It can also be an appropriate sanitation system for people living in areas where water is scarce or where there are no public sewage services. Systems of ecological sanitation can therefore make an important contribution to reducing the total of 2.6 billion people who presently live without access to basic sanitation.

Recycling of domestic water (grey water)

As discussed in the chapter about water, there are many areas of the world that lack access to water. In these regions it is useful to know systems for recycling domestic water so that it can be used in a safe way. This chapter describes some low-cost systems.

39 • The Arborloo

An "Arborloo" is a simple pit toilet, filled with excreta, ash, leaves, and soil, which can later be used as the base for planting a tree. It is easy to construct and cheap to build. The Arborloo is made up of 4 elements:

1. A pit
2. A concrete "ring beam", or pit reinforcement
3. A concrete slab on top of the beam
4. A structure on top of the slab giving shade and privacy

Once it is being used as a toilet, the Arborloo pit is filled up with a mix of excreta, soil, wood ash and leaves. Leaves are put in the base of the pit before use, and every day some soil and wood ash need to be added to the pit. More dry leaves are added to the pit every month. No garbage is put down the Arborloo pit.

When soil, ash, and leaves are added to excreta, it changes quite quickly into compost. The daily addition of soil and ash also helps to reduce flies and smells.

When the Arborloo pit is full, a new toilet is built in another place and a thick layer of soil and leaves is placed over the pit contents. A young tree is planted in this soil. If the process is repeated for several pit toilets, eventually a new orchard of fruit trees or a woodlot of firewood trees will be growing, using the compost formed from the excreta.

1. How to make the concrete slab

The concrete slab is made with a mixture of cement and good quality river sand with some wire reinforcing.

The mould for the concrete slab is made from a ring of bricks laid on level ground.

Mould for a slab. Placing the plastic

Lay the bricks around a circle marked in the ground, one metre in diameter (radius 50cm).

Place sand in the centre of the mould to give the slab a conical shape (it should be higher in the middle than at the rim).

Make a squat hole by placing a shaped plastic bucket or shaped bricks in the slab mould.

Use 5 litres of cement and 30 litres of sand

Now, make up a mixture of fresh cement and good quality river sand. The mixture should contain 5 litres of fresh cement and 30 litres of clean river sand. Mix this thoroughly in a wheelbarrow before adding water.

The sand and cement must be very well mixed. After mixing the dry sand and cement, add water (about 2-3 litres) to make a stiff mix. Mix thoroughly again. Add half the mix to the mould and spread it out evenly.

Take 4 reinforcing wires (you could use old barbed wire, for example), each 3-4 mm in diameter and 90 cm long, and place them in a square shape

Reinforce the slab with 3 wires 3-4 mm in diameter

around the squat hole.
Next, add the rest of the concrete mixture. Spread out evenly and ram it down hard with a wooden float. Smooth it off with a wooden trowel. Add two thick wire handles on either side for lifting.
After about 3 hours, take out the bricks (or bucket) from the squat hole and smooth off the edges with a trowel.
Cover the slab with a plastic sheet overnight.
The following morning, sprinkle the slab with water and cover again. The slab must be kept covered and humid for ten days before moving it.

2. How to make a ring beam

Beginning of a brick ring beam

A ring beam is a reinforcement that helps to keep the top of the pit from falling in. It supports the concrete slab. Soil taken from the pit is rammed in place around it to make the toilet safer. The ring beam and soil help to raise the toilet above ground level and stop rain from getting into the pit and flooding it. The ring beam and surrounding soil help make the toilet stronger.
A ring beam can be made of bricks and anthill mortar. It can also be made from concrete made from cement and clean river sand. The ring beam should be made on slightly raised ground where the toilet is to be built.

2a How to make a brick ring beam
Get some bricks and mark a circle on the ground 80cm in diameter (radius 40cm). Lay the bricks around the circle.
Now make up some anthill mortar by breaking up anthill soil and mixing it with water.
Using a trowel, add the anthill mortar between and above the bricks. Then add a second layer of bricks on the first layer. The upper layer of bricks should sit on the joint between the bricks of the first layer. Use the anthill mortar to hold all the bricks together.
Then dig out the pit inside the ring beam down to 1 metre or even 1.5 metres below ground level. Some of the soil which comes out of the pit is placed around the ring beam and rammed hard in place. This will help to keep the ring beam firmly in its place.

2b How to make a concrete ring beam
If bricks are not available, but you have good river sand and fresh cement, you can make a concrete ring beam.
The same mixture that was used for making the concrete slab is used to make the concrete ring beam: 5 litres of cement and 30 litres of river sand. The cement must be fresh and the river sand very clean. The measurements and the mixes must be exact and ten days' "curing", or drying time, for the cement is required.
To make the ring beam, first level off some ground and lay a plastic sheet over it. Take some bricks and make two circles. The concrete ring beam will be made in between these two circles of bricks.

Lay the bricks so the outer and inner circles will make a ring beam in between them which is 85 cm inside and 115 cm outside. Thus the width of the ring beam will be 15 cm all around. Fill the open spaces between the inner bricks with wet sand.

Once the brick mould has been made, make up the concrete mixture of 5 litres of fresh cement with 30 litres of clean river sand. Mix the dry parts first and then mix in about 3 litres of fresh water. Mix thoroughly again. Add half of this mixture to the mould. Then take a length of 3-4 mm wire and place it on top of the concrete mix, about half way between the inner and outer bricks. The wire acts as a reinforcement for the concrete. Then add the remainder of the concrete mix to the mould and level off with a wooden float. Ram the concrete down with the wooden float. Steel handles can also be added if required. Finish off the edges with a steel trowel.

Cover with plastic sheet and leave overnight. The following morning, sprinkle the ring beam with water. Keep it wet and covered for ten days. After ten days the ring beam can be lifted and put into place. Dig down the pit inside the ring beam to one metre or more and place soil around the ring beam.

Empty a big sack of dry leaves into the bottom of the pit. The leaves will help the contents of the pit to compost. Then lay the slab over the ring beam.

It is best to lay the slab in some mortar placed on the ring beam. This can be made of anthill mortar or weak cement and sand (20 sand:1 cement).

A house structure should now be built over the ring beam and slab, in order to keep the toilet private. The structure should have a roof - for shade and to keep the rain out. There are many ways of making a simple structure using local and inexpensive materials like bamboo, poles and grass.

How to use the Arborloo

Making a concrete ring beam

In order to obtain good compost from the Arborloo it is important to add dry soil, wood ash and leaves to the pit as well as excreta. This mix of excreta, soil, ash and leaves helps to make good compost in the pit.

After every visit to the latrine to defecate, one must add a cup- or can-full of soil mixed with ash (4 parts soil to 1 part ash). This is not necessary after urinating. A container full of this mixture should be kept permanently inside the Arborloo, along with a small can used for measuring out the right amount. Each month it is necessary to empty another sack of leaves into the Arborloo.

Digging inside the ring beam

It is important to maintain cleanliness of the Arborloo to avoid diseases.

Garbage, like plastic or rags, should never be thrown in the Arborloo.

Add leaves at start + monthly

Placing a movable structure.

Continue to use the Arborloo until it is almost full; this is the time to move it to a new place.

To move the Arborloo, first take away or take apart the house.

Remove the concrete slab and ring beam. If it is a brick ring beam, take the bricks apart and re-use them at the new site.

A simple lining for sandy soils

Cover the contents of the pit with leaves and a thick layer (20 cm deep) of good soil.

Now rebuild the brick ring beam in a new place. If you are using a concrete ring beam, it just needs to be moved.

Dig a new pit inside the ring beam and surround the ring beam with soil and ram hard.

Papaya trees planted in old pit

Add a sack of leaves to the bottom of the new pit and replace the slab.

Replace or rebuild the structure and the new Arborloo is ready to use.

The old pit

Cover the pit contents with leaves and plenty of soil.

Either leave this pit to settle and wait for the rains before planting a new young tree, or plant a young tree in the soil and look after it. It will require protection from animals and frequent watering.

Which trees to plant

Good trees for the Arborloo pit include mulberry, moringa, guava, mango, paw paw and banana, but you can also plant many other trees.

Plant the young tree in the layer of soil (20 cm deep) above the compost. It is important to protect the young tree from animals and to water it often. After some time the garden will be full of trees growing in good compost and bearing plentiful fruit or even firewood.

Information and photos courtesy of Peter Morgan, Aquamor Ltd., Zimbabwe, who thanks Marianne Knuth, Annie Kanyemba, and the team from the village of Kafunda for their help in the production of this material.
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40 • The Double Pit Latrine

A double pit latrine is a sanitation system specifically constructed to produce valuable fertilizer for gardens. It consists of two pits. As one is being used the other undergoes the process of composting.

How the double pit latrine works

The double pit latrine is designed so that human waste is transformed into fertilizer over a period of 12 months. In a normal latrine it would not be possible to achieve composting in only 12 months, but this can be done with the addition of soil, ash, and leaves to the pit.

The volume of soil, ash, and leaves added to the pit should be equal to the volume of human waste, and should be distributed evenly throughout, that is to say, it should be added regularly. Fertilizer will not form if soil or ashes are added only occasionally. The transformation to fertilizer is also helped if the soil added is in itself fertile. Adding wet clay, for example, will not lead to a good fertilizer.

After each visit to the pit to defecate, a cup or tin of soil should be added. After urination it is not necessary to add anything, this may lead the pit to fill up rapidly and with too much soil.

An additional advantage of using soil and especially ashes is the fact that they help to reduce odours. After 12 months of composting, the fertilizer can be removed from the pit and used in the garden. In order for this system to work, it is important that the pit that is being used is not filled completely within 12 months. The measures described here will fit for a household of six persons.

Two pits in the same house

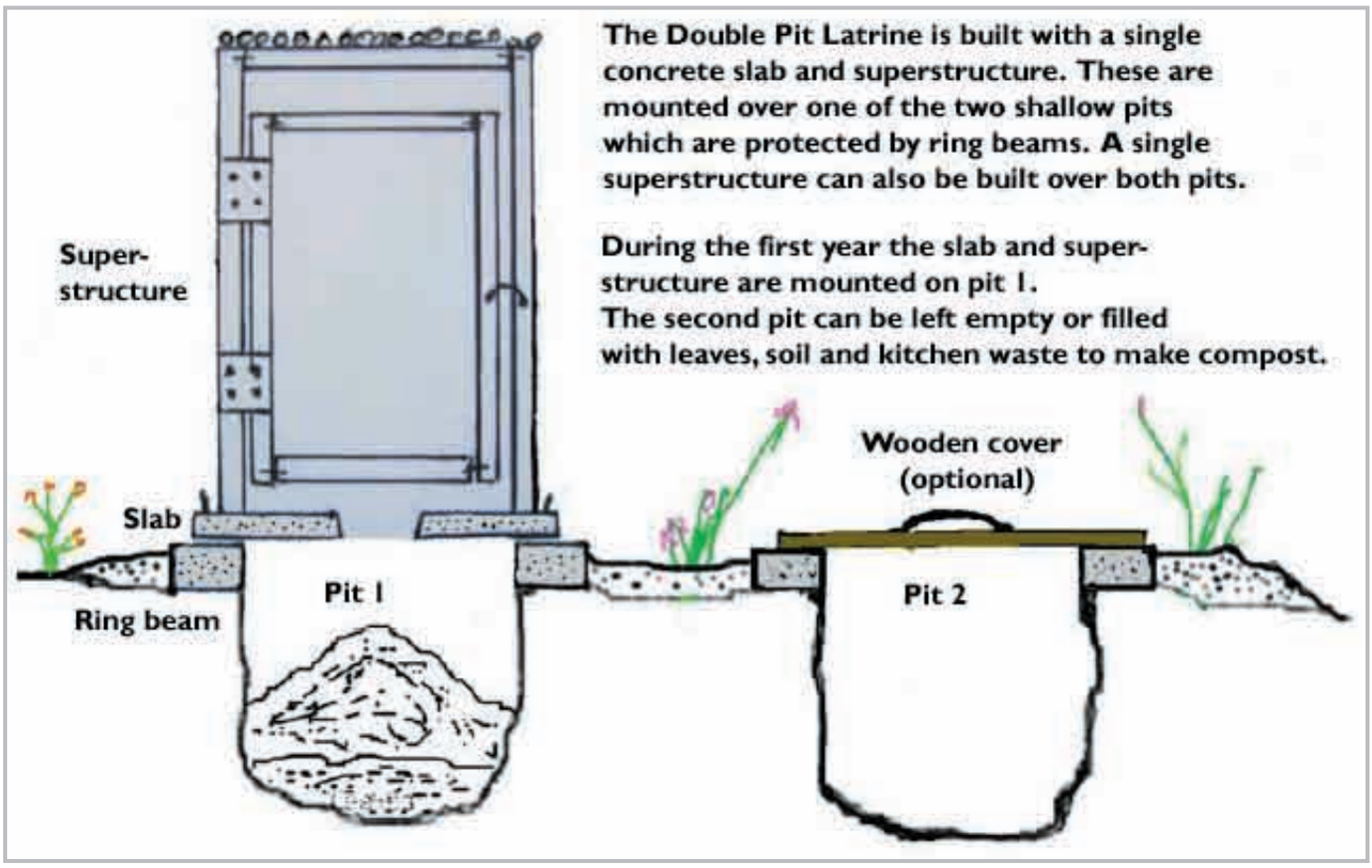
The two pits that constitute the double pit latrine are shallow, each one being about 1.2 metres deep, with 1.5 being the maximum. It is recommended that the user mixes the contents of the pit from time to time so as to take advantage of all the available space and distribute the ingredients evenly. This helps the process of transforming the waste to fertilizer.

When compared to a traditional sanitation system, the double pit latrine has several advantages:

- The excavation of the pit is relatively easy
- There is a small quantity of material in each pit and it is quite porous, which permits more oxygen to enter and promotes the growth of beneficial microorganisms
- The risks of contamination by ground water are reduced because the pit is relatively shallow. Multiplication of harmful bacteria is also harnessed because of the composting process.

A pit lined with bricks lasts many years

It is important to avoid the simultaneous use of both pits. For the composting process to be effective, it must be allowed to run for one year without new human waste being added. In order to reduce the likelihood of both pits being used simultaneously,

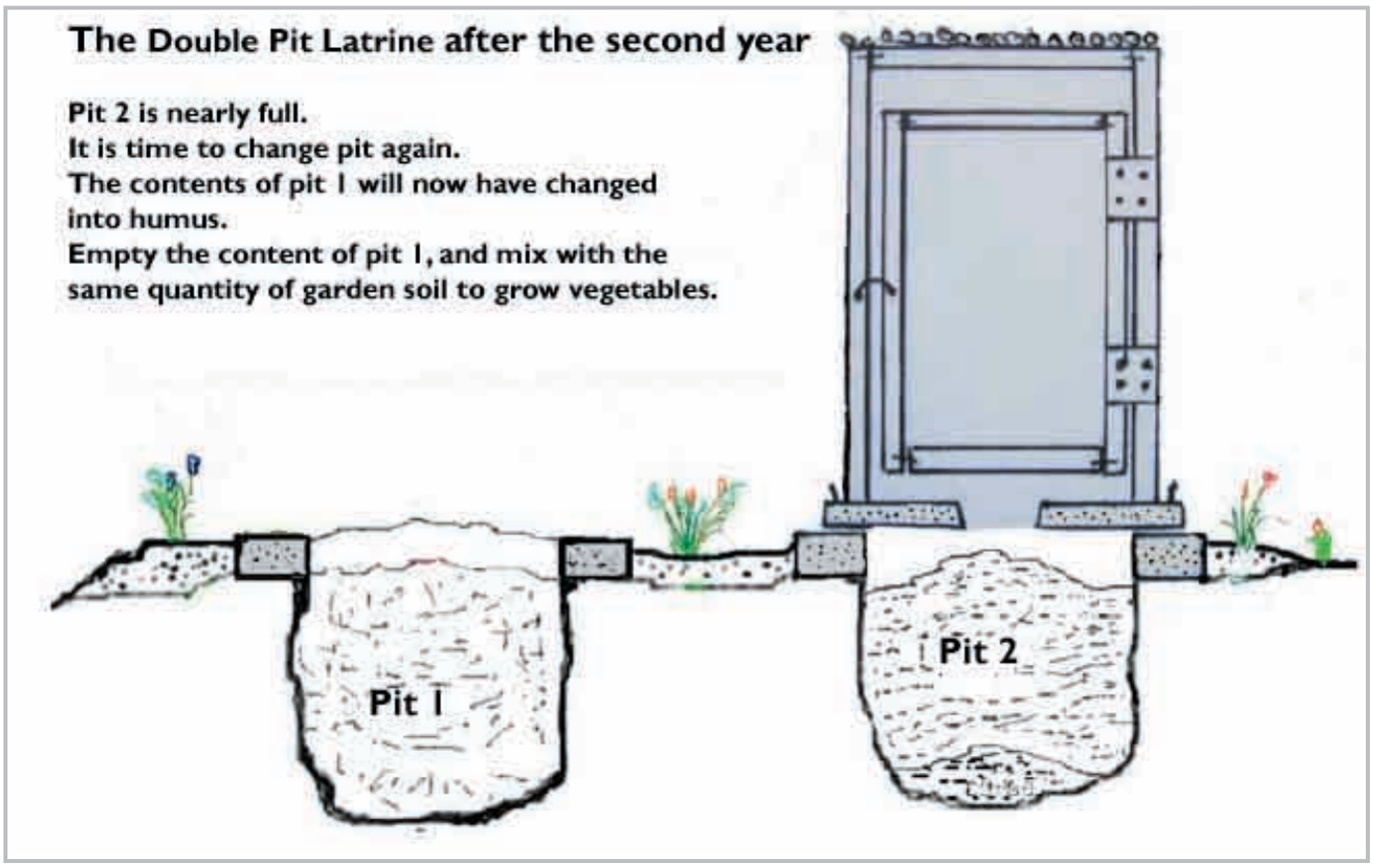


there should only be one latrine slab in the system.

The system can be equipped with a portable structure, like the Arborloo (see previous section), so that moving the superstructure from one pit to the other is easy and convenient. Alternatively, the double pit latrine can have a have a permanent structure covering both pits; many such systems exist in Mozambique and Malawi.

Excavating, or "digging out" conventional pit latrines after use is not commonly practised in Africa, or in any part of the world. Consequently, first time users of the double pit latrine are cautious at first about this part of the latrine management process. Some users will not immediately agree to excavating the pit. They will need to be convinced. It helps if potential users can see other double pit latrine pits excavated without difficulty, and examine the humus for themselves. It also helps if they can see evidence that the mixing of the humus with poor local top soil does actually enhance the growth of vegetables. After a season of use, however, they will be persuaded of the benefits of the system.

If the pit has been filled up faster than expected and there is doubt about the safety of the compost, then it can be transferred to sacks for storage for an additional length of time. By excavating and placing the compost in bags, the material is turned and aerated, and this certainly helps to promote the composting process. This period of extra composting in bags may also be preferred if it is not the season for planting vegetables. (Alternatively, some gardeners may prefer to dig the humus into the bed some time in advance of planting.)



A latrine in itself is not enough to reduce a number of diseases and improve sanitation. It is naturally important to follow basic hygienic rules and for example, have hand washing facilities in connection to the latrine (see section 8 titled "Tippy Tap").
As the above demonstrates, projects supporting the implementation of the double pit latrine require an effective component of education and demonstration. It does require more attention and effort than the use of a normal deep pit latrine.

Information and photos courtesy of Peter Morgan, Aquamor Ltd., Zimbabwe.
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Movable structure and two pits

41 • Wastewater Reuse

How to reuse wastewater in a safe way

This section demonstrates some simple systems for recycling wastewater from kitchens and baths (grey water) so that it can be used for watering in the vegetable and flower garden and - with extra treatment - also for other purposes such as bathing or washing.

There is less and less fresh water available for people around the world. This is because populations are increasing on the one hand, while more water is getting polluted by salt or chemicals on the other. Besides collecting more rainwater, one response to this problem is to reuse as much wastewater. In many places, wastewater from baths and kitchens goes directly into the ground. This water could instead be used to water vegetables or flowers. The nutrients in wastewater will also fertilize the garden.

In developed countries, wastewater is treated to:

- avoid the spread of diseases caused by microorganisms
- reduce the amount of nutrients containing nitrogen and phosphate, which cause water pollution

Most microorganisms that spread diseases do not grow outside the body, but can survive if they are inside faeces. This is why wastewater from toilets (black wastewater) should never be used untreated for irrigation or fertilisation. Grey water does not normally contain these microorganisms and can be used safely in simple ways as described below. Many developed countries have strict rules as to what is allowed. Wastewater has to be filtered through a sand or soil filter (this can be done decoratively as a flower bed). After this it is often only allowed to be used for underground irrigation or for flushing toilets.

Developing countries have less strict rules and it is possible to make safe systems where the grey wastewater is reused for irrigation. It can also be treated very simply so that it can be used for general purposes like bathing, washing, etc. by:

- filtering it through a simple sand filter in a drum or container
- sending it through a shallow pond containing duckweed
- sending it through a reedbed system containing plants like vetiver

The purpose of the filter is to remove food waste, hair etc. This can be done easily by filtering the water through a drum or a container filled with sand. This will remove practically all organic material from the wastewater. Some nutrients (nitrogen and phosphate) will still be there, but these are good for plants. There is no need to remove them if the water is going to be used in the garden. The sand filter will eventually fill up with waste, and the top layer should then be changed. Because the waste in the sand is all organic it can just be buried in a hole.

A duckweed pond or reedbed can be used to clean the waste water so that it can be used for bathing and washing. A duckweed pond might be appropriate for people who keep chickens or ducks since duckweed is very good feed for them. However, with a duckweed pond there is a daily requirement to remove some of the duckweed. A reedbed needs less attention. Once or twice a year the plants in the reedbed, such as vetiver grass, need to be cut. This can then be used for thatching or as mulch in the garden. If you are using vetiver grass, new plants - "tillers" - will be formed at the

base. These can be harvested and sold to be used to make contour rows to prevent erosion.

How to make a sand filter

- Take a fuel drum or plastic barrel that has a top with an opening so you can connect a tube to it. This will be the outlet opening.
- Cut out the bottom, hammering where you cut to avoid sharp edges
- Connect the outlet of the drum to a hose, either using a fitting to the hole in the drum or using tyre rubber to make the attachment leak-proof
- Turn the drum upside down and raise it on some stones so the outlet is free
- Tie a piece of mosquito net like a bag over the drum outlet
- Fill the drum with sand
- Tie a piece of mosquito net like a bag around the hose or pipe bringing wastewater to the filter
- This bag should be emptied every day of the waste collected

The sand filter can be connected to the pond or reedbed with pipes if water can run down by itself. Or you can simply move the filtered water with a bucket.

How to make a duckweed pond

The size of the pond required depends on how much water it has to treat. For every 1000 litres of water you use per day you will need a pond that is 2 square metres in area and about 50 cm deep. Mosquito larvae cannot survive if the duckweed layer is complete, but if you are in an area with high incidence of malaria, it is probably better to make a reedbed system.

Before you start, make sure that you can find duckweed in your area. It usually grows on any small pond containing many nutrients, for example where there are cattle or towns nearby.

Duckweed can also be used as chicken feed

- Make a hole 50 cm deep in the ground
- Make the pond narrow - not more than 2 metres wide - to ensure it is easy to harvest
- Cover the base of the reedbed with a sheet of plastic (not necessary if water does not penetrate into the soil)
- Fill the pond with (waste) water
- Make a system so that overflow water can run out of a pipe instead of flowing over the sides
- Tie a net over the inlet of this pipe, so that the duckweed cannot flow out
- Collect the treated water in a container

A child collects duckweed pushing the duckweeds together using a stick

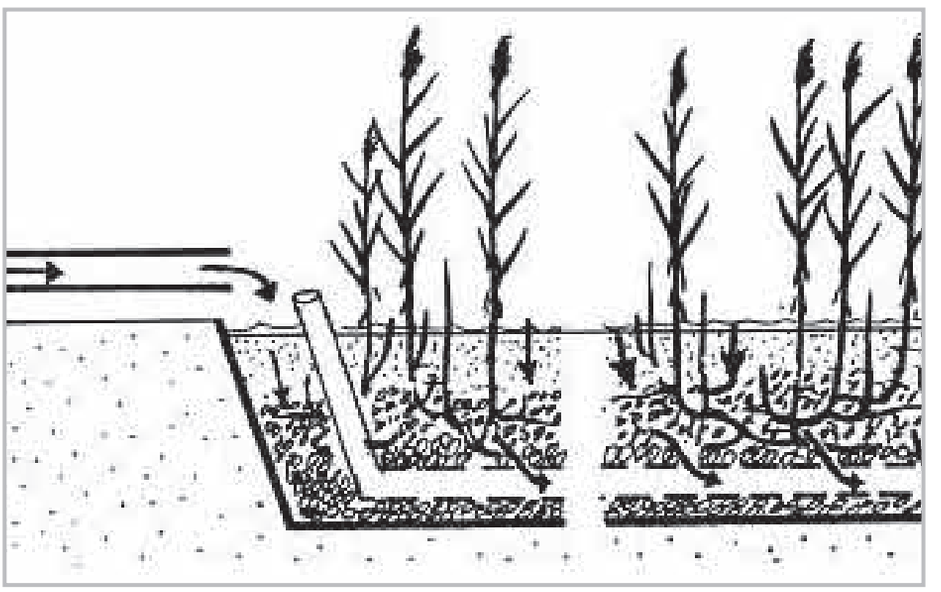
Use the water for gardening until the duckweed are growing well.

Later it can be used for general purposes, but should be treated before drinking by boiling or using the SODIS system (solar disinfection - see section 4). Harvest the duckweed every one or two days by removing half of it with a net. The harvested duckweed is good food for chickens - it can make up one third of their food. Duckweed can also be dried in the sun and used later or sold as feed.

How to make a simple reedbed system

- Make the bed - by removing soil to a depth of 40-50 cm. The reedbed should be created at a relatively low-lying location where the wastewater can flow easily downwards to the reedbed.
- The size of the reedbed should be about one square metre per person in the household
- Cover the base of the reedbed with a sheet of plastic (not necessary if water does not penetrate into the soil)
- Put a drainpipe (a PVC pipe with slots - cut with a saw) at the bottom where the treated water can run out
- Tie a piece of net around the inlet of the drainpipe
- Cover the drain pipe with a layer of small stones or shells. Then fill the reedbed with sand
- Plant reeds such as vetiver, bamboo, papyrus, or wetland plants such as canna lilly or iris
- Lay the pipe delivering wastewater across the reedbed. Close off the end and make many small holes in the pipe, so that the wastewater is distributed right across the reedbed.
- Collect the treated water in a container

Use the water for gardening until the plants are growing well. Later it can be used for general purposes but should be treated before drinking - by boiling or using the SODIS system (solar disinfection - see section 4).



The cultivated reed bed - or constructed wetland. The plants use the nutrients and microorganisms in the sludge decompose the organic material. The waste water is thus cleaned. In most tropical areas the evaporation is high, and it is then not necessary to have a drain for excess water