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परिवर्तनीय वाटर सप्लाय
प्रोजेक्ट कार्यालय

Water Supply and Sanitation Project

प्रभाग १०८

प्रभाग १०८ परिवर्तनीय वाटर सप्लाय
प्रोजेक्ट कार्यालय

September 1982

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Practical Solutions in Drinking Water Supply and Wastes Disposal for Developing Countries

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ABSTRACT

Engineers in developing countries are presented with alternative technological solutions for water supply and waste disposal in rural areas. Local materials and skills are promoted and where possible the usefulness, disadvantages, and limitations of the techniques described are discussed.

There are sections on:

1. water collection from different sources.
2. water treatment (coagulation/flocculation, filtration, chemical dosing and iron removal).
3. water transport and distribution (pipes, simple pumps and waste reduction).
4. wastewater and solid waste disposal (pit latrines, composting septic tanks and aquaprivies).

Keywords: rainwater / groundwater / springwater / surface water / solar distillation / water collection systems / coagulation-flocculation / filtration / chemical dosing / iron removal / aeration / chlorination / pipes / water storage / handpumps / hydraulic rams / public stand pipe / water conservation / pit latrines / composting / septic tank systems / aquaprivies / wastewater disposal / solid waste treatment / appropriate technology / rural areas / developing countries.

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IRC is an internationally operating organization dealing with information and technology support for water and sanitation improvement.

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Practical solutions in drinking water supply and wastes disposal for developing countries

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Introduction

Practical Solutions in Drinking Water Supply and Wates Disposal in Developing Countries started as mail survey by the International Reference Centre. The purpose was to collect field experience and elusive information on alternative techniques, which are uncomplicated, require less maintenance, and which can be managed by local people. These were non-current techniques, adaptations of existing ones or new developments. The aim was to help engineers to develop technological solutions which would best suit the social, cultural and economic conditions of their countries.

The WEDC group of the University of Loughborough prepared this revised edition, for which we express our sincere appreciation, especially for the efforts of Mrs. Susan Ball. From the earlier edition solutions have been retained which have potential for practical application for rural areas, and which promote use of local materials and skills. Additional material from other sources, in particular on excreta and waste disposal, was included in this new edition. It is designed for reference purposes, also for non-specialists; where possible the usefulness, disadvantages and limitations were discussed.

Hopefully wide dissemination will stimulate further thinking on such alternative solutions. Field workers are encouraged to share their experience with colleagues and/or by reporting to IRC. Self-help as an ultimate aim would bring closer the goals of the International Drinking Water Supply and Sanitation Decade.

Ir. T.K. Tjiook
International Reference Centre for
Community Water Supply and Sanitation.

100 Water sources and recovery

Introduction

Drinking water may be obtained from a variety of sources. Large dams and reservoirs are often used for cities, and part of river flow in spate is stored for supply throughout the year. Large dams are expensive so rural people usually have to rely on cheaper and simpler works.

The simplest source, though not necessarily the cheapest, is rainwater. Where rain falls in reasonable quantities throughout the year, rain from roofs retained in tanks is sufficient for household needs. The longer the dry season between rain, the greater the storage required. Low intensity of rainfall needs a greater collection area than heavy rainfall.

Groundwater is probably the most widely used source of rural drinking water. Some practical solutions for drilling and wells are included in this section. However, the greatest problem is usually to find a cheap and reliable pump to raise the water, and this aspect is covered in Section 300.

Surface water is sometimes a source of drinking water, but streams and rivers are likely to be polluted. River water therefore usually requires treatment (Section 200) unless the water is abstracted from the river bed or banks (143).

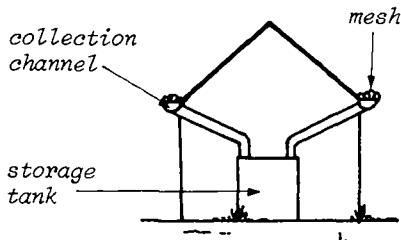
The solutions in the last part of this section (150) are seldom used for community water supply, although there is a widespread interest, particularly in arid regions, in solar distillation.

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Household rainwater catchment tanks

Rainwater falling on roofs can be collected and stored in a tank for domestic use. This is a simple system which is especially useful for isolated buildings which may not have another supply of water.

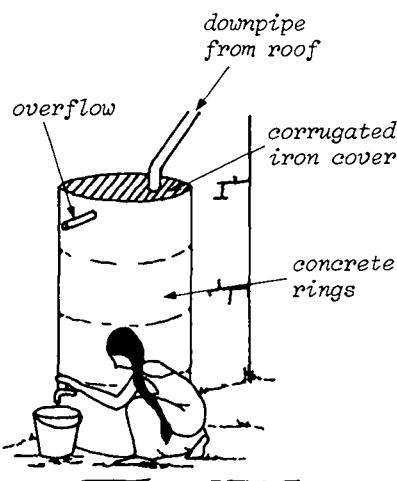
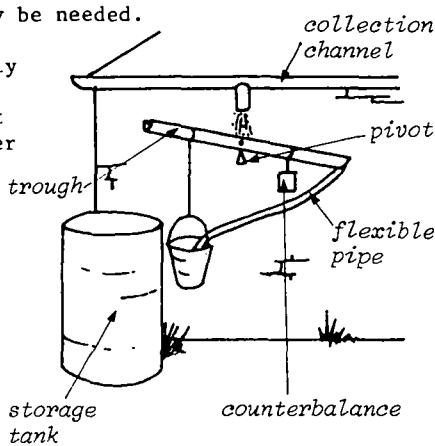


Regular rainfall is needed, and the amount of water which can be stored will depend on the size of the roof and the tank.

The collection channel can be made from metal, plastic, wood or bamboo, and a small bundle of wire mesh put into the tops of down-pipes will stop them from being blocked by leaves.

The quality of the water may be poor due to contamination from the roof, and some form of filter may be needed.

A simple idea for a device which allows the first flush of possibly contaminated rainwater to run to waste is shown here. As the first flush of water fills the container this causes the trough to pivot and the rain is then allowed to flow directly into the storage tank. When the rain stops the container is emptied. This is a particularly useful device in areas where there are long dry periods when dust and leaves can build up on roofs and in pipes.



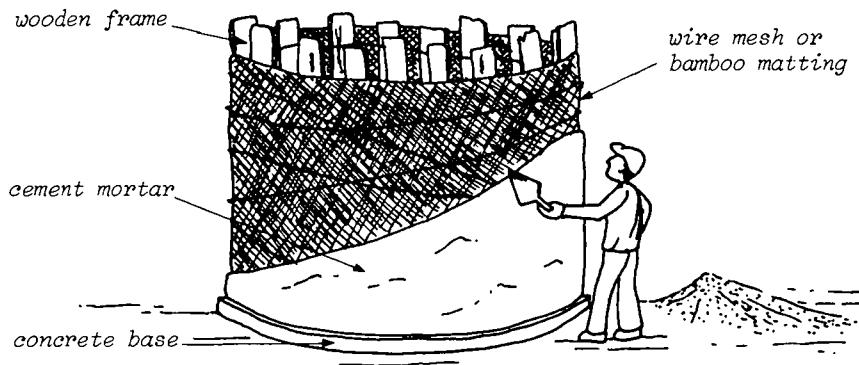
Unreinforced concrete rings can be used to make collection tanks. The rings are cast using special steel moulds, and are 50mm thick, 600mm l . high and 1.5m diameter.

A separate slab is cast for the base of the tank, onto which the rings are joined, using cement mortar to give a waterproof seal. A maximum of four rings can be used and the lower ring is fitted with a tap while the top ring has an overflow pipe.

The inside of the tank is made waterproof with cement mortar.

Quite large tanks can be made from cement mortar, trowelled over a mesh of wire. The reinforcing mesh is wrapped around a frame made of vertical wooden planks held together with wire.

Cement mortar is then laid over the mesh to a thickness of 80mm. When this is dry, the wooden frame is taken away and the inside of the tank is made waterproof with mortar.



Bamboo has tensile strength comparable to mild steel, thus making it a good, cheap alternative to chicken mesh for the reinforcement of these water tanks.

The bamboo is matted into a framework over which the cement mortar is laid to a thickness of 30 to 40mm.

It has been found that three or four village technicians can build a 4,5 or 9m³ tank in this way in two days, to serve one or two houses.

Reported use:

Rainwater catchment is world-wide.

Bamboo reinforcement is used in Indonesia where 1000 tanks have so far been built.

Reference:

DIAN DESA

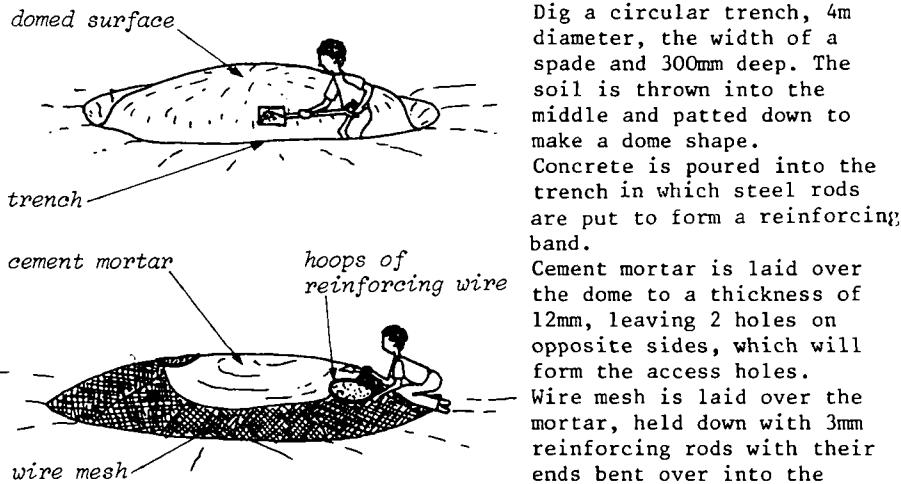
Reed R A

Watt S B (2) and (4)

WEDC

Rainwater Collection Tank

A very good underground tank of about 20 cu m capacity can be built to hold the rainwater collected from the roof of a large building, or from several buildings. The method could be adapted to make larger or smaller tanks according to local requirements.



Dig a circular trench, 4m diameter, the width of a spade and 300mm deep. The soil is thrown into the middle and patted down to make a dome shape.

Concrete is poured into the trench in which steel rods are put to form a reinforcing band.

Cement mortar is laid over the dome to a thickness of 12mm, leaving 2 holes on opposite sides, which will form the access holes.

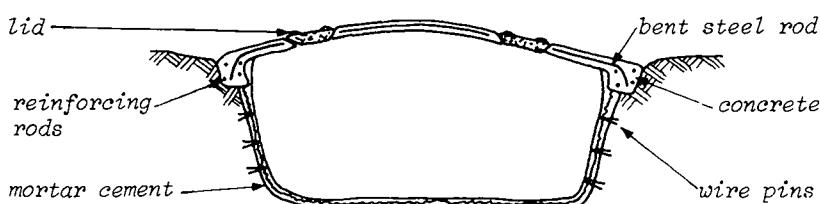
Wire mesh is laid over the mortar, held down with 3mm reinforcing rods with their ends bent over into the concrete filled trench. The inner ends of the rods meet in the centre of the dome.

On top, lay a 50mm thick layer of concrete. Wire hoops are put round the access holes, and here the concrete should be thicker. Concrete lids for the holes are now cast.

After 3-4 days the lids are lifted and the soil dug out from under the dome, as far as the trench and to a depth of 2m, in a bucket-shape.

The walls, floor and roof of the hole are built up with layers of cement mortar and wire mesh, to a thickness of 38mm. The mesh is pinned with bent wire through the concrete, into the earth walls of the hole.

Finally, the whole of the inside is sealed with a waterproofing layer.

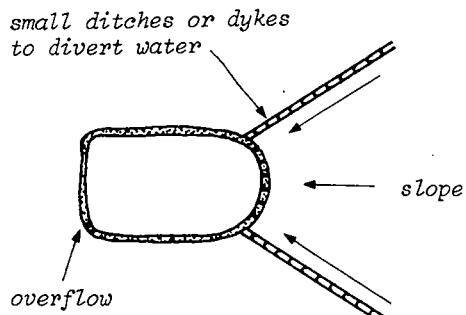


Present use:
South Pacific Islands

Reference:
Calvert Rev.K C and Binning R J

Rainwater Catchment and Storage

In arid areas which have short periods of heavy rain, large amounts of rainwater can be collected and stored in underground tanks for use during the dry season.



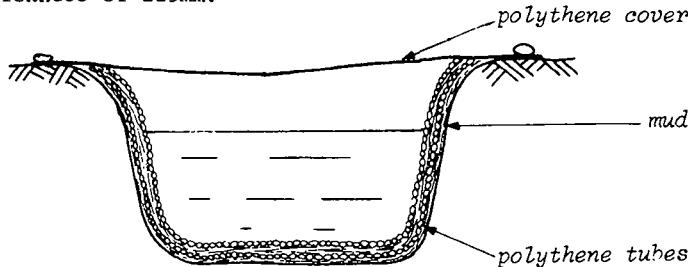
Rain falling on a large area is diverted into the tank. The catchment area can be any large, clear, sloping area, such as roads, playing fields, or constructed clay or concrete aprons.

The inlets to the tank should be properly screened so that they do not become blocked with leaves.

The effectiveness of this method depends on stopping seepage from the tank, so a good lining is important. This can be made

from concrete, stone, brick or polythene.

A lining can be made from polythene tubes, 75mm diameter and about 450mm long. Each tube is filled with a dry mixture of sand and cement and the ends are then tied. The polythene is then perforated and the tubes laid in water for 5 minutes, so that the contents are moistened. The tubes are then used to line the tank in layers with mud between, to a thickness of 225mm.



In some cases, after about 3 years in use, these polythene lined tanks have silted up and collapsed. This happens because of poor maintenance after they were built. It is therefore very important to check and clean out the tanks regularly.

It is also necessary to fence off the area around the tank, to stop animals from polluting the water.

All storage tanks must also be covered to stop loss by evaporation, and to avoid pollution.

Present use:

Concrete and stone tanks are used in many parts of the world.

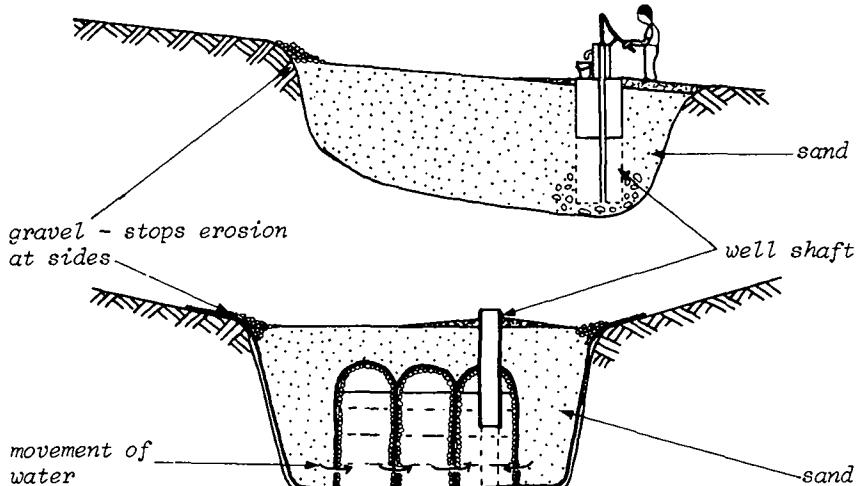
Polythene lined tanks are used in Botswana, Swaziland and Brazil.

Reference:

Intermediate Technology Development Group. (ITDG) (2)

Rainwater Collection and Filter Tanks

Rainwater diverted from roads and other large catchment areas can be stored in a large, sand-filled tank which acts as a horizontal slow sand filter as well as a storage tank. A well can be sunk into the deepest end of the sand tank for easy removal of the water. The water capacity of the sand tank is usually about 40% of the total tank volume.



A more complicated combined filter and storage tank can be built using filled polythene tubes. The tubes are prepared in the same way as for lining storage tanks, but in this case they are used to make dome-shaped structures inside the lined tank.

A well shaft is sunk into one of the domes so that the water is easily pumped out.

Sand is used to fill the tank, over and around the domes, and this acts as a slow filter for the water channeled in from the catchment area. The filtered water enters the domes and is stored inside them.

These combined sand filters and storage tanks protect the water from pollution, and also greatly reduce the loss of water by evaporation.

In practice, the polythene domes are expensive and fairly difficult to build. It is known that in some places, domes built in this way collapsed after about 2 years use, but this was probably due to poor maintenance.

Present use:
Botswana and Sudan

Reference:
Ionides M
Mann H T

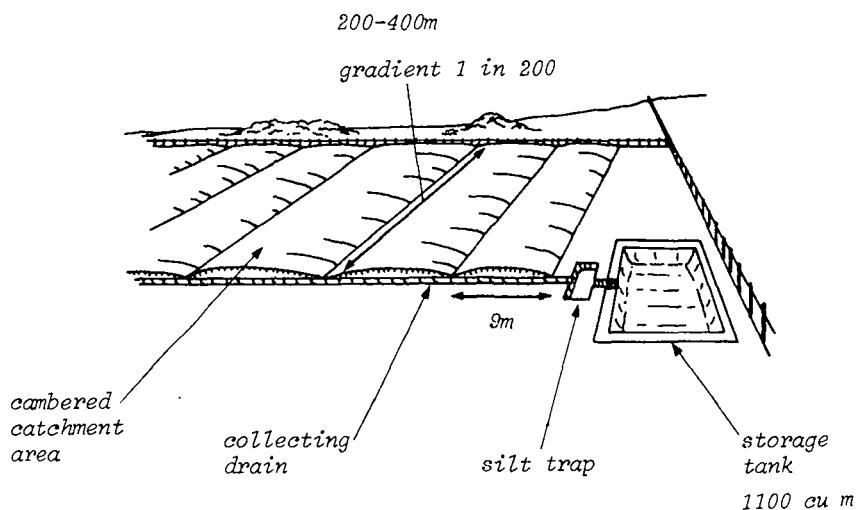
Rainwater Harvesting

In arid areas, a large catchment area is needed to provide a useful amount of water.

The catchment area is rolled and cambered so that water is diverted to collecting ditches at the sides.

The collecting ditches slope towards a silt trap, into which the water is directed before being stored in a large tank.

In some cases it is possible to add chemicals to the soil of the catchment area, which cause the soil to bind together forming an impervious layer. This decreases the amount of water lost through percolation. The same effect can be obtained by covering the ground area with large plastic sheets.



Present use:
Western Australia.

Reference:
National Academy of Sciences.

Water Jars

Large jars for water and grain storage can be very expensive to buy, but they can be made easily from cement mortar, plastered around a simple mould.

The mortar is made from 1 part cement to 2 parts sand, mixed as dry as possible so that it will be strong when it is set.

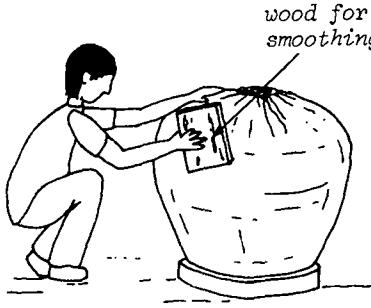


Put the sack onto the base plate and fill the inside space with rice husk, sawdust or sand.

The weight of the filling holds the bottom edge of the sack in place on the plate, which should stick out a little way from under the sack.

When the sack is full, fold up the top and tie it into the shape of a jar.

A piece of wood is used to smooth the sides of the mould into a round shape. The mould is then sprayed with water before it is plastered.



Use 2 pieces of gunny cloth (Hessian sacking), and mark out the jar shape. It should be about 1.25m across the widest part and 1.20m high.

The sides of the sacking are sewn together firmly, leaving the top and bottom open.

After sewing, turn the sack inside out.

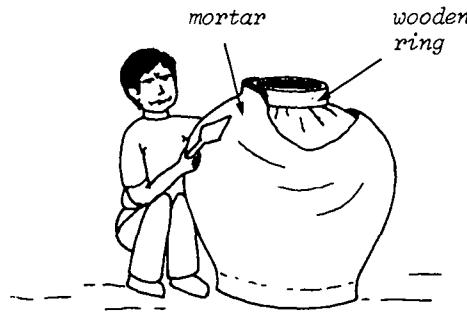
Make a pre-cast concrete plate for the base of the jar, about 600mm diameter and 150mm thick.



A wooden or pre-cast mortar ring is placed on the top of the sack to make the shape of the opening of the jar.

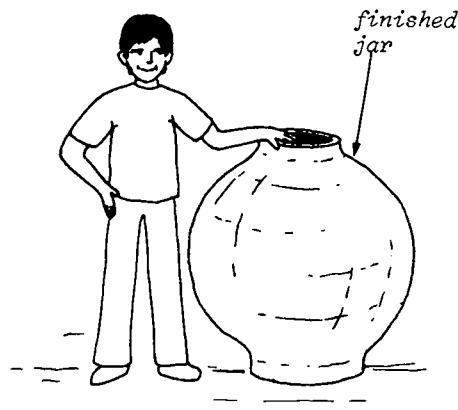
Now the first layer of mortar is trowelled onto the mould, working from the bottom to the top, to a thickness of 5mm.

Carefully plaster the second layer of mortar to the same thickness, and in the same way. Check for weak spots by pushing in a nail or thin piece of wood. At the top, build up the neck of the jar, keeping the thickness even.



The jar is now dried slowly, under a sack or plastic sheet, away from the sun and drying winds.

After 24 hours, the sack and its contents are taken out, and the jar checked for faults which can be corrected with mortar.



Present use:
Thailand

Reference:
Watt S B. (3)

Plastic Taps

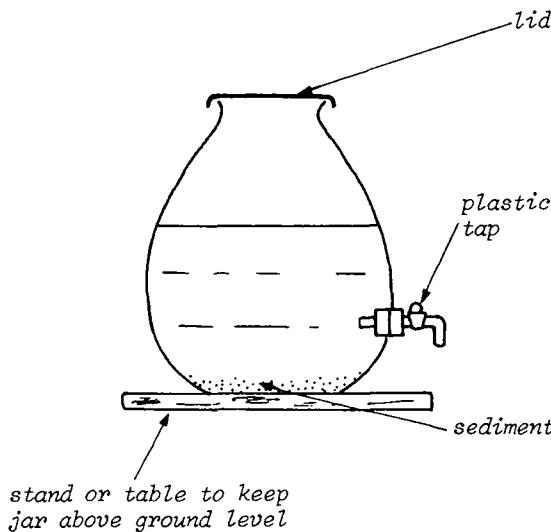
Plastic taps fitted into earthenware or semi-fired clay water jars help to prevent waste, and are a more hygienic way of dispensing water.

A hole is made in the jar before firing. The diameter of the hole depends on the size of taps available.

If the pot is broken the tap can be used again on another jar.

A stand for the jar keeps it clear of the ground, so the risks of contamination are further reduced.

Any sediment in the water settles out below the level of the tap.

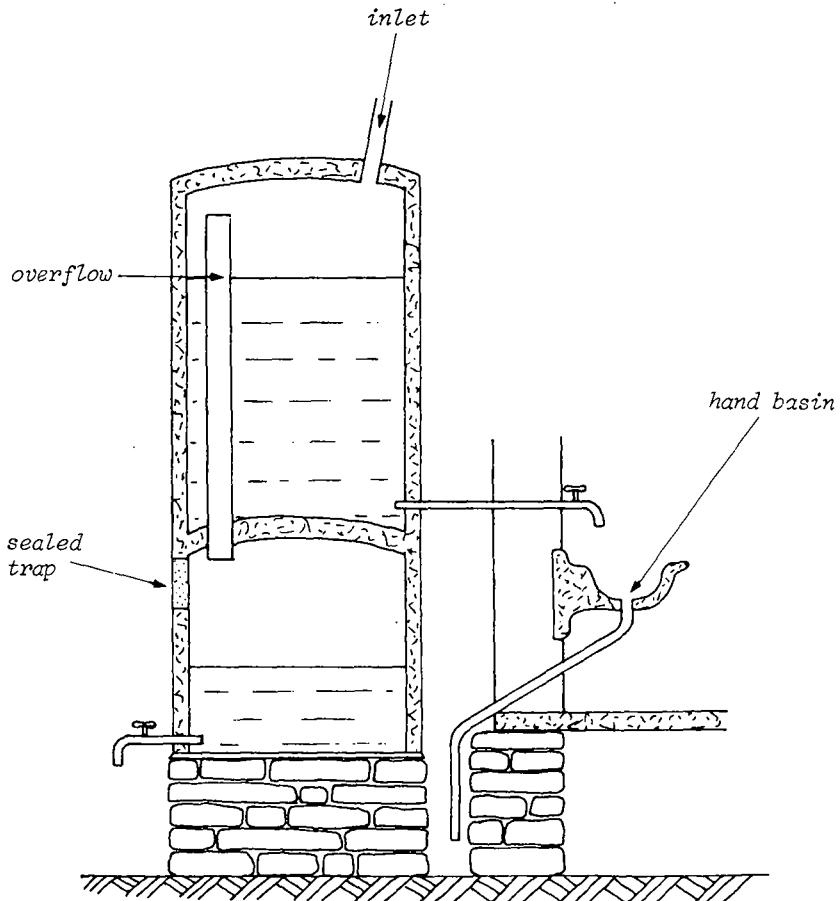


Reference:
Hutton L

Priority water tank

This tank provides a water supply for the bathroom as first priority.

Rainwater comes from the roof to the upper tank first, and any water drained from the lower tank does not affect the bathroom supply.



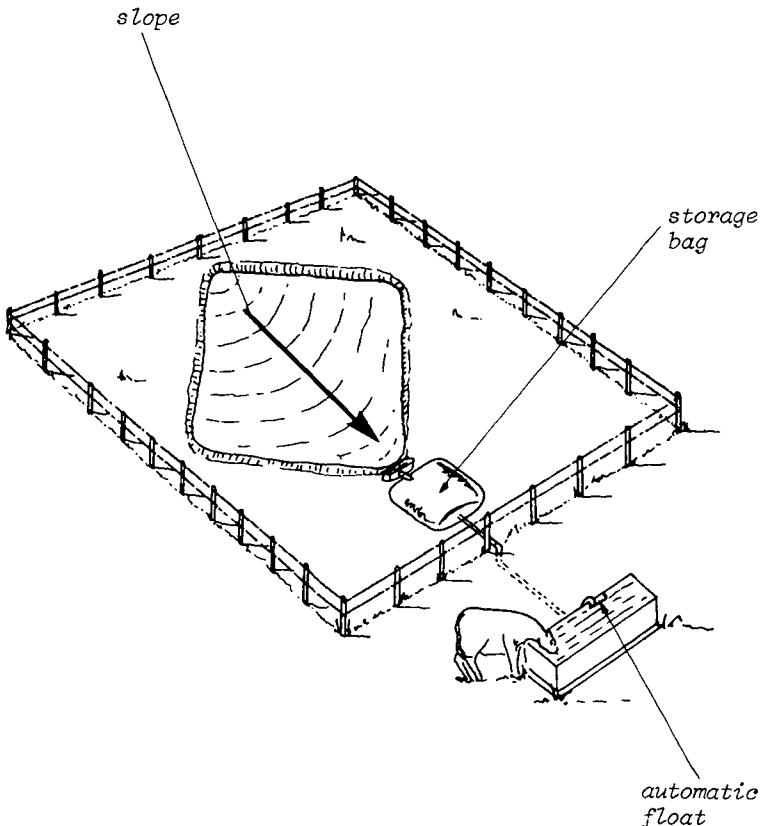
The tanks are made from concrete and the formwork for the lower tank can be removed through an opening which is later closed when the lower tank is properly cured. The formwork for the roof of the upper tank can be left in.

Reference:
ITDG (1)

Rainwater storage and evaporation reduction

The reservoir consists of a large bag of thin rubber or plastic, with a volume up to 200m³. These bags are commercially available. The collecting area around the reservoir is fenced off to keep out animals.

The water is piped from the bag to a drinking trough for cattle, and an automatic float keeps the water in the trough at a particular level.

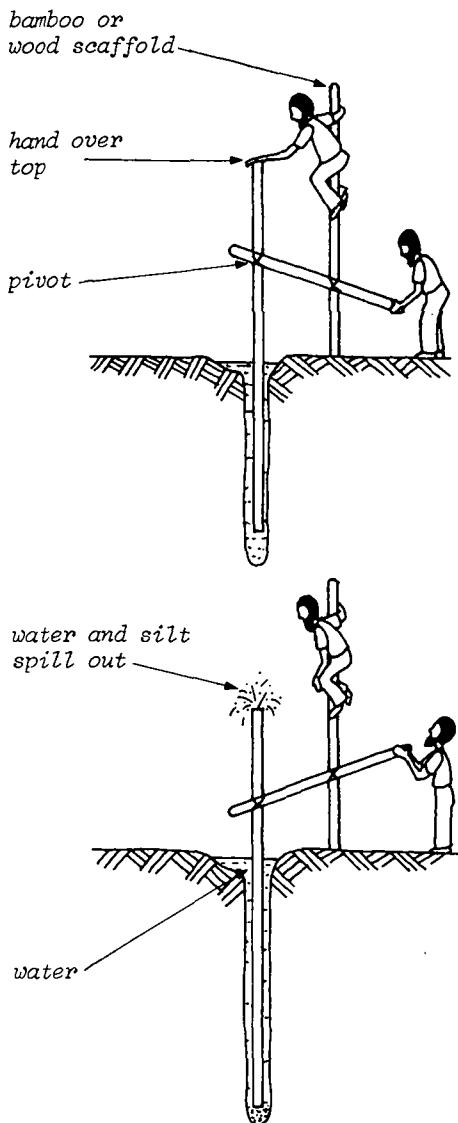


This method is likely to be too expensive for most developing countries. Also, if the water is to be used for community water supply it would probably need treatment before use.

Reported use:
Southern states of the USA

Reference:
Bradley R
VITA document XVI AA-4 (1)

Tubewell hand jetting



The pipe is pumped up and down by the man on the ground. When it moves up the other man seals the top of the pipe with his hand so that water flows from the hole around the pipe, down to the bottom of the pipe, where it helps to scour away the silt. When the pipe is pumped down quickly the man takes his hand away from the top so that water, loose sand and silt spill out. At the same time, the pipe is forced down further into the bottom of the hole, loosening more material to deepen the well.

Jetting tube wells by hand is a very simple operation. Local, cheap materials can be used, and the people need very little training.

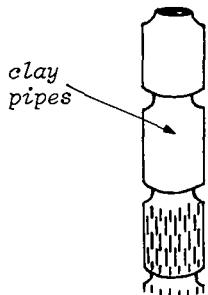
The main disadvantage is that this method can only be used in soft, sedimentary rocks, where the ground water level is high. Also, only small diameter pipes can be used. These should be galvanised pipes, up to about 50mm diameter.

Present use:
River areas of India and Bangladesh

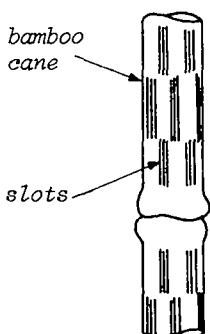
Reference:

Reed R A

Tubewell casings and screens



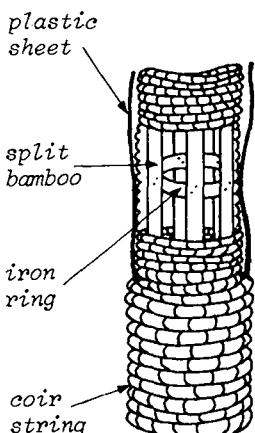
Tube wells are usually lined to stop the sides from collapsing. The linings can be made from clay pipes, made by the local potter. The upper part of the well is lined with blank pipes, while the lower part is lined with slotted pipes. The slots are cut in the clay before it is fired.



Bamboo grows to diameters which make it ideal to use for tube well casings and screens. The casings are made from single canes, usually over 4m long. The partition at each node is gouged out, using a sharp chisel or auger fixed on the end of a rod. The bamboo should be of a type which does not crack easily.

Part of the well casing can be made into a simple screen by drilling holes into it with a hand drill.

One length of bamboo can be joined to the next by wrapping a thin sheet of iron around the joint and fastening it with small nails.



Larger diameter pipes can be made with split bamboo stems nailed to iron rings to make a frame. The lower part of the frame is wrapped in a double layer of coir string and the upper part with a single layer, and a sheet of polyethylene for waterproofing. Coir string makes a good screen as it will not pass sand, and it does not rot below the water line. However it will rot above the water level and where the water table changes seasonally, so it is better to use other materials for the pipes above the water.

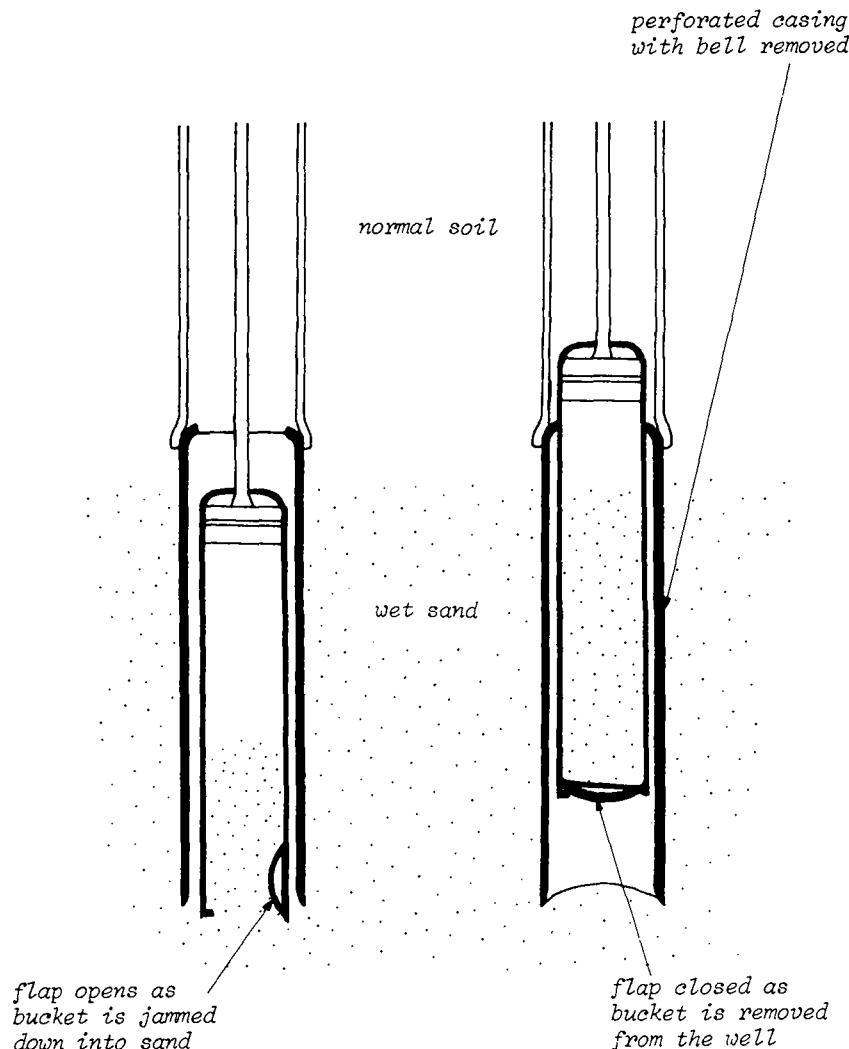
Present use:
India, Ecuador and Assam.

Reference:
Allison S V, Sternberg Y M, and Knight R
Dommen A J
Fernando A D N

Tubewell sand bailer

When loose wet sand is encountered when boring a tube well, and the walls begin to collapse, this tubewell sand bailer allows digging from inside the perforated well casing.

Removal of the sand from within allows further settling of the bottom casing.

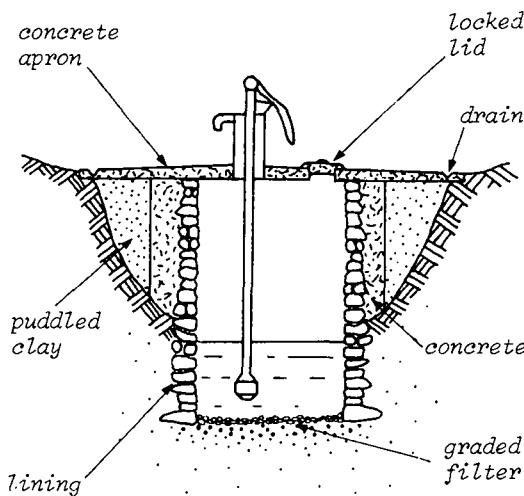


Reported use:
India

Reference:
VITA document XVI AC-4.1 (2)

Hand dug wells - improvements

Open wells are dangerous to the users and often become seriously contaminated. These dangers are easily prevented by a few simple improvements to the existing well.



Lining

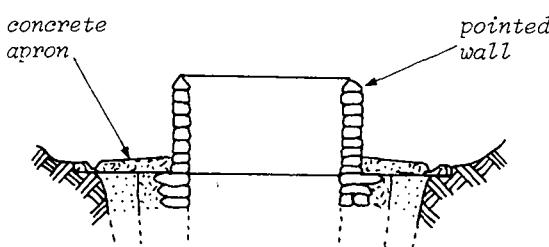
Hand dug wells must be lined. This is done with bricks, stone or concrete so that the upper section of the well is made watertight while the lower part is permeable. The waterproofing is done to stop contaminated surface water from seeping into the well. It is done by digging out the soil around the lining, and then filling in with puddled clay. A layer of concrete between the old well lining and the clay will make the lining completely waterproof.

Well head

The most important improvement which can be made to a well is to build a drainage apron and a head wall or permanent cover. Concrete is the best material to use for the apron, and it is cast so that it slopes away from the well opening, draining away surface water. A shallow drain is also dug around the apron to help drain away any water which collects around the well shaft.

If a pump is used to raise the water, the apron is extended over the well opening so that it is completely enclosed, and the pump is set into the concrete.

If buckets are to be used, a head wall must be built around the well. The wall should be tall enough to stop the users from standing on it, and animals and rubbish from falling in. If the wall is built with a pointed top this will also stop people from standing on it.

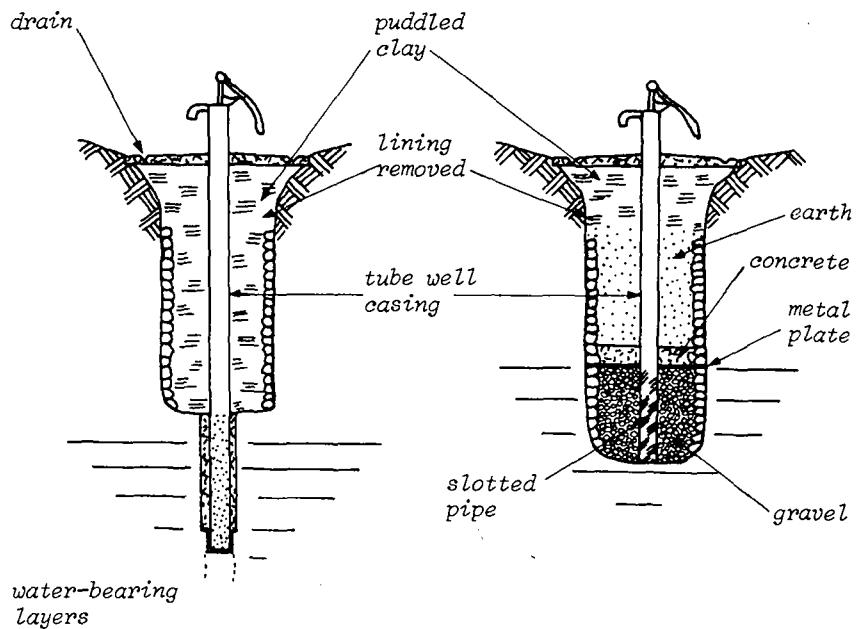


Tube well conversions

If a well runs dry or does not give enough water, it may be improved by sinking a tube well into the bottom of the well, and then infilling the original well with puddled clay. By this method it is possible to reach much further down into the water-bearing layers.

The amount of water collected by this method is often much greater than by the original well.

Alternatively, a slotted tube well can be fitted into the existing well shaft, which is then infilled with gravel and puddled clay. This will improve the quality of the water and make the construction more sanitary.

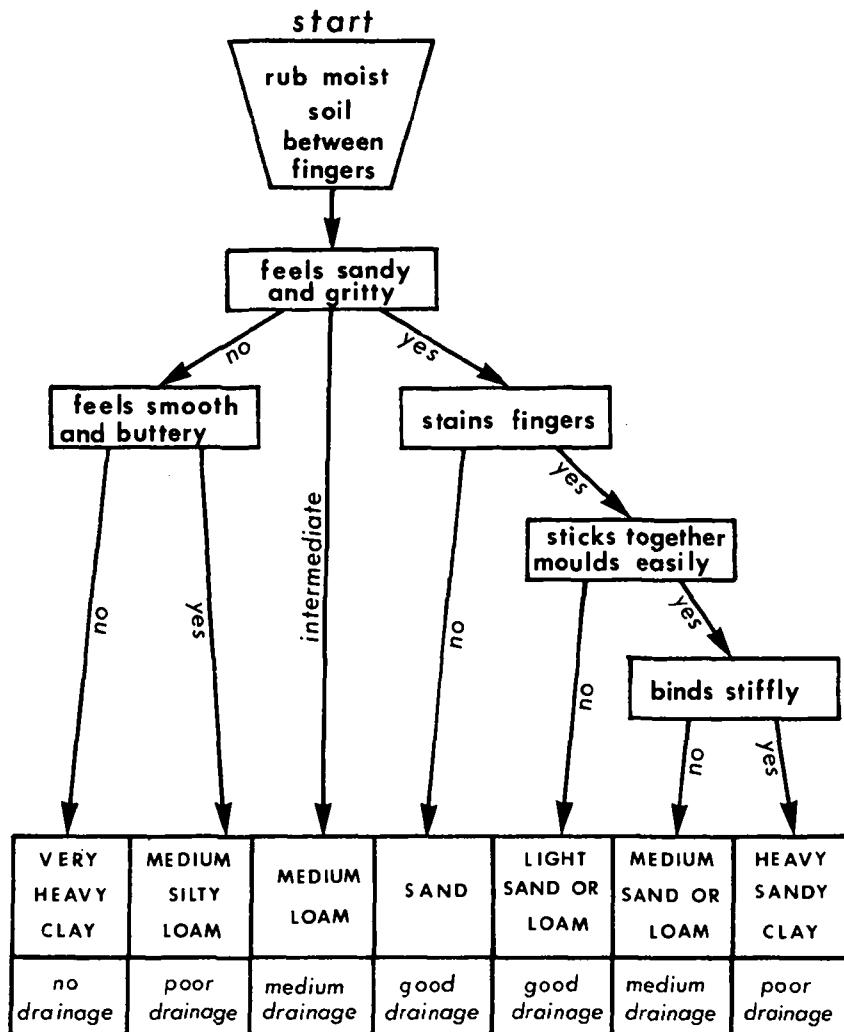


Reference:
 Cairncross S and Feachem R
 Wagner E G and Lanoix J N (2)

Soil types

It is often useful to know the basic soil type of an area before starting to dig a well or latrine.

This chart gives a simple guide to the main soil types and how to identify them quickly.



Reference:
Ciba-Geigy Agrochemicals

Water hole

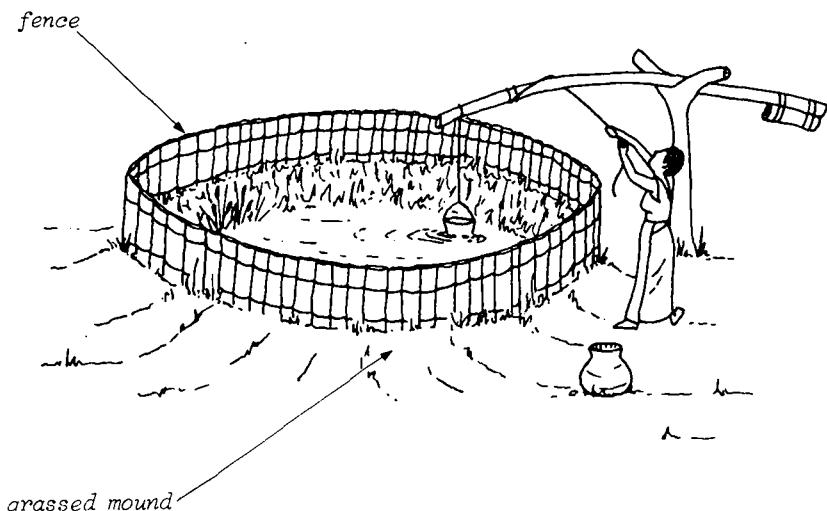
Where a spring emerges on the surface it can provide a supply of water for domestic use.

The simplest way of doing this is to dig out a catch basin at the point where the spring emerges.

The sides of the basin are slightly mounded and grassed or paved with stone to prevent the hole from collapsing or being contaminated with surface water.

The area of the hole is fenced in to stop animals from polluting the water.

The size of the basin will depend on the amount of water flowing from the spring, and the porosity of the soil, but it should be at least 3m diameter and 2m deep to ensure a good supply.



Present use:

Uganda

Reference:

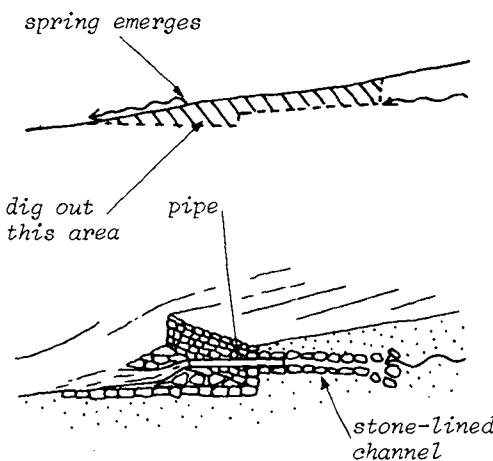
Medical Headquarters, Entebbe.

Protected springs

If a spring is to be used as a domestic water supply, it must be protected in some way so that the water does not become polluted.

A simple way to do this is to dig a trench back along the water bearing layers from where the stream emerges on the surface, about 2-3m back. This water flow channel is then lined with clean stones, and a 1m length of pipe is put into the end of the channel.

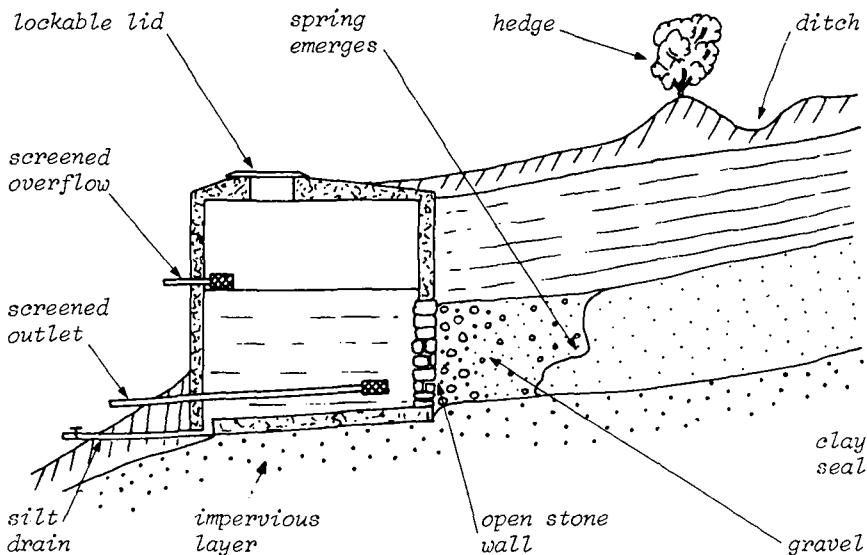
A stone wall is built round the pipe, and stones are set into the dug out area in front of the spring.



The water is allowed to flow freely as before.

The whole area is fenced off and a drainage ditch dug around it to divert surface water.

Another way of protecting a spring source is to build a concrete, stone or brick 'box', into which the water flows. The water can then be drawn off either directly from the box or by piping down the hillside to another storage tank.

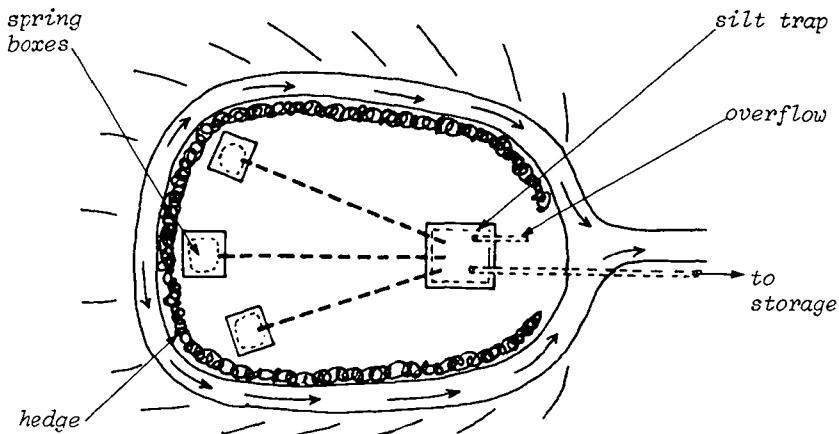


Several of these spring boxes can be built to flow from separate springs into one silt trap, and from there the water is piped to a storage tank.

Spring boxes work well for most small springs where the flow of water is fairly light.

They must be regularly drained and cleaned out, because silt and sand build up quickly in them.

The area must be protected from animals by a fence or a tall hedge, and a ditch should be dug to divert surface water.



Reference:

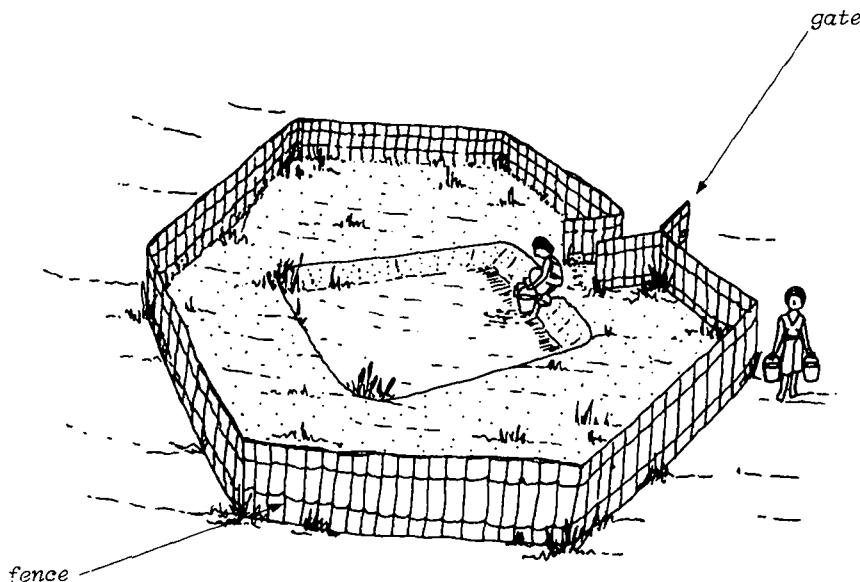
Cairncross S and Feachem R
Medical Headquarters, Entebbe.

Surface Water catchment Basin

If green vegetation persists in a low-lying area, this is a good indication that water is collecting in the soil.

A simple catchment basin can be dug out to collect this water and make it available as a safe domestic water supply for the local people.

The size of the basin depends on how much water collects in the ground, and also on the porosity of the soil. In heavy clay soils, a larger basin can be dug.



It is important that a catchment basin like this is well fenced in so that animals cannot pollute the water.

The water collected in this way must be filtered and disinfected before use for drinking or cooking.

Present use:

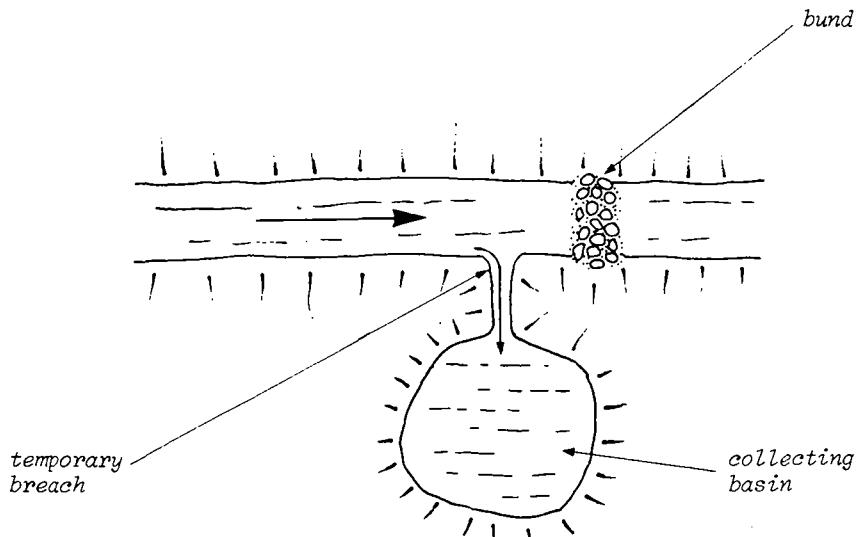
Uganda

Reference:

Medical Headquarters, Entebbe.

Bunding

In small watercourses, up to about 1.5m across, intermittent flow is utilised by blocking the channel with a mixture of stones and clayey soil.



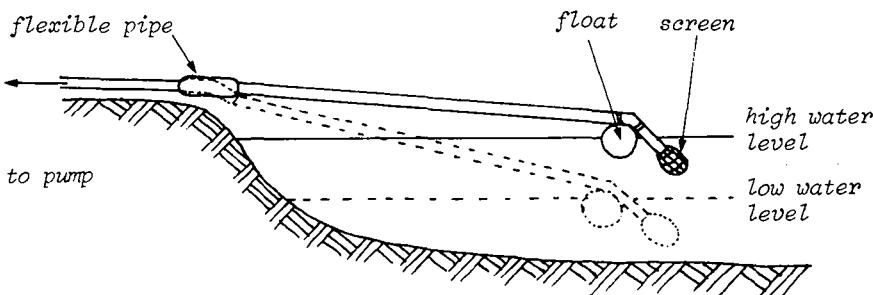
The flow is then diverted into pre-dug collecting basins at the side of the stream channel, by making temporary breaches in the embankment or with siphon tubes.

When sufficient water has been collected, the bund is removed and the watercourse repaired.

Floating intake for lake or pond

If a pond or lake is to be used as a domestic water supply, it is better to draw off water from just below the surface, since the water will be turbid for most of the time. The variation in the level of water can be great, so it is necessary to build a floating intake.

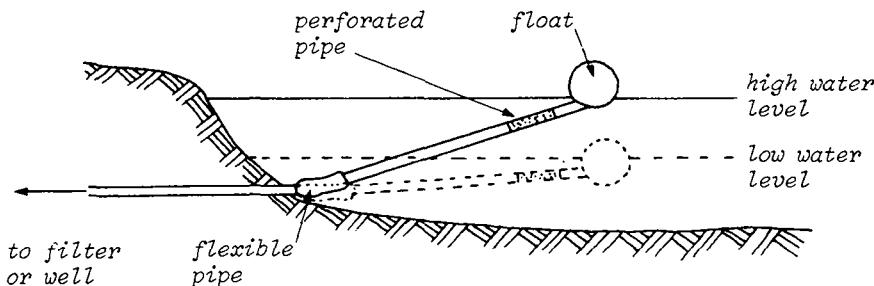
One type of floating intake is made with two lengths of rigid pipe connected at the pond bank by a short length of flexible pipe. An empty barrel or oil drum is attached to the intake end of the pipe and acts as a float. The pipe bends down below the surface of the water. The intake is covered with a screen, such as a bamboo or wicker basket, to stop fish, frogs and dead leaves from getting into the pipe. The pipe system is connected to a pump further up the bank.



Another idea is for use with a filter or collecting well, and the pipe enters the pond below the lowest water level.

Again the rigid sections of pipe are connected by a short length of flexible pipe, and a barrel is used as a float.

In this case the intake is simply a section of the rigid pipe which has been perforated below the float.



In both of these examples the intake always stays below the surface of the water even when the water level rises or falls.

Reference:
World Health Organisation

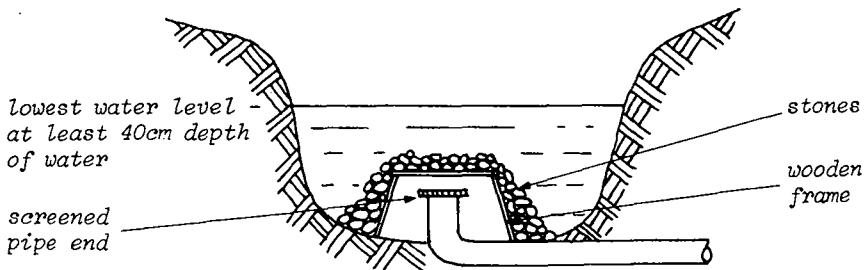
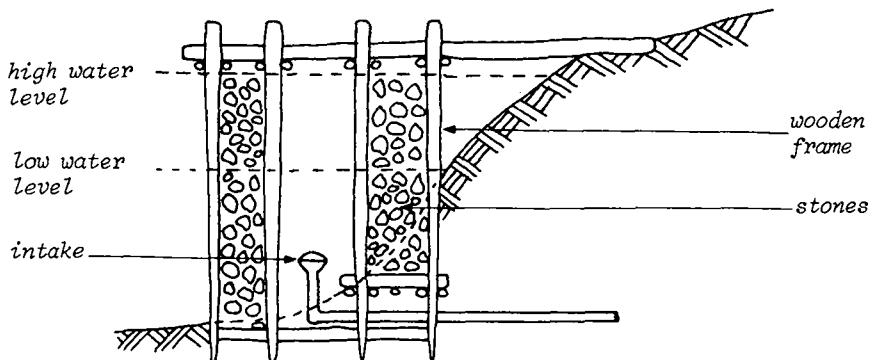
Small river intake structures

Simple protected intakes can be built where the river does not flow too fast.

The intake consists of a submerged pipeline, with a screened mouth at the open end. The inlet should be well below the water level, so that it is not damaged or clogged by floating materials, but it should not be too near the river bed, as it will then become blocked with silt.

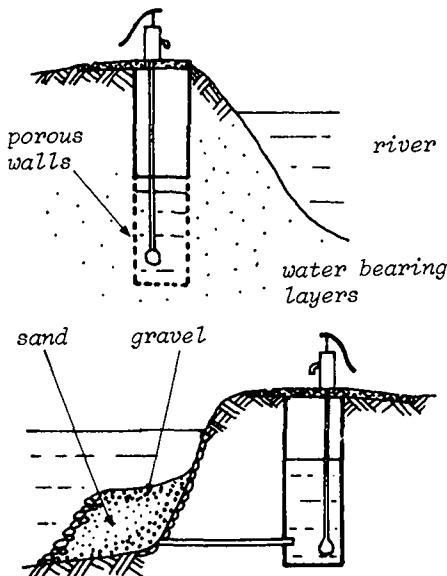
The illustrations show two simple designs for protected intakes. The first design has the intake protected by a wooden frame filled with stones and open at the top above the high water level. This makes it possible to reach the intake for cleaning.

Both types are connected to pumps on the river bank.



Reference:
U N I C E F
Wagner E G and Lanoix J N (2)

Infiltration wells and galleries



Infiltration pipes open under the filter and are connected to a well.

The filter could also be built as an infiltration gallery.

Porous pipes are laid in trenches across the bed, and are packed in with sand and gravel.

Several pipes can be laid, all connected to one well on the bank.

The driving of infiltration pipes can be difficult and expensive, involving constant pumping and support of the trench during the operation.

Also, clogging of the filter sand can cause difficulties, and so the top layer of sand must be regularly scraped off and replaced.

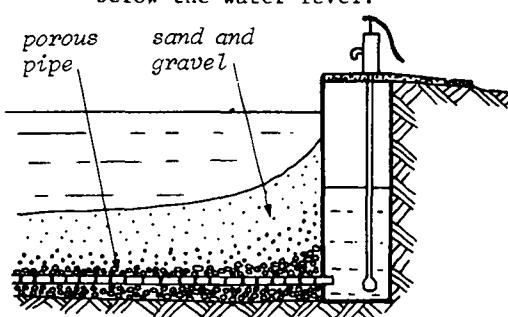
Surface water is usually very polluted, but it can be filtered successfully through the sand and gravel of the river bed. Simple wells can be built where the ground is very permeable. The well is properly lined and has porous walls below the water level.

The ground between the river and the well acts as a slow sand filter, and the water which collects in the well only needs disinfection before use.

If the well is dug deeper than the level of the river bed, it may still supply water from subsurface flow when the river is dry.

More water can be collected if infiltration galleries and pipes are laid under the bed of, or alongside a river or pond.

The simplest way to do this is to build a sand and gravel filter against the river bank, below the water level.



Reference:

Amirtharajah A

Cairncross S and Feachem R

Füresz G

Rajagopalan S and Shiffman M A

Ulap PL

World Health Organisation

Wood W E

Subsurface river flow

Tube wells

Tube well screens of 75mm diameter are sunk to a depth of 2.5m into the river bed and are connected by suction line to a pump. The pump should be a distance away, to avoid damage by floods.

The flow of water can be reversed at times to wash out any silt which may clog the pipes.

The pipe must be firmly fixed and needs careful maintenance

Reported use:

Sri Lanka

Reference:

Kulasingham D S

Subsurface flow filter

In other areas a basin can be dug in a river bed, down to the level of the subsurface flow. The basin is lined with perforated concrete which allows water to enter. The sides of the concrete basin are piled with gravel which increases the permeability.

The basin is then connected to a pump on the river bank, through a pipe.

In this way water is available from the river even in the dry season.

Reported use:

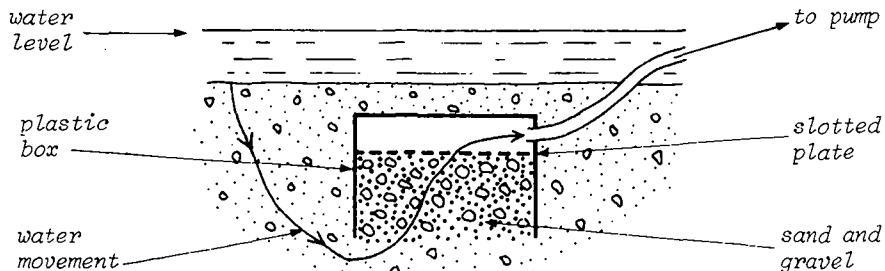
Madagascar

Reference:

Rarafy C A

In-situ sand filter

A simple sand filter can be made beneath the river or pond bed, by sinking a plastic slotted box into the river gravels.



The box is filled with sand and gravel underneath a slotted plate. The top of the box is connected by pipe to a pump on the bank. Water moves up through the filter and the slotted plate and is drawn through the pipe to the collection tank.

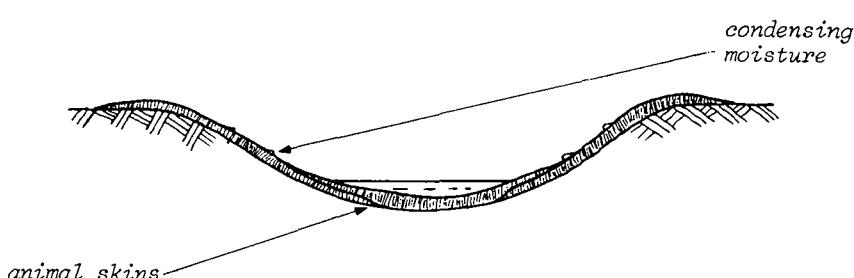
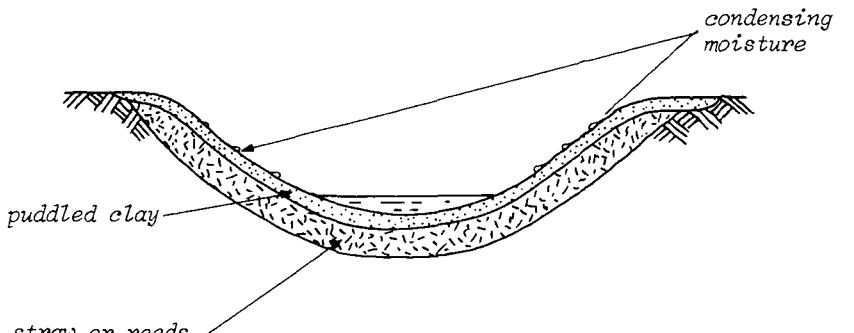
Reference:

Cairncross S and Feachem R

Cansdale G

Dew ponds

A shallow depression is dug out and lined with straw or dried reeds as insulation. Over this is packed a layer of puddled clay. At night the clay cools down by radiation, and moisture condenses on the cold surface.



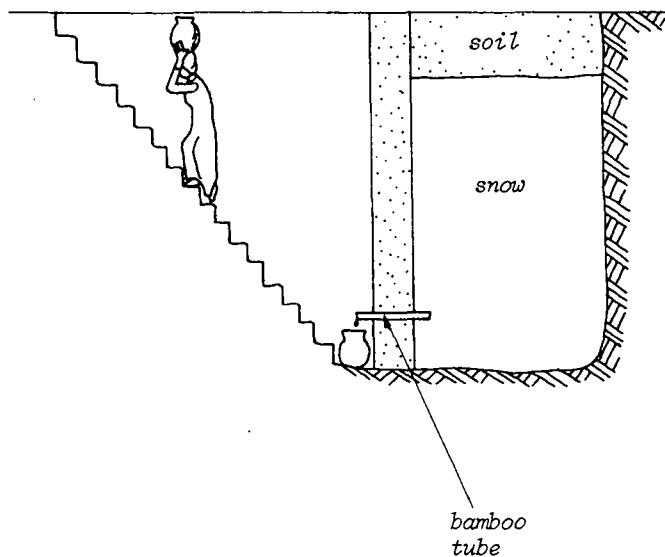
In desert areas, animal skins with the fur side down, will work in the same way.

Dew ponds will only give a small supply of water, so they are not suitable for domestic use, but in isolated areas, they can provide drinking water for animals, or emergency drinking water for people.

Reference:
Hubbard A N and G.

Snow pits

Snow is stored in deep pits of 10m depth, and 6-8m diameter, to be used as drinking water in the Summer. The snow is collected in bags, dumped and compacted in the pit, and the top 2-3m of the pit is filled with soil to act as insulator. A ramp or series of steps is built to the bottom of the pit, where a small bamboo pipe protrudes through the pit wall. Snow melts slowly around the pipe and water trickles out into a pot.



It is claimed that the storage in one such pit supplies the village of 10 families with drinking water for two years.

Reported use:
Afghanistan

Reference:
Prasad Rama

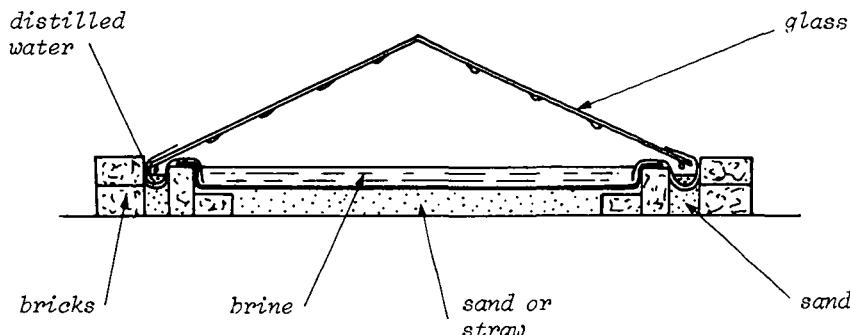
Solar still

In the hot, dry areas of the world, where the only natural water supply may be brackish or salty, a simple still can be built which will use the heat of the sun to distill enough water to supply a small community.

The main structure of the still is a brick trough, 1m wide and 10m long. A second, lower brick wall is built inside this, along the 2 long sides, making troughs, which are then partly filled with sand. These narrow troughs slope slightly to one end of the main trough, where they discharge into a storage tank.

Within the main trough, a bed of straw or sand is laid, to insulate the brine basin. Over the insulation, a layer of thick black plastic is laid as waterproofing. The sand troughs are lined with strong white polythene.

Glass sheets are fixed firmly over the whole structure, to make a sloping roof. Removable glass covers are fixed to the ends of the brine basin so that cleaning is easy.



The brackish or salt water is poured into the brine basin. As the sun heats the liquid it evaporates and condenses on the inside of the glass roof. The condensed water runs down the glass and into the collecting troughs at the sides, to flow down into the storage tank.

A unit of this size has been found to supply 30 litres of water per day, so it can be seen that a very large area of glass is needed if the still has to provide for more than drinking water.

Although the building of the still needs only basic skills, the glass and the seals must be vapour-proof, and so this makes the construction and maintenance difficult.

Capital costs are also fairly high.

Reported use:

The still was designed and tested in Sudan.

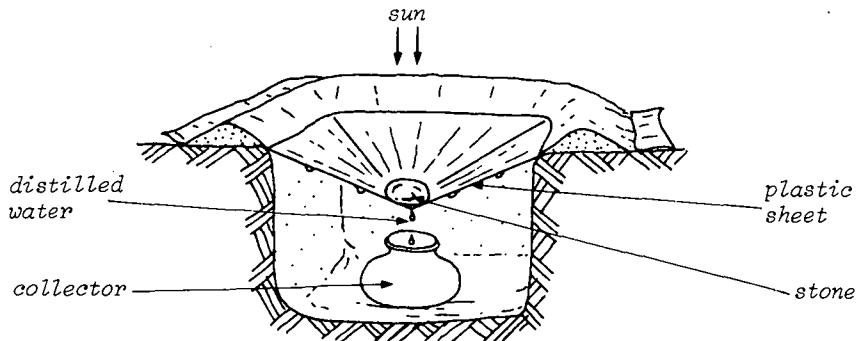
Reference:

Hamid Y H

Distillation of underground water

When no other water is available, underground water can be collected by simple distillation. Water evaporates from the trench and condenses on the plastic sheet during the following night, running down and dripping into a suitable collecting vessel.

This method is usually used in emergencies as a means of survival.

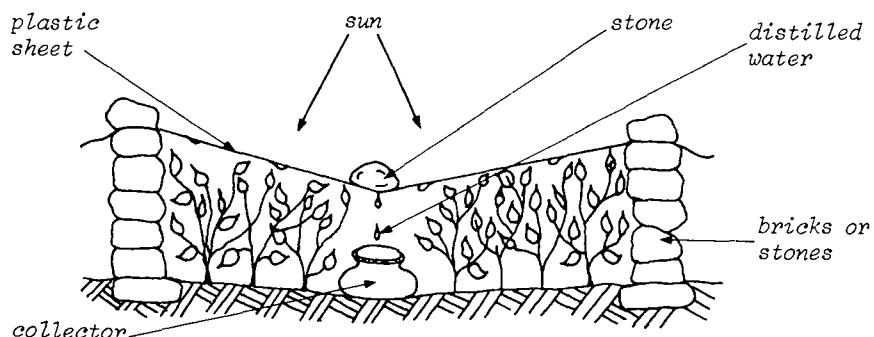


Reported use:
Algeria

Reference:
Jolly P W

Evapotranspirer

This is similar to the distillation of underground water, except that here growing plants draw up the moisture from the soil. Water then transpires from the leaves and condenses on the plastic sheet.



Reported use:
Guatemala

Reference:
McGarry Dr M G

200 Water treatment

Introduction

Most surface water - from rivers, streams and ponds - requires treatment before it can be considered as fit for drinking. This is because it contains suspended particles of soil and decayed vegetable matter. More important, it may have been contaminated by human and animal wastes from villages upstream. Groundwater is often suitable for drinking without treatment, providing that care is taken to prevent its being polluted at the spring, well or borehole. However, some groundwater (and also some surface water) contains substances such as chlorides, sulphates, nitrates and salts of iron and manganese, which make its taste or appearance unpleasant or cause diarrhoea or other illness. Tests can be used to find out the concentration of these substances (210) to determine if the water is drinkable.

The most simple treatment for surface water or rainwater is retention in tanks or basins (220 and also 110), where solids settle to the bottom. Coagulants may be added to encourage very fine solid particles to join together and sink.

Filtration (230) is used in large water treatment plants as well as household systems. Basically a filter encourages particles which are floating in the water to deposit on the filter grains (which are often sand). For community water treatment plants in developing countries the slow sand filter (231) has many advantages. In addition to physical filtration, water is cleaned by biological material which builds up in the top of the sand, and there is further treatment all through the sand bed. Household filters do not have this biological effect. Some have a layer of charcoal in which unpleasant colour, taste and smells may be removed from the water. However, water from all these household filters may still contain disease-causing microbes. Water which may have been contaminated by human excreta should be boiled or chlorinated before use for drinking or cooking.

For wells and small distribution systems, bleaching powder is often used for chlorination as it can be obtained locally. A very weak solution of the bleach is needed and various devices have been used to make sure that an even flow is added to the water (240).

Natural water from surface and underground sources sometimes contains unacceptably high concentrations of iron and manganese, causing discolouration and unpleasant taste. Iron and manganese may be removed by aeration followed by settlement (250).

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| 220 | Coagulation and flocculation | 241 | Simple chlorination |
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| 232 | Small filters | 250 | Iron removal |
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Water quality testing

Test strips have recently been developed which can be used to make a semi-quantitative determination of salts dissolved in water.

The reaction zone of the strip, which is impregnated with sensitive reagents and buffers, is sealed onto a small strip of plastic.

The special combination of substance used make each strip highly selective for any particular salt.

The test is performed by dipping the test zone of a strip into the sample solution and comparing the results with a colour scale. The individual colours on the scale are clearly graduated so as to give a good indication of the concentration. With a little experience it is also possible to detect and evaluate smaller concentrations than those given on the scale.

In most cases it is not necessary to either pre-treat the sample or subsequently treat the test strip.

Full instructions on how to use the strips are given in each pack. When stored under cool, dry conditions, the test strips remain stable for at least two years.

The strips are particularly useful for testing for nitrates, nitrites, sulphate, iron, ammonia, copper and hydrogen.

Also available are colour disc test kits, which contain discs, precalibrated in concentration units, to compare against samples treated with fixed amounts of chemicals.

The most useful of these colour comparison kits are those for testing for chlorine, nitrate, nitrite, ammonia, pH, iron, chromium, cyanide and phosphate.

These colour kits can be used easily in the field and give more accurate results than test strips, but are more expensive to buy and operate.

Coagulants - natural

Moringa seeds

The crushed seeds of Moringa trees (*Moringa oleifera lam* and *Moringa peregrina fiori*) have been found to act as a coagulant. Their performance compares favourably with alum in respect of their rate of reaction and decreased turbidity of treated water. The total bacteria count initially is reduced after coagulation with Moringa seeds, but subsequently increases. A dosing rate of 0.2g of finely crushed seeds per litre of water is suggested as optimum.

Reported use:

Moringa seeds have been used to treat Hafir water and Nile water in Sudan.

Reference:

Jahn Dr Samia Al Azharia

Red Sorrela seeds

Seeds of red sorrela (*Hibiscus sabdariffa*) are dried, crushed and mixed with sodium carbonate in a ratio of 9:1. When needed the crushed seeds are mixed with water and heated to give a milky suspension which is used as a coagulant.

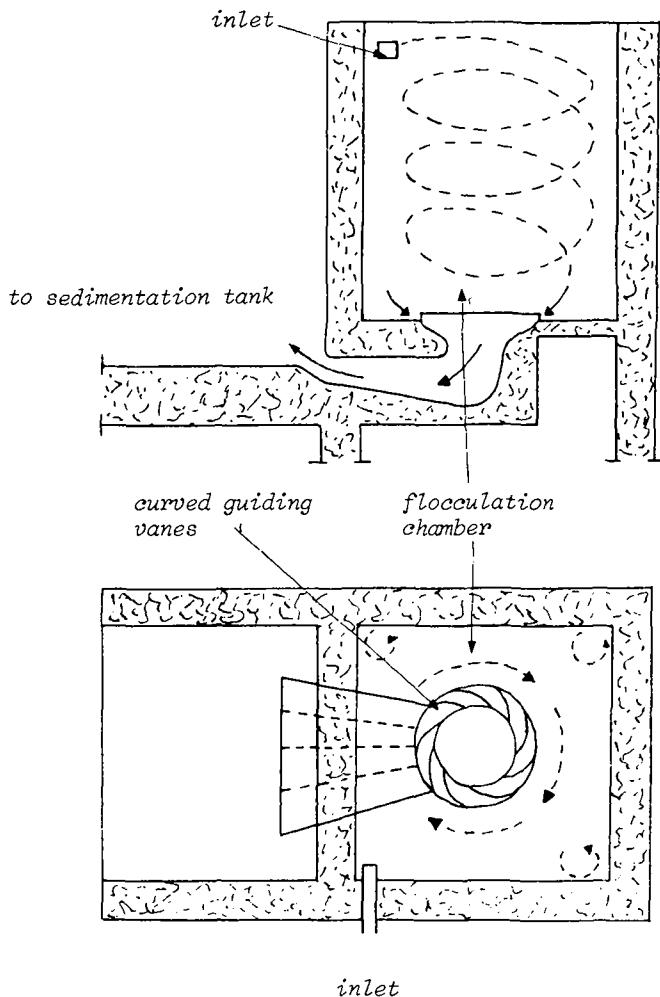
This coagulant is known to give good removal at both low and high turbidity, at lower dosages than would be needed of alum. The coagulant is not affected by phosphates.

Reference:

Bulusu K R and Pathak B N

Hydraulic flocculator

Raw water and coagulant enter at the top, and pass through the chamber, leaving through the curved guiding vanes, which are set over a central opening leading to the sedimentation tank.



Present use:
Argentina

Reference:
Carcedo, Eng. M.

Slow sand filter

This consists basically of a large tank containing a bed of sand. Raw water filters through the sand bed to a set of drains which carry it to the outlet.

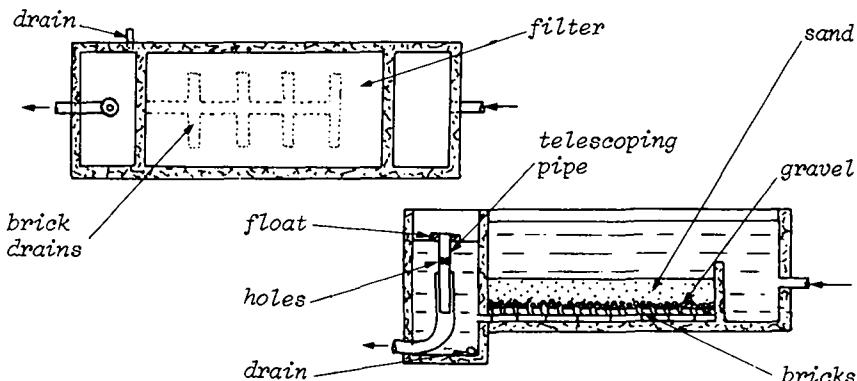
The filter works successfully because the sand grains in the top layers become coated with bacteria which kill micro-organisms and produce a very fine mat which strains the water.

The area of the filter surface is at least $3m^2$ for a capacity of 400 litres every hour, and the tank walls should be 2-4m above the ground.

The sand layer is at least 700mm deep and is always 1m below the surface of the water.

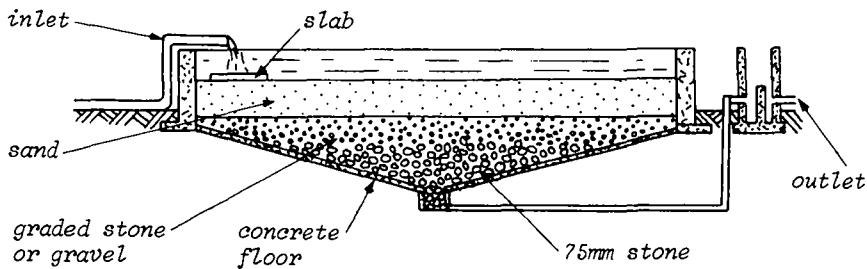
Between the sand layer and the drains are layers of gravel, graded with the coarsest at the bottom.

The drains are made of uncemented bricks laid as shown in the plan.



If the water is fairly clear, the filter will work for several weeks before cleaning becomes necessary. This is done by raking away the top layers of sand and replacing them with fresh sand. If the water is very dirty, sedimentation or another filter may be needed before the slow sand filter is used.

The sand filter may also be built to a circular plan, with a simplified drainage system consisting of a sloping concrete floor draining into a central chamber.



Reference:

Cairncross S and Feachem R
Suphi H S

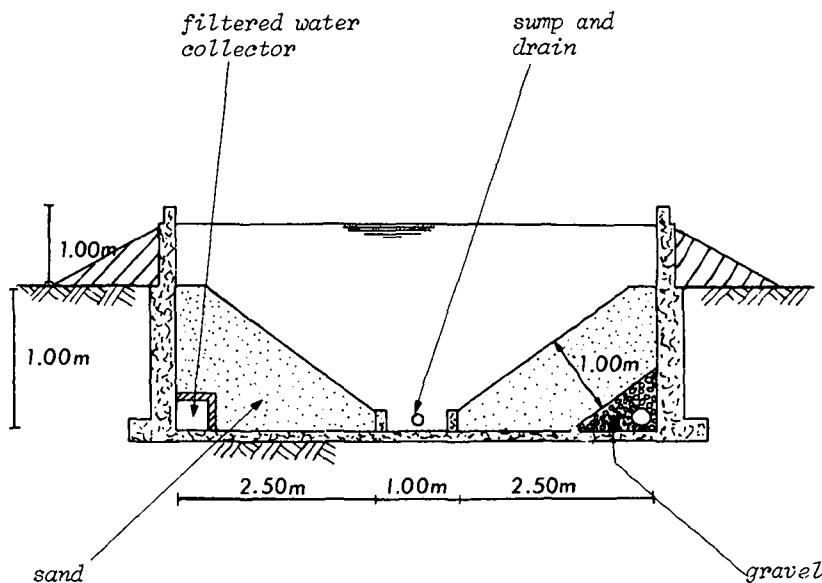
Inclined surface filter

This is a circular slow sand filter which has an inclined sand bed surface.

The filtered water can be collected either by a collector embedded in gravel, or by a pre-cast porous concrete collector, both of which are shown in the drawing.

When cleaning becomes necessary, this should be done with long rakes, from the side, and the central drain should be open.

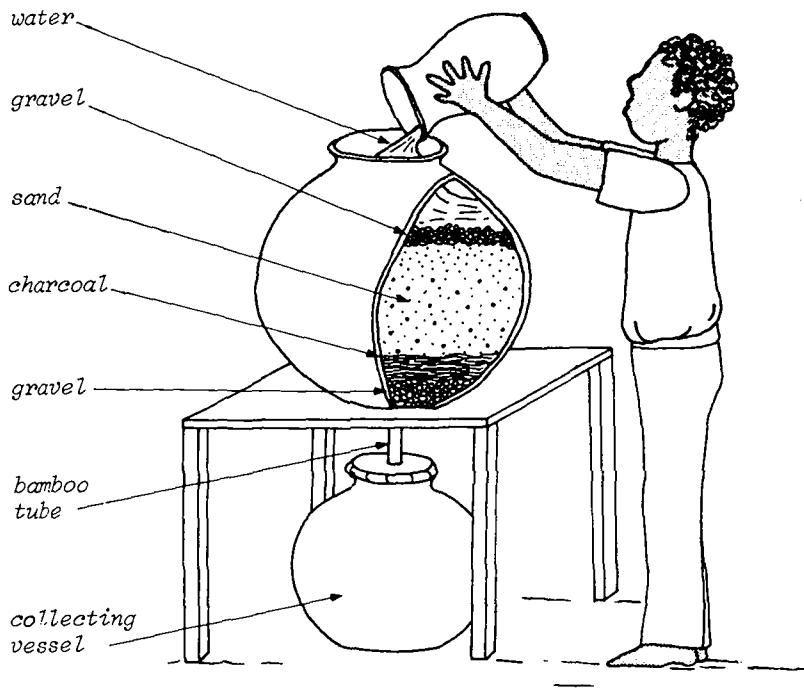
The estimated capacity of the filter shown is 100 cubic metres per day for 2000 people.



Household sand filter

Using wide, earthenware pots, about 750mm high, 1 litre of water can be filtered every minute.

Inside the pot is a thin layer of small stones, about the size of peas. This layer is covered with a layer of charcoal, over which is a thick layer of filter sand. Another layer of gravel can be put on top to stop the sand from being disturbed when water is poured in.



The filtered water passes through a tube from the bottom of the filter pot into a collecting vessel.

Before using the water it should be further treated, either by boiling or by chlorination.

A similar version can be made from 3 or 4 clay pots standing on top of each other. The pots, in turn from the top, contain gravel, sand and charcoal. In the four-pot version the lowest pot is used for storage of the treated water.

The filter is simple to make using local materials, and can be kept working well by occasionally removing the top layers and replacing them with fresh material.

Reported use:

Nigeria, New Guinea, Pakistan and many other countries.

Reference:

Chatiketu S

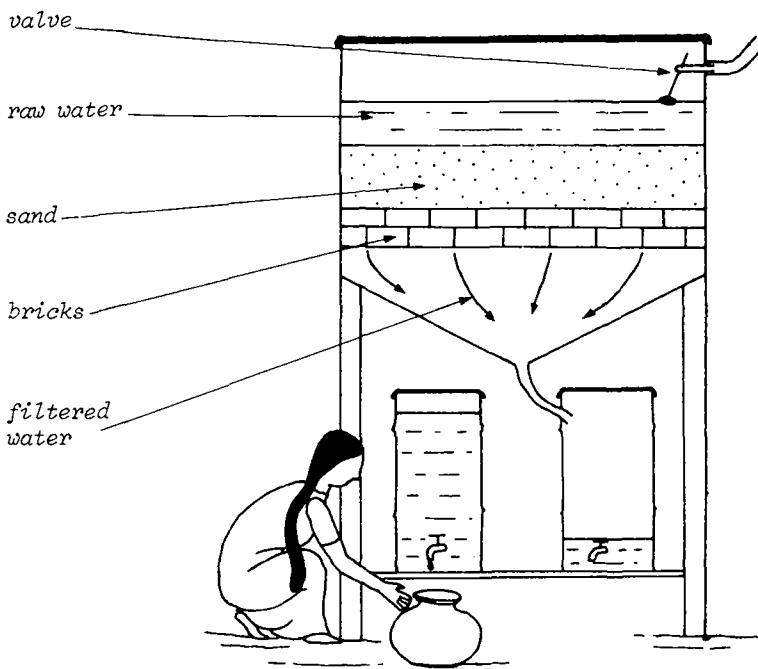
Dabo M T

Wooden household filter

A large wooden tank is built on a stand, leaving enough room underneath for two metal drums.

The tank is filled with 2 layers of bricks, covered with a thick layer of fine sand.

The water to be filtered can be piped directly into the tank, which should be fitted with a valve which closes automatically when the water reaches a certain level. This prevents overflowing and ensures a steady flow of water through the system.



The water when filtered runs from the outlet into one of the drums underneath. When one drum is full, the water in it can be used while the other drum is filling with fresh water. Disinfection is required. ✓

This type of filter is simple to build, and is large enough to give water for a family or group of about 10 people.

Reported use:
Argentina

Reference:
Gueller S

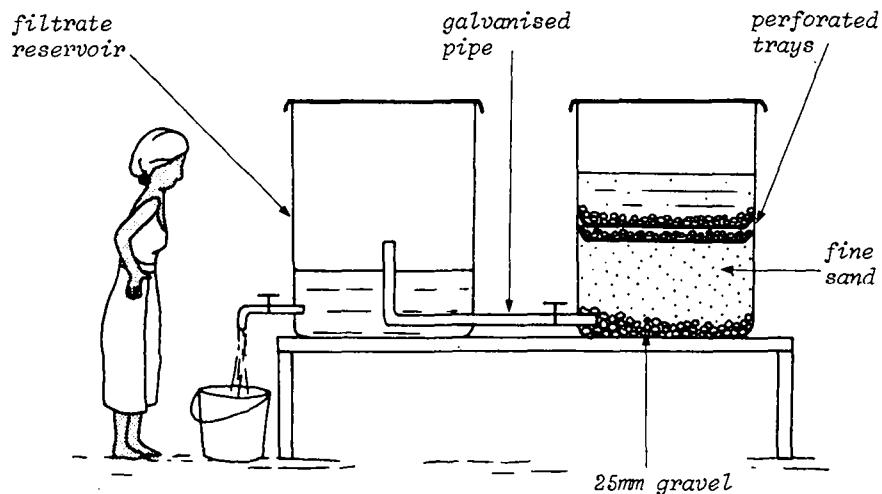
Household filter unit

An improved household filter unit can be built simply, using two clean 200 litre oil drums, standing on a table or platform off the ground. One drum is fitted with a tap and is used as the storage drum for the filtered water.

The other drum contains the filter, with a 100mm layer of gravel at the bottom, covered by a 300mm layer of fine sand. This is covered by 2 perforated trays filled with gravel.

The advantage of using these trays of gravel in the filter is that they can be lifted out in turn for cleaning, without having to stop the filter working.

The high level of the connecting pipe in the storage drum ensures that the sand in the filter stays wet.

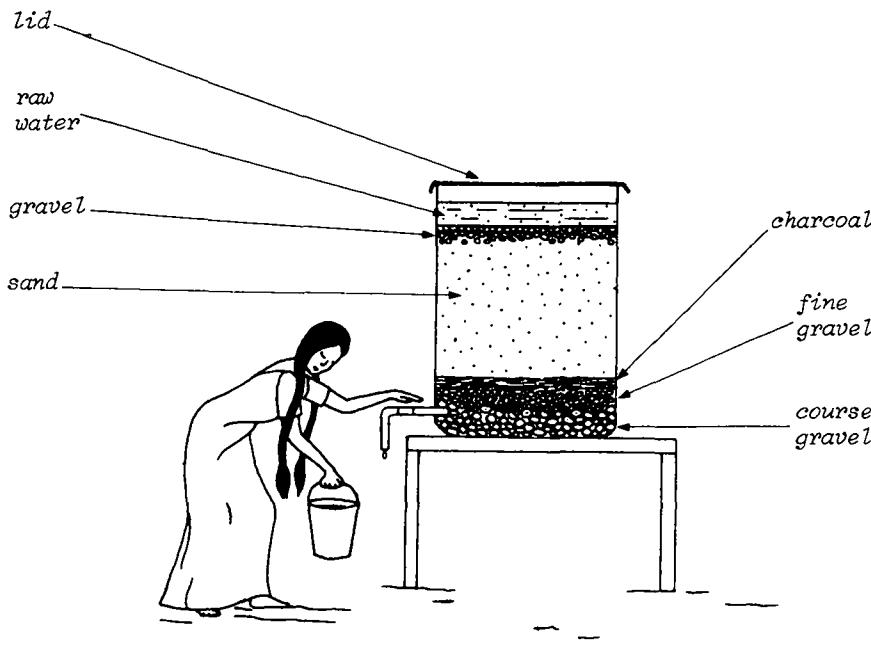


Reported use:
Ghana

Reference:
Kumasi University of Science and Technology

Intermittent filter

This is a filter suitable for use by a single household. An old, clean metal drum is fitted with a tap and a close-fitting lid. Inside the drum, the filter is made of layers of gravel, sand and charcoal. The sand layer is at least 0.65m thick.



Raw water is poured in at the top and allowed to filter through. It is known that this filter will remove most suspended matter, but it is a good idea to boil or chlorinate the water before using it for domestic purposes.

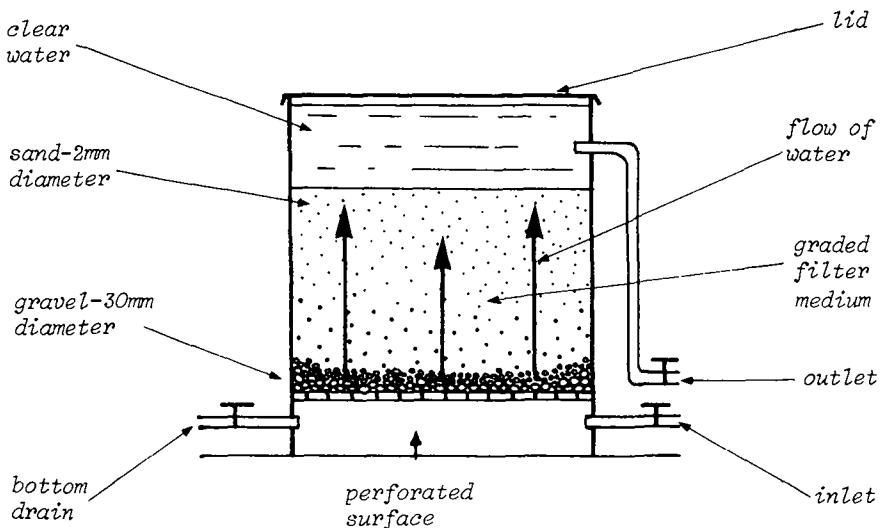
It takes 2 or 3 weeks for the filter to start working properly, so water should not be used for drinking until after this period. After several months' use the filter becomes clogged and the sand and gravel should be replaced.

Reported use:
Iran

Reference:
Merchant Prof.Dr N M

Upflow filter

A larger quantity of water can be filtered using this type of filter although it works at a slower rate than the usual downflow filters, and the water being filtered should be of low turbidity. Raw water is piped in at the bottom of a large tank, and is drawn up through a filter of coarse gravel graded to fine sand.



A reservoir of about 1.2m depth of water can be stored at the top of the tank, to be drawn off as needed. The filter can be backwashed by opening a bottom drain. The capacity of the filter is $150-250\text{m}^3/\text{m}^2/\text{d}$.

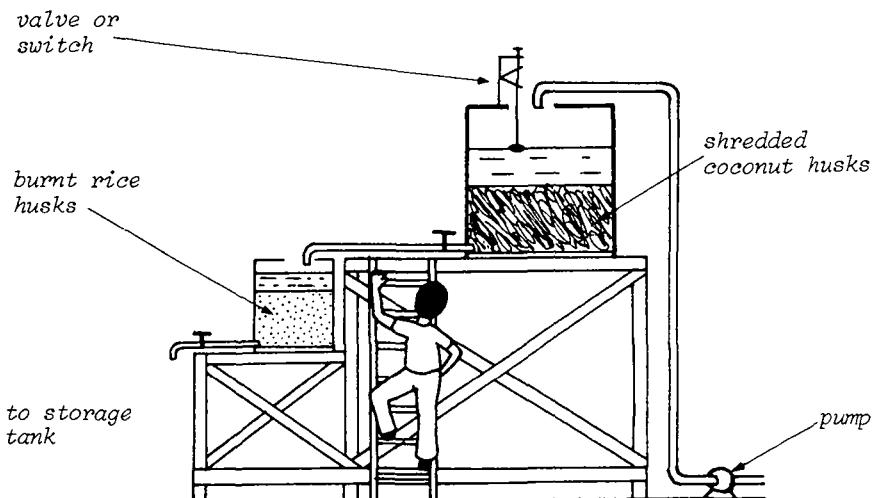
Reported use:
Costa Rica

Reference:
Cordero O

Two stage filter

This filter works slowly, but is easily built from local materials. It also makes use of locally available materials as filter media instead of sand and gravel.

The water to be filtered can either be piped directly into the first filter from an overhead rainwater catchment area, or it can be pumped up, as shown, from another storage tank. If a pump is used, it can be operated automatically by a valve or switch which turns on the pump when the water level in the first tank falls to a certain level.



The first filter contains shredded coconut husks, which can be washed and reused. The water then passes to the second filter which contains burnt rice husks. From here the water can be piped to a storage tank. The filtered water should be chlorinated before use. This system is suitable for a small village water supply.

Crushed coconut shell has been used instead of anthracite as a top layer on the fine sand bed of a dual media filter at the treatment works in Ramtek, Nagpur. Here, no sedimentation is needed, and the filtered water is reported to be of good quality, at considerably cheaper cost.

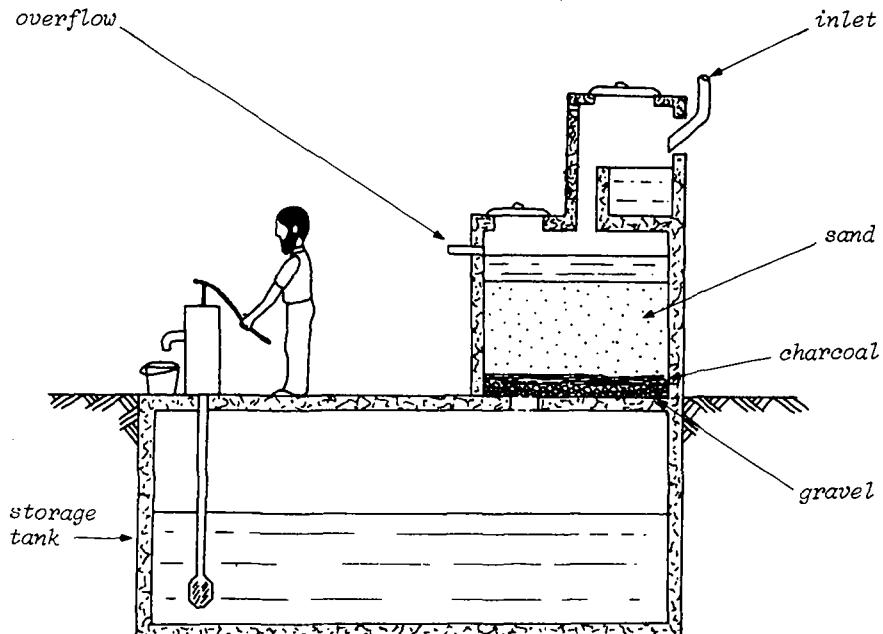
Reported use:
India and Thailand

Reference:
Asian Institute of Technology
Frankel Dr R J
Kardile J N

Individual water supply system

This system consists of a storage tank for collected rainwater, which passes into a filter, which is in turn connected to a large underground storage tank of at least 12m^3 capacity. The water is then pumped to the surface when needed.

For a permanent system it is better to build the storage and filter tanks from concrete, as they need to be quite large and strong.



This system works well, so long as it is checked regularly to make sure the water is flowing steadily.

The filter easily gets clogged, especially if the water is very dirty. When this happens the surface of the sand is scraped off and replaced with fresh sand.

All the tanks are fitted with drains so that they are easily emptied and scrubbed out.

Reported use:
U S A

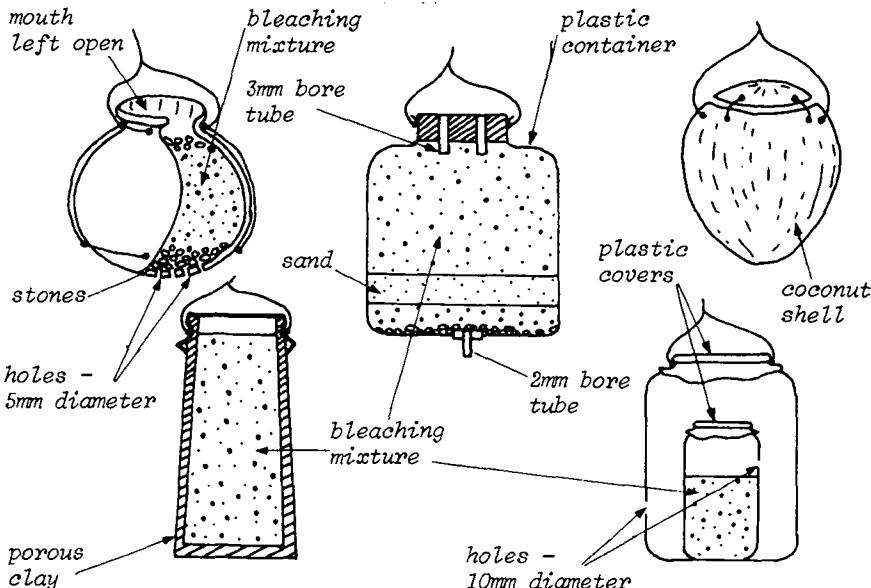
Reference:
Portland Cement Association
US Department of Agriculture
US Department of Health, Education and Welfare

Chlorination pots

A chlorination pot is a simple and effective way to disinfect well water, and can be made easily from local materials.

The container can be a round clay pot with holes drilled in the bottom. It could also be a coconut shell with the top sawn off, an old plastic container, or a piece of PVC tubing with holes drilled in it.

A porous clay pot can be made by the local potter, from clay mixed with some charcoal or rice husk ash. When the pot is fired in a hot oven the carbon burns, giving the clay some porosity.



All these containers should be weighted with a few stones, and then filled with either dry hypochlorite or a mixture of fine sand and hypochlorite.

They will work effectively for 10-15 days, or a little longer if sodium hexametaphosphate is added to the bleaching mixture to keep it soft.

A double pot is suitable for small household wells, and works for two to three weeks.

Reported use:

Pot chlorinators are used in many parts of the world.

Reference:

Chatiketu S

CPHERI (1)

Lo M C

Maniku H

NEERI

Shrivastava L P

IRC Newsletter 4

Solution feeders

For chlorination of larger water supplies, controlled flow of 1% chlorine solution can be used.

A 1% solution can be made up by adding to each litre of water, either: 20gm of hypochlorite powder, 40gm of chlorinated lime, or 250ml of liquid household bleach.

This solution is stored in a large container such as an oil drum, dustbin or plastic jerrycan. If a metal container is used it must be painted on the inside with bitumen paint to prevent rusting.

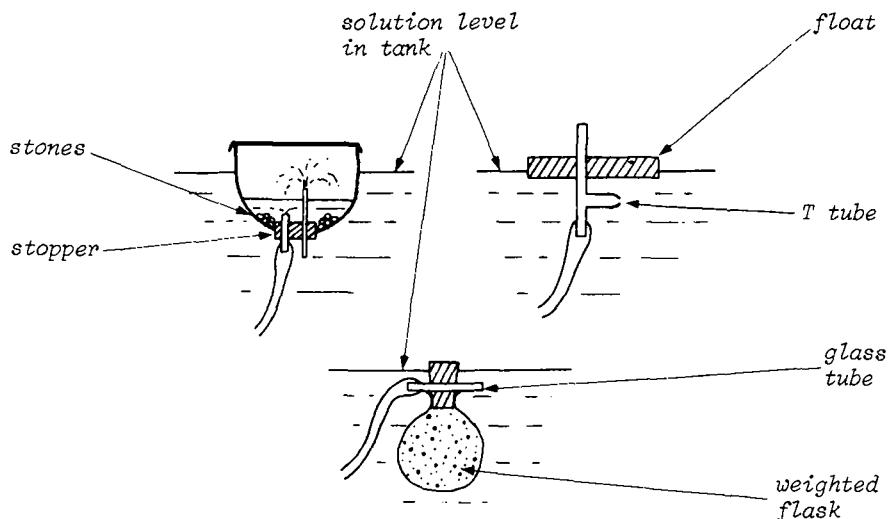
There are several ways to ensure that a constant flow of solution is fed to the water supply:

Floating bowl. The bowl can be made of any waterproof material, weighted with a few stones to keep it floating steadily. A cork or bung in the bottom of the bowl is fitted with 2 tubes, one having a larger bore than the other. The larger bore tube is connected to the outlet by a flexible tube, while the narrower bore tube is fixed with its top below the level of the solution in the tank.

Solution from the tank spouts up into the bowl and passes down the other tube to the outlet.

The bowl always floats on the surface even when the level of the solution gets lower in the tank.

If the solution is flowing too fast, the narrow tube is moved up to be nearer the solution level in the tank.

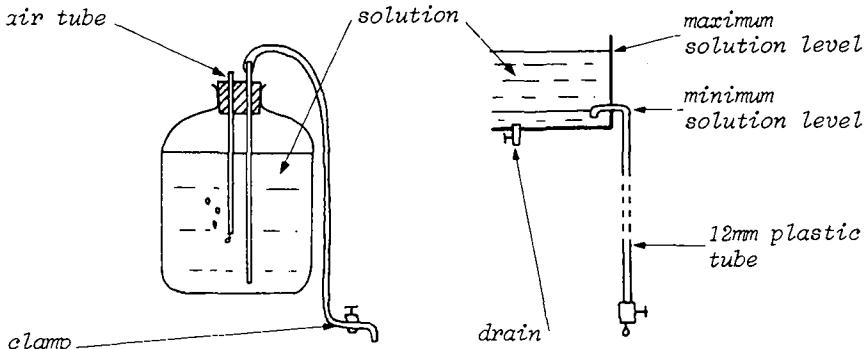


Float and tube. A float is fitted with a glass tee tube attached to a rubber hose leading to the outlet. Alternatively a weighted flask is used as a float, with a straight tube horizontally through the bung and kept below the surface of the solution.

Siphon. Two glass tubes are passed through a stopper into the solution. One tube is left open to the air and the other is joined to a rubber hose.

To start the flow of solution, blow through the air tube.

In all the above ideas, the rate of flow of the solution can be controlled by a valve or clamp on the rubber tube.

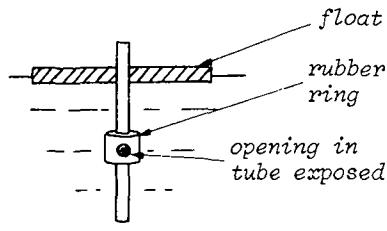


Drip feed. The solution drips at a constant rate from the plastic pipe into the water supply.

The solution tank must be 1m above the water supply, and the difference between maximum and minimum solution levels in the tank is 100mm. This ensures that there is only a small difference in rate of discharge between the two levels and there is no need for further rate control devices.

Dosing device. This can be used instead of a clamp to control rate of flow.

Holes of different sizes are exposed in the tube as the rubber ring is turned round. The larger the holes that are exposed, the faster the flow will be.



Reported use:

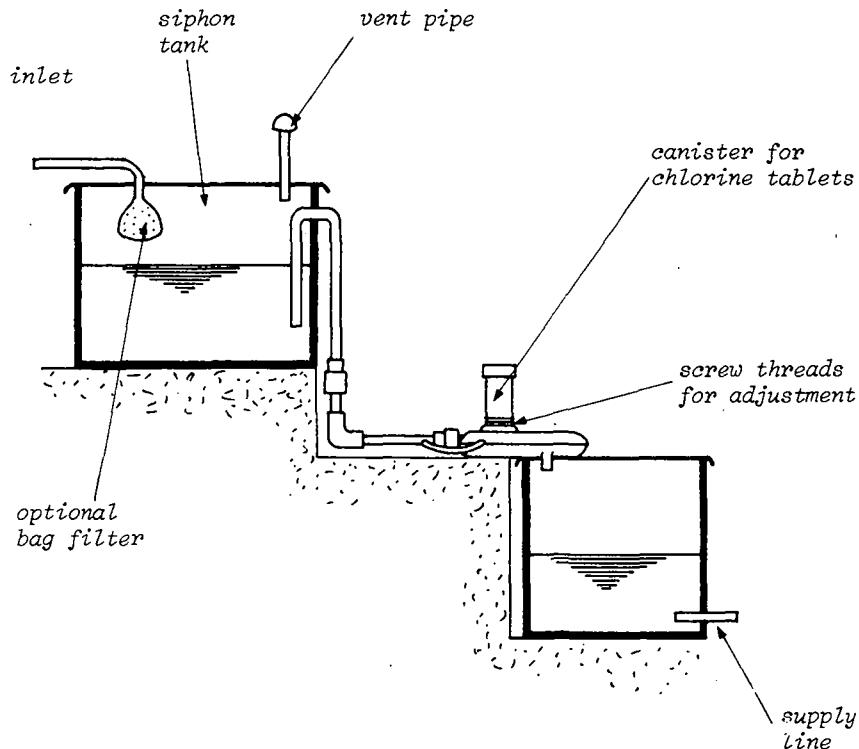
World-wide

Reference:

- Azevedo Netto Prof. J M de
- Bonilla Ing. Luis C G
- Cairncross S and Feachem R
- Carey H N
- CPHERI (1)
- Fisher B N M
- Rossin A C
- Uplap P L
- Wagner E G and Lanoix J N (2)
- WHO/CWS/RD/59.1

Gravity feed chlorinator

A commercially available chlorinator can be used to disinfect water supplies that are delivered on a sporadic, continuous but variable, or low-flow basis.



The chlorinator works on a siphon principle. As the siphon tank empties, the water flow and pressure fluctuate uniformly through the system.

The amount of chlorine dispensed can be adjusted by turning the canister up or down.

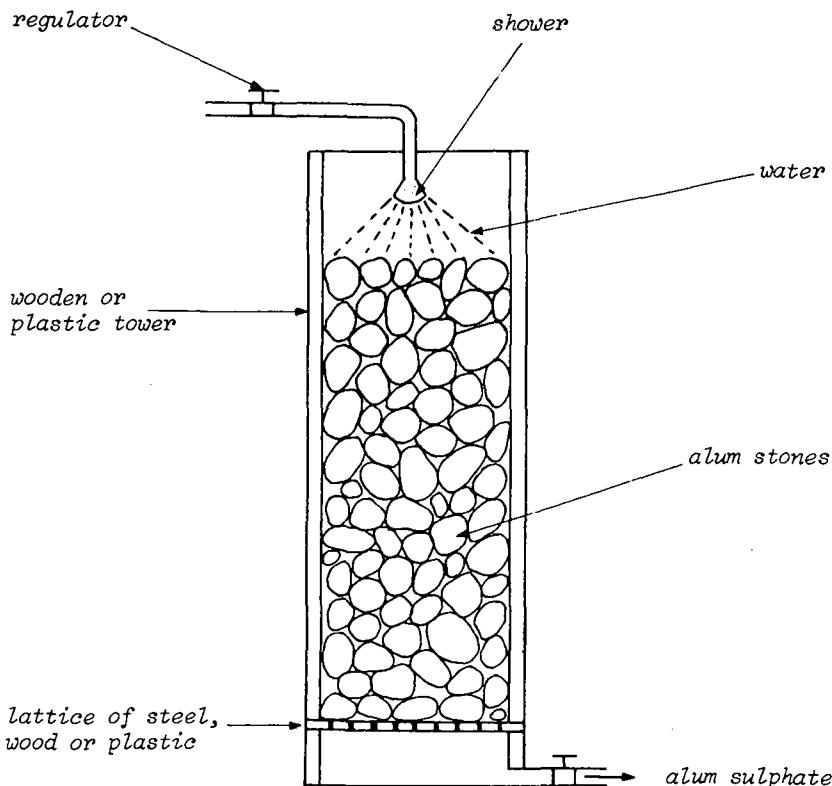
Reference:

VITA US Dept. of Agriculture.

Alum dosing tower

A saturated solution of alum sulphate is obtained by spraying water onto alum lumps which have been packed into a vertical tower about 4m in height.

The amount of water added can be regulated for dosing.



In Indonesia, a ferric aluminium cake has been produced from bauxite waste. This has been found in experiments to compare favourably with commercial alum as a coagulant and dissolves more easily.

Reported use:

Argentina, Chile and Indonesia

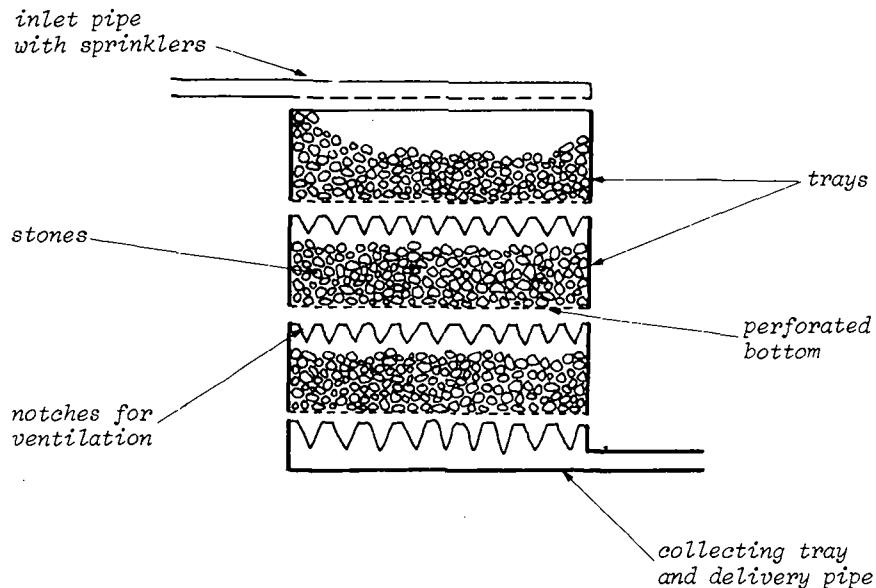
Reference:

Bandung Institute of Technology
Carcedo Eng. M
Rosenfeld B

Trickling filter

The filter unit is made up of trays about 250mm deep, with perforated bottoms. Each tray is filled with broken stone or gravel or coke if this is available.

Large air spaces are left between the trays for good ventilation. The number of trays used will depend on the iron content of the raw water, and the amount of filtering it needs to make it pure. The approximate rate of flow is up to 1600 litres/hour/m².



Reference:

Mann H T and Williamson D

Roof tank for iron removal

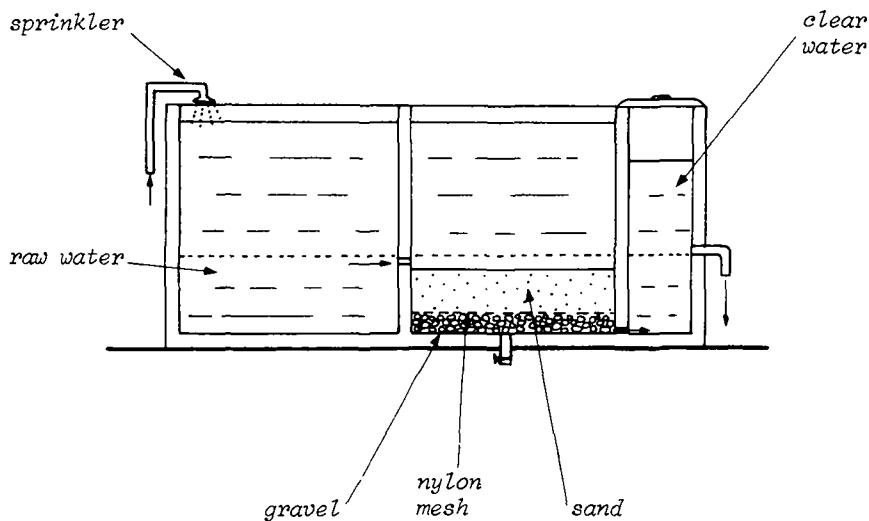
A large roof tank is divided into three compartments, for raw water storage, filtration and clear water storage.

Pumped raw water is sprayed into the first storage tank.

When clear water is drawn off from the third storage tank, this draws more water through the filter.

The filter itself is made from sand and gravel layers with a nylon mesh between.

The amount of water which can be filtered is about 2500 litres/day per m^2 , with a sand depth of 300mm and a gravel depth of 80mm.



Reported use:
India

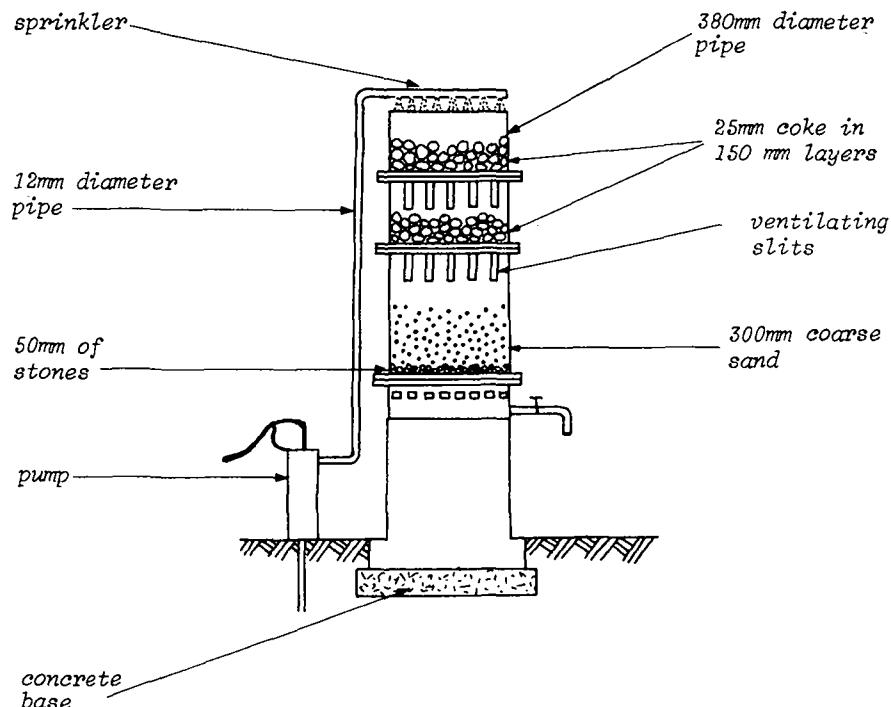
Reference:
Raman A

Iron and manganese removal unit

This unit is suitable for rural purposes, and can be built from several 380mm diameter pipes.

Aeration of the raw water over a series of coke beds is followed by slow sand filtration.

After some time a catalytic oxidation bed is formed which hastens the removal process. No chemicals are needed.



The unit can be worked directly by a handpump.

Raw water containing 1-6mg/litre iron and 0.1-0.3mg/litre manganese is treated in this way at the rate of 200 litres per hour.

Reported use:
India

Reference:
CPHERI (2)

300 Water transport and distribution

Introduction

When a stream or spring is at a higher level than the homes of the people who need its water for drinking and other domestic purposes, the water may be transported by gravity. Usually factory-made pipes are used, but a cheap solution is bamboo pipes (310).

However, in most places water has to be lifted from wells, ponds or streams. Many practical solutions have been developed to do this. Some solutions are primarily for lifting water for irrigation. Many of these are also suitable for raising drinking water and are included here. Other types of lifting device are used only for irrigation and so have been excluded.

Most of the lifting solutions require an input of human or animal energy - by lifting a bucket, operating a handle or turning a wheel. A few solutions do not require any human or animal effort and are therefore very attractive. Pumps using wind power (333.04) are usually expensive. The coil pump (333.05) and the hydraulic ram (350) may be cheap. They use the power in moving water of a stream or canal to lift part of the flow to a farm or village.

For water to be available to people's homes it is often distributed in pipes. For simple systems water is collected from public taps or standposts. IRC/CWS has published information about standpost systems (see Further Reading list), but some waste reduction solutions are given here (360).

Contents

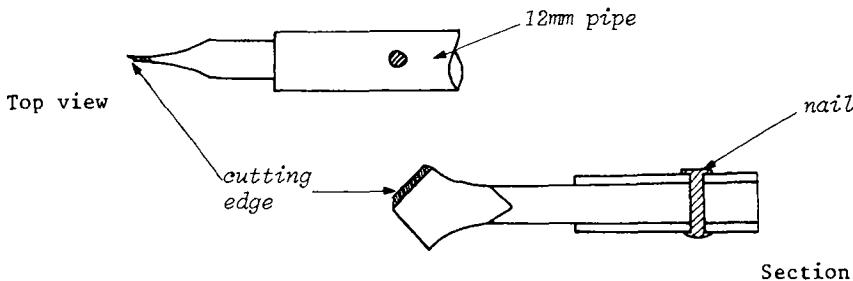
- 310 Pipes
- 320 Storage
- 330 Lifting devices
 - 331 Simple
 - 332 Miscellaneous devices
 - 333 Simple pumps
- 340 Hand pumps
 - 341 Simple
 - 342 Complex
 - 343 Miscellaneous
- 350 Hydraulic rams
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Bamboo water pipes

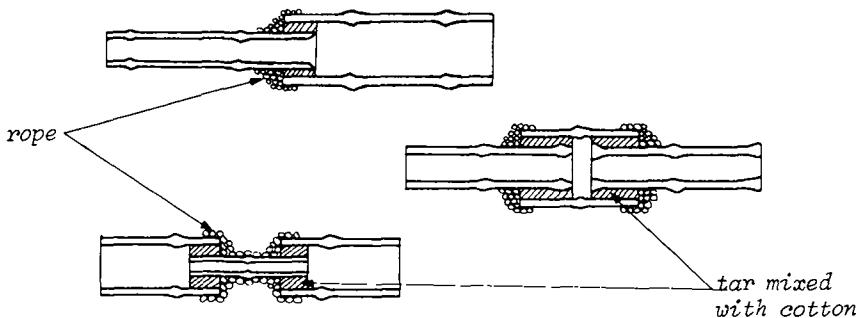
Lengths of bamboo make good water pipes.

The internodes must first be bored out using a piece of sharp steel attached to a long length of small bore water pipe.

It has been found that chisels tend to split the bamboo. A better drill-bit can be made from a piece of 12mm steel rod, (or a bolt). One end of the rod is flattened by hammering it against an anvil. The flattened rod is then ground down to the shape shown in the drawing, so that the two cutting faces lie in parallel directions.



Water-tight joints can be made in several ways, as shown in the drawings below. Soaked cow-hide, rubber inner tubes or tar-soaked rope is used to bind the joints tightly.



For the first three weeks, bamboo pipes give the water an unpleasant taste, but this soon disappears.

Bamboo also removes chlorine from water, so the water must remain in the reservoir long enough to ensure proper disinfection.

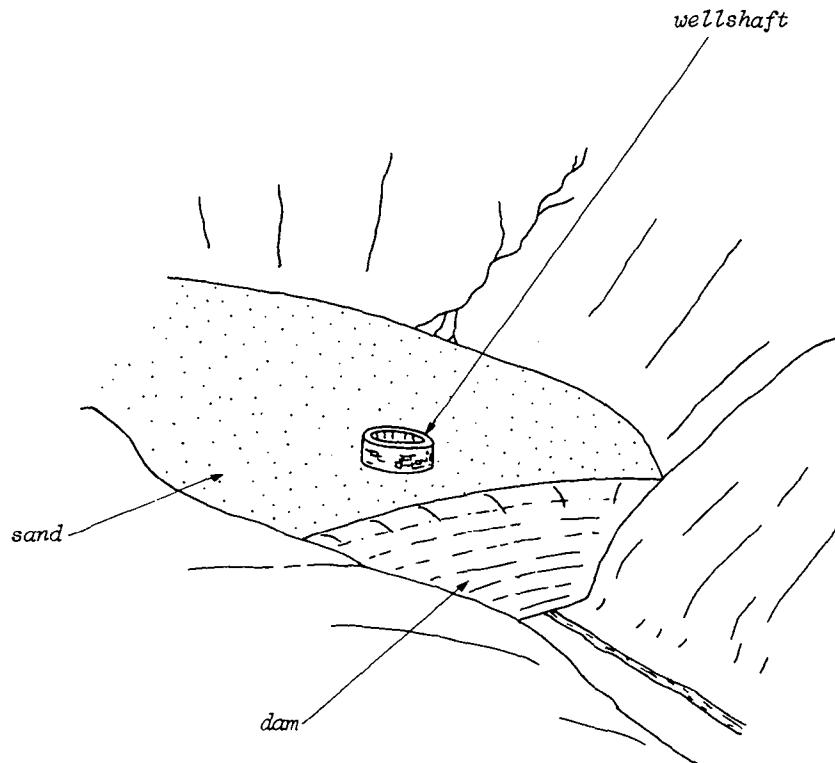
Reported use:
Indonesia and Ethiopia

Reference:
McJunkin F E and Marais G V S
Morgan J

Sand filled reservoir

Loss of water by evaporation is almost completely stopped by this method of water collection.

A dam is built across the riverbed during the dry season. In flood the river deposits sand and gravel behind the dam, which is built up in 1m stages. In this way no mud is deposited. Each metre stage is added when the area behind the dam becomes filled with sand and gravel. The dam is built up to a maximum operating height of 6-10m.



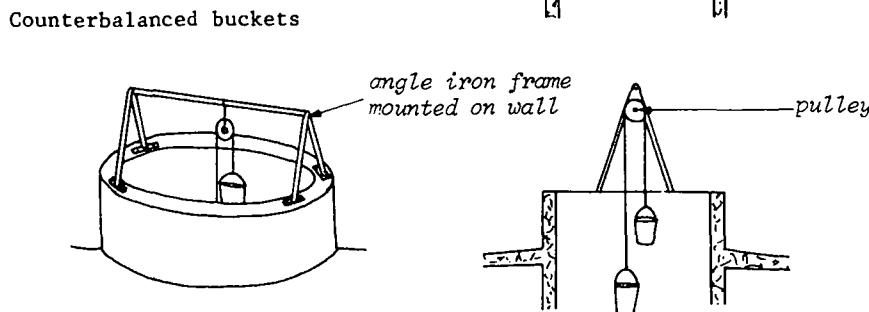
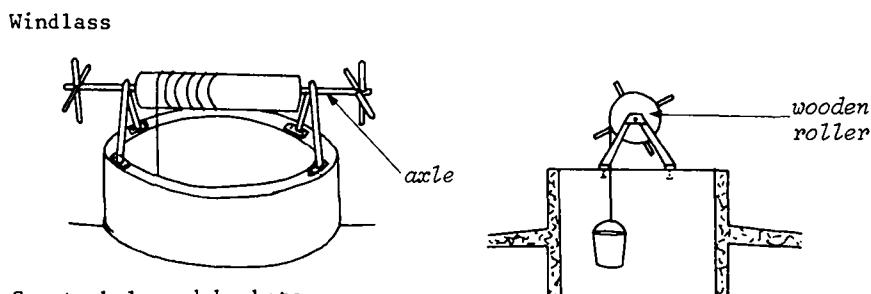
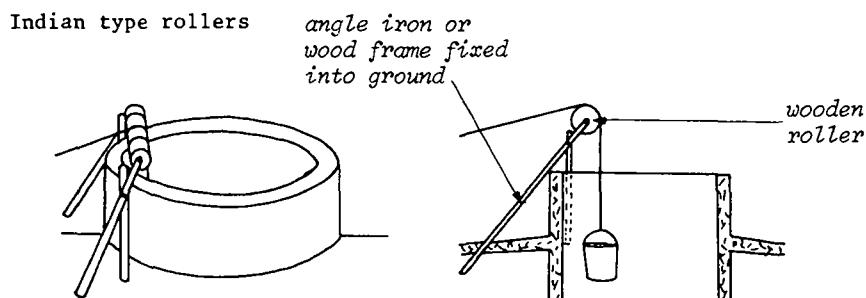
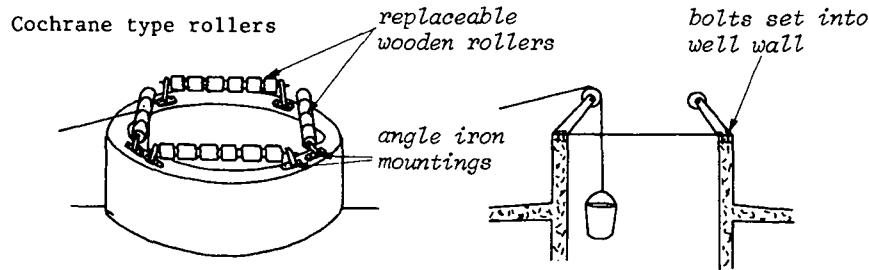
A well shaft or borehole is then sunk into the sand and gravel to enable water to be drawn off.

Although the sand reduces the capacity of the reservoir by about 60%, evaporation is effectively stopped.

Reported use:
South Africa

Reference:
National Academy of Sciences.

Well head lifting devices

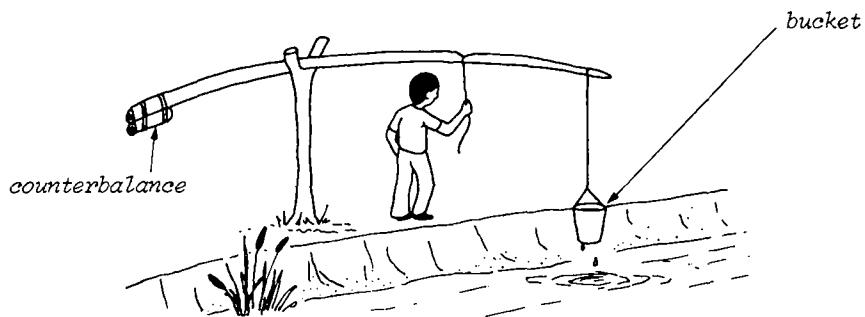


Reference:
Watt S B and Wood W E

Shaduf

A traditional shaduf is a much better way to raise water than a bucket and rope.

The shaduf is a simple arrangement of strong wood or bamboo poles as shown in the diagram. The cross-pole is balanced so that the empty bucket is in the air, and is not put down onto the ground. This means that the risks from contamination of the bucket and rope are much reduced.

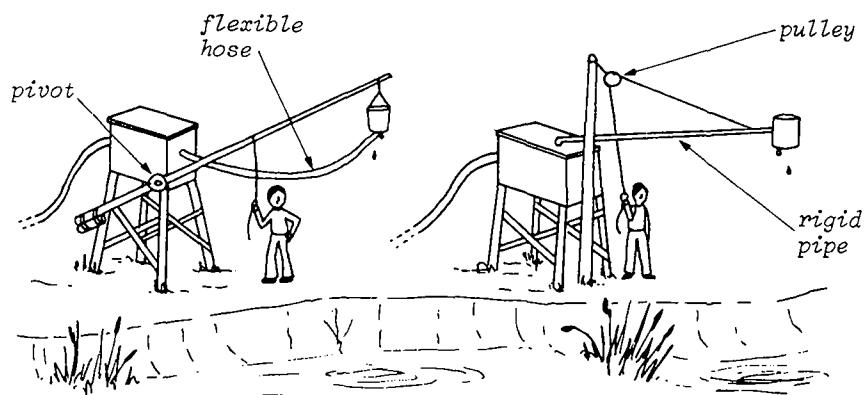


Simple modifications to the traditional design, making the shaduf self-emptying into a storage tank, will make it even safer and easier to use.

The best way to do this is to attach a flexible hose or rigid pipe to the bottom of the bucket, leading into the tank.

When the bucket is raised the water runs down the pipe into the storage tank.

By this method the user need never touch the bucket or put it down onto the ground, so that contamination is very unlikely.



Reference:

SUPHI H S. WHO New Delhi.
Mann H T and Williamson D

Siphon

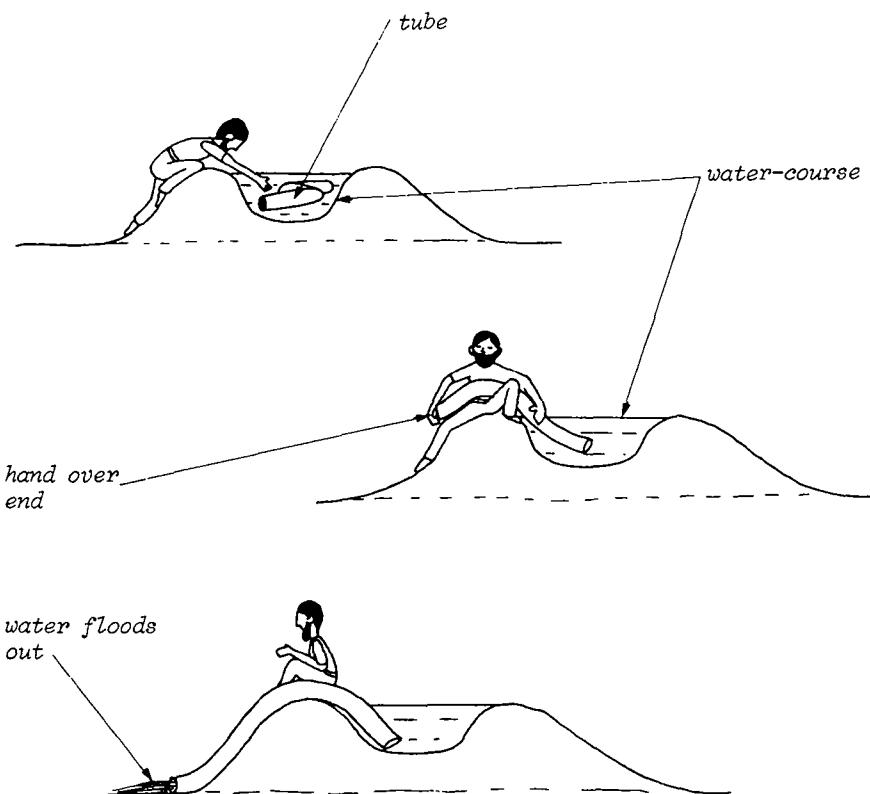
This is a suitable method of lifting water from a canal or water course, down to the adjacent land.

A flexible tube of 25-75mm diameter is totally immersed in the water. One end of the tube is then covered with the hand and lifted over the side of the water channel.

The hand is then taken away and water flows onto the land under its own power, provided the end of the tube is kept at a lower level than the water in the channel.

The other end of the tube is kept at all times below the water surface in the channel.

The rate of flow depends on the difference in level between the channel water level and the point of discharge, and on the diameter of the tube used.



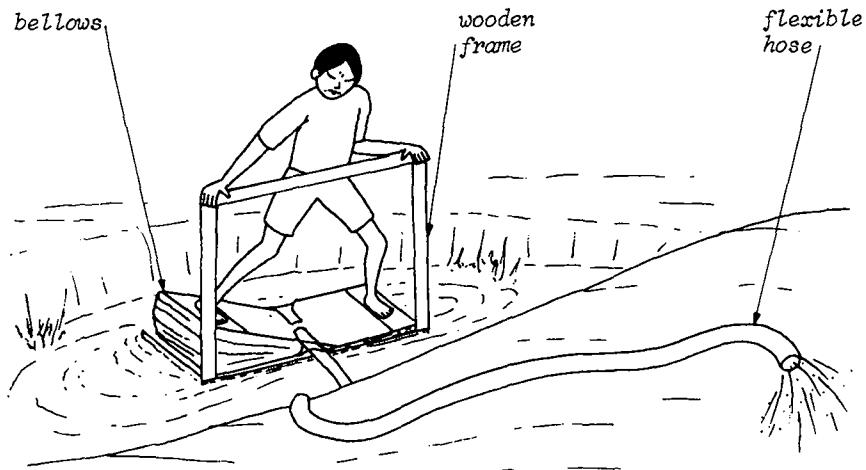
Reference:
WEDC (1)

Bellows pump

This was first designed to meet a need in some areas for a low cost portable, manually operated pump, suitable for low-lift operations such as irrigation and drainage.

The foot-pump is made from two canvas bellows with metal inserts for reinforcement. Each bellows has an inlet and outlet with a flap-valve. The outlets are joined and connected to a length of flexible hose.

The foot-pump is set into the base of a strong wooden frame, as shown in the picture.



To operate the pump, the man stands on the foot rests and shifts his weight from one foot to the other. This causes one of the bellows to compress, forcing the water from the outlet and along the hose. At the same time, more water is being drawn into the other bellows. By shifting his weight rhythmically, a continuous flow of water can be pumped.

The pump unit is easily carried by one man. It is most useful for pumping water from irrigation ditches, open channels and shallow wells, and it can handle water containing mud, small stones and other impurities. It will lift 50 gallons of water per minute to a height of 1-2m.

The pump can be made easily in a small machine shop, and then is very simple to maintain.

Reported use:

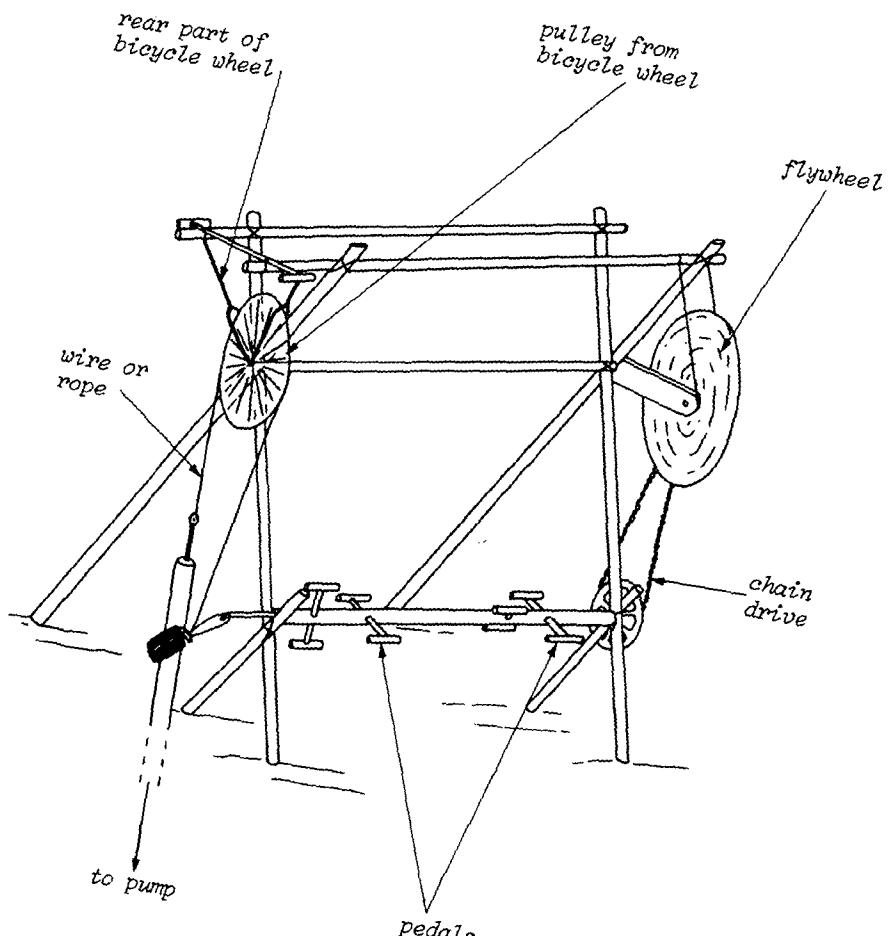
Designed and used in Asia.

Reference:

International Rice Research Institute.

Pedal drive

This is a simple pedal drive for connection with a borehole pump. The main construction is from bicycle parts, as shown in the drawing below. The pedal drive is easily operated by one or two men.

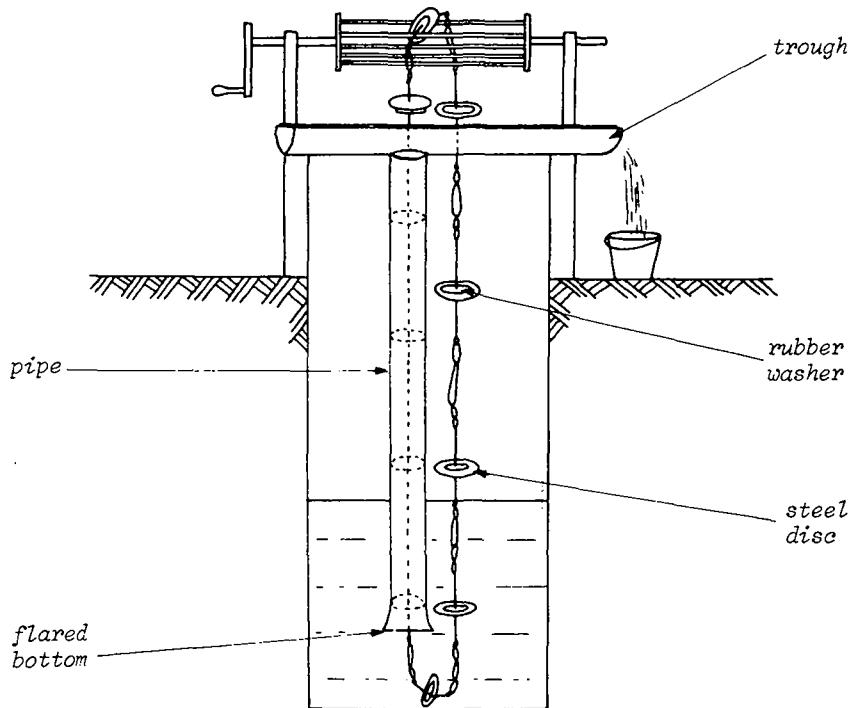


Reference:
Wilson S S

Chain and washer pump

This method of raising water uses steel or wooden discs welded or riveted to short lengths of steel rod, joined together to form a circular chain.

As the handle is turned the chain is pulled up through the pipe, which is the same diameter as the discs, so water is drawn up and discharged into the trough fixed to the well head wall.



Reference:
Cairncross S and Feachem R

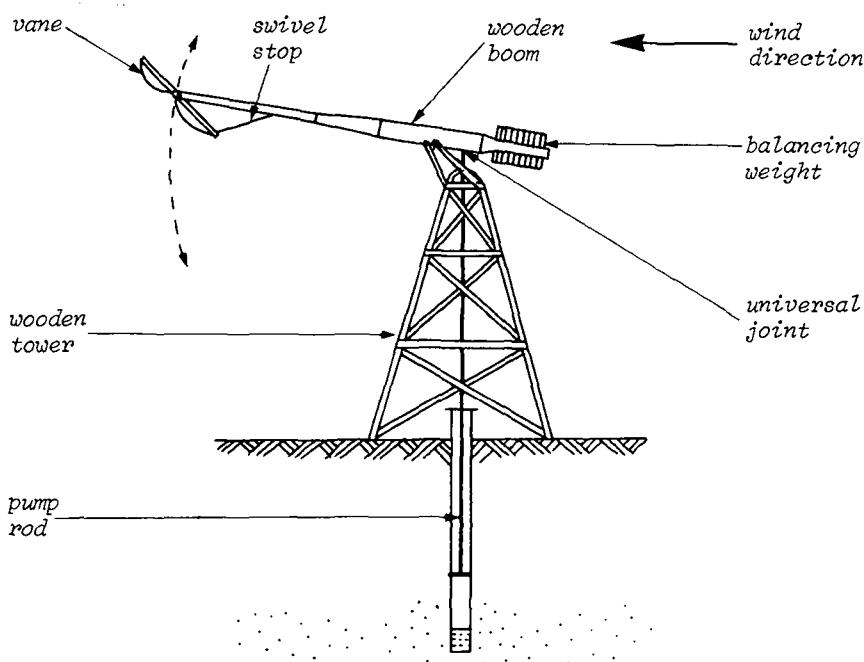
Flapping vane wind pump

This type of pump is a simple way to pump water out of deeper wells at a small flow rate.

It creates an up and down movement so avoiding complicated gearing and motion converters.

The tail vane is pivoted behind the point where lift forces apply, so it is held in either of its extreme positions until the boom reaches its limit of movement. Then the vane is beyond a horizontal position, causing the lift forces to reverse and the boom to swing in the opposite direction.

The boom rotates on the top of the tower so that it can swing in the downwind direction no matter which direction the wind is blowing.



The mean daily output of this pump is $100\text{m}^3/\text{day}$, and the maximum delivery height is 40m.

The amount of wind intercepted is, however, rather small and so the power efficiency of the system is limited to about 0.15.

Reference:

German Foundation for International Development.

Coil pump

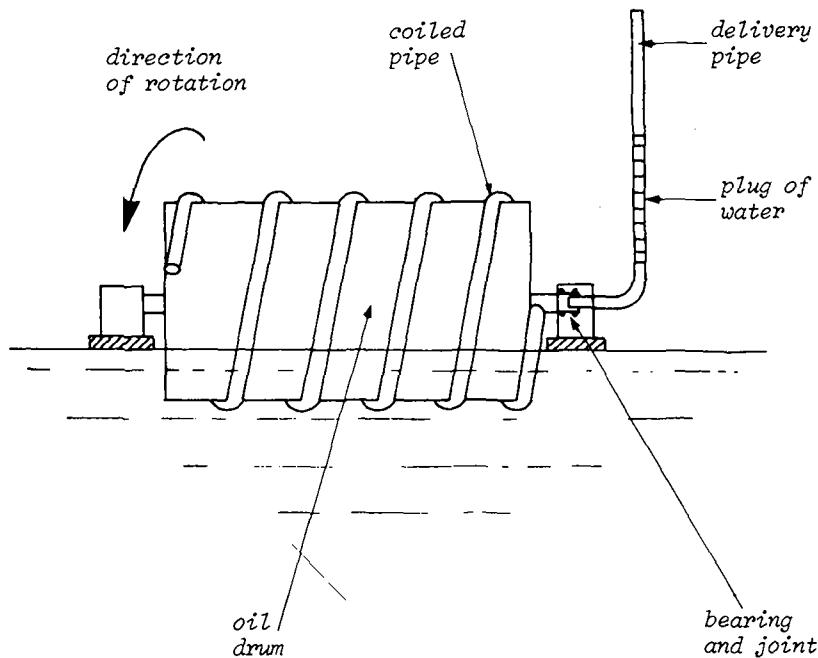
The pump is made from a coiled pipe which is partially immersed in water and rotated.

One end of the pipe is open while the other end is connected to a fixed pipe with a joint and bearings.

As the coil rotates, a plug of water enters the open end of the pipe while it is under water. This passes on round the coil and up the fixed pipe, followed by further plugs of water.

The coil pump is easily made by wrapping a flexible pipe around an oil drum. The only mechanical parts requiring precision are the rotating joint and bearings.

The power to turn the pump can come from a water wheel built around the drum.



A 300mm diameter drum holding a 25mm diameter coiled plastic pipe with 20 coils, will pump water to more than 7m height with discharges of 0.15 litres/second.

Reported use:

The pump is being developed and tested at Loughborough University of Technology, England

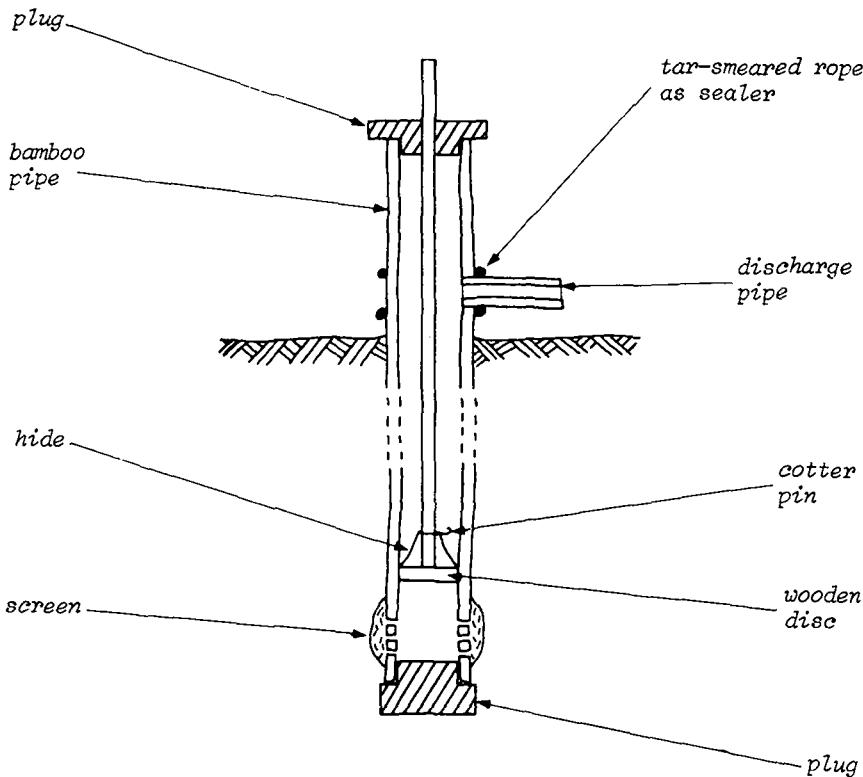
Reference:

Mortimer G H

Bamboo pump

This is a very simple pump to make, using entirely local materials. The pump cylinder is made from 75-100mm diameter bamboo pipes. The foot of the cylinder is made into a screen by drilling holes in the bamboo and packing it round with fibrous material made from palm trees.

Both ends of the cylinder are plugged with maydou wood. The pump rod is made of wood, with a wooden disc at the end, a little smaller in diameter than the pump cylinder, and covered with hide.



Reported use:
Laos

Reference:
Hazbun J A

Simple pump using local materials

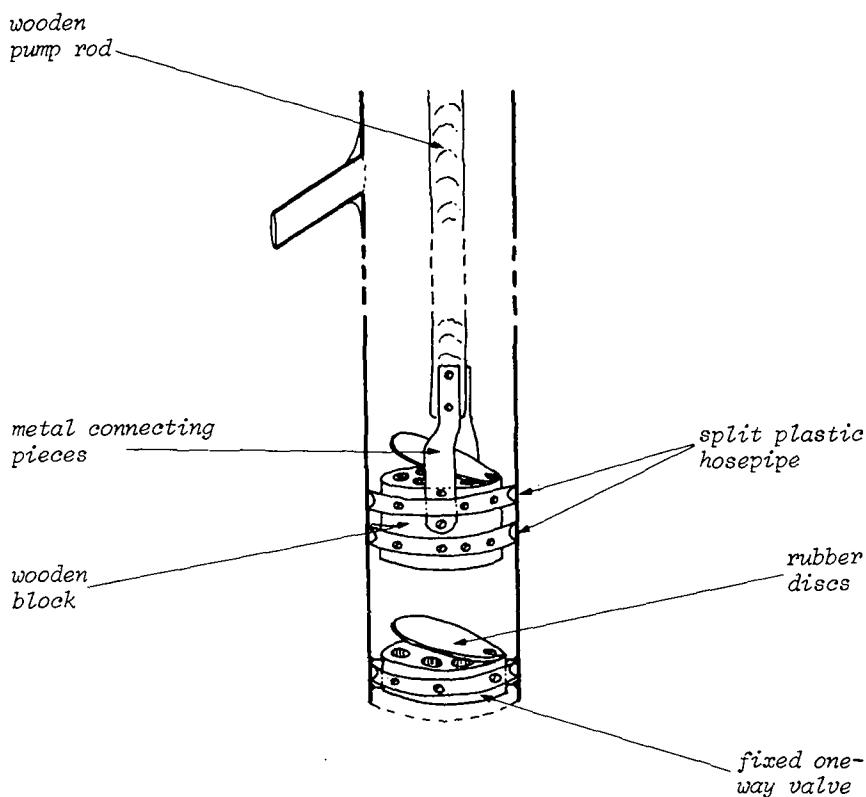
This pump is hand made from local materials.

The pump cylinder can be bamboo or plastic piping, and the pump itself is made of a wooden block with holes drilled in it.

At the foot of the tube is a similar perforated block, and both blocks are fitted with rubber discs which act as valves.

Split plastic hosepipe is fixed around the wooden blocks to act as a seal.

As the pump is forced up, the valve at the bottom of the pipe opens and water is drawn up, while the other valve is closed. When the pump is pushed down, the bottom valve closes and water is forced up through the other, open valve.

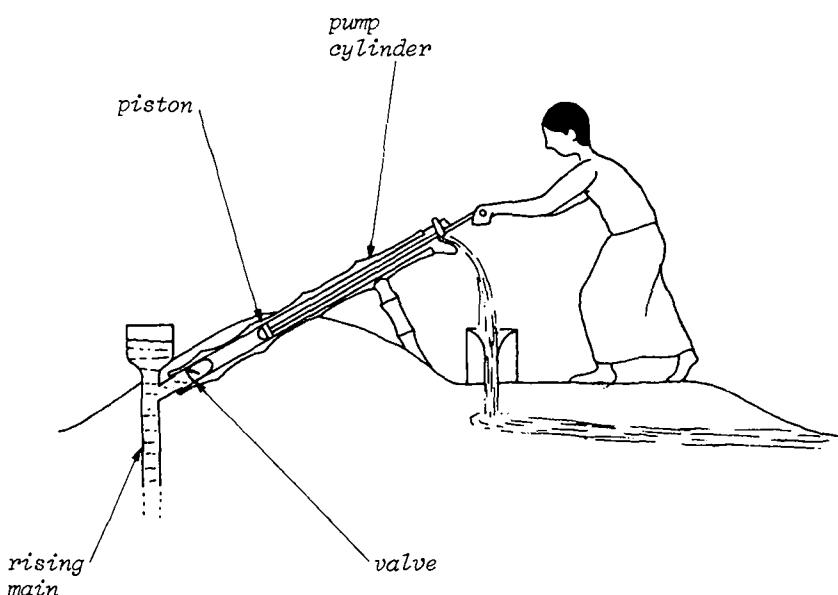


Reported use:
Laos

Reference:
Jolly P W

Rower handpump

This is a PVC suction pump, suitable for use in shallow wells. The handpump section is a 3.5m PVC pipe, 50mm in diameter, attached above the ground to the vertical rising main at an angle of 30° to the horizontal. Valves are made from old rubber inner tubes.



The pump is very cheap and easy to maintain, since there are no bearing points to wear quickly, and parts can be repaired and replaced locally.

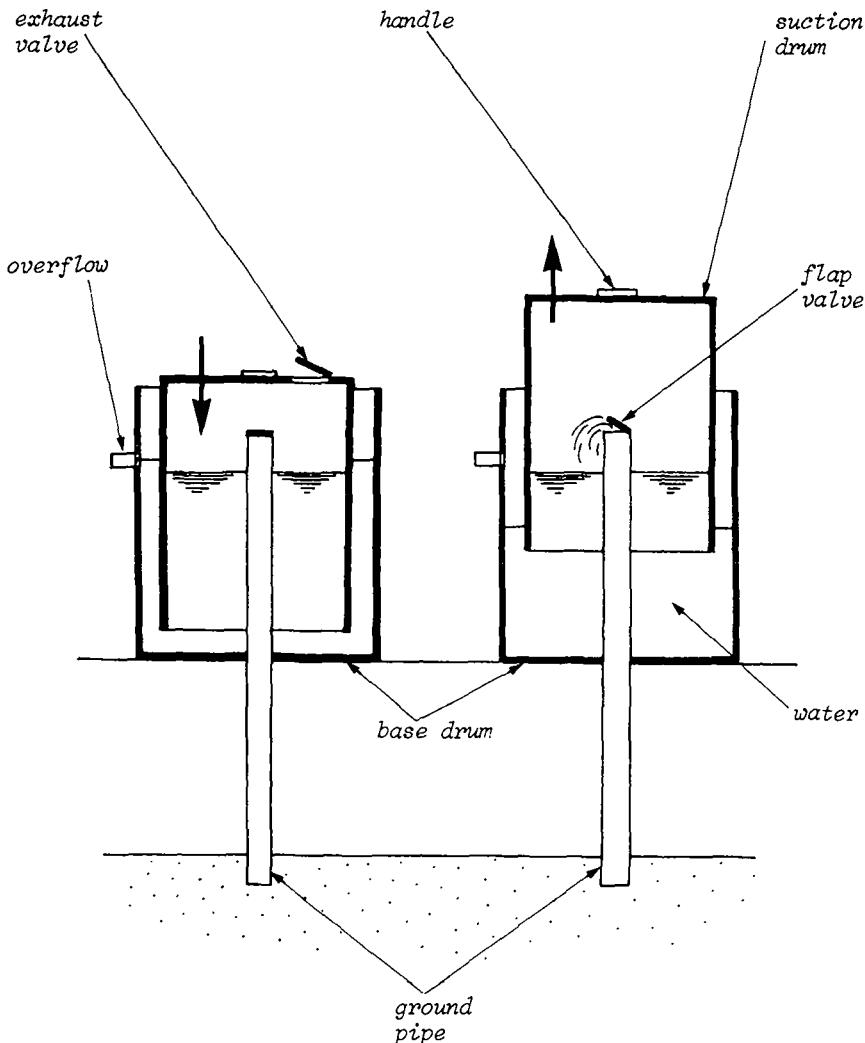
One person can pump more water using this pump than with a cast iron pump, and can pump for longer periods before needing to rest. A suction surge chamber increases the amount of water pumped. The pump is easy to position with little stress on the pump cylinder.

Reported use:
Bangladesh

Reference:
Klassen G

Oil drum pump

This consists of a base drum fitted with an overflow, and a suction drum with an exhaust valve. A ground pipe with a non-return flap-valve is fitted inside the base drum, and reaches below the water level.

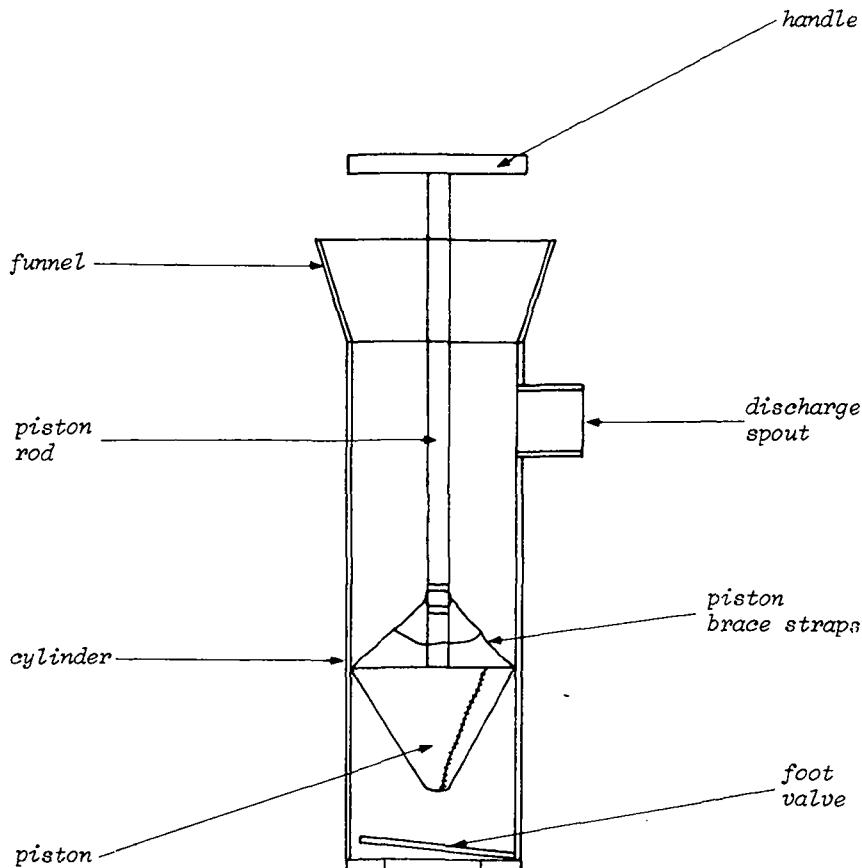


Lifting and lowering the suction drum with the handle causes water to rise in the ground pipe and spill out of the overflow into a suitable container or collecting trough.

Reference:
VITA document XVI AC-8 (3)

Leather cone pump

This is a portable pump, suitable for low-lift operations. It functions through a conical shaped leather piston.



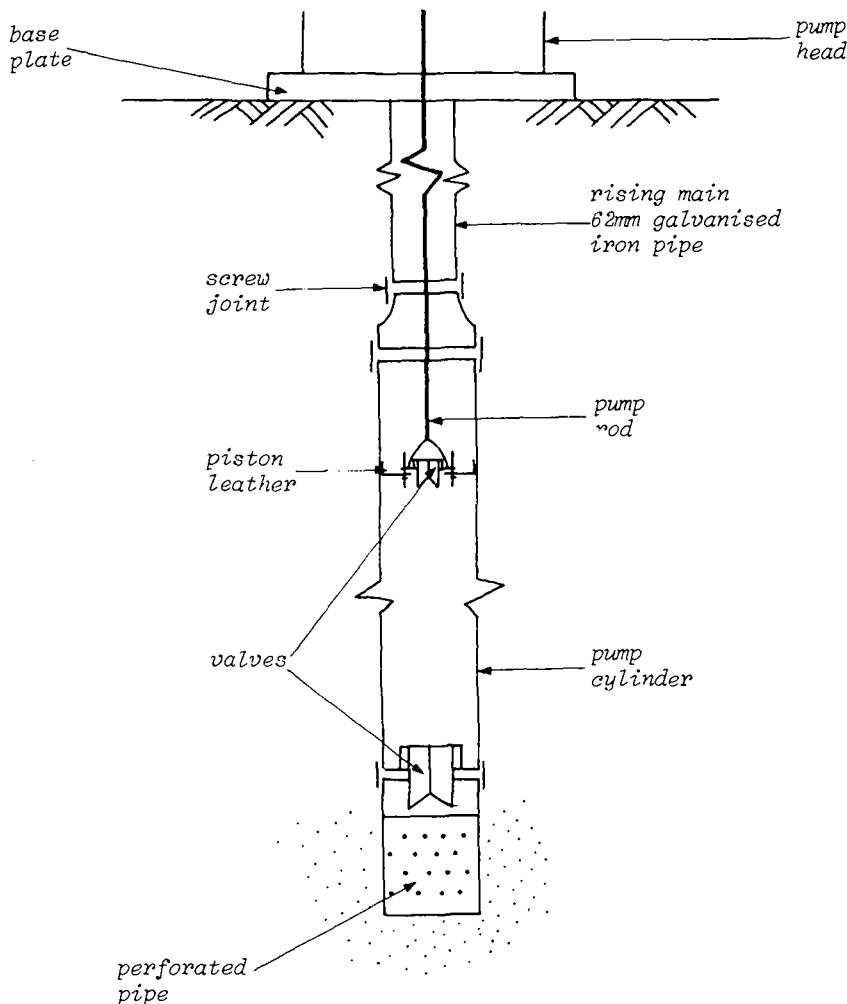
At the upstroke the water above and inside the leather cone causes this to expand and seal against the pump cylinder. Water now enters at the bottom, through the opened foot valve.

At the down stroke the cone folds in and water moves up past the piston.

Reference:
VITA document XVI AC-8 (3)

Handpump using standard galvanised iron fittings

Here, a short piece of 75mm diameter galvanised pipe is used as the pump cylinder, with 12mm diameter galvanised pipes as pumprods. The foot of the cylinder is perforated, and fitted with a fixed valve. The pumprod is also fitted with a valve.

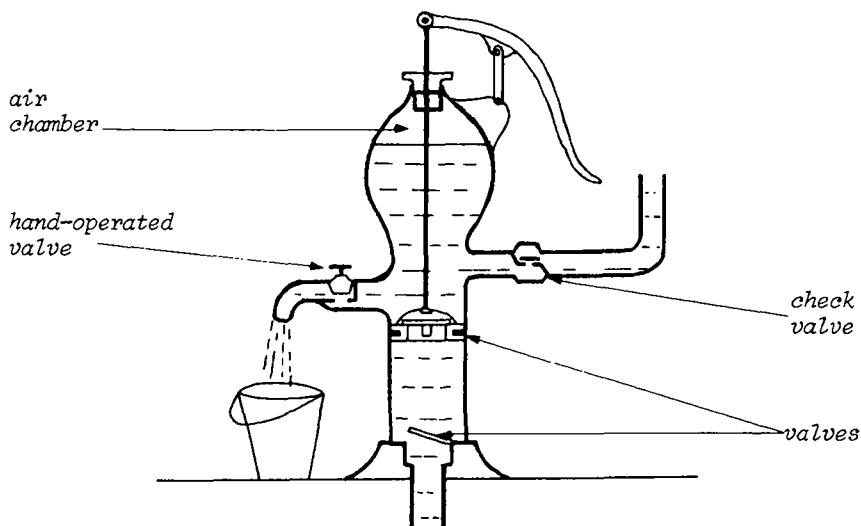


Reported use:
Zambia

Reference:
Suphi H S

Force pump

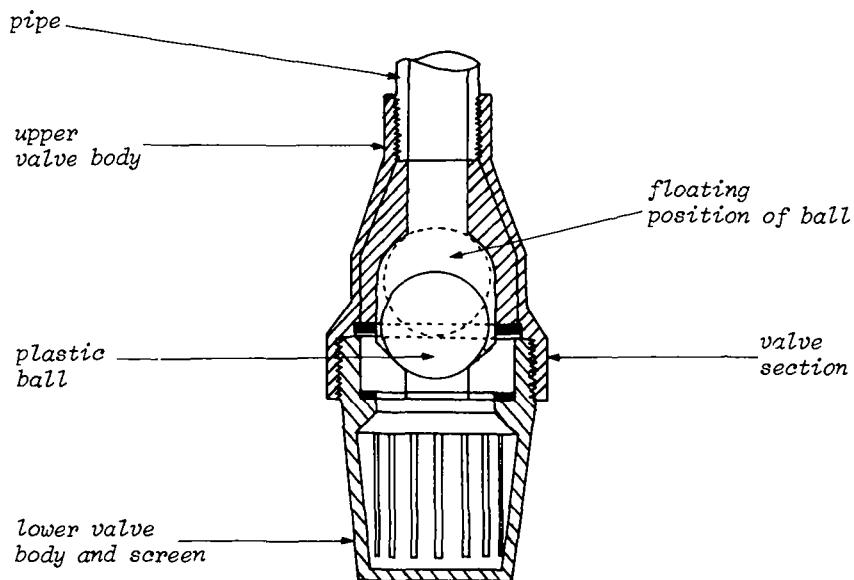
This type of pump can be used either to draw water off directly at the pump, to pump the water up to a higher point by closing the hand operated valve.



Reference:
Wagner E G and Lanoix J N (2)

Floating ball foot valve

This newly-designed foot valve gives improved efficiency because of the easier opening of the valve, using a plastic ball.



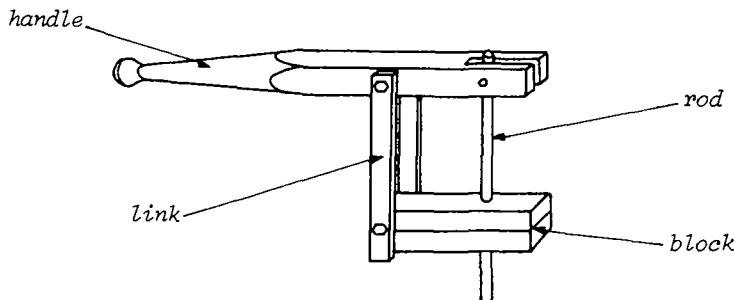
Reference:
Emmanuel V J

Handpump handles

Wooden

This durable handpump mechanism has wooden wearing parts, which are easily replaced by the village carpenter.

It is designed to replace the handle mechanisms of traditional, factory-made iron handpumps.



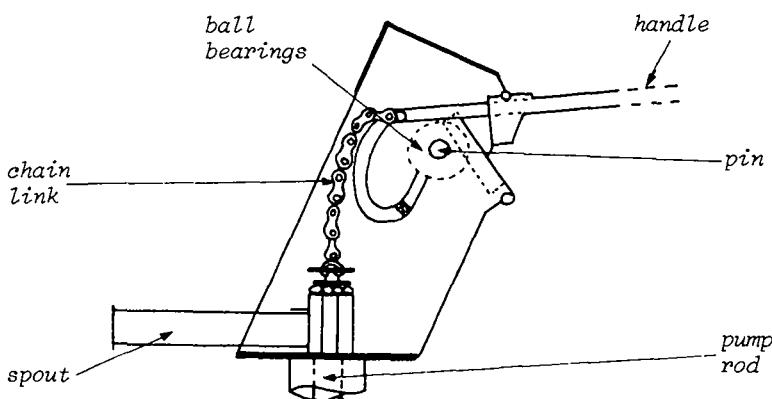
Reference:
VITA document XVI AC-8 (3)

'Chain' type

This type of pump is designed for heavy duty, to serve about one hundred families.

The hand mechanism is made of steel, with sealed roller bearings and heavy duty guided chain.

The pump is expected to have one or two years of heavy use before any maintenance is needed.



Reported use:
India

Reference:
Sandberg L

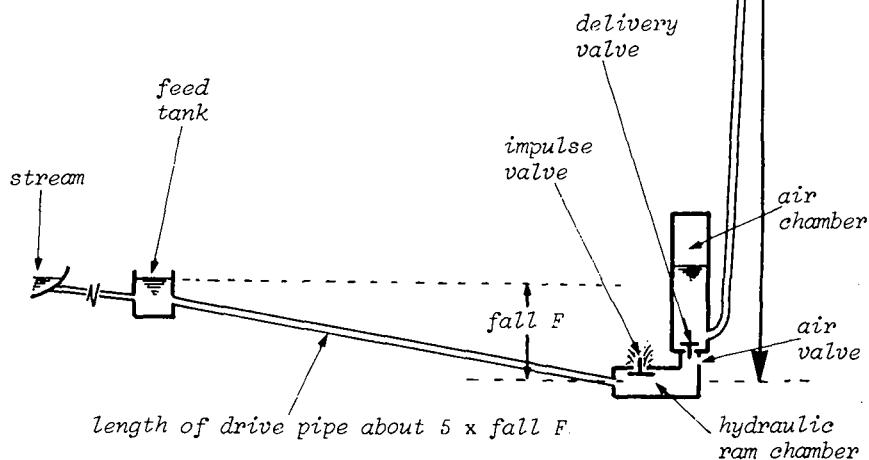
Hydraulic ram system

A hydraulic ram uses the power of falling water to lift a small part of that water to a higher level. It requires no fuel or electricity and operates automatically.

Water from the stream or other source passes along the drive pipe and out of the impulse valve. The flow shuts the valve suddenly, giving high pressure in the ram chamber.

This opens the delivery valve and water goes up the delivery pipe and air chamber, compressing the air at the top of the air chamber. Pressure in the ram chamber then drops, causing the delivery valve to shut and the impulse valve to open. Water flows out of the impulse valve and the cycle is repeated.

Meanwhile the air in the air chamber expands pushing water up the delivery pipe with steady flow. When the pressure drops, some air is drawn in through a small hole (the air valve). This replaces air at the top of the air chamber, some of which becomes dissolved in the delivered water.



The quantity of water which can be delivered is about $\frac{2}{3} \frac{F}{H} \times D$, where D is the volume of water passing along the drive pipe from the feed tank. Put another way, if you want to deliver water at a rate of V cubic metres a day, there must be $1\frac{1}{2} \times H/F$ cubic metres available each day for the drive pipe.

References:

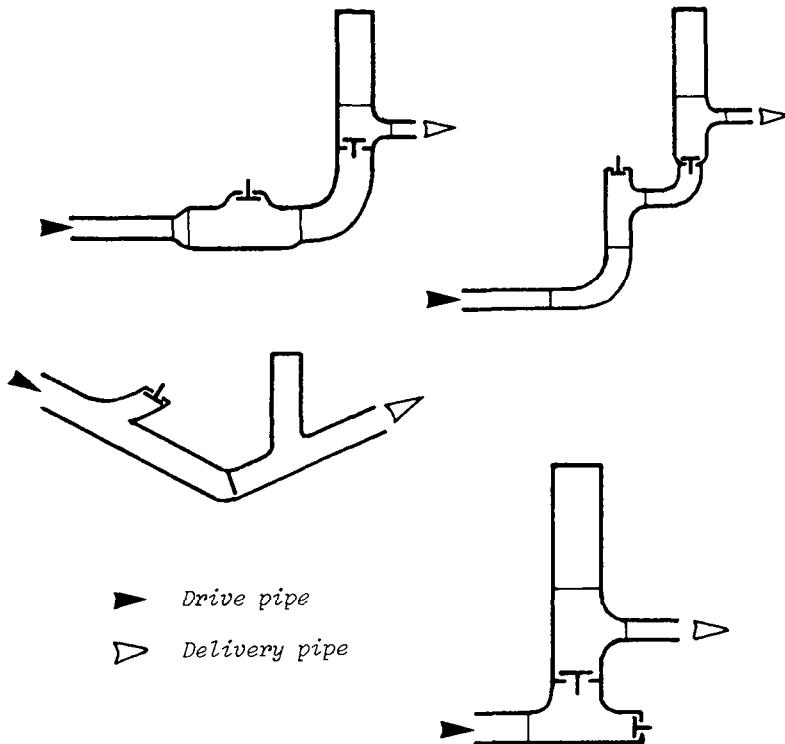
- Blake J
- ITDG (1)
- VITA (4)

Hydraulic ram design

Most commercial hydraulic rams have a cast iron or steel body which is strong and durable. Some rams have been used continuously for more than fifty years.

A cheaper ram can be made locally with standard fittings - pipes, T-pieces, elbows, bends and reducers. Rams can also be fabricated on site by welding pieces of standard pipe together, or making the chamber with concrete.

The following are some arrangements which have been designed and used in various parts of the world.



Reference:

East Coast Aborigine Agricultural Service Centre
ITDG (1)
Martin N and Burton R
VITA (4)

Hydraulic ram valves

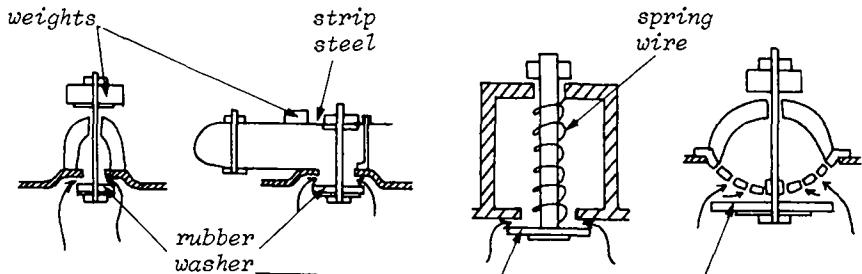
Impulse valve

This should be designed so that its weight and stroke can be adjusted for tuning.

A heavy weight and long stroke allows high flow rates through the impulse valve, building up the powerful pulse needed to drive water up to a high head.

A small weight and short stroke beats more quickly and drives larger volumes of water to lower heads.

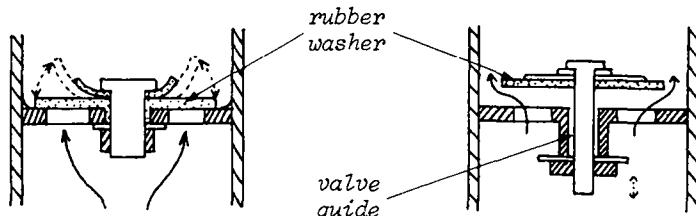
The adjusting mechanism can be constructed in any of these ways:



Delivery valve

This should have a large opening to allow pumped water to enter the air chamber easily.

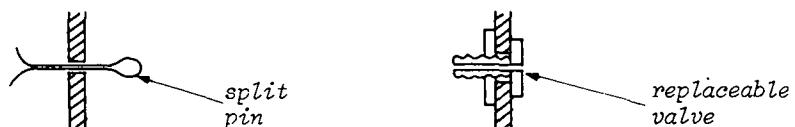
It can be made as a simple non-return valve of stiff rubber, or as a clack valve.



Air valve

This replaces the air in the system which is absorbed or lost into the delivery pipe.

It is adjustable to give a small squirt of water with each compression pulse. If it is too far open the air chamber fills with air and the ram then pumps only air. If it is not open far enough, the ram pounds with a metallic sound and eventually breaks.



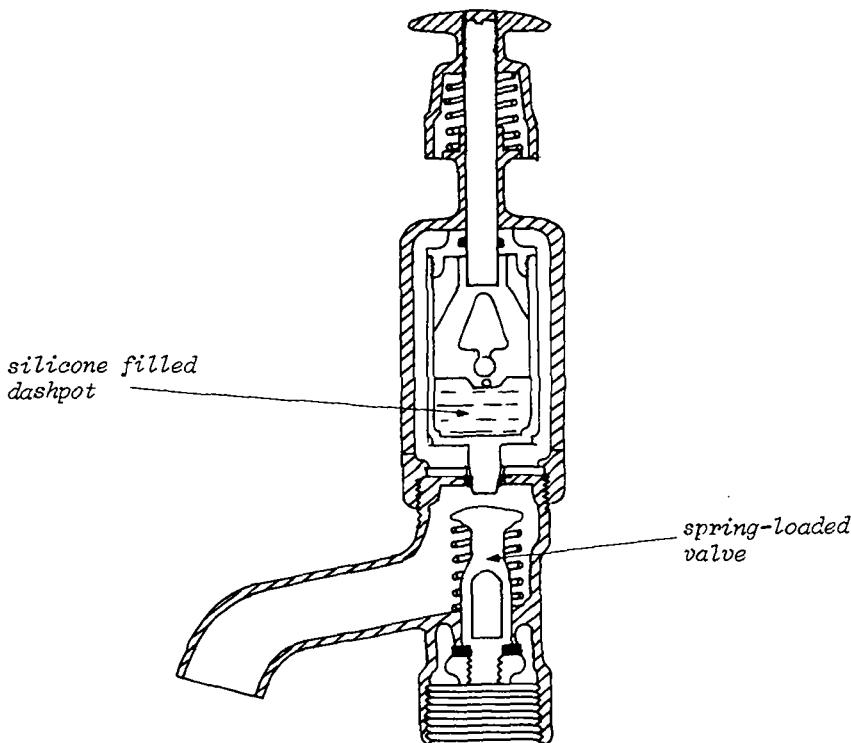
Reference:

Watt S B (1)

Spring loaded faucet

This faucet cannot be held or tied open, and it discharges about 1 litre of water at a time for each push.

By means of a simple dashpot mechanism, the device closes automatically in 6 seconds and must be operated for each discharge.



Reported use:
World-wide

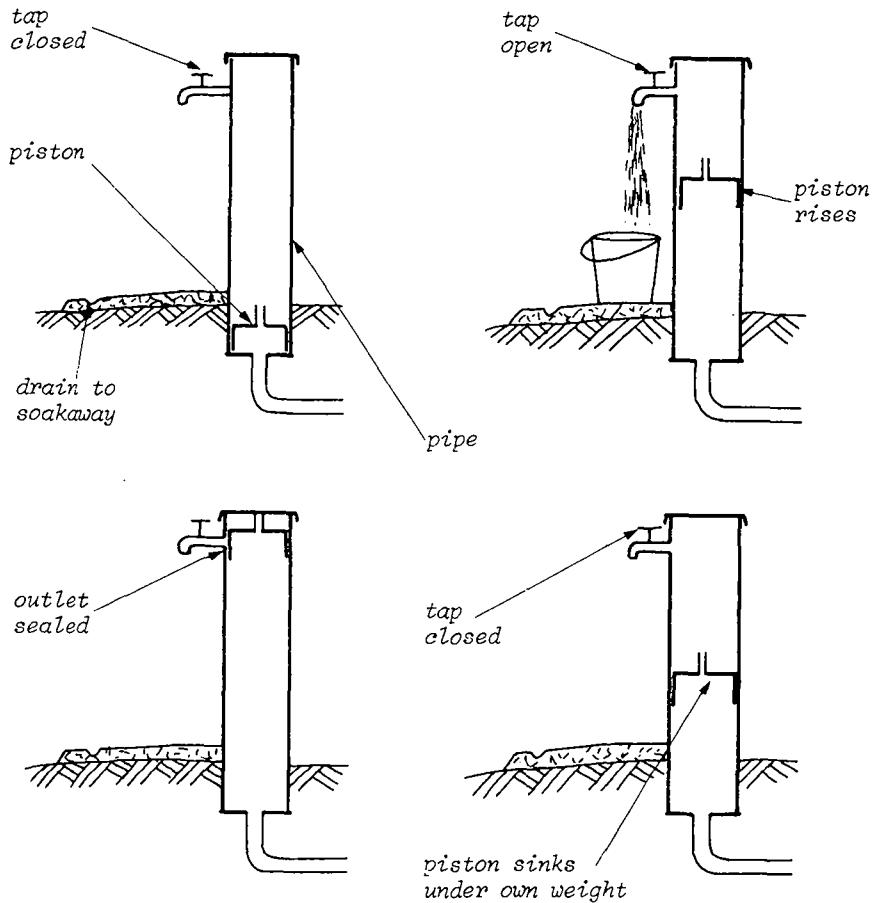
Reference:
Borjesson E K G and Bobeda CM
JAWWA 1964, p.853 - 862

Public standpost

This standpost is used with a gravity or pumped pressure supply.

A 150mm diameter pipe is used, inside which a free piston slides. The piston is made from a piece of 10mm diameter pipe inserted into a rubber sheet, about the same diameter as the main pipe. Between the top of the piston at its lowest position, and the outlet top, the capacity of the standpost is 20 litres.

The opening in the piston and its weight can be adjusted so that the piston rises under the pressure of incoming water when the tap is opened, and sinks slowly when the tap is closed.



Reference:
WHO/CWS/RD/59.1

400 Waste disposal

Introduction

Where money and water are plentiful, water-carried sewerage is appropriate and provides the best sanitation system. But for most people in developing countries alternative methods for the disposal of excreta have to be provided.

The most common low-cost excreta disposal method is some form of pit latrine (410). In the pit faeces decompose. Liquid - urine, water from anal cleansing and the products of decomposition - infiltrates into the ground under and around the pit. The pit may be immediately under the latrine or may be at the side. With a pour-flush latrine (411.07) excreta is washed into the pit from the latrine along a short length of pipe.

In compost latrines (420) faeces are decomposed, or 'composted' in watertight chambers. Vegetable waste is usually added and urine may be excluded. The Biopot (421.02), although included with compost latrines, is really a form of pit latrine as liquid seeps into the ground through the base. In biogas plants (422.03) the gas given off during decomposition of faeces is used for cooking and other purposes although care must be taken to prevent dangerous conditions.

In septic tanks and aqua-privies (430) excreta is partially treated in watertight chambers and the effluent normally percolates into the ground from a stone-filled trench or soakpit (432.02).

The disposal of wastewater which has been used for bathing or washing clothes, dishes and cooking utensils presents problems in unsewered areas. Some form of soakpit (440) is a satisfactory solution where the ground is suitable.

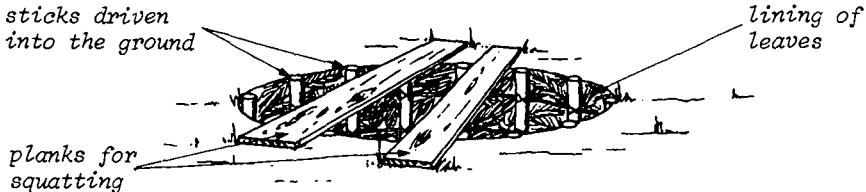
Solid waste (refuse or garbage) is another sanitation problem. One solution is to burn it (450).

Contents

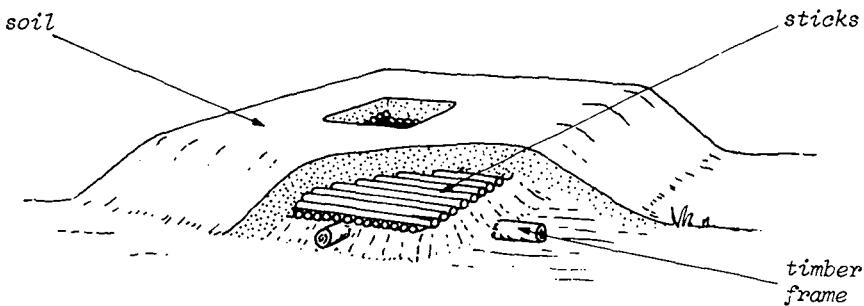
- 410 Pit latrines
 - 411 Types
 - 412 Components
- 420 Composting
 - 421 Composting latrines
 - 422 Separate composting
- 430 Septic tanks and aqua privies
 - 431 The chamber
 - 432 Effluent treatment and disposal
- 440 Wastewater
- 450 Solid waste

Simple pit latrine

In its simplest form, the pit latrine is a hand-dug pit, up to 6m deep and about 1m wide. The sides of the pit may be strengthened and lined with sticks and leaves to help prevent collapse.. The squatting slab can be two planks laid across the opening of the pit.



A safer slab is made by covering the opening of the pit with a timber cross-frame covered with layers of sticks and soil. An opening is left in the centre.



When the pit is full, another is dug nearby, and the shelter is moved to the new site, while the old pit is filled in with soil. The shelter itself can be a simple grass mat hung on a frame of poles, or it may be a more substantial structure with solid walls and a roof.

The cost of building these simple latrines is low, and they can be built by the users without outside help. They are used mainly in rural areas, where one latrine lasts an average family from a few months to several years. Pit latrines in towns are usually better-built.

Pit latrines are only safe where the soil is deep and permeable, and where the water table is below the level of the pit bottom. If the soil is loose and soft or if water softens the sides of the pit it will collapse, unless a strong lining is provided. Also, if water collects in the pit it may become a breeding ground for mosquitoes.

Reference:

- ATH Newsletter 3, WHO
- Feachem R and Cairncross S
- Winblad U, Kilama W and Torstensson K
- Bell M and Pickford J

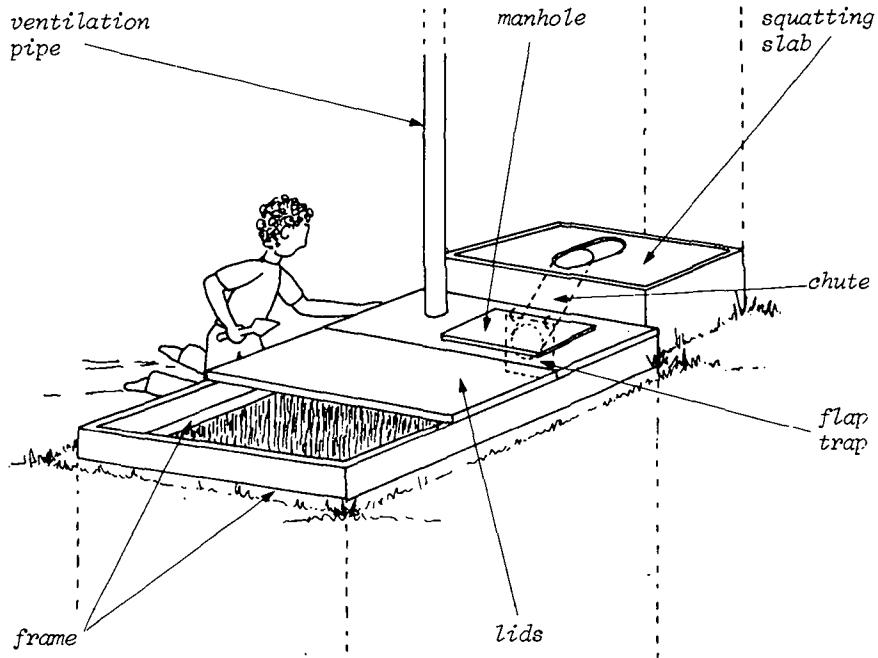
Reid's odourless earth closet

A pit, 1m wide by 2m long is dug, as deep as possible above the ground water level.

A wood or concrete frame is built round the mouth of the pit and the pit sides can be lined, leaving holes in the lining to allow for soakage.

The squatting slab is built offset to one end of the pit, and joined to the pit by a straight chute protected by a flap trap. The pit is then covered with concrete slabs fitted with a manhole and a ventilation pipe.

The covers must be made tight-fitting by sealing the joints with mortar or covering over the slabs with a thick layer of earth. This will prevent flies from getting in.



The pit fills up very slowly and lasts for many years.

It is odourless and so can be built into a house, with the pit dug outside the wall.

Fly breeding is possible in the pit, but if all the parts are tight fitting and are checked regularly, this can be avoided.

The pit must be kept free from liquids, as this can create a risk of mosquito breeding.

Reported use:

Africa

Reference:

Winblad U, Kilama W and Torstensson K
Bell M and Pickford J

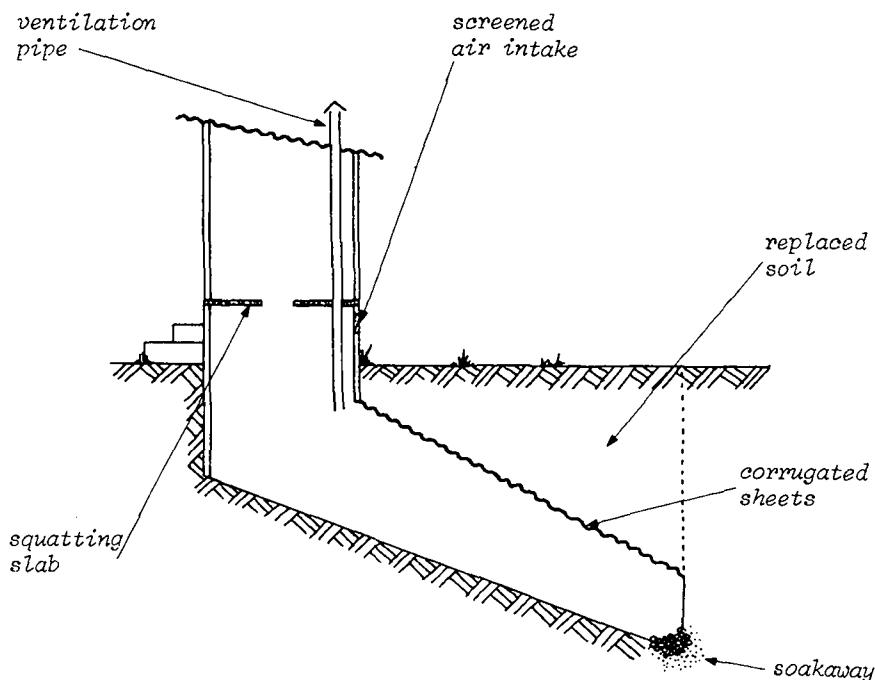
Diagonal pit latrine

In this case, a trench 2.5m long is dug, with one end 300mm deep and the other end 1.7m deep.

The receptacle and squatting slab are built into the shallow end and extend up to 800mm above the ground. An opening is left on the side facing the trench for a screened air intake hole.

At the bottom, the trench becomes narrower and shelves are shaped on the sides about 400mm above the bottom. Corrugated metal sheets are laid on these shelves to make a tunnel from the receptacle end to the lower end, where a soakaway is made.

The soil is then replaced on top of the tunnel, and the shelter is built around the squatting slab.



Because the liquids are drained off, this type of latrine can be used for composting of waste, but to remove the compost the trench must be dug up.

This is a new type of latrine which has so far only been tried on a small scale. It is difficult to build and is liable to collapse.

Reported use:
Tanzania

Reference:
Winblad U, Kilama W and Torstensson K

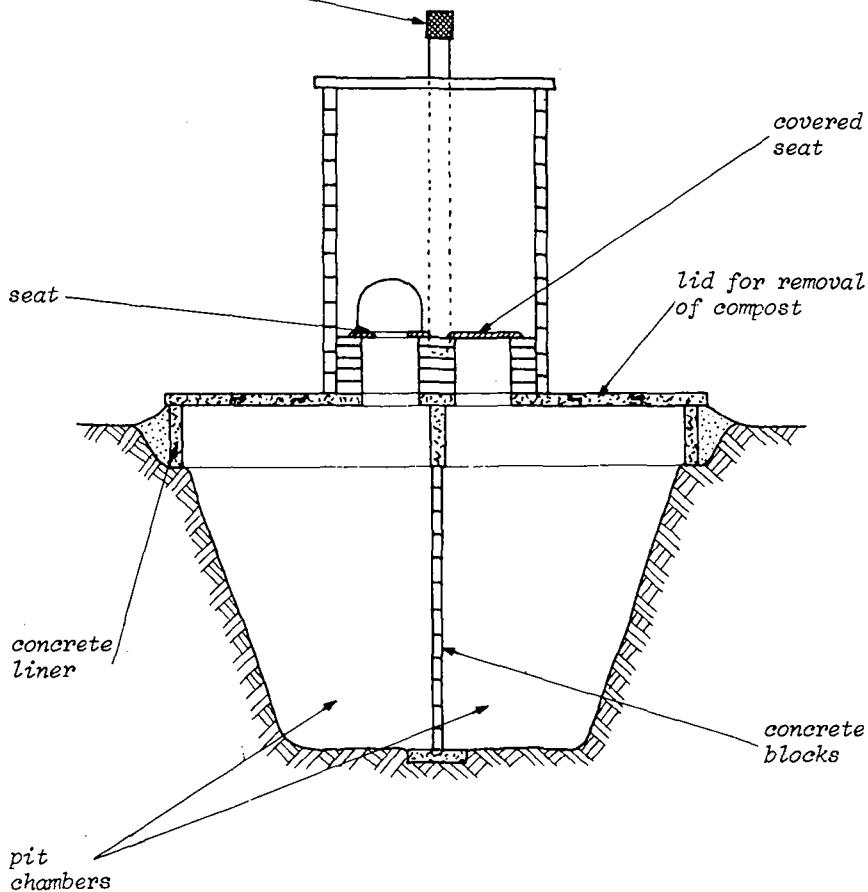
Permanent improved pit latrine

The pit top is supported by a cast-in-situ concrete liner which divides the pit into two chambers.

The covering slab supports two squatting slabs or seats of wood or plastic, one of which is in use at any one time. When one pit chamber is filled, it is covered with a screw-down lid, and the other chamber is used until it is full. By this time the contents of the first chamber have decomposed enough to be removed and used on the land.

The effective volume of each chamber is 1.5m^3 .

*ventilation
pipe*

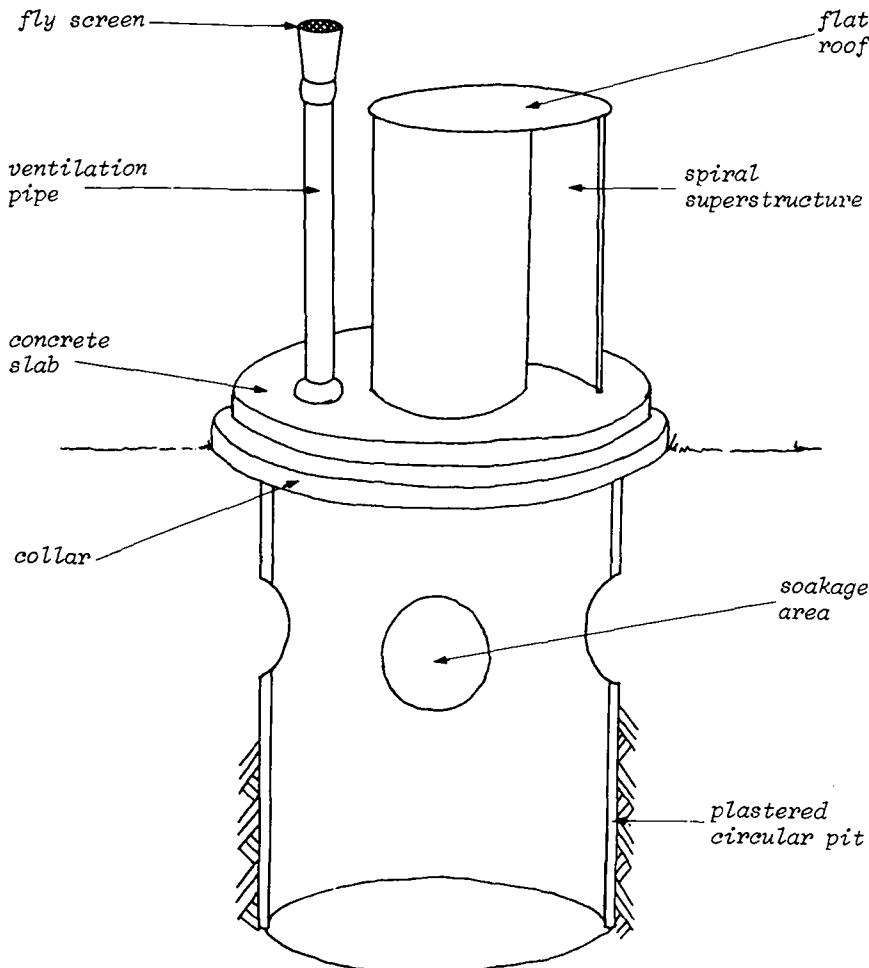


Reference:
Building Research Establishment, UK

Blair ventilated privy

In this case the pit is strengthened by a plaster lining with holes in it to allow for soakage. Around the pit opening, a concrete collar is built to support the concrete squatting slab.

The shelter has a spiral wall, so that a hung door is unnecessary. A 150mm diameter ventilation pipe passes through the slab outside the shelter. The large diameter of the ventilation pipe increases the efficiency of the ventilation system, keeping the privy odourless.



Reference:
Morgan P R (1) and (2)

Borehole latrine

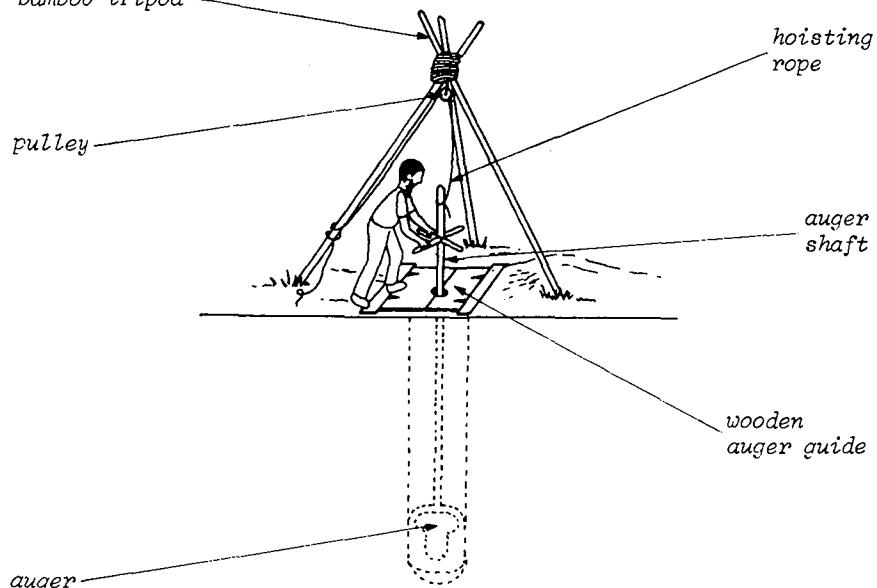
This is a variation of the pit latrine, for which special equipment is needed to dig the pit.

The pit is a vertical hole, 6m deep, bored in the ground with an auger. The auger may be one of several suitable types, provided it has a diameter of 400mm. If it has a smaller diameter the sides of the pit are easily fouled, and larger diameter augers are harder to operate.

The subsoil must be firm but easily cut by the auger. In some places a lining may be necessary to stop the sides from collapsing.

wood or

bamboo tripod



Around the top of the hole is a collar of concrete or other strong material. This supports the weight of the squatting slab, prevents the sides of the hole from collapsing, and helps to stop fly-breeding in the soil under the slab.

This type of latrine fills up faster than an ordinary pit latrine and it is very prone to fly and mosquito breeding.

Also, special equipment is needed which may not be available in the locality.

Reported use:

Bangladesh, Egypt, India and Malaysia

Reference:

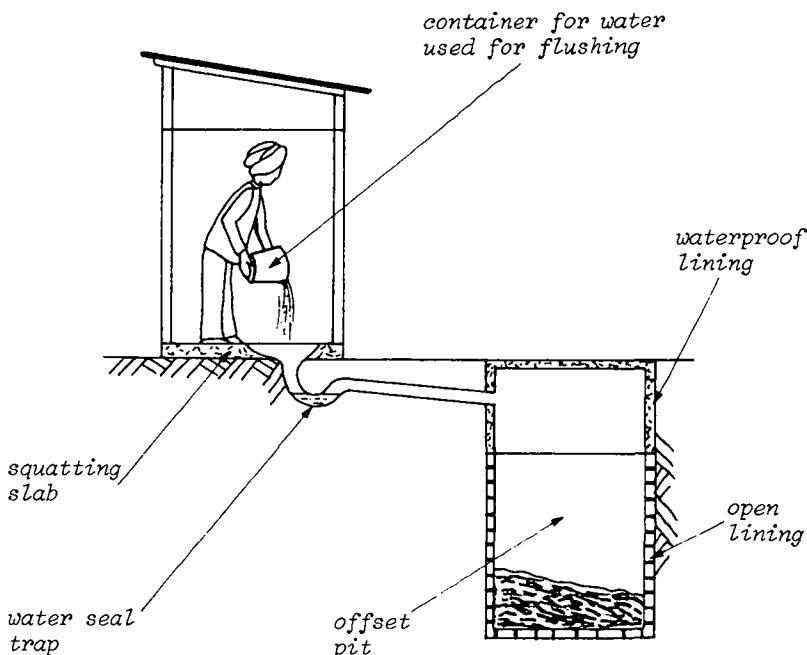
Carter

Pour - flush latrine

The pour-flush latrine is basically an offset pit latrine. In some areas it is known as the PRAI latrine.

The squatting slab is usually specially cast to incorporate a water seal trap, and is set into the floor of the latrine. Excreta is flushed down a short length of pipe from the water seal trap with a small amount of water.

The pit itself should be open lined at the bottom to allow the escape of liquids, while the top section is made waterproof.



In some cases two pits are dug side by side and connected to the latrine by a 'Y' junction. One arm of this junction is at first sealed, so that only one pit fills. When this pit is full, it is sealed and the second pit is unsealed and used. By the time this pit is full, the contents of the first pit can be dug out and used on the land.

The advantage of this type of latrine is that it incorporates a water seal trap, so that fly-breeding in the pit, and odours from it are avoided.

Reported use:

There are some examples in Africa, although they are most common in Asia.

Reference:

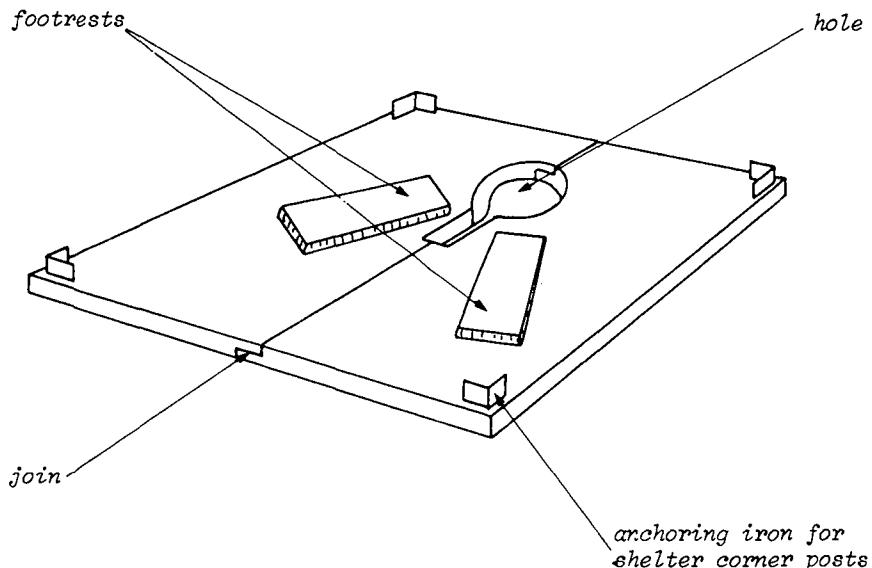
Bell M and Pickford J
Government of India, Ministry of Health

Squatting slabs

The best improvement to the simple pit latrines described earlier is to use a cast concrete slab instead of wooden planks or earth.

The slab may be a simple reinforced slab with a hole. It may be fitted with footrests, depending on local needs.

The problem with a concrete slab is that it is very heavy and difficult to carry and set into place over the pit. This problem may be overcome by casting the slab in two halves, as shown in the drawing. This type of split slab must be kept very clean, as dirt and germs can easily build up in the join.



Concrete slabs are stronger and much easier to keep clean, but they may be expensive to produce if cement is not easily available.

Another alternative in some areas is to use a ceramic slab, or a ceramic inset in a concrete slab. These ceramic slabs are easy to clean, and can be very cheap to produce in some areas.

Reported use:

Concrete slabs are in use world-wide.

Split slabs are used in Nigeria.

Ceramic slabs are used in India.

Reference:

Pickford J

Wagner and Lanoix (1)

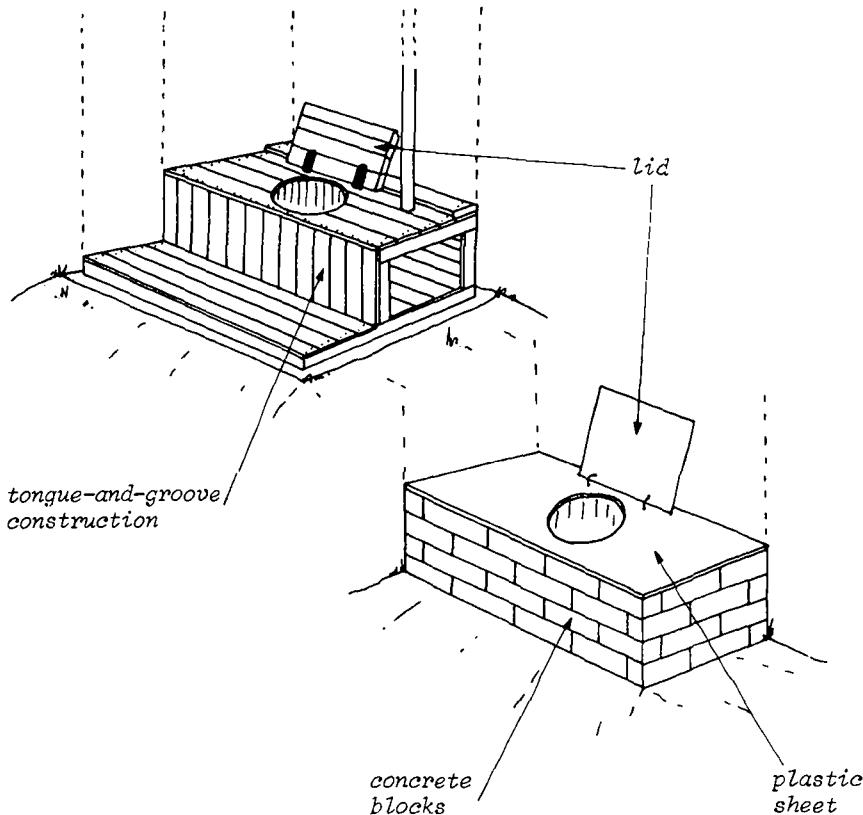
Seats for pit latrines

Where sitting is preferred to squatting, the seat must be well-made of material which is easy to keep clean.

A wooden seat and floor is made from tongue-and-groove timber to keep the pit water and insect proof. The boards on the front of the seat are placed vertically to stop any leakage of urine. The hinges of the lid are made from strips of old car tyre.

Reported use:

USA



Alternatively, the seat is built up from concrete blocks. A large plastic sheet, right across the latrine, is used to cover the top of the seat, with a hole in the middle covered with a lid.

Reported use:

Botswana

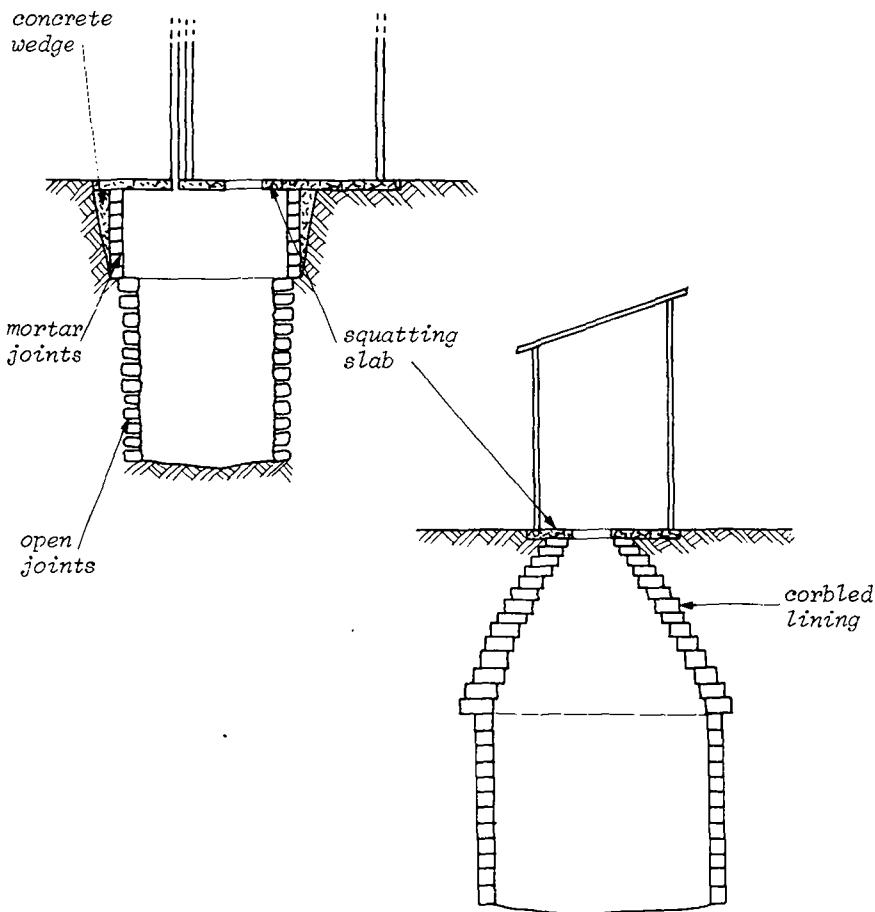
Reference:

Pickford J (1)

Winblad U, Kilama W and Torstensson K

Improved pit linings

The pit is made much safer by a strong lining. This can be made from concrete blocks or masonry. The top metre of the lining is made waterproof with mortar joints, while the lower lining is left open jointed for seepage to take place.



A further improvement is to build the lining like a tandoori oven, that is with the bricks or concrete blocks corbled over. This makes the pit very strong and minimizes the size of the squatting slab needed.

Reported use:
The corbled lining is used in Karachi

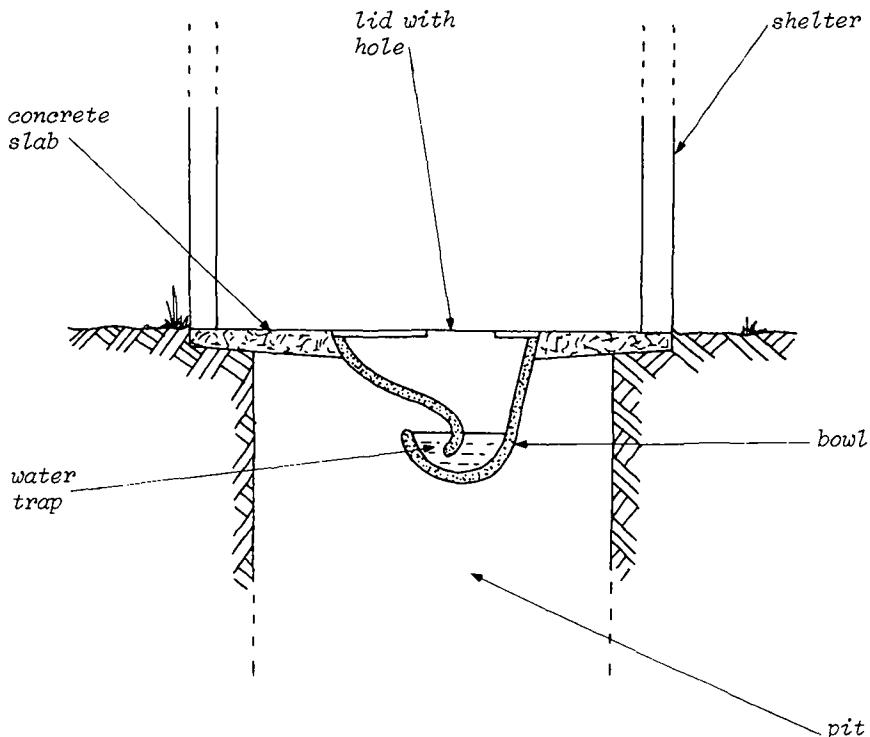
Reference:
Pickford J (1)

Water seal latrine

The water-seal or pour-flush latrine has a slab into which a specially made bowl is set.

The slab is set above or near a pit, borehole, aqua privy or cess-pit.

The bowl is flushed by pouring water from a container into the bowl. This removes all the waste and carries it into the pit. The trap of the bowl must discharge forwards, so that the back wall of the pit is not washed away.



Because of the water seal, fly breeding in the pit is stopped, and odours cannot escape.

When the pit is full, it is sealed and a second pit is dug. After one year or more, the decomposed sludge from the first pit is removed and used as fertiliser.

Reported use:

Bangladesh, India and Thailand.

Reference:

Nayar V P N
PHED

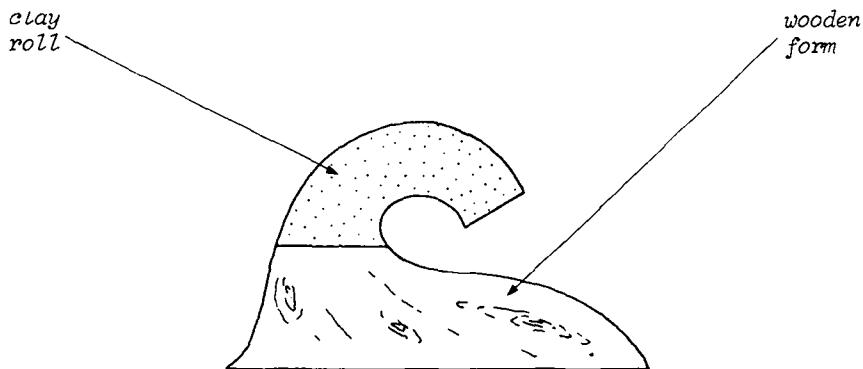
Water seal slab and bowl casting

This method of casting from mortar has been found to be simpler and cheaper than many other methods. The size and shape of the bowls and slabs can be varied according to local needs. Footrests can be included if needed.

A form is made in the shape of the bowl and trap. This form is made in two parts, the main part of solid wood, the trap section of clay. The clay is made into a 'U' shaped roll in a curved pipe mould. The roll is set in place on the main form and smoothed to it so that there is no irregular surface at the join. The complete form is then oiled.

A thin sand/cement slurry is pressed all over the form, and dry cement dusted over it so that the finished bowl will be smooth inside. Stiff mortar is then pressed on and trowelled smooth to a thickness of 12.5mm.

After 24 hours the bowl is removed from the form, taking the clay core with it. The clay is dug out of the trap when the bowl has hardened, and then the whole thing is washed and left to cure.



The finished bowl is cast into the squatting slab by digging a hole in the ground and putting the bowl into it so that its rim is level at 50mm above the ground. Loose soil is packed around the bowl to almost fill the hole, and a wooden frame, 50mm high is put around the bowl. The ground inside this frame is smoothed so that it slopes from the frame to the bowl. Concrete is then poured into the frame, over a layer of reinforcing wire mesh, and smoothed over. When the slab is cured it is lifted and put into position over the pit.

Reported use:
Thailand

Reference:
Wagner and Lanoix (1)

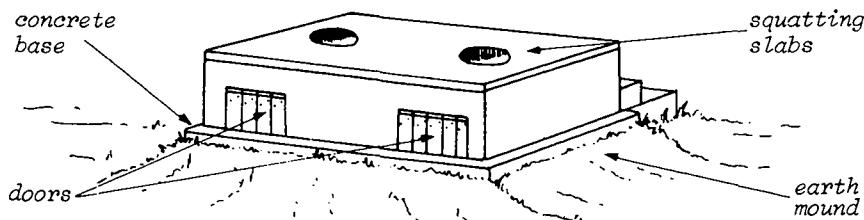
Double vault composting latrine

There are variations of double-vault latrine, depending on local ground conditions.

In waterlogged, flat areas it is best to build the latrine entirely above ground, on a slight mound with a solid waterproof floor. The vaults are built onto this base and are covered with a double squatting slab. There are lids for when the latrine is not in use. At the back of the latrine are doors through which mature compost is removed.

After every use the faeces are covered with a layer of dirt or ash to absorb moisture, stop smell and discourage flies.

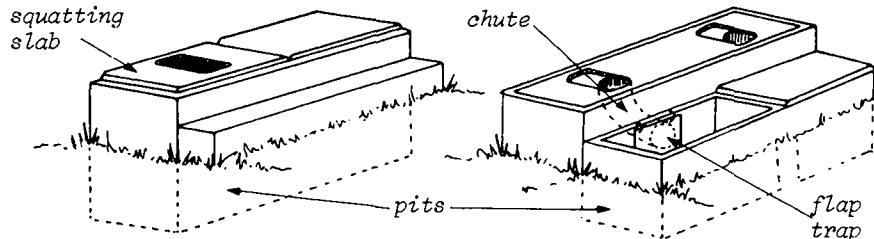
Urine is collected separately so that the material in the vault stays dry.



One vault is used until it is almost full, and then it is sealed and the compost matures while the other vault is filling up.

In areas where the ground water level is low the vaults are built into a shallow pit with permeable earth floors.

The pit can be either below the squatting slabs or offset to one side. The offset pit is better because the chutes have flap-traps fitted which prevent flies and other pests having access to the pit. Household waste and urine are added to the excreta in this case, and dry earth or ashes are used to cover faeces.



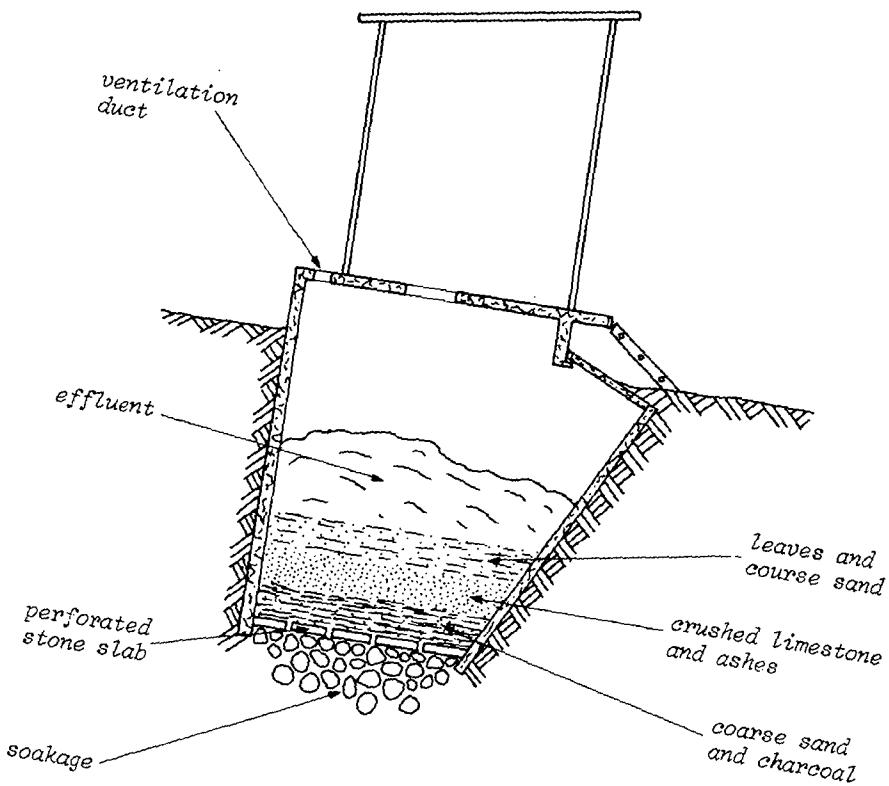
Double vault latrines involve anaerobic decomposition of waste, and so bacteria, viruses and parasites are more likely to be killed before the compost is used. No handling of fresh excreta is involved and there is no pollution of ground water. The latrines are fairly odourless and fly-breeding is kept down.

Reported use:
Vietnam and India

Reference:
Winblad U, Kilama W and Torstensson K
Nimpuno K

Biopot latrine

The biopot consists of a vault underneath the squatting slab. At the bottom of the vault is a filter constructed as shown in the drawing. This filter traps solids and neutralises acids.



Both human and organic household wastes are disposed of in the biopot, decomposing anaerobically in the vault. After six months the compost is removed for use as a dry manure on the land.

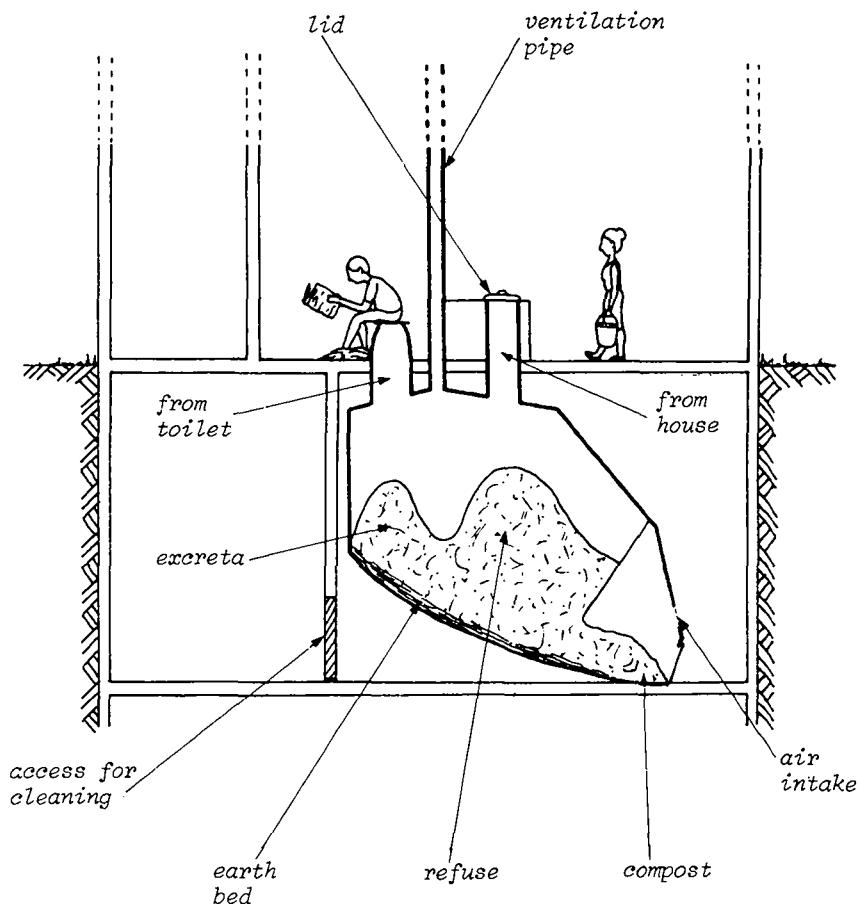
Reported use:
Dodoma, Tanzania

Reference:
Nimpuno K

Multrum composting vault

Organic compostable household waste and excreta are put into the vault. There are separate ports for the introduction of household waste and excreta.

Air is introduced to the unit through special inlets and there is a vertical ventilation pipe.



The excreta and waste mix in piles on a bed of peat, soil, grass or leaves, or a mixture of these.

After decomposition the mature compost is removed from the unit to be used as fertiliser.

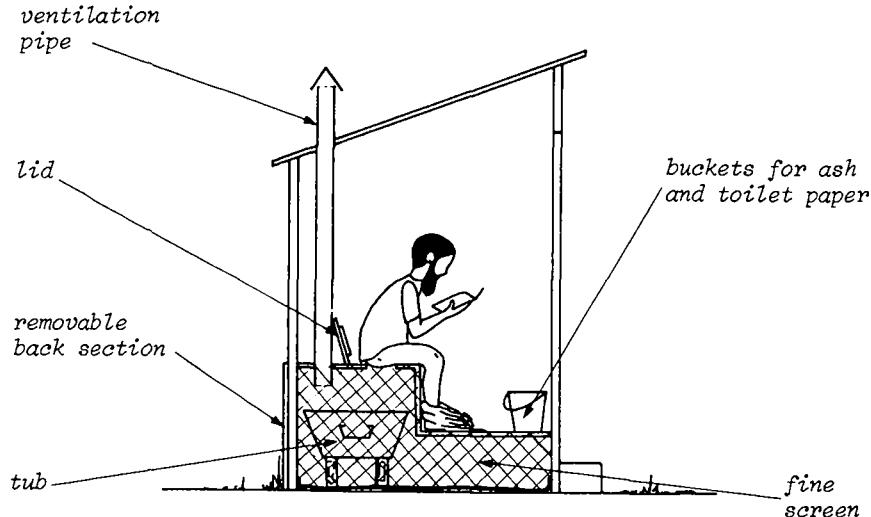
Reported use:
Sweden

Reference:
McGarry Dr M G

Compost privy

A good aerobic compost privy can be built easily from locally available materials. The system will take human and kitchen wastes and reduce them to odourless compost in one to two years.

The privy can be built in a small outhouse or inside the house against an outside wall, to give access to the waste bin.



The privy is built on stilts with a space under the seat and floor screened in for good ventilation. The ground area is covered with a heavy plastic sheet. A large tub with handles is put under the toilet seat, on bricks for good ventilation. Small holes are made in the bottom of the tub so that moisture does not collect in it.

The seat has a removable air-tight lid. The lower back section of the privy wall is hinged or removable, so that the tub can be taken out for emptying. A ventilation pipe from the tub area gives extra ventilation.

The privy works successfully only if the waste in the tub is kept as dry as possible. One should not urinate in the privy if this can be avoided.

After use the waste is covered with a good layer of ash or dirt, which is kept in a bucket in the privy. The ashes soak up the moisture and help to stop odour.

If used in combination with a suitable composting bin system, this privy is a safe way to deal with human and vegetable wastes. There is no pollution of water supplies and no easy access for flies and other pests.

Reference:

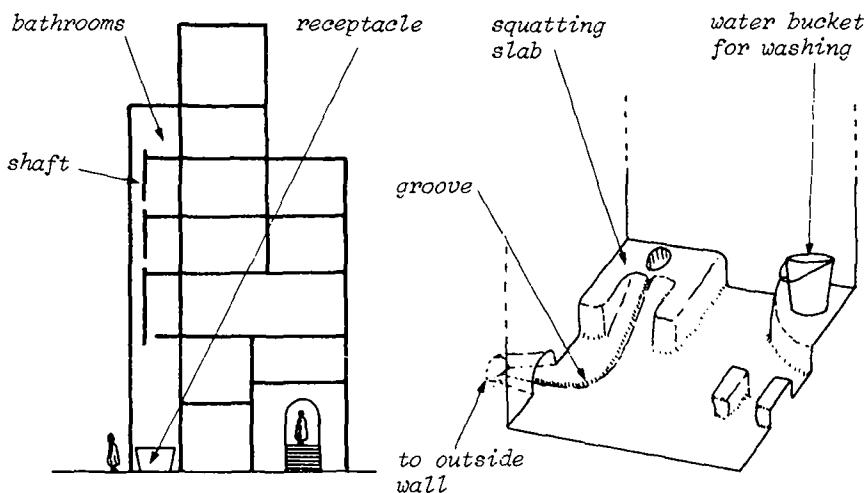
Grimmer D P and Schliekelman M

Long drop latrine

In tall buildings each floor has 1 or 2 lavatory/bathrooms sited next to a vertical shaft which extends up to the highest bathroom and ends at street level with a large receptacle.

The hole in the squatting slab is connected to the shaft, and faeces drop down the shaft into the receptacle.

Urine is drained away from the squatting slab, along a groove in the floor, through a hole to the outside wall, to run down a vertical drainage surface. Most of the urine evaporates on the way down, but any that is left is drained into an underground sump. No liquid is put into the shaft, so all the material stays very dry.



The receptacle is emptied and the contents taken to the public baths, where they are spread on the roof to dry. The dried waste is used as fuel, and after burning, the ashes are sold as fertiliser.

This system can work very well, since it does not pollute water supplies or soil.

However, handling of fresh excreta is a health hazard, and while the waste is drying out on the roof it is accessible to flies.

This is a system which has developed in response to special conditions in crowded old cities. It can be used where there are multi-storey buildings, a hot dry climate, and where water and firewood are scarce.

Reported use:
Yemen

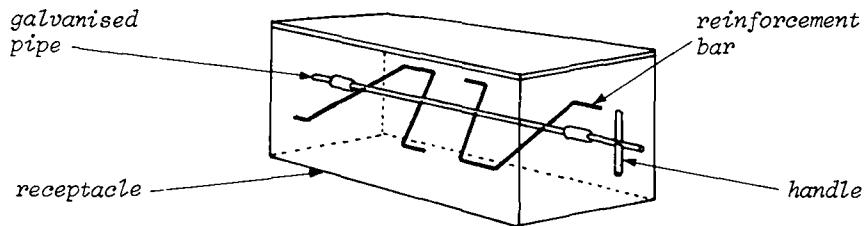
Reference:
Winblad U, Kilama W and Torstensson K
WEDC (1)

Aids to decomposition

Aerator

Organic wastes decompose much faster if air is introduced to the pile. This can be done with perforated pipes, holes left in the piles or large amounts of straw and grass added to the compost.

Turning the compost is also a good idea for a larger receptacle or pile. This may be difficult when the material is in a large bin, so a simple turning device can be made from a piece of galvanised pipe and some bent reinforcement bars.



Where this has been tried the composting material was so solid that the device could not be turned, or the bent bars broke away from the pipe.

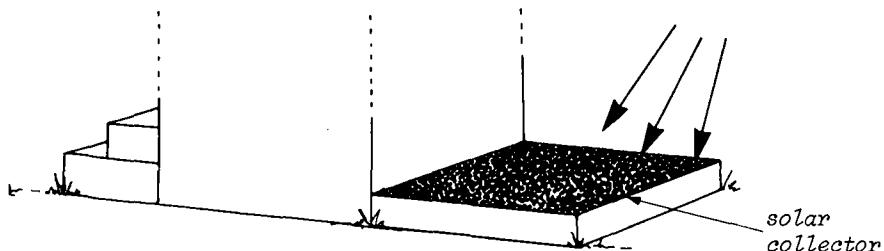
Reported use:
Tanzania

Solar heater

Decomposition rates are increased if the receptacle is designed and placed in such a position that it is heated by the sun. One way of doing this is to use a latrine with the receptacle offset and to put a blackened piece of aluminium sheet or ferrocement over the receptacle.

This lid acts as a solar collector.

Heating of the compost in this way may also help in the control of fly breeding, since high temperatures kill adult flies, eggs and maggots.



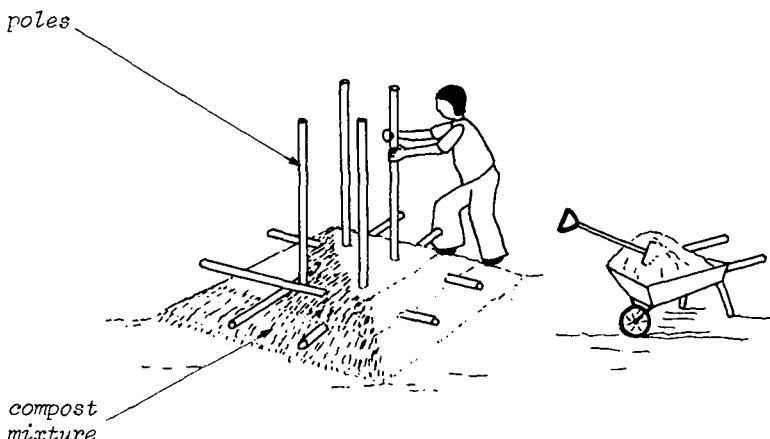
Reference:
Winblad U, Kilama W and Torstensson K

Composting heaps

Four types of raw material are used; human excreta, animal manure, soil and street sweepings, mixed in about equal proportions.

A flat pile of this mixture is made, about 150mm high. Water or urine is added if necessary.

Four pieces of wood or bundles of millet stalks(70-100mm diameter) are placed on top of the pile, cross-wise. At the crossing points, four more sticks are placed, vertically, as shown.



The pile of raw material is then increased to a height of 900mm, and then covered with a 50mm soil/manure layer. This covering layer is important as it prevents rainwater from soaking the pile, reduces evaporation, lessens nitrogen loss, checks fly-breeding and smells, and increases the surface temperature.

When the soil has dried, the wood pieces are pulled out leaving holes through which air movement will help decomposition. In cool weather the holes are blocked to stop cooling of the pile, and in hot weather blocking of holes helps to stop loss of water and nitrogen.

After between 20 and 60 days, the compost has matured and is ready for use in the fields.

Urine collected separately may be added to the compost, but it is usually diluted and used directly on gardens.

This system of composting causes no pollution of lakes and streams and it returns to the soil important humus and nutrients. However, fresh excreta must be collected and transported every day, so handling of raw material cannot be avoided and spillage occurs. Flies have easy access to the material.

Reported use:
China

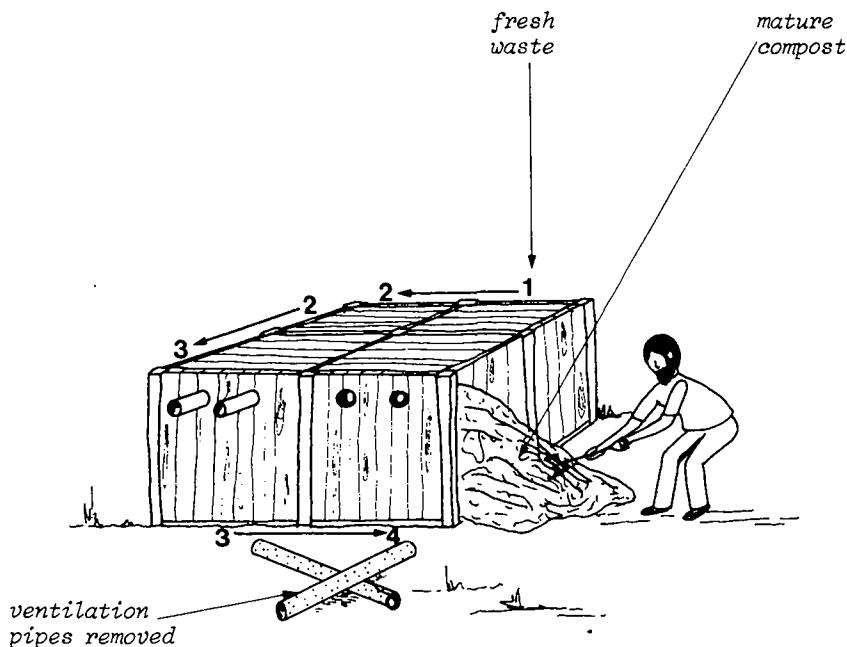
Reference:
Winblad U, Kilama W and Torstensson K

Compost bins

The waste from a compost privy is combined with organic kitchen wastes in a rotating bin system.

There are four bins made from wood or slabs and arranged in a square. Each bin measures 1.5mx1.5mx1.5m and has a removable wall so that the compost can be taken out and turned easily.

The bottoms of the bins are lined with heavy plastic sheets, and the tops are screened or have lids.



The four bins are filled in turn and when they are full the mature compost is taken from the fourth bin to be used as garden fertiliser. Then the compost is taken from the third bin and put into the empty bin. The compost from the second bin is moved into the empty third bin, and that from the first bin is put into the empty second bin.

Now the first bin is empty and can be filled again with fresh waste. In this way the complete cycle takes from one to two years, and the compost is turned at least four times.

More frequent turning speeds up decomposition, as will the use of perforated pipes for better ventilation.

This composting system is very simple and is known to work well. The waste cannot pollute water supplies, and it is a good source of rich compost for the garden.

Reference:

Grimmer D P and Schliekelman M

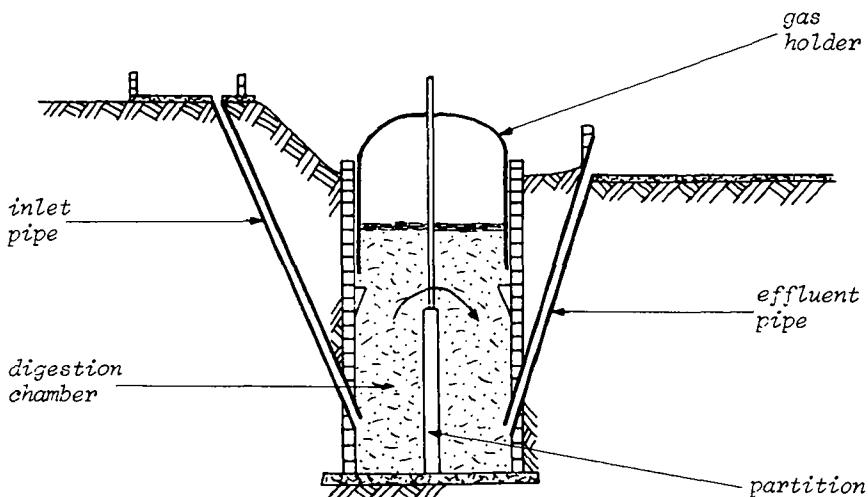
Biogas plant

A biogas plant makes maximum use of human excreta, urine, cow dung and other organic waste material, to produce agricultural fertiliser and methane gas for domestic use.

The digester is basically a large chamber built partly underground and partitioned into two sections inside.

Organic waste and water in a one:one ratio, are fed into the lower part of the first section through an inlet pipe. As it decomposes anaerobically the mixture moves up and into the second section of the chamber. The digested slurry leaves through the outlet pipe between thirty and fifty days later.

The digestion process is concentrated in the chamber, killing off the dangerous organisms usually found in fresh manure, and producing methane gas which collects in the gas holder floating on the liquid surface.



The biogas system helps to control disease, since the digestion process kills off many pathogens and disease carrying organisms. It produces a very rich manure for use as a fertiliser, together with fuel gas for domestic purposes.

The size of the biogas plant depends on many local variables, such as the amount of organic waste available and the size of the local community.

The plant can be dangerous if not designed with these local conditions in mind, and so expert advice should be sought before any attempt is made to build one.

Reported use:

India

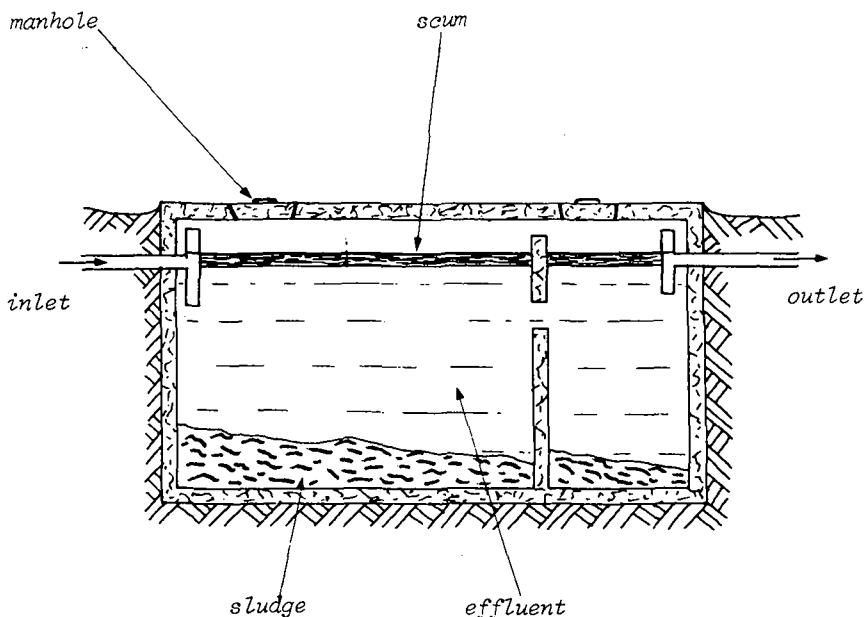
Reference:

Khanna S R
Sagar G

Septic tank

These can be used for single houses or in a small community where flushed toilets are used, but where a sewerage system is impractical. The septic tank is a sealed underground tank with inlets from latrines, and an outlet to a soak pit or drainage field. The tank is usually divided into two chambers, the first being much larger than the second. This encourages better settling out of the sludge.

Heavy solids settle on the bottom of the tank, forming a sludge which decomposes anaerobically, reducing in bulk. Lighter solids and grease float, forming a scum. The liquid which remains after settling out is called effluent, and this is piped away from the tank to a soakaway or drainage field.



The tank is cleaned out every one to four years so that the accumulated solids do not block inlet and outlet pipes. The sludge must be handled carefully, since it is not completely decomposed, and still contains bacteria and other dangerous organisms. The sludge can be further composted outside the tank, and then used as fertiliser.

Reference:
Feachem R and Cairncross S

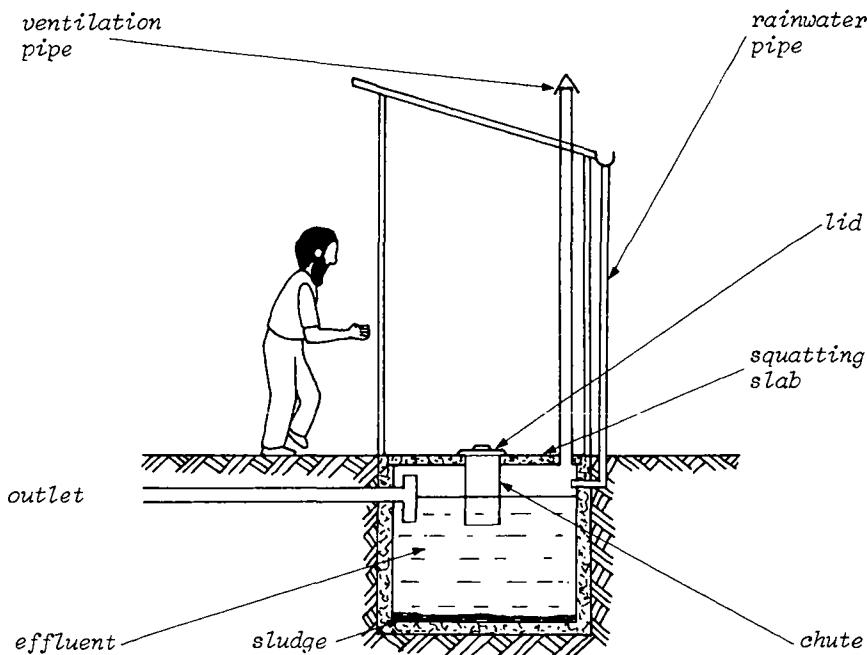
Aqua privy

This is similar to a septic tank, but excreta falls directly into the water-filled chamber below the latrine.

The squatting slab is cast with a chute which leads into the water forming a water seal, which helps to stop odours and fly breeding. A water-seal pour-flush latrine can be used instead.

The tank must be made waterproof, since any leakage causes the water level to fall and the seal to break.

In areas with regular rainfall, the rain falling onto the roof of the shelter can be channeled into the tank, to keep up the water level.



The system works in the same way as a septic tank, with heavy solids falling to the bottom of the tank to be digested anaerobically.

The sludge is cleaned out regularly.

The effluent passes from the tank to a soak pit or drainage field. A ventilation pipe is fitted to allow gases to escape from the tank.

Before it is first used, the tank is filled with water, and a small amount of sludge from another tank is added. This helps to start the digestive process quickly when the privy is used.

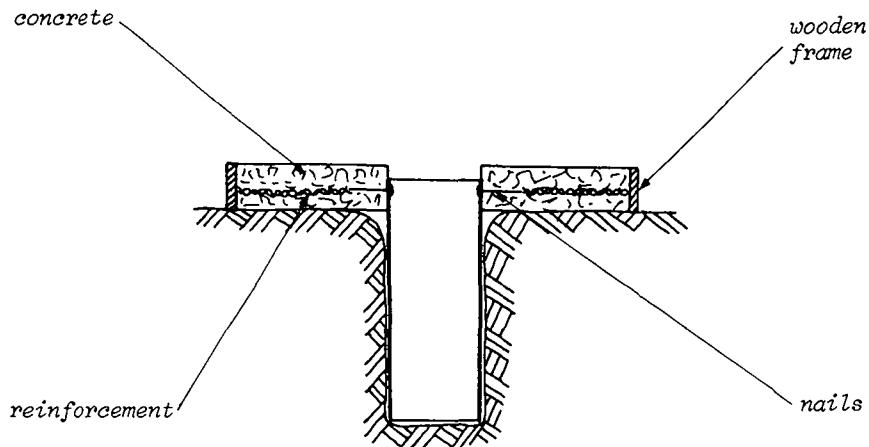
The aqua privy needs regular attention to make sure that blockages do not occur in the chute and outlet pipes.

Reference:

Feachem R and Cairncross S

Slab casting for aqua privies

It can be very difficult to cast the squatting slab for an aqua privy, since it must have a chute incorporated into it. This simplified method has been developed so that slabs can be cast locally without the need for complicated moulds.



The drop pipe is made from wood, concrete or plastic, about 150mm diameter so that it is wide enough to prevent blockage when it is used.

Around the neck of the pipe, four 100mm long nails are set, so that they stick out around the pipe.

A hole is dug in the ground, deep enough to hold the chute, with about 75mm sticking up above ground level. When the chute is in place in the hole a wooden mould is placed around it, to the size of the slab required.

A layer of concrete is poured into the mould, to the height of the nails in the chute. Metal reinforcement is placed on top of this layer, and another layer of concrete poured on top to the height of the frame.

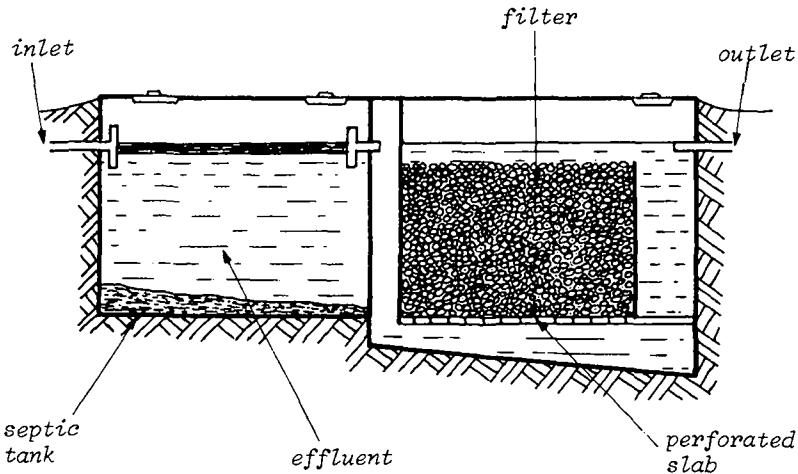
When the slab has cured it is lifted and put into place in the privy. The chute is held firmly in place by the nails set into the concrete layers.

Reported use:
Nigeria

Reference:
Oluwande P A

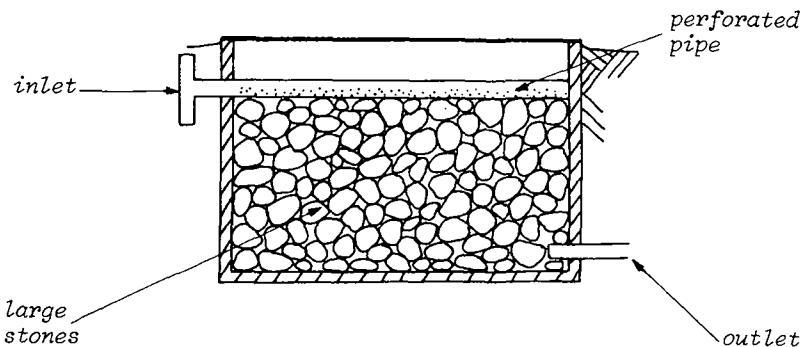
Filter for effluent

The effluent from a large septic tank, or from several tanks in the same area, can be piped to another tank in which a sand and gravel filter has been made.



The effluent filters up through the gravel layers and is then piped to a soak pit.

A similar method uses a downflow filter. The effluent trickles from a perforated pipe, down through a tank full of large stones as shown.



Removal of bacteria and other organisms by this method is reported to be good.

Reported use:
India and Ghana

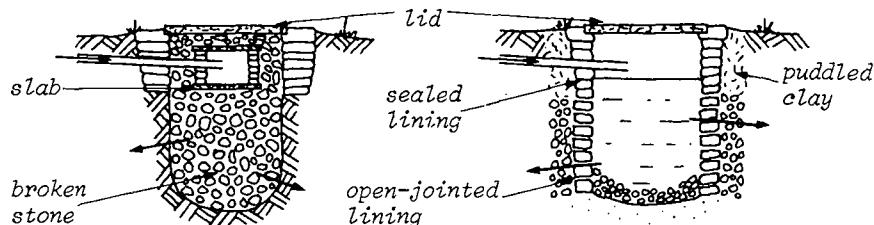
Reference:
Mahabal Prof B L
Pickford J (2)

Soakaways

Effluent from septic tanks and aqua privies, together with other waste water is piped to a soakaway for disposal.

A soakaway can be a pit or a trench, filled with stones, or given a porous or perforated lining through which water seeps into the ground.

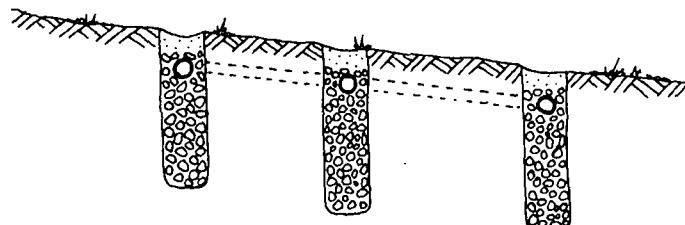
Some digestion takes place, as layers of slime collect around the soil particles.



If the pit is built without a filling of stones, it has been found to have a much longer life and a greatly increased capacity. The pit is also cheaper and easier to build without a filling.

The soakaway may be a fairly small pit, to serve a single aqua privy, or it may be much larger. In some places where a lot of waste water is involved, it may be better to build a trench or drainfield.

Trenches are filled with stones and have open-jointed, 100mm pipes laid on the stones. The effluent passes along and out of the pipes and so is dispersed over a wider area of ground. This reduces the risk of clogged and highly polluted soil in one small area.



A drainfield is just a series of trenches, connected by closed pipes which pass the overflow from one trench to the next in series. Again this disperses the effluent over a much wider area.

When digging the trenches it is important to make them deep and narrow, as most seepage takes place through the sides of the trench, not the bottom which soon becomes clogged.

Soakaways of any sort can only be built where the ground water is low and where the soil is not too fine. They must never be dug near to wells, streams, springs or houses.

Reference:

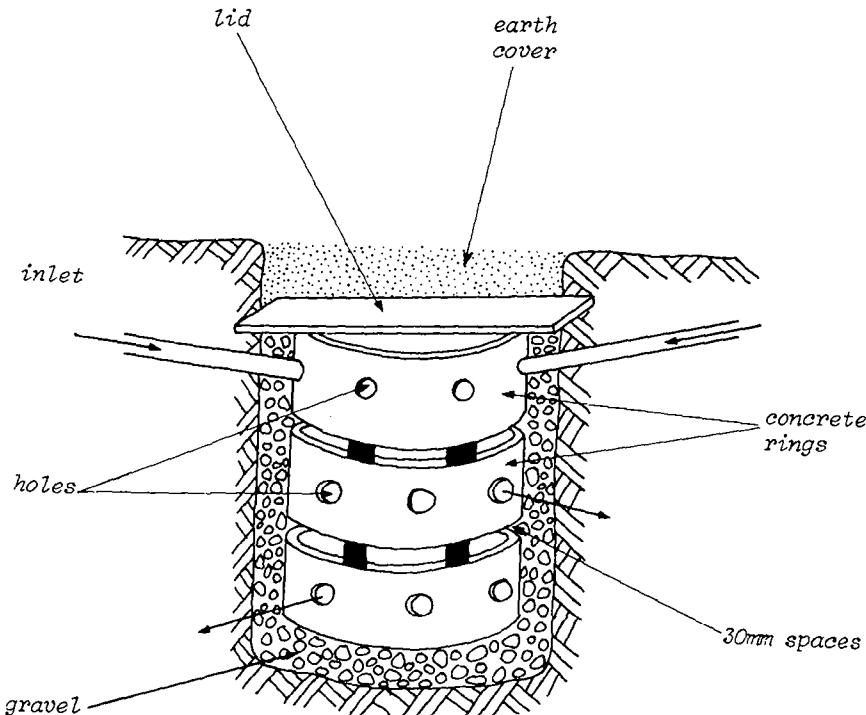
Jolly P W

Raman V

Singh Prof R C

Soak pit

This simple soak pit has three concentric, perforated rings piled up inside it, with spaces between them. Inlet pipes bring waste water inside the rings from where it seeps through the holes into the surrounding gravel layer, and then into the ground.



The soak pit works well, provided that the waste water does not contain a lot of solid material to cause blockages, and also the surrounding ground must be porous.

Reported use:
Laos

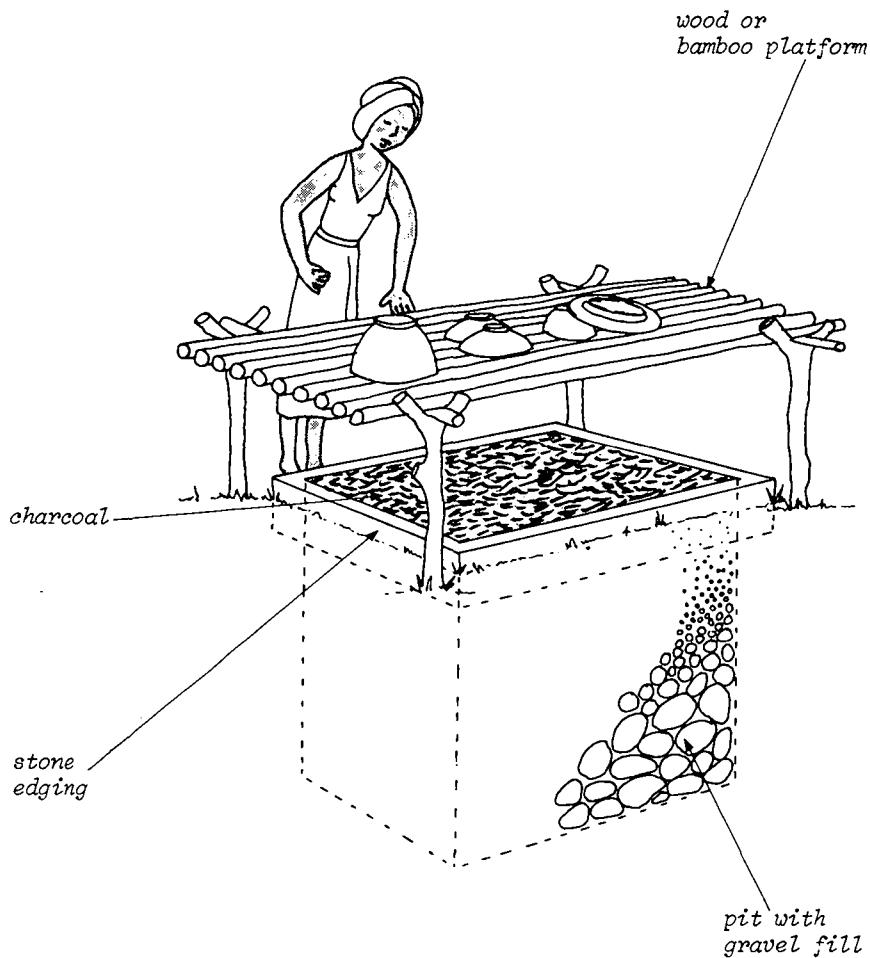
Reference:
Jolly P W

Soakaway for dish washing drainage

A pit is dug about 2m deep, and filled with graded stone and gravel. Around the top of the pit is a stone edging, projecting above ground level, and the top of the pit is covered with a layer of broken charcoal to the top of the edging.

An open wood or bamboo platform is built over the pit.

Water from washing is emptied into the pit and the washed dishes are left to drain and dry over the pit.



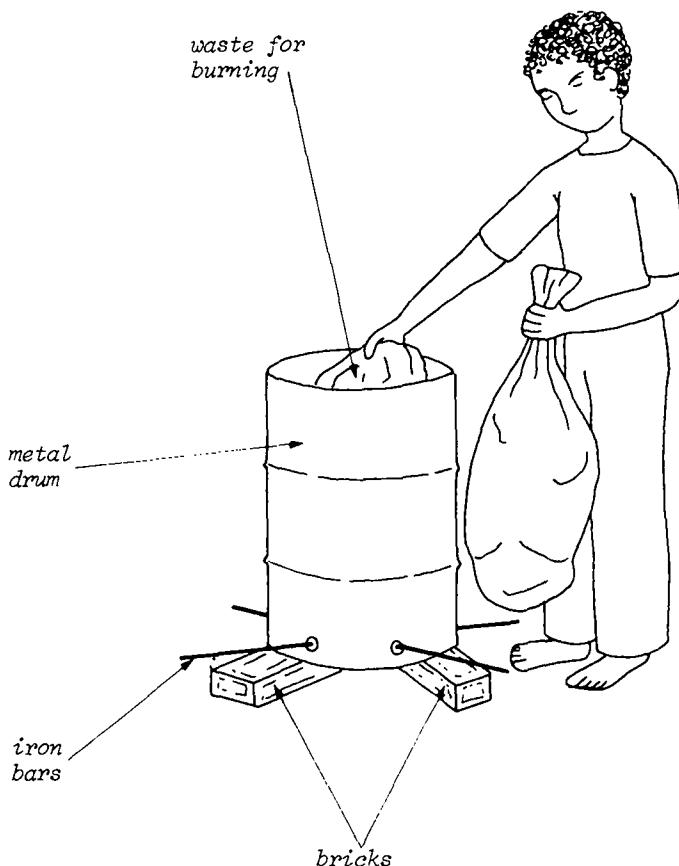
Reference:
Mohammed S
Centre for Building Research

Incinerator

This incinerator is made from an empty metal drum, supported off the ground on 3 or 4 bricks.

Two iron bars are passed through drilled holes towards the bottom of the drum.

Only waste which will burn easily is put into the incinerator.



Reported use:
Guinea

Reference:
Dabo M T

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