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MODULE 5

SLOW SAND FILTERS *

WORKING DRAFT
(not for distribution)

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MODULE 5

SLOW SAND FILTERS

This document was prepared from the English manual developed by David Manz in 1996. The Spanish translation and the preparation of this version was done in collaboration by Lorena Aguilar Revelo, Elías Rosales Escalante and the CEMAT of Guatemala.

Davnor
Water Treatment Technologies Ltd.

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FOREWORD

Access to safe drinking water is one of the basic human needs which remains unsatisfied for millions of individuals around the word. The Pan-American Health Organization estimates that at least 290 million people in Latin America and the Caribbean (about 40% of the population of those areas) still consume water unsuited for drinking purposes or contaminated by harmful microorganisms. In many countries of Africa and Asia, the percentage of the population without access to safe drinking water is even higher. The most affected persons are those with low incomes living in urban and rural areas and who have to obtain their drinking water from sources vulnerable to contamination or from water supply systems that lack adequate treatment or maintenance.

For over 20 years the International Development Research Center (IDRC) of Canada has supported research aimed at the development, testing and implementation of many technologies and community strategies for water supply. Among these are included water pumping devices, water management and storage, protection of water sources, water quality monitoring as well as the different options available to treat the water to be supplied. These various research initiatives were mostly conducted by scientists from developing countries based in local institutions. Many of these projects have emphasized the participation of the communities in the evaluation, adaptation and implementation of the various technologies and strategies.

These projects were successful in their technical development and implementation. However, dissemination efforts have taken place only in an isolated manner. This fragmented approach, rather than the joint application of technologies and intervention strategies, has limited the real health impact they could have at the community level. Limits have been imposed on the possibility of each technology complementing others in the same community to address the sources of contamination and re-contamination, treatment requirements and the community organization needed to ensure the sustainability of the benefits accrued.

In August 1996, the IDRC invited its research partners to participate in a Technology Exchange Workshop in Costa Rica. During this Workshop each of the participants had the chance to present and demonstrate the technologies developed as a result of their research efforts. The demonstrations and discussion that took place during that event have become the basis for the creation of an integrated package of technologies on safe drinking water. The host and coordinator of this event was the Technology Foundation of Costa Rica (*Fundación Tecnológica de Costa Rica* - FUNDATEC).

The present series of modules, resulting from the above mentioned activity, is a collection of practical tools that have already been tested in the field and that can be used by community groups, individual families or institutions and Non Government Organizations (NGOs). Although some of the technologies described in these modules may not be applicable everywhere, we believe that many communities may be able to benefit from these tools, or through the proper combination of them. The contents of each module are described in the back cover of each of the publications.

We hope that each of these documents will serve as an incentive in the search for more integrated approaches aimed at improving the quality and safety of water supplies for poor peri-urban and rural communities around the world.

Gilles Forget

Senior Scientist
Programs Branch, IDRC

TABLE OF CONTENTS

I. INTRODUCTION

Slow Sand Filters

In the late 19th and early 20th c in the West

One of the first techniques applied for cleaning water was the use of slow sand filters. Their use allowed to eliminate most of existing impurities and drastically reduce the number of people suffering from diseases such as cholera.

→ depth or cake (surface straining) Filtration

The principle of filtering is the retention of particles through adherence. This way, turbid waters can be passed through filtering materials to improve their condition. If the water is too turbid, the procedure to improve its quality is to pass it through several filtering stages, or layers. The first filtering layers are normally of coarse materials while the final ones consist of finer filtering materials.

Aside from their adherence capacities, filters harbor a whole microbiological environment as different types of microorganisms, which feed on the organic matter carried by the water being treated, breed and grow on the surfaces of the filtering materials (sand in this case).

In this very interesting way, the microorganisms present in the filtering materials also contribute to clean the water from impurities. Due to the existence of this biological activity it is necessary to keep at all times enough water to cover the filtering materials, so as to maintain the humidity required for the survival of these beneficial microorganisms.

If the water to be filtered contains pathogenic organisms (causing diseases) its disinfection with chlorine before drinking is recommended; and, of course, water has to be disinfected after filtration as to do so before filtration could also damage the biological layer of the filter which, as mentioned before, is very beneficial.

In the following pages we shall describe the manufacturing procedures for the filters recommended by Davnor Water Treatment Technologies Ltd. of Canada for the application of this technique of slow sand filtering at the home level[1]. One of these filters, which was named the "Barrel Filter", takes advantage of this scientific principle and adapts it to the use of plastic and PVC materials. The other filter, described in the second part of this document, is the one called the "Cement Filter". This module also indicates the procedures required to produce them, at the industrial or cottage industry levels, as well as the different materials required and the use of PVC parts.

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[1] A recent study conducted by the National Water Research Institute of Canada (NWRI), with support from IDRC, demonstrated that these small filters are capable of removing from the water not just bacteria but also parasites and toxic substances. This study was conducted utilizing waters with toxic concentrations 10 to 100 times larger than those encountered through normal contamination. The removal rates obtained by filtering through these devices were 83% for total heterotrophic bacteria populations, of 100% for Giardia cysts, of 99.98 % for Crystosporidium cysts, and of 50 to 90% for organic and inorganic toxic substances (Dutka B., et al., 1996)

II. THE BARREL FILTER

A. What is a Barrel Filter?

It is a slow sand filter that can be manufactured with a barrel (container), which can be made of plastic, and that is useful to improve the quality of the water destined for consumption.

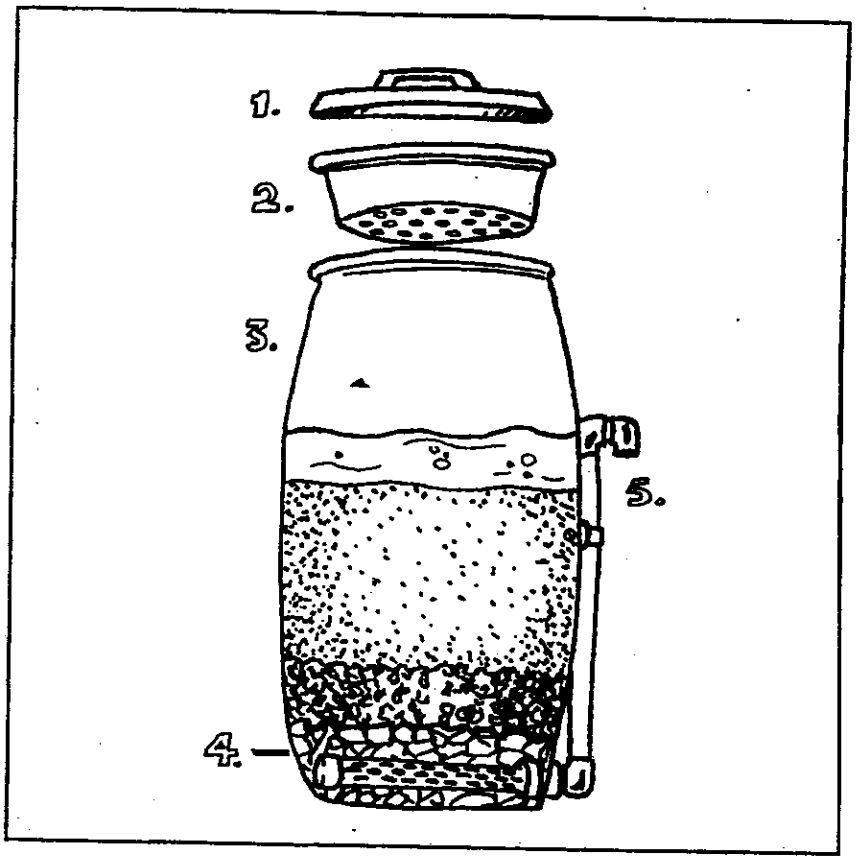
It presents the following advantages:

- Simple to manufacture, with easily acquirable materials.
- Low cost.
- Easy maintenance and use.
- Takes little space, being able to be installed inside the home.
- Protects family health.

B. How does it work?

The dirty water is poured on top of the filter to allow it to pass through the sand and gravel layers, which retain the majority of impurities that the water may carry, including organic matter.

This filter can also eliminate parasite that may be carried by contaminated water. A new filter must have been operating 2 to 3 weeks for it to be able to eliminate bacteria.



C. Components of this type of Slow Sand Filter

1. The Lid:
A cover (could be the same lid of the barrel) that is placed on top of the colander/diffuser basin when water is being filtered. It prevents impurities from falling inside the filter.

2. The colander / diffuser basin:
Is a plastic container with perforations to sieve the larger impurities carried by the water, such as leaves, branches and small stones, plastics, etc. Its most important function is to distribute, in a uniform way, the fall of water over the whole filtering surface (that is why it is called a diffuser basin) thus avoiding damage to the upper sand layer and destruction of the biological layer.

3. **The filtering container:**
Is a barrel or any other plastic container of about 60 l capacity, which is filled with gravel and sand layers. (16 gallons)

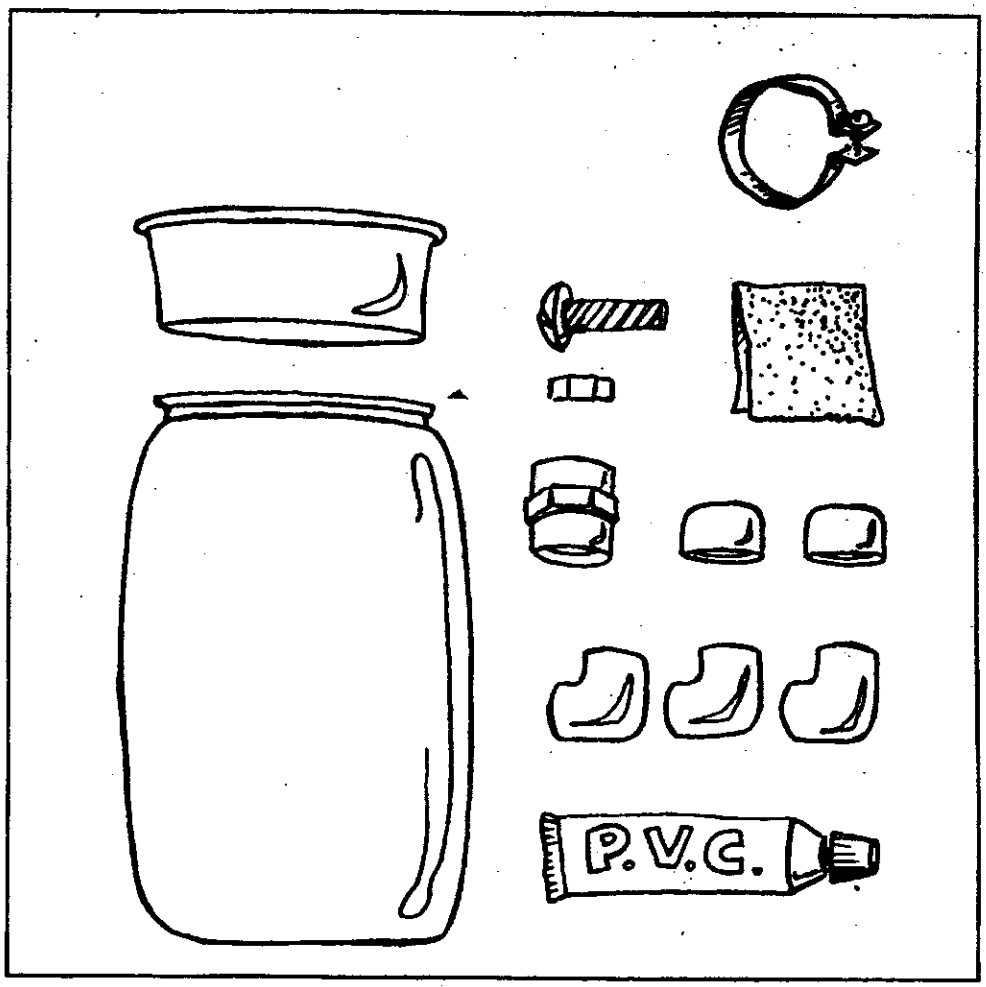
4. **The drainage pipe:**
Is a PVC pipe with holes that receives the filtered water and conducts it towards the outlet pipe.

5. **The outlet pipe:**
Is a PVC pipe that allows the filtered water to flow towards the container that may be used for storage before consumption.

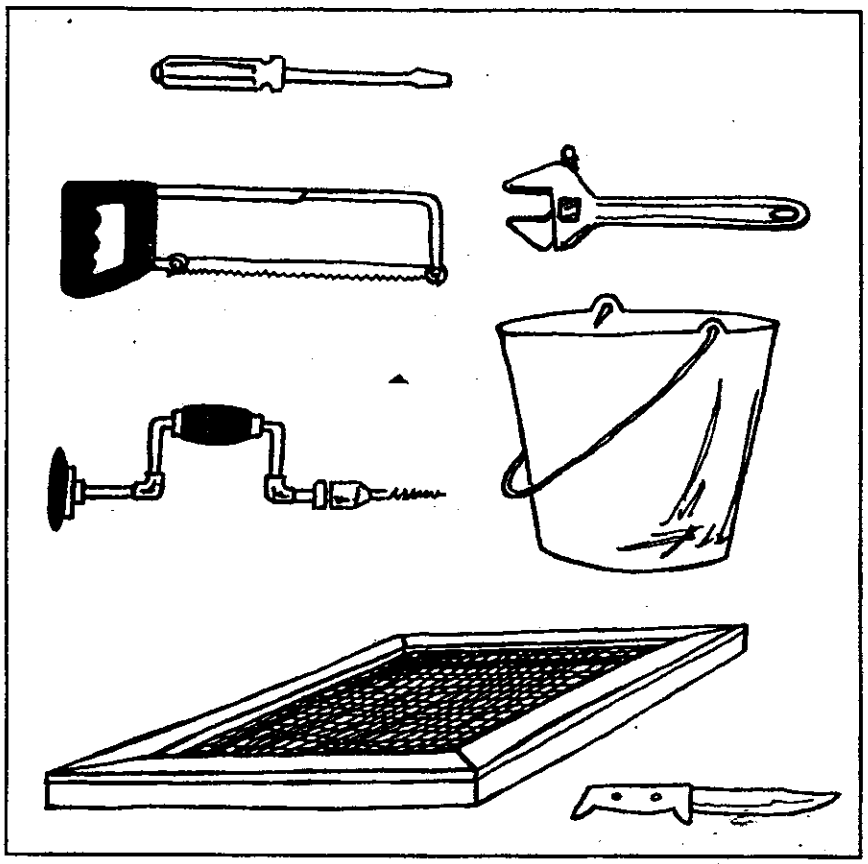
D. How to built it

1. Labour
Any person may build it with proper training.

2. Materials and accessories
1 60 l plastic barrel.
1 15 cm deep plastic container, of the same size than the opening of the barrel (to be used as colander/diffuser basin).
1 plastic lid (the one that comes with the barrel or any other one of the same diameter than the barrel).
1 piece of PVC pipe, 19 mm in diameter and 1.25 m long.
3 90° PVC elbows, 19 mm in diameter.
1 female PVC connector (adapter), threaded, 19 mm in diameter.
1 male PVC connector (adapter), threaded, 19 mm in diameter.
2 female PVC pipe caps, 19 mm in diameter.



1 19 mm pipe brace.
1 stainless steel or bronze bolt, 19 mm long by 6 in diameter, with a nut and a rubber packing.
1 tube of PVC adhesive.
1 sheet of N° 100 sand paper.
1 Teflon tape (optional).
1 tube of silicone sealer.
Rubber gaskets (optional).



3. Tools

1 6 mm sieve (optional, for the gravel).
1 5 mm sieve (optional, also for the gravel).
1 2 mm sieve (for the coarse sand).
1 1 mm sieve (for the fine sand).
1 hacksaw.
1 screwdriver.
2 pipe wrenches.
2 buckets.
1 drill.
1 marker.
1 sharp knife.
1 3 mm drill bit.

E. Procedure

1. Drill small holes in the bottom of the container to be used as colander/diffuser basin. The holes should be 3 mm in diameter and be spaced 25 mm from each other. Avoid making holes larger than 3 mm as they would allow the water to flow too fast through the diffuser basin, disturbing the upper sand layer of the filter.

2. Cut the PVC in 3 sections, as follows:

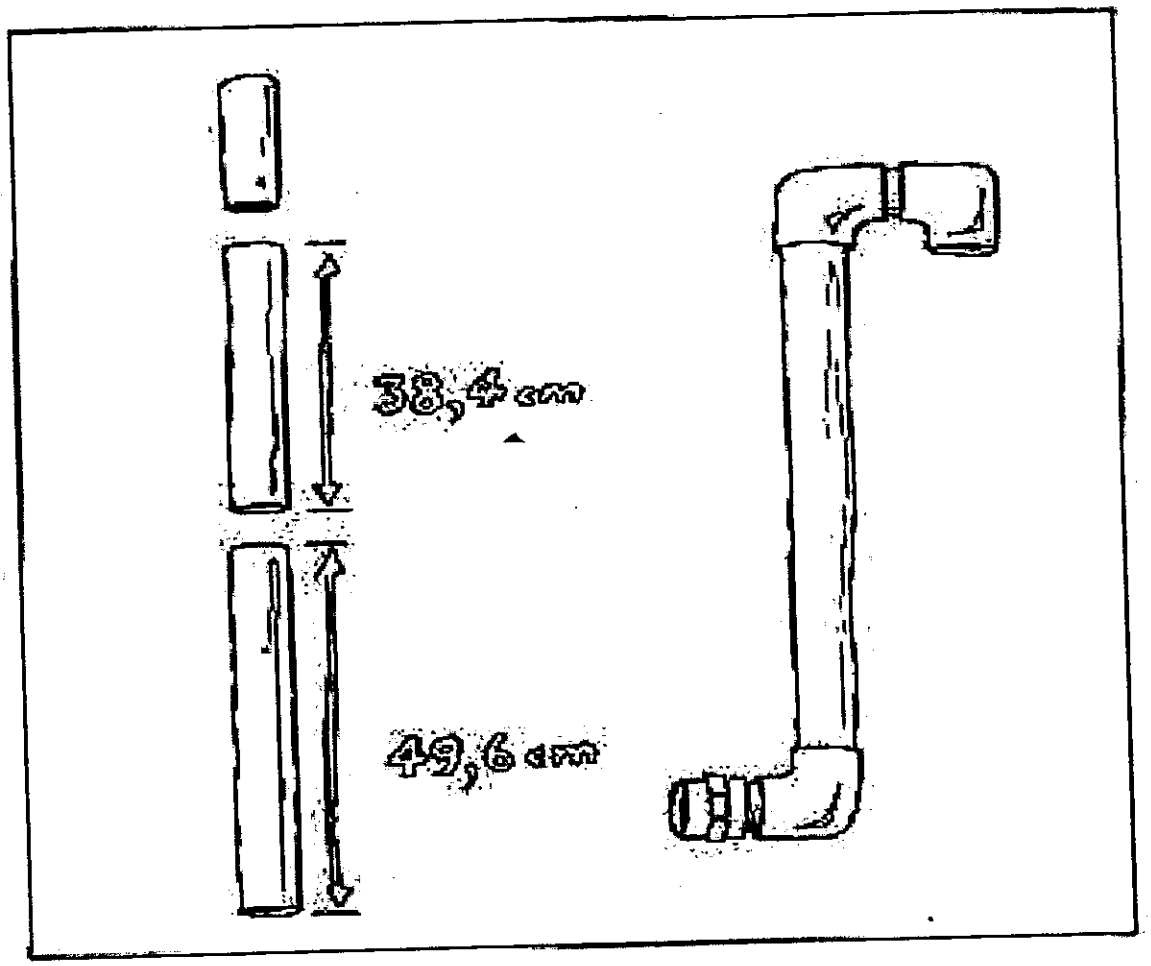
   A 49.6 cm section.

   A 38.4 cm section.

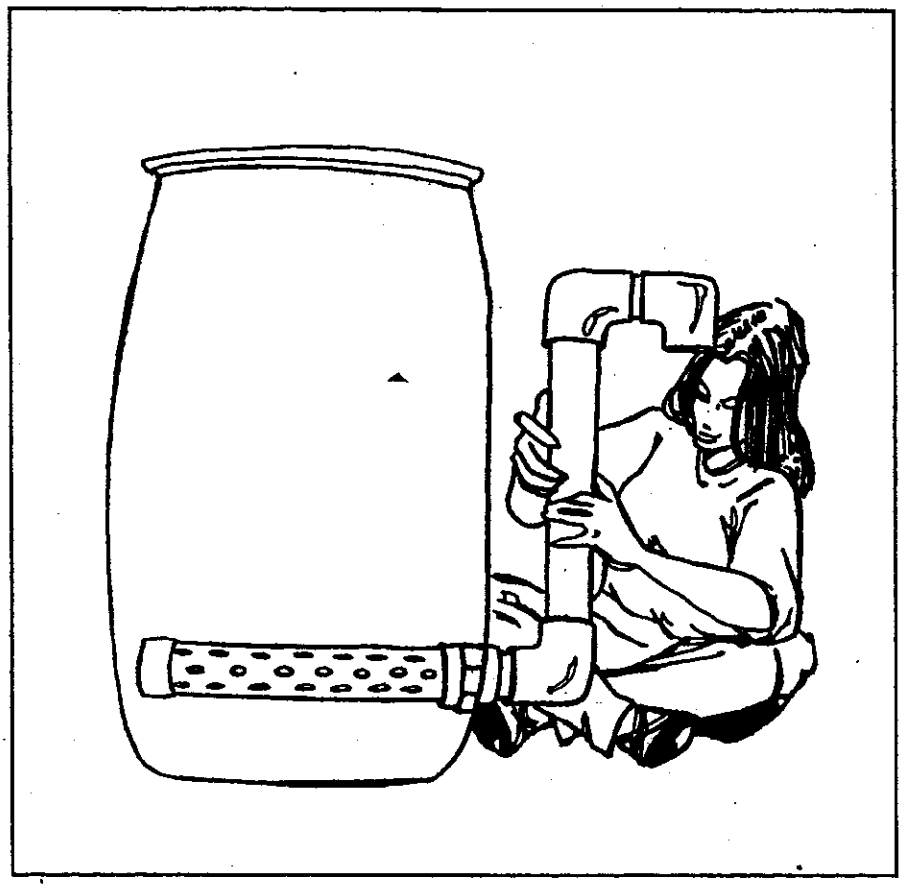
   Keep the remaining section.

3. Glue a 90° elbow joint to each of the ends of the 49.6 cm section. Make sure the openings of these two elbow joints point towards opposite sides (one towards the left and the other towards the right). When finished the section will look like an elongates letter S. This S shaped section will be known as the outlet pipe.

4. Cut a 5 cm section from the leftover pipe and use it to attach and glue the third elbow joint to one of the two elbow joints already glued in the previous step to the 49.6 cm. section. Attach it in such as way as to form a U shape. This end will be the upper end of the outlet pipe.



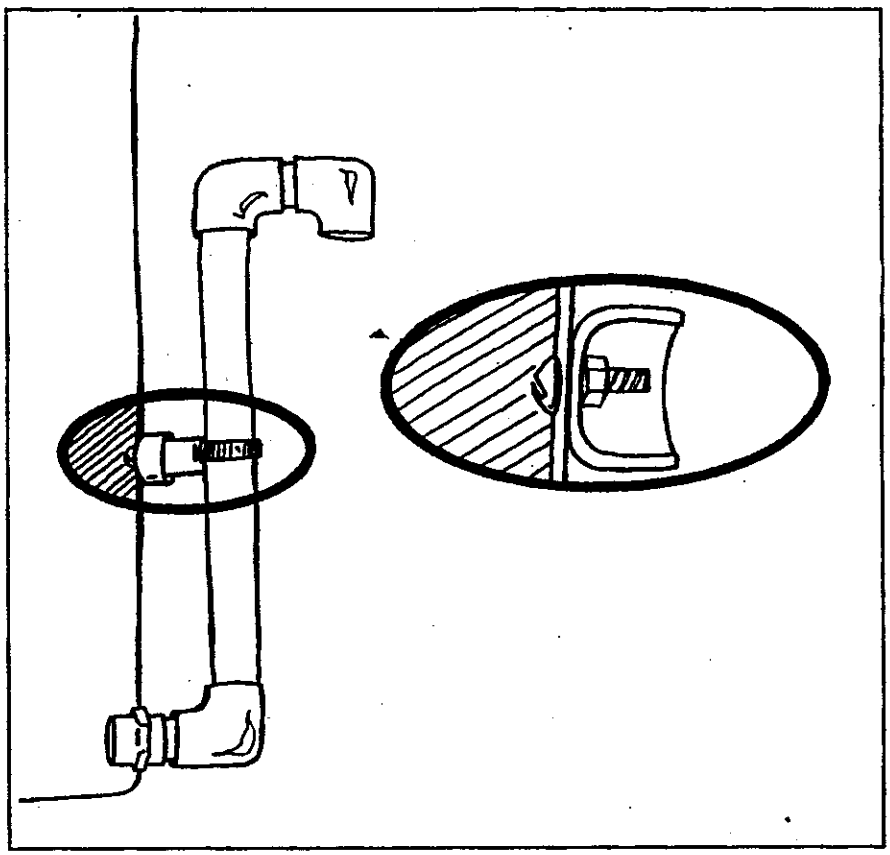
5. With another 5 cm section from the leftover pipe glue the female connector (adaptor) to the lower end of the outlet pipe (the end with just one elbow joint).



6. Make holes in the 38.4 cm section of PVC pipe. The holes must be small enough to avoid the filter's gravel to enter the pipe (use the 5 mm bit). The holes should be at about 12 mm from each other. Glue one of the female PVC pipe caps to one end of this pipe. Glue the other end to the male connector (adapter). This section now assembled is known as the drainage pipe.

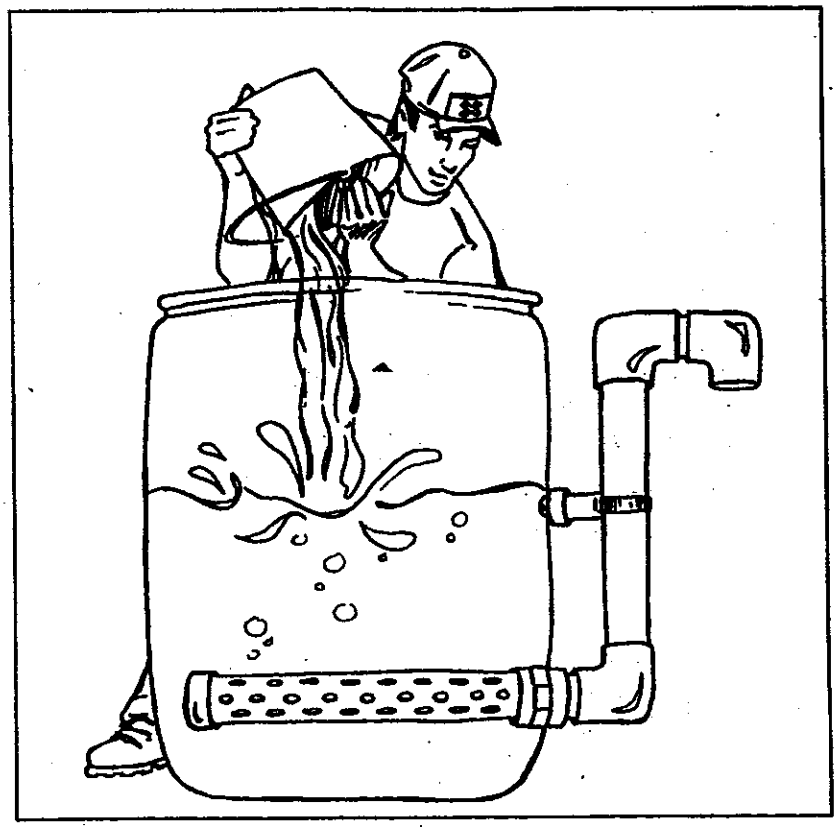
7. With a knife make a perforation of 25 mm in diameter in the lower part of the barrel wall, at about 4 cm from the bottom.

8. Introduce the drainage pipe in the barrel in such a way that the end of the male connector goes out through the perforation you made close to the bottom in the previous step.



9. Connect the exit pipe to the drainage pipe screwing its respective connectors (male and female). If you have a Teflon tape, wrap it around the threaded end of the male connector to allow it to fit better and, if you have them, also use rubber gaskets in this joint. Use the silicon sealant to finish sealing it.

10. At a distance of 38.4 cm from the bottom of the barrel screw the female pipe cap to the outside of the barrel wall, just behind the outlet pipe. The head of the bolt should be in the inside of the barrel. (This pipe cap will serve as a tying point to support the outlet pipe, as it is explained in the next steps). Seal with sealant the hole made by the bolt.



11. Cut another small piece from the leftover pipe, long enough to reach from the female pipe cap that was bolted to the barrel in the previous step to the outlet pipe in from of that pipe cap. Cut two slits with the knife at the end of this pipe piece (to better attach the pipe strap) and, with the slits facing outwards, glue this piece of pipe to the female pipe cap that was bolted into the barrel.

12. With a tape or a piece of gauze tie firmly the outlet pipe to the slits made in the previous step. Place the pipe strap on top of the slits (now covered with tape or gauze) and tighten well for the outlet pipe to be firmly attached in place, preventing it from slipping.

13. To check for leaks, fill the barrel with water until it covers the bolt that attaches the female pipe cap to the barrel wall. If any are found seal them with silicone.

F. How to install it

The filtering materials must be prepared as follows:

- The gravel should be very clean and have a size of approximately 5 to 6 mm. If uniform gravel is not readily available use for this purpose the 6 and 5 mm sieves. The gravel and impurities that remain in the 6 mm sieve should be discarded . The gravel and impurities that fall through the 5 mm sieve should also be discarded , and only the gravel retained by the 5 mm sieve should be used. .

- The sand sizes should be very uniform, from 1 to 2 mm for the coarse sand, to under 1 mm (some as fine as dust) for the fine sand. For this purpose the sand should be sieved. The sand and impurities that stay in the 2 mm sieve should be discarded. The sand that stays in the 1 mm sieve is considered coarse sand and what goes through this sieve will be considered fine sand.

- All materials, after this classification, may be washed before placing inside the container as filtering material to get rid of impurities.

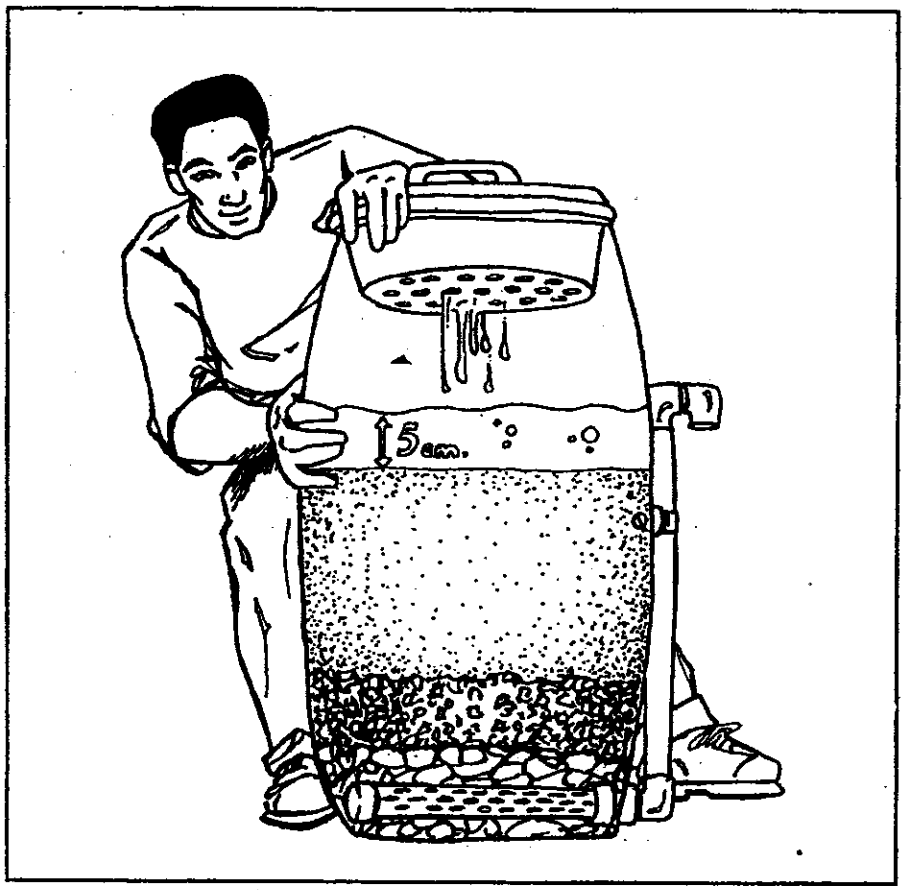
1. Place the barrel where it will be used. Once filled with sand and gravel it should not be moved.

2. Place 7.5 cm of gravel at the bottom of the barrel and level it. The drainage pipe (the perforated pipe) must be covered by at least 2.5 cm of gravel.

3. Add water, as clean as possible, to a level of 10 cm over the gravel.

4. Slowly, add the coarse sand to the water until a 4.5 cm layer accumulates on top of the gravel. Level it well using your hands. Always add the sand to the water. This will allow air to escape from the sand. Keep on adding water as necessary.

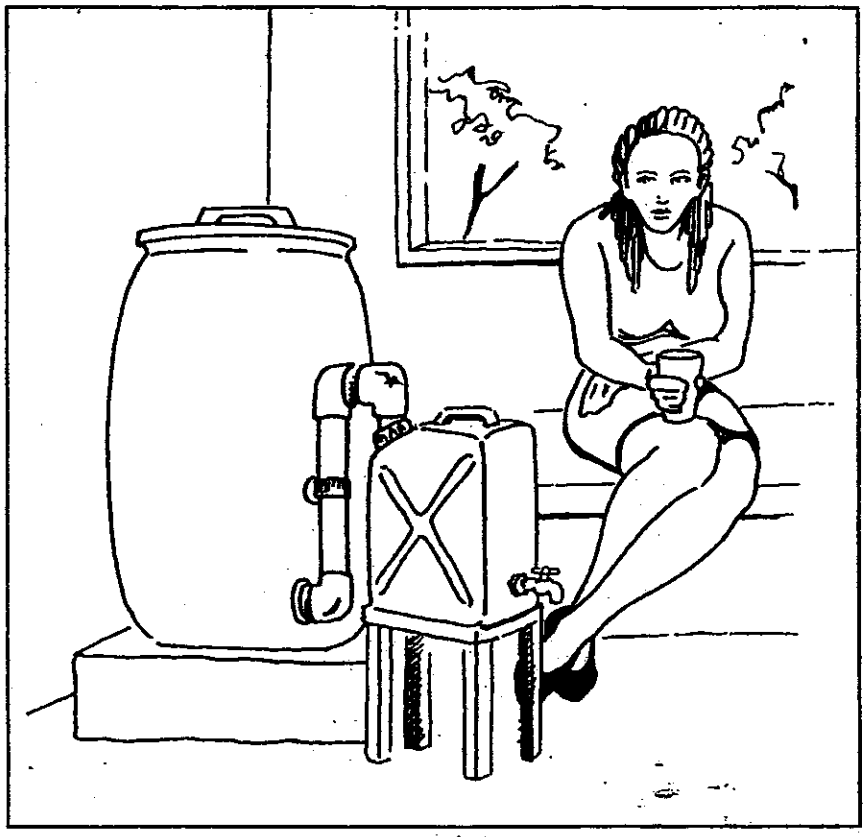
5. Slowly and gradually add the fine sand to the container until a third filtering layer is formed to a level of 5 cm below the water surface. Once this level is reached the water should start flowing through the outlet pipe.



6. Place the colander/diffuser basin in the upper part of the filter.

7. Clean the filter by constantly adding water until it comes out very clean. When the filter is not in use it should be kept with water to a level of approximately 5 cm above the sand.

8 Place the lid on top of the colander/diffuser basin. The filter must remain covered to avoid foreign materials falling in.



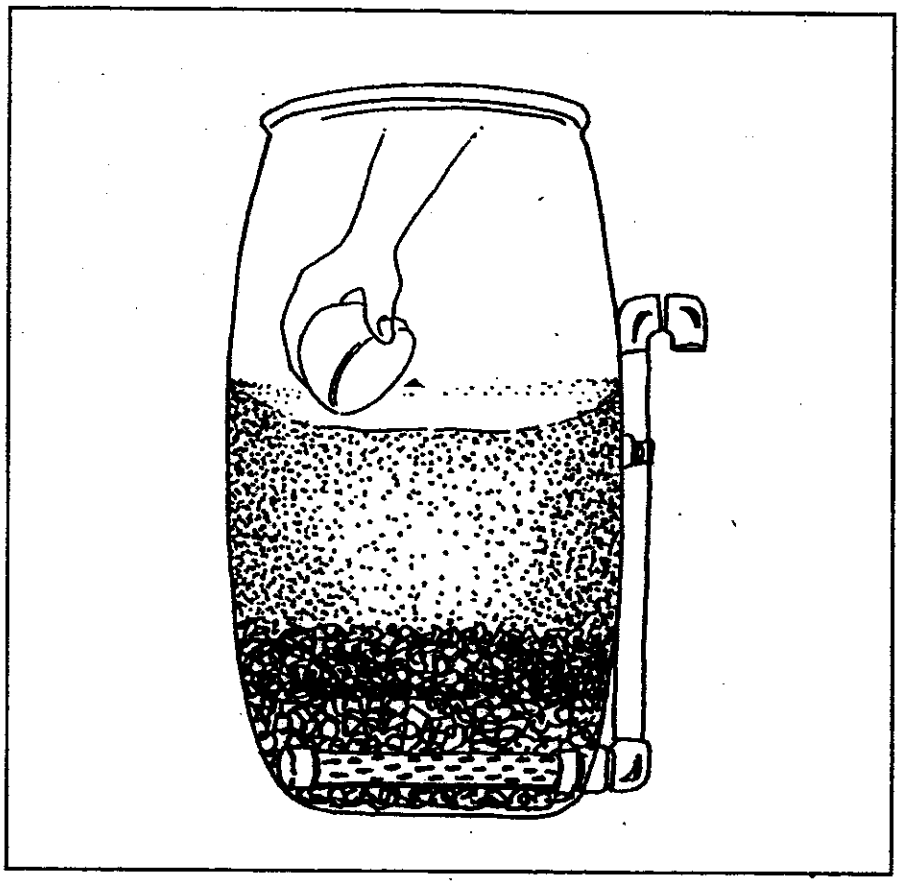
G. How to use it

1. Place a clean and appropriate container under the filter exit.

2. Slowly add water to the filter pouring it always over the colander/diffuser basin and allow it to drain through the filter.

   Never pour water directly over the sand layers.

3. Store the filtered water in a clean container and always keep it well lid. It is very convenient to be ale to draw water from this ~~receipient~~ receptacle through a tap rather than introducing your hand or any tool.



H. How to do maintenance

When the rate of water flow slows down too much it is time for maintenance, for which the following steps are required:

1. Remove the lid and the colander/diffuser basin.

- Lower the water level inside the filter using a small cup to scoop the water has not drained through the outlet pipe.

- Make a small hole in the sand with the cup. Scoop the water that accumulates in it until only wet sand remains.

4. Remove 3 to 5 cm of the fine sand layer and set it aside.

(After washing and drying in the sun, this sand may be reused next time maintenance is performed)

5. Reinstall the colander/diffuser basin.

6. Add water slowly to the filter until water starts flowing once again through the outlet pipe.

7. Remove once again the colander/diffuser basin and add clean fine sand until the layer of sand reaches once again a level of 5 cm below the water surface. Level the surface of the sand

8. Reinstall once more the colander/diffuser basin and the lid.

The filter is ready to be used again. Its normal operation will be reestablished after 2 to 3 days.

I. Recommendations

- Do not move the filter after it has been filled with the filtering material to avoid disturbing the sand and gravel layers. If it must be moved a short distance, ensure at least that vibrations or jarring are minimized.

- If the filter must moved a longer distance, remove the sand and gravel prior to transport. They can be reused in its new location.

- Do not use sand form polluted rivers (like those in which untreated or industrial are drained). Search for clean looking sand bars.

- The filter should not be used as a water storage device.

- Filtered water can be treated with chlorine. The dosages should be small enough for the water not to present a perceptible taste of chlorine.