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Ranquitte, Haiti

Biological Sand Filtration

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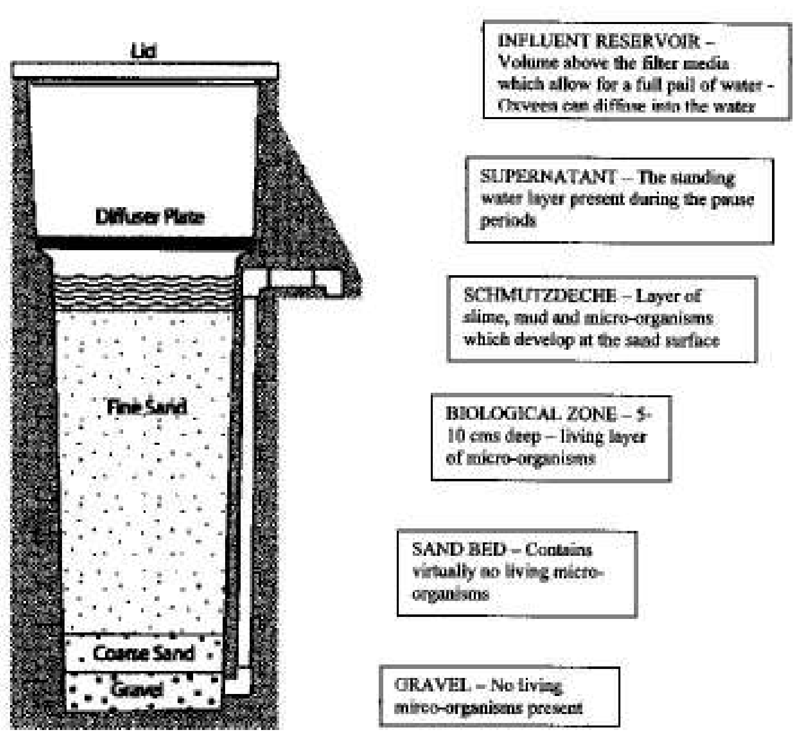
Water Treatment

Raw water is treated in 3 main ways: sedimentation, filtration and disinfection.

Sedimentation:
If the water contains particles of sand, grit and dirt, it can be left in a container for some time to allow the particles to settle. Bacteria often grow attached to particle surfaces. Removal of particles by sedimentation will produce a marked reduction in bacterial concentrations. This is done by allowing a container of water to settle for 2.5 hours.

Filtration:
Filters remove pathogens in several ways. These include straining, where the particles or larger pathogens such as worms become trapped in the small spaces between the grains; absorption, where pathogens become attached to the filter media; or biologic processes where pathogens die naturally or the micro organisms which live in the filter consume the bacteria and pathogens. Examples of filtration systems include rapid sand filters, ceramic filters, slow sand filters and biosand filters.

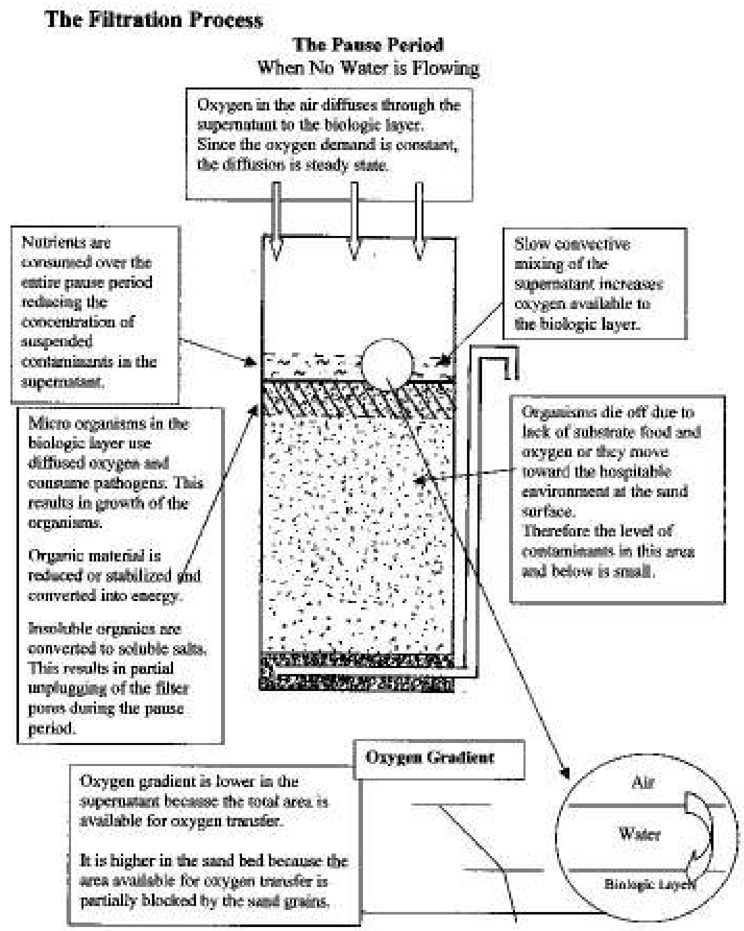
Disinfection:
Disinfection comes about primarily through the destruction of the organism cell walls by oxidation. This oxidation is normally a result of the addition of chemicals such as chlorine. It can also be induced by ultraviolet radiation. Pathogens can hide from disinfecting agents in organic and inorganic residue in the water. Removal of suspended materials by sedimentation and filtration greatly improve the performance of chemical disinfection agents. Examples of this are the addition of chlorine or sodium hypochlorite to water, solar disinfection (SODIS), or solar pasteurization.



BioSand Filter

The major benefits of slow sand filtration are due to the microbiology of the filter. The microbiological community must be kept alive for the filter to be effective. In a conventional slow sand filter, oxygen is supplied to the organisms through dissolved oxygen in the water. Consequently, they are designed to be operated continuously. Also, because the water moves through at a slow rate, the filter beds tend to be very large.

The biosand water filter is an invention that modifies the traditional slow sand filters in such a way that the filters can be built on a smaller scale and can be operated intermittently. These modifications make the filter suitable for use at the household or small group level. This would simply not be possible with conventional slow sand filtration because of the size requirements and the mode of operation.
A bucket of contaminated water is poured into the top of the filter as necessary. The water simply flows through the filter and is collected in another bucket or container at the base of the spout. It normally takes a few minutes for the entire bucket to make its way through the filter. There are no valves or moving parts and the design of the outlet system ensures that a minimum water depth of five centimetres is maintained over the sand when the filter is not in use.
When the water is flowing through the filter, oxygen is supplied to the biologic layer at the top of the sand by the dissolved oxygen in the water. During pause times, when the water is not flowing, the oxygen is obtained by diffusion from the air and by slow convective mixing of the layer of water above the sand. If this layer is kept shallow, enough oxygen is able to pass through to the microorganisms to keep them alive and thus effective.



FILTER OPERATIONS

Consistent operations are very important in a biosand filter

Flow Rates
The micro-organisms are more closely confined near the surface of the sand bed in a biosand water filter than in a continuously operated slow sand filter. This is because in the biosand water filter, the oxygen supply is limited by diffusion from the surface. Because of the thin biologic zone, there is a shorter contact time between the bio film and water during filter runs. Slower filtration rates are therefore required in a biosand filter to produce water of similar bacteriological quality as a continuously operated filter.
The percentage removal of contaminants is inversely proportional to the flow rate through the filter because the biologic reduction of contaminants takes time. Each biosand filter has been designed to allow for a filter loading rate (the flow rate per square metre of filter area) which has proven to be effective in laboratory and field tests.
The amount of water that flows through the biosand filter is controlled by the size of sand media contained within the filter. If the rate is too fast, the efficiency of bacterial removal may be reduced. If the flow rate is too slow, there will be an insufficient amount of treated water, the users will become impatient and may use contaminated sources of water.

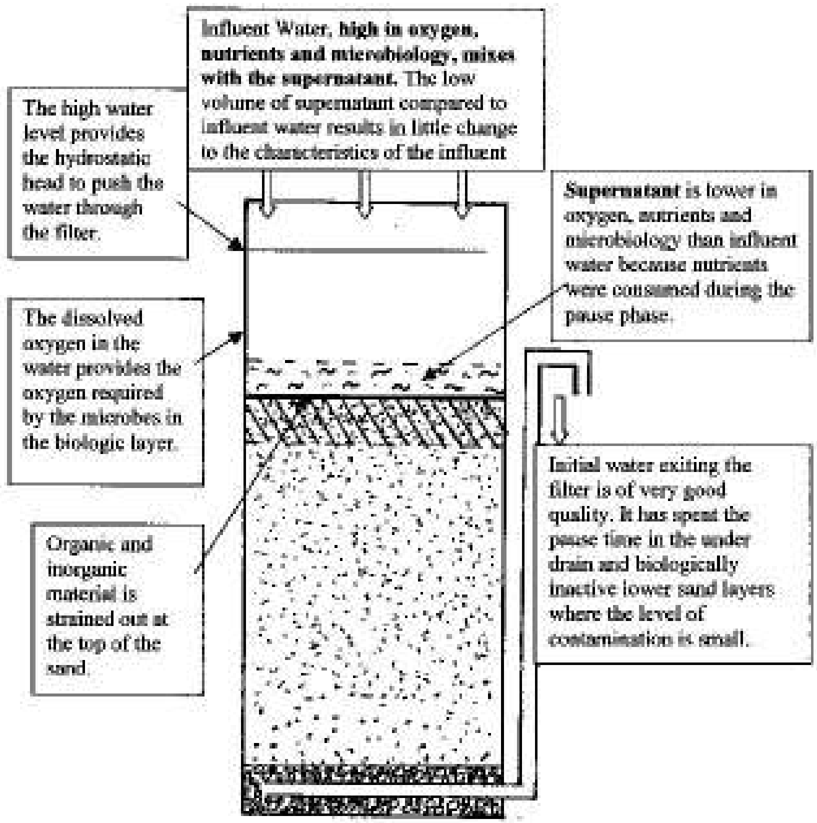
Pause Periods
If the pause period is extended for too long, the micro-organisms will eventually consume all the substrate and then die. This results in a marked reduction in removal efficiency of the filter.
However the pause periods are also very

important because they allow time for the micro-organisms in the biologic layer to consume the pathogens contained in the water, thereby increasing the hydraulic conductivity of the filter. There is an exponential increase in filter hydraulic conductivity as the pause length is increased.
Consequently, the biosand filter is most effective and efficient when operated intermittently.
A pause period is required to allow time for the micro organisms in the biologic zone to consume the pathogens contained in the water. As they are consumed from the biological zone, the flow through the filter can be restored. Flow rates may be increased as the length of pause period is increased. However, if the pause period is extended for too long, the micro organisms will eventually consume all of the food supply and then die off.
Consequently, the biosand filter is most effective and efficient when operated intermittently and consistently. A pause period of 6-12 hours is a suggested time with a minimum of 1 hour and a maximum of 48 hours.

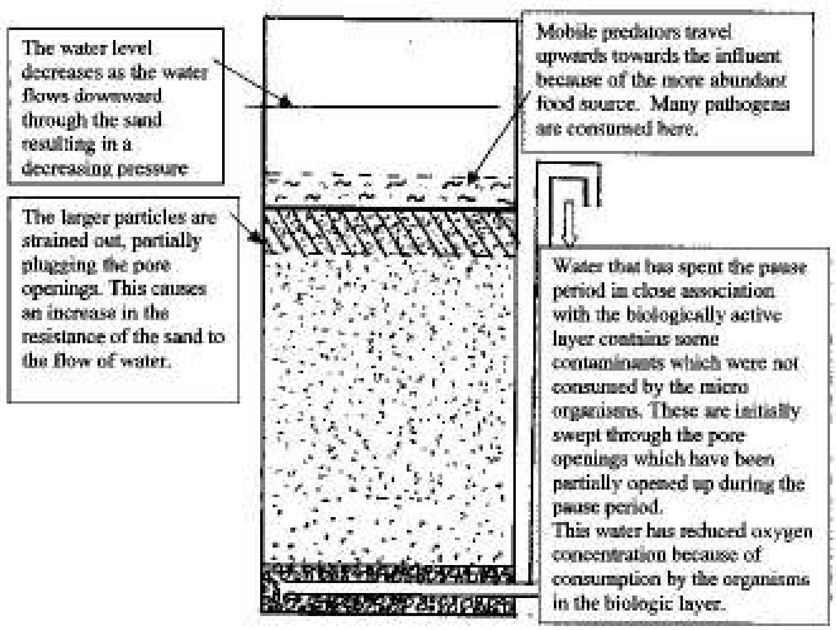
Water Depths
Changes in the water depth during the pause period will change the depth of the bio zone. A greater water depth results in lower oxygen diffusion and consequently a thinner bio zone. With increasing water depth, the bio-layer moves upwards in the sand bed and thus oxidation and metabolism decrease. Eventually, the filter becomes a non living system.
If the water depth during the pause period is increased suddenly and the water level is too deep to allow any oxygen to reach the biologic layer, the entire biologically active zone becomes anaerobic.
Correct operation of the biosand filter will result in a constant water level over the pause periods.
Changes in the water depth above the sand surface will cause a change in the biological zone disrupting the efficiency of the filter. A water depth of greater than 5-8 cm results in lower oxygen diffusion and consequently a thinner biological zone. A high water level can be caused by a blocked outlet spout or by an insufficient amount of sand media. As the water depth increases, the oxidation and metabolism of the micro organisms within the biological zone decrease. Eventually the layer dies off and the filter becomes ineffective.
Correct operation of the biosand filter requires a constant water level of approximately 5 cm (2) above the sand level during the pause periods.

Water Quality
Over time, the micro-organisms in the biologic layer become adapted to conditions where a certain amount of food is available. When an influent spike occurs, whereby an increased level of contamination in the water is present, the micro-organisms are unable to consume or destroy all the contaminants. The spike event may provide enough contaminants that the filter will not degrade and destroy them for several days. Previous experiments have indicated that the largest portion of bacteria from a spike show up in the effluent water the next day.
The water supplied to the filter can be from rain

The Start of the Run



Halfway Through the Run

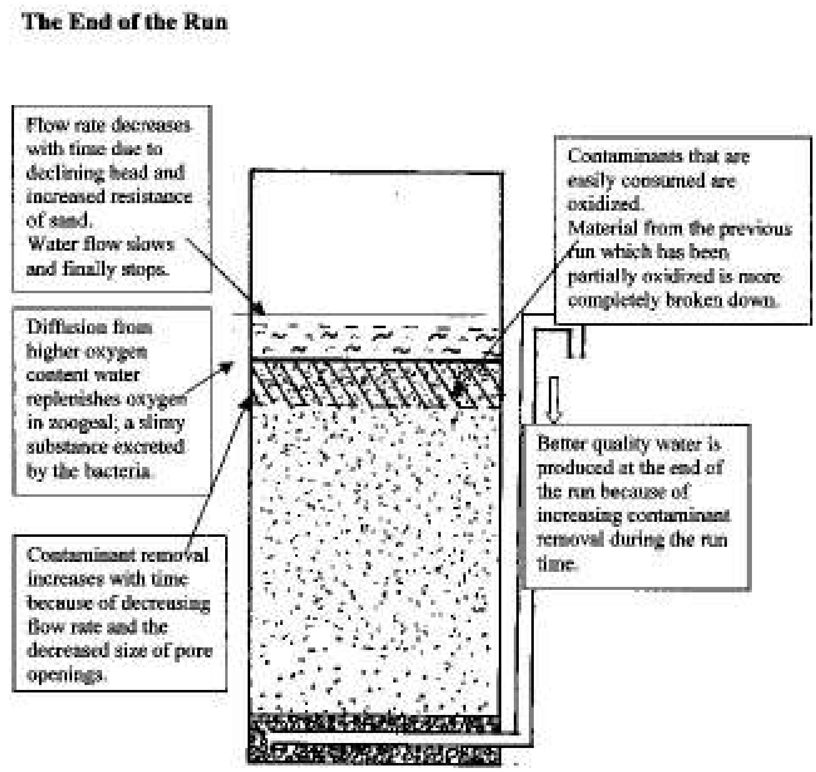


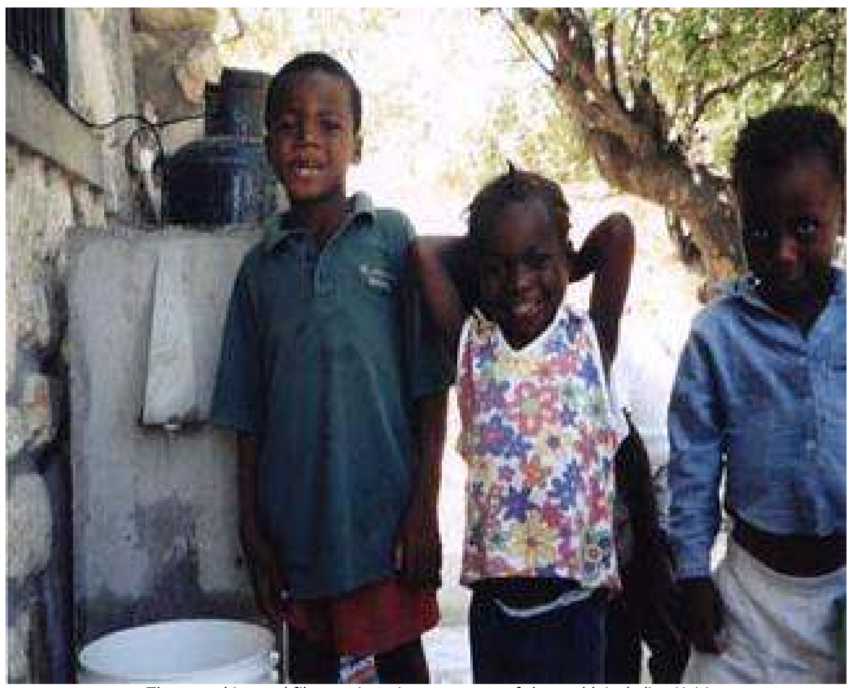
water, deep wells, shallow wells, rivers, lakes, reservoirs or surface water. It should be consistently taken from the same source.
The turbidity or amount of suspended particles in the water is also a key factor in the operation of the filter. It should be relatively free of suspended particles. If the turbidity is greater than 100 NTU, the water should be pre filtered before it goes though the biosand filter. A simple test to measure the turbidity is to use a 2 liter clear plastic soft drink bottle filled with water. Place this on top of large print. If you can see it, the water probably has a turbidity of less than 50 NTU. To ensure the high possible quality water for the users, it is recommended that a disinfection process such as chlorine addition or SODIS be used in conjunction with the biosand filter.

Time
It normally takes a period of three weeks for the biologic layer to develop to maturity in a new filter. During that time, both the removal efficiency and the oxygen demand of the filter increase as the biologic layer grows. The filters are cleaned by stirring up the thin layer of sand at the surface and scooping out the resulting dirty water. After cleaning, the removal efficiency declines somewhat, but increases very quickly to its previous level as the bio-layer is re-established.The following are notes that apply to the biosand filter that can be used when comparing technologies.

Functionality
The term functionality considers how appropriate the technology is for the user.
The BioSand filter is a point of use or household treatment device. The water to be filtered can be obtained from the closest water supply point, whether river, stream or well, carried physically to the filter and used immediately thereafter. The water supply, water treatment and water distribution are therefore all within the control of the individual householder. Effective use of the technology does not require the formation of user groups or other community support which are normally very difficult to develop. The independence of the household makes this technology extremely suitable for use in developing countries which often lack the governance and regulatory processes necessary for effective and efficient multi- family systems.
The operation and maintenance of the filter are simple. There are no moving parts that require skill to operate. When the flow through the filter becomes too low, the maintenance consists simply of washing the top few centimetres of sand. The operation and maintenance of the filter are therefore well within the capacity of the women in the household who are normally responsible for food preparation and care of the children.
The filter takes up very little space and can easily fit into most rooms. In fact, previous experience has shown that because it is so important to the individual household, it normally occupies a place of significance in the living room.

Capital Cost
The cost of providing the potable water to the household is simply the cost of the filter since the cost of the water supply and distribution can be provided by the individual householders labour.




There are bio-sand filter projects in many parts of the world, including Haiti

The cost of a concrete biosand water filter is approximately $15 US. This cost does not change dramatically from country to country, because its principal components, concrete and sand and gravel are readily available in all developing countries. The manufacture of the filters also involves a significant labour component to mix the concrete and place it in the filter mold. The skills required to do this are again readily available in developing countries at a very low cost, and, in fact, can be provided by the individual home owner himself.

Operating Costs

The cost of operating the filter is negligible. There are no consumables involved in the filtration process. There are no moving parts which require replacement on an ongoing basis. Maintenance costs may include the occasional replacement of the filter lid or diffuser basin since these contain wooden components which may rot over time. This cost may amount to $1 to 2 US over a 3 year span. Many systems now have plastic lids and diffuser plates which will not rot. Consequently, once installed, the filter can be used almost indefinitely with negligible cost to the owner.

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