Guidelines

Preparation of Media for the BioSand Water Filter

"When there is no crushed rock!"

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The purpose of preparing and publishing these guidelines on the internet is to provide a readily available common reference to all those involved in BioSand Water Filter manufacture, funding, use, evaluation or support.

Introduction

Two guidelines have been prepared for preparation of media for the BioSand Water Filter, 'Three Layer System' and 'Four Layer System'. Both of these guidelines specify the use of uncontaminated media, preferably crushed rock obtained from quarries. On occasion this type of material is not available. It may be:

- Literally unavailable such as on islands or deltas of very large rivers.
- Prohibitively expensive if it is available.

These circumstances present significant challenges to the successful use of the BioSand Water Filter technology.

Historically, when faced with this situation, individuals and organizations have simply used the 'best' media they have available, which was quite probably contaminated with offending organic matter and associated micro-organisms. The view was that "some treatment was better than nothing". This is a view that I share because the water treatment provided by BioSand Water Filters still produces a quality product that is **always** a substantial improvement over doing nothing.

This guideline describes how to select and prepare media, which is likely contaminated with organic particles (plant or animal in origin), for successful use in the BioSand Water Filter.

Nature of Contaminated Media

Supplies of rock aggregate, (rock already broken into small pieces or collections of river, lake, ocean, or glacier deposits) that are found at or near the surface of the ground will be contain organic matter. The organic matter may exist as discrete particles of plants and animals; or, the organic matter may be attached to the rock particles in the form of a coating or as masses of material simply adhering (stuck) to the rock particles. Other fine inorganic material may also be found.

Virtually all aggregate deposits accessible by surface exaction are contaminated. Beach sand of any type is usually very contaminated. Aggregate material taken from open pits located anywhere near human habitation is also very contaminated.

It does not matter how deep these deposits are because the contaminating material simply washes down from the ground surface with every rain. **The layers of soil, ground or sand do not act like a water filter and certainly not like a BioSand Water Filter as is often thought! Very large pieces of organic material remain near the surface but contaminants, including pathogens, are simply moved further from the surface into the aggregate material.** The BioSand Water Filter is a very carefully engineered product and not a simple 'copy of nature'. There are, in fact, few similarities.

Unfortunately, even the 'best available aggregate materials' taken from areas remote from any human activity; are all likely 'contaminated'. Absence of contamination from human activity does not mean that the water is free from human pathogens. Many human pathogens, particularly parasites and helminths, also thrive within animal populations. Aggregate material **will always be contaminated** if water from the ground surface can freely drain into it.

Determining if Media is Contaminated

Media contamination may be evaluated by first washing a sample very thoroughly in disinfected local water supplies (boiled and cooled). The media sample should not be disinfected. One or two grams of the media sample (about a sugar cube volume) should be placed in a sterilized bottle with 500 ml to 1 litre of disinfected local water and the suspension well shaken. The suspension should be allowed to settle and the water taken to a laboratory for analysis of pathogen indicator organisms including total colliform bacteria and one of either fecal colliform bacteria or Escherichia bacteria. (Carefully follow the instructions provided by the laboratory for bacteria testing.) The presence of these bacteria indicates that the media is contaminated. Clearly, care must be taken to ensure that the media sample was taken from a location typical of the supply and was not contaminated during handling.

Sterilizing or Disinfecting Contaminated Media

Sterilization or disinfection means the killing or deactivation of the micro-organisms in the media. (Micro-organisms are said to be deactivated if their ability to be infectious is removed by inhibiting their ability to expand their population.) Disinfection can be achieved by heating the media to pasteurizing temperatures or possibly using dilute concentrations of disinfectant such as sodium hypochlorite. Neither of these approaches are practical and certainly do not eliminate the problem so long as organic matter, which represents food to the micro-organisms remains in the media. As soon as a filter installed with organically contaminated media is used, the media is colonized by the micro-organisms from the water being treated. The micro-organisms use the organic matter in the media for food and they will be present in the media until the food supply is exhausted. Unfortunately, many of the micro-organisms will 'shed' or 'detach' from the

particulate material and be washed into the water as it moves through and out of the filter. The filtered water may have greater populations of indicator organisms than the untreated water – a clearly upsetting situation if not understood. Several months of normal filter use would be required for micro-organism food supplies to be exhausted.

Particulate organic matter may be removed from an aggregate by washing it very well

The attached organic matter cannot be removed by washing. The only remotely practical technique is to roast the organic matter from the media by heating it to temperatures which cause the organic matter to either vaporize or carbonize (turn into charcoal). The organic matter will not burn as such because of the absence of oxygen within the media itself. If roasting is considered the media MUST be heated at high temperatures until it no longer smokes. Roasted media will 'blacken' because of the carbonizing process. Carbonizing will not affect media performance because the carbon particles do not represent a 'food' for micro-organisms.

Preparation of Media Obtained from Potentially Contaminated Sources

The preferred approach to preparation of potentially contaminated media is to use either of the methods in the guidelines describing the "Three Layer System" or the " Four Layer System". The only major consideration is that the media MUST be thoroughly washed and dried before media production proceeds to insure removal of as much organic particulate material as possible. This suggests that perhaps the "Four Layer System" may be the technique of choice but the "Three Layer System" may be possible to use if sufficient fine materials remain after thorough washing. If the unprocessed media was contaminated then it will still be contaminated after processing.

The question is: "What do we do about the contamination?"

The answer is: "We use the filters normally and we must use the post filtration disinfection procedures."

The BioSand Water Filter is a form of slow sand filtration and this brings several advantages in circumstances where the media is contaminated. Similar to any traditional slow sand filter micro organisms (including pathogens in the form of helminths, parasites, bacteria and viruses) and other particulate material are removed at or very near the surface of the media. Helminths and parasites will be completely removed from the untreated water from the moment the filter is used. Bacteria and virus removal can be expected to be approximately 60% if the water is free of other particulate matter (if particulate matter is present and is removed, bacteria and virus removal can be expected to be 90% or greater). With time a biolayer (or schmutzdecke) will form at the surface of the media and bacteria and virus removals may approach 100%. Some bacteria and viruses can always be expected to pass through the biolayer. In fact virus removal or deactivation seems to require a minimum depth of media and this is a major consideration in the determination of the media design used in the BioSand Water Filter. Bacteria that pass through the biolayer will colonize on the contaminated media in the filter. Enteric

bacteria, (bacteria, such as fecal colliform bacteria, found in the gastro intestinal tract of warm blooded animals), thrive in both anaerobic (no oxygen) and aerobic (oxygen is present) environments. There is very little oxygen in the media below the biolayer and the environment may be considered to be anaerobic. The bacteria will use the contamination on the surface of the particles that comprise the media. The number of bacteria will increase and the bacteria will thrive until all of the food is consumed. Some of these bacteria will detach from the media and leave the filter in the 'treated' water.

Note that most particulate matter, 100% of the helminths, encysted and not encysted parasites and up to 99% or more of the bacteria and viruses found in the untreated water will be removed as soon as the biolayer is formed. However, the number of enteric bacteria detected in the filtered water may be much greater than the number in the unfiltered water until the food on the surfaces of the filter media is consumed. Once all of the food is consumed the filter will demonstrate bacteria removal characteristics associated with filters installed using media that was not contaminated. The time required for the food to be consumed will vary with the severity of the contamination and the amount of water being filtered but should not take longer than a few months. Micro organisms that remain in the filtered water are easily killed using minimum amounts of sodium hypochlorite solution.

Synthetic Media

It may be possible to use crushed concrete made using very fine aggregate (silt or very fine sand) or from crushed clean bricks. Both of these materials crush very easily and in many countries machines are available to facilitate the crushing process. After the media is crushed it should be processed as per the guidelines for the 'Three Layer System" or the "Four Layer System" for media preparation.

Performance Evaluation of Filters Installed Using Contaminated Media

Filter performance should be evaluated by comparing indicator bacteria concentrations in the untreated water with the filtered water. Samples should always be taken in pairs (untreated and treated). Initially, the removal rate will be very low or even negative; but, with time and usage, filter performance will be similar to those filters installed using clean media.

It should be recognized that the BioSand Water Filter is actually part of a treatment system that includes post filtration disinfection, water storage and a method for dispensing the treated water. It is expected that the entire BioSand Water Filter based treatment system is used in every instance; and ultimately, the treatment system should be evaluated on the basis of the quality of the dispensed water. All BioSand Water filter based treatment systems can be expected to provide drinking water that meets World Health Organization drinking water guidelines.

Final Comments

Considering the effort required preparing contaminated media for use in the BioSand Water Filter and the resulting confusion related to the water filter performance, it is obvious that clean crushed rock is the material of choice. Transporting high quality crushed rock (when available) over considerable distances is usually well worth the effort.