Arsenic Removal from Drinking Water
Bio-Sand Filter Design

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For

NON-PROFITS, NGOs and
HEALTH ORGANIZATIONS
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Arsenic poisoning also known as arsenicosis occurs when a person’s body contains greater than normal levels of arsenic, a semi-metallic element. The naturally occurring presence of arsenic in groundwater is a major problem in parts of Cambodia and India that affects millions of rural people. These countries have rivers that flow from major mountain ranges that carry large volumes of sediment and arsenic is carried in these sediments, which are deposited in riverbanks and floodplains. The arsenic is released from the sediments and dissolves into groundwater aquifers. These contaminated waters are pumped to the surface by wells and consumed by the local population which causes arsenicosis.

The most common signs of arsenicosis is the hardening and discoloration of skin on the hands and feet, known as keratosis or melanosis. These skin lesions are prone to infection and gangrene and in extreme cases amputation is necessary to relieve suffering. Beyond these external manifestations, arsenic consumption also increases the risk of developing various internal cancers, most commonly lung and skin cancer. In most situations, arsenic cannot be removed by water treatment techniques typical of developing countries, such as boiling or filtering. Many developing countries, including Cambodia, have set their standard at 50 ppb.

The Cambodia Kanchan Arsenic Filter, Phase I Technical Report FINAL Sep08 Study has demonstrated that iron oxide or common rust has the ability to remove arsenic from water through adsorption. The arsenic becomes attached to the iron oxide and is removed from water. This is great news for Cambodia. A recent report commissioned by the Ministry of Rural Development (MRD) and UNICEF found that an estimated 320,000 people in 1,600 villages are at risk.

Operations of KAF Bio-Sand Filter with iron nails for arsenic removal:
The Kanchan Arsenic Filter was developed to remove arsenic from drinking water by the Massachusetts Institute of Technology (MIT) and a Nepali NGO, Environment and Public Health Organization (ENPHO) based on 7 years of extensive inter-disciplinary laboratory and field studies in rural villages of Nepal (Ngai et al, 2006).

Polluted / contaminated water is poured into the top of the bio-sand filter on a regular schedule. The water flows over the bed of brick chips covering iron nails then through the diffuser, and percolates down through the biological layer, sand and gravel. This treated water then flows through the valve outlet pipe. The rusty nails removes arsenic and the biological layer removes pathogens from the water. The biological layer forms in 15 to 30 days depending on frequency of use.

Disinfection is recommended for the water from the bio-sand filter during the first couple of weeks while the biological layer is being established.
The contaminated water is aerated while it is flowing through the brick chips, nails and diffuser. Dissolved oxygen in the water is provided to the biological layer. Operation of the bio-sand filter should have an average water level of 8 cm above the biological-layer during the pause period. A water depth greater than 8 cm will lessen the oxygen diffusion in the biological layer. A water depth less than 8 cm will evaporate in hot climates and cause the biological layer to die. The pause period is required between water supplies to allow time for the microorganisms in the biological layer to consume / remove pathogens from the contaminated water. The recommended pause period is 6 to 12 hours with 1 hour minimum and 42 hours maximum.

This Bio-Sand Filter (KAF) has been designed to allow for a filter loading rate (flow rate per square meter of filter area) which has proven to be effective in laboratory and field tests. This filter loading rate has been determined to be not more than 600 litres/hour/square metre.

Consistently excellent arsenic removal

Reference: Cambodia Kanchan Arsenic Filter, Phase I Technical Report FINAL Sep08
Requirements / Specifications:

1. Allow approximately up to 30 days to establish the biological treatment layer and 2 weeks to establish rust on the nails.

2. Filter must be used every day to establish and maintain the biological layer

3. Best performance requires that the water source must come from the same location / source; the bio-layer organisms are from the water source (both good and bad organisms). If the water is from a different source then there will be different organisms and this will decrease treatment efficiency.
4. Swirl and dump maintenance will reduce efficiency until the disturbed bio-layer is re-established which could take several days.

5. A pause between adding water of 8 hours (plus or minus 2 hours) is needed between adding water to the sand bio-filter to allow time for the microorganisms in the bio-layer to consume pathogens in the water, and to allow time for the nails to rust properly.

6. The recommended pause period is a minimum of 1 hour and maximum of 48 hours.

Conclusions:

The phase 1 field testing results are positive for people living in rural Cambodia. The contaminated water in the field testing site contains high arsenic and phosphate levels, which must be lowered to less than 50 ppb to provide safe drinking water. The Kanchan Arsenic Filters with iron nails has been found highly effective.

All 10 test filters have consistently reduced arsenic levels from an average of 637 ppb to less than 50 ppb. That is a 95-97% average removal percentage range. In addition, there is no increase arsenic concentration over a 30 week period (8400 liters of water filtered).

It is expected that this research project can fill an important gap in the delivery of safe drinking water for Cambodia. Although arsenic has been found, there is currently no suitable removal technology for Cambodia. A successful verification of the performance of the Kanchan Arsenic Filter can provide policy-makers and implementers a reliable mitigation option to arsenic affected households.

The Kanchan Arsenic Filter was developed by the Massachusetts Institute of Technology (MIT) and a Nepali NGO, Environment and Public Health Organization (ENPHO) based on 7 years of extensive inter-disciplinary laboratory and field studies in rural villages of Nepal (Ngai et al, 2006). This awards-winning filter is an open-content technology and requires no external energy/material input for operation and requires no replacement parts except nails. (Kanchan Arsenic Filter Evaluation of Applicability to Cambodia, Phase I Technical Report)

Toxic Waste:

Dealing with the waste produced post-remediation raises further issues in developing countries. The disposal of arsenic remediation waste is difficult because leaching or loss of arsenic from waste can result in further contamination. Adsorbent technology often results in the formation of arsenic-containing liquid-waste that requires a high standard of waste management for proper and safe disposal. Therefore adsorbents resulting in a solid waste, that is suitable for landfill, are preferable.

Solid wastes can then be tested for their stability and leachability in various settings, and be separated into hazardous and non-hazardous substances. Wherever specific facilities are not
available, this waste may be dealt with informally by spreading it on land, diluting and dispersing it into rivers or casual landfills.

A novel method was recently proposed suggesting that arsenic remediation sludge should be mixed with cow-dung so as to form methylate arsenic which then no longer poses a risk. This is similar to the use of sludge in brick making; mixing it with clay immobilises the arsenic. Designing efficient, long lasting materials that do not require frequent regeneration (hence minimising the total volume of waste needed to be disposed of), is the best way to effectively tackle the issue of waste resulting from arsenic removal.

References:


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Arsenic: Mass Poisoning in the 21st Century Florence Bullough & Chris Moffat, Imperial College London