WITS WATER FILTER,
Arsenic Removal Matrix

A Simple, Low Cost, And Effective Arsenic Removal Filter

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Preliminary (The Useful Bit)

Drinking groundwater contaminated with naturally occurring arsenic is a worldwide public health issue. Argentina has an approximate 40% ground water contamination problem.

A filter to remove arsenic has been tested and approved by the World Health Organisation (WHO). It has been trialled in Bangladesh and found effective to reduce all types of arsenic without chemical treatment.

The filter produces 20-30 litres per hour. This can be used for drinking, cooking and cleaning.

The spent materials in the filter can be recycled and are non toxic with no leaching of the arsenic back into the environment. This filter is now to be made in Argentina for local distribution.

After major trials the filter has been approved by the World Health Organisation (WHO) for general use. The filter has also been recognised by the National Academy of Engineering (North America) for its reliability, ease of use, and maintenance, and social acceptability, and environmental friendliness. It met or exceeded all local government's guidelines for arsenic removal.

The filter removes arsenic species primarily by surface complexation reactions:

=FeOH + H2AsO-4 ?=FeHAsO-4 + H2O (K = 1024)
and =FeOH + HAsO2- 4 ? =FeAsO2- 4 + H2O (K = 1029)

About 30,000 WITS filters have been deployed all over Bangladesh and continue to provide more than a billion litres of safe drinking water.

We are pleased to announce that this product will shortly be available in Argentina. When full production is attained Argentine product will be exported throughout South America.

Introduction (The Technical Bit)

Arsenic poisoning in drinking water is now identified as one of the worst natural disasters on Earth. It is estimated that of the over 25 million people of Argentina, between 8-12 million are drinking water containing more than 50 µg/L (50 ppb or 0.05 mg/L) maximum contamination level (MCL) from wells, streams and rivers contaminated with arsenic.

The prolonged drinking of this water has caused serious illnesses in the form of hyperkeratosis on the palms and feet, fatigue symptoms of arsenicosis, and cancer of the bladder, skin and other organs. The only way to solve this crisis is to drink clean potable water free from arsenic and other toxic impurities.

In this endeavour, we have developed an arsenic water filter and deployed it on a large scale. The filter has been thoroughly studied and passed through several environmental technologies verification programs for arsenic mitigation (ETVAM)projects and approved by the government of Bangladesh (GOB) for household use.

Recently, the filtration technology has been given the highest award from the National Academy of Engineering-Grainger Challenge Prize for Sustainability after testing 15 other competitor technologies. NAE has recognized this innovative technology for its affordability, reliability, ease of maintenance, social acceptability, and environmental friendliness, which met or exceeded the local government's guidelines for arsenic removal.

The arsenic measurement and mitigation research by the group started in 1997. Since then, key papers have been published on both measurement and mitigation. The ability to measure ppb level As(III) and As(V) allowed us to test the filtration technology with real groundwater in the field. The first mitigation technology paper was published in 2000. Since then, several other papers were published on improvement of the technology.

The technology is patented. About 30,000 WITS filters were deployed in 16 districts all over Bangladesh; about 825 WITS filters were installed for primary school children. With regular maintenance many of these filters have been in use for 3 years without a breakthrough. We estimate that more than a billion litres of clean drinking water was consumed from these filters and they continue to provide high-quality water for drinking and cooking. The following is a description of the WITS filter and its performance based on the data obtained from our research, development, and extensive participation in ETVAM.

Chemistry and general considerations (The Science Bit)

In groundwater (pH = 6.5–7.5) arsenic is present in two oxidation states (As(III) in H3AsO3 and As(V) in H2AsO-4 and HAsO2-4). It is known that in most groundwater in Argentina more than 50% of total arsenic is present as the neutral H3AsO3 at groundwater pH. The other 50% is divided equally in two As(V) species H2AsO-4 and HAsO2-4 .

An ideal filter must remove all three species without chemical pre-treatment, without regeneration, and without producing toxic wastes. The unit WITS filter had satisfied these requirements. The WITS filtration systems also passed the ETVAM tests and a similarly made system was tested in Nepal by a MIT group with an arsenic removal capacity of 20 µg/L. The primary active material in the WITS filter is the Arsenic Removal Matrix (ARM), made through a proprietary process to maintain active for a minimum 2 of years.

The ARM removes the inorganic arsenic species quantitatively through all possible reactions. Infrared spectroscopy (IRS) and extended X-ray absorption fine structure (EXAFS) show that arsenate and arsenite formbidentate, binuclear surface complexes with =FeOH (or =FeOOH or hydrous ferric oxide, HFO) as the predominant species tightly immobilized on the ARM surface. Also, inorganic As(III) species are oxidized to As(V) species by the active O-2 , which is produced by the oxidation of soluble Fe(II) with dissolved oxygen. Manganese (1–2% by wt) in ARM catalyzes oxidation of As(III) to As(V). Therefore, the process does not require pre-treatment of water with external oxidizing agents such as hypochlorite or potassium permanganate.

In addition to arsenic species, =FeOH is also known to remove many other toxic species. The primary reactions are: =FeOH + H2AsO-4 ?=FeHAsO-4 + H2O (K = 1024) and =FeOH + HAsO2- 4 ? =FeAsO2-4 + H2O (K= 1029). These intrinsic equilibrium constants indicate very strong complexation and immobilization of inorganic arsenic species. It is known that excess Fe2+, Fe3+, and Ca2+ in groundwater enhance positive charge density of the inner Helmholtz plane of the electrical double layer and specifically binds anionic arsenates to form surface complexes. We found that As(III) and As(V) removal process was independent of the input arsenic concentration i.e., a zero-order reaction. Detailed thermodynamics and kinetics of these reactions are still under investigation.

Tests and performance (The Boring Bit)

The WITS filters were tested only with real groundwater contaminated with arsenic and other species. From the inception of our research, we realized that the fastest way to test for filter efficacy was to use real groundwater containing varied concentrations of arsenic, iron, other inorganic species and water quality parameters in Bangladesh. Thus we selected 6 tube wells in 6 different households where WITS filters were installed. All the filters removed arsenic to less than10 µg/L from an input range of 32–2423 µg/L As(Total). All filters removed soluble Fe below 0.26 mg/L, even from the highest input Fe of 21 mg/L. It is important to mention that we have identified arsenicosis patients in the last 3 locations where arsenic concentrations are above the suggested 300 µg/L.

These experimental filters continue to provide clean potable water for the households. Due to the combination with the material ARM, the other components of the filters and the optimum arrangement of these materials, the WITS filter removes arsenic, iron, manganese and many other inorganic species to a potable water.

Our oldest filter has been working for 5 years now, and with regular maintenance has had no breakthrough. The filter can work at 60 L/hour flow rate without breakthrough. However, due to the unknown water chemistry and varied As(total) in groundwater, we have fixed the flow rate to 20–30 L/hour to ensure long-term use and effluent As(total) below 30 µg/L. In contrast, blank filters breakthrough occurs at 88 Litres groundwater. These experiments also demonstrated that plain sand filter broke through the MCL almost instantaneously. A low iron (1.0 mg/L) containing groundwater was selected for this study to ensure HFO precipitate from this iron would not bias the results by co-precipitation and complexation of arsenic species.

Several NGOs have installed WITS filters in many arsenic affected areas of Bangladesh. One such most affected area is Hajigong, where 165 WITS filters were installed to supply water for 300 arsenicosis patients and 3,000 family members. The results published show As (total)in filtered water was<2µg/L (70% samples), <10µg/L (20% samples), <30 µg/L (10% samples), and none above 30 µg/L from the influent As(total) 600–700 µg/L with at least 50% in the form of more toxic As(III). The study also found no change in flow rate and no maintenance required for 12 months.

Operation and maintenance (The Interesting Bit)

The WITS filter only requires maintenance at approximately 12 moth intervals this is when the apparent flow rate decreases. Experiments show that flow rate may decrease 20–30% per year if groundwater has high iron (>5 mg/L) due to formation and deposition of natural HFO in sand layers. The sand layers (about an inch thick) can be removed, washed and reused or replaced with new sand. The presence of soluble iron and formation of HFO precipitate is also a common problem with other filtration technologies.

Water flow disturbance could also occur through accumulation of sand/ HFO deposits into the tap nozzle, which can be removed by detaching and cleaning the tap in a flowing water stream. Pouring 5 L hot water in each bucket every month has shown to kill pathogenic bacteria and eliminate coli form count. This recommended protocol can be followed once a week where coliform counts are high. We have no records of diarrhoea or other water borne diseases from drinking WITS-filtered water. It appears that the WITS filtration system does not foster pathogenic bacteria on its own.

Except for basic training in hygiene, no special skill is required to maintain the filter. The maintenance process requires about 20–30 mins. Because the WITS filter has no breakthrough, the active media does not require any processing (backwashing, regeneration etc). The filter will produce potable water for at least 1 year. The actual filter life span is determined by the water through put. Except for manufacturing defects, mechanical damage due to mishandling, transportation, and natural disasters (flooding), none of the filters showed MCL breakthrough to this date. garantía del mismo.

Future outlook (The Last Bit)

The present filtration system can be modified and improved. Scaling up for large volume water filtration is being studied in the UK and in Bangladesh. Scaling down to a tabletop unit while maintaining the same efficiency is also under investigation in Argentina.

The filter’s inherent capability to remove thermo tolerant coliform is now proven. Further experiments to prove its efficacy in removing other pathogenic bacteria and virus are being undertaken in UK, Argentina & Bangladesh. It is now clear that in Argentina and many other countries, while the surface water is not potable without treatment and filtration, a major portion of the groundwater is also not potable due to the presence of many toxic species. It appears that the development of low-cost filters is the only way to solve the present drinking water crisis for many countries of the world.

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