Subterranean Arsenic Removal (SAR) Technology for Groundwater Remediation

B. Sen Gupta[1], A. Bandopadhyay[2], S. Mukhopadhyay[3]

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Global Arsenic Scenario

Arsenic is a natural constitutent of the earth's crust and may be found in water that has flowed through arsenic-rich rocks. High concentrations (>10 ppb) of arsenic in groundwater are found in various parts of the world including Argentina, Bangladesh, Chile, China, Hungary, India (West Bengal), Mexico, Nepal, Pakistan, Thailand, USA, and Vietnam. **A 2007 study found that over 137 million people in more than 70 countries are probably affected by arsenic poisoning of drinking water**. 0.01 mg/L or 10 ppb was established as a provisional guideline value for arsenic by USEPA & WHO.

SAR Technology Origin

The SAR Technology was developed by a consortium of European and Indian partners led by Queen's University Belfast, UK and demonstrated at a location near Kolkata during 2005-06 (www.qub.ac.uk/tipot). The technology was subsequently replicated successfully in six arsenic affected areas in West Bengal through World Bank Development Marketplace 2006 programme. It won St Andrew's Prize, Scotland in 2010 and DELPHE 2008 & 2010 grants. SAR was replicated in Washington State (USA) in 2010, Phnom Penh (Cambodia) and Kota Bharu (Malaysia) in collaboration with local water supply agencies and Universities in 2010-2011.

The technology involves a very simple and easily adaptable process to remove arsenic and other heavy metals from groundwater using controlled oxidation by aerial oxygen and bioremediation process taking place inside the aquifer. No chemicals are used and almost no sludge is produced during operational stage since iron and arsenic are trapped under the earth. The operation and maintenance cost is very low and the SAR plants have an expected lifetime of 10 years. The estimated cost of a SAR plant of 4000 lt/cycle capacity is Rs 3,00,000.

Innovation

High concentration of arsenic in groundwater in South Asia is due to the presence of bacteria that use arsenic bearing minerals as a source of energy among one of the available sources, turning insoluble As(V) to soluble As(III). In the SAR process:

1. The underground aquifer is turned into a natural biochemical reactor that removes water-borne arsenic along with iron and manganese.
2. The oxidation processes are accelerated by the autocatalytic effect of the oxidation products and by the chemo-autotrophic micro organisms. No chemicals are used and no sludge is produced in the process, maintaining normal permeability of the aquifer.
3. The entire calculated oxidation process is targeted towards development of an adsorption zone in aquifer, rather than a precipitation zone to avoid metal leaching in future an also to maintain the permeability of aquifer.

SAR Replication Plan

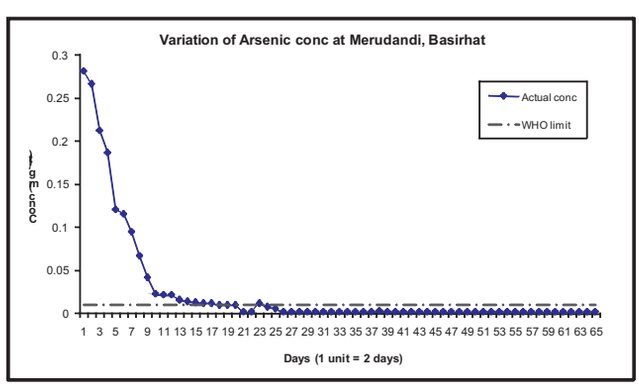
This technology can transform the way arsenic is removed from groundwater in Ganges, Brahmaputra, Mekong delta & other places where the arsenic is of Arsenopyrite origin. This includes affected areas of India, Bangladesh, Cambodia, Nepal, Vietnam and Thailand.

The technology is being implemented in Washington State, USA; Phnom Penh, Cambodia with the help of Royal University of Phnom Penh and Kota Bharu, Malaysia in collaboration with University of Malaya & Air Kelantan Sdn Bhd.

Further R&D regarding scaling-up of the SAR plant & enhancing the enzymatic reaction in the aquifer is under way at University Malaya, Kuala Lumpur, Malaysia, Queen's University-Belfast, UK and National Metallurgical Laboratory - Jamshedpur, India.

Tangible Result

The SAR plants have been able to reduce Arsenic Concentration in Groundwater from as high as 280 ppb to as low as 2 ppb within 45 - 60 days of operation. The performance only gets better with time as the oxidation zone spreads in the aquifer.



Advantages of SAR

1. Almost no sludge is generated during operation.
2. Easiest Technology. Villagers can maintain it.
3. SAR removes heavy metals from the AQUIFER as a whole.
4. Cheap Operation & Maintenance: Rs 400/month for 4000 lt water/day.
5. No clogging by iron precipitation. More there is iron, more effective is SAR.
6. No Chemicals used. Natural Chemistry is the key-word of SAR.

Word of Caution

Uncalculated & unbalanced oxidation of the aquifer, without an expert's advice, can lead to As and Fe precipitation (resulting in As release in later date) rather than adsorption. Also, the abrupt change in redox potential and excess oxidation may destroy the existing bacterial population, making the whole process unstable and ineffective.

Awards & Recognitions

1. European Union Asia Pro-Eco Programme for TiPOT Project in 2004.
2. Winner of the Development Marketplace Global Competition, 2006, hosted by the World Bank.
3. Dhirubhai Ambani Award from IChemE in November 2009.
4. Selected by the Blacksmith Institute - New York & Green Cross- Switzerland as one of the "12 Cases of Cleanup & Success" in the World's Worst Polluted Places Report 2009. (Refer: www.worstpolluted.org)
5. Asia Water Award 2010 at Kuala Lumpur (Dr B. Sen Gupta)
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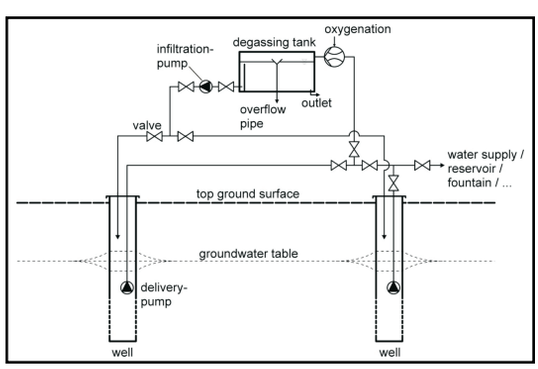
Schematic Diagram of SAR Plant



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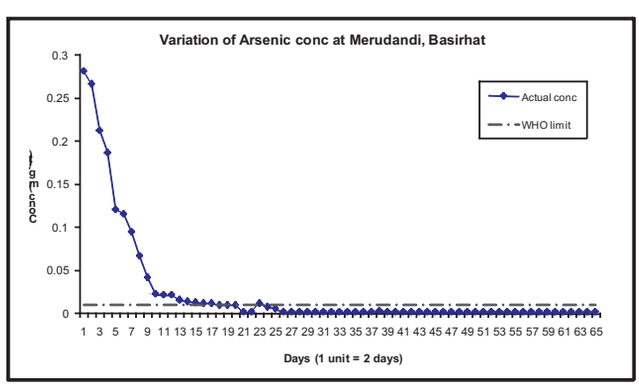

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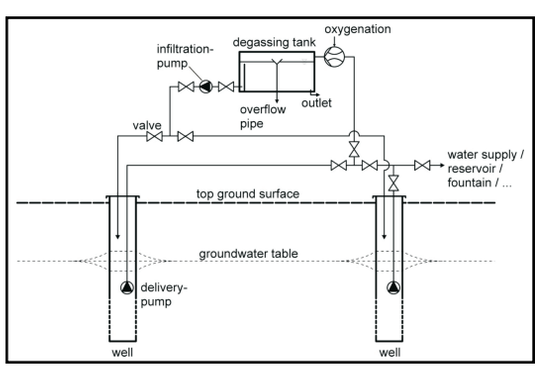

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