Sustainable Mitigation Of Arsenic Contaminated Ground Water In Bihar, India

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ABSTRACT: *The "water surplus" state of Bihar is faced with the serious problem of arsenic contaminated aquifers whose water is used both for drinking and irrigation purposes. A large number of mitigation strategies are being adopted by the authorities, without obtaining the desired results of clean water supplies to the arsenic affected rural population. The objectives of this study were to identify the gaps in such mitigation techniques and to establish a holistic, innovative technology that is integrated with the socio-economic milieu of the study area. An adsorbent based arsenic removal technology has been tested and is being operated with community participation. The results revealed marked reduction in iron and arsenic concentration, effective operational processes and a financially viable clean water production for a community of 25 families, with scope for upscaling this mitigation model.*

1. INTRODUCTION

The Holocene sediments (Acharyya, et al, 2007) of the river basins of the state of Bihar, India, is presently recognized as having the world's most extensive areas of arsenic contaminated underground water. Arsenic is a slow bio-accumulative genotoxin (Faita, et al, 2013) The desirable limit of arsenic in drinking water at 10 µg/L as per WHO guidelines (WHO, 2004) and Bihar's aquifers has registered up to eighteen times more than this limit (Ghosh, et al, 2010). This has exposed approximately 30 million rural inhabitants residing in of the Gangetic Plains of Bihar vulnerable to the carcinogenic properties and other serious symptoms of arsenic poisoning. Furthermore, in the state of Bihar (India), the situation is further aggravated by acute poverty, malnutrition and illiteracy and as such public/community participation becomes essential for any sustainable arsenic mitigation strategy. The objectives of this study therefore were to test an energy-efficient, adsorption- based arsenic filter under private-public ownership model, and generate a cost effective design for providing clean water to the effective community. The principles of participation sought to be the guideless of this initiative, encompass inclusion, equal partnership, transparency, sharing power, sharing responsibility, empowerment and cooperation.

2. METHODS/EXPERIMENTAL

The experiments were carried out with an easy-to-operate adsorbent unit to provide arsenic-safe drinking water using re-generable arsenic adsorbents. When the filter is exhausted, the absorbent material is regenerated. The water of the selected hand pump has more than 90µg/L arsenic with seasonal dilution by 30 µg/L in the monsoon season. A filter, with an upper tank having activated alumina and a lower tank having hybrid anion exchange resin as media, was installed near the hand pump and connected with the same, so as to yield the arsenic (As) and iron (Fe) safe water upon manually operating the hand pump. Waste backwash was made to pass through a coarse sand filter to reduce the arsenic concentration before its release to the environment. Both raw and filtered water were tested for As and Fe concentration by atomic absorption spectrophotometer (AAnalyst 200-PerkinElmer) with a graphite furnace. The precision of analyses was better than 10%. Community involvement was obtained by continuous interactions and interviews with 30 households in the village, and training of selected persons on operation and maintenance of the filter unit.

3. RESULTS AND DISCUSSION

The pilot trials verified the suitability of the system as a viable and sustainable option for arsenic remediation in rural India. The system was successful in reducing both iron and arsenic concentration within WHO permissible limit. This technology conserved scarce power supply in the study area. The filtration process reduced iron to within permissible limit of 2 mg/L of water (WHO, 2008) over a span of 28 months, after which the efficacy of the media declined (Table 1, Graph1).

			Raw Water	Treated Water
Date	Flow (kL)	BVs	Iron (mg/L)	Iron (mg/L)
09-06-2011	22	220	1.26	0.04
09-10-2011	38	380	1.63	0.06
09-12-2011	52	520	1.54	0.08
16-03-2012	71	710	1.64	0.05
20-05-2012	92	920	1.52	0.05
18-09-2012	112	1120	1.39	0.03
15/12/2012	136	1360	1.28	0.06
10-02-2013	161	1610	1.41	0.05
12-05-2013	186	1860	1.3	0.01

Table 1. Iron removal by adsorption filter

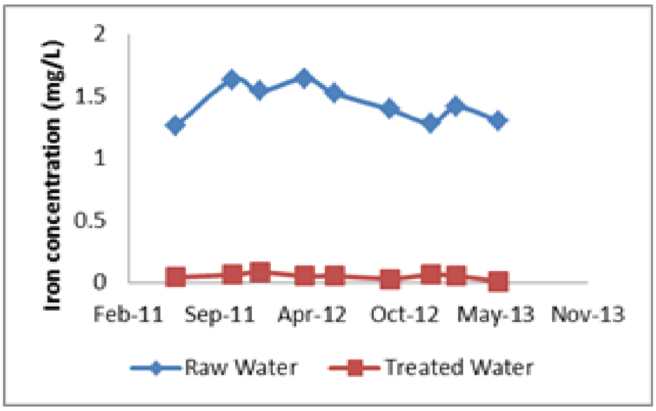

Figure 1. Iron removal by adsorption filter

Safe arsenic levels were also maintained in the filtered water (10µg/L), while the backwash after being subject to sand filtration, had lower arsenic levels than raw water (Table2, Graph2).

			Raw Water	Upper Tank Backwash	Lower Tank Backwash	Sludge Water	Treated Water
Date	Flow (kL)	BVs	As Conc (µg/L)	As Conc (µg/L)	As Conc (µg/L)	AsConc (µg/L)	As Conc (µg/L)
09-06-2011	22	220	122	62	51	260	12
09-10-2011	38	380	109	58	55	290	16
09-12-2011	52	520	109	58	55	290	16
16-03-2012	71	710	123	63	58	290	8
20-05-2012	92	920	118	68	54	310	11
18-09-2012	112	1120	101	65	56	360	9
15/12/2012	136	1360	115	60	53	325	11
10-02-2013	161	1610	105	59	51	310	12
12-05-2013	186	1860	91	54	52	275	14

Table 2. Iron removal by adsorption filter

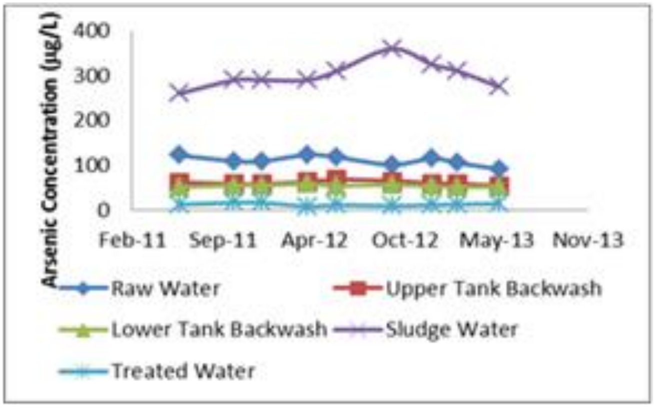

Figure 2. Arsenic removal by adsorption filter

The total arsenic reduction was about 97% and throughout the study period the arsenic concentration in filtered water was below 10 µg/L.A total of thirty families shared the filtered water. The present approach of creating demand for arsenic and iron free water, individual ownership and leadership development was backed by collective decision-making. Making such unaware arsenic affected community change over from one traditional drinking water source to alternate options immediately was very difficult. This filter was accepted by the villagers as it was perceived as an extension of the hand pump in place. Secondly, the issue of granting ownership of the filter to one family was mutually decided by the community and social conflicts avoided. A feasible water pricing mechanism based upon cost-effectiveness of the filter operations was calculated at an affordable sum of INR 0.12 per litre of arsenic free water .This guaranteed proper functioning, maintenance and security of the filter unit, while other hi-tech and expensive mitigation strategies adopted by the stakeholders became defunct. It was proved that sustainable technologies in developing countries greatly depend upon their integration with local socio-economic parameters.

4. CONCLUSIONS

The study confirms that simple and low cost technology for arsenic removal is sustainable through community participation in developing economies like India. The pilot-scale findings conducted in rural Bihar, India demonstrate that a granular media community filter can be a viable option to treat arsenic and iron rich groundwater and supply safe water to poverty stricken rural population at low cost.

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