A SIMPLE HOUSEHOLD DEVICE TO REMOVE ARSENIC FROM GROUNDWATER AND TWO YEARS PERFORMANCE REPORT OF ARSENIC REMOVAL PLANT FOR TREATING GROUND WATER WITH COMMUNITY PARTICIPATION

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Abstract

School of Environmental Studies (SOES) household device for arsenic removal from contaminated water was developed in 1993. The system consists of a filter, tablet, two earthen jars or plastic jars. Tablet contains iron salt, oxidizing agent and activated charcoal. The filter is made of mainly purified fly ash with binder. One tablet is sufficient for 20 liters of contaminated water having arsenic in the maximum range 1000 μg/l. The sludge after arsenic removal rich in arsenic is disposed to soil with cow-dung and arsenic is eliminated from the sludge as volatile arsenic species through the microbes in the cow-dung. Everyday in natural process tons and tons of arsenic, selenium, mercury are eliminated in volatile organic forms through activities of the microbes in soil/sediment. After our successful laboratory testing several units were taken to arsenic affected villages in six districts of West Bengal and tested with contaminated hand tube-wells (arsenic range 300-950 μg/l) from about 100 families. The efficiency was found in the range 93-100%. SOES then jointly with CSIR (Council of Scientific & Industrial Research), Govt. of India filed for 3 national patents (patents are now cleared) in 31st December 1994. CSIR then requested Public Health Engineering Department (PHED); Govt. of West Bengal to test this system in the arsenic affected villages and submits a performance report. CSIR decided that if Govt. of West Bengal after field test finds the system suitable, CSIR would make bulk manufacture of the system. Govt. of West Bengal received 300 units during December 1995 from SOES but till today their test report has not been received. In the meantime various national and international organizations tested the system in laboratory, also in the field and found arsenic removal efficiency is between 93 and 100%. World Health Organization (WHO) then purchased 50 units for use in Bangladesh from CSIR. Asia Arsenic Network (AAN), Japan also purchased 300 units for use in Bangladesh and WHO Bangladesh wanted to purchase further 500 units during January, 1997. When more demand of the system started coming from national and international organizations CSIR decided to test efficiency of the system for one year in field level before they decide to make bulk manufacture. CSIR took a couple of years to take field trial decision. Responsibility was given to NEERI (National Environmental Engineering Research Institute), Nagpur, India to test the efficiency of the device through 150 families in two blocks (Deganga and Gaighata) of North 24-Parganas district, who will use the device for one year

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(field trial started during July 1998). CSIR decided that NEERI will test 100% of the samples while SOES and PHED, Government of West Bengal each will analyze 10% of the same field samples (SOES analyzed 100% of the field samples from its own fund). Final responsibility was given to National Physical Laboratory (NPL), New Delhi (a CSIR institute) for processing and evaluation of the report. Field test was completed during May 2000. Final report has not yet been received.

The pity when millions are drinking arsenic contaminated water in the arsenic affected villages of West Bengal, we have not yet got the clearance from Govt. of West Bengal or CSIR-India whether we could use our system in arsenic affected villages. Field report of SOES shows that if villagers are made aware and trained how to use the household device developed by SOES, the system can be one of the various ways to produce arsenic safe water for household purpose. Some of the points that may be highlighted for SOES system are: (a) about US $ 10 is required for one year to get 20 liters of water per day. (b) since the tablet contains an oxidizing agent water will be safe with respect to microbial contamination (c) after addition of tablet contaminated water turns black due to suspended charcoal and clear water after filtration indicates any leakage from the upper jar (d) water after passing through the system meets the specification of WHO water quality criteria.

In this paper we will also report the performance of seven arsenic removal plants from two organizations for about two years for treating arsenic contaminated hand tube-well water with community participation. Our overall finding from these two studies:

In village predominant India and Bangladesh even a highly successful technology may not succeed in rural areas unless it fits in the rural circumstances and is well accepted by the rural mass. Development of such technology is only possible when a combination is made between technocrats and villagers with proper village level participation.

Introduction

There are 20 countries where groundwater arsenic contamination episodes in the world are known. However, the world's 4 biggest cases of groundwater contamination and the worst sufferings of the people have been in Asia. In order of magnitude these are Bangladesh, West Bengal-India, Inner Mongolia - P.R. China and Taiwan. In all these countries, more and more groundwater withdrawal is taking place because of agricultural irrigation**. We have made a green revolution at the cost of underground water.**

In South East Asia, Bangladesh and West Bengal-India are the most arsenic affected countries. More than 130 million people in these two countries are at risk. Nine districts in West Bengal, India and 47 districts in Bangladesh have arsenic level in groundwater above World Health Organization (WHO) maximum permissible limit of 50 μg/l. The guideline value of arsenic in drinking water of WHO is 10 μg/l. The area and population of the 47 districts in Bangladesh and 9 districts of West Bengal are 112407 km^2 and 93.4 million and 38.865 km^2 and 42.7 million respectively.

Available Techniques for removal of arsenic from groundwater

A variety of treatment technologies like co-precipitation, adsorption, ion exchange and membrane process have been demonstrated to be effective in removing arsenic from contaminated natural

groundwater. However, question remains regarding the efficiency and applicability/ appropriateness of the technologies - particularly because of low influent arsenic concentration and variety of source water composition. Besides, appropriate technology the system must be economically viable and socially acceptable. Techniques available for removal of arsenic from contaminated water are based on mainly four principles:

A. Oxidation of arsenic (III) to arsenic (V) adding suitable oxidizing agent followed by coagulation- sedimentation-filtration (co-precipitation).
B. Adsorption through Al_2O_3, Iron filings (zero valent iron) hydrated iron oxide.
C. Ion exchange through suitable cataion and anion exchanger.
D. Osmosis or electrodialysis (membrane filter)

Various organizations in West Bengal are using mostly principles A & B both for community water supply and as household device in arsenic affected areas. Name of the agencies, location where they are working and principles are given in **Table 1.**

Table 1

Organization	Type	Principle	Where installed	Comment
Public Health Engineering Department (PHED), Government of West Bengal	Community	A	Sujapur, Malda, Uttar Dhaltita and Gobardanga in North 24-Parganas	Technically successful. But long term field evaluation report through independent body is not available mainly to know whether the technology is accepted by the villagers with their cultural, socio-economic, awareness and educational background
All India Institute of Hygiene and Public Health (AIIH&PH), Government of India	Community Household	A	Kochua, Habra II, North 24-Parganas; Dattapukur, Barasat, North 24-Parganas; 4 villages in Tehatta block, Nadia and a few more Not known	Technically successful. But long term field evaluation report through independent body is not available mainly to know whether the technology is accepted by the villagers with their cultural, socio-economic, awareness and educational background
B.E. College, Howrah (Amal Filter)	Community Household	B	4 villages in North 24-Parganas and 4 villages Tehatta block in Nadia and a few more Not known	Technically successful. But long term field evaluation report through independent body is not available mainly to know whether the technology is accepted by the villagers with their cultural, socio-economic, awareness and educational background
School of Environmental Studies with CSIR, New Delhi	Household	A	150 families used for one year in Deganga and Gaighata blocks of North 24-Parganas.	Long-term (one-year) field evaluation done. Monitoring agencies were NEERI (major, 100%), PHED (10%), SOES (100%). Overall data will be evaluated by NPL (National Physical Laboratory, CSIR), New Delhi. Project Funded by CSIR, New Delhi. Evaluation report not yet received.

Activities of other organizations/institutes/laboratories for removal of arsenic from groundwater in other parts of the world

The processes used in arsenic affected areas of Chile and Taiwan for removing arsenic from drinking water at full-scale treatment plant (for high-level arsenic removal) is coagulation. Addition of iron or aluminium coagulants to water facilitates the conversion of soluble arsenic species into insoluble reaction products, which are formed through adsorption mechanisms onto coagulated floc. Because good floc formation followed by filtration is crucial to arsenic removal, a high turbidity effluent indicates poor floc formation and is likely to reduce the efficiency of arsenic removal.

The University of Connecticut (patent pending) has claimed a novel and cost effective Arsenic Remediation Technology (AsRT) for the immobilization of inorganic arsenic such as arsenates and arsenites. The technology uses iron filings (zero valent iron) and sand to reduce inorganic arsenic species to iron co-precipitates, mixed precipitates, and in conjunction with sulfates to arsenopyrites.

In Hungary, the arsenic contamination from groundwater sources (artesian wells) caused serious problem (400000 people are at risk) and ways in removing arsenic have been investigated for about a decade now. A promising, inexpensive solution to the problem was adopted. The arsenic concentration of even high organic matter containing artesian waters can readily be reduced to under the 0.05 mg/l limit, by using the Mg $(OH)_2$ method either on large-scale or in households. The procedure is simple (only needs adding of MgO or $MgCl_2$ and NaOH) efficient and safe.

Although a few more devices are available to remove arsenic from ground water but most are on the basis of the principles as described in A, B, C, and D.

School of Environmental Studies' Simple Household Device To Remove Arsenic From Groundwater Hence Making It Suitable For Drinking And Cooking

This is the only household device in West Bengal which had undergone field trial (one year) in the arsenic affected villages (150 families used the system) to know its efficiency and acceptability. From this village trial result we expect to know the draw back of the device and whether at all to be used in the affected villages and what modifications are needed.

Background (we got the basic idea of Filter-Tablet system for arsenic removal from villagers)

During our field survey we noticed that in some arsenic affected villages many families due to high iron in their tubewell water can not drink the water directly but to make it drinkable they just keep the water after withdraw from tubewell for sometime, when a brown precipitate settles at the bottom and the users decant the upper clear water or use a common filter to arrest the flock. We had observed that by this technique (if the tubewell water contains higher dissolved iron) 60-70% of arsenic is removed. We got the idea from the villagers and then made some modification for a household device using filter and tablet to remove almost 93-100% of arsenic from contaminated water. We started of our own and soon we got financial assistance from Council of Scientific & Industrial Research (CSIR), New Delhi and finally we made jointly with CSIR, 3 Indian patents and one international patent filed for Bangladesh. The 3 patent are

(a) A Composition useful for the removal of arsenic from water and tablets/capsules made from the said composition.
Inventors: Dipankar Chakraborti, Dipankar Das, Amit Chatterjee, Gautam Samanta

(b) Composition useful for making a water filter candle and water filter candle made there of.
Inventors: Dipankar Chakraborti, Dipankar Das, Amit Chatterjee, Gautam Samanta
(c) An improved process for the removal of arsenic from water.
Inventors: Dipankar Chakraborti, Dipankar Das, Amit Chatterjee, Gautam Samanta

Figure-1(a) & **1(b)** show our Filter- Tablet System.

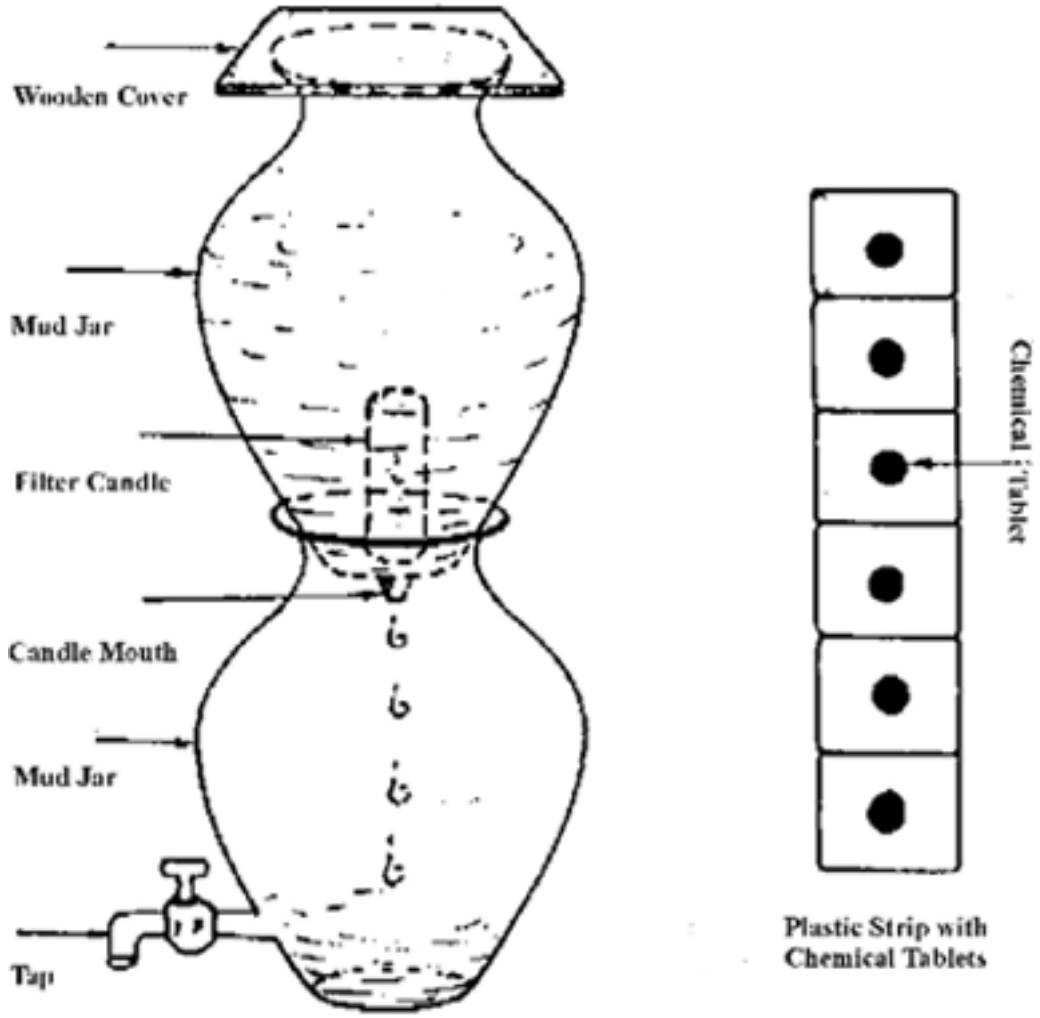

Figure 1(a) Arsenic removal Filter-Tablet system of School of Environmental Studies, Jadavpur University

What is the filter!

We made the filter by using fly ash, clay, charcoal etc. Due to use of fly ash, the filter becomes very strong and quite porous. While preparing the filter we heat it above 1400^0 C in a furnace with charcoal to remove most of the volatile toxic compounds. We made many experiments before using fly ash to know whether it is safe to use fly ash from toxicity point of view. We are making now the filter by hand -mixing in small scale. Pore size and strength of filters are not same in all batches. We feel when we will make large scale with automatic system we will make it better.

What is the tablet!

The black colored tablet contains Fe^{3+} salt, an oxidizing agent and activated charcoal. We spent about a year to get the shape of these chemicals compounds in the form of a tablet. The tablet can be supplied in pouch or in a box. After addition of the tablet to the arsenic contaminated water, water turns black due to presence of carbon and after filtration it is easy to know (from suspended black particles) whether there is any leakage from the filter. The tablets still we are making by hand mixing, so size and quality are not same to all batches. We hope to make it better when large-scale preparation will be done. We have observed that after preparation of tablet its potentiality remains almost same even more then 15 months.

How to use the filter and tablet system to remove arsenic from contaminated water?

We have used two earthen pots or plastic jars for the purpose.

The system is for 20 liters of contaminated water. We feel 20 liter is sufficient for drinking and cooking for a family of 4. The capacity of the system can be increased.

The earthen or plastic container is placed on some suitable place at home. The user will use a plastic bucket or similar container for 20 liters of water. One black tablet from pouch or box is added to the container and 20 liters of water from tubewell pumped in it. The tablet will dissolve immediately making the water black in appearance. For better mixing a wooden or plastic handle can be used. It was then kept for settling about an hour and then poured in the upper jar of the filtering system (it is better to collect the water with tablet in the evening and pour in upper jar of filtering system before going to bed). Immediately clear water will come out as drops from the upper jar to the lower reservoir. If black particles are visible after filtration then there is a possibility of some leakage and filtering system to be checked. The filtered water is safe to drink. Usually 93-100% arsenic is removed. The black flock containing activated charcoal, arsenic on iron oxy-hydroxide will be deposited on the surface of the candle filter.

When to clean the filter and where to dispose the flock

When the filtration rate becomes slow, the filter is to be cleaned. The simple procedure is to pour water in upper jar and clean the filter in the upper container. A brush can to be used to rub the candle-filter. As the filter is of a strong material brushing will not damage the filter. Even after such cleaning if the flow rate drops again within a few days then candle filter to be removed from the pot and to be cleaned thoroughly. The washings of the filter rich in arsenic are disposed at the back yard making a whole on the surface soil and some cow-dung is added to it.

Why cow-dung is to be added to the disposed area of arsenic rich-flock?

It is a burning question how and where to dispose the arsenic rich flock. Many thinks that arsenic rich flock if disposed on soil, it may contaminate the aquifer again. I am not diluting the problem but for your information from only Deganga block of area 201 km^2, from 3000 big dia shallow tubewell in use for irrigation and 6.4 tons of arsenic is falling on soil per year. We had analysed the soil at least from 100 sites and found none of the soil has arsenic above 10 mg/kg (normal concentration 5.6 mg/kg). Most probably microbes are eliminate arsenic falling on soil. We have no idea about long term effect of such huge amount of arsenic depositing on soil.

In our laboratory we made 2 years experiment and found that cow-dung can eliminate arsenic in volatile form [detailed report is available from the Ph.D. thesis "Arsenic species along with other

metal/metalloid present and responsible for arsenic episode in groundwater of West Bengal and a cheap technique to remove arsenic, thus making the groundwater suitable for drinking and cooking" (Jadavpur University, Calcutta, 1995)]. Thus arsenic will go to air. Some people even asked whether air would be contaminated or not. For information, everyday tons of arsenic, mercury and selenium are eliminated as volatile compounds from soil/sediment by natural bio-methylation by microbes. These volatile organometal compounds ultimately decompose and fall in our environment. Of course sea is our best sink.

Some preliminary results from our university laboratory tap water (source underground water) after passing through our filter-tablet system.

To know whether after passing through our Filter-Tablet system the quality of water matches to international standard or not. We made a few preliminary experiments to know the quality of water. **Table 2** shows some physical and chemical parameters of filtered water and compared to international standard. Since the principle of our technique is co-precipitation we expected that all essential elements will be removed from water but we found still some amount remains and we desire that

Field trial data to prove that the Filter-Tablet system is suitable to eliminate arsenic from groundwater.

Scientists from School of Environmental Studies went to six arsenic affected districts during 1993-1995 to see how the technique works in field level. We installed the filtering system in 20 families in each of the six affected districts (North 24-Parganas, South 24-Parganas, Nadia, Bardhaman, Murshidabad and Malda) having elevated level of arsenic in their hand-tubewells (range 360-980 μg/l). Results show arsenic is removed at the level 93-100% and the quality of water is potable.

Analytical report from various other agencies about suitability of our arsenic removal system.

After being satisfied by our laboratory and field trial we sent the system to various National recognised scientific institutes for its evaluation. The agencies evaluated our system were:

National Agencies	Findings (official report)
Industrial Toxicological Research Center, Govt. of India, Lucknow	95-97% removal of arsenic (Report of May 10, 1994)
National Test House, Govt.of India, Calcutta	97.5% (Report of December 8, 1995)
National Environmental Engineering Research Institute (CSIR Institute), Nagpur	93% (Report of July 5, 1995)

Analytical report of International Agencies (test done when the arsenic removal systems were in operating condition in the arsenic affected villages)

Dr. Hironaka from AAN-Japan and Dr. Shoko Oshikawa of AAN Thailand Bureau came to the village to test our units where we installed our experimental household system. Their report is given below.

International Agencies	Findings (official report)
Asia Arsenic Network (AAN), Japan (Analyst: Dr. Hiromi Hironaka)	98.5% (Report of February 8, 1996)
Asia Arsenic Network (AAN), Thailand Bureau (Analyst: Dr. Shoko Oshikawa)	95% (Report of March 13, 1996)

Being satisfied with our arsenic removal system AAN-Japan purchased 300 units from CSIR-New Delhi and installed in Bangladesh. Dr. Chakraborti went to Bangladesh to install the filtering units.

Table 2 Some physical and chemical parameters of filtered water and compared to international standard*

Parameters	WHO Standard	Before Filtration	After Filtration
PH	6.5 - 8.5	7.8	7.7
Specific Conductance (μMhos cm^{-1})	-	72 mg/l	75 mg/l
Chloride	250.0 mg/l	806.67 mg/l	872.25 mg/l
Sulphate	400.0 mg/l	23.5 mg/l	22.7 mg/l
Phosphate	-	0.220 mg/l	0.205 mg/l
Hardness ($CaCO_3$)	500 mg/l	500 mg/l	460 mg/l
Sodium	200 mg/l	387.5 mg/l	392.5 mg/l
Potassium	-	6.4 mg/l	6.5 mg/l
Calcium	100 mg/l	202.5 mg/l	205.0 mg/l
Arsenic	0.01 mg/l	<0.003 mg/l	<0.003 mg/l
Iron	0.30 mg/l	2.361 mg/l	0.040 mg/l
Cadmium	0.005 mg/l	0.003 mg/l	0.0012 mg/l
Cobalt	-	0.008 mg/l	0.0016 mg/l
Chromium	0.05 mg/l	0.014 mg/l	0.002 mg/l
Copper	1.0 mg/l	0.033 mg/l	0.003 mg/l
Lead	0.05 mg/l	0.020 mg/l	0.002 mg/l
Manganese	0.1 mg/l	1.423 mg/l	0.018 mg/l
Zinc	5.0 mg/l	0.080 mg/l	0.006 mg/l

* Source: University tap water

World Health Organization after purchasing 50 filtering system from CSIR, further ordered 500 filtering system for Bangladesh (Ref. BAN CWS 001/C 27th January, 1997, New Delhi, India)

Evaluation Report of West Bengal Government (PHED, West Bengal)

Public Health Engineering Department (PHED) after discussing with CSIR representative and SOES decided to test 300 filtering units in arsenic affected villages of W. Bengal. During 29th December 1995 PHED, West Bengal ordered for 300 Filter-Tablet system from CSIR through School of Environmental Studies, Jadavpur University (Memo No. 24324-24325/3/6/A/95 dt. Cal 29/12/95 of the purchase) for evaluation. We have not yet received any detailed study report from PHED, West Bengal except only one letter (based on 4 experiments) which mentioned, "However, it only removes 50% of the arsenic in water and that may not fruitful to serve the purpose" (Memo No. 869/2/BST dated Barasat 19/3/1996).

One year project for evaluation of "Arsenic Removal Filter-Tablet" system through 150 families in 2 blocks of North-24-Parganas by CSIR.

This was the project funded by CSIR, Govt. of India. CSIR decided 100% analysis of the field trial samples would be done by the NEERI, Nagpur and partly by PHED, Govt. of West Bengal (10%) and SOES (10%). Although SOES was financed by CSIR for 10% analysis but SOES from its own fund had analyzed 100% of field trial samples. It was in the project that National Physical Laboratory (NPL), CSIR, New Delhi through CSIR will process and evaluate results. Official field trial sanction (no. 800(0028)/97/EMR II) from CSIR came to SOES during March 1997. Reason unknown to us field trial started during July 1998 and field trial completed during May 2000. Evaluation report from NPL has not yet been received.

SOES opinion about the device

From our field report we can comment now that Field Trial through actual users is the sure test of a technology. We learnt more about draw back of our system; we also learnt what villagers need through interactions with villagers. Laboratory result, field trial result through our experts may show 100% efficiency but users may use it in a different way so that the system may not be as efficient as it should be. For success of the technology we need to aware and educate the user before, during and after installation of the system.

A few examples- how villagers used our filter -tablet system

1. In earthen pot/ plastic jar some users fitted the filter to the out side of the pot with up side down.
2. One user added 5 tablets for 20 liter of water to get better quality of water. When we asked why did he do this! He replied that if one tablet would produce good water five tablets will make better water.
3. In our laboratory experiment we found tablets are effective at least up to 15 months (as we kept in dark). Some of the villagers kept the tablet container near the oven or outside where sun rays directly falls on tablet container, thus power of oxidation of tablet is partially lost due to decomposition of oxidizing agent and arsenic removal efficiency decreased.
4. Villagers time and again didn't use the system for a few days and so the system went dry causing problem when they started again. If they had kept some water in the container with filter valve closed, this problem would not happen.

Conclusion

Although we have devised "Filter- Tablet System" to remove arsenic from groundwater nevertheless we believe this is to be used in emergency in affected villages for West Bengal-India and Bangladesh. Co-precipitation not only will remove arsenic but also other essential elements from water. The actual solution in these two countries would be achieved through proper watershed management utilising our available surface water. Per capita available surface water of Bangladesh alone is 11000 m^3 the second highest in the world. For West Bengal wet land alone is 4000 km^2. In these two countries rainwater, surface water, flooded river basins, Ox-Bow lakes, dug-wells are plenty. In this millennium when technology is known and scientists, technologists are making potable water from wastewater why should we neglect our vast available surface water resource and opt for groundwater- a source for our natural balance.

TWO YEARS PERFORMANCE REPORT OF ARSENIC REMOVAL PLANT FOR TREATING GROUND WATER WITH COMMUNITY PARTICIPATION

School of Environmental Studies; Jadavpur University, Calcutta is the scientific adviser to a project funded by Japan Government to Chandranath Basu Seva Sangha, village-Betai, Block Tehatta, District Nadia. The goal of the project was:

1. To assess the magnitude of arsenic calamity in Tehatta Block through water analysis.
2. Field survey with medical team to know the extent of people's suffering.
3. Coloring green to safe tube-wells and red to arsenic contaminated tube-wells. Green tube-wells to be rechecked after every 6 months.
4. To find out the possibility of alternative source of drinking water (rainwater, river water, pond water, lake water, dug-well, ring-wells etc. after proper purification) with peoples participation.
5. Arsenic removal from contaminated hand tube-well adopting suitable technology with people's participation.

Although School of Environmental studies at the beginning was advisor to the project but later on, considering the importance and outcome of the project also funded the same project. Japan Govt. funded Rs. 15 lakhs and SOES also matched almost equal amount.

The project started from October 1997 and still in progress. School of Environmental Studies, Jadavpur University is supervising, advising, analysing water and biological samples; visiting the villages with medical team. So far about 7000 water samples had been analysed with each 1500 hair, nail and 1000 urine. Patients were identified and registered.

The report here will only highlight the suitability of 2 arsenic removal technologies installed in 7 locations in Betai and run with people's participation.

At present two arsenic removal technologies are well known in West Bengal for community use

Chandranath Basu Seva Sangha spent 4 lakhs of rupees for installation of 8 units, 4 from each AIIH&PH, Calcutta and B.E. College, Howrah

A. All India Institute of Hygiene and Public Health (AIIH&PH), Calcutta system - described as oxidation of arsenite followed by coprecipitation, where bleaching powder, aluminium sulfate are in use in a hand pump attached Model [for details of the technology: National Workshop on Removal of Arsenic from Drinking Water, 19th and 20th December 1997 (Background Materials), Sponsored by: World Health Organization, Conducted by: All India Institute of Hygiene and Public Health, Calcutta and PHED, Govt. of West Bengal]. About Rs. 40,000 is required for building each unit. At the beginning AIIH&PH people came for building and installed one unit but we made subsequent units.

B. The system developed by Environmental Engineering Laboratory, Civil Engineering Department, Bengal Engineering College, Howrah 711103. In this system aluminium oxide is in use as adsorbent for arsenic removal in hand pump attached model [detailed flow sheet diagram are available from National Workshop on Removal of Arsenic from Drinking Water, 19th and 20th December 1997 (Background Materials), Sponsored by: World Health Organization, Conducted by: All India Institute of Hygiene and Public Health, Calcutta and PHED, Govt. of West Bengal]. The cost of each unit is Rs. 60,000. B.E. College technicians came with the units and installed. One technical person also visited sites about once a month to observe the problem of each unit.

Our Observation

On principle both the techniques are technically sound and flawless if properly used. Both the systems are known for many years and are used in many countries all over the world. The scientists of these two institutes (AIIH&PH & BE College) made a novel attempt to adopt it to arsenic affected villages for removal of arsenic from groundwater considering local need and difficulties.

School of Environmental Studies suggested Chandranath Basu Seva Sangha to install 4 AIIH&PH and 4 BE College's units in Betai. 7 units, 4 from BE College and 3 from AIIH&PH were installed in Betai during last one year. One unit of AIIH&PH was recommended for installation in a very highly arsenic affected area in Bangaon, North 24-Parganas.

School of Environmental Studies is monitoring the arsenic concentration in raw and filtered water fortnightly and also bacteriological suitability of the water was checked once in a month. Dr. Chakraborti visited the plants several times. Collections of samples with preservative for arsenic analysis and for bacteriological analysis in sterilized bottle were done. Samples were analyzed as soon as possible after collection. Kept refrigerated until analysed.

Table-3 shows the arsenic concentration in finished water of the 7 units during about last two years. Out of these seven units, except one unit (No.-2), all others units time and again showed some problems including high arsenic in finished water. Our results of microbiological analysis showed unsuitability of the water (total plate count above permissible limit) once or twice to all the units (except unit no.2). Even villagers observed small worms in finished water and that only happened after the instruments were not in working condition for couple of days and immediately after regeneration.

Each unit except one (no.2) has some problems. The write up below describes merits and demerits of the individual unit.

Unit-1: Ashram Campus, Dangapara, Betai
Caretaker: Ram Krishna

Type of Unit: B.E. College
Families using: 200

Table-3 Water Report From Treatment Plant (B.E. College and AIIH&PH) installed in Betai, Nadia

SL. No	Place	Type of Unit	Arsenic concentration in mg/l							
			Raw	04/07/99	10.08.99	02.02.2000	20.02.2000	15.04.2000	07.05.2000	21.05.2000
1	Ashram Campus Betai, Dangapara, Caretaker: Ram Krishna User 200 families	B.E. College	0.170	<0.003	0.131	<0.003	<0.003	<0.003	0.121	Not functioning
2	Itkhola Para, Betai, Caretaker: Khitish Chandra Adhikari User: 60 families	B.E. College	0.122	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
3	B.R. Ambedkar College, Betai, Caretaker: Prof. M.C. Moulick User: 100 families	B.E. College	0.327	0.056	<0.003	<0.003	<0.003	Not functioning	<0.003	0.035
4	Kharermath (Purba), Jitpur Caretaker: Mangal Biswas,User: 50 famlies	B.E. College	0.235	Not functioning	0.187	0.069	0.012	Not functioning	Not functioning	Not functioning
5**	Jitpur (Tabu para) Caretaker: Dilip Poddar, User: 60 families	AIIH&PH	0.051	0.045	Not functioning	Not functioning	0.006	0.005	<0.003	Not functioning
6	Haripur (Chitka),Betai User: 300 families	AIIH&PH	0.463	Not functioning	Not functioning	Not functioning	Not functioning	0.052	0.092	0.035
7	Muktadaha Para, Betai Caretaker: Jitendra Ghosh,User:150 families	AIIHP&H	0.149	Not functioning	Not functioning	Not functioning	0.024	0.043	0.088	0.081
Continued										

** All surrounding tubewells are quite contaminated. For the plant a new tubewell was installed and luckily the tubewell shows arsenic 0.051

SL. No	Place	Type of Unit	Arsenic concentration in mg/l					
			Raw	04.08.2000	5.10.2000	7.01.2001	23.02.2001	25.03.2001
1	Ashram Campus Betai, Dangapara, Caretaker: Ram Krishna User 200 families	B.E. College	0.170	0.016	0.020	0.029	0.035	0.030
2	Itkhola Para, Betai, Caretaker: Khitish Chandra Adhikari User: 60 families	B.E. College	0.122	<0.003	<0.003	<0.003	<0.003	<0.003
3	B.R. Ambedkar College, Betai, Caretaker: Prof. M.C. Moulick User: 100 families	B.E. College	0.327	<0.003	0.037	<0.003	0.057	<0.003
4	Kharermath (Purba), Jitpur Caretaker: Mangal Biswas,User: 50 famlies	B.E. College	0.235	Not functioning	Not functioning	0.096	0.110	0.131
5**	Jitpur (Tabu para) Caretaker: Dilip Poddar, User: 60 families	AIIH&PH	0.051	0.042	<0.003	0.036	<0.003	<0.003
6	Haripur (Chitka), Betai User: 300 families	AIIH&PH	0.463	0.120	0.098	0.135	0.10	0.077
7	Muktadaha Para, Betai Caretaker: Jitendra Ghosh,User:150 families	AIIH&PH	0.149	0.11	0.088	0.075	0.065	0.028

The unit remains inactive at least a couple of days during every month. Reasons are many: tubewell head broken; leakage from valve; washer not functioning; water is not coming on pumping from underground etc. Arsenic in finished water found twice higher than maximum permissible limit (0.05 mg/l) during our study. Time and again it has been observed that the finished water turns brown after sometime [i.e. precipitation $Fe(OH)_3$]. This indicates that the Al_2O_3 bed was not washed properly. People do not understand the importance of back washing the Al_2O_3 column. This is the unit where about 500 families use the plant for water. It appears that the Al_2O_3 bed is getting exhausted. Still we do not know the money to be required for regeneration and also for replacement of Al_2O_3 in final stage. From the solder joint water leaks time to time. We do not know how long the structure will stand. Too much pressure is on the treatment plant. When the system is in working condition bacteriological study shows the satisfactory result but when the system was not used for few days due to technical problem and started again the bacteriological count becomes unsatisfactory.

Unit-2: Itknola Para, Betai
Caretaker- Khitish Chandra Adhikarai
Type of unit: B.E. College
Families using: 60

The unit is running for last 10 months. The performance of this unit is flawless. One person is doing the maintenance and operation. There is also no leakage from soldering joints. Only 35-40 families drink water from this unit. The villagers of this area better educated and conscious. All pay Rs. 5/- as maintenance cost. Minimum pressure on the instrument. This can be the example how one unit can ideally work if proper maintenance is done and not roughly handled. No bacteriological problem was noticed.

Unit-3: B. R. Ambedkar College, Betai
Caretaker- Prof. M. C. Moulick
Type of unit: B.E. College
Using: College students and 150 families

Although principal of B. R. Ambedkar college, Prof. M. C. Moulick of the college is taking care of the unit but it showed arsenic above 0.05 mg/l two times and according to Dr. Moulick, time to time, there is leakage from soldering area. The instrument also did not function properly a few times. According to Dr. Moulick now frequent backwash is necessary which was not needed so frequently earlier. This unit has also the other problems as described with Unit-1. Bacteriological problem same as Unit 1.

Unit-4: Kharermath (Purba), Jitpur, Betai
Caretaker- Mangal Biswas
Type of unit: B.E. College
Families using: 50

The performance of this BE College unit is the poorest among all 4 units. This is not functioning at all. Most of the time the system is not in working condition. Reasons are many but non co-operation among section of villagers appears the main reason. Most of the villagers are illiterate in this area. We had also noticed that along with water the villagers collecting for drinking Al_2O_3 is also coming. During our last 2 years observation on this unit about a year the system was not in working condition (negligence partly from BE.College, Shibpur and partly from the villagers) and all the time (measured 6 times) water coming out from the plant had arsenic above 0.05 mg/l.

Unit-5: Jitpur (Tabu Para), Betai
Caretaker- Dilip Poddar
Type of unit: AIIH&PH
Families using: 60

When we went to the site on 21st May 2000, system was not working. When asked for the reason, it was told that due to gusty wind the aluminium sheet covering both the tanks was removed and the $Al_2(S0_4)_3$ and bleaching powder containers went away due to wind like a football.
It was further reported that understanding & co-operations among villagers are needed to run the system smoothly. This is the system where the input water is 0.051 mg/l. Nearby hand tubewell was not available for connection, so new tubewell was installed and fortunately the tube-well was found low arsenic. Bacteriological problem noticed when the system was not cleaned after every week also if bleaching powder suspension do not drop.

Unit-6: Haripur (Chika), Betai
Type of unit: AIIH&PH
Families using: 300

Along with the same inconveniences as reported for No.-5, some villagers further complained that from the bleaching powder container due to precipitation the hole of dropping tap blocks and sometime no inflow of bleaching powder solution for a prolonged period. The villagers are not aware of the importance of bleaching powder addition. Bacteriological problem as mentioned for Unit -5.

Unit-7: Muktadaha Para, Betai
Caretaker: Jitendra Ghosh
Type of unit: AIIH&PH
Families using: 150

This unit is located close to the Ashram. Although the villagers at the beginning was getting water free of cost but after a couple of months it was decided that every family will pay Rs. 5.0 (Rupees five) only per month for purchase of bleaching powder, aluminium sulfate and salary of Mr. Ghosh who maintains it. The villagers agreed to this suggestion. We expected a better management. The caretaker of the unit is a young boy Jitendra Ghosh (M/20). I asked him the difficulties and also the good side to run the unit. Mr. Jitendra Ghosh told me:

(a) It was decided that Mr. Ghosh would be paid some money to run the unit. The villagers think as he is paid for this, it is his duty to fill-up the tank and villagers prefer to come and collect water. Mr. Ghosh told time to time he fills up the tank without knowing that he has not added required amount of bleaching powder and aluminium sulfate (as he feels within 15 to 20 minutes).

(b) Although each family promised that they would pay Rs. 5/- per month but most of them do not pay. Mr. Ghosh never got his salary.
(c) Mr. Ghosh told no one would clean the plant if he will not do it.
(d) The villagers do not care whether aluminium sulfate and bleaching powder falling or not in the system. They believe that water coming from tap of the plant is good for drinking.
(e) To clean the unit it takes about 4 hours and after every 15 days when he cleans the tank he observes very dirty (brown) condition of the pebbles and time and again he finds small red coloured worms.
(f) After he fills-up the tank he observes at the surface some oily substance. We had also noticed it on 21st May 2000 during our field visit.

(g) Anima Ghosh of the area told that she found once small red-coloured worm when she took water for drinking from the unit.
(h) Mr. Ghosh feels that after cleaning, the system remains good for one week but after that the inner tank slowly turns dirty and he find worms inside the tank.

Who will help the people in the arsenic affected villages to get safe water!

The villagers of Betai came to know from local leader that government tap-water supply would be in near future to the area as government had already sanctioned money for the area. Thus villagers told that they would get water at free of cost, so they are least interested to pay Rs. 5/- per month in community participation project. It is our findings that many piped water supply schemes are arsenic contaminated in arsenic affected areas of West Bengal but villagers do not understand that and government hides the truth and do not initiate projects with peoples participation for safe water.

Conclusion

In village predominant India and Bangladesh even a highly successful technology may not succeed in rural areas unless it fits in the rural circumstances and is well accepted by the rural mass. Development of such technology is only possible when a combination is made between technocrats and villagers with proper village level participation.