

Approaches for Removal of Arsenic from Tubewell Water for Drinking Purpose

M. D. Hussain , M. A. Haque, M. M. Islam and M .A. Hossen

Deapartment of Farm Power and Machinery,
Bangladesh Agricultural University
Mymensingh-2202

Abstract

Removal of arsenic from tubewell water is possible by passing it through wood charcoal, by chemical treatment, by sedimentation method or by removing the layer floating on arsenic bearing water. It was found that when arsenic water was treated with calcium oxide, it produced arsenic-free water. In this method more than 90 percent removal of arsenic was achieved by adding 0.10% (by weight) calcium oxide to arsenic-contaminated water. After 10 hrs the water becomes arsenic-free. In another experiment, arsenic-bearing water was passed through wood charcoal at different flow rates and it was found that up to 98% removal was possible. If arsenic water (0.45 mg/L) is kept in a big tank (about 3000-liter capacity) for about 9 days, arsenic concentration level is reduced in the top layers to acceptable level (0.05 mg/L). When arsenic-bearing water comes in contact with free air, a thin layer is formed which is nothing but an arsenic compound and its concentration was about 0.7 mg/L. In this way arsenic level can be reduced to acceptable level by repeated removal of the floating layer. Any of the methods mentioned above can be used to produce arsenic-free water and it can be recommended for use in rural areas of Bangladesh.

INTRODUCTION

Safe drinking water is still an important issue in Bangladesh. In the past, most drinking water was used to be harnessed from rivers, ponds, dug wells with little

or no arsenic, but with contamination by pathogens which transmitted various diseases, such as cholera, diarrhea, dysentery, hepatitis and typhoid. To control these diseases, program for safe drinking water initiated the use of tubewells to harness groundwater. Although it succeeded in achieving its goal of supplying water free of pathogens, after a couple of decades since inception, an unexpected side effect has been noticed. This was the detection of inorganic arsenic in tubewell water in many regions of the country. Intake of arsenic associated with food is a common phenomenon, but this arsenic is the low-toxicity organic arsenic. But drinking water derived from underground source contains arsenic in inorganic form, which is of higher toxicity and a significant hazard for human health. Prolonged use of arsenic-rich water for drinking purpose is unsafe and the most commonly reported symptoms of chronic arsenic exposure are hyperpigmentation, depigmentation, keratosis, skin cancer and a number of internal cancers. Cardiovascular and neurological diseases have also been found to be linked to arsenic contamination (WHO, 1999 and Saha, 1998). High concentration of arsenic in water when associated with malnutrition and hepatitis B, which are very common in Bangladesh, accelerate the effects of arsenic poisoning.

According to recent statistics, fifty four out of the sixty four administrative districts are affected by arsenic contamination in tubewell water (WHO, 1997). The number of people drinking arsenic contaminated water has increased over last 25 years due to well drilling and population growth in Bangladesh. The number of affected persons may, therefore, increase further (WHO, 1999). The most important remedial measure is prevention of further exposure by providing safe drinking water. Many programs on arsenic detection and creation of awareness have so far been completed and some are being implemented. But very few efforts have been undertaken for the removal of arsenic from tubewell water except to abandon the arsenic affected tube wells. Yet no proven technologies for the removal of arsenic at water collection points, such as wells, are available (BES, 1999). So, simple technologies for removal of arsenic from tubewell water is of urgent need.

From this point of view, several approaches have been tested in this study to remove or reduce arsenic from tubewell water to safe limit at household level.

METHODOLOGY

Field experiment was conducted at Goneshampur village under Mymensingh sadar upazila during November 2000 to March 2001. Four different approaches were tested for removal or reduction of arsenic level from tube well water. Arsenic concentrations were determined by an arsenic kit provided by NIPSOM.

In the first attempt, arsenic contaminated water was allowed to pass through successive layers of sand and wood charcoal at a controlled flow rate. In this setup, three pitchers (11 liters each) were placed one above another vertically in a bamboo-tripod. The top most pitcher, having a small hole at its bottom, contained arsenic contaminated water. The middle one contained layers of wood charcoal and sand. This pitcher also had a small orifice at its bottom covered with a screen to prevent sand from leaking out. Size of pieces of charcoal was in the range of 1-1.5 cm. Weight of the layers of charcoal was varied (606 gm, 754 gm and 457 gm), while weight of the layer of sand was 4480 gm. The bottom pitcher was used to collect filtered water. Contaminated water was allowed to flow at different flow rates.

For chemical treatment, calcium oxide was added at different doses to arsenic contaminated water and allowed to stay for several hours in a container. In sedimentation method, arsenic contaminated water was kept in a tank (capacity 3000-liter). Every 72 hours arsenic level of the water was tested at 5 different layers of water in the tank. Each layer was 20 cm thick and the 6th layer at the bottom acted as sedimentation trap. Finally, a thin layer, formed at the surface of arsenic contaminated water, was removed and the level of arsenic in the water was tested.

RESULTS AND DISCUSSION

Very good arsenic removal was observed when arsenic contaminated water was allowed to pass through wood charcoal. Table 1 shows percentage of arsenic removal from arsenic-bearing water at different flow rates. It was found that removal of arsenic was higher with lower flow rates through the layer of charcoal. With the successive layers containing 4480 gm of sand and 606 gm of coal, about 97% to 99% removal of arsenic was observed with flow rates varying from 54 to 12 ml/min, respectively. Similar results were found when 754 gm and 757 gm of charcoal were used with the 4480 gm of sand, respectively (Table 2 and Table 3).

Arsenic level of arsenic-bearing water was found to be reduced in sedimentation method, as arsenic is heavier than water. Table 4 shows that arsenic content of different layers of water reduced as time passed. After a period of 216 hours, 1/2 portion of water from the top surface attained safe level of arsenic content while 2/3 portion of water showed safe level of arsenic content after 288 hours of sedimentation period.

While treating with calcium oxide, arsenic contaminated water showed positive response. Table 5 reveals that adding 0.1% (by weight) of lime to arsenic contaminated water, reduced arsenic to safe level after a period of 10 hours, while no arsenic was detected after a period of 16 hours.

Table 1: Arsenic removal from contaminated water by charcoal method at different flow rates (Sand 4480 gm and Coal 606 gm).

Sl. No.	Flow rate (ml/min)	Initial arsenic Content (mg/L)	After filtration (mg/L)	% removal
1	12	0.46	0.004	99
2	30	0.46	0.007	98
3	40	0.46	0.007	98
4	54	0.46	0.013	97
5	126	0.46	0.015	97
6	137	0.46	0.026	94
7	148	0.46	0.028	94
8	150	0.46	0.034	93
9	192	0.46	0.038	92
10	260	0.46	0.05	89
11	265	0.46	0.054	88
12	336	0.46	0.25	46

Table 2: Arsenic removal from contaminated water by charcoal method at different flow rates (Sand 4480 gm and Coal 754 gm).

Sl. No.	Flow rate (ml/min)	Initial arsenic content (mg/L)	After filtration (mg/L)	% removal
1	12	0.46	0.012	97
2	30	0.46	0.014	97
3	40	0.46	0.02	96
4	54	0.46	0.027	94
5	126	0.46	0.047	92
6	137	0.46	0.052	89
7	148	0.46	0.067	85
8	150	0.46	0.066	86
9	192	0.46	0.098	79
10	260	0.46	0.017	63
11	265	0.46	0.22	53
12	336	0.46	0.28	39

During experiment it was found that arsenic contaminated water, when kept in a storage tank, formed a thin layer at the top of its surface after a couple of days. This may occur due to formation of arsenic compound when the water containing arsenic came in contact with free air. Formation of this layer was augmented in the presence of iron in the water. This layer contained excessive level of arsenic (0.7 mg/L). Repeated removal of this thin layer from the top surface reduced the arsenic content to safe level.

Table 3: Arsenic removal from contaminated water by charcoal method at different flow rates (Sand 4480 gm and Coal 757 gm).

Sl. No.	Flow rate (ml/min)	Initial arsenic content (mg/L)	After Filtration (mg/L)	% removal
1	12	0.46	0.006	99
2	30	0.46	0.006	99
3	40	0.46	0.006	99
4	54	0.46	0.011	98
5	126	0.46	0.014	97
6	137	0.46	0.019	96
7	148	0.46	0.02	96
8	150	0.46	0.024	95
9	192	0.46	0.032	93
10	260	0.46	0.04	91
11	265	0.46	0.048	90
12	336	0.46	0.16	65

Table 4 : Reduction of arsenic level from water by sedimentation method

Duration (hrs)	Amount of arsenic (mg/L)					
	1 st layer	2 nd layer	3 rd layer	4 th layer	5 th layer	6 th layer
0	0.45	0.45	0.45	0.45	0.45	Sedimentation trap
72	0.05	0.1	0.2	0.3	0.30	
144	0.05	0.1	0.2	0.2	0.30	
216	0.05	0.03	0.04	0.2	0.3	
288	0.05	0.01	0.01 ⁺	0.02 ⁺	0.2 ⁺	

Table 5: Treatment of arsenic contamination water with Calcium Oxide

Amount of water (gm)	Amount of CaO (gm)	Initial arsenic content (mg/L)	Arsenic concentration (mg/L)			% removal		
			After 1 hr	After 10 hrs	After 16 hrs	After 1 hr	After 10 hrs	After 16 hrs
5000	0.5	0.45 ⁺	0.45 ⁺	0.4	0.4	0.0	11	11
5000	1.0	0.45 ⁺	0.45 ⁺	0.35	0.3	0.0	22	38
5000	2.0	0.45 ⁺	0.4 ⁺	0.25	0.15	0.0	44	67
5000	2.5	0.45 ⁺	0.4 ⁺	0.09	0.06	0.0	80	87
5000	3.0	0.45 ⁺	0.35 ⁺	0.07	0.05	22	84	89
5000	3.5	0.45 ⁺	0.3	0.07	0.05	33	84	89
5000	4.0	0.45 ⁺	0.3	0.05	0.03	33	88	93
5000	4.5	0.45 ⁺	0.3	0.05	0.03	33	88	43
5000	5.0	0.45 ⁺	0.25	0.035	Nil	44	92	100
5000	5.5	0.45 ⁺	0.25	0.03	Nil	44	93	100
5000	6.0	0.45 ⁺	0.25	0.02	Nil	44	96	100
5000	6.5	0.45 ⁺	0.2	0.15	Nil	56	97	100
5000	7.0	0.45 ⁺	0.2	0.01	Nil	56	98	100
5000	7.5	0.45 ⁺	0.15	0.01	Nil	67	98	100
5000	8.0	0.45 ⁺	0.10	0.01	Nil	78	98	100
5000	8.5	0.45 ⁺	0.10	Nil	Nil	78	100	100

CONCLUSION

Experiments conducted so far for arsenic removal showed positive results. It was found that removal of arsenic from drinking water is possible by passing the water at controlled flow rate through wood-charcoal, treating the water with calcium oxide, by sedimentation method and by repeated removal of the top surface layer containing high level of arsenic. These methods may be adopted as cheap and simple technologies for removal of arsenic from drinking water.

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