A SMALL-SCALE ARSENIC AND IRON REMOVAL PLANT

Introduction

Groundwater is the main source of water supply in Bangladesh. Groundwater abstracted from tubewells was considered to be the best option for water supply in rural and peri-urban areas. Unfortunately, arsenic in excess of the acceptable limit has been found in tubewell water in many parts of the world and particularly in Bangladesh.

Alternative options for arsenic-safe water are urgently needed to mitigate arsenic toxicity and protect public health and there has been considerable research into a range of technologies. Some of the common arsenic mitigation technologies include:

- Co-precipitation of arsenic and iron
- Adsorption of arsenic onto coagulated flocs
- Lime treatment
- Adsorption onto sorptive media
- Ion exchange
- Filtering by special membrane
- Microbial process

One low-cost option based on the co-precipitation principle that is showing promises is the arsenic and iron removal plant (AIRP) that has been tested in Bangladesh. This approach to arsenic mitigation is described in this Technical Brief.

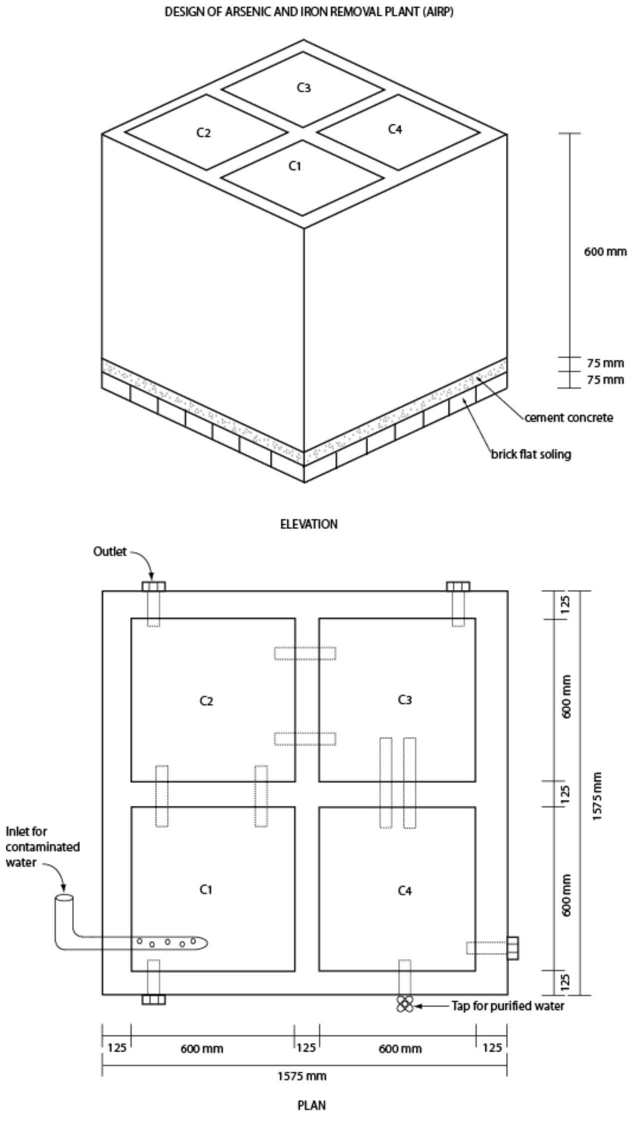

Figure 1: AIRP Design.

How does the AIRP system work?

The basic structure of the 4 chamber plant is shown in Figure 1. Water contaminated with arsenic and iron from the source tubewell is introduced to chamber C1. The water spreads through the perforations of the inlet pipe. This action aerates the water. In the aeration process, oxygen from the air reacts with iron and arsenic in the water. This transforms the soluble arsenic and iron into insoluble compounds. The insoluble arsenic and iron

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precipitates out. Water then passes through chambers C2 and C3. These chambers are filled with different types and size of filter media that arrest the arsenic and iron particles by adsorption and filtration.

Finally, water free from arsenic and iron arrives in the last chamber C4. In this process a 70 to 75 percent reduction in arsenic can be achieved. Therefore, water that has 100–150 ppb (parts per billion) of arsenic could be treated to an acceptable level by the AIRP technology. [Bangladesh standard for allowable arsenic contamination is 50ppb.]

AIRP construction

The following criteria should be used in selecting the site for an AIRP.
- The site for the AIRP should be near the tubewell yielding water contaminated with arsenic and iron
- The plant should be located on flood-free high land
- There should be proper drainage facilities/opportunities
- The plant should be located in a place easily accessible by the community

Materials required for constructing an AIRP are listed in Table 1.

Sl #	Name of construction and media materials	Quantity	Units	Usages/placement	Remarks
Construction materials					
01	Filling sand	0.75	Cubic m	Foundation bed of the plant	Based on the site condition
02	Bricks (Size: 240 mm x 115mm x 70mm)	350-450	Nos.	Structure of the plant	Depends on site condition, drainage facilities
03	Medium Sand	2.0	Cubic m	Masonry and casting works	
04	Cement	3-4	Bag	‘’	
05	Cement additive (Padlu)	0.5	Kg	Plaster works	To make the plant water proof
06	38 mm dia steel pipes	1.6	m	Outlets and intra chamber connection	In between walls of chamber C1-C2 and C2-C3
07	End cap (38 mm)	04	Nos.	Outlet pipe	One with each chambers
08	PVC Pipe (100mm dia)	1.0 to 1.5	m	Feeding water to chamber C1	Distance from the source (tubewell)
09	Plastic net	1.0	Sq. m	Wear GI pipes	To protect passing of media materials during cleaning
10	Strainer pipe (38mm dia)	1.0	m	In between walls of chamber C3-C4	To pass water slowly to the chamber C4 resting media materials
11	Tap/Bib-Cock	01	Nos.	Outer side of the chamber C4	Fit at a convenient height for users to draw water easily
12	Steel sheet	2.5	Sq. m	As cover of the plant	
12	25 mm Flat bar (5mm thick)	15	m	‘’	
Media/filling materials and operation instruments					
14	12mm down graded brick chips	0.25	Sq. m	Chamber C1	For one time
15	6mm down graded stone chips/pea gravels	0.25	Sq. m	Chamber C2	“
16	Course sand (FM-2.0 to 2.5)	0.25	Sq. m	Chamber C3	“
17	Iron nails	200-400	gm	Chamber C1	(If iron contamination is low in raw water)
18	Pipe wrench	01	No.	To open/close outlets	

Table 1: Construction materials and filter media required for an AIRP suitable for 10 households

technical brief

Steps for preparing the site

- Clean the site (2.0 m x 2.0 m) close to the contaminated water source
- Water source (tubewell) should be at the left side (first corner) of the plant
- If the soil condition of the bed of the plant has been found loose/slushy, then additional earth should be excavated and filled with compact sand as per site condition
- 3 inches thick cement concrete (CC) or Reinforced Cement Concrete (RCC) with proportion of 1:2:4 (cement:sand:brick chips) over Brick Flat Soling (BFS) platform should be constructed. Note that the foundation bed of the plant should be constructed considering the level of nearby drainage network so that wastewater could pass easily from the plant; If necessary, the bed of the plant may be raised by additional brick work on the periphery (outer wall) of the plant

Steps for constructing the superstructure

- Start the 5 inch (127mm) thick brick masonry work of the outer and inner walls after completing the CC/RCC bed (at least 24 hours delay is required). The height of the walls should be up to 600mm.
- Each chamber should be equal in size (600mm x 600 mm x 600 mm).
- After the brick works, plaster the walls with neat cement finishing (NCF) with 1:4 mortar (cement:sand) ratio. Water resistant additive (padlu) may be used during plaster works to keep the chambers impermeable. About 0.5 kg of padlu should be mixed with one bag of cement (50 kg) for making the plaster mortar.
- Side drain should be constructed with proper slope and connected to nearby drainage networks.

Steps for adding fittings and fixtures:

- One outlet pipe for each chamber should be placed about 10 mm above the plant bed. The outlet should have an end cap at the outside and a plastic net placed on the inner side. The outlet pipe should be put in place during the brickwork stage. These outlets will drain wastewater while cleaning the chambers.
- Better drainage of wastewater and other settings of the plant should be considered while placing the outlet pipes.
- A perforated PVC pipe (100mm diameter) should be placed at chamber C1 as the inlet to introduce raw water from the contaminated tubewell into the plant. The perforated portion of the pipe should be fully within chamber C1.
- Pipes should be placed for circulating water between chambers as well. Between chambers C1 and C2, two galvanized iron (GI) pipes (38mm diameter and 150 mm long) covered with plastic net at both ends should be placed at the top level of the finished plant bed. Between chambers C2 and C3, two similar pipes should be placed at the middle height from the bed.
- Between chambers C3 and C4, two PVC strainers (38mm in diameter and 450 mm in length) should be placed between chambers C3 and C4 at the top level of the finished plant bed. The strainers should have end caps at chamber C3 and open ends at chamber C4. About 300mm length of the strainers should be within chamber C3.
- An outlet with a stopcock (tap) should be placed at chamber C4 about 150 mm above the finished bed of the plant. This will let users collect purified water. The outlet should be located so that the users could easily collect water by commonly used pots.

- A cover made of corrugated iron (CI) sheet should be used to keep the plant (chamber materials and water) safe and free from dust and other contaminates. The cover could be hinged on one end so that it may be lifted for inspection and cleaning and put back in place afterwards.

- If the height of the existing tube well (water sources contaminated with arsenic and iron) is too low then it should be raised up to the level that water can be easily flow into chamber C1 through a perforated PVC pipe.

- Fill chambers C1, C2 and C3 with filter media as described in Table 1.

Note: Proper and timely curing should be maintained during construction for strength and durability of the plant.

Figure 2: Construction of AIRP.
Photo: Moin/DRIK*.*

Figure 3: Typical Chamber of a plant.
Photo: Moin/DRIK.

AIRP operation and maintenance

Steps for operation set up:

- Close end caps of all outlet pipes at first

- Pump water from the contaminated tubewell to flow though the inlet pipe into chamber C1

- Continue pumping to fill chambers C1, C2 and C3. When the water level in chamber C4 rises to the same level as other chambers, then the end caps of the outlets should be opened to flush out water from all chambers. This should be repeated at least three times

- After the initial three flushing cycles, the plant should be ready for operation. Water may be collected from the pure water outlet in chamber C4 for drinking and cooking

Performance monitoring of the plant:

- For a quick check, collect a glass of water from chamber C4 and put some green pieces of plucked guava leaves in it and observe the water

- If no changes occur in the water, the performance of the plant is satisfactory and the user could use water for drinking and other cooking

- If the colour of the water in the glass darkens within 30 to 60 seconds, the performance of the plant is not satisfactory. In this case, renew the filter media and repeat the set up process

- For a more confirmatory test, use an arsenic field kit to test the treated water

Maintenance

- Regularly clean the outer sides/periphery of the plant and ensure it is free from water logging
- Keep the plant covered with the CI/plastic sheet
- Keep the outlet pipes closed
- After a 7 days interval flush out the water (opening the outlets) 2 or 3 times and clean the chambers
- After one month or if the performance of the plant is found to be unsatisfactory (test with the green guava leaves), take out all the media/filter materials separately then clean and wash with hot water mixed with bleaching powder (10 gm per liter of water), dry in sunlight and refill.
- After one year or if the performance of the plant is found unsatisfactory then all filter/media materials should be replaced by new materials
- Water containing a lot of iron contamination quickly reduces the adsorption and filtration capacity of the filter/media materials. In this case, the filter materials need to be cleaned more regularly to keep the plant functional. But if the iron concentration in the raw water is low, then iron can be added (iron pins/nails could be added with brick chips) to chamber C4

Figure 4: Demonstration of AIRP operation. Photo: Moin/DRIK.

Figure 5: Arsenic removal monitoring with guava leaves. Photo: Moin/DRIK.

Box 1: Facts about arsenic

What is arsenic?
Arsenic is a metal that is soluble in water. It has no taste, colour or smell. It is highly poisonous.

Where does it come from?
It naturally occurs in groundwater in many parts of the world.

What happens if one intakes arsenic?
At high dose, a person may die instantly. At low dose, arsenic may cause chronic diseases such as skin lesions, cancer, gangrene, etc. The safe limit in water according to Bangladesh standard is 50 parts per billion (50 micrograms per litre).

How do you detect arsenic in water?
There are field kits available. Water may be tested by the field kits and compared against colour charts to indicate approximate arsenic concentration.

How to cope with arsenic in water?
The best option is to stop drinking arsenic contaminated water. One should switch to an arsenic-safe source or treat the raw water to reduce the arsenic concentration before drinking.

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