Highly Arsenic-contaminated Areas in Bangladesh and Development of Multi Gravel Sand Filter

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Abstract

In Bangladesh, many arsenic mitigations have been conducted these 22 years since the first detection of As-contamination of groundwater in 1993. A DPHE/JICA report made clear the situation of arsenic mitigation in 2010. According to the report, 19 million people do not have access to any safety water options (SWOs) yet, and also 4.6 million people are still living where As-contaminated ratio is more than 80% but safe water coverage is less than 20%. It is the worst As-contaminated areas. The Asia Arsenic Network (AAN) had the chance to study the situations of As-mitigation and construct SWOs in some of these worst areas. There were many highly As-contaminated tube wells (As>0.5mg/L) with low Fe-concentrations. AIRP/GSF, used considerably in Bangladesh, can not be applied to these highly As-contaminated tube wells because that the iron concentration in tube well water needs to satisfy the condition of Fe/As>20. In order to supply safe water in the highly As-contaminated areas, an improved GSF (multi GSF) is now being developed. This paper describes the situations of highly As-contaminated areas and the improved GSF under development.

Keywords: Arsenic, Groundwater, Arsenic removal, Bangladesh

1. INTRODUCTION

Twenty-two (22) years have passed since 1993 when the arsenic contamination was first detected in Chapai Nawabganj District in Bangladesh. Many organizations, governmental, non-governmental and international, have made efforts to tackle the problem. Asia Arsenic Network (AAN), too, has implemented many arsenic mitigation projects since 1996. Regarding the installation of safe water options, AAN has constructed about 1,000 units, 20 % of which is AIRP/GSF (Arsenic Iron Removal Plant : General name/Gravel Sand Filter : Original name) mentioned later.

Now 19 million people do not have access to any safety water options (SWOs) yet, according to the DPHE/JICA report (DPHE/JICA, 2010). Twenty (20) years ago, it was estimated that 40 million people needed to get As-safe drinking water. The DPHE/JICA report showed the situations of arsenic mitigation in detail, including that 4.6 million people are living where As-contaminated ratio is more than 80% and yet safe water coverage is less than 20%. It is the worst As-contaminated areas.

AAN had the chance to study the situations of As-mitigation and construct SWOs in two highly arsenic-contaminated areas, including the above-mentioned worst area. The first one is Ashrafpur Union in Chandpur District to the southeast of Dhaka located along the Ganges, where SWOs coverage is less than 20% while

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As-contamination ratio is more than 80% according to the DPHE/JICA report. The other is Dharmapasha Upazila in Sunamganj District to the northeast of Dhaka located near Indian border, where the As-contamination ratio and SWOs coverage are both 40% to 60% in the most contaminated Unions among the 10 Unions of Dharmapasha Upazila according to the DPHE/JICA report.

The AAN projects were performed 2012 to 2014 as for Ashrafpur (Asia Arsenic Network, 2012) and 2014 to 2015 as for Dharmapasha (Asia Arsenic Network, 2015).

The survey in both the areas showed that a lot of tube wells were highly contaminated with arsenic (As>0.5mg/L) and the concentration of As and Fe did not show linear relation which is often seen at the As-contaminated areas in Asia countries. Moreover, there were many tube wells which have high As-concentration with low Fe-concentration, and also tube wells with low As-concentration but with high Fe-concentration. These highly As-contaminated areas are, as we say, the most difficult areas to obtain the safe water sources and left in Bangladesh unsettled.

On the other hand, the AIRP/GSF technology, developed by Univ. of Miyazaki (UOM) & AAN, has been working well in Bangladesh until now. The arsenic is to be removed by the co-precipitation of iron, resolved in the groundwater, after aeration (So it is called generally as Arsenic Iron Removal Pant). In the AIRP, the aeration is caused at the Inlet tank and the co-precipitated material is to be settled in the gravel voids at the Gravel tank, and finally the tube well water is filtrated slowly at the Sand tank (So we originally named Grave Sand Filter).

The As-removal ratio of AIRP/GSF is roughly 80% to 90%. In installation of AIRP/GSF, the value of 80% is used based on the safe side, and the arsenic-contaminated tube wells of As<0.20mg/L is specifically selected. And also, the Fe-concentration of the tube well water is to satisfy the ratio of Fe/As>20 to remove arsenic by co-precipitation of iron.

Due to these conditions of As and Fe for installation of AIRP/GSF, the technology is not effective to the above-mentioned "the most difficult areas to obtain the safe water sources". To solve this problem, a "multi GSF" is now being developed.

This paper describes the situations of As-contamination in Ashrafpur Union and Dharmapasha Upazila, and the multi GSF under development.

2. SITUATIONS OF As-CONTAMINATION

2.1 As-contamination in Ashrafpur

There are 20 villages in Ashrafpur Union, where the arsenic concentration of all shallow tube wells of 5,374 were measured by field kit in 2012. The Ninety-nine percent (99%) of tube wells exceeded 0.05mg/L, the permissible value in Bangladesh, as shown in Fig.1

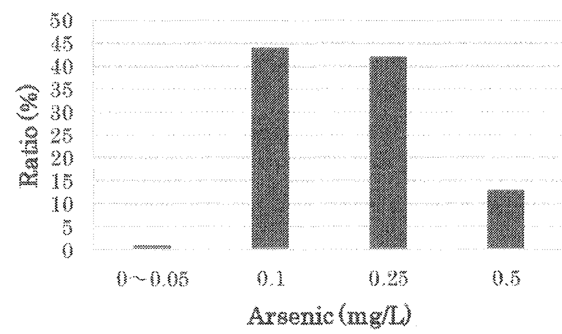

Fig.1 As-concentration of shallow tube well in Ashrafpur

The above-mentioned data by field kit were cross-checked by AAS (Atomic Adsorption Spectrometry) for 300 data, where the iron concentration was measured, too, as shown in Fig.2.

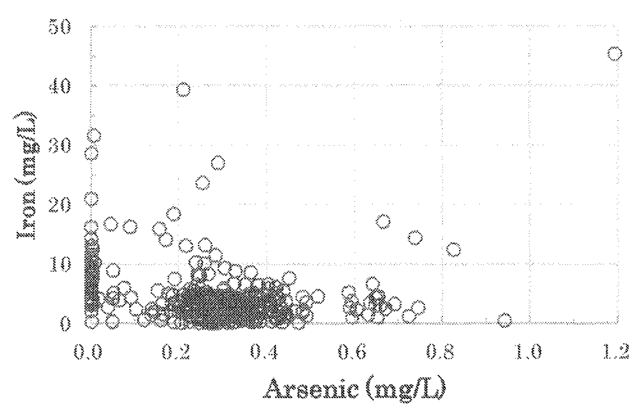

Fig. 2 As-Fe relation of shallow tube well in Ashrafpur

There are tube wells with low Fe-concentration and high As-concentration. As mentioned before, AIRP/GSF has been installed where the conditions of As<0.20mg/L and Fe/As>20 are satisfied. The range of both conditions in Fig.2 is small. And, no linear relation between As and Fe is seen.

Anyway, AIRP/GSF can not be easily applied in Ashrafpur. And, we recognized the needs of GSF development for high As-contaminated tube wells.

There were many As-safe but high Fe-concentrated tube wells. AAN attached Iron removal units (IRUs) to such tube wells and supplied drinking water with pipeline at public facilities as primary and high schools.

2.2 As-contamination in Dharmapasha

The concentration of arsenic & iron of 929 tube wells in Dharmapasha Upazila, which is composed of 10 unions, were measured by field kit in 2014 and shown against the depth of tube wells as shown in Figs. 3 and 4. The total numbers of tube wells in Dharmapasha Upazila was 1,716 and the arsenic concentration of all 1,716 tube wells were measured, but the Fe-concentration was measured for only 929 tube wells out of 1,716.

Fig.3 shows that the ratio of As-contaminated tube wells (As>0.05mg/L) is so large (almost 90%) compared with the 40% to 60% in the DPHE/JICA report. And, As-concentration does not depend on the depth of tube well.

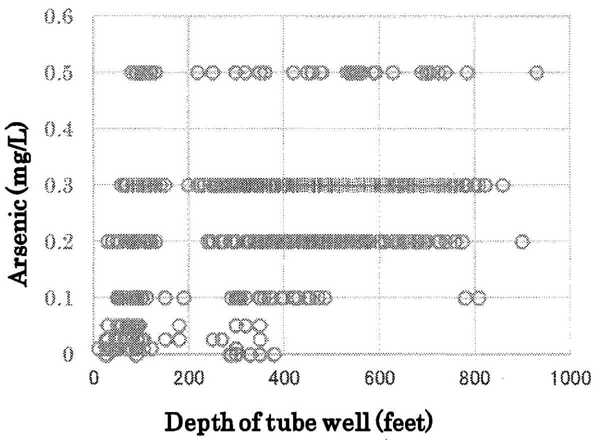

Fig.3 Relation between As-concentration and depth of tube well in Dharmapasha

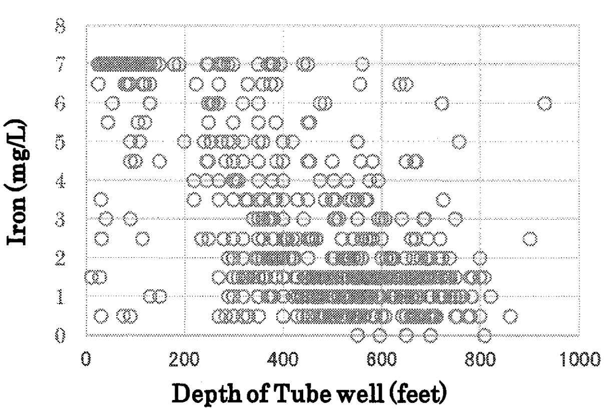

Fig.4 Relation between Fe-concentration and depth of tube well in Dharmapasha

From Fig.4, it seems Fe-concentration, too, is independent of the depth of tube well. And, no relation is observed between concentrations of arsenic and iron from Fig.5. Also, there are many high As-contaminated tube wells with low Fe-concentration which makes it impossible to install a GSF.

In order to supply drinking water, we installed IRUs to arsenic-safe tube wells with high iron concentration and GSF to tube wells in accord with the conditions of As<0.2mg/L and Fe/As>20.

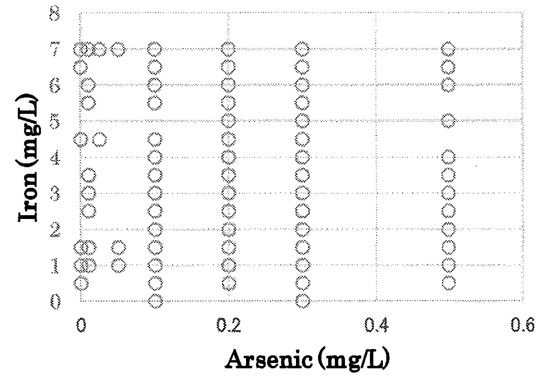

Fig.5 Relation between As-concentration and Fe-concentration in Dharmapasha

3. DEVELOPMENT OF MULTI GSF

AIRP/GSF is mainly composed of a Gravel tank and a Sand tank as shown in Fig.6. The idea of multi GSF is to set an Iron tank and another Gravel tank next to the 1st reservoir tank.

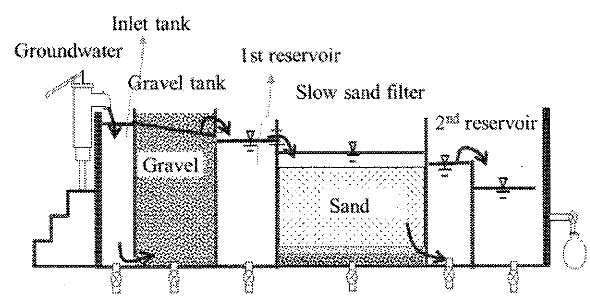

Fig.6 Schematic diagram of AIRP/GSF

In the multi GSF highly As-contaminated groundwater is put into the Inlet tank. The high As-concentration in the Inlet tank water is expected to decrease until 0.2mg/L through Gravel tank. This is the 1st step of As-concentration decrease. If the water of As=0.2mg/L is obtained, we can decrease it to As<0.05mg/L through the additional Gravel tank (2nd step of As-concentration decrease). It is considered that the iron in the groundwater will be consumed completely in the 1st step of As-concentration decrease. Many iron tips are, therefore, to be put in the Iron tank in the 2nd step.

We have an experience to install AIRP/GSF in an arsenic contaminated area along Indus River at Pakistan, where groundwater has only low Fe-concentration. This corresponds to the above-mentioned 2nd step. After deciding the volume of iron tip to satisfy the condition of Fe/As>20 by laboratory test, an appropriate amount of iron tips were placed in the Inlet tank of conventional AIRP/GSF. The arsenic removal performance is shown in Fig.7, where the GSF has 2 gravel tanks for the use of large number of families (Hiroshi Yokota, 2013).

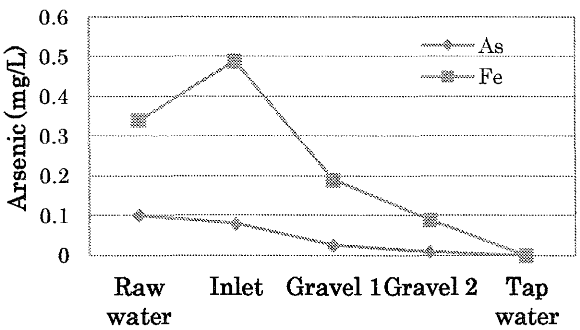

Fig.7 As-removal performance and Fe-consumption of GSF with iron in Pakistan

Fig.8 is another test result for the 2nd step, showing the dissolution & consumption of iron, and decrease of As-concentration at the setting tests of 40 iron bars (diameter=3mm, length=60mm) in the arsenic water of 400ml. The arsenic water is the spring/drainage water from a tunnel construction site in the Southern Kyushu, the iron concentration of which is very low.

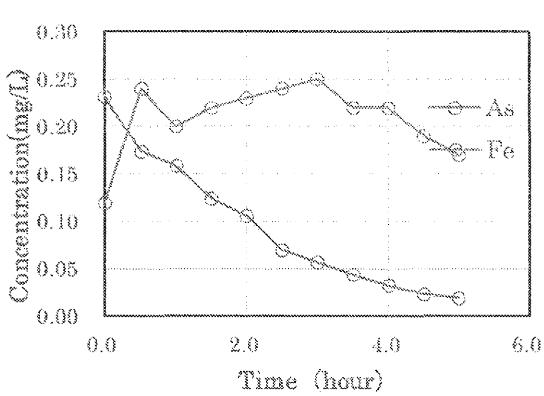

Fig.8 Dissolution & consumption of iron and As-removal performance in laboratory test for As-contaminated drainage of a tunnel in Southern Kyushu

Figs.7 & 8 show the decrease of arsenic concentration with the decrease of iron concentration which increases at the start of the tests. It seems the behavior of iron concentration shows both of the dissolution and consumption of iron.

In the Dharmapasha Project, we put the iron nails into the Inlet tank of GSF in the case that the condition of Fe/As>20 was not satisfied. The performance of As removal is good.

From these experiences, there may be no big problems in the 2nd step for the realization of multi GSF. However, for the 1st step of the multi GSF, the following problems have to be resolved.

First, the standard of Fe/As>20 should be examined for the highly As-contaminated groundwater. If the standard is not effective, we have to get new standard for the highly As-contaminated tube wells.

Secondly, there is a question for exist of such high iron concentration in groundwater, even if the standard of Fe/As>20 is considered effective. It would seem some iron-concentration satisfying Fe/As>20 for highly As-concentrated tube (As=0.4~0.8mg/L) in Fig.2.

When we could not get the high Fe concentration, satisfying Fe/As>20, in the field, we have to put the iron tips in Inlet tank, where we may meet the third problem whether the iron enough dissolve to satisfy Fe/As>20 or not.

The research to resolve such many problems just starts in Bangladesh.

4. CONCLUSION

We introduced here the situations of highly As-contaminated areas in Bangladesh, where the existing safe water options are not useful. As an improved technique of the used option, we proposed here the multi AIRP/GSF to get As-safe drinking water in the highly As-contaminated areas. It is only to put the iron tips into the conventional AIRP/GSF to which an iron tank and a gravel tank are attached. The tests starts in Bangladesh expecting good data.

On the other hand, the arsenic removal by using leading-edge technology, such as ceramics and membrane, is needed at the highly As-contaminated areas. There is, however, no enough industry system in Bangladesh now to maintain the high-technical As-removal options and to treat As-sludge. Those technics should be more introduced in Bangladesh to establish the industry system.

5. REFFERENCES

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