



Assessment of Arsenic Contamination in Ground Water and its Suitable Removal Technology

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Abstract

Assessment of Arsenic contamination in ground water, soil and its suitable removal technology. Simulated experimental studies were carried out to understand the process and factors that efficiency of arsenic removal from groundwater. The main objective was to observed the kinetics of removal of arsenic from synthetic arsenic solutions by in-situ treatment under quiescent conditions and to investigate the effect of additives such as clay, iron oxides and their derivatives on the removal efficiency

Keywords: In-situ treatment, potable, contamination.

Introduction

Arsenic in groundwater is a problem in numerous regions of the world. Many people are exposed to high arsenic concentrations and is at risk of getting ill or even die as a result of arsenic poisoning¹. There are several efficient technologies for the removal of arsenic but often these methods have limitation, such as high costs for installation and operation, the need for chemicals or the production of arsenic contaminated filter sludge². This limitation can make the application difficult, especially in poor regions.

Arsenic removal by ex-situ method are very well researched and technically implemented. Compared to this, in-situ water treatment is new and innovative technology. The process of in-situ treatment of groundwater virtually transfers the processes of the conventional above groundwater plants into the aquifer³. The ground water aquifer is used as a natural biochemical reactor and act as a filter itself. In this method, subterranean groundwater is treated by using atmospheric oxygen as the oxidizing agent. In-situ process is cost efficient, free from sludge handling problem, free from uses of any chemical compounds and easy to operate and handle. It is eco friendly and can remediate organic contaminants, iron, manganese and many other impurities in addition to arsenic⁴.

Arsenic is found in atmosphere, hydrosphere and lithosphere. Arsenic enters into the atmosphere through weathering, biological activity, human activities and volcanic emission as well as through a wide range of humans activities. Arsenic is widely distributed in the environment⁵. The contamination of ground water with toxic materials such as Arsenic comprises a severe environmental problem as these heavy metal cause severe adverse effects on human health⁶. In term of the

population exposed, arsenic contamination affects more than 150 million people in Bengal delta alone. Arsenic (As) is a ubiquitous element found in the atmosphere, soil and rocks, natural waters and plant as well as aquatic life⁷. It is transferred in the environment through combination of natural processes such as weathering reaction, biological activity, human activities and volcanic emission as well as through a range of anthropogenic activities.

A recent study showed that arsenic contaminated area of Bengal delta (GMBD) region (that is West Bengal, India, and Bangladesh) affect an area of around 160,000 km² populated with approximately 147 million people. More than 122 million peoples estimated to be exposed to arsenic concentration above 50 µg/l and many are forced to drink the arsenic contaminated water on daily basis⁸. The arsenic problem in groundwater because of an unfortunate combination of three factors: a source of arsenic (arsenic is present in the aquifer sediments), mobilization (arsenic is released from the sediment to the ground water) and transport (arsenic get transferred into the aquifer in the natural ground water circulation)⁹.

The most possible hypothesis which is best suited in the natural ground water circulation). The most possible hypothesis which is best suited for GMBD region, may include the transportation and release of arsenic. The supplied minerals containing iron and arsenic were oxidized and dissolved in the river water¹⁰. subsequently, in the downstream region the arsenic gets absorbed by iron/manganese/aluminum hydroxide and oxy – hydrides under oxidizing condition during alluvial sediments consumed the oxygen and the condition in sediments is changed from oxidizing to reducing stage und water/drinking water are 20-50 times higher than W.H.O guidelines of 0.01 ppm¹¹.

Material and Methods

The kinetic experiments were carried out in quiescent water to simulate arsenic removal in the aquifer and the effect of various additives that acts as catalysts such as clay; iron ore and hydrated iron oxide were also investigated. Sodium arsenite (NaAsO_2) was dissolved in drinking water and solution containing 0.45 ppm (mg/l) of arsenic was prepared as stock solution. Clay acts as catalyst present in the aquifer for the in-situ removal of arsenic. The clay samples taken for the experiment was extracted from 90 ft. depth at the Kasimpur demonstration plant site where an in-situ arsenic removal demonstration plant has been installed and commissioned. To study the effect of inorganic minerals on the arsenic removal efficiency, iron ore and hydrated iron samples were also used as additives respectively in addition to the requisite amount of clay. Chemical composition of clay was determined by using EDAX system.

Methodology

About 40 mg of Sodium Arsenite was dissolved in 500 ml of drinking water. 2 ml of samples were taken from this 500ml sodium arsenite solution. Drinking water was further added to make 1000 ml solution. From this 500 ml was taken out. 250 ml of aerated water was added to it and 7.5 gm clay (1%) was also added. The content was stirred once and after the desired time interval a samples of 70 ml was taken and was filtered by using Whatman 40 filter paper. The filtrate was analyzed for arsenic using Merck high sensitivity arsenic test kit (Test kit code:-1.17927.0001) which has a measuring range of 0.1-3 ppm. This kit contain reaction bottles and three reagent namely Reagent As-1, Reagent As-2 and reagent As-3. To test for the arsenic concentration first of all 60 ml of the filtered sample was filled in the reaction bottles up to the mark. Than 2 drops of Reagent As-1 was added to it and the bottle was swirled. Then one spoon of reagent As-2 was added to it and the bottle swirled again. Next one spoon of Reagent As-3 was added into the reaction bottle and then reclosed it with the supplied analytical strip inserted into the reaction bottle. The arsenic concentration in the solution is measured by visual comparison of the colors of the analytical test strip after 20 min reaction time with standard color of the analytical test strip. The concentration profile of As and removal efficiency (%) with respect to time was noted down. In other cases, iron ore (1%) as well as hydrated iron ore samples (1%) were added to see the effect of iron ore addition on the arsenic removal efficiency.

Results and Discussion

In our laboratory scale studies, clay, iron ore and hydrated iron ore particles were used in different set of experiments. All the experiments were carried out at room temperatures and in the quiescent water. Figure-1 presents the plot of extent of arsenic removal with time. Clay from 90 ft depth in an arsenic prone area in the Bengal basin (Kashimpur, North 24-Parganas) as

well as clay and iron ore combinations were used as catalysts. It has been observed that when only clay was used, initially there has been a 30% reduction in arsenic concentration followed by a steady state for about 50 min. Arsenic concentration was further reduced by another 40% during the next 75 mins reaching a concentration of around 35 ppb. During these steady states part of the arsenic deposited on clay particles might have redissolved during the arsenic removal process causing a nearly steady concentration of arsenic in solution. It was also observed that in the absence of iron containing compounds, clay alone cannot remove arsenic to below WHO limit (10 ppb).

To observe the effect of presence of iron ore on removal of arsenic, simulated in situ treatment experiments were carried out with 1% clay and 1% iron ore. It has been observed from figure-1 that the extent of arsenic removal increases from 0 to 50% in the first 60 minutes and gradually increases to 92%. This result also indicates that presence of iron oxide/hydroxides is important for efficient removal of arsenic by in-situ treatment process. There are no signs of redissolution of arsenic from the deposited materials as evidenced by absence of steady level of arsenic concentration. The iron flocs present effectively trapped the deposited arsenic from further dissolution to the groundwater.

Experiments were also carried out with 1% clay and 1% iron ore mixture to observe the effect of initial As concentration on arsenic removal efficiency. Experiments were carried out with different as concentration at 120 ppb and with initial As concentration of 80 ppb. It was observed that with initial As concentration of 120 ppb the extent of removal increases from 0 to 50 % in the first 60 minutes and then gradually start increasing to about 92 %.

Similarly in case with initial concentration of 80 ppb, removal efficiency increase from 0 to 50 % in the first 60 minutes and gradually start increasing to about 94%. Thus, arsenic removal efficiency with lower initial As concentration is slightly higher than with the higher initial As concentration. Figure-2 shows the results of the above experiment in terms of arsenic concentration vs time. It was observed that in the case of sample with initial As concentration as 120 ppb reduces to 60 ppb in the first 60 minutes and then gradually decreases to about 10 ppb. Similarly with initial concentration 80 ppb reduces to 40 ppb in the first 60 minutes subsequently the final concentration drop to 5 ppb. Thus samples with lower initial concentration are easier to remove than with high initial As concentration. However, in both cases the post removal arsenic concentration reduces to below the WHO limit (10 ppb).

Experiment was carried out to observe the effect of stirring on removal efficiency with addition of a mixture of 1% clay and 1% iron ore. Stirring is done to make uniform concentration of arsenic ion in the solution. From figure-4, it was observed that in case of experiment with stirring effect removal efficiency increases from 0 to 50 % in the first 60 minutes and gradually

starts increasing and reaches to about 94%. Similarly in experiment carried out without stirring, arsenic removal efficiency increases from 0 to 63 % in the first 60 minutes and subsequently increased to 93%. There is not much difference in

result of the experiment in regard to efficiency removal for experiment with stirring and without stirring. However, initial removal is more efficient with stirring.

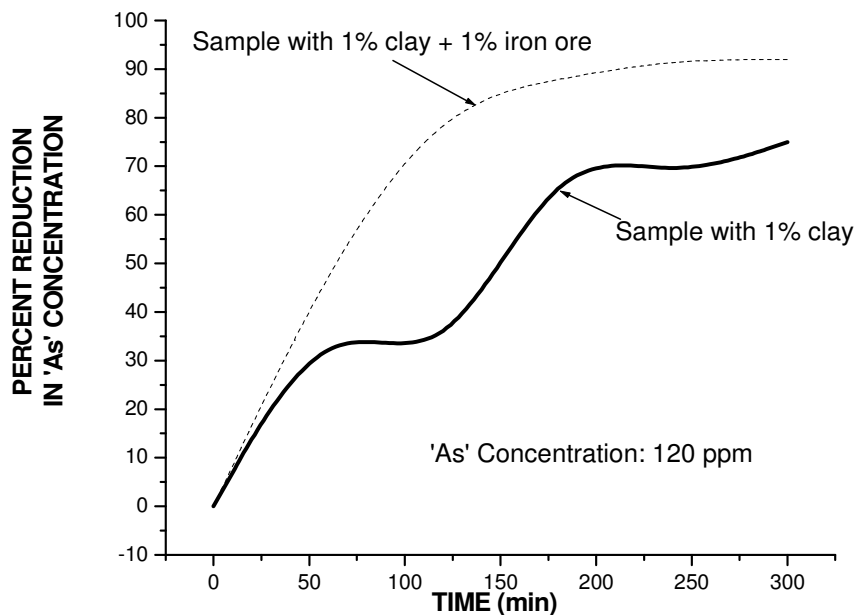


Figure-1

Effect of addition of clay and a mixture of clay and iron ore on the removal efficiency of arsenic during in-situ treatment

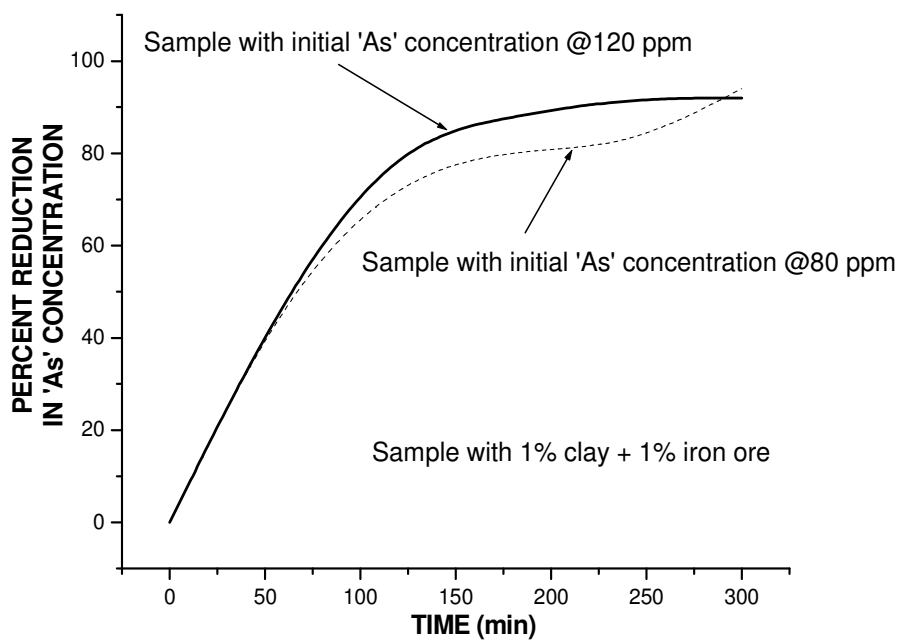


Figure-2

Effect of change in initial arsenic concentration on removal efficiency

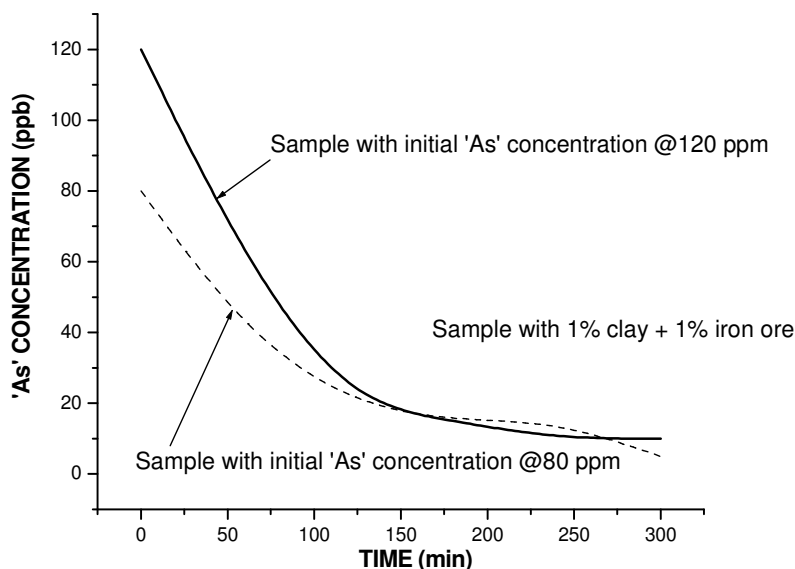


Figure-3
 Effect of initial arsenic concentration on the removal efficiency during in-situ treatment

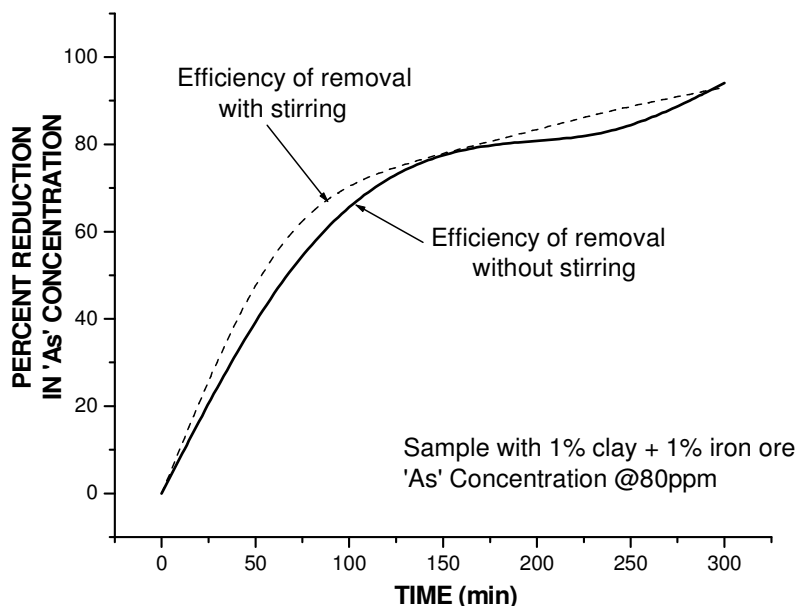


Figure-4
 Effect of stirring on removal efficiency during in-situ treatment of arsenic

Experiment was carried out with 1% hydrated iron ore and 1% clay to observe the effect of addition of hydrated iron ore on removal efficiency (figure-5). Removal efficiency reaches from 0 to 50% in the first 60 minutes and gradually increases and reaches to 93%. Similarly experiment with 1% clay and 1% iron ore removal efficiency increases from 0 to 50 % in the first 60

minutes. Subsequently final rise in removal efficiency is 94%. In regard to efficiency of removal, addition of iron ore and hydrated iron has almost similar efficiency and both the additives prevent redissolution from the precipitated arsenic back to the aquifer.

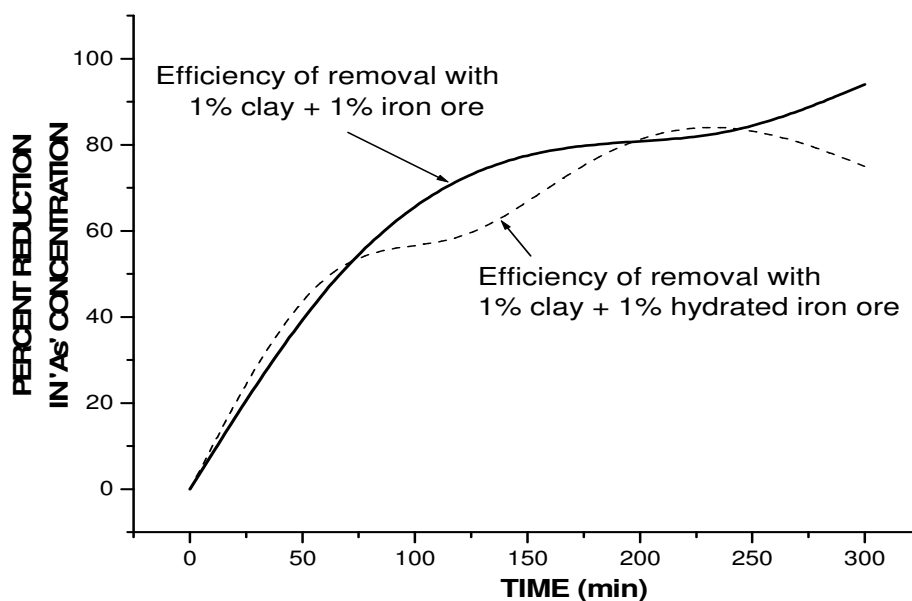


Figure-5
Effect of addition of iron ore and hydrated iron ore on arsenic removal

Conclusion

In our laboratory scale studies, reaction kinetics and behavior of different additives on the in-situ treatment of arsenic were observed. The extent of arsenic removal increases gradually with time. In the absence of iron ore when only clay acts as a catalyst, efficiency of arsenic removal is not very high. The presence of iron ore improves the efficiency of removal of arsenic ion in the solution during the in-situ treatment process as iron ore in a flocculated form acts as a good absorber of precipitated arsenic. The effect of presence of iron ore and hydrated hematite iron ore on the efficiency of removal of arsenic were also observed. In both cases removal efficiency is nearly similar. The effect of initial as concentration on removal efficiency was also observed. Sample with lower value of As concentration is easier to remove than with high initial As concentration.

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