

Arsenic removal from contaminated water: A review of methods

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Abstract— Arsenic in drinking water is a worldwide concern. In nature, arsenic appears in ground water mainly as arsenite [As e [As(V)]. An acceptable norm in many countries, including India, for arsenic (expressed as total arsenic) in drinking water is 10 µg/L . One significant problem encountered in the removal of arsenic from groundwater aquifers and municipal water systems is that arsenic exists as both arsenic (III) compounds and arsenic (V) compounds in water. Arsenic (III) compounds are primarily non-ionic whereas arsenic (V) compounds are primarily ionic at normal drinking water pH levels (ref. 6). Arsenic (III) compounds, or arsenites, are therefore not always readily removed from drinking water by methods that are very effective for removal of arsenic (V) compounds or arsenates. It is sometimes necessary to pre-oxidize any arsenates present to arsenites in order to effectively remove arsenic from drinking water to safe levels. An oxidant that itself or its' products of oxidation are not toxic must introduced into the drinking water to accomplish this.

IndexTerms—Arsenic, ion-exchange, EIX, BDST

1) INTRODUCTION

According to the WHO (World Health Organization) recommendations, the presence of arsenic in the water supply system or commercially used water is extremely harmful and dangerous. Based on the WHO recommendations, EU directives domestic regulations that correspond to above mentioned recommendations, the maximal allowed concentration of total arsenic is 10 µg/L. Lately, the arsenic concentration in commercially used water and tap water used through the public water supply system on the territory of Republic of Macedonia often surpasses the MAC (Maximum Allowed Concentration) value [1-3]. Coagulation process is traditionally realized by adding ferric or aluminum ions (Hering et al., 1996). In this process, fine particles in water first aggregate into coagulates because added ferric or aluminum ions strongly reduce the absolute values of zeta potentials of the particles. Then, arsenic ions (arsenate or arsenite) precipitate with the ferric or aluminum ions on the coagulates, and thus concentrate in the coagulates. After that, the coagulates are separated from water through filtration, eliminating arsenic from the water. The coagulates are termed arsenic-borne coagulates. Coagulation with ferric ions for arsenic removal can be traced back to the late 1960s in Taiwan to treat deep-well water with naturally elevated arsenic concentrations (Shen, 1973). Gullidge and O'Connor (1973) also reported that arsenic could be readily removed from water to a high degree by conventional water treatment using ferric or aluminum ions as coagulants. Since then, there have been a lot of reports on coagulation process for arsenic removal. It has been found that the coagulation is much more effective for the removal of As (V) than As (III). In the case when only As (III) is present, oxidation to convert As (III) to As (V) is needed prior to coagulation. The effective pH for arsenic removal was reported to be 5–7 with aluminum ions, and 5–8 for ferric ions (Sorg and Logsdon, 1978). Besides iron and aluminum compounds, manganese, calcium and magnesium compounds are also of effective coagulants for eliminating arsenic from water in neutral medium (Raje and Swain, 2002; Jiang, 2001). Arsenic removal from water achieved by coagulation process depends on initial arsenic concentration in water (Thirunavukkarasu et al., 2005; Jiang, 2001). The arsenic removal could reach 99% (Jiang, 2001) recently, it was reported that modified coagulation/filtration could give a residual arsenic concentration of 2 mg/l or less for treated well water (Han et al., 2003).

2) LITRETURE REVIEW

Different types of methods of coagulation to remove contaminated water

1.0) Arsenic removal from high-arsenic water by enhanced coagulation with ferric ions and coarse calcite:

Arsenic removal from high-arsenic water in a mine drainage system has been studied through an enhanced coagulation process with ferric ions and coarse calcite (38–74 µm) in this work. The experimental results have shown that arsenic-borne coagulates produced by coagulation with ferric ions alone were very fine, so micro-filtration (membrane as filter medium) was needed to remove the coagulates from water. In the presence of coarse calcite, small arsenic-borne coagulates coated on coarse calcite surfaces, leading the settling rate of the coagulates to considerably increase. The enhanced coagulation followed by conventional filtration (filter paper as filter medium) achieved a very high arsenic removal (over 99%) from high-arsenic water (5 mg/l arsenic concentration), producing a cleaned water with the residual arsenic concentration of 13 mg/l. It has been found that the mechanism by which coarse calcite enhanced the coagulation of high-arsenic water might be due to attractive electrical double layer interaction between small arsenic-borne coagulates and calcite particles, which leads to non-existence of a potential energy barrier between the heterogeneous particles.

2.0) Arsenic Removal from Contaminated Water by Various Physicochemical Processes

Efficiency of ion exchange, electro membrane, and electrochemical ion-exchange (EIX) processes on arsenic removal were evaluated in laboratory. Batch studies were performed with chloride (IRA410) as well as hydroxyl (modified IRA410) exchangeable forms of anion exchange resins (AER), whereas, column study was done with only hydroxyl exchangeable AER to evaluate its performance on arsenic removal. A plate and frame type electrolytic cell with ruthenium dioxide coated titanium plates (RuO₂/Ti) as anode, and stainless steel plates as cathode, was fabricated to do experiment to evaluate the performance on arsenic removal by electro membrane as well as EIX processes. Though, As(V) removal was significant during batch kinetic study, As(III) removal was poor by both the AER. Breakthrough curves were developed by passing As(V) contaminated water at a flow rate of 5 ml/min through 3 different bed depths of 5 cm, 7.5 cm, and 10 cm of modified IRA410 columns having 1 cm internal diameter. The columns could efficiently remove from 500 µg/l of As(V) contaminated water to below 10 µg/l. In electro membrane process, effects of electrolyte concentration, effects of applied voltage, and initial concentration of As(V) were evaluated. EIX process was found to be inefficient in removing As(V) from contaminated water.

Electrocoagulation

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