Studies Regarding the Arsenic Removal from Water

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Abstract: Arsenic is a naturally occurring element in the Earth's crust that is usually found combined with other elements. Studies have reported that inhalation of arsenic results in an increased risk of lung cancer. Arsenic is released to the environment from a variety of natural and anthropogenic sources. Due to these varieties of pollution sources with arsenic, in the present paper it was studied the possibilities of arsenic removal from water through coagulation-precipitation method using the Jar-Test method. As coagulation-precipitation agents were used Fe^{2+}, Fe^{3+} and Al^{3+}. From the experimental data resulted that the optimum conditions of arsenic removal from water are: reaction mass pH = 9 and a coagulation-precipitation agent dose of 200 mg/L; the best coagulation-precipitation agent is Fe^{2+}.

Keywords: water, arsenic removal, coagulation-precipitation method

1. Introduction

Arsenic is released to the environment from a variety of natural and anthropogenic sources. In the environment, arsenic occurs in rocks, soil, water, air, and in biota. Average concentrations in the Earth's crust reportedly range from 1.5 to 5 mg/kg. Higher concentrations are found in some igneous and sedimentary rocks, particularly in iron and manganese ores. In addition, a variety of common minerals contain arsenic, of which the most important are arsenopyrite (FeAsS), realgar (AsS) and orpiment (As_2S_3). Natural concentrations of arsenic in soil typically range from 0.1 to 40 mg/kg, with an average concentration of 5 to 6 mg/kg. Through erosion, dissolution, and weathering, arsenic can be released to ground water or surface water. Geothermal waters can be sources of arsenic in ground water. Other natural sources include volcanism and forest fires [1].

Anthropogenic sources of arsenic relate to its use in the lumber, agriculture, livestock, and general industries. Arsenic is emitted as an air pollutant from external combustion boilers, municipal and hazardous waste incinerators, primary cooper and zinc smelting, glass manufacturing, cooper ore mining, and primary and secondary lead smelting. A significant industrial use of arsenic is the production of lead-acid batteries, while small amounts of very pure arsenic metal are used to produce the semiconductor crystalline gallium arsenide, which is used in computers and other electronic applications. Emissions of arsenic from these activities are due to the presence of trace amounts of arsenic in fuels and materials being processed [1-4].

The Environmental Protection Agency from USA classified the inorganic arsenic in the Group A – Known human carcinogenic substances. The classification of arsenic in group A is based on the higher incidence at humans in pulmonary cancer through inhalation and the higher risk of the skin, bladder, liver and lung cancer through drinking water [1,2].

Arsenic ions can be removed from water through various methods [5-14]. The precipitation/co precipitation was the most used method for the arsenic removal from: contaminated waters, including underground water, surface waters and waters from mine sewerage, drinking waters and residual waters from various applications at pilot or industrial scale. This technology can reduce the arsenic concentration at less than 0.05 mg/L and in some cases under 0.01 mg/L.

For these reasons in this paper we made studies regarding the arsenic removal from water through coagulation-precipitation method using the Jar-Test method.

2. Experimental

For the arsenic removal from water through "Jar-Test" method as coagulation-precipitation agents Al^{3+}, Fe^{2+} and Fe^{3+} were used. The synthetic water containing 100 mg/L arsenic (III) was treated with various doses of coagulation-precipitation agent (100, 200, 300, 400 and 500 mg/L) at various values of the pH of the reaction mass (6, 7, 8, 9, 10 and 11).

The pH of the reaction mass was settled either with NaOH 10% or H_2SO_4 10% solutions. After coagulation, the sample was clarified and then filtered. In the resulted solution was determined the residual concentration of arsenic, iron and aluminum through atomic absorption spectrophotometry, using an atomic absorption spectro-photometer Varian SpectrAA 110.

For the establishment of the arsenic removal optimum conditions, it was determined the dependence of the arsenic residual concentration on the pH of the reaction mass, dose of coagulant and on the nature of the used coagulation–precipitation agent.

3. Results and discussion

The experimental data regarding the dependence of the arsenic ions residual concentration on the pH of the reaction mass and on the dose of the coagulation-precipitation agent for all three studied agents are presented in Figures 1-3.

From the experimental data one may observe that the arsenic residual concentration depends on the pH of the reaction mass and on the dose of the coagulation-precipitation agent. In all three studied cases the arsenic residual concentration decreases with the increase of the pH of the reaction mass up to the value 9 and after this the obtained results are almost constant; the optimum pH of the reaction mass is 9. The residual concentration of arsenic also decreases with the increase of the coagulation-precipitation agent dose. In the case of Al^{3+} the optimum dose is that of 500 mg/L, in the case of Fe^{2+} the optimum dose is that of 200 mg/L and in the case of Fe^{3+} the optimum dose is that of 400 mg/L.
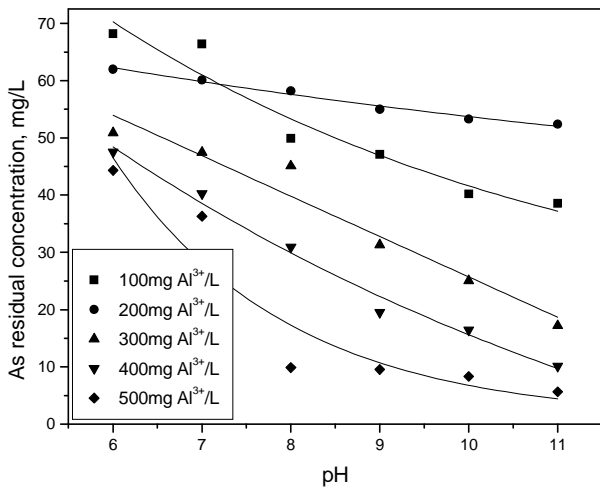
Figure 3. Arsenic residual concentration dependence
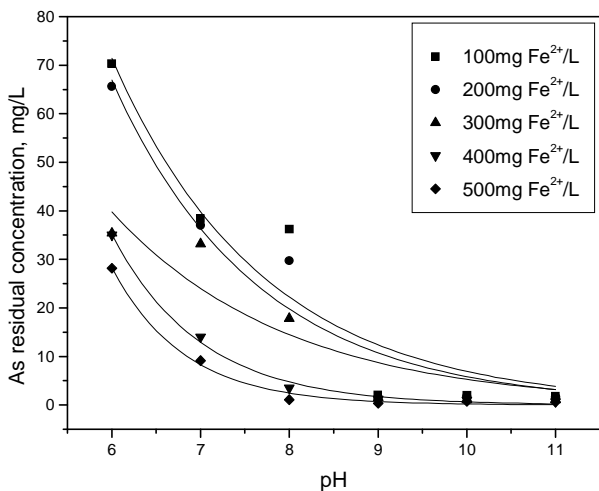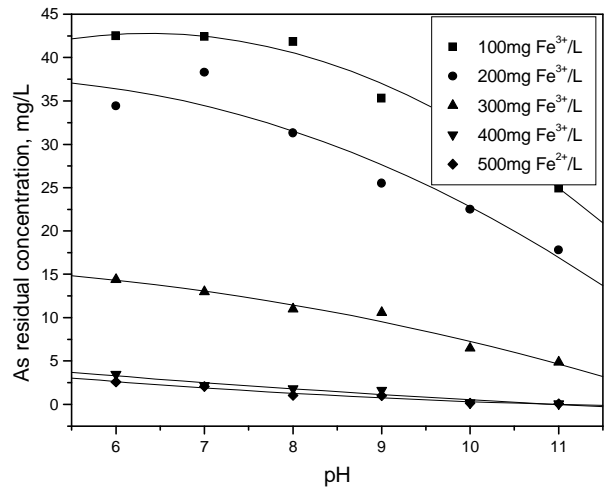on the pH of the reaction mass and the Fe^{3+} dose

The experimental data regarding the dependence of the coagulation precipitation agent residual concentration on the pH of the reaction mass and on the initial dose are presented in Figures 4-6.
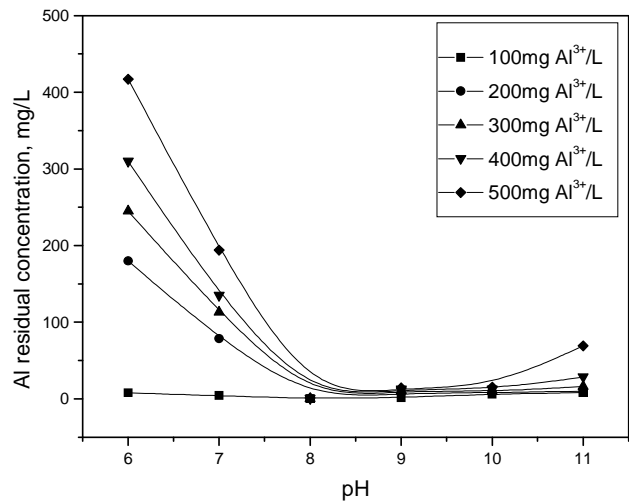
Figure 1. Arsenic residual concentration dependence
on the pH of the reaction mass and the Al^{3+} dose

Figure 4. Aluminum residual concentration dependence
on the pH of the reaction mass and the Al^{3+} dose

Figure 2. Arsenic residual concentration dependence
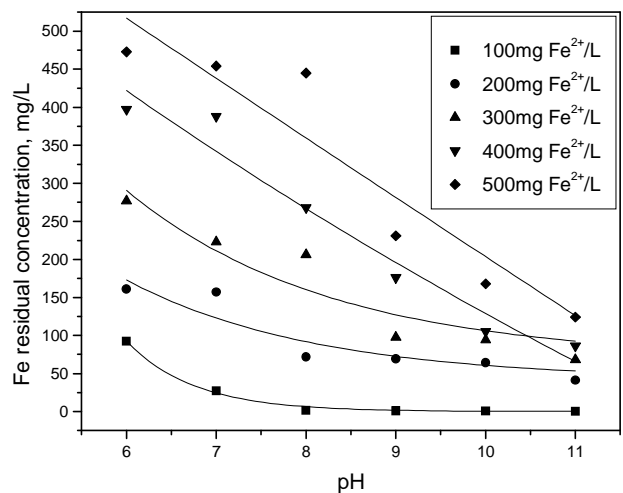on the pH of the reaction mass and the Fe^{2+} dose

Figure 5. Iron residual concentration dependence
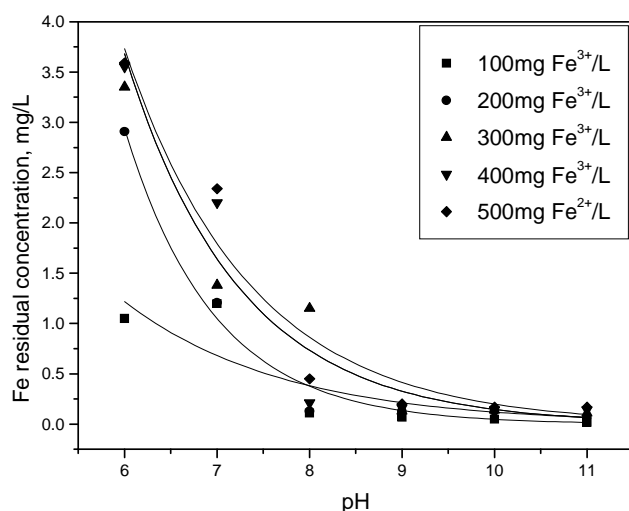on the pH of the reaction mass and the Fe^{2+} dose

Figure 6. Iron residual concentration dependence
on the pH of the reaction mass and the Fe^{3+} dose

From the experimental data one observes that the residual concentration of the used coagulation-precipitation agent increases as the coagulation-precipitation agent dose increases and decreases with the increase of the pH of the reaction mass. Only in the case of Al^{3+} can be observed a slow increasing after the pH > 8.

In order to determine the efficiency of the coagulation-precipitation agent, it was represented the dependence of the arsenic residual concentration on the nature of the coagulation-precipitation agent, in the same experimental conditions: pH = 9 and a dose of 200 mg/L. The experimental data are presented in Figure 7. One observes that the most efficient coagulation-precipitation agent is Fe^{2+}.
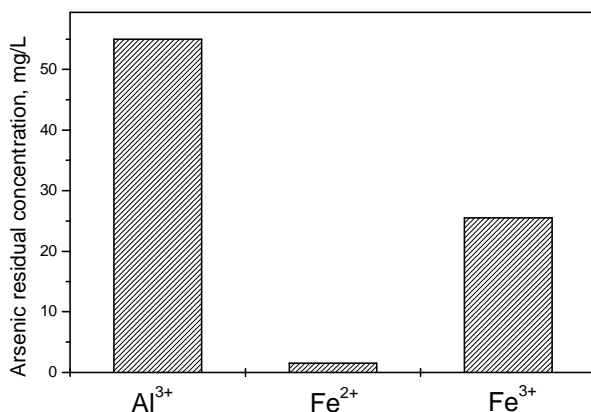

Figure 7. Dependence of arsenic residual concentration
on the nature of the coagulation-precipitation agent

4. Conclusions

In the present paper were studied the arsenic removal possibilities from water through coagulation-precipitation using the "Jar-Test" method. For the arsenic removal from water as coagulation-precipitation agents were used Al^{3+}, Fe^{2+} and Fe^{3+}.

For the establishment of the arsenic elimination optimum conditions it was determined the dependence of the arsenic residual concentration on the pH of the reaction mass, the dose of coagulant and on the nature of the coagulation-precipitation agent.

From the experimental data one concluded that the arsenic residual concentration depends on the pH of the reaction mass and on the dose of the coagulation-precipitation agent. In all three studied cases the arsenic residual concentration decreases with the increase of the pH of the reaction mass up to the value 9; after this value, the obtained results are almost constant; the optimum pH of the reaction mass is 9. The residual concentration of arsenic decreases with the increase of the coagulation-precipitation agent dose. In the case of Al^{3+} the optimum dose is that of 500 mg/L, in the case of Fe^{2+} the optimum dose is that of 200 mg/L and in the case of Fe^{3+} the optimum dose is that of 400 mg/L.

The most efficient coagulation-precipitation agent is Fe^{2+}.

REFERENCES

1. U.S. EPA (Environmental Protection Agency), Arsenic Occurrence In Public Drinking Water Supplies. **2000**. Schulman A.E.
2. U.S. EPA (Environmental Protection Agency), Locating and Estimating Air Emissions from Sources of Arsenic and Arsenic Compounds. **1998**.
3. Negrea P., Negrea A., Lupa L. and Mitoi L., The influence of the interferents from the samples matrix on the arsenite analysis by HG-AAS, Proceedings of the International Symposium on Trace Elements in the Food Chain. Budapest. **2006**. pp. 92-96.
4. Smedley P.L., Kinniburgh G., (2007), A review of the source, behaviour and distribution of arsenic in natural waters, Applied geochemistry. **2007**. pp. 517-568.
5. Ihoş M., Teuca L. and Negrea P., The reduction of the arsenic content from water through electrocoagulation. International Symposium "Environment and Industry". Vol I. Bucharest. **2005**. pp 157-163.
6. Thirunavukkarasu O.S., Viraraghavan T. and Subramanian K.S., Arsenic removal from drinking water using granular ferric hydroxide. Water SA. **2003**. pp. 161-170.
7. Maji S.K., Pal A. and Pal T., Arsenic removal from real-life groundwater by adsorption on laterite soil. *Journal of Hazardous Materials*. vol. 151. **2008**. pp. 811- 820.
8. Pinisakul A., Polprasert C., Porkplan P. and Satayarirod J., Arsenic removal efficiency and mechanisms by electro-chemical precipitation process. *Water Science and Technology*. vol. 46. **2002**. pp. 247-254.
9. Ciardelli M.C., Xu H., Sahai N., Role of Fe(II), phosphate, silicate, sulphate, and carbonate in arsenic uptake by co precipitation in synthetic and natural groundwater. *Water Research*. vol. 42. **2008**. pp. 625-624.
10. Mondal P., Majumder C.B. and Mohanty B., Effects of absorbent dose, its particle size and initial arsenic concentration on the removal of arsenic, iron and manganese from simulated ground water by Fe(III) impregnated activated carbon. *Journal of Hazardous Materials*. vol. 150. **2008**. pp. 695-702.
11. Guo H., Stuben D. and Berner Z., Absorbtion of arsenic (III) and arsenic (V) from groundwater using natural siderite as the absorbent. *Colloid and Interface Science*. vol. 315. **2007**. pp. 47-53.
12. Zeng L., A method for preparing silica-containing iron (III) oxide adsorbents for arsenic removal. *Water Research*. vol. 37. **2003**. pp. 4351-4358.
13. Jeong Y., Maohong F., Singh S., Chuang C.-L., Saha B. and van Leeuwen J.H., Evaluation of iron oxide and aluminium oxide as potential arsenic (V) adsorbents. *Chemical Engineering and Processing*. vol. 46. **2007**. pp. 1030-1039.
14. Zhang Q.L., Lin Y.C., Chen X. and Gao N.Y., A method for preparing ferric activated carbon composites adsorbents to remove arsenic from drinking water. *Journal of Hazardous Materials*. vol. 148. **2007**. pp. 671-678.