

Modeling Approach Of Adsorptive Removal Of Arsenic From Aqueous Solution

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Abstract. Arsenic presence in underground waters is a well-known problem around the world. Last centuries new remediation technologies have been developed for effective arsenic elimination. Nowadays, several physico-chemical remediation techniques are used, such as: adsorption, ionic exchange, coagulation, precipitation, membrane filtration. Adsorption is frequently utilized due to its easy setup and economical cost. Availability of a large number of classical and nonconventional adsorbents as well, transforms adsorption in an attractive remediation technique. Due to arsenic affinity for iron adsorbent, iron content represent a significant parameter.

As adsorption on carbon based materials with graphitic structure is presented in this paper. Influence of contact time and also pH onto As adsorption were studied. Based on experimental data was modeled the influence of contact time over adsorption capacity in order to determine the optimum contact time for maximum adsorption capacity.

Keywords: arsenic, adsorption, composites, mechanism

1. Introduction

The arsenic's presence in the drinking water represents a well-known, difficult environmental issue [Guo H., et al. 2007; Mohan D. and Pittman Jr. C.U., 2007; Vijayaraghavan K., et al. 2009; Baig J.A., et al., 2010; Wu Y., et al. 2012]. According to a WHO report, in the year 2001, about half of the world's population consumed arsenic contaminated water and approximately 9100 people have passed away, 125000 had severe afflictions due to this issue [<http://www.who.int/ipcs/features/arsenic.pdf>].

High quantities of arsenic were reported in the USA, China, Chile, Bangladesh, Taiwan, Mexico, Argentina, Canada, Japan and India [Mohan D. and Pittman Jr. C.U., 2007]. The most affected country in the Pannonia basin is Hungary, but the recent years studies have also shown the existence of high concentrations in northern Serbia and in the north-east part of Croatia. It is obvious that this is a border issue: Hungary-Romania-Serbia-Croatia [Neamtii I. Et.al., 2015; Helen A.L. et.al., 2011].

In the western part of Romania, arsenic concentrations from groundwater are ranged between 10-100 µg/L, but

there are areas where higher concentrations of 100-200 µg/L appear. It is supposed that there are approximately 36000 persons that have been exposed to concentrations of 11-48 µg/L and approximately 14000 persons exposed to arsenic concentrations higher than 50µg/L [Gurzau E.S. and Gurzau A.E. 2001].

Arsenic removal from water is an urgent and important concern, for which several techniques have been developed. These processes include: precipitation - filtration [Mohan D. and Pittman Jr. C.U., 2007], coagulation - precipitation, using as coagulation-precipitation agents aluminum, iron salts and/or limewater [Song S. et. al., 2006; Parga J. R. et. al., 2005; Balasubramanian N. et. al., 2009; Mohan D. and Pittman Jr. C.U., 2007], separation through combined processes such as photocatalysis combined with complexation and filtration [Molinari R., and Argurio P., 2017], aeration, chemical oxidation, oxidation-coagulation or oxidation-precipitation [Anup J. et.al., 2016], electro-coagulation [Tuhin B. and Sanjeev C., 2016; Athziri G., et. al., 2016], separation through membranes such as nanofiltration, reverse osmosis, electrodialysis [Jingwen J. et. al., 2015; Dandan Z. et.al., 201; Salazar H. et.al., 2016], ionic exchange [Chang-Gu L. et.al., 2017; Behrang P. and Jacimaria R. B., 2011; Bruno F. U. et. al., 2012] and adsorption [Rajesh M. D. et. al., 2017; Meththika V. et. al., 2017; Aomi S. and Tomoyuki M., 2016; Sneh L. and Samadder S.R., 2016; Muhammad R., et. al., 2015; Roy P. et. al., 2014;

Mohan D. and Pittman Jr. C. U., 2007].

The techniques based on reverse osmosis and electrodialysis [Qu D. et. al., 2009; Ning R. Y., 2005; Mohan D. and Pittman Jr. C.U., 2007] are generally expensive and have a reduced efficiency unless an oxidation As(III) to As(V) is done beforehand [Kundu S. and Gupta A..K., 2007; Nikolaidis N. P. et. al., 2003].

Because of the affinity that iron based materials present to adsorption of arsenic from groundwaters these are the most used adsorbents in arsenic adsorption processes [Ferguson J. F. and Gavis J., 1972; Roberts L. C., et. al., 2004; Saha B., et.al., 2005; Wilkie J. A. and Hering J. G., 1996; Altundogan H.S. et.al., 2000; Negrea A. et. al., 2010].

As adsorption on carbon based materials with graphitic structure is presented in this paper. Influence of contact

time and also pH onto As adsorption were studied. Based on experimental data was modeled the influence of contact time over adsorption capacity in order to determine the optimum contact time for maximum adsorption capacity.

2. Method and experiment

A new ecofriendly adsorbent was prepared using thermal treatment of a dried material obtained by mixing soluble starch with iron chloride in order to obtain a final mass proportion C:Fe 15:1. Thermal treatment was carried out in nitrogen atmosphere for 6 hours at 600°C.

After preparation the obtained compound was characterized by using XRD, and SEM coupled with EDX probe. During adsorption experiments arsenic concentrations were determined through mass inductively coupled with plasma spectrometry – ICP MS Aurora M90 from Bruker.

Experimental data obtained from adsorption experiments were mathematically modeled in order to determine the optimum contact time for maximum adsorption capacity.

3. Results and discussion

3.1. Characterization of the synthesized material

Synthesized material was characterized using scanning electron microscopy (SEM) coupled with EDX probe and also by using X – Ray Diffraction.

Based on recorded SEM picture presented in figure 1 we can observe that the produced adsorbent material is a carbon based material with a graphite structure presenting iron oxide particles fixed on.

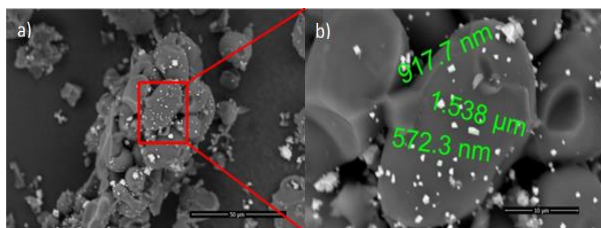


Figure 1. SEM image for synthesized material; a) morphology of carbon particle b) measurements of Fe_3O_4 particles

Also, we can observe the uniform distribution of iron oxide particle over the support surface, and a dimension distribution between 500 and 1600 nm.

3.1.2. X-ray diffraction

From XRD spectra depicted in figure 2 we can observe the presence of two different phases represented by graphite phase and also by magnetite one.

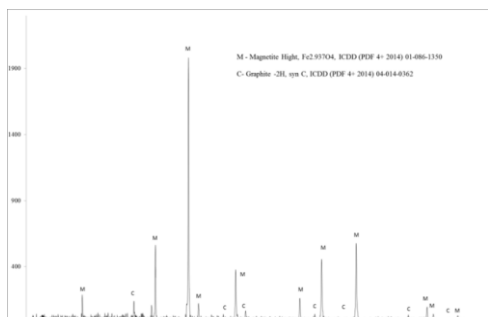


Figure 2. XRD spectra recorded for synthesized material

Based on physico-chemical characterization can conclude that the produced adsorbent material consist in graphite support presenting iron oxide particle fixed onto the structure. Magnetite dimensions are in range 500 – 1500 nm.

3.1. Influence of contact time onto the adsorption capacity

As can be seen from data depicted in figure 3 can observe the bigger influence of contact time on the As adsorption capacity. It can be seen that the adsorption capacity increase with increasing of contact time, reaching an equilibrium after approximately 60 minutes.

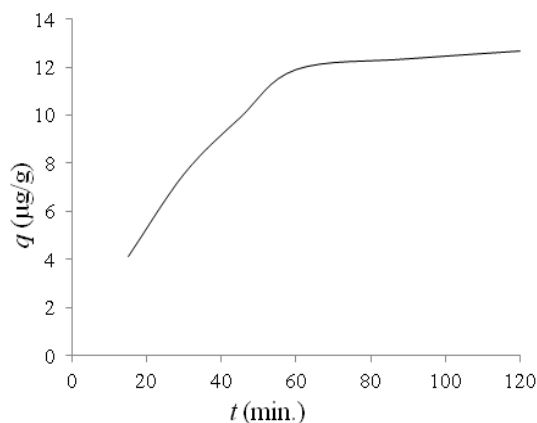


Figure 3. Contact time influence (t) on the adsorption capacity (q)

3.2. The influence of the pH on the adsorption process

Other parameter with great influence on As adsorption is the solution pH. Influence of pH on the As ions adsorption is presented in figure 4. Analyzing data presented in figure 4 can observe an increase of adsorption capacity with increase of pH from 0 to 6, reaching a maximum near ph 6. Further increase of pH lead at decrease of adsorption capacity.

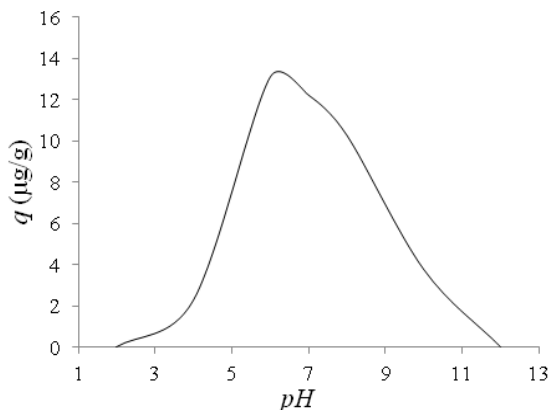


Figure 2. Influence of pH on the adsorption capacity

3.3 Mathematical modeling of contact time influence on As adsorption

Experimental data concerning contact time influence on As adsorption were modeled using a Logistic Model described by equation $y=a/(1+b*\exp(-cx))$.

Modeled data are depicted in figure 5.

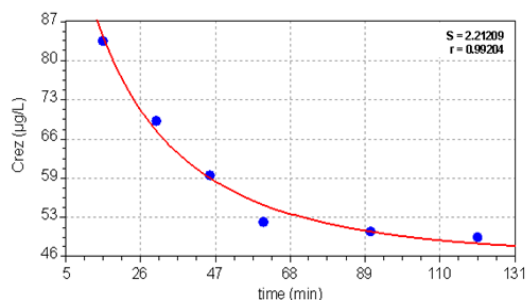


Figure 5. Mathematical modeling of contact time influence on As adsorption

Based on data presented in figure 5 can observe that the maximum adsorption capacity is reached after 58 minutes.

3. Conclusions

Present study deals with the mathematical modeling of contact time influence on the adsorption capacity of As ions. There were also experiments carried out in order to determine the pH influence on the As ions adsorption.

From experimental data can observe that the maximum adsorption capacity was reached after a contact time of 60 minutes. By modeling experimental data was found that the maximum adsorption capacity is reached after 58 minutes.

Studies carried out reveal the great influence of solution pH on the As adsorption. From obtained data can conclude that the As adsorption onto the studied material occurs with best results at pH near 6.

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