Arsenium and selenium removal from aqueous solutions using eco-materials

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Abstract: Environmental engineering deals with several fields, most important of them is represented by water resource protection. It is well known, that natural waters and especially groundwater contain dissolved substances, most of them unharmful for earth life, but also some potentially harmful for human and animal life. Ground waters containing dissolved arsenic and/or selenium are not suitable for human and animal life. Some prerequisite microelements for human life as Selenium becomes toxic when higher quantities are ingested. In comparison, arsenic has acute toxic effect over human and animal life even when low quantities are ingested. In both cases, the maximum amount was limited by OMS at 10 μg L-1.

A new technique was used to produce an iron oxide doped graphite ecofriendly composite material for arsenic and selenium retention from water solutions. Synthesized material was characterized using SEM, EDX, DRX and DTA. Adsorption capacity and adsorption mechanism were established through equilibrium studies. Maximum adsorption capacity was 400 μg As(V) and 625 μg Se(VI) per gram of adsorbent.

Keywords: adsorption, arsenic, eco-material, selenium, toxicity

1. Introduction

Chemical composition of natural waters and especially of groundwater is depended onto the rocks structure and composition. Because they are quartered in rocks, they can dissolve different substances; most of them are not threatening human and animal life. But in some cases groundwaters are contaminated with some substances that can present a real treat to human and animal life. Two of these contaminants are represented by arsenic and selenium which can be founded in aquifer rocks, from which are dissolved mostly under form of inorganic compounds with different oxidation numbers.

In almost all groundwater the average concentration of As and Se is around 2 ppm, which is under the limit recommended by World Health Organization (WHO) for drinking water – 10 μg L^{-1} for both elements. Selenium represents a vital microelement for human life, becoming toxic only when large quantities are ingested or by accumulation over time, instead arsenic has an acute toxic effect on human body even in small quantities. It is well known from century arsenic high toxicity at higher concentrations, but only few years ago has been proved that also long term exposure at smallest concentration has negative health effects.

Main way for getting in contact with arsenic and selenium is represented by consumption of contaminated water. WHO recommend selenium daily intake of 6 – 21 μg/day for newborns and children, until 26 – 35 μg/day for adults, contrary recommended arsenic consumption is zero. At higher concentration selenium becomes toxic leading at acute gastrointestinal, neurological, and respiratory issues.

The present study aims to produce and test an ecofriendly adsorbent used for removal of arsenic, and also selenium ions from aqueous solutions.

2. Method and experiment

Ecofriendly adsorbent was prepared by mixing soluble starch with iron chloride in order to obtain a final mass proportion C:Fe 8:1. Dried material was thermally treated into nitrogen atmosphere for 6 hours at 600°C.

Later prepared material was characterized using XRD, and SEM coupled with EDX probe. Arsenic and selenium concentrations were determined through mass inductively coupled with plasma spectrometry – ICP MS Aurora M90 from Bruker.

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.

Recorded SEM pictures are presented in figure 1. By analyzing data presented in figure 1 can observe that synthesized material consist into a graphite support structure presenting iron oxide particle fixed on top of.

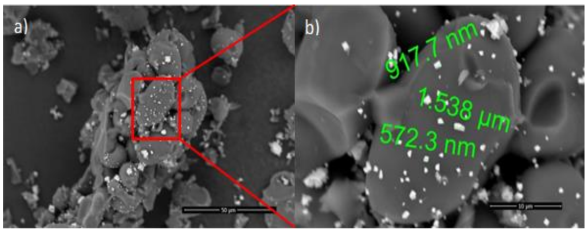

Figure 1. SEM image for synthesized material; a) morphology of carbon particle b) measurements of Fe_xO_y particles

Also, from presented SEM can observe that the iron oxide particles have an uniform distribution onto the support surface, and also they present dimensions from 500 to 1600 nm.

3.1.2. X-ray diffraction

XRD spectra obtained for synthesized material is depicted in figure 2.

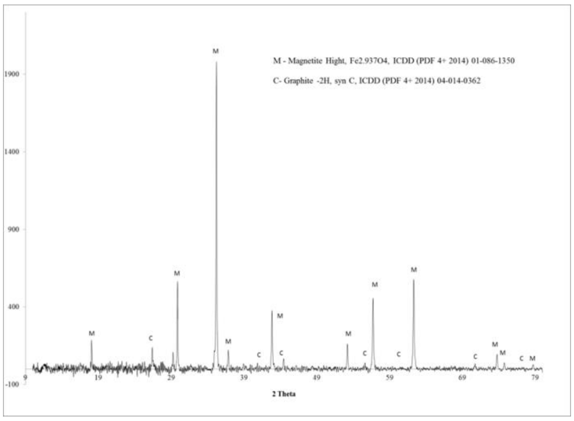

Figure 2. XRD spectra recorded for synthesized material

Based on depicted spectra can observe that the studied material consist in graphite (ICDD (PDF 4+ 2014) 04-014-0362) and magnetite high, $Fe_{2.937}O_4$ (ICDD (PDF 4+) 01-086-1350).

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

3.2 Application of the material for arsenic and selenium removal

3.2.1 Arsenic adsorption

Experimental data obtained for arsenic adsorption onto the synthesized material are depicted in figure 3.

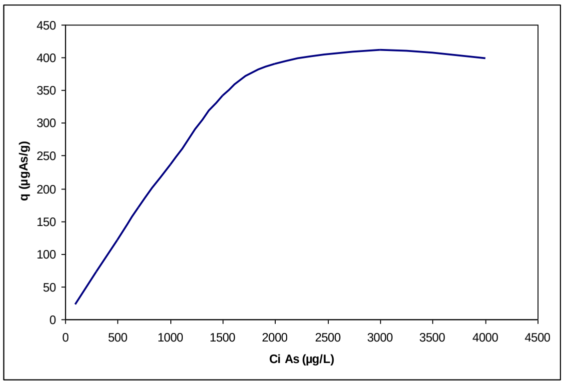

Figure 3. Dependence of adsorption capacity versus As initial concentration

From data depicted in figure 3 can observe that the adsorption capacity have a linear dependence over initial concentration until initial concentration reach 2000 µg L^{-1}, after that the adsorption capacity remains constant with any further increase of As initial concentration. Also, from these experimental study was observed that the maximum adsorption capacity is around 400 µg As/g material.

3.2.2. Selenium adsorption

Similar was studied the adsorption behavior of selenium, obtained data are depicted in figure 4.

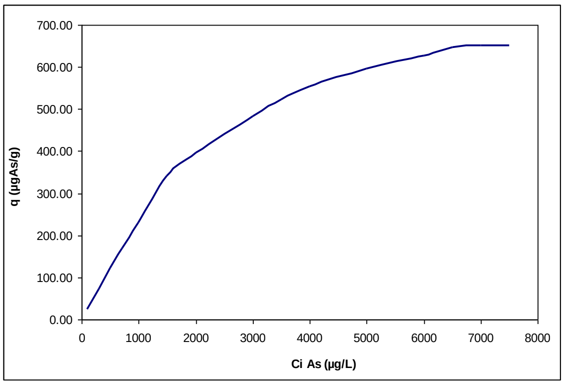

Figure 3. Dependence of adsorption capacity versus As initial concentration

Based on depicted data can observe that the adsorption capacity of Se increase with increase of Se initial concentration until 5000 µg L^{-1}, followed by a constant adsorption for further increase of initial concentration.

4. Conclusions

Present study presents a new synthesis route for an ecofriendly adsorbent for As and Se ions from aqueous solutions. Synthesized material was obtained by thermal treatment of a mixture obtained from soluble starch and iron oxide, which lead at a graphite support with magnetite crystals onto the surface.

Studied material present adsorbent properties for As and Se ions form aqueous solutions. Based on experimental data can conclude that the adsorbent material have a maximum adsorption capacity of 400 400 µg As per g of adsorbent and also a maximum adsorption capacity of 625 μg Se per g of adsorbent.

Experimental data prove that synthesized material can be used as adsorbent for groundwaters, leading at reduction of arsenic and selenium quantities under the detection limit (<0,5 μg/L), which is below WHO recommended limit (10 μg/L).

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