Abstract

Arsenic is considered as a carcinogenic substance for humans, because of the relationship between arsenic in drinking water and cancer development in liver, kidney, skin, lungs and other internal organs. The main forms of arsenic in standard pH values of drinking water are ionic pentavalent arsenic As(V) and uncharged trivalent arsenic As(III). In recent years the presence of arsenic in drinking water at concentrations higher than Maximum Contamination Level (10 μg/L) leaded to the appearance of many removal methods. Adsorption is nowadays the most common removal method and iron oxy-hydroxides are the most widely used class of adsorbents.

This thesis examines the performance of magnetic nanoparticles with core shell structure Fe/MgO in removing arsenic from the alkaline regeneration stream of conventional adsorbents (iron oxy-hydroxides). Regeneration stream is an alkaline solution, usually NaOH, able to remove arsenic from iron oxy-hydroxides which was bounded during the adsorption process. More specifically, examines their performance at high pH values (10 to 12). After the adsorption process removal of nanoparticles will be carried out using a magnetic separation device in order to recycle the regeneration stream.

Initially iron oxy-hydroxides with lepidocrocite structure were synthesized, in a continuous flow reactor. Their arsenic efficiency was then evaluated under conditions similar to those of full-scale plant. After its saturation, regeneration was carried out to collect valuable information on the design of the experiments to evaluate nanoparticles in arsenic removal. The successful experiment of regeneration was the first positive step towards further experimental process. Regarding arsenic concentration in regeneration stream, where nanoparticles are going to be used, it was found quite high so the evaluation of nanoparticles will be carried out at high initial concentrations.

Magnetic nanoparticles were synthesized using physical vapor deposition with solar radiation at Institute Procédés, Matériaux et Energie Solaire France. Structural characterization using transmission electron (TEM) microscopy showed that nanoparticles consists of a spherical metallic iron core with diameter ≈ 46 nm, which is surrounded by a thin layer of MgO (≈ 3 nm). Then adsorption isotherms where carried out for both arsenic forms (III and V) at three different pH values (10, 11 and 12). Results showed that optimum adsorption pH value for both arsenic forms is 11 where adsorption capacity is maximized. Indeed nanoparticles are more effective in removal of As(III) (in the case of high initial concentrations) which is 60 times more toxic.

Preliminary experiments were performed for the operation of magnetic separation using a suitable device, which consists of twelve NdFeB permanent magnets, arranged in two parallel rows of six magnets. The performance of the device was examined, expressed in the percentage removal of magnetic nanoparticles as a function of magnetic field and solution flow rate of nanoparticles through the device. The results showed that large magnetic field values (> 800 Oe) even with a high flow speed e.g. 100 cm^3/min have sufficiently nanoparticles removal (> 80%).

In conclusion the use of nanoparticles reduces toxicity of the regeneration stream which now may be continuously recycled in the system, by reducing further water treatment cost.