Magnetically-driven iron oxy-hydroxides for selenium uptake from water

Kyriaki Kalaitzidou, Alexios Lantas, Theopoula Asimakidou, Nikolaos Maniotis, Konstantinos Simeonidis
Analytical Chemistry Laboratory, Department of Chemical Engineering, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece
Presenter's e-mail address: kalaitzidou@cheng.auth.gr

In recent years, reports concerning the presence of high selenium concentrations in aquatic environments have been continuously increasing. Even though selenium is considered as one of the essential elements for human nutrition, it turns to become a toxic agent when consumed excessively and regularly by sources such as the drinking water triggering selenosis, neurological problems, and even cancer. For this reason, authorities are getting more sensitized to the problem taking measures such as the establishment of more strict regulations related to the maximum concentration in drinking water. Suggestively, the European Commission adopted a maximum selenium concentration level of 20 μg/L [1]. Owed to their surface properties, low crystalline iron oxy-hydroxides (FeOOHs) are mentioned as the most promising nanomaterials for the capture of aqueous selenium forms through an adsorption mechanism [1,2]. Particularly, iron oxy-hydroxides synthesized by the precipitation of iron salts under acidic conditions (< pH 3), were found to be the best performing materials specifically for the Se(IV) species, with high adsorption capacities [3].
This study examines the upgrade of optimum iron oxy-hydroxides for efficient Se(IV) uptake, into a magnetically-responding nanocomposite based on the distribution of Fe_3O_4 nanoparticles in the solid's matrix. Such configuration was designed to overcome the pressure loss issues arising in typical fixed-bed filtration systems by enabling the addition of the nanoadsorbents as a dispersion in the polluted water and their recovery in a magnetic separation setup. Developed nanocomposites were found to maintain relatively high efficiency with the sample of 5 %wt. in Fe_3O_4 nanoparticles succeeding a maximum adsorption capacity of 8.6 mg/g when tested in selenium-polluted water with a composition similar to typical groundwater regulated at pH 7. As proof of the concept, a continuous flow system consisting of a stirring contact reactor for the purification of polluted water by the dispersed nanocomposite was combined with a magnetic separator built by properly arranged permanent magnets. The separator was optimized by carrying out finite elements simulation of the trajectories of nanocomposite units under various geometries, flowrates, and magnets polarities.

The research project was supported by the Hellenic Foundation for Research and Innovation (H.F.R.I.) under the "2nd Call for H.F.R.I. Research Projects to support Post-Doctoral Researchers" (Project Number: 00046 MagnoSorb).

[1] Directive 2020/2184 EU 435 (2020) 1-62
[2] K. Kalaitzidou et al. Water 12 (2020) 672
[3] K. Kalaitzidou et al. J. Environ. Chem. Eng. 8 (2020) 104209
[4] K. Kalaitzidou et al. Sci. Total Environ. 687 (2019) 1197–1206