Biorecovery of selenium from industrial wastewaters

L.C. Staicu*, P.N.L. Lens*, E. van Hullebusch, F. Farges*****

**Pollution Prevention and Control Core, UNESCO-IHE Institute for Water Education, PO Box 3015, 2601 DA, +31 15 2151816, l.staicu@unesco-ihe.org. p.lens@unesco-ihe.org, Delft, The Netherlands.*
***Université Paris-Est, Laboratoire Géomatériaux et Environnement (LGE), EA 4508, 5 bd Descartes, 77454, Fax +33 1 49 32 91 37, Eric.vanHullebusch@univ-Paris-est.fr, Marne-la-Vallée Cedex 2, France*
****Laboratoire de Minéralogie et de Cosmochimie du Muséum, CNRS UMR 7202, Muséum National d'Histoire Naturelle, farges@mnhn.fr, Paris, France*

Keywords: selenium; biogenic; chalcogens; resource; biorecovery.

Selenium is a chalcogen element that shares common properties with sulfur and tellurium. While an essential trace nutrient for mammals, selenium has a narrow window between essentiality and toxicity of only one order of magnitude. Even if it is present in natural sulfides, biolites and around 50 minerals, its abundance on earth is low. Having multiple industrial and domestic applications, ranging from stainless steel additive to photocells and dietary supplements, selenium is consequently in great demand. Since traditional physical-chemical technologies of recovering selenium from wastes are limited by high operational costs and low efficiencies, biorecovery seems to be a more feasible technology (Lenz and Lens, 2008). The present study focuses on developing a biorecovery technology that will maximize the recoverability of limiting resources from selenium-laden industrial wastewaters, as well as on reducing the content of selenium to be discharged below permissible levels.

By using selenium-reducing microorganisms (Bacteria and Archaea) that are able to reduce soluble and toxic forms of selenium, selenate (SeO_4^{2-}) and selenite (SeO_3^{2-}), to less toxic elemental selenium (Se^0) and selenides (Se^{2-}), a twofold aim is reached (Astratinei et al., 2006). Biorecovery not only recovers and reuses a critical resource, but also decontaminates industrial wastewaters and reduces their environmental impact.

Different parameters, like electron donor type, concentration of selenium-soluble species, pH, ionic strength, oxic and anoxic conditions, as well as various separation techniques, namely (ultra)centrifugation, filtration and chemical coagulation, have been employed in our research.

Day 1 Day 14

Figure 1.1 Bioconversion of selenium oxyanions into elemental Se (original results).

Selenate and selenite could undergo biologically-mediated reduction when incubated under anaerobic conditions with mixed cultures of mesophilic inoculum (Figure 1.1). Electron donors, like ethanol or lactate, provide reduction equivalents that will be accepted by the two selenium toxic oxyanions which function like oxygen in aerobic environments. From a biotechnological and toxicological point of view, the formation of less/non toxic forms of any pollutant is a desirable outcome.

The two main separation techniques, centrifugation and filtration, employed in our research showed good recovery rates. Centrifugation was very effective, especially at high relative centrifugal force values, G = 2777 x *g*, which corresponds to 4500 rpm in our graph, with a 91% recovery rate. Filtration through 0.45 μm filters also generated a high recovery rate, ~ 89% (Figure 1.2).

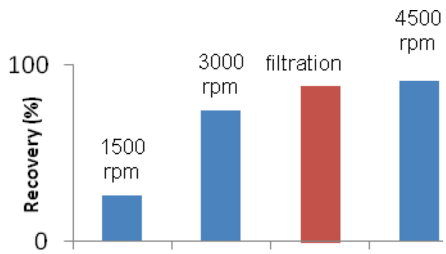

Figure 1.2 Performance of different separation techniques (original results).

In addition, we present for the first time the electro-chemical and settling characteristics of a biogenic elemental selenium suspension. Zeta potential is a measure of electrostatic repulsion or attraction between charged particles. Our suspension is characterized by a negative zeta potential, - 24 mV, therefore to have its charge repressed a counter-charge ion should be used. Charge repression results in the charge neutralization, otherwise known as the point of zero charge, and the settling of particles and can be achieved either by lowering the pH or by adding counter-charged particles, as it is routinely done in chemical coagulation. Since the biogenic elemental selenium suspension is electrically stable, the point of zero charge could not be reached even at low pH values (Figure 1.3). The drop of pH is accompanied by an increase in the diameter of the particles (Figure 1.3), but since their size is in the nanometer range they could not reach the gravitational settling threshold.

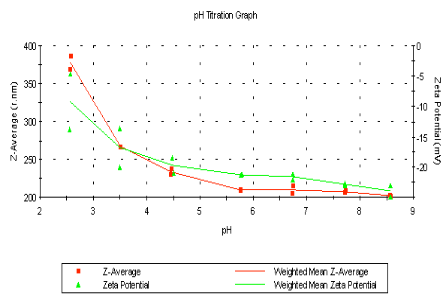

Figure 1.3 Zeta potential as a function of pH (original results).

In conclusion, selenium toxic and bioavailable species, selenate and selenite, could be bioreduced to less/non-toxic Se^0. The biogenic elemental selenium suspension shows interesting properties that require additional investigation. In addition, by using proper separation techniques, filtration and centrifugation, selenium could be recovered and reused in industrial applications.

References

Astratinei, V.; van Hullebusch, E; Lens, P.N.L. (2006). Bioconversion of selenate in methanogenic anaerobic granular sludge, *J. Environ. Qual.*, **35**, 1873-1883.

Lenz, M.; Lens, P.N.L. (2009). The essential toxin: The changing perception of selenium in environmental sciences, *Science of the Total Environment*, **12**, 3620-33.