

Immobilisation of contaminants by industrial magnetite in acidic, phosphate-rich waste leachates

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The scientific community has greatly focused on finding innovative remediation techniques for the decontamination of drinking and waste water. Magnetite (Fe_3O_4) has been suggested to be a significant reductant for contaminants due to its ubiquity in the environment, and its great adsorption capacity and ability to retain metals on its surface [1] owing to its high specific surface area. Its use has become an emerging technology for the treatment of contaminated land and water with a great potential to become an effective and low-cost alternative to conventional remediation techniques. For instance, magnetite has been reported to be efficient in immobilising As [2], Sb [3], and U [4, 5], all USEPA and EU priority pollutants. These redox sensitive contaminants have been reported to be the most problematic, with significant levels, in phosphate rich wastes [6] (i.e. phosphogypsum).

Here, we have taken advantage of a concept of the circular economy, exploiting an existing waste from the steel industry that HYMAG'IN company has transformed into magnetite. Adsorption experiments of As, Sb and U at pH 5.5 showed the efficiency of this industrial magnetite to remove those contaminants from solution in an 87%, 83%, and almost 100%, respectively. On the contrary, the studied treatment method was efficient only for U in phosphate-rich solutions due to the phosphate competition with the anions. For this purpose, we studied the nucleation of a common iron phosphate phase in the studied wastes (i.e. vivianite) and the pH rise, induced by the addition of Fe^0 that is oxidised to Fe^{2+} . As such, we suggest a remediation technique in which vivianite precipitation will precede the reaction with the magnetite, and we provide insights on how the management of the toxic, acidic, and phosphate rich wastes (e.g. phosphogypsum) could profit from this novel remediation strategy.

[1] Gorski et al., 2009, *Env. Sci. Technol.*, 44, 55-60. [2] Zhang et al., 2010, *Sci. Bull.*, 55, 365-372. [3] Kirsch et al., 2008, *Mineralogical Mag.*, 72, 185-189. [4] Scott et al., 2005, *Geochim. Cosmochim. Acta*, 69, 5639-5646. [5] Pan et al., 2020, *Nat. Commun.* 11, 1-12. [6] Papaslioti et al., 2018, *Water Res.* 140, 344-353.