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Ultrasound-Assisted Soil Washing Process for the Removal of Heavy Metals from Clays

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Extended Abstract

The proportion of soils contaminated by a wide range of pollutants (heavy metals, PCBs, pesticides, etc.) of anthropogenic origin is constantly increasing and it is becoming urgent to address this issue. Conventional remediation methods rely on physical, chemical, or biological approaches, or a combination of these. Among remediation methods, soil washing is an effective, relatively fast and widely used process. The present study assesses its coupling with ultrasound, whose propagation in a liquid medium leads to the formation of cavitation bubbles. It focuses on Ni(II) and Zn(II) removal from vermiculite clay by solid-liquid extraction under 20 or 362 kHz ultrasound or in silent conditions. Clay, and more specifically a phyllosilicate, was used to simulate a soil given the importance of this fraction in the soil and its role in the adsorption of metals. Hydrochloric and citric acids were tested. The effects of solid/liquid ratio and particle size were investigated.

The results showed that the use of 20 kHz ultrasound led to particle size diminution and creation of new adsorption sites where some freshly desorbed metal ions could readsorb. Therefore further experiments were performed at high frequency US (362 kHz) and it was shown that fragmentation of the vermiculite particles is then limited.

Desorption rates of Zn^{2+} and Ni^{2+} were monitored as a function of time in the different conditions used. For zinc, the use of 362 kHz ultrasound leads to slightly higher desorption rates compared to silent conditions. The higher frequency of 362 kHz is more effective than 20 kHz because at this frequency the high fragmentation and erosion of the clay leads to the creation of new adsorption sites where metals can re-adsorb. In the nickel case, there is less difference between the three processes and overall kinetics are much slower than for zinc, indicating the poor accessibility of the metal. Besides, obtained yields are much higher for Zn^{2+} than for Ni^{2+}, reflecting different affinities towards the clay.

Metal repartition in the clay before and after treatment was followed by Tessier sequential extraction procedure [1]: exchangeable cations, cations bound to carbonates, reducible fraction, fraction bound to organic matter and residual one. It indicated that more metal elements bound to the challenging residual phase were desorbed with ultrasound compared to silent conditions. This supports the promising application of ultrasound for heavy metal desorption in difficult conditions.

References

[1] A. Tessier, P.G.C. Campbell and M. Bisson, *Analytical Chemistry,* vol. 51, pp. 844-851, 1979.