Heavy metals in industrial sludge: Occurrence, Leaching behavior and Environmental implications

Tran Thi Thu Dung[1,2], Elvira Vassilieva[1], Asefeh Golreihan[1], Nguyen Ky Phung[3], Rudy Swennen[1], and Valérie Cappuyns[1,4]

1KU Leuven, Department of Earth and Environmental Sciences, Celestijnenlaan 200E, 3001 Leuven, Belgium
2 Vietnam National University Ho Chi Minh City, University of Science, Faculty of Environment, 227 Nguyen Van Cu St., W4, D5, Ho Chi Minh City, Vietnam
3 Department of Science and Technology, 244 Dien Bien Phu St., W7, D3, Ho Chi Minh City, Vietnam
4KU Leuven, Center for Economics and Corporate sustainability (CEDON), Warmoesberg 26, B-1000 Brussels, Belgium
E-mail contact: tttdung@hcmus.edu.vn

Industrial activities generate different types of waste, with varying chemical properties. An investigation of the detailed chemical and mineralogical characteristics of these materials may serve as a first step for selecting an appropriate treatment or safe disposal method. This study focuses on arsenic (As) and heavy metals (i.e., Cd, Co, Cu, Cr, Mo, Ni, Pb, and Zn) in three sludge samples derived from industrial wastewater treatment plants in Southern Vietnam. The emphasis is on determining the influence of changing environmental conditions on element mobilization based on a multidisciplinary approach using sample micro analysis (Field Emission Gun Electron Probe Micro Analysis (FEG-EPMA)) in combination with different types of leaching/extraction tests. Bulk chemical composition (ICP-OES measurement after digestion by 3 acids (HNO_{3conc}, $HClO_{4conc}$, and HF_{conc})) showed a high variation of arsenic and heavy metals in the studied sludges: As (8-2410 mg/kg), Cd (0.4-2.0 mg/kg), Co (6-16 mg/kg), Cr (83-588 mg/kg), Cu (131-687 mg/kg), Mo (2-12 mg/kg), Ni (45-146 mg/kg), Pb (28-11347 mg/kg), and Zn (1324-33526 mg/kg). Micro-analysis by FEG-EPMA showed that most of the Zn-rich spots were found in association with S and Si-rich phases in Zn-rich sludge. Other heavy metals could not be detected except Pb (2 spots), that was found in Fe-rich phases in the Pb-rich sludge. In this study, besides the bulk chemical determination, a combination of extractions and leaching tests (i.e., pH-dependence leaching tests and ammonium-EDTA extraction) was used to assess a wide range of possible exposure conditions of the sludge and link it to potential management options. Although the leachability of most of the heavy metals decreased considerably at neutral and alkaline pH-conditions (pH 7-10), the leachable concentrations of arsenic and some heavy metals still exceeded the EU-leaching values for inert waste (As, Cr, Cu, Mo, and Pb) and for non-hazardous waste (As, Ni, and Zn) in some sludge samples.

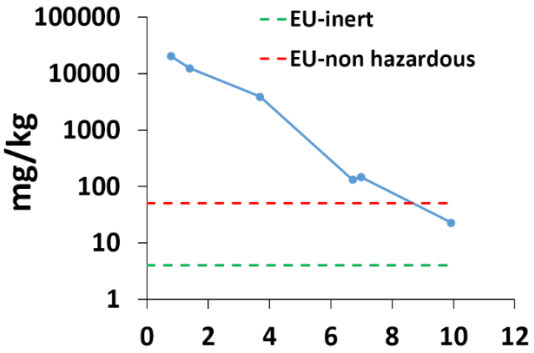

Figure 1: pH dependent leaching behavior of Zn in the Zn-rich sludge.

Chelating agents, such as humic acids, can influence the leaching of heavy metals and arsenic. The potential complexation of heavy metals with chelating agents was assessed by means of an ammonium-EDTA extraction. A textile dying sludge contained very high total Pb-concentrations (11347 mg/kg), which also showed a very high potential mobility, as 85% of the total Pb-content was extracted with ammonium-EDTA. On the one hand, this result implies a thread to the environment, while on the other hand this indicates that washing with EDTA might be the first and efficient step to remediate and recover Pb from this kind of sludge. In the view of resource efficiency, landfilling, which is most often applied in Vietnam, is not a sustainable waste management option for this kind of sludge.