Bioleaching of Heavy Metals from Mining/Metallurgical Wastes and Metals Biorecovery

M. Vemic*, E. van Hullebusch*, F. Bordas, G. Guibaud**, P. Lens*****

*Université Paris-Est, Laboratoire Géomatériaux et Environnement, EA 4508, 5 bd Descartes, 77454 Marne la Vallée Cedex 2, France
**Université de Limoges, Groupement de Recherche Eau – Sol – Environnement (GRESE), Faculté des Sciences & Techniques, 123 avenue Albert Thomas, 87 060 Limoges, France
***UNESCO-IHE Institute for Water Education, Westvest 7, 2611 AX Delft, The Netherlands

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The proposed PhD thesis research will be done in collaboration with a recycling plant (France), which is mainly focused on catalyst and metallic oxide recycling and in the latest period it includes also the crushing step of battery recycling.

In 23rd October 2001 European directive No. 2001/81/CE restricted the emissions of pollutants such as sulphur dioxide, nitrogen oxides, etc. into the atmosphere. Consequently, levels of sulphur in petrol's and diesels should not exceed 10 ppm as from 2009. The result of this directive is a significant increase in the amount of used catalysts, which are used in greater numbers by oil companies to achieve the threshold fixed by the European Commission. In Europe, 25,000 tons of used NiMo catalysts polluted with high levels of vanadium and 1,000 tons of used NiW catalysts are produced each year. The used catalysts contain the components (alumina, sometimes silica, molybdenum, nickel, tungsten, phosphorus, etc.) and the harmful elements captured during the refining process (sulphur, carbon, hydrocarbons, nickel, vanadium, arsenic, etc.). Thus, disposal of spent catalysts represent an increasing environmental problem due to their metallic content, which is being considered as hazardous waste [*Sayilgan et al.*, 2009a].

In order to achieve recycling of this large amount of used catalysts, the recycling plant designed a process allowing the recovery of precious metals from used NiMo, CoMo and NiW catalysts (thus they have second life in the refinery), and thus they are transformed into new raw materials. For this process, the recycling of used catalysts is based on intelligent combinations of processes born of pyrometallurgy and hydrometallurgy.

However, rainfall is causing leaching of the metals from the recycling plant site and storage area. Part of the rainwater is collected in the ponds (ponds act like a storage before processing), and the other part is taken by the wastewater treatment plant, treated and then discharged into the nearby river. Rainwater in the ponds is passing through the settling stage thus forming the sludge which is containing metals. Total metal analysis performed on sludge sample is showing that sludge is containing significant amounts of some metals (see Table 1). The recycling plant has two options, either to dispose (which costs money due to the high disposal costs) or either to recover generated sludge (which brings money due to the high economic value of some metals). Since some of the metals (Mo, W, Cr, Ni, Co and Zn) present in the sludge are especially valuable to the recycling plant (economically and ecologically), recovery of those metals is of primary importance. Additionally future shortage of mentioned metals is a locking point of this research.

Table 1: Total metal concentrations in sludge samples from the recycling plant (analysis performed by ACME Analytical Laboratories, 1:1:1 Aqua Regia digestion ICP-MS analysis).

Analyte	Mo	W	Cr	Ni	Co	Zn
Unit	ppm	ppm	ppm	ppm	ppm	ppm
MDL	0.1	0.1	1	0.1	0.1	1
Decantation Pond	>2000	>100	3408	>10000	>2000	>10000
Upstream Sieving Channel	>2000	>100	5123	>10000	1864	>10000
Filter Press	>2000	>100	1050	8559	>2000	>10000
Permitable limits (mg/kg DW)*	75	-	3000	420	4300	7500

* Maximum metal concentrations in sludge (Adapted from U.S. EPA, 1993).

The main goals of the recycling plant as a research partner are: 1. To achieve the optimum metal value recovery; 2. To recycle metals into ingots which can be directly sold; 3. To achieve a zero waste solution. In order to achieve these goals one question need to be answered (which is the main objective of this research), and that is: Which approach and technology will be the best to achieve highest metals recovery from contaminated sludge, and at the same time bring highest economic benefit to the recycling plant?

This PhD research will be divided into three main research tasks (see Figure 1). The main purpose of this PhD research is to present a theoretical and experimental description of the various speciations, (bio) leaching and (bio) recovery processes: their principle, applicability, methods of predicting and improving of their performance in the treatment of metals from contaminated sludge's. Moreover, a comparative review of the efficiency of these various processes, as well as critical analysis in terms of their advantages, disadvantages and limitations, will be also done. Since Mo is metal of primary importance to the recycling plant (economically), this PhD research will be mainly focused on recovery of Mo and additionally on recovery of W, Cr, Ni, Co and Zn.

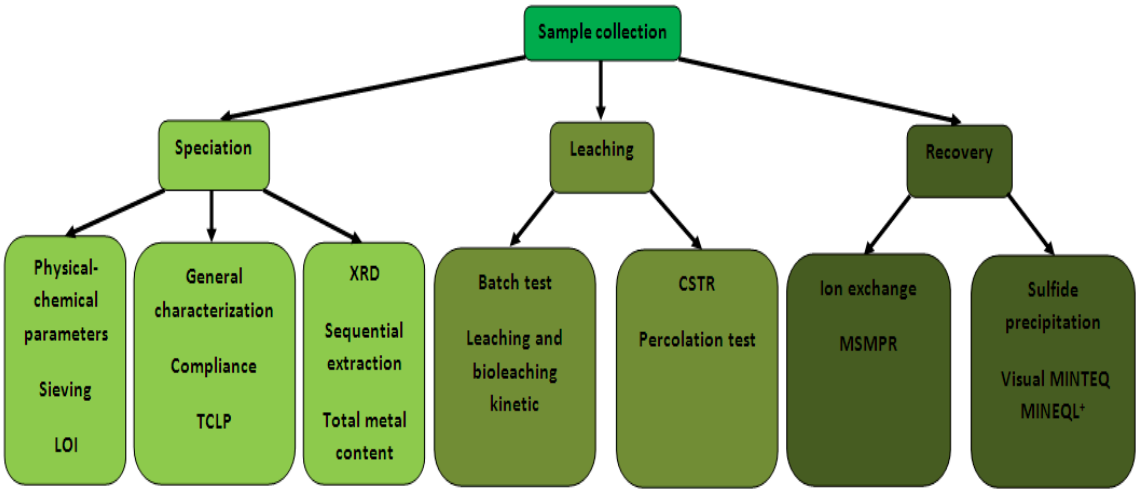

Figure 1: Research work tasks overview.

References

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