Contribution ID : **39** Type : **Presentation**

# As and Cu speciation in mine tailings using synchrotron radiation

*Wednesday, 12 August 2015 19:15 (0:30)*

## Abstract content

Potentially toxic elements are usually present in mine tailings in concentrations that may threat environmental and human health. In this research, mine tailings and soils from “La Aurora”, an abandoned mine, were studied in order to determine As and Cu speciation and understand its mobility in the environment. For this purpose, a combination of sequential chemical extractions (SEP), Flame Atomic Absorption Spectroscopy (FAAS), and X-ray synchrotron techniques (XAS) was used. This mining site is located in Xichu, Mexico and resides in a natural protected area that is recognized for its high biodiversity, biological resources and the existence of some endangered species. This site was exploited principally for Ag, Cu, Zn and Pb until the last cycle in 1957. Our results showed that mine tailings contains As, Pb, Cu and Zn up to 12485, 8760, 1400 and 6668 mg·kg-1, respectively. We established 13 sampling points in mine tailings and 7 in soils nearby. Surface samples as well as 30 cm depth composites were taken at each point. Samples were dried at 500C and sieved to obtain particle sizes <0.25 mm and <0.85 mm. Elemental content analysis were performed by FAAS and X-ray Fluorescence (XRF) for validation purposes. Both methods yield similar results for Cu and As content. Cu is present in mine tailings and soils in a range between 142±19 and 1400±92 mg·kg-1 and 22±2 and 88±5 mg·kg-1, respectively. Repartition of Cu in mine tailings determined by SEP followed this general trend Water soluble > Residual > Organic Bound > Exchangeable > Fe-Mn-Oxides > Carbonate; and in soils as Residual > Organic Bound > Fe-Mn oxides > Carbonate > Water > Exchangeable. X-ray Absorption Near Edge Spectroscopy (XANES) linear combinations fits (LCF), showed Cu is present as Cu 2+ highly mobile species and in minor proportion as Cu+ species as oxides and sulphides. Cu content in mine tailings is available for plants and bioaccesible with percentages around 90% in almost all the points tested. Arsenic was detected in mine tailings and soils in a range between 3140±302 and 12485±398 mg·kg-1 and 209± 10 and 327±10 mg·kg-1, respectively. Repartition of As determined by SEP followed this general trend in mine tailings Crystalline Fe-Oxides > Residual > Exchangeable > Amorphous Fe-Oxides > Specifically sorbed; and in soil as Crystalline Fe-Oxides > Amorphous Fe-Oxides > Exchangeable > Residual > Specifically sorbed. XANES LCFs showed that As is present as a secondary arsenate mineral of similar structure to kankite (FeAsO4·3.5H2O) and beudantite (PbFe3(AsO4)(OH)6). These results suggest that As is forming low soluble species and just a minor fraction is susceptible of mobilization. As fitoaccesible in mine tailings showed percentages between 3-22% and bioaccesible between 4-14%, in soils As fito and bioaccesible showed values around 20%. Extended X-ray Absorption Fine Structure (EXAFS) confirmed the structure of iron arsenate compounds as kankite and beudantite that share the tetrahedral structure AsO4, corresponding to a single scattering of four oxygen atoms at 1.679 Å and a contribution of three Fe atoms at 3.389 Å. Our results provide evidence of natural attenuation of As but the fraction available is still enough to generate a negative impact in the local environment. Cu is present in high soluble species and almost all Cu content is available for plants in addition in soils only insoluble species are retained, this support its high mobility in the surrounding environment.

## Summary

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**Session Classification :** Wednesday III