

## Speciation of Pb and Cu in a wetland impacted by former uranium mining activities

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In France, uranium (U) mining activities have produced a large quantity of waste still containing U-rich minerals and other associated trace elements (TE). Some of them, potentially toxic, can be relatively mobile and redistributed in the various reservoirs of the critical zone such as wetland soils.

The environmental impact of the presence of TE and U contamination is largely influenced by their forms and bearing phase reactivity. Wetlands correspond to areas where the physical and chemical conditions may greatly vary according to the variations of the water table. Therefore, their management requires to determine the solid speciation, stability, and immobilization mechanisms of the associated TE.

Wetland soils impacted by former U mining activities were studied (Rophin, French Massif Central). The highest contamination level was recorded in these soils for Cu, Pb, and U (pollution index Igeo: 3, 4, and 5, respectively) particularly in a white horizon inherited from mining activities. Combined analytical approaches (*i.e.*, SEM, EPMA,  $\mu$ -XRF and  $\mu$ -XANES acquisitions, and selective chemical extractions) were performed to determine the speciation of Cu and Pb to understand their stability.

From  $\mu$ -XANES results, Pb is mainly associated with particulate organic matter (POM). These results are in accordance with chemical extraction results. Moreover, SEM and/or  $\mu$ -XANES permitted to highlight mainly authigenic/inherited stable mineral phases *i.e.*, plumbogummite ( $\text{PbAl}_3(\text{PO}_4)(\text{PO}_3\text{OH})(\text{OH})_6$ ), cerussite ( $\text{PbCO}_3$ ); anglesite ( $\text{PbSO}_4$ ) and hokutolite ( $(\text{Ba,Pb})\text{SO}_4$ ), and to a lesser extent refractory granite minerals with Pb and U (*e.g.*, titanium oxides, REE phosphates, zircons) inherited from the regional granite and U-Pb-rich mineralization.

The variety of Pb and Cu-phases identified in this wetland underlines the various geochemical behavior confirmed by chemical extractions. The leaching test showed very limited Pb mobility on contrary to Cu and U. These latest elements are indeed more prone to be mobilized from the mining deposit even though adsorption of these elements on the POM framing this deposit could however limit their diffusion from the wetland.