Fate of heavy metals in sludge-amended soils: a multiscale approach

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Biosolids are inevitable by-products of the treatment of municipal or industrial wastewater treatment plants. Due to the intensification of water quality requirements and more rigorous environmental laws in Europe, the production of biosolids has sharply increased in recent years. The main management options include incineration, landfill sites, and application to agricultural lands as soil amendment. The use of biosolids in agriculture is widely practiced all over the world since it is the most economical option allowing the recycling of nutrients in plants and of organic matter. However, this practice can be potentially harmful to environment because biosolids contain high concentrations of toxic heavy metals. The fate of potentially toxic elements following short and long term application of biosolids was well reported in the literature but this issue remains strongly controversial within the scientific community. Nevertheless, it is accepted that metal solid phase speciation plays an important role in the control of the long-term stability of metals in biosolid-amended soils.

In this context, we used pH-adsorption edge experiments and synchrotron-based spectroscopy techniques to understand the solid phase speciation of copper, nickel and zinc in a biosolid-amended soil. Comparison of metal adsorption edges for the biosolid-amended soil and the soil sample showed that Cu, Ni, and Zn can be retained by both soil and biosolid components such as amorphous iron phases, organic matter and clay minerals. These results are combined with μ-XRF and μ-XANES data to obtain structural information about the formed surface complexes. The results presented here suggest that even if the metals can be associated with soil components (clay minerals and organic matter), biosolid application will increase metal retention in the biosolid-amended soil by providing reactive organic matter and iron oxide fractions. Among the studied metals, the long-term mobility of Ni could be affected by organic matter degradation while Cu and Zn are strongly associated with iron oxides.