Looking for a 2 years postdoc candidate starting in September 2021.

Topic : BIOMIM'HUMIC: an eco-sustainable biomimetic approach for the rational remediation of polluted sites.

Context: The BIOMIM'HUMIQUE project proposes to combine the natural chelating properties of humic substances (HS) extracted from waste composts (promoting the precepts of a circular economy) with those of biomimetic catalysts in order to develop a new, eco-responsible and sustainable way of remediation of contaminated soils and effluents.

HS are supramolecular associations of small heterogeneous molecules with amphiphilic properties, which are organized in pseudo-micellar domains in aqueous solutions. When recalcitrant hydrophobic organic compounds adsorbed on the surfaces of solid soil particles come into contact with humic solutions, they preferentially partition into the humic hydrophobic domains, thus being removed from the soil. At the same time, the acidic functional groups of humic substances can complex the heavy metals present in the soil and thus extract them. Moreover, the combined use of humic substances and biomimetic catalysts significantly increases the extraction efficiency of certain pollutants. Indeed, the efficiency of these soil washes by humic substances is similar to that obtained by the use of synthetic surfactants. However, the use of the latter has the serious disadvantage of destroying the soil microflora, thus condemning the soil to be evacuated to a disposal site. Conversely, the use of humic solutions on the one hand does not damage the soil biota, and on the other hand promotes additional natural attenuation of the remaining organic contaminants by adding metabolically bioavailable carbon to the soil. In addition to the efficiency, speed and eco-sustainability, another advantage of humic soil washing is that it can be implemented directly on site and that the soils, after treatment, retain their physical, chemical and biological properties and can therefore be returned to their original location.

Objectives: Different types of composts will be characterized from a geochemical point of view using a "humeomic" methodology with the help of nuclear magnetic resonance (NMR) of carbon (^{13}C) and proton (^{1}H) in 1 and 2 dimensions as well as high resolution mass spectrometry (ESI and APPI-Orbitrap-MS and FTICR-MS) and gas chromatography coupled to high resolution mass spectrometry (GC-QTOF MS), in order to determine the molecular nature of humic substances extracted from the different types of composts.

The washing of the contaminated soils will be done in two steps. The first step will consist of washing metals and/or organic pollutants with the HS. The second step will consist in a catalytic copolymerization of the residual contaminants in the humic superstructures. This second step will therefore involve a biomimetic catalyst. The chosen biomimetic catalyst is a synthetic water soluble metal porphyrin that can be used either with an oxidant (H_2O_2) or under solar irradiation. Of particular interest is the use of soluble iron porphyrins which act as catalysts of the covalent coupling of certain organic pollutants of the soil with the phenolic fragments of the exogenous humic substances.

The effectiveness of contaminated soil washing will first be determined at the laboratory scale, on the pollutants of interest for CEA applications, using a panel of polluted soils with various characteristics and pollution levels. In addition, the liquid effluents containing the pollutants will also be characterized by NMR and HRMS in order to better understand the nature of the complexes formed between the chelating molecules from the composts and the organic and inorganic pollutants in order to, ultimately, develop a strategy for purifying the effluents on an ion exchange column

Skills required: Interdisciplinary project at the interface of several disciplines (analytical chemistry, organic geochemistry, soil science, ...) which requires experience in characterization of complex media at the molecular scale and their interactions with organic / inorganic pollutants either by nuclear magnetic resonance (1H, 13C NMR) or by ultra-high resolution mass spectrometry (FT-ICRMS, Orbitrap, non-targeted characterization). Numerous trips between the CEA of Bruyères-Le-Châtel, aproxiamately 20 kms south of Paris, France (ultrahigh resolution mass spectrometry platform, GC/Q-TOF, soil washing,…) and the University of Federico II , Naples (Italy - interdepartmental research center of nuclear magnetic resonance) are to be expected. The candidate must be fluent in English, both orally and in writing.

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