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Changes in metal(loid) fractionation in soils treated with nano zero-valent iron and/or biochar

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Soil contaminated with metals and metalloids such as Cd, Cu, Pb, Zn, and As represents high risk for the environment. It is not the total concentration but the available fraction, which needs to be evaluated in terms of the environmental impacts. Recently, research on nano zero-valent iron (nZVI), biochar (BC) and their modifications has shown promising results towards metal(loid)s stabilisation in soils. Large specific surface area and high reduction ability of nZVI lead to its high sorption efficiency for a wide range of contaminants. Biochar as a product of organic matter decomposition under oxygen-limited conditions represents a strongly efficient sorbent and it can improve soil properties and its fertility at the same time. However, when nZVI or BC is applied into soils, the interactions strongly depends on the pH-Eh conditions, the chemical and mineralogical composition of soils or the water holding capacity (WHC) and the actual moisture content.
In this context, the use of nZVI or BC was investigated under different incubation conditions, i.e. as a function of moisture content, simulating dry and wet seasons, flooding and freezing. The main objectives of this study were to assess (i) the effect of soil water content on the fractionation of metals/metalloids, (ii) the effect of different amendments on the fractionation of metals/metalloids, and (iii) the efficiency of nZVI, biochar or their combination on risk elements stabilisation.
An aliquot of a soil sample was carefully mixed with nZVI and/or BC (1 wt.% or 2 wt.%) and placed in a pot. The pots were maintained at 0%, 30%, 60%, 90% and 130% of WHC for 3 months. Additionally, soil samples prepared at 60% WHC were frozen for 3 months or 15 days, respectively. A control set of samples without amendment was prepared simultaneously. After this incubation period, the samples were dried and subjected to simple and sequential extractions.
Generally, the highest concentrations of Cd and Zn were extracted in fraction A (i.e. exchangeable) both for treated and non-treated samples. However, depending on the moisture content the lowest portion of exchangeable Cd was observed for nZVI-treated samples at 0% and 30% WHC, while exchangeable Zn yielded the lowest values for nZVI-treated samples at 90% and 130% WHC. Biochar was efficient for Cd stabilisation, while nZVI decreased the availability of Zn and As in several cases. The applicability of amendments of different origin were investigated under various environmental scenarios. Wide range of factors need to be taken into account when assessing the efficiency of nZVI or BC in the stabilisation process.