Is the USEtox model for assessing the terrestrial ecotoxicity of trace elements adapted to the agricultural recycling of organic residues?

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Organic residues (OR) are of interest to substitute mineral fertilizers in agriculture. They are however a major contributor to soil chronic trace elements (TE) contamination, which may exert toxic effects on soil organisms and reduce soil fertility. These negative impacts question the long-term sustainability of agricultural OR recycling. To estimate the terrestrial ecotoxicity of TE, a novel method was proposed in the USEtox model for life cycle impact assessment. It computes the comparative toxicity potential (CTP) via pedo-transfer functions and by decomposing it in the four characterization factors: fate, availability, bioavailability, and toxicity towards soil organisms. Beyond the interest of this model, its relevance in the context of OR recycling in agriculture is unknown.

We therefore empirically assessed how this model is adapted to estimate the ecotoxicological impact of copper (Cu) and zinc (Zn) in an OR-amended agricultural soil. A 26 day-long incubation of the soil with or without 31 OR (pig or broiler faeces), showing distinct Cu and Zn concentrations, was carried out in controlled lab conditions that mimic a field application. Initial soil properties (clay, soil organic matter, pH and Al and Fe oxides) were analysed to inform the model. Soil properties (pH, dissolved organic matter – DOM) and TE availability in soil and soil solution, corresponding to the CTP characterization factors, were measured at the end of the incubation experiment in each soil-OR mixture.

Empirically-determined CTPs were different by up to 1.5 log unit from the model estimations for Cu, 0.3 for Zn. The CTP variability measured after OR application in our experiment was comparable to the variability observed for world-wide soils. One explanation is the overestimation of DOM concentration and the absence of consideration of DOM binding properties. Our results overall support the need to improve the model for application to agricultural OR recycling.