Does USEtox predicts adequately Cu and Zn ecotoxicity in soils amended with animal effluents?

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

We empirically assessed how this model is adapted to estimate ecotoxicological impact of Cu and Zn in an AE-amended agricultural soil. A 26 day-long incubation of the soil with or without 31 AE was carried out in controlled lab conditions that mimic a field application. The AE were pig or broiler faeces, showing distinct Cu and Zn concentrations due to different feed. Initial soil properties (clay, soil organic matter, pH and Al/Fe oxides) were analysed to inform the model. Soil properties (pH, dissolved organic matter – DOM) and Cu and Zn availability in soil and soil solution, matching the CTP characterization factors, were measured at the end of the incubation in each soil-AE 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 AE application in our experiment was comparable to the variability observed for world-wide soils. One explanation is the overestimation of DOM concentration and the lack of consideration of DOM binding properties in soil. Our results overall support the need to improve the model for its application to agricultural AE recycling. This will fuel our ability to assess the environmental impacts of feed trace minerals in animal productions.