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Cadmium mobilisation by dissolved organic matter in contaminated soils amended with compost and peat

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Some organic matter (OM) soil amendments derived from biowaste have been shown to reduce plant uptake of Cd, which presents them as an attractive option for mitigating potential health risks on some contaminated soils. However, recent studies have highlighted that dissolved organic matter (DOM) release from the amendments may increase the mobilization of metals in those soils. The provenance of the OM and the quality of the emergent DOM have been suggested as important determinants in the extent to which this occurs. However, these effects have not been systematically tested in different soil environments, where the amount of DOM released from the OM, and its affinity to form Cd-DOM complexes, may vary. Our aim in this work was to explore whether the type of OM soil amendment influences Cd mobility in contaminated soils at different pHs, and if DOM characteristics contribute to this effect.

We spiked three distinct soils with Cd to 2 mg/kg and allowed them to equilibrate for six weeks. We then treated the soils using combinations of three different liming rates and three OM treatments: municipal compost or peat (2.5 % TOC wt/wt soil), and a control with no additional OM. Each combination was replicated thrice. We then further equilibrated the soils until the pHs stabilized at 5.7, 6.5 or 7.5 (± 0.2), after which we conducted a leaching experiment where we collected four soil pore volumes of filtered (0.45 μm) leachate from each replicate. We analysed subsets of the leachates for Cd and DOM concentrations, while subsets from specific lime treatments underwent ultrafiltration to measure the Cd concentrations in the <5 kDa ('truly dissolved') fraction, and diffusive gradients in thin-films (DGT) analysis to measure the chemical lability of the complexed Cd in the leachates. We used 3D excitation-emission matrix (3D-EEM) analysis to assess the DOM quality.

We found that the amount of Cd leached at pH 5.7 was 17-71% lower in the compost amended soils when compared to the unamended soils at the same pH, but the effect was much smaller or insignificant in the peat amended soils. Conversely, in the soils limed to pH >6.5, the amount of Cd leached in two of the soils amended with compost was up to 60% higher than from respective soils without OM amendments, despite the DOM release not increasing significantly. The relative amount of leached Cd in the <5 kDa fraction was the lowest in soils amended with compost, where as little as 40% of the leached Cd was 'truly dissolved'. The size of that fraction decreased with increasing pH in all cases, suggesting increased complexation by colloidal DOM. Aromatic moieties in the compost-derived DOM may be important in complexing Cd; however, these complexes appear to be relatively labile. We conclude that, while compost is effective in binding Cd to the solid organic phases, colloidal DOM released from it may serve as an important mobilizing vector for Cd at higher pHs, which should be accounted for when considering different land-use options on Cd contaminated soils.