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Assessment of changes in trace metal availability of contaminated soils after changes in land use from annual to perennial cropping systems

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For contaminated soils one of the strategies to avoid contamination of the food chain is to change land use towards non-food crops. Such crops like bioenergy crops (for example miscanthus) are mostly perennial. No-tillage and changes in vegetative cover type are known to modify the soil organic matter quality and quantity, which in turn can modify the trace metal bioavailability. But little is known about the impact of changes in land use on soil trace metal bioavailability. The objective of the present work was to assess such changes for contaminated soils when annual crops system is replaced by a perennial crop system.

We studied the available soil metal fractions using two types of EDTA extractions: one at equilibrium (24h) to quantify the soil metal supply, and the second one using kinetic extraction to mimic dynamic process of bioavailability. The kinetic extraction data, when modelled to a two first order reaction, defined two potentially bioavailable metal fractions in the soils i.e. labile metal fraction (supposed to be immediately bioavailable) and less labile metal fractions (supposed to be bioavailable on long term). This last approach can give a new insight to changes in trace metal availability occurring after a disequilibrium in soils as a result of change in land use. The samples used for this study involved two polluted sites where parcels were divided to be cultivated one part under annual crops and the other part under perennial crop i.e. miscanthus. At the time of the soil sampling, miscanthus was three years old. The two sites were very different. They differed in the nature of pollution and soil texture (sandy soil polluted by untreated waste water inputs or silt loam soil polluted by atmospheric fallout) but also in the degree of metal pollution (for Cu, Pb, Cd and Zn) and in the quantity and nature of organic matter (different C/N values).

Extraction results at equilibrium showed that for the silty soil samples the soil metal supplies were lower under perennial crops compared to annual crops whatever the trace element, suggesting a lowering of metal bioavailability under miscanthus. On the contrary for the sandy soil samples, results were different depending on the trace element: Cd and Zn soil supplies were higher under perennial crops compared to annual crops while Cu and Pb soil supplies were the same under perennial or annual crops. These last results pointed out the opposite changes in availability for Cd and Zn in one hand and for Cu and Pb in another hand. Results from kinetics extractions showed that for the silty soil samples and whatever the trace element, the fraction of labile metal forms were found lower under perennial crops compared to annual crops while the fraction of less labile forms did not significantly changed. On the contrary for the sandy soil samples, Cd and Zn labile but also less labile fractions were found higher under perennial crops compared to annual crops. For Cu and Pb, labile fractions decreased and less labile fractions did not significantly changed under perennial crops compared to annual crops.

These results highlight that changes in land use in contaminated soils do affect the soil metal availability by changing the distribution of metals among labile and less labile fractions, thus affecting soil metal bioavailability. But the determinism of theses changes need to be understood to better manage contaminated soils.

Keywords: Trace metals, availability, kinetic extractions, land use, EDTA, miscanthus, soil pollution.