Quantification and modelling of the changing mobility of trace metals in cultivated plots amended by composts of organic urban residues

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Introduction

Organic amendments from urban and livestock residues may increase the contents of certain trace metals in amended horizons after years. However, the evolution of the mobile metal fraction appears less predictable, depending on the variations of total contents but also on variations of retention factors such as pH and organic matter [1, 2]. Our study aims to put in hierarchy these influences through experimental data and modelling, based on a long-term field experiment equipped with fibreglass wick lysimeters.

Material and Methods

The field experiment QualiAgro concerns long-term agronomic and environmental effects of spreading different urban composts, named here:

- MSW, for composts of municipal solid waste sorted before and after collection,
- BIO, a co-compost of green waste and fermentable municipal residue collected separately,
- SGW, a co-compost of sewage sludge and green waste.

They are compared to the use of dairy farm manure (FYM) and to the control without organic amendments.

Maize and winter wheat are cultivated on a deep loess luvisol, according to common practices in the Paris Basin, except for more intense organic amendments, applied every 2 years on wheat stubble. Five plots corresponding to each treatment have been equipped for monitoring transfers of heat, water and solutes [3]. This was achieved in 2007 with fibreglass wick samplers fixed on stainless steel plates at 45 cm depth.

Chemical analyses of collected solutions include pH, DOC, major inorganic solutes, and trace metals. The analyses of Cd, Cu and Zn were performed at the Laboratoire d'Analyses des Sols INRA (Arras, FR).

Modelling

As in [3], Hydrus-1D achieved the modelling of water fluxes. No attempt was done to take into account the disturbance by the lysimeters. For predicting metal concentrations, we tested published "generalized Freundlich" equations [4]. We retained the ones in better agreement with our soil and solution data. E.g., we simulated the metal fluxes with Hydrus-1D, completed by an equation predicting the concentration from "reactive" soil Cu (EDTA extracted), soil OM content, and averaged values of pH and DOC [2].

Results and discussion

Table 1 resumes the ranks observed between treatments when considering pH or a solute concentration in collected waters, applying non parametric paired tests over the whole of 3 winter periods (2007-2010):

DOC: $BIO^{a} > (SGW, FYM, MSW)^{b} > CTRL^{c}$	**pH**: $(BIO, FYM, MSW)^{a} > (CTRL, SGW)^{b}$
Cu: $MSW^{a} > BIO^{b} \geq FYM^{bc} \geq SGW^{cd} \geq CTRL^{d}$	**Zn**: $(MSW, SGW)^{a} > (BIO, CTRL)^{b} > FYM^{c}$

The general trend of increased concentrations, or fluxes, of Cu and Zn in amended plots compared to the control, is rather in contradiction to the predicted effect of higher pHs observed with BIO, FYM and MSW. It is partly explained by increased DOC, and higher reactive metal fractions. But comparisons between the different organic treatments together could not be explained from simplified hypotheses and models outlined here. More precise characterization and modelling of trace metal reactions are needed.

References

[1] Smith SR, 2009 (review). Environ. Intern. 35, 142-156
[2] Tipping et al, 2003. Environ. Pollut. 125, 213-225
[3] Chalhoub M., 2010. PhD, Uni. Paris Sud
[4] Degryse et al, 2009 (review). Europ. J. Soil Sci. 60, 590-612

Keywords

Trace element, heavy metal, lysimeter, organic waste, organic amendment