Modeling Cd and Cu Mobility in Soils Amended by Long-term Urban Waste Compost Applications

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INTRODUCTION

- Compost addition to the soil and tillage tends to affect physical properties and solute transport in soil.
- Long-term applications of urban waste compost may lead to a significant accumulation of certain micropollutants in the soil.
- The organic waste products applied on the soil surface are not incorporated deep into the soil profile, because of the tillage practices, which could influence the transport of inorganic contaminants of low mobility like Cu or Cd.

OBJECTIVE

Numerical modeling was performed using **HYDRUS-2D** to estimate the **movement** of **Cd** and **Cu** from compost incorporation in the tilled layer. Experimental plots regularly amended with co-compost of sewage sludge and green wastes (**SGW**), or a municipal solid waste compost (**MSW**) have been compared to control plot without any organic amendment (**CONT**).

MATERIALS AND METHODS

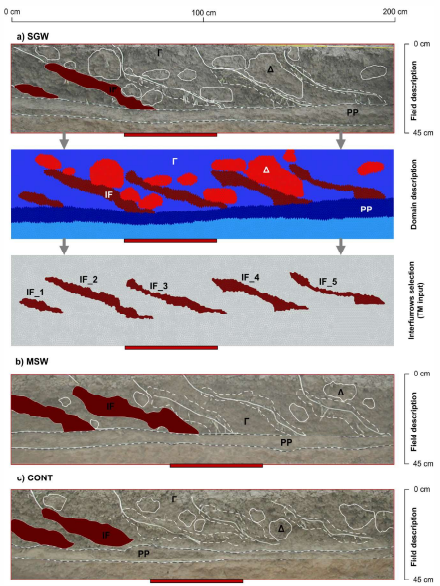
- Long-term field experiment "QualiAgro" https://www6.inra.fr/qualiagro_eng/; Albeluvisol (WRB); Crops: winter wheat (Triticum spp.); maize (Zea mays L.); barley (Hordeum vulgare L.)
- Water and TMs monitoring: 2 wick lysimeters, 5 TDR probes, and 7 tensiometers per plot.
- Ploughed layer structural description: compacted clods (Δ), non-compacted soil (Γ), interfurrows (IF), and the plough pan (PP).
- Different structural zones were implemented into HYDRUS-2D using optimized soil hydraulic properties.
- The increase of Cd and Cu concentrations due to each compost addition was assumed to be located in IFs for further modeling.
- Two approaches for TMs sorption estimation: i)the first approach was based on Kd estimated from ratios between EDTA and CaCl2-extracted metals (**Kd-1**); ii) the second approach based on generic equations (literature), using soil organic carbon (SOC) and pH for Cd, and SOM, pH and DOC for Cu **(Kd-2**).

Basic average properties of applied compost SGW and MSW.

Compost type	pH (H_2O)	OM g kg^{-1}	Organic C g kg^{-1}	Total N g kg^{-1}	C/N ratio	CaCO3 g kg^{-1} dry wt.	Water content %	Bulk density Mg m^{-3}
SGW	7.6	48.8	267.8	23.2	11.8	23.3	66.9	0.42
MSW	7.3	59.3	317.9	17.4	18.8	62.1	58.6	0.29

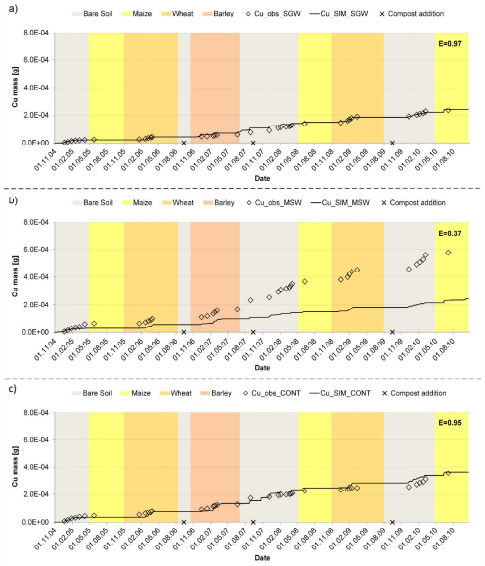
Compost properties and TMs input at four application date.

Compost type	Application date	Amount applied t ha^{-1} DW	pH	Organic C g kg^{-1}	Cd EDTA mg kg^{-1} DW	Cu EDTA mg kg^{-1} DW
SGW	28.9.2004	17.3	7.23	311	0.172	12.2
	11.9.2006	17.7	7.67	245	0.553	56.2
	11.9.2007	15.8	7.40	238	0.634	69.7
	14.9.2009	17.0	7.08	256	0.509	51.8
MSW	28.9.2004	14.6	7.12	263	0.221	9.32
	11.9.2006	9.99	7.53	390	0.443	39.4
	11.9.2007	10.5	6.95	359	0.394	29.9
	14.9.2009	9.43	7.79	310	0.239	11.7



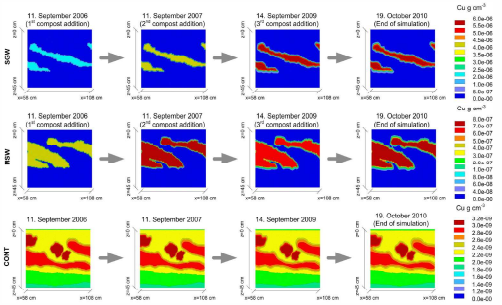
Spatial distribution of different soil zones and scheme of HYDRUS-2D discretization together with IF selection in which the additional trace metals (Cd and Cu) were added with compost addition for a) SGW, b) MSW plots and c) CONT plot without any compost addition.

RESULTS

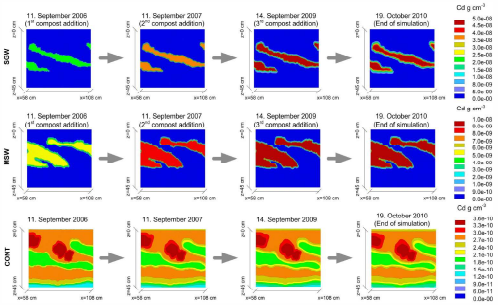


Observed (symbols) and simulated (line) Cu leachate through the lysimeter plates during 2004-2010 period in a) SGW, b) MSW and c) CONT – Kd-1 approach

Observed (symbols) and simulated (line) Cd leachate through the lysimeter plates during 2004-2010 period in a) SGW, b) MSW and c) CONT – Kd-2 approach



Evolution of Cu concentration in soil solution of the first 45 cm during 2004-2010 period including three compost additions in the SGW and MSW plots.



Evolution of Cd concentration in soil solution of the first 45 cm during 2004-2010 period including three compost additions in the SGW and MSW plots.

CONCLUSIONS

- Lysimeter data of Cu leaching were successfully reproduced by using first Kd-1 approach for SGW and CONT plots, while MSW plot showed less successful fitting (model efficiency E_{SGW}=0.97, E_{MSW}=0.37; E_{CONT}=0.95).
- The Cd leaching could be reproduced with the second Kd-2 approach for the two amended plots (E_{SGW}=0.55, E_{MSW}=0.80).
- The poorer fitting with the field data was attributed to less stable organic matter in MSW compost for Cu and by the overestimated influence of the low pH for Cd in the CONT case.
- Numerical modeling revealed interesting results in which, even with the high values of hydraulic conductivity in the IF zones, Cd and Cu showed low mobility. The TMs mobility in the tilled layer is largely reduced due to retention capacity of the applied composts.

Acnowledgements
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