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Laboratory experiment on undisturbed mesocosms: the leaching of heavy metals from contaminated soil

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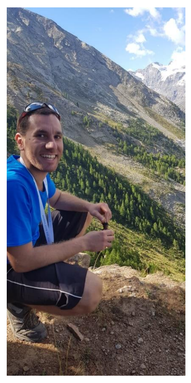


Introduction

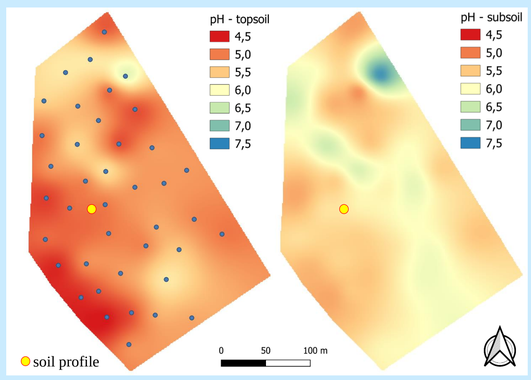
Urban and peri-urban soils provide important ecosystem services (e.g., organic carbon storage, infiltration of rainwater, recreational and cultural functions) and play an important role within the urban ecosystem.

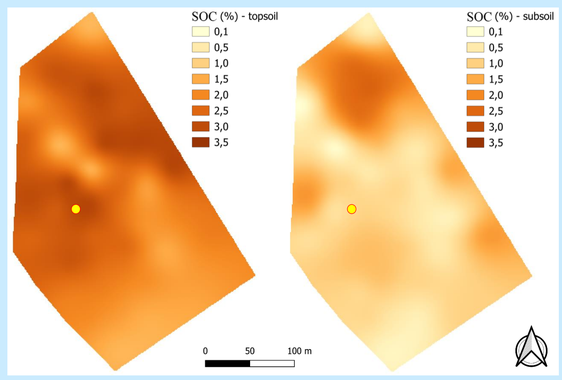
Due to frequent soil mixing, they have unpredictable horizonation and are often poorly structured, with a high concentrations of inorganic and organic contaminants.

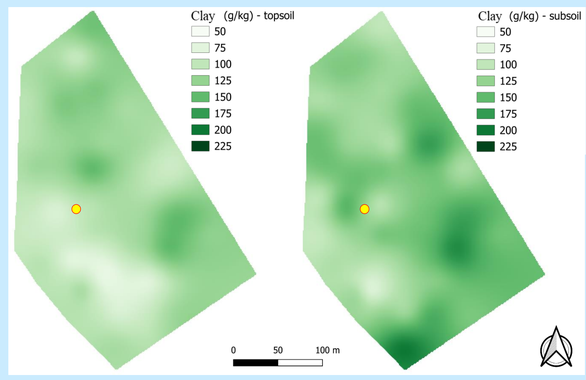
Purpose of this work

One of the most important ecosystem services provided by soil is its ability to slow and mitigate the percolation of pollutants into aquifers, a function of great importance for maintaining good groundwater quality. This study is part of the PNRR project (Biodiversity Future Center, Spoke 5: Urban Biodiversity) and aims to assess the leaching of heavy metals (Cr, Cu, Ni, Pb, and Zn) under controlled laboratory conditions.

Soil spatial characterization







Soil profile characterization

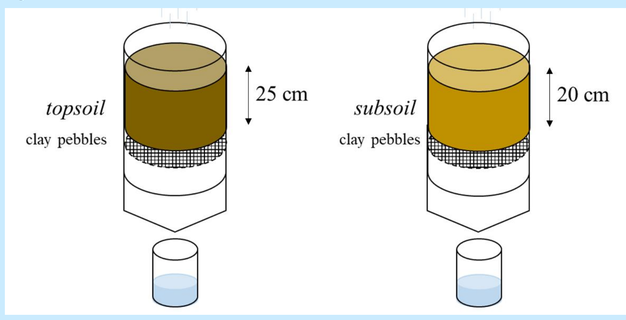
	pH H_2O	organic C %	total N %	C:N	available P mg kg^{-1}	sand g kg^{-1}	silt g kg^{-1}	clay g kg^{-1}	texture class USDA
Ap	4.8	3.13	0.30	10.6	64.40	315	615	70	silt loam
Bwg1	6.1	0.32	0.03	10.6		361	576	63	silt loam
Bwg2	6.4	0.39	0.04	10.3		324	557	119	silt loam
Bwg3	6.5	0.25	0.03	8.4		284	556	160	silt loam
Cg	6.4-6.5	0.26	0.03	9.6		272	584	144	silt loam

	CEC $cmol_{(+)}$ kg^{-1}	Ca^{2+} $cmol_{(+)}$ kg^{-1}	Mg^{2+} $cmol_{(+)}$ kg^{-1}	K^{+} $cmol_{(+)}$ kg^{-1}	Na^{+} $cmol_{(+)}$ kg^{-1}	GSB %
Ap	26.87	10.86	1.17	0.10	0.11	45.6
Bwg1	8.18	6.24	0.57	0.15	0.12	86.6
Bwg2	11.78	8.31	0.85	0.15	0.12	80.1
Bwg3	10.07	7.05	0.88	0.10	0.10	80.7
Cg	10.17	6.95	1.00	0.11	0.14	80.6

The first two horizons (Ap and Bwg1) of a *Cambic Gleyic Umbrisol (Siltic, Aric, Densic, Eutric, Humic)*, with bulk densities of 1.07 and 1.68 g/cm^3 respectively, were used in the laboratory experiments in order to evaluate the leaching of metals under controlled conditions.

Materials & methods

The experiment used undisturbed soil columns (mesocosms) of the Ap and Bwg1 horizons, manually constructed by assembling 14 cm diameter tubes to form 40 cm long cylinders with a 5 cm drainage layer; an extreme meteorological event for the Milan area (150 mm rainfall in 24 hours) was simulated, stressing the system while maintaining a constant water head of 10 mm and collecting the percolated water every hour.



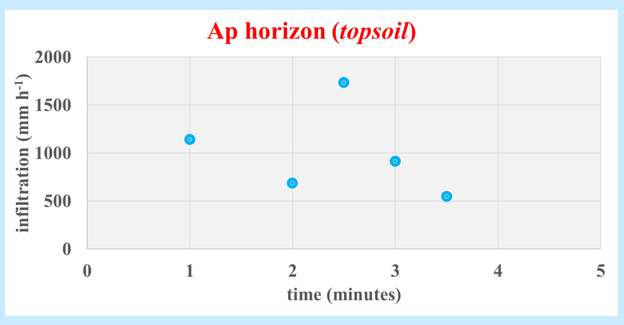
Results and considerations

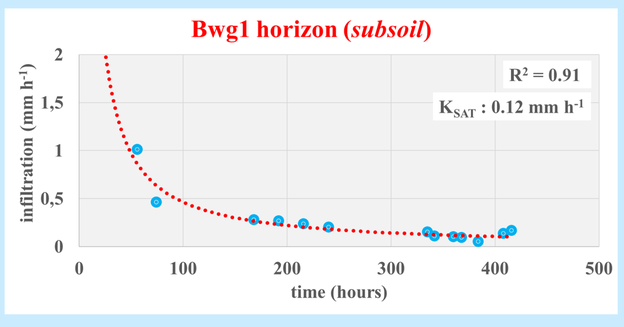
Preliminary data show that water infiltrates very rapidly into the topsoil, but very slowly into the subsoil.

The large difference in infiltration rates can be attributed to the compaction of the subsoil and the high biological activity (particularly earthworm burrowing) of the topsoil.

The water leaches a small fraction of the exchangeable and soluble metal fractions present in both the Ap horizon (Cr: 1.17%; Cu: 1.10%; Ni: 1.55%; Pb: 0.09%; Zn: 0.18%) and the Bwg1 (Cu: 0.03%; Zn: 0.02%).

The very low rate of seepage into the subsoil indicates that the potential risk of heavy metal contamination of deep groundwater is limited.





In progress (and future) activities

Infiltration tests will be carried out on the Ap and Bwg1 horizons after the addition of heavy metals at concentrations equal to the limit values permitted in agriculture for the application of sewage sludge (Council Directive 86/278/EEC).

In addition, a long-term monitoring period (6 months) is underway to assess the leaching of heavy metals from the topsoil and subsoil, replicating a spring-summer rainfall cycle typical of the Milan area. The experiment also aims to verify: (i) the relationship between the rate of water infiltration and the activity of the pedofauna, in particular earthworms; (ii) the root uptake of the exchangeable and soluble fractions of heavy metals by vegetation (*Festuca* spp.).

The data obtained will be used to develop simulation models of soil water infiltration and heavy metal leaching.

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