Identification of hydric functioning patterns during the early pedogenesis of a Constructed Technosol

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Summary

In situ lysimetric columns are here used to study the over-all functioning and pedogenesis of a constructed soil, resulting from the deliberate combination of various anthropic materials. Our work focused on the evolution of the water distribution inside the soil as an indicator of the evolution of the soil structure. Significant results were obtained highlighting the fact that constructed Technosols are structuring by global compaction and change of the porosity distribution involving drastic changes in hydrodynamic. This evolution is fast and intense which can be considered as an original characteristic of Technosols' pedogenesis.

Scientific issue

In soil science, the common approach to describe soil functioning and pedogenesis was classically based on the collection of isolated samples at different depths and time steps (monthly, yearly). Numerical visualization and modeling emerged recently as powerful tools to extrapolate soil behavior. These approaches are mainly based on analytical solutions that transform a succession of discrete parameters into a dynamic evolution of a whole pedon.

On contrary, the use of *in situ* lysimetric device gives access to less (or different) continuous parameters – *i.e.* hydric mass balance, temperature, leachates composition -. Their evolutions reflect the functioning and, in some way, the pedogenic processes that occur at the pedon scale.

Context of the research

Soils developed on non-traditional substrates and largely due to intensive human activity are now referenced as Technosols in the world reference base for soil resources (WRBSR). They are composed of various materials some of which have no equivalent in nature: technogenic materials, *i.e.* artefacts. The process of soil construction for the reclamation of derelict lands is based on the recycling of secondary by-products. Based on the pedological engineering concepts, these artefacts are combined to construct a new soil (Technosol) over *in situ* brownfield substrates. A major scientific issue is to assess the functionality and sustainability of such Technosols. Integrating the fact that constructed soils interact with their environment, they are submitted to a drastic evolution. Our work aims at understanding and predicting the pedogenic processes with a particular attention on the evolution of the structure at different scales by using the analysis of the hydrodynamic.

Materials & methods

Parent materials

Three different artefacts were used: i) a green-waste compost (g.w. compost) mainly composed of urban tree and grass cuttings, licensed under NF U 44-051 standard; ii) a paper-mill sludge (p.m. sludge), which is a by-product of the paper industry; iii) a thermally treated industrial soil (treated soil) excavated from a former coking plant site initially heavily polluted with polycyclic aromatic hydrocarbons (PAHs).

Experimental set-up

Field experiments were set up on the experimental site of the French Scientific Interest Group – Industrial Wasteland (GISFI) (http://www.gisfi.fr), Homécourt, North-Eastern France. The climate is continental with a mean rainfall of 760 mm year–1 and a mean temperature of 10°C (extreme values: 38°C to –22°C). The first device consisted in a 100 m² experimental plot that was sampled every year by digging a pedological pit to observe measure and take samples. The other one is a gravitation equipped lysimetric column of 2 m³ (surface: 1 m², depth: 2m) with different probes (TDR, tensiometer, temperature) at different depth (50, 100 & 150 cm) and a continuous weighing.

Constructed soil formulation

The model constructed soil that is studied is composed of different artefacts that are layered to build a whole pedon. It was designed in a pedological engineering approach with reasoned mixing and superposition of materials (Séré *et al.* 2008). It was filled (Fig. 1) with i) a 45 cm-layer of p.m. sludge, ii) a 125 cm layer of treated soil and p.m. sludge mixture (1:1 volumetric ratio) and iii) a 15 cm layer of g.w. compost.

Results

Experimental plot

The constructed soil profile showed clear evidence of a rapid development of new horizons that can be visually distinguished according to their structure, color and to the root density (Séré *et al.* 2010) (Fig. 1).

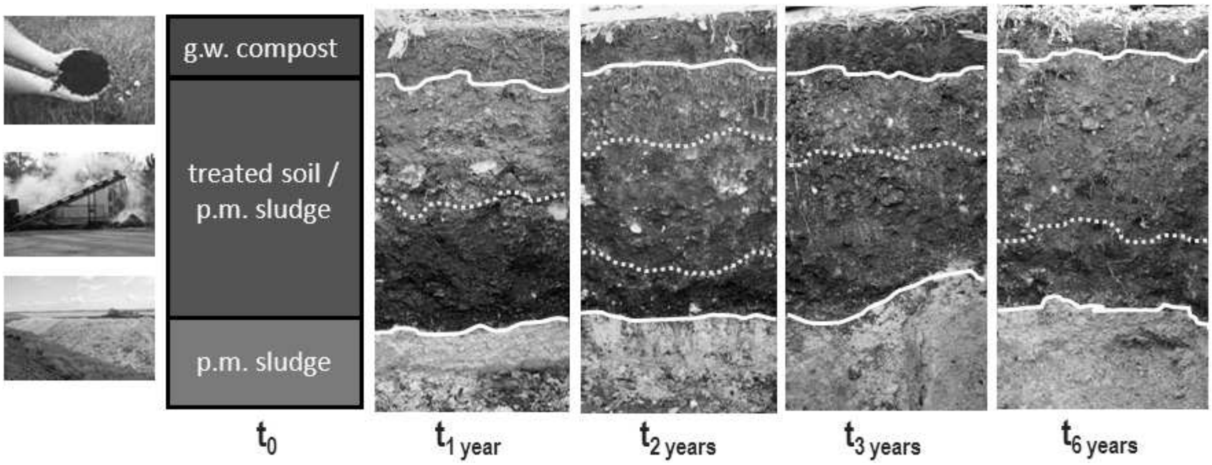

Fig. 1. Chronosequence of the early pedogenesis of a constructed Technosol

The distribution of the porosity (microporosity and macroporosity) evolves within 3 years with an increase of the microporosity in the upper part of the soils, whereas it decreased in the bottom part (Fig. 2).

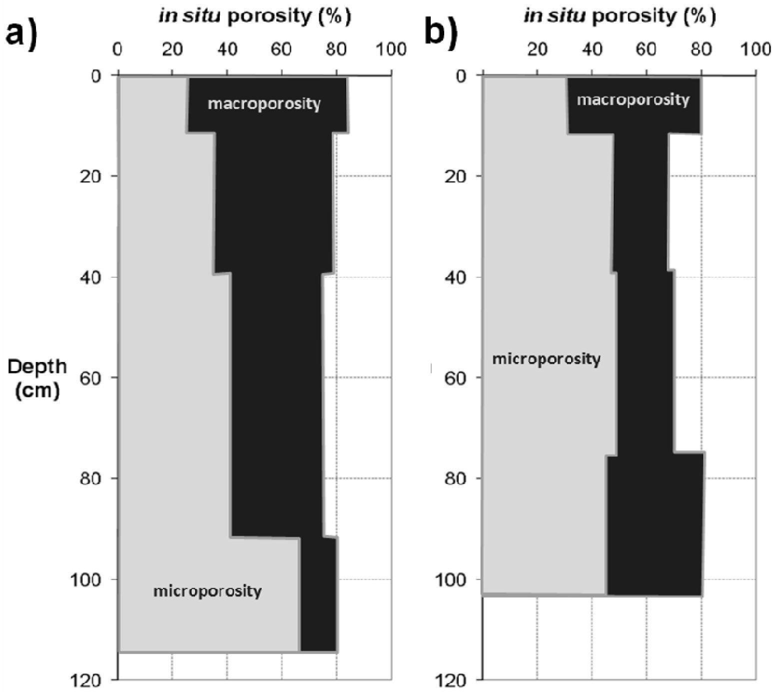

Fig. 2. Evolution of the porosity distribution in profile P over time in the experimental plot a) after 6 months; b) after 30 months

Lysimetric column

The study of the patterns (fast increase – plateau with slight variations – fast decrease) of the water content (Fig. 3) indicates an evolution with time of the hydric functioning during the 3 years. That observation is confirmed by the curve of the leachates volumes (Fig. 3) which slopes of different events (winter/spring vs summer/fall) changed significantly with time. Further considerations including meteorological data indicate that the difference in rainfalls did not explain all of these variations.

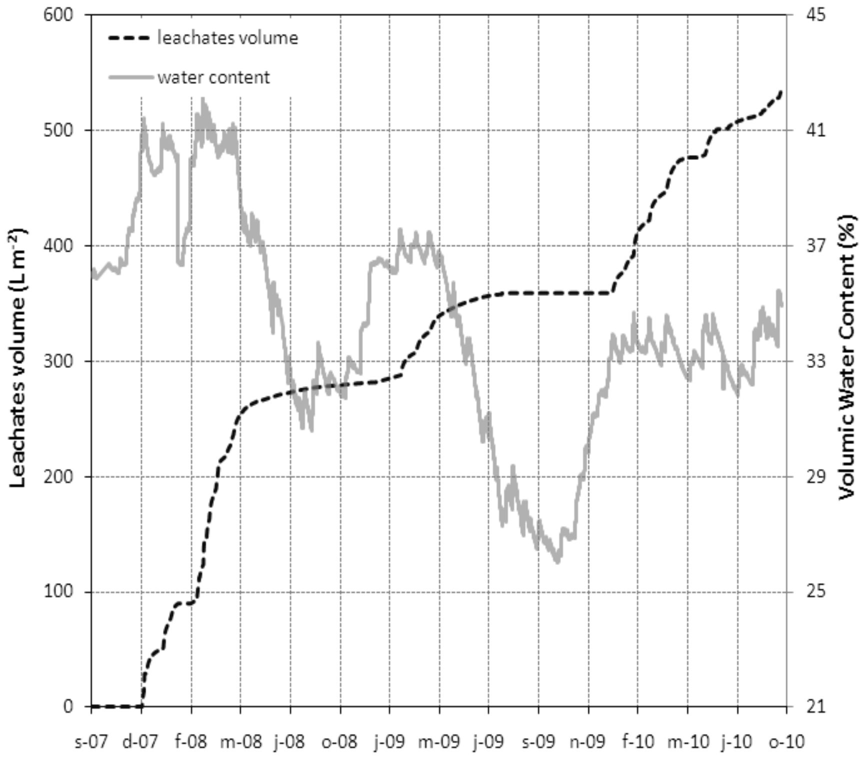

Fig. 3. Evolution of the volumetric water content and of the collected leachates volumes over time in the lysimetric column

Conclusion

Considering punctual parameters (experimental plot) as well as continuous data (lysimetric column), it appears that the early pedogenic evolution of the constructed Technosol is fast and intense. Further works are needed to identify the contribution of the pedogenesis to the evolution of the hydric functioning compared to seasonal changes.

References

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