Combining field measurements and biotest to assess lead and zinc phytoavailability in contaminated urban soils

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1. Introduction

The French legislation on the recycling of wastes from wastewater treatment plants (i.e. sewage sludge and treated wastewater) forbids waste application to soil when total concentration of trace elements in soil exceed a given threshold for each trace element. An exemption is however permitted for soils which exhibit a low mobility and phytoavailability of exceeding trace elements.

A guideline was provided to stakeholders to proof the low mobility and phytoavailability of exceeding trace elements [1]. This guideline requires first to show that the mobility and the phytoavailability of trace elements estimated by chemical extractions is lower than given thresholds and secondly that phytoavailability estimated on soil-grown plants is not higher in contaminated soils than in uncontaminated soils.

Due to the lack of adequate plant biotest at the time the guideline was published (i.e. in 2005), the guideline suggests to measure in the second step trace element phytoavailability in the aerial parts of plants collected in situ in contaminated and uncontaminated soils. Since 2015, a plant biotest (i.e the RHIZOtest) was however standardised specifically to assess trace element phytoavailability. In comparison with field-collected plants, such a biotest should enable to increase the comparability of data achieved in soils exhibiting very contrasted physical-chemical properties or plant species, as for soils usually collected in urban environment.

The present study thus aimed at applying the guideline methodology with the combination of RHIZOtest and field measurements to lead (Pb) and zinc (Zn) contaminated urban soils on which irrigation with treated wastewater was foreseen.

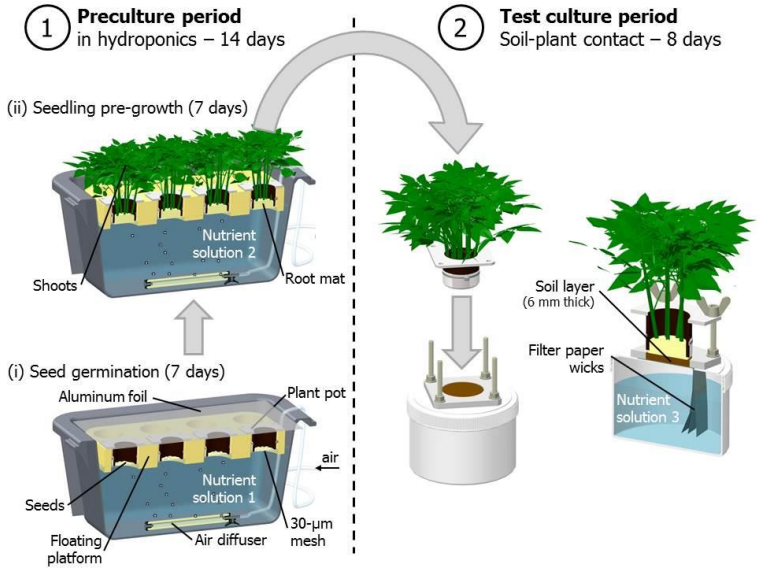

Figure 1: Standardised experimental procedure of plant growth in RHIZOtest [2].

2. Materials and methods

The study was carried out in the city of Le Port in the island of Réunion (Indian ocean). Soils from this city were contaminated in Pb and Zn by the past, intensive industrial activity. Fifteen soil samples (hereafter referred to as soil) were collected in representative sites expected to be irrigated with treated wastewater. Usual physical-chemical properties and total trace element concentration in the 15 soils were measured.

According to the first step of the guideline for exemption [1], the mobility and the phytoavailability of Pb and Zn was first estimated on the 15 soils with $CaCl_2$ and NH_4NO_3 extractions, respectively.

According to the second step of the guideline for exemption [1], the phytoavailability of Pb and Zn was secondly estimated on 10 out of the 15 soils by measuring Pb and Zn concentration in the aerial parts of field-collected plants. In addition, the RHIZOtest was performed on the 10 soils by using fescue (*Festuca arundinacea* cv. calina) as a representative species of graminaceous species collected in the field (*Fig 1*). Phytoavailability was measured as the uptake flux of Pb and Zn in the whole plants exposed to soils.

3. Results and discussion

While NH_4NO_3-extracted trace elements never exceeded the guideline thresholds, the thresholds for the $CaCl_2$ extraction were exceed for Pb and Zn in the soil 4 and for Cu and Cr in the soils 3 and 9. Accordingly, the soil 4 was rejected from exemption and considered as the upper reference for the second step. As total Cu and Cr concentrations in soils 3 and 9 were below the legislation threshold, these soils were not rejected but were considered to watch in the second step. Soils 1, 11, and 13, that exhibited total Pb and Zn concentrations below the legislation threshold, were considered as lower references in the second step. Finally, soils 5, 8, 12, and 15, that exhibited total Pb and Zn concentrations higher than the legislation threshold but lower than soils 3, 9, and 4, were considered as to be tested in the second step.

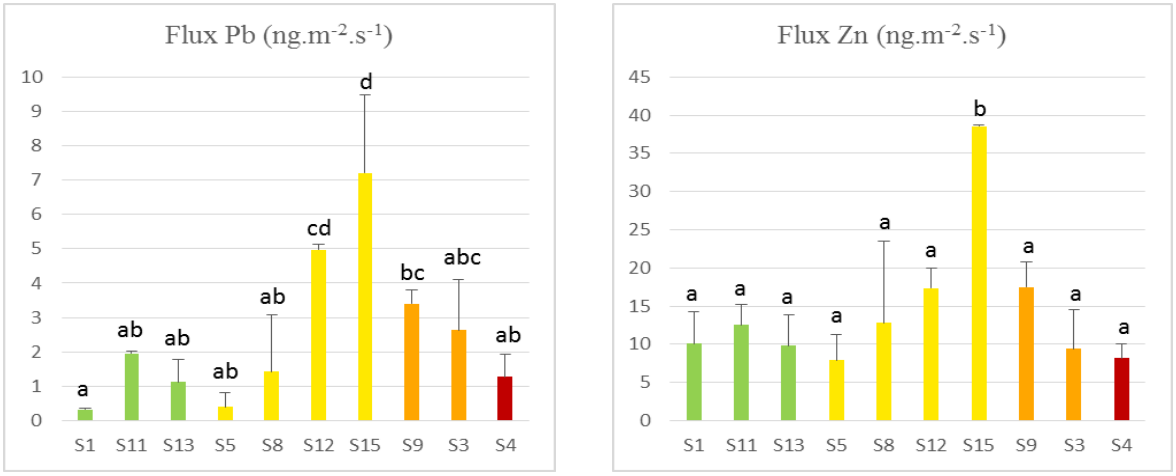

Figure 2: Lead (Pb) and zinc (Zn) phytoavailability measured in RHIZOtest in ten soils. Soils 1, 11, and 13 are lower references, soils 5, 8, 12, and 15 are to be tested, soils 3 and 9 are to watch, and soil 14 is the upper reference (see Results and discussion for rationale).

As expected, field-collected plants exhibited a large range of Pb concentration in leaves, irrespective of total Pb and Zn concentrations and Pb and Zn mobility and phytoavailability measured in soils in the first step. In comparison, RHIZOtest measurements showed that only the soil 15 exhibited a significantly higher phytoavailbility than other soils and have consequently to be rejected from exemption in addition to the soil 4 (*Fig 2*).

4. Conclusions

This study showed how the use of a biotest dedicated to the measurement of trace element phytoavailability in combinaison with field measurements was useful to assess the risk of high phytoavailability in contaminated urban soils.

5. References

[1] ADEME et APCA. 2005. Dérogations relatives à la réglementation sur l'épandage des boues de stations d'épuration. Comment formuler une demande pour les sols à teneurs naturelles élevées en éléments traces métalliques ? Guide technique. J. Béraud, A. Bispo (coord.). D. Baize, T. Sterckeman, A. Piquet, H. Ciesielski, J. Béraud, A. Bispo (authors).

[2] NF EN ISO 16198. 2015. Soil quality – Plant-based test to assess the environmental bioavailability of trace elements to plants.

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