Assessing the Risk of Soilborne Heavy Metals Leaching in an Andosol after Sewage Sludge Spreading

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Introduction

In Réunion, volcanic island in the Indian Ocean (Fig. 1), about 70% of the arable land area is covered by andic soils. Sewage sludge spreading on these soils is generally prohibited because heavy metals content in soils is above the standard threshold values (in mg.kg^{-1} : Cu = 100, Zn = 300, Ni = 50 and Cr = 150) set by French legislation (Doelsch et al., 2006). To assess the risk of heavy metals leaching after sewage sludge application, we circumvented this restriction by working in the laboratory with an original column device.

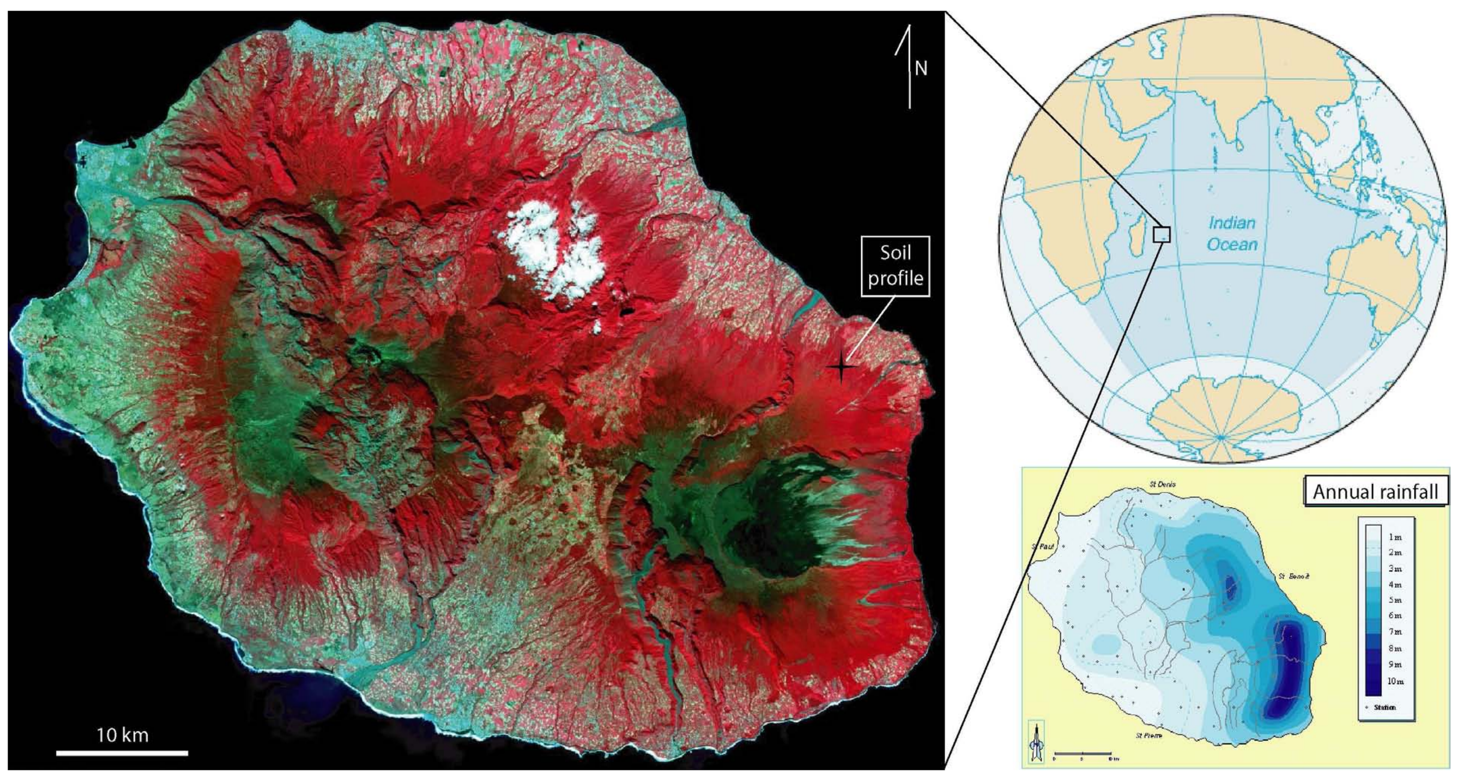

Fig. 1 – Annual rainfall and localisation of Réunion island and the sampling site.

Material and methods

The soil

A Silic Andosol from Sainte-Rose (Fig. 1) was selected for it's high heavy metal contents respectively for H1 (0-22 cm) and H2 (22-50 cm) in mg.kg^{-1}: Cu = 73–126, Zn = 135–167, Ni = 273–581 and Cr = 490–462.

The soil was packed in three large columns (Fig. 2).

The amendment

Sewage sludge was spread (5.4 T.ha^{-1} dry matter equivalent to 350 kg N.ha^{-1}), on columns 1 and 2 while the control column 3 remained untreated. **This amendment represented 8 and 6% of the total initial soil content for Zn and Cu respectively, and ca. 1% for Ni and Cr.**

The measurements

Over a 4-month period these columns received water applications. The columns were equipped equally to monitor water and solutes contents and fluxes (Fig 2). Soil solution and drainage water were collected and used to measure Eh, pH, electrical conductivity (EC), dissolved O_2, dissolved organic carbon (DOC), and Zn, Cu, Cr and Ni contents.

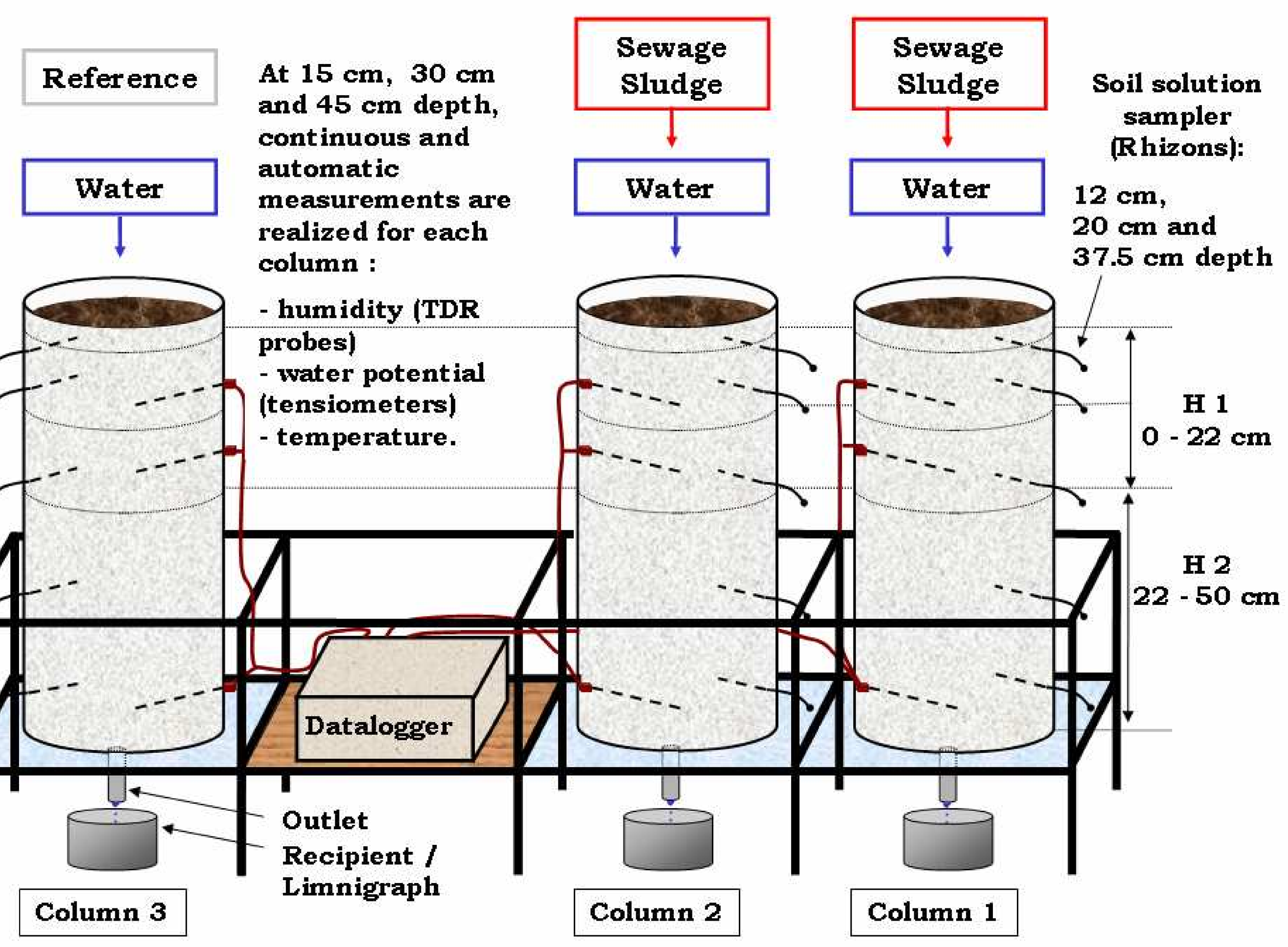

Fig. 2 – Experimental device.

Results and discussion

Physico-chemical parameters

Eh and pH variations were negligible at all depths after 20 days for the three columns. Dissolved O_2 decreased slowly from 4 to 1 mg.L^{-1} for columns 2 and 3 and stayed close to 3 mg.L^{-1} for column 1 (Fig. 3).

At 12 and 20 cm depth, EC increased up to 1.1 mS.cm^{-1} for columns 2 and 3.

For the two amended columns, the peak concentration of DOC (180 mg.L^{-1}) was reached after 90 days (Fig. 3) at 12 and 20 cm depth but no breakthrough at 37.5 cm.

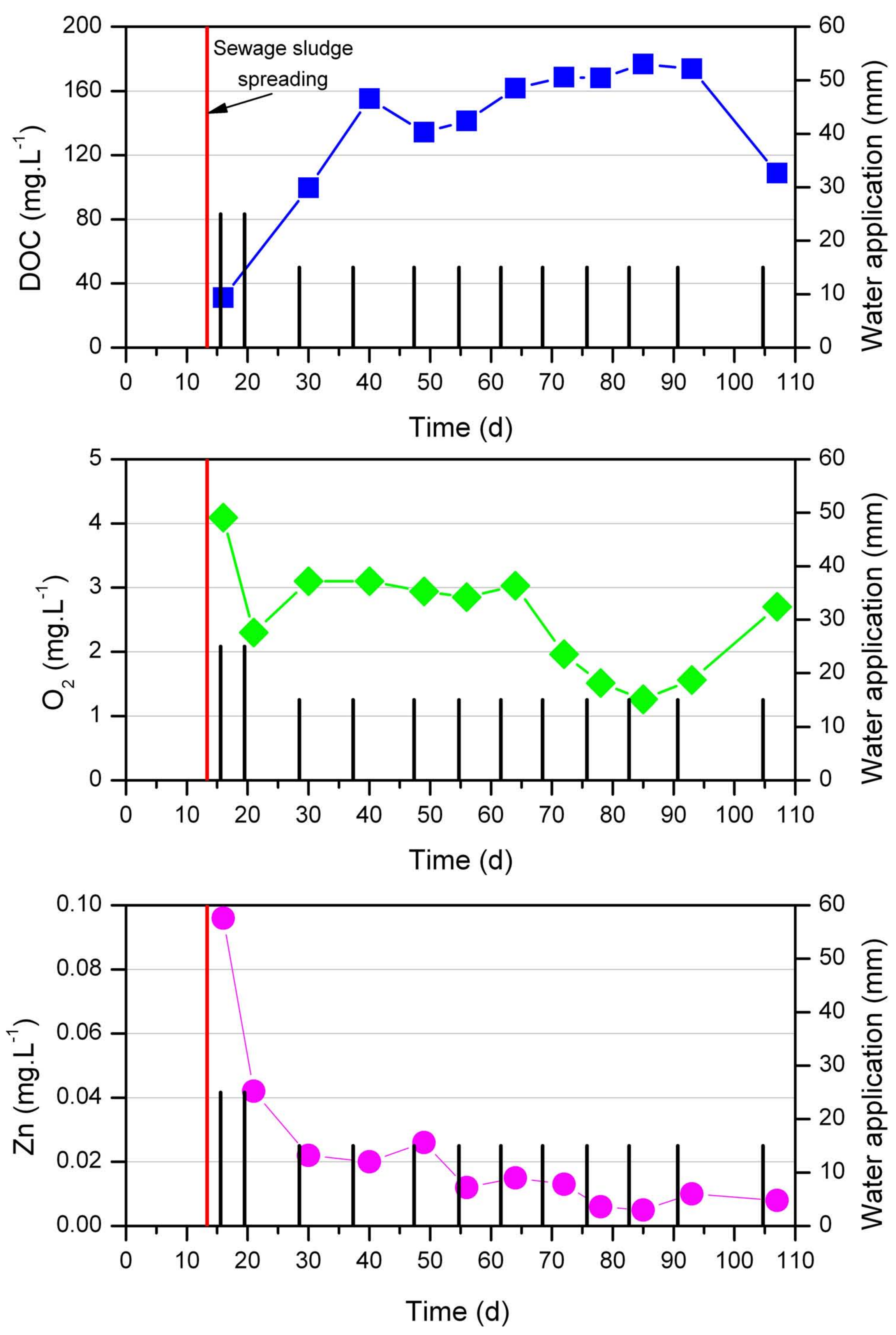

Fig. 3 – Examples of DOC, O_2 and Zn concentration during experimentation (12 cm depth, column 2).

Heavy Metal leaching

In soil solutions, Cr was not mobile (Cr < 0.005 mg.L^{-1}) and Ni and Zn concentrations (Fig. 3) were always very low (Ni < 0.02 mg.L^{-1} and Zn < 0.1 mg.L^{-1}).

Total amounts of leached metals were calculated on the basis of measured water flows and concentrations.

Massive input of sewage sludge induced no substantial heavy metal leaching flux at any depth, in spite of the high initial metals content of the Andosol.

Conclusion

Leaching risk of heavy metals appeared low for this soil after sewage sludge spreading (short term experiment). Longer experiments and investigation on metals speciation is required though to back up this result.

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Reference Doelsch, E., Van de Kerchove, V., Saint Macary, H. (2006) Heavy metal content in soils of Reunion (Indian Ocean). Geoderma.

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