DGT (diffusive gradients in thin films) can model metal uptake by durum wheat from acidic soils amended with sewage sludge and urban composts

Senda Zarrouk[1,2,3,4], **Alain Bermond**[1,4], **Naïma Kolsi Benzina**[2], **Valérie Sappin-Didier**[3] **and Laurence Denaix**[3]

(1) AgroParisTech, Laboratoire de Chimie Analytique, 75005 Paris, FR
(2) INRA, UMR Environment & Arable Crops, 78850, Thiverval-Grignon, FR
(3) INAT, Laboratoire des Sciences du Sol et Environnement, 1082 Tunis, TN
(4) INRA, UMR 1220 TCEM, F-33883 Villenave d_'Ornon, FR
senda.zarrouk@agroparistech.fr

Introduction

It is well kwon that he spreading of sewage sludge or urban compost on agricultural soils increases their total concentration in trace elements, but the effect of these products on metal bioavailability is still unclear. To assess the contamination risk for the humans via the food chain, we need first to predict the uptake of metals from soils by crops. Mathematical models of micro-nutrient uptake by plants have usually been based on models designed for uptake of major nutrients (Barber 1995) [1] but they need a complete set of parameters. An in situ technique, DGT (diffusive gradients in thin-films) developed by Davison and Zhang (1994) [2] measure directly the metal flux to a surface, mimicking the diffusive flux to the roots.

The aim of our work was then to propose a simple way to model the uptake of cadmium and lead in acid soils amended with sewage sludge and urban composts using DGT measurements and root surface.

Material and Methods

Field experiment

Wheat was planted in pots on sandy soil samples contaminated by urban compost or sewage sludge amendments over a twenty year period (experimental site of Couhins, Bordeaux, France, SOERE-PRO). The chemical compositions of soil solution were monitored over a 28-day culture of durum wheat in soils. DGT devices were placed weekly directly on pots.

Modelling

To model the uptake of trace metal in the soil, we assumed that roots absorb all the metals present at their surface through the diffusive and convective fluxes. The total metal uptake Q is then the sum of the metal quantities arriving through mass flow ($Q_{convective}$) and the metal quantities diffusing through the soil to the roots ($Q_{diffusive}$).

Free Cd^{2+} and Pb^{2+} solution concentrations were assessed by calculation using the Visual MINTEQ V.2.30 geochemical model.

Results

The convective flux of metallic ions was less than 23% for Cd or 3% for Pb. The diffusive flux modelled using the DGT flux and root surface area resulted in successful prediction of total metal uptake by young wheat plants but the surface take into account was different depending on the metal. For Pb, the total metal accumulation was correctly estimated considering that only the apex absorbed the metal. For Cd, the better estimation was found if we consider that the total root surface absorb the metal. This could be due to different mechanisms of the plants for the uptake of these two unessential metals.

Conclusion and perspectives

In the case of moderately contaminated soil, DGT application offers the possibility of a simple test procedure to assess risks of metal transfer to plants and then to enter in the food chain. Moreover, it makes it possible to predict the quantities of cadmium or lead accumulated by plants.

References

[1] Barber S A 1995 Soil Nutrient Bioavailability: A Mechanistic Approach. John Wiley & sons Inc, New York pp. 110–132.

[2] Davison W, Zhang H 1994 In-situ Speciation Measurements of Trace Components in Natural-Waters Using Thin-Film Gels. Nature 367: 546-548.

Keywords

Bioavailability, DGT, metals, organic amendment, soil solution