Determination of Metal Speciation in Solution Phase of Biosolid and Contaminated Soil via VisualMinteq Model and Donnan Membrane Technique

Trang Huynh[1], Alan Baker[1], Mike McLaughlin[2], Scott Laidlaw[1] and David Gregory[3]

[1] Applied Ecology Research Group, School of Botany, University of Melbourne, Melbourne, Victoria 3010, AUSTRALIA
[2] CSIRO Land and Water, PMB2 Glen Osmond 5064, AUSTRALIA
[3] Research and Technology, Melbourne Water, Melbourne 3001, AUSTRALIA

INTRODUCTION

Soil solution has been defined as "the aqueous liquid phase of the soil and its solutes"[1]. The soil solution represents the natural medium available for plant growth. Characterisation of the soil solution will allow prediction of plant response to chemicals in the soil environment. Understanding the metal bioavailability and speciation in the soil solution is an important component in understanding the phytoextraction process. The key factor in determining bioavailability and toxicity is the concentration (or activity) of free metal ions [2]. Various techniques have been developed for the analysis of metal speciation in the aqueous phase. Most of these methods have limitations. Recent techniques such as Donnan Dialysis [3], Diffuse Gradient in Thin Film [4] and Donnan Membrane Technique [5], however, may provide a major advance in assessing metals bioavailability. These methods are however time-consuming and laborious. This study aims to find the relationship of Cd, Cu, Zn and Ni species in liquid phase of biosolid and contaminated soils predicted from geochemical models and determined from the Donnan membrane technique. This preliminary study will be applied to further investigations on the bioavailability of trace metals in a biosolid phytoremediation study at the Western Treatment Plant, Werribee, Victoria.

METHODS

Biosolid and contaminated soil samples at the Western Treatment Plan, Werribee, Melbourne Water will be used in this study. Biosolid and soils will be rewetted with Milli-Q water to water holding capacity (about -3 to -5kPa) for 16hrs at 25^{o}C [5]. Non-ionic exchange ceramic cups will be employed to collect the soil solutions. The soil solution will be analysed for: pH, EC immediately. Total heavy metals (Cd, Cu, Zn and Ni) and major cations will be analysed using ICP-OES. The anions such as Cl^-, SO_4^{2-} and NO_3^- will be analyzed on Ion Chromatography. A TOC analyzer will be used to determine the total amount of dissolved organic carbon. The most recent version of geochemical model VisualMinteq will be used to calculate the free species, inorganic and organic complexes for each of these trace elements from the above chemical properties.

The Donnan membrane technique will be carried out in above soil solution samples and directly with soil column. This technique utilizes a continuous flow system with a donor cell and an acceptor cell, separated by a negatively charged membrane held by two O-rings. The donor and acceptor sides are constructed in a similar way to achieve optimal flushing across the membrane, which leads to a minimal flushing time to reach equilibrium. In the first case soil solution samples will be continuously circulated in the donor cell. In the later case the 200g soil column rewetted at water holding capacity will connect with the donor cell. Soil solution is vacuated from the top of soil column and circulated though the donor side. The acceptor cell is connected with a test tube containing 2 mM $Ca(NO_3)_2$ solution at pH 5. After

12, 24, 48 and 96 h, the donor and acceptor solution will be sampled. Free metals Cd^{2+}, Cu^{2+}, Zn^{2+} and Ni^{2+} in acceptor solution and total metals from the donor side will be determined by ICP-OES.

RESULTS AND DISCUSSION

The metal species present as calculated by both methods will be compared and the degree of linearity between them determined. The results will be presented and discussed at the conference.

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