Land application of sewage sludge: A soil columns study

G Gascó[1]*, MC Lobo[2] and F Guerrero[1]

[1]*Departamento de Edafología. Escuela Técnica Superior de Agrónomos. Universidad Politécnica de Madrid. Av. Complutense sn. 28043 Madrid. Spain.*

[2] *IMIA. Finca "El Encín". Apdo. 127. 28800 Alcalá de Henares. Madrid. Spain.*

Abstract

A column study was conducted to assess the potential Cr, Ni, Cu, Zn, Cd and Pb movement through a reconstructed soil profile to which surface composted sewage sludge was applied. Sewage sludge was mixed into the top 100 mm of each column at the rates of 357 (H), 223 (M) and 22 Mg·ha^{-1} (L). Treatment H was calculated according to the critical soil concentration and treatments M and L were calculated according to the amount of metals which may be added to agricultural land on 10 yr average (M) and 1 yr (L) according to European legislation. Soil columns were leached with 5 000 mℓ of water. After leaching, soil columns were sampled at depth intervals of 0 to 100, 100 to 300, 300 to 500 and 500 to 840 mm. Metal balance accounted for over 97% of metals and over 86% of metals were retained in the first 100 mm of the column. The average percentage of metals leached decreased in the order Cd (0.04%) > Cu (0.02) ~ Ni (0.02) ~ Zn (0.02) > Pb (0.01) ~ Cr (0.01). The maximum metal concentration in leachates was lower than the limit value for irrigation water but metal concentrations exceeded the drinking water levels for Pb and Ni in all treatments. Thus, harmful health effects may result from the application of sewage sludge.

Keywords: metals, sewage sludge, soil and water pollution

Introduction

Sewage sludges are inevitable by-products of wastewater purification. Over the past decades, there has been a significant increase in sewage sludge production from wastewater treatment plants due to the major limitations in wastewater disposal and the increase in the percentage of households connected to central treatment plants. Consequently, the world is currently undergoing a rapid increase in sludge production that is expected to continue in coming years.

At the moment, the conventional uses of sewage sludges include industrial utilisation, landfill, combustion and composting for farmland utilisation (Sánchez Monedero et al., 2004). Composted sewage sludge applied to agricultural land to improve soil fertility is a widespread practice in Mediterranean areas. Compost supplies a high content of organic matter with favourable effects on soil physical, chemical and microbiological properties. Organic matter improves soil structure, infiltration rate, aggregate stability to raindrop impact and water holding capacity of the soil (Sort and Alcañiz, 1999). Indeed, the addition of organic residues reduces soil loss and runoff (Ojeda et al., 2003). However, composted sewage sludge has a high metal and soluble salts content which could constitute a toxic threat to plants and a contamination source due to its potential lixiviation to groundwater.

Several countries have regulated the use of sewage sludge in agriculture to avoid harmful effects on soil, vegetation, animals and human being. For example, European Communities (European Community, 1986) and the United States of America (USEPA, 1997a) have fixed limit values for concentrations of metals in soil and sewage sludge for use in agriculture and have determined limit values for amounts of metals which may be added annually, based on a 10-year average in European legislation or 20-year average in American regulations. Nevertheless, regulations in European countries and the USA differ largely with respect to requirements of organic waste quality and the quantities of pollutants which can be added to the soil (Düring and Gäth, 2002). For this reason, both field and laboratory experiments are necessary to measure the critical load which can be supported by different soils.

Various researchers have studied the potential lixiviation of metals after sewage sludge applications in different soils. Berti and Jacobs (1998) studied distribution of trace elements Cr, Ni, Cu, Zn, Cd and Pb in a Typic Hapludaf after application of sewage sludge at total rates of 240, 690 and 870 Mg·ha^{-1} over a period of 10 years and observed that > 90% of metals applied were recovered from surface soil. Sloan et al. (1998) obtained similar percentages of metals recovery in sandy-loam soils after cumulative biosolids loadings of 0, 60, 120 and 180 Mg·ha^{-1}. McGrath and Lane (1989) concluded that metals movement was practically limited to a depth of 100 mm.

However, metal movement occurs and metals leaching through the soil could contaminate groundwater (Reynolds et al., 2002; Emmerich, 1982; Singh et al., 2000).

Soil column studies can be an appropriate methodology to assess metals movement in soils since the possible errors caused by sampling or plant uptake can be avoided. For example, Vogeler (2001) used leaching columns to study copper transport trough a dryland Dystric Fluventic Eutochrept and an Ustollic Haplargid, or more recently, Voegelin et al. (2003) used soil columns to investigate the potential of metal release in response to soil acidification in non-calcareous and neutral soil.

The main objective of this work was to study the balance of metals in a reconstructed soil profile to which three treatments of a composted sewage sludge were applied. The experiment was completed with the measurement of electrical conductivity

* To whom all correspondence should be addressed.
☎ +3491-3365691; fax: +3491-3365680;
e-mail: gabriel.gasco@upm.es
Received 8 September 2004; accepted in revised form 6 March 2005.