Copper Availability in Biosolids

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Table of Contents

Abstract

Biosolids from sewage treatment plants present both problems and opportunities for society. They are rich in organic matter, nutrients and trace elements and so can be effective soil conditioners, potentially improving both soil structure and fertility. However, they commonly contain high concentrations of heavy metals, which can accumulate to toxic levels in soils receiving frequent or high dose applications. Copper (Cu) is one of the metals of chief concern because it often has high concentrations in biosolids and is capable of exerting a toxic effect on soil microbes. Limits are placed on the amounts of biosolids that can be applied to land to prevent soil accumulation of metals, but these regulatory limits are based on the total metal concentrations in soils and biosolids rather than on the portion that is ecologically active. Therefore, current regulations do not take into account the fact that much of the metal content is bound up in a way that renders it non-active, and thus poses no threat to the environment. A more environmentally relevant regulatory system would set its limits using the available portion of metals. Therefore it is important to quantify this available fraction, and to establish a method by which it can be consistently measured. To do this the nature of biosolids needs to be better understood, and the factors controlling the available fraction need to be identified. Also, it is important to determine how the available fraction may change with time.

This PhD project surveyed 24 biosolids from around Australia and characterised them in terms of chemical and physical properties. Available Cu was measured using radio isotopic techniques (^{64}Cu), a Cu^{2+} ion selective electrode, solution extraction, and other methods. A model for predicting available Cu was produced, using the total Cu concentration and the Cu^{2+} ion activity in solution extracts:

$$\text{Available Cu (mg/kg)} = 281.5 \text{ Log Total Cu} - 14.9\ pCu^{2+} - 459 \qquad (R^2 = 0.806)$$

where 'logTotal Cu' is $\log_{10}$ total biosolid Cu concentration (mg/kg).

A 21-month incubation experiment was conducted to monitor Cu availability over time, with the conclusion that it will remain constant if pH is maintained. Biosolid/soil pH had a strong effect on available Cu, hence a regulatory system based on the available Cu fraction that incorporates a pH protection index is proposed. Mineralisation of organic matter did not lead to increases in available Cu, thus no evidence for the time bomb hypothesis was found. However, organic matter was found to be important for Cu sorption in some biosolids, indicating that over a longer term effects of organic mineralisation on Cu availability may be seen, and therefore longer trials (*i.e.* > 10 years) are needed to determine the long-term fate of biosolid Cu.