# The Relative Toxicity andAttenuation of Cd, Cu and Zn on Acidic NSW Soils: A Comparison Between Inorganic Salts and Biosolids Treatments

Mark Whatmuff[1], Michael Warne[2], Mike McLaughlin[2], Kris Broos[2]

[1] New South Wales Department of Primary Industry, Richmond Office, Locked Bag 4, Richmond NSW, 2753 AUSTRALIA (mark.whatmuff@agric.nsw.gov.au),
[2]Centre for Environmental Contaminants Research CSIRO PMB 2 Glen Osmond SA 5064, AUSTRALIA

## INTRODUCTION

Biosolids guidelines in Australia are based mostly on overseas data because there is little information collected under local conditions (McLaughlin *et al.* 2000). At the same time, biosolids guidelines are being inappropriately used as surrogates for regulating other metal containing wastes. To address these issues, a National Biosolids Research Program (NBRP) has been established on sites across Australia. This paper presents results from the NBRP sites in NSW, comparing the toxicity and attenuation of metals applied as metal salts with those applied with biosolids.

## METHODOLOGY

Field trials, each comprising a metal-salt and a biosolids experiment, were established on two contrasting NSW soil types; Flat Paddock (FP) site (Aridisol) and Night Paddock (NP) site (Brown Soil), at a dedicated research facility, SW of Sydney. The metal-salt experiment identified the plant, soil fauna and microbial responses under a worst case scenario. Metals (Cd, Cu and Zn) were applied at a range of soil concentrations (non-toxic to toxic), as either Cl or $NO_3$ salts. The biosolids experiment identified the response to metals applied with biosolids and other waste materials. Biosolids were applied at rates up to four times higher than normal agronomic practice. For both experiments, these responses were determined in terms of both total (*aqua regia* extractable) and easily extractable (using 0.01*M* $CaCl_2$) soil metals, as well as metal levels measured in displaced soil pore water.

Wheat was used as the field test crop with early growth (8 week herbage mass) and grain yield used as indicators of metal phytotoxicity, and grain samples analysed for Cd content. Soils were sampled immediately after treatment application (T0) and under each crop at harvest (T1-T3). Two soil microbial function tests were also carried out (substrate induced nitrification, SIN and substrate induced respiration, SIR) on all treated soils. Samples from the metal salt trials were used to assess the impact of these metals on earthworm survival.

## RESULTS AND DISCUSSION

Initial data (T0) suggest that the soil microbial SIN test was generally more sensitive to excessive soil metal levels, compared to plant growth and toxicity to soil invertebrates, although there were soil type differences (Table 1). Of the methods tested, the SIR test proved to be the least sensitive to applied metals. The response to the applied metals was generally more sensitive on the FP soil indicating that this soil is less able to adsorb the applied metals than at the NP site.

Generally, the microbial $EC_{10}$ data (soil concentration where 10% effect measured) for Cu and Zn at both sites show a toxic response to the inorganic metal-salts, at soil metal concentrations close to or below current NSW biosolids guideline soil metal limits, as do both Cu and Zn plant-growth $EC_{10}$ data for the FP, and Cu $EC_{10}$ data for the NP (data not shown). Although there was no metal toxicity seen in plants grown on biosolids amended

**Table 1. The relative sensitivity of tests used to assess metal toxicity at the experimental site**

| | Most sensitive ... Least Sensitive |
|---|---|
| Night Paddock | |
| Zn | SIN << Growth ≈ Worm mort. ≤ Yield < SIR |
| Cu | Growth << Worm mort. = Yield < SIN < SIR |
| Flat Paddock | |
| Zn | SIN << Growth ≈ Worm mort. ≤ Yield < SIR |
| Cu | SIN = Worm mort. = Growth = Yield < SIR |

Growth = 8 week herbage mass; Yield = grain yield; Worm mort.= worm mortality rate

soils, high biosolids rates lowered soil SIN values on the site. This apparent toxicity occurred at soil metal concentrations well below those expected to cause a toxic response.

Chemical analysis of soils has indicated a decrease over time in the relative concentration of metals in displaced pore waters for both metal-salt and biosolids treated soils. However, similar trends were not seen in the concentration of metals extractable with 0.01*M* $CaCl_2$ (Figure 1), although this effect differed for each of the metals tested. Both of the soils tested are highly acidic in their unamended state (pH measured in 0.01*M* $CaCl_2$ 5 – 5.5 for the NP and pH 4.5 for the FP), and this has contributed to the lack of metal adsorption by the soil.

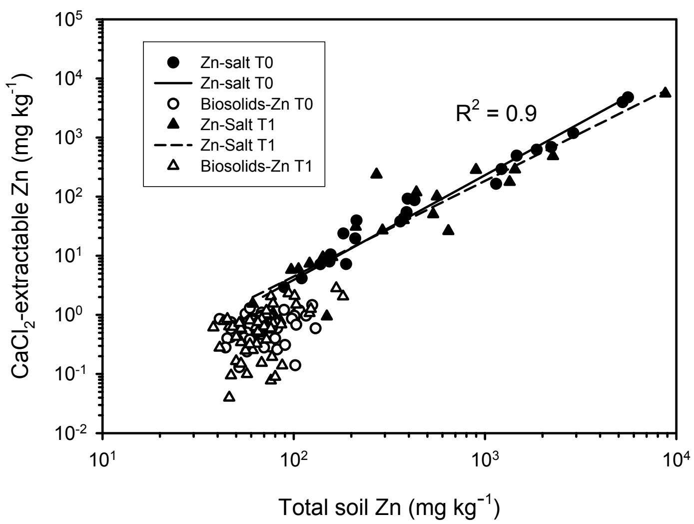


**Figure 1 Changes in the proportion of total soil Zn extractable with $CaCl_2$ from the NP soil in the year following Zn addition as either an inorganic salt or with biosolids. T0 = initial sampling immediately after application and T1 = 1 year sampling**

## CONCLUSIONS

Initial data shows that the microbial populations on these acidic soils are more sensitive to applied metals than plant growth or soil invertebrates (earthworms). There is little evidence for decreased metal extractability in the early years following metal addition to these soils, applied either as inorganic salts or with biosolids.

## REFERENCES


McLaughlin, MJ, Hamon, RE, McLaren, RG, Speir, TW, Rogers, SL. Review: A bioavailability-based rationale for controlling metal and metalloid contamination of agricultural land in Australia and New Zealand. *Australian Journal of Soil Research*. 2000 38(6):1037-1086.