Use of Zinc in Agriculture: an Assessment of Data for Evidence of Accumulation in Waikato Soils, Surface Water and Sediments.

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Abstract

Pastoral soils in the Waikato region of New Zealand have received high mass loads of Zn since the advent of facial eczema remedies. This activity could potentially cause widespread Zn accumulation in receiving soils, and mobilisation and contamination of nearby receiving environments, presenting risk to ecological health. Currently, no studies have examined the environmental fate of significant sources of anthropogenic Zn used in farming. This study assessed the extent and nature of any evidence that facial eczema Zn is causing significant contamination of agricultural soils and associated ecosystems in the Waikato region of New Zealand by examining extensive soil, surface water, and sediment datasets. Farmed surface soils contained two times more AR Zn on average (60.6 mg/kg, $p<0.0001$) than natural soils and significant relative enrichment of SSP fertiliser elements Cd, P, Ca, U, F and Ni. Including Zn, these elements decreased down the soil profile, indicating anthropogenic sources. Zn accumulation occurred more readily in inorganic, granular, and allophanic soils. Laboratory experiments showed rapid Zn adsorption in granular soil at the natural soil pH level of 5.70 (>90% of the total concentration within 5 mins and ~97% at equilibrium). This reduced to ~62% adsorption at pH 4.70, indicating Zn re-mobilization in acid soils. No significant change in Zn concentration was observed in farmed soils (average of 7 years) but a 25% decrease ($p<0.05$) was observed in forestry soils (average of 7.4 years). Approximately 11% of sampled pastoral soils exceeded 100 mg/kg AR Zn but all were below the Biosolids Guideline value of 300 mg/kg. Approximately 112.5 kg Zn/day is carried by the Waikato River ($p<0.0001$), with ~50% in the dissolved fraction. Zn concentrations peaked twice with distance along the Waikato River: first in the upper reaches, along with B, Li, and As, consistent with local geothermal inputs; and again in the lower reaches, as with increased nutrient elements N, P, and turbidity, consistent with runoff from pastoral farming in the catchment area. Rapidly decreasing Zn concentrations in the River's med-section indicated fast adsorption to bed sediments. Zn concentrations and mass load increased during high-flow events in pastoral catchments of the Waikato River and other regional rivers ($p<0.001$), suggesting that soluble Zn is being mobilised. Relative to background levels, 86% of sampled Waikato lake sediments have more than twice as much Zn, and up to 73% of sampled sediments have more than twice as much Co and Ca, suggesting

substantial agricultural surface soil inputs and possible mobilization to bed sediments. Presently, sediment Zn concentrations are not high enough to cause toxicity to sediment dwelling organisms and rural lake ecosystems. Overall, results indicate that Zn is accumulating in agricultural soils and some of this is likely to be mobilised in surface runoff leading to likely accumulation of Zn in receiving lake sediments. Potential issues associated with continued Zn accumulation include loss of soil function, trace element imbalances, potential phytotoxicity, and reduction of habitable lakebeds. A number of recommendations are made, including the need for ongoing monitoring and development of suitable New Zealand ecological guideline values for protection of soil receptors and function.

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