Biosorption and Leaching of Heavy Metals from Activated Sludge Applied to Soil

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Dedicated

to my

Beloved Parents

Abstract

Accumulation of heavy metals in sewage sludge and soil and their subsequent movement to ground water and surface water are major environmental issues. Cadmium (Cd), copper (Cu), zinc (Zn), nickel (Ni) and chromium (Cr) are the most commonly occurring sludge-borne heavy metals in New Zealand. The potential toxicity of these heavy metals depends more on their availability and mobility than on their total content. This study examined the adsorption-desorption and potential leachability of these heavy metals in sewage sludge and a volcanic soil.

Results of adsorption – desorption experiments using Cd, Cu, Zn and Ni showed that activated sewage sludge sorbed Cd, Cu and Zn more effectively than Ni. Adsorption capacities of Cd, Cu and Zn were 35.7-44.8, 14.1-26.4 and 57.5-59.5 mg/g biomass, respectively. The affinity of activated sewage sludge with Ni was very low thereby no further isotherm study was carried in Ni. Biosorption increased with increases in pH. Adsorption capacity also increased with increases in initial metal ion concentration but the adsorption yield decreased. Chloride ion concentration (0.145 N) had a more significant effect on the reduction of adsorption of Cd than on the reduction of the adsorption of either Cu or Zn. A desorption study was carried out using deionized water, 0.1 N Na_2SO_4, 0.1 N K_2SO_4, 0.1 M Na citrate, and 0.1 M Na_2CO_3 solutions and the results showed that Zn desorbed more in every desorbing agent.

Results of the study of the adsorption behaviour of Zn in volcanic Egmont soil in the presence of phosphate showed an increase in adsorption of Zn and the presence of nitrate did not show any significant difference in adsorption. Both 500 and 1000 mg/kg phosphate levels reduced the water-soluble Zn in volcanic Egmont soil remarkably. The desorption study showed that more Zn was desorbed with 0.1 M KNO_3 than with deionized water and 0.1 M KH_2PO_4.

An in situ leaching study was carried out in volcanic Egmont soil using Zn amended sewage sludge and inorganic Zn as Zn sources and soil columns were pretreated with nitrate and phosphate anions. More Zn leached from inorganic Zn applied soil columns than from Zn amended sewage sludge applied soil columns. There was no substantial difference in the amount of Zn leached between nitrate and phosphate

treated columns. Determination of total acid digestible Zn in sewage sludge and inorganic Zn applied soils showed a greater accumulation of Zn in 0-10 cm depth. More Zn moved to the lowest (25-32 cm) depth in the nitrate treated inorganic Zn applied soil column and less Zn moved to the lowest (25-32 cm) soil depth in the phosphate treated sewage sludge applied column.

Fractionation of Zn in Zn amended sewage sludge showed that most of the fractions of Zn were in water-soluble and exchangeable, followed by carbonate and organically complexed forms. However, fractionation of Zn in control volcanic Egmont soil showed that most of the Zn was in oxide and residual forms. After the application of both Zn amended sewage sludge and inorganic Zn, the overall percentages of water-soluble and the exchangeable, carbonate and organically complexed forms of total Zn increased. All the fractions of Zn in both sludge and inorganic Zn applied columns decreased with the increase in soil depthFractionation of Zn in inorganic Zn applied soil showed that the increase in the exchangeable and oxide forms of Zn was higher in the phosphate than in the nitrate treatment. The overall percentage of the water-soluble and the exchangeable and the carbonate forms of total Zn increased except the organic, the oxide and the residual form in inorganic Zn applied soil columns.

The results of this study suggest that activated sewage sludge has a high affinity for Cd, Zn and Cu. Zn desorbed from sewage sludge more easily than Cu indicating that the Zn from the sewage sludge may be more reactive than Cu in soil. Ex situ and in situ studies showed that phosphate remarkably limited the Zn movement in both sewage sludge and inorganic Zn applied soils but nitrate did not have any significant impact on the movement of Zn.

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