DTPA SOIL EXTRACTABLE AND PLANT HEAVY METAL CONCENTRATIONS WITH SOIL-ADDED Cd TREATMENTS

by L. J. MILES and G. R. PARKER*

Department of Forestry and Natural Resources, Purdue University, West Lafayette, Indiana 47907

KEY WORDS

Andropogon scoparius Cadmium Copper DTPA extraction Heavy metal Lead Liatris spicata Monarda fistulosa Poa pratensis Rhus radicans Rudbeckia hirta Zinc

ABSTRACT

Seed of six plant species native to a heavy metal contaminated urban site in northwestern Indiana was collected and grown in soil from the urban site and similar soil collected from a relatively uncontaminated rural site. The rural soil was amended with CdCl₂. Plant tissue and soils were analyzed for Cd, Zn, Pb and Cu.

Soil extractable Cd concentrations increased with increasing soil-added Cd levels, a larger proportion of the added Cd becoming extractable as the soil addition level increases. Soil Cd additions also affected the levels of extractable Zn, Pb, and Cu. Soil extractable Cd levels were not, however, influenced by the plant species grown in the soil. Differences were noted between the two soils for extractable Cd concentrations, but were much smaller than the differences noted in plant Cd concentrations between the two soils.

Plant Cd levels increased linearly with soil Cd addition levels. Composites had higher Cd concentrations than other herbs or grasses tested. Total Cd content of above-ground plant biomass also increased with soil Cd addition levels, but with a non-linear, upper limit type response. Rudbeckia hirta, a composite, had similar Cd concentrations in both top and root biomass, indicating that for this species Cd is not immobilized in the root systems as for other species.

INTRODUCTION

The total amount of an element in the soil is not necessarily a reliable guide to the amount that is available to plants. The elements readily available to the plants are those in the soil solution, those exchangeable ions adsorbed on the exchange sites, and those in the readily decomposed minerals.

The availability of soil Cd to plants has been related to the ratio of the total Cd

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concentration (added) over the Cd sorptive capacity of the soil. Soil pH and CEC are perhaps the two most influential factors controlling the soil's sorptive capacity for Cd and therefore the availability of Cd for plant uptake and accumulation.

Metal analysis of plant tissue is the true measure of availability. Leaf analysis may serve as a valuable guide to diagnosing Cd toxicity. Yields may also be predicted on the basis of plant analysis. Plant species differ greatly, however, with respect to Cd uptake and accumulation, as they do for metals in general, and for metal mobility within the plant.

This study investigates the relationship between soil heavy metal availability and plant species accumulation with additions of Cd. It was also done to determine differences in accumulation of heavy metals by plant species native to a heavy metal contaminated site in northwestern Indiana.

METHODS
Several species native to an urban site contaminated with heavy metals were grown from seed in the greenhouse on soil collected from an uncontaminated rural site with various concentrations of soil-added Cd, and on soil collected from the contaminated urban site with no added Cd. Plant and soil samples were analyzed for metal content (Cd, Zn, Pb, and Cu) with nitric acid digestion of plant material and DTPA extraction of soil. Determinations were made with a Varian AA-6 atomic adsorption spectrophotometer.

DTPA extraction procedures were as given by Lindsay and Norvell. A 2:1 extractant to soil ratio and a two-hour shake time were used. Metal concentrations were determined within forty-eight hours of extraction. Two blanks were run for each extraction block.

Sample weights of 1.000 gram were used for plant analysis when that much sample was available; otherwise the total sample was weighed, placed in a digestion vessel of 300 ml and labeled. Twenty-five ml of concentrated HNO₃ was added to each of the samples which were allowed to set overnight. The next day the samples were heated in a fume hood at approximately 180°C for about four hours until the solution cleared and the final sample volume was approximately 5 ml.

After digestion was complete the samples were allowed to cool to room temperature. Samples were then transferred to 10 ml volumetric flasks. Three aliquots of 1:1 HNO₃ were used to rinse the digestion vessels, each aliquot subsequently being added to the volumetric flask. The volumetrics were then brought up to volume with 1:1 HNO₃ and mixed.

The complete samples were then diluted as needed (a series of one to ten dilutions) using 1:1 HNO₃ as the diluent. All samples and their dilutions were decanted into labels test tubes which were capped, placed in test tube racks, and sealed in plastic bags awaiting determination.

All glassware was acid soaked prior to use. Two blanks were run for each series of digestion blocks. A series of five standards, excluding a control standard, with heavy metal concentration ranges of .05–1.0, 0.5–10.0, and 2–4.0 μg metal/ml for Cd, Zn, Pb, and Cu respectively were used. For DTPA extraction the standard matrix was H₂O. For plant analysis 1:1 HNO₃ was used as the standard matrix.

Absorbance values were recorded for the standards, blanks, and samples; the standards being read both before and after the sample determinations. Simple linear regressions were obtained relating...