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LEAD UPTAKE BY *SOLIDAGO RUGOSA* AND *SPIREA LATIFOLIA*

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Abstract

The uptake of lead from soil by *Spirea latifolia* (Meadowsweet) and *Solidago rugosa* (Golden Rod) was examined. Both species showed a time dependent accumulation of lead in their tissues when grown in soil with elevated lead levels. The concentration of lead in the leaves of the *S. latifolia* was 19.2, 49.8, and 96.3 µg lead/g dry weight plant at 8, 23, and 27 weeks, respectively. The controls plants had 5.0, 27.3, and 29.4 µg lead/g dry weight of plant at the same intervals. Similar accumulations and trends were seen in the stems and roots. The differences were all significant at the 99% level (student's t test). The concentration of lead in the *S. rugosa* leaves was 93.2 and 108.7 3 µg Lead/g dry weight plant at 24 and 28 weeks. The controls had 27.4 and 31.5 µg Lead/g dry weight of plant respectfully. These differences were significant at the 95% level.

Keywords: Heavy metal, Lead, Phytoremediation

Introduction

Lead pellets have been determined to be a source of high lead concentrations in soil at shooting ranges (1-3). The Gettysburg Range is a shooting range located in Orange County, NY. Lead analyses were conducted as part of our environmental chemistry and individual research courses. The Gettysburg firing range had high levels of lead in the soil, sediment and water. The soil contained 280 to > 12,000 µg of Pb per g of soil (wet weight) (4). The lead at this site also appears to be moving into the water and biota at the site. Elevated lead levels were found in worms, tadpoles and plants. *Solidago rugosa* and *Spirea latifolia* accumulated 137 and 152 mg of Pb per g of plant material (wet weight), respectively. The movement of lead from the soil into the biota has been previously demonstrated at other sites. For example, snails accumulated lead at a wetland skeet range in California (5). The uptake of lead by plants has also been demonstrated at a number of other sites (6, 7). This study attempted to determine if *Solidago rugosa* (Golden Rod) and *Spirea latifolia* (Meadowsweet), grown under laboratory conditions, could accumulate significant amounts of lead from contaminated soil.

Materials and Methods

Soil contaminated with approximately 12,000 µg Pb/g soil (wet weight) was collected from the Gettysburg Range. The soil was sieved with 1/4 inch stainless steel mesh, and stored at room temperature. The control soil contained 11 µg Pb/g soil (wet weight) and treated as described above. The lead in both soils was determined as follows. A 1.00 gram wet weight soil or sediment sample was added to 10 mL of 1M HNO_3 and heated without boiling for 10 minutes. Five mL of concentrated nitric acid was added with an additional 30 minutes of heating. The sample was allowed to cool, 10 mL of 30% H_2O_2 was added and the sample warmed for 10 minutes. Lastly, the sample was filtered and adjusted to a final volume of 100 mL with deionized water (8).

Solidago rugosa plants were purchased from North creek Nurseries (Landenberg, PA) and *Spirea latifolia* were purchased from Niche Gardens (Chapel Hill, NC). Each plant was placed in a 4 inch pot filled with a 50/50 mixture of vermiculite and lead contaminated soil or control soil. The vermiculite ensured better drainage and reduced soil compaction. The plants were placed 15 cm from fluorescent lights with a light cycle of 16 hrs of light and 8 hrs of dark.

At each sampling interval, 6 plants of each treatment were sacrificed. Plants were removed from the soil and extensively washed in distilled water to prevent any soil contamination. The *Spirea latifolia* plants were dissected into leaves, stems and roots and the *Solidago rugosa* into roots and leaves. These

Table 1. Lead concentration in *Spirea latifolia* tissues after 3, 23 and 27 weeks growth in contaminated soil.

Plant tissue	Weeks of growth	Control soil µg of Pb/g dry weight	Lead contaminated soil µg of Pb/g dry weight
Leaves	3	5.9 ± 4.7	19.2 ± 2.1
	23	20.5 ± 4.6	74.0 ± 19.9
	27	29.4 ± 3.1	96.3 ± 21.0
Stems	3	3.3 ± 4.8	50.9 ± 7.2
	23	21.0 ± 10.1	60.3 ± 4.8
	27	20.5 ± 4.6	74.0 ± 19.9
Roots	3	8.6 ± 12.7	52.4 ± 5.8
	23	28.4 ± 22.7	187.7 ± 44.5
	27	33.4 ± 7.6	193.8 ± 51.8

cuttings were dried at room temperature for 48 hrs, weighed, and digested in boiling, concentrated nitric acid until a clear liquid was obtained. Sample volumes were brought to 25 ml with concentrated nitric acid and passed through a 0.45 µm filter. The lead samples were then analyzed using graphite furnace atomic absorption spectroscopy in triplets using a lead lamp at 217 nm. Deposition time was 10 sec at 300°C. Atomization occurred for 1 sec at 1750°C and absorbance was determined using a 2.3 sec integration time.

Results and Discussion

Table 1 shows that all the tissues of *Spirea latifolia* accumulated lead from the soil. The amount of lead accumulated by the plants in the contaminated soil was significantly different from the plants in the control soil by the student's t test ($p < 0.01$) for all the tissues and at all three harvest times. *Solidago rugosa* also accumulated lead in their tissues. There was a significant difference in the amount of lead in the roots at 24 and 28 weeks ($p < 0.01$). The accumulation by the *Solidago* leaves was significantly different at 24 weeks ($p < 0.05$) and 28 weeks ($p < 0.01$) (Table 2).

The amount of lead in the greenhouse plants supports the previous findings in wild plants. The *Spirea latifolia* had 96.3 µg of Pb/g of dry plant tissue after 27 weeks while the wild plants had 152.2 µg of Pb/g of plant tissue (wet weight). The *Solidago rugosa* had 108.7 µg of Pb/g of dry plant tissue after 28 weeks while the wild plants had 137.6 µg of Pb/g of tissue (wet weight)(4). It is also unlikely the previous findings were due to soil deposition on the surface of the plants because of the agreement between the two sets of data. The data also supports the suggestions that the lead at the site is moving into the biota. The uptake of lead by plants represent a potential route for the lead to enter the human population through hunting of the local deer population. The deer could been contaminated as they eat the Golden Rod and Meadowsweet which represent up to 7% of the diet of White Tail Deer (10).

The possibility of using these plants for phytoremediation may be limited since it is generally assumed that the plants should be able to accumulate approximately 0.1% of their dry weight as Pb. For example Xiong (11) showed accumulation (2670 µg Pb/g plant (dry weight)) by a hyperaccumulating

Table 2. Lead concentration in *Solidago rugosa* tissues after 24 and 28 weeks growth in contaminated soil.

Plant tissue	Weeks of growth	Control soil µg of Pb/g dry weight	Lead contaminated soil µg of Pb/g dry weight
Leaves	24	27.9 ± 10.8	193.2 ± 16.4
	28	31.5 ± 7.3	108.7 ± 30.1
Roots			
	24	30.7 ± 9.8	147.7 ± 23.9
	28	27.8 ± 6.0	149.0 ± 23.5

strain of a mustard plant, *Brassica pekininesis* when exposed to 1000 µg Pb/g soil. However, the plants used in this study were nursery plants. It is possible that hyperaccumulating strains or ecospecific strains could be developed for this site.

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