A CONTRIBUTION TO THE ENVIRONMENTAL BIOLOGY OF MERCURY ACCUMULATION IN PLANTS

S. M. SIEGEL1*, B. Z. SIEGEL2, CORRADO BARGHIGIANI3, KATHARINE ARATANI1,2,4, PAULINE PENNY5, and DAVID PENNY6

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Abstract. Samples of six common plant species collected in the old mining areas near Prince George, British Columbia (Canada) and Mount Amiata, Tuscany (Italy) show remarkable similarities in the variation of plant/soil Hg concentration ratio with soil Hg content irrespective of species or other biological differences. In contrast, plants sampled in the geothermally active areas of New Zealand, Hawaii and around Mount St. Helens exhibit more individuality in the concentration ratio to soil Hg relationship, but the relationships are distinctly different from the mine site specimens. This distinction is particularly evident when the same species of Equisetum and Plantago taken from these two different areas are compared. These and other data support the hypothesis that specific local environmental factors strongly influence the accumulation of Hg in plants even when the immediate soil concentrations are the same. Our findings show that some plants contain concentrations of total Hg as high as 5500 to 14000 µg kg⁻¹ (dw).

1. Introduction

Recent field work in the Prince George mining areas of British Columbia, and at volcanic Mount St. Helens in Washington State, suggested that there are regional variations in plant-soil Hg distributions patterns and further that the observed differences might reflect on local features specific to each environment (Siegel, 1984, 1985a, b; Siegel et al., 1984, 1985). These distinctions in Hg distribution patterns were based only on Equisetum arvense and Plantago lanceolata, however.

We have now extended our comparisons to include the Mount Amiata mining area in Italy as well as volcanic/geothermal sites in New Zealand, Hawaii, and other sample locations.

2. Experimental

2.1. STUDY SITES AND PLANTS

The Cominco Hg mine at Fort St. James and the nearby city of Prince George have been described (Johnston et al., 1975; Siegel et al., 1985), as have locations near Kilauea Volcano in Hawaii Volcanoes National Park on the Island of Hawaii, and North Island,

1 Department of Botany, University of Hawaii, 3190 Maile Way, Honolulu, HI 96822, U.S.A.
2 Pacific Biomedical Research Center, University of Hawaii, Honolulu, HI 96822, U.S.A.
3 Institute of Biophysics, National Research Council, Pisa, Italy.
4 Kamehameha Schools, Honolulu, Hawaii.
5 Ministry of Works, Wellington, New Zealand.
6 Biology Department, Massey University, Palmerston North, New Zealand.
* Author for all correspondence.

New Zealand (Siegel, B. and Siegel, 1986). Like the Mount St. Helens area, both of these Pacific locations are thermally active.

Mount Amiata in the volcanic area of southern Tuscany was an important active Hg mining and smelting site until about 10 yr ago (Bargagli et al., 1985). In contrast, Olomana peak in Southeast Oahu is an erosional remnant within the caldera of Koolau crater (McDonald and Abbott, 1970). Koolau Volcano is about $2.6 \times 10^6$ yr old, with the present cycle of erosion beginning about $1.3 \times 10^6$ yr ago.

Plants (leaves or non-woody shoots) collected in British Columbia were the ubiquitous Matricaria chamomilla, Plantago lanceolata, and Taraxacum officinale. The mining area on Mount Amiata provided Pinus nigra and Cytisus scoparius. Leptospermum scoparium, a thermally adapted native species (Given, 1980) was sampled in New Zealand between the Rotorua-Taupo area and the Stokes Valley, Wellington. On the Island of Hawaii the principal forest dominant, Metrosideros collina (var.) polymorpha, was used. The only species available over the range of elevations on Olomana were Schinus terebinthifolius and Wikstroemia uva-ursi. Soils were collected in proximity to sampled plants. The upper 3 cm of soil were discarded and the next 3 to 5 cm collected, except at Mount Amiata where samples were taken at 15 cm depths. The soils ranged from clay loams to sandy loams; organic C was not determined.

2.2. Hg Analysis

The procedures for collecting and analysis of plants and soils have been detailed previously (see Siegel et al., 1984, 1985). After HNO$_3$-H$_2$O$_2$ digestion of washed tissues, Hg was determined by flameless atomic absorption spectrophotometry. Each data point is the mean of 3 to 12 sample determinations with standard deviations of $\pm 12$ to $16\%$ of the mean.

Mount Amiata samples (3 to 5) were digested for 6 hr in HNO$_3$ at 120 °C under pressure (Bargagli et al., 1985).

All data were reduced to Hg content on a dry matter basis. Separate samples of shoots and soils were taken for dry matter determination.

3. Results and Discussion

As soil Hg content varies, the plant Hg/soil Hg concentration ratio (CR) of 4 British Columbia species exhibit remarkably uniform behavior (Figure 1). Only at soil levels of less than 50 $\mu$g kg$^{-1}$ is there some degree of spread among the species samples.

At soil levels of 16 to 30 $\mu$g kg$^{-1}$, CR values fluctuated between 1 and 4 in all cases. As the soil reached and then exceeded 300 $\mu$g kg$^{-1}$, the CR fell to about 0.25 and thereafter fluctuated between 0.1 and 0.5. The two species from the Mount Amiata mining area behaved almost indistinguishably from the Canadian species over the entire range from 300 to 5500 $\mu$g kg$^{-1}$ soil Hg.

Simple inspection shows that differences exist between the mine area species and those in volcanic/geothermal zones. Equisetum and Plantago afford a comparison of the same two species at the two distinct locations (Table I).