• Transuranic Behavior in Soils and Plants

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The principal objective of this study is to gather information about soil, plant, and foliar interaction factors that influence the availability of transuranics to agricultural plants and animals. Major areas of emphasis are: 1) soil and soil-microbial processes that influence the formation of ligands, which stabilize transuranic elements in soil solutions, and processes that influence transuranic element long-term behavior in soil and plants; 2) deposition and plant interception of airborne submicronic particles containing the transuranic elements and their susceptibility to leaching; 3) plant processes which influence transport across the plant root membrane and foliar surfaces, the form and sites of deposition of transuranic elements in mature plants; and 4) the integrated effect of soil and plant processes on transuranic element availability to, and form in, animals that consume plants.

Plant absorption of Pu from soils on an absolute (dpm) basis is relatively linear for 64 to 88 days after germination. The absorption does not appear to be related to plant dry-matter production. Studies of Pu content and concentration in plants as a function of dry-matter production indicate that Pu accumulation by plants from soils is regulated and limited by soil processes that determine the quantity of Pu available for plant uptake (Figure 5.1). This available fraction of Pu ranged from 0.4 to 3.1 pg/day for three soils to which Pu nitrate at 10 µCi/g levels had been added.

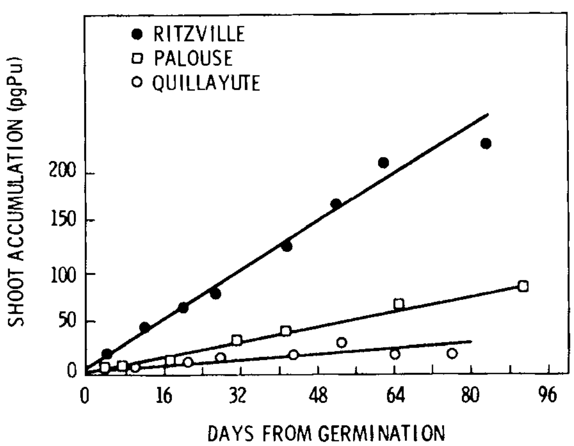

Figure 5.1. Rate at which ^{238}Pu is Absorbed from the Soil by Soybean Plants

Measurements of Pu accumulation with time for individual shoot tissues shows Pu to be relatively mobile in the plant. Evapotranspiration determines the distribution pattern. There is no indication that Pu remobilizes during senescence of plant tissues. Detailed chemical characterization of Pu form in xylem exudates indicates a substantial change in Pu form following root absorption from nutrient solutions containing Pu_2DTPA. After metabolism of Pu by roots, stems and leaves, the solubles were found to contain 28%, 54% and 67% of the Pu, respectively (Table 5.1). The Pu in the soluble fraction was primarily associated with components of >10,000 molecular weight in leaves and roots, whereas stems exhibited a distribution between components in the >10,000 and <500 molecular weight fraction. Plutonium associated with mature seeds is concentrated in the seed hull (85%) and cotyledons (14%). Fractionation of cotyledons to determine the distribution of Pu in soy products indicated that Pu was primarily associated with the insoluble residues and soluble soy whey.

Detailed study of the factors that affect plant absorption of Pu from soils, and the chemical behavior and fate of Pu following plant metabolism provide information about the behavior of Pu that affects soil-plant and plant-animal interactions. The present studies indicate that plant discrimination against actinide absorption by roots does not occur. In fact, the capacity of the

Table 5.1. Distribution and Chemical Fate of ^{238}Pu in Soybean Tissues Accumulated from Hydroponic Solutions Containing Pu_2DTPA_3

	% Distribution of Plutonium			
Tissue Fraction	Roots	Stems	Leaves	Pu_2DTPA_3
Whole tissue	84.0 ± 1.3	0.6 ± 0.3	15.4 ± 1.0	—
Fraction[(a)]				
Soluble	27.7 ± 2.9	54.4 ± 1.9	67.4 ± 3.9	—
Insoluble	72.3 ± 2.9	45.6 ± 1.9	32.6 ± 3.2	—
Fractionation of Solubles:[(b)]				
>10,000	90.3 ± 3.2	60.1 ± 5.1	87.2 ± 7.3	0.1
5,000 - 10,000	5.7 ± 1.1	8.4 ± 6.5	3.1 ± 1.3	0.1
500 - 5,000	2.8 ± 1.9	6.0 ± 1.8	5.8 ± 3.6	92.1
<500	1.2 ± 0.3	25.6 ± 0.4	3.9 ± 2.3	7.9

(a)Homogenized in 0.02 M NH_4OAc, insolubles (cellwalls, organelles and structural proteins) sedimented at 20,000 x G.

(b)Fractionation by ultrafiltration.

plant to accumulate Pu is not unlike that of hydrolyzable elements. The rate at which plant accumulation occurs is limited by those soil processes that result in the formation of soluble chemical species available to the plant. Measurements of Pu distribution and chemical form in soybeans show that once Pu is absorbed by the root, it is mobile within the plant. Pu solubility is maintained by the formation of Pu-complexes. In vegetative tissues such as roots and leaves, more than 85% of the Pu is associated with soluble materials having molecular weights >10,000. While ~60% of the Pu in the soluble fraction of stems is of >10,000 MW, 25% is associated <500 MW components. Previous studies have shown that gastrointestinal absorption of Pu that was previously incorporated (metabolized) into plant tissues was ~2 orders of magnitude higher than from gavage inorganic solutions. More importantly, a consistent 2- to 5-fold increase in gut absorption of Pu was noted when the plant feed included plant stems rather than just leaves alone. The total Pu activity contributed by the stems in the composite tissue feedings was ~13 , but Pu was more soluble and 25% of the soluble activity in stems was of <500 MW. Thus, differences in Pu forms in the plant appeared to be controlling gastro-intestinal absorption. Understanding the chemical behavior of Pu in plants is critically important for re-assessing the plant-to-animal transfer factors in dose assessment models.