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DISTRIBUTION OF SURFACE-DEPOSITED PLUTONIUM IN SOIL AFTER CULTIVATION*

by

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DISCLAIMER

INTRODUCTION

It is widely believed that the hazard of radionuclides near or on the soil surface can be greatly reduced by disking to mix the radionuclides with a large volume of soil. Such dilution would be especially useful for Pu since its greatest hazard to man is by inhalation of airborne particles (LA66;R070). However, one review of data published after Pu was deposited on soil at Palomares, Spain due to an airplane accident involving thermonuclear bombs showed that plowing with a moldboard plow to a depth of 45 cm achieved very little mixing of Pu and soil (F068). To evaluate the effect of standard southeastern U. S. agricultural practices on the final distribution of surface-deposited Pu in soil, a study was begun in 1974 in which wheat and soybeans were grown on fields containing Pu released from stacks of nuclear fuel reprocessing facilities at the Savannah River Plant, Aiken, S. C. (AD in Press; PI in Press).

DESCRIPTION OF THE STUDY AREA

The two fields used for the study were part of an agricultural farm until about 1952 when construction of a nuclear fuel reprocessing facility in H Area was begun. In 1952, the fields were abandoned. Subsequently native vegetation, including a few pines and wild plums, became established. Field 1 measured 175 x 30 m and Field 2 was 115 x 30 m. The centers of Fields 1 and 2 were approximately 230 m and 420 m from the H-Area 62-m stack, respectively.

Soil in both fields was classified as Vaucluse, a highly leached soil characterized by a sandy topsoil and a sandy clay loam subsoil. The topsoil and part of the subsoil of Field 1 was removed and partly replaced with "fill" soil during the construction of the fuel reprocessing facility. Field 2 had a normal soil profile. The physical and chemical characteristics of the soils are summarized in Table 1.

Pu was deposited on the two fields by global fallout and stack releases from two nuclear fuel reprocessing facilities at SRP. However, the H-Area facility contributed most of the Pu to the soil because of its closer proximity. Stack releases during the study had a negligible influence on Pu concentrations in the soil. When the study began in 1974, approximately 1.2 Ci of ^{238,239,240}Pu had been released by the H-Area stack since operations began in 1955, while only 8 mCi were released during 1974 and 1975.

PROCEDURES

The fields were prepared for agricultural crops by removing the pines and cutting the herbaceous vegetation with a tractor-drawn rotary mower. The fields were disked to a depth of ∿20 cm, sub-soiled, redisked, limed, redisked, fertilized, and finally disked again. Before each crop a bush and bog disk-harrow was used for the first disking, and all subsequent disking was by a standard disk-harrow. Wheat seed were sown by hand in November 1974, and covered by shallow disking. The crop was harvested in June 1975. Soybeans were planted with a two-row planter after

the fields were fertilized and disked several times. The crop was harvested in November 1975.

Samples of soil were collected at four different times: (1) before tillage; (2) after soil preparation for wheat; (3) after wheat harvest; and (4) after soybean harvest. There were 18 locations sampled in Field 1, and 12 in Field 2 (PI in Press). Soil cores of 3.8 cm diameter were taken using a split-barrel sampler and divided into 0-5 cm, 5-15 and 15-30 cm depths for Pu analysis.

All samples were analyzed for Pu using procedures previously reported (PI in Press).

"W" tests (HA68) and graphing verified that the concentrations of Pu in soil in this study are log-normally distributed as other scientists have reported in other soil samples (Mc75 and MI71). Therefore, statistical analyses were performed on the logarithm of the Pu concentrations. The reported means and standard deviations are antilogarithms. The upper and lower limits of the range of concentrations are obtained by multiplying and dividing by the standard deviation. Two-thirds of the samples should fall in this range.

RESULTS AND CONCLUSIONS

Downward movement (Table 2) of Pu in the soil was slow during the 20 years before field preparation. This is illustrated by the much higher Pu concentration in the 0-5 cm depth of soil compared to the other depths before tillage. This relationship did not change with extensive tilling.

Tillage including 8-10 diskings, did produce slight increases in the Pu concentrations in the 5-15 cm depth of soil in both fields indicating some mixing of the 0-5 cm and 5-15 cm depths, but the amount of mixing was surprisingly small. The only other significant change was a reduction of the Pu concentration in the 15-30 cm depth of soil in Field 1. There is no apparent explanation for this change.

This study shows that standard agricultural practices used in the Southeastern U. S. will not greatly modify the distribution of Pu in the soil and, therefore, will have relatively minor effects upon the uptake by crop species.

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TABLE 1

Physical and Chemical Characteristics of the Soil in the Two Fields[a]

Soil Depth (cm)		*Field 1*	*Field 2*
		pH	
0-15		4.85 ± 0.30	4.40 ± 0.15
15-30		4.73 ± 0.45	4.48 ± 0.16
		Mechanical Analysis (% of total soil)	
0-15	Sand	53 ± 7	68 ± 9
	Silt	10 ± 2	9 ± 2
	Clay	37 ± 6	23 ± 8
15-30	Sand	52 ± 7	60 ± 9
	Silt	10 ± 2	12 ± 2
	Clay	38 ± 6	28 ± 9
		Cation Exchange Capacity (meq/100 g)	
0-15		7.0 ± 1.4	4.7 ± 1.5
15-30		6.1 ± 1.8	4.3 ± 1.6

a. The ± values are standard deviations

TABLE 2

Plutonium in Soil (pCi/g)[a]

	Field 1 depth (cm)			
Sampling Time	*0-5*	*5-15*	*15-30*	*F test*[b]
Before Tillage	2.5 (2.6)	0.08 (2.5)	0.10 (3.2)	**
After Wheat Planting	4.3 (2.2)	0.33 (4.3)	--	**
After Wheat Harvest	2.6 (3.2)	0.22 (3.5)	0.02 (1.8)	**
After Soybean Harvest	3.6 (2.3)	0.67 (2.5)	0.04 (2.8)	**
F test[b]	NSD	**	**	

	Field 2 depth (cm)			
Sampling Time	*0-5*	*5-15*	*15-30*	*F test*[b]
Before Tillage	0.87 (1.4)	0.10 (3.2)	0.029 (1.8)	**
After Wheat Planting	0.61 (2.2)	0.12 (2.4)	--	**
After Wheat Harvest	0.64 (1.6)	0.26 (2.6)	0.019 (2.4)	**
After Soybean Harvest	0.91 (1.8)	0.32 (2.5)	0.013 (2.4)	**
F test[b]	NSD	*	NSD	

a. The values in () are standard deviations

b. * Significant difference at the 0.05 level of confidence.

** Significant difference at the 0.01 level of confidence.

TABLE 1: Physical and Chemical Characteristics of the Soil in the Two Fields

TABLE 2: Plutonium in Soil (pCi/g)[a]

a. The values in () are standard deviations.

b. * Significant difference at the 0.05 level of confidence.

** Significant difference at the 0.01 level of confidence.