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102

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BURIAL GROUND UPTAKE STUDIES - SURFACE CONTAMINATION

INTRODUCTION

The Waste Disposal Technology Division (WDT) has developed a mathematical computer model, DOSTOMAN, to evaluate the long-term potential hazard associated with burying low-level beta-gamma TRU wastes. The model predicts the dose to man due to radionuclide transfer through environmental pathways after plant operations and waste surveillance cease. Modeling the movement of SRP waste through the various pathways has depended upon the use of radionuclide transfer coefficients obtained from the literature. The agricultural cropping study was designed to provide site-specific transfer coefficients from the SRP burial ground for Cs-137 and Sr-90 to the DOSTOMAN model. The initial study plan was designed to maximize root penetration into the buried waste to determine the worst possible case of radionuclide uptake, transport, and transfer. This study plan was subsequently modified to prevent the root penetration into the waste. This study, then, reports the findings from surficial, aerially deposited materials present at a particular distance from H- and F-Area stacks.

SUMMARY

Agricultural crops were successfully grown to maturity in the soil of the burial ground with minimal amounts of fertilizer, lime, and water. The study plan as modified precluded root growth into the radioactive waste. The concentration ratios of Cs-137, Sr-90, and K-40 (for a comparison of inherent variability) agree very well with reported literature values.

The concentration ratios determined in this study are not valid transfer coefficients for use in the WDT DOSTOMAN model because the values do not represent site-specific data for buried waste. The data generated in this study are representative of any large cleared area at a comparable distance from the H- and F-Area stacks.

A long-term study using lysimeters in which known amounts, kinds, and forms of waste can be placed, soil characteristics determined, water movement monitored, and soil bacterial influences assessed is recommended.

METHODS

Site Selection

Two sites located in the original 80-acre burial ground were selected for the study on the basis of a Health Protection survey

(1980) of the radioactivity in vegetation at the burial ground. Vegetation at one site contained up to 1100 pCi/g of Cs-137 and Sr-90 activity, while that at the other site contained up to 50 pCi/g of comparable activity. The selection of these two distinctly different sites in terms of potential Cs-137 and Sr-90 activity was made to add another dimension to the study plan. Along with the determination of site-specific concentration ratios of Cs-137 and Sr-90 in agricultural crops, we wanted to look at concentration effect on nuclide uptake.

The study sites were each 33.5 m wide and 40 m long. They were shallow-disced to a depth of 25 to 30 cm. Prior to planting, 500 lb of dolomitic lime and 250 lb of fertilizer (5-10-10) were applied to each site. Each study site was subdivided into three sections to allow simultaneous cropping studies.

Crops Planted and Harvested

Corn was planted in March 1981 and harvested in July 1981; soybeans were planted in June 1981 and harvested in November 1981; and wheat was planted in November 1981 and harvested in June 1982.

Sample Collection and Analysis

Because a single plant could not provide enough quantity of material for analyses, several adjacent plants were bunched together into sampling clusters. These clusters were randomly selected within each study plot.

Fourteen randomly selected clusters of five or six corn plants were sampled from the corn crop. The grain was removed from the cobs, and all leaves 2 feet above the ground were collected from each plant in a sampling cluster. Like samples in each cluster were combined. A soil core (15 cm deep and 5 cm diameter) was taken at the base of each corn plant in a cluster, combined, and mixed in a large polyethylene bag. A representative sample to fill a 1-quart cardboard container was then taken for each cluster.

The soybean crop sampling scheme was conducted similarly to the corn except that 10 clusters of 14 to 16 plants each were used. Because of the large amount of splashed soil particles adhering to the soybean leaves, stems, and pods, only the beans were collected. Six soil cores per cluster were taken and composited within each cluster.

The wheat crop consisted of 16 clusters with samples of grain, straw, and soil collected for Cs-137 and Sr-90 determinations. Each cluster was approximately 1.5 m in diameter. Six soil cores were taken and composited within each cluster.

After the maximum growth period and before senescence of the annual crops, several random plants from each crop were carefully dug up to determine the depth of the root network. In all cases, no roots were found deeper than 25 to 30 cm, the depth of loosened soil produced by the shallow-discing method of soil preparation.

Burial ground personnel estimated the waste to start somewhere between 2 feet and 4 feet below the surface. The roots of the three crops planted in the burial ground study plots did not penetrate into the waste, which is consistent with the approved modified study plan.

The site-specific transfer coefficient for the agricultural crops relates the amount of activity taken up by the plant to the amount of activity present in the soil in which the plant grows. The basis for this comparison has been reported in the literature on a gram fresh-weight basis, a gram dry-weight basis, or a gram-ash weight basis. The relationships reported herein are on a dry-weight and ash-weight basis. The relationship is termed the Concentration Ratio (CR) and is defined as:

$$CR = \frac{\text{Activity in Plant/g weight basis}}{\text{Activity in Soil/g same weight basis}}$$

In all cases the activity is expressed in pico curies (pCi).

Although a large amount of variability existed in the Cs-137 and Sr-90 content in the soil samples, the amount was insignificant compared to the expectations derived from the HP 1980 Vegetation Report upon which the study plots were selected. Because of the apparent disparity, the concentration effect portion of the study was eliminated; all samples were treated together statistically, and variation within and among plants was compared to natural K-40 variation.

Results

The CRs for Cs-137, Sr-90, and K-40 in the corn crop have been determined (See Tables 1 through 6). The mean CRs for Cs-137 in leaves and grain, on a dry-weight basis (Table 1) are 0.062 $\pm$0.057 and 0.010 $\pm$0.015, respectively, with ranges of 0.01 to 0.19 (leaves) and 0.001 to 0.061 (grain). The mean CRs for Cs-137 in leaves and grain on an ash-weight basis (Table 2) are 1.01 $\pm$0.91 and 0.74 $\pm$1.10, respectively with ranges of 0.18 to 3.16 (leaves) and 0.18 to 4.37 (grain).

The mean CRs for Sr-90 in corn leaves and grain (Table 3) are 13.1 $\pm$6.0 and 0.15 $\pm$0.08, respectively, on a dry-weight basis, with ranges of 1.4 to 24.0 (leaves) and 0.04 to 0.33 (grain). On an ash-weight basis the mean CRs for Sr-90 in leaves and grain (Table 4) are 193.5 $\pm$78.9 (range 27.3 to 313.3) and 9.30 $\pm$4.73 (range 2.26 to 18.76), respectively.

To determine if this variability was inherent in the soil-plant system the CRs for K-40 were determined, again on a dry-weight and ash-weight basis. The mean CRs on a dry-weight basis for K-40 (Table 5) are 0.248 $\pm$0.146 (range 0.06 to 0.505) for corn leaves and 0.082 $\pm$0.041 (range 0.02 to 0.143) for grain. On an ash-weight basis (Table 6) the mean K-40 CRs are 3.97 $\pm$2.46 (range 0.90 to 7.76) for leaves and 5.30 $\pm$2.90 (range 1.34 to 10.41) for grain.

The CRs for the soybeans have been determined on a dry-weight and ash-weight basis (see Tables 7 through 12). The mean CR for Cs-137 on a dry-weight basis (Table 7) is 1.78 $\pm$1.93 with a range of 0.57 to 7.0. On an ash-weight basis the mean CR for Cs-137 (Table 8) is 41.79 ±49.99 with a range of 10.46 to 178.0. The mean CR for Sr-90 on a dry-weight basis (Table 9) is 2.51 ±0.50 with a range of 1.67 to 2.75 and on an ash-weight basis (Table 10) the mean CR for Sr-90 is 53.24 ±9.89 with a range of 37.01 to 69.33.

The CRs for K-40 were determined for the soybeans and on a dry-weight basis the mean CR is 12.87 ±7.59 with a range of 4.95 to 29.42 (Table 11) while on an ash-weight basis the mean CR is 272.58 ±151.08 with a range of 107.3 to 592.0 (Table 12).

The wheat crop is being analyzed for Cs-137 and Sr-90 at this time. An addendum with appropriate concentration ratios will be prepared when all the results have been obtained.

DISCUSSION

The Cs-137 and Sr-90 concentration ratios obtained for corn and soybeans in this study were compared with reported values. Ng *et al* (1978) reported CRs of 0.04 for Sr-90 and 0.03 for Cs-137 in corn, 0.8 for Sr-90 and 0.1 for Cs-137 in soybeans, and 0.3 for Sr-90 and 0.05 for Cs-137 in wheat. These values are for the edible portions of such plants and are reported on a dry-weight basis. Ng (1982) reported, again, concentration ratios for Sr-90 and Cs-137 for corn and wheat and these values are 0.14 for Sr-90 in corn, 0.10 for Cs-137 in corn, 1.08 for Sr-90 in wheat and 0.18 for Cs-137 in wheat. Hardy and Bennett (1977) have reported a CR of 0.029 ±0.007 for Cs-137 and 0.11 ±0.025 for Sr-90 in corn plus cob on a dry-weight basis. A calculated CR for the Sr-90 data from Romney et al (1960) for wheat, dough-stage grain is 0.13 on a dry-weight basis. Miller (1963) has determined the CR on a dry-weight basis for corn and wheat. The CR for Sr-90 in corn leaves is 0.52 and for corn grain is 0.002. The CR for Sr-90 in wheat stems is 0.32 and in grain is 0.11. The Cs-137 CR in wheat stems is 0.011 and in grain is 0.0017.

Sartor et al (1966) examined the uptake of Sr-85 and Cs-137 in wheat when grown in sand, loam, or clay soils. The concentration ratios of Sr-85 in the stalk were 1.95 (sand), 0.538 (loam), and 0.517 (clay) and in the grain 0.309 (sand), 0.110 (loam), and 0.0653 (clay). The CRs of Cs-137 in the stalk were 0.183 (sand), 0.00438 (loam), and 0.0334 (clay) while in the grain they were 0.0618 (sand), 0.007 (loam), and 0.0129 (clay).

Ng (1982) reported a range of CRs for Sr-90 and Cs-137 for coarse, medium, and fine soils. Recalculating Sr-90 CRs on a dry-weight basis from his data the ranges are 4.4×10^{-2} - 6.8 (coarse), 8.8×10^{-3} - 1.28 (medium), and 1.32×10^{-2} - 1.12 (fine). The CRs ranges for Cs-137 are 1.92×10^{-3} to 1.24×10^{-1} (coarse), 1.72×10^{-4} to 1.04×10^{-2} (medium), and 3.72×10^{-3} to 4.8×10^{-2} (fine). The data from the present study places our burial ground CRs into Ng's category typified by the coarse soils, as he suggests for south-eastern U.S. soils.

The physiology of strontium absorption and distribution in plants was initially studied by Russell and Squire (1958). Several general conclusions came from their work. 1) An equilibrium does not occur between strontium in the shoots and in the roots, 2) upward translocation appears to be an irreversible process, 3) very little redistribution of strontium occurs in the plant, and 4) the greatest accumulation of strontium occurs in the leaves. The present study confirms the earlier work. In the corn crop, comparing only the percent of Sr-90 in the leaves and grain, 98.6 percent was in the leaves (Table 13). For Cs-137 86.3 percent was in the leaves and for K-40 73.8 percent was in the leaves.

This study showed that fruits could be harvested from agricultural crops grown in the soil of the burial ground with minimal amounts of fertilizer, lime, and water supplied. The roots never penetrated into the buried waste, so the concentration ratios (CRs) obtained are indicative of surficial contamination from the H- and F-Area stacks. The CRs compare very favorably with those of other investigators in other regions of the country. This calls into question the importance and/or validity of site-specific values and the increased expense for every facility to conduct its own tests to determine CRs when reported literature values could be adequate.

However, the real importance of site-specific values comes about when the roots of the plants are allowed to penetrate into the waste. Many potential parameters are involved in determining these values, i.e., waste form, concentration, nonradioactive portion of the waste, soil bacteria, water movement rates, soil characteristics and the potential interaction among any or all of the site-specific parameters.

I strongly recommend that future studies be done in which roots get into the waste. Lysimeters would be the ideal tool for these studies because known amounts, kinds, and forms of waste can be placed at varying depths in the lysimeters, and soil characteristics, water movement, and soil bacterial influence on uptake can all be determined or assessed. In addition, I also recommend that samplers be installed to determine the extent and magnitude of aerially deposited materials.

REFERENCES

Boone, F. W., Ng, Y. C., Palms, J. M. "Terrestrial Pathways of Radionuclide Particulates." Health Physics 41(5), 735-747 (1981).

Hardy, E. P. and Bennett, B. G. "Radionuclide Uptake by Cultivated Crops." HASL-321, pp I-19 through I-37 (1977).

Miller, C. F. "Fallout Nuclide Solubility, Foliage Contamination and Plant Part Uptake Contour Ratios." NP-13115, also AD-417665 (1963).

Ng, Y. C. "A Review of Transfer Factors for Assessing the Dose From Radionuclides in Agricultural Products." Nucl. Safety 23(1), 67-71 (1982).

Ng, Y. C., Phillips, W. D., Ricker, Y. E., Tandy, R. K. "Methodology for Assessing Dose Commitment to Individuals and to the Population from Ingestion of Terrestrial Foods Contaminated by Emissions from a Nuclear Fuel Reprocessing Plant at the Savannah River Plant." University of California Report UCID-17743 (1978).

Romney, E. M., Ehrler, W. L., Lange, A. H., Larson, K. H. "Some Environmental Factors Influencing Radiostrontium Uptake by Plants." Plant and Soil 12(1), 41-48 (1960).

Russell, R. S. and Squire, H. M. "The Absorption and Distribution of Strontium in Plants. I. Preliminary Studies in Water Culture." J Exptl. Botany 9, 262-276 (1958).

Sartor, J. D., Lane, W. B., Allen, J. J. "Uptake of Radionuclides by Plants." AD-649009 (1966).

TABLE 1

Cs-137 Determinations in Corn Leaves, Corn Grain, and Soil and Associated Concentration Ratios Expressed on a Dry-Weight Basis

Sample Number	pCi/g Dry Weight - Cs-137 Soil	Leaves	Grain	Concentration Ratio Leaves	Grain
1	50.79 ±4.50*	0.68 ±0.05*	0.14 ±0.01*	0.01	0.003
2	3.99 ±2.00	0.15 ±0.02	0.03 ±0.01	0.04	0.008
3	7.37 ±1.32	0.22 ±0.03	0.03 ±0.01	0.03	0.004
4	5.37 ±1.60	0.13 ±0.01	0.02 ±0.01	0.02	0.004
5	4.17 ±1.83	0.28 ±0.03	0.02 ±0.01	0.07	0.005
6	9.90 ±1.79	0.45 ±0.04	0.04 ±0.01	0.05	0.004
7	15.36 ±2.17	0.65 ±0.06	0.18 ±0.02	0.04	0.012
8A	10.44 ±2.07	0.33 ±0.03	0.05 ±0.01	0.03	0.005
8B	7.47 ±1.61	0.64 ±0.06	0.03 ±0.01	0.09	0.004
9	3.62 ±1.90	0.28 ±0.03	0.05 ±0.01	0.08	0.014
10	80.53 ±6.99	2.26 ±0.16	0.31 ±0.10	0.03	0.004
11	112.50 ±9.45	1.43 ±0.10	0.13 ±0.01	0.01	0.001
12	28.11 ±2.45	5.32 ±0.38	0.48 ±0.04	0.19	0.017
13	<1.32	0.24 ±0.02	0.08 ±0.01	>0.18	>0.061
$\overline{X}$	24.35	0.93	0.11	0.062	0.010
SD	33.79	1.39	0.13	0.057	0.015
Range	<1.32-112.5	0.13-5.32	0.02-0.48	0.01-0.19	0.001-0.061

* Standard Error in Counting

TABLE 2

Cs-137 Determinations in Corn Leaves, Corn Grain, and Soil and Associated Concentration Ratios Expressed on an Ash-Weight Basis

Sample Number	pCi/g Ash - Cs-137 Soil	Leaves	Grain	Concentration Ratio Leaves	Grain
1	53.8 ±4.8*	11.50 ±0.84*	9.61 ±0.76*	0.21	0.18
2	4.2 ±2.4	3.22 ±0.35	2.19 ±0.41	0.77	0.52
3	7.8 ±1.4	3.66 ±0.43	2.19 ±0.43	0.47	0.28
4	5.7 ±1.7	3.03 ±0.31	1.50 ±0.22	0.53	0.26
5	4.5 ±2.0	4.66 ±0.47	1.72 ±0.30	1.04	0.38
6	10.5 ±1.9	6.17 ±0.55	2.73 ±0.36	0.59	0.26
7	16.3 ±2.3	12.50 ±0.94	14.60 ±1.30	0.77	0.90
8A	11.6 ±2.3	5.97 ±0.48	3.80 ±0.37	0.51	0.33
8B	7.9 ±1.7	10.90 ±0.96	2.46 ±0.34	1.38	0.31
9	3.8 ±2.0	4.14 ±0.38	4.11 ±0.34	1.09	1.08
10	85.3 ±7.4	33.30 ±2.40	20.90 ±1.50	0.39	0.25
11	119.0 ±10.0	21.40 ±1.50	5.10 ±0.51	0.18	0.04
12	29.8 ±2.6	84.50 ±6.00	33.50 ±2.50	2.84	1.12
13	<1.4	4.43 ±0.44	6.12 ±0.54	3.16	4.37
$\overline{X}$	25.83	14.96	7.90	.99	0.73
SD	35.73	21.75	9.26	0.92	1.10
Range	<1.4-119.0	3.03-84.5	1.50-33.5	0.18-3.16	0.04-4.37

* Standard Error in Counting

TABLE 3

Sr-90 Determinations in Corn Leaves, Corn Grain, and Soil and Associated Concentration Ratios Expressed on a Dry-Weight Basis

Sample	pCi/g Dry Weight Sr-90			Concentration Ratio	
Number	Soil	Leaves	Grain	Leaves	Grain
1	Lost	11.20 ±0.67*	0.14 ±0.008*	-	-
2	0.77 ±0.05	1.07 ±0.06	0.03 ±0.002	1.4	0.04
3	0.09 ±0.01	1.23 ±0.07	0.03 ±0.002	13.7	0.33
4	0.15 ±0.01	1.56 ±0.09	0.02 ±0.001	10.4	0.13
5	0.17 ±0.01	1.85 ±0.11	0.02 ±0.002	10.9	0.12
6	0.10 ±0.01	2.40 ±0.14	0.02 ±0.001	24.0	0.20
7	0.96 ±0.06	8.38 ±0.50	0.08 ±0.006	8.7	0.08
8A	0.35 ±0.02	5.63 ±0.34	0.06 ±0.008	16.1	0.17
8B	0.43 ±0.03	8.64 ±0.52	0.04 ±0.003	20.1	0.09
9	0.99 ±0.06	8.58 ±0.52	0.22 ±0.01	8.7	0.22
10	1.36 ±0.10	19.64 ±1.18	0.13 ±0.008	14.4	0.10
11	0.69 ±0.05	12.66 ±0.76	0.10 ±0.006	18.3	0.14
12	1.26 ±0.08	20.52 ±1.23	0.13 ±0.008	16.3	0.10
13	0.19 ±0.01	1.42 ±0.14	0.05 ±0.003	7.5	0.26
$\overline{X}$	0.58	7.48	0.08	13.1	0.15
SD	0.45	6.65	0.06	6.0	0.08
Range	0.09-1.36	1.07-20.52	0.02-0.22	1.4-24	0.04-0.33

* Standard error in counting.

TABLE 4

Sr-90 Determinations in Corn Leaves, Corn Grain, and Soil and Associated Concentration Ratios Expressed on an Ash-Weight Basis

Sample	pCi/g Dry Weight Sr-90			Concentration Ratio	
Number	Soil	Leaves	Grain	Leaves	Grain
1	Lost	184.23 ±11.05*	9.41 ±0.57	-	-
2	0.81 ±0.05	22.12 ±1.33	1.83 ±0.11	27.3	2.26
3	0.10 ±0.01	19.41 ±1.17	1.37 ±0.10	194.1	13.70
4	0.16 ±0.01	33.78 ±2.03	1.25 ±0.09	211.1	7.81
5	0.19 ±0.01	29.51 ±1.77	1.50 ±0.12	155.3	7.89
6	0.11 ±0.01	32.12 ±1.93	1.30 ±0.10	292.0	11.82
7	1.02 ±0.06	157.21 ±9.43	6.80 ±0.48	154.1	6.67
8A	0.40 ±0.03	97.75 ±5.87	4.34 ±0.30	244.4	10.85
8B	0.46 ±0.03	144.14 ±8.65	3.04 ±0.18	313.3	6.61
9	1.05 ±0.06	123.87 ±7.43	17.21 ±1.03	118.0	16.39
10	1.45 ±0.10	281.39 ±23.22	8.87 ±0.53	194.1	6.12
11	0.73 ±0.05	187.39 ±11.24	3.95 ±0.24	256.7	5.41
12	1.34 ±0.08	317.12 ±19.03	8.92 ±0.54	236.7	6.66
13	0.21 ±0.01	24.96 ±2.50	3.94 ±0.24	118.9	18.76
$\bar{X}$	0.62	118.21	5.27	193.5	9.30
SD	0.48	99.26	4.56	78.9	4.73
Range	0.10-1.34	22.12-317.12	1.25-17.21	27.3-313.3	2.26-18.76

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* Standard error in counting.

TABLE 5

K-40 Determinations in Corn Leaves, Corn Grain, and Soil and Associated Concentration Ratios Expressed on a Dry-Weight Basis

Sample	pCi/g Dry Weight - K-40			Concentration Ratio	
Number	Soil	Leaves	Grain	Leaves	Grain
1	101.01 ±25.5*	9.41 ±0.72*	3.39 ±0.26*	0.093	0.034
2	25.9 ±24.3	8.58 ±0.72	3.30 ±0.28	0.331	0.127
3	97.38 ±18.9	10.83 ±0.91	4.75 ±0.40	0.111	0.049
4	95.21 ±34.9	4.62 ±0.40	3.05 ±0.22	0.049	0.032
5	<27	13.64 ±1.09	3.31 ±0.25	>0.505	>0.123
6	<50	12.46 ±1.01	3.71 ±0.29	>0.249	>0.074
7	<20	8.43 ±0.67	2.85 ±0.26	>0.422	>0.143
8A	<39	6.67 ±0.56	2.43 ±0.19	>0.171	>0.062
8B	<40	9.28 ±0.82	3.45 ±0.27	>0.232	>0.086
9	<41	9.60 ±0.75	3.25 ±0.23	>0.234	>0.079
10	64.39 ±25.5	13.60 ±1.09	4.02 ±0.30	0.211	0.062
11	<29	11.48 ±0.87	3.50 ±0.30	>0.396	>0.121
12	198.11 ±9.4	11.83 ±0.88	4.04 ±0.33	0.060	0.020
13	<26	10.57 ±0.82	3.37 ±0.25	>0.407	>0.130
$\overline{X}$	61.00	10.07	3.46	0.248	0.082
SD	48.57	2.55	0.56	0.146	0.041
Range	20-198.11	4.62-13.64	2.43-4.75	0.06-0.505	0.02-0.143

* Standard Error in Counting

TABLE 6

K-40 Determinations in Corn Leaves, Corn Grain, and Soil and Associated Concentration Ratios Expressed on an Ash-Weight Basis

Sample Number	pCi/g Dry Weight - K-40 Soil	Leaves	Grain	Concentration Ratio Leaves	Grain
1	107.0 ±27.0*	158.0 ±12.0*	232.0 ±18.0*	1.48	2.17
2	27.3 ±25.6	180.0 ±15.0	238.0 ±20.0	6.59	8.72
3	103.0 ±20.0	179.0 ±15.0	249.0 ±21.0	1.74	2.42
4	101.0 ±37.0	104.0 ±9.0	232.0 ±17.0	1.03	2.30
5	<29.0	225.0 ±18.0	237.0 ±18.0	>7.76	>8.17
6	<53.0	172.0 ±14.0	256.0 ±20.0	>3.25	>4.83
7	<22.0	163.0 ±13.0	229.0 ±21.0	>7.41	>10.41
8A	<43.0	119.0 ±10.0	184.0 ±14.0	>2.77	>4.28
8B	<43.0	158.0 ±14.0	247.0 ±19.0	>3.67	>5.74
9	<43.0	141.0 ±11.0	254.0 ±18.0	>3.28	>5.91
10	68.2 ±27.0	200.0 ±16.0	270.0 ±20.0	2.93	3.96
11	<31.0	172.0 ±13.0	142.0 ±12.0	>5.55	>4.58
12	210.0 ±10.0	188.0 ±14.0	282.0 ±23.0	0.90	1.34
13	<27.0	193.0 ±15.0	252.0 ±19.0	>7.15	>9.33
$\bar{X}$	64.82	168.00	236.0	3.97	5.30
SD	51.37	31.68	35.27	2.46	2.90
Range	<27.0-210.0	104-225	142-282	0.9-7.76	1.34-10.41

* Standard Error in Counting

TABLE 7

Cs-137 Determinations in Soybeans and Soil and Associated Concentration Ratios Expressed on a Dry-Weight Basis

Sample Number	pCi/g Dry Weight - Cs-137 Soil	Soybeans	Concentration Ratio
1	0.11 ±0.03*	0.15 ±0.01*	1.36
2	0.01 ±0.0	0.02 _0.01	2.0
3	0.01 ±0.0	0.07 ±0.01	7.0
4	0.02 ±0.01	0.04 ±0.01	2.0
5	<0.4	0.05 ±0.01	>0.13
6	0.04 ±0.02	0.07 ±0.01	1.75
7	0.12 ±0.02	0.07 ±0.01	0.58
8	0.81 ±0.07	0.46 ±0.03	0.57
9	0.15 ±0.02	0.10 ±0.01	0.67
10	0.12 ±0.02	0.07 ±0.01	0.58
$\overline{X}$	0.18	0.11	1.66
SD	0.25	0.13	1.93
Range	0.01-0.81	0.02-0.46	0.57-7.0

* Standard error in counting.

TABLE 8

Cs-137 Determinations in Soybeans and Soil and Associated Concentration Ratios Expressed on an Ash-Weight Basis

Sample	pCi/g Dry Weight - Cs-137		Concentration
Number	Soil	Soybeans	Ratio
1	0.12 ±0.03*	3.52 ±0.28*	29.33
2	0.01 ±0.00	1.47 ±0.12	147.00
3	0.01 ±0.00	1.78 ±0.16	178.00
4	0.02 ±0.01	0.99 ±0.01	49.50
5	<0.4	1.19 ±0.12	>2.98
6	0.04 ±0.02	1.42 ±0.14	35.50
7	0.13 ±0.02	1.36 ±0.12	10.46
8	0.86 ±0.07	10.30 ±0.75	11.98
9	0.16 ±0.02	2.23 ±0.18	13.94
10	0.12 ±0.02	1.49 ±0.14	12.42
$\overline{X}$	0.19	2.58	49.11
SD	0.26	2.81	61.78
Range	0.01-0.86	0.47-10.30	10.46-178.00

* Standard error in counting.

TABLE 9

Sr-90 Determinations in Soybeans and Soil and Associated Concentration Ratios Expressed on a Dry-Weight Basis

Sample Number	pCi/g Dry Weight - Sr-90 Soil	pCi/g Dry Weight - Sr-90 Soybeans	Concentration Ratio
1	0.15 ±0.01*	0.40 ±0.02*	2.67
2	0.06 ±0.01	0.10 _0.01	1.67
3	0.09 ±0.01	0.17 ±0.01	1.89
4	0.04 ±0.01	0.14 ±0.01	3.50
5	0.03 ±0.01	0.08 ±0.01	2.67
6	0.04 ±0.01	0.11 ±0.01	2.75
7	0.05 ±0.01	0.11 ±0.01	2.20
8	0.05 ±0.01	0.13 ±0.01	2.60
9	0.05 ±0.01	0.13 ±0.01	2.60
10	0.04 ±0.01	0.10 ±0.01	2.50
$\overline{X}$	0.06	0.15	2.51
SD	0.04	0.09	0.50
Range	0.03-0.15	0.08-0.40	1.67-2.75

* Standard error in counting.

TABLE 10

Sr-90 Determinations in Soybeans and Soil and Associated Concentration Ratios Expressed on an Ash-Weight Basis

Sample Number	pCi/g Dry Weight - Sr-90 Soil	Soybeans	Concentration Ratio
1	0.153 ±0.01*	9.01 ±0.54*	58.89
2	0.067 ±0.01	2.48 ±0.15	37.01
3	0.101 ±0.01	4.33 ±0.26	42.87
4	0.047 ±0.01	3.25 ±0.20	69.15
5	0.030 ±0.01	1.78 ±0.11	59.33
6	0.041 ±0.01	2.21 ±0.13	53.90
7	0.056 ±0.01	2.32 ±0.14	41.43
8	0.050 ±0.01	2.96 ±0.18	59.20
9	0.052 ±0.01	2.95 ±0.18	56.73
10	0.041 ±0.01	2.21 ±0.13	53.90
$\overline{X}$	0.064	3.35	53.24
SD	0.037	2.11	9.89
Range	0.03-0.153	1.78-9.01	37.01-69.33

* Standard error in counting.

TABLE 11

K-40 Determinations in Soybeans and Soil and Associated Concentration Ratios Expressed on a Dry-Weight Basis

Sample Number	pCi/g Dry Weight - K-40 Soil	Soybeans	Concentration Ratio
1	2.61 ±0.40*	12.92 ±0.92*	4.95
2	1.02 ±0.24	12.93 ±0.92	12.68
3	1.87 ±0.27	12.43 ±0.89	6.65
4	1.83 ±0.29	9.76 ±0.68	5.33
5	0.90 ±0.26	13.49 ±0.97	14.99
6	0.48 ±0.23	14.12 ±1.0	29.42
7	1.20 ±0.24	13.47 ±0.98	11.23
8	1.19 ±0.25	14.00 ±1.02	11.76
9	1.27 ±0.29	13.15 ±0.94	10.35
10	0.68 ±0.22	14.52 ±1.03	21.35
$\overline{X}$	1.31	13.08	12.87
SD	0.64	1.33	7.59
Range	0.48-2.61	9.76-14.52	4.95-29.42

* Standard error in counting.

TABLE 12

K-40 Determinations in Soybeans and Soil and Associated Concentration Ratios Expressed on an Ash-Weight Basis

Sample Number	pCi/g Dry Weight - K-40 Soil	Soybeans	Concentration Ratio
1	2.74 ±0.40*	294 ±21*	107.30
2	1.07 ±0.24	310 ±22	289.72
3	2.00 ±0.27	308 ±22	154.00
4	1.95 ±0.29	228 ±16	116.92
5	0.95 ±0.26	320 ±23	336.84
6	0.50 ±0.23	296 ±21	592.00
7	1.25 ±0.24	275 ±20	220.00
8	1.26 ±0.25	316 ±23	250.79
9	1.34 ±0.29	295 ±21	220.15
10	0.71 ±0.22	311 ±22	438.03
$\overline{X}$	1.38	295.3	272.58
SD	0.67	27.1	151.08
Range	0.5-2.74	228-320	107.3-592.0

* Standard error in counting.

TABLE 13

Percent of Activity in the Corn Leaves Using Dry-Weight Data

Sample	Radionuclide - Percent in Leaves		
Number	Cs-137	Sr-90	K-40
1	82.9	98.8	73.5
2	83.3	97.3	72.2
3	88.0	97.6	69.5
4	86.7	98.7	60.2
5	83.3	98.9	80.5
6	91.8	99.2	77.1
7	78.3	99.1	74.7
8A	86.8	98.9	73.3
8B	95.5	99.5	72.9
9	84.9	97.5	74.7
10	87.9	99.3	77.2
11	91.7	99.2	76.6
12	91.7	99.4	74.5
13	75.0	96.6	75.8
$\overline{X}$	86.3	98.6	73.8
SD	5.6	0.9	4.7