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STUDIES OF RUTHENIUM AND CESIUM RETENTION ON SOIL-SAWDUST AND SOIL-PEAT MIXTURES

by

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and Irmgard Wintner

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ABSTRACT

Investigations were made to determine whether ruthenium or cesium would be retained in increasing amounts from sodium nitrate solution when the solution was stored in contact with soil and fermentable materials such as sawdust and peat.

Using sodium nitrate solutions ranging from 0.5 to 2.0 molar and storage periods up to 120 days, the following general results were obtained:

1. The retention of ruthenium on soil-sawdust mixtures increases with storage period for sodium nitrate concentrations up to 2.0 molar.
2. Some increase in retention of ruthenium on soil-peat mixtures occurred, but the increases were not very pronounced.
3. There was no appreciable increase in retention with time of cesium on soil-sawdust mixtures.
4. There was no increase in retention with time of cesium on soil-peat mixtures. The peat, however, showed a greater capacity for retaining cesium than the sawdust did.

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INTRODUCTION

Purpose of the Experiment

There are assimilative features of natural soils and organic materials which are effective in retaining certain radioactive materials from mixed fission products. The ion exchange capacities of natural soils, for example, though small as compared with synthetic resins, can be useful in adsorbing small quantities of radioactive metals from dilute solutions. In addition, biological digestion or fermentation can produce natural zeolytic humic materials consisting of unfermented residues and bacterial proteins which will increase the base exchange capacity of soils. This study was made to determine the magnitudes of the ion exchange capacities of natural soils for specific radioactive metals and to determine whether the complexed metals could be made more "retainable" by storage with fermentable materials.

Relation to Low-Level Reactor Wastes Disposal

The experiment is related to the potential disposal of low-level fission products into the ground. This affects the choice of the metals used in the studies as follows.

Over thirty different chemical elements are present in the reactor waste. Many of the isotopes of these elements are short-lived. After storage, the longer lived isotopes, notably of cesium and strontium, are most abundant. Most of the elements, in addition, behave as metals and would be expected to have the ability to exchange with the cations on a natural soil. However, the waste elements receive strong chemical treatment during dissolution of the fuel element in concentrated nitric acid. Some of these elements complex with the nitrate and do not behave only as cations. Ruthenium is an example. Ruthenium exists in a variety of valence states, as cations, complex anions, and neutral oxides. A mechanism which might retain one variety of ruthenium might be quite ineffectual with other varieties. That such is the case is indicated by Straub (1957). Experience at Oak Ridge, Tennessee, where radioactive chemical wastes are discharged into a weathered shale formation showed that ruthenium is not retained in the soil as completely as other elements. In a sense, therefore, ruthenium may be considered an advance indicator of impending passage of other radioactive fission products.

From these considerations it was decided to use, first, ruthenium, then, cesium in the testing program.

Straub, Conrad P., "Disposal of Atomic Power Plant Wastes," Robert A. Taft Sanitary Engineering Center, March 6, 1957.

Ruthenium is used since it migrates swiftly; cesium since, even if it migrates slowly, it is persistent because of its long half-life.

Effect of Digestion or Fermentation

This report deals with a search for natural mechanisms for the conversion of the nitrate-complexed isotopes into cations which may be adsorbed or rendered insoluble. It was thought that the fermentation of organic matter would provide such a mechanism. In addition it was felt that the base exchange capacity of the soil mixture would increase as fermentation progressed.

Using soil as an inoculum and a buffer, it was believed that inexpensive and universally available materials such as sawdust and peat would, following decomposition, cause insoluble organic ruthenium complexes to be formed along with the stabilized organic and microbial materials. At the same time, the nitrate salts would be reduced by the oxygen-consuming bacteria under anaerobic conditions.

Outline of the Experiment

To test these hypotheses, it was decided to study the retention of ruthenium and cesium on various soil-sawdust and soil-peat mixtures after digestion periods of from 0 to 120 days. In addition, the nitrate concentration was varied and all combinations were tested.

LABORATORY PROCEDURE

General: Attempts were made to simulate a compost of clay soil and sawdust or clay soil and peat into which a ruthenium or cesium solution was introduced. After various periods, the storage "columns" were leached (or rinsed through) with distilled water to determine how much of the metal was retained. Tracer techniques were used instead of analytical techniques for ruthenium and cesium determination.

In greater detail, the procedure was as follows:

1. Different proportions of clay soil, sawdust (which is composed of cellulose and lignin) and additional lignin (used to alter the cellulose to lignin ratio) were prepared and loaded into clear, plastic columns, 12 inches long and 3/4 inch in diameter.

2. Solutions composed of ruthenium chloride or cesium nitrate, sodium nitrate in varying concentrations as an interference (since sodium ion competes with ruthenium or cesium for the available exchange capacity of the ion exchange material), and ruthenium -103 or cesium-134 tracer were added to the soil columns.

3. After the storage period, the columns were washed through with distilled water and the activity of

both the leachate and the soil were measured to determine the ruthenium or cesium in each fraction.

Preparation of the Ruthenium Solution

Attempts were made to prepare the ruthenium solution so that it would be similar to the radiochemical waste. This was done by evaporating the ruthenium chloride solution to near dryness in a strong nitric acid solution. In this manner complexing with the nitrate could take place. The pH of the final solution was adjusted to 0.5 to eliminate the effects of varying initial hydrogen ion concentration on the exchange capacity of the soil.

Parameters

Once the columns were filled with the soil and solution, they were stored in a temperature-humidity controlled 20° centigrade room and leached in accordance with a time schedule of 0, 30, 90, and 120 days. Data were compiled for both ruthenium and cesium separately on nine different soil samples, for three different sodium nitrate concentrations and after four different storage periods as follows:

Sodium nitrate concentration	Storage Period, Days			
	0	30	90	120
0.5 M	Soil Type			
	Sawdust Soils		Peat Soils	
1.0 M	100% Sawdust 75% Soil, 25% Sawdust 73% Soil, 25% Sawdust, 2% Lignin		100% Peat 75% Soil, 25% Peat 73% Soil, 25% Peat, 2% Lignin	
2.0 M	70% Soil, 25% Sawdust, 5% Lignin 100% Soil		70% Soil, 25% Peat, 5% Lignin	

All combinations of these factors were tested, both for ruthenium and cesium.

Recording and Calculations of Results

All experimental results were recorded on calculation sheets of the type attached to pages 39 to 42 of this report. Calculations were made directly on these sheets.

On Sample Calculation Sheet No. 1 are recorded the volumes of samples leached through a single column along with the results of measuring the activity in two 1-milliliter aliquots from each sample. The total activity leached from the column can be determined by totalling all the sample activities (counts per minute/milliliter, cpm/ml) times the volume collected (ml). The result is

in total cpm leached as determined from the leachate. This addition is actually carried out on Sample Calculation Sheet No. 2.

The activity applied to the column is the cpm/ml of the initial ruthenium or cesium solution times the volume (ml) applied to the column. In practice, this volume was determined by weighing prior to and after filling the column. The soil was weighed out beforehand and, in general, the same amount of a given soil type was used in each test. This was done in an effort to keep the soil to liquid ratio constant for a given soil series. The results of adsorption are not comparable where there are different relative amounts of surface area in each column.

The first estimate of amount of ruthenium or cesium retained was made, then, by computing the total activity applied and subtracting the total activity found in the leachate. Another estimate was made by determining the total activity remaining on the soil directly. A portion of the soil was dried, weighed and counted in the same well-type scintillation counter used in counting the liquid. The cpm/gram of dry soil times the total number of grams in the column gave an estimate of the total cpm retained. It was possible to use such a simple procedure in this case since preliminary studies had shown that the adsorption of radiation energy by the soil and by the

water was small and nearly equivalent.

Of the two estimates of the ruthenium or cesium retained, the one involving the smaller percentage was believed to be the more reliable. Where almost all the activity was retained, the soil might indicate 105% retention whereas the leachate showed 2% leached from the column. In that case, the figure as determined from the leachate was used. To avoid bias, rules for selection of the best estimate were laid down as follows. If the column retained 80% or more of the activity, the estimate of retention was based on the leachate. If the column retained 20-80% of the activity, an average was taken. If less than 20% was retained, the estimate of retention was based on the soil activity measurement.

Sample Calculation Sheet No. 3 shows the computation procedure for the soil samples. Finally, all the data for the group of columns leached on the same date were put on a summary sheet, part of which is shown on Sample Calculation Sheet No. 4.

Tabulation of Results

The amount of ruthenium or cesium retained on the soil column was computed both in terms of the percentage of the metal applied and in terms of millimoles of the metal retained per gram of dry soil mixture.

Summary sheets are shown for:

1. Ruthenium Retained on Soil-Sawdust Mixtures
2. Ruthenium Retained on Soil-Peat Mixtures
3. Cesium Retained on Soil-Sawdust Mixtures
4. Cesium Retained on Soil-Peat Mixtures

It should be noted that the concentration of the ruthenium solution applied was sometimes different for different soil mixtures. The concentration applied does not vary, however, within a group of tests on a particular soil mixture.

The concentrations of reagents and weights of soil used as well as the amount of material retained as computed by the two independent methods are shown on the summary sheets.

SUMMARY OF FINDINGS

A. Retention of Ruthenium on Soil-Sawdust Columns

The curves in Figure 1 show that the retention of ruthenium on soil-sawdust columns increased with time (storage period) in every case.

It was anticipated that as the concentration of sodium nitrate increased, the initial retention of ruthenium would be reduced owing to the competition of sodium ion for the ion exchange capacity of the column. This was not demonstrated in these studies since the exchangeable amount of ruthenium varied in the ruthenium solutions having different sodium nitrate contents. The sodium nitrate plus ruthenium solutions were prepared individually for each sodium nitrate concentration. Therefore the amount of complexed ruthenium very likely varied in the 0.5, 1.0 and 2.0 molar solutions. This is indicated by the consistent, but mixed, positions of the curves for 0.5, 1.0 and 2.0 molar sodium nitrate in Figure 1. This behavior reflects the difficulty in preparing ruthenium solutions with consistent ratios of the various ionic states of ruthenium and its nitrate complexes.

In addition, the increase in sodium nitrate concentration could ultimately inhibit the increase in ruthenium retention with storage by stopping bacterial action. The

inhibition was not observed up to 2.0 molar sodium nitrate, the maximum concentration tested.

The added lignin fraction was expected to depress the initial ruthenium retention owing to the high sodium content of the lignin used. This effect would be less as the total sodium content increased. However, it appears that this effect was not significant compared with other experimental variations since there are no obvious and consistent differences in the amounts of ruthenium retained on the columns containing 75% soil, 25% sawdust; the columns containing 73% soil, 25% sawdust, 2% lignin; and the columns containing 70% soil, 25% sawdust, 5% lignin. This can be seen from Figure 2.

One soil mixture cannot be compared with another on a "% retained" or "millimole per gram retained" basis, since, as mentioned earlier, variation in the soil to liquid ratio for different soil types is extreme between soil mixtures. A comparison is possible, however, on a volume basis. Each column contained about the same volume of lightly packed soil and each was filled with all the solution it would hold. Comparative estimates of behavior are made, therefore, for equal volumes of soil saturated with the test solution. Figure 2 shows these comparisons.

Specifically, then, it was demonstrated that:

a) the retention of ruthenium increases with length of storage period on mixtures of soil and sawdust;

b) sodium nitrate concentrations of as high as 2.0 molar will not stop the increase in ruthenium retention;

c) the addition of lignin has little practical effect on the retention of ruthenium under the test conditions;

d) with 120 days storage the retention of ruthenium on soil-sawdust mixtures improves, but does not exceed 98%.

B. Retention of Ruthenium on Soil-Peat Columns

In these tests the weight of soil and solution even within columns of a particular soil type were not exactly the same. Therefore, the soil to liquid ratio, which affects the equilibria to a considerable extent, was not constant even within a group of columns containing the same soil mixture. This fact undoubtedly accounts for much of the variation in the experimental result. The weight of soil and millimoles of ruthenium applied to each column are given on the Final Summary Sheets.

The variation in the soil to liquid ratio stemmed from the difficulty with which peat is wetted. Therefore, the experimental variations were correspondingly greater

than in the soil-sawdust studies. Even considering this, it is clear that increases in ruthenium retention with time on soil-peat mixtures are not as pronounced and consistent as on the soil-sawdust mixtures. Whereas the solution added to the soil-sawdust columns contained five millimoles per liter of ruthenium, the solution added to the soil-peat columns contained 40 millimoles per liter except for the peat columns where the added solution contained 20 millimoles per liter. Despite the increase in ruthenium concentration, the percentages retained on soil-sawdust and soil-peat columns are closely comparable.

In the soil-peat columns as in the soil-sawdust columns, no relation was demonstrated between initial ruthenium retention and the different sodium nitrate molarities. This is indicated by curves shown in Figure 3. More important, it was again demonstrated that the 2.0 molar sodium nitrate solution did not inhibit increase in ruthenium retention.

Figure 4 shows the comparison between individual soil types saturated with test solution. The 75% soil, 25% peat; 73% soil, 25% peat, 2% lignin; 70% soil, 25% peat, 5% lignin columns were closely grouped just as in the soil-sawdust studies thereby confirming the conclusion that an altered cellulose-lignin ratio has little noticeable effect on ruthenium retention.

Judging from the similarity in percentage of ruthenium retained, particularly on the soil columns, the percentage retention of ruthenium appears to be nearly independent of the ruthenium concentration in the 5 millimoles/liter to 40 millimoles/liter range.

Table 1. Percentage of Ruthenium Retained on Soil Columns

		Soil Column (5 millimoles Ru/liter)		Soil Column (40 millimoles Ru/liter)		Number of Times Increase in mm/gm Retained (8.0)
		Ruthenium Retained		Ruthenium Retained		
$NaNO_3$	Days	Percent	mm/gm	Percent	mm/gm	
0.5	0	91.9%	.0029	86.4%	.0247	8.5
	30	98.5%	.0031	93.3%	.0265	8.5
	90	99.6%	.0032	92.7%	.0268	8.4
	120	97.5%	.0031	91.4%	.0256	8.3
1.0	0	81.7%	.0024	63.9%	.0207	8.6
	30	-	-	80.4%	.0231	-
	90	99.0%	.0027	75.8%	.0227	8.4
	120	99.3%	.0028	88.6%	.0186	6.6
2.0	0	94.1%	.0029	87.2%	.0249	8.6
	30	97.6%	.0033	98.9%	.0300	9.0
	90	95.7%	.0033	98.6%	.0281	8.5
	120	97.4%	.0034	98.3%	.0287	8.4

From these studies, then, the following results may be derived:

a) Increases in ruthenium retention with storage on soil-peat columns occur but are not very pronounced or consistent. Sawdust appears to be far more effective than peat in this respect, at

least for the 120 days storage period tested.

b) Sodium nitrate concentrations in the 0.5 to 2.0 molar range do not show specific influence on initial ruthenium retention or on increase in ruthenium retention with time. The 2.0 molar sodium nitrate concentration did not prevent the increase in ruthenium retention.

c) Additional lignin did not appreciably increase or retard ruthenium retention.

d) The ultimate retention of ruthenium was normally less than 98%. Under these conditions, near-total retention of ruthenium seems unlikely even with longer storage periods.

e) The percentage retention of ruthenium on soil is near-constant when ruthenium concentration is in the 5 to 40 millimoles/liter range.

C. Retention of Cesium on Soil-Sawdust Columns

There is no appreciable increase in retention of cesium on soil-sawdust columns with up to 120 days storage.

Since the cesium solution was prepared by simply dissolving cesium nitrate, the ionic state of the cesium was closely the same in each test. Because of this, the amount of cesium retained by a particular soil type as shown in Figure 5, declined with increasing sodium nitrate concentration. This behavior suggests that the retention is primarily due to ion exchange.

Once again it was found that alteration of the cellulose-lignin ratio did not materially affect the retention.

Sawdust has very little ability to retain cesium. Maximum retention under test conditions for a 20 millimole per liter concentration of cesium was only 3.6%. With 2.0 molar sodium nitrate, this figure fell to less than 1%.

The soil-sawdust mixtures retained only 66.5% as a maximum, 31% as a minimum. Average retentions were as follows:

Table 2. Average Percent Retention of Cesium on Soil-Sawdust Columns

	Sawdust	75% Soil 25% Sawdust	73% Soil 25% Sawdust 2% Lignin	70% Soil 25% Sawdust 5% Lignin
0.5 M $NaNO_3$	3.1%	63.1%	59.6%	58.3%
1.0 M $NaNO_3$	2.2%	47.7%	47.0%	48.7%
2.0 M $NaNO_3$	0.9%	34.1%	34.7%	35.7%

The decrease in cesium retention with added lignin in the soil-sawdust mixture is due to the sodium ion in the lignin. As mentioned earlier, the relative effect of the added sodium would decrease with increase in the total sodium content and so the effect seems most pronounced in the 0.5 M sodium nitrate solution.

D. Retention of Cesium on Soil-Peat Columns

No increase in retention of cesium with storage time on peat or peat-soil mixtures was observed. This is evident from Figure 6. Percentage retention of cesium on the peat alone, however, was far greater than on the sawdust alone.

Since the results seem consistent from storage period to storage period, average values for the retention of cesium on the soil-peat columns have been computed as follows.

Table 3. Average Percent Retention of Cesium on Soil-Peat Columns

	Peat	75% Soil 25% Peat	75% Soil 25% Peat 2% Lignin	70% Soil 25% Peat 5% Lignin
0.5 M $NaNO_3$	22.0%	66.5%	63.0%	59.2%
1.0 M $NaNO_3$	13.5%	50.6%	51.3%	52.6%
2.0 M $NaNO_3$	8.9%	37.0%	37.4%	37.8%

A decrease in cesium retention with added lignin for the 0.5 M sodium nitrate soil-peat mixtures is noted. This effect does not appear in the 1.0 and 2.0 molar sodium nitrate solutions, however. The difference is obscured by the experimental errors.

Again, the experimental variation was greater for the peat columns than the sawdust columns owing to the difficulty encountered in wetting the peat.

For the cesium studies, then, the following general observations may be made:

a) No appreciable increase of cesium retention with time is observed with storage period on either soil-sawdust or soil-peat columns.

b) Peat has several times more exchange capacity for cesium than sawdust has.

c) Increase in sodium nitrate concentration of the test solutions resulted in reduced retention of cesium. This confirms the belief that this is an ion exchange mechanism.

d) The addition of lignin does not promote an increase in the amount of cesium retained. The sodium added along with the lignin, however, is seen to tend to decrease the amount of cesium retained.

e) Under the test conditions, the percentages of cesium retained on soil-sawdust and soil-peat mixtures (34% - 67%) are quite low when compared with the requirements for decontamination of water containing radioactive materials.

CONCLUSIONS

Under the proper conditions, appreciable amounts of ruthenium can be removed from solution and held on mixtures of soil-sawdust and soil-peat. In the case of storage on mixtures of soil and sawdust, the amount of ruthenium retained may be expected to continue to increase whereas on soil-peat mixtures increase is uncertain. The amount of ruthenium remaining in solution usually exceeds 2% while in contact with the soil mixture.

Storage on the clay soil without additional sawdust or peat appears most effective, especially for rapid decontamination. Such a procedure could possibly be useful for at least partially decontaminating small quantities of drinking water during a time of gross catastrophe.

From a practical standpoint, cesium is not retained on sawdust and only to a small extent on peat. While clay soil can retain a sizable quantity of cesium in comparison with sawdust or peat, the decontamination of the solution in contact with soil is far from complete. Perhaps more favorable soil to liquid ratios would result in better decontamination factors for cesium, but even if this were the case the method does not look promising for use where high degrees of decontamination and retention are necessary.

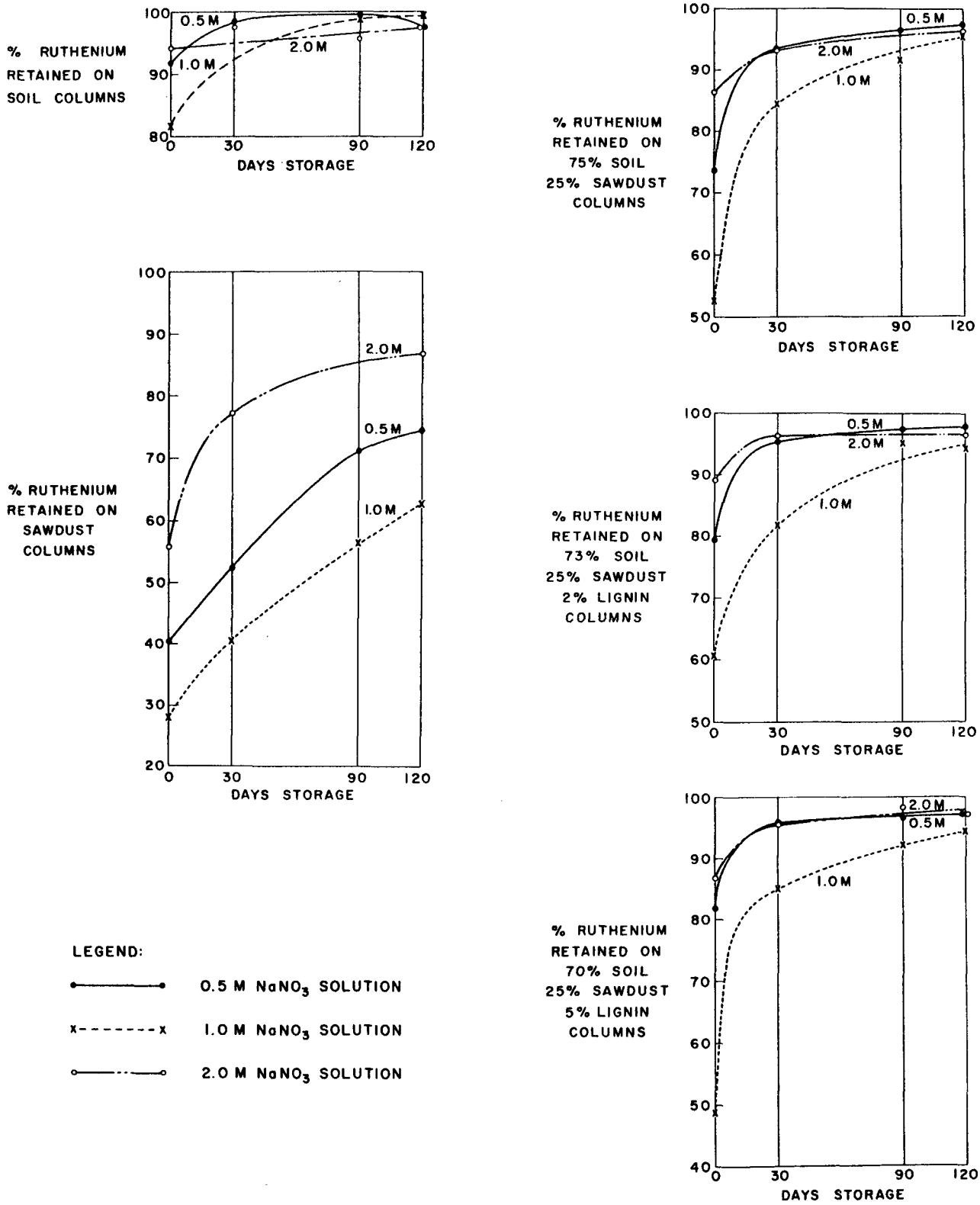


FIGURE 1: RUTHENIUM RETENTION ON SOIL-SAWDUST COLUMNS

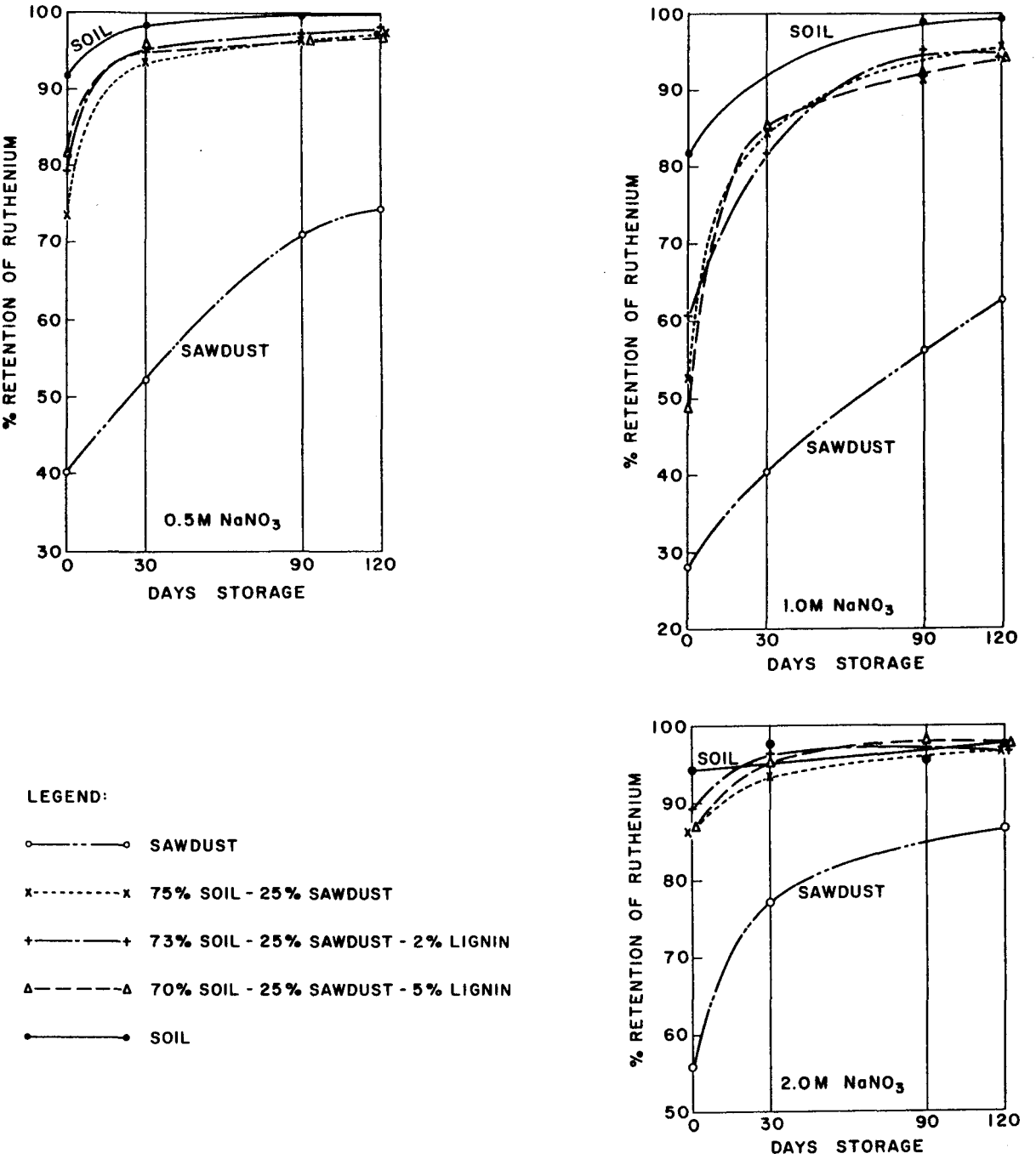


FIGURE 2: RUTHENIUM RETENTION ON SOIL-SAWDUST COLUMNS

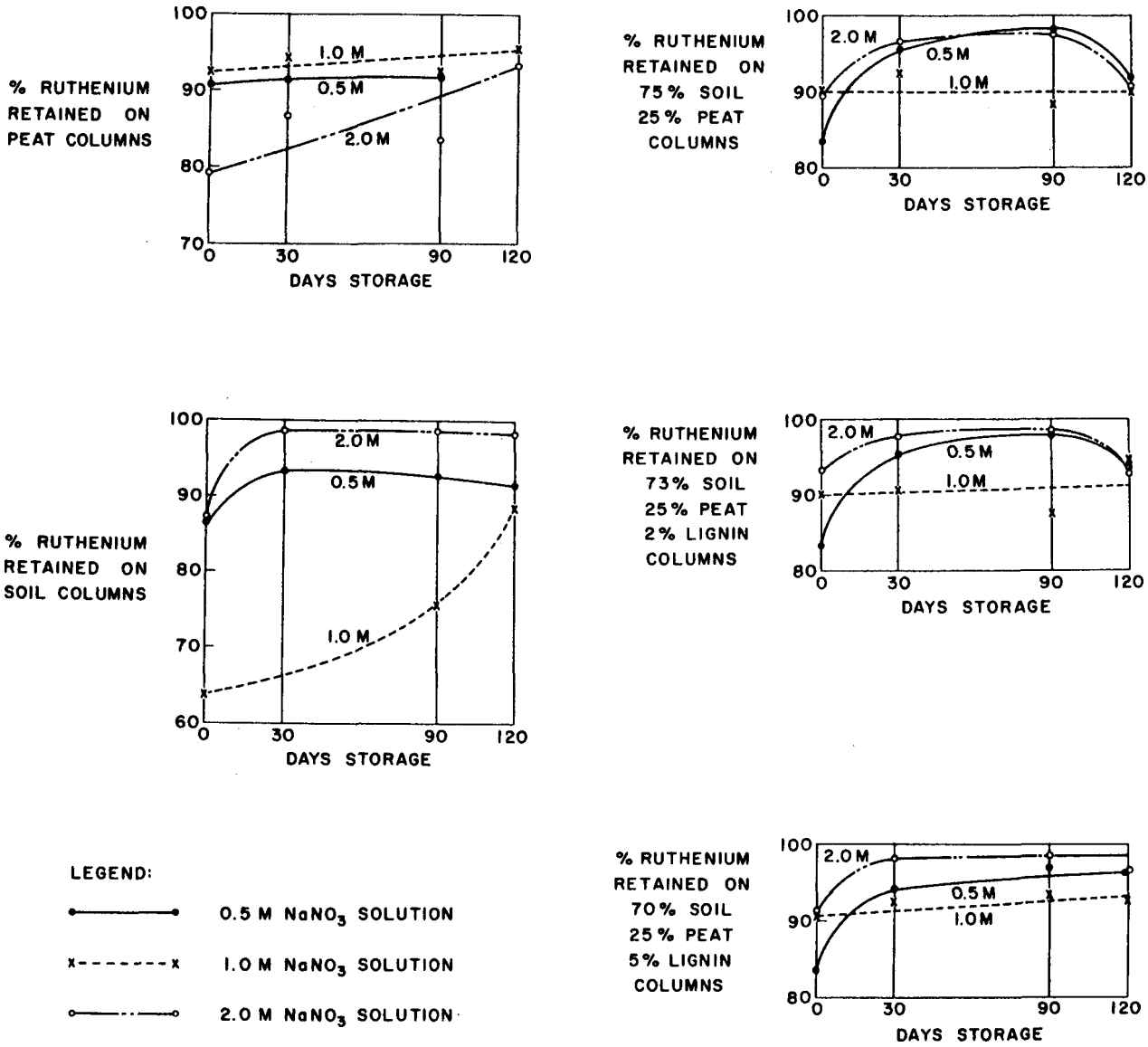
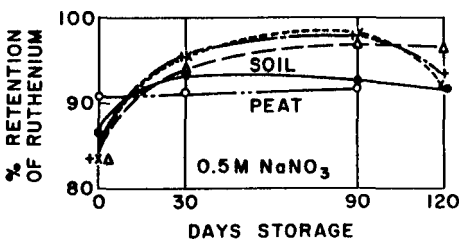
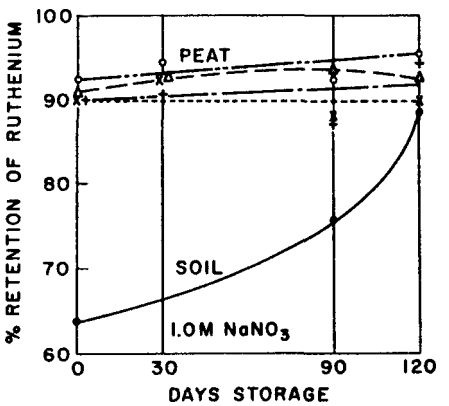


FIGURE 3: RUTHENIUM RETENTION ON SOIL-PEAT COLUMNS





LEGEND:

- PEAT
- 75% SOIL - 25% PEAT
- 73% SOIL - 25% PEAT - 2% LIGNIN
- 70% SOIL - 25% PEAT - 5% LIGNIN
- SOIL

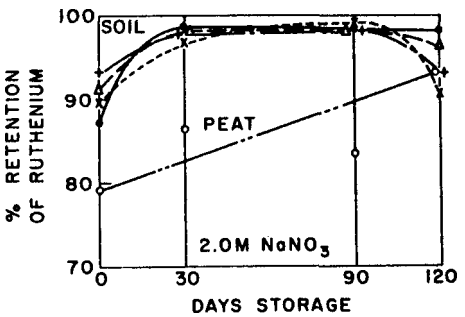


FIGURE 4: RUTHENIUM RETENTION ON SOIL-PEAT COLUMNS

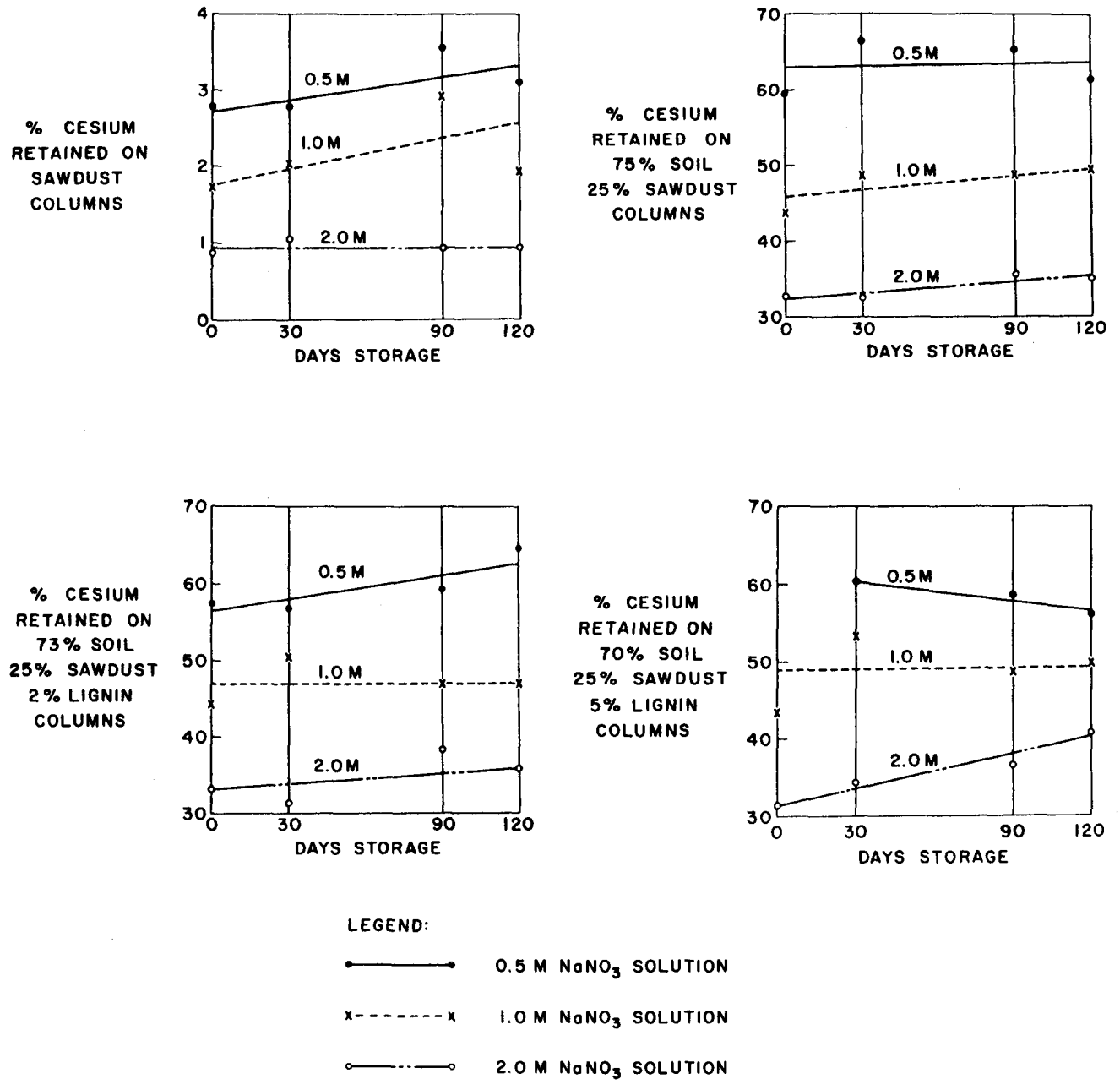


FIGURE 5: CESIUM RETENTION ON SOIL-SAWDUST COLUMNS

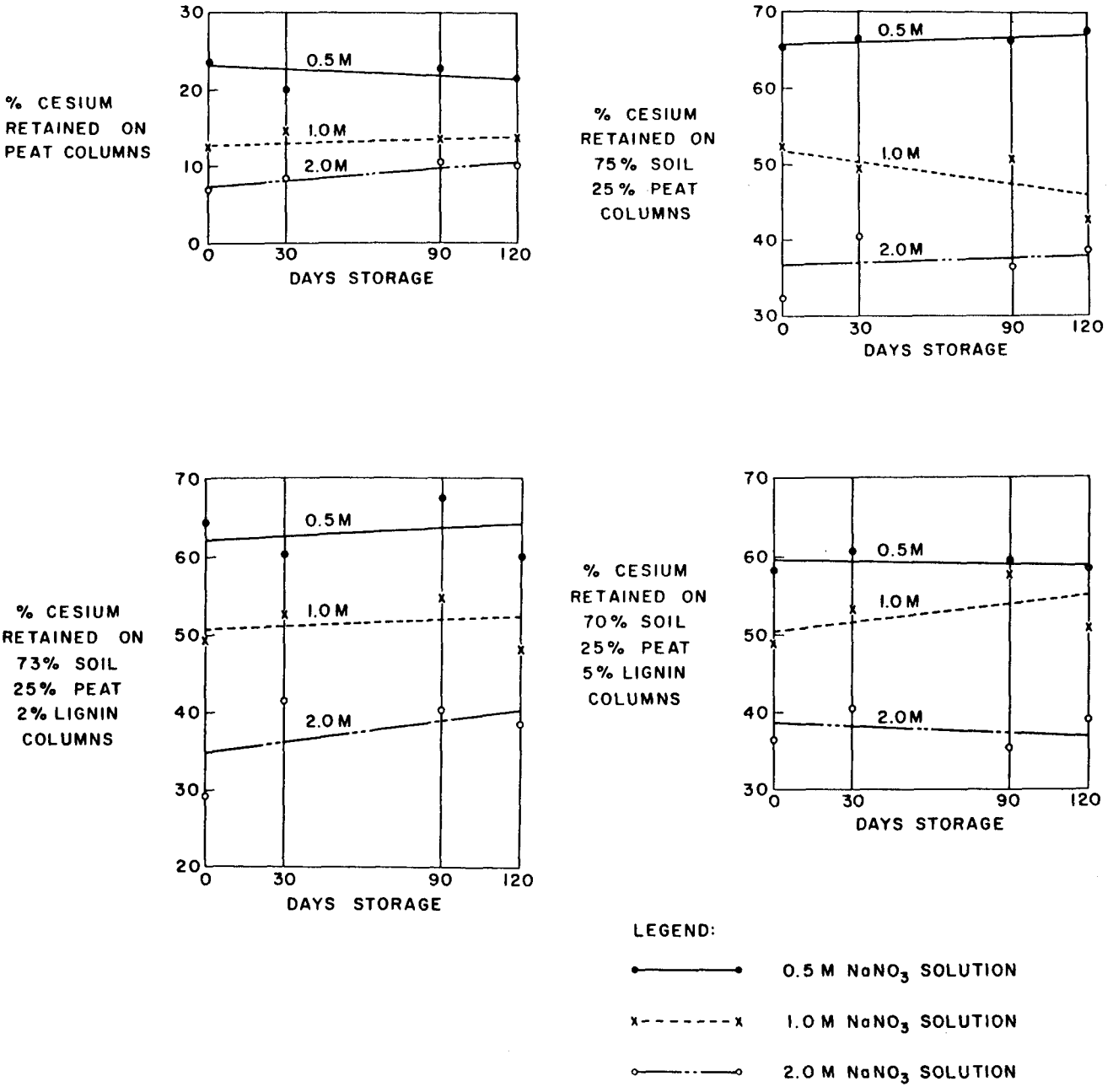


FIGURE 6: CESIUM RETENTION ON SOIL-PEAT COLUMNS

STORAGE TIME, DAYS	COMPOSITION OF MATERIAL	WEIGHT OF MATERIAL IN COLUMN, GRAMS	COMPOSITION OF LIQUID	MILLIMOLES Ru IN LIQUID APPLIED TO COLUMN	MILLIMOLES Ru LEACHED	MILLIMOLES Ru RETAINED PER GRAM OF SOIL MIXTURE		PERCENT Ru RETAINED
						CALCULATED FROM LEACHATE	MEASURED IN SOIL	
			0.5 M $NaNO_3$					
	Sawdust	12.4	0.005 M Ru	0.3335	.2039	.0104*	.0112*	40.1
	75% Soil - 25% Sawdust	32.0	"	0.3170	.0933	.00699*	.00760*	73.7
0	73% Soil - 25% Sawdust-2% Lignin	40.0	"	0.2930	.0598	.00582*	.00638	79.4
	70% Soil - 25% Sawdust-5% Lignin	40.0	"	0.2925	.0526	.00599*	.00619	81.9
	Soil	75.0	"	0.2335	.0156	.00290*	.00282	91.9
	Sawdust	12.4	"	.3655	.1490	.0184*	.0124*	52.2
	75% Soil - 25% Sawdust	32.0	"	.3155	.0139	.00924*	.00984	93.7
30	73% Soil - 25% Sawdust-2% Lignin	40.0	"	.3040	.0193	.00725*	.00756	95.4
	70% Soil - 25% Sawdust-5% Lignin	40.0	"	.2950	.0177	.00708*	.00786	96.0
	Soil	75.0	"	.2375	.0234	.00312*	.00303	98.5
	Sawdust	13.9	"	.3540	.1019	.0181*	.0230	71.0
	75% Soil - 25% Sawdust	32.0	"	.3085	.01045	.00932*	.0105	96.6
90	73% Soil - 25% Sawdust-2% Lignin	40.0	"	.3015	.0081	.00734*	.00797	97.4
	70% Soil - 25% Sawdust-5% Lignin	40.0	"	.2965	.0102	.00716*	.00730	96.6
	Soil	75.0	"	.2440	.0013	.00324*	.00377	99.6
	Sawdust	10.6	"	.3635	.0834	.0264*	.0246*	74.3
	75% Soil - 25% Sawdust	32.0	"	.3020	.0080	.00920*	.00946	97.5
120	73% Soil - 25% Sawdust-2% Lignin	40.0	"	.3045	.00624	.00746*	.0070	98.0
	70% Soil - 25% Sawdust-5% Lignin	40.0	"	.2980	.00726	.00726*	.00698	97.4
	Soil	75.0	"	.2415	.0059	.00314*	.00286	97.5

*Values used in computing "percent retained."

Summary Sheet: Retention of Ruthenium on Soil-Sawdust Columns
0.5 Molar Sodium Nitrate

STORAGE TIME, DAYS	COMPOSITION OF MATERIAL	WEIGHT OF MATERIAL IN COLUMN, GRAMS	COMPOSITION OF LIQUID	MILLIMOLES Ru IN LIQUID APPLIED TO COLUMN	MILLIMOLES Ru LEACHED	MILLIMOLES Ru RETAINED PER GRAM OF SOIL MIXTURE		PERCENT Ru RETAINED
						CALCULATED FROM LEACHATE	MEASURED IN SOIL	
0	Sawdust	16.7	1.0 M $NaNO_3$ / 0.005 mM Ru	0.3375	0.2435	.00564*	.00567*	28.0
	75% Soil - 25% Sawdust	31.7	"	.3090	.1730	.00546*	.00480*	52.6
	73% Soil - 25% Sawdust-2% Lignin	43.1	"	.3120	.1110	.00466*	.00411*	60.6
	70% Soil - 25% Sawdust-5% Lignin	35.0	"	.3270	.1655	.00461*	.00451*	48.8
	Soil	81.0	"	.2215	.0312	.00235*	.00210*	81.7
34	Sawdust	17.2	"	.3410	.2108	.00756*	.00853*	40.4
	75% Soil - 25% Sawdust	40.6	"	.3025	.0471	.00630*	.00708	84.5
	73% Soil- 25% Sawdust-2% Lignin	40.7	"	.3240	.0590	.00651*	.00804	81.8
	70% Soil - 25% Sawdust -5% Lignin	34.6	"	.3230	.0478	.00796*	.00860	85.2
	Soil	-	"	-	-	-	-	-
90	Sawdust	16.8	"	.3405	.3299	.0106*	.0121*	56.2
	75% Soil - 25% Sawdust	38.2	"	.3085	.2344	.00741*	.00894	91.7
	73% Soil - 25% Sawdust-2% Lignin	41.1	"	.3195	.2455	.00741*	.00794	95.2
	70% Soil - 25% Sawdust-5% Lignin	35.0	"	.3250	.2394	.00856*	.00908	92.1
	Soil	81.1	"	.2215	.1945	.00270*	.00286	99.0
110	Sawdust	16.9	"	.3365	.3241	.0119*	.0130*	62.8
	75% Soil - 25% Sawdust	44.4	"	.3055	.2397	.00658*	.00650	95.6
	73% Soil - 25% Sawdust-2% Lignin	45.8	"	.2965	.2355	.00610*	.00672	94.3
	70% Soil - 25% Sawdust-5% Lignin	40.3	"	.3160	.2418	.00742*	.00832	94.6
	Soil	77.5	"	.2195	.1914	.00281*	.00270	99.3

*Values used in computing "percent retained."

Summary Sheet: Retention of Ruthenium on Soil Sawdust Columns
1.0 Molar Sodium Nitrate

STORAGE TIME, DAYS	COMPOSITION OF MATERIAL	WEIGHT OF MATERIAL IN COLUMN, GRAMS	COMPOSITION OF LIQUID	MILLIMOLES Ru IN LIQUID APPLIED TO COLUMN	MILLIMOLES Ru LEACHED	MILLIMOLES Ru RETAINED PER GRAM OF SOIL MIXTURE		PERCENT Ru RETAINED
						CALCULATED FROM LEACHATE	MEASURED IN SOIL	
0	Sawdust	13.7	2.0 M $NaNO_3$ 0.005 M Ru	0.3485	0.1582	0.0139*	0.0145*	55.8
	75% Soil - 25% Sawdust	32.0	"	.3395	.0464	.00916*	.00930	86.3
	73% Soil - 25% Sawdust-2% Lignin	40.0	"	.3395	.0366	.00757*	.00723	89.2
	70% Soil - 25% Sawdust-5% Lignin	40.0	"	.2965	.0387	.00644*	.00654	86.9
	Soil	75.0	"	.2300	.0128	.00289*	.00227	94.1
39-40	Sawdust	13.7	"	.3695	.0762	.0214*	.0202*	77.1
	75% Soil - 25% Sawdust	32.0	"	.3495	.0241	.0102*	.00914	93.4
	73% Soil - 25% Sawdust-2% Lignin	40.0	"	.3340	.0124	.00804*	.00777	96.3
	70% Soil - 25% Sawdust-5% Lignin	40.0	"	.3230	.0144	.00772*	.00722	95.7
	Soil	75.0	"	.2515	.0060	.00327*	.00296	97.6
90	Sawdust	13.5	"	.3740	-	-	.0255	-
	75% Soil - 25% Sawdust	32.0	"	.3585	-	-	.0116	-
	73% Soil - 25% Sawdust-2% Lignin	40.0	"	.3100	-	-	.00836	-
	70% Soil - 25% Sawdust-5% Lignin	40.0	"	.3155	.00861	.00776*	.0065	98.4
	Soil	75.0	"	.2620	.0071	.00334*	.00318	95.7
120	Sawdust	13.7	"	.3770	.0491	.0239*	.0289	86.8
	75% Soil - 25% Sawdust	32.0	"	.3515	.0130	.0106*	.0115	96.5
	73% Soil - 25% Sawdust-2% Lignin	40.0	"	.3310	.0095	.0080*	.0083	96.6
	70% Soil - 25% Sawdust-5% Lignin	40.0	"	.3085	.0081	.0075*	.0081	97.3
	Soil	75.0	"	.2625	.0065	.00341*	.00284	97.4

*Values used in computing "percent retained."

Summary Sheet: Retention of Ruthenium on Soil-Sawdust Columns
2.0 Molar Sodium Nitrate

STORAGE TIME, DAYS	COMPOSITION OF MATERIAL	WEIGHT OF MATERIAL IN COLUMN, GRAMS	COMPOSITION OF LIQUID	MILLIMOLES Ru IN LIQUID APPLIED TO COLUMN	MILLIMOLES Ru LEACHED	MILLIMOLES Ru RETAINED PER GRAM OF SOIL MIXTURE		PERCENT Ru RETAINED
						CALCULATED FROM LEACHATE	MEASURED IN SOIL	
0	Peat	13.0	0.5 M $NaNO_3$ / 0.02 M Ru	1.164	.1073	.0813*	.0785	90.8
	75% Soil - 25% Peat	36.0	0.5 M $NaNO_3$ / 0.04 M Ru	2.228	.3640	.0517*	.0519	83.5
	73% Soil - 25% Peat - 2% Lignin	40.0	"	2.040	.3400	.0425*	.0443	83.3
	70% Soil - 25% Peat - 5% Lignin	40.0	"	1.944	.318	.0407*	.0425	83.7
	Soil	70.0	"	2.000	.2714	.0247*	.0239	86.4
30	Peat	13.0	0.02 M Ru	1.098	.0986	.0770*	.0798	91.1
	75% Soil - 25% Peat	36.0	0.04 M Ru	2.192	.0930	.0583*	.0467	95.7
	73% Soil - 25% Peat - 2% Lignin	40.0	"	1.884	.0898	.0449*	.0357	95.3
	70% Soil - 25% Peat - 5% Lignin	40.0	"	1.956	.1075	.0462*	.0417	94.1
	Soil	70.0	"	1.988	.1364	.0265*	.0259	93.3
90	Peat	13.0	0.02 M Ru	1.182	.0975	.0834*	.0923	91.7
	75% Soil - 25% Peat	36.0	0.04 M Ru	2.076	.0339	.0567*	.0492	98.3
	73% Soil - 25% Peat - 2% Lignin	40.0	"	1.860	.0364	.0456*	.0416	98.0
	70% Soil - 25% Peat - 5% Lignin	40.0	"	1.840	.0570	.0446*	.0406	97.0
	Soil	70.0	"	2.028	.1545	.0268*	.0226	92.7
123	Peat	12.0	0.02 M Ru	1.044	-	-	.0988	-
	75% Soil - 25% Peat	36.0	0.04 M Ru	1.864	.149	.0476*	.0476	91.9
	73% Soil - 25% Peat - 2% Lignin	40.0	"	1.864	.1253	.0435*	.0422	93.3
	70% Soil - 25% Peat - 5% Lignin	38.0	"	1.988	.0835	.0503*	.0458	96.2
	Soil	70.0	"	1.964	.1752	.0256*	.0283	91.4

*Values used in computing "percent retained."

Summary Sheet: Retention of Ruthenium on Soil-Peat Columns
0.5 Molar Sodium Nitrate

STORAGE TIME, DAYS	COMPOSITION OF MATERIAL	WEIGHT OF MATERIAL IN COLUMN, GRAMS	COMPOSITION OF LIQUID	MILLIMOLES Ru IN LIQUID APPLIED TO COLUMN	MILLIMOLES Ru LEACHED	MILLIMOLES Ru RETAINED PER GRAM OF SOIL MIXTURE		PERCENT Ru RETAINED
						CALCULATED FROM LEACHATE	MEASURED IN SOIL	
0	Peat	11.2	1.0 M $NaNO_3$ 0.01 M Ru	0.463	.0344	.0382*	.0354	92.5
	75% Soil - 25% Peat	29.8	0.02 M Ru	1.160	.1168	.0350*	.0337	90.0
	73% Soil - 25% Peat - 2% Lignin	31.0	"	1.204	.120	.0349*	.0366	90.0
	70% Soil - 25% Peat - 5% Lignin	36.0	"	1.126	.106	.0283*	.0278	90.4
	Soil	70.3	0.04 M Ru	2.276	.650	.0231*	.0183*	63.9
33	Peat	9.7	0.01 M Ru	0.500	.0278	.0487*	.0427	94.5
	75% Soil - 25% Peat	29.3	0.02 M Ru	1.192	.0928	.0375*	.0363	92.2
	73% Soil - 25% Peat - 2% Lignin	29.6	"	1.162	.1065	.0356*	.0334	90.7
	70% Soil - 25% Peat - 5% Lignin	35.2	"	1.206	.067	.0323*	.0307	92.3
	Soil	69.9	0.04 M Ru	2.008	-	-	.0231	-
90	Peat	11.9	0.01 M Ru	0.604	.0473	.0468*	.0533	92.2
	75% Soil - 25% Peat	29.0	0.02 M Ru	1.158	.1395	.0351*	.0395	88.2
	73% Soil - 25% Peat - 2% Lignin	30.1	"	1.126	.1378	.0328*	.0368	87.7
	70% Soil - 25% Peat - 5% Lignin	32.5	"	1.144	.0763	.0329*	.0355	93.5
	Soil	70.1	0.04 M Ru	2.100	.4004	.0242*	.0212*	75.8
120	Peat	8.9	0.01 M Ru	0.618	.0283	.0662*	.0654	95.3
	75% Soil - 25% Peat	29.8	0.02 M Ru	1.132	.0111	.0342*	.0368	90.0
	73% Soil - 25% Peat - 2% Lignin	29.8	"	1.134	.0060	.0360*	.0379	94.6
	70% Soil - 25% Peat - 5% Lignin	27.8	"	1.166	.0083	.0389*	.0397	92.8
	Soil	70.3	0.04 M Ru	1.476	.0166	.0186*	.0111	88.6

*Values used in computing "Percent retained."

Summary Sheet: Retention of Ruthenium on Soil-Peat Columns
1.0 Molar Sodium Nitrate

STORAGE TIME, DAYS	COMPOSITION OF MATERIAL	WEIGHT OF MATERIAL IN COLUMN, GRAMS	COMPOSITION OF LIQUID	MILLIMOLES Ru IN LIQUID APPLIED TO COLUMN	MILLIMOLES Ru LEACHED	MILLIMOLES Ru RETAINED PER GRAM OF SOIL MIXTURE		PERCENT Ru RETAINED
						CALCULATED FROM LEACHATE	MEASURED IN SOIL	
0	Peat	12.0	2.0 M $NaNO_3$ 0.02 M Ru	0.964	.199	.0637*	.0636*	79.2
	75% Soil - 25% Peat	36.0	0.04 M Ru	2.036	.212	.0507*	.0496	89.7
	73% Soil - 25% Peat - 2% Lignin	40.0	"	1.984	.132	.0463*	.0423	93.3
	70% Soil - 25% Peat - 5% Lignin	38.0	"	1.960	.175	.0470*	.0439	91.1
	Soil	70.0	"	2.000	.256	.0249*	.0239	87.2
32	Peat	12.0	0.02 M Ru	0.750	.101	.0541*	.0613	86.6
	75% Soil - 25% Peat	36.0	0.04 M Ru	2.128	.0695	.0572*	.0552	96.8
	73% Soil - 25% Peat - 2% Lignin	40.0	"	2.136	.0425	.0523*	.0515	97.9
	70% Soil -25% Peat - 5% Lignin	38.0	"	1.908	.0354	.0483*	.0461	98.2
	Soil	70.0	"	2.124	.0273	.0300*	.0250	98.9
90	Peat	12.0	0.02 M Ru	0.716	0.119	.0498*	.0541	83.5
	75% Soil - 25% Peat	36.0	0.04 M Ru	2.068	.0396	.0563*	.0603	98.0
	73% Soil - 25% Peat - 2% Lignin	40.0	"	2.056	.0320	.0506*	.0578	98.4
	70% Soil - 25% Peat - 5% Lignin	38.0	"	2.380	.0313	.0618*	.0718	98.7
	Soil	70.0	"	1.996	.0315	.0281*	.0278	98.6
120	Peat	12.0	0.02 M Ru	1.178	-	-	.0914*	93.1
	75% Soil - 25% Peat	36.0	0.04 M Ru	2.316	.217	.0583*	.0706	90.6
	73% Soil - 25% Peat - 2% Lignin	40.0	"	2.256	.154	.0525*	.0635	93.1
	70% Soil - 25% Peat - 5% Lignin	38.0	"	2.216	.0834	.0562*	.0642	96.4
	Soil	70.0	"	2.044	.0374	.0287*	.0257	98.3

*Values used in computing "percent retained."

Summary Sheet: Retention of Ruthenium on Soil-Peat Columns
2.0 Molar Sodium Nitrate

STORAGE TIME, DAYS	COMPOSITION OF MATERIAL	WEIGHT OF MATERIAL IN COLUMN, GRAMS	COMPOSITION OF LIQUID	MILLIMOLES Cs IN LIQUID APPLIED TO COLUMN	MILLIMOLES Cs LEACHED	MILLIMOLES Cs RETAINED PER GRAM OF SOIL MIXTURE		PERCENT Cs RETAINED
						CALCULATED FROM LEACHATE	MEASURED IN SOIL	
0	Sawdust	15.0	0.5 M $NaNO_3$ / 0.02 M Cs	1.392	1.445	0	.0026*	2.8
	75% Soil - 25% Sawdust	40.0	"	1.132	.469	.0166*	.0170*	59.4
	73% Soil - 25% Sawdust-2% Lignin	40.0	"	1.154	.499	.0164*	.0169*	57.4
	70% Soil - 25% Sawdust-5% Lignin	40.0	"	1.136	-	-	-	-
32	Sawdust	15.0	"	1.384	1.308	.0050	.0026*	2.8
	75% Soil - 25% Sawdust-	40.0	"	1.098	.361	.0184*	.0182*	66.5
	73% Soil - 25% Sawdust-2% Lignin	40.0	"	1.170	.506	.0166*	.0167*	56.8
	70% Soil - 25% Sawdust-5% Lignin	40.0	"	1.130	.455	.0168*	.0172*	60.1
90	Sawdust	15.0	"	1.384	1.265	.0079	.0033*	3.57
	75% Soil - 25% Sawdust	40.0	"	1.142	.384	.0190*	.0183*	65.2
	73% Soil - 25% Sawdust-2% Lignin	40.0	"	1.212	.452	.0190*	.0169*	59.2
	70% Soil - 25% Sawdust-5% Lignin	40.0	"	1.122	.447	.0169*	.0161*	58.7
120	Sawdust	15.0	"	1.386	1.300	.0057	.0029*	3.1
	75% Soil - 25% Sawdust	40.0	"	1.156	.458	.0175*	.0178*	61.1
	73% Soil - 25% Sawdust-2% Lignin	40.0	"	1.176	.390	.0197*	.0184*	64.8
	70% Soil - 25% Sawdust-5% Lignin	40.0	"	1.166	.502	.0166*	.0161*	56.0

*Values used in computing "Percent retained."

Summary Sheet: Retention of Cesium on Soil-Sawdust Columns
0.5 Molar Sodium Nitrate

STORAGE TIME, DAYS	COMPOSITION OF MATERIAL	WEIGHT OF MATERIAL IN COLUMN, GRAMS	COMPOSITION OF LIQUID	MILLIMOLES Cs IN LIQUID APPLIED TO COLUMN	MILLIMOLES Cs LEACHED	MILLIMOLES Cs RETAINED PER GRAM OF SOIL MIXTURE		PERCENT Cs RETAINED
						CALCULATED FROM LEACHATE	MEASURED IN SOIL	
0	Sawdust	15.0	1.0 M $NaNO_3$ / 0.02 M Cs	1.470	1.385	.0057	.0017*	1.73
	75% Soil - 25% Sawdust	39.3	"	1.294	.702	.0151*	.0137*	43.8
	73% Soil - 25% Sawdust-2% Lignin	40.4	"	1.262	.678	.0144*	.0132*	44.2
	70% Soil - 25% Sawdust-5% Lignin	39.6	"	1.204	.658	.0138*	.0128*	43.4
30	Sawdust	13.7	"	1.412	1.395	.0013	.0021*	2.03
	75% Soil - 25% Sawdust	39.8	"	1.218	.615	.0152*	.0146*	48.7
	73% Soil - 25% Sawdust-2% Lignin	40.3	"	1.202	.584	.0153*	.0148*	50.5
	70% Soil - 25% Sawdust-5% Lignin	39.9	"	1.252	.553	.0175*	.0159*	53.2
90	Sawdust	13.8	"	1.420	-	-	.0030*	2.91
	75% Soil - 25% Sawdust	38.9	"	1.262	.606	.0169*	.0148*	48.9
	73% Soil - 25% Sawdust-2% Lignin	37.7	"	1.258	.608	.0172*	.0141*	46.7
	70% Soil - 25% Sawdust-5% Lignin	39.5	"	1.242	.597	.0163*	.0141*	48.4
120	Sawdust	14.0	"	1.374	1.254	.0086	.0019*	1.94
	75% Soil - 25% Sawdust	39.6	"	1.230	.582	.0164*	.0144*	49.5
	73% Soil - 25% Sawdust-2% Lignin	39.8	"	1.286	.647	.0161*	.0141*	46.7
	70% Soil - 25% Sawdust-5% Lignin	39.9	"	1.216	.561	.0164*	.0140*	49.6

*Values used in computing "percent retained."

Summary Sheet: Retention of Cesium on Soil-Sawdust Columns
1.0 Molar Sodium Nitrate

STORAGE TIME, DAYS	COMPOSITION OF MATERIAL	WEIGHT OF MATERIAL IN COLUMN, GRAMS	COMPOSITION OF LIQUID	MILLIMOLES Cs IN LIQUID APPLIED TO COLUMN	MILLIMOLES Cs LEACHED	MILLIMOLES Cs RETAINED PER GRAM OF SOIL MIXTURE		PERCENT Cs RETAINED
						CALCULATED FROM LEACHATE	MEASURED IN SOIL	
	Sawdust	15.0	2.0 M $NaNO_3$ 0.02 M Cs	1.384	1.294	.0060	.0008*	.87
0	75% Soil - 25% Sawdust	40.0	"	1.260	.812	.0112*	.0095*	32.9
	73% Soil - 25% Sawdust-2% Lignin	40.0	"	1.196	.765	.0108*	.0090*	33.1
	70% Soil - 25% Sawdust-5% Lignin	40.0	"	1.240	.810	.0108*	.0086*	31.3
	Sawdust	15.0	"	1.454	1.443	.0007	.0010*	1.03
32	75% Soil - 25% Sawdust	40.0	"	1.278	.844	.0109*	.0100*	32.6
	73% Soil - 25% Sawdust-2% Lignin	40.0	"	1.272	.840	.0108*	.0091*	31.3
	70% Soil - 25% Sawdust-5% Lignin	40.0	"	1.170	.738	.0108*	.0093*	34.3
	Sawdust	15.0	"	1.470	1.352	.0079	.0009*	.92
90	75% Soil - 25% Sawdust	40.0	"	1.254	.750	.0126*	.0098*	35.7
	73% Soil - 25% Sawdust-2% Lignin	40.0	"	1.226	.744	.0121*	.0094*	38.3
	70% Soil - 25% Sawdust-5% Lignin	40.0	"	1.246	.780	.0117*	.0091*	36.5
	Sawdust	15.0	"	1.472	1.337	.0090	.0009*	.92
120	75% Soil - 25% Sawdust	40.0	"	1.254	.783	.0118*	.0102*	35.0
	73% Soil - 25% Sawdust-2% Lignin	40.0	"	1.272	.773	.0125*	.0096*	35.9
	70% Soil - 25% Sawdust-5% Lignin	40.0	"	1.186	.733	.0113*	.0092*	40.6

*Values used in computing "percent retained."

Summary Sheet: Retention of Cesium on Soil-Sawdust Columns
2.0 Molar Sodium Nitrate

STORAGE TIME, DAYS	COMPOSITION OF MATERIAL	WEIGHT OF MATERIAL IN COLUMN, GRAMS	COMPOSITION OF LIQUID	MILLIMOLES Cs IN LIQUID APPLIED TO COLUMN	MILLIMOLES Cs LEACHED	MILLIMOLES Cs RETAINED PER GRAM OF SOIL MIXTURE		PERCENT Cs RETAINED
						CALCULATED FROM LEACHATE	MEASURED IN SOIL	
0	Peat	16.0	0.5 M $NaNO_3$ 0.02 M Cs	1.012	.851	.0101*	.0150	23.7
	75% Soil - 25% Peat	40.0	"	1.006	.353	.0163*	.0167*	65.3
	73% Soil - 25% Peat - 2% Lignin	40.0	"	1.042	.377	.0166*	.0170*	64.4
	70% Soil - 25% Peat - 5% Lignin	40.0	"	1.026	.443	.0146*	.0153*	58.2
30	Peat	16.0	"	1.178	.942	.0147*	.0148*	20.0
	75% Soil - 25% Peat	40.0	"	1.086	.348	.0185*	.0178*	66.7
	73% Soil - 25% Peat - 2% Lignin	40.0	"	1.020	.429	.0148*	.0159*	60.2
	70% Soil - 25% Peat - 5% Lignin	40.0	"	1.036	.377	.0165*	.0152*	60.8
90	Peat	16.0	"	1.128	.888	.0150*	.0170*	22.7
	75% Soil - 25% Peat	40.0	"	1.080	.366	.0179*	.0179*	66.3
	73% Soil - 25% Peat - 2% Lignin	40.0	"	1.084	.339	.0186*	.0180*	67.5
	70% Soil - 25% Peat - 5% Lignin	40.0	"	1.092	.439	.0163*	.0162*	59.5
124	Peat	16.0	"	1.160	.908	.0157*	.0155*	21.5
	75% Soil - 25% Peat	40.0	"	1.062	.339	.0180*	.0180*	67.7
	73% Soil - 25% Peat - 2% Lignin	40.0	"	1.138	.443	.0174*	.0169*	60.0
	70% Soil - 25% Peat - 5% Lignin	40.0	"	1.094	.415	.0165*	.0149*	58.4

*Values used in computing "percent retained."

Summary Sheet: Retention of Cesium on Soil-Peat Columns
0.5 Molar Sodium Nitrate

STORAGE TIME, DAYS	COMPOSITION OF MATERIAL	WEIGHT OF MATERIAL IN COLUMN, GRAMS	COMPOSITION OF LIQUID	MILLIMOLES Cs IN LIQUID APPLIED TO COLUMN	MILLIMOLES Cs LEACHED	MILLIMOLES Cs RETAINED PER GRAM OF SOIL MIXTURE		PERCENT Cs RETAINED
						CALCULATED FROM LEACHATE	MEASURED IN SOIL	
0	Peat	16.0	1.0 M $NaNO_3$ 0.02 M Cs	1.198	1.085	.0071	.0093*	12.4
	75% Soil - 25% Peat	40.0	"	1.040	.508	.0133*	.0138*	52.2
	73% Soil - 25% Peat - 2% Lignin	40.0	"	1.104	.562	.0136*	.0136*	49.3
	70% Soil - 25% Peat - 5% Lignin	40.0	"	1.012	.512	.0125*	.0122*	48.8
32	Peat	16.0	"	1.134	.932	.0126	.0102*	14.4
	75% Soil - 25% Peat	40.0	"	1.068	.513	.0139*	.0125*	49.4
	73% Soil - 25% Peat - 2% Lignin	40.0	"	1.088	.486	.0150*	.0138*	52.9
	70% Soil - 25% Peat - 5% Lignin	40.0	"	1.102	.468	.0158*	.0137*	53.4
90	Peat	16.0	"	1.136	.914	.0139	.0095*	13.4
	75% Soil - 25% Peat	40.0	"	1.092	.504	.0147*	.0130*	50.7
	73% Soil - 25% Peat - 2% Lignin	40.0	"	1.034	.488	.0137*	.0147*	54.8
	70% Soil - 25% Peat - 5% Lignin	40.0	"	1.068	.410	.0165*	.0142*	57.5
124	Peat	16.0	"	1.138	.911	.0142	.0099*	13.9
	75% Soil - 25% Peat	40.0	"	1.096	.594	.0126*	.0110*	42.7
	73% Soil - 25% Peat - 2% Lignin	40.0	"	1.072	.524	.0137*	.0122*	48.3
	70% Soil - 25% Peat - 5% Lignin	40.0	"	1.068	.499	.0142*	.0128*	50.6

*Values used in computing "percent retained."

Summary Sheet: Retention of Cesium on Soil-Peat Columns
1.0 Molar Sodium Nitrate

STORAGE TIME, DAYS	COMPOSITION OF MATERIAL	WEIGHT OF MATERIAL IN COLUMN, GRAMS	COMPOSITION OF LIQUID	MILLIMOLES Cs IN LIQUID APPLIED TO COLUMN	MILLIMOLES Cs LEACHED	MILLIMOLES Cs RETAINED PER GRAM OF SOIL MIXTURE		PERCENT Cs RETAINED
						CALCULATED FROM LEACHATE	MEASURED IN SOIL	
0	Peat	16.0	2.0 M $NaNO_3$ / 0.02 M Cs	1.208	1.041	.0105	.0053*	7.0
	75% Soil - 25% Peat	40.0	"	1.210	.796	.0104*	.0092*	32.3
	73% Soil - 25% Peat - 2% Lignin	40.0	"	1.110	.774	.0084*	.0078*	29.1
	70% Soil - 25% Peat - 5% Lignin	40.0	"	1.056	.642	.0104*	.0088*	36.4
30	Peat	16.0	"	1.110	.902	.0130	.0058*	8.4
	75% Soil - 25% Peat	40.0	"	.998	.561	.0109*	.0093*	40.4
	73% Soil - 25% Peat - 2% Lignin	40.0	"	1.116	.618	.0125*	.0108*	41.8
	70% Soil - 25% Peat - 5% Lignin	40.0	"	1.032	.600	.0108*	.0101*	40.5
92	Peat	16.0	"	.912	.740	.0108	.0059*	10.3
	75% Soil - 25% Peat	40.0	"	1.108	.649	.0115*	.0087*	36.5
	73% Soil - 25% Peat - 2% Lignin	40.0	"	1.042	.580	.0116*	.0091*	40.2
	70% Soil - 25% Peat - 5% Lignin	40.0	"	1.048	.658	.0098*	.0087*	35.3
124	Peat	16.0	"	1.038	.832	.0128	.0065*	10.0
	75% Soil - 25% Peat	40.0	"	1.110	.623	.0122*	.0093*	38.7
	73% Soil - 25% Peat - 2% Lignin	40.0	"	1.180	.662	.0130*	.0098*	38.6
	70% Soil - 25% Peat - 5% Lignin	40.0	"	1.030	.578	.0113*	.0088*	39.0

*Values used in computing "percent retained."

Summary Sheet: Retention of Cesium on Soil-Peat Columns
2.0 Molar Sodium Nitrate

SAMPLE CALCULATION SHEET NO. 1

Determination of Activity Leached from Columns after Storage

Ruthenium
Peat
0.5 M $NaNO_3$
90 Days Storage

Storage Date:
8-8-58 to 11-6-58

	Register/Scale/Minutes		Scale = 256
Background:	4/223/5) 4/204/5)	4/213/5 Mean =	248 cpm
Control: (Ruthenium solution added to column)	52/193/5) 52/136/5) 52/ 48/5)	52/121/5 Mean =	2687 cpm -248 b.g. 2439 cpm

Samples Leached:				Mean cpm -Background
1) 25 ml	a) 7/ 21/5	b) 7/ 23/5	c) 7/187/5	126
2) 25 ml	6/102/5	6/ 86/5		78
3) 25 ml	5/213/5	5/ 84/5		37
4) 25 ml	4/221/5	5/126/5		17
5) 50 ml	5/ 40/5	5/ 38/5		15
6) 50 ml	5/108/5	5/139/5		32
7) 100 ml	5/148/5	5/ 80/5		31

One milliliter portions of the leachate samples were taken for counting. Counting was done with a Nuclear-Chicago Well-Type Scintillation Counter, thallium-activated sodium iodide crystal, and Model 161 A Scaling Unit. Counting of the controls and leached samples took place on the same day to eliminate the need for decay corrections.

SAMPLE CALCULATION SHEET NO. 2

Total Activity Leached from Columns

Ruthenium
Peat
0.5 M $NaNO_3$
90 Days Storage

Storage Date:
8-8-58 to 11-6-58

Weight of Peat: 13.0 g

Vol. of Liquid Applied	x	Activity Applied cpm/ml*	=	Total cpm
59.1 ml	x	2439	=	144,145

	cpm Eluted: ml x cpm*	
1)	25 x 126 =	3150
2)	25 x 78 =	1950
3)	25 x 37 =	925
4)	25 x 17 =	425
5)	50 x 15 =	750
6)	50 x 32 =	1600
7)	100 x 31 =	3100
		11,900 Total cpm leached from column

Total cpm in column	144,145	
Total cpm leached	11,900	
cpm retained	132,245	as determined from leachate

* Computed on Sample Calculation Sheet No. 1

SAMPLE CALCULATION SHEET NO. 3

Determination of Activity Remaining on Soil

Ruthenium
Peat
0.5 M $NaNO_3$
90 Days Storage

Storage Date:
8-8-58 to 11-6-58

Background: 5/107/5 = 226 cpm

Sample	Weight, gm			
1)	.250	55/ 90/5)		
2)	.250	54/254/5)	Mean	2834
3)	.250	55/181/5)	-b.g.	226
				2608 cpm

Wt. of Peat Sample	Mean cpm Sample - Background	Decay Correction**
.250 gm	2608	1.08

$$\text{cpm/gm of peat} = \frac{2608}{.250} \times 1.08 = 11{,}297$$

Total cpm retained by column = 13.0 x 11,267 cpm/gm

= 146,471 as determined from peat sample.

**Decay Correction is determined by dividing the activity of the ruthenium solution on the day the leachate is counted by the activity of the same solution on the day the soil activity is measured.

SAMPLE CALCULATION SHEET NO. 4

Summary of Results - Storage Columns

Ruthenium (0.02 M)
Peat
0.5 M $NaNO_3$
90 Days Storage

Storage Date:
8-8-58 to 11-6-58

cpm			cpm	MM Ru	Percentage
Applied	Eluted	Retained (Calculated)	Retained on Peat	Retained* per g Peat	of Ru Retained
144,145	11,900	132,245	146,471	.0834	91.8**

* Calculation:

.918 x 20 MM Ru/l x .0591 l Ru-solution/13.0 g Peat =

.0834 MM Ru per g Peat.

**In this case the "% retained" is computed using the result from the leachate (132,245/144,145 x 100%) in acoordance with the rule set down on page 6.