

BNL-NUREG -31567

INFORMAL REPORT

LIMITED DISTRIBUTION

EVALUATION OF ISOTOPE MIGRATION-LAND BURIAL
WATER CHEMISTRY AT COMMERCIALY OPERATED LOW-LEVEL
RADIOACTIVE WASTE DISPOSAL SITES

QUARTERLY PROGRESS REPORT
APRIL - JUNE 1982

R. F. PIETRZAK AND R. DAYAL

NUCLEAR WASTE MANAGEMENT DIVISION

DEPARTMENT OF NUCLEAR ENERGY BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK 11973



Prepared for the U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
Contract No. DE-AC02-76CH00016

8209030377 820731
PDR RES
8209030377 PDR

NOTICE

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, or any of their employees, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for any third party's use, or the results of such use, of any information, apparatus, product or process disclosed in this report, or represents that its use by such third party would not infringe privately owned rights.

The views expressed in this report are not necessarily those of the U.S. Nuclear Regulatory Commission.

Available from
GPO Sales Program
Division of Technical Information and Document Control
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555
and
National Technical Information Service
Springfield, Virginia 22161

BNL-NUREG-31567
INFORMAL REPORT
LIMITED DISTRIBUTION

EVALUATION OF ISOTOPE MIGRATION - LAND BURIAL

WATER CHEMISTRY AT COMMERCIALY OPERATED LOW-LEVEL
RADIOACTIVE WASTE DISPOSAL SITES

QUARTERLY PROGRESS REPORT
APRIL - JUNE 1982

R. F. Pietrzak and R. Dayal
Principal Investigators

Contributors
M. Chin Sun Chong
J. Clinton
M. Kinsley

Manuscript Completed - July 1982
Date Published - July 1982

DONALD G. SCHWEITZER, HEAD
NUCLEAR WASTE MANAGEMENT DIVISION
DEPARTMENT OF NUCLEAR ENERGY, BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC., UPTON, NEW YORK

Prepared for the U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
Contract No. DE-AC02-76CH00016
Fin No. A-3042

SUMMARY

This report presents work performed in the Shallow-Land Burial Program (FIN A-3042) during the third quarter of fiscal year 1982.

- Trench waters from the Maxey Flats disposal site were analyzed for gamma emitting radionuclides.
- The physical characteristics of sediment from the Hawthorne formation at Barnwell were determined. Characterization analyses of sediments from Sheffield were initiated.
- The sediment core taken from beneath trench 2 at Barnwell was reanalyzed for ^{60}Co using appropriate sediment standards.
- Experiments to determine the retardation factors and diffusion coefficients of radionuclides in sediment from the Hawthorne formation at Barnwell were initiated.
- The leaching of a cement waste form in an environment simulating unsaturated water flow conditions over the waste form buried in Hawthorne sediment was initiated.

EVALUATION OF ISOTOPE MIGRATION - LAND BURIAL WATER CHEMISTRY
AT COMMERCIALY OPERATED LOW-LEVEL RADIOACTIVE WASTE DISPOSAL SITES
QUARTERLY PROGRESS REPORT, APRIL-JUNE 1982

1. TRENCH WATER CHEMISTRY - MAXEY FLATS (J. Clinton and M. T. Kinsley)

1.1 Dissolved Radionuclides

Trench waters collected from the Maxey Flats disposal site in October, 1981 were analyzed for gamma emitting radionuclides. Chemical parameters measured in the field and major inorganic ion content were reported in the previous quarterly reports (Pietrzak and Dayal, 1982a; 1982b).

1.1.1 Experimental

Anoxic trench waters were filtered through 0.45 μ m membrane filters to remove particulate matter. Acidified aliquots were analyzed by gamma-ray spectroscopy on a Ge(Li) detector system for 60,000 sec.

1.1.2 Results

The concentrations of the radionuclides identified are shown in Table 1.1.

Gross alpha, beta and tritium radiochemical analyses remain to be completed. Radiochemical separations for ^{90}Sr and plutonium isotopes are in progress.

1.2 Chelating Agents

Filtered, acidified (pH <2) aliquots (~500 mL) of Maxey Flats trench waters were sent to L. J. Kirby and T. Toste at PNL for the analysis of chelating agents such as NTA, DTPA, EDTA and TTHA*.

*NTA - nitrilotriacetic acid.
DTPA - diethylenetriaminepentaacetic acid.
EDTA - ethylenediaminetetraacetic acid.
TTHA - triethylenetetraminehexaacetic acid.

Table 1.1

Concentration of Gamma Emitting Dissolved Radionuclides in Trench Waters
From the Maxey Flats Disposal Site (Collected October 1981)

Radionuclide	Activity pCi/L (+2σ)*						
	Trench 7-3	Trench 19W	Trench 23M	Trench 27	Trench 33L4	Trench 33L8	Trench 35
²⁴¹ Am	3.9x10 ² (25)	4.5x10 ⁴ (1)	1.4x10 ² (20)	3.0x10 ² (20)	<40	<30	4.4x10 ² (8)
⁶⁰ Co	1.6x10 ³ (3)	2.9x10 ⁴ (1)	1.5x10 ³ (2)	5.2x10 ³ (1)	1.4x10 ¹ (10)	1.4x10 ² (8)	1.5x10 ² (9)
¹³⁴ Cs	1.0x10 ² (40)	<50	<20	4.5x10 ¹ (30)	<40	<20	1.2x10 ² (9)
¹³⁷ Cs	1.0x10 ⁵ (1)	1.2x10 ⁴ (1)	3.2x10 ³ (1)	1.2x10 ⁴ (1)	<60	8.9x10 ¹ (10)	1.0x10 ⁴ (1)

*The number in () represents 2σ counting uncertainty.

2. SEDIMENT CHARACTERIZATION

2.1 Barnwell Sediment (M. Chin Sun Chong and R. F. Pietrzak)

A 55-gallon drum of sediment from the Hawthorne formation, sampled west of trench 32, at the Barnwell disposal site was obtained in February, 1982 (Piciulo, 1982). The material is being characterized for use in the waste form leaching and column retardation experiments described in later sections of this report.

2.1.1 Experimental

Procedures being used to characterize the sediment are listed in Appendix A. The sediment was air dried, sieved to exclude gravel and pebbles (>2 mm) and homogenized by hand mixing. The amount of material coarser than 2 mm is estimated to be less than one percent of the total sediment weight.

2.1.2 Results

The characterization data for the air dried, homogenized, and sieved (<2 mm) sediment are given in Table 2.1.

Table 2.1

Sieved Sediment (<2 mm) from the Hawthorne Formation at Barnwell
(Collected February 1982)

Parameter ^a	Average \pm s.d.
Moisture (weight %)	2.44 \pm 0.04
Sand (weight %)	66 \pm 2
Silt (weight %)	4 \pm 3
Clay (weight %)	30 \pm 1
Cation Exchange Capacity (meq/100 g)	4.0 \pm 0.4
Organic Matter (weight %)	2.6 \pm 0.1
Surface Area (m ² /g)	132 \pm 15
Extractable iron (weight %)	4.7 \pm 0.3

^aSediment was air dried at ambient temperature, homogenized and sieved to pass a 2 mm sieve. Less than 1% of the sediment was >2mm.

In addition, we have determined the average particle density, bulk density, porosity, and hydraulic conductivity of packed Barnwell sediment (<2 mm). The data for these parameters are given in Table 2.2.

Table 2.2

Physical Characteristics of Air Dried, Packed Barnwell Sediment
(< 2 mm)

Average Particle Density	2.616 ± 0.002 g/cm ³
Bulk Density	1.25 ± 0.01 g/cm ³
Porosity	$52.2 \pm 0.2\%$
Hydraulic Conductivity (under saturated conditons)	$1.15 \pm 0.01 \times 10^{-3}$ cm/sec

2.2 Sheffield Sediment

Four sediment cores were collected 25 feet west of USGS well 503 by Shelby tubes at the Sheffield disposal site (May 1982). The sediment cores represent samples of Peroia Loess, Radnor Till, Hulick Till, and Roxana Silt. In addition, pebbly sand sediment was obtained from the tunnel beneath the trenches. The characterization analysis has been initiated. These materials will be used for radionuclide sorption measurements.

2.3 ⁶⁰Co Distribution in a Sediment Core from Beneath Disposal Trenches at the Barnwell Disposal Site (M. Chin Sun Chong, J. Clinton, and R. F. Pietrzak)2.3.1 Introduction

In previous reports [Czyscinski et al. (1981) and Czyscinski and Weiss (1981)], we presented preliminary data on the distribution of ⁶⁰Co in a sediment core taken beneath disposal trench 2 at the Barnwell site (see Fig. 2.1). At that time, due to the unavailability of proper standards, aqueous standard solutions containing varying amounts of ⁶⁰Co were used for analysis. In addition, the sediment samples were not homogenized prior to counting. Because of these discrepancies, we considered it important to reanalyze the entire length of the core for ⁶⁰Co using proper sediment standards and sample geometries. Details of sample homogenization and preparation of standards are given below.

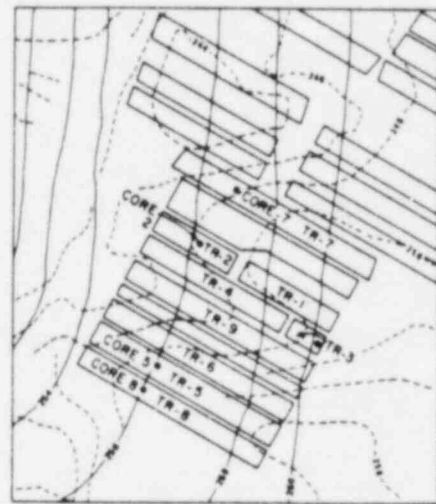
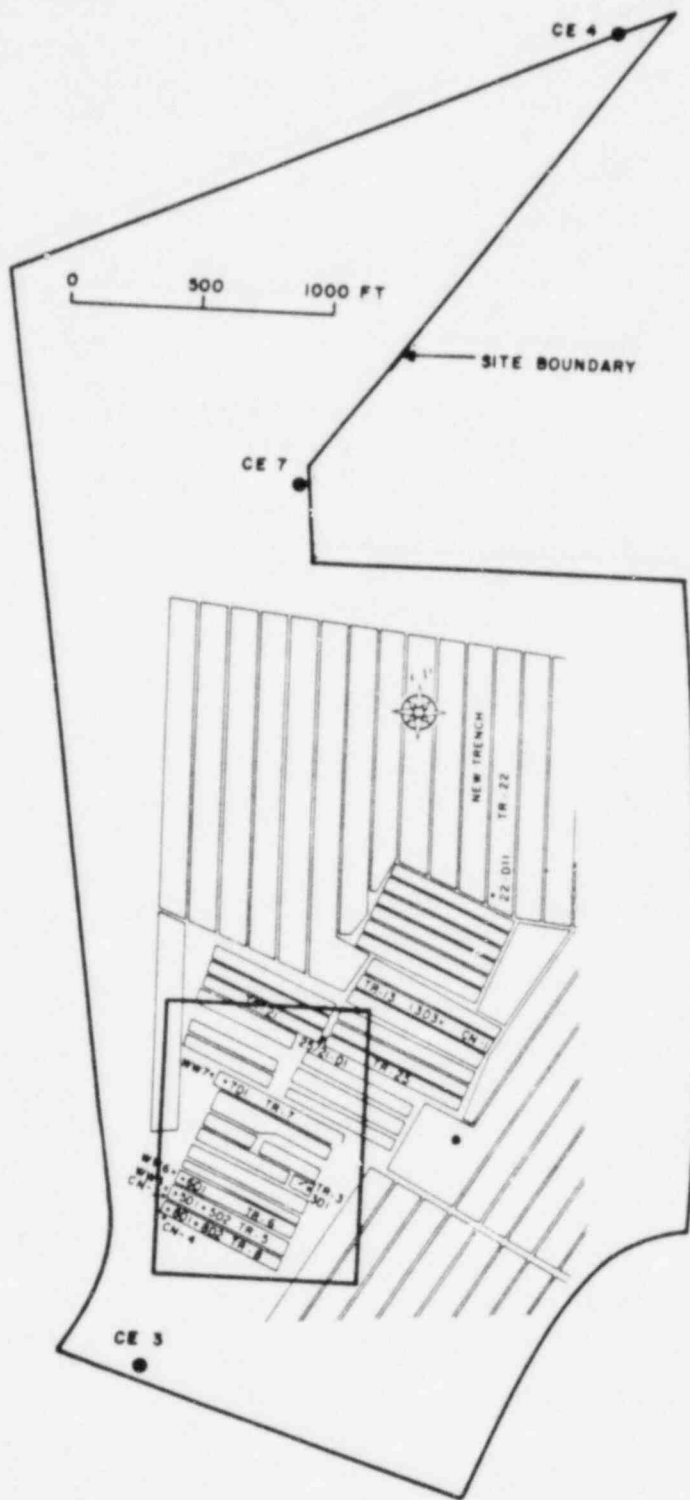


Figure 2.1 Locator map of the Barnwell disposal facility, showing the position of trench 2.

2.3.2 Experimental

The sediment core was sectioned into small plugs, approximately 2.5 cm in diameter by 5 cm in length. These plugs were kept in preweighed glass weighing bottles equipped with a ground glass lid to retain the moisture.

Pore water was removed from each sediment plug by distillation (Czyscinski et al., 1981). The sediment sample was dried and pulverized using a Wig-L-Bug vibrator. The pulverized sample was homogenized prior to counting in an aluminum can. The gamma ray spectrum of each sample was obtained by counting for 1000 minutes on a Ge(Li) detector and multichannel analyzer system.

Calibration of the Ge(Li) system was accomplished by counting homogenized sediment standards (50, 100 and 200 grams). These sediment standards had been prepared from a National Bureau of Standards mixed gamma ray reference solution (J. R. Stiemers, BNL, personal communication). The standards were counted in aluminum cans having the same geometries as those containing the samples. The weights of the standards bracketed the actual weights of the samples counted.

2.3.3 Results

The new results for the trench 2 core are listed in Table 2.3. As shown in Figure 2.2, most of the ^{60}Co activity in core 2 is confined to the upper six segments (approx. 30 cm). Below this depth, the activity drops off sharply to levels slightly above background levels. It should be noted that during the coring operation, in-hole gamma logging showed the presence of ^{60}Co for core 2 only (J. Cahill, U. S. Geological Survey, personal communication).

The activity distribution in core 2 is interesting in that a zone of low ^{60}Co concentration extends well below the main area of contamination (Figure 2.2). From chromatographic concepts, this "leading edge" of the migrating ^{60}Co front will move much further than the main body of contamination. In addition, a small peak of activity for ^{60}Co occurs in the leading edge. In the absence of information pertaining to the sorption kinetics of cobalt in these sandy sediments, it is not possible to unequivocally explain the radioisotope distribution observed in the core.

Table 2.3

Distribution of ^{60}Co Activity in Barmwell Trench 2 Core
Correct to April, 1979

Depth (m)	^{60}Co Activity ($2\sigma\%$) ^a (pCi/g dry sediment)
8.76 - 8.81	747 (0.2)
8.81 - 8.86	587 (0.4)
8.86 - 8.92	443 (0.4)
9.02 - 9.04	134 (0.6)
9.04 - 9.09	48.7 (1)
9.09 - 9.14	6.8 (4)
9.20 - 9.25	1.8 (6)
9.25 - 9.30	2.5 (5)
9.30 - 9.35	1.9 (6)
9.45 - 9.49	1.5 (7)
9.49 - 9.52	1.9 (6)
9.52 - 9.56	2.6 (5)
9.56 - 9.60	4.9 (3)
9.70 - 9.74	6.2 (3)
9.74 - 9.78	4.4 (4)
9.78 - 9.83	19.7 (2)
9.83 - 9.91	3.4 (4)
9.91 - 9.94	5.9 (3)
9.94 - 10.01	3.2 (4)
10.01 - 10.03	3.2 (6)
10.11 - 10.16	12.2 (2)
10.16 - 10.22	16.7 (2)
10.22 - 10.29	21.1 (2)
10.36 - 10.41	4.2 (4)
10.41 - 10.46	3.6 (4)
10.46 - 10.52	2.4 (6)
10.52 - 10.67	1.2 (9)
10.67 - 10.72	0.43 (14)
10.72 - 10.77	0.25 (21)
10.77 - 10.82	0.23 (10)
10.82 - 10.87	0.25 (22)
10.97 - 11.02	0.17 (30)
11.02 - 11.12	0.20 (24)
11.12 - 11.18	0.15 (22)
11.18 - 11.23	0.20 (22)
11.23 - 11.28	0.07 (28)
11.28 - 11.34	0.11 (33)
11.34 - 11.40	0.16 (36)
11.59 - 11.67	0.24 (12)
11.67 - 11.74	0.07 (90)
11.74 - 11.79	<0.02
11.79 - 11.84	<0.02

^aThe number in () represents $2\sigma\%$ counting uncertainty.

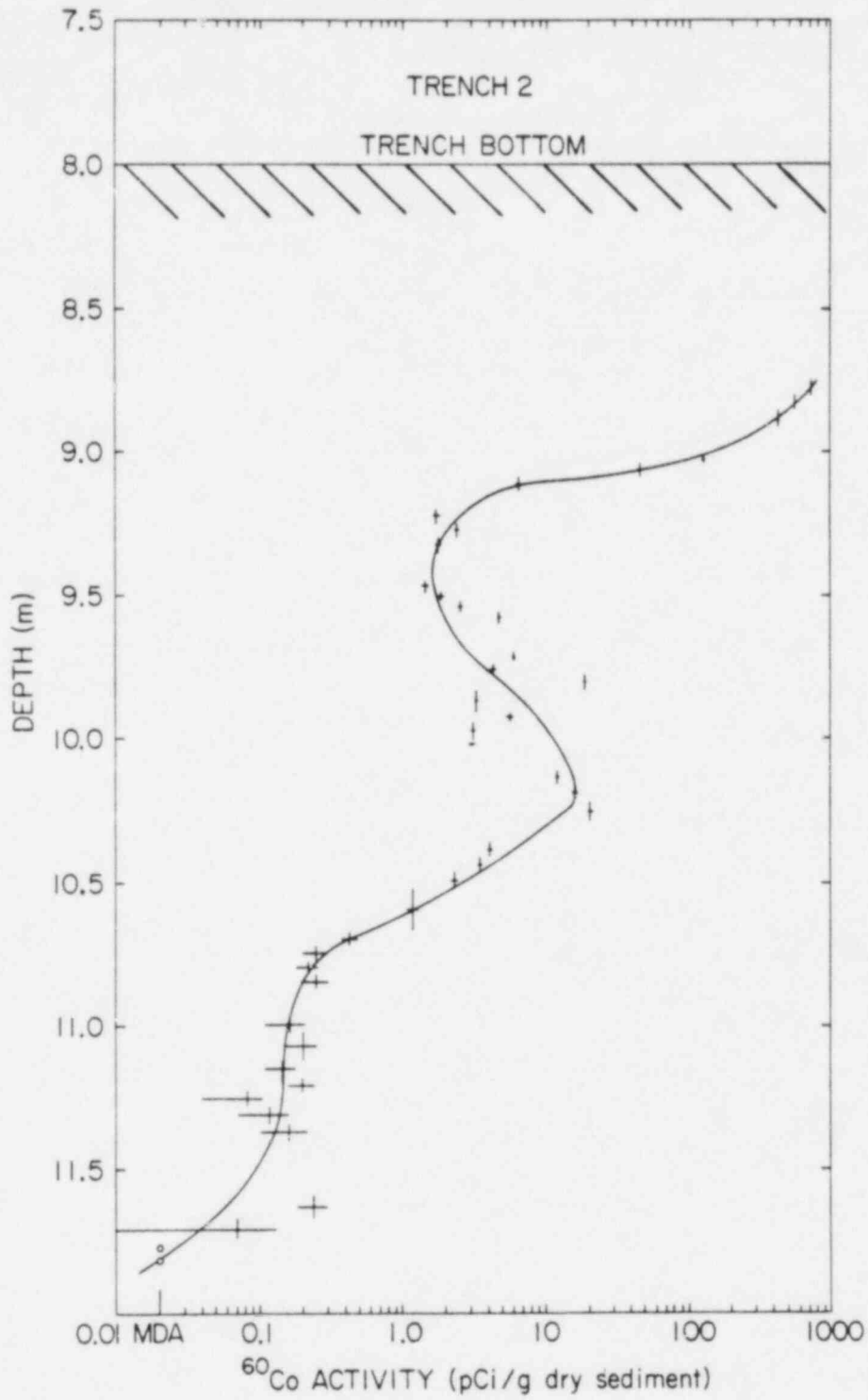


Figure 2.2 Distribution of ^{60}Co activity in trench 2 core from Barnwell. Activity corrected to April 1979.

3. SORPTION OF RADIONUCLIDES

3.1 Column Retardation Factors (M. T. Kinsley and R. F. Pietrzak)

3.1.1 Introduction

Radionuclide retardation experiments were initiated using sediment from the Hawthorne formation at Barnwell and a simulated Barnwell trench 6D1 water. The general theory for the retardation experiments were discussed earlier (Pietrzak and Dayal, 1982a) and the experimental procedure is based on the recommendations of Relyea (1981). The characteristics of the sediment are given in Tables 2.1 and 2.2 in this report, and the composition of the simulated Barnwell trench 6D1 water is given in Table 3.1.

Table 3.1

Composition of Simulated Barnwell Trench Water^a

Cations	Concentration mmoles/L	Anions	Concentration mmoles/L
Na ⁺¹	1.34	HCO ₃ ⁻¹	1.10
K ⁺¹	0.075	SO ₄ ⁻²	0.48
NH ₄ ⁺¹	0.26	Cl ⁻¹	0.38
Ca ⁺²	0.35	NO ₃ ⁻¹	0.30
Mg ⁺²	0.060		
Mn ⁺²	0.013		

SiO₂ = 0.12 mmoles/L^b

^aThe composition simulates water from trench sump 6D1 at Barnwell (Czyscinski and Weiss, 1981). The pH of the solution is adjusted to 6.0 with hydrochloric acid.

^bAdded as sodium metasilicate Na₂SiO₃·9H₂O.

3.1.2 Experimental

A schematic of the apparatus for radionuclide retardation testing by continuous water flow through a sediment core is shown in Figure 3.1.

Preliminary experimental work was performed with a short (1.0 in. long x 1.0 in. diam) cylindrical column of sediment from the Hawthorne formation at Barnwell. A deionized water solution containing approximately 1600 ppm sodium as sodium chloride was pumped through the core at 0.2 mL/h. The sodium content of the effluent solution was measured as a function of time by atomic absorption spectroscopy.

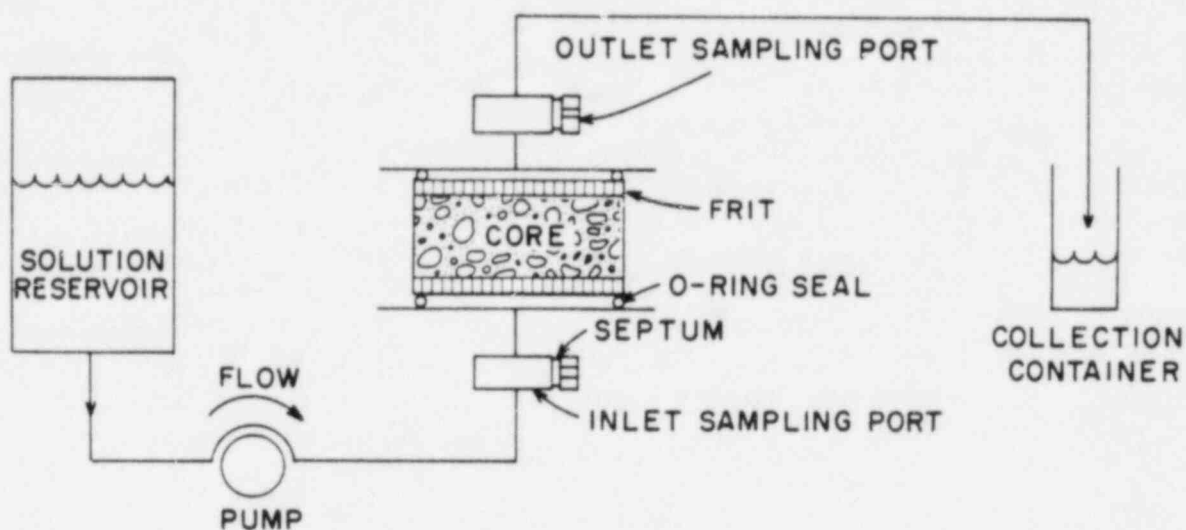


Figure 3.1 Schematic of apparatus for radionuclide retardation testing by continuous water flow through a sediment core.

Based on the recommendations of Relyea (1981), we are now using large columns for radionuclide retardation testing. The large column was made of clear cellulose acetate (inside diameter = 3.5 in.; length = 18.0 in.). A photograph of the sediment column with the solution reservoir, pump and sample collector is shown in Figure 3.2. Approximately 3000 g of sediment was used to fill the column. An upward flow of simulated Barnwell trench 6D1 water was maintained through the column for several days before the actual experiments were initiated. To determine the column void volume, a spike of tritiated water ($\sim 3 \mu\text{Ci}/\text{mL}$) was introduced at the inflow port. The effluent was monitored for tritium by liquid scintillation counting. Samples for liquid scintillation counting were prepared by using 1 mL aliquots of the effluent water per 10 mL of scintillation cocktail.

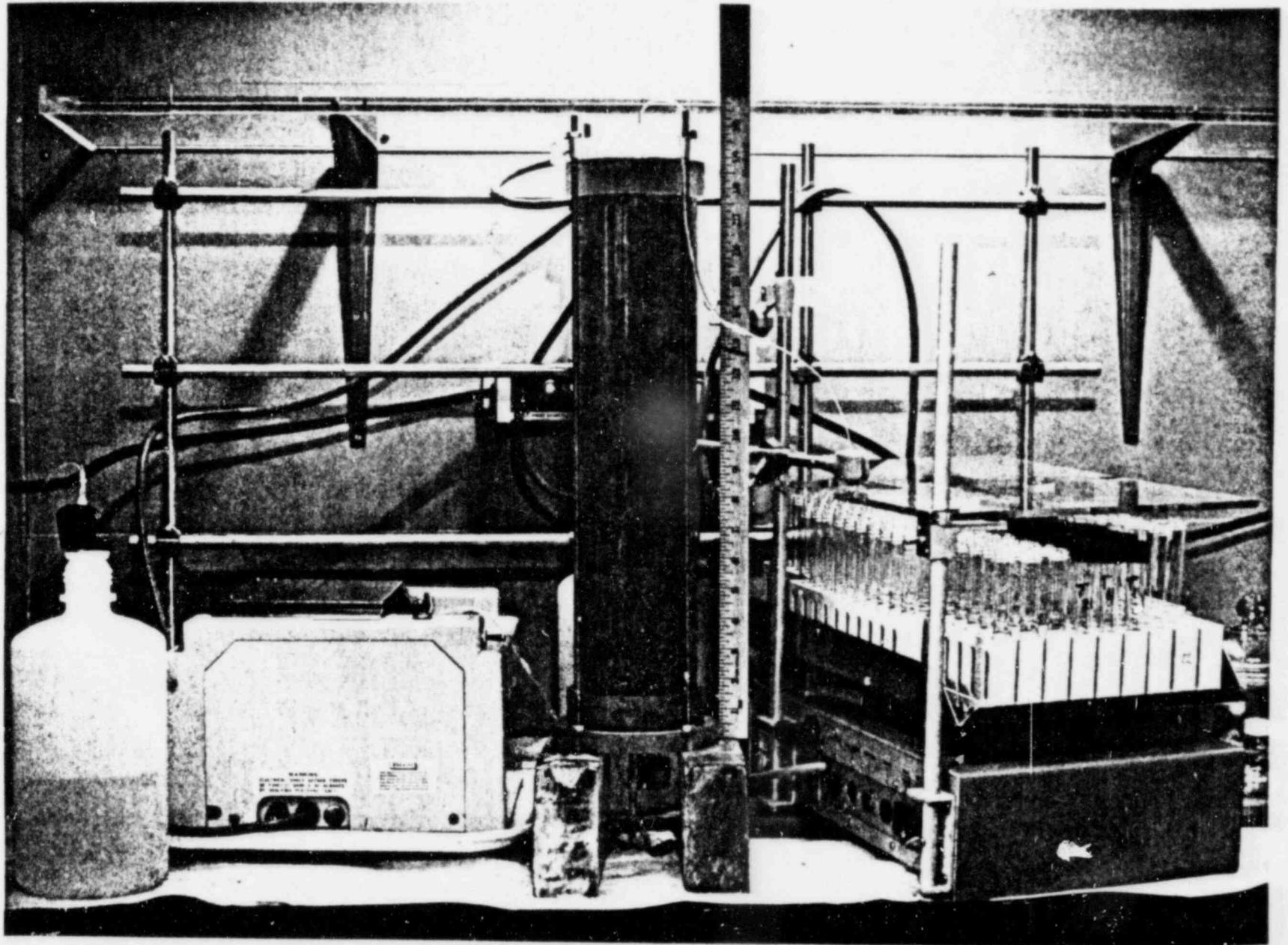


Figure 3.2 Apparatus for column radionuclide retardation experiments.

3.1.3 Current Progress

Experiments are in progress to measure the column pore volume by the rate of travel of a tritiated water spike. Preliminary experiments were performed with a short column of sediment (1 in. diam x 1 in. length) as a scoping experiment in which sodium chloride spiked distilled water was used as a nonsorbed tracer measured by atomic absorption spectroscopy (Figure 3.2). Tritiated water flow experiments with the large (3.5 in. diam x 18 in. length) column are in progress and data will be presented in a future report.

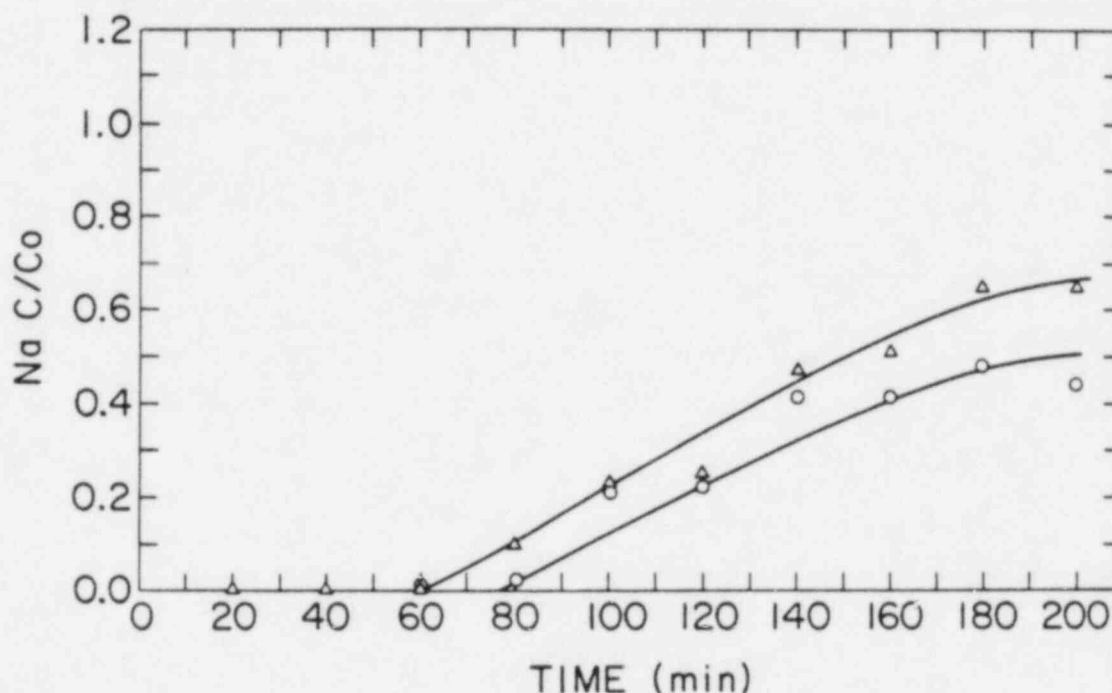


Figure 3.3 Sodium ion transport through a small column (1 in. diam x 1 in. long) of sediment from the Hawthorne formation at Barnwell. The initial solution consisted of 1600 ppm Na^+ as NaCl in distilled water. The flow rate through the column was 0.2 mL/h.

3.2 Diffusion of Radionuclides (R. F. Pietrzak)

3.2.1 Introduction

Scoping experiments to determine the diffusion coefficients of radionuclides in water saturated sediments from the Barnwell disposal site were initiated. The general theory for this experiment was discussed in an earlier report (Pietrzak and Dayal, 1982b) and the experimental procedure was based on the radionuclide penetration depth method described by Fried et al. (1980). The characteristics of the sediment from the Hawthorne formation at Barnwell were given in Table 2.2 and the composition of simulated Barnwell trench 6D1 water was given in Table 3.1.

3.2.2 Experimental

Diffusion cells were constructed for a series of scoping experiments from polypropylene disposable syringes. One syringe (inside diameter = 2 cm, height = ~5 cm) was used to hold wet sediment and another to hold the simulated trench water. The water and sediment were separated by a membrane filter (Millipore type BS, 2.0 μm pore size). The upper and lower parts of the cell were sealed together with epoxy resin. Wet sediment (~30 g) was packed into the lower syringe in such a manner as to avoid the presence of air bubbles or voids. The upper half of the cells were filled with simulated Barnwell trench 6D1 water. The sediment and trench water were allowed to equilibrate for a week or more.

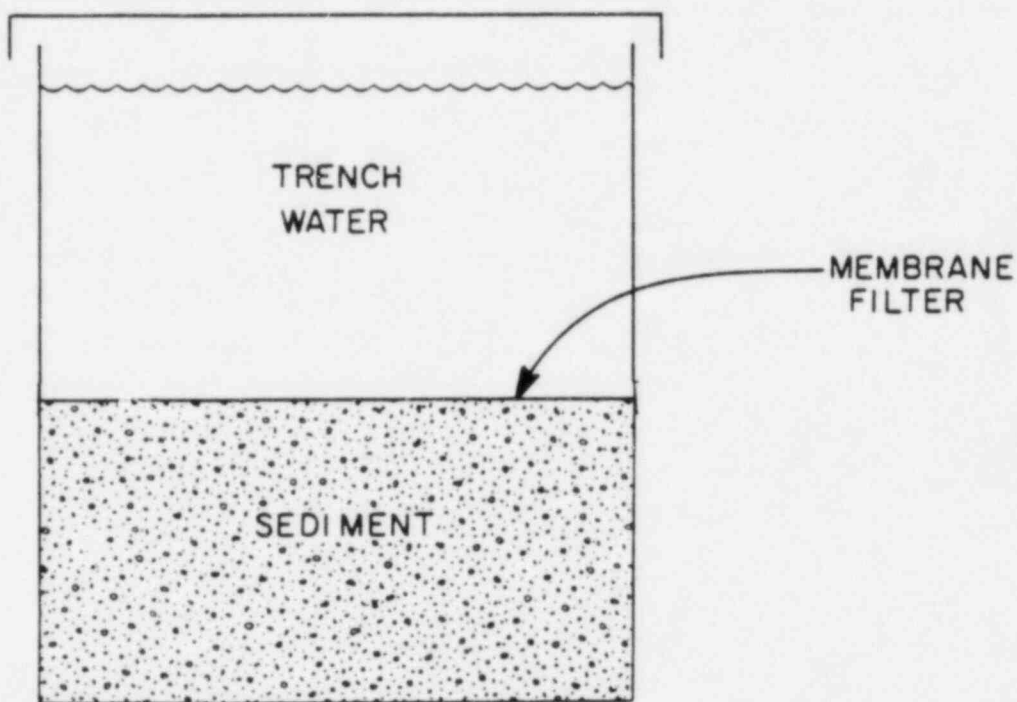


Figure 3.4 Schematic of the apparatus to measure the penetration depth of radionuclides by diffusion.

3.2.2.1 Tritiated Water Diffusion

Tritiated water (~20 μL of 3 $\mu\text{Ci/mL}$ HTO), added to the trench water, was used in the experiments to measure the diffusion of tritium in sediment. The cells were stored at ambient room temperature (~22°C) and allowed to equilibrate. At the termination of the experiment, the solution in the upper cell was poured off. The sediment in the lower cell was frozen. The frozen sediment was sliced into ~2mm sections. The tritium content in the pore water

of each section was determined by liquid scintillation counting as follows. Distilled water (4.00 mL) was added to each wet core section. Aliquots (1.0 mL) of the supernatant solution were added to the scintillation cocktail (10 mL, Packard Instagel) and counted. The tritium content of the sediment pore water relative to the concentration in the core top is presented as a function of core depth in Figures 3.5 and 3.6. The tritium diffusion experiments were terminated after 2.17 and 3.10 days. These data suggest that future experiments should be conducted with longer cores. In addition, if available, intact sediment cores will be used in these experiments.

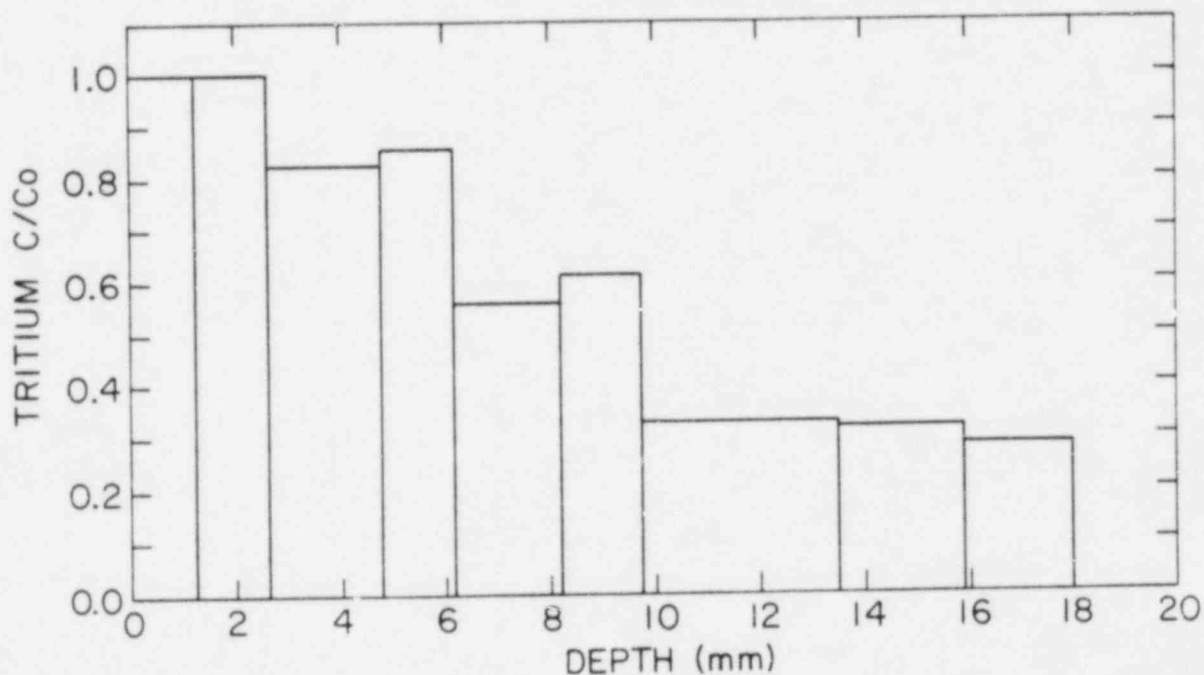


Figure 3.5 Profile of tritium diffusion in pore water of a repacked sediment core from the Hawthorne formation at Barnwell. Simulated Barnwell 6D1 trench water was used. The experimental time was 2.17 days.

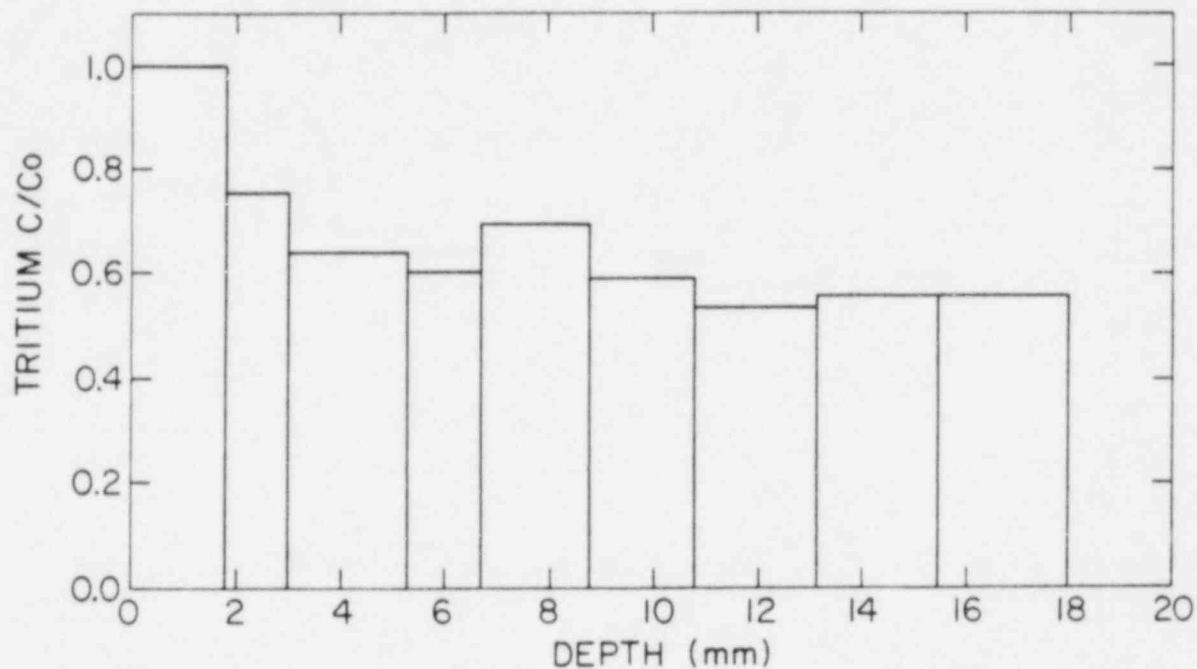


Figure 3.6 Profile of tritium diffusion in pore water of a repacked sediment core from the Hawthorne formation at Barnwell. Simulated Barnwell 6D1 trench water was used. The experimental time was 3.10 days.

3.2.2.2 Radionuclide Tracer Diffusion

Experiments to measure the diffusion of radionuclides in sediment were performed. Solutions of radionuclides (0.5 M HCl for ^{85}Sr , $^{134,137}\text{Cs}$, ^{60}Co , and 8 M HNO_3 for ^{241}Am) were evaporated to dryness. The salts were converted to chlorides by the addition of concentrated hydrochloric acid and evaporation of this solution to dryness. The radionuclide salts were dissolved in simulated Barnwell 6D1 trench water (~1 μCi per radionuclide in 25 mL of trench water). In the diffusion experiments, radionuclide spiked trench water was added to the upper chamber of the diffusion cell in which the lower chamber was filled with wet sediment. The solution was separated from the sediment by a membrane filter (Millipore, type BS, 2.0 μm pore range). The experiments were allowed to run for 2 and 17 days. At the conclusion of the experiments, the solution in the upper cell was poured off. The sediment in the bottom cell was frozen. The sediment core was sliced into ~2 mm sections, and the radionuclide activity in each section was determined by gamma-ray spectroscopy using a Ge(Li) detector. Radionuclide content of each core section is shown as a function of depth in Figures 3.7, 3.8, 3.9, 3.10, and 3.11.

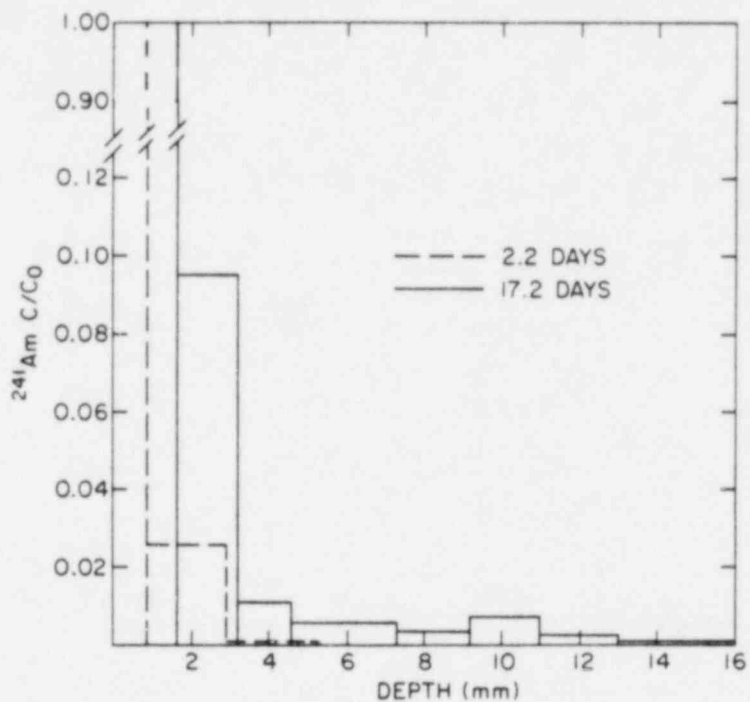


Figure 3.7 Profile of ^{241}Am penetration in a repacked sediment core from the Hawthorne formation at Barnwell.

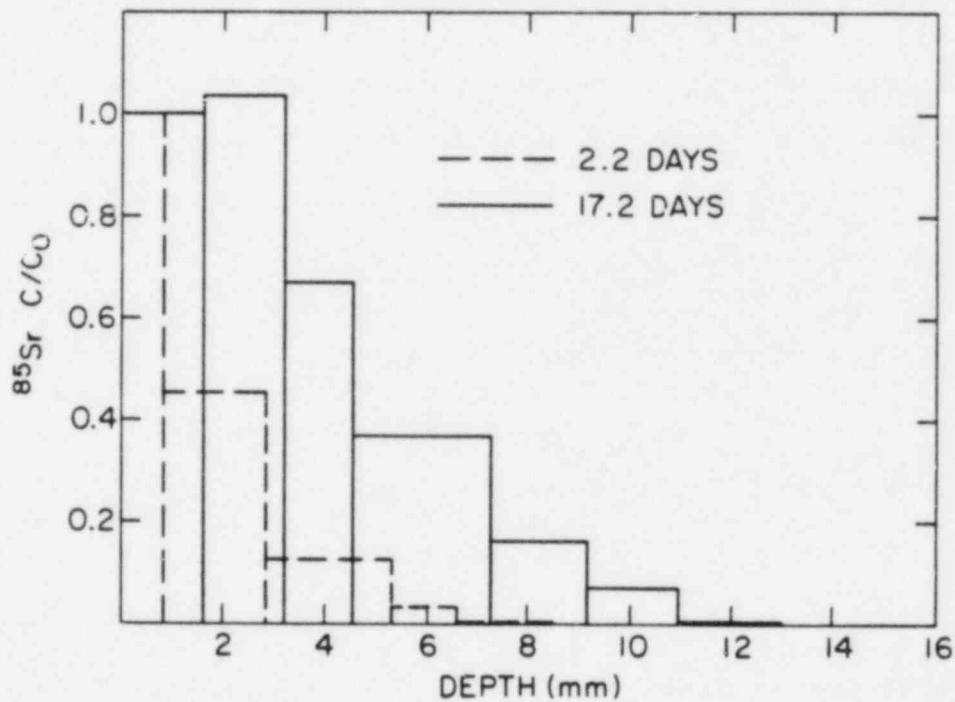


Figure 3.8 Profile of ^{85}Sr penetration in a repacked sediment core from the Hawthorne formation at Barnwell.

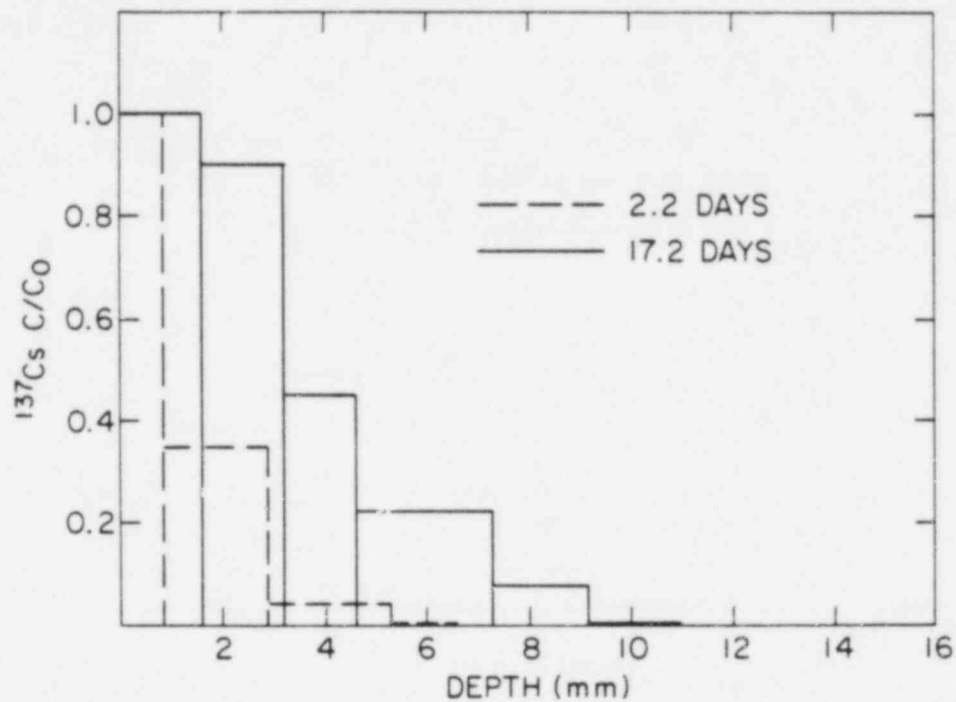


Figure 3.9 Profile of ^{137}Cs penetration in a repacked sediment core from the Hawthorne formation at Barnwell.

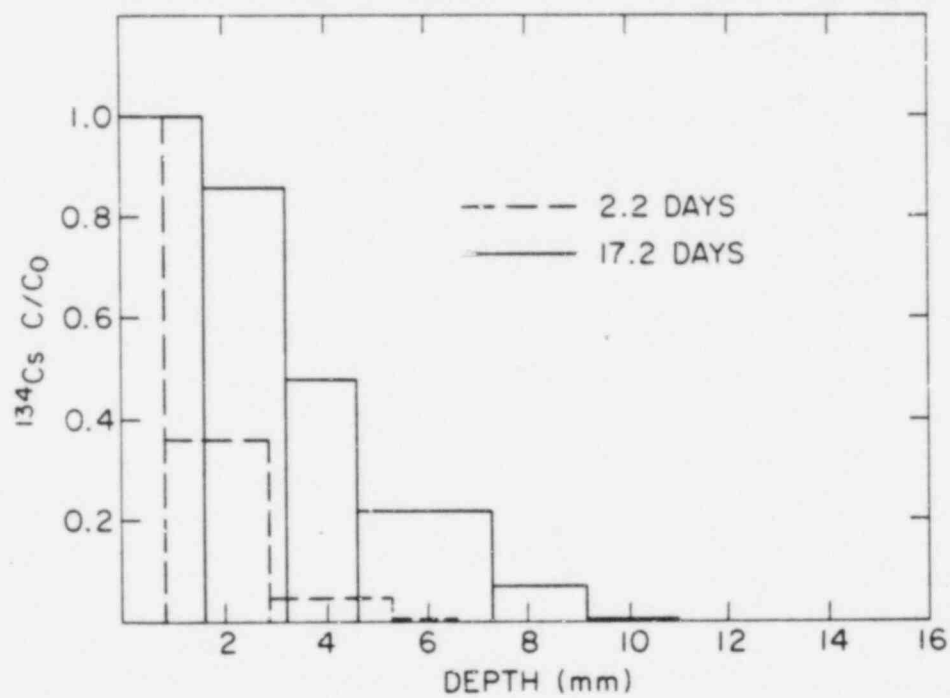


Figure 3.10 Profile of ^{134}Cs penetration in a repacked sediment core from the Hawthorne formation at Barnwell.

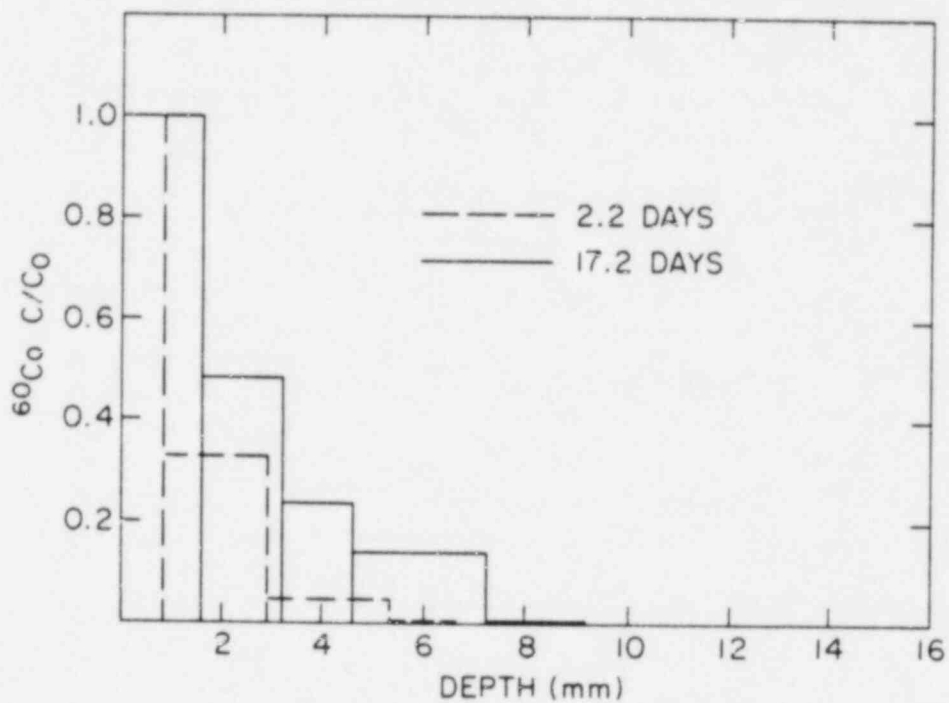


Figure 3.11 Profile of ^{60}Co penetration in a repacked sediment core from the Hawthorne formation at Barnwell.

3.3 Current Progress

The diffusion profiles, given in Figures 3.5 to 3.11, are now being modeled to calculate the diffusion coefficients of both sorptive and non-sorptive radionuclides. Further experiments to determine radionuclide diffusion coefficients will be performed with intact sediment cores and for longer periods.

4. LEACHING OF WASTE FORMS IN SIMULATED TRENCH ENVIRONMENTS
(M. Chin Sun Chong, J. Clinton, M. T. Kinsley, and R. F. Pietrzak)

4.1 Introduction

Experiments were initiated to leach solidified waste under realistic conditions of unsaturated water flow over a waste form buried in sediment. Materials simulating the Barnwell disposal site were selected for this study. The general description of the experiments has been reported earlier (Pietrzak and Dayal, 1982a).

4.2 Experimental

Waste forms prepared in the laboratory were placed in porous media and leached under continuous unsaturated flow conditions (Figures 4.1 and 4.2). Two types of porous media are being used: sediment from the Hawthorne formation at Barnwell and high density polyethylene beads (HDPE beads). The experiment with HDPE beads was conducted to determine the leachability of the waste form with minimal sorption of the radionuclides onto the surrounding medium. The waste forms were surrounded on all sides by a 2-in.-thick layer of the porous media.

In a separate program at BNL (A-3027), experiments are under way to study the effect of alternate wet dry cycles on waste form leachability (Morcos and Dayal, 1981). In these tests, HDPE beads are being used as inert medium surrounding the waste form.

The waste form being used is an organic ion exchange resin solidified in Portland I cement. Spent ion exchange resins are expected to be primarily in the sodium form. To simulate typical conditions for spent resins, the resins used in this study (Rohm and Haas IRN-77, H⁺ form) were converted to the Na⁺ form prior to loading with radiotracers. The radiotracers used were ⁸⁵Sr and ¹³⁷Cs. The waste-cement-water formulation used in the form (2-in.-diam x 4-in.-long cylinder) was identical to those used in the "scale up" study in the container program at BNL (Morcos and Weiss, 1982). The preparation of the organic cation exchange resin and resin/cement composites are described by Morcos and Dayal (1982).

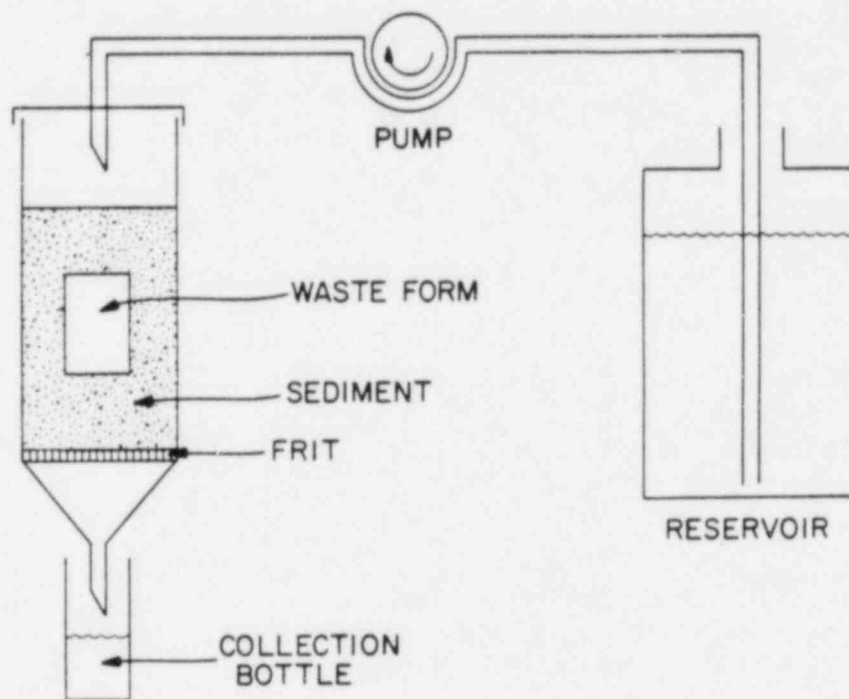


Figure 4.1 Schematic of apparatus to measure leaching of solidified waste in a porous solid medium with continuous unsaturated leachant solution flow.

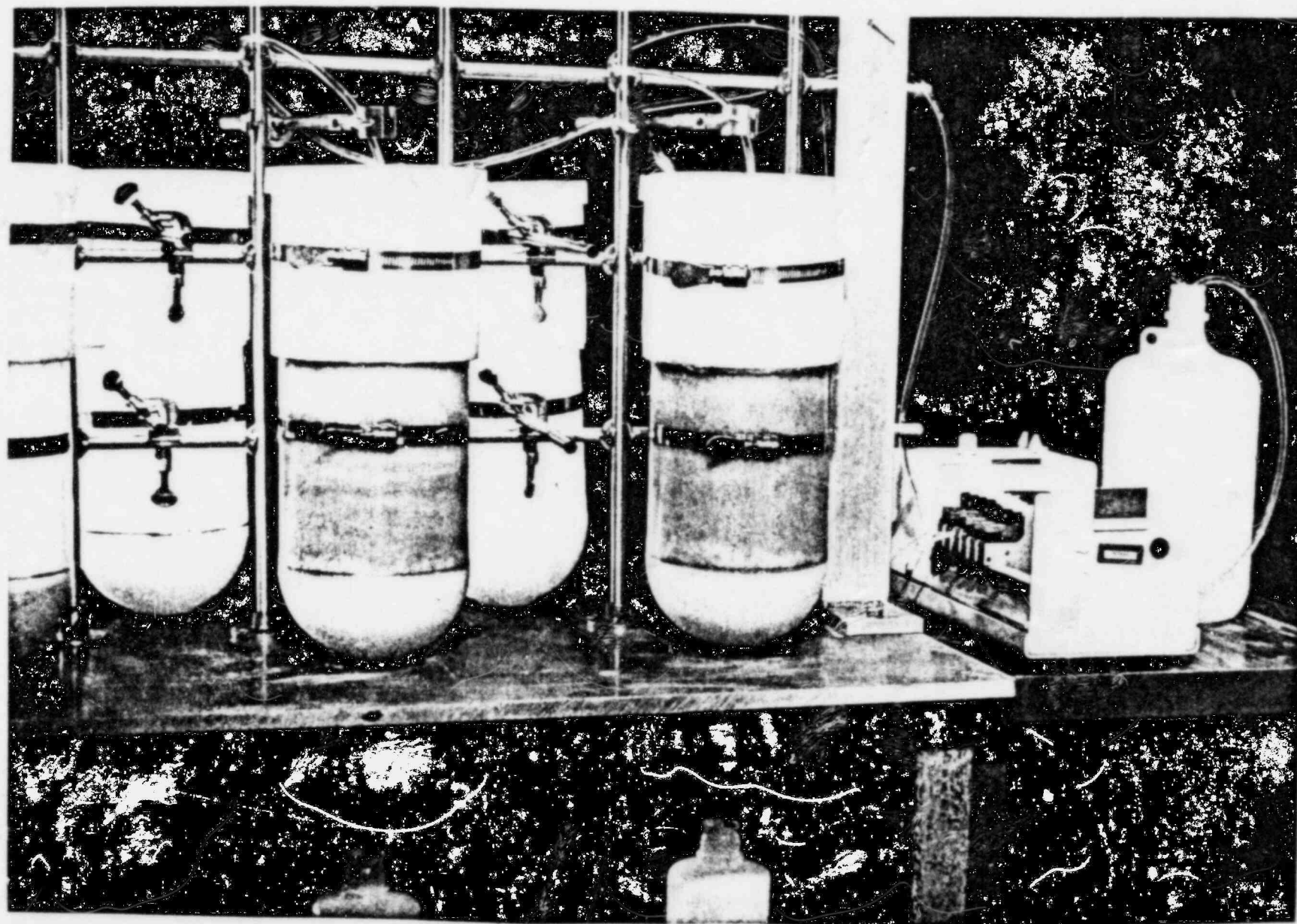


Figure 4.2 Apparatus to measure leaching of solidified waste in a porous solid medium with continuous unsaturated leachant solution flow.

4.3 Leaching Solution

A simulated Barnwell trench 6Dl water (Table 3.1) was used in the experiments.

4.4 Preliminary Tests

The characteristics of the sediment from the Hawthorne formation are given in Table 2.2. The characteristics of the HDPE beads are presented in Table 4.1 and Figure 4.3. Cation exchange capacities were determined by ammonium displacement of sodium ion at a pH of 7.0 and was 0.3 ± 0.2 meq/100 g. Morcos and Dayal (1982) determined the CEC of HDPE beads using a modified procedure of Dayal and Duedall (1979) and reported no detectable sorption of radiotracers (^{137}Cs , ^{85}Sr , or ^{60}Co) by the HDPE beads.

Table 4.1

Characteristics of the High Density Polyethylene Beads
(Dow Product HDPE-69065, "2" mm Beads)

Particle Size ^a (mm)	Weight Percent ($\bar{x} \pm \text{s.d.}$) ^b
>4.76	1.3 \pm 0.8
4.76 - 4.00	7 \pm 3
4.00 - 3.36	20 \pm 3
3.36 - 2.00	70 \pm 7
2.00 - 1.19	1.4 \pm 0.3
<1.19	0.3 \pm 0.2

^aU.S. standard sieves with square holes were used.

^bThe weight percent is the average of eight observations with 100.0 ± 0.1 g samples.
s.d. = standard deviation.

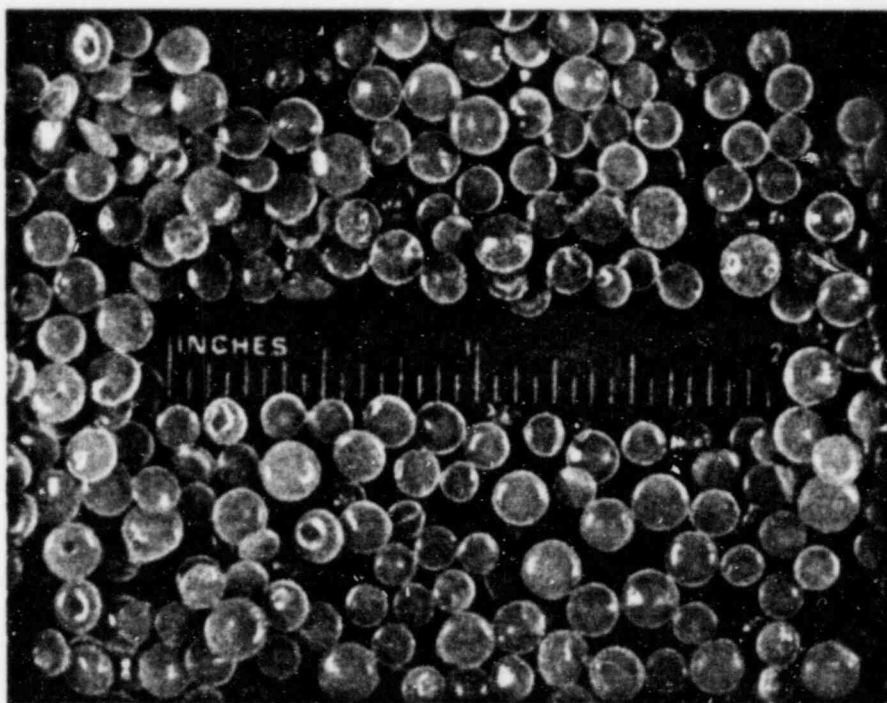


Figure 4.3 High density polyethylene beads (Dow product HDPE beads - 69065).

4.5 Current Progress

The resin cement composites were placed on a two-inch layer of porous medium overlying a polyethylene screen and a one-inch layer of HDPE beads placed at the bottom of the apparatus. The cylindrical resin/cement composites were placed axially parallel to the polyethylene container walls. The annulus formed between the container walls and the waste form was filled with the porous medium. Additional porous medium was added to form a two-inch layer above the top of the waste form. The total amount of HDPE beads and Hawthorne sediment needed to fill the columns individually was 2350 g and 4100 g, respectively.

Continuous leachant flow was maintained by a constant rate pump (Manostat) of ~10 mL/h.

After about two weeks of operation, both ^{137}Cs and ^{85}Sr were observed in the effluent solution of the polyethylene bead column. In the sediment column, no activity has been observed so far. At the end of the two week period, the pH of solution from the polyethylene bead column was about 7.8 while that from the sediment column was 4.0. The pH of 4.0 corresponds to the pH of the sediment from the Hawthorne formation at Barnwell that Piciulo et al.(1982) reported. The pH of the inflowing solution is approximately 6.0.

5. REFERENCES

- Blake, G. R., "Particle Density," in Methods of Soil Analysis, Part 1, Chapter 29, pp. 371-373, C. A. Black, Editor, Amer. Soc. Agron., Wisc. (1965).
- Branauer, S., P. Emmet, and E. Teller, "Adsorption of Gasses in Multimolecular Layers," Jour. Amer. Chem. Soc. 60, 309-319 (1938).
- Czyscinski, K. S., and A. J. Weiss, Brookhaven National Laboratory, "Evaluation of Isotope Migration-Land Burial Water Chemistry at Commercially Operated Low-Level Radioactive Waste Disposal Sites, Status Report, October 1979-September 1980," NUREG/CR-1862, BNL-NUREG-51315 (1981).
- Czyscinski, K. S., R. F. Pietrzak, and A. J. Weiss, Brookhaven National Laboratory, "Evaluation of Isotope Migration-Land Burial Water Chemistry at Commercially Operated Low-Level Radioactive Waste Disposal Sites, Status Report, October-December 1980," NUREG/CR-2124, BNL-NUREG-51383 (1981).
- Day, P. R., "Particle Fractionation and Particle Size Analysis," in Methods of Soil Analysis, Part 1, Chapter 43, pp. 545-567, C. A. Black, Editor, Amer. Soc. Agron., Wisc. (1965).
- Dayal, R. and I. W. Duedall, "Sediment and Water Column Properties at the Farallon Islands Radioactive Waste Dumpsites," Final report submitted to the Office of Radiation Programs, U.S. EPA, Contract Number 68-01-3907 (1979).
- Folk, R. L., Petrology of Sedimentary Rocks, pp. 16-52, Hemphill's, Austin, Texas (1965).
- Fried, S., A. Friedman, J. Hines, R. Sjoblom, G. Schmitz, and F. Schreiner, "Measurement of Penetration Depths of Plutonium and Americium in Sediment From the Ocean Floor," Scientific Basis for Nuclear Waste Management, Vol. 2, pp. 647-654, C. M. J. Northrup, Jr., Ed., Plenum Press, New York (1980).
- Klute, A., "Laboratory Measurement of Hydraulic Conductivity of Saturated Soil," in Methods of Soil Analysis, Part 1, Chapter 13, pp. 210-221, C. A. Black, Editor, Amer. Soc. Agron., Wisc. (1965).
- Morcos, N., and R. Dayal, Brookhaven National Laboratory, "Properties of Radioactive Wastes and Waste Containers, Quarterly Progress Report, January-March 1982," BNL-NUREG-31412 (1982).
- Mortland, M. M., and W. D. Kemper, "Surface Area," in Methods of Soil Analysis, Part 1, Chap. 42, pp. 532-544, C. A. Black, Editor, Amer. Soc. Agron., Wisc. (1965).

- Piciulo, P. L., C. E. Shea, and R. E. Barletta, Brookhaven National Laboratory, "Analyses of Soils at Low-Level Radioactive Waste Disposal Sites," BNL-NUREG-31388 (1982).
- Pietrzak R. F., and R. Dayal, Brookhaven National Laboratory, "Evaluation of Isotope Migration-Land Burial Water Chemistry at Commercially Operated Low-Level Radioactive Waste Disposal Sites, Quarterly Progress Report, October-December 1981," NUREG/CR-2192, BNL-NUREG-51409, Vol. 1, No. 3, (1982a).
- Pietrzak, R. F., and R. Dayal, Brookhaven National Laboratory, "Evaluation of Isotope Migration-Land Burial Water Chemistry at Commercially Operated Low-Level Radioactive Waste Disposal Sites, Quarterly Progress Report, January-March 1982," BNL-NUREG-31386 (1982b).
- Relyea, J. F., "Column Method for Determining Retardation Factors," Status Report, PNL-4031, UC-70 (1981).
- Richards, L. A., Editor., "Diagnosis and Improvement of Saline and Alkali Soils," in U.S. Dept. of Agriculture Handbook 60, U.S. Government Printing Office, Washington, D.C. (1969).
- U. S. Department of Agriculture (USDA), Procedures for Collecting Soil Samples and Methods of Analysis for Soil Survey, Soil Survey Investigations Report No.1, Soil Conservation Service, Washington, D.C. (1982).
- U. S. Department of Agriculture, (USDA), Soil Survey Laboratory Methods and Procedures for Collecting Soil Samples, Soil Survey Investigations Report No. 1, Soil Conservation Service, Washington, D.C. (1972).
- Vomocil, J. A., "Porosity," in Methods of Soil Analysis, Part 1, Chapter 21, pp. 299-314, C. A. Black, Editor, Amer. Soc. Agron., Wisc. (1965).
- Whittig, L. D., "X-Ray Diffraction Techniques for Mineral Identification and Mineralogical Composition," in Methods of Soil Analysis, Part, 1, Chapter 49, pp. 671-698, C. A. Black, Editor, Amer. Soc. Agron., Wisc. (1965).

APPENDIX A

ANALYTICAL METHODS FOR SEDIMENT CHARACTERIZATION

Representative samples of site specific materials used in the sorption experiments were characterized as follows. Bulk samples were disaggregated, air dried, and <2 mm material used for analysis. Analytical methods are summarized in the table below.

Table A.1

Sediment Characterization - Analytical Procedures

Parameter	Procedure	References
Percent Moisture	2 hours at 110°C	USDA, 1972; 1982
Particle Size Distribution	Sieving and Pipette Analysis	Folk, 1965 Day in Black, 1965 USDA, 1982
Surface Area	<u>Organic Liquid</u> Ethylene Glycol (EG)	Mortland and Kemper in Black, 1965
	<u>Gas</u> N ₂ Adsorption (BET)	Branauer et al., 1938
Fine Fraction Mineralogy	Standard Techniques of X-ray and Petrographic Analysis	Whittig in Black, 1965
Extractable Iron	Dithionite Citrate Extraction	USDA, 1972; 1982
Organic Matter	Peroxide Digestion	USDA, 1972; 1982
Carbonate Material	Gravimetrically by Loss of CO ₂	Allison and Moodie in Black, 1965, USDA 1972; 1982
Cation Exchange Capacity	Ammonium Acetate Na ⁺ Displacement pH 7.0	Richards, 1969
Average Particle Density	Pycnometer	Blake in Black, 1965
Bulk Density	Weight/Volume	Blake in Black, 1965
Porosity	Calculation	Vomocil in Black, 1965
Hydraulic Conductivity	Saturated Disturbed Sediment	Klute in Black, 1965 Richards, 1969