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SORPTION PROPERTIES OF CARBON-14 ON SAVANNAH RIVER PLANT SOIL (U)

by WSRC Contact - W. H. Carlton

E. I. du Pont de Nemours and Company
Savannah River Plant
Aiken, South Carolina 29808

Other Authors:

P. F. McIntyre

DISCLAIMER

TECHNICAL DIVISION
SAVANNAH RIVER LABORATORY

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Burial Ground

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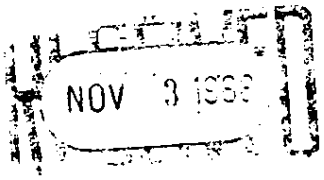
M E M O R A N D U M

CC: G.T. Wright 773-A
E.L. Albenesius 773-A
C.R. Sherman, 703-A
D.E. Gordon 703-52A
J.L. Steele, 773-42A
W.G. Holmes, 773-42A
C.M. King, 773-42A
W.R. McDonell, 773-42A
D.E. Stephenson, 773-42A
O.M. Morris, SRP 703-H
M.A. Ebra, 703-H
M.A. Phifer, 703-H
J.N. Chen, 703-H
LLW Group (6)
SRL Records (4)



October 18, 1988

To: H.F. Sturm, Jr, 773-43A

From: P.F. McIntyre

SORPTION PROPERTIES OF CARBON-14 ON SAVANNAH RIVER PLANT SOIL

SUMMARY

Batch experiments performed using ^{14}C, Savannah River Plant (SRP) soil, and SRP burial ground groundwater indicate that the distribution coefficient, or K_d, for ^{14}C in the form of carbonates is typically 2 ml/g after 7 hours of equilibration and 55 ml/g after 72 hours. These results were obtained for samples containing ^{14}C concentrations ranging from 4.2 nCi/ml up to 40.9 nCi/ml. For comparison the concentration of ^{14}C in the sump leachate of the defense waste lysimeters [1] have ranged from 0.06 nCi/ml to 0.9 nCi/ml.

INTRODUCTION

Carbon-14 is a relatively long lived radionuclide with a half life of 5730 years. Significant quantities of ^{14}C have been disposed of in SRP burial grounds (643-G and 643-7G). Estimates indicate that the inventory is as high as 6600 Curies [2]. Carbon-14 is produced in the moderator of SRP reactors, as a result of the $^{17}O(n,\alpha)\ ^{14}C$ reaction. Most of the ^{14}C was removed using ion exchange resins and subsequently sent to the burial grounds for disposal. Disposal records indicate that some of the ^{14}C was buried in sealed stainless steel vessels and some was disposed as bare resin. Waste management is determining the fraction buried in sealed vessels versus the fraction disposed as bare resin.

The defense waste lysimeter experiments indicate that the ^{14}C concentration is typically 0.35 Ci per cubic foot of resin [3]. Sampling of sump leachate from four defense waste lysimeters indicate that the annual fractional release of ^{14}C from the exchange resin, through approximately 3 feet of soil and to the sump below, ranged from 4×10^{-5} to 7×10^{-4} [3]. The purpose of this experiment is to determine the K_d for ^{14}C in order to determine the migration behavior of this radionuclide under typical SRP burial ground conditions.

RESULTS AND DISCUSSION

Prior to this work, not much work has been done to determine the sorption properties of ^{14}C on soil under conditions typical to the SRP burial grounds. Batch soil experiments were performed to determine the distribution coefficient, K_d, for ^{14}C on SRP soil. Actual SRP soil was collected and used in these experiments. The soil composition is typically 72% sand, 5% silt and 23% clay with a moisture content near 16%. To ensure that these results typify the burial ground, the groundwater used in these experiments was taken from well I-17 in 643-G. The pH of the groundwater was 6.0 and the E_h was measured at 618 mV. The average concentrations of metals and other ions present in the groundwater are reported elsewhere [4].

The ^{14}C used in the batch soil experiments was purchased from Isotope Products Laboratories. The solution (No.:153-004-A-1) consisted of a sodium carbonate in H_2O and ethanol solution with an activity of 19.62 µCi/ml at 20 °C and is implicitly traceable to the National Bureau of Standards. Three stock solutions were prepared using 50 ml of I-17 groundwater plus 0.01 ml, 0.05 ml and 0.1 ml of the ^{14}C standard which corresponded to concentrations of 3.9 nCi/ml, 19.6 nCi/ml and 39.2 nCi/ml, respectively. These activities were determined by pipetting 2.0 ml aliquots into 20 ml of Optifluor, liquid scintillation cocktail and counting for 3 minutes. These were the initial concentration of the unsorbed ^{14}C, and were labeled, C14-A, C14-B and C14-C (see Table 1).

The batch soil experiments were performed, in duplicate, using 2.0 grams of SRP soil (~ 40 mesh) which was placed in a centrifuge cone and filled with 15.0 ml of I-17 groundwater from each of the stock solutions. The samples were labeled C14-A1, C14-A2, C14-B1, C14-B2, C14-C1 and C14-C2. After 7 hours initial samples were taken from C14-A1, C14-B1 and C14-C1. These samples were removed from the shaker and centrifuged for 5 minutes. A 2.0 ml aliquot of the supernate, from each, was pipetted into 20 ml of Optifluor and counted for 3 minutes on a liquid scintillation counter. These results are shown in Table 2. To ensure Quality Assurance a blank and tritium standard was run with all samples.

After 72 hours, all 6 samples were removed from the shaker and centrifuged for approximately 5 minutes. The first 2.0 ml aliquot of supernate was removed from samples C14-A2, C14-B2 and C14-C2. A second 2.0 ml was removed from samples: C14-A1, C14-B1 and C14-C1. Two ml from each sample was pipetted into 20 ml of Optifluor and counted for 3 minutes on a liquid scintillation counter. These results are shown in Table 2.

The distribution coefficient, K_d, is calculated using the following equation:

$$K_d \text{ (ml/g)} = \frac{(I - C)\,R}{C} \qquad \text{(Eq 1)}$$

where I is the initial concentration of the ^{14}C radionuclide, C is the final concentration of ^{14}C radionuclide remaining in the solution at the end of the experiment and R is the ratio of (batch volume of water)/(batch weight of soil); and was 7.5 ml/g in these studies. Substitution of the results from 7 hours equilibration into Equation 1, yields an average K_d of 1.9 ml/g. Using the 72 hours of equilibration results in Equation 1 yields an average K_d of 55 ml/g.

CONCLUSIONS

The K_d for ^{14}C was determined to be 1.9 ml/g after 7 hours and 55 ml/g after 72 hours of equilibration using SRP burial ground soil and groundwater. This agrees well with K_d values of other anionic components under similar SRP conditions. The K_d of the anionic cobalt complex was determined to be 5-30 ml/g in previous studies [5]. The results of these sorption experiments will provide information on the migration behavior of ^{14}C in the SRP burial grounds.

RECOMMENDATIONS

All future transport modeling of ^{14}C should be performed using a K_d value of 2 ml/g which conservatively represents conditions present in the SRP burial grounds.

QUALITY ASSURANCE

The data from these studies are recorded in Notebook E 43322 pgs 79-83 in accordance with QA procedures and the SRL Procedures Manual

REFERENCES

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TABLE 1. CONCENTRATIONS OF ^{14}C IN STOCK SOLUTIONS.

Solution I.D.	Concentration Calculated* (nCi/ml)	Concentration Experimental** (nCi/ml)
C12-A	3.9	4.2
C14-B	19.6	21.0
C14-C	39.2	40.9

*Calculated based on ^{14}C activity of 19.62 µCi/ml at 20 °C.

** Experimental results obtained using liquid scintillation counting. Results documented in notebook E 433322 pps 81, 82.

TABLE 2. SOIL EQUILIBRATION RESULTS FOR 14C IN SRP GROUNDWATER AND SRP SOIL.

Sample I.D.	^{14}C in 2.0 ml Stock Solution (dpm)	Equilibration Time (Hours)	^{14}C in 2.0 ml Supernate after after Equilibration (dpm)	K_d (ml/g)
C14-A1	18623	7	14280	2.3
C14-B1	92393	7	74030	1.9
C14-C1	180588	7	148910	1.6
C14-A1	18623	72	2116	50.7
C14-A2	18623	72	2186	56.4
C14-B1	92393	72	9390	57.5
C14-B2	92393	72	12737	46.9
C14-C1	180588	72	16852	63.2
C14-C2	180588	72	21798	54.6

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