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GEOCHEMISTRY OF TRENCH LEACHATES AT LOW-LEVEL RADIOACTIVE WASTE BURIAL SITES

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ABSTRACT

Trench leachates from the low-level radioactive waste burial sites at Maxey Flats, Kentucky and Barnwell, South Carolina were sampled and analyzed for dissolved inorganic, organic, and radionuclide constituents. Relative to local groundwaters, the trench leachates exhibit significant modifications in major ion and radionuclide compositions. The formation and composition of the leachates can be attributed to site-specific hydrological and geochemical factors. Leaching and microbial degradation of waste materials are considered to be the important geochemical processes controlling the leachate compositions. Elevated concentrations of Na, K, Ca, Mg, Cl, dissolved organic and inorganic carbon, and various anthropogenic radionuclides reflect leaching of waste materials. Anoxic conditions as characterized by depletion of dissolved oxygen and sulphate, and high contents of alkalinity and ammonia reflect microbial decomposition of organic waste materials. Because of relatively stagnant water accumulations, the extent of modification is much greater in the Maxey Flats leachates as compared with those from Barnwell.

INTRODUCTION

Information on the chemical and radionuclide composition of trench leachates and on the processes that control radionuclide mobility is important in predicting radionuclide transport at shallow land burial sites. This information is needed by the U. S. Nuclear Regulatory Commission for development of criteria for selection of future low-level radioactive waste disposal sites.

During the past several years, Brookhaven National Laboratory (BNL) has been involved in a field and laboratory program to study the source term characteristics of existing commercially operated low-level radioactive disposal sites. As part of this research effort, four waste disposal sites in the humid, eastern United States have been sampled multiply over a period of six years: Barnwell, South Carolina; Maxey Flats, Kentucky; Sheffield, Illinois; and West Valley, New York. The characteristics of trench leachates collected during earlier sampling trips have been reported previously (Pietrzak et al., 1982; Czyscinski and Weiss, 1981; Weiss and Colombo, 1980). In this report, we present results of the analysis of trench leachates collected during a more recent sampling trip to Maxey Flats (Dayal et al., 1984; Pietrzak and Dayal, 1982). For comparison purposes, we have also included leachate data for trenches sampled in March 1979 and May 1980 at Barnwell. A discussion of geochemical factors controlling the formation and composition of trench leachates, and contributing to contrasting leachate chemistries at Maxey Flats and Barnwell disposal sites is presented.

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SITE GEOLOGY AND OPERATION HISTORY

Barnwell Site

The Barnwell low-level radioactive waste disposal site is located in Barnwell county in southwestern South Carolina. The climate of the area is characterized by warm, humid summers and mild winters. The mean annual precipitation reported for the period 1951-1980 is 46.6 inches.

As reported by Cahill (1982), the Barnwell disposal site is underlain by sediments of the Atlantic Coastal Plain, which are relatively unconsolidated and are composed of stratified gravel, sand, silt, clay and limestone. These unconsolidated sediments, in turn, are underlain by Triassic rocks. The unsaturated zone at Barnwell extends from the land surface to just above the water table and is comprised of the eolian sands and part of the Hawthorne Formation. The sediments in the unsaturated zone are generally fine grained sands mixed with minor amounts of clay and coarse sand. The depth of the water table varies from 28 to 45 feet. The burial trenches are usually 22 feet deep, 50-100 feet wide and 500-1000 feet long. The trench bottoms are 8-26 feet above the water table. About two feet of sand is placed in the trench bottom to allow drainage of infiltrating water so that contact between water and the waste is minimized.

The burial site is owned by the State of South Carolina and operated by Chem-Nuclear Systems, Inc. since it was licensed in 1971. About 75% by volume of the radioactive waste buried at Barnwell comes from the nuclear power industry. The remaining material is derived from non-fuel cycle activities, such as pharmaceutical industry, hospitals, universities and medical research institutions.

Maxey Flats Site

The Maxey Flats low-level radioactive waste disposal site is located in northeastern Kentucky on a plateau about 300-400 feet above the surrounding valleys. The area is underlain by shales, siltstones and sandstones. The region has a humid continental climate with sharp contrast between winter and summer months. The mean annual precipitation for the period 1931-1955 is reported to be 45.8 inches.

As reported by Zehner (1983), the upper 1 to 25 feet at the disposal site is regolith composed of weathered shale of the Nancy member, which is underlain by indurated, unweathered shale. Most of the burial trenches are excavated in weathered shale and are underlain by a 1.5-foot-thick sandstone bed, at a depth of approximately 25 feet deep. The trenches, which are about 250 to 360 feet long, 20 to 35 feet deep, and 20 feet wide, are separated by 5 to 10 feet of shale and covered with 3 to 10 feet of compacted clay and crushed shale. About 80% of the rocks underlying the burial site are shale. Because of the extremely low hydraulic conductivity of the bedrock, virtually most groundwater movement occurs through fractures. Saturated zones are present in the upper part of the Nancy member. The uppermost water table is perched in the soil zone above the poorly permeable Nancy member.

The site was operated by Nuclear Engineering Company, Inc. (NECO) and in May 1963 the first radioactive material was buried. By 1972, some of the completed trenches were filled or partially filled with infiltrating rainwater, due to the very low permeability of the soil and of unweathered shale underlying the trenches. Subsequently, the disposal site was closed in 1977. A water management program was initiated to remove the accumulated water from the trenches and prevent further entry of water. The Commonwealth of Kentucky assumed control of the site in May 1978.

Most of the radioactive waste at Maxey Flats is believed to be large volume, low hazard-potential solid waste. Higher activity waste such as reactor resins, filters and irradiated reactor parts have also been buried along with 430 kg of special nuclear material. Special nuclear material consist of plutonium, uranium-233 and enriched uranium-235.

EXPERIMENTAL

Field Sampling and Measurements

The location of the various waste trenches at the Maxey Flats and Barnwell disposal sites is shown in Figure 1. Seven trenches 7-3, 19W, 23M, 27, 33L4, 33L8 and 35 were sampled at Maxey Flats in October 1981 using anaerobic sampling procedures described in previous reports (Pietrzak et al., 1982; Czyscinski and Weiss 1981; Weiss and Colombo, 1980). Using similar sampling procedures, leachates were also collected from trenches 3D1, 5D2, 6D1, 8D2, 8D3, 13D4, 18D5, and 25/21D1 at Barnwell in March 1979 and May 1980. Trenches 6D1 and 25/21D1 were sampled during both sampling trips to Barnwell. Therefore, the 1979 and 1980 samplings are identified by placing A and B, respectively, in front of 6D1 and 25/21D1. An on-site well No. 6 was also sampled at the Barnwell site on an earlier sampling trip in March 1978. During the leachate samplings in the field, in-line measurements of temperature, specific conductance, dissolved oxygen, sulphide, Eh, and pH were performed under anaerobic conditions using methods reported previously (Weiss and Colombo, 1980).

Laboratory Water Analysis

The water samples were stored at 4°C in an inert atmosphere to prevent oxidation. In the laboratory, an aliquot of each sample was filtered anaerobically through a 0.45 μm membrane filter and analyzed immediately for alkalinity (titration), ferrous and total iron (colorimetric), ammonia (probe), and pH (probe). Another fraction was filtered under similar, anaerobic conditions and the filtrate was analyzed for anions (chloride, fluoride, nitrate and sulfate by ion chromatographic analysis and colorimetric methods), dissolved inorganic carbon and total carbon (Beckman Carbon Analyzer). A third aliquot of each sample was filtered and acidified with ultrapure nitric acid and subsequently analyzed for dissolved radionuclides and dissolved metals.

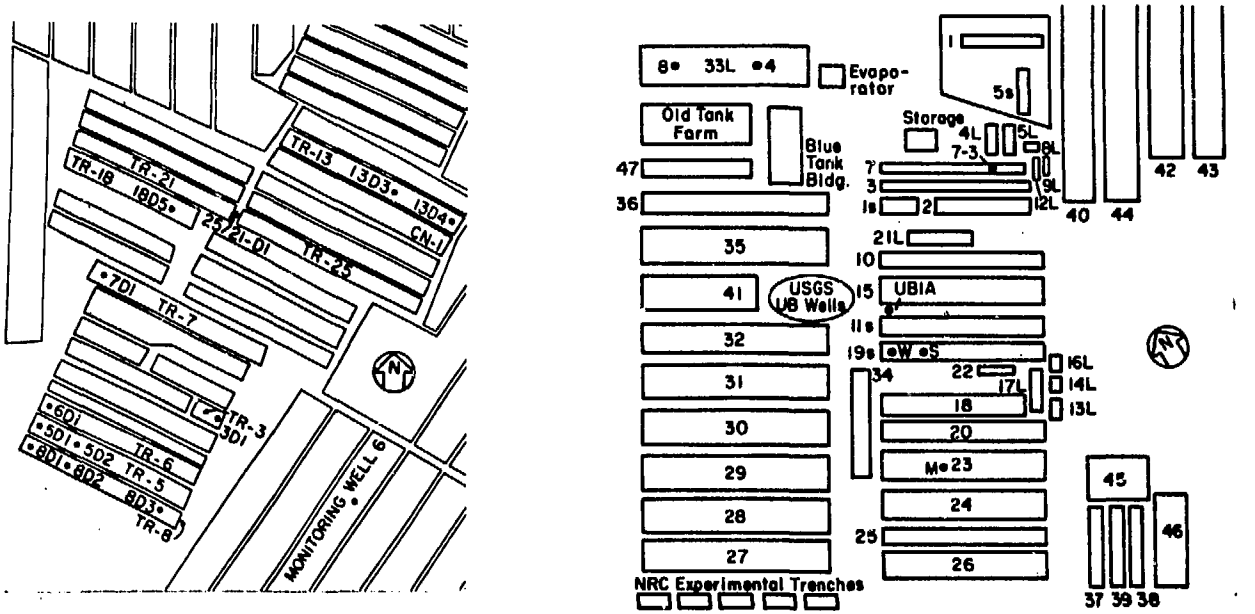

Figure 1 Locations and identification of burial trenches and experimental wells at (a) Barnwell and (b) Maxey Flats waste disposal sites. At the Barnwell site, the trench sumps are identified by a suffix letter and a numeral. For example, 8D1, 8D2, and 8D3 represent sumps D1, D2, and D3 of Trench 8. At the Maxey Flats site, letter "L" or "S" corresponds to solidified liquid or solid waste disposed of in a trench. Sumps are denoted by suffix letter or a numeral. 33L4 and 8 correspond to sumps 4 and 8 of Trench 33L. Similarly, letter M represents sump of Trench 23 and W and S represent sumps in Trench 19S.

Radionulide analyses were performed by liquid scintillation counting (tritium), Ge-(Li) gamma-ray spectroscopy (Am-241, Co-60, Cs-134, Cs-137), and radiochemical separations, followed by α spectroscopy (Pu-238, Pu-239,240) and gross β counting (Sr-90). Atomic absorption methods were used to determine dissolved metals. Further details of laboratory methods are given in previous reports (Pietrzak et al., 1982; Czyscinski and Weiss, 1981; Weiss and Colombo, 1980).

RESULTS

Field Parameters

Field data on specific conductance, dissolved oxygen, Eh, pH, sulphide, and temperature for trench leachates sampled at Maxey Flats in October 1981 and at Barnwell in March 1979 and May 1980 are given in Table 1. Data for an on-site well No. 6 at Barnwell are also included in Table 1. An on-site well UB1A, sampled in March 1978 at Maxey Flats, was found to be contaminated with waste constituents, presumably derived from neighboring trenches. Consequently, we used an average well water composition based on compositions of several off-site shallow wells reported by Zehner (1983) to represent the typical groundwater composition at Maxey Flats.

TABLE 1
FIELD MEASUREMENTS OF TRENCH AND WELL WATERS SAMPLED AT BARNWELL AND MAXEY FLATS DISPOSAL SITES

Sampling Location	Date Sampled	Temperature (°C)	Specific Conductance (μmho/cm)	Dissolved Oxygen (mg/L)	Eh (mV, SHE)[a]	pH	Sulphide (mV)[b]
Barnwell Site							
3D1	3/79	13.0	210	0.1	+225	5.8	c
5D2	3/79	19.0	600	0.8	+148	6.6	c
A-6D1	3/79	19.5	370	1.3	+358	5.9	c
B-6D1	5/80	15.3	260	4.2	+350	6.1	c
8D2	3/79	19.0	1400	1.5	+308	6.6	c
8D3	5/80	16.0	2600	0.25	+130	7.4	c
13D4	5/80	17.0	30	4.3	+390	7.6	c
18D5	5/80	12.8	42	3.0	+330	7.0	c
A-25/21D1	3/79	18.5	550	1.0	+538	5.9	c
B-25/21D1	5/80	13.3	190	0.15	+160	6.2	c
Well #6	3/78	18.0	35	0.10	c	6.8	c
Maxey Flats Site							
7-3	10/81	16.5	12000	0.10	-44	7.4	-324
19W	10/81	15.0	2100	0.10	-27	6.5	-465
23M	10/81	17.0	4800	0.05	-38	7.5	-302
27	10/81	16.0	6600	<0.05	+17	6.8	-353
33L4	10/81	17.0	6400	0.05	-54	12.0	-278
33L8	10/81	18.0	2000	0.25	-135	6.0	-125
35	10/81	17.0	3400	0.10	-14	8.2	-486
Well Water[d]		c	2740	0.10	c	6.8	c

[a]Eh values are reported relative to the Standard Hydrogen Electrode (SHE).
[b]The sulphide electrode was calibrated in the laboratory using the method developed by Berner (1963).
[c]Not measured.
[d]Average values for off-site shallow wells as reported by Zehner (1983).

The results show that Maxey Flats leachates are depleted in dissolved oxygen, indicating anoxic conditions in the trenches. Anoxic conditions are also indicated by negative sulphide and redox potentials. In contrast to Maxey Flats leachates, the Barnwell leachates exhibit positive redox potentials and higher dissolved oxygen concentrations, indicating more chemically oxidized waters.

Relative to the well waters, most trench leachates exhibit much higher specific conductance. The highest values observed were 2600 µmho/cm for trench 8D3 at Barnwell and 12000 µmho/cm for trench 7-3 at Maxey Flats.

Major Ion Chemistry

An ion balance of the major cations and anions present in each leachate sample was conducted to determine the completeness of the trench water analyses. Equivalents of the major cations and anions were compared to calculate the ion balance error. In most cases, the error in ion balance was found to be small, suggesting that the analyses are relatively complete and accurate. However, for Barnwell leachates 3D1, 5D2, A-6D1, 13D4, and 18D5 the error was appreciable. Consequently, we have not considered these data further in this report. The major cation and anion compositions of trench leachates and well waters from the two sites are presented in Table 2. Also included in Table 2 are data for alkalinity, dissolved inorganic and organic carbon and silica.

Relative to the composition of average well water, most leachates from Maxey Flats exhibit enrichment to varying degrees of Na, K, Ca, Mg, Cl, NO_3, Fe, and alkalinity. These enrichments are also reflected in high specific conductance of the leachates, especially for leachate 7-3 which has very high concentrations of Na, Cl, and SO_4 ions, and leachate 27 which has a high concentration of Cl ions. Another important characteristic exhibited by Maxey Flats leachates is strong depletion of sulphate, relative to the well water. The dissolved organic and inorganic carbon levels are also observed to be significantly higher than that reported for on-site well water (Dayal et al., 1984).

The Barnwell leachates also exhibit enrichment in most dissolved constituents, relative to the composition of well water. However, the extent of enrichment is not as great as that observed for Maxey Flats leachates. This is also reflected by much lower values for specific conductance. In addition, unlike the Maxey Flats leachates, the Barnwell leachates are generally not depleted in sulphate and not enriched in potassium. Only leachates 8D3 and B-25/21D1 are depleted in sulphate, relative to the well water. Relatively high contents of dissolved organic and inorganic carbon and alkalinity are also observed in most Barnwell leachates.

TABLE 2
COMPOSITION OF TRENCH AND WELL WATERS SAMPLED AT BARNWELL AND MAXEY FLATS DISPOSAL SITES

	Concentration (mg/L)													
	Barnwell Site						Maxey Flats Site							
	B-6D1	8D2	8D3	A-25/21D1	B-25/21D1	Well # 6	7-3	19W	23M	27	33L4	33L8	35	Well Water[a]
Dissolved Constituents														
Chloride	13.3	85	47	42	12.1	2.9	2500	231	575	2340	361	37	235	23
Flouride	b	b	b	b	b	b	44	4.0	5.3	b	b	3.7	45	b
Nitrate (as N)	4.2	8.0	<0.1	15	<0.1	<0.1	8.5	0.53	28	17.3	9.9	1.6	0.67	0.02
Sulfate	45	34	7	56	<5	17	1320	<1.5	57	<1.5	<1.5	15	<1.5	133
Ammonia (as N)	4	59	205	25	35	2	75	45	100	116	26	50	37	b
Barium	0.6	<1	0.5	<1	<0.5	<0.5	<0.5	0.7	<0.5	15	7	<0.5	0.5	b
Calcium	14	34	82	21	10	3.6	107	49	11	220	864	190	26	43
Iron-Total	<1	1.2	24	0.2	6.1	<1	16	65	7	165	0.2	43	0.9	17
Iron-Ferrous	b	b	b	b	b	b	12	62	5.8	164	b	42	0.8	b
Magnesium	1	18	40	3	3	0.15	193	128	230	350	<0.2	49	330	24
Manganese	0.7	0.7	0.9	0.3	0.6	<0.1	1.9	0.5	<0.1	1.7	<0.1	1.8	0.3	b
Potassium	3	12	18	4	1	12	329	27	77	87	102	11	51	9
Sodium	28	87	120	37	11	15	2140	231	825	554	180	50	614	56
Strontium	b	b	b	b	b	<0.5	0.7	0.6	<0.3	2.3	8.0	<0.3	<0.3	b
Alkalinity (as $CaCO_3$)	86	600	1340	80	104	61	1150	1040	2420	312	2120	1080	2310	279
Inorganic Carbon	8	130	258	38	17	6	220	170	520	57	1	330	390	b
Organic Carbon (DOC)	7	170	203	12	6	6	730	430	780	493	1500	160	540	b
Silica (SiO_2)	7	6	5	5	7	<1	b	b	b	b	b	b	b	18

[a]Average concentration of off-site shallow well waters at the Maxey Flats site (Zehner, 1983).
[b]Not determined.

Dissolved Radionuclides

The maximum concentrations of H-3, Am-241, Co-60, Cs-134, Cs-137, Pu-238, Pu-239,240, and Sr-90 observed in Maxey Flats and Barnwell leachates are shown in Figure 2. Detailed radionuclide data for the individual trenches are given in previous reports (Dayal et al., 1984; Czyscinski and Weiss, 1981). The results show that radionuclide concentrations are consistently lower in Barnwell leachates, compared to those from Maxey Flats. Tritium is the most abundant radionuclide in the leachates, approaching concentrations in the range of 10^9-10^{10} pCi/L. The concentrations of other radionuclides in the Maxey Flats leachates vary from 10^3 pCi/L for Cs-134 to ~10^6 pCi/L for Sr-90. At the Barnwell site, the maximum concentrations observed are from one to four orders of magnitude lower than those at the Maxey Flats site, and range from ~1 pCi/L for Pu-239,240 to 10^2-10^3 pCi/L for Cs-137 and Co-60.

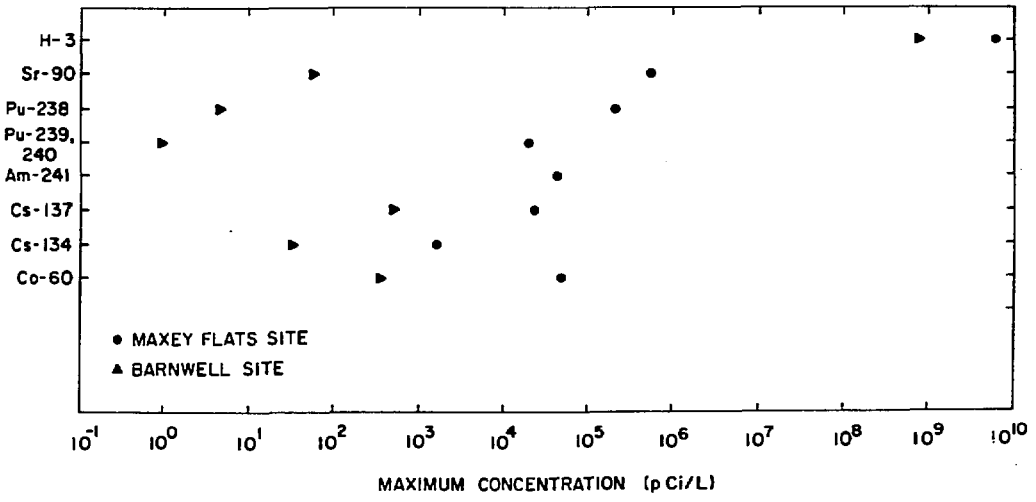

Figure 2 Maximum radionuclide concentrations observed in Barnwell and Maxey Flats trench leachates.

DISCUSSION

The results reported in this study are important because they provide insight into factors and processes controlling the formation and composition of trench leachates. Consideration of hydrological and geochemical factors helps elucidate the development of anoxic conditions in the trenches and the contrasting leachate chemistries observed at the two sites. The trench leachate data are interpreted in terms of waste-derived constituents and microbial degradation products.

Hydrological Considerations

The hydrological factors determine to a large extent the nature and amount of leachate produced in a given trench. At the Maxey Flats site, the waste trenches are located in shale of relatively low hydraulic conductivity (10^{-9} m/s). Consequently, this leads to accumulation of rainwater that infiltrates through the trench caps. Such stagnant accumulations of water and eventual overflow at Maxey Flats has been termed the "Bathtub Effect." Because of the long residence time of accumlated water in the trenches, prolong leaching and microbial degradation of the buried waste material can be expected to occur.

At the Barnwell site, the trenches are located in sandy soil of relatively high hydraulic conductivity (10^{-5} m/s). Consequently, the trenches represent well-drained systems, where the accumulated water has a relatively short residence time and is not continually present in the trenches.

Geochemical Considerations

Among the processes controlling the composition of trench leachates, microbial degradation and leaching of waste materials are considered to be important. Solubility constraints may also limit the concentrations of certain radionuclides, cations and anions present in trench leachates, especially at Maxey Flats, where the trenches represent relatively closed, stagnant systems.

(a) Microbial Degradation of Organic Waste

The development of anoxic conditions in trench leachates, especially at Maxey Flats, can be attributed to microbial degradation of organic matter present in the buried wastes. A large fraction of wastes buried in the trenches at both sites consists of unconsolidated organic materials. Many components of these materials are subject to both aerobic and anaerobic microbial degradation processes.

Given the relatively stagnant leachate accumulations in the trenches at Maxey Flats, the dissolved oxygen is consumed rapidly during aerobic decomposition processes. Following depletion of oxygen, further degradation of organic material occurs by anaerobic processes. The anaerobic degradation of organic matter involves denitrification, followed successively by sulphate reduction and methane generation. During the aerobic and anaerobic oxidation of organic matter, there is a continual production and buildup of decomposition products such as carbon dioxide and ammonia which cause the alkalinity, total aqueous CO_2, and ammonia contents of the trench leachates to increase. Concurrently, dissolved oxygen, sulphate, and nitrate are consumed, resulting in negative redox and sulphide potentials. Iron reduction contributes to high concentration of dissolved iron, present primarily as Fe^{2+}.

Relative to average well water composition, Maxey Flats leachates are characterized by high concentrations of total aqueous CO_2, ammonia, Fe^{2+} and alkalinity, and are generally depleted in dissolved oxygen and sulphate. Although sulphide enrichment is expected, relatively low sulphide levels in the leachates may reflect competing processes of sulphide generation and removal by precipitation as authigenic iron sulphides, with the residual dissolved iron in the leachates representing iron in excess of the amount precipitated as iron sulphides or carbonates. The anomalously high NO_3^- levels in some Maxey Flats leachates, where depletion of both sulphate and dissolved oxygen is observed, may indicate a waste-derived source.

Although the redox potential of Barnwell leachates indicates oxidizing conditions (Table 1), elevated levels of alkalinity and ammonia, relative to local groundwater composition, reflect the effects of microbial degradation processes. In terms of anion composition, the Barnwell leachates 8D3 and B-25/21D1 are very similar to most Maxey Flats leachates, that is, strongly depleted in sulphate and enriched in alkalinity. Leachates A-25/21D1 and B-25/21D1 represent samplings in 3/79 and 7/80, respectively. It is interesting to note that, relative to A-25/21D1, leachate B-25/21D1 exhibits enhanced depletion of sulphate and dissolved oxygen, lower redox potential, and higher alkalinity and dissolved iron concentrations, probably reflecting a more advanced stage of microbial decomposition of organic waste materials in trench 25/21D1, thus resulting in increased build up of the observed degradation products. However, relative to groundwater compositions, the Maxey Flats leachates reflect generally greater modification due to bacterial and waste leaching processes than the Barnwell leachates.

It appears that alkalinity and sulphate levels in the trenches may serve as a relative measure of the extent of microbial degradation activity in the trenches, depending on the quantity and reactivity of organic waste materials and the residence time of accumulated water in the trenches. However, in relatively stagnant water accumulations having a long residence time such as those represented by the trenches at Maxey Flats, continual buildup of degradation products such as alkalinity and sulphide (sulphate depletion) can result in precipitation of authigenic metal carbonates and sulphides, where the metals are either waste-derived or represent corrosion products such as Fe^{2+}. Our preliminary analysis of Maxey Flats leachate data using the geochemical code WATEQF to determine aqueous speciation and calculate chemical equilibria in the trenches indicates that siderite, calcite, dolomite, rhodocrosite, and iron sulphides may be controlling the Fe^{2+}, Mn^{2+}, Ca, Mg, carbonate, and sulphide concentrations in the leachates. Therefore, in relatively closed systems, the effects of solubility constraints should be considered in interpreting quantitatively sulphate, sulphide, and alkalinity data in terms of microbial decomposition processes.

(b) Leaching of Buried Waste

Water accumulations in the trenches lead to prolonged leaching of buried waste materials, resulting in the presence and build up of various waste-derived constituents in the leachates. The nature and extent of modification

of infiltrated water due to waste leaching is a function of the quantity and the characteristics of the waste and the residence time of accumulated water. Elevated concentrations of various dissolved constituents in the leachates such as sodium, potassium, magnesium, calcium, ferrous iron, chloride, inorganic and organic dissolved carbon, and several anthropogenic radionuclides can be directly attributed to leaching of waste materials.

The water accumulations in the trenches at Maxey Flats have a relatively long residence time. This allows prolonged leaching of the buried waste and leads to buildup of waste derived constituents, resulting in elevated concentrations of Cl, Na, K, Mg, Ca, Fe^{2+}, dissolved organic and inorganic carbon, and several radionuclides. For example, the relatively high concentrations of Ca^{2+} and CO_3^{2-} in leachate 33L4 can be attributed to their release from the leaching of cement, which was used as a solidification agent for immobilizing liquid waste disposed in this trench. A high pH value of 12 reported for leachate 33L4 (Table 1) further reflects the influence of cement binder on leachate chemistry.

The high concentrations of chloride in leachates 7-3 and 27, fluoride in leachates 7-3 and 35, sodium and sulphate in 7-3 are probably a result of leaching of waste materials. Similarly, elevated concentrations of both dissolved organic and inorganic carbon, and iron in the leachates also indicate a waste-derived source. The presence of organic chelating agents such as EDTA, DTPA and NTA (Weiss and Colombo, 1982), used as decontaminating solutions in both fuel and non-fuel cycle activities, in Maxey Flats leachates also indicates buried waste to be their source.

The Barnwell leachate compositions also indicate enrichment in most cations associated with waste leaching, relative to the well water composition. However, the extent of enrichment is not as great as that observed in Maxey Flats leachates. This is also reflected by lower specific conductance for Barnwell leachates. Data on leachate radionuclide concentrations as displayed in Figure 2 also show that Barnwell leachates exhibit consistently lower concentrations of H-3, Am-241, Pu-238, Pu-239,240, Co-60, Cs-134, Cs-137, and Sr-90 than those of Maxey Flats.

Since both Na^+ and Cl^- ions are known to behave conservatively and are also truly waste-derived, it appears that their concentration levels in the leachates, relative to that in well water, could serve as a relative measure of the extent of leaching of waste materials. Among the radionuclides, tritium is the most readily leachable and since it does not participate in chemical reactions, it may also be used as a conservative measure of leaching of radioactive materials.

SUMMARY AND CONCLUSIONS

Relative to local groundwaters, both Barnwell and Maxey Flats leachates exhibit significant modifications in terms of their dissolved constituents. The nature and extent of the observed modifications can be attributed primarily to microbial degradation and leaching of buried waste materials.

The development of strong anoxic conditions in Maxey Flats leachates, as characterized by low redox potential, low dissolved oxygen and sulphate concentrations, and high contents of alkalinity and ammonia, is a result of aerobic and anaerobic oxidation of organic matter in waste materials. Elevated concentrations of Na, K, Ca, Mg, Fe, Cl, dissolved organic and inorganic carbon, and several radionuclides such as H-3, Am-241, Co-60, Cs-134, Cs-137, Sr-90, Pu-238, and Pu-239,240 are believed to be a consequence of the leaching of waste materials.

In contrast, most Barnwell trench leachates are oxidizing. However, high alkalinity and ammonia contents, relative to local groundwater, do indicate that microbial degradation processes are operative in the Barnwell trenches. In particular, leachates 8D3 and B-25/21D1 reflect a strongly anoxic character similar to that of the Maxey Flats leachates. Furthermore, the presence and concentration levels of certain cations and several radionuclides indicate buried waste to be the likely source. Because of stagnant water accumulations having a relatively long residence time, the effects of microbial degradation and leaching of waste materials are more pronounced on Maxey Flats leachates than on the leachates in Barnwell trenches, which represent well-drained systems, where the accumulated water has a relatively short residence time and is not continually present in the trenches.

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