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MICROBIAL EFFECTS ON RADIOACTIVE WASTES AT SLB SITES*

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A.J. Weiss and P. Colombo
Department of Nuclear Energy
Brookhaven National Laboratory
Upton, New York 11793

ABSTRACT

A significant fraction of DOE and commercially generated low-level radioactive waste consists of organic materials. These materials are subject to degradation by microorganisms present in the shallow land burial environment and may contribute to enhanced migration of radionuclides through the formation of gases, mobile complexes and bioaccumulation. This scanning study will determine the effects of microbial degradation at present disposal sites and their impact on shallow land burial performance criteria, trench construction and segregation of organic wastes.

The main objective of this program is to determine the significant effects of microbial activities on shallow land burial (SLB). The program is in support of DOE/LLW Management Program alpha milestones B, C, and D.

INTRODUCTION

A significant fraction of DOE and commercially generated low-level radioactive waste consists of organic materials such as those shown in Table 1. These materials are subject to degradation by microorganisms present in the shallow land burial disposal environment and the wastes themselves. This degradation, in turn, may contribute to enhanced migration of radionuclides (and chemically toxic compounds) into the biosphere by a number of mechanisms. Such microbial effects include direct attack on the waste form/container, alteration of the trench environment (e.g., pH, redox potential), formation of mobile complexes,

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Table 1. Typical Organic Materials Buried At Shallow Land Disposal Sites

Clothing	Oils
Plastics	Ion Exchange Resins
Paper	Liquid Scintillation Cocktails
Cellulosics	Animal Carcasses
Rubber	Solidification Agents
Solvents	

bioaccumulation and gas generation. Problems relevant to subsidence and trench deterioration have also been attributed to microbial degradation of solid organic wastes.

While several mechanisms for enhanced radionuclide migration as a result of microbial degradation have been proposed (and some observed), there is no consensus concerning which mechanisms predominate or whether they are even significant. The significance of microbial degradation, however, may vary widely between humid and arid sites.

The biodegradation of organic wastes, if indeed significant to radionuclide migration, may impact several areas of waste disposal technology. In particular, it may suggest the segregation or even exclusion of some organic wastes from burial at a given site. This could also affect acceptable waste forms (solidification agents) and the need for additional waste treatment operations, such as incineration, which are aimed at decreasing the amount of organic wastes in disposal. Microbial degradation may influence shallow land burial siting criteria and trench construction. It may also impact interim storage and transportation of organic wastes.

This scanning study will determine the significance of the biodegradation of organic low-level radioactive wastes in shallow land burial and, if significant, ascertain which mechanisms predominate and under what conditions. Recommendations will be developed with the object of minimizing the impact of microbial degradation or radionuclide migration.

PROGRAM OBJECTIVES

The objectives of this program are: (1) determine the significance of microbial degradation of organic wastes on radionuclide migration in shallow land burial for both humid and arid sites, (2) establish which mechanisms predominate, (3) ascertain the conditions under which these mechanisms operate, (4) provide recommendations directed towards minimizing the effect of degradation on the mobility of radionuclides in shallow land burial (such as segregation/exclusion of some wastes/waste forms) and (5) assess the impact of these recommendations on waste treatment, interim storage, transportation and disposal.

This work was identified as a major data need in "Unresolved Technical Issues in Land Burial of Low-Level Radioactive Wastes," ORNL/NFW-79/62 (October 1979). The program is in direct support of DOE/LLW Management Program Alpha Milestone B, "Develop technology for waste treatment, handling, and packaging for shallow land burial site disposal", Milestone C, "Develop technology and documentation to support a shallow land burial site", and Milestone D, "Develop remedial action technology for shallow land burial sites".

PROGRAM AREAS

The program will consist of literature and experimental work, where required, to identify the significant mechanisms that may contribute to the migration of radioactivity at shallow land burial sites resulting from microbial degradation of organic materials. Work tasks for FY 82 include: (1) Identification of significant microbial degradation mechanisms, (2) Assessment of microflora in humid and arid SLB sites, (3) Bioaccumulation and transformation of radionuclides, (4) Microbial generation of volatile compounds, (5) Microbial degradation of organic compounds and organo-radionuclide complexes, and (6) Other mechanisms that may enhance radionuclide migration.

Identification of Significant Microbial Degradation Mechanisms

A literature search will be made to determine the present state of knowledge dealing with radionuclide movement attributed to microbial activities at shallow land burial sites. Technology gaps will be identified and experimental work will be conducted to generate new data or to supplement existing data where required.

Assessment Of Microflora In Humid And Arid SLB Sites

Microorganisms indigenous to humid and arid SLB sites, such as aerobic, anaerobic, sulfate reducing, denitrifying and methanogenic bacteria will be identified and classified with respect to the role they play in the decomposition of organic materials. This will permit quantification of both the potential for microbial interactions with low-level radioactive waste materials and the effects of these interactions on enhanced migration of radionuclides.

Bioaccumulation And Transformation Of Radionuclides

Microorganisms are capable of uptake and retention of various radionuclides which can be transported by ground water movements and released to the environment upon cell lysis. Several isolates of bacteria from the trench environment will be evaluated for their ability to bioaccumulate one or more of the radionuclides (e.g., ^{60}Co, ^{90}Sr, $^{134,137}Cs$, $^{238,239,240}Pu$) normally found in SLB trenches.

Microbial Generation Of Volatile Compounds

Organic compounds, in soils, can be degraded by bacterial action to yield H_2, CH_4, CO_2, H_2S, NO_x, low molecular weight volatile organic acids, alcohols, aldehydes, ketones and esters under aerobic and anaerobic conditions. Trenches at SLB sites are known to contain ^{14}C-carbon compounds and tritium in abundance. Volatile gases resulting from microbial activity, such as CO_2, CH_4, H_2, H_2S, will not only contain radioactivity but could result in possible container pressurization and explosion. Radioactive gases emanating from selected trenches at a humid and arid SLB site will be identified and quantified. This work will be done on a limited basis for the purpose of assessing the amounts of ^{14}C-tagged and tritiated methane released into the atmosphere as well as its impact on personnel safety and other life forms at the burial site.

Microbial Degradation Of Organic Compounds And Organo-Radionuclide Complexes

Organic wastes can be degraded by microbial processes to innocuous compounds or transformed into compounds having an affinity to form complexes with radionuclides. Microorganisms can also act upon existing organo-radionuclide complexes to release radionuclides as water

insoluble compounds or as compounds which can easily be transported by ground water movement. The rate of degradation of the various organic materials found in SLB trenches and organo-radionuclide complexes will be determined.

Other Mechanisms

Microbial interaction with radionuclides could also enhance volatilization through alkylation reactions. Methylation of heavy metals occurs under both aerobic and anaerobic conditions to form volatile toxic compounds. Attempts will be made to identify and characterize radioactive methylated compounds resulting from microbial activities although the production of such species has not been previously reported in the literature. Microbial production of chelated radionuclides will also be examined.

SIGNIFICANT RESULTS

Since this is a new program that commenced in FY 1982, significant results are not available.