CHARACTERIZATION AND REMEDIAL PLANNING FOR NON-RADIOLOGICAL TOXICANTS AT UMTRA PROJECT SITES

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ABSTRACT

The congressional mandate for the Uranium Mill Tailings Remedial Action (UMTRA) Project is to clean up 24 inactive uranium processing facilities around the United States. Remedial actions are performed as necessary to meet standards established by the Environmental Protection Agency (EPA) for levels of Ra-226 in soil. However, potentially hazardous non-radioactive materials have been encountered at a number of UMTRA Project sites, sometimes requiring action beyond that necessary to meet the EPA standards. Foremost among these non-radiological toxicants (NRTs) are metals and metalloids such as arsenic, molybdenum, selenium, and vanadium: elements that are closely associated with the tailings matrix. In most cases, there are no clear regulatory guidelines or standards to dictate cleanup levels for these substances.

A multidisciplinary task force was organized to manage the handing of NRTs at UMTRA Project sites. It was decided that a general procedure was needed to: 1) characterize NRTs at each site, 2) establish site-specific guidelines for cleaning up these substances to a safe level, and 3) identify appropriate remedial actions. Formulation of the procedure has involved the following elements:

- Identification and characterization of biogeochemical pathways linking the contamination at UMTRA Project sites to humans; quantification of factors such as solubility, sorption, and uptake of NRTs.
- Establishment of toxicity risk factors for substances relative to exposure mode; determination of the most important pathways in terms of exposure potential.
- Maximum utilization of existing data or archived samples available for each site, and recognition of inter-site variation with respect to hazards, environmental characteristics, land-use, etc.
- Review of potentially applicable regulations and guidelines, including precedents that allow for the accommodation of inter-site variability.

At the heart of the procedure is a pathway analysis approach for determining the acceptable residual levels of the NRTs that may remain in the soil after a tailings pile has been relocated. The analysis may also be used to determine the engineering values (e.g., cover infiltration rate) required to assure an adequate degree of isolation of the NRTs. The analysis utilizes a technique named DECHEM© that closely parallels the DECOM© method already used for radionuclides at mixed waste sites (1). The methodology employs user-friendly microcomputer software that permits insertion of site-specific parameters to guide the characterization and management of NRTs at all UMTRA Project sites.

This paper describes the approach that has been taken on the UMTRA Project toward developing this methodology and implementing it on a trial basis at two sites where NRTs require immediate attention.

INTRODUCTION

The goal of the Uranium Mill Tailings Remedial Action (UMTRA) Project is to clean up 24 inactive uranium processing facilities around the United States. The project is managed by the U.S. Department of Energy. The general approach is to consolidate contaminated materials into a single engineered embankment, either at the original tailings site or at an alternate disposal site with characteristics conducive to long-term isolation. A principle consideration in remedial planning has been the radiological standard, promulgated by the Environmental Protection Agency (EPA), for the cleanup of Radium-226 in soil to a level of 5 picocuries per gram in the top 15 cm and 15 pCi/gm thereunder (2). This determines the depth of excavation for contaminated areas such as raffinate ponds, millyards, sites of windblown deposition, and (when tailings are relocated) subpile soils.

However, it became evident at a number of UMTRA Project sites that remedial action to the Ra-226 standard would not necessarily remove or isolate other hazardous substances to an acceptable degree. For instance, metals and metalloids such as arsenic, molybdenum, selenium, and vanadium are sometimes present in elevated concentrations in the tailings. Since these may be more mobile than Ra-226, they may migrate deeper into subpile soils than would Ra-226.

It was discovered during remedial planning at the UMTRA Project site in Lakeview, Oregon, that As would remain at potentially elevated levels in subpile soils after the tailings and Ra-226 contaminated soil were relocated to a permanent disposal site. No regulatory guidelines were available to dictate cleanup levels, so a preliminary site-specific determination was made that As should be cleaned up to 50 parts per million. However, this cleanup level proved impractical during remedial action and verification, prompting contractors under DOE direction to perform a very conservative site-specific pathways analysis that led to a more realistic standard several times higher than the original value.

The developments at Lakeview and elsewhere prompted the DOE to assemble a multidisciplinary, inter-organizational task force to manage the characterization and remedial planning for non-radiological toxicants (NRTs) at the 24 UMTRA Project sites. Under DOE leadership, an NRT task force was organized, consisting of individuals (including several authors of this paper) from the project's Technical Assistance Contractor and Remedial Action Contractor. This task force was provided with the technical expertise and scope of authority to effect rapid action on all issues and developments related to NRTs.

An important objective of the NRT task force has been to develop a procedure for characterizing NRTs at a site in order to establish cleanup criteria, which may or may not call for remedial action beyond that required for compliance with the standard for Ra-226 in soil. Although the same procedural steps are to be performed at each site, the ensuing guidelines should be site-specific, based on such factors as contaminant form, environment, and land use. This paper describes the task force's general approach to developing the procedure, as well as the various component activities and progress made to date.

NRT PROCEDURE

General Approach The initial effort has focused on metallic elements that are closely associated with the tailings and that, due to increased mobility, may contaminate a larger volume of soil than Ra-226. These include the non-radioactive metals and metalloids mentioned above (As, Mo, Se, and V), as well as the elements thorium and uranium, which can be highly mobile in certain geochemical environments. These elements were selected based on the frequency and concentrations of their occurrence at UMTRA Project sites, as well as the general comparability among their chemical properties.

It was decided that the procedure and resultant cleanup criteria should address the potential health risks associated with these metallic NRTs (Th and U included) at a site, as determined from an analysis of the potential exposure pathways, including groundwater, and subsequent exposure rates. A consultant (John E. Till) was approached for the purpose of adapting DECOM© , which is a method for specifying radionuclide cleanup criteria at mixed waste sites (1), to the establishment of similar criteria for metallic NRTs at UMTRA Project sites. The adapted version, called DECHEM , could be used to determine excavation depths for raffinate ponds, millyards, and subpile soils (where tailings are to be relocated). DECHEM© could also be used to determine engineering values such as cover permeability for stabilized tailings embankments. Cover permeability is important because it affects the rate of contaminant migration toward groundwater, for which contaminant levels will soon be regulated under standards proposed by the EPA.

The following sections describe the specific activities underway to develop and validate the NRT procedure.

Regulatory Analysis

Regulations and lines of jurisdiction are not clear for many of the NRTs at UMTRA Project sites. The NRT procedure could indicate the need for remedial actions that are not necessarily within the DOE's scope of responsibility as defined in the UMTRA Project's authorizing legislation (Uranium Mill Tailings Radiation Control Act of 1978; Public Law 95-604). This analysis is intended to clarify DOE's responsibility for NRTs, and to examine other

federal regulations that specify potentially meaningful standards and guidelines. Acceptable concentration limits and their underlying health bases are being examined in:

- The Clean Air Act
- The National Emissions Standards for Hazardous Pollutants
- The Clean Water Act
- The Resource Conservation and Recovery Act
- The Comprehensive Environmental Response Compensation and Liability Act
- The National Institute for Occupational Safety and Health Worker Exposure Standards.

The Regulatory Analysis also examines the relationship between the NRT procedure and the proposed EPA standards for contaminants in groundwater. The goal is to ensure that the procedure's assumptions and recommendations are consistent with the evolving network of regulations that relate to the characterization, remedial action, and monitoring of NRTs.

TABLE I

Parameters for DECHEM in the NRT Database

General	Locational
Annual Precipitation	Longitude
Annual Evaporation	Latitude
Depth to Groundwater	Depth (above mean sea level)
Thickness of Final Cover	pH
Hydraulic Conductivity of Cover	Oxidation/Reduction Potential
Leach-test Coefficient	Cation Exchange Capacity
Grazing	[$CaCO_3$]
Gardening	[As], [Mo], [Se], [^{230}Th]
Vegetal Productivity	[U], [V], [Ca, Mg, Na, K, SO_4, Cl, Mn, Fe]

NRT Database

The NRT database provides access to the information required to characterize NRTs at UMTRA Project sites and execute the DECHEM methodology for establishing remedial action guidelines. The database also provides access to source documentation for NRT-related activities on the UMTRA Project. Access is available to project participants via modem communications with the IBM PS/2 Model 80. A password determines whether the user can change information and download files or is limited to read-only access. Table I lists parameters required for the execution of DECHEM at each site. These include general parameters describing environmental and land-use conditions, as well as locational parameters describing soil properties and contamination at the various sampling locations. The data support DECHEM's predictions of contaminant mobility and migration along the various pathways to humans.

The NRT database also contains the toxicological information required to assess the potential health affects of exposure to metallic NRTs. Toxicological values, expressed when possible in milligrams per kilogram body weight, are in the numeric portion of the database and are supported by citations and abstracts in the source-document portion of the database. The database is organized as shown in Fig. 1 using the Paradox© relational database software, and is consistent with the user-friendly nature of the entire NRT procedure. The specific application was written using the built-in programming language. The program, menu driven at all levels, includes integrated help screens. The flexible structure allows changes and additions to be made as the project progresses and specific needs are defined. The numeric portion of the database can export values directly to the DECHEM model, whereas the source-document portion can be reviewed for additional information and explanation. A bulletin board is available from the main menu for updates and messages for all project participants.

NRT Procedure

The procedure involves a series of steps for characterizing NRTs, determining an acceptable level of health risk, and establishing cleanup criteria. Table II lists these steps as they were conceived at the beginning of the NRT study.

The central activity in the NRT procedure will be the execution of the interactive computer code, DECHEM©, being developed for use on microcomputers by NRT project participants. Based on inputs from the NRT database, DECHEM will determine acceptable soil concentrations of NRTs in terms of health risk and compliance with EPA requirements (especially the proposed groundwater standards). Input data will be as described in the previous section, and health risks from hazardous chemicals in soils will be assumed to be additive.

Primary pathways of exposure considered in the code are (1) consumption of groundwater affected by contaminants from an UMTRA Project site, (2) ingestion of food produced on the site (produce, leafy vegetables, milk, and meat), and (3) inhalation of resuspended soil. DECHEM's models calculate the depletion of each NRT from the soil at an UMTRA Project site up to the time where DOE relinquishes control of that site. The principal loss mechanisms are leaching, chemical reactions, and water

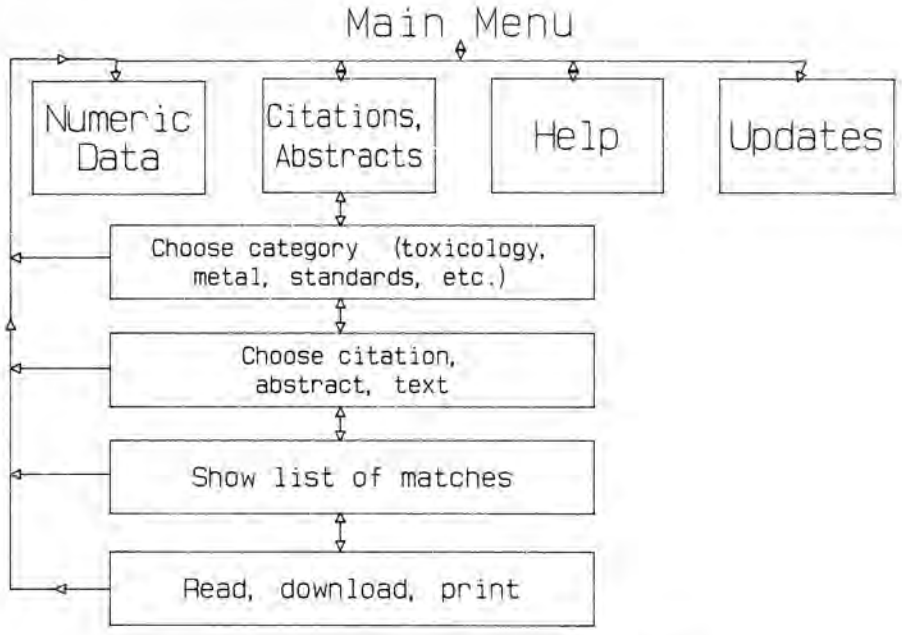

Fig. 1. Organization of the NRT Database.

TABLE II

Conceptual Steps in the NRT Procedure

1.	Characterize NRTs at Site X.	This defines the extent of contamination and identifies potential indicator NRTs[a].
2.	Model Potential Exposure Pathways at Site X.	This establishes numerical relationships between levels of indicator NRTs in soil at Site X and resultant human exposures.
3.	Apply Toxicological Data from the Literature.	This establishes potential health effects associated with exposure to an indicator NRT.
4.	Establish an Acceptable Level of Health Risk for Humans living near Site X.	This provides a basis for determining how much NRT in the soil would cause an unacceptable exposure, hence unacceptable health risk.
5.	Specify Cleanup Criteria for indicator NRTs at Site X.	This provides a basis for decisions in remedial planning involving residual NRT levels, excavation depth, cover conductivity, and so forth.

[a] Indicator NRTs are those hazardous constituents that appear to be most toxic and mobile at a given site.

transport. The output of DECHEM will consist of tabular predictions of uniform NRT concentrations in soils from five to 100 centimeters deep. DECHEM will indicate the depth below which NRT concentrations would not result in unacceptable exposure rates to the public via inhalation or ingestion. At the option of the user, a pathway analysis for a given soil depth may be calculated and printed.

DECHEM's output may be interpreted to determine the appropriate excavation depth for subpile soils and other contaminated materials, or to identify the appropriate hydraulic conductivities for cover materials in a stabilized tailings embankment. DECHEM's output may help in applications for Alternate Concentration Limits under the proposed EPA groundwater standards.

Validation of the NRT Procedure Prior to its general use on the UMTRA Project, the procedure will be executed on a trial basis at two sites where metallic NRTs may occur at hazardous levels. The validation process has begun with the selection of the Riverton and Green River sites, where tailings are to be relocated (as opposed to stabilized in place) and guidance is needed both for excavation depth and engineering of the final embankment.

Background information has been compiled for both sites to address the general parameters in Table 1, and to provide a preliminary indication of the contamination by NRTs. For instance, information on the type of milling process (acid versus alkali) is useful in predicting the chemical forms and relative mobilities of certain NRTs. Previous studies on the economic feasibility of recovering selected metallic mineral resources from tailings at UMTRA Project sites also provide an indication of the metals present.

The most important part of the NRT characterization process for the validation sites (and ultimately for all UMTRA Project sites) is the selective analysis of samples that were collected previously for Ra-226 analysis and subsequently archived. These samples are analyzed for the soil parameters in Table I and are selected to represent the following components of the environment at an UMTRA Project site:

- tailings (to characterize the dominant source term at the permanent disposal site)
- subpile soil (especially beneath the excavation depth required by the Ra-226 standards)
- millyard and ore storage areas
- raffinate ponds
- areas of windblown deposition of tailings and contaminants
- control (unaffected) locations.

Archived samples were selected for analysis in order to estimate NRT contamination as a function of depth. It is anticipated that sufficient data are available from the archived samples to execute DECHEM meaningfully; however, additional samples will be collected and analyzed for NRTs at the validation sites if necessary to obtain appropriate guidelines.

Once the archived samples have been analyzed and the microcomputer code for DECHEM is operational, trial runs will be performed for both the Green River and Riverton sites. Recommended excavation depths and other DECHEM outputs will be evaluated for their reasonableness and consistency with all the data available for the validation site. If necessary, additional sampling and analysis will be performed to check the accuracy of DECHEM's predictions. The procedure will be demonstrated to EPA on a preliminary basis and the validation process will be completed prior to its release for general use on the UMTRA Project.

CONCLUSION

The NRT procedure should be operational and validated by the middle of 1988. The result will be improved remedial planning for NRTs at all UMTRA Project sites. The DECHEM code and associated methodology will also have applications in part or whole to the characterization and remedial planning for hazardous substances wherever these may occur in soils.

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