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A DATABASE OF INFORMATION ON TECHNOLOGIES FOR HAZARDOUS WASTE SITE REMEDIATION

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ABSTRACT

A personal-computer-based database and user interface has been developed for retrieving and reviewing information on technologies applicable to the environmental remediation of hazardous waste sites. This system and its information represent a useful source of technology information for people preparing, reviewing, or approving site remediation plans or evaluating remediation technologies. The system includes a variety of information for approximately 90 distinct remedial action technologies. A general text description of each technology is provided, together with basic engineering or design parameters and flowcharts. Information on applying a given technology includes the applicability of the technology to specific contaminants, associated technologies that may be required in conjunction to provide for complete remediation of a site, technical limitations and constraints on the use of the technology, and identification of information or site data needed to deploy the technology at a particular site. U.S. federal regulatory information relating to each technology is also provided. In addition, the system identifies sources for more detailed information for these technologies (i.e., references and specific sites where these technologies have been used). Technologies to be considered can be selected from the complete list of technologies for which information is included, or can be chosen from a shorter list of technologies matching a set of user-specified remediation objectives. The technology information is compiled from a wide variety of sources. The system is designed to support the assessment of remedial alternatives at U.S. sites, but should be readily adaptable to other environmental remediation situations throughout the world.

HAZARDOUS WASTE SITE REMEDIATION

Past industrial operations and waste management practices have created a number of specific sites throughout the U.S. that are contaminated with various types of uncontrolled hazardous materials. Similar sites exist throughout the world, and increasing attention is being paid to the need for cleanup of these sites. In the U.S., cleanup of these sites is governed primarily by either the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or the Resource Conservation and Recovery Act (RCRA). Similar regulatory requirements exist or are emerging in other countries.

Several key characteristics of these hazardous waste sites are worth noting. First, the number of such sites is quite large, thus requiring substantial numbers of people to be involved in planning for cleanup activities at specific sites. Second, the characteristics of such sites are complex and vary considerably from site to site. Therefore, assessment of site conditions and determination of

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appropriate responses is a complicated, time-consuming task requiring access to information about what remedial technologies can be applied in particular circumstances.

For any site, once appropriate response actions have been identified, plans for site cleanup must receive the necessary approvals. This approval process involves a number of reviews by people of varied technical background.

Because of the great complexity and large number of waste sites facing the U.S. Department of Energy (DOE) for potential cleanup, DOE is supporting the development of a computer-based methodology to streamline the remedial investigation/feasibility study process. This methodology is called the Remedial Action Assessment System (RAAS). As part of the RAAS methodology, a personal-computer-based database and user interface called the Technology Information System (TIS) has been developed for retrieving and reviewing information on technologies applicable to the environmental remediation of hazardous waste sites. This has resulted in a useful source of technology information for people preparing, reviewing, or approving site remediation plans or evaluating remediation technologies. It is also expected to result in significant reductions in the costs associated with these activities.

TECHNOLOGY INFORMATION NEEDS FOR SITE REMEDIATION PLANNING

Most technologists, even those with considerable experience, have a relatively constrained understanding of the whole range of site remediation technologies. Those that have a broad understanding of the range of potentially useful technologies may lack depth in their knowledge, and those with specialized technical understanding may find their knowledge limited to only a relatively small number of the technologies. Either of these limitations can impede a person's ability to give adequate, balanced consideration to technology options for application to a specific site. In addition, the review and approval process for remediation plans is likely to involved non-technologists, and these people without the technological training or background are even more constrained. Therefore, it is desirable to have available a basic, consistent set of information on the range of technologies that are applicable to site remediation. This not only provides a basis for individual analysis of options, but also insures that the various people involved are working from a consistent baseline, thus maximizing efficacy and comparability of their results.

The TIS is not intended to provide complete information on any technology. Rather, it functions like an electronic encyclopedia, sorting and presenting information to quickly familiarize engineers and planners with consistent information on available remediation technologies. The system helps such users focus quickly on the remediation technologies most likely to be effective for a particular site and presents concise, easy-to-use information about those technologies, helping users identify the key factors and constraints to consider in a particular situation. Pointers are also provided to more detailed information, should that be needed.

General information is provided on the basic description and uses of the various technologies, limitations and constraints on the use of a given technology, and the specific data needed to determine the applicability of a technology to a particular set of site conditions. In addition to information about remedial technologies themselves, the system contains auxiliary information about hazardous and radioactive contaminants and the U.S. federal regulations that govern their disposal. This auxiliary information helps users to further understand the technical and regulatory constraints that affect the application of the various remedial technologies.

REMEDIATION TECHNOLOGIES

The TIS database contains information on approximately 90 remedial technologies that are established (i.e., currently available) in the U.S. and could therefore be potentially used for cleanup on U.S. DOE sites. These 90 technologies can also be identified using over 200 synonyms, to ensure that generic technologies known by various specific names can be easily found. Technologies that may be under development but are not yet established in practice are not included in the system, because such technologies are not available to meet remedial action needs today. As new technologies become established, they can be added to the database.

There are three basic approaches, or "general response actions", to the remediation of a particular site. Each of these approaches relies on one or more technology functions in order to succeed. These general response actions and remediation technology functions are discussed below.

General Response Actions

Although there is a wide variation in the technologies available for site remediation, there are three basic approaches to the remediation of a site:

Isolate Potential Receptors: This approach is to isolate potential receptors from contaminants at or migrating from the site. If the potential receptors do not come into contact with the contaminants, then the contaminants cannot harm them. The primary function involved here is institutional control.

Contain Contamination on the Site: By containing any contaminants on a site, potential receptors offsite can be protected. This approach involves elimination of offsite migration coupled with control of site access.

Remove and Manage/Destroy Contamination: If contamination is removed from the site and either destroyed or otherwise managed to prevent public exposure to it, then access to the remediated site can be restored. Several different technology functions can be employed to successfully implement this approach, depending on the characteristics of the specific site and the contamination involved.

Remediation Technology Functions

The remedial technologies in the TIS database are organized into ten categories according to the function performed by the individual technology. These functional categories are described below, and examples of technologies within each category are provided. Only a few of the individual technologies are included in more than one category. For example, in situ vitrification reduces mobility of contaminants and also reduces contaminant toxicity.

In general, technologies from several categories will be used together to carry out one of the general response actions discussed above, and thus accomplish a site remediation. For example,

recovery or removal of the contaminated material will be required prior to any ex situ treatment of the material, and even after treatment, the material will require appropriate disposal.

Institutional Control: These technologies support control of site use and access to minimize public interaction with the site. Examples of institutional control technologies include access controls and land use restrictions.

Containment: These technologies are aimed at containing contaminants to prevent their release from a site. Examples include such measures as use of liners, subsurface drainage, and erosion control.

Recovery or Removal: This category includes technologies that can be used to recover contaminants for further action or to remove them from a site. Common examples include dredging and excavation.

Ex Situ Volume Reduction: Reduction of contaminated volume is an important function in handling recovered or removed materials. The basic idea is to separate the contamination from the other material, thus concentrating contamination into a smaller volume. These technologies cover a range of technological sophistication, and include such things as dewatering, ion exchange, and thermal desorption.

In Situ Volume Reduction: Some methods of volume reduction can be used in situ, without the need for a preceding recovery or removal step. Examples of such techniques include bioaccumulation and soil vapor extraction.

Ex Situ Toxicity Reduction: Toxicity reduction is another strategy for reducing the hazards associated with a contaminated material. Incineration and other thermal methods are classic examples; other possibilities include biological treatment methods, neutralization, and catalytic destruction.

In Situ Toxicity Reduction: Some methods of toxicity reduction can be applied to uncontained site contaminants to effectively clean up a site. In situ biodegradation and photolysis are examples of this.

Ex Situ Mobility Reduction: Another function of treatment can be reduction of the mobility of the contaminants. Solidification and stabilization, encapsulation, and molten solids processing all reduce contaminant mobilities.

In Situ Mobility Reduction: In some cases, it is desirable to reduce the mobility of contaminants without recovering or removing them from a site. Methods such as in situ solidification and in situ vitrification are applicable to this function.

Disposal: After recovery and removal from a site, and even after treatment, materials require appropriate disposal, as governed by applicable regulations and standards, to preclude creating another problem site. A variety of disposal technologies are available, including landfills, discharges to water or to the atmosphere, materials reuse, and waste to energy.

TYPES OF TECHNOLOGY INFORMATION INCLUDED IN THE DATABASE

As indicated above, a range of information is provided for each technology in the TIS database. The specific types of information included are discussed here.

Descriptive Information

- a graphical depiction or flow diagram of the process
- a brief narrative description of the process, including a definition of any basic options available
- engineering parameters such as power and space requirements

Application Information

- identification of contaminants for which the technology is applicable, supplemented with physical and chemical data about the individual contaminants
- data requirements (important information or parameters that should be considered in deciding whether or how to implement the technology)
- U.S. federal regulatory constraints such as compliance with air, water, and solid waste discharge regulations
- limiting technical constraints, such as pH or particulate loading limits on feed materials, to a unit process
- other processes that are frequently combined with the selected technology (processes for pretreatment or treatment of residual waste streams)

Additional Information

- a list of sites where the technology has been considered or implemented in the past
- a list of key technical references that a user can consult if he or she needs more detailed information.

FUNCTIONS OF THE USER INTERFACE TO THE DATABASE

The TIS user interface is a personal-computer-based software package that performs several functions, as described here.

Technology Sorting/Selection and Information Retrieval

The primary function of the TIS user interface is to allow sorting and selection of the remedial technologies in the database, followed by retrieval of the available information on selected technologies. The various individual technologies can be sorted and selected based on technology function (as discussed above), the contaminated medium involved at a site, and/or the specific contaminant(s) present. By specifying these site conditions or parameters, the user can narrow the list of technologies to be considered to those applicable to the particular circumstances of interest. This also allows the user to examine the sensitivity of the list of candidate technologies to the specified parameters, to verify and understand the robustness of the list.

Once a particular technology is selected, information about that technology can be retrieved for on-screen viewing or, for most types of information, printed for subsequent use.

Identification of Associated Technologies

As mentioned previously, several different technologies used together will often be needed to accomplish a site remediation. A function is provided within the user interface to identify technologies that may be used in association with the selected technology under the specified site conditions. This then allows the user to consider not only the technology to be used to perform a single function, but also the various combinations of technologies needed for a complete remediation.

Access to Auxiliary Information

Access is provided to two types of auxiliary information to extend the usefulness of the database.

Contaminant Data: Selected physical and chemical data is available for examination on the approximately 400 contaminants included in the TIS database. Data provided include synonyms, contaminant class, chemical formula, molecular weight, melting point, boiling point, water solubility, vapor pressure, Henry's Law constant, carbon/matter partition coefficient, and octanol/water partition coefficients. All of these properties have an impact on the applicability of a technology to a specific contaminant, and are provided as an aid to understanding the applicability or non-applicability of various technologies in specific situations. The contaminant data included in the database are derived from the U.S. Environmental Protection Agency (EPA) Treatability Database (EPA 1990).

U.S. Federal Regulatory Data: The TIS database includes U.S. federal regulatory information that relates to applying the various technologies. For each technology, regulatory constraints are identified that apply to the site at which the technology is applied (site constraints), the use of the technology (action constraints), and/or the contaminants to which it may be applied (contaminant constraints). Note that, in addition to the federal regulations, state and local regulations may apply at particular DOE sites, but these state and local regulations are not included in the TIS database.

For all but disposal technologies, the regulatory information included is qualitative rather than quantitative. This regulatory information is typically provided as an identification of the parameter or action that has an associated regulatory constraint and a citation for the corresponding federal regulation that applies. This information is intended to alert the user to the primary regulatory issues that are involved with using a particular technology, while identifying the regulations that should be reviewed in detail. A comprehensive discussion of each regulation that may apply is beyond the scope of the TIS.

For disposal technologies, more specific contaminant constraint information is included. Release or disposal of contaminated media (e.g., treated soil or water) is typically limited by one or more U.S. federal regulations that constrain the amount or concentration of specific contaminants. Therefore, for disposal technologies, the quantitative limits that apply to each of the contaminants are included. Table 1 lists the U.S. federal regulations for which the database contains such quantitative data.

Table 1: U.S. Federal Regulations Applicable to Disposal Technologies

Clean Air Act
Clean Water Act
Comprehensive Environmental Response, Compensation, and Liability Act
Federal Insecticide, Fungicide, and Rodenticide Act
Resource Conservation and Recovery Act
Safe Drinking Water Act
Toxic Substance Control Act
Atomic Energy Act
DOE Order 5400.5, Radiation Protection of the Public and the Environment
DOE Order 5820.2A, Radioactive Waste Management

APPLICATION OF THE TECHNOLOGY INFORMATION SYSTEM OUTSIDE OF THE UNITED STATES

Although the TIS is designed to support the assessment of remedial alternatives at U.S. sites, and specifically at DOE sites, it should be readily adaptable to other environmental remediation situations throughout the U.S. and the world. Much of the information included is generic and is not dependent on the country in which a site is located. Several of the information types included, however, are more or less specific to the U.S.

The regulatory information included in the database is based on U.S. federal regulations, and would not generally be applicable in other countries. Exceptions might exist if other countries used or are using U.S. federal regulations as the basis for developing their own; in such a case, many of the numeric regulatory limits are likely to remain consistent. However, even in countries with entirely different regulations, the U.S. regulatory information included in the database can still serve as a check on the reasonableness of a proposed technology application.

The database also includes some other information that is based on standard U.S. practices that may not be applicable in some areas. The technology descriptions and engineering parameters are based on standard practices in developed countries; conditions in developing countries (e.g.,

difficulty in obtaining machinery, relative labor costs) might dictate the use of entirely different methods. However, the general response actions and the basic functions that are to be achieved by a site remediation project would remain applicable anywhere.

Used carefully and thoughtfully, the database and user interface should be generally applicable to remediation planning efforts throughout the U.S. and the world.

REFERENCES

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 (commonly known as Superfund). 42 USC 9601 et seq., as amended.

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