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Project Summary

Literature-Review Screening Techniques for the Evaluation of Land Treatment of Industrial Wastes

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This report describes a four-stage literature-review screening process for identifying waste streams that are listed as hazardous in the Federal Register (Vol. 45, pp. 74890-74892, November 12, 1980). The method will allow the evaluation of promising candidate waste streams for land treatment.

The first stage is an inorganic screen for waste streams listed as hazardous solely on the basis of heavy metal content. The basis for screening was the assimilative capacity of a soil with a pH of 6.5 and a cation exchange capacity of 15. Calculations are made of the land area required to assimilate the quantity of waste generated by a single plant of average size over a period of 10 years. If the calculated area was no greater than 40 ha (100 acres), the waste stream was considered to be high priority for research. Only the listed waste streams from the petroleum refining industry ranked high in priority on the basis of this screen. The petroleum refining industry wastes are listed as hazardous because of high chromium and lead concentrations. Of course, these streams also contain petro-chemicals that are degraded in a land treatment system.

Stage 2 is an organic screen for waste streams listed as hazardous solely on the basis of organic chemical content. The screening is based primarily on the potential for degradation of hazardous components in the soil. A number of industrial wastes were identified as promising candidates for land treatment.

Stage 3 is an inorganic and an organic screen in sequence to the two streams listed as hazardous because they contained both heavy metals and organic chemicals. Ammonia still lime sludge is a promising candidate for land treatment research.

Stage 4 involves waste streams listed as hazardous on the basis of cyanide content. Available data are insufficient to identify promising research candidates. Heavy metals are more likely to be the land-limiting constituents than cyanides, since the latter can be degraded in a suitably designed land treatment facility. Information on heavy metal content was not available.

This Project Summary was developed by EPA's Municipal Environmental Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Background

Land-treated hazardous waste constituents are detoxified or immobilized through the controlled use of physical, chemical, and biological processes that occur naturally in the upper 15 to 20 cm (6 to 8 in.) of soil systems. Examples of the types of treatment that can occur in the well-aerated soil systems include:

- Aerobic microbial decomposition of organic chemical components of the waste;
- Chemical oxidation and/or hydrolysis.
- Ion exchange;
- Precipitation; and
- Neutralization.

Land treatment has been used for oily wastes from the petroleum refining industry for more than 25 years. None of these land treatment facilities, which are located in many different parts of the country, are known to have resulted in damage to human health or the environment. Furthermore, extensive monitoring of field sites has demonstrated that certain types of oily wastes are transformed in an aerobic soil environment to a less hazardous or nonhazardous composition.

Land treatment is mainly used for hazardous wastes from petroleum refining, but this method may be feasible for other types of wastes. If feasibility can be demonstrated, land treatment has two potential advantages over alternative treatment and disposal methods. First, land treatment is considerably less expensive than incineration, secure chemical landfill, and other types of physical, chemical, and biological treatment processes. Second, if a land treatment site is well controlled, subsequent beneficial uses of the land are not precluded.

Federal regulations governing the use of land treatment for the management of a hazardous waste require a demonstration of the effectiveness of the method. In particular, it must be shown that the waste can be made less hazardous or nonhazardous by biological degradation or chemical reactions occurring in or on the soil.

The U.S. Environmental Protection Agency (EPA) has issued a Technical Resource Document that describes a systematic methodology for evaluating the technical feasibility of land treatment for any particular hazardous waste (Brown, K. W., and Associates, "Hazardous Waste Land Treatment," EPA #SW-874, U.S. Environmental Protection Agency, September 1980). In general, a three-step process is involved.

1. Detailed analysis of the waste and review of available information on the biological and chemical action of natural soil treatment processes on each of the waste constituents. This step can provide a preliminary indication of whether or not land treatment is sufficiently promising to warrant further investigation. In general, this step will also identify gaps in the available data base that need to be filled through subsequent laboratory or field tests.
2. Laboratory and greenhouse studies under simulated field conditions to obtain basic data on degradability, sorption, mobility, volatilization, and toxicity. These data should be suitable for developing a preliminary land treatment facility design and operating plan.
3. Pilot field studies to verify the technical and economic feasibility and the environmental acceptability of the preliminary design and operating plan formulated in Step 2.

Each step in the above process requires an increased commitment of resources.

Objectives

The purpose of this report is to present a screening process for identifying waste streams that are listed as hazardous in the Federal Register (Vol. 45, pp. 74890-74892, November 12, 1980) and that are promising candidates for land treatment research. The specific objectives of the contract were:

- To develop a literature review screening technique for the evaluation of land treatment of industrial wastes.
- To identify listed hazardous waste streams potentially amenable to land treatment.
- To make use of readily available data to rank listed waste streams in order of potential land treatment feasibility.

Methods for Assessing Waste Streams

Assimilation

A listed hazardous waste is potentially amenable to land treatment if the hazardous components can be assimilated within the upper 15 to 20 cm (6 to 8 in.) of the soil into which the waste is incorporated. The hazardous components of a waste are said to be assimilated if:

— the application area can be used for any other purpose at the end of the post-closure period; and

— migration from the application area of waste-related chemicals (i.e., components of the waste and their transformation products) does not adversely affect human health or the environment at any time during or after the period of application.

The potential for assimilation is the major attraction of land treatment as a hazardous waste management option. If land treatment proves to be appropriate, it can be applied without an irreversible or irretrievable commitment of land resources.

Very few data are available to assess the assimilative capacity of a particular site for a specific waste stream. Such an assessment must generally be done on a waste-specific, site-specific basis, as described in the EPA Technical Resource Document on land treatment.

Land Treatment Scenario

To screen potential waste stream candidates, a land treatment scenario was developed, and listed waste streams were ranked on the basis of known hazardous components. The elements of the land treatment scenario are as follows:

- The annual application rate of a listed waste stream is assumed to be equal to the average generation rate of that waste stream from a typical manufacturing plant. (In other words, it is assumed that the land treatment site is dedicated to waste of a particular type generated by a single plant.)
- The available application area is assumed to be no greater than 40 ha (100 acres), which is the size of a relatively large landfill. The assumption is that no larger area would be dedicated to an individual waste stream from a single plant. In practice, the median size of existing facilities is only 5.5 ha (13.5 acres), and facilities of several hundred acres do exist.
- The depth of waste incorporation is assumed to be 15 cm (6 in.) -- the technical agricultural zone or plow layer.

- The site is assumed to be used for land treatment of wastes for a period of 10 years.
- The soil pH is assumed to be maintained between 6 and 7.5. These conditions are generally not difficult to maintain, and they strongly affect the accumulation limits of heavy metals in the soil.

Screens

Two screens were developed -- an inorganic and an organic screen. The inorganic screen was applied to wastes that are listed because of hazardous heavy metal components. The organic screen was applied to wastes that are listed because of hazardous organic chemical components. Both screens were applied to wastes that are listed as hazardous because of both heavy metal and organic chemical components.

Inorganic Screening Method

The inorganic screen is quite straightforward and is based on the land-limiting constituent concept (i.e., the area of land required to assimilate a given amount of toxic waste is determined by the most persistent toxic constituent present) The first step is to calculate the quantity of each heavy metal generated in the waste stream of an average plant over a 10-year period. Data for this calculation were obtained primarily from the EPA background document supporting the listing of the waste stream. The second step in the inorganic screen is to determine the area required to assimilate the heavy metal components of the waste stream. This area is calculated by dividing the output from the first step (total kg of metal in the waste over a 10-year period) by the allowable cumulative limit (kg/ha) for the metal in question.

If the calculated area required for assimilation of any heavy metal in the waste stream exceeds 40 ha (100 acres), the waste stream is given a low priority for further research. If the area is less than 40 ha (100 acres), the waste stream is assigned a high priority for research.

Organic Screening Method

The persistence of the individual chemical constituents that make up each waste stream is the most important factor in determining the suitability of the waste stream for land treatment. For screening purposes, the persistence might most conveniently be expressed in terms of the expected half-life for degradation of the chemical in the soil environment. From the half-life it would be possible to calculate the degree of treatment that could be accomplished over a given period. Unfortunately, the data needed to estimate the half lives of organic chemicals in soils are not generally available. But a biodegradation study conducted by Tabak et al. (H.H. Tabak, S.A. Guare, C.I. Mashni, and E.F. Barth, "Biodegradability Studies with Priority Pollutant Organic Compounds," U.S. Environmental Protection Agency, 1980) provided a good data base for evaluating the persistence of a broad range of organic waste components. The study uses an aqueous medium and a sewage-sludge-derived microbial population rather than a soil or simulated soil situation. Though the absolute degradation rates reported cannot be assumed to apply to a soil environment, the data provide a useful indication of the relative persistence of many organic chemicals.

The following steps are involved in the screening process developed for the listed waste streams whose hazardous components are all organic chemicals:

1. A persistence score is assigned to each hazardous component that forms a basis for listing the waste stream.

2. A persistence score is calculated for each waste stream based on the persistence scores of its hazardous components.

3. Each waste stream is assigned to one of the following categories, based on the waste stream persistence scores calculated in Step 2:

   Category I--Least persistent waste stream,

   Category II--Moderately persistent waste stream, or

   Category III--Highly persistent waste stream.

4. Priorities are set for future research on waste streams within each category based on other available data (e.g., organic loading, hydraulic loading, toxicity of degradation products, reactivity with water) or significant gaps in the data base.

Results

Of the waste streams that were listed as hazardous only because of the presence of heavy metal species, only those from the petroleum refining industry appear to be high priority candidates for land treatment research (see Table 1). The rankings are based solely on waste stream components cited as the basis for listing. Waste streams that were listed as hazardous only because of the presence of organic chemical species were assigned a high or moderate priority for research (see Table 1).

Only two waste streams are listed because they contain both heavy metal and organic chemical species that are considered hazardous--aqueous spent antimony waste from fluoromethane production and ammonia still lime sludge from coking operations. The latter has been assigned a high priority for research based on the data available.

The presence of cyanides does not preclude land treatment, since these chemicals are degraded in soils. Though cyanide is the basis for listing the waste streams in this group, the land-limiting constituent is likely to be a heavy metal that is also present. Available data on the heavy metal contents of these waste streams are insufficient to allow ranking.

Discussion

Limitations of the Screening Methods

The screening results provide only a relative ranking of listed hazardous waste streams in terms of their suitability for land treatment. Waste streams assigned a low priority for research are not necessarily unsuitable for land treatment. Rather, they only appear to be less suitable than waste streams assigned a high priority based on available data.

In fact, the feasibility of land treatment can be strongly influenced by both trace quantities of hazardous constituents not cited as a basis for listing and by constituents not normally considered hazardous. For example, small quantities of highly persistent polynuclear aromatic hydrocarbons may critically limit application rates of petroleum refining wastes at a particular site, and salt must be considered in assessing land treatment feasibility even though it is not normally considered hazardous.

Thus all constituents of the waste stream should be known to assess the suitability of land treatment for a given waste stream. But for the screening purposes of this report, it is sufficient to consider only the potential treatability of the hazardous components cited as a basis for listing.

Table 1. High- and Moderate-Priority Candidates for Land Treatment Research

EPA No.	*Waste Stream Description*	*Priority*
Inorganics:		
K048 - K052	*Petroleum refining wastes (hazardous due to chromium and lead)*	*High*
Organics:		
K009	*Still bottoms from production of acetaldehyde from ethylene*	*High*
K010	*Distillation side cuts from the production of acetaldehyde from ethylene*	*High*
K013	*Bottom stream from the acetonitrile column in the production of acrylonitrile.*	*High*
K014	*Bottoms from the acetonitrile purification column in the production of acrylonitrile*	*High*
K093	*Distillation light ends from the production of phthalic anhydride from ortho-xylene*	*High*
K026	*Stripping still tails from the production of methyl ethyl pyridines*	*High*
K036	*Still bottoms from toluene reclamation distillation in the production of disulfoton*	*High*
K037	*Wastewater treatment sludges from the production of disulfoton*	*High*
F004	*Spent cresols, cresylic acid, and nitrobenzene, and still bottoms from recovery of these solvents*	*Moderate-High*
K047	*Heavy ends (still bottoms) from the purification column in the production of epichlorohydrin*	*Moderate-High*
K011	*Bottom stream from the wastewater stripper in the production of acrylonitrile*	*Moderate*
K015	*Still bottoms from the distillation of benzyl chloride*	*Moderate*
K023	*Distillation light ends from the production of phthalic anhydride from naphthalene*	*Moderate*
K094	*Distillation bottoms from the production of phthalic anhydride from orthoxylene*	*Moderate*
K038	*Wastewater from the washing and stripping of phorate production*	*Moderate*
K039	*Filter cake from the filtration of diethylphosphorodithioic acid in the production of phorate*	*Moderate*
K040	*Wastewater treatment sludge from the production of phorate*	*Moderate*
Mixed organics and inorganics:		
K060	*Ammonia still lime sludge from coking operations*	*High*

Recommendations for Improving the Screening

A research plan needs to be developed for improving the screening of hazardous waste streams that appear to be primary candidates for land treatment (Table 1). Applied research on one or more specific waste streams from individual plants is recommended. Applied research contributes directly to solving the immediate and urgent national problems of developing cost-effective hazardous waste management methods. Basic research on establishing the assimilative capacity of various types of soil systems for individual organic chemical constituents of waste streams would be of considerable scientific interest and value.

The following four steps should be involved in an applied research program:

1. Secure the cooperation of a plant that generates a high-priority waste stream to assure the availability of the waste and a potential user of any treatment method developed.

2. Obtain specific documented data on the waste stream, including quantity and frequency of generation and major and trace organic and inorganic constituents.

3. Characterize the site or alternative sites for a possible land treatment facility.

4. Analyze potential waste and site interactions and identify significant data gaps and areas of uncertainty.

Data that would typically need to be developed include (a) mechanisms of degradation of the waste constituents under the prevailing site conditions, (b) mobility of the constituents and degradation products, and (c) toxicity indices for hazardous components and degradation products that could be released from a land treatment site.

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***Robert Landreth** and **Laura Ringenbach** are the EPA Project Officers (see below).*
The complete report, entitled "Literature-Review Screening Techniques for the Evaluation of Land Treatment of Industrial Wastes," (Order No. PB 84-110 386; Cost: $10.00, subject to change) will be available only from:
National Technical Information Service
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