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Project Summary

Evaluation of Source Term Initial Conditions for Modeling Leachate Migration from Landfills

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Leachate migration modeling is a necessary part of conducting exposure assessments in the development of land disposal regulations for solid wastes. Development of toxicity characteristics to define leachate concentration levels that pose unacceptable risks to humans and the environment requires modeling studies for a wide range of leachate generation-migration scenarios. This study investigated the influence of five alternative modeling initial conditions on down-gradient ground water concentrations predicted by two models (MULTIMED and AT123D) and for four typical hazardous waste constituents. Differences between steady-state and transient conditions also were investigated.

The alternate initial conditions studied were shown to be representative of typical leachate patterns reported from laboratory and field studies. The square wave pulse initial condition was found to be the most conservative representation of leachate generation for both models. Sorptive and degradation properties of chemicals strongly influence predictions and, for some chemicals, steady-state modeling and transient modeling of the same scenario produced significantly different results.

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

Overview

The study described in this report is part of an ongoing investigation of the behavior of land disposal systems for solid and hazardous wastes. Major program objectives are development, testing, and implementation of predictive tools for use in land disposal regulations that protect human health and the environment. The U.S. Environmental Protection Agency's Office of Solid Waste and Emergency Response is a major collaborator with the Office of Research and Development in the overall research program and has participated in the development and execution of this study. The modeling scenario and the modeling details under investigation are part of the Office of Solid Waste's current approach to modeling leachate migration from land disposal units. In particular, the development of solid waste characteristics that render such wastes hazardous under expected future management conditions has evolved to include the use of models and their boundary conditions as described in this report.

The work summarized in this report advances knowledge of how modeling assumptions influence predicted exposures, how boundary conditions compare to laboratory and field observations, how different dominant chemical properties influence predicted exposures, and how currently available models can be used to refine exposure estimates.

The appropriate selection and use of mathematical models in conducting exposure estimates within a regulatory framework depends on many different factors. Paramount among them are the system being modeled and the data available to describe its features. In cases where site-specific decisions are under study—for example, the siting, design, or permitting of a disposal facility—site characterization data are particularly important.

Once a site has been completely characterized and the study objectives clearly defined, then choices among individual models to use, boundary conditions to apply, and validation studies to complete can be made. Often the model calibration process is used to refine the approach and test the model to insure that the specific circumstances under study are represented in the most nearly accurate manner. For example, measured site data can be used to define the most appropriate model, including the model boundary conditions, and the best choice of parameter values.

Boundary conditions and parameter values become much more problematic, however, when scenarios or hypothetical case studies are modeled as a means of developing more generic regulations and standards or when only screening level analyses are desired. The most appropriate set of assumptions is not always apparent, and often the major issue is not only how representative but also how "safe" the assumptions are given the wide variety of possible circumstances.

The main emphasis of the report is an analysis of two major assumptions used in the OSW modeling. The first assumption is that the contaminant source has a sufficiently large mass to enable an assumption of an infinite source. That is, the down gradient contamination, once reached, will be maintained. The second assumption is that transient behavior is unimportant, permitting the overall response to be represented by steady-state estimates.

These two assumptions are convenient as an interface between the modeling and the physical tests proposed as a means to measure the leachability of a given waste. The assumptions also dominate the choice of modeling boundary conditions, especially the initial conditions. The form or shape of the initial conditions is determined by the steady-state assumptions; magnitudes are determined by reference to the leaching test values.

In the study, literature searches were performed to identify alternate leachate models, leachate characteristics, and model initial conditions. Based on available leachate data, the range of initial conditions that are most consistent with observed data was determined. Modeling simulations were conducted with different models and initial conditions to characterize groundwater contaminant sensitivities for a range of scenarios and chemical properties.

Findings

Four key findings were apparent with respect to leachate quantity and quality. First, leachates vary widely in quantity and quality among different sites and change with time at a given site. Second, leachate quantity responds to precipitation infiltration and the subsequent water balance. Several models exist with which to predict quantities, and many are variants on the USEPA HELP model. Third, time histories of leachates rarely are measured, but existing data suggest a range of patterns from relatively constant concentrations to declining concentrations with time. Fourth, for regulatory modeling purposes, leachate time patterns can be represented by a limited number of simple curves including square wave pulses, exponentially decaying pulses, and a series of pulses emulating highly variable concentrations.

For some chemicals, steady-state and transient modeling of leachate migration give remarkably different results. In such cases, steady-state modeling is inappropriate. Sorption and transformation rates are most important in this regard.

Transient modeling results are influenced strongly by the duration of inputs corresponding to available source mass within the facility. Departure from steady-state results for any given duration depends on chemical properties.

The square wave pulse load pattern consistently produced the highest concentrations for all chemicals and all locations. Differences in concentrations among the five pulse types were insignificant for some combinations of chemicals and locations for the scenario investigated.

For highly sorptive chemicals, time variability of the leachate inputs is relatively unimportant when predicting maximum down gradient concentrations. This applies as long as the total mass and duration of leaching is the same.

For less sorptive, more mobile chemicals, the duration of the leaching period is more important in influencing down gradient concentrations than the leachate variability during the period. This is true under conditions where the total mass loading is the same.

Transient modeling should be implemented in regulatory modeling analyses of leachate migration from landfills.

For the OSW modeling scenario, square wave pulse inputs are the most conservative option in selection of modeling initial conditions to represent leachate generation.

Additional field studies to characterize detailed patterns of solid waste leachates are needed to better define modeling assumptions.

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The complete report, entitled "Evaluation of Source Term Initial Conditions for Modeling Leachate Migration from Landfills," (Order No. PB93-131464/AS; Cost: $19.50; subject to change) will be available only from:

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