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Project Summary

MULTIMED, the Multimedia Exposure Assessment Model for Evaluating the Land Disposal of Wastes--Model Theory

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The MULTIMED computer model simulates the transport and transformation of contaminants released from a hazardous waste disposal facility into the multimedia environment. Release to air and soil, including the unsaturated and saturated zones, and possible interception of the subsurface contaminant plume by a surface stream is represented by the model. The model further simulates contaminant movement through the air, soil, ground water, and surface water media to humans and other potentially affected species. MULTIMED is intended for general exposure and risk assessments of waste facilities and for analyses of the impacts of engineering and management controls. This report provides the conceptual and theoretical details of the various modules and the Monte Carlo simulation technique.

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 of the same title (see Project Report ordering information at back).

Overview

The Multimedia Exposure Assessment Model (MULTIMED) simulates the movement of contaminants leaching from a waste disposal facility. The model includes two options for simulating leachate flux. Either the infiltration rate to the unsaturated or saturated zone can be specified directly or a landfill module can be used to estimate the infiltration rate. The landfill module is one-dimensional and steady-state, and simulates the effect of precipitation, runoff, infiltration, evapotranspiration, barrier layers (which can include flexible membrane liners), and lateral drainage.

A steady-state, one-dimensional, semi-analytical module simulates flow in the unsaturated zone. The output from this module, water saturation as a function of depth, is used as input to the unsaturated zone transport module. The latter simulates transient, one-dimensional (vertical) transport in the unsaturated zone and includes the effects of longitudinal dispersion, linear adsorption, and first-order decay.

Output from the unsaturated zone modules—that is, steady-state or time series contaminant concentrations at the water table—is used to couple the unsaturated zone module with the steady-state or transient, semi-analytical saturated zone transport module. The latter includes one-dimensional uniform flow, three-dimensional dispersion, linear adsorption, first-order decay, and dilution due to direct infiltration into the ground-water plume.

Contamination of a surface stream due to the complete interception of a steady-state saturated zone plume is simulated by the surface water module. Finally, the air emissions and the atmosphere dispersion modules simulate the movement of chemicals into the atmosphere.

At this time, the air modules of the model are not linked to the other model modules. As a result, the estimated release of contaminants to the air is independent of the estimated contaminant release to the subsurface and surface water.

The fate of contaminants in the various media depends on the chemical properties of the contaminants as well as a number of media- and environment-specific parameters. The uncertainty in these parameters is quantified using the Monte Carlo simulation technique.

To enhance the user-friendly nature of the model, separate interactive pre- and postprocessing software have been developed for use in creating and editing input and in plotting model output.

MULTIMED uses analytical and semi-analytical solution techniques to solve the mathematical equations describing flow and transport. The simplifying assumptions required to obtain the analytical solutions limit the complexity of the systems that can be represented by MULTIMED.

The model does not account for site-specific spatial variability, the shape of the land disposal facility, site-specific boundary conditions, multiple aquifers, or pumping wells. Nor can MULTIMED simulate some processes, such as flow in fractures and chemical reactions between contaminants, that can have a significant effect on the concentration of contaminants at a site. In more complex systems, it may be beneficial to use MULTIMED as a "screening level" model, which would allow a user to obtain an understanding of a system of interest. A numerical model could then be used if sufficient input data are available and if decision makers require the detailed information available from a more complex model.

Physical Scenario

The physical scenario simulated by the model is a land disposal facility that releases pollutants into the air, soil, and/or ground water. In response to a number of complex physical, chemical, and biological processes, pollutants move in the multimedia environment, resulting in potential toxic exposure to humans and other receptors.

In the model, the processes affecting air emissions are not linked to the processes affecting subsurface transport. In other words, the concentration calculated in the one medium is not affected by the release of the contaminant to the other medium.

The sources of pollutants considered in the initial version of the model are either leachate from a waste disposal facility or air emissions during the post-closure period. Inadequate long-term functioning or failure of the facility's engineering controls (i.e., caps and liners) are assumed to occur after closure and to result in the release of leachate to soil or ground water beneath the facility and emission of vapor to the atmosphere. Note that the use of the air emission module is most appropriate for high concentrations of waste in the facility. Also, the model does not include fate processes that affect metals, such as complexation and solids precipitation.

Model Capabilities

During the course of model development, emphasis was placed on the creation of a unified, user-friendly software framework, with the capability of performing uncertainty analysis, that can easily be enhanced by adding modules or modifying existing modules.

The transport and transformation of contaminants critically depend on a number of media-specific parameters. Typically, many of these parameters exhibit spatial and temporal variability as well as variability due to measurement errors. MULTIMED can analyze the impact of uncertainty and variability in the model inputs on the model outputs (concentrations at specified points in the multimedia environment), using the Monte Carlo simulation technique.

To enhance the user-friendly nature of the model, separate interactive preprocessing and postprocessing software have been developed, using the ANNIE Interaction Development Environment (AIDE), to create and edit input and to plot model output. The pre- and postprocessors have not been integrated with MULTIMED because of the size limitations of desktop computers. Therefore, after using the preprocessor to create or modify input, the model is run in batch mode. Afterwards, the postprocessor can be used to produce plots of the Monte Carlo output or concentration versus time.

Finally, model results can be used manually to "back-calculate" the maximum source concentration (for a steady-state, infinite contaminant source) of a chemical that would ensure protection of human health or the environment at a down-gradient point of exposure.

Obtaining MULTIMED Software

The MULTIMED computer code may be obtained by sending a request to Model Distribution Coordinator, Center for Exposure Assessment Modeling, Environmental Research Laboratory, U.S. Environmental Protection Agency, Athens GA 30605-2720. Please include either five 5.25-in (double-sided, double density, DS/DD 360KB) diskettes or two 3.5-in (double-sided, high-density, DS/HD 1.44MB, error free) diskettes. The MULTIMED code will be copied to your diskettes and returned to you. You also may obtain model theory documentation on diskette by sending two 3.5-in (DS/HD) diskettes to the modeling center; hard copies may be obtained from the National Technical Information Service (see ordering information on the next page).

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The complete report, entitled "MULTIMED, the Multimedia Exposure Assessment Model for Evaluating the Land Disposal of Wastes--Model Theory," (Order No. PB93-186 252/AS; Cost: $27.00, subject to change) will be available only from:
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