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Session II - Modeling and Risk Assessment

Modeling Overview - Dr. Zubair Saleem

Dr. Zubair Saleem, of EPA's Office Solid Waste, presented information on EPA's efforts to model the leaching behavior of wastes. He began his presentation by emphasizing that the TCLP was designed for a specific waste mismanagement scenario and that it works well in the context of that scenario. When applied outside of its original intent, it may not work as well.

Dr. Saleem noted that when wastes are placed in a landfill, they are subjected to various physical, chemical, and biological processes that can result in the creation of new compounds in the waste, changes in the mass and volume of the waste, the creation of different phases within the waste and within the landfill. In order to accurately predict the concentration of the contaminants in the leachate, one must account for these changes.

Dr. Saleem pointed out that biological transformations can lead to the production of methane, carbon dioxide, water, and various metabolic byproducts. These same biological processes produce heat, which changes the temperature of the waste itself. The temperature changes, in turn, affect the transport of the chemical constituents of the waste, both in terms of the rates of transport and the concentrations that are found in the leachate.

He went on to say that when gases are produced in the landfill, there is an increase in the pressure within the landfill, in both the liquid phase materials and the solid material. If the pressure increases high enough, it can create channels within the landfill, through which liquids may move. Thus, one must also account for factors such as gas production.

Therefore, in order to create a successful model of a landfill, one must account for the flow of water, gases, and non-aqueous phase liquids (NAPLs), and heat conductance, as well as the other physical characteristics of the landfill and the waste.

Computer models need to include all of these factors in their design. Dr. Saleem stated that a good fate and transport model will contain three specific modules covering flow, transport, and reactions. These three modules then interact with one another in the model to predict the concentrations of the constituents across both space and time.

Dr. Saleem indicated that when EPA develops a model, they also attempt to ensure that it is both robust and stable, as well as computationally accurate. EPA uses a Monte Carlo approach for models, which may involve hundreds of thousands of iterations of the model to generate the output. Once a robust, stable, and accurate model has been developed, it may be possible to simplify it to some degree, so that it is easier to use or addresses more generic situations. Such simplifications involve a degree of compromise.

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Dr. Saleem explained that EPA has been working for some time on a composite model with transformation products (CMTP) and they are actively seeking field data that can be used to validate the model. The general features of this landfill model include the infiltration of precipitation into the landfill, which passes through the waste, picking up contaminants and transporting them through an unsaturated zone below the landfill and ultimately into the water table.

Dr. Saleem indicated that the three modules (flow, transport, and reactions) are often run with different time steps. The flow module often uses larger time steps than the other modules. The transport and reaction modules typically use smaller time steps, since they are linked to one another and reactions that occur in the leachate or the waste will affect the transport of materials. The reaction module acts as both a source and a sink to the transport module.

A typical model will include a three-phase flow model (water, gas, NAPL) and will account for pressure, velocities of the flows, and the temperature within the landfill. The model includes data on the organic carbon content, various forms of sulfur and sulfides, and metals. Carbon dioxide and methane production are modeled. Organic compounds are considered in two general weight ranges: high molecular weight organics and low molecular weight organics. The transformation products are also included in the CMTP. As each module is run, the model looks for convergence of the outputs and when that occurs, the model moves on to the next time step.

Dr. Saleem indicated that a typical model might run on a high-powered PC for two hours in order to model 1000 days of time in a landfill. He noted that even with a powerful computer, modeling a 100-year period of a landfill will take a tremendous amount of time.

Dr. Saleem noted that EPA had not obtained enough field data to make many meaningful comparisons but that they were working with the data that they have while they solicit data from outside sources. Dr. Saleem concluded his presentation by displaying various outputs of the model and illustrating some of the input data that has been provided by researchers such as Dr. Kosson.

At the end of his presentation, Dr. Saleem addressed questions from the participants. Bart Simmons, Cal/EPA, asked about the uncertainties in the model input. Specifically, using a DQO approach, he asked how accurate a test such as the TCLP would have to be in order to be of comparable certainty to the model. Mr. Simmons noted that modelers deal with coefficients of variation (CVs) in the range of 0.3 to 3, while analytical chemists are upset when the CV is as large as 0.4. Dr. Saleem jokingly replied that once the model was completed, you might not need a test such as the TCLP. Dr. Saleem continued in a more serious vein, noting that while the model would not necessarily replace the TCLP for the waste characterization scenario, it would be useful in many other scenarios to which the TCLP might not apply. Ginny Colten-Bradley, EPA, also responded, noting that some of the model parameters had associated variabilities that are measured in orders of magnitude. These uncertainties are carried through the Monte Carlo analysis. She noted that until one performs the sensitivity analysis of the model, one cannot tell what the DQOs would have to be for a given test such as the TCLP.

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John Phillips, Ford Motor Company, asked if the model was based on current landfill construction techniques, such as small cells and caps that limited infiltration, or on older landfill practices, and if the model had to be specific to each landfill. Dr. Saleem responded that the model could include a wide range of landfill designs and construction techniques, and that the model could be landfill-specific, or it could be more generic, such as when EPA wishes to generalize across a range of landfills. Mr. Phillips continued, asking how much information needed to be known about the chemistry of the waste itself. Dr. Saleem indicated that with more data, the model will be more accurate.

David Friedman, EPA, asked how the model handled different forms of the same waste, say a vitrified waste and the original waste material with the same chemical composition? Dr. Saleem responded that the reaction module accounts for the forms of the waste, since the vitrified waste would have different reaction rates then the original waste form.

Hans van der Sloot, NERF, commented that he doubted that any model would ever replace the actual testing of wastes. However, he said that he sees great potential for models in predicting leaching behavior over long time frames. He noted from his own work that often models fail because of some aspect that was not included in the model, but that becomes apparent when the model results are compared to test data. He noted that testing has a purpose, as does modeling. Testing may be quick, in time frames of days to weeks, in order to develop input data for the models. Dr. van der Sloot stressed the need to integrate both aspects of the process. Dr. Saleem agreed.

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