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The Application of Life Cycle Assessment to Environmental Management

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Background and Aims

Life-cycle Assessment (LCA) is a scientific tool to evaluate the environmental impact of a product, process or activity 'from cradle to grave'. Originally developed to assess the environmental performance of products, it is now used to evaluate a variety of activities including solid waste management. The objective of this session was to learn about ongoing research on the application of life-cycle analysis to waste management and to consider the following questions: (1) Do LCA models present a clear definition of their purpose and the meaning of their results. (2) How is the uncertainty in the LCA model input data reflected in the model results? (3) Is LCA model output always unique or reliable?

Session Participants

Morton Barlaz	Development of a Decision Support Tool for Comparison of Solid Waste Management Alternatives Using Life-Cycle Analysis
Toshihiko Matsuto	Comparison of Alternatives for Managing Solid Waste
Åsa Moberg	Environmental Effects of Landfilling of Solid Waste Compared to Other Options: Assumptions and Boundaries in Life Cycle Assessment

The papers by Drs. Barlaz and Matsuto both addressed the development of models to evaluate complete solid waste management systems, however their model structure represents two extremes: one is detailed (Barlaz) and other is simplified (Matsuto).

Session Content

There was considerable discussion on a number of aspects of LCA as it applies to solid waste management. This discussion served to emphasize many areas where the complexity of solid waste management in general, and landfills in particular, makes the use of life-cycle analysis difficult.

Time-Scale

One issue that was raised was the appropriate time-scale to use for gaseous emissions from landfills. It is well recognized that different components of waste degrade at different rates and that the waste buried today may result in gas production for decades to centuries depending upon the waste and environmental conditions in the landfill. There was concern that the manner in which the time of emissions was reported could affect the results of comparative analyses involving landfills.

The discussion of time-scale extended beyond the gas to metals leaching. There was debate about whether the potential leaching of a heavy metal must be considered as a long-term emission based only on the presence of the metal in the landfill, irrespective of whether actual leaching is expected. All agreed that fundamental information on the long-term behavior of metals in landfills was necessary to insure the best possible life-cycle analysis of landfills.

Environmental Impact

A second issue identified was the use of life-cycle analysis to actually calculate environmental impacts. This requires that both the quantity and location of a given emission be known. This is quite difficult in solid waste management. For example, when a landfill is located in a community, there will be some gaseous emissions because even under the best of circumstances, landfill gas collection efficiencies are less than 100%. However, the energy recovered from this gas will result in avoided emissions at a power plant that is not likely to be located in the same community. Similarly, when a material is recycled, there is increased activity within a community to collect, separate and transport recyclables. The recyclable material is then shipped to a manufacturing facility for recycling. The benefit of recycling may be that less energy is required when producing a product-based on a recycled material. Here too, while there are decreased emissions on a global basis, there may actually be increased emissions in a community that is starting a recycling program.

Another aspect of environmental impact analysis is in using LCA results for decision-making. For example, there is a need to determine the relative importance or weighting of different air and water pollutants. There was also discussion of how LCA could be used to assess ecosystem toxicity which also relates to the location of an emission. While all participants recognized these questions as important, there was no consensus on the answers.

Infrequent Events and Risk

There was some discussion of whether an infrequent event should be considered in LCA. One example of an infrequent event is a landfill fire where both the frequency and actual emissions resulting from fires are poorly defined. A second, more difficult example involves a natural disaster. A landfill containing combustion ash may have little environmental impact because any leachate that is produced is collected and treated. However, in a natural disaster, the landfill liner could be destroyed, resulting in a significant environmental release. It was suggested that infrequent events be considered in a risk assessment and not as part of the LCA process.

Modeling Technique

Solid waste management is very complex system. Thus, detailed models with large numbers of variables and equations can be written. However, considering the limitations described above, our ability to mathematically represent all aspects of solid waste management is imperfect. There are also practical limitations such as the rapid development of new technology and differing conditions in different parts of the world. Thus, to the extent possible, simple models that are easily updated have an advantage and it is desirable to identify an optimal tradeoff between simple and complex models. Of course, different models may be required for different study objectives.

Summary

Life-cycle analysis represents a powerful tool and can be applied to all aspects of solid waste management. However, the limits of LCA must be recognized and decisions must be made in consideration of both LCA results and issues that are more difficult to quantify.