

## **Summary of the Session:** *Bioreactor Landfills: Full-Scale Implementation Issues*

**Session Coordinators:** Debra R. Reinhart, Ph.D., P.E., University of Central Florida and Nicole Berge, Tufts University

### **Session Description**

Full-scale bioreactor landfills have been operated now for well over a decade, resulting in the acquisition of design and operating experience and data. While the concept has been well proven in the laboratory and even at pilot scale, full-scale applications have been more recent and less documented. Many of these experiences have revealed scale-up issues that merit discussion and exploration. Therefore, the objective of this session was to share and provide foundation information regarding full-scale implementation of bioreactors to stimulate discussion and address the following questions:

1. What are optimal design criteria and operating strategies?
2. What are chief impediments to successful operation of a bioreactor landfill?
3. Do bioreactor landfills meet their intended purpose (i.e., enhanced gas production resulting in energy production, reduced long-term emissions, cost-effective waste management, improved leachate quality, etc.)?
4. What are future directions and research needs?

### **Session Presentations**

- Introduction, Debra R. Reinhart, Ph.D., P.E., University of Central Florida
- An update on the Florida bioreactor landfill demonstration projects underway at three landfills in Florida, Debra R. Reinhart, Ph.D., P.E., University of Central Florida
- Technical and environmental performances assessment for a bioreactor landfill, Rana Adib , CREED: Centre de Recherches pour l'Environnement
- Landfill gas recovery and characterization at bioreactor and conventional landfills, Roger Green, WMI
- Dutch sustainable landfill research program: four years experience with the bioreactor test cell, Landgraaf, Hans Woelders, Essent Milieu
- Lessons from a six-year French research program on landfill bioreactors, C. Legueult, SUEZ Environment.
- Discussion of session questions

## **Session Discussion and Outcomes**

Presentations documenting full-scale bioreactor landfill experiences were made by researchers from the US, France, and Netherlands. During the presentations, issues regarding control of temperature, leachate and gas emissions (i.e. ammonia and chloride removal, VOC production), and leachate injection strategies (i.e. vertical vs horizontal injection) were discussed.

Following the presentations, the questions outlined in the session description were posed and a group discussion commenced. In particular, operating impediments, monitoring issues, research needs, and the need for defining the goals of bioreactor landfills became the prevalent focus of the discussion. Additionally, the lack of data available to allow for adequate modeling of bioreactor landfills was discussed.

Comments and issues that arose during the discussion are documented below and are organized with the session question the comments address:

### 1. What are optimal design criteria and operating strategies?

Questions regarding the optimal leachate injection method were posed. In particular, a discussion regarding vertical and horizontal leachate injection occurred.

Researchers commented that vertical injection wells were best in retrofit landfills, as well as in situations in which buried daily cover may become problems (i.e. wells at different depths to promote uniform distribution). Additionally, experience has found that horizontal wells may result in water perching, depending on waste permeability. The parameter that seemed to indicate which injection method may be best for a landfill is the waste permeability (in both vertical and horizontal directions).

Temperature control, when adding air, is also an important parameter and requires a well planned operating strategy. In the landfills in which higher temperatures were detected, it was found that the addition of additional moisture aided in reducing temperatures. Thus, when operating a landfill aerobically, temperature should be a design criterion.

It was mentioned several times that the key to operating a bioreactor landfill is adequate control of all processes.

### 2. What are chief impediments to successful operation of a bioreactor landfill?

Some researchers commented that a major impediment to successful operating is removing compounds such as ammonia-nitrogen and chloride. Both ammonia and chloride concentrations remain high in bioreactor landfills. Sulfate was also mentioned as a potential impediment. Sulfate concentrations have been shown to inhibit methanogenesis and potentially impact hydrolysis. Hydrogen sulfide is also a concern, as it can inhibit hydrolysis.

Moisture measurement and distribution was also brought up as an impediment. Distribution of moisture was discussed (see above) as was the adequate monitoring of in-situ moisture. A discussion regarding point measurements and geophysical methods occurred. Many methods were discussed. It was suggested that a review paper being published in Waste Management that is coming out soon be consulted about measurement issues, as it provides information concerning the different measurement methods.

3. Do bioreactor landfills meet their intended purpose (i.e., enhanced gas production resulting in energy production, reduced long-term emissions, cost-effective waste management, improved leachate quality, etc.)?

It was decided that defining the goals of a bioreactor is a critical first step of the design and operation of a bioreactor, as well as a critical step when modeling the processes. The question posed was whether the goal should be to shorten waste stabilization or to allow for the addition of more waste.

4. What are future directions and research needs?

The following issues were discussed:

- Biodegradation of TOC was brought up as a research need. Is TOC degradable? How long will it take to degrade all of the carbon? Does carbon become available as the landfill ages? Will recirculation of leachate/moisture aid in degrading slowly degradable carbon?
- More research evaluating removal of ammonia and chloride is needed.
- Additional research involving moisture distribution and measurement is needed.
- More modeling needs to be conducted to understand the process.
- More information regarding the impact on sulfate and hydrogen sulfide is needed.
- How do we more adequately define the leachate recirculation rates?
- Does air addition impact surface VOC concentrations?