5.4. LANDFILL BIOREACTOR

A bioreactor landfill is a municipal solid waste landfill (MSWLF) in which liquids are added to help bacteria break down the waste. The increase in waste degradation and stabilization is accomplished through the addition of liquid and air to enhance microbial processes. This bioreactor concept differs from the traditional "dry tomb" municipal landfill approach.

Types of Bioreactor Landfills

Aerobic - In an aerobic bioreactor landfill, leachate is removed from the bottom layer, piped to liquids storage tanks, and re-circulated into the landfill in a controlled manner. Air is injected into the waste mass using vertical or horizontal wells to promote aerobic activity and accelerate waste stabilization. Leachate - formed when rain water filters through wastes placed in a landfill. When this liquid comes in contact with buried wastes, it leaches, or draws out, chemicals or constituents from those wastes.

- Anaerobic - In an anaerobic bioreactor landfill, moist ure is added to the waste mass in the form of re-circulated leachate and other sources to obtain optimal moisture levels. Biodegradation occurs in the absence of oxygen (anaerobically) and produces landfill gas. Landfill gas - primarily methane - can be captured to minimize greenhouse gas emissions and can be used for energy projects.
- Hybrid (Aerobic-Anaerobic) - The hybrid bioreactor landfill accelerates waste degradation by employing a sequential aerobic-anaerobic treatment to rapidly degrade organics in the upper sections of the landfill and collect gas from lower sections. Operation as a hybrid results in the earlier onset of methanogenesis compared to aerobic landfills.

Unique Features to Bioreactors

The bioreactor accelerates the decomposition and stabilization of waste. At a minimum, leachate is injected into the bioreactor to stimulate the natural biodegradation process. Bioreactors often need other liquids such as storm water, wastewater, and wastewater treatment plant sludges to supplement leachate. This enhances the microbiological process by purposeful control of the moisture content, and differs from

a landfill that simply recirculates leachate for liquids management. Landfills that simply recirculate leachate may not necessarily operate as optimized bioreactors.

Moisture content is the single most important factor that promotes the accelerated decomposition. The bioreactor technology relies on maintaining optimal moisture content near field capacity - approximately 35 to 65 percent - and adds liquids when it is necessary to maintain that percentage. The moisture content, combined with the biological action of naturally occurring microbes, decomposes the waste. The microbes can be either aerobic or anaerobic. A side effect of the bioreactor is that it produces landfill gas (LFG) like methane in an anaerobic unit at an earlier stage in the landfill's life at an overall much higher rate of generation than traditional landfills.

Potential Advantages of Bioreactor Landfills

Decomposition and biological stabilization of the waste in a bioreactor landfill can occur in a much shorter time than in a traditional "dry tomb" landfill. This can provide a potential decrease in long-term environmental risks and landfill operating and post-closure costs. Potential advantages of bioreactors include the following:

- Decomposition and biological stabilization in years versus decades in "dry tombs"
- Lower waste toxicity and mobility due to both aerobic and anaerobic conditions
- Reduced leachate disposal costs
- A 15 to 30 percent gain in landfill space due to an increase in density of waste mass
- Significant increased LFG generation that, when captured, can be used for energy use onsite or sold.
- Reduced post-closure care.

Landfill Methane Gas Outreach Program:

The Landfill Methane Gas Outreach Program (LMOP) is a voluntary program that works cooperatively with industry stakeholders and waste officials to reduce or avoid methane emissions from landfills. LMOP encourages the recovery and beneficial use of biogas generated from organic municipal solid waste (MSW).

Due to degradation of organics and the sequestration of inorganics, research has shown that municipal solid waste can be rapidly degraded and made less hazardous by enhancing and controlling the moisture within the landfill under aerobic and/or anaerobic conditions. Leachate quality in a bioreactor rapidly improves, which leads to reduced leachate disposal costs. Landfill volume may also decrease with the recovered airspace offering landfill operators the full operating life of the landfill.

LFG emitted by a bioreactor landfill consists primarily of methane and carbon dioxide, as well as lesser amounts of volatile organic chemicals and/or hazardous air pollutants. Research indicates that the operation of a bioreactor may generate LFG earlier in the process and at a higher rate than the traditional landfill. The bioreactor LFG is also generated over a shorter period of time, because the LFG emissions decline as the accelerated decomposition process depletes the source waste faster than in a traditional landfill. The net result appears to be that the bioreactor produces more LFG overall than the traditional landfill does.

Special Considerations for Bioreactor Landfills

Several considerations about bioreactor landfills must be examined and understood before EPA can identify specific bioreactor standards or recommend operating parameters. Bioreactor landfills generally are engineered systems that have higher initial capital costs and require additional monitoring and control during their operating life, but are expected to involve less monitoring over the duration of the post-closure period than conventional “dry tomb” landfills. Issues that need to be addressed during both design and operation of a bioreactor landfill include the following:

- Increased gas emissions
- Increased odors
- Physical instability of waste mass due to increased moisture and density
- Instability of liner systems
- Surface seeps
- Landfill fires