Development of Model Parameters for Prediction of Methane Production from Paper Industry Landfills

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The US EPA requires the installation of gas control equipment at landfills that produce more than 50 metric tons of NMOC per year or have a design capacity of 2.5 million metric tons or 2.5 million m^3. These criteria were developed based on landfill gas emission data applicable to landfills that primarily receive municipal solid waste (MSW). The anaerobic biodegradation of MSW to methane and carbon dioxide in landfills is well established and cellulose and hemicellulose have been shown to be the principal biodegradable constituents. However, there is substantial uncertainty associated with gas production, even from relatively well characterized landfills that receive primarily MSW.

The pulp and paper industry (P&PI) generates a number of wastes that are managed by burial in a landfill. While some of these wastes have a significant cellulosic component, they are substantially different from the wastes typically buried in MSW landfills. In addition, there is substantial variability in the specific wastes that are landfilled at a particular paper mill. Thus, based on differences between MSW and P&PI waste composition, there is little similarity between expected methane yields from MSW and P&PI waste.

The overall objective of this research is to measure methane yields and decomposition rates for the major components of P&PI waste that are buried in landfills. Experimental work has been conducted in two phases. Initial work was conducted to measure ultimate methane yields under optimal conditions in laboratory (4-L) reactors. Reactors were incubated in a water bath at 37°C. Five residuals (wastewater treatment plant sludges) were selected for study and methane production was measured in the presence and absence of nutrient additions. Nutrients were considered to be a potentially significant variable because paper industry residuals are often relatively low in N and P relative to MSW. In addition, the effect of both ash and causticizing waste on methane yield were tested for one residual as such wastes are typically buried along with residuals in P&PI landfills. All tests were conducted in triplicate.

While laboratory experiments can provide data on ultimate methane yields, they provide only a hint of the appropriate rate of decomposition under field conditions. Thus, a second phase of experimental work is in progress to measure decomposition rates under field conditions. Twelve columns were buried in a P&PI industry landfill in Michigan. Reactors were constructed from 25-cm diameter, schedule 40 PVC pipes that were closed with end caps to provide a gas tight seal. The volume of each column is 77L. Each column includes an inlet line for moisture addition, an outlet line for leachate sampling and an outlet for gas which is piped to an above ground storage shed. Four residuals were tested and again, all tests were conducted in triplicate. In addition to gas production, the temperature both inside and outside of the in situ columns was measured.

The results of the laboratory-measured ultimate methane yields for five P&PI residuals are presented in Table 1. The addition of nutrients stimulated the initial rate of methane production for residuals B and D. Amongst materials A-C, for which laboratory testing is completed, nutrients did not result in an increased methane yield although nutrients did stimulate the initial rate of methane production for Residual B. Testing of residuals D and E was started at a later time and is still in progress.

The composition of solids removed from each reactor have been characterized by measurement of the cellulose, hemicellulose and lignin concentration as well as their biochemical methane potential (BMP). These data show extensive decomposition of the cellulose and hemicellulose in all materials tested and reductions of roughly 90% in the BMPs before and after decomposition.

Field reactors initiated with residuals A, B, D and E have been monitored since November, 2000. Residual A was not field tested because the mill that produced this material has closed. With the exception of one reactor filled with residual B, methane yields have been negligible over the first 660 days of testing. Although the reactors show methane in their headspace, methane concentrations have not consistently increased and gas production has been quite low. The leachate pH has been suboptimal for methanogenesis and the leachate COD ranges from 6 - 17 g/L. In addition, reactor temperatures are generally below 20°C. Thus, the field reactors appear to be in the acid phase of decomposition and the project team is considering whether to externally neutralize the leachate to stimulate methanogenesis, or wait until the reactors progress to a more active methane producing phase on their own.

The presentation will include an integrated analysis of the laboratory and field data and is intended to stimulate discussion on appropriate techniques for estimating decay rates under field conditions.

Table 1 Summary of Materials Tested and Ultimate Methane Yields

Treatment	Description	Days of Monitoring	Methane Yield (L/dry kg)
Residual A	Combined Primary and Secondary Residual	236	69.9
Residual A + Nutrients		236	59.6
Residual A + Nutrients + Causticizing Waste		N/A	0
Residual A + Ash		200	83.6
Residual B	Combined Primary and Secondary Residual	341	69.5
Residual B + Nutrients		341	70.9
Residual C + Nutrients	Combined Primary and Secondary Residual	342	128.1
Residual C		342	129.7
Residual D	Primary Residual	443	99.9*
Residual D + Nutrients		273	125.3
Residual E	Primary Residual	443	61.5*
Residual E + Nutrients		443	56.3*

* Tests are still in progress