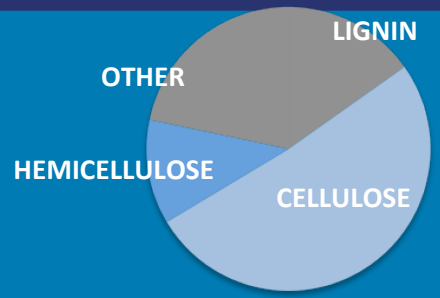
AEROBIC LANDFILL TECHNOLOGIES

seanspeer@aerolantech.ca
403-829-9152

Moisture Balance

WASTE CHARACTERIZATION

Landfilled waste is a highly heterogeneous material that varies in characteristics from region to region and even annually within regions due to changes in waste diversion habits. It is therefore difficult to accurately characterize the waste in landfills. In 2003 the US EPA held a workshop on bioreactor landfills where industry experts discussed the techniques and presented case studies on pilot scale sites. At this workshop, technical experts provided an overarching estimate for landfilled waste as containing on average 63% cellulose and hemicellulose that can be degraded to produce landfill gas.



CELLULOSE HYDROLYSIS

The cellulose and hemicellulose that is present in the waste must be converted from it's crystalline state to an aqueous phase before it can be converted to simple sugars that are finally degraded to produce landfill gas. This is a complex process that can involve many different enzymes produced by microorganisms in the landfilled waste. Due to the heterogeneous nature of the waste, and variations in the microorganisms present, the specific enzymes involved in the process, and the specific end product are difficult simplify for a landfill model. The technical experts at the US EPA conference have offered an average liquid demand for this process as 4 moles of water per 6 moles of carbon degraded from the cellulose/hemicellulose mixture. This can be simplified to 4 moles of water required per mole of glucose produced through hydrolysis.

Mass basis

Converting the molar requirements of water for the hydrolysis of cellulose/hemicellulose to a mass basis results in a requirement of 1 tonne (1000L) of water per tonne of carbon in the landfill. Every tonne of glucose produced in this reaction requires 0.4 tonnes (400L) of water.

$$\left[\overset{CELLULOSE}{\left(C_6H_{10}O_5\right)_n}+\overset{HEMICELLULOSE}{\left(C_5H_8O_4\right)_n}\right]_{crystal}\xrightarrow{H_2O}\left[\left(C_6H_{10}O_5\right)_n+\left(C_5H_8O_4\right)_n\right]_{aq}$$

$$\left[\left(C_6H_{10}O_5\right)_n+\left(C_5H_8O_4\right)_n\right]_{aq}+8H_2O\xrightarrow{Enzymes}2C_6H_{12}O_6+\left[\left(C_6H_{10}O_5\right)_{n-1}+\left(C_5H_8O_4\right)_{n-1}\right]_{aq}$$

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MOISTURE PRODUCTION

A stoichiometric analysis of the oxidation of the glucose produced via hydrolysis of the cellulose/hemicellulose in the landfill demonstrates that 6 moles of water are produced per 6 moles of carbon that is oxidized (or per mole of glucose oxidized). On a mass basis, every mole of carbon oxidized produces 1.5 tonnes (1500L) of water. Every tonne of glucose oxidized produces 0.6 tonnes (600L of water).

$$C_6H_{12}O_2 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$$

MOISTURE BALANCE

Comparing the volume of moisture that is required for cellulose/hemicellulose with the amount of water produced from the oxidation of glucose demonstrates that is the overall reactions the production of water is 1.5 times greater than the water requirements. Therefore the aerobic process will not require moisture addition to maintain the process. Any additional moisture can be removed as vapour in the extracted landfill gas, thereby not producing leachate.

$$\left[\left(C_6H_{10}O_5\right)_n + \left(C_5H_8O_4\right)_n\right]_{aq} + 8H_2O \xrightarrow{Enzymes} 2C_6H_{12}O_6 + \left[\left(C_6H_{10}O_5\right)_{n-1} + \left(C_5H_8O_4\right)_{n-1}\right]_{aq} + 6O_2 \longrightarrow 6CO_2 + 6H_2O + \left[\left(C_6H_{10}O_5\right)_{n-1} + \left(C_5H_8O_4\right)_{n-1}\right]_{aq}$$

	WATER USED/WATER PRODUCED (PER TONNE CARBON)
CELLULOSE/HEMICELLULOSE HYDROLYSIS	- 1 TONNE (1000L)
GLUCOSE OXIDATION	1.5 TONNES (1500L)
TOTAL EXCESS WATER	0.5 TONNES (500L)