Abstract

Methane Oxidation in Simulated Landfill Cover Soils

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With about 40 to 70 Mt of methane emitted each year worldwide, landfills are the largest anthropogenic source of this greenhouse gas in North America. Landfill gas collection reduces methane emissions by 50 to 60%. The remaining 40 to 50% of landfill gas is emitted to the atmosphere. While the number and the efficiency of landfill gas extraction systems is increasing, other significant reductions of methane emissions from landfills are necessary. Methane oxidation in the top cover soil layer has been shown to provide a methane emission reduction potential of 10 to 70% of the methane produced.

This study was conducted to evaluate the effects of different materials, used to simulate landfill cover soils, tested under different conditions. By creating optimal ambient conditions for methanotrophic bacteria in cover layers, it is possible to increase the microbial activity and to attain very high oxidation rates. Temperature, moisture content, and oxygen penetration are among the most important factors for methane oxidation. The main goal of this research is to find a material or a mixture of materials that optimize all factors and provide the highest rate of methane oxidation. The final results will be applied to engineer the design and to improve the operational conditions of landfill surface covers applicable on different types of landfills with or without collection systems.

A test series of six column reactors was conducted. Each column was constructed from 20 cm diameter PVC pipe containing a 50 cm thick layer of soil. The columns were filled with 1) soil (mixed clay, silt, and sand), 2) soil & compost, 3) soil & sand, 4) soil & pulp sludge, and 5) clay & soil. The sixth column was filled with soil and run at low temperature. The columns were fed from below by synthetic landfill gas, composed of a 45:45% mixture of methane and carbon dioxide, and 10% neon (used as a tracer gas). A gas flow flux was $2.34 \cdot 10^{-7}$g CH_4 $cm^{-2}d^{-1}$, which was lower midrange of reported landfill methane fluxes. Atmospheric conditions were maintained at the top of the soil where air inflow was 300 mL min^{-1}. Fresh soil was collected from the Clover Bar Landfill, an active municipal landfill in Edmonton, Canada. All materials were air-dried prior to filling of the columns.

Our results showed the constant presence of methane oxidation even under low temperature (4°C) and low moisture content (5-10% by volume). A mixture of 50:50 vol.% of soil and pulp sludge showed methane reduction of between 65% and 85% of the applied flux with the reduction rate of about 150 g of CH_4 $m^{-2}d^{-1}$. This rate is very close to the methane oxidation potential rate measured for the same soil by incubation tests before. Under lower moisture content the intensity of the reaction is the same throughout the entire depth, while an increase in moisture content limits oxygen penetration so that the most intensive reaction occurs at 15 to 25 cm of depth.

In the next planned phase of research, field scale tests with the best soil profile from the column tests, will be performed, based on the findings of the lab tests. These tests will be performed under actual atmospheric conditions over a 12-month period. During winter the oxidation layers will be insulated. The significance of these tests is to develop an engineered

cover layer that will passively reduce greenhouse gas emissions. This approach is applicable as a stand-alone method at smaller, remote and older landfills (where gas generation is low, or gas use infeasible), or in conjunction with landfill gas extraction at large landfills to reduce the part of methane that can not be collected.