Calgary Gas - Managing landfill gas in arid climates using methane-oxidizing alternative final covers

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Imagine that it's the 1960s and you're driving to the local landfill, which is in the middle of the countryside, miles from any settlement. Fast-forward to today and you find that, far from being in the middle of nowhere, the landfill is now just 300 metres from the closest house in a huge subdivision, and will be surrounded by homes in a few years.

This is the situation that BFI Canada Inc. has encountered as owner and operator of the Calgary Landfill at the southern limit of the City of Calgary, Alberta. The landfill will require closure in the upcoming years after enjoying an excellent long-term relationship with its neighbours. BFI's proposal that the closed landfill offer public site access connected to the city's trail system was well received and has been incorporated into the closure design plans. The dilemma the company faced was to find a simple method to reduce landfill gas emissions in order to prevent potential odor, to avoid exposure of future public users and to reduce greenhouse gas emissions.

Because Calgary is situated in a semi-arid climatic region, the landfill waste stays relatively dry and generates gas so slowly that an active gas collection system (such as a system of wells, headers and flares) cannot be supported. However, the Calgary Landfill is an ideal candidate for an alternative final cover to *passively* eliminate methane as it moves slowly up through the cover. This process, which is similar to biofiltration used in eliminating composting odors, is known as "methane oxidation."

Methane oxidation

Methane oxidation is the natural biochemical conversion of methane to carbon dioxide. A group of methane oxidizing organisms (known as Methanotrophs) convert one tonne of methane -- with a global warming potential the same as that of 23 tonnes of CO_2 -- into approximately 2.75 tonnes of CO_2. Thus, the net reduction in greenhouse gas effect per tonne of methane oxidized is about 21 tonnes of CO_2 equivalents. Methane oxidizing bacteria, however, only work at temperatures above 5°C and reach their optimum activity at a cover temperature of about 35°C (with a moisture content in the cover of between 15 per cent and 25 per cent by volume). Freezing conditions in the cover during winter, a normal condition in Calgary, can stop oxidation entirely.

BFI decided that the applicability of this process to the minimization of fugitive landfill gas at the Calgary Landfill was worthy of research.

The research, assisted by a contribution from the Climate Change Central Office of Alberta Environment, commenced in 2001 with a survey of the site to identify any gas "hot spots" and measure the current emission rates of methane across the surface of the landfill. Several hot spots were found, but most of the surface area exhibited low emission rates. The entire site was estimated to emit about 20,000 tonnes per year of CO2 equivalents, of which about 66 per cent was contributed by methane. Thus, the reduction of methane releases would result in a significant overall reduction of greenhouse gas emissions. These measurements provided the parameters for the design of an initial pilot test plot which preceded a full-scale alternative final cover test area consisting of a central methane oxidation ("MethOx") bed fed with landfill gas from a system of shallow gas-collection trenches below the cover.

The MethOx system is designed to: operate passively without external energy or manpower; function effectively during warm weather and during cold winter temperatures (down to minus 40°C and, under a variety of moisture conditions from very dry to very wet); to use locally available materials, such as natural soils, innocuous byproduct materials (such as yard-waste compost, tire shreds, etc.); and, be suitable for construction by available landfill equipment.

The full-scale pilot MethOx oxidation bed incorporates a network of gas collection trenches, over an area of about 4,600 m2 that channel gas to a central bed of about 100 m2. The MethOx bed (*shown on Figure 1.*) consists of yard waste compost of about one metre depth, which, to prevent freezing in winter, is warmed with heat from within the landfill transferred from below up and into the MethOx bed with a passive heat exchange pipe.

Results

The MethOx bed has operated continuously since August 2003 and, importantly, throughout the winter of 2003/2004, without freezing. The performance of the gas collection trenches and the central bed has virtually eliminated methane emissions by oxidation of the methane (which would otherwise be fugitive) as it passes through the bed towards the surface. In particular, instrumentation of the MethOx bed has shown that:

1. Methane emission rates have declined to zero, down from initial emission rates of between 2 to 44 grams of methane per square metre per day before the test;

2. Methane oxidation rates of up to (and sometimes over) 90 per cent have occurred; and,

3. Methane oxidation slows during cold winter temperatures, but does not stop, due to the heat transfer from the landfill depths during these times.

BFI has concluded that incorporation of the MethOx bed system into the final cover is a viable alternative landfill cover design for the Calgary Landfill. The final cover will therefore include a series of granular collection trenches constructed below the final cap to "feed" landfill gas to several MethOx oxidation beds across the landfill top surface. These trenches and beds will be built concurrently with the final cover, which will be constructed traditionally of compacted clay and topsoil between the trenches and MethOx beds. Once completed, only a small fraction of the landfill surface area (about one per cent) will be covered by the MethOx beds; the remaining area will be conventional landfill final cover.

Through passive oxidation and the supplemental heating mechanisms, and with long-lasting bed materials, methane oxidation cover beds will require very little maintenance and no external operating effort. Monitoring, which can be accomplished remotely, can verify the oxidation rate and these measurements will also allow calculation of potential greenhouse gas reduction credits for verification. In the case of the Calgary Landfill, these credits could amount to the value of several thousand tonnes of CO2 equivalent each year.

Successful use of this technology will reduce, if not in some cases eliminate, landfill gas as a significant post-closure issue at those landfills where climate or site size prevent the generation of landfill gas at recoverable rates. As a result of the use of an alternative final cover, the goal of maximizing public safety and reducing global warming impacts will be enhanced by the increased "at-source" managed conversion of methane to carbon dioxide through the MethOx cover system.