Attenuation of Non-Methane Organic Compounds (NMOCs) in Landfill Cover Soil

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Introduction

- In addition to CH_4 and CO_2 landfill gas often contains a high number of different volatile non-methane organic components (NMOCs) including chlorinated hydrocarbons and aromatics
- Typical NMOC concentrations range between 10-250 mg m^{-3}
- A significant part of the methane might be oxidized by methanotrophic bacteria in top soil covers before being released into the atmosphere
- A defining characteristic of the methanotrophic bacteria is the enzyme *methane monooxygenase* (MMO), which has a broad substrate range performing oxidative conversions of halogenated aliphatic hydrocarbons (co-metabolism)

Objective

To investigate attenuation mechanisms and rates, as well as net emission rates for NMOC species at landfills

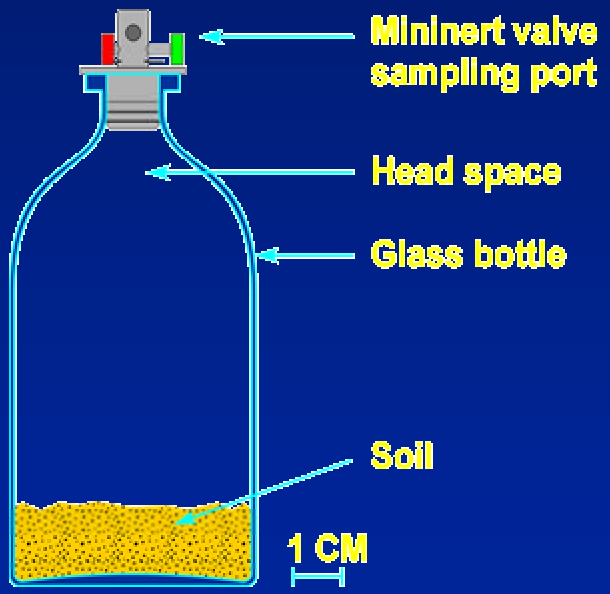
- **The investigation was carried out as a combined field and laboratory investigation to provide the first field measurements of speciated NMOC emissions in parallel with laboratory studies of attenuation in cover soils**
- **The investigation was conducted at Lapoyade landfill located in the western part of France**

Laboratory soil microcosms experiments

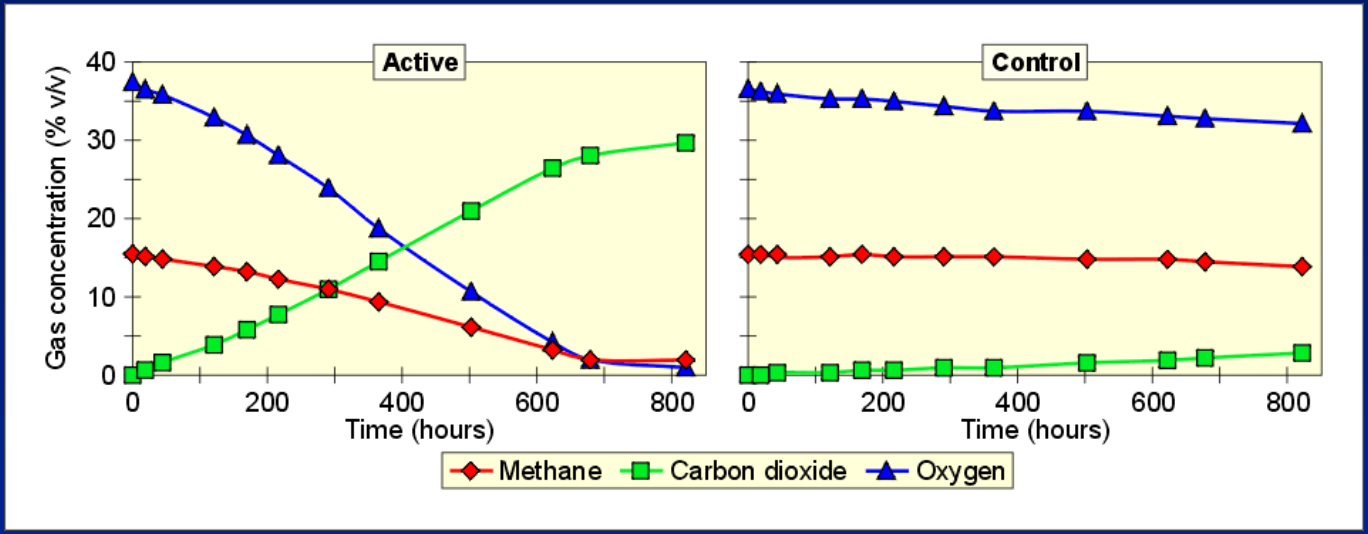
The degradability of selected NMOCs was investigated in soil microcosms

Soil microcosm

- 20 g moist soil
- water content of 20 %w/w
- room temperature 22 °C
- pre-incubation
- initial conc.: methane 15 %vol. and oxygen 30 %vol.
- initial NMOC conc.: 20-2000 µg/L



Methane oxidation in landfill cover soil



Relative concentration of methane, oxygen and carbon dioxide as function of time showing methane oxidation in a batch experiment containing 20g soil pre-exposed to landfill gas.

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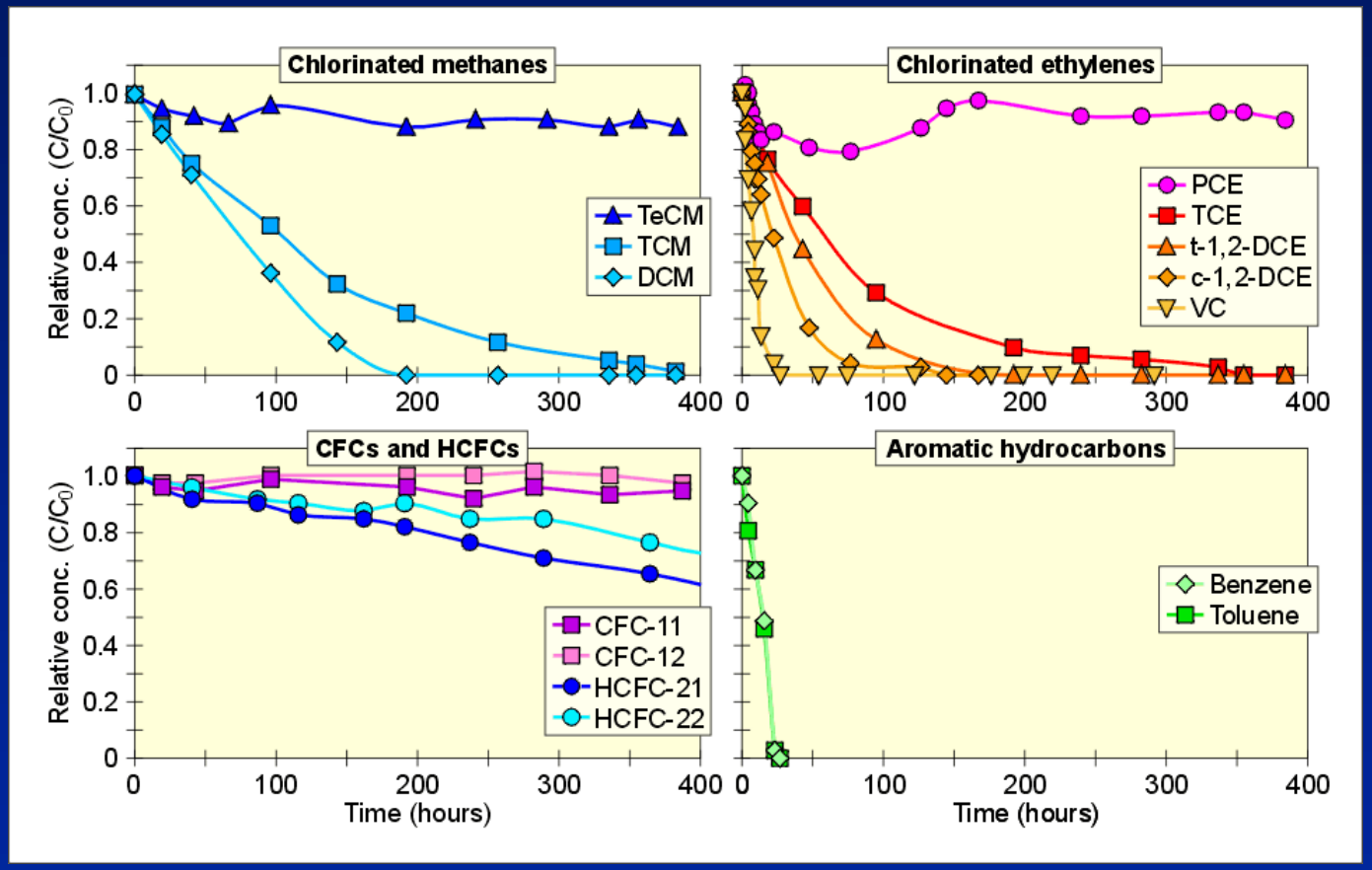
Degradation of selected NMOCs in landfill cover soil



Relative concentration of selected NMOCs as a function of time in a batch experiment containing 20g soil pre-exposed to landfill gas.

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Results of microcosm experiments

- The soil hold capacity for methane oxidation with oxidation rates up to 35 $\mu g\ CH_4\ g^{-1}\ d^{-1}$
- All lower halogenated compounds were shown degradable and the degradation occurred in parallel with methane oxidation. Oxidation rates varied between 0.06-8.6 $\mu g\ g^{-1}\ d^{-1}$
- In general, the degradation rates of the chlorinated hydrocarbons were inversely related to the chlorine/carbon ratios
- Fully halogenated compounds were not degraded in presence of oxygen and methane.
- Simple box calculation using the obtained oxidation rates showed that soil covers can have a significant effect in reducing the emission from landfills

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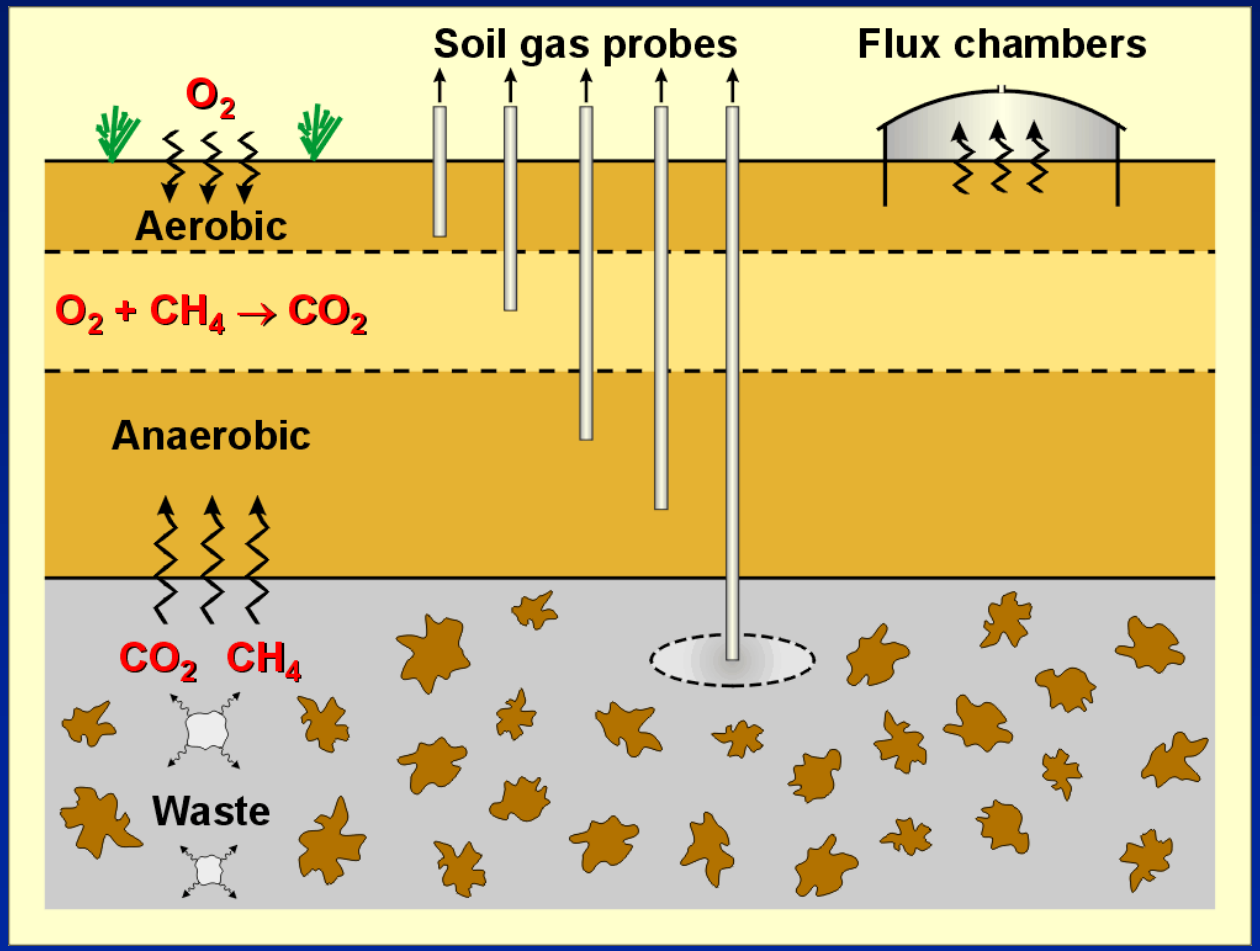
Field investigations

- The field investigations included measurements of methane and NMOC emissions
- 42 trace organics were included in the analysis including alkanes, alkenes, chlorinated hydrocarbons and aromatic hydrocarbons (Det. limit NMOCs = 20ppb)
- The measurements were conducted at two different areas: a temporarily covered waste cell and a permanently covered waste cell
- Isotope techniques to determine methane oxidation (conducted by Jeffrey Chanton)

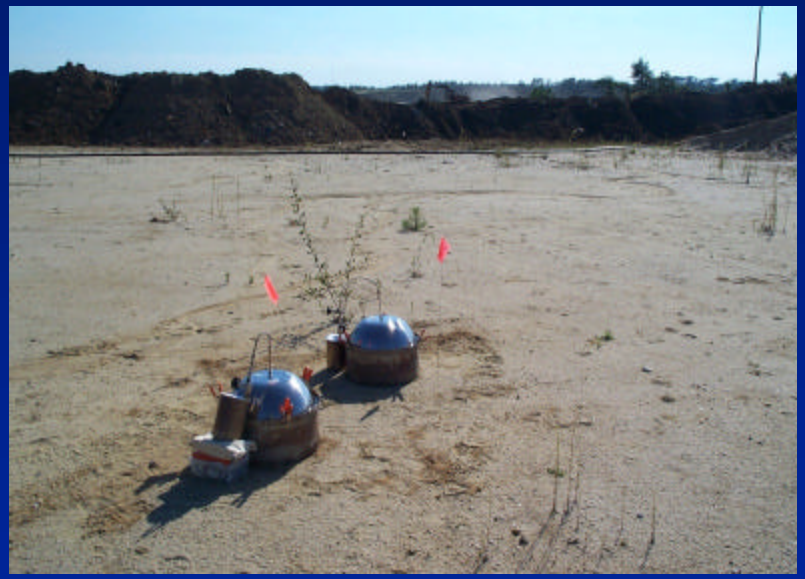
Methodology - flux chambers and soil gas profiles



Installation of flux chambers

Permanently covered cell

Temporarily covered cell



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Gas sampling using canisters

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Surface gas emissions

Flux (g m^{-2} d^{-1})		Permanent covered cell	Temporary covered cell
Methane	Average	1.97±0.88	37.8±14.4
	Max.	16.2	78.2
	Negative	yes	no
	Oxidation (%)	40±7	3.8±1.3
VOCs	Range	10^{-7} - 10^{-5}	10^{-5} - 10^{-4}
	Negative	yes	rare

- **The NMOC emission mainly consisted of compounds that were shown not or only slowly degradable in incubation experiments while an up-take of easily degradable compounds was found**
- **The soil cover on the permanently covered cell had an a mitigating effect on the gas emission due to higher microbial activity**

Conclusions

- Methanotrophic bacteria in landfill cover soils are capable of co-oxidizing a large number of NMOCs such as lower chlorinated hydrocarbons
- Degradation of fully halogenated compounds in the oxic zone in landfill covers is limited. However these compounds may be transformed under anaerobic conditions within the waste
- Negative flux measurements of methane and NMOCs indicates that landfill under some conditions may function as sinks of NMOCs
- Landfill soil covers have a potential of attenuation of trace organics and thereby reducing the emission of trace components from landfills