FACTORS GOVERNING LATERAL GAS MIGRATION AND SUBSEQUENT EMISSION IN SOIL ADJACENT TO AN OLD LANDFILL

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Introduction
The migration and emission of landfill gas (LFG) may potentially lead to negative effects in the surroundings, for example; fire and explosion hazards, health risks, damage to vegetation, odour nuisances, groundwater contamination, and global climate effects (Kjeldsen, 1996). The main environmental hazards related to LFG are believed to be the explosion hazards and the global climate effects. Over a 100-year span, methane has a global warming potential of 21 (kg CH₄/kg CO₂) because of its stronger molar absorption coefficient for infrared radiation and longer residence time in the atmosphere (Lelieveld, 1998).

Barometric pressure is believed to be a major factor controlling methane emissions from landfills. A decline in barometric pressure will draw out landfill gas, while increases in barometric pressure will result in decline in landfill gas emissions.

Many older landfills, which are placed in abandoned gravel pits are unlined, and compacted waste and impermeable top covers encourage lateral gas migration. However no one has investigated emissions of LFG from soils adjacent to landfills. The objective of this study was to investigate lateral gas migration and subsequent emissions in soil adjacent to an old municipal landfill, in order to determine the most important controlling factors.

Methods
The field investigations were carried out at Skellingsted Landfill, Denmark. The landfill received domestic and industrial waste from 1971 to 1990. The landfill is placed in an old gravel pit and there are no liners. Sampling equipment was installed along two transects with the first station in the top cover of the landfill and the subsequent stations on a line perpendicular to the landfill border. Each transect consisted of 9 measuring stations, and each station consisted of a stationary flux chamber, soil gas probes to measure gas concentrations and pressure above barometric pressure at 6 depths and probes to measure the volumetric soil moisture content at 5 depths down to 1 m below surface (b.s.). Measuring campaigns were conducted approximately every second week from May 1997 to May 1998 and during a drop in barometric pressure intensive measurements were conducted for two days.

Results & Discussion
In general the concentrations of landfill gas in the soil varied showing that the lateral gas migration is a very dynamic system. There was a statistical significantly seasonal variation in

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the methane concentrations 1 m b.s. Close to the landfill the methane concentrations were low in the summer and significantly higher in the winter. For the carbon dioxide concentrations the opposite was observed. This was caused by oxidation of methane to carbon dioxide. Further away from the landfill the concentrations of both methane and carbon dioxide were statistically significant higher in the winter compared with the summer caused by the higher soil moisture content in the topsoil in the winter. The higher water content reduced the vertical gas emission.

There were large variations in the measured emissions during the one-year measuring period, and there was a significantly seasonal variation in the emissions with very low fluxes of methane in the summer and higher fluxes in the winter. For carbon dioxide the seasonal variation was the opposite with high fluxes in the summer and lower fluxes in the winter. These seasonal variations were caused by the temperature dependent methane oxidation. Statistical analysis showed that soil moisture content was the factor describing the largest part of the variation in the fluxes.

Pressure above the barometric pressure was measured in the soil in areas, which was affected by landfill gas during the measuring period. This indicated that advective flux was important for the gas migration. The measured gas concentrations and fluxes were used as input to a numeric gas transport model. The model was used to evaluate the sensitivity of the concentrations and the fluxes to changes in: methane oxidation, diffusion, gas permeability, barometric pressure and soil moisture content. The results of the sensitivity analysis indicated that landfill gas migration was most sensitive to air permeability and soil moisture content, and that diffusion had no influence at all.

The intensive measurements during a drop in the barometric pressure showed a clear connection between the gas concentrations in the soil, the emissions and the decreasing barometric pressure. The concentrations and the fluxes increased as the barometric pressure decreased. Large changes in especially the methane concentrations were observed in the soil within very short time. The changes in both methane and carbon dioxide fluxes were also large.

References