Composés odorants dans le biogaz
+ Seuils olfactifs

VIRIDIS

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Projet d'établissement d'un lieu d'enfouissemen sanitaire à Saint-Cyrille-de-Lessard

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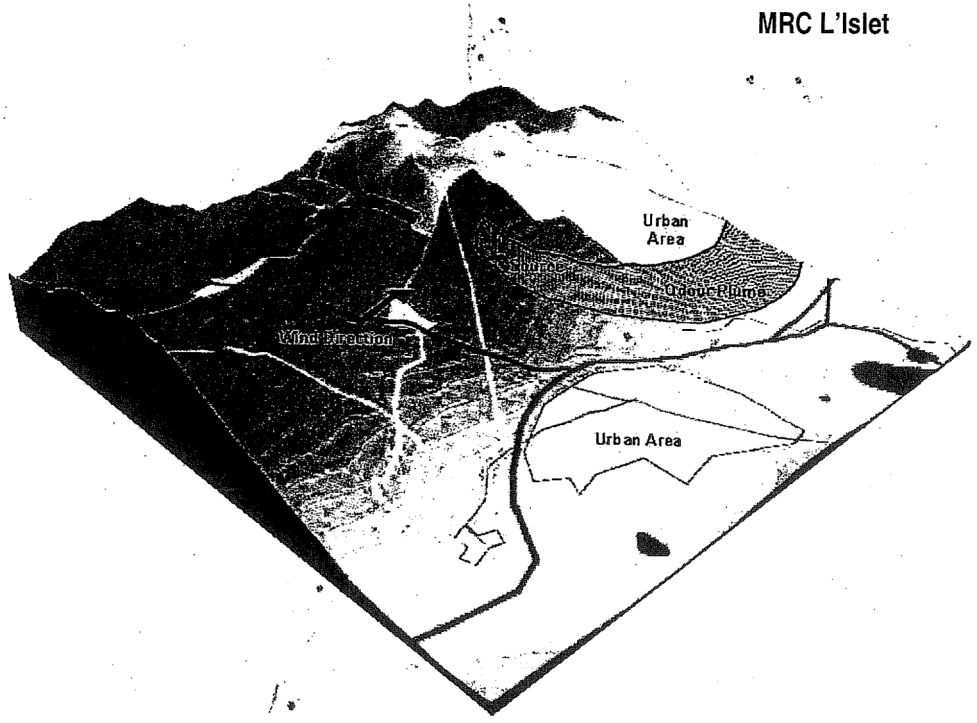

Managing Odour Risk at Landfill Sites: Main Report

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3.2 Odour Measurement

Measurement of the concentration of an odorant compound is a straightforward process. Samples of LFG are collected and analysed by appropriate chemical methods to identify the particular odorant compound required. However, the perception of odour is more complex. One recognised and established method of assessing odour is the determination of the number of Odour Units (OU) for a substance. OUs are determined using an odour panel, a panel of 5-10 people exposed to changing concentrations of the odorant.

The concentration at which 50% of the panel can detect the smell is deemed the Odour Detection Threshold (ODT) and by definition has an odour unit (OU) value of 1. The concentration at which 50% of the panel can recognise the smell is termed the Odour Recognition Threshold (ORT). Measurement of these thresholds is expressed in OU, the number of dilutions of the starting concentration required before the odour can no longer be detected. It is also possible to measure the actual concentration of the odorant chemical present in the sample at the ODT.

It can be seen that while the OU method takes account of variations in human olfactory acuity, it is a time consuming process and therefore a costly process. The costs incurred involve the collection of gas samples, forming a panel of 5-10 persons and running successive dilutions and panel testing of the odour samples as necessary, until the 50% detection threshold is achieved.

To maximise the quantity of work that could be undertaken for the agreed budget, it was decided to use the technically valid but simpler approach of basing the odour dispersion modelling on the chemical concentration of the odorant species determined at its ODT. This approach is simpler, as is does not require the establishment of an odour panel or the associated odour sample control measures. A review of olfactory studies produced by the American Industrial Hygiene Association (AIHA, 1997) has produced a list of 'A' rated ODT data from the studies reviewed and these data was used in the present study.

The ODT was used in favour of the ORT for two reasons: while an odour may not be identifiable, its characteristics may still be considered to be a nuisance; and the pragmatic reason that there no suitable data on ORT could be sourced compared with ODT data.

The approach of using the chemical concentration at the ODT rather than OUs has the additional benefit of using a parameter that could subsequently be measured in the field with suitable equipment to give real-time measurements. However this approach takes account of any synergistic effects between chemicals.

3.3 Odorous Compounds in Landfill Gas

Over 300 trace compounds have been identified in LFG. Unpleasant odours are usually associated with the sulphur-containing compounds, primarily mercaptans and sulphides. The vast range of trace compounds measured in LFG is a reflection of both the anaerobic decomposition processes taking place in the waste mass and the wide range of chemicals introduced via the industrial and commercial waste streams.

A list of common odorant compounds with low ODTs found typically in LFG, the reported range of concentrations in LFG and their ODT concentrations is presented in Table 1 and Figure 2 below. The range of reported ODT values represents only the minimum value and does not indicate the range of concentrations at which compounds can be detected.

Odorant Compound	Reported Concentration in LFG* (mg m-3)			Reported ODT Range** (mg m-3)		
Butanoic acid	0.1	-	210	0.0000029	-	9
Butyl Mercaptan	0.01	-	16.1	0.006	-	12
Diethyl disulphide	0.1	-	1.0	0.0003	-	0.02
Dimethyl disulphide	0.02	-	40	0.00023	-	12
Dimethyl sulphide	0.02	-	135	0.00033	-	0.6
Ethyl mercaptan	0.1	-	120	0.00025	-	0.001
Methyl mercaptan	0.005	-	430	0.0000003	-	0.02
Ethyl butanoate	0.1	-	350	0.00003	-	0.28
Hydrogen sulphide	0.0005	-	97,152	0.0001	-	2.8
Methyl butanoate	0.2	-	125	0.0019	-	0.077
Propyl mercaptan	0.05	-	2.1	0.0000025	-	0.00014
Xylene	0.0015	-	1100	0.0002	-	100
* *based on average of LFG literature derived values*						
** AIHA 1999 and AEAT 1994 & 1997						

Table 1: ODT of Selected LFG Trace Components

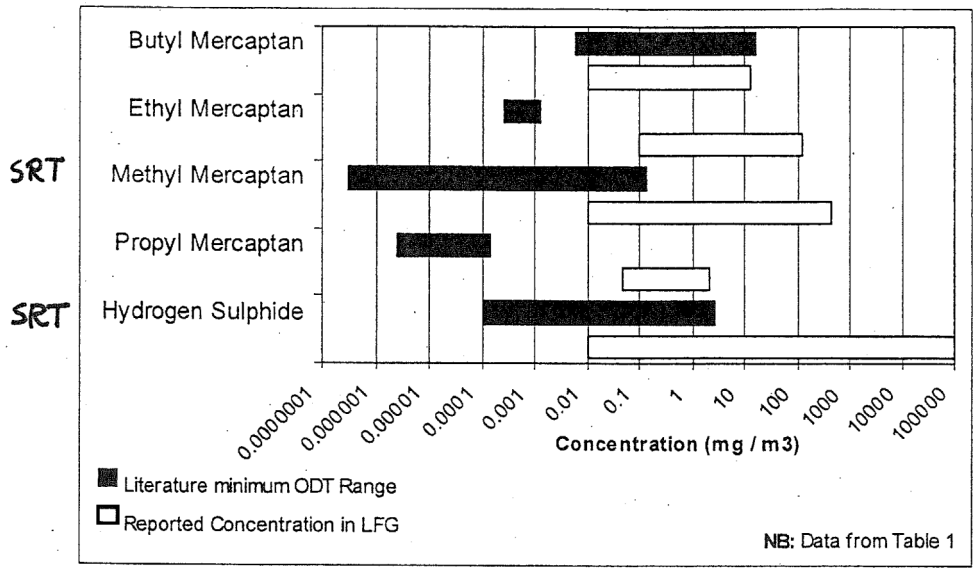

Figure 2: Comparison of the ODT for selected LFG trace components and their reported concentration in LFG

It can be seen clearly that there is a broad range of reported odorant concentrations and ODT values. Such variations in the range of intrinsic key odour data makes it certain that odour complaints from LFG will vary greatly from one seemingly identical site to another. In addition extrinsic factors such as the extent of capping, the type and extent of the gas control system and its efficacy, the surrounding terrain and features etc. will influence the potential for odour events. As a consequence the comparison of odour issues between sites is a complex matter.

Offensive, sulphur-based odorant compounds found in LFG typically have the lowest ODT concentrations, making them the most likely source of unpleasant odours in LFG (for a given concentration). Table 2 presents the reported concentrations found in LFG for four sulphur-containing compounds, part of the mercaptan series (Appendix 3). The four mercaptans, methyl-. butyl-, ethyl- and propyl mercaptan (also known as methanethiol, butanethiol, ethanethiol and propanethiol), are all found in LFG at concentrations well above their ODT. Hydrogen sulphide, also widely found in LFG, is included for comparison.

Sulphur Containing Compounds	Reported Values (mgm^{-3})			Odorant to Methane Ratio***
	Min Value*	Max Value	Average Value**	
Methyl mercaptan	0.01	430	36	3.17×10^{-6}
Ethyl mercaptan	0.10	120	11	2.98×10^{-6}
Butyl mercaptan	0.01	13	2.1	2.95×10^{-6}
Propyl mercaptan	0.05	2.1	0.88	6.45×10^{-6}
Hydrogen sulphide	0.00	97152	1210	1.62×10^{-4}

** Value <0.01mgm^{-3} reported as 0.00*
*** based on average of literature derived values*
**** assumes 50% methane and unit concentration of 1mgm^{-3} (Appendix 4.7)*

Table 2: Selected Sulphur Containing Compounds in LFG (50% methane)

Using the reported concentrations of these compounds (or any other compound of interest) in LFG, the ratio of the odorant species to methane can be calculated. Based on this calculated ratio the equivalent mass emission rate of the odorant can be deduced from the measured methane emission rate. The odorant ratio will change depending

Odour Source	Methane Flux Rates ($mg\ m^{-2}\ s^{-1}$ – areas, or $mg\ s^{-1}$ – point sources*)	
	Current Study Range (Average)	Range of Reported Values (Bond *et al*, 2000)
Active working area	n/a	$4.2x10^{-2}$
Daily cover	$3.1x10^{-1}$	n/a
Flank –temporary cover (Sandy)	$1.2x10^{-2}$ – $2.4x10^{-1}$	n/a
Flank –temporary cover (Clayey Soil)	$1.0x10^{2}$*	$5.0x10^{-3}$
Temporary Cap (Sandy)	$6.0x10^{-2}$	n/a
Temporary Cap (Soil)	$6.2x10^{0}$	$5.0x10^{-2}$ – $1.0x10^{0}$
Restored (Capped)	0.0 – $4.0x10^{-3}$	$5.0x10^{-5}$ – $4.1x10^{-2}$
Freely venting gas well*	$2.2x10^{3}$ – $4.0x10^{3}$	n/a
Man-hole cover over 1.2m diameter leachate chamber*	$4.6x10^{-2}$	n/a
* Single observation: not to be regarded as typical		

Table 8: Measured Emission Values for Methane from Landfill Odour Sources

Table A2: Physical Properties of Four Selected Mercaptans and Hydrogen Sulphide

Compound	Chemical Formula	Odour Character	MW	BP (^{0}C)	Density (g/ml)	Solubility (ppmw @ 25 ^{0}C)	Pv (mm Hg @ 25^{0}C)	Odour Threshold Values (mg m^{-3}))	
								AEA Reported Range	AIHA Reported Range
Methyl Mercaptan	CH_4S	Rotten cabbage	48	6	0.87	23300	1516	6×10^{-5} -1.6	3×10^{-7} - 6×10^{-2}
Ethyl Mercaptan	C_2H_6S	Rotten cabbage	62	35	0.84	527	527	2.5×10^{-4} – 0.2	6.6×10^{-4} – 10^{-3}
Propyl Mercaptan	C_3H_8S	Not reported	76	57	0.81	N/a	155	2.5×10^{-6} – 1.4×10^{-4}	n/a
Butyl Mercaptan	$C_4H_{10}S$	Skunk	90	98	0.84	55	55	n/a	2.7×10^{-3} - 3.7×10^{-3}
Hydrogen Sulphide	H_2S	Rotten eggs	34	-60	1.5	4000	N/a	10^{-4} -2.8	$1.6 \times 10^{-3} \times 7 \times 10^{-2}$

N/a = not available