

Table of contents	Page number
Chapter 1 – Literature review	1
Chapter 2 – Pilot study; simulation of landfill and setting up parameters of a bioreactor	29
Chapter 3 – Microbial populations in waste and soils; isolation, purification and identification of methanogens and methanotrophs in waste and landfill cover soils	55
Chapter 4 – Methane productions and oxidation in landfills in relation to soil properties	97
Chapter 5 – Summary of conclusion	152
References	162

ABSTRACT

Emission of methane has become a problem in the past decades worldwide. It is believed to have adverse effects on climate change as it is said to be 21 times more potent than carbon dioxide. The main source of methane emission is landfills, which are thus far, the cheapest and most commonly used method of waste disposal. Methane is produced anaerobically by methanogenic bacteria in the landfills and is supposed to be oxidised by soil bacteria in the aerobic region. However, some is lost in the atmosphere.

In this study, we observed the effect of different soils that can be used as landfill cover soil, on the compaction and methane oxidation. Three soil types namely garden soil, sandy soil and uncultivated (veld) soil while landfill soil was a control. At the start of the experiment in a simulated laboratory scale, the soils had bacterial counts of 7.5 log cfu/ml, 5.0 log cfu/ml and 7.0 log cfu/ml respectively. Methane production was at 6% and the reduction levels per soil were 0%, 1% and 0% respectively. Due to less methane production, the waste composition was changed to increase putrecibles, and methane production was increased to approximately 8% on average. The oxidation was not improved, however, addition of compost in the soil at 10% showed better methane oxidation. The soils were further inoculated with isolated cultures from soils and that had little effect on methane oxidation. From this, we concluded that the bacterial numbers had little effect on methane oxidation but addition of organic matter improved oxidation rate. The soil properties showed that garden soil was porous and could not hold together. Sandy soil on the other hand, had little clay and loses water quickly which is one of the parameters for methane oxidation. These two factors may cause soil land shift and expose waste. Veld soil in comparison with the two above, had enough clay and could be compacted better. Although garden soil oxidized methane better than the other soils, the veld soil is recommended as it is more workable than the rest of the soils.

Waste on the other hand, showed that increased putrecibles increased production of methane. However, like in soil experiment, addition of cow dung as extra inoculum had no effect on methane production. The counts were at 5 log cfu/ml at start and ended at 8 log cfu/ml with addition of sewage and cowdung.

The leachate varied with the age of the experiment that is, from straw yellow in week one to blackish-brown in week six. From scanning electron microscope, there was yeast presence in leachate and resulted in fermentation.

LIST OF FIGURES

	page
Figure 1.1	
1.1 Landfill operation	4
1.2 Methane production	6
1.3 Methane structure	7
1.4 Harvesting biogas	21
Figure 2.1	
2.1 Microbial pathways	34
2.2 Bioreactor set-up	36
2.3 System in operation	38
2.4 Connections in system	43
2.5 Gas displacement unit	44
2.6 A & B Isolates from waste and soil	47
2.7 Gas analysis	48
2.8 1 & 2 Electrophoresis gel	48
2.9 Fungal growth on soil	49
Figure 3.1	
3.1 Glycolysis pathways	65
3.2 Methane production	67
3.3 Methane production and oxidation in puddies	75
3.4 Methanotrophs in work fields	77
3.5 a – f Isolated cultures	85
3.6 a – f Waste volume	86
3.7 a & b Colour change in waste	87
3.8 a & b Methanogens in leachate	87
3.8 c – f ESP production by bacteria	88
3.9 a – d Gel electrograms	88
3.10 Leachate colour change	89
3.11 Molecular ecological analysis	94
Figure 4.1	
4.1 Soil structure	104
4.2 Soil analysis	110
4.3 Alternative covers	114

4.4 Geological investigations	114
4.5 Geotechnical test	116
4.6 a & b Set-up in study	129
4.7 Apparatus used	131
4.8 Soil test	133
4.9 i – iii Gas analysis electrograms	140

LIST OF TABLES

Table 1.1	Methanogenic reactions	13
1.2	Volatile organic compounds	25
Table 2.1	Composition of refuse	39
Table 3.1	Characteristic of methanotrophs	68
3.2	ΔG produced by methanogenic reactions	69
3.3	Methanotrophs in soil types	73
Table 4.1	Selected properties	102
4.2	Classification of mechanical elements	103
4.3	Elements in soil	105
4.4	Gas yields	120
4.5	Idealized reactions of bacteria	121
4.6	Modified recipe	130
4.7	Compiled results	136
4.8	Particle size	136

ACKNOWLEDGEMENT

I would like to thank God for giving me the strength and the opportunity for furthering my studies. Let him be praised.

To my supervisors for their time, patience and their guidance. Vince, you are really appreciated. Denise, your editorial input and to all who had an input in finishing this study (technical staff, Chemistry for gas analysis and engineering personnel).

My family, thank you for believing in me and standing by my side, you are great guys.

To my colleagues, thank you very much. Your support is really appreciated, your assistance and support was very helpful.

Anybody who was involved, Springfield landfill for allowing me to take samples. Olifantsvlei waste water treatment for giving me sludge, the environmental engineering for helping me with soil analysis and mechanical engineering department for building some equipment for me.

Lastly, the NRF for financial support.

