



**EFFECT OF COMPACTION AND MOISTURE  
CONTENT ON GAS TRANSPORT AND WATER  
RETENTION IN LANDFILL COVER SOIL;  
MAHARAGAMA LANDFILL AS A CASE STUDY**

BY

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## Abstract

In Sri Lanka, Engineered landfills are not being used and only very few controlled landfills are available. The usual procedure is to cover the waste with a good cover soil without providing gas venting facilities. This can be found at Maharagama dumpsite too. Hazardous gaseous and liquid landfill emissions are major problems of landfills. Since gas venting facilities are not provided, pressure inside the waste layer is very high compared to the atmosphere. Hence cover soil of the waste disposal site plays a major role in emission of landfill gases. Once the solid waste is covered with soil these gases are released to the atmosphere with high pressure, through this cover soil. Therefore studying the cover soil parameters are of paramount importance in evaluating and predicting its future gas emission. The Soil gas diffusion coefficient ( $D_p$ ) and Air Permeability ( $k_a$ ) govern transport and emission of gases to the atmosphere such as of green house gases and volatile organic chemicals in the unsaturated zone. Further, considering gas diffusion coefficient in free air ( $D_o$ ) in this study, soil gas diffusivity ( $D_p/D_o$ ) and air permeability ( $k_a$ ) were measured in the soil which was used as the cover soil of Maharagama waste disposal site. The objectives of the research study were (a) to study about the gas transport parameters of landfill cover soil and (b) to understand effect of compaction and moisture content of the soil on the gas diffusivity ( $D_p/D_o$ ) and air permeability ( $k_a$ ). Measurements were done in 100cm<sup>3</sup> repacked soil samples at different compaction levels with the existing moisture contents( normal compacted samples) and soil water matric potentials from pF= 1, 1.5,2,3,4.1 ( pF = -log,!" If'matric potential in em H<sub>2</sub>O), air dried and oven dried conditions( pF controlled samples).

In-situ air permeability was measured at the field in order to compare the laboratory and field measurements. At the same time the methane concentration in the research area was measured and a methane concentration contour map was produced.

The air permeability changes from 0 to 100 flm<sup>2</sup> while the soil air content varies from 0 to 0.35 m<sup>3</sup> m<sup>-3</sup>, For the pF controlled samples kavaries from 0 to 100 flm<sup>2</sup> and



soil air content varies from 0.02 to 0.35 m<sup>3</sup> m<sup>-3</sup>. In the case of normal compacted soil sample leavaries from 0 to 80 Jlm<sup>2</sup> while the soil air content varies from 0 to 0.28 m<sup>3</sup> mo<sup>3</sup>. The soil gas diffusivity changes from 0 to 0.09 for the pF controlled samples and 0 to 0.07 for the normal compacted samples. The increase of dry density and reduction of water content increases the amount of soil air content and hence increased the soil gas transport parameters. At the fully dry condition and the with the maximum soil air content and the gas diffusion is around 9% of the gas diffusion coefficient in free air. With dry conditions the changes of soil structure properties also affects the soil gas transport, especially for the soil air permeability. According to the methane concentration contour map the methane concentration is very close to the atmospheric methane concentration all around the ground area except at few hot spots.

Considering the results of this research, Maharagama waste disposal site final cover soil can be expressed as a very less gas exchangeable material. However, it is a very good capping material and the produced landfill gas from the waste layer is trying to migrate through the loosely compacted points around the ground area (high methane concentration was observed in few loosely compacted points). Methane concentration contour map further verifies the experimental results. At the same time, due to low gas exchange through the cover soil, the waste layer will be maintained in an anaerobic condition and hence the green house gas (methane) production is definitely enhanced. In the future, methane emission could be increased through the loose compacted points. These points can become (hotspots) and the formation of the cracks around the ground area would also be possible with time. A long term study is needed to observe the future gas emission at this location.

## DECLARATION

I certify that dissertation does not incorporate without acknowledgement of any material previously submitted for a Degree or Diploma in any University and to the best of my knowledge and believe that it does not contain any material previously published or written or orally communicated by other person or except where due reference is made in the text.

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## CONTENTS

<b>CHAPTER 01. INTRODUCTION.....</b>	<b>1</b>
<b>1.1. Details of waste generated in Sri Lanka.....</b>	<b>4</b>
<b>1.2. The study site.....</b>	<b>6</b>
<b>1.3. Scope and objective of the study.....</b>	<b>8</b>
1.3.1. Scope .....	8
1.3.2. Objectives .....	8
<b>1.4. Outline of layout of the report .....</b>	<b>9</b>
<b>CHAPTER 02. LITERATURE REVIEW .....</b>	<b>10</b>
<b>2.1. Gas generation mechanisms .....</b>	<b>10</b>
2.1.1. Evaporation/ volatilization .....	10
2.1.2. Biological degradation or decomposition.....	10
2.1.2.1. <i>Phase I. Aerobic decomposition.....</i>	<i>12</i>
2.1.2.2. <i>Phase II. Anaerobic /thermophilic decomposition.....</i>	<i>12</i>
2.1.2.3. <i>Phase III. Anaerobic/methanogenic decomposition.....</i>	<i>12</i>
2.1.3. Chemical reactions .....	12
<b>2.2. Landfill gases.....</b>	<b>14</b>
<b>2.3. The importance of considering the effect of compaction and moisture content of cover soil to gas transport. ....</b>	<b>15</b>
<b>2.4. Gas transport through the cover soil.....</b>	<b>15</b>
2.4.1. Gas Diffusivity ( $D_p/D_0$ ) .....	16
2.4.2. Air Permeability ( $k_a$ ).....	18
<b>2.5. Water retention in soil .....</b>	<b>20</b>
2.5.1. Water retention curve .....	21
<b>2.6. Soil structure .....</b>	<b>24</b>
<b>2.7. Predictive models for soil gas transport parameters. ....</b>	<b>28</b>
2.7.1. Predictive models for soil gas diffusivity.....	28
2.7.2. Predictive models for soil air permeability.....	31

<b>CHAPTER 03. MATERIALS AND METHODS .....</b>	<b>34</b>
<b>3.1. Introduction.....</b>	<b>34</b>
<b>3.2. Step 1 - Disturbed soil samples. ....</b>	<b>36</b>
3.2.1. Air Permeability ( $k_a$ ) measurements and calculation. ....	37
3.2.2. Measurement and calculation of gas diffusion coefficient. ....	39
3.2.3. Controlling moisture content (pF) of the soil sample.....	42
3.2.3.1. Sand box apparatus .....	44
3.2.3.2. Pressure plate extractor .....	45
<b>3.3. Step 2 – In-situ air permeability .....</b>	<b>46</b>
3.3.1. Measurements of In-situ air permeability ( $k_a$ In-situ).....	46
3.3.2. Calculation of In-situ air permeability.....	47
<b>3.4. Step 3- Undisturbed soil samples.....</b>	<b>48</b>
3.4.1 Measurements for field collected samples.....	48
<b>3.5. Methane concentration contour map of Maharagama waste disposal site.....</b>	<b>49</b>
<b>CHAPTER 04. RESULTS AND DISCUSSION.....</b>	<b>51</b>
4.1. Proctor compaction test results .....	51
4.2. Particle size distribution curve (Combined sieve and hydrometer analysis).....	52
4.3 Atterberg limits test. ....	53
4.4. Specific gravity test results.....	54
4.5. Electrical conductivity test results.....	54
4.6. Air Permeability variation with the soil air content. ....	54
4.7. Soil gas diffusivity variation with the soil air content.....	58
4.8. Water retention curve.....	59
4.9. Tortuosity variation with the soil air content.....	60
4.10. Equivalent pore diameter variation with the soil air content. ....	61
4.11.Methane concentration contour map of Maharagama waste disposal site.....	62
<b>CHAPTER 05. CONCLUSIONS .....</b>	<b>64</b>
<b>REFERENCE.....</b>	<b>67</b>



## LIST OF TABLES

Table 1.1. Municipal solid waste generation in Sri Lanka ( Some major districts) in 2004.....	4
Table 1.2. Comparative waste generation and composition data.....	5



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## LIST OF FIGURES

Figure 1.1.Landfills of Sri Lanka (uncontrolled waste disposal sites) .....	3
Figure 1.2. Overall plan of the mini cricket ground.....	6
Figure 1.3.(a) The gabion wall around the ground.....	7
Figure 2.1.Typical landfill gas evaluation. (Sharma and Reddy, 2004).....	11
Figure 2.2 Three stage biological decomposition of solid waste (Sharma and Reddy, 2004).....	11
Figure 2.3.Water retention curve for a sand, clay loam, clay, and peat. ....	21
Figure 2.4 The first published Water retention curve (Buckingham, 1907).....	23
Figure 2.5. Composition of soil.....	24
Figure 2.6. Phase diagram of soil.....	25
Figure 2.7. Soil pore structure.....	32
Figure 3.1. Testing procedures.....	35
Figure 3.2.Sampling Procedure for the method 1.....	36
Figure 3.3. Schematic diagram to describe air permeability measuring apparatus. ..	38
Figure 3.4.Schematic diagram showing the experimental apparatus used to measure soil-gas diffusion coefficient.....	40
Figure 3.5.Photograph of gas diffusion measurement arrangement.....	40
Figure 3.6. Boundary conditions in the apparatus. ( Jury et al, 2004).....	41
Figure 3.7. Sand box apparatus.....	43
Figure 3.8. Assembled sandbox apparatus as given in the manual of the sand box..	44
Figure 3.9.Illustration of pressure plate extractor.....	45
Figure 3.10.Photo graph of a pressure plate extractor.....	45
Figure 3.11.Mechanism of In-situ air permeability.....	46
Figure 3.12.In-situ air permeability.....	47
Figure 3.13. Pictorial view of Laser Methane detector .....	49
Figure 3.14.(a)-Photograph of site measurements of methane concentration using laser methane detector .....	50
Figure 4.1.Standard Proctor compaction curve for Maharagama waste disposal site cover soil.....	51
Figure 4.2.Particle size distribution curve (combined sieve and hydrometer analysis) .....	52



Figure 4.3. Atterberg limits test results. ....	53
Figure 4.4. Soil air permeability variation with soil air content. ....	55
Figure 4.5. Comparison of existing power law models with the observed data. ....	57
Figure 4.6. Gas diffusivity variations with the soil air content. ....	58
Figure 4.7. Water retention curve for the Maharagama Waste disposal site final cover soil. ....	59
Figure 4.8. Tortuosity variation with the soil air content. ....	60
Figure 4.9. Equivalent pore diameter variation with the soil air content. ....	61
Figure 4.10. Methane concentration contour map for Maharagama waste disposal dump site. ....	62



## LIST OF SYMBOLS

$a_s$	- cross sectional area of the soil sample ( $m^2$ )
$A$	- shape factor (m)
$b$	- Campbell pore-size distribution index (-)
$C_g$	- soil-gas concentration ( $kg\ m^{-3}$ , $mg\ l^{-1}$ )
$C_r$	- relative soil-gas concentration (-)
$C_o$	- oxygen concentration in the atmosphere ( $mg\ l^{-1}$ )
$C_i$	- initial concentration in the diffusion chamber ( $mg\ l^{-1}$ )
$D$	- diameter of the soil sample(m)
$d_{eq}$	- Equivalent pore diameter(m)
$D_p/D_o$	- soil-gas diffusivity (-)
$D_p$	- gas diffusion coefficient in soil ( $m^2\ soil\ air\ m^{-1}\ soil\ sec^{-1}$ )
$D_o$	- gas diffusion coefficient in free air ( $m^2\ air\ sec^{-1}$ )
$g$	- gravitational acceleration ( $m\ sec^{-2}$ )
$k_a$	- air permeability ( $\mu m^2$ )
$k_{a, in-situ}$	- In-situ air permeability( $\mu m^2$ )
$k_{a,100}$	- air permeability at soil water matric potential at 100 cm $H_2O$ ( $\mu m^2$ )
$L_s$	- length of the sample(m)
$Q$	- flow rate of the gas through the soil layer( $m^3/s$ )
$X$	- pore connectivity factor( $m^3$ )
$\epsilon$	- soil air content.( $m^3/m^3$ )
$\eta$	- dynamic viscosity (g/ cm s)
$\Delta P$	- pressure difference across the sample
$\theta$	- soil water content( $m^3/m^3$ )
$\psi$	- soil water potential (m)
$\Phi$	- total porosity of the soil( $m^3/m^3$ )
$\epsilon_{100}$	- soil air content at soil water matric potential at 100 cm $H_2O$ ( $m^3/m^3$ )
$\tau$	- tortuosity (-)