Characteristics of municipal solid wastes from selected plots located at up-slope and down-slope of the dumping site: A case study in Udapalatha/Gampola

N.K. Wijewardane[1], Koide Takahiro[2], M.I.M. Mowjood[3], Kawamoto Ken[2], L. C. Kurukulasuriya[4]
[1]Post Graduate Institute of Agriculture
University of Peradeniya
Peradeniya
Sri Lanka
[2] Institute for Environmental Science and Technology
Saitama University
255 Shimo-Okubo, Sakura-ku
Saitama 338-8570
Japan
[3]Department of Agricultural Engineering
Faculty of Agriculture
University of Peradeniya
Peradeniya
Sri Lanka
[4]Department of Civil Engineering
Faculty of Engineering
University of Peradeniya
Peradeniya
Sri Lanka
E-mail:nkw.pdn@gmail.com

Abstract: *Open dumpsite has become the most widely used and common practices in most of the developing countries in waste management due to their lack of will, technology, capital and virtuous attitudes. This has elevated the risk to the ecosystem and humans derived by the improper dumping of waste in bare lands, sloping lands (valleys, river banks), wet lands etc. Characterization of waste is an important primary stage in studying dumpsites in sloping lands to identify its effects and potential remedial actions, and to develop new technologies to reduce their adverse effects on the environment and society. In this research, waste characteristics of some selected plots located at up and down slope of a dumpsite were studied to identify the possible difference and their relationships with the slope. The results revealed that waste characteristics such as ash content, combustible content, ignition loss and aggregated soil content vary in the plots located at up and down slope, suggesting that the rolling and sliding of larger particles in high sloping dumpsites has a profound effect in varying waste characteristics. This was further confirmed by the particle size distribution of both plots.*

Keywords: *Waste characteristics, sliding and rolling of waste, up and down slope, waste characteristics, open dumpsites.*

1. INTRODUCTION

In developing countries municipal solid waste management has become a serious issue due to their inability to manage their waste in an environmentally and human friendly manner so far. As a result the implementation of improved land disposal practices is succeeding at varying rates depending upon the available resources and national regulatory standards for municipal solid waste management. The need to improve land disposal practices is being forced along by highly concentrated populations, where rural residents are moving to cities resulting in rapid urban population growth which has created an increasing demand for the development of new technologies for better waste management and disposal methods. However, when the developing countries cannot afford such an advanced and new methods to mitigate the environmental and social effects, illegal open dumping dominates the scenario.

Open dumpsites, being the most common and immediate solution to dispose the waste generated by the municipalities of the developing countries induced by their lack of will, technology, capital and virtuous attitudes to perceive waste as resource, has been unable to diminish the environmental and social issues caused by the discarded waste. The opposition from the general public for the naissance created by the open dumpsites, has forced the administrative parties to localize the dumpsites in remote areas where less inhabited by humans. This has lead the dumpsites to be created in remote areas generally where the population is less and thus generated many environmental issues in these areas. Hence, most of the waste generated by the developing countries is being openly dumped (World bank, 2011) in bare lands, valleys, river banks, wet lands etc. threatening the ecosystem to be degraded in an increasing rate.

Characterization of waste is the process of determining the chemical and physical characteristics of waste which is an important primary stage of studying dumpsites to identify their effects and potential remedial actions and to develop new technologies to reduce their adverse effects on the environment and society. Characteristics of waste in dumpsites depend on various aspects including its geophysical nature and environmental conditions. Slope is an important geophysical factor in dumpsites which has a profound effect on waste characteristics. As per Johannessen and Boyer (1999) most of the dumpsites located in sloping lands and the hypothesis of this study is that the up and down slope waste characteristics could be different in such dumping in sloping lands.

So that study of the variation of the characteristics of waste dumped in sloping lands is of great significance in identifying the important physical and chemical processes occurring in the dumpsites which ultimately causes the environmental degradation. The objective of this study was to identify the possible variation of waste characteristics of up slope and down slope in open dumping in slopping land.

2. METHODOLOGY

2.1. Site selection

The selected dumpsite was located near the right bank of Mahaweli river where a steep slope of 36 % exists in Udapalatha Pradeshiya Sabha (PS) in the central province of Sri Lanka which has been used by both Gampola Urban council and Udapalatha PS for around seven years to dump their waste and it has been abandoned six months earlier before waste sampling on December 2011, so that dumpsite conditions do not change during the study period. This dumpsite is located in the wet zone of Sri Lanka where the average annual rainfall is above 2000 mm with an average annual temperature of 24.7 ^{0}C (Statistical Abstract, 2010).

2.2. Sampling

Samples were obtained from easily accessible two plots from the middle transect of this abandoned site to represent the sloping topography. One sample was taken from the surface of up slope (Top - N 07^{0} 08' 34.2'', E 80^{0} 34' 42.1'') and the other from the surface of down slope (Bottom - N 07^{0} 08' 34.4'', E 80^{0} 34' 40.9'') (Figure 1). The distance between the sampling points was 50 m with an elevation difference of 18 m accounting for 36 % of slope. The samples were collected into air tight polythene bags with an air trap and brought to the laboratory for the analysis.

2.3. Laboratory analysis

The samples were immediately prepared for the drying by mixing the sample on the floor with a shovel followed by composite sampling (Figure 2) and then a part of the sample containing approximately 5-10 kg, was selected for drying at 110 ^{0}C for 48 hours.

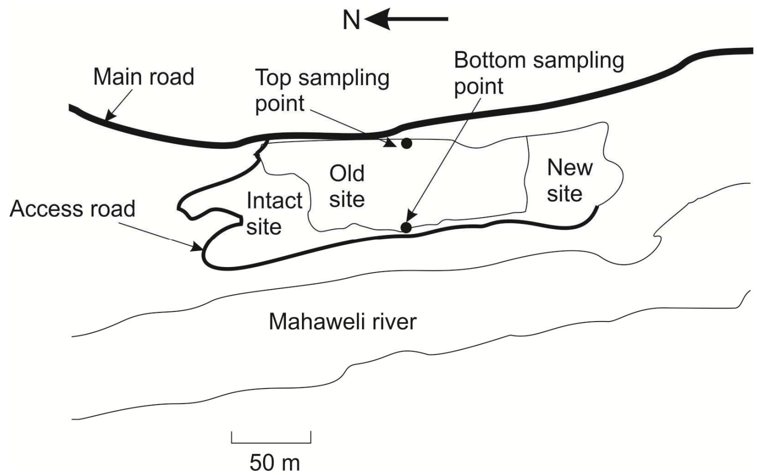

Figure 1 Sampling points of the Udapalatha/Gampola dumpsite

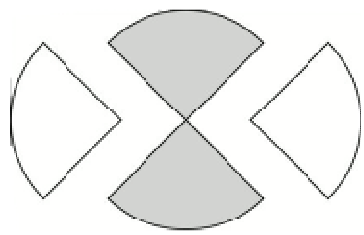

Figure 2 Conceptual diagram of divided sample into four segments

Bulk density and the moisture content were determined. The dried samples were then categorized into different waste types such as Kitchen waste, Paper, Hard plastic, Soft plastic, Metal, Glass, Ceramic, Leather & Rubber, Textile, Grass & Wood, Rock, Cemented material, Aggregated soil and Others to obtain the composition of the waste followed by the determination of ash content of each category by ignition at 800 ºC for two hours. Particle density of the samples was obtained according to the JIS A 1202 Japanese standards (Equivalent to ASTM D854-10) for the dried samples followed by the particle size distribution (JIS A 1204; Equivalent to ASTM D422-63). Raw parts of the samples were subjected to the analysis of pH, EC and liquid limit & plastic limit test according to the JIS A 1205 (Equivalent to ASTM D4318-10). All these parameters were selected to identify all the possible differences due to geophysical conditions and the processes.

After the determination of ash content of the sample, combustible content (C) was calculated as follows:

$$C = 100 - M_w - A_{wet} \qquad (1)$$

where M_w is moisture content (%) and A_{wet} is the ash content (%) wet basis. Lower calorific values were calculated by proximity analysis as shown in Eq. 2 and 3 as explained by Watanabe (2000) and the reference values were obtained from a previous JICA report (2003):

$$H_{total} = \sum ((A(i) + V(i)) / (W \times H(i)) \qquad (2)$$

$$H_{available} = H_{total} + 0.6 \times (\sum (M_{air}(i) + M_{ult}(i)) + 18/2\ (hydrogen)) / W \qquad (3)$$

where A(i) is the ash content of i^{th} waste component, V(i) is the volatile content of i^{th} waste component, H(i) is the heat value of i^{th} waste component, $M_{air}(i)$ is the air dryable moisture content of i^{th} waste component, $M_{ult}(i)$ is ultimately dryable moisture content of i^{th} waste component and W is the total weight.
Ignition loss (L_i) is calculated as follows:

$$L_i = 100 - A_{<2mm} \qquad (4)$$

where $A_{<2mm}$ is the ash content (%) of the particles of size less than 2 mm diameter.

3. RESULTS AND DISCUSSION

Variation of the measured parameters of the two sampling points is shown in Table 1 which can be used to compare the parameters between the two plots to identify the effect of slope on waste characteristics.

As shown in table 1, most of the parameters were same for both plots located at up and down slope except ash content, combustible content, ignition loss, pH and aggregated soil content. Ash content is higher in the plot at down slope and so that combustible content is lower in the plot at down slope than that of the plot at up slope as these two parameters are inversely related. Ignition loss is lower in the plot at down slope and this may be due to the elevated ash content in the plot at down slope. When considering the waste composition, aggregated soil percentage is higher in the plot at down slope than in the plot at up slope (Figure 3).

Table 1 Comparison of data between up and down slopes

Parameter	Up slope	Down slope
Moisture content (%)	26	26
Ash content (%)	199	622
Combustible content (%)	577	14
Unit volume mass (kg m^{-3})	5.71	6.00
Lower heating value (kcal kg^{-1})	739	613
Particle density of < 10 mm (g cm^{-3})	2.61	2.59
Particle density of < 2 mm (g cm^{-3})	2.31	2.29
pH	12.8	7.9
EC (µS cm^{-1})	267	224
Ignition loss (%)	90	7
Liquid limit (%)	58.0	42.1
Plastic limit (%)	57.6	41.8
Plasticity index	0.4	0.3

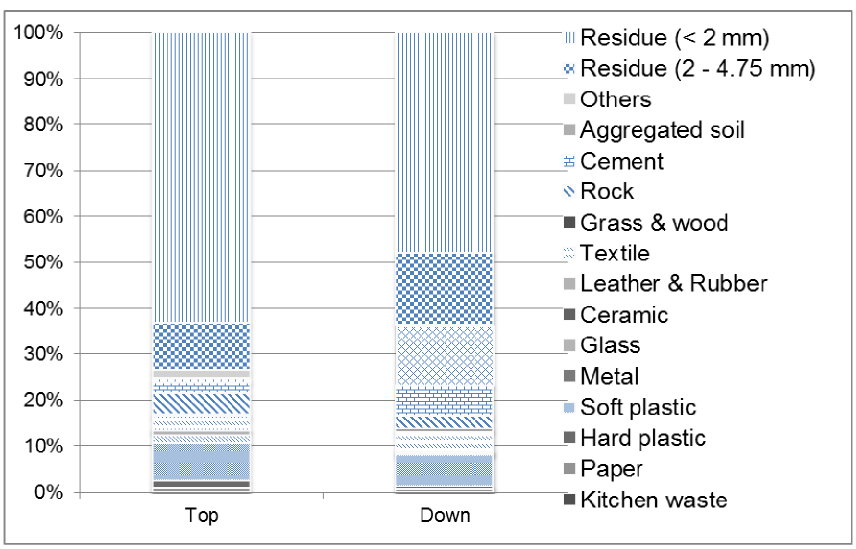

Figure 3 waste composition of up and down slope

The particle size distribution (Figure 4) of these samples clearly shows a difference of distribution of both of the plots compared to that of the intact soil. The plot at down slope has more larger particles compared to the plot at up slope within the range of 1 – 10 mm of particle size where more smaller particles are retained in the plot at up slope. This situation can be further explained as a result of settling of waste induced by three main phenomenon i.e. rolling, sliding and erosion (Figure 5).

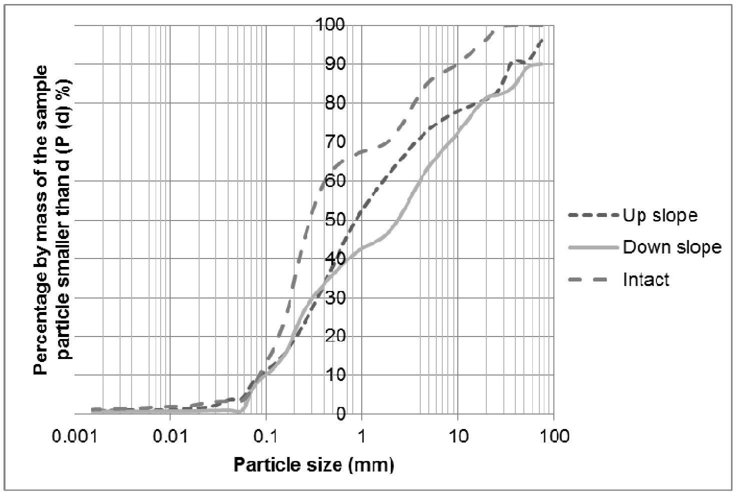

Figure 4 Particle size distribution of up and down slopes

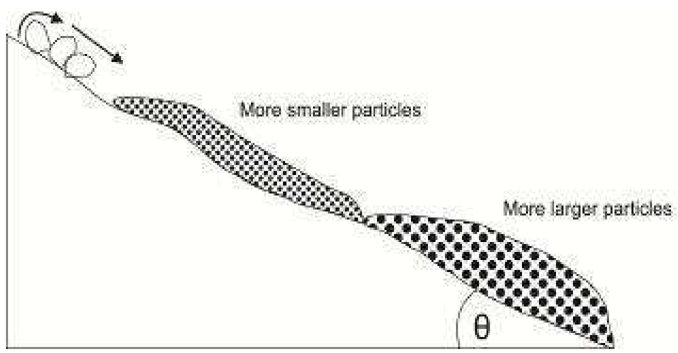

Figure 5 Conceptual diagram of sliding and rolling of waste leading to settle larger particles in down slope

According to Xu *et al.* (2008) the peak friction angle of waste is 18.6^{o} and this is the maximum angle in which waste can be retained without rolling and sliding. As the slope of the studied dumpsite is 36 % ($\theta = 19.8^{o}$) which is larger than the peak friction angle, waste is subjected to rolling, sliding and erosion which ultimately results in settlement of larger particle in down slope and smaller particles retained in upslope (Figure 5). The particle size distribution of up and down slopes clearly suggest this settlement of larger particles in the down slope as the larger particles are higher in down slope and so that it is obvious that the rolling and sliding have become significant than the erosion in this site otherwise more smaller particles would have been eroded and settled in the down slope.

4. CONCLUSIONS

Characteristics of waste in some selected plots located at up slope and down slope are different in ash content, combustible content, ignition loss and aggregated soil content. This is mainly due to accumulation of larger particles including aggregated soil in down slope as a result of rolling, sliding and erosion of waste dumped in up slope. Particle size distribution of these locations clearly shows the rolling and sliding of larger particles in high sloping dumpsites, where the slope is higher than the peak friction angle of 18.6^0. This will be helpful to properly select sampling locations in dumpsites for characterisation studies.

5. ACKNOWLEDGMENTS

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