Reducing the Volume of Municipal Solid Waste in Karadiyana Dumpsite by Using Compaction Method

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***Abstract*—** *The Karadiyana dumpsite is located 25 km from the financial capital of Sri Lanka. It serves two urban councils and four local authorities. It is considered to be one of the most polluted dumpsites in Colombo District. Water retaining marshy habitats of some rare and indigenous fauna and flora species have been affected because of these low lying waste dumping lands. Due to land fragmentation like issues arisen with the increasing population, the land area for the waste dumping has become limited. On the same time, the volume of waste collected in dumping sites has been increased. The Karadiyana site has also being threatened by the overfilling problem due to Municipal Solid Waste (MSW). As a solution for this matter, a Composting and Material Recovery program is being conducted at the site which has not proven to be sufficient to solve the problem. This dumpsite will soon be unsuitable for the use, if this problem remains. Reducing the waste volume by compacting MSW and providing more space for waste dumping can be introduced as one possible solution for this issue. Reduction of volume in dump directly combines with compaction ratio. In this research, the compaction ratios in MSW in Karadiyana dumpsite was calculated and the volume reduction by using laboratory tests were studied. As the results of this research, maximum compaction ratio range 3.1 to 1 through 5.7 to 1 and volume reduction in dumpsite was in the mix sample 464831 m^3 and separating category was 482887 m^3. Resulting in a Volume difference about 18056 m^3. Considering Karadiyana dumping site, this volume is not large. Therefore, both methods are acceptable but sample separation is rather a difficult task in a site of this nature.*

***Keywords*—** Solid waste, Compaction, Volume

I. INTRODUCTION

According to the record of January 2015 at Karadiyana dumping site, the reported total waste intake to Karadiyana dumping site is around 300 to 350 MT/day and the details of the contributions from different local authorities and authorized institutes have been Dehiwala MC is the major contributor that is around 42%. The Contributions by Moratuwa MC, Kasbawa UC and Boralasgamuwa UC are 28.57%, 10% and 4.29% respectively. The total contribution from the other authorized institutes is around 14.29%.

The details of the analysis of January 2015 in Karadiyana dumping site including the composition of the incoming waste streams are as follows,

a. The short term compost-able component of the incoming waste is around 52% and around 182 Mt/Day in weight basis.
b. The Long term Biodegradable component of the incoming waste is around 27% and around 94 Mt/Day in weight basis.

It is important to note that the quantity of Hazardous materials such as leather, rubber and clinical waste percentages are very much low, that is less than 1%.
The percentages of non-perishable materials such as polythene, plastic, paper, glass and metal are remarkable which gives a clue for the profitable material recovery program at the dumping site.

Open dumping is an environmental hazardous waste disposal method but it is not affecting people directly if the dumping site is isolated from them. With the government failure of establishing dumping sites away from high population density areas, habitats closer to dumping sites became problematic.

People near by the dumping sites have to face different types of health, social and economic problems. Karadiyana is one of the dumping sites in Colombo area and it has being operated for last three decades. It has become very difficult to find a solution for these dumping sites. Separation of mixed wastes of various categories at the dumping site makes the recycling procedure harder. The composting plant operates at Karadiyana is not capable of using all the categories of wastes. And also some sides of elevated dumping areas causes Hazardous and poisonous elements leach down to the ground water and contaminate the water bodies around.

Ultimately, a little portion of waste been dumped is recycled at Karadiyana dumping site which is insufficient

in preventing the site becoming unusable. Open dumping method become unsuccessful when there is no any measures to reduce waste.

As a solution for this, Composting and Material Recovery program is being conducted at the site but that program is not enough to solve the problem. This dumping site will be unusable near future if anyone cannot find a successful solution for this waste overfilling problem. Therefore the main objective of the research is to find the optimum compaction of solid waste and thereby to land fill the current dump site in a sustainable manner.

II. LITERATURE REVIEW

Open dumping is an environmental hazardous waste disposal method but it is not affecting people directly if the dumping site is isolated from them. With the government failure of establishing dumping sites away from high population density areas, habitats closer to dumping sites became problematic. People near by the dumping sites have to face different types of health, social and economic problems. It has become very difficult to find a solution for these dumping sites. Separation of mixed wastes of various categories at the dumping site makes the recycling procedure harder.

The composting plant operates at Karadiyana is not capable of using use all the categories of wastes. And also some sides of elevated dumping areas slip and crack. Hazardous and poisonous elements leach down to the ground water and contaminate the water bodies around. Ultimately, a little portion of waste is recycled at Karadiyana dumping site which won't be sufficient of preventing the site is been unusable. Open dumping method become unsuccessful when there is no any measures to reduce waste.

Following are some waste reduction methods used in the fields of waste management.

1. Burned in open pits,
   In this method, municipal solid waste disposal has been conducted by disposal on low-value lands where the wastes were burned in open pits.
2. Sanitary landfills,
   Sanitary landfills differed from the open-pit burning and disposal since burning was no longer allowed and each day's waste was covered with a thin layer of soil. This soil layer was designed to reduce, but not necessarily eliminate releases of odor and prevent vermin from entering into the waste
3. Development of the Sanitary Landfill
   Burning was stopped and a few inches of soil was placed over the waste at the close of each day. When the landfill became full, some additional soil was placed over the landfill to grade the landfill surface. Sometimes these closed landfills were then used for parks, industrial/commercial development and other purposes.
4. High pressure (>7 kg/cm^{2}compaction),
   Compact systems with a capacity 7 kg/cm^2 up to 351.5 kg/cm^2 or 5000 lb/in^2 come under this category. In such systems, specialized compaction equipment is used to compress solid wastes into blocks or bales of various sizes.

When wastes are compressed, their volume is reduced, which is normally expressed in percentage and computed by equation (Ramachandra, 2009)

Volume of waste before compaction, m^3 =Vi

Volume of waste after compaction m^3 = Vf

- Volume reduction % = (Vi-Vf)/Vi*100
- The compaction ration of the waste is given as,

Compaction ratio =Vi/Vf

Samples are separated as Long term Biodegradable, Cotton, Nylon, Plastic, Polythene, PVC, Rubber, News Paper, Cardboards, Sponch /Rejiform, Construction Demolitions, Glass and Easily Bio degradable. Classification system suggested by Landva and Clark (1986) helped to prepare the classification of Municipal Solid Waste (MSW).

II. METHODOLOGY

After having a comprehensive interview with the professional related with the Karadiyana dump site, the history of dumping site, present waste management method and previous researches related to the Karadiyana dumpsite were discovered. After the initial survey, twenty five samples were collected from the selected area in the dumping site. There in the dumpsite a particular place had been allocated for dumping of Easily Bio degradable waste and other places contained mixed MSW.

These mixed wastes contained, long term Biodegradable, Cotton, Nylon, Plastic, Polythene, PVC, Rubber, News Paper, Cardboards, Sponge /Regiform, Construction Demolitions, Glass and Easily Bio degradable.

With the survey of the previous researches done in the field it was realize that more than 7 kg/cm^2 compaction effort is required for the compaction test. And also, the compaction ratio of the samples was measured.

By using the laboratory condition for compaction, compaction ratio was measured. The tensile testing machine was prepared for testing (figure 1). The tensile testing machine, concrete mould and mechanical attachment were used for this compaction test.

MSW Samples were collected from May to September in 2015. Twenty five samples were collected during that period. These collected samples were brought into Civil Engineering laboratory, KDU for testing. Compaction test was done for mix sample as well as sample separated by categories. Laboratory testing was done using the method below.

a. Mould was fixed accordingly.
b. Initial weight of sample was recorded.

Figure 1: Tensile testing machine, concrete mould and mechanical attachment

c. Mould was filled with sample and compressed by tensile testing machine.
d. Compressed height and load were recorded. This compression work was done until the mould fill with compressed sample
e. Mould was removed and sample cube was collected as shown in figure 2.
f. Volume and weight of cube were recorded.
g. Moisture content (%) and compaction ratio were calculated.
h. The same process was followed for all samples.

Figure 2: Compacted MSW Sample

After the laboratory testing, graph content compaction ratio variations with waste type, moisture content and soil content were plotted. Variation of compaction ratio was recognized with waste type, moisture content and soil content by using graphs. According to the recognition of compaction ratio, the optimum one was found.

These optimum compaction ratios are able to be used for the calculation of volume reduction in Karadiyana dumping site.Volume of the landfill after the compaction and the volume reduction of total dumping site after the compaction will have to be calculated using compaction ratio and approximate volume of the dumpsite.

III. Results and Discussion

A. Composition of the sample

Samples were separated in to categories and weighed. The

Total average weight of each category was calculated using those weights. According to the results, the normal composition of a sample is shown in the table

Table 01: average composition of waste

Category	Total avg %
Food, Garden and Animal waste	79.25
Textiles	2.55
Plastic	1.59
Polythene	8.26
PVC	0.13
Rubber	0.11
Paper, Cardboards	6.07
Sponge/Regiform	0.0011
Construction Demolitions	1.02
Glass	0.94
Others	0.17
TOTAL	100

B. Mixed sample test results

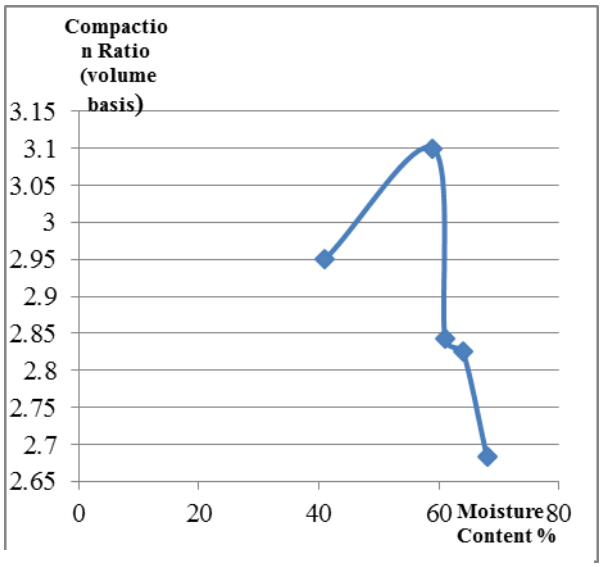

Figure 3: Compaction ratio variation moisture content in Mix sample

Other than moisture content, particle size distribution of the collected samples directly affected to the variation of the compaction ratio. Normally, the compaction ratios varied in between 3.1 to 2.68. Moisture content in mix sample varied in between 41% to 68%. Percentage of Food, Garden and Animal waste affected to the moisture content stay in this range. According to the figure;

- Optimum moisture content is 59%.
- Maximum compaction ratio is 3.1.

C. Paper, cardboards test results

According to the composition of the sample, Paper, Cardboards percentage is 6.07%. Moisture content is varied in between 4.5% to 11%. Other than moisture content, type of paper directly affected to this high variation of the compaction ratio. Optimum moisture content is 7.7%.Maximum compaction ratio is 5.7.

D. Textile sample test results

According to the composition of the sample, textiles percentage is 2.55%. Textile contents nylon and cotton. Compaction ratio changes according to the percentage of nylon and cotton in the textile, other than the variations in moisture content. Content of nylon and cotton affected to the compaction ratio changes, Optimum moisture content is 29%. Maximum compaction ratio is 4.19.

E. Plastic test results

According to the composition of the sample, plastic percentage is 1.59% and small amount of moisture content is in plastics. Other than, the moisture content, hardness of plastic is affected to compaction ratio. Plastic in dumping site have various type of hardness as examples PVC pipes needs a higher compaction compared with a plastic bottle. So the compaction rate changes in a larger range. It affects this sudden reduction of the compaction ratio. Optimum moisture content is 3.1%. Maximum compaction ratio is 4.8

F. Food, Garden & Animal waste

According to the composition of the sample, the maximum percentage of the sample is Food, Garden and Animal waste. The variations of the compaction ratio after mixing soil with the samples in different ratios, compaction ratio varied in between 3.6 to 4.6 and soil content varied 10% to 50%.Optimum soil content is 19%. Maximum compaction ratio is 4.6.

G. Comparison of mixed waste and the individual waste

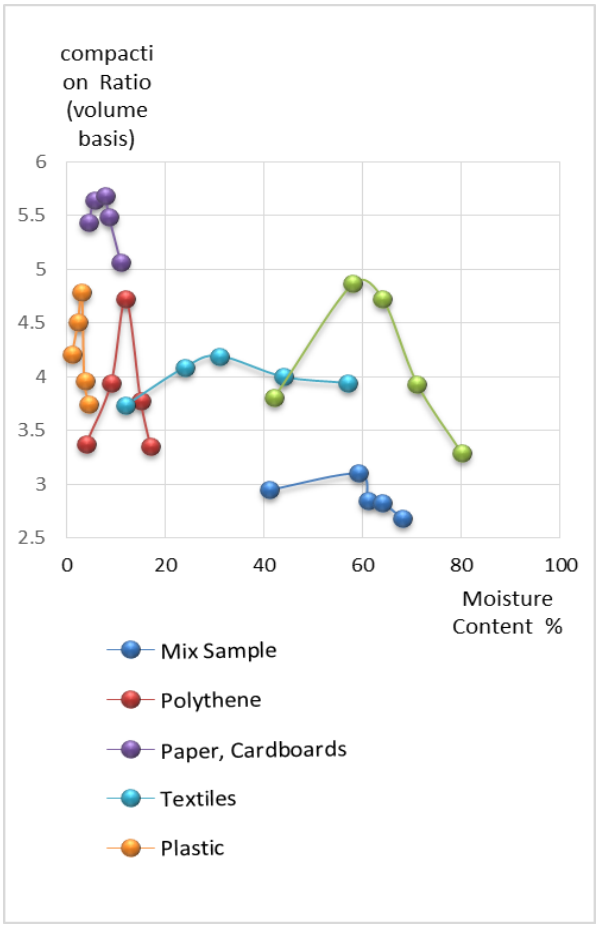

Figure 4: Comparison of the mixed & individual MSW

H. Existing volume at the open dumpsite Karadiyana

The volume of dump has been increased by 156678 m^3 according to volume calculation of karadiyana management during last five years.

Considering both values, the approximate volume is 686179 m^3.

1) Karadiyana dumpsite compacted as mix sample,

- Approx. volume in Karadiyana dumpsite = 686179 m^3
- Maximum compaction ratio in mix sample = 3.1
- Compacted volume = 686179/3.1 = 221348 m^3
- Volume reduction = 686179-221348 = 464831 m^3

Table 02: reduction of each waste by compaction

Category	Total volume (m^3) in category	Maximum compaction ratio	Compacted volume (m^3)	Volume reduction %
Food, Garden & Animal waste	671234.6	4.90	136986.7	79.68%
Textiles	28187.6	4.19	6727.3	76.13%
Plastic	17731.1	4.80	3694.0	79.16%
Polythene	119423.7	4.70	25409.3	78.72%
Paper, Cardboards	173705.9	5.70	30474.7	82.46%
Total	1010282.9		203292.0	79.88%

Among the two methods above, maximum reduction in the compacted volume can be achieved by separating samples into categories before compaction, but there is not a big difference in both results.

- Compacted volume in mix sample is 221348 m^3
- Compacted volume in sample separating category is 203292 m^3
  -Volume difference is about 18056 m^3.

Considering Karadiyana dumping site, this volume is not large. Therefore, both methods are acceptable but sample separation is rather a difficult task in a site like this. High technology and labour force are needed. When considering that factor into the account, compaction of the mixed waste rather than separating into categories is suitable.

There is ability to compact dump after separating them in To categories. And also there is ability to separate the waste as polythene, plastic, paper, glass and metal and those categories can be used for recycling process. 79.25% of Food, Garden and Animal waste in Karadiyana dumpsite can be used as materials for compost production in this research study maximum compaction ratio range 3.1 to 1 through 5.7 to 1. Compaction effect will be increased maximum compaction ratio come to this range.

III.CONCLUSION

Compaction ratio in MSW is mainly depend on the Category of waste, Moisture content in waste and Compaction effort provided to compact the waste.
According to category of mix sample, the maximum percentage of waste, 79.25% is Food, Garden and Animal waste.
Other than that, all the categories of waste are below 9% from the total weight.
Soil content varied 10% to 50%. Compaction ratio is varied in between 3.6 to 4.6. Maximum compaction ratio and Optimum soil content % are 4.6, 19%. Compaction efforts were provided in laboratory test in between 1466kN/m^2 to 3377kN/m^2 range in whole research.
The volume reduction in dumpsite was in the mix sample 464831 m3 and separating category was 482887 m3. Resulting in a Volume difference about 18056 m3. Considering Karadiyana dumping site, this volume is not large. But when considering other factors such as labour needed to categorize these waste. Mixed MSW compaction is much more practical as a solution for the overfilling of the dumpsite.

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