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INVESTIGATING THE POSSIBILITY OF MIXING FOOD AND YARD WASTE FOR AN EFFECTIVE COMPOST PRODUCT AT AN EXISTING PILOT-SCALE COMPOSTING PLANT

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ABSTRACT

Composting is a natural biological process that reduces the waste stream into a product that can be used as a conditioner. The existing Pilot-Scale composting plant at General Sir John Kotelawala Defence University (KDU) totally utilizes yard waste for its function. However, a large amount of food waste is also being generated from the kitchen of the University. The main objective of this research was to investigate the possibility of mixing food and yard wastes in the process of composting to determine the optimum ratio between food and yard waste for an effective compost product. In addition, the effect of certain parameters on the effectiveness of composting process, sand content, particle size, and the weight and volume reduction during the composting process was investigated. The research was conducted at the existing Pilot-Scale composting plant at KDU premises. Different ratios of yard and food waste were mixed together to determine the most appropriate ratio between yard and food waste for effective compost product. The results of the study revealed that the parameters measured during the research were within the standard range when the percentage of food waste varies between 0% and 30% by volume. The most effective ratio between food and yard are 83% and 87%, respectively. Therefore, the existing Pilot-Scale composting plant at KDU can be modified by utilizing a mixture of food and yard waste to produce effective compost product.

KEY WORDS: *Compost, Food waste, Yard waste, Optimum ratio*

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1. INTRODUCTION

Generation of solid waste is a significant problem in most of the developing countries (Eheliyagoda & Prematilake, 2016). Solid Waste Management is the one thing just about every city government provides for its residents. While service levels, environmental impacts and costs vary dramatically, solid waste management is arguably the most important municipal service, and it serves as a prerequisite for other municipal actions (Hoornweg & Bhada- Tata 2012). Recycling is one of the Solid Waste management processes used in all around the world. There are two methods of recycling of organic wastes, i.e. aerobic digestion and anaerobic digestion of organic wastes. Composting is an aerobic digestion process used most commonly in the world.

Composting is the option that, with few exceptions, best fits within the limited resources available in developing countries where the biogenous waste is the main fraction in the public waste collection. (Rouse et el., 2008; Binner, 2016; Cofie et al., 2016). Technical guidelines on Solid waste management in Sri Lanka (p. 16) defines composting is the controlled biological decomposition of organic solid wastes materials under aerobic conditions. Also it is a process of letting nature transform organic materials into a material with environmentally beneficial applications. The process uses various microorganisms such as bacteria and fungi to break down the organic compounds into simpler substance. By properly managing air, moisture and nutrients, the composting process can transform large quantities of organic material into compost in a relatively short time.

Compost is an organic soil conditioner that has been stabilized to a humus-like product that is free of viable human and plant pathogens and plant seeds. It does not attract insects or vectors, can be handled and stored without nuisance, and is beneficial to the growth of plants. There are different composting methods available around the world. Turned windrows method is the most common composting method in Sri Lanka (CEA, 2016). All of the compost plants operated under the Pilisaru project which was implemented by the government of Sri Lanka in the year 2008 as a solution for the municipal solid waste, uses a low cost, static windrow-turning composting system. (CEA, 2016)

Kotelawala Defence University (KDU) has a Pilot-Scale composting plant which also uses windrow method. It uses only yard waste for the composting process. However, a large amounts of food waste are also being generated from the kitchen of the University. The possibility of using both yard waste and food waste for the composting process for an effective compost product was investigated in this research. The effectiveness of the composting process is dependent upon the environmental conditions present within the composting system, i.e. oxygen, temperature, moisture, material disturbance, organic matter and the size and activity of microbial populations. Traditionally, it tended to be a low-cost process with most applications being for single and low-density development. Organic decomposition naturally occurs in soils and composting artificially creates this soil environment. This process, which normally takes several months, can be speeded up and controlled using various techniques.

There are some specific guidelines for aerobic composting process in Sri Lanka, according to the technical guidelines on solid waste management in Sri Lanka which is published by Central Environmental Authority. When considering about the parameters that effect on the composting process, each parameter has an optimum value for an effective composting. Also there are some specifications for Compost from Municipal Solid Waste and Agricultural Waste (Sri Lanka Standard 1246: 2003).

Main objective of this research is to identify the optimum ratio between yard waste and food waste to achieve the efficient compost product. In addition, the effect of certain parameters, such as moisture content, pH, and temperature on composting process was also determined during the research. Further, the percentages of volume and weight reduction, sand content and the particle size were also determined for each sample.

With proper control of moisture, temperature and aeration, a composting plant can reduce the volume and weight of raw waste materials. Composting generally results in a 50 to 70 percent reduction in volume and a weight loss in the order of 40 to 80 per cent. Some of the shrinkage and weight loss is due to the transformation of loose, bulky material into finely textured compost and the loss of CO_2 and water to the atmosphere. During the process, nitrogen is lost to the atmosphere as ammonia (NH_3). In addition, the greenhouse gases, carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) are emitted. Despite some losses, composting does retain most of the nutrients provided by the raw material and stores them as stable organic compounds.

2. METHODOLOGY

2.1 PREPARATION OF SAMPLES

The yard waste collected within the KDU premises and the leftover food discharged from the KDU kitchen were used for all the experiments for this research. Ten different ratios of both garden and food waste were mixed together by their volume as shown in table 1, and those mixtures were left for aerobic digestion by providing required conditions for the process.

Table 1 - Mixing ratios of garden and food waste

Mixture no:	Garden waste		Food waste	
	%*	V** (l)	%*	V** (l)
1	100	150	0	-
2	90	135	10	15
3	80	120	20	30
4	70	105	30	45
5	60	90	40	60
6	50	75	50	75
7	40	60	60	90
8	30	45	70	105
9	10	15	90	135
10	0	-	100	150

*=Percentage, **= Volume

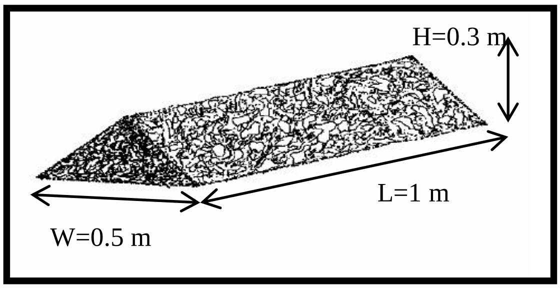

Figure 1 - Dimensions of windrow used for the experiment

2.2 MEASUREMENTS OF PARAMETERS

Relevant measuring instruments such as DO meter, and pH meter were used to test the conditions such as oxygen content and pH value. Selected parameters measured during the process are temperature, moisture content, pH value and the oxygen content.

Methods of measurements are as follows;

1. Moisture content was measured by weighing a known amount of waste sample that was taken from the mixture before and after drying.
2. Temperature was measured using a temperature probe in pH meter, always in identical locations.
3. pH was measured using a pH meter. The probe will be inserted into the identical locations.

All the measurements were taken twice a week in two locations of the profile, in the depths of 0.25, 0.50 and 0.75 m from the top. With the reduction of volume of piles, the measurements were taken from mid depth of the profile in three locations. The average values of each parameter were determined by using measured values.

Figure 2 – Measurement of Parameters

Initial and final weight and the volume of each mixture were measured and recorded to determine the percentages of weight reduction and volume reduction respectively. In addition, sand content and particle size of the digested samples were determined. For that, sieve analysis and sand content test were conducted in the KDU laboratory.

Turning was done twice a week to provide required air to the piles and moisture content of each pile was maintained by watering.

Figure 3 – Manual turning of compost samples

3. RESULTS AND DISCUSSION

3.1 VARIATIONS OF PARAMETERS WITH THE TIME

3.1.1 VARIATION OF MOISTURE CONTENT

According to Figure 4, moisture content variation of each sample is within the limits (45% – 65%). Therefore, the effect of moisture content is same for each sample.

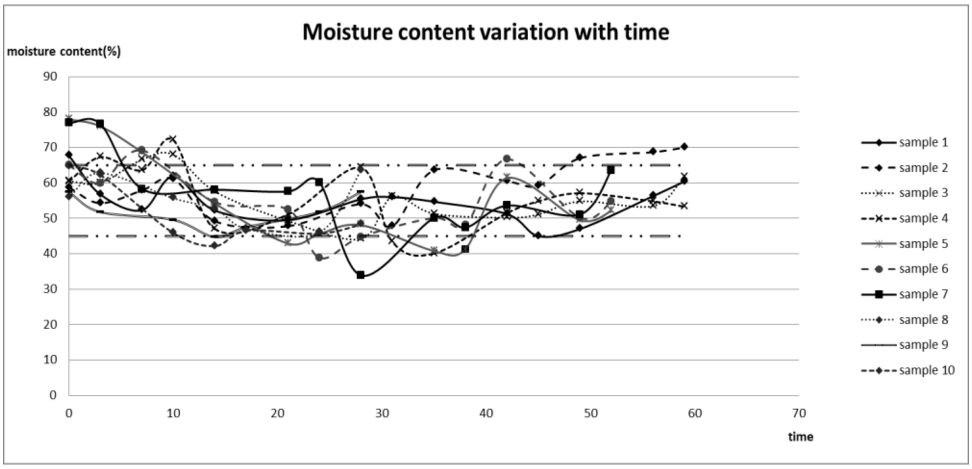

Figure 4 - Moisture content variation with time

3.1.2 VARIATION OF TEMPERATURE

Figure 5 shows the temperature variation of composting samples. In cold composting method, the temperature does not exceed 30°C. Initial temperature of each sample is around 27°C - 30°C (atmospheric temperature). Except the sample 1, all other samples have temperatures higher than 30°C within the 1st week and then the temperature value gradually decreases to 30°C. After the 1st week, the temperature slightly varies around 30°C. The reason for these variations is that in normal practice, composting begins at ambient temperature (mesophilic range) and progresses to and through a thermophilic phase, followed by a descent to the mesophilic level.

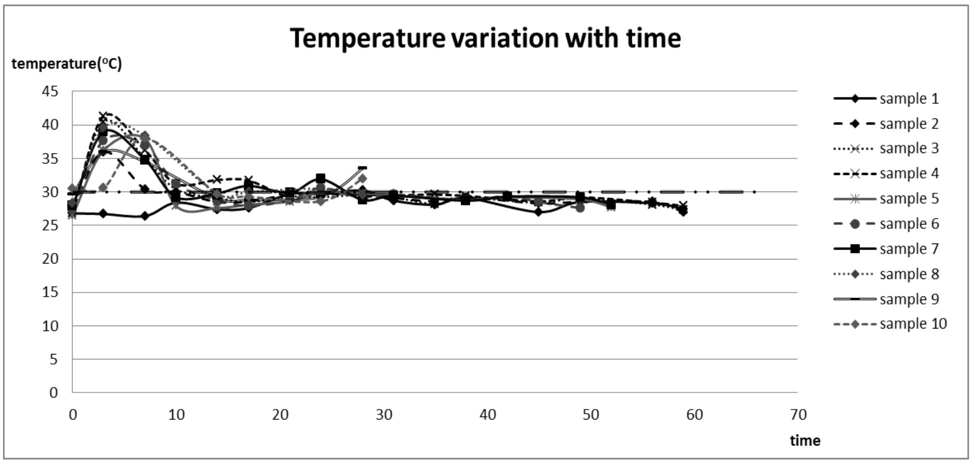

Figure 5 - Temperature variation with time

3.1.3 VARIATION OF pH VALUE

By maintaining oxygen content, temperature and moisture content values of each sample variation of pH was determined along with the time. Figure 6 shows the variation of pH values in each sample within the duration of composting compared to the limit of 5.5 – 8.

Samples 1, 2, 3 and 4 show a similar kind of variation in pH. Initially those curves have a drop in pH. However, after a 2 week period of composting process, it soon begins to rise to levels as high as pH 9.0-10.0. The initial drop reflects the synthesis of organic acids. The acids serve as substrates for succeeding microbial populations. The subsequent rise, in turn, reflects the utilization of the acids by the microbes. Initial drop of pH in sample 4 around day 10 is much higher than that of the other 3 cases. That means the formation of acids in sample 4 is higher than that of the other 3 samples. In the mid of the 3rd week, again pH drops down to 7 and again it rises up to pH 9.0-9.5 at the start of the 4th week. Again, it shows formation of acids and utilization of acid by the microbes. After completing an 8 week period of composting, the pH comes to 7.0 and the sample becomes neutral. At this stage compost samples become suitable for the plant growth.

Sample 5 has a different kind of variation than all other samples. It shows several drops and rises in pH in a systematic way. However, the drops are smaller compared to the rises in pH. By gradually increasing the pH, it reaches up to pH 9.0 at the end of the 5th week and after the 6th week it drops down to pH 7.5.

Sample 6 and 7 have almost similar kind of variation in pH. Initially they have pH around 4.0 due to higher percentage of food waste than in previous samples. At day 14 both reach to pH 10.0 due to the utilization of acids by microbes. This peak value was reached by the samples 6 and 7 earlier compared to the sample 1- 4. Again, they drop in pH down to 4.0 due to formation of acids and subsequently it increases. After completing 6 weeks, they reach pH 7.5.

Sample 8, 9 and 10 have relatively low pH values around 4.0-5.0 throughout the period due to the higher percentage of food waste. Formation of acids in the samples 8, 9, 10 is much higher than in that of other samples.

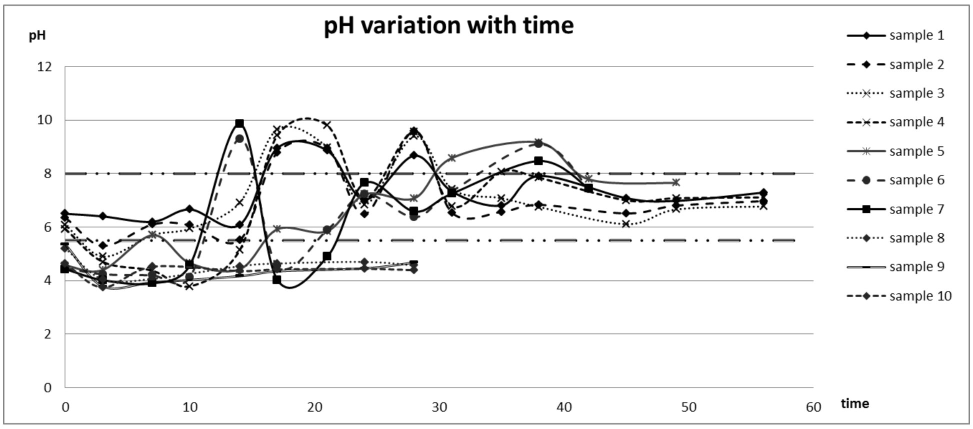

Figure 6 - pH value variation with time

3.2 VOLUME AND WEIGHT REDUCTION

According to Table 2, percentages of volume reduction of sample 1 to sample 7 are varied around 85% and sample 8, 9 and 10 have around 90% of volume reduction. Expected volume reduction in composting is within the range of 50-70%. All the samples exceed the 80% reduction.

Table 2 demonstrates the weight reduction percentages of each sample. When we use garden waste only, the percentage of weight reduction is very less compared to the other samples. The percentage of weight reduction gradually increases with the increment of the ratio of food waste. Sample 1 - 4 have a 10% gap within each sample whereas samples 4 - 7 have smaller increments in percentage of weight reduction.

Table 2 - Volume and Weight reduction percentages

Experime nt no	Initial volume (m^3)	Volume after digestion (m3)	Initial weight (kg)	Weight after digestion (kg)	Percentage of volume reduction (%)	Percentage of weight reduction (%)
1	0.15	0.02	10.36	4.761	86.7	54
2	0.15	0.0235	15.7	5.645	84.3	64
3	0.15	0.0225	20.47	5.445	85	73.4
4	0.15	0.0215	28.86	4.12	85.7	85.7
5	0.15	0.019	22.21	2.861	87.3	87.1
6	0.15	0.023	34.36	3.195	84.7	90.7
7	0.15	0.0255	47.25	4.445	83	90.6
8	0.15	0.018	63.9	4.336	88	93.2
9	0.15	0.015	74.2	3.552	90	95.2
10	0.1	0.007	56.4	2.334	93	95.3

3.3 SIEVE ANALYSIS

Residue percentage increases with the increase of the ratio of food waste. The residue percentages of each sample are shown in Table 3. Sample 1 to 5 have less residue percentages of 10-15%. The percentages of residues of samples 8,9,10 increase due to the agglomerate of food waste particles. When increasing the food waste percentage of the mixture, the void spaces in the sample are reduced. Due to that, an anaerobic condition could occur within the sample. Also, an unpleasant odour is released with the increment of percentage of food waste in the mixture. That may also result in the conglomeration of food particles with the increment of bacterial operation within the sample. It is not a characteristic of effective composting. According to the sieve analysis samples 1-5 are more effective than samples 6-10.

Table 3 - Residue percentages

Experiment no	Initial weight of sample (g)	Weight of residues (g)	Residue percentage (%)
1	100	10.9	10.9
2	100	14.1	14.1
3	100	13.6	13.6
4	100	9.1	9.1
5	100	16.3	16.3
6	100	21.7	21.7
7	100	20.6	20.6
8	100	33.9	33.9
9	100	40.2	40.2
10	100	63.2	63.2

3.4 SAND CONTENT

Sand content of final product should be less than 10% by mass, according to the Specifications for Compost from Municipal Solid Waste and Agricultural Waste (Sri Lanka Standard 1246: 2003). Except sample 1, others have sand content less than 10% according to the Table 4.

Table 4 - Sand content percentages

Experiment no	Initial weight of sample(g)	Weight of sand (g)	Sand content percentage (%)
1	100	11.5	11.5
2	100	3.2	3.2
3	100	2.7	2.7
4	100	3.9	3.9
5	100	3.2	3.2
6	100	3.5	3.5
7	100	9.1	9.1
8	100	1.4	1.4
9	100	1.8	1.8
10	100	1.5	1.5

Sand content percentages of all the samples are not very high. All are within the acceptable range except sample 1. However, we can see that with the increase of garden waste percentage in the sample, the percentage of sand content increases.

4. CONCLUSIONS

The results of the study revealed that, when the food waste percentage of the mixture increases, the void spaces are reduced. Due to that, an anaerobic condition can occur within the sample. That may result in the conglomeration of food particles. That is not a characteristic of effective composting. Also, an unpleasant odour comes into existence with the increment of percentage of food waste in the mixture. They were not effective due to the conglomeration. It seems that, the samples having higher percentage of food waste than 70% in the mixture are not effective under normal conditions. It may require special conditions and controls. The parameters that were measured during the research were within the standard range when the percentage of food waste varied between 0% and 30% by volume. The most effective ratio between food and yard wastes was 30% and 70% by volume. In addition, the average weight and volume reduction of the samples were 83% and 87%, respectively. Therefore, the existing Pilot-Scale composting plant at KDU can be modified by utilizing a mixture of food and yard waste to produce effective compost product.

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