Effect of Leachate Application on the Composting of Organic Fraction of Municipal Solid Waste

S Wijetunga[1*], KVDR Rajitha[1] and C Malwana[2]

[1*]Department of Agricultural Engineering, Faculty of Agriculture, University of Ruhuna, Kamburupitiya, Sri Lanka
[2]Central Environmental Authority, Kirindiwela, Sri Lanka

Abstract
The disposal of generated leachate is one of the major problems in the composting of Organic Fraction of Municipal Solid Waste (OFMSW). Therefore, it is essential to have a proper, environmental friendly leachate disposal method. The objective of this study was to determine the quality of compost produced from OFMSW by the application of leachate generated during composting process. Research was conducted in composting yard at "Green Park" land filling site Kirindiwela, Western Province of Sri Lanka. The experimental compost beds were prepared (1x1x1 m) manually in the composting site. Completely randomized design (CRD) with four different leachate dilution levels (100%, 50%, 25% and 0% leachate), each having three replicates was used for the experiment. After one week, leachate (35 L) was added to experimental composing units while turning of composting beds, once a week. Temperature was measured daily while Electrical Conductivity (EC), pH, Moisture Content (MC), Organic Carbon (OC) were recorded weekly. At the end of the study (~ 12 Weeks), composting quality parameters were also determined. Temperature profiles in experimental composting piles during study period showed that the composting process was satisfactory. pH though was acidic (5-7) at the beginning, reached to near 8 at the end of the study. Showing that the organic matter was hydrolyzed by microorganism, electrical conductivity was high (13-15 mS) at the beginning but finally reduced (~10). The electrical conductivity of compost in all experimental composting piles were higher than the that of recommended EC (0.5-4.0 mS) values while pH, MC, OC and bulk density were within the recommended range. Further, Nitrogen, Phosphorus, Potassium contents were well within the recommended range. Even though significant increase of nutrients (N, P and K) in leachate added compost was noted, all nutrients were within the recommended level. Therefore, it can be concluded that use of leachate does not have significant bad impact on compost quality. Addition of leachate reduces the disposal burden of leachate while increasing the nutrient levels of compost significantly.

Keywords: Compost, Leachate, Municipal Solid Wastes
***Corresponding Author**:* swije@ageng.ruh.ac.lk

Introduction
Disposal of municipal solid waste (MSW) is one of the major environmental problems many developing countries like Sri Lanka. Unregulated and improper disposal of MSW is one of the major reasons for the environmental pollution. The numbers of technological options are available for the safe disposal of wastes. Composting is one of the important technologies that can be used for the safe disposal OFMSW while producing an environmentally safe organic amendment to enrich the soil. In Sri Lanka, Numerous efforts have been taken to dispose OFMSW by means of composting in recent years. Local authorities that basically involve in the disposal of MSW are supported financially and technically by Central Environmental Authority of Sri Lanka to buildup small and medium scale composting facilities. However, a number of difficulties are being faced by the operators of these composting facilities. One of the main problems associated with the composting facilities is the management and treatment of leachates, which has a high organic load, cannot be stored in the plant (Trujillo et al., 2006). Moreover, it cannot be disposed to open environment due to the threat of environmental pollution. Therefore, it is essential to have a proper method for the safe disposal of generated leachate without creating problems to the environment. Numerous physical, chemical and biological methods have been taken to treat leachate generated form composting facilities (Wiszniowski et al., 2006; Trujillo et al., 2006). It has been shown that those methods have advantages and disadvantages over each other. However, the use of leachate for the improvement of compost quality has not been sufficiently reported.

Therefore, this research was carried out to determine the quality of compost produced from OFMSW by the application of leachate, which is produced during composting process, to the composting piles during composting process at several occasions. Moreover, it attempted to find the optimum dilution ratio of leachate to be applied to the organic wastes which are being composted.

Materials and Methods

This study was conducted at "Green Park" land filling site operated and managed by the Central Environmental Authority of Sri Lanka in Kirindiwela, Gampaha. At the beginning of the study, the composition of waste was determined by separating the different components of waste, manually, to find out the fraction of organic wastes which are suitable for composting. Three leachate levels and a control with three replicates were used in this study (100% - T1, 50% - T2, 25% - T3, 0%-T4). Volume of leachate or water applied to each experimental compost bed was about 35 L. The completely randomized design was used in the experiments.

The organic fraction was separated from MSW and used for the experiment. Required amounts of OFMSW were taken for the preparation of 12 compost beds according to the experimental design. Compost beds were prepared (~1x1x1 m) in the composing yard maintained by the management of Green Park landfilling site. Leachate required for the study was collected from the composting site. After one week, while turning of compost beds, leachate was applied to the beds at selected dilution ratios based on the experimental design, once a week until sixth week. However, turning of composting beds were performed further four weeks (up to 10th week) without the application of leachate. Then, all experimental composting beds were kept for curing further two weeks.

The different parameters that influence on the composting process were determined at predetermined time intervals during composting process. Temperature was measured daily throughout the composting process by using a thermometer. Temperatures were taken from three places of the composting piles (same height from the top). The height of composting piles at which temperature were recorded are ~30 cm from the top. Moisture content (MC), and Organic Carbon (OC) were recorded according to the standard methods, weekly. The pH and EC were determined according to the method outlined by Gupta (2004).

At the end of the study (~ 12 Weeks), the composting quality parameters (Nitrogen, available Phosphorus, Potassium, etc.) were also determined in all experimental composting piles to find out the effect of leachate on composting process. Micro Kjeldhal method was used for the determination of Nitrogen while available phosphorous was determined by the borax extractable phosphorus method (Gupta, 2004). Bulk density of the final compost was also measured using standard methods. Recovery percentage of the compost was determined based on the fresh weight of waste and weigh of final compost, which shows the efficiency of the composting process.

Results and Discussion

The bulk density of waste received to Green Park land filling site was ~735.2 kg/m^3. Biodegradable fraction of MSW was about 70 % indicating that the wastes are suitable for composting as well as other methods that involve microorganism such as biogas production. Temperature is very important parameter for the microbial activity during composting process. Under optimal conditions, composting process proceeds through three phases namely the mesophilic phase (10-40^{o} C), the thermophilic phase (40-60^{o} C) and cooling phases (40-10^{o} C) and the length of the composting phases depends upon the nature of the organic matter and the efficiency of the process, which is directly related to the degree of aeration and agitation (Tuomela et al.,2000).Temperature variation during composting process in all composting experimental units showed almost similar pattern indicating that the composting process proceeds with ideal conditions. The quick drops and rises of temperature in composting piles during study period occurred due the turning of composting piles. Temperature at the end of the study was almost similar in all composing beds showing reduced the microbial activity.

Organic Carbon content of experimental composting piles reduced gradually during the study period indicating that microorganism extracts energy for their growth and development by consuming organic materials. At the beginning of the study organic Carbon content was high in all experimental composting piles and it decreased with the time due to the consumption of Carbon by microorganism. Carbon contents of all leachate added treatments were higher than the control. However, during composting process, no significant differences between treatments ($p > 0.05$) were noticed (Table 1).

Generally, soluble and easily degradable carbon sources, such as monosaccharides, starch and lipids are utilized by microorganisms in the early stage of composting, decreasing the pH since the end products of this processes are organic acids. In the next stage microorganisms start to degrade proteins, resulting in ammonium and an increasing the pH (Tuomela et al., 2000). However, in our study, the pH variation was quite different and it was gradually increased up to sixth week and then reduced, in all experimental composting piles.

The electrical conductivity of composting piles in different treatment was also determined. At the beginning of the study EC was between 13-15mS/cm and increased up to 19mS/cm indicating the increasing the solubility of organic materials by microorganisms. The common problem with all the biowaste composts is high EC values (above 4.0 mS/cm) and EC correlated mainly with the concentration of nitrogen salts (Manios, 2004). With the consumption of organic materials by microorganism EC (Denitrification) was gradually reduced at the end of the composting process.

Nitrogen contents of the final compost of different treatments were significantly different ($p<0.05$) may be due to different ratios of leachate application. Treatments with100 % leachate showed the highest Nitrogen content (1.29%) while the lowest value (0.93 %) was recorded in control where water was applied in instead of leachate.

C/N ratio is very important parameter for the microbial degradation processes. Even though C/N ratio of final composting were within recommended range, a significant difference was noticed ($p<0.05$). Phosphorus (0.69 %) and Potassium (1.14 %) contents were significantly higher than that of other treatments in final product of compost produced by adding 100% of leachate. The bulk density of compost produced by the application of leachate was higher than that of control where only water was added.

Important properties of compost and their standard values (in Sri Lanka) are shown in the Table 1. Physical and chemical parameters determined in compost of this study were compared with the standard values and it was found that the most of those parameters are well within the standard values (Gamage et al., 2011).

Based on the study it can be concluded that the application of leachate during composting process improve the nutrients such as Nitrogen, Phosphorus and Potassium in compost. No significant changes of pH and EC were observed during composting process by addition of leachate. Although the most of quality parameters of compost in all experimental composting piles were within the recommended values (except pH and EC), the compost output (recovery rate) in the second treatment where 50% diluted leachate was used higher than that of other treatments. Therefore, the use of 50 % diluted leachate can be recommended to apply during composting process. Moreover, the use of leachate for composting can improve the quality of compost while addressing the disposal problems of leachate. However, further studies are suggested to evaluate the cost and benefit of the application of leachate.

Table 1: Comparison of selected physical and chemical parameters of compost produced in this experiment with Sri Lankan standards

Property	SLS Standard	Experimental Compost			
		Treatment1	Treatment2	Treatment3	Control
pH	6.5-8.0	8.09[b]	8.08[d]	8.25[a]	8.04[c]
EC	0.5-4.0	11.39[b]	10.26[d]	11.94[a]	10.5[c]
Moisture %	20-30	22.98	25.63	22.38	26.88
OC % (Min)	20.00	23.52[a]	25.63[a]	24.00[a]	17.19[b]
Nitrogen % (Min)	1.00	1.29[a]	1.08[b]	1.02[c]	0.93[d]
C:N ratio	10-25	18.21:1[d]	20.71-1[b]	23.5:1[a]	19.09:1[c]
Phosphorus (%)	0.5	0.69[a]	0.67[b]	0.62[c]	0.51[d]
Potassium (%)	1	1.14[a]	1.12[b]	1.04[c]	0.81[d]
Bulk Density (kg/m^3)	475-600	520.07[d]	538.55[b]	505.73[c]	572.76[a]

References

Gamage DAS, Wijesekara SSRMDHR., Sarathchandra G W N L, Basnayake BFA, & Costa WA JM (2011). Estimation of Nitrate and Phosphate Leaching from Lysimeter Simulation of Rice Straw Landfill Bioreactor and Evaluation of Fertilizer Quality of Resulting Compost. *Tropical Agricultural Research*, *22*(1), 220-228.

Gupta PK, (2004). *Soil, Plant, Water And Fertilizer Analysis.* book, Agrobios (India). Retrieved from https://books.google.lk/books?id=xAKsnAEACAAJ

Manios T, (2004). The composting potential of different organic solid wastes: Experience from the island of Crete. *Environment International, 29*(8), 1079–1089. https://doi.org/10.1016/S0160-4120(03)00119-3

Trujillo D, Font X, & Sanchez A, (2006). Use of Fenton reaction for the treatment of leachate from composting of different wastes.*Journal of Hazardous Materials, 138*(1),201–204.m https://doi.org/10.1016/j.jhazmat.2006.05.053

Tuomela M, Vikman M, Hatakka A, & Itävaara M, (2000). Biodegradation of lignin in a compost environment: A review. *Bioresource Technology, 72*(2), 169–183. https://doi.org/10.1016/S0960-8524(99)00104-2

Wiszniowski J, Robert D, Surmacz-Gorska J, Miksch K, & Weber JV, (2006). Landfill leachate treatment methods: A review. *Environmental Chemistry Letters*. https://doi.org/10.1007/s10311-005-0016-z