Vermicomposting of municipal solid wastes

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Abstract The purpose of this study is the production of compost out of municipal solid waste (MSW) through the method of vermicomposting using *Eisenia foetida*. Within the scope of this study, the quality of municipal solid waste compost that is produced as a result of composting process through the method of vermicomposting and the conditions of treatment were compared. 14 reactors were used and each of them had 3 kg of waste capacity. In five reactors, municipal organic solid waste that underwent a predecomposition in other five reactors, municipal organic solid waste that did not undergone a predissociation was going to be vermicomposted. In four reactors, municipal organic solid waste were composted through classical methods and these reactors were observed as control reactors. Throughout the study, some analyses was carried out on the samples of leachate that came through the reactors and the process of compost was observed. In order to determine the quality of compost that was produced after the completion of composting process, the analyses including fermenting degree (rottegrad), cytotoxicity, hygiene (salmonella) and heavy metal (copper, lead, cadmium, nickel, zinc, chrome) were implemented.

Keywords: Vermicomposting, *Eisenia foetida*, compost quality, municipal solid waste.

1. Introduction

Vermicomposting is a biological degradation process based on the synergistic interaction of microorganisms and worms [Diaz, 1993]. While microorganisms are responsible for the biochemical dissociation of organic matter, worms are the process manager for ensuring that the surface area for microbial activity and thus biological activity is dramatically increased in terms of degradation and processing of the substrate. Worms function like mechanical stirrers and break up organic matter [CRC Press, 2004; CRC Press, 2011]. Biological, physical and chemical state regimes gradually reduce the C/N ratio, increase the surface area of microorganisms, and provide a more suitable environment for microbial activity and decomposition [Dominguez and Edwards, 2004]. Vermicomposting can reduce the volume of domestic organic waste by 79-85% [Nair *et al.*, 2006]. Vermicomposting method from organic wastes having about 50-55% of domestic solid waste and to determine the quality of the produced compost. The amount of waste produced in Istanbul is 14500 tons/day. Composting organic parts of domestic solid wastes by vermicomposting is considered as an alternative sustainable solution for reducing the amount of organic waste to landfill sites. Restrictions on the storage of biodegradable wastes are introduced in the regulation on the regular storage of wastes [Turkish Official Gazette, 2010] The amount of biodegradable waste that is produced in 2005 is said to be 75% by weight of total biodegradable waste produced in 2005, reduced to 50% within 20 years (2018 year) and 35% within 15 years (2020 year). Therefore biodegradable reduction of the amount of organic waste is an alternative to remediation compatible with waste management strategies in Turkey and vermicomposting is a sustainable method of disposal that serves this purpose.

2. Materials and Methods

In this study, vermicomposting method, compost production with actively composting of worms was done. Usability of the produced compost has been evaluated. Within the scope of this study, 10 vermicompost reactors with triple moving cascade were used. In the study, Eisenia foetida worm (Figure 1-f) was preferred due to organic waste consumption in vermicompost method, high level of worm reproductive activity and resistance to environmental conditions. The inventory and consumables supplied and used within the scope of the study are given in Table 1. Reactors and solid waste used in this study are presented in Figure 1. Properties of waste and reactor are given Table 1. Parameters analyzed in vermicomposting, measurement method and frequency are given Table 2. Comparison of chemical properties of classical&vermicompost are presented Table 3 [Erşahin, 2007]. Composting and vermicomposting are capable of degrading various types of organic waste, thus enabling them to be adopted widely [Lin *et al.*, 2016].

Table 1. Some initial physical and chemical properties of waste used in this study for vermicomposting and classical composting.

Parameters	Reactors and waste properties		
	R1	R2	R3

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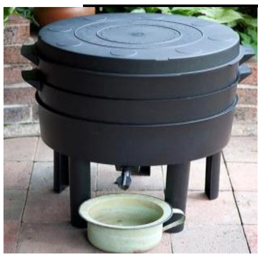
	R1	R2	R3
Water content, (%)	68	64	71
pH	6,96	7,24	7,1
TKN	19,4	23,2	18,6
C/N	21	23	26

Table 2. Parameters analyzed in vermicomposting, measurement method and frequency in this study

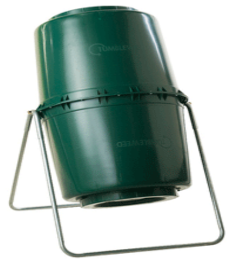
Parameters	Analysis Method	Measurement frequency
pH	pH meter	Weekly
Conductivity	Conductivity Meter	Weekly
COD	(TMECC,2001)	Weekly
Organic Substances	Ash Oven	Weekly
Volatile solids	Methods of Soil Analysis	Weekly
TKN	Methods of Soil Analysis	Weekly
Water content	Methods of Soil Analysis	Weekly
NH4-N	Methods of Soil Analysis	Weekly
Phosphate	SM 4500P-D Tin Chloride	At the beginning and end
Heavy metals (Cu, Zn, Cd, Cr, Pb, Ni)	Atomic absorption spectrophotometer	At the beginning and end
Temperature	Portable thermometer	Daily
TOC	Methods of Soil Analysis	Weekly
Self-Heating Test	Dewar Self-Heating	at the end
Salmonella Test	Salmonella Rapid Test	at the end
Worm Quantity	Gravimeter	Weekly
	Leachate Analysis	
pH	pH meter	Weekly
Conductivity	Conductivity Meter	Weekly
COD	APHA (1995) 5220-D	Weekly
Heavy metals	Atomic absorption spectrophotometer	At the end of each study

Table 3. Comparison of chemical properties of classical&vermicompost

Parameters	Classical compost	Vermi-Compost
pH	7,8	6,8
Conductivity, mmhos/cm	3,6	11,7
TN, %	0,8	1,94
NO3-N, ppm	156,5	902
TP, %	0,35	0,47
K, %	0,48	0,7
Ca, %	2,27	4,4
Na, %	<0,01	0,02
Mg, %	0,57	0,46
Fe, ppm	11690	7563
Zn, ppm	128	278
Mn, ppm	414	475
Cu, ppm	17	27
B, ppm	25	34
Al, ppm	7380	7012



(a)



(b)

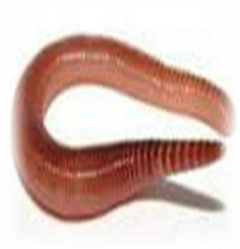
(c)

(d)

(e)

(R1)

(R2) (R3)



(R4) (f)

Figure 1. Reactors used in the study and organic wastes putted in the reactors: **a.** Vermicomposting reactors, **b.** Classical composting reactor, **c.** Mixed municipal solid waste, **d.** Separated organic waste for composting and vermicomposting, **e.** Organic waste putted in the classical composting reactor, **R1**. Organic waste putted in the R1 reactor for vermicomposting, **R2**. Organic waste putted in the R2 reactor for vermicomposting, **R3.** Organic waste putted in the R3 reactor for vermicomposting, **R4.** Organic waste putted in the R4 reactor for vermicomposting.

3. Results and discussion

In this study, the compostability of domestic solid wastes under controlled conditions was investigated using Eisenia foetida worms. Since worms are sensitive to environmental conditions, they were found to die during the study period. Due to worm deaths, the vermicompost product has become harder. The project aimed to determine how the composting process would be affected if pre-composting was not carried out or not, whether or not the domestic solid waste was subjected to pre-decomposition, size reduction was applied / not applied. It has been determined that Eisenia foetida worms adapt more quickly to pre-decomposed wastes. It has been found that reducing the solid waste size positively affects the composting process. It has been concluded that subjecting organic solid wastes to vermicomposting after classical precomposting positively affects vermicompost quality. Figure 3 and Figure 4 are presented in pictures about vermicomposting processes for 1 weeks and six weeks, respectively.

(R1) (R2)

(R3) (R4)

Figure 3. The appearance of the reactors after one weeks.

(R1) (R1)

(R1) (R1)

Figure 3. The appearance of the reactors after six weeks.

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