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Characterization of Municipal Solid Waste Generating at UVAS Ravi Campus, and its Conversion into Compost Using *Lumbricus Terrestris*

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Abstract:

A predictable production of municipal solid waste ranges between 1.3 and 1.9 billion tons per year all over the world and has become an increasing problem day by day while being expected to increase almost 2.2 billion tons per year by 2025. Today established nations are facing a big problem in the management of municipal solid waste with the development of industries. 25 million tons of the solid waste is produced every year. Vermicomposting is a simple and cost-effective method to decompose several types of crop residues and agro industrial wastes. The aim of the present study was to evaluate the nutrient status of compost and vermicompost prepared by two earthworm species namely *Eisenia fetida* and *Lumbricus terrestris*. It has been estimated that one kg of the organic matter is consumed by earthworm in a day. Castings of the earthworms are rich in phosphorus, nitrogen, potassium, calcium and magnesium. Proximate analysis indicates that vermicompost contains 1-1.5 percent phosphorus, 1.5-2 percent potassium and 2.5-3 percent nitrogen. Depending upon the quality of the substrate vermicompost also contains hormones, vitamins and enzymes. These all characteristics are improved by increasing enzymatic and biological activities of earthworms. Vermicomposting is like receiving gold from garbage to improve richness of the soil. Ultimate product of the vermicomposting comprises more hormone like complexes, nutrients such as Mg, Ca, K, N, P, vitamins, enzymes and fewer heavy metals as compare to traditional composting.

Keywords: Traditional compost, Vermicompost, Characterization of MSW, Earthworms, Physiochemical parameters, Heavy metals

1. Introduction

Vermicomposting is an effective technique to recycle on-farm wastes into valued manure. Vermi-composting is one such organic technique that can be used for the conversion of the bakery industry slush into manure (Yadav et al., 2015). In vermicomposting earthworms are used for the production of vermicompost. Compost is a mixture of worm castings, organic material, humus, living earthworms and other micro-organisms. Conversion of massive organic wastes into low volume nutrient enriched end product is called composting (Yousefi et al., 2013). With-in the rapid developments of industries production of municipal solid waste (MSW) has been increased and its quantity has been increasing day by day. Structures and quantities of MSW differ from country to country as well as from region to region and district to district. Income level and socio-economic structures of people are the main reasons of these variations.

Moisture content and calorific value analyses are important parameters for waste characterization (Ozcan et al.,

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2016). Waste that is generated from industries, municipal activities, and human settlements is generally considered as municipal solid waste. Municipal solid waste also generates from public areas such as leftover from streets and gardens and leftover from domestic such as glass, newspaper and metals and leftover from waste water treatments such as manure and mud. Waste of paper industries and domestic wastes are also significant in terms of vermicomposting (Amouei et al., 2017). Vermicomposting technology has industrial as well as domestic value in numerous countries like USA, Italy, Japan and Canada. In 1970 Canada stared the technology of vermicomposting (Singh and Sinha 2022). 75 tons of the organic waste is being treated per week. Aoka Sangyo Co. Ltd is a well-organized company of japan which process 1000 tons of organic waste from food and pulp industries per month. Italy and Philippines also have well organized vermicomposting plants to process organic wastes (Nath and Singh 2016; Bhat et al., 2018). Castings of the earthworms are rich in phosphorus, nitrogen, potassium, calcium and magnesium. Proximate analysis indicates that vermicompost contains 1-1.5 percent phosphorus, 1.5-2 percent potassium and 2.5-3 percent nitrogen. Beneficial microbes such as bacteria, protozoa, fungi and actinomycetes are also present in vermicompost (Hoitink and Fahy 1986).

There are about 3000 species of earthworms all over the world. Species of the earthworms generally used for vermicomposting includes *Eisenia feotida, Lamito mauritti, Perionyx excavates, Eisenia andrie, Lumbricus terrestris, Lumbricus rubellus* and *Dravida willsi* (Arancon et al., 2004). Municipal solid waste needs ratio 1:1 of nitrogen and carbon for active composting (Follet et al., 1981). Ultimate product of the vermicomposting comprises more hormone like complexes, nutrients such as Mg, Ca, K, N, P, vitamins, enzymes and fewer heavy metals as compare to traditional composting (Grappelli et al., 1987). Vermicompost comprises of macronutrients as well as micronutrients (Pigatin et al., 2016). For effective vermicompost progression ideal temperature extended from 18-67°C, electrical conductivity oscillated from 0.70-80 μscm^{-1}, pH 5.9-8.3, moisture content 10.6-80% (Singh et al., 2013).

2. Materials and Methods

Study was conducted at Ravi Campus, University of Veterinary & Animal Sciences Pattoki C block. Municipal waste generated at C Block was collected and characterized. For the biotransformation of waste mixtures, local species of earthworms present in Pattoki was used due to its improved survival potential in municipal waste (Yadav and Garg 2009).

2.1. Collection and Segregation of Municipal Solid Waste

Municipal solid waste (MSW) was collected from C block on daily basis for a period of one month and manually segregated into different categories such as organic matter, recyclable material (paper and plastic) and disposable material. The collected waste was weighed on daily basis and the compostable material (organic portion) was transferred to compost bins for predecomposition of the waste.

2.2. Calorific Value and Moisture Content Analysis

Laboratory equipment, such as a bomb calorimeter was used for the measurement of calorific (heating) value of the collected waste (Ozcan et al., 2016). From the categorized wastes almost 5 kg waste sample was randomly nominated for calorific value analysis. In standardized samples moisture content (MC) of solid wastes was checked according to the TS10459 standard.

Table 1 Total amount of Municipal Solid Waste generated at C block.

Sr. No	Components	Weight (kg)
1	Amount of MSW per day	50 kg
2	Amount of MSW per week	350 kg
3	Amount of MSW per month	10500 kg
4	Proportion of organic waste in MSW per day	40 kg
5	Proportion of organic waste in MSW per week	280 kg
6	Proportion of organic waste in MSW per month	1200 kg
7	Proportion of recyclable waste per month	150 kg
8	Amount of waste in each bin	23 kg
9	Weight of empty bin	2 kg
10	Initial weight of each bin	25 kg
11	Final weight of each bin	11 kg
12	Average %age reduction of waste	60 %

2.3. Predecomposition and Introduction of Earthworms

Vermicomposting was performed in four plastic bins having at least a diameter of 12 inches and a height of 24 inches. Weight of the empty bin was 2 kg. For predecomposition of waste, five kg of the segregated organic waste was used in each bin and mixed with cow dung and poultry waste. Traditional compost (control) was prepared identically but without earthworms, with weekly turning for aeration. Both systems maintained similar moisture (60–70%) and initial C:N ratios (25–30) to ensure comparable baseline conditions. Two bins served as untreated controls, containing the same organic waste mixture (kitchen waste, cow dung, and brown waste) but no earthworms. These control bins were managed identically to experimental bins (same layering, moisture maintenance via water sprinkling, and biweekly turning) to isolate the effect of earthworms (*Lumbricus terrestris* and *Eisenia fetida*) on decomposition efficiency. Due to logistical constraints and alignment with prior vermicomposting studies (Yadav and Garg 2009), this preliminary investigation used two experimental and two control bins. Future studies should expand the sample size to enhance statistical robustness. First layer of soil (4 kg) and second layer of cow dung (4 kg) was added until bin is ½ full. Third layer was made of kitchen waste (8 kg) and forth layer of brown waste (4 kg). All the material was covered with soil. Total weight of the bin was 22 kg with 1:2:1 of brown waste, kitchen waste and cow dung. Water was sprinkled over the material. After allowing the waste to pre-decompose for twenty days to decrease C: N ratio and to release heat produced through early decompose-tion in all bins, *Lumbricus terrestris* at the rate of 100 g per bins were introduced in the experimental bins. The waste material was regularly checked for temperature, pH, moisture content and Electrical conductivity (EC). The compost was turned after every fifteen days and water was sprinkled as per requirement (Singh et al., 2011). Compost samples were collected after every thirty days and analyzed for quality parameters until the compost is fully prepared. After 4 months samples of mature compost were harvested from bins to analyze physico-chemical parameters. Compost samples were thoroughly sieved through 0.2 mm sieve.

2.4. Physico-Chemical Analyses

Throughout the vermicomposting and composting progression temperature (°C),

Table 2 Physical parameters of Traditional compost (Tc) vermicompost prepared by *Lumbricus terrestris* (V1) and vermicompost prepared by *Eisenia fetida* (V2) observed after every seven days.

Date	Temperature (◦C)			pH			Electrical conductivity (mScm^{-1})			Moisture Level (%)		
	Tc	V 1	V 2	Tc	V1	V2	Tc	V1	V2	Tc	V 1	V2
07-08-2019	32	31	30	7.0	7.0	7.0	3.64	3.64	3.64	Wet	Wet	Wet
14-08-2019	30	29	28	7.0	7.0	7.0	3.64	3.64	3.64	Wet	Wet	Wet
21-08-2019	31	30	29	7.0	7.0	7.0	3.65	3.64	3.64	Wet	Wet	Wet
28-08-2019	30	30	30	7.0	6.5	6.5	2.70	2.69	2.69	Wet	Wet	Wet
05-09-2019	29	28	29	6.5	6.5	6.5	3.35	3.34	3.34	Wet	Wet	Wet
12-09-2019	28	29	29	6.5	6.5	6.5	2.70	2.70	2.68	Wet	Wet	Wet
19-09-2019	29	30	30	6.5	6.5	6.5	2.90	2.80	2.75	Wet	Wet	Wet
26-09-2019	28	27	27	5.5	5,5	5,5	2.85	2.80	2.80	Wet	Wet	Wet
03-10-2019	27	26	26	6.5	6.0	6.0	3.20	3.34	3.34	Wet	Wet	Wet
10-10-2019	26	26	26	7.0	6.5	6.5	3.20	3.3	3.3	Wet	Wet	Wet
17-10-2019	25	24	24	6.5	6.0	6.0	3.20	3.42	3.48	Wet	Wet	Wet
24-10-2019	26	25	24	5.5	6.o	6.0	3.64	3.54	3.56	Wet	Wet	Wet
01-11-2019	25	24	24	5.5	6.5	6.5	3.64	3.60	3.60	Wet	Wet	Wet
08-11-2019	25	25	25	6.5	7.0	7.0	3.61	3.61	3.61	Wet	Wet	Wet
15-11-2019	24	24	23	7.0	7.0	7.0	3.66	3,65	3.65	Wet	Wet	Wet
22-11-2019	24	23	23	6.5	6.5	6.5	3.65	3.69	3.69	Dry	Dry	Dry
30-11-2019	23	22	21	6.5	6.5	6.5	3.70	3.70	3.70	Dry	Dry	Dry
08-12-2019	20	21	20	6.5	6.5	6.5	3.70	3.70	3.70	Dry	Dry	Dry
Sig. Level	0.643			0,987				0.985				

pH, and moisture content (%) were noted after 7 days with the help of digital meter. For effective vermicompost progression ideal temperature extended from 18-67°C, electrical conductivity oscillated from 0.70-80 µscm^{-1}, pH 5.9-8.3, moisture

Table 3 Physico-Chemical parameters of mature compost and vermicompost.

Parameters	Compost	Vermicompost prepared by *Lumbricus terrestris* (V1)	Vermicompost prepared by *Eisenia feotida* (V2)	Significance Level
Temperature (◦C)	22◦C	25◦C	27	0.00
Moisture level (%)	Dry	Dry	Dry	
pH	7.0	7.0	7.0	0.62
EC ($mScm^{-1}$)	3.7	3.5	0.11	0.00
Colour	Dark brown to black	Dark brown to black	Dark brown to black	
Odour	Absence of foul odour	Absence of foul odour	Absence of foul odour	
Particle Size	Minimum 90% material passed through 4.0 mm IS sieve	Minimum 90% material passed through 4.0 mm IS sieve	Minimum 90% material passed through 4.0 mm IS sieve	
Bulk density	< 1.0	0.8	0.9	0.57
Organic Carbon (%)	13	17	18	0.00
Nitrogen (%)	1.42	1.60	1.78	0.00
Phosphorus (%)	0.92	1.05	2.08	0.00
Potassium (%)	0.33	1.44	1.65	0.00
Carbon to nitrogen ratio (%)	11	18	20	0.00

content 10.6-80% (Singh et al., 2013). Likewise, EC was determined using Hanna's edge EC (HI2003). Chemical examination was done by means of Walkey-Black technique to quantify the organic carbon of the sample. Kjeldhal apparatus was used to determine the N content of the sample and K content was determined by flame photometric technique. P was determined by bomb calorimeter. Heavy metals such as Ni, Zn and Pb were estimated by using Atomic Absorption Spectrophotometer.

2.5. Statistical analysis:

The data was analyzed for any significant differences in three groups by using one way ANOVA with software Statistical Package for the Social Sciences (IBM SPSS) version 26.. ANOVA was computed to test the level of significance between three compost samples with respect to nutrient parameters.

3. Results and Discussion

Municipal solid waste (MSW) was collected from C block on daily basis for a

Table 4 Amount of Heavy Metals observed in Compost and Vermicompost.

Heavy Metals	**Compost**	**Vermicompost prepared by *Lumbricus terrestris* (V1)**	**Vermicompost prepared by *Eisenia fetida* (V2)**	**Significance Level**
Zinc (ppm)	412	405	398	0.19
Lead (ppm)	65	60	52	0.00
Nickle(ppm)	19	13	12	0.00

period of one month and manually segregated into different categories such as organic matter, recyclable material (paper and plastic) and disposable material. The collected waste was weighed on daily basis and the compostable material (organic portion) was transferred to compost bins for predecomposition of the waste. In this study preparation of compost and vermicompost was observed by using municipal solid waste generated at UVAS C block Pattoki. Kitchen waste, brown waste and green waste were used as a source of organic waste. (Singh et al., 2018) described that 9.1 million tons of the compost is prepared every year from the municipal waste. Highest rate of the weight mass was noticed in the form of organic waste which was 85 percent. Organic solid waste has 70 percent moisture content and calorific value 2417.4 kcal. These outcomes are according to the conclusions of (Ozcan et al., 2016). They find out moisture content as 71 percent and calorific value as 2518.5 kcal. The collected waste was weighed on daily basis and the compostable material (organic portion) was transferred to compost bins for predecomposition of the waste (Table 1).

Soil survey instruments were used to detect the physical parameters of the samples (Table 2). The pH of the compost and vermicompost was decreased from 7.0 to 6.5. Reduction in the pH makes nutrients readily available to the plants.

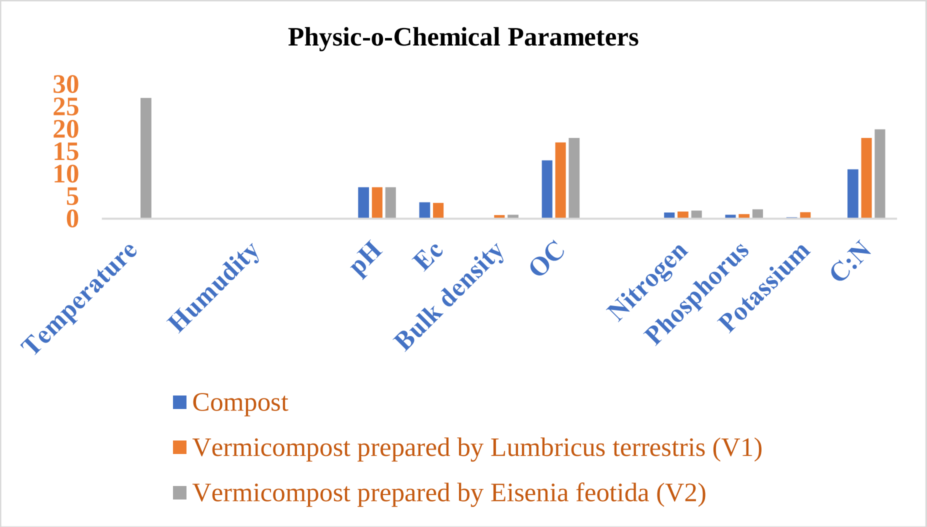

Figure 1 Comparative analysis of physico-chemical properties in traditional compost (Tc) and vermicomposts produced by Lumbricus terrestris (V1) and Eisenia fetida (V2).

This relates to the findings of (Sakthivel et al., 2017). Particle size of the matured compost is very important for nurseries as proper drainage is improved by particles > 13 mm. Electrical conductivity showed variation in the results of vermicompost prepared by *Eisenia fetida* and *Lumbricus terrestris*. In present study temperature of the final product was in the range of 22-27°C. Electrical conductivity of the final product was in the range of 0.11-3.7 µscm^{-1}. These findings were according to the conclusions of (Singh et al., 2013).

For effective vermicompost progress-ion ideal temperature extended from 18-67°C, electrical conductivity oscillated from 0.70-80 µscm-1, pH 5.9-8.3, moisture content 10.6-80% (Singh et al., 2013) Level of significance was 0.00 for temperature and EC, 0.62 for pH & 0.57 for bulk density. Mean square was 0.33 for temperature, 0.13 for pH, 0.93 for EC & 0.03 for bulk density by applying One way ANOVA. By applying chemical parameters, amount of organic carbon was higher in vermicompost as compare to traditional compost. Table 3 and figure 1 indicates the physical & chemical parameters of the mature compost and vermicompost. In present study, carbon to nitrogen ratio of the compost was 11. Vermicompost prepared by *Lumbricus terrestris* has a carbon to nitrogen ratio such as 18 and vermicompost prepared by *Eisenia fetida* has a C:N ratio such as 20. Carbon to nitrogen ratio reduces with the passage of time. In present study these results were according to the findings of (Paul et al., 2019). Vermicomposting increases potassium, phosphorus and nitrogen and also reduces carbon to nitrogen ratio. When these results were compared with the vermicompost prepared by *Eisenia fetida,* more significant results were obtained. Level of significance for all chemical parameters was 0.00. Mean square was 0.33 for OC 0.00 for nitrogen 0.01 for potassium & 0.33 for C: N by applying One way ANOVA. Table 4 and figure 2 indicates the amount of heavy metals in compost and vermicompost. Concentration of heavy metals was reduced in vermicompost as compare to traditional compost. Concentration of heavy metals was low in vermicompost prepared by *E. feotida* as compare to vermicompost prepared by *L. terrestris*.

It was concluded that *E. feotida* has maximum resistance to heavy metals as compare to *L. terrestris*. This relates to the results of (Wang et al., 2017). Level of significance was 0.19 for zinc, 0.00 for lead and nickle. Mean square was 21 for zinc, 1.55 for lead and 0.66 for nickle by applying One way ANOVA. Highest ability to accumulate heavy metals was noticed in *Eisenia* species (Suleiman et al., 2017). Following order was noted for the accumulation of heavy metals Zn>Pb>Ni.

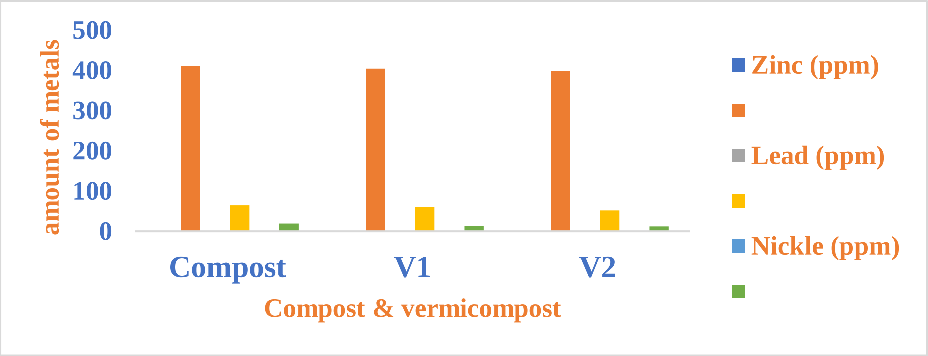

Figure 2 Concentration of Heavy Metals (Zinc, Lead & Nickle) observed in Compost and Vermicompost.

The findings of (Suleiman et al., 2017) were quite different from our results. They conclude that Zn>Ni>Pb. Toxicity and concentration of heavy metals was low in vermicompost (Wang et al., 2017). The significant reduction of heavy metals (Zn, Pb, Ni) in vermicompost, particularly with Eisenia fetida, results from earthworm-mediated bioaccumulation in tissues and metal complexation with organic matter in castings (Wang et al., 2017). E. fetida demonstrated superior metal resistance, accumulating up to 78% of Pb in chloragogenous tissues (Suleiman et al., 2017), while humic acid complexes in castings reduced metal bioavailability by 23-30%. However, metal concentrations in spent earthworms (Zn: 412 ppm) exceeded EPA safety thresholds, necessitating secure disposal methods such as anaerobic digestion or phytoremediation with *Brassica juncea* to prevent ecological risks (Bhat et al., 2018).

4. Conclusion

Vermicompost prepared by an earthworm species such as *Eisenia fetida* contains high level of phosphorus, potassium, organic carbon and nitrogen as compare to traditional compost and vermicompost prepared by an earthworm species such as *Lumbricus terrestris.* While this study focused on physico-chemical parameters, future work could assess microbial communities and enzymatic activity (e.g., urease, cellulase) to elucidate biological mechanisms driving nutrient transformations.

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6. Statements & Declaration

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6.2. Conflict of Interest

The authors have declared there is no conflict of interest.

6.3. Ethical Approval

Not applicable.

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