



ESTIMATION OF PHYSICO-CHEMICAL PROPERTIES OF VERMIWASH OF DIFFERENT COMBINATIONS OF MSW WITH ANIMAL DUNG THROUGH VERMICOMPOSTING BY EARTHWORM *EISENIA FETIDA*

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Abstract

The municipal solid wastes (MSW) caused environmental hazards and various ill effects on human life and their domestic animals. Management of MSW through vermicomposting by the help of epigeic earthworm *Eisenia fetida* had an appropriate alternative technology for recycling and production of organic fertilizers. The significant decrease in pH, C/N ratio and organic carbon whereas, significant increase in the level of potassium, phosphorus and calcium in different combinations of vermiwash of MSW with animal dung with respect to the initial feed mixture were observed. The organic carbon was significantly decreased 67.42 % MG₂₅ (MSW with goat dung in ratio of 75:25). The pH of initial mixture in all combinations was tending to acidic/neutral nature. The nitrogen content in vermiwash was significantly increased 68.02% in MG₅₀ (MSW with goat dung in ratio of 50:50) where as maximum organic nitrogen observed 28.31 in MG₂₅ (MSW to goat dung ratio 75:25). The C/N ratio in all vermiwash was ranged 6.80 to 25.30 and significantly decreased in initial feed mixture. Data obtained from present study is helpful to prepare the specific type of combination of vermiwash for particular nutrients. The aim of present study was to investigate the production and characteristics of vermiwash of MSW with different animal dung by earthworm *Eisenia fetida*.

Key word: Municipal solid wastes, animal dung, *Eisenia fetida*, vermicomposting, vermiwash, physico-chemical analysis.

Introduction

The municipal solid wastes (MSW) caused environmental hazards and various ill effects on human life and their domestic animals, if their proper management and disposal practices are not available. The need of MSW management which caused serious concern due to the dumping sites near the road/population side and they also create noxious gases and other pollution problems. Although some research works have been done on the potential of earthworms in vermicomposting of solid wastes particularly household, MSW, livestock excreta and agro-wastes in to potent organic fertilizers (Nath *et al.* 2009; Bhartiya and Singh 2012; Chauhan and Singh 2012; 2013).

Indiscriminate use of chemical fertilizers and pesticide in agriculture has been disturbed the soil texture and physicochemical properties as well as affect the human health and environment (Gupta 2005; Mall *et al.* 2005; Meena 2007). Loss of tests and flavors in food materials takes place and more susceptible to diseases with loss of their storage and keeping quality (Eastman *et al.* 2001). Nutrients like protein, amino acids, ascorbic acid reduced in foodstuffs by use of nitrogenous, phosphatic fertilizers in soil due to used of chemical fertilizers and pesticides (Marinari *et al.* 2000).

The epigeic earthworm species *Eisenia fetida* is a suitable earthworm species for vermicomposting which have short life cycle, small size and high rate of conversion of organic wastes as well as reproduction (Nath *et al.* 2009; Chauhan and Singh 2012). Different microorganisms (bacteria, actinomycetes, algae and fungi) were colonized in the intestine of earthworm and as a result the concentration of various enzymes, plant hormones, growth stimulator, and vitamins were increased directly or indirectly during vermicomposting (Suthar 2010).

Vermicomposting of MSW by the help of epigeic earthworm had an appropriate alternative for safe, hygienic and cost effective disposal of municipal solid wastes and convert to good quality liquid biofertilizers. The aim of present study was to investigate the production and characteristics of vermiwash of MSW with different animal dung by earthworm *Eisenia fetida*.

Materials and Methods

Collection of wastes

Municipal solid wastes were collected from the local municipality from the Gorakhpur city. Animal wastes viz. buffalo, cow, goat and horse dung was collected from different form houses of Gorakhpur city. Municipal solid wastes and different animal dung (buffalo, cow, goat and horse dung) were sprayed in layer of about 0.25 to 0.75 m for aeration and solarization. After this wastes were exposed to the sunlight for 5 to 10 days to remove the various harmful organism and noxious gases.

Collection of earthworm

Earthworm *Eisenia fetida* used for experiment was obtained from Vermiculture Research Centre, Department of Zoology, D. D. U. Gorakhpur University, (U.P.) India.

Experiment set up for vermicomposting

Vermibeds of animal dung with MSW in different ratios were prepared on the cemented earth surface. Five proportions of MSW with different animal dung were taken for preparation of vermibeds (Table 1). The size of each vermibed was (30 cm x 30 cm x 10 cm). Thus, formed vermibeds were moistened daily and incubated 50 adult individual of *E. fetida* placed in each vermibed. They were covered with jute pockets and moisten daily up to 40–50 days for maintaining the moisture (50–60 % RH). After 1-week interval, vermibed was turned manually. After 50–60 days, tea-like granular vermicompost appears on the upper surface of each vermibed (Nath *et al.* 2009).

Extraction of vermish

Vermish was extracted from vermicompost of different combination of MSW and animal dung in different ratio (100:0, 75:25, 50:50, 25:75, 0:100 w/w) with abundant earthworms by the help of vermish collecting device. The apparatus is made from plastic drum having capacity of two liter and a tap at the bottom. The drum is filled with broken bricks, about 3 cm thickened which is followed by sand layer of 2-3 cm thickness. The vermish collecting device was filled by 1kg vermicompost with more *Eisenia fetida* earthworms population, simultaneously 1l fresh water was added in to and after 10h a container kept below the tap for the collection of vermish. The watery extract fresh vermish drained out off use for the chemical estimation and stored at 10°C for further use (Nath *et al.* 2009).

Chemical Analysis

The pH was determined by using a double distilled water suspension of each waste in the ratio of 1:10 (w/v) that has been agitated mechanically for 30 minutes and filtered through Whatmans No.1 filter paper. Organic carbon was measured by the method of Nelson and Sommers (1982). Kjeldahl nitrogen determined after digesting the sample with conc. H₂SO₄ and HClO₄ (9:1 v/v) according to the method of Bremner and Mulvaney (1982). Total Phosphorus was analyzed by using the colorimetric method with molybdenum in sulfuric acid (Garg *et al.* 2005). Total potassium determined after digesting the sample in diacidic mixture (conc. HNO₃: conc. HClO₄=4:1, v/v), by flame photometer (Elica, CL 22 D, Hyderabad, India).

Statistical Analysis

All experiments were replicated six times. The t-test was applied between the different parameter of vermish of initial feed mixture and final vermish. Correlation matrix calculated among chemicals of vermish of combination of MSW with different animal dung (Dhamu and Ramamoorthy, 2008).

Results

The significant physico-chemical change was observed in vermish of different combination of MSW with animal dung (cow, goat, buffalo, horse) with respect to initial feed mixture (Table 2-3 and Fig. 1-2). Significant decrease in the levels of carbon, C/N ratio and pH was observed in all the combinations of feed materials. Table 4 showed the linear correlation coefficients between the different chemical parameters. There were moderate-to-high correlations between the different parameters.

However, the nitrogen, phosphorous, potassium and calcium were increases significantly in vermish in all the combinations of livestock's excreta with municipal solid wastes. The carbon content in initial feed material was significant high (609.82±1.45 g/kg) in MSW and lower (434.54±1.57 g/kg) in MG₁₀₀. The total Kjeldahl nitrogen was significant highest (14.25±1.26 g/kg) in pre treated vermibed of MC₅₀ whereas after vermicomposting significant highest (28.31±1.85 g/kg) was observed in vermish of MG₂₅. The maximum increase Kjeldahl nitrogen (68.02%) was noted in MG₇₅ during vermicomposting. The pH was observed 7.24±1.15 to 7.85±1.55 in initial feed material of different combination of MSW whereas, 6.87±1.03 was noted alone in MSW for vermicomposting. The maximum 6.53 % decrease in the level of pH in MC₁₀₀ and the C/N ratio in 84.74 % at level of 12.77±1.82 were noted. The level of pH was shifted from neutral to slight basic in vermish obtained from all the combinations. The C/N ratio in initial feed material was ranged from 34.82±1.87 in MC₅₀ to 83.25±1.58 in MG₁₀₀ combinations and after vermicomposting in vermish was significantly decreased 6.80±1.38 to 25.30±1.58 level (Table 2, Fig. 1).

Total potassium was significant lowest (5.24±0.53 g/kg) in initial feed mixture of MC₁₀₀ while highest (8.85±0.65 g/kg) in vermish of MG₅₀. Phosphorus content ranged from 3.87±0.47 g/kg in MC₇₅ to 9.35±0.51 in MH₂₅ before vermicomposting. The total available phosphorus was significantly high (10.85±0.45 g/kg) in vermish of MH₂₅. The total calcium was observed significantly high (6.21±0.43 g/kg) in vermish of MG₂₅, whereas maximum significant increase (66.29 %) calcium was observed in combination of MG₂₅ (Table 3, Fig. 2).

Table 4 shows the correlation matrix between different chemical parameters. There was some positive and negative correlate observed. Total Kjeldahl nitrogen was closely correlate with C/N ratio and total potassium was positively correlate to pH, total phosphorus, and total calcium (p<0.001).

Discussion

The significant change were obtained in physico-chemical properties of vermish of vermicompost of animal dung with MSW with respect to control. The feed materials of earthworm have become physico-chemically changed after vermicomposting due to the vermic activity of earthworm *Eisenia fetida* (Gupta 2005). Earthworms also play an important role in stabilization of inorganic to organic plant nutrients form and increase the soil fertility (Ranganathan 2006). The vermicomposting process increases the mineralization rate. In vermish add the organic nutrients many times along with plant growth hormones and vitamins (Atiyeh *et al.* 2002). During vermicomposting increases the soil nutrients, micro-flora, and convert organic wastes into valuable products in end product (Ndegwa and Thompson 2001; Garg and Kaushik 2005; Payal *et al.* 2006).

When organic wastes pass through the gut of worm, the nutrients get converted from unavailable form to available forms, which consequently enrich the worm cast with higher quality plant nutrient (Gupta and Garg 2008). The carbon content was significant highest in initial feed material of MSW, it may be due to presence of high amount of organic compound in MSW (Kaviraj and Sharma 2003) and due to feeding action of earthworm and degradation by microbes in the intestine of earthworm (Kaushik and Garg 2003; Suthar 2007; Venkatesh and Eevera 2008).

The C/N ratio decreased in the all combination of MSW with animal dung due to microbial decomposition is one of the major factors (Nath *et al.* 2009; Chauhan and Singh 2012). This reduction in the form of release of carbon as CO₂, in which there is a greater availability of feed, followed by a long period of slow degradation (Nath *et al.* 2009; Garg and Gupta 2011; Chauhan and Singh 2013). Reduction of C/N ratio results in addition of animal dung in MSW and influencing vermicomposting rate, similar result observed by (Parthasarathi and Ranganathan 2000; Muthukumravel *et al.* 2008). The shifting of pH from base to acidic or neutral was observed due to mineralization of nitrogen and phosphate into nitrate and orthophosphate respectively (Garg *et al.* 2006; Nath *et al.* 2009; Chauhan and Singh 2012).

The maximum decrease in pH level was observed in MC₁₀₀. During vermicomposting the decrease in pH is also likely due to production of CO₂, ammonia and organic acid by activity of earthworm and micro-organism in its intestine (Komilis and Ham 2006; Sharma *et al.* 2011).

There was significant increase total Kjeldahl nitrogen in vermiwash compare to initial feed material may be due degradation of organic carbon and addition of some gut products in the form of castings, urine and dead tissues of the earthworm (Tripathi and Bharadwaj 2004). The significant phosphorus was observed in vermiwash of MH₂₅ which was probably because of the solubilization and stabilization of phosphorous done by micro organism present in earthworm gut the phosphatase enzyme also increase the total phosphorous (Aira *et al.* 2002; Suthar and Ram 2008). The micro-organisms during vermicomposting produce soluble potassium similar result reported by (Kaviraj and Sharma 2003). The vermiwash of MG₂₅ showed highest calcium level was noticed due to the high rate of mineralization during vermicompost by *Eisenia fetida* (Garg *et al.* 2006; Nath *et al.* 2009, Chauhan and Singh 2012). The vermiwash of MSW showed higher level of micro and macro nutrients than initial feed mixture.

Conclusion

The present study is information about the management of MSW and production of liquid biofertiliser (vermiwash). The earthworm *Eisenia fetida* caused significant increase in the levels of nitrogen, potassium, phosphorus, calcium and decrease in the levels of organic carbon, C/N ratio and pH through vermic-activity during vermicomposting. Thus vermicomposting can be a better technology for the conversion of toxic health hazardous wastes into valuable biofertilizer. Vermicomposting is less expensive, non hazardous and eco-friendly for human as well as animal health. The specific nutrients rich vermiwash of the specific combination of the MSW and animal dung can be helpful in specific nutrient deficient crops.

Acknowledgement

Authors are thankful to University Grant Commission (UGC) New Delhi Project F. No- 42-527/2013 (SR) for financial assistance.

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Annexure

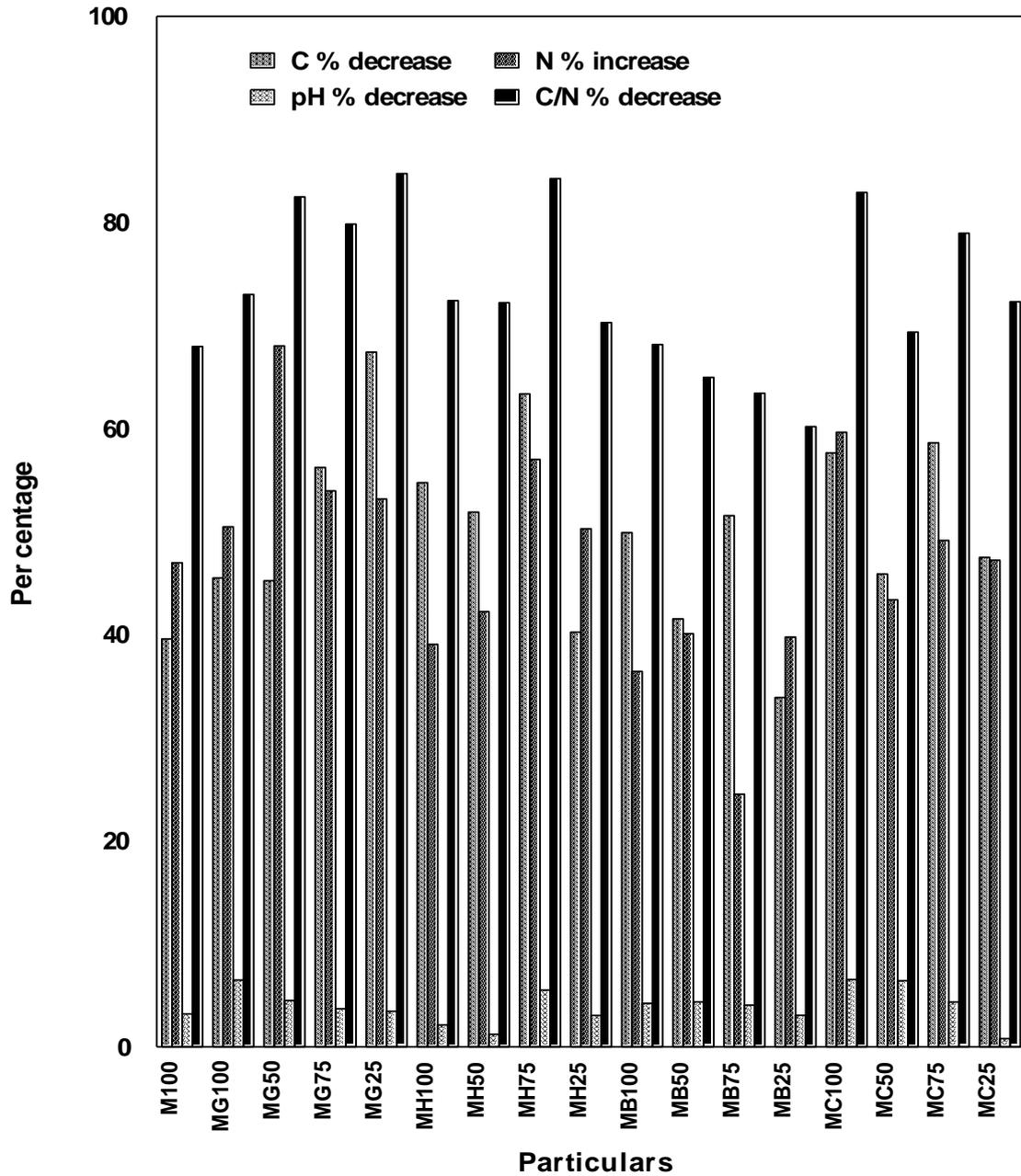


Figure 1. The per-cent age changes carbon (% decrease), nitrogen (% increase), pH (% decrease) and C/N ratio (% decrease) in vermiwash during management of MSW with different animal dung.

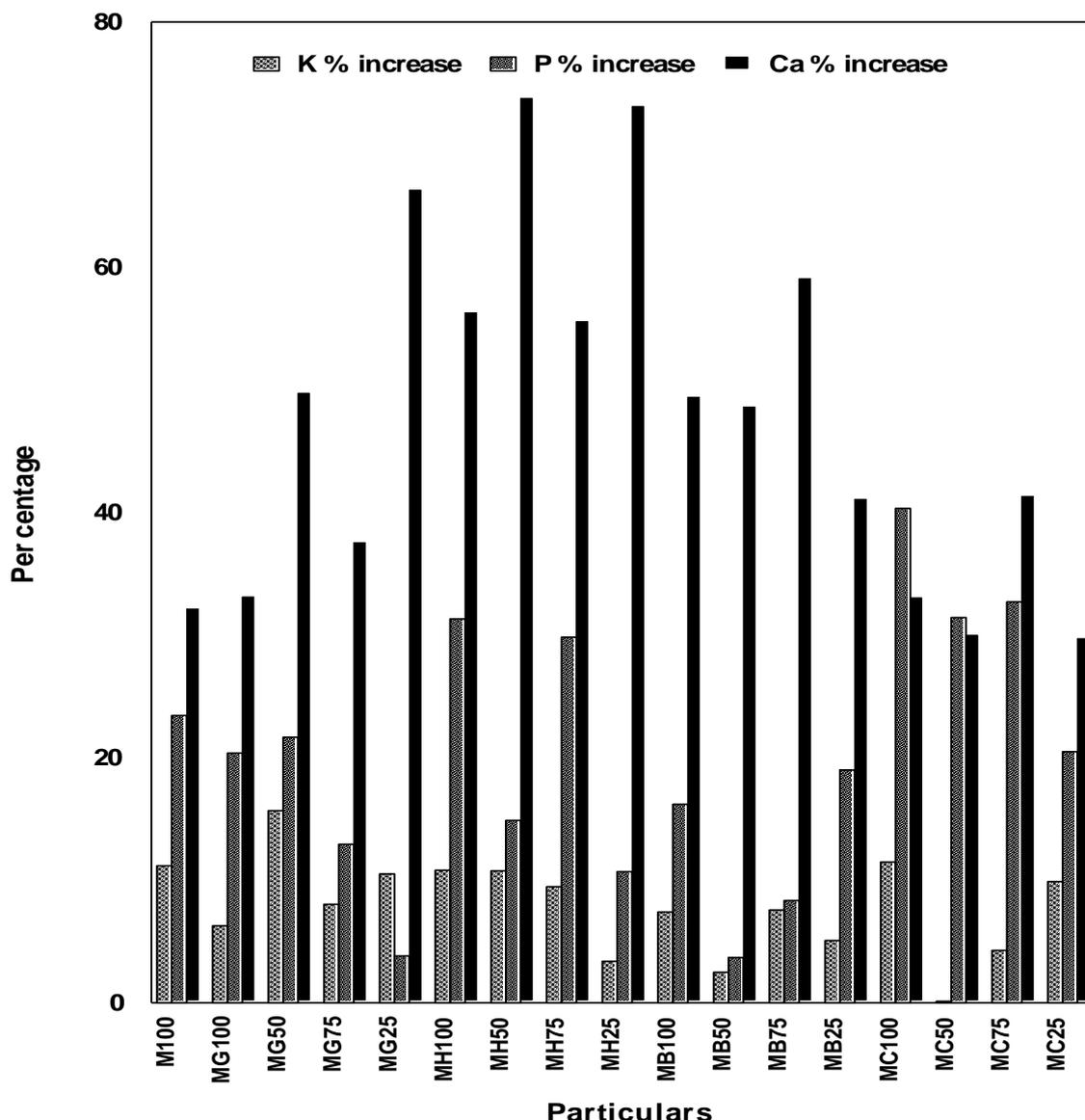


Figure 2. The per-cent age changes potassium, phosphorus and calcium (% increase) in vermiwash during management of MSW with different animal dung.

Table 1. Different combinations of municipal solid wastes with different animal dung for experiment.

Particulars	MSW (municipal solid wastes)	Animal dung	Ratio (MSW:Animal dung) w/w
M ₁₀₀	MSW	-	100:0
MG ₁₀₀	MSW	Goat dung	0:100
MG ₇₅	MSW	Goat dung	25:75
MG ₅₀	MSW	Goat dung	50:50
MG ₂₅	MSW	Goat dung	75:25
MH ₁₀₀	MSW	Horse dung	0:100
MH ₇₅	MSW	Horse dung	25:75
MH ₅₀	MSW	Horse dung	50:50
MH ₂₅	MSW	Horse dung	75:25
MB ₁₀₀	MSW	Buffalo dung	0:100
MB ₇₅	MSW	Buffalo dung	25:75
MB ₅₀	MSW	Buffalo dung	50:50
MB ₂₅	MSW	Buffalo dung	75:25
MC ₁₀₀	MSW	Cow dung	0:100
MC ₇₅	MSW	Cow dung	25:75
MC ₅₀	MSW	Cow dung	50:50
MC ₂₅	MSW	Cow dung	75:25

M(MSW), MG(MSW+Goat dung), MH(MSW+Horse dung), MB(MSW +Buffalo dung), MC (MSW +Cow dung)

Table 2. The concentration of carbon, nitrogen, pH and C/N ratio in initial feed mixture and vermiwash of municipal solid wastes with combinations of different animal dung.

Particulars	CIM(g/kg)	CVW(g/kg)	NIM(g/kg)	NVW(g/kg)	pHIM	pHVW	C/NIM	C/NVW
M ₁₀₀	609.82±1.45	368.41±1.25*	7.72±1.58	14.56±1.25*	6.87±1.03	6.65±1.80*	78.99±1.24	25.30±1.58*
MG ₁₀₀	434.54±1.57	236.82±1.98*	5.22±1.76	10.54±1.17*	7.55±1.12	7.06±1.19*	83.25±1.58	22.47±1.35*
MG ₇₅	587.53±1.85	257.15±1.21*	9.27±1.15	20.13±1.52*	7.56±1.17	7.28±1.19*	63.38±1.34	12.77±1.82*
MG ₅₀	562.80±1.78	308.25±1.06*	8.13±1.97	25.42±1.23*	7.78±1.13	7.43±1.14*	69.23±1.79	12.13±1.57*
MG ₂₅	590.54±1.12	192.42±1.03*	7.26±1.20	28.31±1.85*	7.83±1.24	7.56±1.16*	44.54±1.36	6.80±1.38*
MH ₁₀₀	477.65±1.57	216.15±1.45*	5.21±1.45	8.55±1.15*	7.51±1.14	7.35±1.14*	81.68±1.58	25.28±1.59*
MH ₇₅	558.35±1.57	204.53±1.68*	7.52±1.16	17.49±1.65*	7.24±1.15	6.84±1.14*	74.25±1.28	11.69±1.64*
MH ₅₀	530.86±1.24	255.38±1.54*	13.21±1.25	22.87±1.15*	7.34±1.16	7.25±1.26*	40.19±1.96	11.17±1.76*
MH ₂₅	592.64±1.87	354.18±1.91*	11.56±1.14	23.25±1.79*	7.55±1.27	7.32±1.23*	51.27±1.82	15.23±1.57*
MB ₁₀₀	514.25±1.78	257.64±1.72*	7.26±1.12	11.42±1.13*	7.56±1.19	7.24±1.12*	70.83±1.75	22.56±1.98*
MB ₇₅	587.40±1.47	284.57±1.79*	13.82±1.24	18.31±1.13*	7.66±1.16	7.35±1.23*	42.50±1.68	15.54±1.84*
MB ₅₀	556.93±1.54	325.65±1.87*	14.57±1.16	24.32±1.24*	7.57±1.17	7.24±1.15*	38.22±1.37	13.39±1.76*
MB ₂₅	598.28±1.79	395.46±1.46*	14.13±1.24	23.46±1.14*	7.85±1.55	7.61±1.14*	42.34±1.88	16.86±1.98*
MC ₁₀₀	485.48±1.56	205.64±1.85*	6.57±1.14	16.28±1.13*	7.35±1.19	6.87±1.15*	73.89±1.46	12.63±1.28*
MC ₇₅	547.51±1.46	226.57±1.67*	9.45±1.12	18.58±1.15*	7.58±1.14	7.25±1.54*	57.94±1.67	12.19±1.82*
MC ₅₀	496.19±1.64	268.56±1.75*	14.25±1.26	25.17±1.18*	7.63±1.16	7.14±1.14*	34.82±1.87	10.67±1.57*
MC ₂₅	587.35±1.85	308.35±1.68*	13.64±1.25	25.85±1.17*	7.54±1.16	7.48±1.26*	43.06±1.56	11.93±1.47*

CIM= total organic carbon in initial feed material, CVW= total organic carbon in vermiwash, NIM= total Kjeldahl nitrogen in initial feed material, NVW= total Kjeldahl nitrogen in vermiwash, C/NIM=C:N ratio in initial feed material, C/NVM=C : N ratio in vermiwash.

Each value is the mean ± SD of six replicates. *Significant (P<0.05) 't' test between initial feed material and vermiwash.

Table 3. The concentration of potassium, phosphorus and calcium in initial feed mixture and vermiwash of municipal solid wastes with combinations of different animal dung.

Particulars	KIM (g/kg)	KVW(g/kg)	PIM (g/kg)	PVW (g/kg)	CaIM (g/kg)	CaVW (g/kg)
M ₁₀₀	5.64±0.42	6.35±0.51*	4.87±0.39	6.36±0.42*	1.52±0.43	2.24±0.19*
MG ₁₀₀	6.42±0.53	6.85±0.50*	4.34±0.33	5.45±0.46*	1.92±0.53	2.87±0.42*
MG ₇₅	6.86±0.52	7.46±0.62*	4.85±0.37	5.57±0.47*	2.43±0.42	3.89±0.37*
MG ₅₀	7.32±0.58	8.68±0.52*	5.75±0.43	7.34±0.53*	1.87±0.52	3.72±0.35*
MG ₂₅	7.92±0.67	8.85±0.65*	8.32±0.45	8.65±0.59*	1.81±0.62	5.37±0.32*
MH ₁₀₀	7.51±0.89	8.42±0.63*	7.24±0.43	10.54±0.61*	1.84±0.53	4.21±0.34*
MH ₇₅	7.84±0.64	8.66±0.68*	5.86±0.43	8.35±0.59*	1.52±0.48	3.42±0.45*
MH ₅₀	7.46±0.72	8.36±0.63*	8.87±0.52	10.42±0.65*	1.54±0.41	5.87±0.45*
MH ₂₅	8.27±0.71	8.56±0.69*	9.35±0.51	10.47±0.52*	1.67±0.59	6.21±0.43*
MB ₁₀₀	6.87±0.62	7.42±0.52*	5.38±0.49	6.42±0.45*	1.68±0.41	3.32±0.43*
MB ₇₅	7.82±0.67	8.46±0.42*	5.38±0.43	5.87±0.54*	1.85±0.43	4.52±0.46*
MB ₅₀	8.21±0.65	8.42±0.49*	7.56±0.51	7.85±0.52*	2.40±0.43	4.67±0.45*
MB ₂₅	8.40±0.64	8.84±0.45*	8.79±0.54	10.85±0.45*	2.87±0.45	4.87±0.32*
MC ₁₀₀	5.24±0.53	5.92±0.41*	4.32±0.39	7.24±0.53*	1.48±0.46	2.21±0.34*
MC ₇₅	6.93±0.54	7.24±0.53*	3.87±0.47	5.75±0.41*	1.42±0.54	2.42±0.26*
MC ₅₀	7.45±0.67	7.46±0.52*	5.26±0.45	7.67±0.50*	2.50±0.46	3.57±0.38*
MC ₂₅	7.11±0.62	7.89±0.50*	7.69±0.53	9.67±0.52*	1.68±0.50	2.39±0.21*

KIM= total potassium in initial feed material, KVW= total potassium in vermiwash, PIM= P= total phosphorus in initial feed material, PVW= P= total phosphorus in vermiwash, CaIM= total calcium in initial feed material, CaVW= total calcium in vermiwash,

Each value is the mean ± SD of six replicates. *Significant (P<0.05) 't' test between initial feed material and vermiwash.

Table 4. Correlation matrix between different biochemical parameters of vermiwash.

Parameters	CVW	NVW	pHVW	C/NVW	KVW	PVW	CaVW
CVW	1.000						
NVW	0.287	1.000					
pHVW	0.153	0.494	1.000				
C/NVW	0.238	-0.821	-0.309	1.000			
KVW	0.155	0.478	0.684	-0.323	1.000		
PVW	0.241	0.331	0.419	-0.123	0.583	1.000	
CaVW	0.187	0.415	0.531	-0.252	0.750	0.573	1.000

VW= vermiwash, C= total organic carbon, N= total Kjeldahl nitrogen (g/l), C/N=C to N ratio, K= total potassium, P= total phosphorus, Ca= total calcium (g/l).