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Physico–chemical analysis and Management of different combinations of sugar mill and distillery effluents with different animal dungs during vermicomposting by earthworm *Eisenia fetida*

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Abstract

Sugar mill effluents and distillery effluents are harmful for human health and environment. These effluents are having higher amount of suspended solids, dissolved solids, chloride, sulphate, nitrate, and calcium etc. The vermicomposting is suitable way for proper management of these wastes with the help of earthworm *Eisenia fetida.* After treatment of different combination of these wastes are uses as initial feed mixture for *E. fetida* during vermicomposting. The physico-chemical property of different combinations of effluents of sugar mill and distillery with animal dungs was observed before and after vermicomposting. There was significant increase in total kjeldhal nitrogen (TKN) 5.8±0.18 g/kg in cow dung, total available phosphorous (TAP) 12.2±0.16 g/kg in DE, total potassium (TK) 16.3±0.36 g/kg in DE, total calcium (TCa) 3.2±0.2 g/kg in SME+BD level and significant decreased in C:N ratio 76.2±1.26 in DE+CD, total organic carbon (TOC) 139.1.13 g/kg in SME (sugar mill effluents), electrical conductivity (EC) 1.3±0.04 and moisture 52.3±1.26 % relative humidity in CD of final vermicompost with respect to initial feed mixture. The temperature of initial feed mixture was significantly decreased after vermicomposting. The pH of initial feed mixture in all the combinations tends to acidic/ neutral nature. The aim of present study to management of sugar mill effluents and distillery effluents as well as determined the chemical compositions of the different combination beds before and after vermicomposting.

Keywords: Sugar mill effluents, Distillery effluents, Animal dungs, Vermicomposting, *Eisenia fetida*, Physico-chemical analysis

1. Introduction

Industrial wastes like distillery effluents and sugar mill sludges caused environmental hazards and various ill effects on the human health (Pandey and Carney, 1994; Suthar and Singh, 2008). Generation of million of tons of sugar mill effluents, distillery spent wash and animal wastes are produced annually and have cause odor and pollution problems (Gupta, 2005; Garg et al, 2006; Nath et al, 2009) and also animals dung and municipal solid wastes are serious problem for human health (Bhartiya and Singh, 2012). Diverse sugar and distillery effluents directly disposed in soil and water cause major pollution problems. The sugar and distillery industry play an important role in the economic development of India but the effluents released produce a high degree of organic pollution in both aquatic and terrestrial ecosystem (Ayyasamy et al., 2008; Doke et al., 2011). Alcohol is produced in India by fermentation of molasses, the mother liquor left after the sugar production is spent wash which is brown in colour with high temperature, low pH and high ash content (Pandey and Carney, 1994). Animal wastes are also a serious problem if not proper managed (Gupta, 2005).

The microbial decomposition of the wastes produced various harmful gases which causes odour problems (Michell, 1997; Gunadi *et al.,* 2002; Gunadi and Edward, 2003; Garg *et al.,* 2006). Reinecke *et al.,* (1992) reported that the solid wastes of textile mill, sugar mill, dairy plant sludge and municipal solid wastes are harmful to human being and their cattle. Effluent from distilleries contains large amounts of dissolved matter. These organic matters are readily decomposed by microbial decomposition consequently its discharge to river stream which affect the aquatic life stream. Pandey and Carney, (1994) also reported that the effluents from cane sugar industries and distilleries contains large amount of dissolved organic matter. Vermicomposting is an eco-biotechnological process that transforms energy rich and complex organic substances into stabilized humus-like product–vermicompost (Suthar and Singh, 2008). Vermicomposting is the best option for management of animal dung and agro wastes by epigeic earthworm which can convert biological wastes into nutrient rich organic manure (Garg et al; 2005). The epigeic earthworm *Eisenia fetida*, well suitable species of earthworm for vermicomposting (Nadegwa and Thompson, 2001). *E. fetida* is responsible for the remove of toxic metals from different animal dung with kitchen wastes (Bhartiya and

Singh, 2011). Management of these biological wastes through vermicomposting is one of the better options by epigeic earthworms. *Eisenia fetida* play an important role for management of these wastes (Gupta, 2005). Atharasopoulous (1993) use the vermibiotechnology for the management of aerobically established effluents of derived vine fruit industry. Atiyeh *et al.*, 2000 have reported that earthworms are helpful for management of cow manure and their effect on germination and growth of plants. Butt, (1993) used the earthworms for management of paper mill sludge and spent brewery yeast. To use of appropriate technique for the management of harmful industrial wastes produced from cane sugar and distillery industries and will be help to change harmful effluents in to valuable and potent vermicompost as a product. The potent vermicompost used in sustainable agriculture because continuous use of chemical fertilizer has leaded to decline the soil fertility and productivity of agricultural crops and also causing deficiency and imbalance of micronutrients (Manning, 2000; Peng *et al.*, 2006). The aim of present study was primarily management of industrial wastes, biowastes, as well as to observed the physico-chemical property of sugar mill and distillery effluents alone and with combination of different animal dungs before and after vermicomposting.

2. Materials and Methods

2.1 Collection of wastes and earthworm

Cane sugar and distillery effluents were collected from Saraiyan (Saradar Nagar) Sugar and Distillery mill, Saradar Nagar, Gorakhpur, UP. The different animal dung was collected from different farm houses of the Gorakhpur district. The cultured earthworm *Eisenia fetida* was used for vermicomposting.

2.2 Experimental setup for vermicomposting

Vermicomposting was conducted in the cemented earth surface. The different combinations of animal dung with sugar mill effluents/distillery effluents in different ratio. The size of each vermibed was kept 3m x 1m x 9cm. Prepared vermibeds were moist daily and inoculate 2kg of cultured *Eisenia foetida* in each bed. The beds were covered with jute pockets and moisten the bed daily up to 40 – 50 days for maintaining the moisture content. After one week interval, mixture of bed was manually turned up to 3 weeks. After 50 – 60 days granular tea loke vermicompost appeared on the upper surface of beds (Bhatnagar and Palta, 1998).

2.3 Chemical Analysis

The pH and electrical conductivity were determined using a double distilled water suspension of each wastes in the ratio 1:10 (w/v) that has been agitated mechanically for 30 minutes and filtered through Whatsman No. 1 filter paper, and temperature was mentioned by digital thermometer. Total organic carbon was measured by the method of Nelson and Sommer (1982). Total Khjeldhal nitrogen was determined after digesting the sample with Conc. H_2SO_4 and Conc. $HClO_4$. (9:9 v/v) according to the method of Bremner and Malvaney (1982). Total phosphorus was analyzed using the calorimeter method with molybdenum in sulfuric acid (Garg et al., 2006). Total potassium was determined after digesting the sample in diacidic mixture (HNO_3: $HClO_4$ = 4:1, v/v), by flame photometer (Elica, CL 22 D, Hyderabad, India).

2.4 Statistical Analysis

All the studies were replicated at least 6 times mean ± SD. Two way analysis of variance applied in between initial feed mixture of effluent of cane sugar and distillery industries with different combinations of animal dung and final vermicomposts for chemical analysis as well as the significant growth of various crops between different vermicomposts. Student't' test were applied in between control and mixture of soil with different vermicomposts (Sokal and Rohlf, 1973).

3. Result

The different physico-chemical parameter of different combinations of sugar sludge influents and distillery with animals dungs (cow, buffalo, goat and pig) were observed before and after vermicomposting by earthworm *E. fetida*. There was significant increase in the level of TKN, TK, TP and TCa where as the significant decrease was observed temperature, pH, moisture, EC, TOC, and C/N ratio (Table.1, 2). There was statically Each value is the mean ± SD of six replicate Two way analysis of variance for significance ($P<0.05$) applied between different physico-chemical parameter of sugar mill, distillery sludge with different animal dung before and final vermicomposting.

The different physico-chemical parameter of SME (sugar mill effluents) was observed temperature, moisture, EC, TCA at the level of (33±2.82 ^oC, 98.4±1.72 % relative humidity, 3.4±0.03 dS/m, 2.7±0.01 gm/kg) were observed in initial feed mixture respectively. The colour of initial feed mixture of DE (distillery effluents) had reddish brown and odor was USBS (unpleasant smell of burnt sugar). It was containing high amount of C/N & TP in the level of (98.2±1.29 and 6.4±0.02 gm/kg respectively). The combination of both SME and DE (sugar mill effluents and distillery effluents) was unpleasant smell with brown colour. The cow dung has highly TOC (482.8±1.84 g/kg) and TK (5.2±0.07 gm/kg). Although TOC was observed in buffalo dung (8.5±0.02 gm/kg), yellowish black colour and high pH and TKN (6.6±0.12 gm/kg) in before vermicomposting but after vermicomposting all value of different physico-chemical parameter was significantly increased in different combinations. After vermicomposting of SME (sugar mill effluents) colour change into brownish and odorless. The temperature and C/N ratio were significantly decreased in the combinations of DE+CD (distilary effluentes+cow dung) the level of 25.2±1.52 and 76.2±1.26 after vermicomposting the pH of SME+BD (sugar mill effluents +buffalo dung) in the lowest value observed the significant level of 6.6±0.01. The moisture was observed in SME+DE+BD at the level of 70.2+0.08 % relative humidity. The electrical conductivity and TOC were significantly decreased in the combination of DE+BD and SME+CD value of (1.4±0.05ds/m and 161.1±1.11 g/kg) respectively. After vermicompost of cow dung TKN and TCa were increased 15.8±0.18 and 3.2±0.2 g/kg where as TK and TP of distillery effluents were 16.3±0.36 and 12.2±0.14 g/kg respectively (Table-1).

The different physico-chemical parameter of SME, DE with combination of goat and pig dung before and after vermicomposting by *E. fetida* (Table-2). The *E. fetida* was responsible for changing colour and odor in different combinations of SME, DE with goat and pig dung due to vermic activity. The mostly colour change in to brownish and odorless of final vermicompost. The pH and C/N ratio were observed in the sugar mill effluent as decreased the level of (6.5±0.06 and 86.8±1.86) from initial feed mixture in final vermicompost by *E. fetida*. The temperate was decreased in the combinations of SME+DE+GD in final vermicompost (25.9±1.29 ^{0}C). In control pig dung EC regarded value 0.74±0.01dS/m and significant decreased TOC was (282.3±1.28 g/kg). TK and TP were exposed the maximum value (16.3±0.36 and 12.2±0.14 g/kg respectively) in DE where as TCa (3.1±0.03 g/kg) in the combination of control SME. The vermicompost of control goat dung showed that the moisture was decreased (34.3+1.43 % relative humidity) and increased TKN (at the level of 10.3±0.02 g/kg).

4. Discussion

The different physico-chemical parameter observed before and after vermicomposting different combinations of sugar mill sludge and distillery influents. The colour of initial feed mixtures had reddish brown and odor may be due to presence of different sulphur derivative compounds. Decreased C/N ratio due to respiration as well as production of mucus and nitrogenous exrcreta so result decrease in final vermicompost (Suthar and Singh, 2008; Tripathi and Bhardwaj, 2004; Loh et al, 2005). The *E. fetida* was responsible for changing colour and odor in different combinations maybe due to vermic-activity. The significant decrease temperature in all final vermicompost may be due to decrease microbial activity in final vermicompost supported by (Garg and Kaushik, 2005; Chauhan and Singh, 2011). In all final vermicompost decreased TOC compare to initial feed mixture due to released CO_2 during respiration (Suthar and Singh, 2008; Garg and Kaushik, 2005). A decrease pH also is an important factor in nitrogen retention as this element is lost as volatile ammonia at higher pH value (Hartenstein and Hartenstien, 1981). The vermicompost of control goat dung showed that the moisture was decreased and increased TKN. Hand et al. 1988 reported that *E. fetida* in cow dung slurry increased the nitrate-nitrogen content. Tripathi and Bhardwaj, (2004) stated that reduced the organic carbon might be responsible for nitrogen addition in the form of. Nitrogenous excretory substances, growth stimulatory hormone and enzyme from the gut of earthworm. Kaviraj and Sharma (2003) reported that TK was increased 5% by *lampito mauritii* and 10% by the *Esenia fetida* during the earthworm activity in different biological wastes. The concentration of N,P, K in vermicompost high due to mineralization of these elements by the help of microbial and enzymetic activity ingut of earthworm (Pathasarathe and Ranganathan 2000).

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Table 1 Different physico-chemical parameter of sugar mill, distillery sludge with cow and buffalo dung – before and after vermicomposting by *E.fetida*

Before vermicomposting													
Wastes Combinations	Ratio	Colour	Odor	Temp °C	pH	Moisture %	EC (dSm^{-1})	TOC (g/kg)	TKN (g/kg)	C/N (g/kg)	TK (g/kg)	TP (g/kg)	TCa (g/kg)
SME	-	Brown	alcoholic	**33±2.82**	7.2±0.02	**98.4±1.72**	**3.4±0.03**	**280.24±1.02**	3.2±0.04	86.6±1.68	**0.7±0.01**	**2.3±0.01**	**2.7±0.01**
DE	-	Reddish brown	USBS	28±2.32	7.4±0.12	91.6±1.61	**1.8±0.01**	330.2±1.03	**2.1±0.12**	**98.2±1.29**	1.2±0.03	**6.4±0.02**	1.8±0.03
SME+ DE	1:1	Brown	US	**27±1.51**	**6.8±0.06**	88.6±0.98	2.3±0.02	305.8±1.52	2.9±0.91	94.1±1.14	2.2±0.04	4.6±0.02	2.3±0.06
CD	-	Light Brown	US	28±1.98	8.2±0.07	**58.2±1.14**	2.1±0.02	**482.8±1.84**	6.1±0.06	78.1±1.17	**5.2±0.07**	3.6±0.03	**1.3±0.2**
SME+ CD	1:1	Brown	US	29.5±2.16	7.4±0.16	79.2±1.91	2.6±0.06	386.7±1.68	4.7±0.11	80.6±1.62	2.8±0.10	3.1±0.02	2.1±0.3
SME+ CD	1:2	Brown	US	31.6±1.86	7.6±0.01	71.2±0.84	2.2±0.04	397.6±1.76	5.1±0.05	77.4±1.47	3.1±0.04	3.5±0.01	1.6±0.6
DE + CD	1:1	Brown	US	29.6±1.23	6.7±0.03	76.1±0.81	1.9±0.08	402.2±1.42	4.3±0.07	91.6±1.19	3.4±0.07	4.8±0.04	1.6±0.1
DE + CD	1:2	Brown	US	31.6±1.91	7.4±0.02	70.6±1.62	2.04±0.07	421.8±1.12	5.1±0.06	80.6±1.08	4.2±0.06	4.0±0.04	1.5±0.3
SME+ DE+CD	1:1:1	Brown	US	28.3±1.72	7.6±0.9	78.1±1.41	2.2±0.07	391.6±1.93	4.8±0.12	80.5±1.58	3.9±0.11	4.2±0.02	1.9±0.4
SME+ DE + CD	1:1:2	Brown	US	30.6±1.63	7.8±0.07	71.2±1.61	2.0±0.02	402.6±1.24	5.3±0.08	75.8±1.78	4.3±0.08	3.9±0.11	1.7±0.6
BD	-	Yellowish black	US	31.9±1.02	**8.5±0.02**	72.6±1.79	2.6±0.08	516.7±1.16	**6.6±0.12**	77.2±1.27	4.9±0.14	5.1±0.05	**1.3±0.2**
SME+BD	1:1	Brownish	US	32.2±1.62	7.6±0.06	86.1±1.56	3.1±0.09	402.9±1.04	5.1±0.06	76.8±1.86	2.4±0.08	3.4±0.06	2.2±0.3
SME+BD	1:2	Black	US	30.1±2.01	7.6±0.02	81.3±1.63	2.8±0.03	428.6±1.21	5.8±0.13	**71.9±0.19**	2.9±0.12	4.1±0.04	1.7±0.5
DE+BD	1:1	Brown	US	30.6±1.91	**6.8±0.01**	82.1±1.28	2.3±0.01	431.6±1.34	4.1±0.25	98.1±1.39	3.1±0.04	5.9±0.06	1.7±0.1
DE+BD	1:2	Brown	US	31.6±1.6	7.4±0.02	77.1±1.81	2.7±0.04	458.3±1.54	5.3±0.51	90.6±1.09	3.8±0.12	5.2±0.07	1.6±0.3
SME+DE+BD	1:1:1	Black	US	28.2±1.72	7.5±0.06	81.6±1.18	2.6±0.06	414.2±1.14	4.8±0.12	85.3±1.38	3.7±0.11	5.0±0.05	2.0±0.3
SME+DE+BD	1:1:2	Brown	US	30.1±1.34	7.9±0.09	76.2±1.61	3.2±0.07	438.1±1.84	5.1±0.06	84.8±1.48	4.2±0.07	5.4±0.08	1.8±0.6

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Final vermicompost													
SME	-	Brownish	Nil	**28.7±1.72**	**6.5±0.06**	**91.2±1.19**	**2.7±0.09**	**139.2±1.13**	**1.6±0.17**	86.8±1.86	**0.06±0.01**	**3.4±0.07**	**3.1±0.03**
DE	-	SRB	Nil	26.4±1.46	**6.9±0.09**	88.1±1.08	1.7±0.08	**249.2±1.94**	2.6±0.08	95.7±1.59	**16.3±0.36**	**12.2±0.14**	2.4±0.01
SME+DE	1:1	Whitish brown	Nil	26.1±1.62	6.8±0.06	82.3±1.28	2.1±0.03	163.2±1.31	2.1±0.02	82.5±1.18	6.8±0.14	10.6±0.07	2.8±0.02
CD	-	Brownish	Nil	25.8±1.85	6.8±0.08	**52.3±1.26**	2.2±0.04	178.4±1.18	**15.8±0.18**	78.2±1.72	5.9±0.13	7.2±0.09	**1.8±0.02**
SME+CD	1:1	Brownish	Nil	27.9±1.29	6.7±0.01	73.2±1.38	2.5±0.07	161.1±1.11	8.8±0.05	83.4±1.48	2.6±0.08	5.1±0.06	2.6±0.4
SME+CD	1:2	Brownish	Nil	27.1±1.72	6.8±0.06	66.3±1.67	2.4±0.06	167.3±1.67	11.4±0.02	79.1±1.19	4.1±0.05	6.1±0.04	2.1±0.7
DE+CD	1:1	Brownish	Nil	26.1±1.06	6.7±0.02	72.9±1.73	1.9±0.01	214.2±1.42	9.1±0.10	89.1±1.89	11.2±0.09	9.7±0.15	1.9±0.3
DE+CD	1:2	Brownish	Nil	25.7±1.52	6.8±0.02	65.2±1.57	2.1±0.13	203.2±1.03	11.7±0.08	**76.2±1.26**	9.5±0.13	8.9±0.18	**1.8±0.4**
SME+DE+CD	1:1:1	Brownish	Nil	25.9±1.29	6.8±0.02	68.9±1.85	2.1±0.03	170.2±1.07	8.9±0.17	112.2±1.11	6.3±0.12	8.9±0.14	2.4±0.1
SME+DE+CD	1:1:2	Brownish	Nil	25.8±1.85	**6.9±0.03**	62.5±1.27	2.2±0.14	174.2±1.41	11.1±0.13	119.3±1.39	6.1±0.08	8.2±0.03	2.1±0.1
BD	-	Dark Brown	Nil	28.2±1.28	6.8±0.06	64.3±1.47	**1.3±0.04**	198.4±1.81	15.4±0.19	132.4±1.41	6.9±0.14	7.1±0.06	2.8±0.3
SME+BD	1:1	Brownish	Nil	28.4±1.42	6.6±0.01	79.3±1.78	2.1±0.02	162.2±1.21	8.9±0.17	110.5±1.06	3.6±0.08	5.3±0.08	**3.1±0.2**
SME+BD	1:2	Brownish	Nil	28.1±1.12	6.7±0.13	72.1±1.28	1.6±0.05	176.8±1.76	10.1±0.11	118.2±1.81	4.9±0.12	5.9±0.07	2.4±0.5
DE+BD	1:1	Brownish	Nil	27.6±1.62	**6.9±0.15**	77.4±1.76	1.5±0.04	220.1±1.02	9.1±0.12	131.7±1.73	11.9±0.12	9.6±0.06	2.3±0.3
DE+BD	1:2	Brownish	Nil	27.9±1.97	6.8±0.02	71.2±1.18	1.4±0.05	214.2±1.14	11.2±0.21	**132.6±1.62**	10.2±0.06	8.8±0.08	2.1±0.4
SME+DE+BD	1:1:1	Brownish	Nil	27.2±1.27	6.7±0.01	74.2±1.48	1.7±0.06	180.3±1.08	8.7±1.08	118.2±1.81	6.9±0.16	8.6±0.06	2.6±0.6
SME+DE+BD	1:1:2	Brownish	Nil	**21.7±1.72**	6.6±0.06	70.2±1.08	1.5±0.04	184.2±1.48	10.9±0.08	112.6±1.62	7.1±0.09	8.3±0.03	2.3±0.4

SRB= Slightly reddish brown, SME= Sugar mill effluents, USBS= Unpleasant smell of burnt sugar, US= Unpleasant smell, DE= Distillery effluents, CD= Cow dung, BD= Buffalo dung

Each value is the mean ± SD of six replicate, Two way analysis of variance (ANOVA) for significance ($P<0.05$) applied between different physico-chemical parameter of sugar mill, distillery sludge with different animal dung before and final vermicomposting.

Table 2 Different physico-chemical parameter of sugar mill, distillery sludge with goat and pig dung – before and after vermicomposting by *E.fetida*

Before vermicomposting

Wastes Combinations	Ratio	Colour	Odor	Temp °C	pH	Moisture %	EC (dSm^{-1})	TOC (g/kg)	TKN (g/kg)	C/N	TK (g/kg)	TP (g/kg)	TCa (g/kg)
SME	-	Brown	alcoholic	**33±2.82**	**7.2±0.02**	**98.4±1.72**	**3.4±0.03**	**280.24±1.02**	3.2±0.04	86.6±1.68	**0.7±0.01**	**2.3±0.01**	**2.7±0.01**
DE	-	Reddish brown	USBS	**28±2.32**	7.4±0.12	91.6±1.61	1.8±0.01	330.2±1.03	**2.1±0.12**	98.2±1.29	1.2±0.03	**6.4±0.02**	1.8±0.03
GD	-	Black	US	29.1±1.02	**8.5±0.01**	**39.6±0.61**	2.6±0.03	436.7±1.34	**4.6±0.12**	93.8±1.39	6.1±0.08	4.1±0.04	**1.7±0.5**
SME+GD	1:1	Brown	US	30.2±1.21	7.8±0.01	69.2±0.42	3.1±0.04	354.3±1.53	3.8±0.11	92.1±1.29	3.5±0.09	3.1±0.03	2.2±0.3
SME+GD	1:2	Brown	US	29.2±1.61	7.9±0.06	58.2±1.47	2.8±0.04	331.1±1.31	4.1±0..05	**80.7±1.08**	4.1±0.07	3.4±0.06	2.1±0.1
DE+GD	1:1	Brown	US	28.3±1.62	7.9±0.08	65.3±1.56	2.2±0.04	383.2±1.83	3.4±0.07	98.6±1.86	3.7±0.11	5.3±0.07	1.8±0.3
DE+GD	1:2	Brown	US	29.1±1.87	8.0±0.06	56.1±1.58	2.4±0.06	398.2±1.93	3.8±0.11	99.1±1.19	4.4±0.09	4.9±0.12	**1.7±0.2**
SME+DE+GD	1:1:1	Brown	US	28.1±1.01	7.7±0.03	64.3±1.44	2.3±0.02	368.1±1.63	3.7±0.10	96.4±1.69	4.1±0.06	4.4±0.07	2.0±0.3
SME+DE+GD	1:1:2	Brown	US	29.1±1.17	7.9±0.02	55.1±1.57	2.6±0.08	394.2±1.94	4.1±0.05	92.6±1.29	4.7±0.13	4.2±0.05	1.9±0.4
PD	-	Black	US	31.2±1.61	7.9±0.08	46.3±1.34	**1.1±0.07**	520.1±1.25	**4.6±0.01**	110.2±1.16	**7.6±0.15**	4.1±0.03	2.2±0.05
SME+PD	1:1	Whitish Brown	US	32.1±1.43	7.6±0.06	71.2±1.78	2.3±0.07	398.2±1.93	3.9±0.12	102.5±1.06	4.2±0.07	3.2±0.04	2.5±0.01
SME+PD	1:2	Brown	US	31.2±1.81	7.7±0.04	62.3±1.26	1.9±0.09	432.1±1.34	4.1±0.05	105.3±1.03	5.3±0.09	3.4±0.06	2.4±0.03
DE+PD	1:1	Brown	US	29.2±1.18	7.7±0.02	67.9±1.76	1.4±0.01	421.3±1.24	3.4±0.07	**123.3±1.21**	4.4±0.08	5.1±0.05	2.1±0.01
DE+PD	1:2	Brown	US	30.2±1.61	7.8±0.03	60.3±1.07	1.3±0.02	**455.2±1.54**	3.8±0.11	119.7±1.79	5.4±0.09	4.7±0.10	2.2±0.02
SME+DE+PD	1:1:1	Brown	US	29.3±1.72	7.4±0.04	66.3±0.86	1.7±0.03	410.3±1.14	3.8±0.11	107.8±1.81	4.9±0.13	4.3±0.06	2.3±0.04
SME+DE+PD	1:1:2	Brown	US	30.2±1.43	7.6±0.07	59.3±0.95	1.5±0.09	445.3±1.45	4.1±0.05	108.5±1.01	5.8±0.14	4.1±0.04	2.2±0.01

Final vermicompost

SME	-	Brownish	Nil	**28.7±1.72**	**6.5±0.06**	**91.2±1.19**	**2.7±0.09**	**139.2±1.13**	**1.6±0.17**	**86.8±1.86**	**0.06±0.01**	**3.4±0.07**	**3.1±0.03**
DE	-	SRB	Nil	26.4±1.46	6.9±0.09	88.1±1.08	1.7±0.08	249.2±1.94	2.6±0.08	95.7±1.59	**16.3±0.36**	**12.2±0.14**	2.4±0.01
GD	-	Dark Brown	Nil	26.1±1.61	6.7±0.07	**34.3±1.43**	1.2±0.03	222.3±1.23	**10.3±0.02**	148.3±1.84	6.9±0.14	5.3±0.05	2.5±0.3
SME+GD	1:1	Brownish	Nil	27.3±1.32	6.6±0.12	62.3±1.27	2.1±0.02	181.9±1.81	5.9±0.14	117.2±1.71	3.5±0.09	4.4±0.04	2.6±0.4
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SME+GD	1:2	Brownish	Nil	26.9±1.92	6.7±0.01	53.2±1.36	1.7±0.07	194.6±1.14	7.4±0.11	127.3±1.71	4.6±0.11	4.7±0.07	2.6±0.2
DE+GD	1:1	Brownish	Nil	26.3±1.62	6.8±0.14	61.2±1.17	1.5±0.05	236.2±1.62	6.4±0.17	120.5±1.05	11.6±0.08	8.8±0.08	2.3±0.4
DE+GD	1:2	Brownish	Nil	26.2±1.26	6.7±0.13	52.3±1.26	1.3±0.04	230.1±1.02	7.6±0.31	130.3±1.31	10.1±0.01	7.6±0.06	**2.2±0.6**
SME+DE+GD	1:1:1	Brownish	Nil	26.1±1.06	6.8±0.02	58.8±1.86	1.7±0.06	193.5±1.31	6.1±0.16	112.6±1.26	6.9±0.13	7.9±0.07	2.6±0.4
SME+DE+GD+	1:1:2	Brownish	Nil	**25.9±1.29**	6.7±0.01	51.3±1.16	1.5±0.06	201.1±1.12	7.5±0.14	127.3±1.37	7.1±0.06	6.9±0.09	2.3±0.6
PD	-	Dark Brown	Nil	28.3±1.38	**7.3±0.04**	41.3±1.41	**0.74±0.01**	**282.3±1.28**	9.6±0.16	**156.3±1.61**	7.4±0.12	6.4±0.04	2.3±0.61
SME+PD	1:1	Brownish	Nil	28.5±1.52	6.9±0.03	66.3±1.16	1.7±0.06	210.1±1.01	5.6±0.15	120.1±1.21	3.7±0.11	4.9±0.09	2.7±0.03
SME+PD	1:2	Brownish	Nil	28.4±1.42	7.2±0.07	57.5±1.76	1.4±0.05	234.6±1.42	6.9±0.39	132.6±1.23	4.9±0.12	5.4±0.05	2.6±0.04
DE+PD	1:1	Brownish	Nil	27.4±1.27	7.1±0.06	64.8±1.47	1.2±0.03	266.3±1.62	4.8±0.48	126.4±1.26	11.8±0.01	9.3±0.11	2.4±0.02
DE+PD	1:2	Brownish	Nil	27.7±1.72	7.2±0.05	60.1±1.07	1.1±0.02	271.3±1.17	5.5±0.05	136.2±1.63	10.3±0.04	8.3±0.11	2.3±0.06
SME+DE+PG	1:1:1	Brownish	Nil	27.2±1.22	7.1±0.70	61.3±1.26	1.4±0.05	223.1±1.32	5.8±0.08	119.2±1.11	7.1±0.06	8.5±0.03	2.6±0.03
SME+DE+PG	1:1:2	Brownish	Nil	27.6±1.62	7.1±0.17	54.3±1.42	1.2±0.01	243.1±1.34	7.1±0.16	131±1.31	7.2±0.08	7.7±0.12	2.4±0.04