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Research Article

BENEFICIAL INFLUENCE OF ELEPHANT DUNG ON CONVENTIONAL VERMICOMPOSTING TECHNOLOGY

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ABSTRACT

The study was aimed to evaluate the nutrient element of vermicompost produced from different vermibed materials *viz* elephant dung and cow dung. Triplicate vermireactors were run distinctly by the addition of precomposted cow dung, elephant dung and garden soil with various proportions, which comprises 100% elephant dung, 100% cow dung, 50% elephant dung+50% cow dung, 50% elephant dung+50% garden soil and 50% cow dung+50%garden soil. Vermireactors were operated with ten individuals of fully clitellated earthworm *Eudrilus eugeniae* and maintained for 45 days. The result revealed that all the macro nutrients were found to be significantly higher in compost made from elephant dung as one of the vermibed material. The C/N ratio was decreased in all vermicompost and maximum reduction was observed in elephant dung compost by 11.28 ± 0.48. The pH of the vermicompost was neutralized and slightly alkaline which indicate the maturity and stability of the vermicompost. The present studies were concluded that the supplementation of elephant dung along with conventional vermiculture practices has the potential to increase the bioenrichment of the vermicompost.

Keywords: Earthworm, vermireactors, elephant dung, cow dung, *Eudrilus eugeniae*

1. INTRODUCTION

Traditional method of waste dumping such as land filling and open burning are unmaintainable due to accumulation and creation of toxic substances and gases from the waste which have impending adverse effects on the environment [1]. Hence the renovation of organic solid waste in to beneficial materials is an indispensible component in resource recovery and recycling principles. Vermicomposting method is an eco-friendly and economically viable technology for converting animal dung in to organic manure [2]. In contrast to traditional microbial waste treatment, vermicomposting results in the bioconversion of the waste stream into two useful products *viz*, the earthworm biomass and the vermicompost. The former product can further be processed into proteins viz fish meal and high-graded horticultural compost [3-6].

The chemical, as well as biological, composition of the substrate material are always of primary importance for large scale vermiculture practices. According to Edwards [3], the type, quality and quantity of organic wastes are very important for determining the growth rate of earthworms. The carbon: nitrogen ratio were used as a measure of substrate quality [7] and low carbon: nitrogen ratio increases metabolic efficiency of decomposer micro-flora that in turn increases decomposition rates [7, 8]. Higher nitrogen ratio assists in faster growth and larger production of cocoons [9].

A comparison on the physico-chemical composition of the elephant dung [10,11] with that of the major food plants of elephants [12] shows that many of the important minerals, such as nitrogen, phosphorus and potassium, occur at a higher percentage in the dung than in the food materials. Since elephants are poor digester of food and their semi digested dung are rich in partially decomposed plant materials, mainly fibres and seeds, it can be used in vermicomposting technology [13].

According to Ismail, 1997 [14] in a typical vermicomposting unit the fresh or dry cattle dung are used above the basal layer of vermireactor. The present study compares the quality of vermicompost by using different vermibed materials *viz.*, elephant dung and cow dung.

2. MATERIALS AND METHODS

2.1. Earthworm

Eudrilus eugeniae was selected for the vermicomposting procedure since it is widely using known epigeic species, having the potential of organic waste decomposition [15-18] because of its high voracity in feeding habit and high reproductive capacity. The fully clitellated earthworms were collected from Kanuvai Organic farm, Coimbatore and ten worms were introduced in to each treatment by maintaining moisture 70-80%.

2.2. Pre-composting

The elephant dung and cow dung were collected from Perur temple and Perur cattle farm, Coimbatore, Tamil Nadu. The fresh animal dung were subjected to pre-composting up to15 days, since precomposting is an essential procedure to avoid mortality of earthworms by heat. The manure wre composted as specified by Ismail, 1997 [14] by adding water and turning it every day to lower the temperature and stabilize the pH.

3. EXPERIMENTAL

Vermireactors with identical width, height and length were charged with identical quantities of animal dung with different concentration in each series. Five series of such reactors were used in triplicate (100% cow dung, 100% elephant dung, 50% cow dung + 50% elephant dung, 50% cow dung + 50% garden soil, 50% elephant dung + 50% garden soil). In each series of vermireactor were run with 10 individuals of earthworm *Eudrilus eugeniae* per 2 Kg of reactor volume.

3.1. Reactor operation

All the reactors were sheltered in an identical environment at temperatures which were kept at 29±2°C during the day and 27±2°C during the night, the diurnal temperature alteration were always within 4°C. The moisture content of the reactor was sustained at 70%-80% by observing of loss of moisture and adequate replenishment. The ambient humidity fluctuated from 70% to 80% during the course of the experiment.

The purpose of the experiment is to assess the nutrient composition of vermicompost by the earthworms as a function of composting of different animal dung. To achieve this objective the reactors were operated in a standardized and extensively reported earlier by the authors [9, 20]. In this manner the vermicompost were separated 45 days to assess the nutrient compositions.

3.2. Chemical analysis

The pH was determined by using a double distilled water suspension of each sample (at a ratio of 1:10 (w/v)). The total organic carbon was measured by dichromate digestion [21], total nitrogen was evaluated using Micro-Kjeldahl method [22], phosphate were determined by colorimetric method [23], potassium by flame photometric method and micro nutrients *viz.,* Cu, Fe, Mn, and Zn by atomic absorption spectrophotometric method.

3.3. Statistical analysis

The data were analyzed using one way analysis of variance (ANOVA) and Duncan's multiple ranged tests. All the values were analyzed at the significant level 5, where P<0.05 was considered as statistically significant. Statistical analyses were done by using IBM SPSS version 20 software.

4. RESULTS AND DISCUSSION

4.1. Characterization of vermibed materials

Table 1 reveals that the chemical analysis of the reactor substrate, in which elephant dung comprises the maximum amount of macronutrients like N and P and micronutrients *viz.*, Mn, Zn and OC when compared to the cow dung and garden soil.

It can be observed that cow dung had highest level of Cu, Fe, Mn, and pH. Comparing with cow dung and garden soil, C/N ratio of the reactor substrate were significantly higher in elephant dung. Excluding pH and moisture all other nutrients analyzed in reactor substrate were statistically significant.

Table 1: Chemical analysis of vermibed material

Reactor substrate	P^H	OC %	N%	C/N Ratio	P Kg/ha	K Kg/ha	Cu Ppm	Fe Ppm	Mn ppm	Zn ppm
ED	6.9 ± 0.06^a	52.07 ± 0.29^a	1.205 ± 0.27	43.1 ± 0.08^a	297.0567 ± 2.43^b	891.26 ± 3.27^a	3.29 ± 0.19^a	15.36 ± 0.22^b	30.08 ± 0.32^a	21.57 ± 0.25^b
CD	6.8 ± 0.10^a	34.11 ± 0.20^b	1.115 ± 0.26	30.5 ± 0.06^b	305.73 ± 1.57^a	891.12 ± 0.85^a	0.38 ± 0.04^c	19.38 ± 0.21^a	69.00 ± 0.25^b	18.22 ± 0.28^a
GS	6.7 ± 0.06^a	8.10 ± 0.29^c	0.867 ± 0.18	27.1 ± 0.11^a	36.46 ± 1.73^c	548.3 ± 0.31^b	2.70 ± 0.10^b	14.76 ± 0.25^b	28.13 ± 0.64^c	13.61 ± 0.24^c
ANOVA										
F	2.663^*	525.978^{***}	86.796^{***}	228.302^{***}	710.492^{***}	191.898^{***}	57.415^{***}	21.112^{***}	1365.830^{***}	15.617^{***}

F values and significance (*) are shown for each sample. P< 0.05 are significant n = 3, C/N carbon to nitrogen ratio, ED- elephant dung, CD- cow dung, GS- garden soil

According to Williams and Haynes [24], the herbivore dung forms the first of many steps in the course of nutrient cycling. Most mammals use only a small quantity of the nutrients they consume, with 60-99% of the ingested nutrients reverted to the soil in the form of dung and urine and this dung provides a considerable source of nutrients necessary for plant productivity in the form of available elements. Elephant dung is an abundant resource with over 150 kg (wet weight) of dung deposited per elephant per day [25]. Although widely used in the tropics as a fertilizer, many of the important minerals for plant growth, such as N, P and K, which occur within elephant dung, are present at higher concentrations within the dung than in the ingested food materials [26-28].

4.2. Chemical analysis of vermicompost

The results of vermicompost of different vermibed media are summarized in Table 2. Significant variations in nutrient level were observed in each treatment. All the factors analyzed in the present study were statistically significant with P<0.05. The elephant dung vermicomposts with varying concentration enhanced the level of nutrients *viz.,* OC, Fe, Zn (100% elephant dung), total nitrogen (50 % elephant dung +50% cow dung), and total potassium (50 % elephant dung + 50% garden soil) specifying their richness in nutrient content. Elephant dung vermicompost were more enhance than the other vermicomposts prepared from cow dung. The P, content of vermicompost were observed maximum in cow dung compost (353.57 ± 0.20 Kg/ha) and the combination of the elephant dung + cow dung elevated the P content of the vermicompost and it observed as 347.67 ± 0.32 Kg/ha. The micronutrients Cu and Mn were found to be elevated in the vermicompost generated from 50% cow dung + 50% garden soil. The pH of the vermicompost showed in the following trend of variations : 100% CD > 50% ED+GS > 100% ED > 50% ED+CD >50% CD+GS.

Table2: Chemical analysis of vermicompost

Reactor substrate	P^H	OC %	N%	C/N Ratio	P Kg/ha	K Kg/ha	Cu Ppm	Fe Ppm	Mn ppm	Zn ppm
100% ED	7.3 ±0.26^{ab}	30.30±0.50^{a}	1.24± 0.02^{b}	24.40±0.40^{a}	298.10±1.24^{a}	892.75± 0.12^{b}	0.29±0.01^{c}	32.53±1.15^{a}	77.76± 2.54^{a}	38.00± 0.04^{b}
50% ED + 50% GS	7.37±0.13^{a}	29.14±0.42^{a}	1.23±0.02^{bc}	23.73±0.49^{a}	301.56±8.68^{a}	897.196±0.40^{a}	0.39±0.08^{c}	20.95±1.12^{b}	76.64± 7.13^{b}	34.33± 0.15^{b}
50%ED+ 50% CD	7.27±0.09^{ab}	30.03±0.66^{a}	1.26±0.02^{a}	23.83±0.43^{b}	347.67± 0.32^{b}	875.78 ±0.24^{c}	0.61±0.01^{b}	21.21±0.40^{b}	78.76± 4.94^{c}	28.20± 0.19^{b}
100% CD	7.66±0.12^{a}	19.21±0.36^{b}	1.17±0.01^{c}	16.53±0.27^{c}	351.83± 1.66^{b}	852.96±0.3527^{d}	0.28±0.00^{c}	22.07±1.16^{b}	70.37± 3.10^{d}	25.19± 0.14^{b}
50% CD+ 50% GS	6.83±0.03^{b}	16.24±0.35^{c}	1.16±0.03^{d}	14.20±0.25^{c}	353.57± 0.20^{b}	850.93 ± 0.42^{e}	0.99±0.04^{a}	21.78±0.70^{b}	111.32±5.69^{e}	21.73± 0.24^{a}
ANOVA										
F	4.088*	203.244***	57.933***	71.599***	31.122***	1691.012***	55.010***	16.305***	1607.100***	10.593***

F values and significance (*) are shown for each sample. p < 0.05 are significant n = 3, C/N carbon to nitrogen ratio, ED- elephant dung, CD- cow dung, GS- garden soil

4.3. pH

The pH of the vermibed material showed slightly acidic range between 6.7±0.06 and 6.9±0.06 and the vermicompost showed increase in P^H range between 6.83 ±0.03 to 7.66±0.12 (Fig.1). pH towards neutrality should be important in retaining nitrogen as this element is lost as volatile ammonia at high pH values [29] and seems to promote the nutrient availability to the plants. The carbonic anhydrase present in the earthworm calciferous gland catalyses the fixation of CO_2 as $CaCO_3$ thereby prevent the reduction of H+ ions concentration [17]. The increase in the pH values of the present study during vermicomposting is supported with the previous studies of [30-32]. Since pH is known to elevate during the latter stages of vermicomposting. Thus, neutral and partially alkaline pH values are commonly observed as indicators of stable vermicomposts [33].

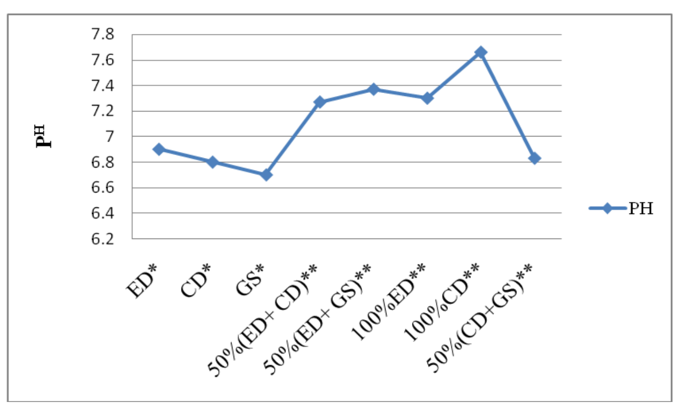

Fig. 1: pH range in vermibed material and vermicompost.

** Vermibed material before composting, **Vermicompost*

4.4. Organic Carbon, Nitrogen

The organic carbon have an essential role in maintenance of soil health, its deficiency will reduces storage capacity of soil nitrogen, phosphorus, sulfur and leads to reduction in soil fertility [34]. In vermicomposting the organic matter is degraded by earthworm and subsequent microbial degradation. Earthworm modifies substrate conditions, which consequently affects carbon losses from substrates through microbial respiration in the form of CO_2 and even through mineralization of OC [17]. Besides, Dominguez and Edwards [35] evidently validated that OC reduces from the substrate as CO_2 during vermicomposting by the combined actions of earthworms and microorganisms. Earthworms release mucus and enzymes stimulating microbial action, while the microorganisms offer extracellular enzymes within the worms' guts [35]. Accordingly, in the present study, the OC were significantly reduced in all the treatments when compared to reactor substrate. Reduction of maximum OC was observed in the treatment with 100% elephant dung as the vermibed material by 52.07± 0.29 % to 30.30 ± 0.50.

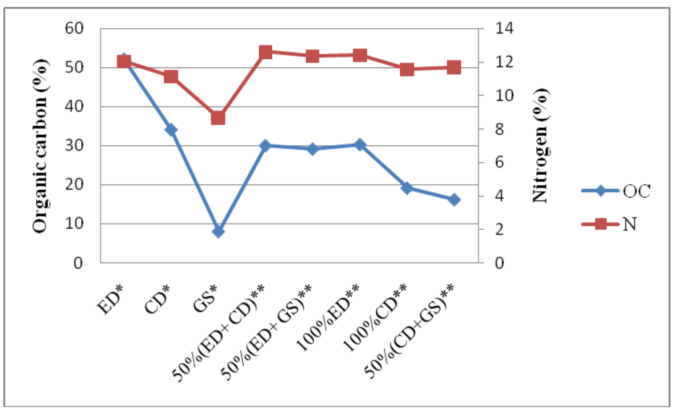

Fig.2: Percentage of OC & N in vermibed material and vermicompost.

** Vermibed material before composting, **Vermicompost*

The elephant dung mixed with cow dung in the ratio 1:1 enriched the maximum level of total N in the vermicompost by 1.24±0.02% (Fig.2). All the treatment showed the increase in total N when compared to the vermibed material. The increasing trend of N in the vermicomposts generated by the earthworm species in the present study correlated with the findings of previous reports of Bouche et al. [36] and Balamurugan et al. [37]. The nitrogenous excrements, mucous, enzymes, growth stimulating hormones and degraded tissue of the earthworm after their death have the significant role in enhancing the total N content in the vermicompost. Several studies reported that decomposition of organic materials by earthworm expedites the N mineralization process and consequent changes in the N profile of the substrates [38-41]. Satchell 1967 [42] elucidated that over 70 % of the N in the tissues of dead earthworm was mineralized in less than 20 days. However, decomposition activities and N enhancement by earthworms also depend upon the quality of the reactor substrates.

4.5. C/N Ratio

The C/N ratio of the substrate material displays the organic waste mineralization and stabilization during the process of composting or vermicomposting. Higher C/N ratio indicates slow degradation of substrate [43], and the lower the C/N ratio, the higher in the efficiency level of mineralization by the species. In the present study Lower C/N ratio of vermicompost were observed in treatment containing cow dung and elephant dung at the ratio of 1:1, which increased the organic matter mineralization more efficiently (Fig.3). The loss of carbon through microbial respiration and mineralization and simultaneous addition of nitrogen by worms in the form of mucus and nitrogenous excretory material lowered the C/N ratio of the substrates [44-46].

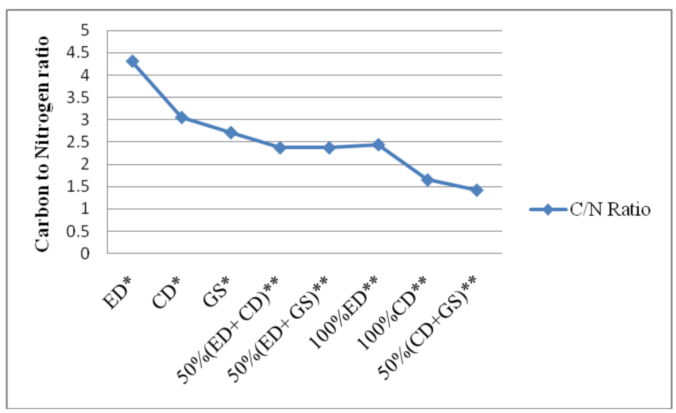

Fig.3: C/N Ratio of vermibed material and vermicompost

** Vermibed material before composting, **Vermicompost*

4.6. Phosphorus and Potassium

The total phosphorus content were higher in the vermicompost to that of initial substrates. The combination of elephant dung and cow dung vermibed material at the ratio of 1:1 elevated the P content of the vermicompost (347.67 ± 0.32) (Fig.5). The enriched P level in vermicompost advocates phosphorous mineralization during the process. The worms during vermicomposting transformed the insoluble P into soluble forms with the help of P solubilizing microorganisms through phosphatases present in the gut, making it more available to plants [47-49]. Roisin [50] proved the high level P content in the elephant dung than the ingested plant materials. In the present study, among the chemical characterization of vermibed materials, 50% cow dung and garden soil possess maximum amount of P (353.57±0.20) content than the others. Hence by combining the cow dung and elephant dung may provide the additional amount of P in the mineralization process of earthworms.

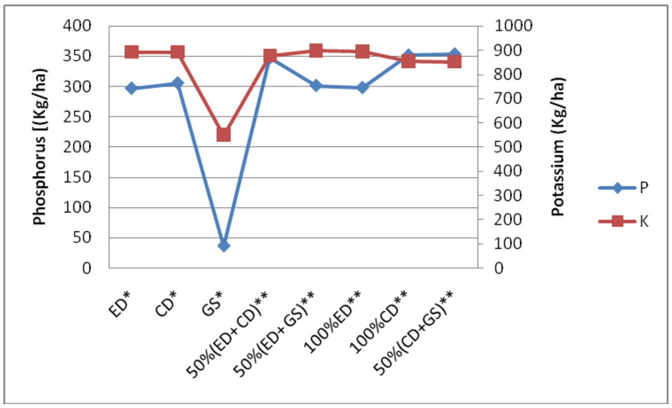

Fig. 4: Quantity of P & K (Kg/ha) in vermibed material and vermicompost

* *Vermibed material before composting, **Vermicompost*

Vermicomposting verified to be an efficient process for recuperating higher K from organic waste [47, 51&52]. The present findings supported to those of Delgado *et al.* 1995 [53] who validated that higher K concentration in the end product prepared from sewage sludge. The rise in K of the vermicompost in relation to that of substrate was probably because of physical decomposition of organic matter of waste due to biological grinding during passage through the gut, coupled with enzymatic activity in worm's gut, which may have caused its increase [54]. The microorganisms present in the worm's gut probably converted insoluble K into the soluble form by producing microbial enzymes [55].

4.7. Micronutrients

The micronutrients *viz*, Iron (Fe), Copper (Cu), Zinc (Zn), and Manganese (Mn) in small amounts are equally important for plant development as the primary nutrients [56, 57]. Fe stimulates formation of chlorophyll, acts as an oxygen carrier promotes reactions that involve cell division and growth. Cu acts as a catalyst for plant process, increases the carbohydrate content in plants, endorses color intensity, and also increase the flavor of fruits and vegetables. Zn promotes the growth of plant hormones and enzyme system and also aids in seed formation. Mn functions as part of certain enzyme systems and aids in chlorophyll synthesis. In the present study the percentage difference of micronutrients elements were also observed in precompost and vermicompost materials (Table 2). The vermicompost of cow dung and garden soil in the ratio of 1:1 shows higher amount of Mn (111.32±5.69). By comparing with reactor material micronutrients in the vermicompost was significantly increased and it was correlated with previous reports.

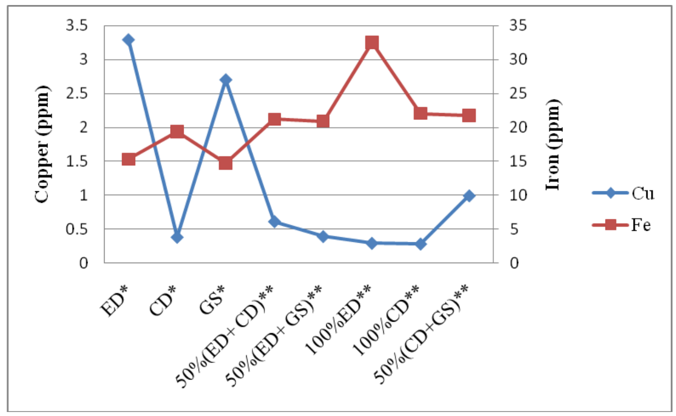

Fig. 5: Quantity of Cu & Fe (ppm) in vermibed material and vermicompost

* *Vermibed material before composting, **Vermicompost*

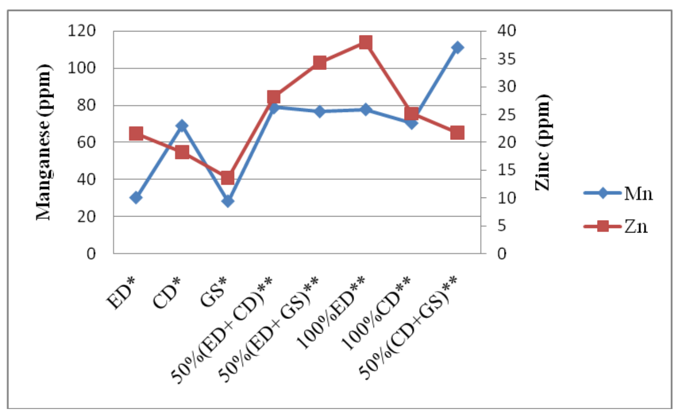

Fig. 6: Quantity of Mn& Zn (ppm) in vermibed material and vermicompost

* *Vermibed material before composting, **Vermicompost*

5. CONCLUSIONS

The pH, OC, N, P, K, C/N ratio, and micronutrient level of all the precomposted samples subjected to vermicomposting reached the standards quality of vermicompost. It is concluded that vermicompost produced from elephant dung as one of the vermibed material possessed higher macro nutrients compared to other compost materials. In the traditional vermicomposting method cow dung is used as the vermibed material and our present study postulates elephant dung could be used as vermibed material, Because it is highly enhancing the macro and micro nutrients, so we strongly recommend elephant dung in the vermicomposting practices along with the cow dung, since elephant dung possess semi digested plant materials enriched with cellulose, proteins and fibre contents.

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