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Role Of Substrate Particle Size On Vermicomposting Of Pre-Cooked Vegetable Market Waste

Senthilkumar Palaniappan*[1] and Kavimani Thirugnanasambandam[2]

[1]Assistant Professor and [2]Associate Professor, Department of Civil Engineering, Government College of Engineering, Thanjavur, Tamil Nadu, India
*toopls@gmail.com

ABSTRACT

Past studies report that pre-composting of waste is highly required and 10-15 cm of substrate depth is optimum for conventional vermicomposting, which leads to encroachment of large land area and long time in the process. Keeping this as a core problem, an attempt was made to accelerate and digest the high volume of waste by modifying the conventional vermicomposting to engineered vermicomposting. In the engineered process, the substrate depth was raised to a maximum of 30 cm and elimination of pre-composting by pre-processing (chopping, pulverizing, stocking, and drying) the waste. The study also aims in determining the ideal substrate particle size distribution for vermicomposting by experimenting with five different substrate particle mix. Pre-processed waste were sieved using of IS sieves for extracting the substrate particles of different sizes (less than 1.7 mm, between 2.36 mm and 1.7 mm, between 4.75 and 2.36 mm, and between 6.30 mm and 4.75 mm). Then the sieved particles were mixed at six different combinations (T1, T2, T3, T4, T5 and T6) and then vermicomposted (E. fetida). Results revealed that vermi bin loaded with T3 and T4 combinations produced good volume reduction and biomass growth.

Keywords: *Vermicomposting, Substrate particle size, E. fetida.*

I. INTRODUCTION

Due to availability of diverse climate in India, all varieties of vegetables harvested all over the country. Due to high population growth, the need for organic vegetables increases rapidly day by day. Due to the extraordinary need, large quantity of high organic vegetable wastes are generated within short period. After harvesting the commercial part from vegetables reaming organic portions were simply dumped on land. These organic waste dumping generate pollution in multi dimension in the natural environment (air, water, soil etc.). Due to over dumping of huge quantity of organic waste negatively influences the climatic conditions such as release of greenhouse gases, intrusion of leachates into water bodies and it also affects the human health by breeding various uncontrollable diseases. These organic vegetable wastes are simply biodegradable so possibility of recycling is more when compared to non-biodegradable waste. Recycling of organic vegetable waste positively effects on reduction of pollutants which caused by decomposable matter. As a part of recycling, these huge amounts of vegetable wastes are used for vermicomposting process. Vermicompost obtained from organic vegetable wastes are found to be high nutritive value, which acts as replenishment for chemical fertilizer. Similarly, vermicompost acts as soil conditioner and it enhances the plant growth factors. Thus, vermicomposting of large quantity of vegetable waste positively effects on creating the job and decreasing the pollution in the environment. Several studies have been conducted on vermi conversion of different waste such as distillery sludge [1] paper and pulp industry sludge [2 and 3] coffee industry [4], sewage sludge [5], tannery sludge [6], milk industry waste [7], municipal solid waste sludge [8], sugar industry waste [9] and animal wastewater treatment sludge [10]. However, most of the studies discussed about moisture content [11], heavy metals [12], temperature [13], C/N ratio [14], stocking density and feed rate [15].

Very few studies are accessible on the vermicomposting of vegetable waste such as [16], [17], [18], and [19]. These studies shows lack of knowledge on effects of particle size on vermicomposting of vegetable waste. The objects of the study was (a) accelerate the vermicomposting process by transforming the conventional vermicomposting into engineered vermicomposting. (b) assess the influence of substrate particle size on abiotic factors (pH, Moisture and Temperature), substrate depth reduction and worm biomass growth and (c) optimize the substrate particle size for improved vermicomposting process.

II. MATERIAL AND METHODS

A Experimental Setup

Vermi bins specification

Seven vermi bins made of Poly vinyl chloride (PVC) pipes and each vermi bin have dimensions of 40 cm height and 15.24 cm diameter (Figure 1). In each bin, top 5 cm and bottom 5 cm were left as free board and drain bed respectively. Providing free board on top of the bin will prevent the escape of earthworm from the bins. The drain bed at the bottom of the bin was filled with pebbles of size 6 mm - 8 mm. An outlet was provided at the bottom of each vermin bin to collect the vermi wash as excess moisture if not drained will form a discomforting zone to worms by suffocating them16. Out of seven bins, six with different particle size mix. The bins named T1, T2, T3, T4, T5, T6 and C as control unit.

Preparation of mix trials

Table 4 represents the substrate trial mix used for the study. Initially the pre-processed waste was sieved and particle with different sizes were extracted sizes less than 1.7 mm, between 2.36 mm and 1.7 mm, between 4.75 and 2.36 mm, and between 6.30 mm and 4.75 mm). Then the extracted substrate with different particle sizes were mixed together at different proportions. The mix proportions percentage with its weight are listed in Table 4.

C Filling the substrate and inoculating the earth worms

All the bins (T1, T2, T3, T4, T5 and T6) filled with processed vegetable waste (1.2 kg each) was run for 2 days before inoculating the earthworms. This will drain the presence of unwanted organic gases and stabilize the fluctuations of control parameters like moisture, temperature and pH in the substrate. On weight basis each bin was inoculated with worms (E.fetida) weighing 100 ± 10 gm. In parallel, a control unit(C1) and a conventional unit(C2) were also maintained for comparing the consolidation and volume reduction of substrate mass in the bins.

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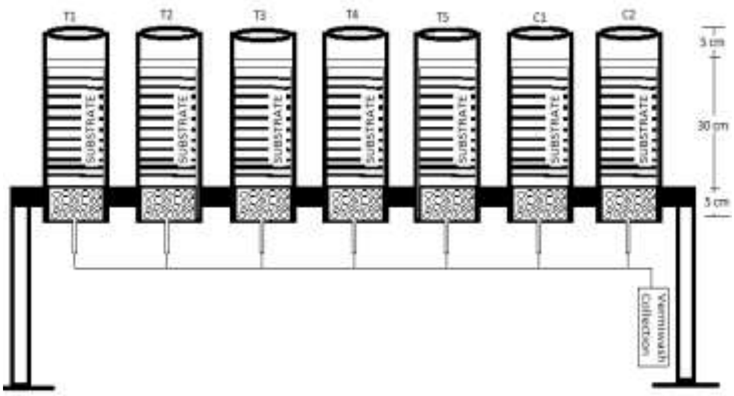

Fig 1 Schematic diagram of Vermibins

Chemical analysis

The initial chemical analysis of pre-processed waste reports the following: pH 8.1 ± 0.5, total organic carbon (TOC) 46.35 ± 0.5 mg/g; total Kjeldahl nitrogen (TKN) 1.63 ± 0.3 mg/g, total available phosphorus (TAP) 5.32 ± 0.21 mg/g; total potassium (TK) 33.26 ± 0. 8 mg/g; and C/N ratio was found to be 28.43. The pH value was measured using a digital pH meter (LI 120 Elico India) in the filtrate attained by dissolving the sample in twice volume of distilled water. Total organic carbon (TOC), Nelson and Sommers method (1982). Total Nitrogen was determined, Kjeldahl distillation method (Bremner 1996). Phosphorous and Potassium was of each sample was determined by standard method of Jackson, using Flame photometer. The ratio of C/N was found by using measured values of carbon C and nitrogen N.

III. RESULTS AND DISCUSSIONS

Table 1 shows the depth reduction and temperature of substrate in the vermi bins during the experimental duration. The experiment was conducted for 90 days. All the parameters reported in the table are mean of the respective replicates.

Influence of substrate size particles on Temperature

Temperature is an important factor to manage the physicochemical status of annelids and high temperature affects the existence condition of the worms in the Vermibin. The optimum temperature range for earthworms during vermicomposting process is 25–28 ° C [10]. It is well known that temperature will influence the development and sexual reproduction rate of earthworms. On the other hand the surface casting, growth rate and burrowing activity had become more dependent on temperature than on moisture [20]. After vermicomposting of 90 days, the temperature drastically rises from 28°C to 34°C. Fig 2 shows difference between atmospheric temperature and recorded bin temperature (A-B).

From table 1 it was observed that, at the depth of 22.50 cm in all Vermibin achieved maximum temperature when compared to all other depths (Fig 2 – a, b, c and d). This may be due to the interference of atmospheric air flow up to a depth of 15 cm in the vermi bin and at 30 cm depth there is a possibility of air interfere through drain bed pores. Consolidation of substrate also plays significant role in increasing of temperature. Similarly, T4 bin reaches very high temperature of (34°C) this may be due to the effect of increasing substrate size of particles. Moisture content of the Vermibin significantly affected by T4 bin which reduces the moistness available in the substrates. It is evident from above results substrate particle size will influence the temperature available in the Vermibin. Therefore, optimum particle size is needed to be concern to achieve high efficiency vermicomposting process.

Table 1 Variations of substrate depth and temperature in various trial units

Day	Ta	T1			T2			T3			T4			T5			T6			C		
		d	T1	MC	d	T2	MC	d	T3	MC	d	T4	MC	d	T5	MC	d	T6	MC	d	T	MC
0	30.4	30.00	32.2	48	30.00	32.0	48	30.00	31.9	54	30.00	32.8	54	30.00	31.6	62	30.00	34.3	68	30.00	34.1	69
5	30.2	29.00	31.3	47	29.00	31.5	46	29.00	31.65	53	29.00	31.7	56	29.00	32.6	61	29.00	33.9	67	29.00	33.8	67
10	27.9	27.97	31.4	48	28.27	30.2	45	28.00	31.45	51	28.12	29.9	55	27.95	31.9	62	28.43	31.7	68	28.37	31.5	68
15	31.0	26.80	33.7	46	27.28	33.2	45	27.15	32.15	53	27.05	32.5	52	27.23	34.1	60	27.50	32.9	66	28.42	31.6	66
20	29.6	26.15	31.4	44	26.52	31.7	44	26.02	31.5	52	25.92	32.3	57	25.72	31.1	59	27.25	31.7	64	28.24	31.7	63
25	30.7	25.28	31.9	46	26.20	31.7	43	25.18	32.9	53	25.08	32.9	56	25.28	32.7	58	26.43	32.3	63	27.95	32.7	62
30	32.2	23.8	33.7	48	25.10	33.4	49	23.80	32.2	55	23.70	33.9	56	23.60	33.6	59	25.12	33.6	62	27.65	33.6	61
35	30.1	22.8	31.7	45	23.12	31.3	48	22.55	31.7	51	22.45	31.8	54	22.67	31.4	60	24.70	32.9	66	27.15	32.3	65
40	31.9	22.5	33.9	46	22.70	34.6	48	22.10	32.65	52	22.00	34.9	53	21.60	33.9	58	23.50	32.9	65	26.68	32.4	64
45	30.4	21.97	31.5	43	22.05	31.2	48	21.45	31.7	54	21.35	31.9	54	21.10	31.4	59	23.15	32.3	66	26.15	33.1	65
50	29.9	20.90	31.3	45	21.13	30.9	47	21.03	30.9	53	20.93	30.6	55	20.68	30.7	58	22.70	30.9	67	25.75	30.9	66
55	28.5	19.95	30.4	48	19.76	29.3	47	19.51	29.5	54	19.41	30	54	19.25	28.9	59	22.60	29.3	68	25.10	29.7	67
60	29.3	19.00	30.5	47	18.40	30.1	46	18.00	30.7	56	17.90	30.9	57	17.82	29.9	58	22.10	30.5	65	24.70	30.7	64
65	30.5	17.33	31.6	49	16.00	31.9	46	16.07	31.7	57	15.97	31.4	58	16.08	31.6	60	21.50	31.6	64	23.95	31.8	63
70	30.1	15.67	31.7	51	14.00	31.7	50	14.15	31.9	57	14.05	31.6	56	14.35	31.8	59	21.10	31	65	23.55	31.2	64
75	29.2	15.24	28.9	50	13.00	29.1	51	13.61	29	52	13.51	28.7	54	13.55	29	58	20.25	30.4	63	23.20	30.8	62
80	28.7	14.8	28.4	51	12.65	28.3	50	13.07	28.1	55	12.97	28.3	57	12.75	28.1	58	19.62	29.6	64	22.85	29.9	63
85	28.3	13.65	27.9	52	12.25	28.0	52	12.34	27.9	56	12.24	28.1	56	12.73	28.2	57	19.22	29.5	62	22.45	29.9	61
90	28.9	11	28.7	52	11.06	28.4	52	10.80	28.6	54	10.57	28.5	55	12.25	28.7	56	18.82	29.3	60	22.10	29.6	59

***Note**: **d**: Depth of the substrate with respect to time, cm; **T**: Substrate temperature, ˚C; **T_a**: Ambient (room) temperature, ˚C and conventional bin (CV)*

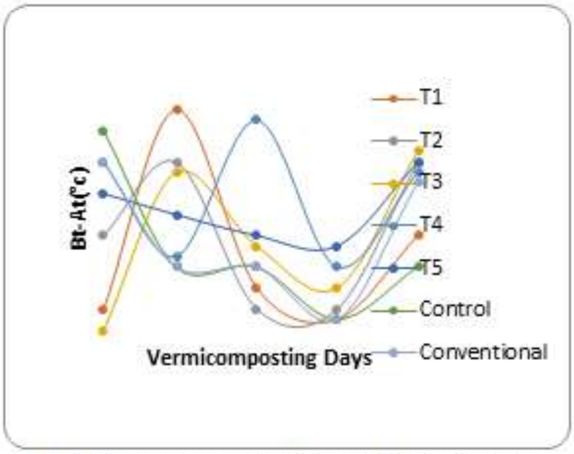

Fig 2(a) Temperature difference in 7.5cm Depth

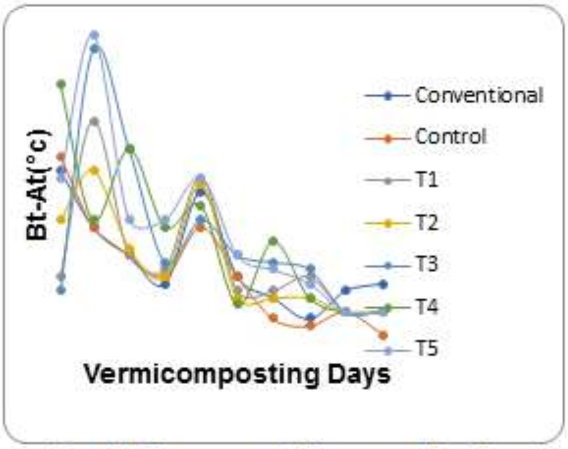

Fig 2(b) Temperature difference in 15cm Depth

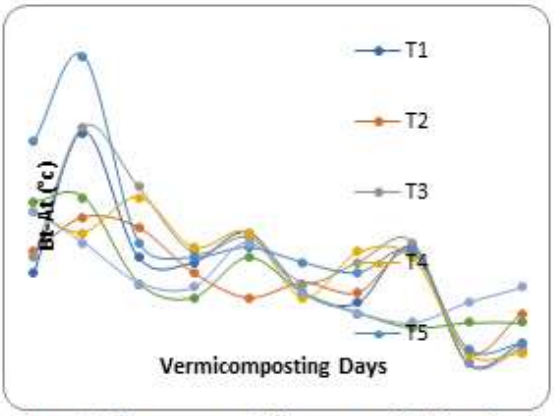

Fig 2(c) Temperature difference in 22.50cm Depth

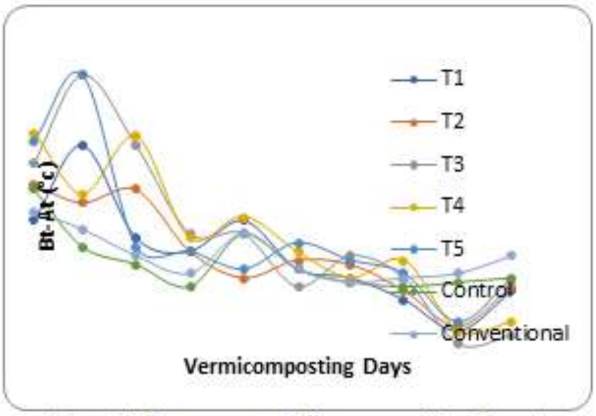

Fig 2(d) Temperature difference in 30cm Depth

Fig 2 (a, b, c, d) Temperature variations recorded in various trial bins

Influence of substrate particel size on moisture content

Fig 3 a, 3b, 3c, and 3d represents the moisture variations recorded in various trial units during the experiment.

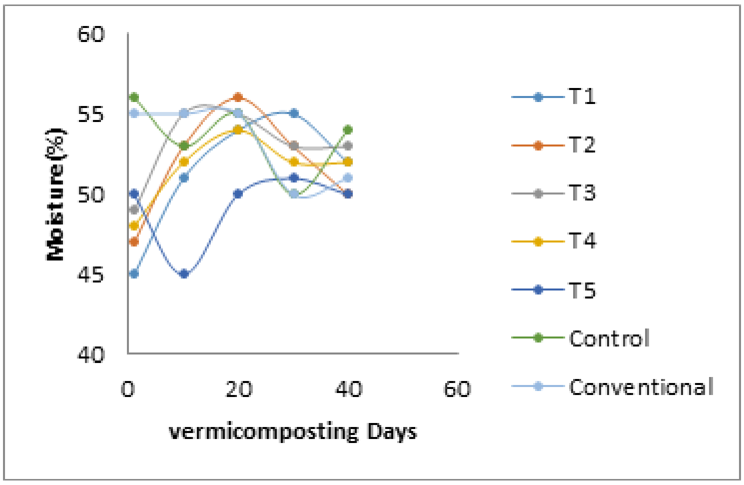

Fig 3(a) Moisture difference in 7.5 cm depth

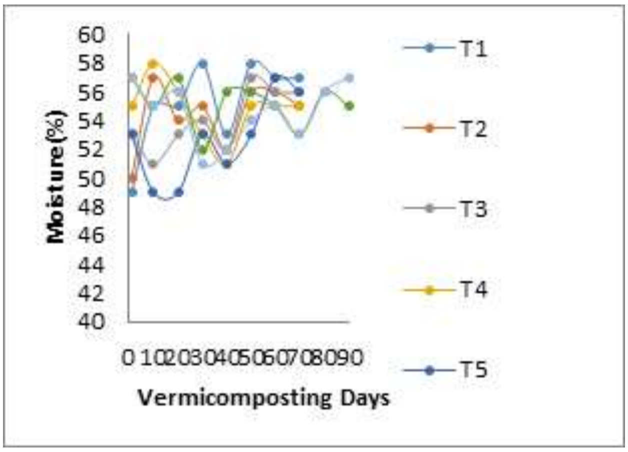

Fig 3(b) Moisture difference in 15 cm depth

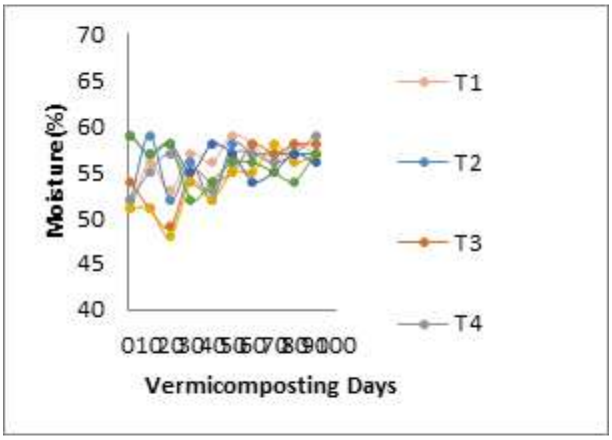

Fig 3(c) Moisture difference in 22.50 cm depth

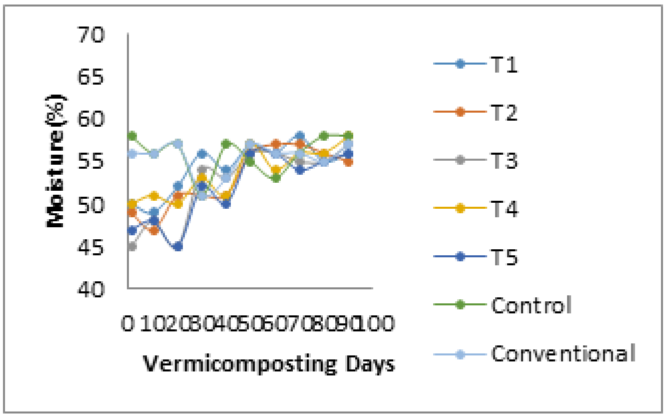

Fig 3(d) Moisture difference in 30 cm depth

Moisture is one of the important parameter which directly influences the vermicomposting process. Earthworms breathe through their skin therefore the system must have ideal moisture content. Optimum moisture range for vermicomposting process is 65-70% [21]. Higher and lower moisture content influences directly on life cycle of earthworms. Adequate moisture content decelerates the process of vermicomposting by suffocating the respiral activity of earthworms and low moisture content can cause mortality of earthworms in vermicomposting. To maintain optimum moisture content, moisture loss was replenished by adding the equivalent amount of tap water, which can be associated with water evaporation [22].

During vermicomposting moisture content of the substrate undergoes considerable changes, this may be attributed by particle size lowers the moisture content of the substrate. From the above (fig 3a, 3b , 3c, 3d) it was observed that, the substrate size does not possess considerable changes in depth 7.50 cm of all Vermibin. There was a negligible difference available on 15.0 cm depth from all the Vermibin this may be due to substrate size on this depth obtained very low changes in moisture level.

Influence of particel size on pH

Figure 4a, 4b, 4c, and 4d represents the pH variations recorded in various trail units during the experiment

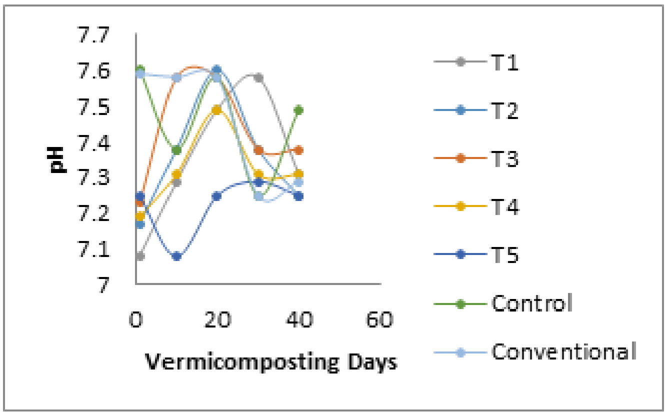

Fig 4(a) P^H difference in 7.5 cm depth

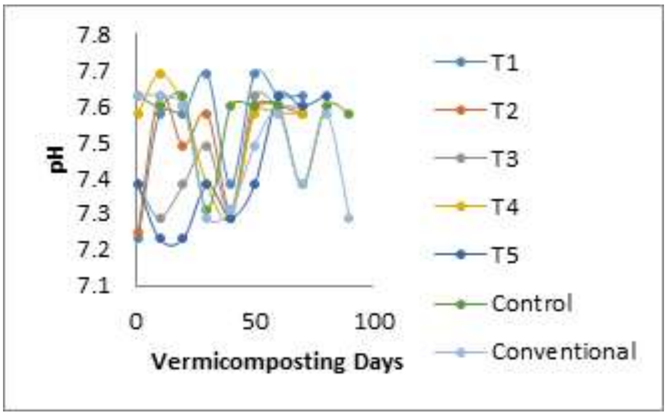

Fig 4(b) P^H difference in 15 cm depth

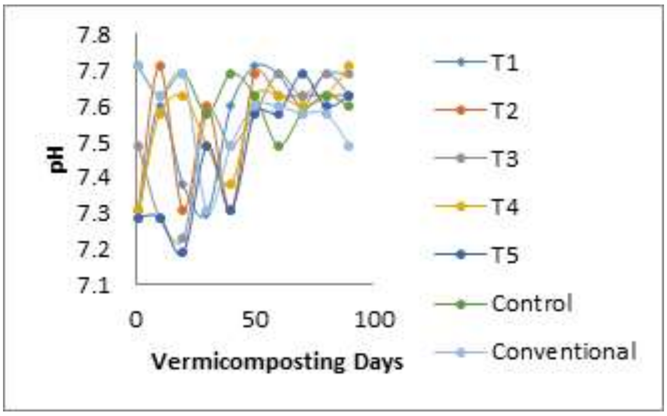

Fig 4(c) P^H difference 22.5 cm depth

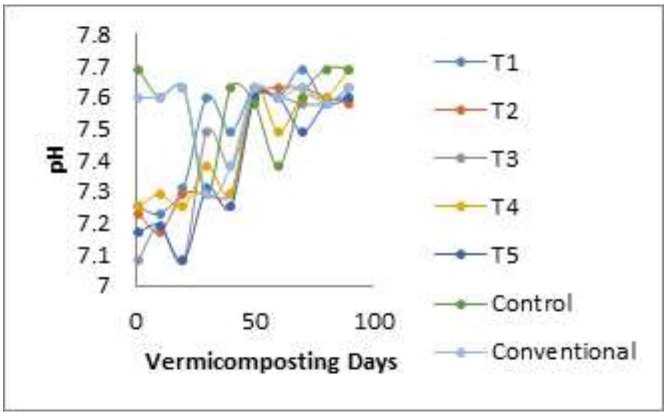

Fig 4(d) P^H difference in 30 cm depth

The pH of the initial raw material greatly influences the composting and vermicomposting process. Varma and Ajay, 2016 [19] found that pH ranging from slight acidic (6.5) to neutral range (8.0) is optimum for composting and vermicomposting and also pH is one of the most frequent parameters used to characterize the quality of final compost. Nedgwa et al, 2000 [15] found that the pH shift in vermicomposting system is dynamic and substrate dependent and the value of pH depends upon the various factors like types, characteristics, chemical composition of substrate. Significantly moisture level of the substrate is directly proportional to the pH value. The acceptable pH range, for vermicomposting (both earthworms and microorganisms activity) is 5.5–8.5. However, optimum pH is neutral or near neutral.

Initially, pH value of our substrate were found to be near alkaline condition (8.1 to 8.5). In the course of vermicomposting the substrate undergoes various considerable changes. After vermicomposting of organic waste (90 days), pH values of all Vermibin were found to be declined when compared to its initial stage. Thus reduction in pH was attributed by various parameters like production of CO_2, mineralization of Nitrogen and Phosphorus compounds, and production of Humic, fulvic and organic acid by mutual action of earthworms and microbes during decomposition of organic wastes might have resulted in lowering of pH [16 and 9]. Similar results like vermicomposting of fruit and vegetable wastes with cattle manure have been reported by [21].

During vermicomposting pH of the substrate was reduced up to 7.0 to 7.8 from its initial stage of vermicomposting (Fig 4.1). The substrate size affects the moisture content of the substrate as a result pH value gets dropped. First three layers of substrate (7.50, 15.0, 22.50 cm) shows increasing order of pH (Fig 4.1) and significantly 30 cm shows lower pH compared to all other layers. Noticeably, 22.50 cm layer holds the maximum pH in all vermibins when compared to other layers (7.50, 15.0, 30 cm) (Fig 4.2). Maximum pH content in 22.50 cm is endorsed by various reasons.

This is due to the 7.50 cm exposed to open atmosphere so it reduces moisture of the substrate and affects pH. The pH of 15.0 cm is high when compared to its previous layer which is due to the vertical movement of water/ gravity of water flow. Due to vertical vermibin the water does not hold in 7.5cm layer so it directly emanates into second layer (15.0 cm).Whereas lowermost and fourth layer (30.0 cm) holds very low pH (but in neutral condition) and lower moisture content. At the bottom of vertical vermibin, a drain hole is kept and through that drain hole excess water gets out and the dry atmospheric air may get incurred.

Due to the above reasons 30.0 cm layer holds poor pH. The third layer (22.50 cm) holds higher pH this may be attributed by vertical movement of water arrested at this layer and availability of some adverse reasons in other layers which leads to higher pH in this particular layer during the entire process of vermicomposting. Contradictory results like increase of pH (but neutral) have been observed by [23] this may be due to vermicomposting of high quantity of orange peel with low quantity of cattle manure (2:1). Citric acid present in the orange peel affects the pH and tends to move in the increasing order. Thus the increased pH does not affect vermicomposting, it because the increased pH is within the limit 8.26 (slight acidic).

The maximum substrate size (T4) bin shows lower pH when compared to all other bins (Fig 4.2). This is due to the maximum aeration which indirectly affects the pH and tends to move into slight acidic condition. This slight acidic condition may be lethal to earthworms by affecting survival conditions of worms in the substrate.

Henceforth it is concluded that like other basic conditions (moisture, temperature and pH) substrate particle size is also needed to be optimize to avoid the mortality of earthworms in vermicomposting.

Nutrients status on pre-processed and vermicomposted vegetable waste

Fig 5 illustrates the nutrient statues of the pre-processed vegetable waste during different stage of the process (Chopped, pulverized and dried). Fig 6 pictures the nutrient status of pre-processed (initial), conventional and engineered (Final) vermicomposted waste. During the experimentation the samples were collected at different location in the vermi bins and air dried by spreading them in open environment.

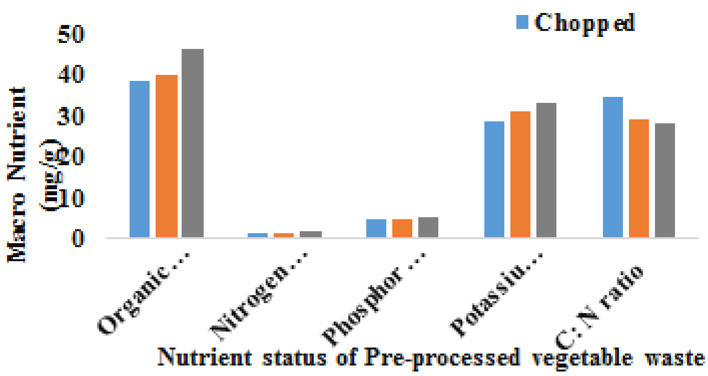

Fig 5 Nutrient statues of Pre-processed waste

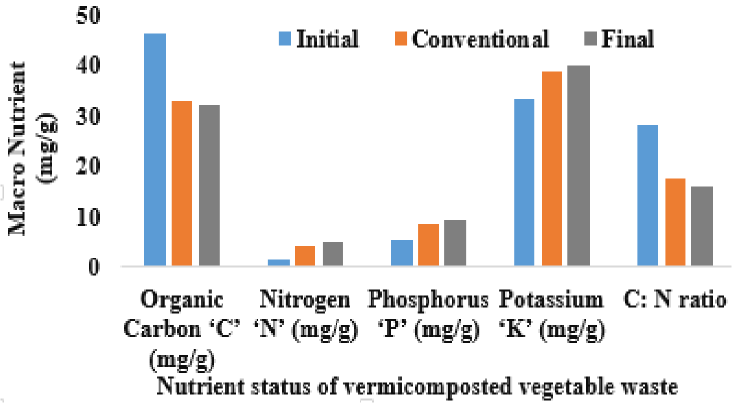

Fig 6 Nutrient status of vermicompost

i. Organic carbon

Initially, the organic carbon in chopped waste was found to be 38.62 mg/g and is further increased when it undergoes pulverizing and drying. Increase of organic carbon was attributed by addition of cow dung in waste. Because cow dung have high organic content which results in increased proportion of organic carbon. Once substrate was well dried the organic carbon was found to be 46.35 mg/g. Fig shows proportion of organic carbon in pre-processed waste

In general, an organic carbon losses has been observed during the vermicomposting process. After vermicomposting, organic carbon was found to be reduced 33.12 mg/g (conventional) and 32.08 mg/g (aerated). The losses of organic compound were significantly affected by composting and followed by vermicomposting process. The reduction in carbon could be due to the respiration activity of earthworms and microorganisms. The organic carbon is lost as CO_2 and N increases as a result of carbon loss. Earthworm modifies substrate conditions, which consequently affects carbon losses from the substrate through microbial respiration in the form of CO_2 and even through mineralization of organic matter. Because of the combined action of microorganisms and the earthworms a large fraction of the organic matter in the initial substrates was let as CO_2 by the end of the vermicomposting period. The losses of organic compound were significantly affected by composting and vermicomposting. It was known that the percentage of carbon decreased from ambient to mesophilic, mesophilic to thermophilic followed by cooling down stage during the period of vermicomposting which shows the decomposition of waste by microbial population. The carbon was being decomposed by the microbial biomass present in the compost, part of the carbon in the decomposing residues evolved as CO_2 and a part was assimilated by the microbial biomass [17]. Addition of cow dung as palatable waste results in the reduction of C/N ratio, and influencing vermicomposting rate by increasing certain macronutrients in vermicompost [24]. Below Fig 4.2 shows changes in Nutriental status during and final stage of the vermicomposting. Parallel results have been observed during vermicomposting of vegetable waste [25].

ii. Nitrogen

Nitrogen is foremost essential nutrient for plant metabolic activities and it also acts as a soil conditioner. For micro-organisms, nitrogen is essential for synthesis of protein and sexual reproduction. In vermicomposting, nitrogen content in vermicast was depends on the initial nitrogen content present in the feedstock and the extent of decomposition. At the end of vermicomposting, the nitrogen content was found to be increased from its initial stage 1.63 mg/g of vermicomposting to 4.36 mg/g (conventional) and 5.11 mg/g (aerated) as shown in 4.7. High nitrogen content in final cast was attributed by various reasons like, decrease in pH at the end of vermicomposting where higher pH nitrogen is lost as volatile ammonia.

Loss of organic carbon in final stage of vermicomposting tends to impact on improved nitrogen content. Earthworms also have impact on increased nitrogen content by addition of nitrogen in final cast in the form of mucus, nitrogenous excretory substances, growth stimulating hormones, enzymes and dead tissues from earthworms and these nitrogen-rich substances were not originally presented in feed and might have contributed to increase the nitrogen content [17]. Similar results like increased nitrogen content in final compost have been observed during vermicomposting of vegetable waste amended with cattle manure [16].

iii. Phosphorous

Phosphorus concentration in the final vermicompost seems to be an essential nutrient for the photosynthesis of plants, and it is available to plants as inorganic ions and it also one of the most important parameter that indicates the quality of manure/ final cast. At the end of vermicomposting, the phosphorous content was found to be increased from its initial stage 8.53 mg/g of vermicomposting to 9.25 mg/g (conventional) and 5.32 mg/g (aerated) as shown in figure 4.7. High phosphorous content in final cast was endorsed by mutual action of worms and micro-organisms. The organic matter in the passage of the gut of earthworms converts phosphorous in a form, which is more acceptable to plants. The release of phosphorus was performed partly by the phosphate in the gut of the earthworms and also by the phosphorus solubilizing microorganisms present in the worm casts. Similar results have been observed during vermicomposting of market waste and garden waste [17].

iv. Potassium

Potassium is one of the important nutrient for plant metabolic activities and it is one of the key factor that indicates the quality of compost material. In vermicomposting, potassium content in final compost was depends on the initial potassium content present in the substrate and the degree of decomposition. At the end of vermicomposting, the potassium content was found to be increased from its initial stage 33.26 mg/g of vermicomposting to 38.99 mg/g (conventional) and 39.98 mg/g (aerated) as shown in figure 4.7.

Results shows significant increase of potassium in final compost which was endorsed by combined actions of earthworms and micro-organisms. [19] concluded that when organic waste passes through the gut of worm some quantity of organic minerals are converted into nutrient rich organic manure. Potassium enhancement is also attributed by some amino acid producing micro-organisms which involves in conversion of insoluble K into soluble form [8]. Parallel results have been observed during vermicomposting of market waste and garden waste [25].

v. C/N ratio

The ratio of carbon and Nitrogen is referred as C/N ratio. The carbon and Nitrogen are the significant parameters that need to be analysed before and after vermicomposting. Microorganisms use carbon for energy and growth, while nitrogen is essential for protein synthesis and reproduction. The change in the C/N ratios reflects in the organic matter decomposition and stabilization during Vermicomposting. The decomposition of organic matter is brought about by living organisms which utilize the carbon for building cell structures. High efficiency yield is obtained when C/N ratio range is 20:1 to 40:1. But the optimum ratio of carbon to nitrogen is approximately 30:1.

The microorganisms need about 20–30 times more carbon than nitrogen Hence it is important to provide carbon and nitrogen in appropriate proportions. During vermicomposting, the C/N ratio was found to be decreased sharply 17.46 (conventional) and 16.22 (aerated) from its 28.43 (initial stage) of vermicomposting. Loss of carbon is endorsed by various reasons like release of CO_2 by respiration activity of micro-organisms and enhancement of nitrogen by combined action of worms and organisms. Due to above reasons, the C/N ratio is found to be lowered. Similar results have been observed during vermicomposting of market waste and garden waste [17].

Influence of substrate size on substrate depth reduction and Vermicompost recovery

Fig 7 represents the depth reduction of waste and volume of vermi cast generated during the experimentation.

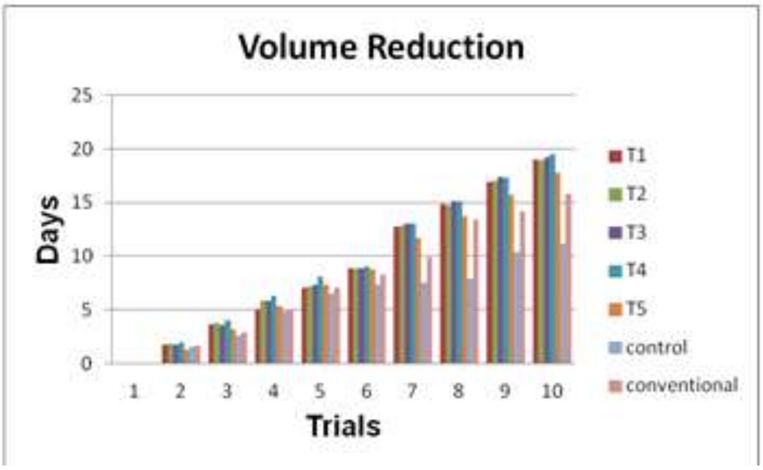

Fig 7 Depth redution of waste and Volume of vermicast generated

In general, Vermicompost/vermicast refers to organic manure produced by earthworms. It is a mixture of worm castings (faecal excretions), organic material including humus and excretions.. The products of vermiculture act as environmentally friendly long-term soil conditioners containing nutrients readily available to plants, which greatly improve soil performance and crop yields. It has evidently found that 30-50% increases in nitrogen uptake, 100% increases in potassium and phosphate uptake, increases in root length, root numbers, and shoot length, and 40-60% increases in efficiency of plant yields.

From the results it was found that, there is no vermicast generation achieved in control bin. Because of absence of earthworms in control bin. High quantity of vermicast generated (615 g) in T4 bin followed by T3, T5, T1 and T2. This because of availability of optimum condition for vermicast generation in T4 bin is constantly available throughout the process of vermicomposting. There is no significant difference in vermicast generation in CV and control bin. This may be due to the high percentage of smaller diameter partice does not possess major difference in vermicomposting..

Influence of substrate size particles on biomass growth

Figure 8 pictures the biomass growth recorded during the experimentation.

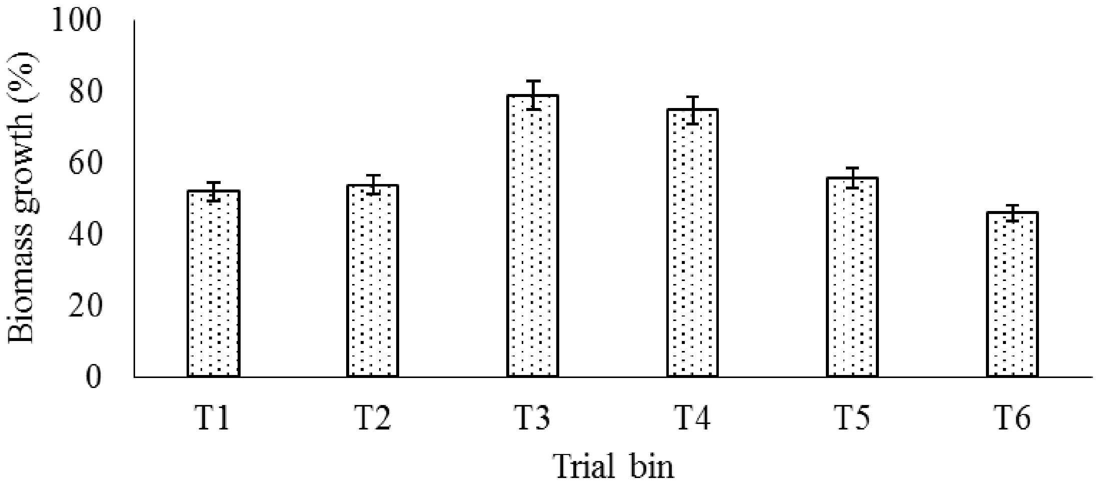

Figure 8 Biomass growth in vermi bins

The amount of food that can be consumed daily by earthworm varies with a number of factors such as particle size of food, state of decomposition of the food, C: N ratio of food, salt content in food etc. Small particle size of feed waste will ensure the worms to speed up the vermicomposting process. This small particle size allows the proper aeration through the pile of waste material and available to worms. The quantity of food taken by a worm varies from 100 to 300 mg/g body weight/day (Edwards and Fletcher, 1988). After vermicomposting of 90 days, there was no worm mortality observed in any of the waste treatments. Worm biomass increased continuously, during the vermicomposting period. All the Vermibin shows positive biomass growth and there was a noticeable difference in biomass from one treatment to another treatment. High biomass growth was achieved on T4 followed by T3, T5, T1 and T2. Low biomass growth on T2 shows, substrate size particles does not possess any significance changes in Vermibin. Where as **T4** bin shows maximum biomass growth this may be due to abiotic factors were found to be optimum and there is no negative effects of substrate size particles were found.

IV. CONCLUSION

The outcome of this bench scale experimental study reveals that substrate particle size will influence the waste digestion rate in vermi composting. In addition, pre-processing the waste will eliminate the pre-composting process in vermicomposting and save considerable time. As per the results revealed, the cumulative substrate depth reduction (d) perform well for all the aerated bins. The performance of bin 'T3' seems to be the quit good, but maintaining the optimum moisture (50-65%) and temperature (27 ±2 °C) in the bins T5, T1 and T2 difficult because of greater than 1.75 mm substrate size particles present at various trial bins duration per day. Further cumulative substrate depth reduction (d) was high in the bins 'T4' bin. The study also reveals that augmenting less than 1.75 mm substrate size particles is insufficient and creates anaerobic conditions in the pile.

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