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An Experimental Study on Accelerating the Vermicomposting Process by Stocking Vegetable Market Waste

Senthilkumar Palaniappan and Murugappan Alagappan

Department of Civil Engineering, Annamalai University, Chidambaram, India
plsphd15@gmail.com

ABSTRACT

The purpose of this observational work is to produce an innovative engineered technique in vegetable market waste management. Even though many treatment methods were currently adopted in treating the organic green waste (composting, land fill, vermicomposting etc.,) but vermicomposting is highly commended, since it converts the green waste into enriched nutrient manure with less operational cost. The trouble with the vermicomposting process is, it consumes more time. And very particular, when it comes to vermicomposting, the waste should be pre-composted for two weeks (depends on the nature of waste) before they fed to worms to avoid the impact load on worms (Ndegwa and Thompson, 1999). This work focuses on getting rid of the pre-composting process in vermicomposting, by carrying the green waste and feed the stocked waste to vermi at the needed time. This will shorten the time expelled in the process and high percent of intensity reduction of waste will be attained. The findings from the current study show the high feasibility of using the modified vermicomposting process because of the following reasons; (i) high volume reduction of waste in short duration. (ii) The stocked waste can be utilized at any time for vermicomposting (iii) 40%-time difference was recorded in the modified vermicomposting process than the formal one.

Key words: Vermicomposting, Pre-composting (PC) and Stocked green waste

INTRODUCTION

Technical and industrial revolution in the universe has shifted thousands of people from rural to urban regions. Meanwhile, many places are urbanized, which contribute to higher generation and absorption of solid waste in a restricted area. India alone produces around 42 million tons of solid waste every year in which 45-60% are biodegradable, this will change according to the dwellers and locations [1]. And convertible as manure [2]. Presently, a major portion of organic waste is dumped in the open yards, which creates an organic load on ground water by leaching and also emits greenhouse gases in the air [3]. Vermicomposting is one of the best methods for eliminating these problems. Earthworms have been used for waste stabilization for many years, all around the world [4]. According to science, vermicomposting is a process; combining the biotic and abiotic environment to digest the biodegradable solid waste into useful products (vermicast) with the help of worms (vermi in Latin). It is also defined as a mesophilic process that utilizes microorganisms and worms are proved to be more active at temperature level 10 - 32°C. Compared to composting the digestion of waste is faster, because the vermicast holds a significant population of a microbe’s in it. This microbe will act like a pest repellent and they are effective plant growth regulator [5].

Worm Species and Reproduction

Most red earthworms (Eudrilus Euginiae) have consistently used for commercial composting or worm farming, due to their relatively high tolerance of environmental variations [6]. Earthworms are hermaphroditic - that is, each worm is both sex (male and female) abilities to lay eggs and mature the eggs laid by other vermi. On suitable environmental conditions an adult worm will harvest an egg shell every 7 to 10 days. Each shell will hold more than 12 (approximately and varies with type of worms) hatchlings. The growth will initiate from 14 - 21 days of hatched. The newborn will reach the adult stage after six weeks and this means the population of worms will double every month. With this background knowledge an attempt is made to accelerate the conventional vermicomposting process by eliminating the pre-composting period. In Parallel the quality of vermin cast was also studied and reported.

MATERIALS AND METHODS

The initial phase of the experimental study is involved in the breeding the earth worms in plastic bins. The worms, which used for the experimental study named as 'eudrilus Eugenia' or more commonly known as African red worms. For the bedding material, pebbles were used as the first layer; this ensures the proper drainage in the system. A film of loamy soil or a garden soil was used as the next layer. Moistened coconut dust or rice husk and shredded paper were used as the third layer of the bedding. Finally, on top, some dry leaves and crushed eggshells are spared to keep the moisture at a constant rate. During the breeding period the worms were breaded in a controlled environment. The control parameters are shown in Table 1.

Stocking Processes of Vegetable Market Waste

For the study, vegetable waste (4kg) was collected from the local vegetable market. From the collected waste, plastics and other inert derbies were removed manually by adopting proper safety measures. The segregated waste was chopped and pulped into a paste. With this pulp, cow dung was added with a ratio of 1:2 and thoroughly mixed. Adding cow dung will enhance the bonding in waste pulp and supplies enriched substrate to worms. Then the pulped waste mixture was molded and dried under the sun for three days. The chopped and dried or stocked waste is shown in Figure 1.

Table - 1 Controlled Parameters during the Breeding of Earthworms

Parameters	Optimum range	Average measured value
Temperature	(10-35)^{0}C	30^{0}C
Moisture	60-75%	65% (Wet basis)
pH	4.5-9	7.5

Table - 2 Measurement Options of other Core Parameters

Parameter	Principle	Unit	Reference
Volatile Solids	Ignition at 550C	% (Dry basis)	Standard Method (1980)
Moisture %	Oven Heating at 105% C	%	Standard Method (1980)
Temperature	Compost Thermometer	^{0}C	………….
pH	Glass electrode	-	Standard Method (1980)
Total Organic Carbon	Total carbon analyzer	%ppm	-
TKN or N %	Macro – Kjedahl Method	%(Dry basis)	APHA (2005)
Micronutrients	Gas chromatic graph		

Fig. 1 shredded and Stocked Vegetable waste

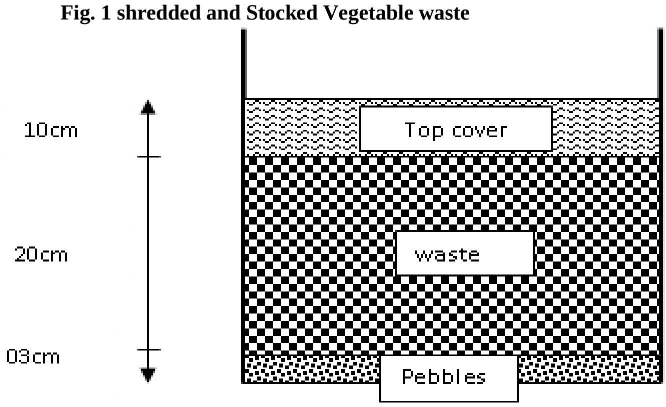

Fig.2 Vermi bin

EXPERIMENTAL PROCEDURE

Two identical laboratory scale set up of worm bins was made, the worm bin was provided with holes at bottom for drainage and to collect the vermin-wash (Figure 2). The bin was placed in an earthen stand and a tray was kept at the bottom of bin to collect the vermiwash. The bin was covered at top using wetted cotton cloth (with ensuring the flow of air) to prevent the entry of foreign matters and other insects. The earthworms are light sensitive; hence the experimental setup was placed in a dark place with temperature ranges between 24°C to 26°C. Out of the two vermin bins, one was filled with stocked green waste and the other with pre-composted waste. Parameters like pH, Temperature and Moisture content were monitored regularly and controlled within optimum limits. Samples were collected on day basis without disturbing the bed and analysed.

Method of Analysis: Water extraction

Solid samples were converted into water format by taking ten grams of waste and mixed with 40ml of distilled waste and shacked in a mechanical shaker for 18 hours. After completion of agitation, the surface water was removed by decantation followed by pressure filtration or centrifugation and preserved at 4°C for later analysis for various parameters such as Sulphate, Sodium, Calcium, Potassium, and Phosphate. The measurement option of other core parameters like Volatile Solids (%), Moisture content (%), Temperature (°C), pH, Total Organic Carbon (TOC), and Total Kjedahl Nitrogen (TKN), are given in table 2.

RESULTS AND DISCUSSION

Before Vermicomposting Process

Table 3 and 4 picture the values of primary parameters like pH, Electrical Conductivity (E.C), temperature, Moisture Content (M.C) and the values of micro and macro nutrient in ppm. All the listed parameters were recorded before the vermicomposting period. From the recorded values it was well evident that the Percentage of macro and the micronutrient level were less in pre-composted waste. This may due to the presence of microbial community, which actively involved in the disintegration process during the pre-composting phase. In the stocked green waste there was not much difference between wet (waste pulp) and dry waste. Few parameters like moisture content and electrical conductivity shows a drastic difference and this may due to the percentage of water content in the waste.

During the Vermicomposting Process

pH

The pH was slightly alkaline in nature in pre-composted waste may due to the presence of fungi and other microbial population, which effectively involved in the degradation process [9]. These microbial communities are primarily responsible for the production of extra-cellular enzymes [10]. And also for the production of CO_2, ammonia, NO_3, and other organic which may induce the alkaline nature of the pre-composted waste. But in the subsequent vermicomposting period, it got stabilized and it shifted near to the neutral condition (Figure. 3). During this period of shifting the pH of pre-composted waste was kept on fluctuating. This may due to the mineralization of nitrogen and phosphorus into nitrates/nitrites and ortho-phosphates, respectively, and also due the conversion of organic matter into CO_2 and homes by microorganisms. The pH of the stock waste was almost in neutral condition which clearly pictures the absence of microbial population at dry condition. And during the vermicomposting period the presence of these microbial populations was not as high as in pre-composted waste, and hence the pH stood almost in neutral condition for the entire vermicomposting period.

Electrical Conductivity (EC)

The electrical conductivity of the waste tended to fall with respect to the age of digestion of waste (Figure 4). On the vermicomposting stage the electrical conductivity pictures an upward trend in stock waste and shows failing at the initial stage of pre composted waste which may be due to the initial loss of organic substrate caused by compost microorganisms and worms. And also an organic portion was disintegrated in to mineral salts for subsequent process, showing a falling trend. The rising trend in stock waste may be due to the dry nature of the waste and may also due the absorption of nutrient in vermicast, since the porous nature of the waste.

Total Organic Carbon (TOC)

The carbon substrates in the west were utilized by the worms and other microorganism in the bed. The carbon was utilized for respiration and for the cell growth in microorganism [10]. When comparing the with conventional vermin compost process, high margin of TOC reduction was achieved in the modified vermin composting process (Figure 5). This may due to the easy and high consumption of carbon by worms [11]. And the high reduction of TOC may also due to the size of the substrate and blend of cow dung, which may enhance the metabolic activity of worms and other microorganism. Further, the reduction of TOC in the stock waste may due to high secretion of mucus, ammonium and urea in worm's body fluids, which encourage bacterial growth in the substrate, which may also contribute in the reduction of carbon level.

Table - 3 Primary Parameters

Type of Waste	pH	EC "Mill-mho /cm"	Moisture content %	Ash %	Volatile Solids %	TOC ppm	TKN ppm	C/N ratio
Pre-composted waste	8.80	1.15	76.4	1.48	98.6	38.4	1.55	24.77
Before drying	6.45	1.52	86.3	1.68	98.3	47.9	1.52	32.18
After dried	6.99	0.802	-	2.63	97.3	46.35	1.63	27.76

Table - 4 Micro Nutrient in ppm

Type of Waste	Phosphate	Sulphate	potassium	Calcium	Lithium	Sodium
Pre-composted waste	4.87	18.78	35.32	7.34	0.45	20.88
Before drying	4.38	19.36	34.78	7.89	0.68	20.2
After dried	5.32	20.34	33.26	7.46	0.56	19.4

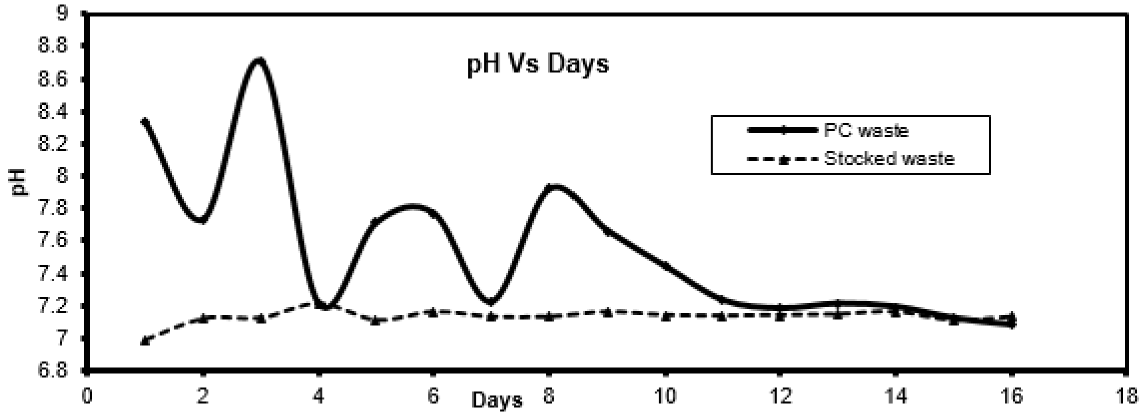

Fig.3 pH Vs days

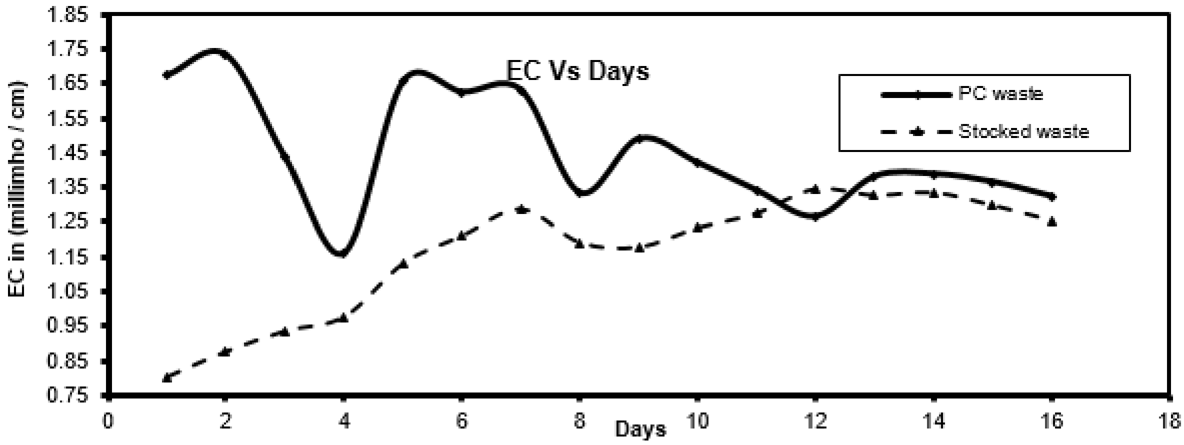

Fig. 4 EC Vs days

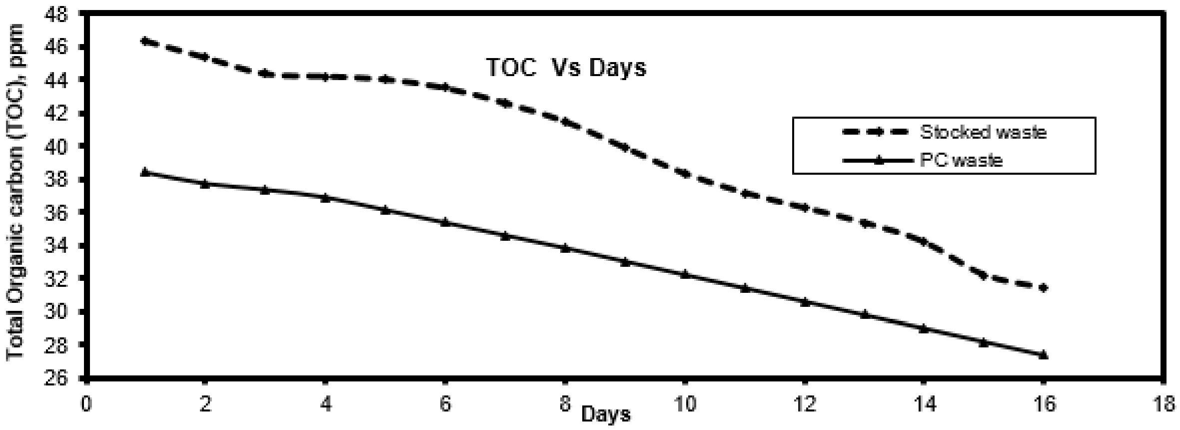

Fig. 5 TOC Vs days

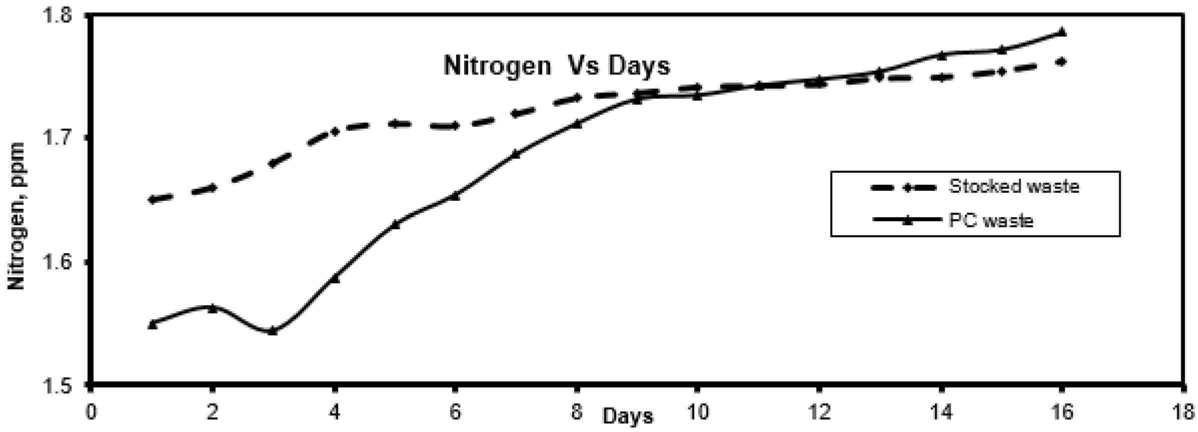

Fig. 6 Nitrogen Vs days

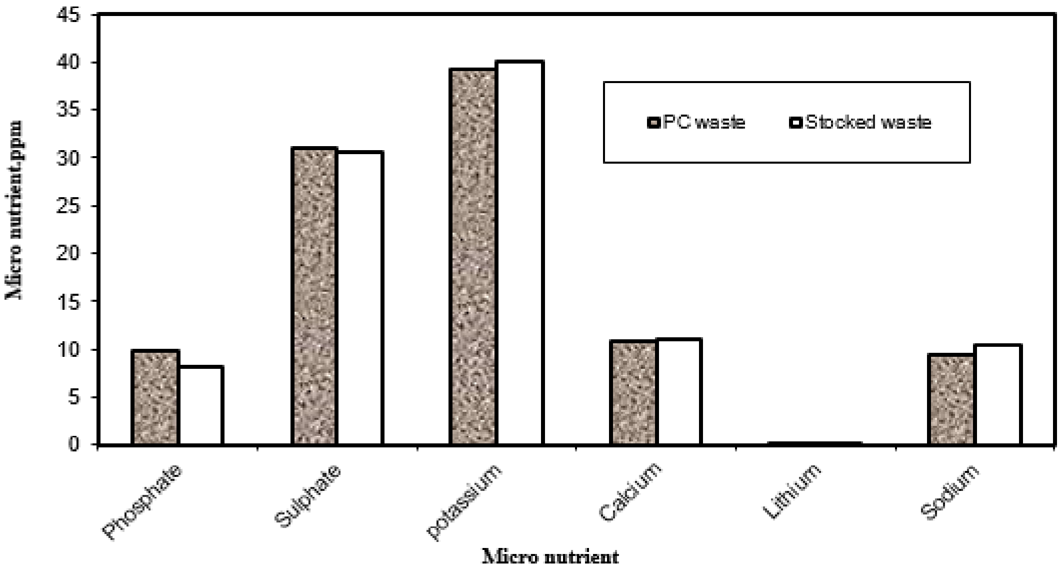

Fig. 7 Level of Micro Nutrient in the vermi cast

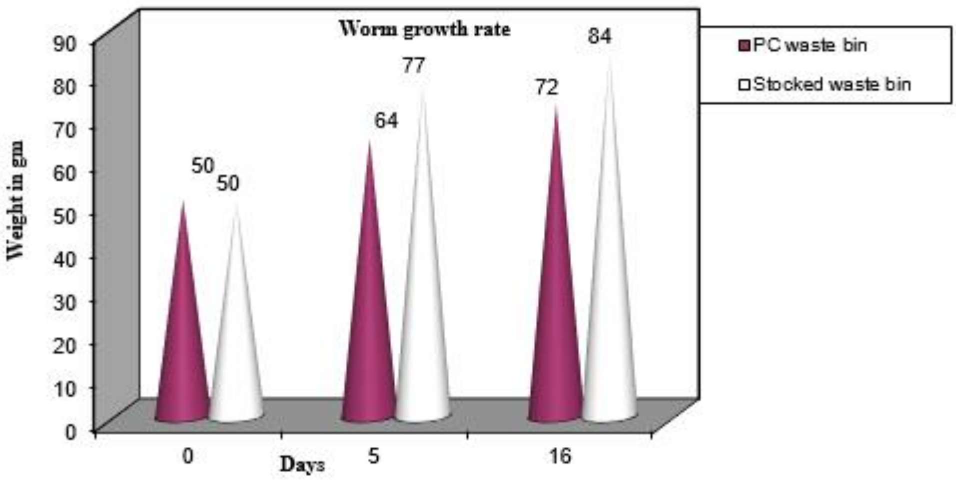

Fig. 8 Biomass growth rate

Nitrogen (N)

The rise in the nitrogen content can be clarified by simple mass balance relationship between worm's population and biomass. At the same time the nitrogen content increased in vermicomposting, this might be due to the nitrogen release by earthworm's metabolic product and dead tissues [12]. Moreover, a dip in the pH may also be a significant factor in nitrogen reduction as this element is lost as volatile ammonia at lower pH values [10]. It also, evident that by enhancing nitrogen mineralization, earthworms have a greater impact on nitrogen transformation in manure, so that, nitrogen gets remembered in the form of nitrate [13]. Apart from that the initial low level of nitrogen level in the stock waste may due to the dry nature of it (Figure 6).

Micro Nutrient

The level of micronutrient content in the vermicast of the two reactors is given in Figure 7. Apart from Carbon and Nitrogen, the other nutrients that are essential for the plant growth are phosphorus, potassium, calcium, lithium, etc. It has been revealed from the study the level of other micronutrients not having marginal difference between modified and conventional vermicomposting process.

Biomass Growth Rate

The result obtained from the experiment, pictures that the worms grew better in the modified vermin composting process, wherein the conventional vermicomposting process the growth rate was 18 percent lower (Figure 8). The reason for these growth rate variations may due to the consumption of Carbon source by microorganism in the pre-composting process (pile). But this process was eliminated in the altered process. And also in the conventional process the worms have put excess energy to disintegrate the huge chucks of waste [14], to desirable size that also plays an important role in the bio- mass growth rate.

CONCLUSION

From the experimental study it has been concluded that vermicomposting considered as one of the most suitable methods for the treatment of vegetable market waste, since the waste possesses a high fraction of organic matter. In the convention vermicomposting process the waste was pre-composted and fed to worms. This process, increase the time of waste degradation process and it also requires man power. This was eliminated in the modified process, since the waste were pulped, molded and dried under the Sun and the same can vermicompost at the needed time. This will reduce the manpower and very high volume reduction of waste was achieved in short duration. The secondary benefit of the modified vermicomposting process is the bio-mass growth rate. Approximately 20 percent higher growth rate was achieved in the modified process than the conventional one. The waste can be stocked and reused, reduce the menace of foul smell emission and other nuisance cause by insects.

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