Stabilization of Vegetable Market Waste through Vermicomposting

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Abstract: ***Vegetable wastes from market and homes are source of environmental pollution, global climatic changes and human health hazards. Methods of their disposal and management are not satisfactory. Earlier studies on vermicomposting of kitchen and vegetable waste could not provide a simple and satisfactory method of waste recycling. Therefore, the study was taken up. Vegetable waste was mixed with paper, sand-soil mixture and after pre-decomposition for 20 days, 30 earthworms were released. The cultures were maintained for three months and then observations on number and weight of worms, temperature, pH and NPK value of the medium were recorded. Different results were obtained in different combinations of three waste mixtures. Usually dung slurry (50%) is sprinkled for maintaining proper moisture in the vermicomposting medium. The best results were obtained in 5:1:2 mixture of vegetable waste, paper waste and soil-sand mixture with a maximum increase in worm population and worm biomass. Analysis of vermicompost revealed maximum nitrogen (1.94%), potassium (1.19%) and phosphorus (1.11%) content in this mixture. Thus it is concluded that vegetable waste can be converted into high quality vermicompost in an environment friendly manner. Promotion of vermicomposting of household waste will help in environmental conservation, organic farming and sustainable development.***

Keywords: Vegetable waste; Paper waste; *Eudrilus eugeniae*; Vermicomposting; Waste recycling.

1. Introduction

Several environmental problems originate from municipal solid waste (MSW) as they are not being properly managed. The major part of Indian MSW includes vegetable waste [23]. The vegetable waste in MSW is mainly contributed by waste from vegetable markets, restaurants, canteens, juice centers and household kitchens. All cities, towns, districts have vegetable markets producing significant amount of waste. At present, collection, transportation and disposal of waste are a big problem. The major methods of disposal include dumping, heaping, land filling and burning and the major problems are environmental pollution, lechates, foul smells, green house gases, spread of diseases and other health hazards. We are facing escalating socio-economic and environmental problems in dealing with current and future planning of disposal and management of fruit and vegetable market waste. Though, proper legislative rules and National Disposal Standards have been made, but they are not strictly obeyed and waste stuffs are not properly handled and they often pollute the environment. Hence more sustainable and eco-friendly waste management systems are to be devised and adopted. Vermicomposting has been identified as one of the potential activities in managing MSW, since it is a natural process, cost effective and is accomplished in a shorter duration. Vermicompost in recent years has gained importance because of it contains favourable aerobic bacteria and has higher nutrient value such as nitrogen, phosphorous, potassium etc. [2], [1].

Several studies have demonstrated that owing to their high nutrient value, food and vegetable wastes could provide valuable resource, if properly handled through recycling including composting and vermicomposting. The native vegetable waste is not suitable for survival and growth of environment friendly aerobic bacteria and earthworms due to high moisture content, bulk density, improper C/N ratio, acidic pH and anaerobic conditions. If these conditions are optimized by amending the waste with other stuffs, vermicomposting can be successfully performed. Earlier studies have demonstrated that vegetable and kitchen wastes can be successfully processed through vermicomposting after mixing with other waste stuffs and cattle dung slurry [5],[3],[6],[16],[9],[25],[17]. These experiments were conducted in the laboratory and have complex and cumbersome steps involving chopping, sun / air drying, powdering, mixing with large amounts of cattle dung were involved. Recently it has been demonstrated kitchen waste can be vermicomposted in combination with sand-soil mixture and shredded paper using a simpler method in bamboo baskets [7]. Simple methods of vermicomposting of particular waste category should have high degree of adaptability. Therefore, the present study on vermicomposting of vegetable waste in plastic containers was carried out.

2. Materials and Methods

In the present study efforts were made to recycle vegetable market waste through culture of earthworm *Eudrilus eugeniae* in plastic containers (20 kg capacity), with four holes in the bottom for removal of excess of liquids. In order to find out a suitable medium for vermiculture, experiments with different ratios of three waste stuffs (vegetable waste, shredded paper and sand-soil) were conducted. The waste mixtures were maintained in the containers for 10 days without addition of water. The liquid lechate from vegetable waste could easily be absorbed by sand-soil and shredded paper. The contents of the container were turned up-side down so that the whole mixture got uniformly moistened and then 500 ml of dung slurry (50%) was sprinkled on surface to accelerate aerobic bacteria mediated degradation process. The pre-decomposition period was continued for next 10 days.

During this total period of 20 days heat and foul smell produced by anaerobic bacteria based decay of waste get reduced, pathogenicity declines and activities of aerobic bacteria get enhanced. Now 30 earthworms were released in each container and the containers covered with garden mesh, were maintained for three months. In order to maintain optimum moisture, 50% dung slurry was sprinkled as and when required and the medium was gently turned up-side down for proper aeration.

Then observations on the number and weight of adult, baby worms, juveniles and cocoons, worm population growth and biomass production were recorded. All results reported are the means of three replicate. The results were statistically analyzed at 0.05 levels using one way analysis of variance (ANOVA) and Bonferroni t- test was used as a post-hoc analysis to compare the means (Sigma Stat, Version 3.5).

The followings chemical parameters of vermicompost were analyzed: Organic carbon was determined by [27]. Total Kjeldahl nitrogen (N) was determined as per method of [4]. Available phosphorus was analyzed by employing method [18] and Potassium was determined by ammonium acetate extractable method [22]. The pH of the composts was determined using glass electrode pH meter [10]. All the above nutrients and C/N ratios were analyzed. The earthworm population and cocoons were estimated by hand sorting and counted at the completion of 90 days through washing over a sieve [13].

3. Results

It was observed in separate preliminary experiment that earthworms do not survive in decaying fresh/pre-decomposed vegetable waste, pre-decomposed paper waste (PW) as well as in soil-sand mixture. Their performance was not satisfactory in pre-decomposed mixtures of vegetable waste and shredded paper waster. On the other hand, earthworms survived well in a mixture of these three waste stuffs. Thus it was decided to use variable amount of rotting vegetable waste for mixing with 2kg of sieved soil-sand mixture and 1 kg of shredded paper in order to balance its moisture and nutrient content and C/N ratio. It was observed that the number of adult worms, total bio-number (Adults + baby worms+ juveniles + cocoons) and respective biomass increased with increasing amount of organic waste from 1 to 5 parts of the waste mixture. Thus the best results were obtained in a ratio of organic waste, paper waste and soil-sand mixture (5:1:2), in which there was 664.43 % increase in worm population and 395.40 % increase in biomass which is better in comparison of their standard medium dung in which 635.56 % increase in worm population and 367.82 % increase in biomass. With further increase of organic waste, rather lesser number of worms, babies and cocoons and lesser amount of biomass were observed (Table 1,2 and Fig. 1), indicating that excess of organic waste creates unsuitable conditions of pH, aeration, C/N ratio for the life of earthworms. However the excess of other wastes, paper and soil-sand is also not suitable for the worms and an optimum ratio of waste materials is required for satisfactory vermicomposting performance. It was noticed that foul smell begins to emerge from the decaying waste biomass from 3rd day and the biomass gets heated. In organic waste alone, the foul smell was very strong, long-lasting and unbearable, while in mixtures of three wastes, the smell was mild and disappeared within 10 days. The temperature of the mixture also cooled down a faster rate. The pH of the organic waste is vary from acidic to basic (2.5 up to 9.5) during predecomposition and basic to neutral (9.5 up to 7.0) during vermicomposting.

The observations further revealed that number and weight of earthworms (including adult, baby worms and juveniles) increased in all waste combinations containing low or high vegetable waste. Higher values of both parameters (number and weight of worms) in the form of percent change in number and weight of worms were reported, *viz.* 42.23 % and 40.41 % (in 1:1:2), 72.2 % and 63.04 % (in 2:1:2), 137.8 % and 92.83 % (in 3:1:2), 280 % and 235.20 % (in 4:1:2), 401.1 % and 393.06 % (in 5:1:2), 160 % and 85.19 % (in 6:1:2), 53.33 % and 40.46 % (in 7:1:2) & 380 % and 365.61 % in dung only (Fig. 1). Number and weight of cocoons increased in all waste combinations containing low or high vegetable waste (table 1 and 2). The results of population growth and biomass production of earthworms showed variations in different culture media was 100 % and 40.89 % (1:1:2), 157.76 % and 63.84 % (2:1:2), 245.56 % and 93.68 % (in 3:1:2), 485.56 % and 236.60 % (in 4:1:2), 664.43 % and 395.39 % (in 5:1:2), 262.23 % and 85.87 % (in 6:1:2), 118.9 % and 40.93 % (in 7:1:2) & 635.56 % and 367.82 % in dung only as shown in fig.1.Thus it seems that vegetable waste, paper waste and soil-sand mixture is a suitable medium for vermicomposting.

After predecomposition period of 20 days, pH value of all these raw organic waste was observed as high during the vermicomposting process, pH value of phases was increasing due to mixing of inoculants and this was slightly decreasing as shown in graph. It shows that the alkalinity of the bio-compost is slowly reducing in the process (Fig.2). The increased trend of NPK in the vermicompost depends upon the quality of raw organic waste used (shown in fig. 3, 4 and 5 respectively). It has been proved that vermicompost is highly nutritive 'organic fertilizer' and more powerful 'growth promoter' over the conventional composts and a 'protective farm input' against the 'destructive' chemical fertilizers which have destroyed the soil properties and decreased its natural fertility over the years. Vermicompost is rich in NPK (nitrogen 2-3%, phosphorus 1.55-2.25%, and potassium 1.85-2.25%), micronutrients, beneficial soil microbes and it also contains plant growth hormones and enzymes. Vermicompost retains nutrients for longer time, while the conventional compost fails to deliver the required amount of macro and micronutrients including the vital NPK to the plants. Vermicompost contains plant hormones like auxin and gibberlins and enzymes which are believed to stimulate plant growth and discourage plant pathogens. It improves the fertility and water holding capacity of the soil. It also enriches the soil with useful microorganisms which add different enzymes like phosphatases and cellulases to the soil.

4. Discussion

As early as in 1910 it was reported by Russel that earthworms rapidly decompose organic matter and increase nitrification in the soil which increases crop production. Later on it was observed that of epigeic earthworms can be used for bioconversion of large amounts of organic wastes into high quality compost and the process is known as vermicomposting (Edwards *et al*., 1998; Kale *et al*., 1982; Benitez *et al*., 2000; Aira *et al*., 2002; Agrawal, 2005 a, b, 2008; Agrawal and Agrawal, 2006; Ranganathan, 2006; Kaur *et al*., 2010; Suriyanayanam *et al.,* 2010). It was reported by Kale and Krishnamoorthy (1978) that different species of earthworms have different preferences towards organic matter and cattle dung is the best medium for vermiculture. Different types of organic wastes can be used for vermicomposting, mostly in combination with cattle dung.

Some earlier workers have demonstrated that food and kitchen waste mixed with other waste stuffs and cattle dung can be subjected to vermicomposting process. Small pieces of sun and air - dried kitchen waste topped by garden soil in earthen bowls was used for vermicomposting using *Perionyx excavates* (Chaudhary *et al*., 2000). Chauhan *et al.* (2010) employed mixture of equal amounts (W/W) of small pieces of partially decomposed vegetable waste and partially decomposed cow dung for vermicomposting in plastic containers using *Eisenia foetida*, *Eudrilus eugeniae*, and *Perionyx excavates*. The best results were obtained with *Eisenia foetida*, followed by *Eudrilus eugeniae.* It was reported by Khwairakpam and Kalamdhad (2011) that vegetable waste was not ideal for growth and reproduction of earthworms, but when amended with cattle manure produced high quality stable compost free from pathogens using different earthworm species *Eisenia fetida*, *Eudrilus eugeniae* and *Perionyx excavates* in monocultures and polyculture set ups. In most of the studies larger amounts of dung was mixed with kitchen waste, without considering the fact that the target waste is organic waste, not the dung. Further, the target waste was usually subjected to cumbersome processes of chopping, air drying, powdering, mixing it with cattle dung, aerobic self-composting and finally vermicomposting [3], [6], [16], [9], [19], [17]. Such complicated techniques are un-desirable and may become hurdle in popularization of vermicomposting.

Sunitha [25] identified that leachate, fly menace, obnoxious odors are the major problems of decaying food and kitchen wastes. These problems could be solved by simple use of Leachate Absorbing Raw Material (LARM) like cocopith, bagasse or jute waste for complete aerobic composting and vermicomposting. Such LARM (cocopith, bagasse or jute waste) are not available everywhere, therefore I have used sand-soil mixture and shredded waste paper act as LARM and serve the purpose of balancing the nutrient content, C/N ratio and bulk density of the waste medium to make it suitable for vermicomposting. Further attempts have also been made to simplify the vermicomposting process and to eliminate or minimize the use of cattle dung because it may not be possible to manage it for some people. In our studies dung was not used at all [7] or only dung slurry was sprayed to fasten the vermicomposting process (present study). The results of present study on increase in number and weight of earthworms are in accordance with that of other workers [6], [24].

pH: pH value of all these raw organic waste was observed as high during the vermicomposting process, pH value of phases was increasing due to mixing of inoculants and this was slightly decreasing as shown in graph. It shows that the alkalinity of the bio-compost is slowly reducing in the process (Fig.2). The near-neutral pH of vermicompost may be attributed by the secretion of NH_4^+ions that reduce the pool of H^+ ions [11] and the activity of calciferous glands in earthworms containing carbonic anhydrase that catalyze the fixation of CO_2 as $CaCO_3$, thereby preventing the fall in pH [13].

Nitrogen, Phosphorus, Potassium (NPK) and Carbon/Nitrogen Ratio: The increased trend of NPK in the vermicompost and C/N ration is about 15 to 20:1 for good compost. But the C/N ratio is depends upon the quality of raw organic waste used (shown in fig. 3, 4 and 5 respectively) is in consistence with the findings of Kale [14] described composition of the vermicompost as: organic carbon - 9.15 to 17.98%, total nitrogen - 0.5 to 1.5%, available phosphorus - 0.1 to 0.3%, available potassium - 0.15 to 0.56%. The vermicompost acts as an excellent base for the establishment and multiplication of beneficial / symbiotic microbes. It being a natural means of soil fertility management fits well into integrated plant nutrient management strategy for sustainable agriculture.

The findings of present study are similar to [25]. Sand-soil mixture and shredded waste paper act as LARM and serve the purpose of balancing the nutrient content, C/N ratio and bulk density of the waste medium. It is interesting to note that vermicomosting performance of vegetable waste with paper waste and sand-soil (5:1:2) mixture was at par with dung alone with little use of dung slurry. Hence vegetable waste can be easily vermicomposed at home level without involvement of complex and cumbersome processing.

Development of simple method of vermicomposting of household (food and kitchen) waste should be a welcome event as it will help in solving problems of solid waste management and in improving community health.

5. Conclusion

It may be concluded from the study that vegetable market waste or domestic organic waste can be recycled at consumer (home) level by amending with sand-soil and waste paper shredding in container or tank units. The method is simple, efficient, inexpensive and user friendly. The vermicompost of vegetable waste acts as an excellent base for the establishment and multiplication of beneficial / symbiotic microbes. It being a natural means of soil fertility management fits well into integrated plant nutrient management strategy for sustainable agriculture. The large scale practice of vermicomposting may have far reaching effect in environmental conservation, sustainable development and improving community health. Moreover, this waste management technology mediated by earthworms could also be utilized for self employment, resource generation in rural areas and a big income generation resource especially in urban cities.

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Table 1: Showing number of adults, juveniles and cocoons of *E. eugeniae*

S.N.	*Organic Ratio (VW +PW +Soil-Sand)*	*Initial No. of worms*	*Final No. of worms (Mean±S.E.)*	*No. of baby worms and Juveniles (Mean±S.E.)*	*No. of cocoons (Mean±S.E.)*
1	1: 1: 2	30	26 ±0.57*	16.67±2.40*	17.333±1.45*
2	2: 1: 2	30	28.33 ±1.45*	23.33±0.88*	25.67±2.33*
3	3: 1: 2	30	32.67 ±1.45*	38.67±1.20*	32.33±1.45*
4	4: 1: 2	30	45.67 ±0.88*	68.33±2.02*	61.667±1.76*
5	5: 1: 2	30	65.33 ±1.45^{ns}	85±1.73 ^{ns}	79±2.30 ^{ns}
6	6: 1: 2	30	37 ±1.73*	41±1.73*	30.67±1.76*
7	7: 1: 2	30	28.33 ±1.20*	17.67±1.45*	19.67±1.45*
8	Dung alone (control)	30	63±1.15	81±1.73	76.67±2.33

Values are expressed as mean± SE of three observations (n=3) P<0.050
(*) = values are significant when compared to control
(ns)=No significant value when compared to control

Table 2: Showing weight (gm) of adults, baby worms, juveniles and cocoons of *E. eugeniae*

S.N.	*Organic Ratio (VW +PW +Soil-Sand)*	*Initial wt. of worms (Mean±S.E.)*	*Final wt. of worms (Mean±S.E.)*	*Wt. of baby worms and juveniles (Mean±S.E.)*	*Wt. of cocoons (Mean±S.E.)*
1	1: 1: 2	28.63±0.81	29.83±0.97*	10.37±1.01*	0.14±0.008*
2	2: 1: 2	26.9±0.50	29.93±0.58*	13.93±0.39*	0.21±0.017*
3	3: 1: 2	29.87±0.84	40.13±1.90*	17.47±0.38*	0.25±0.015*
4	4: 1: 2	28.83±0.75	51.07±1.19*	45.57±1.65*	0.403±0.012*
5	5: 1: 2	28.4±0.55	78.13±1.39 ns	61.9±2.08 ^{ns}	0.663±0.015 ns
6	6: 1: 2	32.9±1.42	41.3±1.52*	19.63±1.47*	0.22±0.020*
7	7: 1: 2	30.3±0.76	32.03±2.00*	10.53±0.52*	0.14±0.012*
8	Dung alone (control)	28.5±0.94	75.2±1.70	57.5±0.95	0.63±0.023

Values are expressed as mean± SE of three observations (n=3) P<0.050
(*) = values are significant when compared to control
(ns)=No significant value when compared to control

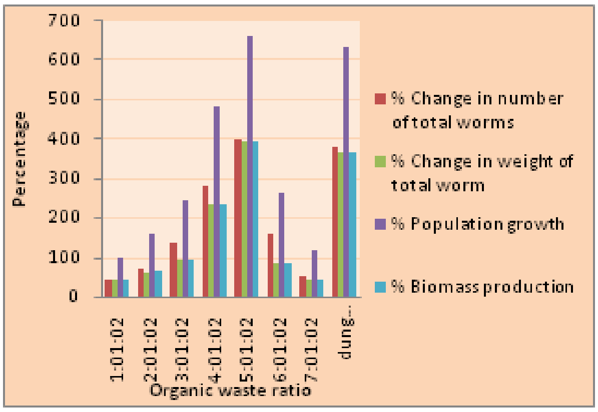

Figure 1: Percent change in number, weight of adults, Population growth rate & % biomass production in different combination-

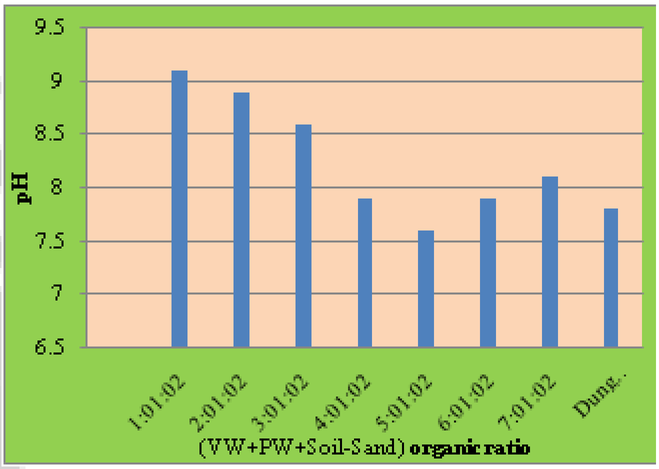

Figure 2: Showing variation of pH in different culture media (organic ratio)

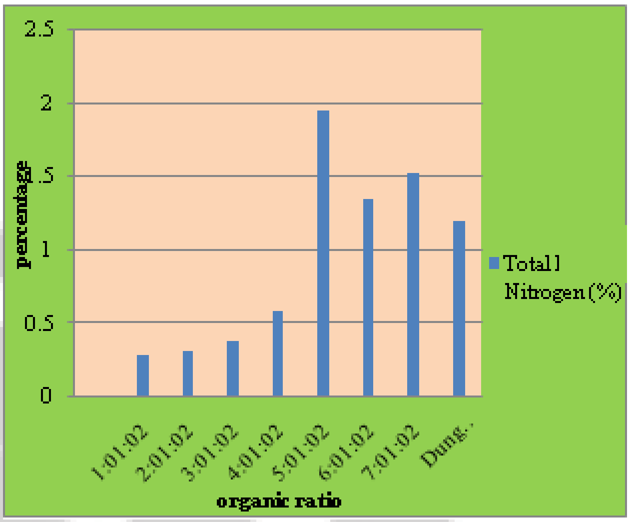

Figure 3: Showing variation of Total Nitrogen in different culture media (organic ratio)

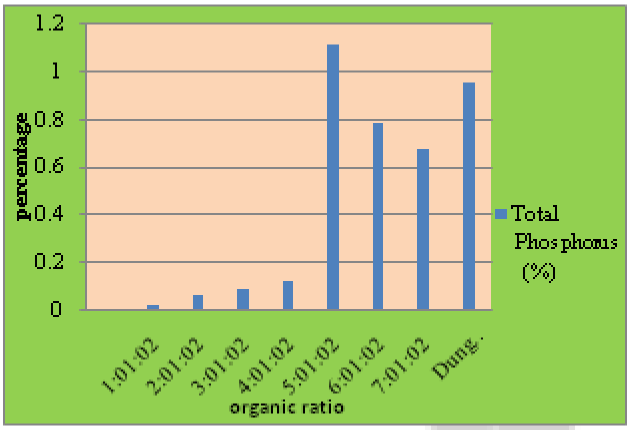

Figure 4: Showing variation of Total Phosphorus in different culture media (organic ratio)

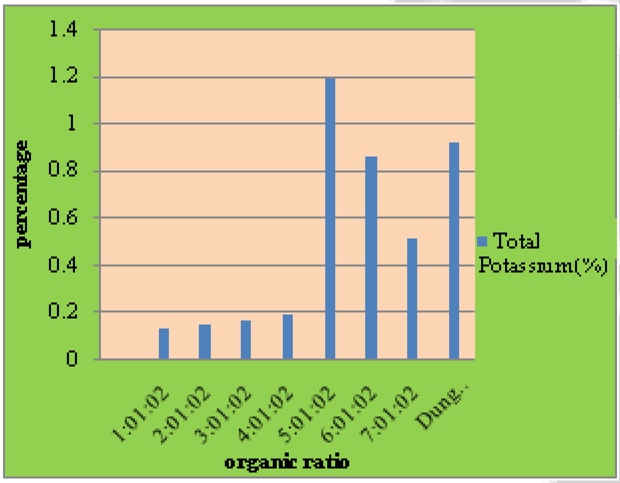

Figure 5: Showing variation of Total Potassium in different culture media (organic ratio)

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