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ESTIMATION OF PHYSICO-CHEMICAL CHANGES OF DIFFERENT COMBINATIONS OF COW DUNG WITH VEGETABLE WASTE AND BANANA PEELS BY THE EARTHWORM *EUTYPHOEUS WALTONI*

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ABSTRACT

Management of solid waste has become a worldwide problem and it is getting more complicated day by day because of the rise in industrialization, population, and the waste produced by animals. To overcome this problem, it is very necessary to develop a relevant technology by which we can not only minimise the organic waste burden but can also produce million tons of plant nutrients from these wastes. Vermicomposting is one of the best, cheap and eco-friendly process for decomposing organic waste into odour-free humus like material with the help of earthworms. The present study was conducted to investigate the physico-chemical changes of cow dung mixed with vegetable waste and banana peels in different ratios after the processing of earthworm *Eutyphoeus waltoni*. It showed significant decrease in pH, EC, TOC and C/N ratio whereas significant increase in TKN, TK, TAP and TCa. This study clearly indicates that composting of vegetable wastes, banana peels and cow dung by the earthworm *Eutyphoeus waltoni* had not only produced a value added product but simultaneously reduced the burden of wastes.

KEYWORDS: Banana peel, Cow dung, *Eutyphoeus*, Physico-chemical, Vegetable waste.

INTRODUCTION

Management of organic solid wastes and its efficient disposal has become more problematic due to intensive agriculture, industrialization and rapid increase in the population over the last few years.[1] The production of large amount of organic wastes create several environmental and disposal issues which requires a sustainable approach to minimize this problem.[2, 3] Use of large quantities of chemical fertilizers have also changed the physico-chemical texture of soil, resulting in unfertile soil and reduced productivity.[4] For maintaining healthy environment it has become very important to work on this issue.[5] Kitchen waste is one of the major source of organic wastes produced in India. These wastes are mainly of organic in nature and contribute approximately 70-80% of solid wastes.[6] In India, annually approximately 320 million tons of agricultural wastes are produced. Vegetable wastes are found to be in the major proportion of all the agricultural wastes produced in India.[7] Vegetable wastes are pure organic material which can be easily decomposed in comparison of other wastes. Banana is the second largest fruit produced which contributes about 16% of the total food production in the world. The largest producer of banana fruit is India. The peel of banana is rich in micronutrients (K, P, Ca, Mg), vitamins and poly-unsaturated fatty acids.[8, 9] Tons of cow dung produced in India every year and creates several environmental and odour problems but at the same time act as powerful manures and rich in minerals and non-assimilated carbohydrates.[10]

In the hierarchy of integrated solid waste management vermicomposting technology is being considered as a potential tool which has been verified in literatures.[11] In this technique organic waste material is stabilized by the combined performance of earthworms and micro-organisms which turns the organic wastes into the compost of high nutritional value.[12] Compost which is of high nutritional value obtained from this technique not only supply nutrients for the growth of plants but also improves the soil in its physical properties.[13,14] Earthworms play a significant role in the enhancement of soil fertility by improving soil physical, chemical, and biological properties.[15,16] By the vermifiltration technology earthworms are also helpful in treating the waste water.[17] *Eutyphoeus waltoni* is a type of an anecic species which are known as humus formers and they have the potential of organic waste consumption which can also modify the structure of the soil.[18, 19]

Keeping in view of the above facts, the aim of this study was to evaluate the changes in physico-chemical composition of waste mixtures i.e. vegetable wastes and banana peels mixed with cow dung in different ratios after the processing of the earthworm *Eutyphoeus waltoni*.

MATERIAL AND METHODS

Collection and rearing of the earthworm *Eutyphoeus waltoni*

The cultured earthworm *Eutyphoeus waltoni* from the vermiculture Laboratory, Department of Zoology, Deen Dayal Upadhyaya, Gorakhpur University, Gorakhpur were used for the experiment. For this, vermibed were prepared by using garden litter with cow dung on a cemented surface in the laboratory. Young cultured earthworms were used for the experiments.

Collection of Cow dung, banana peels and vegetable wastes

Cow dung was collected from the local farm houses of different areas of Gorakhpur district. Vegetable wastes and banana peels were procured from the local residential colonies of the Gorakhpur district. These organic wastes were spread in a layer and exposed to sunlight for 10 days to remove various harmful organisms and noxious gases and then used in the experiment.[10]

Experimental setup

The experiment was conducted on cemented surface. Two kilograms (Kg) of each five different combinations of cow dung with vegetable wastes and banana peels i.e., CD+VW (1:1), CD+VW (2:1), CD+BP (1:1), CD+BP (2:1), CD+VW+BP (1:1:1) and CD alone were prepared in beds of (30 x 30 x10 cm^3) at room temperature (27±2 ^{0}C) in the dark. In order to eliminate volatile substances the vermicomposting beds were turned over manually every 24 hours for 2 weeks. After this dried sample of each vermibed were collected. Thereafter, 20 young *Eutyphoeus waltoni* were inoculated into each bed. The moisture of all the treatments was maintained at 60-70% by sprinkling water during the experiment in order to provide optimal environmental conditions for worms. After vermicomposting for 90 days, sample from each vermibed were collected again and composting was terminated because the residuals of bedding materials in the treatments had been eaten up by *Eutyphoeus waltoni*. For further analysis the collected dried and homogenized samples were grind into fine particles. Each experiment was replicated six times.

Chemical analysis

The pH and electrical conductivity were determined by using a double distilled water suspension of each sample in the ratio of 1:10 (w/v) which had been agitated mechanically for 30 minutes and filtered through Whatman no. 1 filter paper; TOC was measured after igniting the sample in a Muffle furnace at 550 ^{0}C for 50 minutes by the method of Nelson and

Sommers (1982). TKN was measured by Micro-Kjeldhal method of Bremner and Mulvaney [20] after digesting the sample in digestion mixture (H_2SO_4 and $HClO_4$, 9:1 v/v). TAP was analyzed by using the calorimetric method with molybdenum in sulphuric acid and TK was determined after digesting the sample in diacid mixture conc. Of $HN0_3$:$HClO_4$ (4:1 v/v) using a flame photometer.[10]

Statistical analysis

All the experiments were replicated six times for obtaining consistency in the result and finding out the mean with standard error. To analyze the significant difference between the combinations analysis of variance was applied; to identify the homogenous type of bedding with respect to reproduction and growth from the control student t test ($P<0.05$) was performed.

RESULTS AND DISCUSSION

With respect to the initial feed mixture the pH of all the vermibed was significantly decreased after the processing of *Eutyphoeus waltoni* (Table 1; Figure 1). The pH of final composted material of cow dung with vegetable wastes and banana peels by *Eutyphoeus waltoni* showed variations compared to the initial feed mixture. Maximum decrease of 16.24% (8.13 ± 0.07 to 6.81 ± 0.09) and minimum decrease of 11.24% (7.30 ± 0.09 to 6.48 ± 0.05) were observed in CD+VW (2:1) and CD+BP+VW (1:1:1) respectively, between all the combinations of cow dung with vegetable wastes and banana peels. Similar results have been reported by various researchers during the processing of wastes by earthworms.[21] These changes in the pH take place due to the degradation of organic solid wastes. Mineralization of nitrogen and phosphorus into nitrites/nitrates as well as phosphates may have decreased pH of different mixtures of feed material.[22]

The final EC of all the vermibed after the processing of *Eutyphoeus waltoni* was significantly decreased with respect to the initial feed mixture (Table 1; Figure 1). The EC of composted mixture of cow dung with vegetable wastes and banana peels showed variations compared to the initial values. Among all the combinations of cow dung with vegetable wastes and banana peels maximum decrease of 54.81% (2.81 ± 0.01 to 1.27 ± 0.02) and minimum decrease of 40.70% (2.31 ± 0.01 to 1.37 ± 0.01) were observed in CD+VW (1:1) and CD alone respectively. Previous researchers have been reported that the final vermicompost contains about 28% to 46% EC.[23] EC significantly declined in the final composted material which was about 28.69% in the management of bio sludge of the beverage industry.[24]

Table 1: Concentration of pH and EC in initial feed mixtures and final vermicompost of cow dung mixed with vegetable waste and banana peels in different combinations.

Combinations	pH			EC (ds/m)		
	IFM	**VC**	**% decrease**	**IFM**	**VC**	**% decrease**
CD	7.78 ± 0.06	6.68 ± 0.07*	14.14	2.31 ± 0.01	1.37 ± 0.01*	40.70
CD+VW (1:1)	7.61 ± 0.08	6.43 ± 0.06*	15.51	2.81 ± 0.01	1.27 ± 0.02*	54.81
CD+VW (2:1)	8.13 ± 0.07	6.81 ± 0.09*	16.24	2.58 ± 0.01	1.18 ± 0.01*	54.27
CD+BP (1:1)	7.50 ± 0.07	6.36 ± 0.04*	15.20	2.47 ± 0.01	1.15 ± 0.01*	53.45
CD+BP (2:1)	7.73 ± 0.06	6.58 ± 0.08*	14.88	2.39 ± 0.02	1.13 ± 0.01*	52.72
CD+BP+VW (1:1:1)	7.30 ± 0.09	6.48 ± 0.05*	11.24	2.27 ± 0.01	1.14 ± 0.00*	49.78

Each value is the mean ± SE of six replicates. IFM = Initial Feed Material, VC = Vermicompost, CD = Cow Dung, BP = Banana peel, VW = Vegetable Waste

*Significant ($P < 0.05$)'t' test between before and after vermicomposting in 30.0x30.0x10.0 cm^3 area of vermicompost bed.

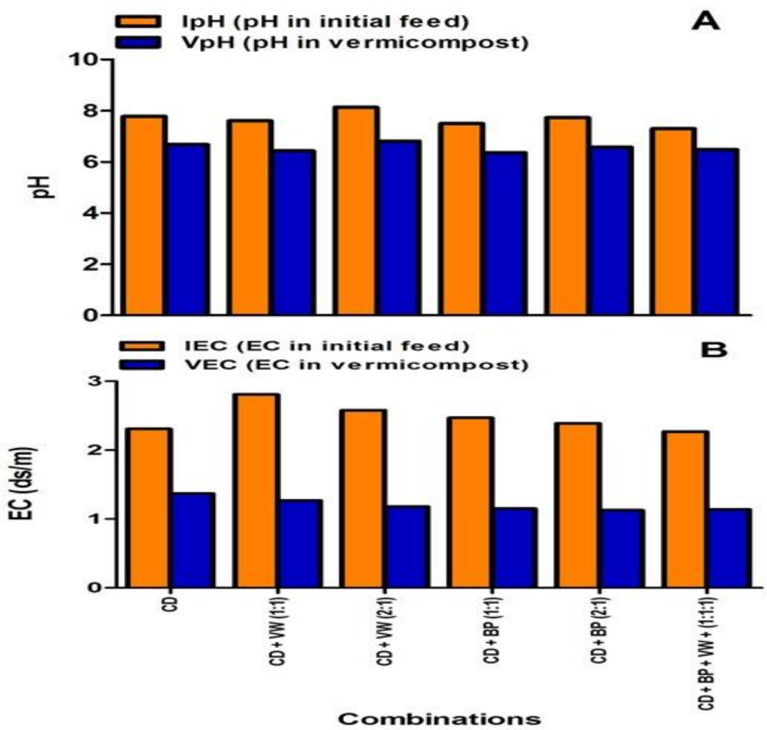

Figure 1: Concentration of pH (A) and EC (B) in initial feed material and the vermicompost of different combinations of cow dung with vegetable wastes and banana peels by *Eutyphoeus waltoni.* IpH= pH in initial feed material, VpH= pH in

vermicompost, IEC= electrical conductivity in initial feed material, VEC= electrical conductivity in vermicompost, CD= cow dung, VW= vegetable waste, BP= banana peel.

The TOC content declined in all the feed mixture after the processing of earthworm *Eutyphoeus waltoni* (Table 2; Figure 2). Earthworms along with micro-organisms consume the available carbon as a source of energy which may have decreased a large portion of TOC in the form of CO_2. The TOC of final composted mixture of cow dung with vegetable wastes and banana peels showed significant decrease compared to the initial values. Maximum decrease of 55.59% (558.83 ± 0.82 to 248.23 ± 0.92) and minimum decrease of 48.51% (549.76 ± 0.10 to 283.09 ± 0.10) were observed in the combination of CD+VW (1:1) and CD+BP (1:1), respectively. While doing the vermicomposting of garden waste, kitchen waste and cow dung by using the earthworm *Eisenia fetida* reduction of TOC was reported at the end of the process.[25] During the vermicomposting of municipal and industrial wastes the reduction of TOC into CO_2 had been observed.[26] The reduction of TOC from 24% to 60% during the process of vermicomposting has been reported in an earlier research.[27]

(Table 2; Figure 2) shows the TKN content in all the feed mixtures of cow dung with vegetable wastes and banana peels. A significant increase in the TKN content was observed in all the feed mixtures of cow dung with vegetable wastes and banana peels. Among all the combinations of cow dung with vegetable wastes and banana peels maximum increase of TKN was observed in the combination of CD+VW (1:1) which is 63.31% (7.89 ± 0.34 to 21.50 ± 0.02) and minimum increase of TKN was observed in the combination of CD+BP+VW (1:1:1) which is 57.51% (7.45 ± 0.03 to 17.53 ± 0.03). Nitrogen enhancement in the composted mixture might be the result of loss of organic carbon.[28] Enhancement of TKN in the final composted material after the processing of earthworms may caused due to the mineralization and addition of several by products or assimilatory product through the earthworms.[29] Nitrogen content may also increased by the mineralization of C- rich matters and action of N-fixing bacteria present in the feed mixture.[30] Nitrogen content was increased 2.16 fold during the vermicomposting process using kitchen waste, rotting foliage and cow dung.[31] Degradation of dead worms may also be a reason for increasing the nitrogen content in the final composted mixture as significant portion of worm is protein.[32]

Table 2: Concentration of TOC and TKN in initial feed mixtures and final vermicompost of cow dung mixed with vegetable waste and banana peels in different combinations.

Combinations	TOC (g/kg)			TKN (g/kg)		
	IFM	VC	% decrease	IFM	VC	% increase
CD	468.03 ± 0.03	220.88 ± 0.06*	52.81	5.80 ± 0.02	15.54 ± 0.01*	62.68
CD+VW (1:1)	558.83 ± 0.82	248.23 ± 0.92*	55.59	7.89 ± 0.34	21.50 ± 0.02*	63.31
CD+VW (2:1)	543.40 ± 0.12	278.99 ± 0.12*	48.66	7.08 ± 0.01	17.05 ± 0.01*	58.48
CD+BP (1:1)	549.76 ± 0.10	283.09 ± 0.10*	48.51	6.82 ± 0.03	16.62 ± 0.02*	58.97
CD+BP (2:1)	538.77 ± 0.08	270.83 ± 0.08*	49.74	6.34 ± 0.03	16.39± 0.02*	61.32
CD+BP+VW (1:1:1)	542.25 ± 0.06	275.38 ± 0.06*	49.22	7.45 ± 0.03	17.53± 0.03*	57.51

Each value is the mean ± SE of six replicates. IFM = Initial Feed Material, VC = Vermicompost, CD = Cow Dung, BP = Banana peel, VW = Vegetable Waste

*Significant ($P < 0.05$) ‘t’ test between before and after vermicomposting in 30.0x30.0x10.0 cm^3 area of vermicompost bed.

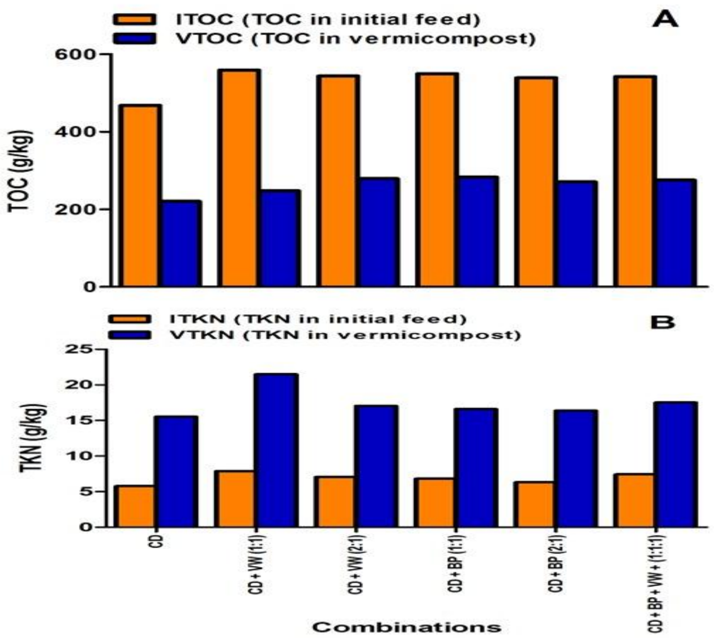

Figure 2: Concentration of TOC (A) and TKN (B) in initial feed material and the vermicompost of different combinations of cow dung with vegetable wastes and banana peels by *Eutyphoeus waltoni*. ITOC= total organic carbon in initial feed material,

VTOC= total organic carbon in vermicompost, ITKN= total kjeldahl nitrogen in initial feed material, VTKN= total kjeldahl nitrogen in vermicompost, CD= cow dung, VW= vegetable waste, BP= banana peel.

C/N ratio is one of the highly accepted parameter for checking the compost maturation. It represents the mineralization and stabilization of organic wastes during the process of vermicomposting.[33] The C/N ratio declined in all the combinations of cow dung with vegetable wastes and banana peels after the processing of earthworm *Eutyphoeus waltoni* (Table 3; Figure 3). After the processing of earthworms C/N ratio declines due to the loss of carbon as well as addition of nitrogen at the same time.[34, 24] In all the combinations of cow dung with vegetable wastes and banana peels the C/N ratio decreased from (70.82-84.94) to (11.54-17.03). After the processing of earthworm *Eutyphoeus waltoni* the maximum decrease of the C/N ratio was 83.71% which was observed in CD+VW (1:1) and minimum decrease of C/N ratio was 78.42% which was observed in the combination of CD+BP+VW (1:1:1). C/N ratio declined sharply during the process of vermicomposting reported in many studies.[35]

(Table 3; Figure 3) shows the TK content in all the feed mixtures of cow dung with vegetable wastes and banana peels. TK content was increased significantly in all the combinations of feed mixtures after the processing of *Eutyphoeus waltoni*. Among all the combinations of cow dung with vegetable wastes and banana peels maximum increase of TK was observed in the combination of CD+BP (1:1) i.e. 19.88% (6.21 ± 0.01 to 7.75 ± 0.02) and minimum increase of TK was observed in the CD alone i.e. 11.75% (5.26 ± 0.02 to 5.96 ± 0.01). Enhanced mineralization rate due to the increase in microbial activity during vermicomposting process and production of acids by mirco-organisms play a key role in solubilising insoluble potassium.[36]

Table 3: Concentration of C:N ratio and TK in initial feed mixtures and final vermicompost of cow dung mixed with vegetable waste and banana peels in different combinations.

Combinations	C:N ratio			TK (g/kg)		
	IFM	VC	% decrease	IFM	VC	% increase
CD	80.69 ± 0.28	14.21 ± 0.02*	82.39	5.26 ± 0.02	5.96 ± 0.01*	11.75
CD+VW (1:1)	70.82 ± 0.19	11.54 ± 0.01*	83.71	7.22 ± 0.03	8.35 ± 0.04*	13.54
CD+VW (2:1)	76.65 ±	16.34 ±	78.69	6.72 ± 0.06	7.83 ±	14.18

	0.20	0.01*			0.05*	
CD+BP (1:1)	80.60 ± 0.33	17.03 ± 0.03*	78.88	6.21 ± 0.01	7.75 ± 0.02*	19.88
CD+BP (2:1)	84.94 ± 0.49	16.51 ± 0.02*	80.57	6.12 ± 0.02	7.36 ± 0.05*	16.85
CD+BP+VW (1:1:1)	72.73 ± 0.29	15.70 ± 0.03*	78.42	6.81 ± 0.03	7.91 ± 0.03*	13.91

Each value is the mean ± SE of six replicates. IFM = Initial Feed Material, VC = Vermicompost, CD = Cow dung, BP = Banana peel, VW = Vegetable Waste

*Significant ($P < 0.05$) 't' test between before and after vermicomposting in 30.0x30.0x10.0 cm^3 area of vermicompost bed.

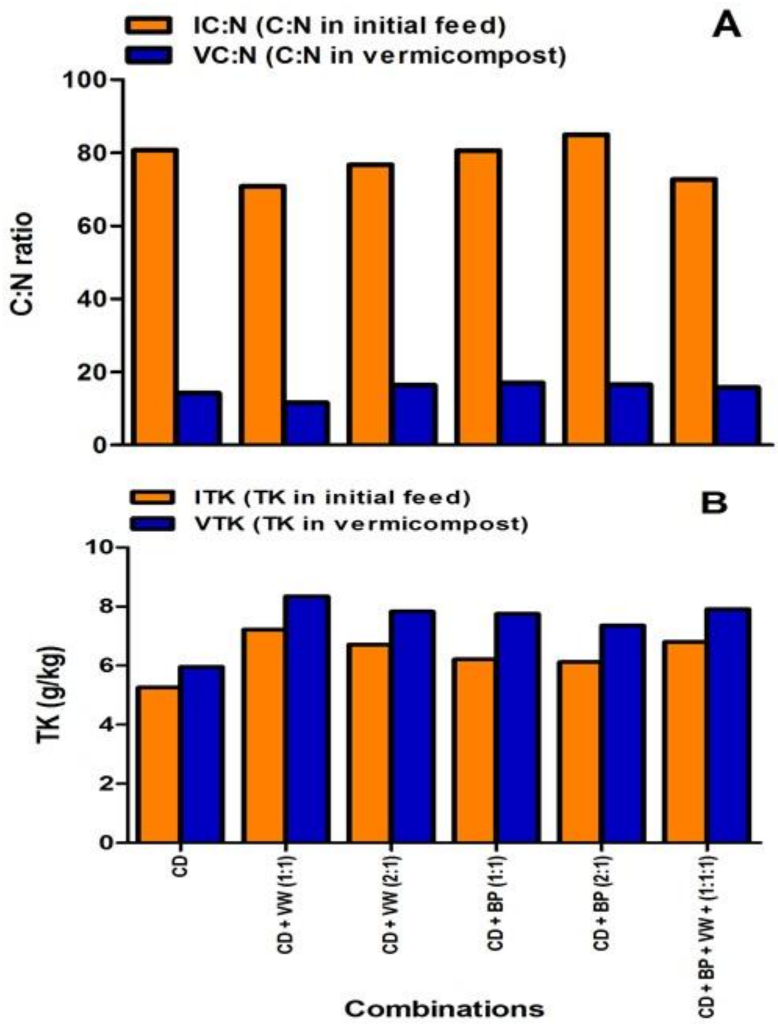

Figure 3: Concentration of C/N ratio (A) and TK (B) in initial feed material and the vermicompost of different combinations of cow dung with vegetable wastes and banana peels by *Eutyphoeus waltoni.* IC/N= carbon to nitrogen ratio in initial feed material, VC/N= carbon to nitrogen ratio in vermicompost, ITK= total potassium in initial feed

material, VTK= total potassium in vermicompost, CD= cow dung, VW= vegetable waste, BP= banana peel.

Total available phosphorus is significantly higher in all the composted feed mixtures of cow dung with vegetable wastes and banana peels than the initial feed mixtures. Total available phosphorus significantly increased from 29.88% to 35.65% in all the combination of cow dung with vegetable wastes and banana peels (Table 4; Figure 4). Among all the combinations of cow dung with vegetable wastes and banana peels maximum increase of TAP was observed in the combination of CD+VW (1:1) i.e. 35.65% (4.82 ± 0.00 to 7.49 ± 0.02) and minimum increase of TAP was observed in the combination of CD+BP+VW (1:1:1) i.e. 29.88% (4.93 ± 0.01 to 7.03 ± 0.02). Enhancement of TAP content is associated to the quality of feed materials, processing time and worms.[22] Mineralization and mobilization of phosphorus by bacterial and phosphatase activities of earthworms may result as increased TP during vermicomposting.[37] After the processing of earthworms increase of 25% in phosphorus content of paper waste sludge has been reported.[38]

Total calcium is significantly higher in all the final composted mixture compared to the initial feed mixture of cow dung mixed with vegetable wastes and banana peels (Table 4; Figure 4). Maximum increase of 33.73% of calcium was observed in CD alone (1.71 ± 0.03 to 2.58 ± 0.03). Minimum increase of 7.51% of calcium was observed in CD+BP+VW (1:1:1) (2.75 ± 0.05 to 2.93 ± 0.03). Increase of total calcium in the final composted mixture by earthworms had been observed.[23] The calcium metabolism in the gut of earthworms was primarily responsible to increase the inorganic calcium in worm cast.[39]

Table 4: Concentration of TAP and TCa in initial feed mixtures and final vermicompost of cow dung mixed with vegetable waste and banana peels in different combinations.

Combinations	TAP (g/kg)			TCa (g/kg)		
	IFM	VC	% increase	IFM	VC	% increase
CD	3.14 ± 0.03	4.87 ± 0.01*	35.53	1.71 ± 0.03	2.58 ± 0.03*	33.73
CD+VW (1:1)	4.82 ± 0.00	7.49 ± 0.02*	35.65	2.71 ± 0.15	3.38 ± 0.24*	19.83
CD+VW (2:1)	4.88 ± 0.16	7.16 ± 0.03*	31.85	2.51 ± 0.26	3.26 ± 0.03*	23.01
CD+BP (1:1)	4.78 ± 0.05	6.97 ± 0.01*	31.43	2.38 ± 0.13	2.68 ± 0.13*	11.20
CD+BP (2:1)	4.63 ±	6.83 ±	32.22	2.21 ±	2.51 ±	11.96

	0.02	0.03*		0.15	0.08*	
CD+BP+VW (1:1:1)	4.93 ± 0.01	7.03 ± 0.02*	29.88	2.75 ± 0.05	2.93 ± 0.03*	7.51

Each value is the mean ± SE of six replicates. IFM = Initial Feed Material, VC = Vermicompost, CD = Cow dung, BP = Banana peel, VW = Vegetable Waste

*Significant ($P < 0.05$) 't' test between before and after vermicomposting in 30.0x30.0x10.0 cm^3 area of vermicompost bed.

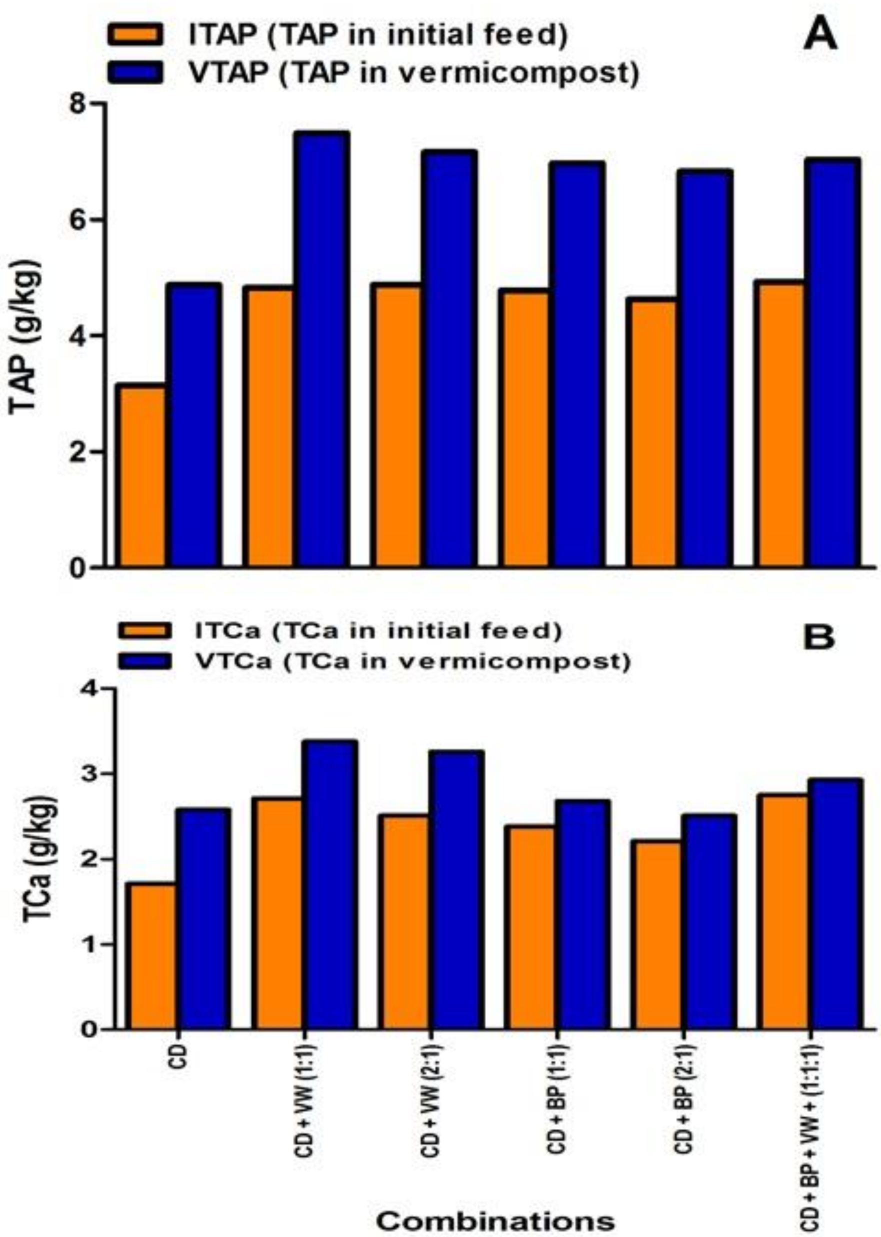

Figure 4: Concentration of TAP (A) and TCa (B) in initial feed material and the vermicompost of different combinations of cow dung with vegetable wastes and banana peels by *Eutyphoeus waltoni.* ITAP= total available phosphorus in initial feed material,

VTAP= total available phosphorus in vermicompost, ICa= total calcium in initial feed material, VCa= total calcium in vermicompost, CD= cow dung, VW= vegetable waste, BP= banana peel.

CONCLUSION

Conversion of different type of wastes by earthworms into potential products which are rich in plant nutrients can truly bring economic prosperity for farmers and simultaneously reduce the burden of organic wastes. This study clearly reveal the significant changes in the physico-chemical properties of cow dung mixed with vegetable wastes and banana peels in different ratios after the processing of earthworm *Eutyphoeus waltoni.* On the basis of nutrient content in the final composted mixture after the processing of *Eutyphoeus waltoni*, it might be the indication that this technology can reduce the burden of synthetic fertilizers. Experimental data provide a sound basis that this technology of obtaining organic fertilizers by using earthworms will not only reduce the load of synthetic fertilizers but will also act as a soil conditioner and a source of plant nutrients in agriculture.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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