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PHYSICO-CHEMICAL CHARACTERIZATION OF VERMICOMPOST PRODUCED FROM BANANA PEEL AND BUFFALO DUNG USING *LAMPITO MAURITII*

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Abstract: The management of organic solid waste has become a major environmental concern due to rapid population growth and increasing agricultural activities. This study investigated the physico-chemical changes occurring during vermicomposting of banana peels (BP) and buffalo dung (BD) using the earthworm *Lampito mauritii*. Various feed combinations, including BD alone and BD+BP in the ratios of 1:1, 1:2, 1:3, 1:4, 2:1, 3:1, and 4:1, were prepared and maintained for 90 days. Different physico-chemical parameters were analyzed before and after vermicomposting. The vermicomposting activity of *Lampito mauritii* effectively transformed the feed mixture into nutrient-rich vermicompost. The concentrations of total Kjeldahl nitrogen (TKN), total potassium (TK), total available phosphorus (TAP) and total calcium (TCa) increased significantly in the final vermicompost compared with the initial feed materials, whereas the level of pH, electrical conductivity (EC), total organic carbon (TOC) and the C: N ratio decreased significantly. The results demonstrate that buffalo dung and banana peels are suitable feed materials for producing nutrient-rich vermicompost. Therefore, vermicomposting with *Lampito mauritii* offers an eco-friendly, sustainable, and economically viable approach for converting organic waste into nutrient rich organic manure and reducing environmental pollution.

Keywords: Banana peels, Buffalo dung, *Lampito mauritii*, Vermicomposting, Waste recycling.

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INTRODUCTION

India generates a substantial quantity of domestic organic waste every year. The increasing generation of organic waste due to rapid population growth has become one of the most significant environmental challenges worldwide (Mary *et al*., 2019; Siddiqui and Singh, 2024a). The management of biological waste, particularly fruit and animal waste, has become a very serious environmental concern due to rapid urbanization worldwide (Yadav and Singh, 2024). The generation of large quantities of biodegradable waste, such as animal dung and kitchen waste, often creates disposal problems and environmental pollution if not properly and effectively managed. Improper disposal and management of these wastes may negatively affect both human health and the environment (Kaviraj and Sharma, 2003; Mohite *et al.*, 2024).

Buffalo dung is abundantly available in rural areas and is rich in organic matter and essential nutrients. India produces more than several million tonnes of buffalo dung annually. Buffalo dung provides an excellent substrate for vermicomposting because of its high nutrient content, particularly nitrogen, phosphorus, potassium, and calcium (Sharma and Iqbal, 2022). Aboul-Enein *et al.* (2016) reported that banana peels constitute a significant proportion of household organic waste and contain appreciable amounts of potassium, phosphorus, and other micronutrients. Banana peels contain high concentrations of potassium, followed by magnesium, calcium, sodium, and other minerals (Mohapatra *et al.*, 2010; Siddiqui and Singh, 2023a). Proper recycling of these wastes into valuable organic manure can contribute significantly to sustainable agriculture.

Vermicomposting is an eco-friendly and efficient biotechnological process in which earthworms and microorganisms convert organic waste into stabilized, humus-like material rich in plant nutrients (Singh and Singh, 2024). The earthworm *Lampito mauritii*, a commonly available anecic species, has been widely recognized for its ability to consume large quantities of organic residues and enhance nutrient mineralization during the composting process (Tripathi and Bhardwaj, 2004; Chaudhuri and Debnath, 2020; Suvedha *et al.*, 2024). The earthworms are friends of farmers and act as antioxidant as well as biomarker of pollution (Verma, 2017; Deswal *et al.,* 2020; Singh and Fatima, 2022). Their activities not only accelerate the decomposition process but also improve the physico-chemical properties of the final compost. Different combinations of organic waste influence the rate of decomposition and nutrient enrichment during vermicomposting (Singh *et al.*, 2020; Kumari and Kumari, 2025).

Therefore, it is important to evaluate effectively the physico-chemical changes that occur during the vermicomposting of banana peel mixed with buffalo dung in different proportions. The present study was undertaken to compare different feed combinations of banana peel and buffalo dung processed by *Lampito mauritii* in order to identify the most suitable feed combination for the production of nutrient-rich vermicompost. The results of the present study provide useful information for selecting an appropriate feed combination for vermicompost production and may contribute to the efficient utilization of banana peel waste through sustainable organic waste management.

MATERIALS AND METHODS

Collection and rearing of Earthworm *Lampito mauritii*

Young and healthy cultured earthworms of *Lampito mauritii* were obtained from the Vermibiotechnology Laboratory, Department of Zoology, D.D.U. Gorakhpur University, Gorakhpur, India, and used for the experiment. The earthworms were acclimatized well under controlled laboratory conditions before the experiment. Vermibeds were prepared on a cemented floor using partially decomposed buffalo dung and garden waste to maintain suitable moisture and aeration for earthworm activity and survival. Only healthy and active earthworms were selected for the experimental study.

Collection of Banana peels and Buffalo dung

Banana peels (BP) were obtained from household sources, while buffalo dung (BD) was collected from nearby dairy farms in the Gorakhpur district. Before being used in the experiment, all collected materials were air-dried and allowed to pre-decompose for approximately ten days in order to reduce potentially harmful volatile compounds and partially stabilize the substrates before earthworm introduction (Garg *et al.*, 2005).

Experimental Setup

The experiment was conducted on a cemented surface under laboratory conditions. Vermibeds of size 30 × 30 × 10 cm^3 were prepared using 2 kg of feed material. Different combinations of buffalo dung and banana peel were prepared in the ratios BD+BP (1:1), BD+BP (1:2), BD+BP (1:3), BD+BP (1:4), BD+BP (2:1), BD+BP (3:1), and BD+BP (4:1), while buffalo dung (BD) alone was maintained as the control. The beds were kept at room temperature (27 ± 2°C). During the initial two weeks, the vermibeds were manually turned every 24 h to facilitate pre-decomposition and reduce harmful volatile substances. After the pre-decomposition period, dried samples from each vermibed were collected and considered as the initial feed material (IFM) for physico-chemical analysis. Subsequently, twenty newly hatched *Lampito mauritii* were introduced into each vermibed. Moisture content was maintained between 60 and 70% throughout the 90-day vermicomposting period by regular sprinkling of water, providing favourable conditions for earthworm growth and activity. At the end of the experiment, vermicompost (VC) samples were collected from each treatment for further physico-chemical analysis. The treatment combinations were maintained in separate vermibeds throughout the experimental period. Each treatment was replicated six times (Singh and Singh, 2023; Yadav and Singh, 2026).

Physico-Chemical Analysis

The pH and electrical conductivity (EC) of each sample were determined in a 1:10 (w/v) suspension prepared with double-distilled water. The suspension was mechanically shaken for 30 min and filtered through Whatman No. 1 filter paper. Total organic carbon (TOC) was estimated by the method of Nelson and Sommers (1982). The total Kjeldahl nitrogen (TKN) was determined after digestion of the sample with concentrated H_2SO_4 and $HClO_4$ (9:1, v/v) following the procedure of Bremner and Mulvaney (1982). Total available phosphorus (TAP) was estimated by the molybdenum blue method (Garg *et al.*, 2005). The sample was extracted with 0.002 N H_2SO_4, followed by ammonium molybdate and $SnCl_2$ treatment. Absorbance was recorded at 690 nm, and TAP (%) was calculated as P × V / W × 100. Total potassium (TK) was measured using a flame photometer, whereas total calcium (TCa) was determined by standard analytical procedures (Yadav and Singh, 2026).

Statistical Analysis

All experiments were replicated six times to ensure the consistency of the results. The results were expressed as mean ± standard error (SE). Analysis of variance (ANOVA) was used to evaluate differences among the experimental combinations. The t-test was used to compare the initial feed material and final vermicompost at $P < 0.05$ (Sokal and Rohlf, 1973).

RESULTS AND DISCUSSION

Vermicomposting of buffalo dung (BD) and banana peels (BP) resulted in significant physico-chemical changes. In the present experiment, the physico-chemical quality of the final vermicompost was considerably improved by vermicomposting buffalo dung with banana peels. Effective organic waste decomposition and stability have been shown by the reduction in pH, electrical conductivity, total organic carbon, and C/N ratio seen in all treatment combinations. The levels of total Kjeldahl nitrogen, potassium, phosphorus, and calcium increased significantly at a similar duration, indicating that nutrients were enriched during the process of vermicomposting.

pH and Electrical Conductivity (EC)

The pH values of the initial feed combinations and the final vermicompost produced from buffalo dung and banana peels by the vermic activity of *Lampito mauritii* are presented in fig. 1. Buffalo dung alone showed the greatest decrease in pH, from 8.85±0.05 to 6.88±0.03 (22.26%), whereas the BD+BP (1:4) combination showed the least decrease in pH, from 6.32±0.05 to 6.08±0.05 (3.80%). The pH of different feed material mixtures decreased as a result of the decomposition of nitrogen as well as phosphorus into nitrites/nitrates and phosphorus, as reported by Ndegwa *et al.* (2000). The pH drop during vermicomposting has also been associated with microorganisms producing CO_2, ammonia, and organic acids (Sharma *et al.*, 2011). Earthworm activity can also lower the pH of the final product through the formation of humic and fulvic acids (Chauhan and Singh, 2012; Singh and Singh, 2023).

The EC of all the vermibeds was significantly reduced after vermicomposting by Lampito mauritii compared with the initial feed mixture (Fig. 1). Buffalo dung had the highest decrease of 43.20% (2.94±0.04 to 1.67±0.08 ds/m), while the BD+BP (4:1) combination had the lowest decrease of 38.49% (2.91±0.13 to 1.79±0.02 ds/m). Earthworms and related microbes use and alter soluble salts, causing a reduction in EC. During vermicomposting, earthworms and microbial communities absorb soluble salts, which cause a decrease in EC (Kaviraj and Sharma, 2003). Ansari and Rajpersaud (2012) observed that the EC of the initial feed combination decreased significantly during the vermicomposting process. Their conclusions correlate with the decrease in EC seen in this analysis.

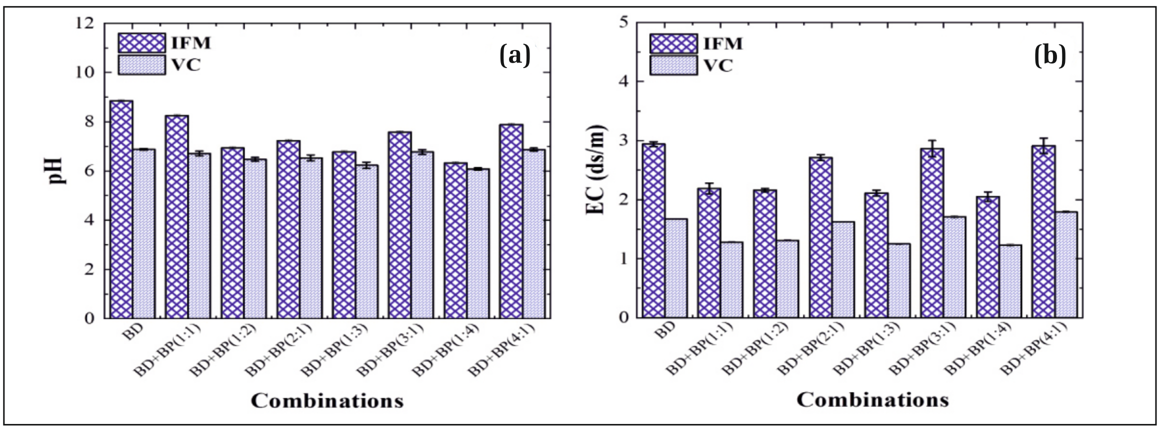

Fig. 1: Concentration of pH (a) and EC (b) in initial feed material and the vermicompost of different combinations of buffalo dung with banana peels by *Lampito mauritii*.

Total Organic Carbon (TOC) and Total Kjeldahl Nitrogen (TKN)

Figure 2 shows that the total organic carbon level reduced significantly in each combination. The combinations of BD+BP (1:1) and BD+BP (1:4) showed a maximum drop of 58.82% (435.17±0.72 to 179.21±1.42 g/kg) and the lowest decrease of 47.88% (409.11±0.42 to 213.21±0.80 g/kg), respectively. Research studies consistently show a considerable reduction in total organic carbon during vermicomposting due to the oxidation of organic waste and microbial respiration (Hait and Tare, 2011; Zhou *et al.*, 2021). Earthworms also appear to influence nitrogen cycling during vermicomposting. Umar and Sharif (2013), observed that a reduction in organic carbon was associated with an increase in nitrogen concentration. A decrease in TOC during vermicomposting has also been reported by Prakash and Karmegam (2010) and Bhat *et al.* (2014) in sugar mill waste. Similarly, Suthar and Singh (2008) suggested that earthworm activity reduces TOC through the loss of carbon as CO_2 during the decomposition process.

Figure 2 shows that during vermicomposting, TKN significantly increased in all feed mixtures. Among all the combinations of buffalo dung and banana peels, the combination of BD+BP (1:1) showed the maximum increase in TKN, by 53.31% (6.64±0.03 to 10.18±0.05 g/kg), while the combination of BD+BP (2:1) showed the lowest increase, at 41.55% (6.45±0.01 to 9.13±0.02 g/kg). Previous studies have demonstrated that earthworm mucus, casts, and excretory secretions enhance the compost with nitrogenous chemicals (Edwards and Arancon, 2022). As reported in earlier research, carbon loss during decomposition causes nitrogen in the final product to become more concentrated (Nath *et al.*, 2009; Singh and Singh, 2023; Siddiqui and Singh, 2024b). Therefore, the notable increase in TKN observed in this analysis indicates enhanced fertilizing properties and nutrient enrichment.

C/N ratio and Total Potassium (TK)

The C/N ratio decreased significantly in all feed combinations, indicating efficient decomposition and stabilization of the organic substrates (Fig. 3). The C/N ratio decreased from 65.53 ± 0.91 to 17.60 ± 1.03 and from 69.06 ± 0.75 to 24.65 ± 1.18 in different combinations of buffalo dung and banana peels. During vermicomposting by the earthworm *Lampito mauritii*, the BD+BP (1:1) combination exhibited the highest reduction in the C/N ratio (73.14%), while the minimum decrease of 64.31% was observed in the BD+BP (1:2) combination. As reported in previous studies, simultaneous nitrogen enrichment and carbon mineralization during vermicomposting cause the C/N ratio to drop (Biruntha *et al.*, 2020). Senesi (1989) observed that a reduced C/N ratio indicated significant stabilization of organic matter and a higher degree of organic matter decomposition. Cow dung, being a readily decomposable organic waste, lowers the C/N ratio and increases the macronutrient composition of vermicompost, thereby enhancing the rate of composting (Muthukumaravel *et al.*, 2008). Activity of earthworm improves the humification during the process of vermicomposting, lowering the C/N ratio (Suthar, 2006).

Figure 3 shows that TK increased by 37.25% (5.02±0.05 to 6.89±0.03 g/kg) in the BD+BP (4:1) combination, whereas the lowest increase of 13.00% (5.54±0.04 to 6.26±0.01 g/kg) in the BD+BP (1:1) combination of buffalo dung and banana peels. Due to microbial solubilisation and mechanical breakdown of organic substrates, previous vermicomposting studies have consistently demonstrated an increase in potassium concentration (Boruah and Deka, 2025). The agricultural value of vermicompost is greatly enhanced by increased potassium availability. Thus, the continuous increase in TK seen in this study is similar to the findings of Pramanik *et al.* (2007) and Hait and Tare (2011).

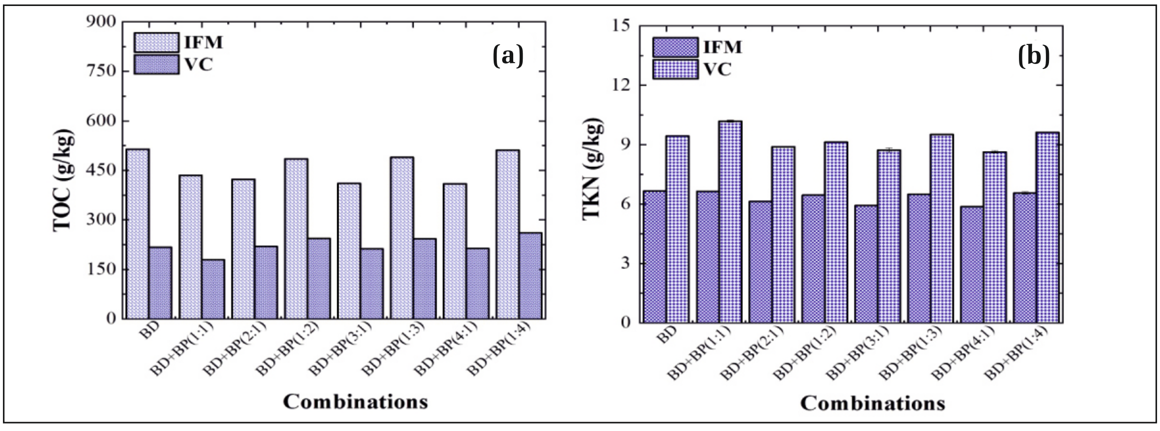

Fig. 2: Concentration of TOC (a), TKN (b) in initial feed material and the vermicompost of different combinations of buffalo dung with banana peels by *Lampito mauritii*.

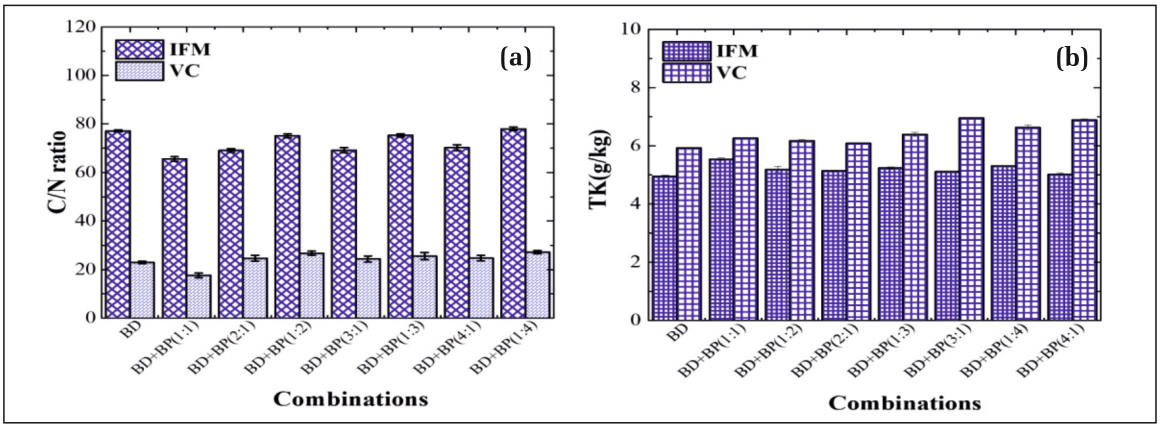

Fig. 3: Concentration of C/N ratio (a), and TK (b), in initial feed material and the vermicompost of different combinations of buffalo dung with banana peels by *Lampito mauritii*.

Total Available Phosphorus (TAP) and Total Calcium (TCa)

All vermicomposted combinations showed a significant increase in TAP (Fig. 4). TAP increased by 24.51% (4.57±0.11 to 5.69±0.09 g/kg) in the BD+BP (1:2) combination and by 8.73% (4.81±0.02 to 5.23±0.03 g/kg) in the BD+BP (4:1) combination. Due to increased phosphate activity, microbial solubilisation, and the production of organic acid, which transform insoluble phosphates into forms that plants can absorb, several experimental studies have observed an increase in TAP during vermicomposting (Bhattacharya and Chattopadhyay, 2002; Abou El Seoud *et al.*, 2022). Increased TAP directly improves the quality of composting material, according to previous studies. The substantial TAP improvement in the present study is consistent with the results of Singh and Singh (2023) and Siddiqui and Singh (2023b).

During vermicomposting, the concentration of TCa increased significantly in all feed mixtures containing banana peels and buffalo dung (Fig. 4). BD+BP (1:3) ratio showed a maximum rise of 33.58% (2.68±0.08 to 3.58±0.18 g/kg), whereas the BD+BP (1:4) combination showed the lowest increase of 18.82% (2.71±0.08 to 3.22±0.10 g/kg). The increased amount of inorganic calcium in worm casts is thought to be caused by digestive processes related to calcium metabolism (Garg *et al.*, 2006). As demonstrated in studies, cast deposition and earthworm gut metabolism cause the TCa concentration to increase during vermicomposting (Das *et al.*, 2012; Rehman *et al.*, 2025). Singh and Singh, (2023) observed a similar pattern of TCa during vermicomposting. Soil accumulation and neutralizing capacity are enhanced by increased calcium. Sangwan *et al.* (2010) found that press mud vermicompost made with *Eisenia fetida* had higher concentrations of N, P, and Ca. They suggested that vermicomposting mixed with cow dung up to 50% could serve as an effective technology for neutralizing pH while converting waste into nutrient-rich fertilizers.

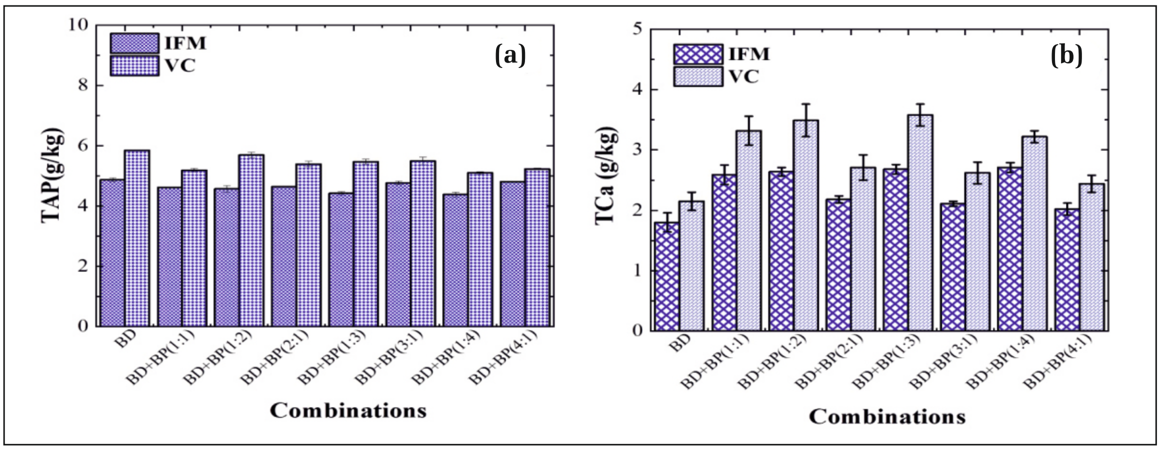

Fig. 4: Concentration of TAP (a) and TCa (b) in initial feed material and the vermicompost of different combinations of buffalo dung with banana peels by *Lampito mauritii*.

CONCLUSIONS

The present study demonstrated that vermicomposting of buffalo dung and banana peels using *Lampito mauritii* resulted in substantial changes in physicochemical properties, including reduction in the pH, EC, TOC, and C/N ratio in all feed combinations, indicating effective decomposition and stabilization of organic matter. In contrast, the concentrations of TKN, TK, TAP and TCa increased during vermicomposting. Among the different feed combinations, BD+BP (1:1) exhibited the greatest reduction in TOC and C/N ratio, along with the highest increase in TKN, indicating superior organic matter stabilization and nitrogen enrichment. The study observed that banana peels and buffalo dung are suitable feed materials for producing nutrient-rich vermicompost. Through vermicomposting with *Lampito mauritii*, the BD+BP (1:1) combination was found to be most suitable among all the combinations for recycling banana peels waste into nutrient-rich organic fertilizer. Thus, this approach provides an efficient, sustainable, and environmentally friendly method for organic waste management.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this research work.

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