Conversion Of Groundnut Shell into Vermicompost By Utilizing Bacterial Consortium and *Eudrilus Eugeniae*

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Abstract

Introduction: This study aimed to enhance the biodegradation of groundnut shells through pre-digestion with selected effective microorganisms and evaluate their subsequent conversion into vermicompost using *Eudrilus eugeniae*. **Objectives:** The specific objectives were to: (1) pre-digest groundnut shells using a bacterial consortium, (2) assess the vermicomposting efficiency of two substrate mixtures *viz.,* 50:50 and 60:40 ratios of pre-digested groundnut shells to cow dung, and (3) compare the physical, chemical, and biological characteristics of the resulting vermicompost with a control. **Methodology:** The experiment was conducted over a period of 35 days. Groundnut shells were pre-treated with a bacterial consortium and combined with cow dung in two proportions: 50:50 (2000 g each of pre-digested groundnut shells and cow dung) and 60:40 (2400 g pre-digested shells with 1600 g cow dung). Vermicomposting was performed using *E. eugeniae*, and the resulting compost was analyzed

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for key physical, chemical, and biological properties. **Results:** The 60:40 mixture resulted in greater vermicompost output and a higher number of cocoons and juvenile worms, indicating better reproductive performance. In contrast, the 50:50 mixture produced vermicompost with significantly higher concentrations of macro- and micronutrients, along with greater microbial activity. **Conclusion:** A 50:50 ratio of pre-digested groundnut shells and cow dung is optimal for producing nutrient-rich vermicompost using *E. eugeniae*, making it a suitable choice for sustainable organic waste management.

Key Words: Groundnut Shell, Bacterial Consortium, *Eudrilus eugeniae*, Vermicompost

INTRODUCTION

India generates an estimated 350 million tons of agricultural waste each year, comprising leaf litter, crop residues, animal manure, and various agro-industrial byproducts. A significant portion of this biomass is either landfilled or openly burned, contributing to severe environmental degradation and air pollution. Recycling and value-added conversion of these wastes present a sustainable approach in reducing environmental impact and enhancing agricultural productivity[1].

Several strategies have been proposed for managing agricultural waste, including composting, waste to energy (WTE), animal feed production, and mushroom cultivation[2]. Among these, vermicomposting a biological process that leverages the synergistic action of microorganisms and earthworms is widely recognized for its efficiency and environmental benefits. This process converts organic matter into a humus-like material rich in essential nutrients, improving soil health by enhancing water retention, aeration, porosity, and microbial activity, ultimately promoting better plant growth and yield.

Groundnut shells, an abundant agro-waste, pose a challenge for direct biodegradation due to their complex composition rich in lignin, lignocellulose, and hemicellulose[3,4,5]. Their natural resistance to decomposition necessitates a pre-treatment step to facilitate microbial breakdown. One promising method involves pre-digesting the shells using a bacterial consortium, which accelerates the degradation of complex polymers, making the material more accessible for vermicomposting.

Despite the extensive research on organic waste management, there is limited literature on the combined use of bacterial consortia for pre-digesting groundnut shells followed by vermicomposting using *Eudrilus eugeniae*.

OBJECTIVES

1. To enhance the biodegradability of groundnut shells through pre-digestion using an effective bacterial consortium.
2. To assess the vermicomposting performance of various mixtures of pre-digested groundnut shells and cow dung using *Eudrilus eugeniae*.
3. To compare the physical, chemical, and biological properties of the resulting vermicomposting with those of a control (cow dung-only vermicompost).

MATERIALS AND METHODS

Groundnut shells and cow dung were sourced from Puthanampatti village and transported to the laboratory premises of Nehru Memorial College (Autonomous) for further processing and experimentation. A bacterial consortium was formulated based on the protocol described by Viji[6] (2015). This consortium was used for enhancing the decomposition process and is hereafter referred to as the "waste decomposer." To prepare the bacterial inoculum, 1 kg of jaggery was dissolved in 100 litres of distilled water in a clean container. Subsequently, 30 ml of the tailored bacterial consortium was added to this solution. The mixture was stirred thoroughly, covered with a lid, and left to ferment for seven days under ambient conditions. The resulting solution was used as the microbial inoculum for further application. Groundnut shells were spread out on a clean surface and exposed to direct sunlight for five days. During this period, water was sprinkled twice daily to maintain adequate moisture. The same pre-treatment procedure was applied to cow dung. After sun-drying, both materials were transferred to a shaded area and allowed to cure for an additional five days. To initiate the decomposition process, 1 kg of pre-treated groundnut shells was evenly spread on a clean surface, and 100 ml of the prepared waste decomposer inoculum was uniformly sprayed over the layer. This was followed by the addition of another 1 kg layer of groundnut shells, and the process was repeated until the compost heap reached a height of approximately 1 meter. Water was intermittently sprinkled to maintain a moisture content between 60% and 70%. The heap was then covered with wet jute fabric to retain moisture and facilitate bacterial activity. The setup was left undisturbed for 15 days to allow for partial decomposition.

Table 1: Experimental Tray Preparation

Concentration#	Experiments	Weight of the pre-digested groundnut shell	Weight of the Cow dung	Number of earthworms inoculated
50:50	Treatment	2000	2000	100
	Control	2000	2000	-
60:40	Treatment	2400	1600	100
	Control	2400	1600	-

#Both treatment and control trays were prepared in triplicates and maintained

Before the inoculation of earthworms, pH, moisture and temperature contents of feed material was measured in all the trays and the same were found to be between 6.5 and 7.5, 40 and 60% and 25 and 30º C, respectively. The species of earthworm used for vermicomposting, *Eudrilus eugeniae*, was sourced from the vermicomposting facility at Nehru Memorial College (Autonomous) in Puthanampatti, Tiruchirappalli, for this research. Its identification was verified through morphological features as outlined by Talashilkar and Dosani[7] and Blakemore[8]. The composting process was considered complete when the material exhibited a dark brown to black coloration, indicating maturity. At this stage, all watering was ceased. Vermicompost samples were subsequently collected from each experimental tray and allowed to air-dry at ambient room temperature (approximately 28°C). The dried samples were then sealed in zip-lock polythene bags and stored under controlled conditions for subsequent analysis. The collected vermicompost and compost underwent thorough physico-chemical and microbiological evaluations in accordance with established protocols. The pH and electrical conductivity (EC) of these samples were measured using a digital pH meter and a digital conductivity meter (Elico make), respectively, as outlined by Tandon[9]. The moisture content was assessed using the method specified by Tandon[9]. Organic carbon levels were determined through the partial oxidation technique of Walkley and Black[10], while total nitrogen content was evaluated using the Micro-Kjeldahl method[9]. Total phosphorus and sulphur were measured spectrophotometrically following Tandon's[9] method. Total potassium and sodium were quantified via the flame photometric method[9], and total calcium and magnesium were assessed using the versenate titration method as described by Trivedy and Goel[11]. Finally, the C:N ratio was calculated according to the guidelines provided by Anon[12]. To determine the significance of differences between the initial and final parameters of each treatment, a paired samples t-test was conducted. Statistical significance was assessed at three confidence levels: 0.05%, 0.01%, and 0.001%. All statistical analyses were performed using SPSS (Statistical Package for the Social Sciences), version 16.0, for Windows.

RESULTS AND DISCUSSION

Table 2 summarizes the composition of pre-digested substrate (groundnut shell treated with the waste decomposer) and its subsequent bioconversion into vermicompost by *Eudrilus eugeniae* at two substrates to cow dung ratios: 50:50 and 60:40. The average total yield of vermicompost was 2206 g for the 50:50 treatment, compared to 1565 g in its corresponding control. Similarly, the 60:40 treatment produced 2233 g of vermicompost, while its control yielded 1425 g.

The mean percentage conversion of groundnut shell to vermicompost was 55% in the 50:50 treatment and 39% in the control, whereas the 60:40 treatment exhibited a conversion rate of 56%, compared to 50% in the control. In terms of biological activity, the average number of cocoons and hatchlings recorded was 60 and 125, respectively, for the 50:50 treatment, and 90 and 140, respectively, for the 60:40 treatment (Table 2).

Table 2: The extent of composition of predigested food (groundnut shell predigested with waste decomposer) and its bioconversion into vermicompost by *E. eugeniae* in 50:50 and 60:40 concentrations. Each value represents the mean of three observations.

S. No.	Particulars	50:50 Concentration		60:40 Concentration	
		E. eugeniae	**Control**	***E. eugeniae***	**Control**
1	Weight of predigested groundnut shell (g)	2000	2000	2400	2400
2	Weight of cured cow dung (g)	2000	2000	1600	1600
3	Total weight of predigested mixture (g)	4000	4000	4000	4000
4	Number of adult worms introduced	100	-	100	-
5	Total weight of compost/vermicompost (g)	2206	1565	2233	1425
6	Percent conversion of vermicompost (%)	55	39	56	36
7	Mean number of cocoons observed in each tray	60	-	90	-
8	Mean number of young ones observed in each tray	125	-	140	-

The pH of all experimental trays showed a significant reduction compared to the control. The lowest pH value was recorded in the vermicompost harvested from the 50:50 experimental trays (7.35 ± 0.04). Statistically, there was no significant difference in pH reduction between vermicompost and compost at both 50:50 and 60:40 concentrations ($p > 0.001$) (Table 3). These findings align with previous vermicomposting studies, which have also reported compost pH within a neutral range[13,14,15]. Amouei *et al.*[16] suggested that as decomposition progresses, microbial metabolic activity leads to the production of alkaline compounds such as ammonium, shifting the pH toward the alkaline side. Additionally, Huang *et al.*[14] proposed that compost with near-neutral pH, as observed in this study, may be beneficial for the remediation of acidic soils.

The Electrical Conductivity ranged from 1.53 ± 0.35 dSm^{-1} to 3.53 ± 0.32 dSm^{-1} in the compost and vermicompost harvested from 50:50 and 60:40 experimental trays, respectively. They show significant difference between vermicompost, and compost harvested from 50:50 and 60:40 experimental trays ($p<0.001$) (Table 3). An increase in the concentration of nutrients *i.e.,* phosphorus, potassium, sodium and calcium are the major reason that results in increased levels of electrical conductivity. A high salt concentration can lead to phytotoxicity, making electrical conductivity (EC) a key indicator of the suitability and safety of compost and vermicompost for agricultural use[17]. In this study, the EC values of the produced vermicompost remained below the threshold of 4 dSm^{-1}, indicating its safe application to soil[18].

There was significant increase ($p<0.001$) in moisture content in all the experimental trays in comparison with control. The mean Moisture content of the vermicompost were found to be low in the 50:50 experimental trays *i.e.,* 22.3 ± 4.16% (Table 3). When the moisture content of the vermicompost is increased then it also increases the activities and reproduction of earthworms[19].

Table 3: The magnitude of pH, Electrical Conductivity and Moisture content of the vermicompost produced by *E. eugeniae* utilizing groundnut shell (pre-digested with waste decomposer) in 50:50 and 60:40 concentrations and control. Each value represents Mean (Mean ± S.D.) of three individual observations.

Concentrations	pH		t Test	Standard for Vermicompost#
	Vermicompost Mean ± S.D.	Compost Mean ± S.D.		
50:50	7.35 ± 0.04	9.36 ± 0.23	**0.26**[NS]	**6.5 -7.5**
60:40	8.02 ± 0.02	9.02 ± 0.02	**0.12**[NS]	
	Electrical Conductivity		**t Test**	**Standard for Vermicompost#**
50:50	3.04 ± 0.02	1.53 ± 0.35	**0.001***	**Not more than 4**
60:40	3.53 ± 0.32	2.53 ± 0.35	**0.001***	
	Moisture		**t Test**	**Standard for Vermicompost#**
50:50	22.3 ± 4.16	13.3 ± 3.51	**0.001***	**14.0 – 25.0**
60:40	21.6 ± 4.16	13.12 ± 3.16	**0.001***	

#Source: Tandon[9], * indicates statistically significant at $p<0.001$; NS – Not Significant.

The Organic Carbon showed significantly decreased level ($p<0.001$) in all the experimental trays against control. The mean Organic Carbon content was found to be lowest in the vermicompost harvested from 50:50 experimental trays (26.6 ± 2.08%) while the same was quantified to be highest in the control trays (50:50 concentration) (45 ± 3%). Remarkable difference could be observed between vermicompost and compost harvested from 50:50 and 60:40 concentrations (Table 4). During the composting process, total organic carbon content decreased as organic matter stabilized through the combined action of earthworms and microorganisms. The reduction in organic carbon observed in this study aligns with previous findings by Negi and Suthar[20], Prakash and Karmegam[21], and Sharma and Garg[22].

The end product showed higher levels of Total Calcium and Total Magnesium in all the experimental trays than the control. Statistically, the Total Calcium and Total Magnesium increase was not different between vermicompost and compost (50:50 and 60:40 concentrations) ($p<0.001$). The maximum mean Total Calcium and Total Magnesium of vermicompost was quantified as 3.46 ± 0.02% and 4.12 ± 0.01%, respectively in the 50:50 experimental trays. On the other hand, the minimum Total Calcium and Total Magnesium of vermicompost was quantified *i.e.,* 0.85 ± 0.05% (60:40 concentration) and 1.26 ± 0.02% in the control trays (50:50 concentration) (Table 4). The significantly increased levels of Total Calcium and Total Magnesium in the vermicompost could be due to the combined action of microorganisms and earthworms which increase the mineralization of organic matter when it passes through the gut of earthworms.

Table 4: The extent of Organic Carbon, Total Calcium and Total Magnesium of the vermicompost produced by *E. eugeniae* utilizing groundnut shell (pre-digested with waste decomposer) in 50:50 and 60:40 concentrations and control. Each value represents Mean (Mean ± S.D.) of three individual observations.

Concentrations	**Organic Carbon (%)**		**t Test**	**Standard for Vermicompost#**
	Vermicompost Mean ± S.D.	**Compost Mean ± S.D.**		
50:50	26.6 ± 2.08	45 ± 3	**0.001***	**Minimum 18%**
60:40	30 ± 1	41 ± 4	**0.001***	
	Total Calcium (%)		**t Test**	**Standard for Vermicompost#**
50:50	3.46 ± 0.02	1.14 ± 0.02	**0.05^{NS}**	**-**
60:40	1.86 ± 0.04	0.85 ± 0.05	**0.05^{NS}**	
	Total Magnesium (%)		**t Test**	**Standard for Vermicompost#**
50:50	4.12 ± 0.01	1.26 ± 0.02	**0.07^{NS}**	**-**
60:40	3.16 ± 0.02	1.56 ± 0.06	**0.06^{NS}**	

#Source: Tandon[9], * indicates statistically significant at p<0.001; NS – Not Significant.

The vermicompost harvested from the 50:50 experimental trays had significantly increased level of Total Nitrogen (2.04 ± 0.03%) than the other experimental trays and control. The Total Nitrogen content of the vermicompost and compost harvested from 50:50 and 60:40 experimental trays were significantly different from each other (p<0.001) (Table 5). This increase may result from nitrogen contributions by the earthworm through mucus, nitrogenous excretory materials, growth-stimulating hormones, enzymes, nitrogen-fixing bacteria, and decomposed earthworm tissues.

Significantly increased levels in Total Phosphorous was found in all the experimental trays as compared to control ($p<0.001$). It is evident from the results that the vermicompost harvested from the 50:50 experimental trays had a highest amount of Total Phosphorus *i.e.,* 2.03 ± 0.02%. On the other hand, the control trays (50:50 concentration) had the lowest amount of Total Phosphorus *i.e.,* 0.85 ± 0.05%. Remarkable difference among vermicompost and compost harvested from 50:50 and 60:40 concentrations could be observed for Total Phosphorus ($p<0.001$) (Table 5). According to Huang *et al.*[14] and Huang and Xia[23] and Parthasarathi *et al.*[24], the increased levels of TP in the vermicompost is due to the mineralization of phosphorus by the action of phosphatase enzyme present in the earthworms' mucus. Additionally, Huang and Xia[23] convincingly reported that the mucus secreted by earthworms help in the mineralization and humification of organic matter, while also promoting microbial activity. Further, Ghosh *et al.*[25] recently demonstrated that enzymes such as phosphatase and phytase play a crucial role in phosphorus mineralization, with phosphatase activity being especially influential during the initial stages of the vermicomposting process.

The mean Total Potassium content was observed to be high *i.e.,* 2.22 ± 0.02% in the 50:50 experimental trays while it was found to be low *i.e.,* 1.01 ± 0.03% in the 60:40 control trays. The Total Potassium content of the vermicompost and compost obtained from 50:50 and 60:40 experiments were significantly different from each other ($p<0.001$) (Table 5). The enrichment of K concentration in vermicompost is mainly attributed to the synergistic action of earthworms and associated microorganisms, which accelerate organic matter decomposition and enhance the solubilization of mineral nutrients[26,27]. Earthworm gut enzymes and microbial metabolites play an essential role in converting insoluble forms of potassium into plant-available fractions, while their casts further enrich the substrate with exchangeable minerals[28,29]. In the present study, pre-digestion of groundnut shells using a bacterial consortium might have enhanced the degradation of lignocellulosic components, facilitating greater release of potassium from the bound organic matrix. Similar improvements in nutrient recovery through microbial inoculation have been reported in cow dung–based vermicomposting systems[30]. The apparent increase in potassium concentration may also be related to the relative concentration effect, where loss of organic carbon during vermistabilization proportionally raises the concentration of mineral constituents[20]. Overall, the 50:50 mixture demonstrated a balanced substrate composition that supported active microbial metabolism and enhanced nutrient bioavailability, corroborating recent evidence that optimized substrate ratios yield vermicompost with superior nutrient content and soil fertility potential[29,30].

Table 5: The quantity of Total Nitrogen, Total Phosphorus and Total Potassium of the vermicompost produced by *E. eugeniae* utilizing groundnut shell (pre-digested with waste decomposer) in 50:50 and 60:40 concentrations and control. Each value represents Mean (Mean ± S.D.) of three individual observations.

Concentrations	Total Nitrogen (%)		t Test	Standard for Vermicompost#
	Vermicompost Mean ± S.D.	Compost Mean ± S.D.		
50:50	2.04 ± 0.03	0.55 ± 0.02	**0.01***	**>1**
60:40	1.25 ± 0.03	0.75 ± 0.02	**0.01***	
	Total Potassium (%)		**t Test**	**Standard for Vermicompost#**
50:50	2.22 ± 0.02	1.03 ± 0.02	**0.001***	**>1**
60:40	1.91 ± 0.03	1.01 ± 0.03	**0.001***	
	Total Phosphorus (%)		**t Test**	**Standard for Vermicompost#**
50:50	2.03 ± 0.02	0.75 ± 0.02	**0.001***	**>1**
60:40	1.51 ± 0.03	0.85 ± 0.05	**0.001***	

#Source: Tandon[9], * indicates statistically significant at $p<0.001$; NS – Not Significant.

The Total Sodium did not show a significant difference between vermicompost and compost harvested from 50:50 and 60:40 concentrations ($p>0.001$) (Table 6). The mean amount of Total Sodium was found to be lowest in the vermicompost harvested from 60:40 experimental trays (1.12 ± 0.01%), while the same was quantified to be highest in the compost harvested from 50:50 experimental trays (4.12 ± 0.01%). In their research on vermicomposting of solid waste from the herbal pharmaceutical industry, Singh and Suthar[31] found differing outcomes, indicating that earthworms might consume the accessible portion of salts, which results in a reduction of sodium levels in the final substrate[32].

The mean Total Sulphur content was ranged from 1.13 ± 0.02% (Compost; 60:40 concentration) to 3.47 ± 0.0% (Vermicompost; 50:50 concentration). The Total Sulphur contents of the vermicompost and compost of 50:50 and 60:40 experimental trays were significantly different from each other (p<0.001) (Table 76. The present findings align with those of Viji and Neelanarayanan[33], who reported higher sulphur (S) concentrations in vermicompost derived from leaf litter.

The decreased levels of C:N ratio was observed in the vermicompost obtained from the 50:50 experimental trays (13:1). C:N ratio did not show a significant difference between vermicompost and compost obtained from 50:50 and 60:40 concentrations (p>0.001) (Table 6). The decrease in the C:N ratio resulted from a simultaneous increase in total nitrogen and a decline in carbon. As one of the key indicators of organic waste stabilization, a C:N ratio of less than 20:1 signifies compost maturity, making it highly suitable for agricultural use[34,35]. The reduction in the C:N ratio can be attributed to the rapid decomposition of organic matter, microbial respiration, and the excretion of nitrogenous waste.

Table 6: The propensity of Total Sodium, Total Sulphur and C:N ratio content of the vermicompost produced by *E. eugeniae* utilizing groundnut shell (pre-digested with waste decomposer) in 50:50 and 60:40 concentrations and control. Each value represents Mean (Mean ± S.D.) of three individual observations.

Concentrations	Total Sodium (%)		t Test	Standard for Vermicompost#
	Vermicompost Mean ± S.D.	Compost Mean ± S.D.		
50:50	1.33 ± 0.01	4.12 ± 0.01	**0.05NS**	-
60:40	1.12 ± 0.01	3.24 ± 0.01	**0.05NS**	
	Total Sulphur (%)		**t Test**	**Standard for Vermicompost#**
50:50	3.47 ± 0.01	1.21 ± 0.05	**0.001***	-
60:40	3.13 ± 0.02	1.13 ± 0.02	**0.001***	
	C:N ratio		**t Test**	**Standard for Vermicompost#**
50:50	13:1	81:1	**0.05NS**	**10:1 – 20:1**
60:40	18:1	54:1	**0.05NS**	

#Source: Tandon[9], * indicates statistically significant at p<0.001; NS – Not Significant.

The total bacterial population did not exhibit any statistically significant differences between the compost and vermicompost derived from the 50:50 and 60:40 substrate ratios ($p > 0.001$). However, significant variations were observed in the total fungal population among the compost and vermicompost samples across both treatment concentrations ($p < 0.001$). Likewise, the population of actinomycetes showed a statistically significant difference between treatments ($p < 0.001$), with vermicompost samples generally demonstrating higher microbial activity (Fig. 1). These findings align with previous studies reporting increased microbial populations in vermicompost. For instance, Suthar and Gairola[36] observed enhanced microbial activity in vermicompost produced from leaf litter and cattle dung using *Eisenia fetida*. Similarly, elevated populations of bacteria, fungi, and actinomycetes were noted in vermicomposts generated from sugarcane trash, pressmud, municipal solid waste, and other organic residues combined with cattle dung using species such as *Perionyx ceylanensis*[37.38], *Perionyx excavatus*[39], and *Drawida sulcata*[40,41]. These previous results strongly support the observations of the current study.

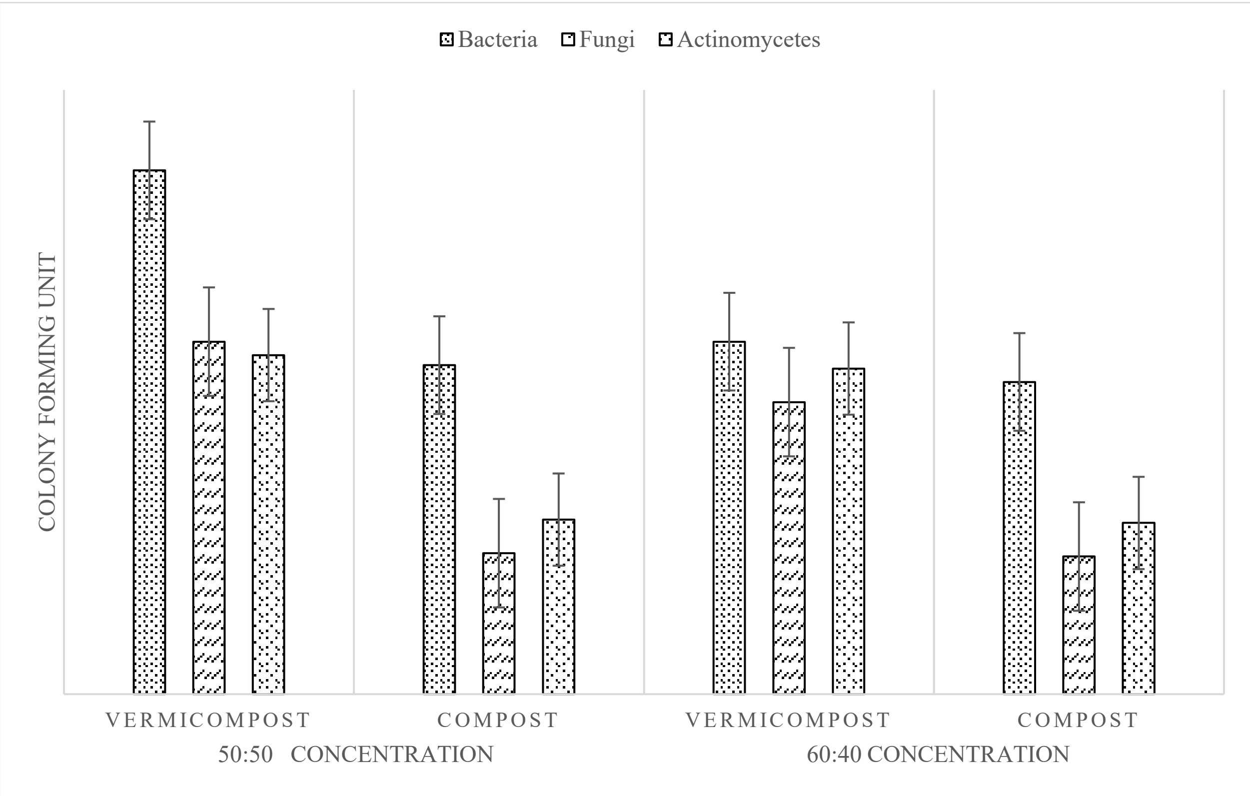

Fig. 1: The extent of microbial population in the vermicompost produced by *E. eugeniae* utilizing groundnut shell (pre-digested with waste decomposer) in 50:50 and 60:40 concentrations and control.

The present study demonstrates the efficacy of a selected bacterial consortium (waste decomposer) in the pre-digestion of groundnut shells, thereby enhancing their biodegradability and facilitating efficient bioconversion into nutrient-rich vermicompost. Among the tested substrate ratios (groundnut shell:cow dung), both 50:50 and 60:40 mixtures supported successful vermicomposting using *Eudrilus eugeniae*. However, the 50:50 ratio exhibited superior performance, yielding vermicompost enriched with essential macro- and micronutrients, as well as a higher abundance of beneficial microbial populations. These results suggest that pre-digested groundnut shells, particularly at a 50:50 mixing ratio with cow dung, serve as an effective feedstock for vermicomposting. The resulting high-quality vermicompost can be directly applied by farmers to enhance soil fertility and crop productivity. Additionally, surplus production offers potential for local commercialization, providing an alternative income source. Adoption of this sustainable practice can reduce dependence on synthetic agrochemicals, improve soil health, and promote environmentally friendly farming systems capable of producing chemical-free food for both livestock and human consumption.

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Conflict of Interest

All Authors declared that there is no conflict of interest.

REFERENCES

[1] Velmurugan, K.; Annamalai, V. First report on toddy palm shell-based vermicompost by *Eisenia fetida*. *Int. J. Environ. Sci. Technol.* 2022, 1-14. https://doi.org/10.1007/s13762-022-04597-8

[2] Lim, S.F.; Matu, S.U. Utilization of agro-wastes to produce biofertilizer. *Int. J. Energy Environ. Eng.* 2015, 6, 31–35.

[3] Wani, K.A.; Mamta Rao, R.J. Bioconversion of garden waste, kitchen waste and cow dung into value-added products using earthworm *Eisenia fetida*. *Saudi J. Biol. Sci.* 2013, 20, 149–154.

[4] Sanchez, D.T.; Sanchez, M.I.D.; Paulo Jr J.F.; Peconcillo Jr L.B.; Flores, M.C.A.; Labrado, O.A.; Godinez, J.A.T.; Panzo, R.C.; Wong, R.L. *Eudrilus Eugeniae*: Detritivores and Ecologically Efficient Bio-Agents for Waste Management Technology. *Int. J. Mod. Agric.,* 2021, 10, 781-795.

[5] Biabani, A.; Carpenter-Boggs, L.; Gholizadeh, A. Reproduction efficiency of *Eisenia fetida* and substrate changes during vermicomposting of organic materials. *Compost Sci. Util.* 2018, 26, 209–215.

[6] Viji, J. Efficacy of consortia of Microbial Inoculants for the pre-digestion of agro-wastes for Vermicomposting Technology. 2015, Thesis submitted to Bharathidasan University, Tiruchirappalli, Tamil Nadu, India.

[7] Talashilkar, S.C.; Dosani, A.A.K. Earthworms in Agriculture. Agrobios, India. 2005. p. 182.

[8] Blakemore, R.J. Cosmopolitan Earthworms- an Eco-Taxonomic Guide to the peregrine species of the world. 4th Edition. VermEcology, Australia. 2010. p 1200.

[9] Tandon, H.L.S. (Ed.). Methods of analysis soils, plants, fertilizers and organic manures. Fertilizers development and Organization, New Delhi, India. 2005. p 204.

[10] Walkley, A.; Black, I. A. An examination of the degtjareff method for determining soil organic matter and prepared modification of the chronic acid titration method. *Soil Sci.,* 1934, 34, 29–38.

[11] Trivedy, R.K.; Goel, P.K. Chemical and Biological Methods for water pollution studies. Environmental Publications, Kared, India. 1986. p. 250.

[12] Anonymous. The Fertiliser (Control) Order, The fertiliser Association of India, Rakmo Press Pvt. Ltd, New Delhi. 2006. p 278.

[13] Chaudhuri, S.P.; Pal, K.T.; Bhattacharjee, G.; Dey K.S. Chemical changes during vermicomposting (*Perionyx excavatus*) of kitchen wastes. *Trop. Ecol.*2000, 41, 107-110.

[14] Huang, K.; Xia, H.; Cui, G.; and Li, F. Effects of earthworms on nitrification and ammonia oxidizers in vermicomposting systems for recycling of fruit and vegetable wastes. *Sci. Total Environ.* 2017, 578, 337–345. https://doi.org/10.1016/j.scitotenv.2016.10.172

[15] Chi, K.; Ansari, A.; Hamer, S. Effect of vermicompost using different substrates on the growth and development of pak choi, *Brassica rapa* subsp chinensis. *Agric. Int.* 2018, 5, 5-15. http://www.indianjournals.com/ijor

[16] Amouei, A.; Yousefi, Z.; Khosravi, T. Comparison of vermicompost characteristics produced from sewage sludge of wood and paper industry and household solid wastes. *J. Environ. Health Sci. Eng.* 2017, 15, 1-6. https://doi.org/10.1186/s40201-017-0269-z

[17] Lazcano, C.; Brandon, M.G.; Dominguez, J. Comparison of the effectiveness of composting and vermicomposting for the biological stabilization of cattle manure. *Chemosphere.* 2008, 72, 1013-1019.

[18] Viji , J.; Neelanarayanan, P. Production of vermicompost by utilizing paddy (*Oryza sativa*) straw (pre-digested with *Trichoderma viride*) and *Eudrilus eugeniae, Perionyx excavatus* and *Lampito mauritii*. *Int. J. Pharma Bio Sci.* 2013, 4, 986-995.

[19] Diksha, Y.A.; Hajam, R.; Kumar, R. Physico-chemical evaluation of vermicompost prepared from temple waste using *Eisenia fetida*. *Asian J. Agric. Res.* 2022, 16, 1-12.

[20] Negi, R.; Suthar, S. Degradation of paper mill wastewater sludge and cow dung by fungi and earthworms during vermicomposting. *J. Clean. Prod.,* 2018. 201, 842–852. https://doi.org/10.1016/j.jclepro.2018.08.068.

[21] Prakash, M.; Karmegam, N. Vermistabilization of pressmud using *Perionyx ceylanensis* Mich. *Bioresour. Technol.,* 2010, 101, 8464–8468. https://doi.org/10.1016/j.biortech.2010.06.002

[22] Sharma, K.; Garg, V.K. Conversion of a toxic weed into vermicompost by *Eisenia fetida*: Nutrient content and earthworm fecundity. *Bioresour. Technol. Rep.* 2020, 11, 100530. https://doi.org/10.1016/j.biteb.2020.100530

[23] Huang, K.; Xia, H. Role of earthworms' mucus in vermicomposting system: biodegradation tests based on humification and microbial activity. *Sci. Total Environ.* 2018, 610, 703–708.

[24] Parthasarathi, K.; Balamurugan, M.; Prashija, K.V.; Jayanthi, L.; Basha, S.A. Potential of *Perionyx excavatus* (Perrier) in lignocellulosic solid waste management and quality vermifertilizer production for soil health. *Int. J. Recycl. Org. Waste Agric.* 2016, 5, 65–86.

[25] Ghosh, S.; Goswami, A.J.; Ghosh, G.K.; and Pramanik, P. Quantifying the relative role of phytase and phosphatase enzymes in phosphorus mineralization during vermicomposting of fibrous tea factory waste. *Ecol. Eng.* 2018, 116, 97–103.

[26] Yatoo, A. M.; Sofi, J. A.; Malik, M. A.; Ahmad, P. Production of nutrient-enriched vermicompost from mixed organic residues using *Eisenia fetida*. *Agronomy.* 2022, 12(11), 2745. https://doi.org/10.3390/agronomy12112745

[27] Vyas, P. Vermicomposting with microbial amendment: Mechanisms and nutrient dynamics. *Appl. Soil Ecol.* 2022, 177, 104579. https://doi.org/10.1016/j.apsoil.2022.104579

[28] Chen, Y.; Wang, C.; Li, C. Effects of mixed application of cow manure and botanical residues on soil available phosphorus and potassium. *Front. Environ. Sci.,* 2023, 11, 112034. https://doi.org/10.3389/fenvs.2023.0112034

[29] Sande, T. J.; Berek, A. K.; Karanja, D. S. Enhancing sustainable crop production through integrated use of vermicompost and mineral amendments: A review. *Front. Agron.,* 2024, 6, 1523191. https://doi.org/10.3389/fagro.2024.1523191

[30] Toor, M. D.; Kumar, P.; Singh, R. Vermicompost rate effects on soil fertility and morpho-physiological performance of crops. *Plants.* 2024, 13(4), 871. https://doi.org/10.3390/plants13040871

[31] Suthar, S.; Singh, S. Feasibility of vermicomposting in biostabilization of sludge from a distillery industry. *Science of the Total Environment.* 2008. 394 (2-3), 237-243.

[32] Taeporamaysamai, O.; Ratanatamskul, C. Co-composting of various organic substrates from municipal solid waste using an on-site prototype vermicomposting reactor. *Int. Biodeterior. Biodegrad.,* 2016, 113, 357-366. http://dx.doi.org/10.1016/j.ibiod.2016.05.009

[33] Viji, J.; Neelanarayanan, P. Vermiconversion of Mixed Leaves Litter (pre-digested with Fungal Consortium) by using *Eudrilus eugeniae, Perionyx excavatus* and *Lampito mauritii*. *Int. J. Pharma Bio Sci.,* 2018, 9(4), 221-227.

[34] Senesi, N. Composted materials as organic fertilizers. *Sci. Total Environ.* 1989, 81-82, 521-542.

[35] Ramnarain, Y.I.; Ansari, A.A.; Ori, L. Vermicomposting of different organic materials using the epigeic earthworm *Eisenia foetida*. *Int. J. Recycl. Org. Waste Agric.* 2018, 8, 23-36.

[36] Suthar, S.; Gairola, S. Nutrient recovery from urban forest leaf litter waste solids using *Eisenia fetida*. *Ecol. Eng.* 2014, 71, 660–666. https://doi.org/10.1016/j.ecoleng.2014.08.010.

[37] John Paul, J.A.; Karmegam, N.; Daniel, T. Municipal solid waste (MSW) vermi- composting with an epigeic earthworm, *Perionyx ceylanensis* Mich. *Bioresour. Technol.* 2011, 102, 6769–6773. https://doi.org/10.1016/j.biortech.2011.03.089.

[38] Karmegam, N.: Karthikeyan, V.; Ambika, D. Vermicomposting of sugarcane trash and leaf litter in combination with pressmud using the earthworm, *Perionyx ceylanensis*. In: Vermitechnology III (Ed.: Karmegam, N.). *Dyn. Soil Dyn Plant.* 2012, 6 (SI-1), 57–64.

[39] Yuvaraj, A.; Karmegam, N.; Thangaraj, R. Vermistabilization of paper mill sludge by an epigeic earthworm *Perionyx excavatus*: mitigation strategies for sustainable environmental management. *Ecol. Eng.,* 2018b, 120, 187–197. https://doi.org/10.1016/j.ecoleng.2018.06.008.

[40] Yuvaraj, A.; Thangaraj, R.; Maheswaran, R. Decomposition of poultry litter through vermicomposting using earthworm *Drawida sulcata* and its effect on plant growth. *Int. J. Environ. Sci. Technol.* 2018a, 16, 7241-7254. https://doi.org/10.1007/s13762-018-2083-2.

[41] Negi, R.; Singh, S. Degradation of paper mill wastewater sludge and cow dung by brown-rot fungi *Oligoporus placenta* and earthworm (*Eisenia fetida*) during vermicomposting. *J. Clean. Prod.* 2018, 201(10), 842-852. https://doi.org/10.1016/j.jclepro.2018.08.068