

## RESEARCH ARTICLE

**COMPARATIVE ANALYSIS OF VERMICOMPOST QUALITY PRODUCED FROM RICE STRAW AND VEGETABLE WASTE EMPLOYING EARTHWORM *EISENIA FETIDA***

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**Abstract:** Soil health and crop production can be effectively maintained by using renewable biological resources, such as compost and vermicompost. With an annual production of nearly 87 mt of rice and 120 mt of paddy straw, rice (*Oryza sativa* L.) is the most important cereal crop in India. The majority of the paddy straw produced is used for roofing material, animal feed, fuel, and packaging and remainder is burned in the field. Paddy straw, however, is also not recommended as an animal feed because of its low protein content, weak palatability, high silica (11–25%) and lignin content (12%), as well as its low digestibility. The present study investigates the vermicompost preparation using paddy straw and vegetable waste along with biogas slurry in different proportions. Four treatments were selected having different ratios of paddy straw, biogas slurry and vegetable waste T1 (5:2:3), T2 (4:2:4), T3 (3:5:2) and T4 (2:3:5), respectively. The earthworm used for making compost was *Eiseniafoetida*. Preparation takes 84, 73, 66, 51 days for T1, T2, T3, and T4. During vermicomposting experiment, pH among all the treatments was decreased at the final stage as compared to the initial substrate. T3 showed highest increase in nitrogen content followed by T1, T2 and T4. The treatment T1 indicated highest initial and final potassium content. TOC reduction, as compared to initial level was in the order: T4 (49.06%)>T3 (35.28%)>T2 (27.73%)>T1 (17.84%). T3 although took 84 days but turned out to be best in terms of nutrients availability.

**Keywords:** Biogas slurry, NPK, Paddy straw, Vegetable waste, Vermicompost

## INTRODUCTION

Over the past several decades, the use of chemical fertilizers has increased greatly, which has resulted in a heavy reliance on chemical fertilizers in traditional farming systems. While chemical fertilisers have undoubtedly enhanced crop output by a factor of ten, their continued and imbalanced application has had a deleterious effect on soil health, especially as crop yields have stalled in recent decades. Chemical fertilisers are continuously applied without regard for the soil's physical, chemical, and biological qualities. This leads to the depletion of secondary and micronutrients in the soil, which adds to the soil-plant connection being out of balance. The soil's microbial community has also been negatively impacted by an imbalanced fertiliser application. Additionally, excessive fertiliser application contaminates surface and groundwater bodies, particularly through nitrate leaching (Pumentel, 1996), resulting in negative environmental consequences that pose major health

risks to humans and animals. In the current context, an integrated climate-resilient crop management module is required to ensure long-term soil health and crop productivity. Recycling organic waste is one approach to reduce the use of chemical fertilisers in the situation above. Vermicomposting is a biological process that involves interactions between earthworms and microorganisms that efficiently convert different types of organic waste into nutrient-rich manure (Pigatin *et al.*, 2016, Amouei *et al.*, 2017). It is the process of converting organic waste into nutrient-rich compost by using earthworms. It is believed that earthworms play an important role in agriculture; they eat dead organic waste and discard it as garbage. In addition to improving soil fertility, earthworms accelerate the decomposition of plant litter and organic matter by releasing minerals in a form that is more readily absorbed by plants. Therefore, using vermicompost as compost in soil will accumulate organic carbon, improve nutrients status, capacity for cation exchange, microbial activity and microbial biomass carbon.

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Solid wastes generated by agricultural, domestic, and industrial activities contribute to pollution, climate change, and ultimately upset the ecological balance (Lim and Wu, 2016). A large amount of agricultural residue is produced in the form of crop straw, cobs, husks, stalks, etc. Approximately 45% of global rice production is composed of rice straw, the largest agricultural crop residue.

India, the world's second largest rice producer, produces about 112 MMT of rice straw annually. However, most of the rice straw (80%) is unused and remains in the fields (Singh *et al.*, 2016). Furthermore, burning rice straw in agricultural fields is a common practice in Asia, especially in India, which contributes to smog and air pollution, along with the destruction of many nutrients it contains (Yan *et al.*, 2013). Problems with rice straw disposal require a sustainable recycling waste management system. In agriculture, these wastes can be vermicomposted to recycle nutrients and maintain soils healthy. Earthworms and microorganisms work together to change waste materials' biological, physical, and chemical properties. In short, vermicompost is a stabilized, odourless, homogenous, peat-like material that is relatively rich in nutrients with only a small amount of toxic substances (Ndegwa and Thompson, 2001). It offers simplicity, profitability, and efficient degradation of all non-toxic biodegradable wastes. Vermicompost has been produced from a variety of crop residues and agro-industrial wastes. Chauhan and Singh (2013) investigated the effects of straw and bran residues on the growth and reproduction of *E. fetida*. Pigatin *et al.* (2016) report that cattle manure, orange peels, and filter cakes can be successfully converted to vermicompost. Vermicomposting of press sludge, a residue from the sugarcane industry and cattle manure, was studied by Bhat *et al.* (2016). Grewal *et al.* (2016) experimented the bioconversion of rice husk, paddy straw and spent mushroom paddy straw by the earthworm. It was concluded that of the three substrates examined, vermicompost from spent mushroom paddy straw substrate was the best in terms of nutrient content and early convertibility. In a recent study, Amouei *et*

*al.* (2017) investigated the vermicomposting of household and paper industry waste. In the present study, rice straw and vegetable waste was mixed with biogas slurry in varying proportions for vermicomposting. Sharma and Garg (2018) compared the vermicompost prepared from rice straw and paper waste and found that NPK content and heavy metal was higher in the vermicompost. Experiments are conducted for the efficacy of rice straw and paper trash mixed in various ratios. There have been a few studies that have looked into the use of rice straw (Suthar, 2008; Yan *et al.*, 2013; Lim and Wu, 2016, Hussain *et al.*, 2016) and paper waste (Gupta and Garg, 2009; Ravindran and Mkeni, 2016; Mupambwa *et al.*, 2016) for vermicomposting. But none for vermicomposting mixture of paddy straw, vegetable waste and biogas slurry.

## MATERIALS AND METHODS

The experiment was conducted in the month of Dec-Feb, 2021 at laboratory of Department of Renewable and Bio-energy Engineering, College of Agricultural Engineering and Technology, CCSHAU, Hisar, Haryana.

### Collection of waste material and earthworms

Rice straw was collected from agricultural fields located in Hisar (India) and vegetable waste from vegetable market mandi, Hisar. Biogas slurry was collected from a University Dairy farm, LUVAS Hisar, India. Earthworms, *Eisenia fetida*, were collected from stock cultures maintained by the authors in the Department of Renewable and Bio-Energy Engineering laboratory, CCSHAU, Hisar using cow manure as the culture medium.

### Preparation of experimental media

Experiment was conducted in vermibeds with one vermibed having two treatments. Four different treatments were planted having different compositions of paddy straw, biogas slurry and vegetable waste with total weight of 50 kg for each treatment. Table 1 shows the vermicomposting treatment in vermibeds. Experimental setup is shown in Figure 1.

**Table 1.** Vermicompost treatment composition

Treatment	Paddy Straw (%)	Biogas Slurry (%)	Vegetable Waste (%)
T1	50	20	30
T2	40	20	40
T3	30	50	20
T4	20	30	50



**Figure 1:** Experimental setup for vermicomposting

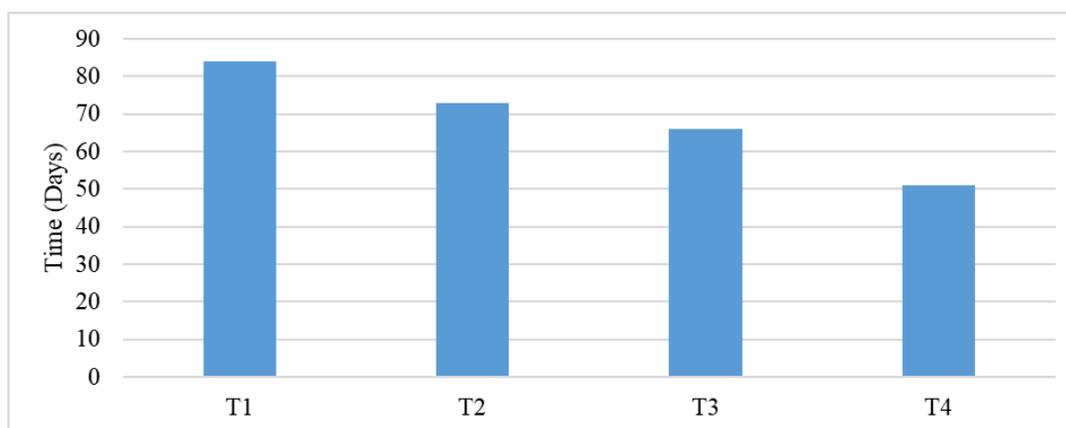
Prior to making the different composition/mixing of all the 3 substrates, paddy straw and vegetable waste was chopped to reduce the particle size to enhance the surface area of material for proper aeration and activity of earthworms. Water was sprinkled on the vermibeds at regular intervals to maintain humid environment for the earthworms. The earthworm used for making compost was *Eiseniafoetida*, which is the most commonly used species of earthworms for this process. Moisture content of all the treatments varied between 50–65% during the experiment. The highest and lowest ambient temperature were also recorded and found to vary between 4–33°C. Samples from different locations of all the four vermibeds were collected for the analysis of different parameters and checking the decomposition level. pH was measured using digital pH meter. Moisture content of all the vermicompost samples was estimated using oven dry method. Colour analysis of vermicompost samples was done with the help of Munsell colour chart. It was observed

that T1 took maximum time of 84 days to change its colour from brown to dark reddish brown while T4 with 20% paddy straw took 51 days for the same colour change. T2 and T3 on the other hand changed from dark brown and brown to dark reddish to black in 73 and 66 days, respectively.

The experiment was carried out during winter season (i.e. between December, 2020–February, 2021). It was observed that treatment T4 with 20% paddy straw had taken least time of 51 days for vermicompost preparation whereas the combinations with higher amounts of paddy straw took higher time (i.e. 84, 73, and 66 days with 50%, 40% and 30% paddy straw (Figure 2)).

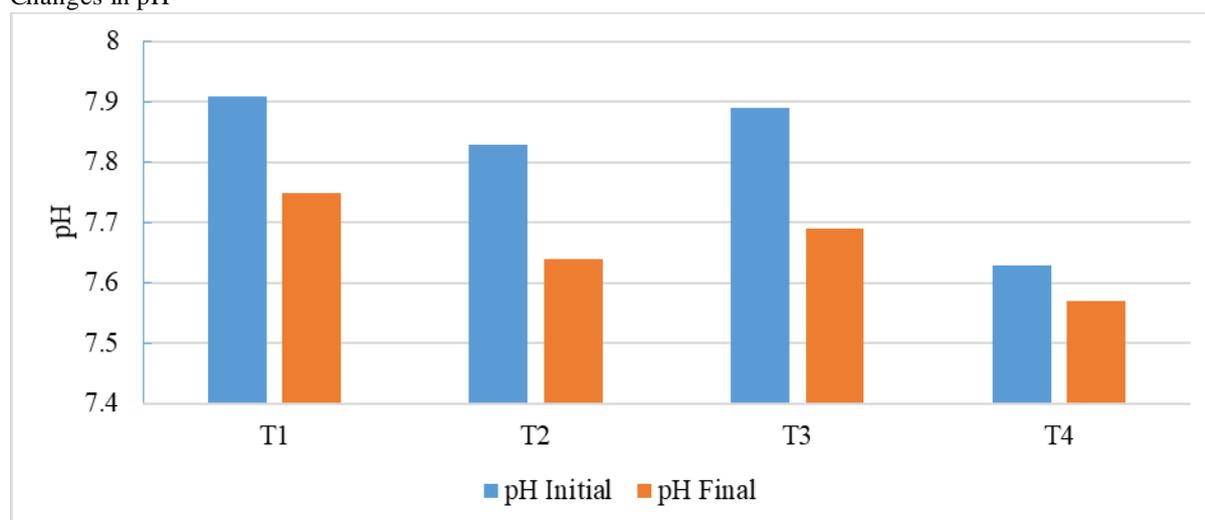
**RESULTS AND DISCUSSION**

Among all the treatments, T4 took least amount of time and T1 the most for vermicompost preparation. T1, T2, T3 and T4 took 84,73,66 and 51 days, respectively.



**Figure 2:** Time taken for vermicompost preparation in different treatments

Changes in pH

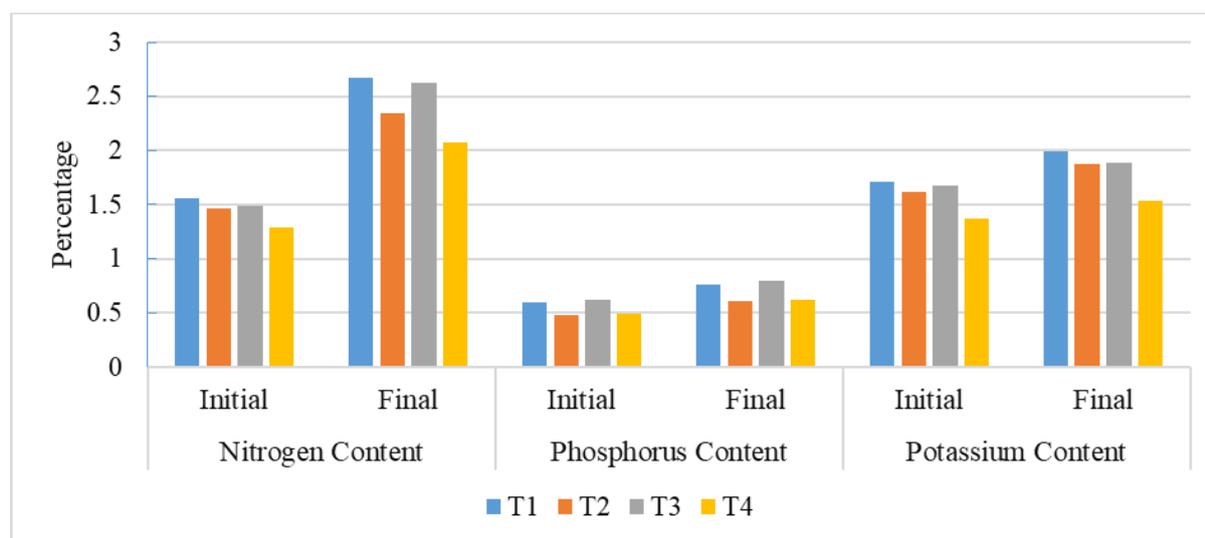


**Figure 3:** Initial and final pH for the treatments

Variation in pH during vermicomposting depends on the biochemical composition of the substrates. Increase and decrease in pH is due to the production of organic acids and ammonia during the process. During vermicomposting experiment, pH among all the treatments was decreased at the final stage as compared to the initial substrate (Figure 3). This change in pH observed may be due to the conversion of N and P into nitrates and orthophosphates. In addition to this, bioconversion of organic material into organic acids and intermediates may have also reduced the pH. Resulting pH range in all the

treatments (7.75–7.57) is near to the optimal recommended pH of around 7.5 for application to agricultural fields or using as potting media.

Changes in nitrogen, phosphorus and potassium  
The estimation of nitrogen and phosphorus was carried out using spectrophotometer method after acid digestion of vermicompost samples. Potassium was also estimated using flame photometric method. The maximum change was observed in nitrogen content during vermicomposting while phosphorus and potassium content did not vary much (Figure 4).



**Figure 4:** Comparison of initial and final nitrogen, phosphorus and potassium content

Nitrogen content changed from 1.56% to 2.63% in T1, 1.47% to 2.35% in T2, 1.49% to 2.67% in T3 and 1.29% to 2.08% in T4. It was observed that nitrogen content was higher in all the treatments after vermicomposting but to different extent. T3 showed highest increase in nitrogen content (76.51%), which may be attributed to the fact that T3 had 50% biogas

slurry which itself is a nitrogen rich organic matter and also acts as great source of feed for the earthworms. T2 and T4 showed almost similar increase (i.e. 59% and 61%, respectively) in nitrogen content. Initial nitrogen content was highest in T1 which may be due to its composition consisting of 50% paddy straw, which is also a higher nitrogen

content substrate. Phosphorus content altered from 0.59% to 0.76% in T1, 0.48% to 0.61% in T2, 0.62% to 0.79% in T3 and 0.49% to 0.62% in T4. Highest initial phosphorus content was found in T3 which may be due to its composition consisting of 50% biogas slurry. Potassium content was recorded with help of flame photometer and it has also been increased from 1.71% to 1.99%, 1.62% to 1.87%, 1.68% to 1.89% and 1.37% to 1.53% for T1, T2, T3 and T4, respectively. The treatment T1 indicated highest initial and final potassium content which may be ascribed to the fact that paddy straw is rich in potassium content and T1 consisted of 50% paddy straw.

Changes in total organic carbon

Total organic carbon decreased after vermicomposting in all the treatments; however, the degree of TOC reduction was different. TOC reduction, as compared to initial level was in the order: T4 (49.06%)>T3 (35.28%)>T2 (27.73%)>T1 (17.84%). It has been observed that in treatments having higher percentage of paddy straw, TOC reduction was minimal. TOC reduction may be attributed to mineralization of organic matter and its utilization by earthworms as feed. Loss of carbon in the form of CO<sub>2</sub> by microbial metabolic activities is also responsible for TOC reduction which also confirms with similar findings in vermicomposting of organic matter.

## CONCLUSION

Vermicompost treatment with 50% paddy straw, 20% biogas slurry and 30% vegetable waste though matured late (84 days) as compared to other treatments but has proved to be better in terms of nutrient availability (N:2.67%, P:0.76%, K:1.99%). Therefore, farmers can effectively use paddy straw in combination with vegetable waste and biogas slurry for vermicompost preparation. Using paddy straw and vegetable waste as a substrate will enable vermicomposting to achieve its maximum benefits. This eco-friendly technology is both economically attractive and safe for the environment.

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