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# SUSTAINABLE AGRICULTURE

## INNOVATIONS AND INTERDISCIPILINARY APPROACHES


Editors
Dr. Reema Sonker
Dr. Sayed Ajaz Fatima
Dr Madhuri Gulave
Dr. Raju Potharaju

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# SUSTAINABLE AGRICULTURE: INNOVATIONS AND INTERDISCIPLINARY APPROACHES

***Editors***

**Dr. Reema Sonker**
Assistant professor
Department of Zoology K.S. Saket
P.G. College Ayodhya affiliated to Dr. Ram Manoher Lohia Awadh University
Ayodhya, India.

**Mrs. Sayed Ajaz Fatima**
Lecturer
M. C. E. S. 'S Mumbra College of Arts, Commerce & Science
Anant koliwada behind Mumbra police station, Mumbra, Thane: 400612, India.

**Dr. Janhavi Ashish Arekar**
Assistant Professor and Head
Department of Botany at Smt. Devkiba Mohansinhji Chauhan
College of Commerce and Science, Silvassa – UT of Dadra and Nagar Haveli & Diu
Daman, India.

**Dr. Raju Potharaju**
Assistant Professor (Guest)
Department of Botany in C.K.M. Govt. Arts and Science College,
Warangal, Telangana, India.

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# Sustainable Agriculture: Innovations and Interdisciplinary Approaches

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# Qualitative Analysis of Vermicompost from Two Different Methods Employing Earthworm *Eisenia fetida*

**Mr. Bagal Amrut Mohan**

**Dr. Kumbhar Digvijay Shripati**

Department of Zoology, Rajarshi Chhatrapati Shahu College, Kolhapur (M.S.), India.

**Email:** vdigvi84@gmail.com

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## Abstract

The use of earthworms for composting of organic matter has been known technology since many years. The earthworm species *Eisenia fetida* has been widely and commonly used for this purpose. Sustainable agriculture relies greatly on renewable resources like biologically fixed nitrogen or product prepared from waste and residues. Vermicompost is one of the potential renewable resources in organic farming which can offer sustainability. Vermicompost was prepared in vermicomposting unit maintained at college campus. Vermicomposting is a process that involves chemical, physical and biological transformations of agricultural residues of plant and animal origin through the use of worms and microorganisms. Recycling of waste and residues by using compost worm increases available nutrient content of substrates. Enrichment of vermicompost with minerals and bio-inoculants increases nutritional status and quality of vermicompost. The study evaluated the physical and chemical characteristics of vermicompost mixtures to optimize nutrient extraction. Two different methods were studied by employing the earthworm species Eisenia Fetida in order to analyze the quality of Vermicompost in terms of their physico-chemical properties. Method 1 contains rice straw and paper waste whereas Method 2 contains cow dung and garden waste. Major chemical nutrients, including Total Organic Carbon (TOC), Iron (Fe), Copper (Cu), Zinc (Zn), Magnesium (Mn), Nitrogen (N), Phosphorous (P), Potassium (K), and Sulphate (S) as well as physical parameters such as pH, Electrical Conductivity (EC), Moisture content were analyzed. The results revealed that, method 2 is most effective as compared to method 1 as far as all physico-chemical parameters are concerned.

***Keywords:*** *Eisenia fetida*, Organic farming, physico-chemical parameters, Sustainable agriculture, Vermicompost.

## Introduction

The excessive utilization of synthetic fertilizers is a significant contributor to the degradation of our environment. The ongoing application of these unbalanced fertilizers in farming has detrimental effects on both the fertility of the soil and the productivity of agricultural systems. Biofertilizer is a natural substance that contains living microorganisms obtained from plant roots or cultivated soil. They have no effect on soil health and environment. Vermicompost other role in atmospheric nitrogen fixation and phosphorous solubilization, these also helpful for plant growth hormones provides and increase tolerance towards drought, moisture stress. A small amount of biofertilizer can do wonders because each gram of the biofertilizer carrier contains at least 10 million active cells of a specific strain (Anandaraj and Delapierre, 2010).

Earthworms play a crucial role in effectively handling different types of organic waste to create valuable products such as vermicompost and worm biomass. Efficiently repurposing diverse organic wastes is an innovative endeavor in organic waste management, addressing numerous environmental challenges. Earthworms facilitate the conversion of nutrients in organic waste, making them accessible for plant growth. This process, known as mineralization, is aided by saprophytic microorganisms residing in the earthworms' digestive system (Ansari and Hanief, 2015). Vermi technology is a valuable approach for transforming organic wastes into beneficial products such as vermicompost, worm biomass, and vermiwash. The quantity of worm biomass can differ depending on the specific earthworm species, the type of food they consume, and the prevailing environmental conditions. Various researchers have explored vermicomposting using diverse species of earthworms and a range of organic waste materials, including sewage sludge (Mitchell, 1977), pig manure (Chan and Griffiths, 1988), cotton industrial wastes (Albanell et.al., 1988), industrial and vegetable wastes (Bano et.al., 1987) and paper mill wastes (Butt, 1993) etc. Vermicomposting serves as a valuable method for producing organic fertilizers and also offers an economical source of animal feed protein in the form of worm biomass for the fish and poultry industries (Edwards, 1988; Kale, 2000). The organic waste produced in agricultural fields and gardens is plentiful, leading to significant challenges in disposal and serving as major contributors to environmental pollution (Inbar et.al., 1993). All of these waste materials can be effectively utilized in vermitechnology to produce high quality vermicompost and worm biomass.

Vermicomposting is a straightforward biotechnological method where earthworms are used to transform the organic waste material to organic compost. In the process of vermicomposting, microbes play a crucial role in breaking down the organic matter, while earthworms act as mechanical mixers, shredding the organic material. This helps alter its biological, physical, and chemical properties,




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gradually reducing the C:N ratio and increasing the surface area that microorganisms can access. It's a dynamic partnership that transforms the waste into beneficial compost. A wide range of safe, non-salty, biodegradable agricultural leftovers, animal manure, urban, and industrial organic waste can be utilized for vermicomposting. It's a fantastic way to repurpose these materials and turn them into valuable compost. Vermicompost is a fantastic soil enhancer that offers greater nutrient accessibility for plant growth. It's uniform in composition, visually appealing, and has lower levels of impurities. Additionally, it has the ability to retain nutrients for an extended period of time. It's a wonderful choice for promoting healthy plant growth and maintaining soil quality (Ndegwa and Thompson, 2000). Vermicompost is packed with vital nutrients for plants, such as nitrogen (N), phosphorus (P) and potassium (K). The best part is that these nutrients are present in forms that are highly soluble and easily accessible to plants (Ndegwa and Thompson, 2001).

## Materials and Methods

### Vermicompost Bed Preparation

The High-Density Polyethylene (HDPE) vermicompost bag is utilized for vermicomposting, with a bag size of 10 X 3 X 3 Feet and equipped with a water drainage system. The earth level is maintained at a 0.3-inch slope on one side to facilitate the removal of excess water from one side of the bed. The regular watering is necessary to maintain 60-70% moisture, which is essential for the earthworms and to facilitate faster decomposition. Vermicomposting used an organic material ratio of 1:1 and was properly arranged layer by layer.

### Unit 1: Rice Straw and Paper Waste

1. The second bed was constructed similarly to the first vermicompost bed, with the only being the use of different organic waste materials.
2. The base layer consisted of rice straw compost material inoculated with earthworm culture, with regular watering to maintain moisture levels.
3. The second layer was comprised of paper waste, with the addition of earthworm culture.
4. The upper layer consisted of compost material, again using rice straw, and inoculated with earthworm culture.
5. The final layer consisted of paper waste with earthworm culture, and water was again spread to maintain moisture levels.

### Unit 2: Garden Waste and Cow Dung

1. To create a vermicompost bed, start with a base layer of dry garden waste. Then, add an earthworm culture and water to moisten the materials.
2. The second layer consists of dry cow dung that has been treated to remove

unwanted gases and heat. Again, add the earthworm culture on top.

3. Repeat the process for the next layer, using garden waste and the earthworm culture, and ensure it is properly watered.
4. The fourth layer is the same as the second layer, made up of dry cow dung, with the addition of the earthworm culture. Remember to spread water evenly throughout the pile.

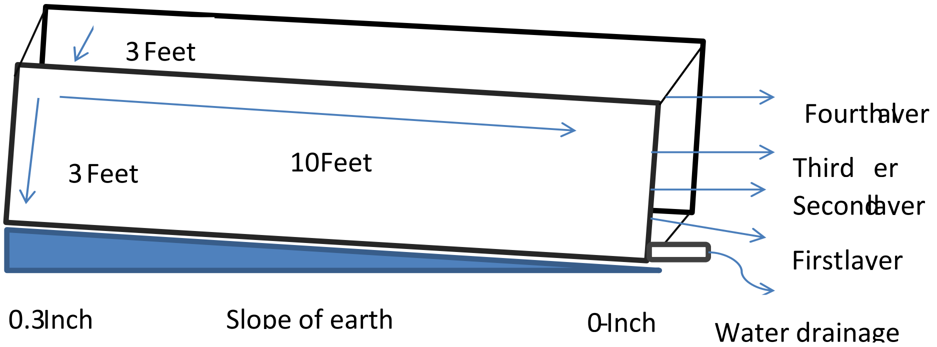


***Fig. 1. Method of preparation of vermibed for both methods***

**Harvesting of Vermicompost**

The vermicompost will be prepared after within 80-90 days in a vermibed. The resulting vermicompost was high in humus content, with a black granular structure, odourless nature, and mild weight. As the earthworm species reached the upper layer of the vermibed, before collecting the compost to avoid water spread, the earthworms were encouraged to move toward the bottom of the bed. The worms and unwanted rock granules were separated with the help of a sieve with a mesh size of 4mm. The compost was then collected in plastic bags and placed in a cool location. The same method was used for both units for the collection of compost.

***Table: 1. Physicochemical Analysis Parameters of Vermicompost***

| **Sr.No** | **Parameters** | **Methodology / Techniques** |
|---|---|---|
| 1 | Moisture (%) | Gravimetric analysis |
| 2 | Total Organic Carbon (%) | Empirical Method |
| 3 | PH | Potentiometric Method |
| 4 | Electrical Conductivity (ds m-1) | Four-Electrode conductivity Measurement Method |



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| | | |
|---|---|---|
| 5 | Total Nitrogen (%) | Kjeldahl Method |
| 6 | Total phosphorus (%) | Colorimetric Method |
| 7 | Total Potassium (%) | Flame Photometric Method |
| 8 | Total Sulfate (%) | Colorimetric Method |
| 9 | Iron (ppm) | Colorimetric Method |
| 10 | Manganese (ppm) | Simple Titrimetric Method |
| 11 | Zinc (ppm) | Colorimetric Method |
| 12 | Copper (Cu) | Colorimetric Method |

**Results and Discussion**

The impact of earthworms on nutrient content varied depending on organic waste and climatic conditions.

***Table: 2. Methodology Used to Analyze Various Physico-Chemical Parameters***

| Parameters | Method 1 | Method 2 | Parameters | Method 1 | Method 2 |
|---|---|---|---|---|---|
| Moisture (%) | 38.6 | 54.2 | EC (ds m-1) | 3.40 | 3.49 |
| Total Organic Carbon (%) | 26.16 | 30.86 | Total Nitrogen (%) | 1.48 | 2.87 |
| PH | 6.95 | 6.63 | Total phosphorus (%) | 0.78 | 2.13 |
| Total Potassium (%) | 1.20 | 1.34 | Manganese (ppm) | 98.64 | 131.24 |
| Total Sulphate (%) | 0.38 | 0.61 | Zinc (ppm) | 72.06 | 92.41 |
| Iron (ppm) | 151.75 | 201.21 | Copper (ppm) | 21.53 | 28.29 |

**Total Organic Carbon (TOC) and Moisture**

Total Organic Carbon (TOC) is a crucial parameter in vermicomposting, serving as an indicator of compost decomposition and maturity. In the present study, TOC content was found to be maximum in method-2 i.e. 30.86% and minimum 26.16% in method- 1. TOC levels are often cited as a key indicator of compost maturity and decomposition progress (Ndegwa and Thompson, 2000; Atiyeh et al., 2002).

Soil moisture plays an important role in agricultural monitoring, drought and flood forecasting, forest fire prediction, water supply management, and other natural resource activities. The comparative analysis of the moisture content results from both methods and the findings from the research paper by Pathania et al. (2020) reveals interesting insights. The first method yields lower moisture range of 38.6% and the second method 54.2%. This suggests that the second method indicating its potential superiority or better alignment with established methodologies.

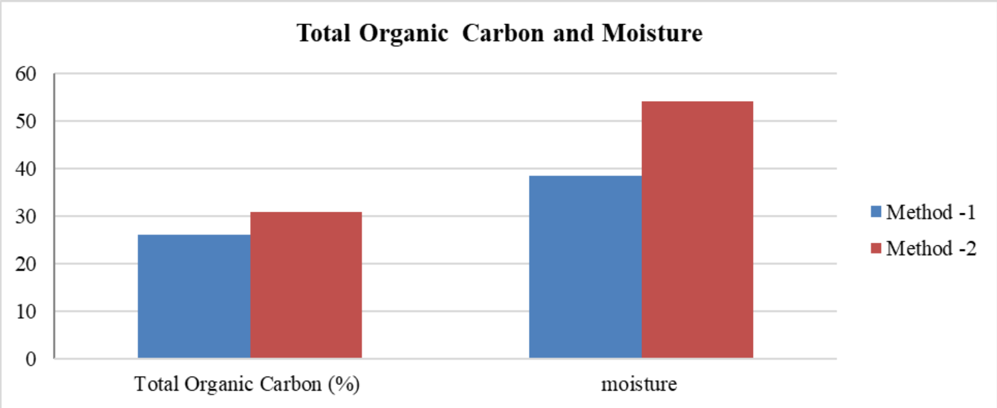


***Fig 2. TOC and Moisture content in vermicompost prepared by both Methods***

**P$^H$**

p$^H$ influences the activity of microorganisms involved in the decomposition process, affecting the rate and quality of vermicomposting. Additionally, pH can reflect the chemical composition of the vermicompost, altering its effectiveness as a soil amendment. The vemicompost gained by first method has a pH of 6.93 and that of the second method has 6.63.




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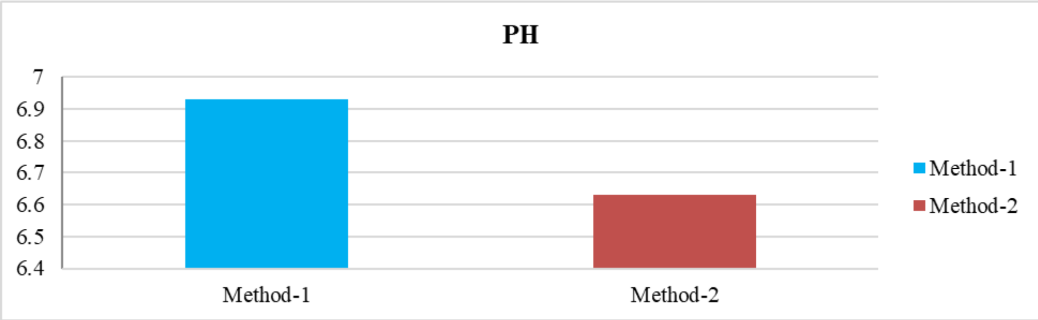


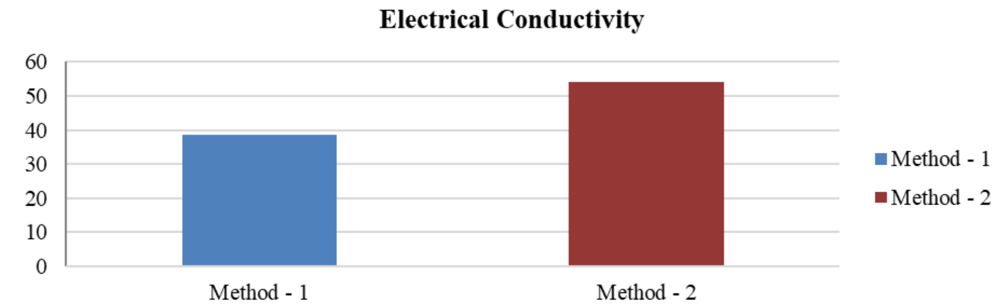


***Fig. 3. PH level found in both Vermicompost Methods*.**

## Electrical Conductivity (EC)

Electrical conductivity (EC) is an important indicator of the nutrient content and stability of vermicompost. It provides a measure of the total dissolved salts in the vermicompost, which can indicate its nutrient content and its potential to impact soil salinity. High EC levels may indicate a high concentration of nutrients, which can be beneficial for plant growth but may also lead to salt buildup in the soil over time. The recorded EC of Vermicompost from first method was 38.6 dS m-1, while that of the second method was 54.2 dS m-1.

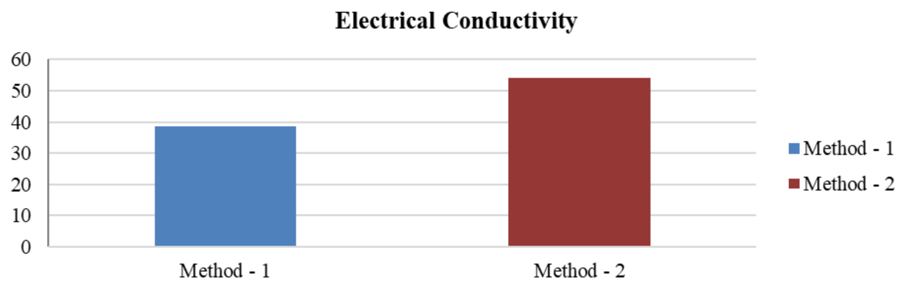


***Fig. 4. Comparison of EC in vermicompost produced from two Methods.***

## Iron (fe), Manganese (Mn), Zinc (Zn), Copper (cu):

**Iron (Fe):** Iron is an important nutrient in manure. It plays a crucial role in various plant physiological processes, including photosynthesis, respiration, and nitrogen fixation. Iron deficiency in plants can lead to chlorosis, reduced growth, and lower yields. Vermicompost enriched with iron can help improve soil health and fertility, leading to better plant growth and productivity. The recorded value of iron in vermicompost obtained from method 1 was 151.75%, whereas from the second second method was 201% indicates significant variation between the two methods in terms of the measured values.

**Manganese (Mn):** The research findings show a significant difference in magnesium levels between the two methods. Vermicompost obtained from Method 2 shows a higher magnesium range (131.24%) compared to Method 1 (98.64%), indicating that Method 2 is more efficient in enriching magnesium content.

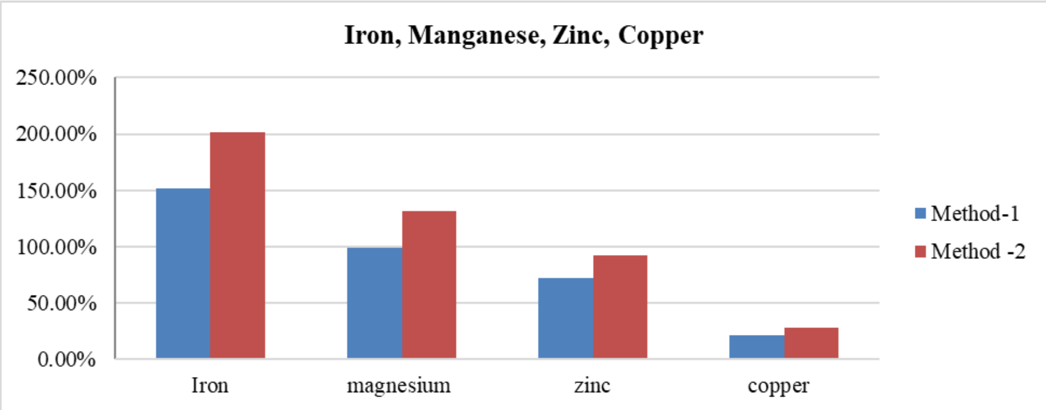


***Fig. 5. Comparison of Iron, Manganese, Zinc, and Copper***

**Zinc (Zn):** Zinc is an essential plant micronutrient, plays a crucial role in various physiological processes such as enzyme activity, protein synthesis, and growth regulation. Vermicompost enriched with zinc can significantly improve plant growth, development, and overall yield. Zinc deficiency in plants can lead to stunted growth, reduced yield, and susceptibility to diseases. The Vermicompost obtained from first method shows a zinc value as 72.06%, while the second method shows value of 92.41%. This indicates a substantial variation in zinc content between the two methods.

**Copper (Cu):** Copper is required for various physiological processes such as photosynthesis, enzyme activation and cell wall formation. Vermicompost enriched with copper can improve plant growth, development, and overall health. The research outcomes reveal a significant variance in copper levels between the two methods. 21.53 ppm copper was obtained in first method whereas; second method exhibited a higher range of 28.29 ppm. This suggests that the second method may be more effective in enhancing copper levels compared to the first.


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**Nitrogen, Phosphorous, Potassium, Sulphate:**

Nitrogen (N2): Nitrogen plays an important role in plant growth and development. It is a key component of amino acids, proteins, and chlorophyll, essential for photosynthesis and overall plant metabolism. In vermicompost, nitrogen exists in organic form, gradually released as per the requirement of plants, promoting steady growth without the risk of nitrogen leaching. Vermicompost rich in nitrogen enhances soil fertility, improves soil structure, and stimulates microbial activity, ultimately boosting crop yields. The comparative analysis of nitrogen content between the two methods and the findings of Kumar et al. (2010) reveals interesting insights. The first method yielded a nitrogen content of 1.48%, while the second method yields 2.87%.

**Potassium (K):** Potassium is associated with movement of water, nutrients and carbohydrates. The potassium content was found maximum in second method (1.35) as compared to first (1.20).

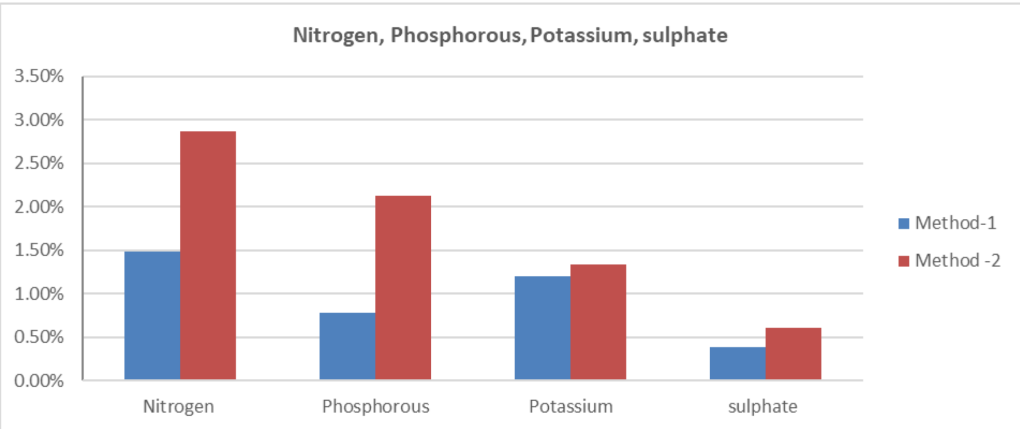


*Fig.6. Comparison of Nitrogen, phosphorus, Potassium, and Sulphate*

**Phosphorous (P):** Phosphorous involved in enhancing soil fertility and promoting plant growth. As organic matter decomposes during vermicomposting, phosphorus becomes more soluble and available for plant uptake. This nutrient helps in root development, flowering, and fruiting. The comparative analysis of phosphorus content between the two methods reveals that the vermicompost produced from second method (2.13) is more effective than first method (0.78).

**Summary And Conclusion**

Vermicompost enhances the structural stability of soil and reduces the vulnerability of soil erosion. Over the years vermicomposting has emerged as a sustainable technology for proper disposal of organic waste, production of organic fertilizer, and minimalistic use of chemical fertilizers.

Earthworms are the significant drivers of the process, as they fragment, aerate and condition the substrate. The organic matter on its passage through the gizzard of the earthworm is grounded into fine powder after which the microorganisms, fermenting substances and digestive enzymes act on them, helping their breakdown within the gut, and finally passes out in the form of casts which are further acted upon by earthworm gut-associated microbes transform them into vermicompost. Earthworms act as automated blenders and transform organic matter into more evenly sized particles, which gives the final substrate an earthy appearance.

The study revealed that the physico-chemical properties of vermicompost can be prepared by using two different methods have good values as compared to any other organic compost. Method: 2 (Cow dung + Garden waste) indicates higher values of all the physico-chemical parameters as compared to method: 1 (Rice straw + Paper waste). The substrates used influenced physicochemical and biological properties of vermicompost and are recommended for vermicomposting and its production. The earthworm species employed for vermicomposting is Eisenia Fetida and is easily available in farmer's field so can mitigate the manure problems. The use of Eisenia Fetida for vermicomposting of residues on the basis of their nutrient content may reduce the burden of synthetic fertilizers.

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