Vermicomposting; Physical and chemical analysis of organic waste composts

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***Abstract*: Vermicomposting is a biological process of efficient treatment of organic wastes in order to increase soil fertility. The objective of this study was to evaluate the physical and chemical properties of vermicompost prepared by various organic wastes such as dry leaves, domestic waste, crop waste, cow dung, produced by the action of two authenticated species of earthworms i.e Eisenia foetida and Eudrilus eugeniae. Citric acid and other acidic material of the kitchen waste (e.g. - peels of lemon, garlic & onion, etc.) were avoided for the preparation of vermicompost as it repels earthworms and produces a foul smell. The physiochemical parameters of vermicompost samples were analyzed by standard specified methods. Results revealed that vermicompost contains a high number of micronutrients as well as macronutrients. This study concludes that vermicompost prepared from organic wastes can act as a valuable biofertilizer for the sustainable growth of land and its restoration. This study also indicates that vermicompost of organic wastes like domestic waste, crop waste, and cow waste, dry leaves also contain plant growth regulators in final vermicompost which is beneficial for plant growth.**

Index terms: Organic wastes, Eisenia foetida, Eudrilus eugeniae, vermicomposting, physio-chemical analysis of vermicompost.

I. Introduction

Vermicomposting is a process in which vermicompost is produced by earthworms and is proving to be an extremely nourishing organic fertilizer and more omnipotent growth promoter over the traditional compost. It has a protective function against the pestilential chemical fertilizers which destroy the soil richness and affect natural soil fertility adversely. Vermicompost is rich in NPK, micronutrients, crude proteins, beneficial soil microbes, and growth-promoting plant hormones and enzymes. Vermicompost can withhold nutrients for a longer period of time, while the traditional compost fails to provide the essential amount of macro and micronutrients to plants in a shorter time, the vermicompost does.

Vermicompost works as a 'slow-release organic fertilizer' whereas the chemical fertilizers release their nutrients more rapidly in soil and soon get depleted. Nitrogen and phosphorus are not completely available to the roots of the plant in the first year, because nitrogen and phosphorus compost are higher in 'ammonium content' while the vermicompost contains a higher content of 'nitrates' which is an extensively available form of nitrogen to plants. Vermicompost acts as an efficient 'soil conditioner' and its prolonged application over the years lead to the up gradation of soil quality and soil fertility.

Vermicompost possesses high-water holding capacity, aeration, and drainage. The soil treated with vermicompost over the years is characterized by near-neutral pH and more electrical conductivity. The high levels of beneficial microbial population in vermicompost paves a way for inhibition of plant pathogens by out-competing plant pathogens for available food resources. Vermicomposting improves the physiochemical and biological properties of the soil and also contributes to organic enrichment [1, 2].

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 [3]. Earthworms act as automated blenders and transform organic matter into more evenly sized particles, which gives the final substrate an earthy appearance.

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. Both vermicompost and its body liquid vermi wash have proven to be significant growth promoters and protectors for crop plants.

Vermicomposting refers to the production of compost by utilizing earthworms to transform organic waste into high-quality compost that mainly consists of worm castings in addition to decayed organic matter [4,5,22]. Over the years, vermicomposting technology has paved a way for effective food waste management diverting from conventional methods of waste disposal including landfills. In the past few decades, the use of vermicompost has been encouraged by agriculturists. Vermiagro production technology has resulted in sustainable food production to meet the growing demands of organic foods in society. Fertilizer shortage is expected in the near future as the fertilizers are produced from non–renewable sources of energy [6].

II. Materials and methods

Study region

The study on physiochemical analysis of vermicompost was carried out in the Department of organic agriculture and natural farming of CSKHPKV Palampur and Vermicompost produced by using organic waste like rice straw, cow dung, domestic waste, dry

leaves, and grass. Two authenticated species of earthworms were used to recycle organic waste into valuable and nutritional-rich manure. The study was carried out in different steps.

Methods

Vermicompost bed construction:

The vermicompost bed of 10'×5'×6' was constructed in a shady area devoid of waterlogging at a temperature of about 10-30℃ following Ismail (2005).

- First layer composed of a material that was not easily decomposed. E.g.- thick dry grass, dry banana leaves. Waste was cut into 2-3 inches of small pieces and spread evenly over the bed (6-7.5cm). A thick layer of about 4-5 inches was spread over it.
- 1-2kg of vermiculture which includes 800-1000 adult earthworm's species of Eisenia foetida and Eudrilus eugeniae, eggs, and cocoons was added on the top of the second layer and was covered with a thin layer of cow dung.
- Next layer composed of organic biomass (5-6") and water was sprinkled over it.
- Uppermost layer was of cow dung, dry leaves, and grass up to 3" height.

The pit was kept moist by watering it at regular intervals for the next 30 days. The bed should neither be dry nor wet.

Fully decomposed and ready vermicompost was dark brown, odorless, and in the form of fine particles. Compost was harvested from top to bottom layer by layer, sieved, and stored in a shaded area.

Import of Earthworms:

- **Selection of Earthworms for Vermicomposting process:**

Two authenticated species of earthworms were used in the vermicomposting process, i.e., Eisenia foetida and Eudrilus eugeniae. These are efficient to maintain the vermicomposting process and are ideal species suitable for vermicomposting under tropical conditions. These species have a high fecundity rate with moderate biomass production together with a longer period of survival more than one year. The worms were cultured in a vermi-bed containing partially decomposed cow dung with organic waste.

- **Harvesting of Compost:**

The compost was prepared in 60-90 days. The prepared compost was black granular, mild weight, and rich in humus. When the earthworm's species reached the upper layer of vermibed, it means compost was ready to harvest. Before 2-3 days of harvesting, the watering of the bed was stopped so that the earthworms start to move towards the bottom of the bed. The worms were separated with the help of a sieve having size 4mm. During separation, the worms and thick material remained on the top of the sieve. The harvested composed was located in a heap exposed to sunlight in order that maximum of the worms circulates right all the way down to the cool base of the heap.

Physio-chemical analysis of vermicompost:

Samples were collected to analyze the physio-chemical characteristics of matured vermicompost and traditional compost by stand method as per fertilizers (control) order 1985. Samples were collected and processed for analysis of major nutrients nitrogen (N), phosphorous (P), potassium (K), crude protein, copper (Cu), zinc (Zn), iron (Fe), manganese (Mn). The moisture content, electrical conductivity, and pH were also recorded. Analysis was done using the methods applied in the soil laboratory of the Organic Agriculture and Natural farming Department of CSKHPKV Palampur, pH using pH meter, electrical conductivity (mS) using a conductivity meter, nitrogen (%) using the Kjeldahl's method by Bremmer and Mulvaney (1982) [7], phosphorus content (%) determined by using the spectrometer by colorimetric method, potassium content (%) was determined by using flame-photometer Bansal and Kapoor (2000) [8], copper, zinc, iron, and manganese (%) determined by using Atomic Absorption Spectrophotometer.

III. Results and discussion

Vermicompost produced after 50-60 days of earthworm's activity was dark brown in colour and it was found that the sample has no odor, moisture content of the vermicompost was 59.88g and 54.11g. The pH of the sample was 6.8 and the EC of the sample was 0.56mS. The result demonstrates a significant increase in N (2.597%), P (0.44%), K (0.9979%), Mn (0.00806%), Zn (0.0050%), Fe (0.0144%), Cu (0.0053%) (Table 1).

Composition of vermicompost: The average chemical composition of vermicompost shows that the vermicompost is slightly acidic in reaction with a pH value of 6.8 containing micro and macronutrients required for plant growth. Vermicompost is very useful as it contains high amount of organic matter and adds to the fertility of the soil.

Vermicomposting appears to be the most effective biofertilizer which not only increases plant growth and productivity by nutrient supply but also is most effective and pollution-free. Vermicompost promotes soil aggregation and stabilizes the soil structure. This improves the air-water relationship of soil, thus increasing the water retention capacity and encouraging extensive development of the root system of plants. Mineralization of nutrients is observed to be enhanced, therefore resulting in boosting crop productivity.

- **Moisture content:** The observed moisture content of the vermicompost sample was 54.11%. A study showed that 50% moisture content was the minimal requirement for the rapid rise in microbial activity (Fig. 1).
- **pH:** The observed pH of the vermicompost sample was 6.8 which was found to increase fecundity, biomass, and cast production of earthworms. Dominguez and Edwards (2011), reported a pH range of 5-9 during the process, the value reaching near neutrality when the vermicompost was ready for the harvest.
- **EC (Electrical Conductivity):** Electrical conductivity is the indicator of soluble salt concentration. The electrical conductivity of the vermicompost sample was 0.56 mS. Electrical conductivity is dependent on freely available minerals and ions generated during ingestion and excretion by the earthworms [9] and the raw materials used for vermicomposting [10]. The increase in EC in the vermicompost could be due to the loss of weight of organic matter and the release of different mineral salts in available [11,12,13].

- **Nitrogen(N):** The observed nitrogen content of the sample is 2.597%. The optimum range of nitrogen content is about 0.5-1.50%. The increase in the total nitrogen content shows the good quality of bio-compost. Suthar (2007) [14] suggested that the earthworms enhance the nitrogen levels in the vermicomposting substrate by adding their excretory products, mucus, body fluids, and enzymes even through decaying tissues of dead worms in the vermicomposting subsystem (Fig. 2). In the present study, nitrogen level is recorded higher in the manure compost (Table 2).
- **Phosphorous(P):** In the present study, the phosphorus content is 0.44%. The optimum range of phosphorus in vermicompost ranges between0.1-0.30%. Goswami (2002) [15] suggested that higher phosphorus content in the vermicompost shows the compost produced is of good quality and highly nutritious.
- **Potassium(K):** The observed potassium content of the vermicompost sample is 0.9979%. In earlier studies, potassium values between 0.54% and 1.72% were reported [16, 17, 18, 19].
- **Micronutrients:** The values of micronutrients such as Mn, Cu, Fe and Zn i.e., 0.00806%, 0.0144%, 0.0053%, 0.0050% revealed that the main reason for the increase in the micronutrients in the vermicompost might be due to the release of an excess number of micronutrients and heavy metals from the earthworm's body into the environment through the calciferous glands (. Tripathi and Bhardwaj (2004) [20] recorded both increases and decreases in the level of Fe and Cu. Parthasarathi (2008) [21] observed similar results in different organic wastes. The difference of micronutrients and metals in the different wastes may be due to the differential mineralization rates due to the combined effect of earthworms and microorganisms (Table 3).

IV. Conclusions

This present study was conducted to check the nutrient status of vermicompost of various organic wastes. The study showed that the moisture content of the sample was 59.88% & 54.11% which was sufficient to increase the microbial activity. The value of NPK was within the optimum range i.e., 2.597%, 0.44%, 0.997% respectively, which reveals that they act as plant growth promoters and increase the fertility of the soil. Vermicompost works as a "slow-release" fertilizer and also acts as a plant protector against certain diseases and pests. Rapid use of vermicompost may reduce or replace dangerous agrochemicals progressively, thus benefiting the farmers and ecology of the nation in every way. Some essential micronutrients like-Mn, Fe, Cu, and Zn were also checked, and they were within the values of optimum range i.e., Mn-0.00806%, Fe-0.0144%, Cu-0.0053%, Zn-0.0050%. Some physical properties of vermicompost were also seen such as pH was 6.8, moisture content was 59.88% & 54.11% and electrical conductivity was 0.56mS. This indicates that the sample of the present study had all the essential micronutrients and macronutrients which leads towards the achievement of getting on environment-friendly nutrient-rich fertilizer for the agriculture sector.

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Table 1: Showing physical parameters of vermicompost (Macronutrients)

Moisture Content	pH	Electrical Conductivity
54.11%	6.8	0.56 mS

Table 2: Showing chemical parameters of vermicompost (Macronutrients)

Nitrogen	Phosphorus	Potassium	Crude protein
2.597%	0.44%	0.9979%	16.231g

Table 3: Showing chemical parameters of vermicompost (Micronutrients)

Iron	Zinc	Manganese	Copper
0.0144	0.0050	0.00806	0.0053

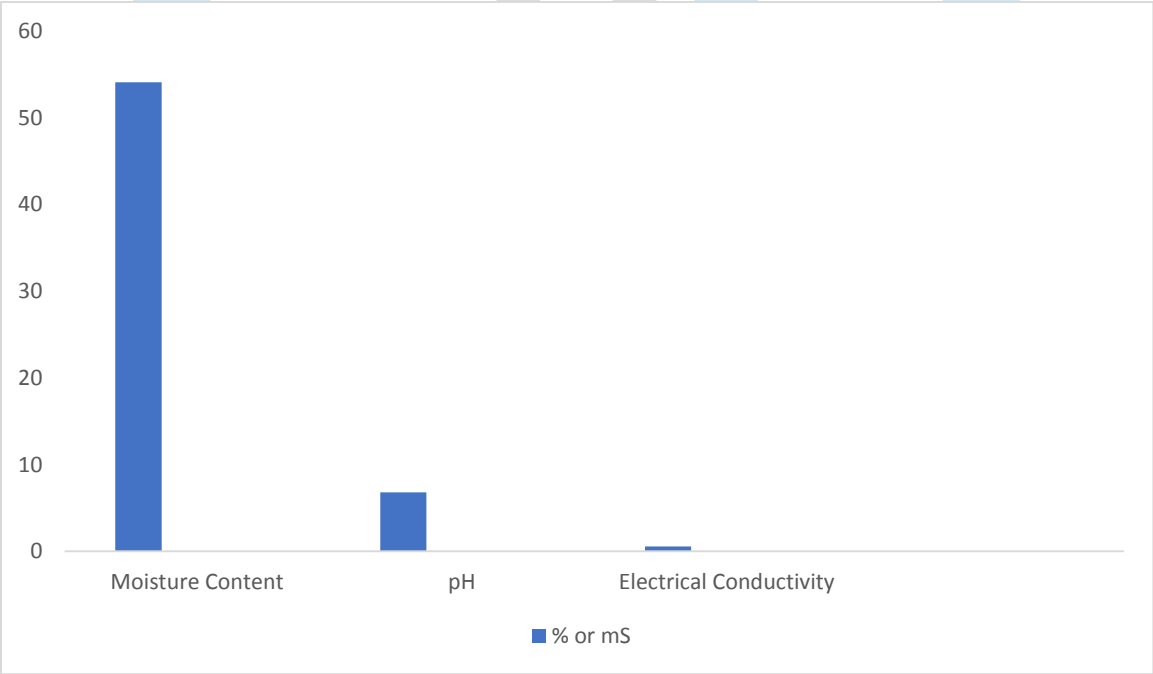

Figure 1: Graphical representation of physical parameters of vermicompost

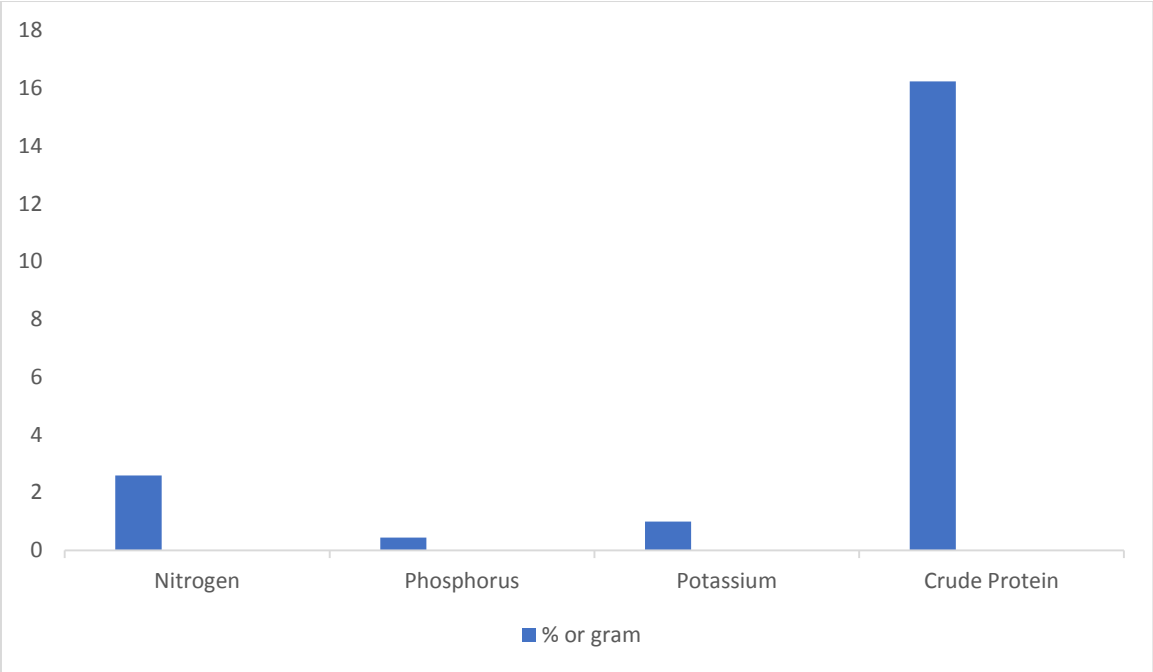

Figure 2: Graphical representation of chemical parameters of vermicompost (macronutrients).

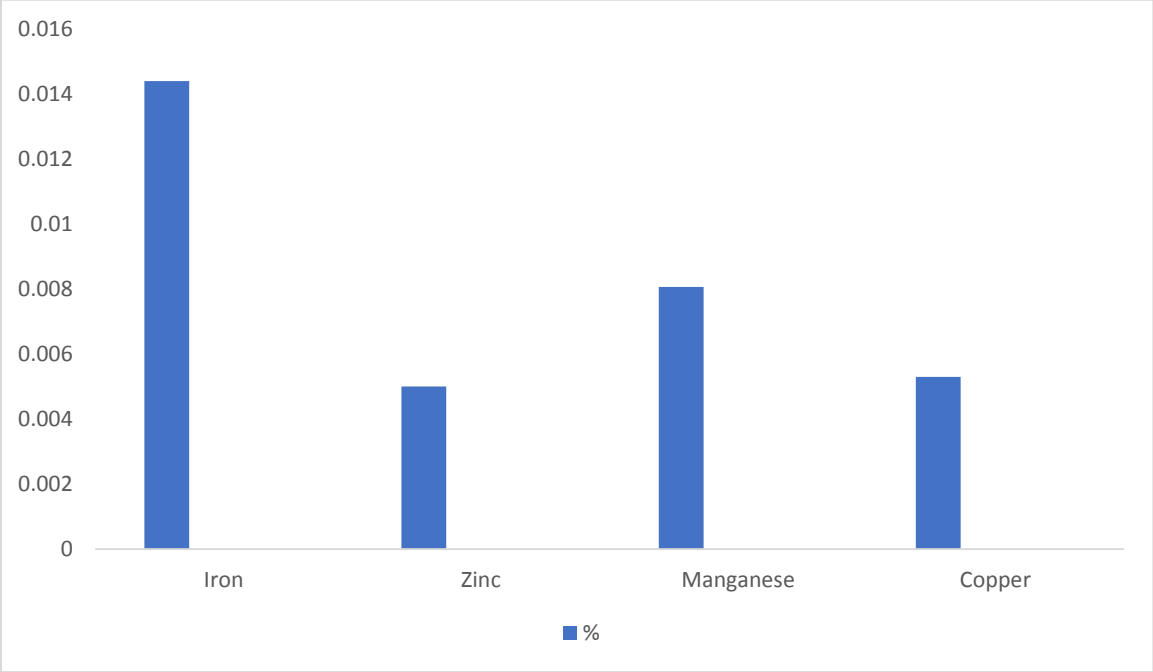

Figure 3: Graphical representation of chemical parameters of vermicompost (micronutrients).