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Micro and Macro Nutrient Analysis on Vermicomposting Properties of Native Indian *Lampito mauritii*

A. Suvedha [a], G. B. BrindhaDevi [a*], E. Logeswari [b] and K. Revathi [b*]

[a] *Department of Zoology, Queen Mary's College, Chennai – 600004, India.*
[b] *Sri Venkateshwaraa Medical College Hospital and Research Centre, Puducherry, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

India's native *Lampito mauritii,* a purely anecic peregrine has proven to be an effective tool for reducing organic waste in vermicomposting techniques. This study focuses on nutrient analysis and the analysis of physicochemical parameters in *Lampito mauritii* using the vermicomposting method. The results obtained from this study were elucidated using Physicochemical Parameters such as Moisture Content, Particle size, Odor and Color, pH and Electrical Conductivity and macronutrient analysis for Potassium, Available Phosphorus, Soluble calcium and magnesium, Chloride, Available boron, Micronutrients and Heavy metals. In our study macro and micro mineral analysis showed increased concentration in vermicompost. Heavy metal concentration is also considerably high in vermicompost. These results show the impact of *Lampito mauritii* in enriching the soil quality.

**Corresponding author: Email: brindhadevi_zool@queenmaryscollege.edu.in, reva63@rediffmail.com;*

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Keywords: Lampito mauritii; physiochemical parameters; heavy metals; test soil; vermicompost.

1. INTRODUCTION

Earthworms are referred as ecosystem engineers because it constitutes major of the soil biomass. They act as a good soil conditioner. They are important soil animal which also plays a major role in biogeochemical cycles. Since earthworms are ecosystem engineers, they actively participate in the soil particles as well as in organic transfer in any geographic position which improves the physic-chemical characteristics of soil pH, organic matter, micronutrients, macronutrients, and heavy metals [1].

India's native *Lampito mauritii*, a purely anecic peregrine is a useful tool for cutting down on organic waste [2,3]. In *Lampito mauritii* (Kinberg), reproduction is amphimictic, sexual, and biparental [4]. In agroecosystems, earthworms represent a prominent invertebrate biomass commonly detected in terrestrial fauna. Earthworm plays a major role in enhancing the soil fecundity and founding [5]. Earthworms are a valuable biological resource that mostly inhabits land, need damp soil that is rich in organic matter, and feeds during night time [6,7]. Merely a small number of the 5,500 earthworm species identified globally are employed in vermicomposting procedures [8]. More than 505 distinct earthworm species and subspecies, organized into 67 genera and 10 families are found in India [3].

Vermicompost technology is the biotransformation of organic waste into vermicasts under the influence of earthworms.

Use of organic source of fertilizers like vermicompost is an effective solution to the problem as it substitutes the chemical inputs in crop productivity and thus not only reduces the economic cost but leads to production of organic manure which fetches higher price in the market. Now, recently there is a growing demand for organic manure, which is healthier for consumers and also environment friendly. These dark brown vermicasts also known as vermicompost are suitable for use as an environmentally friendly biofertilizer [9].

The raw materials used to make high-quality compost are mainly residues from local agriculture and agro-industry [9-10]. Vermicompost and vermiwash can be used as biofertilizers, which are organically rich in the main fertilizer nutrients, viz. nitrogen (N), phosphorus (P) and potassium (K). The use of biofertilizers derived from vermicompost has been reported to improve soil quality. The application of vermicompost enhances soil health and crop productivity due to improved nutrient uptake [11]. Vermicompost also improve soil health, plant growth, and enriches the microbial communities and its activity in soil [12].

Now, recently there is growing demand for organic manure, which is healthier for consumers and also environment friendly [13].

- Impact of application time, vermiwash, and vermicompost has an effect on the physicochemical characteristics of soil. Microorganisms are essential to the breakdown and stabilization of organic substances derived from garbage. Thus, the processes of composting and vermicomposting allow for the stabilization and recycling of biodegradable organic leftovers. Both processes aerobic and bio oxidative is involved in different aspects of vermicomposting. The earthworms' involvement in the composting process accelerates the pace of mineralization by encouraging the aeration and fragmentation of organic materials [14]. Earthworm- decomposed organic materials are further transformed by microorganisms during the vermicompost maturation phase. The resulting vermicompost is full of organic matter, nutrients, and compounds that encourage plant growth that are created by the stomach bacteria of earthworms [15,16]. Earthworm consumes fresh cow manure and transforms it into vermicompost. The following are the ways that organic matter helps to sustain soil health and productivity:
- The organic matter are rich source of plant nutrients and microbial energy;
- It functions as a chelating agent and cation exchanger;
- It heightens the physical state of the soil [17].

2. MATERIALS AND METHODS

2.1 Study Site

The study was conducted in the Queen Mary's College research room facility, located at 13.04450 N, 80.27900 E, and the site where the vermicomposts were prepared. The specimens of earthworms included in this investigation were collected from the area surrounding Queen Mary's College campus. The entire vermicompost unit was maintained between 18 and 25^0 C with a moisture level of 60 to 80% for a period of 120 days.

2.2 Experimental Setup

The monoculture method, which entails cultivating the earthworm species *Lampito mauritii* in grow bags, the vermicomposting facility was set up. The vermicomposting unit was placed in a cool, shaded, elevated space with a high relative humidity. The pH of the soil was maintained from 6.4 to 7. As the level of pH lowers, the earthworm development rate falls down. Earthworms require more organic matter to grow and develop and for proper drainage, gritty sand was made as the base layer. The bedding layers consisted of soil, dried leaves, dry straw, cow dung, and leftover kitchen scraps. Each layer was of two to three inches, and the mixture was allowed to rest for fifteen to twenty days for pre- decomposition to set.

The ratio of the soil to cow dung combination was one-third. Once the material was pre-decomposed, twenty mature *Lampito mauritii* worms, measuring 8±0.5 cm in length and 300±50 mg in weight, were introduced to the composting bin. 100 grams of wheat bran and 100 grams of rice bran were placed on top of the vermicompost mixture. Probiotic curd was also added after a week. The entire setup was moistened to 60–80%; if not wet the water was sprinkled. Less water kills the earthworms, and too much water drives them away. All the way through the procedure, moisture content was maintained. Over the growbags, wet gunny bags were used to block light, keep away ants and other insects, and maintain a constant humidity level. To allow gasses to escape and to cool the vermicompost unit, regular watering and proper aeration was maintained. The earthworms' continued survival and the emergence of new generations were signs of healthy compost. After 120 days, the mixture yielded weightless humus with a rich, dark color. *Lampito mauritii* was placed in regular garden soil for the control unit's configuration.

2.3 Physicochemical Parameters

2.3.1 Moisture content

By the oven-dried method drying at 105^0 C, the moisture content of the vermicompost and the test soil was determined. The moisture content was taken as a percentage of the received mass. The moisture content was determined using the formula given below:

$$\text{Moisture content, \%} = [(A - B) \times 100] / A$$

Where, A is the test specimens mass in grams as received, B is the oven-dried specimens mass in grams and 100 is percentage constant.

2.4 Particle Size, Odor and Color

The mature vermicompost's texture was assessed by hand feel, color, and odor following different treatments.

2.5 pH and Electrical Conductivity

10g of the sample was taken in a flask, and 500ml of distilled water was added and stirred for three to five minutes. The mixture was allowed to settle for five minutes, a pH meter fitted with a glass electrode was used to check the level of the pH.

Water was extracted using a 1:2 extraction ratio from the air-dried soil at 250C±10C to dissolve the electrolytes. After adjusting the temperature, the suspended extract's electrical conductivity was noted.

2.6 Nutrient Analysis

2.6.1 Potassium

Solid waste containing organic components were broken down when treated with sulfuric-nitric acid mixture. After burning the ash to produce the appropriate sulfates, the residue was further treated with an acidic mixture which contained HF to remove silica and the sample was passed through Flame Photometric Analysis [18].

2.6.2 Available phosphorus

To find the amount of accessible phosphorus in soil samples, Olsen's approach (Olsen et al., 1954) was applied for alkali soil species.

2.6.3 Soluble calcium and magnesium

The EDTA Titrimetric technique was used to determine magnesium and calcium levels. The accuracy, simplicity, and speed of the EDTA titration method, which was created by Cheng and Bray in 1951 [19], make it the recommended approach.

Magnesium and calcium soluble in water were determined from the extract of saturated soil. In a solution of ammonium acetate extract, exchangeable calcium and magnesium was calculated. A spectrophotometric analysis using atomic absorption was used to estimate the amounts of Ca and Mg. Since cations were found in high concentrations in arid and semi-arid soils, titration methods were followed.

2.6.4 Chloride

In order to assess the amount of soluble salts present, chloride was measured from a soil saturation extract. The silver nitrate titration method was used for estimation.

2.6.5 Available boron

Available boron was estimated by colorimetric method (Hatcher, J.T.; Wilcox) [20].

2.7 Micronutrients and Heavy Metal Analysis

Flame Atomic Absorption Spectrometry (FAAS) was used to assess the presence of heavy metals including lead, arsenic, cadmium, and chromium as well as micronutrients like iron, manganese, zinc, copper, molybdenum, and nickel.

Soil samples were analyzed by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES) or Flame Atomic Absorption Spectrometry (FLAA).

Graphite Furnace AA (GFAA) or Inductively Coupled Spectrometry (ICP- MS) was used for preparation of sediment, mud, and soil samples.

3. RESULTS AND DISCUSSION

Due to the richness of nutrient in vermicompost there is increased growth rate of plants with high yield of its products and also economically beneficial. Vermicompost stabilizes the soil structure, maintains soil retention capacity and balances the air-water relationship of the soil. Mineralization of nutrients is enriched with increased crop productivity [21].

The primary determinants of earthworm growth are the physicochemical and nutritional qualities of the soil; typically, high feeding levels are reflected in excessive cocoon formation rates [22].

The stability of vermicompost was directly correlated with its quality [23]. The vermicompost and soil sample findings for the various physicochemical parameters were examined. Vermicompost had a higher nutritional content compared to regular garden soil.

3.1 pH, Moisture & Electrical Conductivity

Vermicompost had a pH of 7.4, moisture 60%, whereas soil had a pH of 7.8 and70% moisture content. The pH value at neutral level should be considered significant. During the vermicomposting process, the pH typically decreases from alkaline to acidic or neutral [24].

Electrical conductivity of the soil is 566µS/cm; whereas the electrical conductivity of vermicompost is 609µS/cm.

3.2 Macronutrient Analysis

The macromineral composition of the vermicompost showed higher values than that of the soil over the study period of 120 days, which indicates vermicompost richer in macronutrients. Vermicompost have more exchangeable calcium, magnesium, potassium than the soil [21].

From Table 1, it was found that the t-values calculated for the scores based on the soluble Calcium in Soil compared with vermicompost did not differ significantly, whereas soluble Magnesium differed significantly and vermicompost shows more Soluble Magnesium than soil.

3.3 Nitrogen

When compared to soil, the vermicompost's overall nitrogen content increased during the preparation process. Probiotics have the ability to enhance vermicompost and increase soil fertility. Additionally, earthworms take nitrogen from the compost materials and transfer it to the substrate in the form of mucus, bodily fluids, growth-stimulating hormones, enzymes, and excretory secretions, raising the nitrogen levels. It was reported that the nitrogen concentration has increased by 2.0–2.4 times. In order to maintain the form of the mineral nitrogen, the earthworm accelerated the mineralization of nitrogen in the substrate [25]. The process of vermicomposting released nitrogen from the dead tissues and metabolic waste of earthworms. Because of the loss of organic carbon, growth-stimulating hormones and other nitrogenous excretory compounds might have been added to the nitrogen [26].

Cow dung showed the largest increase in nitrogen concentration [16]. Both earthworm guts and worm droppings include bacteria that fix nitrogen; the nitrogen content of the droppings is comparatively higher than that of the soil [27]. The presence of nitrogen-fixing bacteria, which raise the soil's nitrogen level, may be the cause of the notable increase in nitrogen found in vermicompost [28].

Atiyeh [29] found that the conventional compost was higher in ‘ammonium’, while the vermicompost tended to be higher in ‘nitrates’, which is the more available form of nitrogen. In concordance with the above findings, our study also showed increased level of nitrogen content in vermicompost than the soil.

As discussed above, the nitrogen content level was higher in vermicompost in our study when compared to the nitrogen level of the soil.

3.4 Total Organic Carbon (%)

Vermicompost's organic carbon releases nutrients into the soil gradually, allowing plants to readily absorb the available nutrients [28].

Compared to the control soil, the total organic carbon rose during the 120-day vermicompost preparation process. Vermicompost had 0.65% of its total organic carbon, whereas control soil contained 0.58%. Since organic molecules constitute the foundation of all living things, carbon is an essential part of them and provides the energy needed for the composting process [13]. In our study, carbon content is higher in vermicompost than that of soil.

3.5 Chloride

From Table 2, it was found that the t-values calculated for the scores based on the chloride in soil compared with vermicompost differed significantly, where vermicompost shows more chloride than soil.

3.6 Available Phosphorous (mg/kg)

Vermicompost showed higher concentration of phosphorous than that of the soil.The amount of phosphorus that was accessible was doubled during the 120-day vermicompost preparation process. Soil has a score of 15 and vermicompost has a score of 36. After nitrogen, phosphorus is the mineral that limits plant growth the most. It is acrucial component of plant growth. The soil around earthworms has more accessible P than the soil without earthworms [30].

The t-values calculated for the scores based on the Available Phosphorous in Soil compared with vermicompost differed significantly, where vermicompost shows more Phosphorous than soil illustrated in Table 3.

Table 1. Soluble calcium and magnesium analysis in soil and vermicompost

Parameters	Soil		Vermicompost		t Test	Sig
	Mean	SD	Mean	SD		
Soluble Calcium (mg/kg)	394	35.62	416	40.87	1.14	P > 0.05
Soluble Magnesium (mg/kg)	74	8.47	112	8.01	9.21	P < 0.01

Table 2. Chloride analysis in soil and vermicompost

Parameters	Soil		Vermicompost		t Test	Sig
	Mean	SD	Mean	SD		
Chloride (mg/kg)	286	24.68	324	22.91	3.19	P < 0.01

Table 3. Phosphorous analysis in soil and vermicompost

Parameters	Soil		Vermicompost		t Test	Sig
	Mean	SD	Mean	SD		
Available Phosphorous (mg/kg)	15	1.03	36	2.85	19.60	P < 0.01

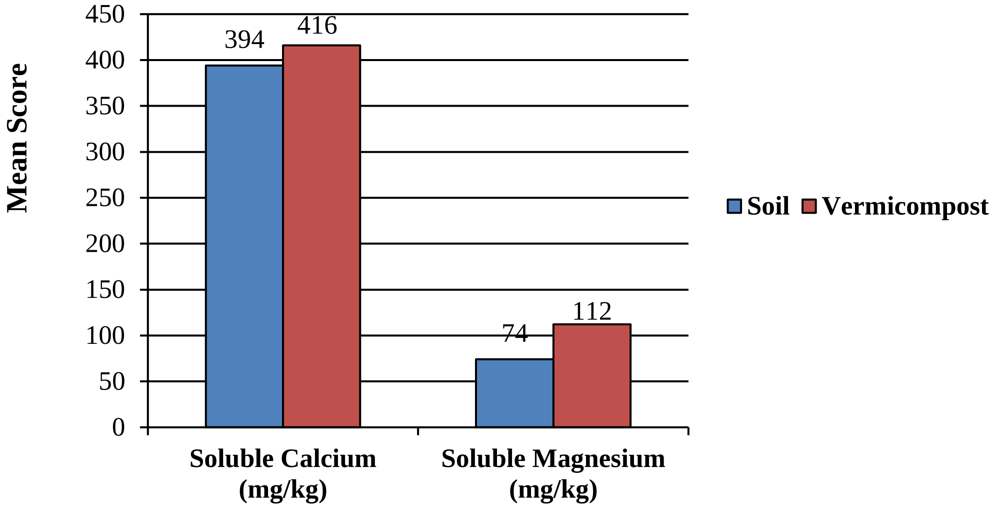

Fig. 1. Profile of mean score on soluble calcium & magnesium present in soil and vermicompost

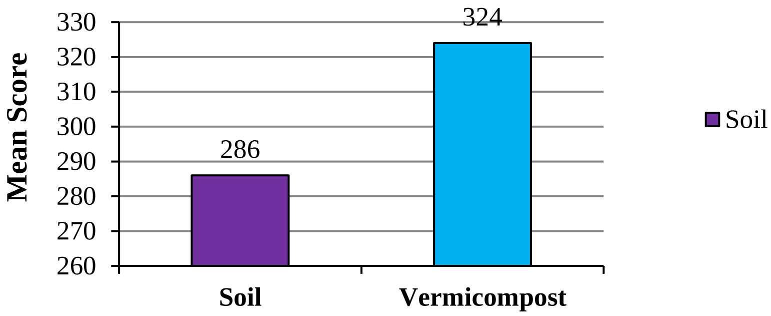

Fig. 2. Profile of mean score on chloride (mg/kg) present in soil and vermicompost

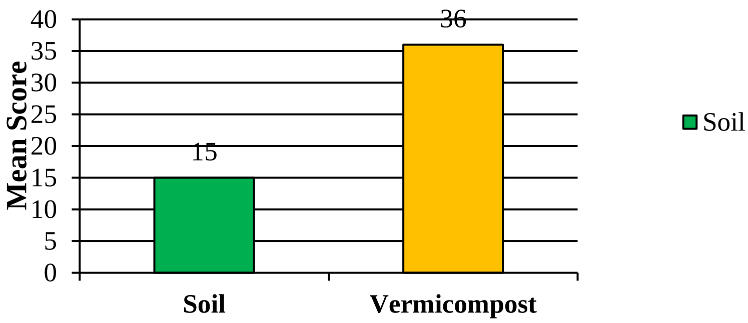

Fig. 3. Profile of mean score on available phosphorous (mg/kg) present in soil and vermicompost

3.7 Available Potassium as (K)

Potassium (K) is one of the seventeen essential elements required by plants for healthy growth and reproductions, which is associated with water movement, nutrients and carbohydrates. It enhances enzymes activation, improves crop quality and protein synthesis in plants. The potassium content of vermicompost is higher than that of the test soil sample over a period of 120 days. The result agreed with [31].

It was found from Table 4, that the t-values calculated for potassium content in Soil compared with vermicompost differed significantly, where soil shows more potassium than contain vermicompost.

3.8 Available Boron

The t-values calculated for the scores based on the Available Boron in soil compared with vermicompost doesn't differ significantly, illustrated in Table 5.

Table 4. Potassium Analysis in Soil and Vermicompost

Parameters	Soil		Vermicompost		t Test	Sig
	Mean	SD	Mean	SD		
Potassium (mg/kg)	907	40.26	828	30.73	4.41	P < 0.01

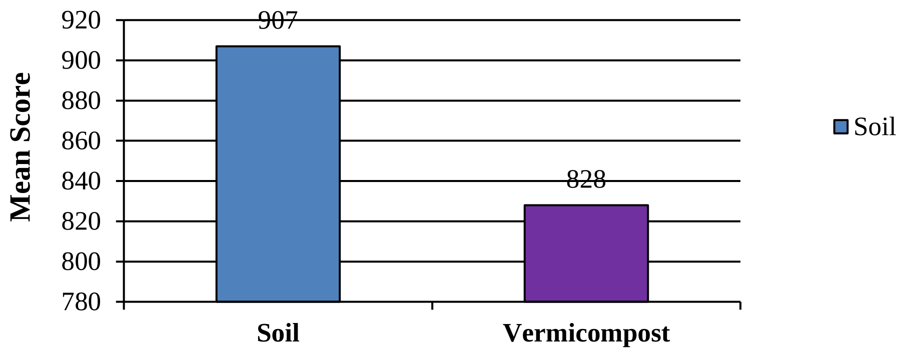

Fig. 4. Profile of mean score on potassium (mg/kg) present in soil and vermicompost

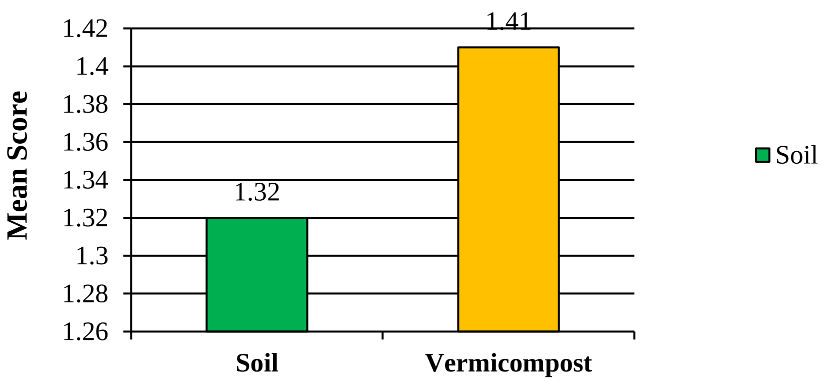

Fig. 5. Profile of mean score on available boron (mg/kg) present in soil and vermicompost

Table 5. Available boron in soil and vermicompost

Parameters	Soil		Vermicompost		t Test	Sig
	Mean	SD	Mean	SD		
Available Boron (mg/kg)	1.32	0.09	1.41	0.41	0.60	P > 0.05

Table 6. Micro minerals and heavy metal analysis

Parameters	Soil		Vermicompost		t Test	Sig
	Mean	SD	Mean	SD		
Lead (mg/kg)	8.74	1.22	19.5	4.74	6.21	P < 0.01
Chromium (mg/kg)	26.2	4.86	34.1	7.35	2.53	P < 0.05
Iron (%)	0.927	0.3	0.978	0.45	0.26	P > 0.05
Manganese (mg/kg)	196.7	21.25	215.3	15.83	1.98	P < 0.05
Zinc (mg/kg)	52.9	8.62	65.6	7.76	3.09	P < 0.01
Copper (mg/kg)	37.4	3.03	44.2	2.85	4.62	P < 0.01
Nickel (mg/kg)	20.9	3.9	24.3	2.87	1.98	P < 0.05

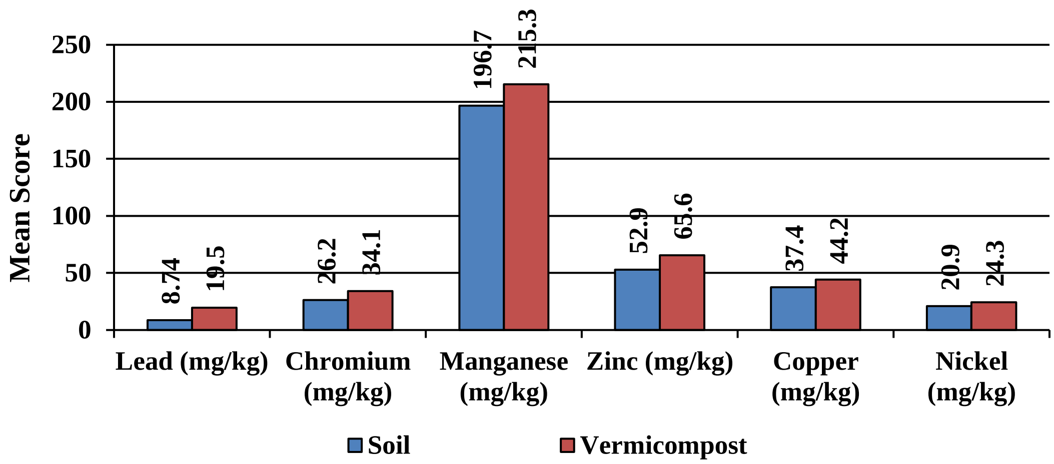

Fig. 6. Profile of mean score on micro minerals and heavy metal present in soil and vermicompost

3.9 Micromineral Composition and Heavy Metal Analysis

After a 120-day study period, the micromineral composition of the vermicompost were analysed and the results of iron, copper, zinc and manganese were observed. The value of iron in soil was lower than the value of the vermicompost and was also similar in the case of copper, zinc, and manganese.

Iron plays an important part in plant life, which helps in overall metabolism of plants. Earthworm in vermicomposting releases excess amount of iron and heavy metals from earthworm body into the environment through the calciferous gland [32]. Next to the iron, manganese is the second greatest required micronutrient which helps in plants respiration, photosynthesis, and nitrogen absorption. Manganese acts as a catalyst for many enzymes and aids in photosynthesis and also in chlorophyll production [33,34]. Impact of heavy metals on the vermicompost as well as the soil was also studied and the results were illustrated in the Table 6.

4. CONCLUSION

Chemical fertilizers change the physicochemical characteristics of soil, have a negative impact on the microbial populations in the soil, and reduce soil productivity overall [35].

Earthworms are important because they have a huge potential for improving soil and are suitable on a continuous basis. Ground bioresearch is acknowledged as the foundation of sustainable livelihood and food security [36].

Earthworm-produced feces provide easily accessible, labile organic substrates for soil and compost-dwelling bacteria, hence promoting microbial activity and growth. In addition to accelerating the decomposition activities of bacteria and other microbes, the worms secrete enzymes like lipases, proteases, cellulases and chitinases that facilitate the rapid biochemical conversion of protein and cellulosic materials in a variety of organic wastes. This process also helps the bacteria transform into tissues and enhances the quality of vermicompost [37].

For vermicomposting organic substrates like press mud and leaf litter, anecic earthworms known as *Lampito mauritii* are claimed to be common in most soil types in South India and other parts of India [7,5].

Over the decades, vermicompost research on earthworms played an important role in environmental studies. Vermicompost experiments on *Lampito mauritii* demonstrate the impact of soil chemical components on this species.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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