



## Physicochemical analysis of compost and vermicompost of banana and water hyacinth leaf wastes processed by using the earthworm *Eisenia fetida*

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### Abstract

Vermicomposting is a viable biotechnology process for recycling forestry-livestock organic waste materials because it decomposes and stabilizes residues thus it contributes to diminishing environmental problems. This promising technology not only decreases the subsistence of solid waste but also produces valuable plant nutrients. The present study deals with the vermicomposting of leaf wastes of Banana leaves and Water hyacinth leaves into vermicompost by using the earthworm *Eisenia fetida*. The compost (without worms) and vermicompost (with earthworm) *Eisenia fetida* is produced by a mixture of different individual organic wastes with cow dung in the ratio of 1:1 on a dry weight basis. All the experimental sets both compost (T<sub>1</sub>- Banana leaf with cow dung, T<sub>2</sub>- Water hyacinth leaf with cow dung, T<sub>3</sub>- Banana leaf and Water hyacinth leaf with cow dung) and vermicompost (VT<sub>1</sub>, VT<sub>2</sub> and VT<sub>3</sub>) were maintained with moisture (70-80%) and temperature (25-30°C). All the experimental sets were terminated after 60 days. Both compost and vermicompost were collected separately in polythene bags and were analyzed for the nutrient status. All the parameters (pH, EC, N, P, K, S, Ca, Mg, Cu, Zn, Fe, and Mn) were slightly more in the vermicompost produced by the action of epigeic earthworm *Eisenia fetida* than in the normal compost produced by the saprophytic micro-organisms except organic carbon (OC). Vermicompost had higher quantity of all essential physicochemical parameters, macro and micro plant nutrients indicating the achievement of getting an environmentally friendly nutrients rich fertilizer than the compost (without worm) for the agriculture.

**Keywords:** Banana leaf, water hyacinth leaf, *Eisenia fetida*: compost, vermicompost, physico-chemical parameters

### Introduction

Leaf waste is one type of organic waste that is processed through earthworms. There has always been an issue with the significant amount of leaf litter produced by trees growing in forests, along roads, rail lines, in gardens, and on farms. In India, several million tons of organic waste is generated annually including leaves, husk, sawdust, steam bark, flowers, etc. (Nagar *et al.*, 2017) [26]. Thus, deteriorating the environment and health. In the cities, leaf litters are burnt which causes several health problems, especially respiratory like asthma and heart diseases (Aalok and Tripathi., 2013) [1]. One kind of organic waste that is broken down by earthworms is leaf waste. Leaf waste is one type of organic waste which is processed by earthworms.

An example of an organic waste product is leaf litter, which can be turned into nutrient-rich vermicompost by earthworm processing and then applied to crops as a biofertilizer.

Banana (*Musa paradisiaca*, L) is a significant horticultural crop in Kerala and Tamil Nadu. Every year, India generates about 3000 million tons of organic waste, of which about 0.5 million tons are banana waste (Gopal *et al.*, 2009) [16]. Around 120 countries cultivate bananas, which results in 86 t of crop waste per hectare (Khatua *et al.*, 2018) [19]. Tamil Nadu is the state that grows the most bananas in the nation, producing about 9 million metric tons (MT) of them annually. However, poor post-harvest handling techniques result in enormous waste every year. Currently, 2.7 million MT, or an average of 30%, of Tamil Nadu's banana crop is wasted, mostly because the state, lacks an integrated cold chain infrastructure (Vidya *et al.*, 2020) [43]. An enormous amount of waste is produced during the growing of bananas in a single crop season, the stems alone produce about 30 tons of waste per acre.

Water hyacinth, or *Eichhornia crassipes*, is a free-floating aquatic weed plant that can be found in most bodies of water worldwide, is well-known for growing in almost all types of wetlands, from large riverine lakes to tiny fish ponds (known as "Beels"). It is one of the most problematic invasive alien species worldwide and is thought to be the worst water weed in the world (Nishizaki., 2004) [29]. The weed clogs waterways, rivers, and entire lakes, making it difficult to fish, navigate, irrigate, or generate electricity (Patil *et al.*, 2012) [31]. The weed can be used as a good source for vermicomposting and is a beneficial absorber of nitrogen, phosphorus, and potassium from water. Two major issues facing contemporary society are concurrently resolved by vermicomposting (Sakthika and Sornalaksmi., 2019) [36].

The nutrient-rich organic manure left behind by earthworms contains humus, NPK, micronutrients, growth hormones, beneficial bacteria, enzymes, and antibiotics (Kumar *et al.*, 2018) [21]. By releasing mineral elements in forms that are easily absorbed by plants, earthworms improve soil fertility and speed up the breakdown of organic matter and plant litter. As soil-dwelling organisms, earthworms are essential to the processes of soil formation and fertility maintenance (Devanathan and Senthilmurugan., 2023) [14]. The waste material or base substrate used to prepare the vermicompost usually determines how many nutrients it contains. Chemical fertilizers are used extensively these days, which eventually degrades the quality of the soil (Abu Bakar Azizi *et al.*, 2015) [2]. Vermicomposting is becoming a viable method for managing organic waste, making organic fertilizer, and lowering the need for chemical fertilizers (Piya *et al.*, 2018) [33]. Vermicompost production has been documented from the leaves of a variety of plants, including *Saccharum officinarum* leaf (Cai *et al.*, 2020) [10], *Saraca*

asoca leaf (Prakash Duwadi *et al.*, 2021) <sup>[34]</sup>, *Tectona grandis* leaf (Arumugam *et al.*, 2015; Nagar *et al.*, 2019) <sup>[5, 27]</sup>, *Azadirachta indica* leaf (Nayeem-Shah *et al.*, 2015; Thamizharasan *et al.*, 2021) <sup>[28, 41]</sup>, *Eucalyptus teriticornis* leaf (Nagar *et al.*, 2017), *Lawsonia inermis* leaf (Kathireswari *et al.*, 2023) <sup>[18]</sup>, *Musa paradisiaca* leaf (Kumar *et al.*, 2023) <sup>[22]</sup>, *Ananas comosus* leaf (Chaudhuri *et al.*, 2016) <sup>[12]</sup>, *Mangifera indica* leaf (Kumari *et al.*, 2020) <sup>[23]</sup>, *Psidium guajava* leaf (Shukla *et al.*, 2014) <sup>[39]</sup>, *Diospyros melanoxylon* (Rao *et al.*, 2015) <sup>[35]</sup>, *Polyalthia longifolia* leaf (Selvan and Prabha., 2014) <sup>[37]</sup>, *Eichhornia crassipes* leaf (Balasubramanian *et al.*, 2013; Ansari *et al.*, 2024) <sup>[3, 7]</sup>, *Zea mays* leaf (Younas *et al.*, 2021) <sup>[46]</sup>, *Samanea saman* leaf (Klomklang *et al.*, 2021) <sup>[20]</sup>, *Camellia sinensis* leaf (Chaudhuri and Jamatia., 2021) <sup>[11]</sup> and *Prosopis juliflora* (Patnaik *et al.*, 2022) <sup>[32]</sup>.

The goal of the current study is to use the earthworm *Eisenia fetida* to vermiculite banana (*Musa paradisiaca*) and water hyacinth (*Eichhornia crassipes*) leaf wastes into vermicompost. Cow dung was combined with the waste biomass of banana and water hyacinth leaves during the study. Compost (devoid of worms) and vermicompost containing earthworms (*Eisenia fetida*) are made by combining various separate organic wastes with cow dung.

## Materials and methods

### Selection of earthworm

The earthworm of *Eisenia fetida* earthworms was chosen to evaluate the vermicomposting process's degradation efficiency using particular organic waste and the quality of

the stabilized end product, vermicompost, as determined by physicochemical parameter analysis.

### Vermiculture

Earthworm culture is known as vermiculture. The goal is to continuously increase the number of worms to obtain a sustainable harvest. The worms are used to expand a vermicomposting operation. The breeding stock of *Eisenia fetida* was obtained from the culture maintained in the vermibio-tech laboratory, Department of Zoology, Annamalai University, India.

### Collection of organic wastes

#### Cow dung

In the current experiment, cow dung was gathered in a gunny bag from the dairy and surrounding areas of Annamalai University and transported to the vermicomposting lab, Department of Zoology, Tamil Nadu, India. Cow dung free of urine was collected separately and in sufficient quantities for an experiment where it was sun-dried and powdered.

#### Leaf litters

Banana (*Musa paradisiaca*) and Water hyacinth (*Eichhornia crassipes*) leaf litter, which was gathered at random from the Annamalai University campus in Tamil Nadu, India, is used as substrate. The leaf litter of Banana (*Musa paradisiaca*) and Water hyacinth (*Eichhornia crassipes*) was collected, dried, chopped into small pieces, and stored in a container in the vermicomposting lab, Department of Zoology, Annamalai University.



Banana Tree



Water Hyacinth Plant



Banana Leaf Waste



Water Hyacinth Leaf Waste

**Plate 1:** Experiments on composting and vermicomposting with different organic waste



Cow Dung

*Eisenia Fetida*Treatment T<sub>1</sub>-T<sub>3</sub>, VT<sub>1</sub>-VT<sub>3</sub>

Vermicompost

**Plate 2:** Experiments on composting and vermicomposting with different organic waste

## Methods

### Experimental process of vermicomposting

The processes of composting and vermicomposting were carried out in plastic containers. In the current study, a compost mixture was made using Banana (*Musa paradisiaca*) and Water hyacinth (*Eichhornia crassipes*) leaves in a ratio determined by the experiment description listed in Table 1. T<sub>1</sub>, T<sub>2</sub>, and T<sub>3</sub> compost experiment (without worms). In each of the setups listed in Table 2 and referred to as VT<sub>1</sub>, VT<sub>2</sub>, and VT<sub>3</sub>, vermicompost experiment (with worms) 45g of earthworm *Eisenia fetida* were inoculated using the same kinds of mixture.

Banana leaves (*Musa paradisiaca*) T<sub>1</sub> and VT<sub>1</sub> in a 1:1 ratio (750g + 750g) with cow dung. Water hyacinth leaves (*Eichhornia crassipes*) T<sub>2</sub> and VT<sub>2</sub> groups and mixed 1:1 (750g + 750g) with cow dung. Banana leaves (*Musa paradisiaca*) and Water hyacinth leaves (*Eichhornia crassipes*) are combined with cow dung in a 1:1:1 ratio (500g + 500g + 500g) for T<sub>3</sub> and VT<sub>3</sub>. In the treatment description mentioned above, all of the compost mixtures were weighed on a dry weight basis and thoroughly mixed with water to ensure moisture content. After that, the content was given two weeks to begin its natural breakdown. Because partially degraded organic waste is preferred by earthworms over fresh waste. The T<sub>1</sub>, T<sub>2</sub>, and T<sub>3</sub> experimental treatments without earthworms. Experiments VT<sub>1</sub>, VT<sub>2</sub>, and VT<sub>3</sub> were inoculated with 45g of earthworms *Eisenia fetida* in each experiment. Every experiment set up on top is shielded by a net, jute bags, and steel mesh because *Eisenia fetida* is protected from rats,

moles, frogs, birds, flatworms, red ants, centipedes, and other insects. All of the aforementioned experiments were conducted at the Vermitechnology Laboratory, Department of Zoology, Annamalai University.

### Analysis of Physico-chemical parameters of compost and vermicompost samples

After 75 days, a homogenized substrate sample (10g dry weight basis) was extracted for macro and micronutrient analysis in the compost and vermicompost materials for each trial. The standard analytical procedures were applied to the compost and vermicompost samples for the following experiment pH, electrical conductivity, organic carbon (OC), available nitrogen (N), available phosphorus (P), available potassium (K), available sulphur (S), exchangeable calcium (Ca), exchangeable magnesium (Mg), copper (Cu), zinc (Zn), iron (Fe), and manganese (Mn). Physicochemical analysis such as pH was estimated as per the procedure described by ISI Bulletin (1982)<sup>[9]</sup> and Electrical conductivity (EC) mS/cm was determined by ISI Bulletin (1982). The organic carbon content was determined using an empirical method outlined by Walkley and Black (1934)<sup>[44]</sup>. The Kjeldahl method was used to ascertain the vermicompost samples' total nitrogen content, by Singh and Pradhan (1981)<sup>[40]</sup>. Jackson's (1973)<sup>[17]</sup> colorimetric method was used to estimate the substrate's total phosphorus content. Total potassium was measured in the compost and vermicompost using a flame photometer by Jackson (1973)<sup>[17]</sup>. The availability of sulfur was determined by Yasushi and Shinjiro (2010)<sup>[47]</sup>. The exchangeable calcium and

magnesium were determined by Apha (1995) [4]. Determination of micronutrients Zinc (Zn), Iron (Fe), Copper (Cu), and Manganese (Mn) have been analyzed by Lindsay and Norvell (1978) [24] using an atomic absorption spectrophotometer [AAS 414].

**Statistical analyses**

Each experiment was carried out in triplicate, and an analytical mean value was determined.

**Results and discussion**

The physicochemical parameters of various treatments changed considerably during vermicomposting by the epigeic earthworm *Eisenia fetida*. The final vermicompost product from the three treatments (VT<sub>1</sub>, VT<sub>2</sub>, and VT<sub>3</sub>) exhibited a pleasant earthy odor, a granular texture, a darker

color, and homogeneity compared to natural composts (T<sub>1</sub>, T<sub>2</sub>, and T<sub>3</sub>).

**Physico-chemical Parameters.** The study examined various physicochemical parameters of organic wastes combined with cow dung, including pH, electrical conductivity (EC), organic carbon (OC), available nitrogen (N), phosphorus (P), potassium (K), sulfur (S), exchangeable calcium (Ca), exchangeable magnesium (Mg), copper (Cu), zinc (Zn), iron (Fe), and manganese (Mn). The Treatments were:

**T<sub>1</sub>-VT<sub>1</sub>:** Banana leaves (*Musa paradisiaca*) with cow dung 1:1 ratio

**T<sub>2</sub>-VT<sub>2</sub>:** Water hyacinth leaves (*Eichhornia crassipes*) with cow dung 1:1

**T<sub>3</sub>-VT<sub>3</sub>:** Banana and water hyacinth leaves with cow dung 1:1:1

**Table 1:** Status on physicochemical parameters of compost (without worms) produced out of a mixture of different organic wastes and cow dung

S. No	Physicochemical parameters	Compost of different organic wastes: cow dung		
		Banana leaf wastes (T <sub>1</sub> )	Water hyacinth leaf wastes (T <sub>2</sub> )	Banana leaf and water hyacinth leaf (T <sub>3</sub> )
1	pH	6.40	6.60	6.80
2	Electrical conductivity (EC) (mS/cm)	4.50 X 10 <sup>2</sup>	4.60 X 10 <sup>2</sup>	4.80 X 10 <sup>2</sup>
3	Organic carbon (OC)	21.00%	26.50%	28.00%
4	Available nitrogen (N)	0.74%	0.80%	0.89%
5	Phosphorus (P)	0.81%	0.88%	0.95%
6	Available potassium (K)	0.68%	0.77%	0.84%
7	Available Sulphur (S)	0.27%	0.35%	0.40%
8	Exchangeable calcium (Ca)	1.48%	1.56%	1.61%
9	Exchangeable magnesium (Mg)	0.31%	0.36%	0.41%
10	Copper (Cu)	70ppm	65ppm	60ppm
11	Zinc (Zn)	200ppm	260ppm	310ppm
12	Iron (Fe)	130ppm	160ppm	210ppm
13	Manganese (Mn)	240ppm	290ppm	330ppm

**Table 2:** Status of the physicochemical parameters of vermicompost (with worms) produced by the action of earthworms *Eisenia fetida* is made of a mixture of different organic wastes and cow dung

S. No	Physicochemical parameters	Compost of different organic wastes: cow dung		
		Banana leaf wastes (VT <sub>1</sub> )	Water hyacinth leaf wastes (VT <sub>2</sub> )	Banana leaf and Water hyacinth leaf (VT <sub>3</sub> )
1	pH	6.70	6.90	7.0
2	Electrical conductivity (EC) (mS/cm)	4.60 X 10 <sup>2</sup>	4.80 X 10 <sup>2</sup>	5.00 X 10 <sup>2</sup>
3	Organic carbon (OC)	11.40%	11.80%	12.10%
4	Available nitrogen (N)	1.62%	1.70%	1.78%
5	Phosphorus (P)	1.31%	1.36%	1.40%
6	Available potassium (K)	1.30%	1.35%	1.42%
7	Available Sulphur (S)	0.34%	0.39%	0.48%
8	Exchangeable calcium (Ca)	1.53%	1.66%	1.78%
9	Exchangeable magnesium (Mg)	0.35%	0.41%	0.48%
10	Copper (Cu)	90ppm	75ppm	110ppm
11	Zinc (Zn)	260ppm	320ppm	370ppm
12	Iron (Fe)	160ppm	200ppm	240ppm
13	Manganese (Mn)	270ppm	310ppm	380ppm

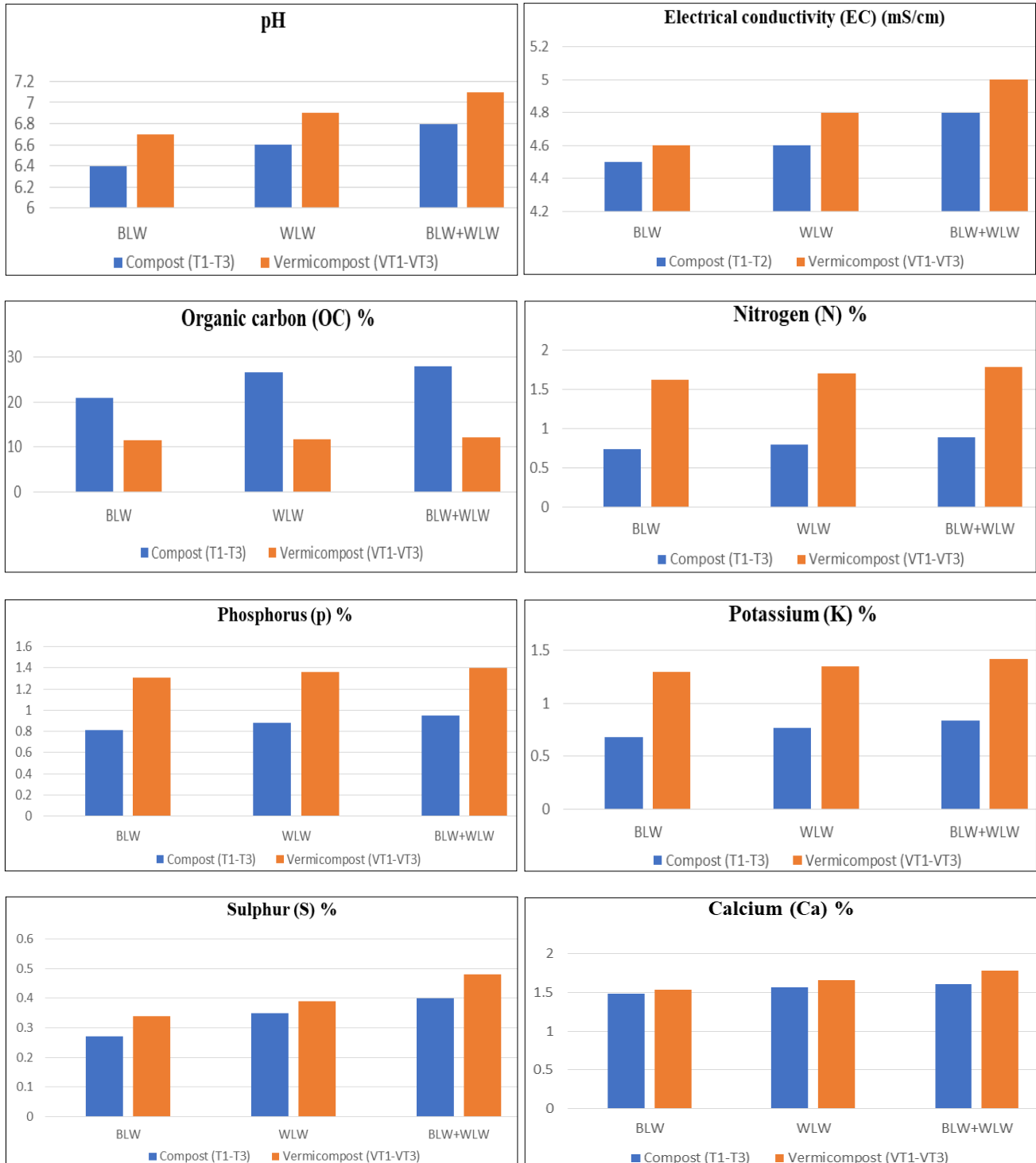
The pH of natural composts (T<sub>1</sub>-6.40, T<sub>2</sub>-6.60, T<sub>3</sub>-6.80) increased slightly in vermicomposts (VT<sub>1</sub>-6.70, VT<sub>2</sub>-6.90, VT<sub>3</sub>-7.0), indicating a shift toward a more alkaline environment (Tables 3 and 4, Graph 1). This increase in pH could be due to microbial metabolism producing CO<sub>2</sub> and organic acids during decomposition (Shahbaz *et al.*, 2017) [38]. Vermicomposts showed significantly higher electrical conductivity (VT<sub>1</sub>-4.60 mS/cm, VT<sub>2</sub>-4.80 mS/cm, VT<sub>3</sub>-5.00 mS/cm) compared to natural composts (T<sub>1</sub>-4.50 mS/cm, T<sub>2</sub>-4.60 mS/cm, T<sub>3</sub>-4.80 mS/cm) (Tables 1 and 2, Graph 1).

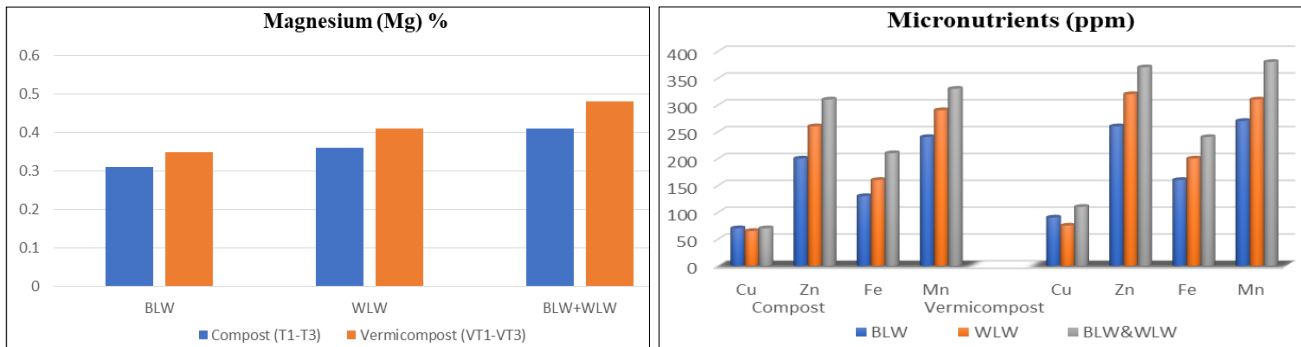
This increase is likely due to the release of mineral salts such as potassium, phosphate, and ammonium during the vermicomposting process (Gondek *et al.*, 2020) [15]. This reduction is attributed to the high biodegradation rate by earthworms and microorganisms, and the utilization of organic carbon by earthworms' growth (Zheng *et al.*, 2018) [48]. Vermicomposts exhibited significantly higher nitrogen content (VT<sub>3</sub>-1.78%, VT<sub>2</sub>-1.70%, VT<sub>1</sub>-1.62%) compared to composts (T<sub>1</sub>-0.74%, T<sub>2</sub>-0.80%, T<sub>3</sub>-0.89%) (Tables 1 and 2, Graph 1). This increase is due to nitrogen mineralization by

earthworms and the presence of nitrogenous excretory substances and enzymes in vermicompost (Nyamusamba *et al.*, 2023; Badhwar and Singh, 2021) [6, 30]. Phosphorus content was higher in vermicomposts (VT<sub>3</sub>-1.40%, VT<sub>2</sub>-1.36%, VT<sub>1</sub>-1.31%) compared to composts (T<sub>1</sub>-0.81%, T<sub>2</sub>-0.88%, T<sub>3</sub>-0.95%) (Tables 1 and 2, Graph 1). Earthworms enhance phosphorus availability through mineralization during vermicomposting (Bhat *et al.*, 2018) [8]. In the vermicompost potassium content was increased is due to the efficient breakdown of organic matter by earthworms, releasing mineral ions like potassium (Madan and Yadav, 2012) [25].

The available Sulfur (S), Exchangeable Calcium (Ca), and Exchangeable Magnesium (Mg) Vermicomposts had higher

concentrations of sulfur, calcium, and magnesium compared to composts (Tables 1 and 2, Graphs 1). This increase is due to the mineralization process facilitated by earthworms and microorganisms (Court *et al.*, 2021) [13]. All the micronutrients Iron (Fe), Copper (C), Zinc (Zn), and Manganese (Mn) were also observed more in the vermicompost rather than in the composts of various organic waste including cow dung (Tables 1 and 2, Graphs 1) attributed to the degradation and mineralization process by the action of earthworms and microorganisms. Some researchers reported increased micronutrient (Heavy metals) concentrations in the product of vermicomposting (Yadav *et al.*, 2013; Varma *et al.*, 2015 and Piya *et al.*, 2018) [33, 42, 45].





**Graph 1:** Comparison of physicochemical parameters in the compost and vermicompost produced out of different organic wastes

## Conclusion

From this study, it can be concluded that vermicomposting is a better technology than compost for converting different types of organic waste into manure. Chemical analysis shows that vermicompost has higher soil nutrients than compost except organic carbon. The present study showed that good-quality vermicompost could be prepared from dry leaves. When India is facing a shortage in supplying chemical fertilizer to all its farmers to increase food production and gradually switching over to an evergreen revolution through integrated nutrient management where vermicompost plays an important role, none can afford to destroy these dry leaves by burning. Vermicomposting is a sustainable, low-cost, and easy solution for the beneficial utilization of such huge quantities of dry leaves.

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