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# EVALUATION OF PHYSICO-CHEMICAL PROPERTIES AND PLANT GROWTH STUDIES OF VERMICOMPOST PRODUCED BY EARTHWORMS FROM SOME TERRESTRIAL AND AQUATIC PLANT LEAVES

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*Key words : Vermicomposting, Cocosnucifera, Acacia auriculiformis, Musa paradisiaca, Pistia, Nelumbo, Hydrilla.*

Abstract – Vermicomposts processed from certain terrestrial (*Cocosnucifera, Acacia auriculiformis* and *Musa paradisiaca*) and aquatic (*Pistia* sp., *Nelumbo* sp. and *Hydrilla* sp.) plant leaves were analysed for various physico-chemical parameters like pH, electric conductivity (EC), total dissolved solids (TDS), organic carbon, nitrites and total phosphorus. The range of pH in different vermicompost samples were from 6.27±0.01 (*Hydrilla* sp.) to 6.77±0.01 (*Pistia* sp.); electrical conductivity from 176±0.0µS (*Musa paradisiaca*) to 448±2.0µS (aquatic plant mixture); TDS from 101±0.0mg/L (*Musa paradisiaca*) to 312±2.0 mg/L (*Pistia* sp.); organic carbon from 2.20±0.0% (*Acacia auriculiformis*) to 4.70±0.02% (terrestrial plant mixture); nitrites from 2.40±0.01 µg/L (terrestrial plant mixture) to 5.20±0.01 µg/L (*Musa paradisiaca*); total phosphorous from 0.035±.0.0 mg/100g (*Acacia auriculiformis*) to 0.13±.0.0 mg/100g (terrestrial plant mixture). Plant growth study (mean plant height) was conducted in the seedlings of *Vigna unguiculata* L for each treatment. The plant height was increased significantly in the pots filled with vermicomposts of *Cocosnucifera, Acacia auriculiformis, Musa paradisiaca, Hydrilla* sp., terrestrial plant mixture and aquatic plant mixture. It was inhibited and not significant in the pots filled with vermicomposts of *Pistia* sp. and *Nelumbo* sp. It can be summarized that for *Vigna unguiculata* L, the best growth substrate regarding plant height is vermicompost prepared from leaf materials of *Hydrilla* sp. followed by *Cocosnucifera*.

## INTRODUCTION

Vermicomposting is a simple and rapid biotechnological process of degradation of organic matter, in which certain species of earthworms are used to increase the process of waste conversion and produce a better end product known as vermicompost. It is a mesophilic process and the process is faster than composting because the material is passes through the earthworm gut and transformation takes place, where by the resulting earthworm castings (worm manure) are rich in microbial activity and plant growth regulators. It is easy to prepare, has excellent properties and is absolutely harmless to plants. Vermiculture has become a popular source of organic farming as it improves the soil texture and quality (Bisen *et al*., 2011). Earthworms consume various organic wastes and reduce the volume by 40-60%. Each earthworm weighs about 0.5g to 0.6g, eats waste equivalent to its body weight and produces cast equivalent to about 50 percent of the waste it consume in a day. These worm castings have been analyzed for chemical and biological properties. The moisture content of casting ranges between 32% and 66% and the pH is around 7.0. The worm castings contain higher percentage (nearly two fold) of both macro and micronutrients than the garden compost.

Vermicomposting technologyis a fast growing one with its pollution free, cost effective and efficient nature (Hemalatha, 2012). Vermicomposting is defined as low cost technology to utilize the organic waste by earthworms in collaboration with microorganisms to yield worm cast which is rich in nutrition and organic matter (Albanell *et al*., 1988; Hand *et al*., 1988). In this process lots of energy is released which is maintained by frequent mixing and watering to provide a mesophilic condition of 10-32 °C for proper functioning of microorganisms and earthworms. Vermicompost is a good source of nitrogen, potassium and phosphorus and it has high water holding capacity and act as good plant growth promoters and regulator which is used by the plant as and when needed, through mineralization (Dominguez *et al*., 1997).

Vermiculture can be practiced anywhere, even on a small scale, and easily be integrated into any agricultural system. The characteristics of vermicompost is similar to the soil found in deciduous woodlands and mixed forests. It is black, odourless and crumby substrate and has balanced nutrition composition for plants. It contained above-average number of microorganisms which revitalize the soil. It is loose at stable soil structure and absolutely free from all types of synthetic chemical additives. Earthworms helps to provide excellent conditions for the buildup of a number of useful organisms and consequently the soil with its teeming millions of organism, becomes highly suitable for plant growth. Vermicompost has found to be effective in enhancing the elongation of stem, biomass production and root formation. It can promote vigorous growth of seedling and integration with inorganic fertilizers increase the yield of various crops (Edwards *et al*., 2004; Ghosh *et al*., 1999). Nutrients in vermicompost are present in readily available forms for plant uptake such as nitrates, exchangeable phosphorus, potassium, calcium, and magnesium (Orozco *et al*., 1996). This study was carried out to evaluate the physico-chemical properties and plant (*Vigna unguiculata* L) growth studies of vermicompost produced by earthworms from some terrestrial (*Cocos nucifera, Acacia auriculiformis* and *Musa paradisiaca*) and aquatic (*Pistia* sp., *Nelumbo* sp. and *Hydrilla* sp.) plant leaves.

## MATERIALS AND METHODS

The experiments for vermicompost production were set according to the standard method described by Joshi and Vig (2010).½ Kg of cattle dung, 1 Kg of sieved black and red soil mixtures and ½ Kg of partially composted leaf materials were used as raw materials to prepare vermicompost. The leaf materials were collected individually and in combination from the three different terrestrial plants namely, *Cocosnucifera, Acacia auriculiformis* and *Musa paradisiaca* and also collected individually and in combination from the three different aquatic plants namely, *Pistia* sp., *Nelumbo* sp. and *Hydrilla* sp. Experiments were conducted by taking sixteen sets of pots in triplicates(total forty-eight pots), out of these, first (control) and second (test) set of pots were used for the production of vermicompost by *Cocosnucifera*, similarly third (control) and fourth (test) sets were used for *Acacia auriculiformis*, fifth (control) and sixth (test) sets were used for *Musa paradisiaca* and seventh (control) and eighth (test) sets were used for leaf mixtures of terrestrial plants, ninth (control) and tenth (test) sets were used for *Pistia* sp., eleventh (control) and twelfth (test) sets were used for *Nelumbo* sp., thirteenth (control) and fourteenth (test) sets were used for *Hydrilla* sp. and fifteenth (control) and sixteenth (test) sets were used for leaf mixtures of aquatic plants.

Beds were prepared in all sixteen sets of pots by making the layers using the sieved soil, cattle dung and respective leaf materials. Then about fifteen earthworms (*Eisenia foetida*) were added to eight set of pots (twenty four pots) which were selected as test. Eight set of pots (twenty four pots) selected as control were treated without earthworms. The surface of all pots were covered with muslin cloth and water was sprinkled for all forty-eight pots every day. Vermicompost were harvested from all pots after four months of experimental duration, dried, sieved and analyzed for physico-chemical parameters such as pH, electric conductivity (EC), total dissolved solids (TDS), organic carbon, nitrites and total phosphorus. pH and conductivity were determined by using Systronics water analyzer 371 kit. TDS, organic carbon, nitrites and total phosphorus were estimated by following the standard procedure prescribed by Trivedy and Goel (1986) and APHA (2005). Plant growth studies were conducted by sowing the seeds of *Vigna unguiculata* L in sixteen set of potsfilled with compost (control) and vermicompost (test) samples in triplicates. The plants were allowed to grow over a period of 8 weeks. Then, plants were observed and the mean plant height was measured in each experimental set up.

## RESULTS

The results of physico-chemical parameters and plant growth studies of vermicompost produced by earthworms from terrestrial and aquatic plant leaves are presented in Table 1 and 2. Earthworm species (*Eisenia foetida*) used for the experiment is showed in

Fig.1. Vermicompost production in pots are showed in Fig. 2 and 3. Plant (*Vigna unguiculata*) growth (height) studies using various compost samples are showed in Fig. 4, 5, 6 and 7. The pH recorded in the vermicompost prepared from *Cocosnucifera* leaf materials was 6.46±0.0, electrical conductivity - 368±1.0µS, TDS - 249±2.0 mg/L, organic carbon - 2.86±0.01%, nitrites - 3.40±0.02 µg/L, total phosphorous - 0.07±.0.0 mg/100g. The pH recorded in the vermicompost prepared from *Acacia auriculiformis* leaf materials was 6.47±0.01, electrical conductivity - 336±1.0 µS, TDS - 138±0.0 mg/L, organic carbon - 2.20±0.0%, nitrites - 2.60±0.01 µg/L, total phosphorous - 0.035±.0.0 mg/100g. The pH of *Musa paradisiaca* vermicompost was 6.60±0.0, electrical conductivity - 176±0.0µS, TDS - 101±0.0 mg/L, organic carbon - 2.82±0.0%, nitrites - 5.20±0.01 µg/L, total phosphorous - 0.07±.0.0 mg/100g. The pH of vermicompost of terrestrial plant leaf mixture was found to be 6.49±0.01, electrical conductivity - 412±0.0µS, TDS - 229±2.0 mg/L, organic carbon - 4.70±0.02%, nitrites - 2.40±0.01 µg/L, total phosphorous - 0.13±.0.0 mg/100g.

The pH of vermicompost produced from *Pistia* sp. comes out to be 6.77±0.01, electrical conductivity - 506±1.0µS, TDS - 312±2.0 mg/L, organic carbon - 3.15±0.58%, nitrites - 4.10±0.01 µg/L, total phosphorous - 0.06±.0.0 mg/100g. The pH of vermicompost produced from *Nelumbo* sp. was 6.50±0.0, electrical conductivity - 216±0.0 µS, TDS - 126±1.0 mg/L, organic carbon - 2.70±0.0%, nitrites - 3.40±0.0 µg/L, total phosphorous - 0.06±.0.0 mg/

Table 1. Physico-chemical and biological parameters of vermicompost samples from terrestrial plant leaves (mean±SD)

| Vermicompost Samples | *Cocos* sp. | | *Acacia*sp. | | *Musa* sp. | | Mixture of *Cocos* sp., *Acacia* sp. and *Musa* sp. | |
|---|---|---|---|---|---|---|---|---|
| | Control | Test | Control | Test | Control | Test | Control | Test |
| pH | 7.38±0.01 | 6.46±0.0 | 6.27±0.0 | 6.47±0.01 | 6.46±0.01 | 6.60±0.0 | 6.24±0.0 | 6.49±0.01 |
| Conductivity (µS) | 317±1.0 | 368±1.0 | 662±2.0 | 336±1.0 | 458±0.0 | 176±0.0 | 289±1.0 | 412±0.0 |
| TDS (mg/L) | 176±0.58 | 249±2.0 | 368±2.0 | 138±0.0 | 249±0.58 | 101±0.0 | 160±0.0 | 229±2.0 |
| Organic carbon (%) | 2.45±0.0 | 2.86±0.01 | 2.40±0.0 | 2.20±0.0 | 2.40±0.0 | 2.82±0.0 | 4.50±0.0 | 4.70±0.02 |
| Nitrites (µg/L) | 2.20±0.01 | 3.40±0.02 | 0.08±0.01 | 2.60±0.01 | 4.40±0.03 | 5.20±0.01 | 0.12±0.0 | 2.40±0.01 |
| Total phosphorous (mg/100g) | 0.013±0.0 | 0.07±0.0 | 0.025±0.0 | 0.035±0.0 | 0.35±0.0 | 0.07±0.0 | 0.07±0.0 | 0.13±0.0 |
| Plant (*Vigna unguiculata* L) height (cm) | 58.3±2.0 | 64.5±3.0 | 50.0±2.0 | 55.0±1.0 | 68.0±2.0 | 72.5±0.0 | 69.0±2.0 | 72.2±3.0 |
| Difference in plant height (cm) | 6.2 | | 5.0 | | 4.5 | | 3.2 | |

Table 2. Physico-chemical and biological parameters of vermicompost samples from aquatic plant leaves (mean±SD)

| Vermicompost Samples | *Pistia* sp. | | *Nelumbo* sp. | | *Hydrilla* sp. | | Mixture of *Pistia* sp., *Nelumbo* sp. and *Hydrilla* sp. | |
|---|---|---|---|---|---|---|---|---|
| | Control | Test | Control | Test | Control | Test | Control | Test |
| pH | 7.02±0.0 | 6.77±0.01 | 6.28±0.0 | 6.50±0.0 | 6.40±0.0 | 6.27±0.01 | 7.38±0.01 | 6.43±0.0 |
| Conductivity (µS) | 157±0.0 | 506±1.0 | 708±2.0 | 216±0.0 | 473±1.0 | 325±1.0 | 317±0.0 | 448±2.0 |
| TDS (mg/L) | 97±1.0 | 312±2.0 | 364±2.0 | 126±1.0 | 290±2.0 | 172±1.0 | 176±2.0 | 259±2.0 |
| Organic carbon (%) | 2.60±0.01 | 3.15±0.58 | 2.80±0.0 | 2.70±0.0 | 3.10±0.01 | 2.60±0.58 | 3.30±0.01 | 3.10±0.0 |
| Nitrites (µg/L) | 4.10±0.01 | 5.24±0.02 | 4.10±0.0 | 3.40±0.0 | 6.70±0.02 | 4.81±0.03 | 1.60±0.02 | 3.40±0.0 |
| Total phosphorous (mg/100g) | 0.002±0.0 | 0.06±0.0 | 0.001±0.0 | 0.01±0.0 | 0.35±0.0 | 0.04±0.0 | 0.01±0.0 | 0.04±0.0 |
| Plant (*Vigna unguiculata* L) growth (cm) | 67.2±0.10 | 63.0±1.0 | 56.4±1.0 | 53.0±2.0 | 46.0±2.0 | 54.0±1.0 | 63.0±0.0 | 66.8±0.0 |
| Difference in plant height (cm) | -4.2 | | -3.4 | | 8.0 | | 3.8 | |

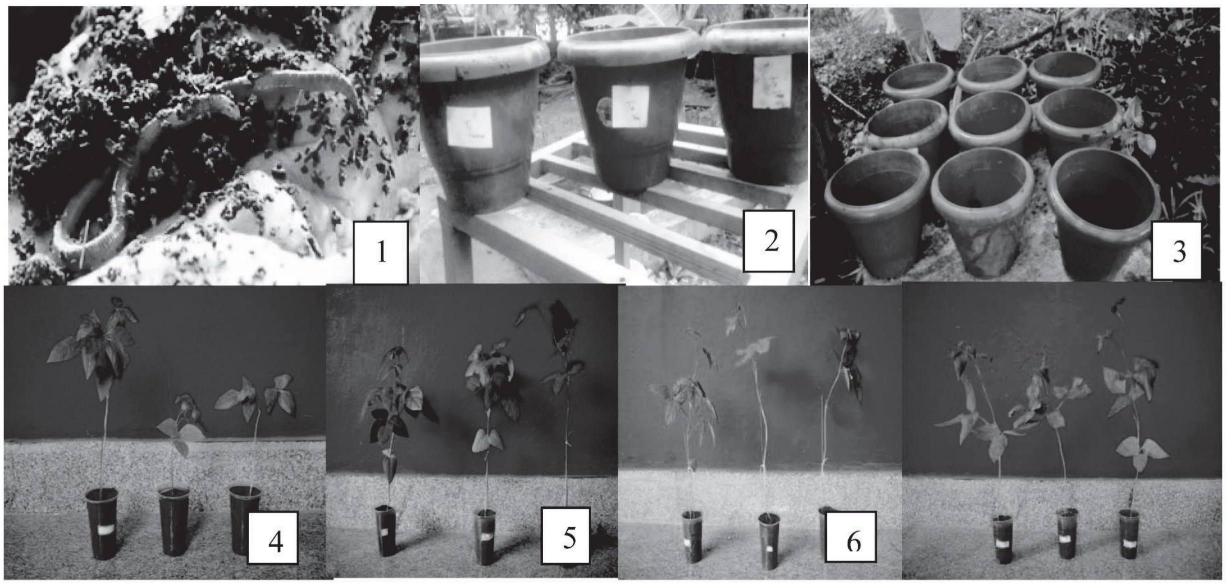


Fig. 1. Earthworm species *Eisenia foetida* Fig. 2 and 3. Vermicompost production in pots
Fig. 4, 5, 6 and 7. Plant (*Vigna unguiculata* L) growth studies using various compost samples

100g. The pH of vermicompost produced from *Hydrilla* sp. was 6.27±0.01, electrical conductivity - 325±1.0µS, TDS - 172±1.0 mg/L, organic carbon - 2.60±0.58%, nitrites - 4.81±0.03 µg/L, total phosphorous - 0.04±.0.0mg/100g. The pH of vermicompost produced from aquatic plant mixture comes out to be 6.43±0.0. electrical conductivity - 448±2.0µS, TDS - 259±2.0 mg/L, organic carbon - 3.10±0.0%, nitrites - 3.40±0.0 µg/L, total phosphorous - 0.04±.0.0 mg/100g. The height of plant (*Vigna unguiculata*) recorded in the pot filled with the vermicompost prepared from *Cocosnucifera* was 64.5±3.0 cm, *Acacia auriculiformis*-55.0±1.0 cm, *Musa paradisiaca*-72.5±0.0 cm, terrestrial plant mixture - 72.2±0.0 cm, *Pistia* sp. -63.0±1.0 cm, *Nelumbo* sp. -53.0±2.0 cm, *Hydrilla* sp. - 54±1.0 cm and aquatic plant mixture -66.8±.0.0 cm.

## DISCUSSION

Vermicomposting has been arising as an innovative ecotechnology for the conversion of various types of wastes into humus like material known as vermicompost. Vermicompost is humus like, finely granulated and stabilized material which can be used as a soil conditioner to reintegrate the organic matter to the agricultural soil. The earthworms are known to ingest partially decomposed leaf litter (microbial degradated) and transform them into mineral-rich manure and enrich the soil with organic matter. Certain earthworm species are capable of consuming a wide range of organic wastes from sewage sludge, animal wastes, agricultural residues, domestic wastes, to industrial wastes. The success of the process depends upon several process parameters like quality of raw material, pH, conductivity, moisture, temperature, aeration, type of vermicomposting system and earthworm species used. Under favorable conditions of temperature and moisture, earthworms maintain the aerobic conditions in the vermicomposting process, ingest organic waste materials and produce a humus-like substance which is more homogeneous than the organic wastes or raw materials used (Edwards and Burrows, 1988).

The application of vermicompost favorably affects soil pH, microbial population and soil enzyme activities (Maheswarappa *et al*. 1999). It also reducesthe proportion of water-soluble chemical, which cause possible environmental contamination (Mitchell and Edwards, 1997). The pH of vermicompost from different wastes have also been reported like sheep manure - 8.6 (Gutiérrez-Miceli *et al*., 2007), sewage sludge - 7.2 (Masciandaro *et al*., 2000). Joshi and Vig (2010) reported the pH of cattle dung vermicompost as 8.48 and different proportions of soil and cattle dung vermicompost as 3.7 and 3.8. In this study, the pH recorded in different vermicompost was ranged from 6.27±0.01 (*Hydrilla* sp.) to 6.77±0.01 (*Pistia* sp.). Electrical conductivity was increased in vermicomposts prepared from *Cocosnucifera, Pistia* sp., terrestrial plant mixture and aquatic plant mixture than control, however, it was decreased in vermicomposts prepared from *Acacia auriculiformis, Musa paradisiaca*, *Nelumbo* sp. and *Hydrilla* sp. than control. TDS specify the various kinds of minerals such as carbonates, bicarbonates, chlorides, sulphates, phosphates, nitrates and manganese present in vermicompost. The TDS reported in different vermicompost samples was ranged from 101±0.0 mg/L (*Musa paradisiaca*) to 312±2.0 mg/L (*Pistia* sp.).

In vermicomposting process, several physical, chemical and the biological reactions take place, thereby resulting changes in the organic matter in a certain period of time (Kumar *et al*., 2017). The physical actions include fragmentation, turn over and aeration, whereas biochemical actions include enzymatic digestion, nitrogen enrichment, transport of inorganic and organic materials. During this process, important plant nutrients such as nitrogen, potassium, phosphorus and calcium present in the waste materials are converted through microbial action into such chemical forms which are much more soluble and available to the plants than those in the parent substrate (Ndegwa and Thompson, 2001). The organic carbon reported in different vermicompost samples was ranged from 2.20±0.0% (*Acacia auriculiformis*) to 4.70±0.02% (terrestrial plant mixture).

Atiyeh *et al*., (2000) recorded that the conventional compost has a greater amount of ammonium whereas it was determined that the vermicompost has a higher quantity of nitrates which is the readily available form of nitrogen to aid superior growth and yield of plants. They also discovered that vermicompost has higher nitrogen availability and other plant nutrients like phosphorus, potassium, sulphur and magnesium and they showed considerable increase when vermicompost was added to the soil as compared to conventional compost. In this study, the nitrites recorded in different vermicompost samples was ranged from 2.40±0.01 μg/L (terrestrial plant mixture) to 5.20±0.01 μg/L (*Musa paradisiaca*). Iyer *et al.* (2012) analyzed the comparative percent content of nitrogen and phosphorus in partially decompost and vermicompost samples. It was observed that nitrogen and phosphorus content was found to be higher in the partial decompost (3.0% nitrogen and 0.4% phosphorus) and lower in vermicompost (0.2% nitrogen and 0.28% phosphorus). The study also helped in isolating efficient nitrogen fixing and phosphate solubilizing microorganisms which could be evaluated further for their efficacy towards growth and yield of cropplants. In this study, the total phosphorous recorded in different vermicompost samples was ranged from 0.035±.0.0 mg/100g (*Acacia auriculiformis*) to 0.13±.0.0 mg/100g (terrestrial plant mixture).

Bhat and Limaye (2012) studied the nutrient status and plant growth promoting potential of prepared vermicompost. Compost and plain soil were kept as control. The physico-chemical parameters like pH, organic carbon, nitrogen, average phosphorus, calcium, magnesium and chloride content were analyzed at regular intervals, over a period of 48 days. On 48$^{th}$ day, pH of the vermicompost was found to be 7, with organic carbon-10.30%, nitrogen-0.85%, phosphorus-0.15%, calcium-1.96%, magnesium-0.80% and chloride-0.30 mg/mL. The moisture content of the vermicompost was 78.05% with a water holding capacity of 79%. Flowering capacity, height of plant, breadth and length of leaves was found more in vermicompost as compared to controls. Studies on vermicompost indicate that it increases macropore space ranging from 50 to 500 μm, resulting in improved air-water relationship in the soil which favorably affect plant growth (Marinari *et al*., 2000). Vermicompost also has a positive effect on vegetative growth, stimulating shoot and root development (Edwards *et al*., 2004). The effects include alterations in seedling morphology such as increased leaf area and root branching. Vermicompost has also been shown to stimulate plant flowering, increasing the number and biomass of the flowers produced as well as increasing fruit yield (Atiyeh *et al*., 2000, 2002; Arancon *et al*., 2004; 2008; Singh *et al*., 2008). In this study, mean plant (*Vigna unguiculata* L) height in vermicompost treatments were significantly greater in the pots filled with vermicomposts of *Cocosnucifera, Acacia auriculiformis*, *Musa paradisiaca, Hydrilla* sp., terrestrial plant mixture and aquatic plant mixture than control. The plant height was inhibited and not significant in the pots filled with vermicomposts of *Pistia* sp. and *Nelumbo* sp. It can be summarized that for *Vigna unguiculata* L. the best growth substrate regarding plant height is vermicompost prepared from leaf materials of *Hydrilla* sp. followed by *Cocosnucifera*.

## CONCLUSION

Physico-chemical variations were reported in different vermicompost compared to control. Electrical conductivity, TDS, organic carbon, nitrites and total phosphorous were increased than in vermicomposts prepared from *Cocos nucifera*, *Pistia* sp. and terrestrial plant mixture than control. Vermicompost prepared from *Cocosnucifera, Acacia auriculiformis*, *Musa paradisiaca*, *Hydrilla* sp., terrestrial plant mixture and aquatic plant mixture influenced significantly the growth of *Vigna unguiculata* L, whereas vermicompost prepared from *Pistia* sp. And *Nelumbo* sp. are not significantly influenced the growth of *Vigna unguiculata* L. It can be concluded that the best growth substrate regarding plant height for *Vigna unguiculata* L, is vermicompost prepared from leaf materials of *Hydrilla* sp. followed by *Cocos nucifera*.

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