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Vermicompost: A Sustainable Soil Amendment for Carbon Sequestration, Enhancing Microbial Growth and Physicochemical Properties of Non-Agriculture Soil

Tanaji S. Bhagat[*1], Rama S. Lokhande[2], Narendra H. Petha[3]
Basic Sciences School, Chemistry, Jaipur National University, Jaipur, Rajasthan[1*,2]
Indofil Industries Limited, Thane, Mumbai[3,4]
tanajibhagst@gmail.com, rama.lokhande@yahoo.com
npetha@indofil.com, jchandorkar@indofil.com

Abstract: *Vermicompost is proved to be one of the best natural/organic fertilizers for the soil amendment for restoring physicochemical and biological properties of the soil. The chemical composition of the vermicompost depends on the substrate and contains the micro and macro nutrients, various bio molecules like cytokinin, auxins, PGR's, enzymes required for seed germination, healthy microbial and plant growth. The use of organic amendment like vermicompost, organic manure is simple, user-friendly, eco-friendlyand sustainable alternative for soil restructuring. It was observed that vermicompost has ability tomaintain the carbon to nitrogen ratio for healthy microbial growth, slow down the use of chemical fertilizers, pesticides, increase disease resistance in crop and thereby yield per hector of the crop land by converting non agriculture land into fertile crop land. Organic amendments like vermicompost are proven to be essential for mitigating the climate change, healthy ecosystem and wellness and wellbeing of the globe.*

Keywords: Vermicompost, Organic fertilizer, Soil Amendment, Carbon to Nitrogen ratio, Seed germination, Physicochemical Properties

I. INTRODUCTION

Due to excessive use of Chemical fertilizers, Pesticides, chemically modified water-soluble Micro and Macro nutrients and lack organic amendments like crop residues, animal feces, compost, manures, vermicompost, monocropping system, the global soil is found to be deficient in carbon, nitrogen and other essential micro and macro nutrients required for healthy growth of plants. Due to Carbon and Nitrogen deficiency, poor water holding capacity, the microbial growth in soil started deteriorating globally. Soil chemistry is only one of many factors that are affecting microbial growth, biogeochemical cycle, plant and animal growth and the climate change.In order to change the soil chemistry, organic amendments are very essential.

Due to poor microbial growth in soil, the carbon sequestration potential of the soil has been decreased and that has affected the ideal carbon to nitrogen ratio required for healthy plant growth. Because of improper carbon sequestration and excessive use of chemical fertilizers, the gases like carbon dioxide and oxides of nitrogen getting released into environment and contributing to global warming and thereby climate change[1][2].

Carbon and nitrogen are one important aspect for maintaining the soil physical, chemical and biological properties. Carbon sequestration is only achieved by nitrogen fixation. Various farming techniques like, intercropping of cereals and legumes could be one of the best possible options for carbon sequestration and increasing the Soil Organic Carbon (SOC), over period of time. This intercropping system not only support to carbon sequestration but support to soil erosion up to 45 to 50 % also[3][4].

There is unbreakable natural correlation between plants and soil. The growth of plant in particular type of the soil is depends on the physical, chemical and biological properties of the soil. Similarly, the growth of particular plant is also responsible for altering or modifying the physical, chemical and biological properties of the soil. The interface between

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the plant roots and the soil is very complex to define, but the roots of the plants secrete various phytochemicals in the soil in their vicinity which boots the soil heath and also microbial growth[5].

The colour and the texture of the soil is one of the physical parameters to determine the physical and chemical properties of the soil. The sandy red soil is having remarkable concentration of iron than that of off white or creamy sandy loam soil but having very poor water holding and retention capacity and hence plant roots couldn't able to absorb water and nutrients and leads to poor plant growth as compared to that of sandy loam, loam and clay soils.

In order to change the soil texture and mitigate the climate change various techniques of soil amendments like, addition of plant residues with compost, industrial effluents, effluents from sewage treatment plants, kitchen wastes, municipal wastes having 30 to 40 % of moisture could be employed[6][7].

Vermicomposting was found to be one of the best techniques for amending the soil physicochemical and biological properties. The chemical composition of the vermicompost produced is mostly depends on the substrate used. It is also found that the vermicompost not only contain the micro and macro nutrients but various bio molecules like cytokinin, auxins, plant growth regulators and various useful enzymes required for the healthy growth of plants and microorganism present in the soil[8]-[10].

By considering all above aspects and potential of Vermicompost, author decided to study the Successive progress of vermicomposting process by studying the physicochemical properties, Total microbial count of vermicompost (vermicasts) and garden soil and then study the impact of the amendmentof Vermicompost with garden soilto study changes the physicochemical properties of sandy garden soil after amendments.

Present study is based on addition of known quantity of vermicompost in garden soil, studyvarious physicochemical parameters, total microbial count of the vermicompost and the soil before and after amendment, impact of vermicompost amendment on seed germination and healthy plant growth.

II. Materials And Methods

About 1 kg Vermicompost and 1 kg garden soil was taken for the experiment. 300 g of vermicompost was mixed with 700 g of gardens oil, after drying at 105 ± 2 ºC in thermostatically controlled oven. The various physico chemical parameters, total microbial count of vermicompost, garden soil and garden soil amended with vermicompost were studied. The impact of vermicompost amendment was also studied by seed germination and plant growth in garden soil and garden soil amended with vermicompost[11].

III. Physical and Chemical Analysis

Various physico chemical parameters like pH and electrical conductivity (EC), Total Organic Carbon, Total Nitrogen, Phosphorous, Calcium, Manganese and Zinc content of the Vermicompost, garden soil and the Garden soil amended with vermicompost were determined[12][13].

A. pH and electrical conductivity (EC)

The pH and electrical conductivity of (1 %, w/w) of the test solution in deionised water was determined after calibrating the instruments using standard solutions.

B. Determination of Total Organic Carbon (TOC)

Total Organic Carbon (TOC) was determined byWalkley and Black method (Walkely and Black, 1934).

C. Determination of Total Nitrogen (N)

Nitrogen was determined by micro-Kjeldhal method (Bremner and Mulvaney 1982).

D. Determination of Phosphorous:

Phosphorous was determined by Ammonium Molybdophosphate method by Uv- Visible Spectrophotometry.

E. Determination of Potassium (K) and calcium (Ca):

K and Ca were determined by flame photometry.

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F. Determination of Manganese (Mn) and Zinc (Zn)

The Zinc and Manganese content was determined by complex ometric titration using standard EDTA solution.

G. Determination Water Holding/Retention Capacity

20 gram Vermicompost/garden soil/garden soil amended with vermicompost sample was weighed accurately in 250 mL beaker, 50 mL deionised water was added and allowed to rest for 24 hours. After 24 hours, the material was filtered through What man paper No.42., the beaker is washed with deionised water till the material is completely transferred to the paper. The excess water is allowed to drain and then residue along with the paper is weighed for to determine the water holding/retention capacity of 0 hours. Similarly, the water holding 24, 48, 72, 96, 120, 144 was determined using following formula.

Water holding/retention capacity:

$$\% C = \frac{(A-B) \times 100}{W}$$

Where, A = Weight of filter paper along with residue
B = Weight of filter paper
W = Sample weight in g

H. Determination Particle Size of Aqueous Suspension

The particle size of the aqueous suspension of garden soil and the vermicompost was determined by the particle size analyser (Malvern). The particle size inmicron at d(10), d(50) and d(90) was determined.

I. Determination of Total Microbial Count

The total microbial count of vermicompost, garden soil and vermicompost amended garden soil was determined by using nutrient agar medium.

J. Sterilization of Glass Wares

All the glass wares (Petri plate, test tubes, slides conical flask, inoculum needle, measuring cylinder, and beaker) were cleaned by cleaning solution. Then, they were washed by soap solution and tap water. Finally, they were washed with distilled water and dried and sterilized in hot air oven at 120°C for 15 minutes. All the solutions and media were sterilized in autoclave.

Preparation of Sample for Pour Plate

1 gm sample was dissolved in 100 mL deionised and used for plating.

Pour Plate Technique:

About 100 microliter of sample was poured into a sterile Petri plate and about 15 mL of nutrient agar medium was added, then gently rotated it to spread the sample by hand and the petri plates were kept in room temperature and observed for 24 -72 hrs for bacterial and fungal colonies developed.

Table 1: Physicochemical properties of Garden soil

Parameters	Garden soil	Vermicompost	Garden soil amended with Vermicompost
pH	6.79 ± 0.04	7.18 ± 0.07	6.89 ± 0.04
Electrical Conductivity (µs/cm)	8.17 ± 0.06	534 ± 0.04	275 ± 0.03
TOC (%, w/w)	8.09 ± 0.15	48.25 ± 0.05	38.46 ± 0.07
N (%, w/w)	0.11 ± 0.06	1.75 ± 0.07	1.09 ± 0.07
P (%, w/w)	0.74 ± 0.03	2.48 ± 0.03	1.52 ± 0.06
K (%, w/w)	0.77 ± 0.13	2.23 ± 0.08	1.43 ± 0.04
Ca (%, w/w)	0.85 ± 0.09	1.66 ± 0.11	1.03 ± 0.09

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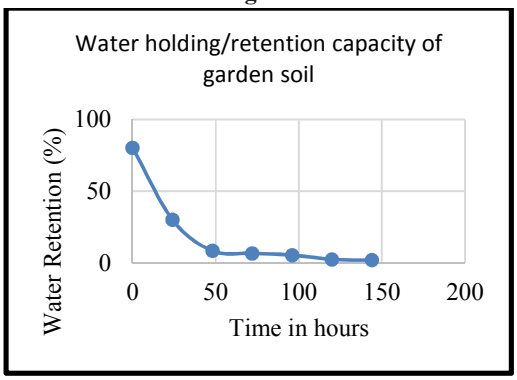
Mn (%, w/w)	0.65 ± 0.15	0.98 ± 0.12	0.64 ± 0.09
Zn (%, w/w)	0.79 ± 0.07	0.85 ± 0.03	0.81 ± 0.07
C:N	73.55 ± 0.11	27.53 ± 0.08	35.28 ± 0.04
Bulk Density (g/mL)	1.0423 ± 0.13	0.6711 ± 0.11	0.8251 ± 0.12

Figure 1:



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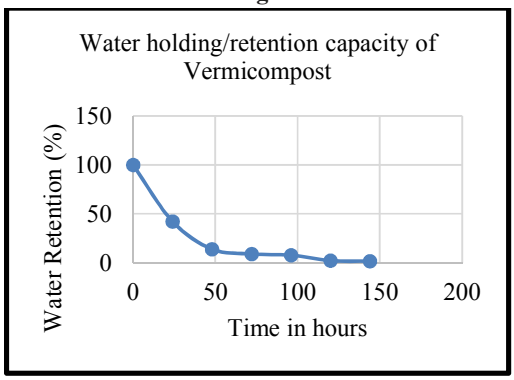

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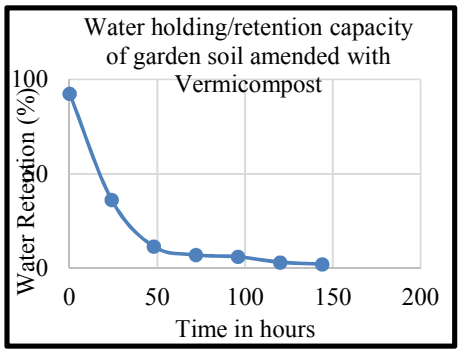

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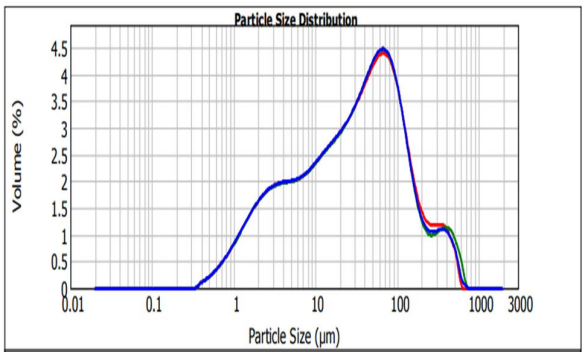

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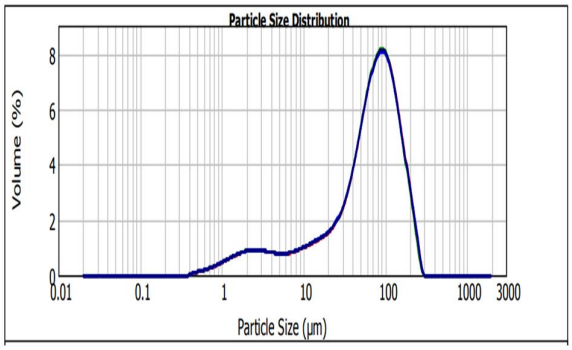
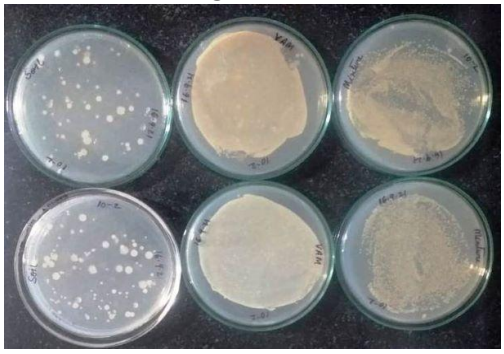


Figure 6



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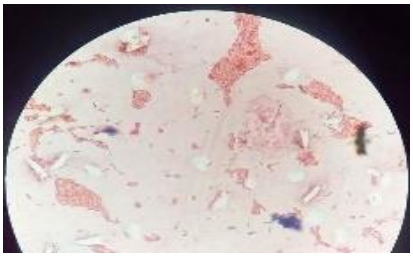

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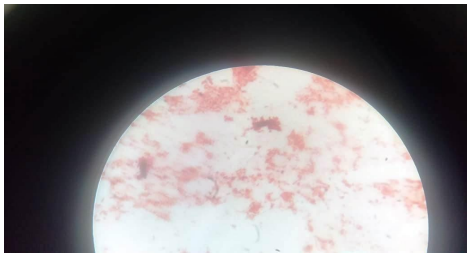

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Figure 9

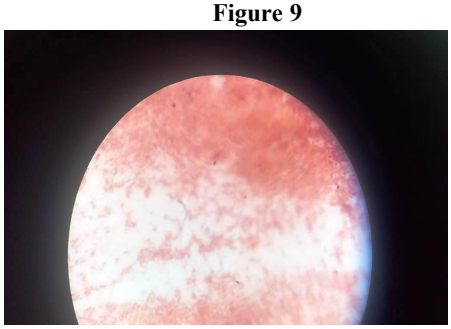

Figure 10

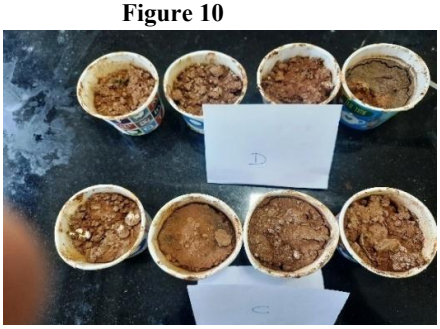

Figure 11

Figure 12

Figure 13

IV. Result And Discussion:

As shown in Table: 1, the pH of garden soil, Vermicompost and the Vermicompost amended with garden soil having almost similar pH, ranges from 6.8 to 7. The garden soil shows very less electrical conductivity 8.17 ± 0.06µs/cm, whereas, vermicompost and garden soil amended with vermicompost shows comparatively higher electrical conductivity of 534 ± 0.04µs/cm and 275 ± 0.03µs/cm, respectively. The total carbon content in garden soil was found to be very less 8.09 ± 0.15 % as compared to that of Vermicompost 48.25 ± 0.05 % and Vermicompost amended with garden soil. The total nitrogen content is also found to be very less, 0.11 ± 0.06 % in garden soil as compared to the Vermicompost, 1.75 ± 0.07 % and garden soil amended with Vermicompost, 1.09 ± 0.07 %. The phosphorous, potassium, calcium, manganese and Zinc contents also found to be quite less, 0.74, 0.77, 0.85, 0.65, 0.79 % in garden soil as compared to the Vermicompost,2.48, 2.23, 1.66, 0.98, 0.85 % and garden soil amended with vermicompost, 1.52, 1.43, 1.03, 0.64, 0.81, respectively[14].

The Bulk density **(Figure: 1,2,3)** was found to be quite higher, 1.0423 ± 0.13 g/mL, as compared to that of Vermicompost, 0.6711 ± 0.11 g/mL and garden soil amended with vermicompost, 0.8251 ± 0.12 g/mL respectively.

The water holding/retention capacity of garden soil is also observed comparatively poor, 80.27 %, as compared to the Vermicompost, 99.96 % and garden soil amended with Vermicompost, 92.51 %, at 0 hours, respectively. The water holding/retention was found to be dropped more in garden soil after 24 hours, 29.95 %, as compared to Vermicompost, 42.09 % and garden soil amended with vermicompost, 36.22 %, respectively. The water holding/ retention after 120 hours was found to be almost same, 2.22 to 2.06 in both garden soil and Vermicompost, whereas it is found to be quite higher, 3.18 % in garden soil amended with vermicompost.

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From the above results, it was observed that the carbon content and the carbon to nitrogen ratio in garden soil is very less and very high respectively. Because of very high carbon to nitrogen ratio, the microbial growth in soil becomes inactive, which results in poor electrical conductivity, mineralization, increase in bulk density and there by poor water holding capacity as compared to the vermicompost. After the amendment, it was observed that the carbon content and carbon to nitrogen ratio has been modified and that has impacted on decreasing the bulk density, increasing the water holding capacity and mineralization[15].

To identify the basic difference in water holding/retention capacity in Vermicompost and the garden soil, the particle size**(Figure: 4 and 5)** of aqueous suspensions was determined by particle size analyser. From the particle size distribution of the suspension, it was observed that, the 10 % particles are having particle size 5.30 microns, 50 % particles having particle size 68.70 microns and 90 % particles having particle size 157.60 microns in garden soil, whereas in vermicompost, 10 % particles are having particle size, 2.34 microns, 50 % particles having particle size 30.71 micron and the 90 % particles having particle size of 153.21 microns, respectively.

From the particle size distribution of aqueous suspension, it was observed that, the 10 % and 50 % particles in garden soil having particle size almost double as that of in Vermicompost which has impacted on the poor water holding capacity of garden soil as compared to that of Vermicompost[15].

To study the microbial growth in garden soil, Vermicompost and garden soil amended with vermicompost, total microbial count was determined by using nutrient agar medium and pours plate method.

From the microbial test,**(Figure:6)**it was observed that, very few microbial colonies were present in garden soil, whereas in vermicompost, almost 95 % of the whole area of the culture medium was occupied by microbial colonies. The impact of vermicompost amendment was also seen in garden soil amended with vermicompost, where almost 80 % of the whole area of the culture medium was occupied by microbial colonies.

The colonies were also verified by Graham's test and found both Graham positive and negative species. **(Figure: 7,8,9)**. From the microbial test it was observed that, the garden soil having very less population of microbial species, which has impacted on poor water holding capacity, high bulk density, very high carbon to nitrogen ratio, poor mineralization and particle size of the soil particles. From the Vermicompost amended garden soil, it was observed that, the microbial growth becomes active and multiply very quickly and contributing to change the physical, chemical and biological properties in sustainable manner[17]..

The impact of vermicompost amendment in garden soil was also studied by seed germination, vegetative growth, flowering and fruiting. The capsicum seeds were isolated from the fruits of capsicum from local market, dried in sunlight.Two sets of vermicompost amended garden soil and garden soil were made in paper glass. About five seed of capsicum were sown in each glass and watered thoroughly. Both the sets were light watered every three days. After fifth day, the germination was observed in sets prepared with garden soil amended with vermicompost, whereas, no germination seen in set prepared from garden soil. After 10 days, the seedlings in sets prepared from garden soil amended with vermicompost acquired height of 3 to 5 centimetres and with 2 to 4 leaves, but no germination was seen in sets prepared from garden soil **(Figure: 10 and 11)**, after transplanting, the seedlings acquired desired vegetative growth, flowering and fruiting **(Figure: 12 and 13)**.

From the seed germination test it was observed that organic amendments are very essential for good soil microbial health, increasing the water holding capacity of the soil, seed germination and healthy plant growth and sustainable agricultural growth[18]-[20].

V. CONCLUSION

From the present study it is concluded that, the soils are getting deficient in carbon and nitrogen content and there by the carbon to nitrogen ratio does not remains proper for healthy microbial growth and mineralization. Due to poor microbial growth and improper mineralization, the physico chemical properties of the soil like, water holding capacity, bulk density getting deteriorated and impacted of seed germination, plant vegetative growth, flowering and fruiting and yield per hector. From the study it could be concluded that, the use of organic amendment like Vermicompost, Organic manure, Green manureis simple, user-friendly, eco-friendly, cost effective and sustainable alternative for soil restructuring. It is very essential to slow down the use of chemical fertilizers, pesticides and demanding the use of bio fertilizers and bio pesticides for mitigating the climate change, healthy ecosystem and wellness and wellbeing of the globe.

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