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Physico-chemical characterization of vermicompost and enriched vermicompost

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Abstract
To assess vermicompost derived from agricultural wastes as a bedding material and to identify an enriched vermicompost (EVC) that is superior over conventional vermicompost (CV). Vermicompost is a type of compost made from cow dung and paddy straw. The experiment was carried out with two different types of sources animal excreta and plant biomass. These Vermicompost's were tested for moisture content, bulk density (BD), pH, electrical conductivity (EC), total organic carbon (TOC), nitrogen (N), phosphorus (P), potassium (K), sulphur (S), calcium (Ca), iron (Fe), copper (Cu), manganese (Mn), zinc (Zn), azotobacter, rhizobium and phosphate solubilizing bacteria (PSB) by standard procedures. At maturity enriched vermicompost content TOC (6.10%), N (33.02%), P (66.39%), K (9.10%), S (35%), Ca (88.06%), Fe (26.06%), Cu (23.48%), Mn (30.78%), Zn (19.79%), azotobacter (15.55%), rhizobium (4.65%) and PSB (40.54%) respectively which higher than normal vermicompost. Total P content increased when cow dung with rock phosphate and phosphate solubilizing bacteria was used as one of the bedding materials. It was concluded that the animal excreta and agriculture waste used as bedding material has the greatest influence on the physical, chemical and biological of matured vermicompost. Since vermicompost have a high nutritive value and a low C:N ratio, they are suitable for use in the field.

Keywords: Enriched vermicompost, nutrients transformation, agricultural sustainability

Introduction
Sustainable agriculture relies greatly on renewable resources like biologically fixed nitrogen or product prepared from waste and residues. Vermicompost is one of the potential renewable resources which can offer sustainability in agriculture. But, due to lesser NPK content in recycled waste and residues these are not becoming popular among farming community. However, use of these renewable resources in agriculture is essential on sustainability consideration. Thus, these renewable resources are required to be enriched.
Vermicompost has been proved important agricultural input having potential to sustain fertility of the soil. Its nutritional content can further be increased by enriching it with nitrogen fixing and phosphate solubilizing bacteria (Kumar and Singh, 2001; Pramanit *et al*., 2007). Enrichment of vermicompost with rock phosphate and phosphate solubilizing bacteria also improves nutritional status of vermicompost (Rani and Jha, 2018). To test the suitability of this rock phosphate and bio-inoculants enriched vermicompost for agricultural sustainability, there is an urgent need of experiments to examine the characterization of vermicompost.

Materials and Method
To study on Physico-chemical characterization of vermicompost and enriched vermicompost, different Types vermicompost were prepared at vermicompost production unit during the year 2017-18. The detailed description of the materials used and methods employed during the investigation has been outlined below in this chapter.

Location details of experimental site for vermicompost production
Vermicompost was prepared at vermicompost production unit of Bihar Agricultural College, Sabour, Bhagalpur, Bihar. Geographically, this college is located in Agro-climatic Zone III A of south Bihar at 25 °50' N latitude, 87 °19' E longitude and at an altitude of 52.73 meters above mean sea-level. Hot desiccating summer, cold winter and moderate rainfall are the characteristic climatic feature of Sabour. May is the hottest month with an average maximum temperature of 35 to 39 ^{0}C. However, January is the coldest month of the year with mean minimum temperature varies from 5 to 10 ^{0}C.

The average annual rainfall is 1380 mm, precipitating mostly between mid- June to mid-October.

Methods of vermicompost production

Two types of vermicompost were prepared by adopting heap method of vermicomposting. For preparing the normal vermicompost, pre-digested waste-residue mixture is heaped. Dimension of heap was 3m L X 1.4m W X 0.9m H. Pre-digested waste-residue mixture in heap was cooled by sprinkling of water for 5-7 days. Worms (*Eisenia foetida*) were introduced in cool substrate @ 2000 per tonne waste-residue mixture. Heap was covered with old gunny bags and moisture level was maintained by regular use of water for sprinkling on heaps. After 21 days of worm's introduction in heap, upper layer converted into tea like structure. Irrigation was stopped for 2-3 days and cast was collected for sieving and packaging.

To prepare enriched compost, Purulia rock phosphate @ 5% (wt./wt.), along with telecom powder-based phosphate solubilizing bacteria culture @ 100g per tones were mixed in waste-residue mixture during pre-digestion and pre-digested material was used for heaping. Rest of the methods will be similar as adopted for production of normal vermicompost.

Analysis of vermicompost

For determination of pH, electrical conductivity, total organic carbon, nitrogen, phosphorus, potash, micronutrients, microbial population in both, normal and enriched vermicompost, methods proposed by fertilizer control order (FCO), 1985 were employed. Brief description of analytical procedure employed for some important parameters has been discussed below:

Estimation of pH

25 g of compost was converted into a suspension in 50 ml of distilled water. Suspension was shaken on a rotary shaker for 2 hours. Suspension was filtered through Whatman No. 1 or equivalent filter paper under vacuum using a Buchner funnel. pH of the filtrate was measured by pH meter.

Estimation of EC

Fresh sample of organic fertilizer will be passed through a 2-4 mm sieve. 20 gm of the sample will be mixed with 100 ml of distilled water to it to give a ratio of 1:5. Suspension will be Stir for about an hour at regular intervals. Conductivity meter will be calibrated by using 0.01 M potassium chloride solution. Conductivity of the unfiltered organic fertilizer suspension will be measured

Estimation of moisture

Prepared sample (about 5 gm) was weighed in a clean, dry Petri Dish. It was heated in an oven for about 5 hours at 650^0C ±1ºC to constant weight. Then, it was cooled in a desiccator and weighed. Loss in weight was reported in percentage. Result was verified with the help of digital moisture meter

Estimation of Bulk density

100 ml Measuring cylinder was weighed (W_1 g). Cylinder was filled with sample up to 100 mark and volume was recorded (V_1 ml). Cylinder along with the sample was weighed (W_2 g). Cylinder was tapped for two minutes and compact volume was recorded (V_2). Bulk density (B.D.) was calculated with the help of following formula:

$B.D = W_2 - W_1 / V_1 - V_2$

Estimation of Total Organic Carbon

Accurately weighed 10 gm of sample was dried in oven at 105^0C for 6 hrs, in a pre-weighed crucible and this material was ignited in a Muffle furnace at 650 – 700ºC for 6-8 hrs. Then, it was cooled to room temperature and kept in desiccator for 12 hrs. Contents with crucible were weighed.

Estimation of total Nitrogen

Total nitrogen present in soil was determined by total digestion with accelerator mixture (K_2SO_4:CuSO4: Se: 100:10:1), salicylic acid-sulphuric acid mixture and sodium thio-sulphate clear digest was distilled with 40% NaOH and liberated NH_3 was collected in 4% boric acid and mixed indicator and titrated with 0.02 N H_2SO_4 as described by Piper, (1966).

Estimation of phosphate

10 gm oven dried sample was weighed in 50 g capacity silica crucible and subjected to ignite in muffle furnace at 650ºC – 700ºC for 6-8 hrs to obtain ash. Crucible was cooled and kept in a Desiccator. Contents will be transferred to a 100 ml beaker. 30 ml 25% HCl was added. Crucible was washed with 10 ml 25% HCl twice and contents were transferred to Beaker. Beaker was heated over hot plate for 10-15 minute and it was kept for 4 hrs. Then, it was filtered through Whatman No.1 filter paper. Filter paper was washed with distilled water 4-5 times (till acid free). Volume of filtrate was made up to 250 ml in a volumetric flask. Total P was estimated by gravimetric quinoline molybdate method (Jackson, 1973) [6].

Estimation of Potassium

5g sample was taken in a porcelain crucible and the sample will be ignited to ash at 650- 700 C in a muffle furnace. Ash was cooled and it was dissolved in 5 ml concentrated hydrochloric acid then it was transferred in a 250 ml beaker with several washing of distilled water and heated it. Again, it was transferred to a 100 ml volumetric flask and volume was made up to the mark. The solution was diluted and filtered with distilled water so that the Concentration of K in the working solution remains in the range of 0 to 20 ppm. K content in solution was determined by flame photometer using the K- filter after necessary setting and calibration of the instrument. Similarly, flame photometer reading of solutions having variable K concentrations was recorded to prepare the stander curve (Jackson, 1973) [6].

Microbial Count (PSB, azotobacter and rhizobium)

The microbial population was enumerated by adopting the serial dilution plate technique (Allen, 1957).

Results

The organic substance used for vermicomposting is the crucial factor of the composition, physical and chemical properties of vermicompost. Two types of vermicompost like normal vermicompost (NVC) prepared from cow dung and other enriched vermicompost (EVC), produced by using cow dung, plant residues, rock phosphate, phospho-gypsum, *Azolla* and bio-inoculants (phosphate solubilizing bacteria and *azotobacter*) were produced and samples were collected for analysis of (i) moisture, (ii) bulk density (iii) pH (iv) EC, (v) total organic carbon (vi) total content of N, P, K, (vii) Fe, Cu, Mn, Zn (viii) microbial population (phosphate solubilizing bacteria, rhizobium and *azotobacter*) by standard methods as described in the chapter “Materials and Methods”. Therefore, this study has been taken to evaluate physicochemical characteristics of two different types of vermicompost for comparison.

Results of physicochemical properties of two types of vermicompost are presented in table 1. It is vivid from the data that moisture content of both the vermicompost almost similar (22.6 percent in normal vermicompost, however, 22.2 percent in enriched vermicompost). Bulk density of these vermicompost samples were also similar (0.75 Mg m^{-1} in normal vermicompost and 0.73 Mg m^{-1} in enriched vermicompost). pH values of EVC were 6.65, however that of NVC was 6.94. The magnitude of pH increase was higher in normal vermicompost (0.29). Electrical conductivity (EC) value showed opposite trend. Highest EC value of EVC (3.51 d S m^{-1}) was higher than that of the NVC (3.42 dS m^{-1}). Total organic carbon content in enriched vermicompost was 18.98 percent and that in normal vermicompost was 18.15 percent. The total nitrogen content in NVC and EVC were 1.42 and 2.12 percent respectively. Total phosphorus and potassium present in enriched vermicompost were 2.41 and 1.21 percent respectively. However, total phosphorus and potassium content in NVC were only 0.957 and 1.1 percent respectively. It is obvious from the data that total phosphorus and potassium content in NVC were respectively 60.29 and 9 percent lower than that in EVC.

Table 1: Physico-chemical characteristics of vermicompost and enriched vermicompost

S. No.	Character	Vermicompost	Enriched Vermicompost
1.	Moisture (%)	22.6	22.2
2.	Bulk density (Mg m^{-3})	0.75	0.73
3.	pH (1:2)	6.94	6.65
4.	EC (1:5) (dS m^{-1})	3.42	3.51
5.	Fe (ppm)	153.94	208.19
6.	Mn (ppm)	103.44	149.44
7.	Zn (ppm)	82.06	102.31
8.	Cu (ppm)	24.63	32.19
9.	Total organic carbon (%)	28.15	29.98
10.	Total Nitrogen (%)	1.42	2.12
11.	Total P (%)	0.81	2.41
12.	Total K (%)	1.1	1.21
13.	Total S (%)	0.41	0.63
14.	Total Ca (%)	0.90	7.54
15.	*Azotobacter* ($\times10^6$ g^{-1} dry soil)	7.6	9.0
16.	*Rhizobium* ($\times10^6$ g^{-1} dry soil)	4.1	4.3
17.	Phosphate solubilizing bacteria ($\times10^6$ g^{-1} dry soil)	4.4	7.4

Discussion

Vermicomposting is a process that involves chemical, physical, and biological transformations of agricultural residues of plant and animal origin through the use of worms and microorganisms (Garg and Gupta, 2009) [4]. Composting involves a wide variety of physical, chemical and biological alterations of the nutrients. Meso-organisms like worms and millipeds can break down larger aggregates of organic matter mostly by mechanical means. Chemical changes in the composting process are mediated by microorganisms, primarily fungi, and bacteria that indicates the presence of little quantities of soluble salts in the vermicompost casts and soluble salt content is more in enriched vermicompost than normal vermicompost. Irshad *et al*. (2013) reported that higher EC values in composted manures could be attributed to the release of salts from the manure with the passage of time. A similar result was reported by (Ilker UZ *et al.* 2016; Kumar *et al.* 2018) [7] in vermicompost.

Recycling of waste and residues by using compost worm increases available nutrient content of substrates (Theunissen *et al*., 2010). Enrichment of vermicompost with minerals and bio-inoculants increases nutritional status and quality of vermicompost (Kumar and Singh, 2001; Rani and Jha, 2018). Probably due to these reason, nutrional quality of enriched vermicompost was found to be higher than that of the normal vermicompost.

Conclusion

The study revealed that the physico chemical properties of vermicompost can be prepared by using various, pre-digested waste-residue mixture is heaped. These substrates influenced physicochemical and biological properties of vermicompost and are recommended for vermicomposting and its production. These species are easily available in farmer’s field so can mitigate the manure problems. The use of *Eisenia foetida* for vermicomposting of residues on the basis of their nutrient content may reduce the burden of synthetic fertilizers. The wastes from pre-digested farm waste-residue mixture raised on marginal lands can be used for recycling and conversion of quality manure.

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