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Chemical and Physical Analysis of Organic Matter Transformations During Composting of Different Composts and Manures

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ABSTRACT

Composting is the biological decomposition and stabilization of organic matter. It is an excellent example of the practical use of biotechnology, natural resource management and environment conservation. The present study was conducted to evaluate the effect of different preparation methodology on the physical and chemical parameters of three different (NADEP, Vermicompost and FYM) organic composts and manures. The rise and fall in temperature in the composts and manures showed that temperature was low at the initial stage of composting process and sharply increased. The maximum rise in temperature was observed in case of NADEP compost, whereas in vermicompost, the maximum rise in temperature of 37.8^{0}C was observed. In case of all the composts, a gradual decrease in pH value with advancement of composting process was observed and pH remained alkaline throughout the composting process and at maturity stage it was almost neutral. During composting on an average, moisture remained between 60-70 % in case of all the composts and manures. Composts and manures were further analysed for the concentration of different nutrients (i.e. Nitrogen, Phosphorus, Potassium, Sulphur, Iron, Manganese, Copper and Zinc), heap porosity and recovery percentage.

Keywords: Compost, manures, NADEP, Vermicompost, FYM.

INTRODUCTION

Organisms have produced waste and other organisms have used the energy and nutrients contained in that waste since the beginning of life on earth. Recycling of organic waste is an integrated function of any ecosystem. In composting naturally occurring ability of organisms to recycle organic waste is used for the benefit of humans in an accelerated degradation of organic waste. It is the biological decomposition and stabilization of organic matter which is an environment viable option for manure management [1]. By knowing the process of composting we can manage organic waste more accurately and make it more efficient according to our requirements. Composting, manuring is an excellent example of the practical use of biotechnology, natural resource management and environment conservation. It involves a highly complex biological process, involving many species of bacteria, fungi and actinomycetes, which covert a low-value material into a high value product. A wide range of bio-wastes can be composted including materials generated by agriculture, food processing, wood processing, sewage treatment, industrial and municipal waste and composting also act as an important tool for carbon sequestration. Farmers practising organic farming use manure from extensive conventional livestock systems due to lack of animal manure from organic producers. In one of the studies, the objective was to know whether on-farm prepared compost mainly consisting of vegetal residues can be a good alternative. It was hypothesized that the type and application method of the organic fertilizer input affect the yield and quality of the potato crop. In a field experiment carried out in 2001 in North Yorkshire with an identical level of N-input, cattle manure-based compost increased potato yield significantly compared with chicken manure fertilizer pellets [2]. Differences in the organic fertilization regimes can lead to large differences in the environmental effects of organic farming [3]. Willekens *et al*. [4] also demonstrated that application of mature compost resulted in a faster development of the potato crop in the initial weeks of the growing season, which was important for sufficient yields in organic potato growing.

Many composting systems have been used for treatment of different wastes under different conditions. Common systems at large scale includes (i) naturally aerated windrow systems - long rows with a triangular cross section; (ii) forced aeration static pile systems; and (iii) tunnel systems – closed rotating cylinders, while smaller scale systems include static or rotating composts. Most published research on composting has been on batch processes, probably because most large-scale operations are batch systems. However, some work on fed-batch composting was documented several decades ago [5,6] and in recent years, interest in continuous composting has increased, especially in Asia [7-9]. This is associated with an increased use of decentralised composting machines, mainly for food waste in households and restaurants, and the reported experiments have therefore been carried out on food waste, either real [8] or artificial (dog food)[7].

Keeping in view the importance of composting of study has been taken. In this work different type of composts and manures were prepared and their physical and chemical parameters were compared.

MATERIALS AND METHODS

The details of materials and methodologies adopted are as given below:

Experimental details

Organic composts and manures = 3

a. NADEP compost
b. Vermicompost
c. Farm Yard Manure (FYM)

Methods to prepare different composts and manures: Different type of composts and manures were prepared as per basic methodology given. The detailed method of preparation of each is given below:

NADEP Compost

1. Dimension: 3× 3 × 3 feet
2. Material used (for each pit):

a. Plant material	=	400 kg.
b. Cow dung	=	14 kg.
c. Soil	=	200 kg.

3. Procedure: A simple, rectangular brick tank with enough spaces maintained between the bricks (partial honeycomb pattern) to provide necessary aeration was constructed. The honeycomb wall was approximately nine inches thick. The tank was erected with bricks and by the use of mud mortar. Bricks used were kiln-fired. Before charging the tank with the materials, the inner walls, the tank bed and outer walls were pasted with mud-cowdung paste.

Step 1: Plant waste was filled up to a height of six inches in the first layer.
Step 2: About two kg of cow dung was dissolved in 40 to 50 liters of water and sprinkled on the plant waste uniformly.
Step 3: The wet cowdung-sprinkled waste was covered with 20 kg of soil free from materials like glass, stones and plastic.
Step 4: Thereafter, the tank was filled with this series of three layers in the same sequence up to half feet above the rim of the tank in the shape of a parabola. Top was covered with a three-inch layer of soil all around and plastered with liquid cowdung slurry carefully.

Vermicompost
1. Dimensions: 5×4×1 feet
2. Material used (for each heap):

d.	Plant waste	=	200 kg
e.	Farm yard manure	=	170 kg
f.	Earthworms	=	1.5kg
g.	Grass mulch	=	1 kg
h.	Slowly decomposable material	=	1.5 kg

3. Procedure: Land was levelled and a rectangular area of 5 × 4 feet was prepared. After land leveling, some water was sprinkled to moisten the area.

Step 1: A 5-7 cm layer of bedding material finely chopped composed of slowly decomposable material (coconut husk, dry banana leaves and paddy straw) was spread.
Step 2: Above the bedding layer, partially decomposed (15 days old) about 15 days old farm yard manure was spread uniformly.
Step 3: Over the layer of this decomposed dung, about 1.5 kg. (approx. 400 in numbers) earthworms culture consisting of adults, young ones, cocoons etc. was spread uniformly.
Step 4: A layer containing mixture in ratio of 1:2 of fresh cow dung and waste material (weeds, grass) chopped into smaller pieces, was spread over worms. The height of heap was made up to approximately 30 cm of height.
Step 5: Finally a layer of grass mulch (3-4cm) was spread on the top.

Farm Yard Manure (FYM)
1. Dimensions: 5×4×3 feet
2. Material used (for each heap):

a.	Farm yard waste	=	750 kg
b.	Grass mulch	=	3 kg

3. Procedure: A pit having size of 5 x 4 x 3 feet was prepared. Before charging the tank with the materials, the inner walls and the tank bed was wetted with cow dung dissolved in water. Then cow dung well mixed with water was added to the pit up to 3 feet height. Finally the pit was covered with 3 kg grass mulch.

Determination of physical parameters: Various physical parameters of the composts and manures like temperature, moisture, heap porosity and recovery percentage were recorded by following the standard procedures. During the process of compost development, temperature was observed twice a week with the help of digital thermometer. During the process of compost development moisture was recorded once a week as per method of AOAC [10] Total porosity of heap was determined by method described by Black [11] for the determination of % total pore space. Recovery percentage was determined at compost maturity as per the method of AOAC [10]

Determination of chemical parameters: Various chemical parameters like organic carbon (OC), pH, total P, total K, total N, total S and cation micronutrients were recorded in different composts and manures by following the standard procedures. Organic carbon was estimated by ignition method as described by Black [11]. During the process of compost development, pH was recorded once a week by method as described by Jackson [12]. Samples were digested with di-acid mixture and total Phosphorus was estimated by developing Vanadomolybdo Phosphoric acid yellow colour method [12]. Samples were digested with di-acid mixture and total Phosphorus was estimated by developing Vanadomolybdo Phosphoric acid yellow colour method [12]. Samples were digested with di-acid mixture and total Potassium was estimated using Flame spectrophotometry [13]. Total nitrogen was determined by conventional Kjeldahl method [12]. Samples were digested with di-acid mixture and total S was estimated by using turbidimetric method [14]. Samples were digested with di-acid mixture and cation micronutrients were estimated using Atomic absorption spectrophotometer [13].

RESULTS AND DISCUSSION

Temperature changes during composting: Compost development process is traditionally classified according to the temperature changes during the process. As microbial populations change during the different stages of composting, so does the temperature like - mesophilic stage (20-40^{0}C), thermophilic stage (above 40^{0}C) followed by stabilization or curing stage (cooling period) as clearly stated by Madigan *et al* [15]. All these stages were observed in all the studied composts except Vermicompost, where the temperature did not even reach 40^{0}C. The rise and fall in temperature in the composts and manures showed that temperature was low at the initial stage of composting process andthen sharply increased. In vermicompost, there is no thermophilic stage as stated by Madigan *et al.* [15], may be because if the temperature would have increased more than 35^{0}C the worms would have died [16].

During decomposition of organic substances, the chemical energy in the material is partly released as heat and partly used for the construction of new substances within the organisms consuming the organic material. A large proportion is released as heat [17], which tends to increase the temperature of compost. Time taken by various composts to attain maximum temperature varied, depending upon their nature. It was attained after 2 weeks in vermicompost and 3 weeks in NADEP compost and FYM compost. When the three composts were compared, highest temperature was recorded in NADEP compost (42.98^{0}C) where as it was lowest (37.80 ^{0}C) in case of vermicompost. Higher temperature suggests more microbial activity, which can lead to faster maturation of composts as stated by Waksman *et al*. [18]. This was also seen in the present study as the BD compost matured faster than all other inoculated composts. The duration of composting process also varied in different composts. Vermicompost was matured in 12 weeks followed by NADEP (15 weeks) and FYM reached the maturity stage of the compost in 20 weeks (Fig.1).

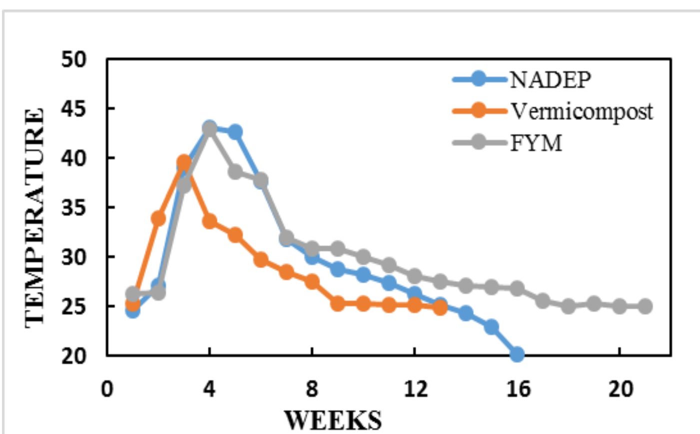

Fig. 1 Temperature (^{0}C) regime of different composts at different time intervals

pH changes during composting: The hydrogen ion concentration (pH) was higher at the initial phase of composting process and gradually decreased towards the end of composting process. The pH values changed during composting, due to changes in the chemical composition of the composting material as stated by [19]. Perusal of data revealed that pH remained alkaline throughout the composting process and at maturity stage, it was almost neutral. Normally pH of final compost product remained between 7.0 and 8.5 [20] as also recorded in this study. The pH became almost neutral after 10th week in case of vermicompost, 14th week in NADEP compost and 20th week in case of FYM. Carpenter-Boggs *et al.*[21] has advocated that a potential enzymatic and biological activity is generally greater at a more neutral pH. The value was attained when the various compost reached the maturity phase. pH <5 is unfavorable for bacteria, and prevents a number of important processes including colonization of compost by bacterial biocontrol agents [22]. This was not the case in any of the studied composts.

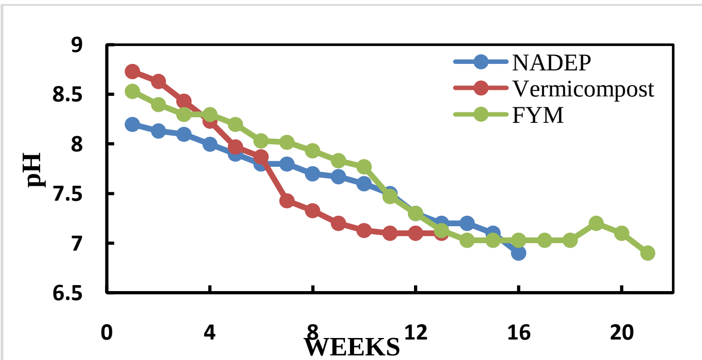

Fig. 2 pH change regime of different composts at different time

Moisture changes during composting: All living organisms need water, so moisture is essential for the function of the composting process. In the present study, moisture % was maximum at the initial phase of composting process i.e. 0-1 week and slowly decreased during compost development and on an average remained between 60-70% (Fig.3). Miller [23] stated that for the microorganisms, there is no upper limit for the water content as such, but excessive moisture reduces the air space in the compost matrix and thus causes oxygen limitation. Gajalakshmi and Abbasi [24] has advocated that the optimum water content for composting varies with the waste to be composted, but generally the mixture should be at 50-60%. Whereas, WERL [25] has stated that the ideal moisture for maximum biological activity is 60-80 % of WHC. Microbial activity is strongly influenced by moisture content; activity decreases under dry conditions, and aerobic activity decreases under water-logged conditions due to the resulting decrease in air supply as advocated by Richard *et al.* [26]. Water addition on the dry substrate can often speed up the composting process [27]. All the composts under study were adequately moistened (as revealed from data) during the whole process, thereby ensuring the proper microbial activity.

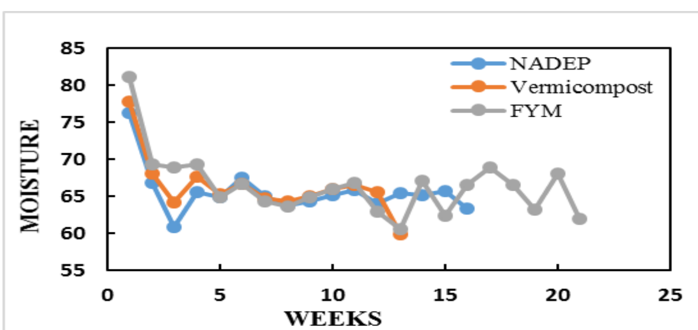

Fig. 3 Moisture (%) regime of different composts at different time Organic Carbon, Nutrients, C:N ratio, Recovery % and Heap porosity

NADEP: Concentration of total nitrogen, phosphorus and potassium 2.0, 0.5 and 0.4 % respectively. Concentration of sulphur, iron, copper, zinc and manganese were 24.9 ppm, 4210.3 ppm, 26.8 ppm, 330.1 ppm, and 321.1 ppm respectively. Organic carbon concentration was 37.3 % and C: N ratio of resultant compost obtained were 18.7:1. Recovery percentage and heap porosity were 65.7% and 79.7 % respectively.

Vermicompost: Concentration of total nitrogen, phosphorus and potassium 1.8, 0.5 and 0.6% respectively. Concentration of sulphur, iron, copper, zinc and manganese were 48.7 ppm, 4329.3 ppm, 27.4 ppm, 45.8 ppm, and 384.8 ppm respectively. Organic carbon concentration was 37.3 % and C: N ratio of resultant compost obtained were 20.7:1. Recovery percentage and heap porosity were 57.8 % and 72.8 % respectively.

FYM: Concentration of total nitrogen, phosphorus and potassium 2.1, 0.5 and 0.6 % respectively. Concentration of sulphur, iron, copper, zinc and manganese were 57.4 24.9 ppm, 3654.3 ppm, 27.2 ppm, 118.6 ppm, and 326.4 ppm respectively. Organic carbon concentration was 37.3 % and C: N ratio of resultant compost obtained were 17.8. Recovery percentage and heap porosity were 58.9 and 79.8 % respectively.

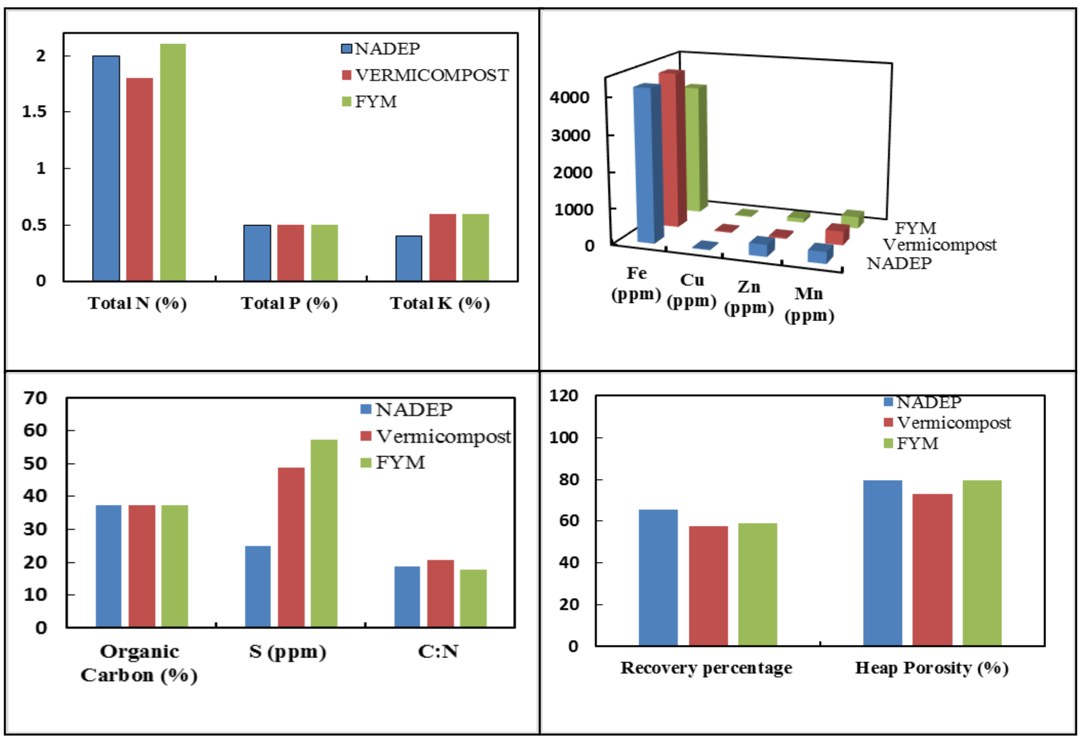

Fig 4. Concentration of various nutrients, organic carbon (%) and content in different, C:N ratio, recovery percentage (%) andheap porosity (%) in different composts and manures.

APPLICATIONS

Study was conducted to evaluate the effect of different preparation methodology on the physical and chemical parameters of three different (NADEP, Vermicompost and FYM) organic composts and manures. Time taken for various composts to attain maximum temperature varied, depending upon their nature. The recovery percentage, heap porosity, bacterial counts were varied, depending upon the type of compost and manures.

CONCLUSIONS

Compost can be defined as the stabilized and sanitized product of composting, which has undergone an initial, rapid stage of decomposition, is beneficial to plant growth and has certain humic characteristics, making the composting of waste, a key issue for sustainable agriculture and resource management. The present study was conducted to evaluate the effect of different preparation methodology on the physical and chemical parameters of three different (NADEP, Vermicompost and FYM) organic composts and manures. Time taken by various composts to attain maximum temperature varied, depending upon their nature. It was attained after 2 weeks in vermicompost and 3 weeks in NADEP compost and FYM. The duration of composting process varied in different composts. Vermicompost matured in 12 weeks followed by NADEP (15 weeks) and FYM reached the maturity stage of the compost in 20 weeks. pH remained alkaline throughout the composting process and at maturity stage it was almost neutral. It became constant after 10 weeks in case of Vermicompost, 14 weeks in case of NADEP compost, and 20 weeks in FYM. During composting on an average, moisture remained between 60-70 % in case of all the composts and manures The concentration of macro nutrients (N, P, K, S) and cation micro-nutrients (Fe, Cu, Zn, Mn) as well as other parameters of study (recovery percentage, heap porosity, bacterial count) varied, depending upon the type of compost and manures.

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