Physicochemical Analysis of Different Types of Compost

Dr.Meetali Das Gupta[1], Dr. Shrutika Kumthekar[2]

[1]Associate Professor, [1]Department of Chemistry, Guru Nanak College of Arts, Science & Commerce, G.T.B.Nagar, Mumbai-400037, India
[2]Assistant Professor, [2]Department of Botany, Guru Nanak College of Arts, Science & Commerce, G.T.B.Nagar, Mumbai-400037, India

Abstract
Municipal solid waste has significantly increased due to the increase in population, expanding urbanization and insufficient waste management systems. Waste management has become a big challenge since it is causing a major threat to environment. Composting is one of the most efficient ways of converting the biodegradable solid waste into organic fertilizer. The main objective of this study is to convert different samples of wet waste such as kitchen waste, flower waste and garden waste into compost and check their maturity and stability by evaluating the physical and chemical parameters. The co-relation between some of the parameters was also studied. The results were in agreement with the standard values which indicates that this method can be promoted as a viable waste management method.

Keywords: Composting, wet waste, waste management

INTRODUCTION

The Municipal solid waste is categorized into wet waste, dry waste and hazardous waste. Since all the types of waste are disposed into municipal bins, they get mixed and leads to multiple problems. The most common method adopted is dumping of all the waste into landfills which results in air, water and environment pollution due to the emission of greenhouse gases. In cities due to large population, unavailability of space, infrastructure and non-participation of individuals, there is a tremendous problem of treatment and management of waste [1]. Composting of agricultural waste and municipal solid waste has a long history and is commonly used to recycle the wet waste to organic manure back into the soil. It is an aerobic biological process which uses microorganisms to convert the biodegradable organic waste into humus like product. This process destroys pathogens, converts nitrogen to stable form, reduces the volume of waste and improves the nature of the waste. Since compost is rich in organic matter it is a source of plant nutrient [2, 3]. The main purpose of this research paper is to find ways to treat the enormous quantity of solid waste and recover the useful organic material in a cost effective and environment friendly manner. In the present investigation, different wet wastes were converted to manure by the composting process and the physical and chemical properties were evaluated.

MATERIALS AND METHODS

Preparation of Compost: The wet waste from the college canteen, garden waste, dry leaves from college garden and flower waste obtained during festivals were collected for preparing the following samples.

Table 1 Types of waste samples

Sample	Type of Waste
1	Kitchen waste and dry leaves
2	Kitchen waste, flower waste and dry leaves
3	Flower waste, garden waste and dry leaves

Aerobic composting was carried out in different barrels and compost pit for the different samples. The base of the pits was layered with dry leaves and above this layer bacterial inoculum was added. Further on this layer, wet waste was added. It was churned regularly so that the bacteria receive sufficient amount of oxygen. Water was sprinkled as and when required to maintain the moisture level. The final compost of all the three samples were obtained in 2-3 months, were sun dried and powdered for analysis. The pH, electrical conductivity, bulk density, porosity, moisture content, water holding capacity, total organic matter, organic carbon content, nitrogen content and C/N ratio were determined [4, 5, 6].

Determination of pH

10 gm dried compost was transferred to a beaker. 25 ml of distilled water was added to it. The solution was stirred and allowed to stand for 60 minutes till the compost settled down. The supernatant was separated using Whatman filter paper No. 41 and the filtrate was used for taking the readings. pH of the filtrate was measured using a calibrated pH meter.

Determination of electrical conductivity

10 gm dried compost was mixed with 25 ml of distilled water. The solution was stirred and allowed to stand for 60 minutes till the compost settled down. The supernatant was separated using Whatman filter paper No. 41 and the electrical conductivity of the filtrate was measured on a conductometer.

Determination of bulk density

The compost was dried at 110°C for 90 minutes until constant weight was obtained. Weighed compost was transferred in a measuring cylinder and the level occupied by the compost was noted. The bulk density was calculated from the equation:

$$\text{Bulk Density} = \frac{\text{Weight of compost (gm)}}{\text{Volume of compost (cm}^3\text{)}}$$

Determination of porosity

The compost was taken in a measuring cylinder and the volume was noted as sample volume. A known volume of water was taken in another measuring cylinder. The compost was saturated with water up to the surface level. The volume of the water used is equal to the pore volume. The porosity was calculated from the equation:

$$\%\ \text{Porosity} = \frac{\text{Pore volume}}{\text{Sample volume + Pore volume}} \times 100$$

Determination of Moisture Content

A weighed amount of compost was taken. The compost was dried in an oven at 110°C till constant weight was obtained. The values were substituted in the formula and the moisture content was determined.

$$\% \text{ Moisture content} = \frac{\text{loss of water}}{\text{Weight of compost before drying}} \times 100$$

Determination of water holding capacity

25g of compost was taken in a funnel layered with filter paper. The funnel was placed on a measuring cylinder. 50ml water was poured on it. The filtrate was collected and the volume was measured in a measuring cylinder. The water holding capacity was calculated from the equation:

$$\% \text{ Water holding capacity} = \frac{\text{Volume of water retained}}{\text{Weight of sample}} \times 100$$

Total organic matter

A weighed amount of compost sample was taken in a crucible and dried in an oven at 110°C. The crucible was placed above a Bunsen burner and heated till the sample was converted to ash. The crucible ash was weighed. The percentage of total organic matter was calculated.

$$\text{Total Organic matter: } \frac{\text{Weight of compost after heating}}{\text{Weight of compost before heating}} \times 100$$

Determination of organic carbon content

The organic carbon content present in the compost was estimated by Walkley - Black method.

Determination of nitrogen content

Total nitrogen was estimated by Kjeldahl method.

Determination of C/N ratio

It is the ratio of total carbon content to the nitrogen content.

STATISTICAL ANALYSIS

The different samples were analyzed in triplicates and the mean standard deviation was reported by using Microsoft Excel 2020.

RESULTS

The compost obtained from sample 1(Kitchen wet and dry leaves) was brown in color and had a granular texture (Figure 1 B). The compost obtained from sample 2 (Kitchen waste, flower waste and dry leaves) was brown black in color and had a granular texture (Fig.1 D). The compost obtained from sample 3 (Flower waste, garden waste and dry leaves) was dark brown in color and had a fine texture (Fig. 1 F). None of the compost had foul smell.

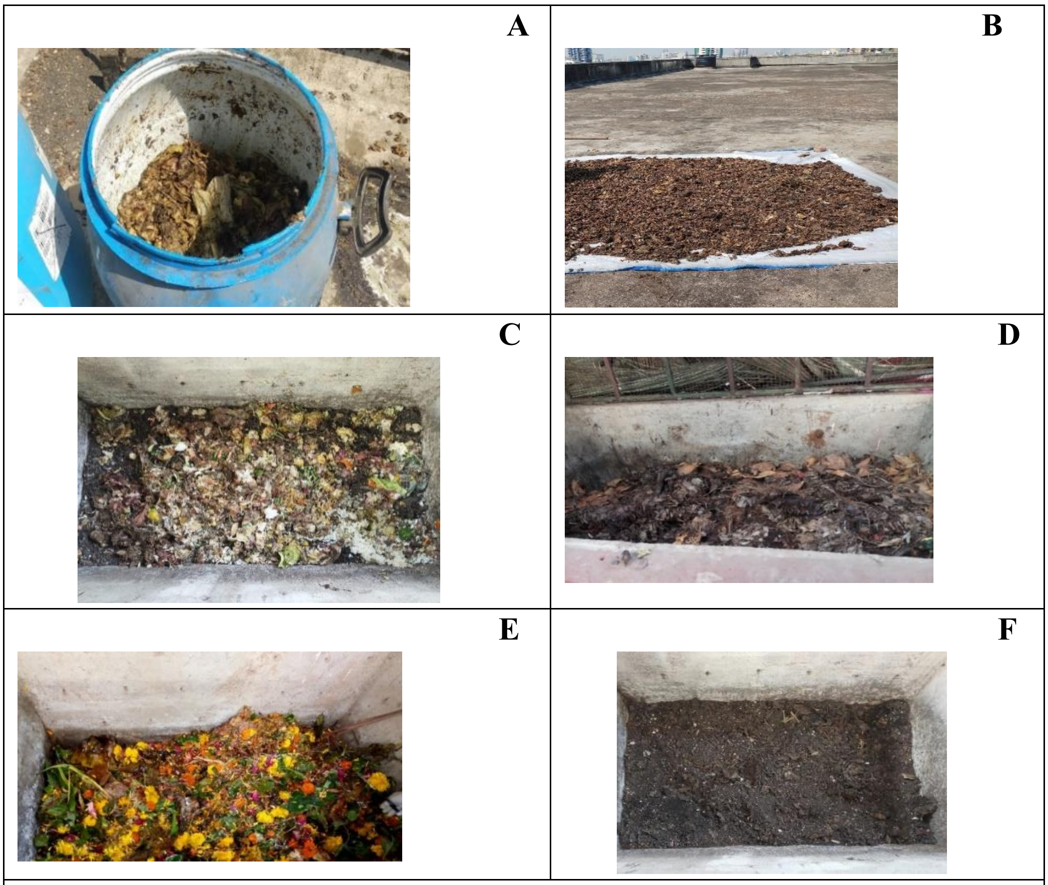


Figure 1: Preparation of different types of Compost

A: Initial stage of Kitchen waste and dry leaves (sample 1)
B: Final stage of Kitchen waste and dry leaves (sample 1)
C: Initial stage of Kitchen waste, flower waste and dry leaves (sample 2)
D: Final stage of Kitchen waste, flower waste and dry leaves (sample 2)
E: Initial stage of Flower waste, garden waste and dry leaves (sample 3)
F: Final stage of Flower waste, garden waste and dry leaves (sample 3)

Table 2 Results of physical and chemical parameters of different compost samples

Parameters	Kitchen waste and dry leaves (Sample 1)	Kitchen waste, flower waste and dry leaves (Sample 2)	Flower waste, garden waste and dry leaves (Sample 3)
pH	7.6 ± 0.1	7.5 ± 0.2	7.4 + 0.2
Electrical conductivity (mmho/cm)	5.23 ± 0.04	5.41 ± 0.03	5.45 ± 0.02
Bulk density (g/cm^3)	0.918 ± 0.03	0.921 ± 0.01	0.930 ± 0.02
Porosity	55 ± 0.5	53.1 ± 0.4	49.3 ± 0.3
Moisture content %	41.6 ± 0.1	40 ± 0.3	38 ± 0.2
Water holding capacity %	59 ± 1	55 ± 1	51 ± 2
Total organic matter %	29.1 ± 0.3	28.7 ± 0.3	28.2 ± 0.2
Organic carbon content %	16.1 ± 0.2	15.8 ± 0.1	15.3 ± 0.2

Nitrogen content %	0.92 ± 0.03	0.87 ± 0.01	0.84 ± 0.02
C/N ratio	17.5	18.1	18.2

pH is a measure of acidity or alkalinity of the compost. The value of pH of sample 1 was found to be 7.6, sample 2 was found to be 7.5 and sample 3 was found to be 7.4 (Table 2), which is in accordance with the ideal range of 5.0 - 8.5 as suggested by [7]. A neutral pH is desirable for most of the plants. Thus, the compost samples will be suitable for the growth of the plants.

Electrical conductivity is the measure of dissolved salts in the compost. The electrical conductivity value as seen in table 2 was 5.23 mmho/ cm for sample 1, 5.41 mmho/ cm for sample 2 and 5.45 mmho/ cm for sample 3. Electrical conductivity is generally in the range of 1 to 10 mmho/ cm. [8]. Thus the values of electrical conductivity of all the samples are within the prescribed range.

Bulk density of compost is a measure of mass within a given volume and it controls the conditions of microbial activity. It is an indicator of soil compaction. It influences the porosity, free air space and moisture content [9]. Higher values of bulk density indicate an increase in mass and decrease in porosity and air volume [10]. The value of bulk density (Table 2) of sample 1 was found to be 0.918 g/cm^3, sample 2 was found to be 0.921 g/cm^3 and sample 3 was 0.930 g/cm^3 which agrees with the values reported by [4].

Porosity is the volume of empty or pore space in the compost. The porosity values were 55%, 53.1% and 49.3 % for sample 1, sample 2 and sample 3 respectively (Table 2), which is similar to the value reported by [11]. Porosity depends on bulk density and moisture content of compost [6].

Figure 2 Co- relation between Porosity and Bulk density

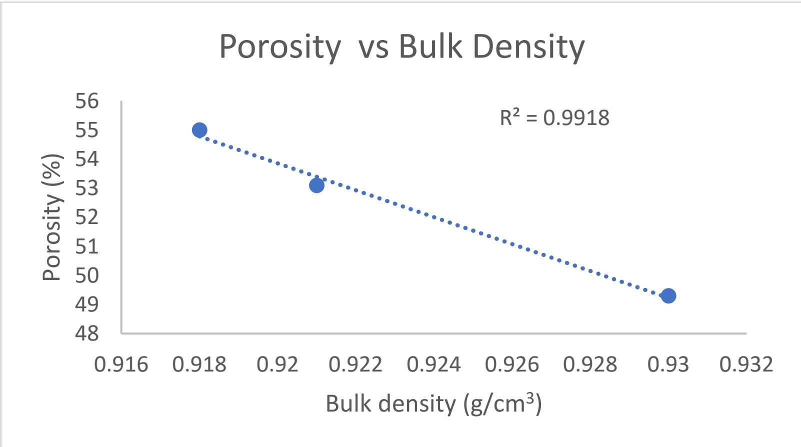


Figure 2 indicates a strong relationship between porosity and bulk density of the samples. The regression value obtained between the porosity and bulk density of samples is R^2 =0.99. The result indicates that as porosity increases bulk density of the sample decreases. This result agrees with those obtained by [6, 12]. K.Azim, et al. 2017 stated that higher values of bulk density is due to increase in mass and decrease in porosity and air volume.

Moisture content is the weight of water in a material and is generally expressed as percentage by weight. Moisture content of sample 1, sample 2 and sample 3 was 41.6%, 40% and 38 % respectively (Table 2). Ideally moisture content is in the range of 30-50%. Higher value of moisture results in composts which will be clumpy and if the value is less, the compost will be dusty [5]. Compost with high moisture will have high water holding capacity and high organic matter [8].

Figure 3 Co- relation between Moisture content and Bulk density

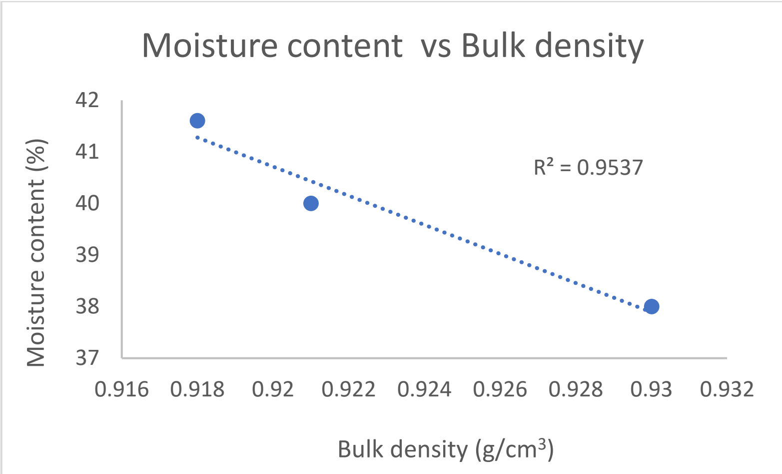
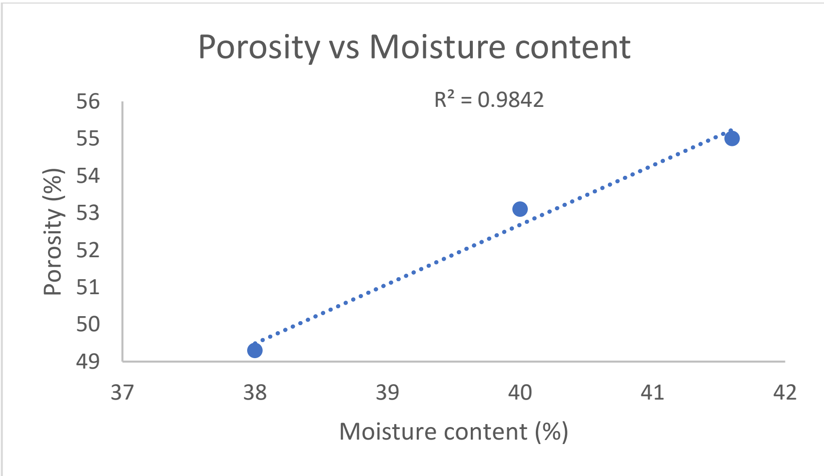


Figure 3 indicates a relationship between moisture and bulk density of the samples. The regression value obtained is R^2 =0.95. The result indicates that as moisture decreases the bulk density of the sample increases, thus it implies a negative co-relation between the two parameters. This result agreed with those obtained by [11].

Figure 4 Co- relation between Porosity and Moisture content



In above figure 4, a relationship between porosity and moisture content was observed, which are directly proportional to each other. A similar observation was also reported by [6].

The water holding capacity is the ability to hold water in the spaces of compost and it is one of the important agronomic parameters. The value of water holding capacity (Table 2) of sample1, sample 2 and sample 3 was found to be 59%, 55% and 51 % respectively which is in the desired range [13]. Different types of soil retain different amounts of water, depending on the particle size and the amount of organic matter. When compost is mixed with the soil, there is an increase in amount of water retention.

Total organic matter is the amount of organic carbon in the sample. The total organic matter was found to be 29.1%, 28.7 % and 28.2 % (Table 2) for the respective samples 1, 2 and 3. These results are in agreement with the results obtained by [14] who stated that in a mature compost, the total organic matter must be below 30 % which indicates the stability and maturity of the compost.

Figure 5: Co-relation between Bulk density and Total organic matter

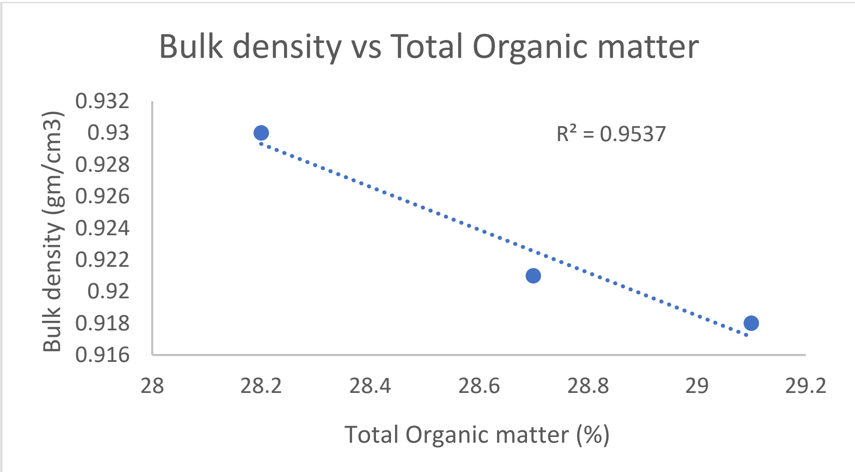


Figure 5 shows the relationship between the bulk density and the total organic matter of the samples. The regression value obtained between the bulk density of samples and total organic matter is R^2 =0.95, which indicates a strong co- relation between the two parameters. Both the parameters were found to be inversely proportional. A similar observation was also reported by [6].

Carbon is one of the important components of compost as it serves as a source of energy and elemental composition for microorganisms [9]. The microorganisms consume carbon during aerobic fermentation. The organic carbon content of sample 1 was 16.1%, sample 2 was 15.8 % and sample 3 was 15.3 % (Table 2) which agrees with the results obtained by [4, 6]. Thus the compost sample prove to be a good organic fertilizer.

Nitrogen is essential for the synthesis of amino acids, nucleic acids and as building blocks of proteins [9]. It is required for cell growth and is thus an important macronutrient. The nitrogen content of sample 1 was found to be 0.92 % , sample 2 was found to be 0.87%, sample 3 was found to be 0.84% (Table 2), which is in agreement with the values reported by [6, 8, 15].

Carbon to nitrogen ratio affects the composting process and quality of compost product [16]. It is an indicator of compost stability and availability of nitrogen. Compost with C/N ratio > 30 will immobilize N if applied to soil, while those with C/N ration < 20 will break-down organic N to inorganic N [8, 17]. The calculated C/N ratio of sample 1, sample 2 and sample 3 was found to be 17.5, 18.1, and 18.2 (Table

2) respectively, which is in the desired range [6, 18] thus proving that the compost samples will act as a good soil conditioner. Rosen C.J., et al.,1993 found that a C/N ratio of 15-20 is ideal for compost [19].

CONCLUSION

The success of composting depends on the characteristic of the compost obtained. The knowledge of maturity and stability indicators help in deciding the quality of compost. In the present study, the results of all the parameters were in the desired and acceptable range which indicates that matured compost was obtained from all the samples. Thus the compost is of good quality and can be used as a good soil conditioner and organic fertilizer. The chemical fertilizers which are harmful can be replaced by organic fertilizers produced from wet waste. Composting is thus the most promising economically feasible, environmentally sustainable waste management approach.

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