

# Comparison of Physio-Chemical Characteristics of Different Compost Samples

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## Abstract

The objective of the current study was to compare and analyze physiochemical characteristics of compost samples and determination of solid waste being dumped in a landfill site in Lahore, Pakistan. Different compost samples were analyzed to evaluate their physiochemical characteristics. The samples tested were collected from three different sources, i.e., Waste Buster, Kinnaird College, and Lahore Compost Private Limited, and compared with the waste sample dumped at Mahmood Booti landfill site. The analysis showed that the percentage composition of organics was highest than the other components in all the samples. The parameters that were analyzed include pH, moisture content, bulk density, salinity, carbon-nitrogen ratio, sodicity, available carbon, burned carbon, potassium, phosphorous, nitrogen, pathogens, gravel, and stones. The results were compared to the permissible limits according to The Pakistan Environmental Protection Agency (EPA) guidelines. Most of the sample components were under the permissible limits, whereas a few others were not, such as potassium and burned carbon. The amount of potassium was found to be 0.60 mg/L, 0.61 mg/L, and 0.61 mg/L for the samples collected from Waste Buster, Kinnaird College, and Lahore Compost Private Limited, respectively. This is much less than the standards set by the EPA i.e., 620-2280 mg/L which can lead to deficiency of nutrients in the compost. Burned carbon was found to be 46%, and 41% in the samples from Waste Buster and Kinnaird College respectively, which is higher than the standard of 35%. The higher amount of burned carbon can damage the plants and is not desired. The salinity content was also found to be higher in the sample from Kinnaird College which was 8.99 dS/m compared to the standard of 4.0 dS/m. The compost sample of Lahore Compost Private Limited was found to be the best among the tested samples.

**Keywords:** Smart Grid, DSSNet, SDN Emulator, Power Simulator, ONOS, OpenDSS

## 1. Introduction

Solid waste can be defined as useless and unwanted material in the solid state derived from different activities and discarded by the society [1]. It is produced either by production processes or from the domestic or commercial sectors when objects or materials are discarded after use [2]. Waste is generated continuously in different ways from our daily activities. There

are different kinds and categories of waste dumped into landfill sites like organics, plastic, glass, metals, paper etc. Proper solid waste management is very important in order to minimize harmful effects of hazardous solid waste on the environment. Solid waste can be managed with the help integrated waste management plan [3]. Solid waste management is a serious problem in most of the urban cities of Pakistan because large amount of waste is being generated every day in different cities of the country. Solid Waste Management (SWM) has long been a neglected sector due to lack of strong commitment of

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government in Pakistan. Major cities of Pakistan face acute problems in managing solid waste generated in thousands of tons due to rapid growth of population as well as shortage of resources. Heaps of waste and polluted environment are becoming a permanent feature in some areas of Lahore: the heart of Pakistan and provincial capital of Punjab. It generates 5000 tons of waste every day [4]. The solid waste management system in Pakistan consists of three kinds of collection systems: primary collection, secondary collection, and open dumping of waste. 90% of solid waste is openly dumped while only 60% of solid waste is collected and disposed of in Pakistan. Most of the uncontrolled dumped waste lies along street, roads, parks, railway lines etc. of different cities of Pakistan [5].

Solid waste management is extremely important for improving the living standards of people and in saving the environment we live in [6]. It leads to neat, clean and healthy society. Solid waste management prevents and control heaps of rubbish and garbage being openly dumped into different areas of cities. It prevents spreading of bad smells and odors that could disturb human beings. The most important benefit of solid waste management is that it minimizes and control the spread of dangerous viruses that could lead to chronic diseases like Malaria, Dengue, and Hepatitis [5]. Out of the total waste generated in Lahore, 76% of it is disposed of into different dumping sites [7]. These dumping sites include Mahmood Booti, Saggian, and Baggarian. The waste is sent without segregation to different dumping sites of Lahore as a result hazardous and toxic waste is treated along with ordinary waste as a result large heaps of untreated waste are dumped without any specialize treatment which has harmful effects on the environment. The other 24% waste is openly dumped to different parks, streets and unwanted lands [8]. The uncontrolled open dumping sites are a serious threat for the environment especially for soil, ground water and most importantly for human health however the effects of waste can be minimized by carefully disposing of waste of each house properly [9, 10]. The threats of waste can be minimized and controlled by segregating, recycling, and reusing the organic waste being dumped into different landfill sites [11-13]. Reducing the amount of waste by composting organic waste can greatly decrease the amount of waste being generated every day. It will also provide us cost effective and natural fertilizer that will condition soil and will lead to efficient plant growth [14, 15].

Mehmood Booti is one the biggest landfill site of Lahore. Most of the waste generated from different sectors of Lahore is sent to this site without any segregation. Major percentage composition of waste is organic waste. Mahmood Booti is the only authorized dumping site owned by the City District Government Lahore (CDGL) and is located north of Bund Road. The site is in flood plain of river Ravi which flows at a distance of 5 km away. The site is spread over an area of 32 hectares which includes 15 hectares of the Lahore Compost Plant. The solid waste collected from the Aziz Bhatti Town, Shalimar Town, Data Town, and a part of Gulberg Town is handled by Mehmood Booti dumping site. The direction of flow of ground water in the study area is from North to South and the velocity of flow lies in range of 1-1.5 cm/day [16]. The solid waste is presently being openly dumped and no measures are being done to segregate the organic waste from inorganic waste.

There is a need to properly manage the waste in Pakistan. The initiative has been started by the Government starting from the major cities, however this should be expanded to other cities and villages as well. This study focuses on the analysis of physio-chemical characteristics of compost samples collected from three different collection sites, Waste Buster, Kinnaird College, and Lahore Compost Private Limited, and dumped at Mahmood Booti landfill site. The next section explains the

methodology used for the analyses, followed by the results and discussion. Conclusions are presented at the end along with future recommendations.

## 2. Methodology

Figure 1 shows the simplified summary of this work, i.e., the sources of the samples and the parameters tested.

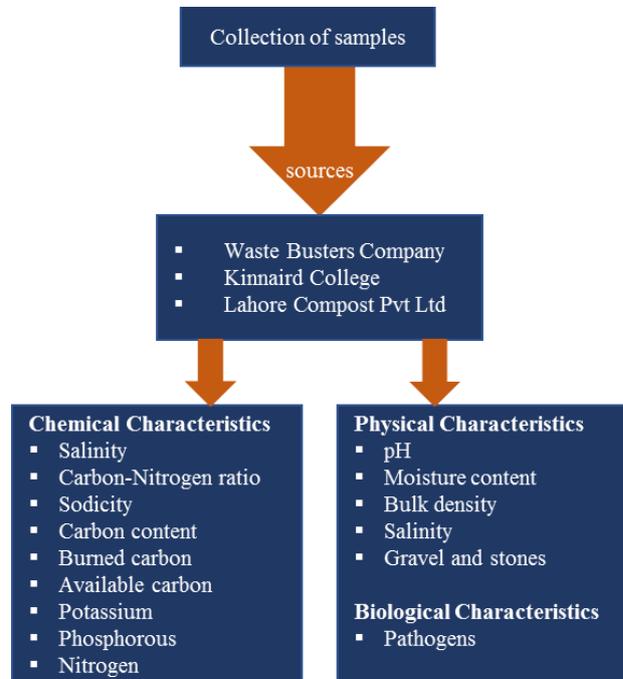


Fig. 1. Sample collection sites and the various parameters tested

The following methodology was adopted for this research work.

### 2.1. Collection of Samples

The compost samples were collected from Waste Busters Company, Kinnaird College, and Lahore Compost Private Limited. A 5kg Sample of waste from Mehmood Booti was also collected to determine percentage composition and to evaluate potential of making compost.

### 2.2. Analysis of Various Parameters

Various tests of compost samples were conducted in the laboratory. These tests were carried out to analyze different parameters of compost, as given in Table 1.

Table 1: Parameters analyzed, instruments used, and the standard methods

Parameters	Instruments	Standard Method
pH	▪ pH meter	ASTM D1293–12
Moisture content	▪ Oven ▪ Weighing Balance	ASTM D2216–10
Bulk density	▪ Weighing balance ▪ Measuring cylinder	ASTM D7263

Carbon-Nitrogen ratio	<ul style="list-style-type: none"> <li>▪ Kjeldahl apparatus</li> <li>▪ Non-dispersive infrared detector</li> <li>▪ Gravity convection (capable of maintaining a stable temperature of up to 200°C)</li> <li>▪ Combustion furnace</li> <li>▪ LECO CR-412 Carbon analyzer</li> <li>▪ Analytical balance (capable of weighing to 1 mg)</li> <li>▪ Glass measuring scoop</li> <li>▪ Mortar and Pestle</li> <li>▪ Aluminum weighing boats</li> <li>▪ Forceps</li> <li>▪ Glass wool</li> </ul>	ASTM 5310:P05001A
Nutrients: ▪ Potassium ▪ Nitrogen ▪ Phosphorous	<ul style="list-style-type: none"> <li>▪ Flame photometric</li> <li>▪ Kjeldahl</li> <li>▪ Spectrophotometer</li> </ul>	ASTM D1127 ASTM D5762 ASTM E1070
Impurities Pathogens Stones	<ul style="list-style-type: none"> <li>▪ Incubator</li> <li>▪ Clipper</li> <li>▪ Sieve</li> </ul>	ASTM D6734
Carbon content ▪ Available ▪ Burned	<ul style="list-style-type: none"> <li>▪ Non-dispersive infrared sensor</li> <li>▪ Gravity convection</li> <li>▪ Combustion furnace (capable of heating glassware at 400°C for at least 4 hours)</li> <li>▪ LECO CR-412 carbon analyzer</li> <li>▪ IR detector</li> <li>▪ 36 position auto sampler rack</li> <li>▪ Glazed and unglazed combustion boats</li> <li>▪ Analytical balance (capable of weighing to 1 mg)</li> <li>▪ Calibrated weights</li> <li>▪ Glass measuring scoop</li> <li>▪ Mortar and pestle</li> <li>▪ Aluminum weighing boats</li> <li>▪ Forceps</li> <li>▪ Glass wool</li> </ul>	ASTM 5310
Salinity	<ul style="list-style-type: none"> <li>▪ Oven</li> <li>▪ Hamer</li> <li>▪ Salinity meter</li> </ul>	ASTM D4542
Sodicity	<ul style="list-style-type: none"> <li>▪ Weighing balance</li> <li>▪ Plastic containers or glass Erlenmeyer flasks</li> <li>▪ Automatic solution dispenser</li> <li>▪ Reciprocating shaker</li> <li>▪ Vacuum line and suction apparatus</li> <li>▪ Conductivity cell</li> <li>▪ Conductivity meter</li> <li>▪ ICP-AES or ion chromatography (IC)/flow injection analysis (FIA)</li> </ul>	ASTM D3875-08

**2.3. Determination of pH**

To measure the pH, solution of 100g of compost sample and 5ml of water was made. The solution was mixed well. The pH of compost samples was determined with the pH meter.

**2.4. Determination of Moisture Content**

Pre-weighted samples of wet compost were kept in oven at temperature of 105°C for 2 hours. The dry weight was determined, and moisture content was calculated by the following formula:

$$\text{Moisture content} = \frac{\{(\text{initial weight} - \text{final weight}) / \text{initial weight}\} \times 100}{(1)}$$

**2.5. Determination of Bulk Density**

10 grams of compost sample was taken in measuring cylinder and 0.5 cm<sup>3</sup> of water was added to find out its volume. The bulk density was then calculated by the following formula:

$$\text{Bulk density} = \text{mass} / \text{volume} \quad (2)$$

**2.6. Determination of Carbon-Nitrogen Ratio**

To evaluate the carbon-nitrogen ratio, percentage of carbon and nitrogen was determined and then the ratio was calculated.

**2.7 Determination of Carbon Content**

For determination of carbon content, the reagents used were: Phosphoric acid, Calcium Carbonate (99% purity), Granular copper (20-30 mesh), and Oxygen (99% purity). The glassware and ceramics used in the entire process were first tarred for four hours at 400°C. The samples were kept at temperature - 20°C until processing. The samples were dried at 40°C. A portion of compost sample was separated, grounded, and homogenized. The dried aliquot of homogenized sample was kept in an aluminum-weighing pan for drying at temperature of 105°C. LECO CR-412 Carbon Analyzer used for analysis of sample was calibrated using calcium carbonate. The amount of calcium carbonate standards used were 0.01g, 0.05g, 0.10g, 0.25g, and 0.50g. For the calibration curve an empty carbon-free combustion boat was analyzed as a blank. The calibration curve helped to provide analysis range of 0.0-0.06g. A continuing mid-level standard calibration check was analyzed after every ten samples. For carbon analysis 0.35g of dried, grounded, and homogenized sample was placed into carbon-free, neat combustion boat. The boat was kept on the auto-sampler and placed onto the LECO carbon analyzer. Phosphoric acid drops were added into the samples drop by drop until the sample did not bubble anymore and was totally moist with acid. Later the samples were kept in oven for 24 hours at 40°C. The samples after 24 hours were then transferred to another oven at 105°C. After the samples were dried up the boat was kept onto auto-sampler rack and loaded to LECO carbon analyzer.

**2.8. Determination of Nitrogen Content**

Nitrogen in the compost samples was detected with the help of Kjeldahl method. The process includes three steps:

**2.8.1. Solution preparation**

1g of each compost sample was added into 12ml H<sub>2</sub>SO<sub>4</sub>. A solution was made of 3.5g potassium sulphate (K<sub>2</sub>SO<sub>4</sub>) and 0.4g of copper sulphate (CuSO<sub>4</sub>). The mixture was added to 50ml H<sub>2</sub>O. The solution was heated for 1 hour at 420°C. The sample was then added to round bottle flask.

### 2.8.2. Distillation process

40g of sodium hydroxide (NaOH) was added to 100ml water and this mixture was also added in round bottle flask. 20ml HCL and 200ml water was placed in conical flask and connected to Kjeldahl apparatus to trap ammonia gas. The process led to formation of bubbles. The ammonia was trapped in a cylinder and the sample was titrated.

### 2.8.3. Titration

During the titration process 2 drops of phenolphthalein was added in the sample solution containing ammonia and a standard solution Sodium Hydroxide in burette. The titration continued until the color of sample containing conical flask changed. The value on the burette was noted down when the color of the solution in conical flask started to change. The value found out was the amount of nitrogen contained in the sample. The carbon-nitrogen ratio was found out by dividing the amount of carbon by the amount of nitrogen.

### 2.9. Determination of Potassium

A 2.5g of the grounded compost sample was weighed and was added to 400ml beaker. 125ml of deionized water and 50ml of ammonium oxalate solution was added into the sample containing beaker. The solution was boiled for 30 minutes. After boiling the solution was allowed to cool and slight excess of ammonium hydroxide solution was added into the beaker. After cooling the solution was poured in 250ml volumetric flask for dilution to volume. The solution was mixed, and a portion of the solution was filtered with the help of What man No.30 filter paper and the filtrate was placed in clean and dried 350 ml beaker. A 25ml aliquot of the filtrate was transferred to 500ml of volumetric flask for dilution to volume by adding deionized water. The solution was well mixed. The suitable amount of aliquot was transferred to 100ml volumetric flask so that the final solution contained approximately 16ppm K<sub>2</sub>O. The solution was diluted to 100ml with deionized water and mixed well.

#### 2.9.1. Standard preparation

A 5.779g of potassium dihydrogen phosphate that has been previously dried for one hour at 105°C in oven, was dissolved in 50ml of deionized water and transferred to a 1 liter volumetric flask and diluted to volume with deionized water. The solution had 2000 ppm K<sub>2</sub>O in it. 50ml of 2000ppm K<sub>2</sub>O standard solution was poured into a 1 liter volumetric flask and diluted to volume by adding deionized water into it. Further standards were prepared that contained 10, 12, 14, 15, 16, 17, 18 and 20 ppm K<sub>2</sub>O by diluting 10, 12, 14, 15, 16, 17, 18 and 20 ml respectively of the 100ppm K<sub>2</sub>O solution to 100ml.

#### 2.9.2. Method

All the equipment were set up. The instrument was set to zero using deionized water. Using 20 ppm K<sub>2</sub>O solution instrument was set to 100 and then aspirated 10, 12, 14, 16 and 18 ppm solutions for three times. The mean readings for each concentration were taken. The aspiration of sample was done, and the readings were recorded. Potassium concentration in the compost sample was found out by referring to the calibration graph. Two further standard solutions were prepared to contain 1ppm more and 1ppm less concentration of K<sub>2</sub>O than the potassium concentration of sample solution. The instrument was set to 100 with the 20 ppm K<sub>2</sub>O solution, the lower standard solution, the higher standard solution, and the sample solution were aspirated. The procedure was repeated twice, and the mean value was considered of each set of three readings. The calibration curve was made and the concentration of K<sub>2</sub>O

in the sample was found out with the help of graph. The following equation is used:

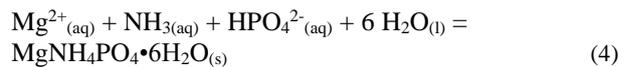
$$\% \text{ of K}_2\text{O} = \frac{\text{K}_2\text{O (ppm) in sample solution} \times 20}{\text{Volume of aliquot}} \quad (3)$$

### 2.10. Determination of Phosphorous

The gravimetric analysis was done to analyze amount of phosphorous in compost. P<sub>2</sub>O<sub>5</sub> is the acid anhydride of H<sub>3</sub>PO<sub>4</sub> that consists of phosphate ion (PO<sub>4</sub><sup>3-</sup>). The acid anhydride is derived by dehydration of the corresponding acid hence we get the corresponding acid by mixing anhydride with water.

#### 2.10.1. Technique

The gravimetric analysis technique was used. An analyte was precipitated and then weighed. The weight of precipitate was used to find out how much analyte was present. The solid precipitate formed was separated through filtration. In the experiment, the two solutions were prepared. One solution contained the compost sample in which we wanted to find out phosphorous containing ions and the second solution contained magnesium (Mg<sup>2+</sup>) ions. A third solution was also prepared that contained aqueous ammonia dissolved in water. All three solutions were mixed, and the precipitate formed was MgNH<sub>4</sub>PO<sub>4</sub>•6H<sub>2</sub>O. The “•6H<sub>2</sub>O” is the water of hydration with 6 molecules of water that was part of crystal structure of the precipitate formed. The equation below shows the reaction:



In order to find out amount of phosphorous in the precipitate, the precipitate was weighed from known quantity of compost sample. The balanced chemical equation was used to find out mass of precipitate to the mass of P<sub>2</sub>O<sub>5</sub>.

#### 2.10.2. Procedure

3 grams of each compost sample was dissolved into 50ml of water and mixed well until the compost is completely dissolved in water. The undissolved solid particles were filtered off while liquid filtrate was taken. The solid particles separated as filtrate on filter paper was washed with water. Careful rinsing was done to make sure P<sub>2</sub>O<sub>5</sub> stays on the material collected on filter paper and do not fall off or disappear. Excess of Mg<sup>2+</sup> was added to 50ml of MgSO<sub>4</sub>. The solution was added slowly in aqueous ammonia. The step was repeated until precipitate formation stopped after ammonia is added. The resulting mixture was mixed well and allowed to settle for 10 minutes. The filter paper was weighed. The precipitate was filtered using vacuum filtration. The precipitate was, MgNH<sub>4</sub>PO<sub>4</sub>•6H<sub>2</sub>O. Aspirator was left to run for 45 minutes. Air was passed through the precipitate which helped to dry the solid and filter paper. After the solid had dried, filter paper was weighed again. The weight of filter paper was subtracted from the final weight to obtain mass of recovered precipitate. The Equation 4 was used, molar masses and the amount utilized and obtained helped determine amount of phosphorous in the compost sample

### 2.11. Determination of Gravel and Stones

Sieving is a simple technique for separating particles of different sizes. Gravels and stones were determined with the help of sieve. The compost samples almost 500g were made to shake in sieve that contained three sizes of holes to separate 3 sizes of stones. The holes were of sizes such as 2.36mm,

112µm, and smaller than 112 µm. After separation the stones and particles of different sizes found were weighed to attain the required result.

**2.12. Determination of Pathogens**

Improperly thermally treated compost can allow pathogens to survive. Pathogens can regrow in finished compost due to recontamination or incomplete pathogen-kill. Pathogens were detected by mixing 2ml of water and 1g compost samples in vortex mixer making up 10µL of solution sample. MacConkey agar was taken, added to water and autoclaved at 121°C for 20 minutes to make it sterile. Agar solution was placed in petri dish and 10µL of sample solution was added into it with the help of a micro pipette. The petri dish was placed into incubator for 48 hours at 37°C. After 48 hours the colonies were formed and counted as CFU (colony forming unit).

**2.13. Determination of Salinity**

Compost that are saline have high amount of calcium and magnesium salts and therefore they tend to have pH less than 8.5. Saline compost may consist of bound particles of clay, silt, sand, and organic matter. Examples of salts are sodium chloride (common table salt) and calcium sulphate (gypsum). To perform the field test, we added compost sample into distilled water in a testing container and a calibrated salinity meter was used. Compost sample was left to dry prior to the test. The test involved adding one part compost for every five parts water, 50g of compost with 250 ml of water. The container was shaken for three minutes to make sure all the salts are dissolved in the water. For clay loams and clay soils, more shaking (for one minute every 3 minutes repeated three times) brought more salts into the solution and increased the accuracy of the test. The solution was allowed to settle for a minute before testing. The salinity meter was placed in the solution and the readings shown were note down.

**2.14. Determination of Sodicity**

Sodicity is a term given to the amount of sodium held in a compost. Sodium is a cation (positive ion) that is held loosely on clay particles in compost. It is one of many types of cations that are bound to clay particles. Other types bound to clay particles include calcium, magnesium, potassium, and hydrogen. When sodium makes up more than about 5% of all cations bound to clay particles, compost is said to be sodic.

The amount of sodium as a proportion of all cations in a compost is the main measure of sodicity and is termed the exchangeable sodium percentage (ESP). Sodic compost has an ESP greater than 15. ESP is the sodium adsorbed on soil particles as a percentage of the cation exchange capacity (CEC). It was calculated by finding out sodium, potassium, calcium, and magnesium from compost samples. CEC is often estimated as the sum of the major exchangeable cations, including Hydrogen. Both cations and CEC are expressed as meq/100g. ESP can also be calculated as:

$$ESP = \{ [Na^+] / [Ca^{+2} + Mg^{+2} + Na^{+2} + K^+] \} \times 100 \quad (5)$$

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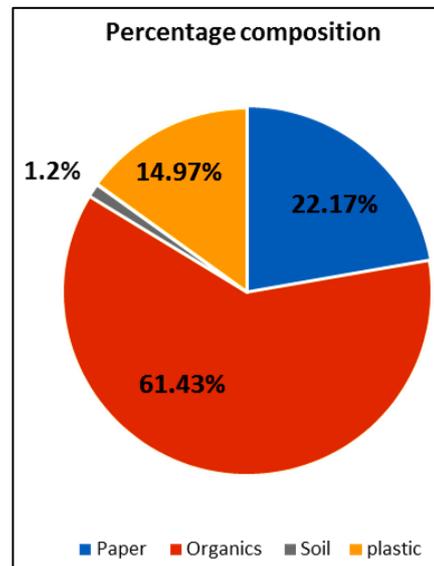
$$ESP = \{ [Na^+] / CEC \} \times 100 \quad (6)$$

**3. Results and Discussion**

A 5 kg waste sample was collected from Mehmood Booti for analyses of percentage composition of different components of waste particularly for finding out percentage composition of organic waste being dumped in Mehmood Booti every day. The sample collected was brought into the laboratory for segregation. The waste contained paper, organics, soil, and plastics. Table 2 shows the weights, percentage and moisture contents of different elements present in the waste. The results are also shown in Figure 2 as pie chart. The highest percentage was of organic components i.e., 61.43%. The organic waste found in sample included grasses, coverings of fruits, vegetables, over ripe fruits, and damaged eatables. The second highest percentage was of paper. The paper components included newspapers, used papers, tissue papers, textbooks, and notebooks. Soil and plastic were least in the waste sample with glasses, bottles, and plates. The percentage of soil and plastic was 1.2% and 14.97% respectively. Organic material had the highest moisture content of 37.48%. The second highest moisture content was of soil (33.33%). Paper had moisture content 18.74%, and the lowest moisture content was of plastic. This shows that the sample has the highest organic material with highest moisture content. Therefore, if the organic material is segregated it will not only reduce the waste quantity disposed to Mehmood Booti landfill site, but this organic waste contains high level of moisture due to natural material in it which can be utilized by plant and can lead to efficient plant growth.

**Table 2: Weights, percentage composition, and moisture contents of different components of waste sample collected from Mehmood Booti landfill site**

Components	Weights (kg)	Percentage composition (%)	Moisture contents (%)
Paper	1.1087	22.17	18.74
Organics	3.0441	61.43	37.48
Soil	0.06	1.2	33.33
Plastic	0.742	14.97	10.45



**Fig. 2. Percentage composition of components found in waste sample of Mehmood Booti**

Waste Buster Company collects waste from different cities of Pakistan. It collects waste by door-to-door collection, debris removal, industrial waste collection, and hospital waste collection, and makes compost for various kinds of crops. The compost sample collected from Waste Buster was analyzed for its physical and chemical characteristics. Most of its parameter were within the range set by EPA. The two parameters: burned carbon and potassium were not within the range. The amount of potassium was found to be low in all three composts because potassium is soluble in water, so it leaches away easily in case of rainfalls or if water accidentally enters the compost piles. Burned carbon was found to be high because of presence of more humus in compost.

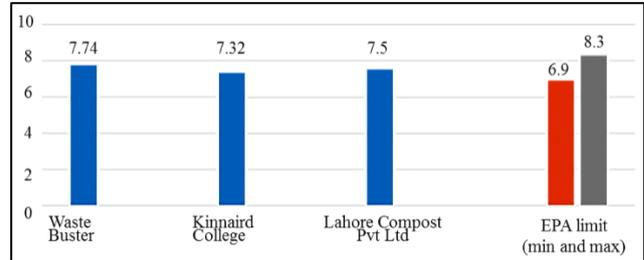
Compost of Kinnaird College was also collected, which is made by collecting leaves and grasses from lawns of Kinnaird College. All the parameters except salinity, potassium, and burned carbon were within permissible limit of EPA. Kinnaird college compost sample was much saline then required. It had salinity up to 8.99 dS/m which is above the limit of 4.0 dS/m. The compost sample was found to be saline because dead leaves, and animal and bird feces. Potassium amount was 0.61mg/l, also quite less than the required limit of 620-2280 mg/l because potassium is soluble in water hence it can leach easily if compost comes in contact with water. The rainfalls leaches away potassium in compost pile of Kinnaird college.

Another sample was taken from Lahore Compost Pvt Ltd. It is the first public project that does large scale municipal waste recycling. The project uses organic contents of Municipal solid waste of Lahore city for conversion into useful component compost or natural fertilizers. It also contained less amount of potassium i.e., 0.61 mg/l then permissible limit 620-2280 mg/l because potassium leaches away easily as it is soluble in water so rainfall washes away potassium from compost piles easily. Table 3 shows the percentage of various components found in different samples along with the EPA limit.

**Table 3: Results of parameters analyzed for compost samples of three sources**

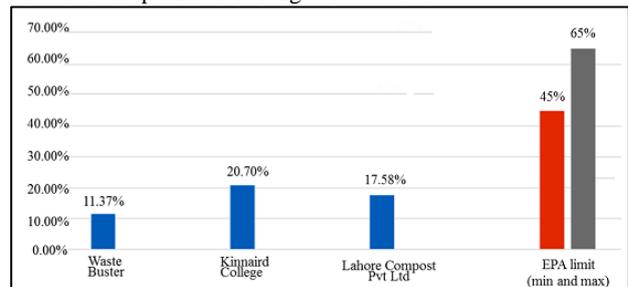
Parameters	EPA limit	Waste Busters	Kinnaird College	Lahore Compost Pvt Ltd
pH	6.9-8.3	7.74	7.32	7.5
Moisture content (%)	45-65	11.37	20.7	17.58
Bulk density (g/cm <sup>3</sup> )	1.6	0.67	0.40	0.45
Salinity (dS/m)	4.0	2.89	8.99	2.69
Carbon-Nitrogen ratio	<25:1	17:1	12:1	18:1
Sodicity	<15	19.2	29.6	34
Available carbon (%)	>35	20	15	22.4
Burned carbon (%)	>35	46	41	25
Potassium (mg/l)	620-2280	0.60	0.60	0.61
Phosphorous (mg/l)	50-120	75	51	73
Nitrogen (%)	15-240	20	20	30
Pathogens (MPN/g)	1000	12	9	13
Gravels and stones (mm)	>5mm	2.36mm, 12µm, <112µm	2.36mm, 112 µm	2.36 mm, 112µm

Higher or lower pH can affect pH of soil which can affect soil and plant growth. The pH of all three compost samples was within the permissible limit i.e., 6.9 to 8.3, as shown in Figure 3. The pH of Waste Buster sample was 7.74, while that of Kinnaird College sample was 7.32, and of Lahore Compost Pvt Ltd was 7.50.



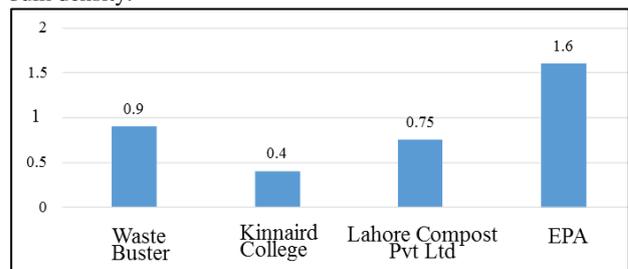
**Fig. 3. pH of three compost samples and the permissible limit set by EPA**

The moisture content of Waste Buster compost was 11.37% which is the lowest moisture content of all three composts while that of Kinnaird College compost was 20.7% which is the highest of all three composts, and the moisture content of Lahore Compost Pvt Ltd was 17.58%. These results are depicted in Figure 4. All three composts have moisture content far below the permissible range of 45 to 65%.



**Fig. 4. Moisture content of three compost samples and the EPA permissible limit**

The bulk density of compost should be less than 1.6g/cm<sup>3</sup> because compost with bulk density above 1.6g/cm<sup>3</sup> tends to restrict plant growth. All three composts tested had bulk density within the permissible range, shown in Figure 5. The bulk density of waste buster was 0.67 g/cm<sup>3</sup> which is the least bulk density of all three composts, while the bulk density of Kinnaird College compost was 0.40 g/cm<sup>3</sup> which is the highest density. The compost of Kinnaird College was only made up of green material like leaves, trees, and dead flowers therefore it had high amount of moisture and hence more density while compost samples of Lahore Compost Pvt Ltd and Waste Buster are made from household and commercial waste, therefore it tends to have low moisture and mass contents leading to lower bulk density.



**Fig. 5. Bulk density of three compost samples and the EPA permissible limit**

The salinity of Lahore Compost Pvt Ltd and Waste Buster was 2.69 dS/m and 2.89 dS/m, respectively which is under the prescribed limit of 4.0 dS/m set by EPA. The value of salinity of Kinnaird College compost (8.99 dS/m) was much above the prescribed limit. This was due to high amount of magnesium and calcium in water used for making compost piles. The animal feces that eventually get into compost pile also lead to higher salinity in compost. The salt also comes from sand, silt, and clay that comes with soil and leaves used for composting. Gypsum (calcium sulphate) used for construction in the College also adds to salinity in compost pile. These results are depicted in Figure 6.

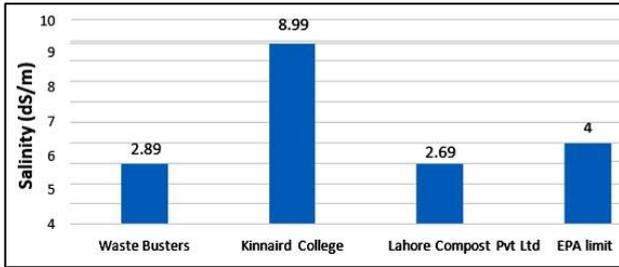


Fig. 6. Salinity of three compost samples and the EPA permissible limit

The compost is considered sodic if it has ESP greater than 15. All the compost samples tested in this study turned out to be sodic as shown in Figure 7. The sodicity in compost comes from positive ions in compost that are loosely bound to calcium, magnesium, sodium, hydrogen, and other positive ions. Sodicity level is high in all the three compost samples because they are made up of green waste which has high positive ions in them.

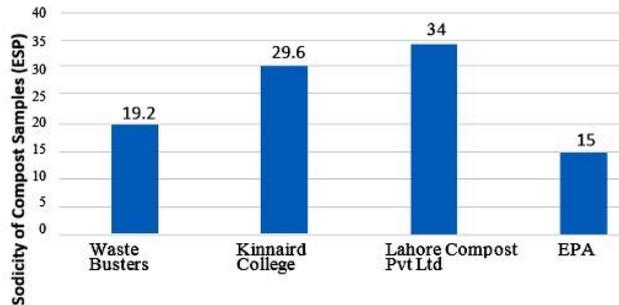


Fig. 7. Sodicity of three compost samples and the EPA permissible limit

Available carbon and burned carbon should be less than 35% in a compost according to the EPA guidelines. The available carbon within all three compost samples was within the specified limit. The sample of Lahore Compost Pvt Ltd showed highest level of available carbon (22.4%), while Kinnaird College compost sample had the lowest available carbon (15%). The available carbon is found to be higher in Lahore Compost Pvt Ltd compost and Waste Buster compost because of the brown waste like sawdust, straw, and wood. The burned carbon level in the two compost samples was found to be higher than the prescribed limit of 35%. The Waste Buster and Kinnaird College samples had 46% and 41% of burned carbon content, respectively. These results are shown in Figure 8.

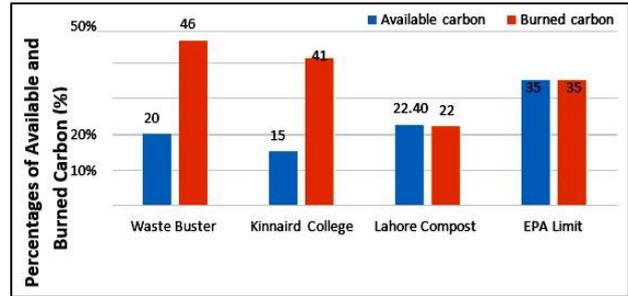


Fig. 8. Available and burned carbon of three compost samples and the EPA permissible limit

Carbon-Nitrogen ratio of all compost should be less than 25:1 according to the EPA, and all the samples tested were found to contain this ratio within the prescribed limit as shown in Figure 9. Lahore Compost Pvt Ltd compost sample had the highest carbon-nitrogen ratio while the Kinnaird College compost sample had the lowest ratio. The compost samples from Waste Buster and Lahore Compost Pvt Ltd had high carbon-nitrogen ratio as carbon comes from brown waste and nitrogen comes from green waste and the compost made from household waste contains both kind of waste while Kinnaird College compost sample only contains green waste thus it contains less carbon-nitrogen ratio as compared to the other two samples.

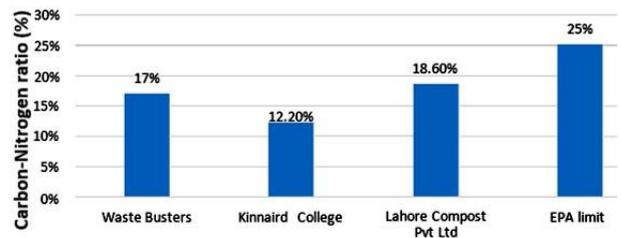


Fig. 9. Carbon-Nitrogen ratio of three compost samples and the EPA permissible limit

The amount of phosphorous was also within the permissible limit of 50-120 mg/l in all the samples analyzed in this study. The results are depicted in Figure 10. All three compost samples contained sufficient amount of phosphorous because phosphorous comes from green waste and all three compost samples were made from waste that was enriched with high amount of organic waste.

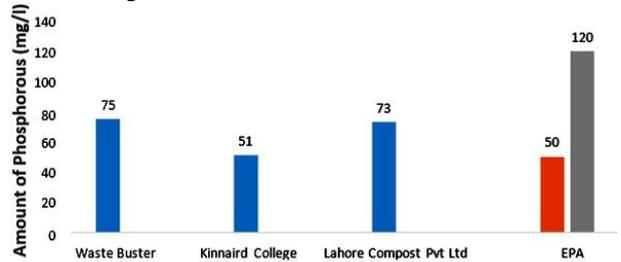


Fig. 10. Amount of phosphorous in three compost samples and the EPA permissible limit

The nitrogen level in a compost should be within the limit of 15-240 mg/l, and all three samples contained considerable nitrogen level within the specified range. The compost of Lahore Compost Pvt Ltd had highest nitrogen level of 30 mg/l due to excess bio solids in the waste while Kinnaird College and Waste buster compost had Nitrogen level of 20 mg/l due to less bio solids available in waste used for making compost. Figure 11 shows the results for the nitrogen level in the compost samples.

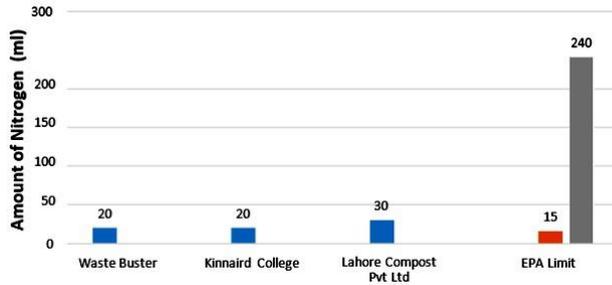


Fig. 11. Amount of nitrogen in three compost samples and the EPA permissible limit

The amount of potassium found in all three compost samples was much below the permissible limit of 620-2280 mg/l. The wood ash is high in potassium and usually the household waste lacks in this therefore very less potassium was found out in all three compost samples. Also, the potassium compounds are usually water soluble as a result they are likely to wash out of the compost piles during heavy rainfalls. The pathogens colonies in all compost samples were almost negligible and much below the prescribed range of 1000MPN/g, as shown in Figure 12. In all the compost samples, no stones were found to be larger than the permissible limit of 5mm. These samples were mostly made up of household waste, dead leaves and grasses therefore very less stones and gravels were found in all three compost samples.

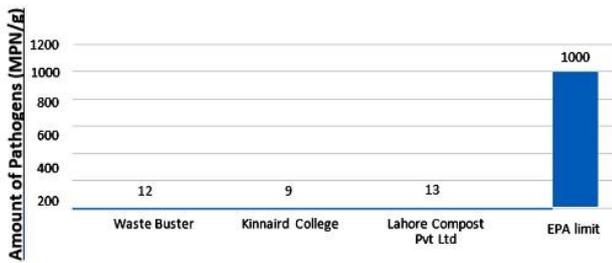


Fig. 12. Amount of pathogens in three compost samples and the EPA permissible limit

#### 4. Conclusion

It can be concluded that waste being dumped in landfill site Mehmood Booti have high amount of organic content which can be utilized to make cheap organic soil conditioner. If the organic material is segregated the amount of solid waste being dumped in Mehmood Booti landfill site will be reduced. The three compost samples had most parameters within the permissible limit set by EPA, however the Lahore Compost Pvt Ltd compost was found out to be the best compost because it had almost all parameters within the permissible limit, only potassium was below the standard limit, hence it has the potential to be used as a soil conditioner if only the amount of potassium can be raised to reach the permissible limit. Certain parameters in all three compost samples were not within the permissible limit. The most important parameter is the amount potassium as it is an essential nutrient required by soil, however all the samples lacked in it. The parameters like salinity and burned carbon were also not within the permissible limit in compost samples from Kinnaird College and Waste Buster which could inhibit plant growth. There is a need to work on improving the quality of the compost samples.

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