PHYSICO-CHEMICAL PARAMETERS OF KITCHEN WASTE AND VARIOUS COMPOST SAMPLES

The experimental design included the entire work was divided in three phases i.e. kitchen waste collection and its analysis, compost preparation and its analysis and value added compost preparation and its analysis as already mentioned in Chapter 3. The results pertaining to the study undertaken have been tabulated and discussed in this chapter.

The mean values of physico-chemical analysis of various samples for different experimental groups (kitchen waste, Group I, Group II, Group III, Group IV, Group V are given in Table 4.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Various Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kitchen Waste</td>
<td>Group I (Control)</td>
</tr>
<tr>
<td>MC (%)</td>
<td>85.98±3.65</td>
</tr>
<tr>
<td>pH</td>
<td>4.48±0.21</td>
</tr>
<tr>
<td>EC (dS/cm)</td>
<td>0.055±0.030</td>
</tr>
<tr>
<td>OC (%)</td>
<td>6.51±0.21</td>
</tr>
<tr>
<td>N (%)</td>
<td>0.00±0.00</td>
</tr>
<tr>
<td>P (%)</td>
<td>0.35±0.00</td>
</tr>
<tr>
<td>K (%)</td>
<td>0.28±0.05</td>
</tr>
<tr>
<td>Ca (%)</td>
<td>0.16±0.02</td>
</tr>
<tr>
<td>Mg (%)</td>
<td>0.15±0.01</td>
</tr>
</tbody>
</table>

Values in Mean±S.D; NS = Non Significant; *Significant at 0.05 level of significance; **Significant at 0.01 level of significance

The physico-chemical analysis of kitchen waste and prepared compost samples was experimentally carried out in the laboratory to determine Moisture Content, pH, Electrical Conductivity, Organic carbon, Available Phosphorus, Total Nitrogen, Exchangeable Potassium, Calcium and Magnesium. The results of the afore mentioned parameters are discussed below:-
Moisture Content (MC)

Moisture content (MC) is a measure of the amount of water found within a material at any given time. MC is expressed as the percentage of the mass of the material that is contributed by the mass of contained water. MC was observed for kitchen waste and Group I to Group V and the results are stated below:

![Figure 17: Moisture Content in kitchen waste and various compost samples](image)

Figure 17: Moisture Content in kitchen waste and various compost samples

It has been analysed from Figure 17 that kitchen waste has the maximum moisture content i.e. 85.98±3.65 whereas Group III (compost using Enzyme Powder) showed the least percentage of moisture content i.e. 14.22±1.73. Other treated groups of compost samples i.e. Group I, II, IV and V found to be 23.0467±2.34, 21.1633±1.44, 16.7733±0.64 and 14.4033±0.52 respectively. It was found from statistical studies that MC is significant lower at (P<0.05) level in control compost and vermicompost and highly significantly (P<0.01) lower in compost prepared by enzyme powder, composting culture and compost prepared by using NSDL.
Moisture content is a measure of the amount of moisture present in a compost sample and is expressed as a percentage of fresh weight. Moisture content of composting is an important environmental variable as it provides a medium for the transport of dissolved nutrients which are essential for the physiological and metabolic activities of micro-organisms (Elango et al. 2009).

Moisture content of over 65% can cause oxygen depletion (Gray et al. 1971b; Rhyckeboer and Mergaert, 2003). The moisture content of the compost affects the structural and thermal properties of the materials, as well as the rate of biodegradation (Stentiford, 1996; Nakasaki et al. 2004). Oxygen accessibility interferes in presence of excess water, while too little moisture slow down the diffusion of soluble molecules and microbial activity hence rate of composting also reduces. Moisture content decreases from 85% is due to heat generation during thermophilic phase and due to high evaporation rates. Decrease in moisture content has been observed by (Biotreat, 2003) from 10 days to 60 days which is due to heat generated by biological metabolism and air flow increase the water evaporation, consequently decreasing the moisture content. This is in consistence with the present study results. In our study it was observed that in all matured compost samples it ranges from 14-20%. Initially moisture content was found nearly 85% in raw kitchen waste. Decline in the moisture content percentage during composting due to high evaporating rates has been also recorded by Larney and Blackshow (2003).

Although moisture is necessary to sustain the biological decomposition vital to the composting process but dry compost is easier to manage and store without causing a trouble. Only after the process of composting is completed, drying could be considered as a necessary prerequisite for storage or sale.
(b) **pH**

The pH changes in samples are governed by the amount of free CO₂, carbonates and bicarbonate. pH was observed for kitchen waste and Group I to Group V and results are stated below:

![Figure 18](image)

**Figure 18: pH in kitchen waste and various compost samples**

It has been analysed from above Figure 18 that kitchen waste has the minimum pH i.e. 4.48±0.21 whereas Group II (vermicompost) showed the maximum pH i.e. 8.71±0.26. The difference in kitchen waste and prepared compost sample is nearly double, which creates a lot of significance in current research study. pH of other treated groups of compost samples i.e. Group I, III, IV and V was found to be 8.3567±0.29, 7.3467±0.28, 7.5167±0.87 & 7.7767±0.52 respectively. It was inferred from statistical studies that pH is significant higher at 0.05 level in control compost, vermicompost, compost prepared by enzyme powder and NSDL when compared to the kitchen waste. pH in the compost prepared by using NSDL was found to be highly significantly (P<0.01) increased.

All the samples lie in the slightly alkaline range with a little variation except kitchen waste. Kitchen waste has the minimum pH i.e. 4.48±0.21 i.e. it is acidic.
nature. As per (Li and Li, 2010), due to presence of fermentation bacteria like lactic acid bacteria, kitchen waste is generally found to be acidic in nature. Lactic acid produced is toxic to other bacteria present, therefore in order to make kitchen waste less acidic a buffer is usually added.

pH was found higher in Control compost sample and in vermicompost as compared to other compost samples, which may be due to high mineralization of nitrogen and phosphorus into nitrates/nitrites and ortho-phosphate. In vermicompost sample it is high, which may be due to the activity of calciferous glands in earthworms containing carbonic anhydrase that catalyzes the fixation of carbon and as calcium carbonate, therefore preventing the fall in pH (Pattnaik and Reddy 2009; Kale et al. 1982).

The alkaline nature of compost was also reported by Tchobanogolous et al. 1993, which is indicative of good composting process. Alkaline values of pH generally indicate stable composts which show that the process is completed and the products have reached maturity (Ranalli et al. 2001). The mature compost emitted pleasant earthy smell. The pH value settles to between 7.5~8.0 as the compost stabilizes. Inbar and Chen (1993) reported similar findings. Existence of carboxylic and phenolic groups within humic acids could have resulted in lowering of pH while ammonium ions raised the pH of the system (Bisen et al. 2011). Tognetti et al. (2005) also observed that the degradation of short chained fatty acids and ammonification of organic nitrogen increased the pH. The pH subsequently increased probably due to the breakdown of protein based solid waste materials and release of ammonia (Jeris and Regan, 1973, Crawford, 1983 and Guoxue, et al. 2001).

pH values in mentioned range could be because of the degradation of organic material producing ammonium ions and humic acids, both of the components inversely affecting the pH. This could be the same reason for our findings that results are more likely in slightly alkaline range.

Wani et al. 2013, found that vermicomposting of kitchen waste, garden waste and cow dung showed a similar pattern of change in pH. pH falls in the range of 6.34±0.06 and 8.13±0.06, respectively, which is within the optimal range for plant growth and shows a shift from initial acidic condition toward neutral condition.
(c) **Electrical Conductivity (EC)**

Electrical conductivity is defined as the ability of a solution to carry electrical charge which is a measure of the soluble salt content of compost. The salt content of compost includes the presence of chloride, sodium, potassium, nitrate, ammonia salts and sulphate (Brinton, 2003). The electrical conductivity of compost and vermicompost is dependent on the raw materials utilized in the process along with their ion concentration (Atiyeh *et al.* 2002).

EC values observed for kitchen waste and Group I to Group V and results are depicted below:-

![Figure 19: Electrical Conductivity in kitchen waste and various compost samples](image)

As clearly indicated in Figure 19 that kitchen waste has the maximum EC i.e. 0.0554±0.030 whereas Group III (compost using Enzyme Powder) showed minimum EC i.e. 0.0367±0.037 respectively. Other treated groups of compost samples i.e. Group I, II, IV and V EC was found to be 0.040±0.047, 0.0455±0.067, 0.0475±0.078 and 0.0371±0.004 respectively. According to Pathak *et al.* 2011, a low EC could be an indicator of complex nutrients and therefore desirable. Low EC
was found in Group III and Group V. It was found that EC is non-significant all groups as compared to kitchen waste. Other way of enhancement of the EC in Group II and IV may be due to the degradation of organic matter to release more cations as also suggested by Campbell, et al. 1997.

According to Pathak et al. 2011, electrical conductivity is inversely proportional to concentration of nutrient. Lower is EC, higher is the salt’s concentration. Electrical conductivity is a measure of soluble salt content like nitrate and nitrite. In our study, in prepared compost samples EC was found decreased from kitchen waste and was minimum in Group III and Group V, which may indicate higher concentration of nutrients.

EC may be associated to the compost’s and vermicompost’s water carrying capacity, Cation Exchange Capacity (CEC), porosity, texture and particle size. It was suggested that greater particle water carrying capacity, CEC and porosity will result in a higher EC (Grisso et al. 2009). It may be the same reason that other compost samples had higher EC as compared to Group III and Group V. The influence of EC on the quality of compost and vermicompost is significant as it decides their salinity and suitability for crop growth. As per the present investigation, EC of vermicompost sample was more than that in control, in compost by using enzyme powder and compost by using composting culture. This might be due to the loss of organic matter which most likely led to a higher concentration of ions which would have increased EC (Kiefer and Rivin, 2004).
(d) **Organic Carbon (OC)**

Organic carbon is the amount of carbon found in an organic compound. Organic Carbon as observed for Kitchen Waste and Group I to Group V and results are stated below:

![Organic Carbon in kitchen waste and various compost samples](image)

*Figure 20: Organic Carbon in kitchen waste and various compost samples*

It is clear from Figure 20 that Group III (compost using Enzyme Powder) showed the maximum Organic Carbon content i.e. 41.6±0.2 whereas kitchen waste had the minimum Organic Carbon content i.e. 6.51±0.21. In other treated groups of compost samples i.e. Group I, II, IV and V OC was found to be 15.91±0.44, 12.63±0.2, 26.6±0.4 and 15.79±0.6 respectively. Values of organic carbon are highly significantly (P<0.01) in all the compost samples when compared to kitchen waste.

Microbes and earthworms are involved in Composting and Vermicomposting methods involve. Microbial and enzymatic activity could be responsible. The joint process results in to carbon removal from substrates in the form of carbon dioxide. According to Crawford (1983) due to microbial respiration and mineralization of organic matter, the organic carbon is lost as CO₂. This observation was also
observed by Fang et al. (2000) and Cabrera et al. (2005) that a part of the organic carbon is released as CO$_2$ and a part is assimilated by the microbial biomass. Carbon is used as source of energy by the microorganisms while decomposing the organic matter. In our study increase in organic carbon was found from 6.51±0.21 to 41.6±0.2. Values are high which may be due to the vegetable waste which is highly organic and contain high carbohydrates and proteins. The organisms *Rhizobium*, *Azotobacter* and *Lactobillus* utilized organic matter and converted into reusable fertilizer by improving the quality of compost with increase in organic carbon and nitrogen. This study was also observed by Beloso et al. 1993. However, there is no specific value for carbon. Organic content is directly proportional to carbon content, Jackson (1979). In Group III organic carbon is found high (41.6%) may be due to low moisture content in the compost.
(e) **Total Nitrogen (TN)**

Nitrogen is one of the important macronutrient which is required for plants growth and is often deficient in soil. Nitrogen promotes rapid growth, and is important for photosynthesis as it is a part of chlorophyll. Plants root absorbs nitrogen in the form of NO₃ and NH₄. Total Nitrogen values as observed for kitchen waste and Group I to Group V are given below:-

![Graph showing Total Nitrogen in kitchen waste and various compost samples](image)

**Figure 21: Total Nitrogen in kitchen waste and various compost samples**

Changes in total nitrogen of the composting and vermicomposting of kitchen waste selected for the present studies are shown in Table 21. Results show that kitchen waste did not have any form of measureable nitrogen content whereas Groups I, II, III, IV and V showed a significant and measureable nitrogen concentration i.e. 0.1067±0.14, 0.1400±0.18, 0.1400±0.036, 0.1133±0.044 and 0.1267±0.04 respectively. Values are significantly increased (P<0.05) in control compost and vermicompost sample and highly significantly increased (P<0.01) in compost prepared by enzyme powder, composting culture and NSDL, when compared to kitchen waste.
Nitrogen was found to be highest in Group II (vermicompost) and Group III (compost using Enzyme Powder). Measurable value was also find in Group V. As suggested by Gunadi et al. (2002) and Bisen et al. (2011) the nitrogen level of vermicompost increased by earthworm action by nitrogen transformation through microbial action, deposition of mucus and nitrogenous wastes released by earthworms. The final nitrogen content in vermicompost depends upon the initial nitrogen present in the waste and the extent of decomposition. Result confirms the findings of several workers who reported that the earthworms promote microbial growth as well as microbial activity (Edward et al. 1996). Higher microbial activity in the earthworm cast was also reported by Teotia et al. (1950) and Kollmannsperger (1956).

In Group V it may be high as NSDL contains Actinomycetes, Thermophilus, Thermobasillus, & Basillus spp. & nitrogen fixing bacteria. NSDL also contains of fermentation products of plant extracts, vermiwash and cow urine.

As stated by Bhadauria et al. 2002, ingredients of cow urine are 95% water, 2.5% urea, salts, 2.5% minerals, hormones, and enzymes. It contains iron, calcium, carbonic acid, potash, nitrogen, phosphorus, ammonia, sulphur, manganese, phosphates, potassium, uric acid, urea, amino acids, cytokine, enzymes, lactose etc. Addition of cow's urine in organic waste led better quality of compost as it contains higher amount of major macro-and micro-nutrients as well as contains useful microflora like Bacteria, Fungi and Actinomycetes.

However, increase in the total nitrogen for all prepared compost samples was found. It is because during composting, nitrogen becomes concentrated, due to degradation of organic matter (Genevini et al. 1997). It was also suggested that increase in nitrogen during composting shows an agronomic value (Vuorinen and Saharinen, 1998).

In a study carried out by Sharma et al. 2011, it was found that the nitrate content was high in both compost and vermicompost samples of kitchen waste. There was no loss of nitrogen during the composting process as indicated by high value of nitrate (Francou et al. 2008).
Similarly, in vermicomposting, available nitrogen also gets attached with various metabolic products like growth stimulating hormones and dead tissues (Tripathi and Bhardwaj, 2004; Araujo et al. 2004).

(f) **Available Phosphorus (P)**

Phosphorus is another important plant nutrient which is found in high concentration in compost and majorly used as a constituent of fertilizers for agriculture and farm production. Phosphorus was calculated in kitchen waste and Group I to Group V and results are stated below:-

![Available Phosphorus in kitchen waste and various compost samples](image)

**Figure 22: Available Phosphorus in kitchen waste and various compost samples**

Among the composts analysed all the compost samples showed increase in their phosphorus content. Phosphorus percentage was analysed from the Figure 22 above. The results show that Group V (compost using NSDL) contained maximum phosphorus i.e. 1.34±0.00 and Group II (vermicompost) contained minimum phosphorus i.e. 0.3±0.01. Whereas kitchen waste, Group I, III and IV had a significant and measureable Phosphorus concentration i.e. 0.35±0.00, 0.75±0.02, 0.65±0.02 and 0.67±0.01 respectively. Values have significantly increased (P<0.05)
in control compost and compost prepared by composting culture and significantly (P<0.05) decreased in vermicompost. Values have shown a highly significant (P<0.01) increase in compost prepared by enzyme powder and NSDL.

It was found to be high in Group V i.e. compost prepared by NSDL which may be due to its composition.

Organic waste compost has been reported to effectively supply phosphorus to soil with soil phosphorous concentration increasing application rates (Iglesias-Jimenez et al. 1993; Zhang et al. 2007). Some reports observed that organic waste compost provided equivalent amounts of phosphorus to soil as mineral fertilizers (Iglesias-Jimenez et al. 1993).

Sharma et al.(2011) phosphate content in mature compost sample (2.530 mg/kg) was found to be higher than vermicomposted sample (0.518 mg/kg) and the fresh sample (2.227 mg/kg) in kitchen waste.

Chaudhuri et al. 2000 reported during vermicomposting of kitchen waste, increased phosphate content during composting was noticed after 20 days process but decrease in phosphate content after 40 days. In our study phosphorus was found high in composting samples as compared to vermicomposting samples. These results are in consistence with our results.

The comparative study of all groups reveals that various comports have significant effect on producing available phosphorus content in different compost samples.
(g) **Exchangeable Potassium (K)**

Potassium is the third essential fertilizer element. It has an important role in the growth of plants, synthesis of amino acids and proteins (Velmurugan and Ramanujam, 2011). Compost contains concentrated potassium. Potassium in compost help plants fight against diseases, aids in photosynthesis and encourages fruit production. Potassium was calculated in kitchen waste and Group I to Group V and results as shown below:

*Figure 23: Exchangeable Potassium in kitchen waste and various compost samples*

Potassium was another measurable parameter and percentage of potassium can be analysed from above Figure 23 above. Increase in potassium content was observed in prepared various compost samples. Similar observations were also made by Guerra-Rodriguez *et al.* (2001). An experiment conducted by Pathak *et al.* (2012), revealed that kitchen waste compost had significant amount of nutrients for plant growth. Results show that kitchen waste contained minimum measurable potassium i.e. 0.28±0.05. Whereas Group III (compost using Enzyme Powder) and V (compost using NSDL) had a significant and measureable high potassium concentration i.e.
Results and Discussion

0.92±0.08 and 0.72±0.12 respectively. Exchangeable Potassium in Group I, II and Group IV was found to be 0.66±0.07, 0.35±0.8 and 0.67±0.12 respectively. Values were found to be non-significant in vermicompost sample. Values are significantly increased (P<0.05) in control and compost prepared by composting culture. Values have significantly (P<0.01) increased in compost prepared by enzyme powder and NSDL.

In Group III it may be high due to the production of acid in degradation of organic material through the microorganisms which is responsible for increase in potassium content as also suggested by Hartenstein and Hartenstein, 1981; Elvira et al. 1998; Kaviraj and Sharma, 2003; Garg et al. 2006; Suthar, 2007; Tajbakhsh et al. 2008; Adi and Noor, 2009; Khwairakpam and Bhargava, 2009.

Research conducted by Wani et al. 2013 in garden and kitchen waste along with cow dung, results of the study reveal that potassium increase was significantly higher in kitchen waste as compared to cow dung and garden waste. During composting, acid production due to increased activity of microbes, plays an important role in solubilizing the insoluble potassium.
(h) Calcium (Ca)

Exchangeable calcium gives reasonable good estimates of potential nutrient availability in plants. Calcium was calculated in kitchen waste and Group I to Group V and results are stated below:

![Figure 24: Calcium in kitchen waste and various compost samples](image)

Calcium is another measurable parameter and percentage of calcium produced was analysed from above Figure 24. Results states that kitchen waste found minimum measurable calcium i.e. 0.16±0.02. Whereas Groups I, II, III, IV and V produce a significant and measureable calcium concentartation i.e. 0.82±0.05, 0.34±0.02, 0.51±0.04, 0.45±0.07 and 0.86±0.17 respectively. Values are found non-significant in compost prepared by enzyme powder. Values are significantly increased (P<0.05) in control compost, vermicompost and compost prepared by composting culture. Values are have significantly increased (P<0.01) in compost prepared by NSDL.

Calcium content was found highest in Group V (compost using NSDL). Increase in calcium content compared to other compost samples may be attributed to
the catalytic activity of carbonic anhydrase. Presence of this enzyme generates CaCO₃ on the fixation of CO₂ (Padmavathiamma et al. 2008). Wani et al. 2013 found that calcium content was low in both fresh (0.347 mg/g) and vermicompost sample (0.213 mg/g) as compared compost sample (0.400 mg/g). Same findings are in corroboration with our results which shows that Calcium content was found to be high in all the composts prepared (Group I to Group V) as compared to kitchen waste.
(i) **Magnesium (Mg)**

Exchangeable Magnesium gives reasonable good estimates of potential nutrient availability in plants. Magnesium was calculated in kitchen waste and Group I to Group V and the results are as shown below:-

Results of Magnesium analysis show that kitchen waste produce minimum measurable Mg i.e. 0.15±0.01 and Group V (compost using NSDL) produce maximum Mg i.e. 0.50±0.07. However, Groups I, II, III and IV produce a significant and measurable Mg concentration i.e. 0.40±0.03, 0.25±0, 0.19±0.02 and 0.22±0.02 respectively. Values are significantly increased (P<0.05) in control compost, vermicompost and compost prepared by enzyme powder and composting culture. Values of Magnesium were found to be highly significant (P<0.01) in compost prepared by NSDL.

Sharma *et al.* (2011) found that high magnesium was found in fresh sample of spinach but decreased during composting and vermicomposting. Similar results were also given by Chaudhuri *et al.* (2000) and Ahmed and Syedomar, (2007).
Above results Show that in Group V, Total Nitrogen, Exchangeable Potassium, Calcium and Magnesium were found high, the reason may be due to the NSDL contains Actinomycetes, Thermophilus, Thermobasillus, & Basillus spp. & nitrogen fixing bacteria. NSDL also contains of fermentation products of plant extracts, vermiwash and cow urine.

After the laboratory and statistical analysis of various physico-chemical parameters of the different composts prepared from kitchen waste (Group I to Group V), it was concluded that the compost prepared with the help of NSDL (Nature’s Suraksha De-composer Liquid) i.e. Group V, proved to be the best suited bio-enhancer in the present study. Therefore, it was selected for further value addition studies. However, it can be further concluded that Enzyme Powder, Vermicompost and Composting Culture, can also be carried out for value addition along with buttermilk, sugarcane juice and vermiwash.
DISCUSSION AND COMPARISON OF RESULTS OF VALUE ADDED COMPOST

After preparation of different composts and their analyses (Phase II), NSDL was found to be the best suitable for value addition among all the compost samples (Group I- Group V). For value addition of this compost different value added compost samples were prepared by using buttermilk, sugarcane juice and vermiwash in triplicate form. As buttermilk helps in fast composting process, sugarcane juice is helpful for micro-organisms growth and vermiwash is rich in micro and macro nutrients which are beneficial for plant growth. One kg of kitchen waste was collected in each earthen pot. Thus total eighteen earthen pots were used. Prepared Groups are given follows:-

- Gp VA-I (a) - 50 ml NSDL+25 ml Buttermilk
- Gp VA-I (b) - 50 ml NSDL+50 ml Buttermilk
- Gp VA-II (a) - 50 ml NSDL+25 ml Sugarcane Juice
- Gp VA-II (b) - 50 ml NSDL+50 ml Sugarcane Juice
- Gp VA-III (a) - 50 ml NSDL+25 ml Vermiwash
- Gp VA-III (b) - 50 ml NSDL+50 ml Vermiwash

Mean Physico-chemical analysis of various parameters (Moisture Content, pH, Electrical Conductivity, Organic Carbon, Total Nitrogen, Available Phosphorus, Exchangeable Potassium, Calcium, Magnesium) of all the Value Added Compost [Gp VA-I (a)- Gp VA-III (b)] are as shown in table given below:-
Table 5: Mean of Physico-chemical Parameters of Various Value Added Compost Samples

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value Added Compost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NSDL Compost from Phase II</td>
</tr>
<tr>
<td>MC (%)</td>
<td>14.40±0.52</td>
</tr>
<tr>
<td>pH</td>
<td>7.77±0.52</td>
</tr>
<tr>
<td>EC(dS/cm)</td>
<td>0.03±0.004</td>
</tr>
<tr>
<td>OC (%)</td>
<td>15.79±0.68</td>
</tr>
<tr>
<td>N (%)</td>
<td>0.12±0.04</td>
</tr>
<tr>
<td>P (%)</td>
<td>1.34±0.00</td>
</tr>
<tr>
<td>K (%)</td>
<td>0.72±0.12</td>
</tr>
<tr>
<td>Ca (%)</td>
<td>0.86±0.17</td>
</tr>
<tr>
<td>Mg (%)</td>
<td>0.50±0.07</td>
</tr>
</tbody>
</table>

Values in Mean±S.D; NS = Non Significant; *Significant at 0.05 level of significance; **Significant at 0.01 level of significance
The Physico-chemical parameters analysed were same as those analysed in Phase II. Although NPK was focused but moisture content, pH, EC, organic carbon was also observed. Results of the afore mentioned parameters have been discussed below:-

(a) Moisture Content (MC)

Moisture content was between 24-50% in all the value added compost samples. It was found from statistical studies that MC is significantly higher (P<0.05) in compost prepared by 25 ml buttermilk, 50 ml buttermilk, 25 ml sugarcane juice and 50 ml sugarcane juice along with NSDL as compared to compost prepared by NSDL. However it was found to be significantly highest (P<0.01) in the compost prepared 25 ml and 50 ml vermiwash along with NSDL. According to Gray et al. 1971b and Rhyckeboer, 2003, at the time of maturity, drying is considered for storage or sale.

![Figure 26: Moisture Content in various value added compost samples](image)
(b) **pH**

The pH varies between 7.96 to 8.56 in all value added compost samples. Compost prepared by 25 ml buttermilk along with NSDL was found to be non-significant. It was found from statistical studies that pH is significant higher (P<0.05) in compost prepared by 50 ml buttermilk, 25 ml sugarcane juice, 50 ml sugarcane juice along with NSDL. However it was found to be highly significantly (P<0.01) increased in compost prepared 25 ml and 50 ml vermiwash along with NSDL. The alkaline nature of compost was also reported by Tchobanogolous *et al.* 1993, which is indicative of good composting process. Inbar and Chen (1993) reported similar findings. In a study by Basheer *et al.* (2013) in vermicomposting of paper waste and cow dung (1:1), pH (7.6) was found to be maximum in vermiwash treated compost followed by Trichoderma (7.5) and Jaggery + Buttermilk (7.5), while least value for pH was observed in control compost (7.3). These alkaline values are more or less close to our results. The reason behind slightly high pH values may be due to high mineralization of nitrogen and phosphorous into nitrates/nitrites and ortho-phosphate. Our results are also in consistence with Albasha *et al.* 2015. Similar results were observed by Michel and Reddy in 1998 and Gunadi *et al.* in 2002, in composts of fruit and vegetable wastes and cattle manure.

![Figure 27: pH of various value added compost samples](image-url)
Results and Discussion

(c) Electrical Conductivity (EC)

In value added compost samples EC was found between the range of 1.15±0.011-1.35±0.054 in all value added compost samples. EC was found minimum in Gp VA- III (a), Gp VA- III (b). Low EC could be an indicator of complex nutrients and therefore desirable, as described earlier. It was found that EC is significant higher at 0.05 level in all value added groups as compared to NSDL. However it was found to be highest significant increased in compost prepared 25 ml buttermilk, 50 ml buttermilk and 25 ml sugarcane juice. Values are highly significantly increased in 25 ml and 50 ml vermiwash along with NSDL if compared with compost prepared by NSDL. If values compared within value added groups, results shows decline in EC in compost prepared by 25 ml and 50 ml vermiwash along with NSDL. Other way of enhancement of the EC in Group II (a) and II (b) may be due to the degradation of organic matter to release more cations as also suggested by Campbell, et al. 1997. Basheer (2013) found that the EC values obtained from various treatments were 0.36 in vermiwash, 0.50 in trichoderma, 0.70 in Jaggery + Buttermilk and 0.85 in control. Our results found between the range of 0.367±0.037-0.0475±0.078.

Figure 28: Electrical Conductivity of various value added compost samples
(d) **Organic Carbon (OC)**

Organic carbon was found from 12.68% to 28.5% in all value added compost samples. Values are found non-significant in Gp VA-I (a) i.e. with 25 ml buttermilk and Gp VA-II (a) i.e. with 25 ml sugarcane juice. Values are significantly increased in Gp VA-I (b) i.e. with 50 ml buttermilk and Gp VA-III (a) i.e. with 25 ml vermiwash and highly significantly increased found in Gp VA-I (b) i.e. with 50 ml buttermilk and significantly decreased in Gp VA-III (b) i.e. with 25 ml vermiwash. Values are found highly significantly increased in Gp VA-II (b) i.e. compost prepared by 50 ml sugarcane juice along with NSDL and GpVA-III (b) i.e. compost prepared by 50 ml vermiwash along with NSDL. According to Jackson (1979), there is no specific value for carbon. Organic content is directly proportional to the carbon content. Quality of compost is also indicated by the organic content. Wani et al. (2013) found that microorganisms may use carbon as a source of energy which may be further responsible for change in organic carbon. Same observation was found by Fang et al. (2000) and Cabrera et al. (2005). Values are found significantly high in compost prepared by 50 ml sugarcane juice and 50 ml vermiwash, it may be due to high organic content and contain high carbohydrates and proteins. This study was also observed by Beloso et al. 1993. The reason may be also due to high content of organic carbon present in sugarcane and vermiwash.

![Figure 29: Organic Carbon of various value added compost samples](image-url)
(e) **Total Nitrogen (TN)**

If we compare results found in Phase II with the findings of Phase III, it was found that total nitrogen was found increased. Earlier it was found 0.1267% in compost prepared by NSDL. In value added compost sample it was found maximum in compost prepared by NSDL along with 50 ml vermiwash. As earlier discussed the composition of NSDL, which is a good source of nitrogen. Although vermiwash is a part of its composition but when additional 50 ml vermiwash was added, it was found to be increase from 0.1267% to 2.01%. TN was found non-significant in compost prepared by 25 ml sugarcane juice along with NSDL. It was found from statistical studies that TN is significant higher at .05 level in compost prepared by 25 ml and 50 ml buttermilk, 50 ml sugarcane juice and 25 ml vermiwash as compared to NSDL. However, it was found to be highest (P<0.01) in compost prepared by 50 ml vermiwash along with NSDL. Wani et al. (2013) observed that total nitrogen consists of the inorganic forms of nitrogen NH$_4$-N and NO$_3$-N. TN content was higher (1.97±0.07) in cow dung followed by kitchen waste (1.30±0.02). In the form of mucus, growth stimulating hormones, nitrogenous excretory substances and enzymes from earthworms associated with the increase in nitrogen content as reported by Tripathi and Bhardwaj in 2004. The mineral nitrogen may be retained in the nitrate form by nitrogen transformations in manure, by enhancing nitrogen mineralization, Atiyeh et al. (2000). It has been found that the final nitrogen content of the compost is also dependent on the extent of decomposition (Crawford, 1983; Gaur and Singh, 1995). Same trend was followed with other parameters like phosphorus, calcium, magnesium.
Results and Discussion

Figure 30: Nitrogen Content of various value added compost samples
Available Phosphorus (P)

Increase in Phosphorus was observed from 1.34% to 1.79% in compost prepared by NSDL along with 50 ml vermiwash. Phosphorus was found non-significant in compost prepared by 25 ml vermiwash along with NSDL. It was found from statistical studies that phosphorus is significant higher at 0.05 level in compost prepared by 50 ml vermiwash along with NSDL as compared to NSDL. Values are significantly lowest in compost prepared by 25 ml and 50 ml sugarcane juice along with NSDL. However it was found to be highly significantly (P<0.01) decreased in the compost prepared 25 ml and 50 ml buttermilk along with NSDL. It may be due to the presence of additional vermiwash as it is rich in phosphorus content. This might be due higher P-solubilizers population (Chowdappa et al. 1999) or probably due to mobilization and mineralization of phosphorus due to of bacterial and faecal phosphatase activity of earthworms (Garg et al. 2006). In a study by Basheer et al. (2013) in vermicomposting of paper waste and cow dung (1:1), the maximum phosphorus content was observed in Trichoderma (1.41%) followed by vermiwash (1.30%), Jaggery + Buttermilk (1.28%) and control (1.18%). According to Padmavathiamma et al. (2008) suggested that phosphorus content depends on acid formation during organic matter decomposition process by microorganisms which is responsible for phosphorus content.

Figure 31: Available Phosphorus of various value added compost samples
(g) **Exchangeable Potassium (K)**

In case of potassium, it shows that in NSDL along with vermiwash, rate of solubilizing of insoluble potassium is higher due to presence of microorganisms. It was found from statistical studies that potassium is significantly lower at 0.05 level in compost prepared by 25 ml buttermilk, 50 ml buttermilk, 25 ml sugarcane juice and 25 ml vermiwash along with NSDL as compared to NSDL. Values are highly significantly lowest (P<0.01) in compost prepared by 50 ml sugarcane juice and 50 ml vermiwash along with NSDL. Within value added groups values are found highest in compost prepared by 50 ml vermiwash along with NSDL. If we compare with results found in Phase-II, results are found decreased. In a study carried out by Basheer and Agrawal (2015) found that garden waste and cow dung in the ratio 1:1 was best. Trichoderma, vermiwash & jaggery+buttermilk and control were used as compost enhancers. The potassium content was maximum in trichoderma treated compost followed by vermiwash, jaggery + buttermilk. Minimum potassium content was observed in control group without any additive. It may be due to the production of acid in degradation of organic material through the microorganisms is the important process for solubilization of insoluble potassium as discussed earlier also.

![Figure 32: Exchangeable Potassium content of various value added compost samples](image)
(h) Calcium (Ca)

Increase in calcium content was also noted from 0.86% to 1.84%. Highest value was observed in compost prepared by NSDL along with 50 ml vermiwash. Compost prepared by 25 ml buttermilk along with NSDL is found non-significant. It was found from statistical studies that calcium is significantly higher at 0.05 level in compost prepared by 50 ml buttermilk, 25 ml sugarcane juice and 25 ml vermiwash along with NSDL as compared to NSDL. Values are highly significantly (P<0.01) increased in compost prepared by 50 ml sugarcane juice and 50 ml vermiwash along with NSDL. The increase in Ca content is also demonstrated by Pierce (1972) who stated that the chemical composition of faecal material of earthworms is may be responsible for this. This may be enhanced in vermiwash. Similar result was also observed by Spiers et al. (1986) who reported that earthworms convert calcium oxalate crystals in ingested fungal hyphae to calcium bicarbonate which is then egested in cast material, which increases calcium availability.

![Graph showing calcium content of various compost samples](image)
(i) **Magnesium (Mg)**

Magnesium content was found increased from 0.50% to 1.63%. It was found highest in again compost prepared by NSDL along with 50 ml vermiwash. Compost prepared by 25 ml sugarcane juice along with NSDL is found non-significant. It was found from statistical studies that magnesium is significantly higher at 0.05 level in compost prepared by 25 ml and 50 ml buttermilk, 50 ml sugarcane juice and 25 ml vermiwash along with NSDL as compared to NSDL. Values are highly significantly (P<0.01) increased in compost prepared by 50 ml vermiwash along with NSDL.

![Figure 34: Magnesium Content of various value added compost samples](image)

After statistical examination of all physico-chemical results in phase III, it was observed that value added compost sample of NSDL along with 50 ml Vermiwash has the highest significance in comparison with other compost samples. Thus it could be considered as the most promising compost bio-enhancer among all which were studied in the present research work.