

Comparative Analysis of Different Combinations of Composting and Testing of Soil Physical Properties

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Abstract During composting process, soils undergo many changes in their physical, chemical and biological properties. Composting has been widely known as an aerobic process during which organic matter is decomposed to humus like substances broken into many organic materials or compounds. The project aims to compare and analyze different combination of composting that yield different properties and nature of soils, and testing their soil physical properties. Dug three compost pits each 1.5 m in depth, labeled compost pit A consisting of potato peels – the only kitchen waste most common around the college hostels, compost pit B consisting of leaf litter and other garden trimmings and compost pit C consisting of cow dung and the other as a controlled experiment with no composting practices.

Keywords: Soil, parameters, pit, composting, analysis, properties

1. Introduction

Soil can be defined as the unconsolidated mineral or organic material on the surface of the earth arising from a particular parent material that has been subjected to and shows the effects of climate macro and micro-organisms, the topography of its location in the landscape, and time (Keesstra, et al., 2016). Soils are vital for life on earth, though it is not an infinite resource, meaning its loss and degradation is not recoverable within a human lifespan (Brevik, et al., 2015). Soil supports the growth of higher plants, mainly providing a medium for plant roots and to supply nutrient elements to the plant (Hayat, Ali, Amara, Khalid, & Ahmed, 2010). Soil properties are the principal factor controlling the fate of water in the hydrologic system (Perk, 2013). Soil functions as nature's recycling system- the waste products and dead bodies of plants, animals, and people are assimilated and their basic elements are made available for reuse by the next generation of life (Davidson & Janssens, 2016). Soil also provides habitats to living organisms of unimaginable numbers and diversity, from small mammals and reptiles to tiny insects to microscopic cells (Wolters, 2001). In human-built ecosystems, soil plays an important role as an engineering medium (Bender, Wagg, & Heijden, 2016). Its physical properties in general comprises of: soil color – due to minerals present and organic matter content, soils can exhibit a wide range of grey, black, white, browns, yellows, green and red colors even during weather and topographical factors as well (Melville & Atkinson, 1985); temperature -

temperature is one of the key factors affecting the composting process. During microbial breakdown of organic matter, compost heat is produced as a by product (Nakasaka, Shoda, & Kubota, 1985); soil pH – it is often expressed as the measure of hydrogen ion concentration or the measure of acidity and alkalinity of a solution or a sample (Stevens, Laughlin, & Malone, 1998). In addition it is also one of the decisive factors affecting metal solubility, plant growth, plant nutrient uptake and movement and many other reaction (Epstein, 1997); moisture content – it is the quality of water contained in the soil. It forms a major part of plant itself along with it is essential for physiological activities, acts as a solvent and nutrient carrier and maintains the turbidity of plants (Lang & Smith, 2007); soil texture – due to physical weathering it results in a wide range in size of soil particles from stones to gravel and finally to sand, silt and small clay particles (Jones, 1983); bulk density – it is an indicator of soil compaction and soil health. It affects infiltration, rooting depth, available water capacity, soil porosity, plant nutrient availability and soil micro-organism activity which influence the key soil processes and productivity (Williams, Ahuja, & Naney, 1992); organic carbon – it is a measurable component of soil organic matter which consists of relatively available carbon in the form of fresh plant remains, or animal residues and various stages of decomposition of cells and tissues of other soil microorganisms (Chan, 2001). Its importance constitutes of determining soil fertility, a stimulant of natural carbon cycle, promoting the structural, biological and physical health of soil and a buffer against harmful substances (Quine & Zhang, 2002).

During composting process, soil undergoes many changes in their physical, chemical and biological properties (Cooperband, 2000). Composting has been widely known as an aerobic process during which organic matter is decomposed to humus like substances broken into many organic materials or compounds. According to (Epstein, 1997) compost production is considered an economic and environmentally friendly means to reduce waste especially home-made, kitchen organic waste going into landfills and other forms of dumping sites. It has also been shown that composting can have another beneficial effect such as removal of pathogen inoculant or weed seeds, as a method of erosion control and a source of nutrient for sustainable re-vegetation of degraded soils (Jiang, Wang, Haiyan, Labzovskii, & Liu, 2019). Therefore, this research mainly focuses on comparing and analysis of different combination of composting and testing their soil physical properties.

1.1. Aim

Comparison and analysis of different combination of composting that yield different properties and nature of soils, and testing their soil physical properties.

1.2. Objective

To test the soil properties from each combination of composting practices that we have created, compost pits comprising of potato peels, leaf litter and cow dung separately. To compare and determine the hypothesis towards confirming which combination of composting is faster and more efficient depending on our results. To conclude upon our result and show which is best option for managing waste generated from our household, while also confirming simple ways to utilize soil management in and around us.

2. Methodology

2.1. Study Methods

We have opted to dig three compost pits measuring 1.5 m in depth, labeled compost pit A consisting of potato peels – the only kitchen waste most common around the college hostels, compost pit B consisting of leaf litter and other garden trimmings and compost pit C consisting of cow dung and the other as a controlled experiment with no composting practices. The various combination of compost in each pit was then added with some layers of soil and the pits were covered with plank

to avoid contamination of the compost during rainfall.

2.2. Study Area

The study was conducted near one of the hostels (Degree Hostel VI) of Sherubtse College under Royal University of Bhutan. The project was part of requirement of undergraduate course assessment. For the digging of compost pit and collection of our soil sample, we chose a site near DH 6 (Degree Hostel 6) as it was near the college vicinity therefore eliminating our time constraints while attending the compost progress.

2.3. Data collection and Laboratory Work (Instruments used)

The primary data for this study was collected by doing laboratory experiments in an Environmental Science Laboratory (ESL), Sherubtse College, Royal University of Bhutan. To conduct the comparative analysis of soil properties from different combination of compost pits, collection of soil samples was our top priority. With the samples, various physical parameters of the soil were tested;

- a) Soil Color - by referring to Munsell's Soil Color book.
- b) Soil pH - by using digital pH meter.
- c) Soil texture - by applying sieve method and deducing the result by referring Soil Texture Triangle
- d) Moisture content - by applying weighing method and calculating it by Gravimetric method.
- e) Organic Carbon - by implementing Walkley-Black Method.

2.4. Update (Progress Check)

We started our work by digging three compost pits and would realize that with different combinations of composting implemented, all three of the pits would require time to decompose with the soil and yield good compost. So, we tended to them every week, made sure to mix them, cover them from the rain and much foggy weather. Added little bit of water, and exposed it to direct sunlight at all times. Until 4 weeks and 4 days later our compost pit showed some signs of decomposition especially for leaf litter and cow dung pits but for potato peels, the rate of decomposition had been much slow as we noticed potato peels still fresh and thick that we needed another additional days for it to be turned into a fully perfect compost.

2.5. Data and Observations

2.5.1. Soil Color

Compost combinations	Potato Compost Pit (A)	Leaf Compost Pit (B)	Cow dung Compost Pit (C)	Controlled experiment
Color	Yellowish Brown	Dark Brown	Very dark brown	Brownish yellow

2.5.2. Soil pH

Compost combinations	Compost Pit A	Compost Pit B	Compost Pit C	Controlled experiment
pH value	7.1	7.1	7.6	7.3

2.5.3. Soil Texture

Compost Combinations	Compost Pit A	Compost Pit B	Compost Pit C	Controlled Experiment
2 mm (Sand)	38.08 g	39.26 g	64.71 g	43.09 g
0.212 mm (Silt)	58.53 g	55.51 g	34.86 g	54.65 g
0.025 mm (Clay)	2.5 g	4.1 g	0.18 g	1.9 g
Resulting Texture	Silty Clay Loam	Silty Clay Loam	Clay	Silty Clay

2.5.4. Moisture Content

Soil Sample	Compost Pit A		Compost Pit B		Compost Pit C		Controlled	
	A	B	A	B	A	B	A	B
Weight of the petri dish (W ₁)	42.97 g	42.20 g	43.54 g	45.66 g	56.83 g	47.83 g	64.72 g	45.60 g
Average	42.58 g		44.6 g		52.1 g		55.14 g	
Weight of the petri dish + weight of the moist soil (W ₂)	82.97 g	82.20 g	83.54 g	85.66 g	96.83 g	87.38 g	104.72 g	85.60 g
Average	82.58 g		84.6 g		92.10 g		95.16 g	
Weight of the petri dish + weight of the dried soil (W ₃)	76.66 g	76.38 g	76.99 g	80.52 g	89.96 g	83.40 g	99.45 g	80.79 g

Average	76.52 g	78.75 g	86.68 g	90.12 g
Moisture Content = (W2-W3/W3-W1) *100	17.85 %	17.13 %	15.67 %	14.4 %

2.5.5. Organic Carbon

Composts	mL of Fe ²⁺ Solution used to titrate sample (S)	mL of Fe ²⁺ Solution used to titrate blank solution (B)	Milliequivalent wt. of C in gram	Gram of soil	moles of Fe ²⁺ (M)	% of Carbon
controlled Soil	17.8 mL	20 mL	0.003	0.5 g	0.5 M	2.8 %
Potato compost	17.2 mL	20 mL	0.003	0.5 g	0.5 M	3.4 %
Leaf compost	17.5 mL	20 mL	0.003	0.5 g	0.5 M	3.1 %
Cow dung compost	16.4 mL	20 mL	0.003	0.5 g	0.5 M	4.2 %

$$\% \text{ of C} = \frac{(B-S) \times M \text{ of Fe}^{2+} \times 0.003 \times 100}{g \text{ of soil}}$$

3. Results and Discussion

3.1. Soil Color

The entire compost pit gave a different colored soil as compared to the controlled soil. Our controlled experiment soil with no composting effect was brownish yellow in color. However, after the decomposition of the different compost, the color of the soil has also changed. We found that the Potato compost was yellowish Brown in color, Leaf litter compost with dark brown and the cow dung compost with very dark brown in color. This is because during composting process, the soil and the matter in the pit can undergo homogenization of the color and with humidification due to the outside climate, it could accelerate the decomposition process turning it into brown most of the time and very dark earthy or blackish as well. In the compost pit containing cow dung, it showed favorable results of very dark brown, loose, homogeneous and surprisingly no foul odor at all.

3.2. Soil pH

Regarding the pH, every compost pit had a favorable value ranging from 7.1-7.6 which is neutral and there were no significance differences.

According to (Mayes, Batty, Younger, Jarvis, Koiv, Vohla & Mander, 2009) mature compost such as ours generally has a pH between 6 and 8. It is also concluded that compost microorganisms can operate best under neutral to slightly alkaline conditions. In terms of crop cultivation, they can also thrive in soil conditions that have a neutral pH. The microbial process can also inflict varying changes in pH values as well. Therefore, we concluded that the soil sample we studied and the different composts we prepared were slightly alkaline and favorable for supporting plant growth.

3.3. Soil Texture

The soil texture of the controlled soil (sample soil) was silty clay and upon the decomposition of the different compost, the soil texture has changed. The compost pit with potato peel and leaf litter compost showed silty clay loam texture, while the compost pit with cow dung compost showed clay texture. According to (Brady & Weil, 2014) the best type of the soil for the agricultural purposes, loamy soils are considered the best soils for the growth of most crops. Soils with a loam textures such as sandy loam, silty loam, clay loam, silty clay loam and loamy sand are a

combination of soil particle sizes which together provide desirable characteristics. Therefore, we concluded that the potato and leaf litter composts are suitable for the growth of many crops. However, the cow dung compost with clay texture is suitable for growing crops like paddy, which requires a lot of water. Clay soils are rich in nutrients and they possess the ability to retain plenty of moisture which makes it suitable for the growth of paddy.

3.4. Moisture Content

Generally the moisture content of the soil ranges from 10% to 45 %, however it depends upon the weather conditions and it may go higher during monsoon seasons (Reynolds, 2006). With reference to the controlled experiment measuring 14.4% of moisture content, it is evident that the different composting has altered the moisture content. We found out that the potato and leave compost have higher moisture content of 17.85% and 17.13% respectively. This is because composting has improved the fertility of soil by transforming the potato peels and leaves in to nutrient rich organic matters. Moreover, research shows that the amount of organic matter in a soil increases the availability of water and increase the water holding capacity of the soil reducing evaporation and runoff (Bonnie, 2018). Similarly, cow dung compost has can also add generous amount of organic matter and improved the moisture holding capacity (15.67 %). So we can conclude that the different composting has improved the soil moisture content.

3.5. Organic Carbon

Soil organic carbon is the most important properties of the soil and it is the basis of soil fertility. It is evident that the organic carbon of soil will increase on addition of different compost. In our experiment, the soil organic carbon of the controlled was found to have 2.8 % of organic carbon and upon the addition of different of composting, it has altered the organic carbon of the soil. The organic carbon of the compost pit with cow dung has the highest organic carbon content with 4.2% followed by potato compost (3.4 %) and leaf compost (3.1%). The optimum range of soil organic carbon for growing lawns is between 2 to 3 percent and for landscapes and gardens for growing flowers 4 to 6 percent of the organic soil carbon is preferable (Clara & Fatma, 2017). Therefore, we concluded that on addition of different composting the organic carbon of the soil is improved and we found that the cow dung has the highest carbon content in it which makes it more favorable for the growth of crops.

4. Conclusion

Regarding our second objective, we have found out that the cow dung composting combination was much faster in the decomposition process then followed by leaf litter and potato peels. The cow dung compost has also shown to have much greater organic carbon for the soil and have the ability to retain many important nutrients for the growth of certain crops such as paddy. Cow dung compost can also be able to hold significant amount of moisture and the color from it represented a favorable dark brown with loose soil aggregates and no unpleasant odor. With regards to pH, every combination of compost has yielded significant results of having neutral scale which is favorable for agricultural practices and plant growth as well.

Overall the process of composting is a very spontaneous process that could have many benefits to the soil structure and its properties. Overall it has led to the sustainability of an area where it could improve waste management by reducing organic wastes from our household in landfills or in municipal waste disposal bins. Therefore, composting prevents a greater number of wastes lying around and encourages natural recycling methods of providing carbon and organic matter to the soil for its fertility, growth and nutrients for crop cultivation and its production as well. Using composting methods has also shown that with good soil quality and its parameter standard has led to the improvement of creating clean and green horticultural practices and the potential for organic agriculture.

5. Limitations

During our field experimentation, the decomposition process in the compost pit was very slow due to rainfall and foggy weather that occurred so we had to continuously rely on sunlight and had to come up with an intervention plan to cover the compost pit with sack covers so that we could also let little air to get in. It was unfortunate that we were not able to test temperature and bulk density parameters due to technical irregularities as there were no proper functioning of instruments such as thermometer (Temperature) and Vernier Caliper (Bulk Density) which was important for us to conduct the experiment and come up with more accurate results.

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