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Organic matter and properties of soil in forest and agriculture areas

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Abstract
Soil organic carbon (SOC) is one of the major components of soil. It includes plants, animals, and microbial residue in all stages of decomposition. SOC determines the quality, growth, and productivity of the soil. Different studies have shown that the amount of soil organic matter is found higher in forest land than in agricultural land. The study aims to quantify the amount of soil organic matter and also determine the other related soil properties of forest and agricultural land soils. Hence, the forest and agricultural land of Sandhikharka Municipality, Arghakhanchi is selected as the study area. The present research is based on random systematic sampling. The samples were collected from the forest and agricultural land. 10 samples were collected from each land use. The percentage of soil organic carbon was determined by Walkey and Black Method. For the calculation of soil, the organic matter percentage of soil organic carbon was multiplied by 1.724. Bulk Density was calculated by the core sampler method. The soil organic matter of forest land was found to be greater than agricultural land. Soil organic matter decreased with an increase in temperature. Bulk density was found higher in agricultural land soil than in forest soil. Bulk density shows a positive response to the increasing soil depth. Soil organic matter (SOM) is found higher in forest soil than in agricultural land and bulk density decreases with the increase in SOM.

Keywords: Bulk density, soil organic carbon, soil organic matter, soil ph, soil water content

1. Introduction

1.1 Background

Soil, the unconsolidated cover of the earth consists of inorganic and organic components, water, air, and living organism. Soil provides nutrients for plants and is capable of supporting plant growth (Xiao *et al.*, 2015) [32]. Soil is created by and responsive to organisms, climate, geological processes, and the chemistry of the above-ground atmosphere (Richter and Markewitz, 1995) [24]. Soil is also an important source of aquatic carbon, with implications for biogeochemical processes in rivers, lakes, and estuaries. Despite its recognized importance, there is a widely divergent view of the nature of soil organic matter.

1.1.1 Soil Organic Matter

Soil organic matter is composed mainly of carbon, hydrogen, and oxygen, and has small amounts of other elements, such as nitrogen, phosphorous, sulfur, potassium, calcium, and magnesium contained in organic residues. It contains more organic carbon than global vegetation and the atmosphere combined (Lehmann and Kleber, 2015) [14].

Soil type, climate, and management influence organic matter (OM) inputs to soil and its turnover or decomposition. Rainfall is a major driver of plant growth (biomass) and biological activity which results in the decomposition of OM that enters soil (Bot and Benites, 2005) [6]. SOM consists of organic compounds that are enriched in carbon (Ontl *et al.*, 2012) [19]. Soil organic carbon (SOC) is not a uniform material but rather a complex mixture of organic compounds at different stages of decomposition.

The amount of OC present in the soil is the balance between inputs of organic material from the biota, which depend on the type of vegetation and its productivity at a particular site, and losses primarily through heterotrophic respiration (Post *et al.*, 1982) [23]. The OM decomposition rate more slowly as temperature decreases. (Hoyle *et al*., 2006) [12].

Soil organic matter has many advantages such as, it helps to reduce the bulk density, giving resistance to soil compaction, soil erosion, and enhanced soil fertility, and also reduces greenhouse gases by soil carbon sequestration (Overstreet and Hughes, 2009) [20].

1.1.2 Soil Organic Carbon

The total carbon present in the soil is the collective sum of both inorganic and organic carbon. Inorganic carbon is present in the form of carbonate minerals while organic carbon is present in the OM fraction (Nelson and Sommers, 1996) [17]. Carbon and plant growth are interlinked with each other. Soil organic carbon influences soil features such as color, nutrient turnover, nutrient holding capacity, and stability which affect the water relation, workability, and aeration (Chaudhari *et al*.,2013) [10].

1.1.3 Soil Bulk Density

The bulk density of the soil varies with the soil structure conditions, it increases with the change in OM content, soil profile depth, compaction, and porosity (Chaudhari *et al*., 2013) [10].

Soil bulk density (SBD) can be defined as the weight of the soil in a given volume (Brown and Wherrett, 2017) [9]. Bulk density is a general soil property that is affected by some chemical and physical properties of soil. Generally, soil rich in OM and that has loose soil pore have lower bulk density. Silt and clay soil have lower bulk density than sandy soil (Soil Quality indicators; Bulk Density, 2008) [28].

Compaction of soil means the soil has a high value of Bulk Density (BD). SBD affects the infiltration and available water. Soil water content and SBD are inversely proportional to each other, the greater the value of SBD less will be the water holding capacity of the soil (Păltineanu *et al*., 2015) [22]. Soil bulk density has great importance for understanding the biological, chemical, and physical properties of soil (Al-shammary *et al*., 2018) [2].

1.1.4 Soil Water Content

Water content refers to the amount of water held in the soil. The water holding capacity of a soil depends on the size of the pore (the smaller the pore stronger the force holding water in the soil) and the surface tension of water (Plant and Soil Science eLibrary, 2017) also the amount of water in soil different according to the texture and structure of the soil.

Soil water content is a soil property that plays a vital role in biophysical processes, such as seed germination plant growth, and also for plant nutrition (Bittelli, 2011) [4].

1.1.5 Soil pH

Soil pH is defined as the negative logarithm of the hydrogen ion concentration in soil. Soil pH also refers to the measurement of soil solution's acidity and alkalinity (McCauley *et al*., 2017) [15]. Soil pH is also called as soil reaction which is an indicator of the acidity and alkalinity of soil and is measured in pH units. pH scales range from 0 to 14, an increase in pH scale leads to alkalinity, and a decrease in pH scale leads to increased acidity (Soil pH: What It Means, 2017).

Soil pH is an important factor as it governs the availability of nutrients in plants (Beaulieu, 2017). Soil pH is influenced by factors including OM decomposition, nitrogen fertilizer source, weather of minerals and parent matter, climate, and land management practices (McCauley *et al*., 2009) [15].

2. Materials and Methods

2.1 Study Area

The study is carried out in forest and agriculture areas of Sandhikharka Municipality ward no 5 Arghakhanchi. The study area is about 376 km from Kathmandu valley. Geographically Sandhikharka Municipality is located at the altitude of 960 m from mean sea level. The latitude and longitude of Sandhikharka are 27.9650 degrees N, and 83.1435 degrees E respectively. Alfisols types of soil is found in Sandhikharka municipality. As per data available at the district forest office, the forest of the Arghakhanchi is mostly deciduous, semi-deciduous, subtropical tropical sal forest which is dominated by *Shorea robusta*, followed by *Pinus roxburghii*, *Schima Wallichii*, *Bambusa vulgaris.* The Agriculture land is cultivated with *Zea mays* L. (Linneus) followed by *Triticum*, *Oryza*, *Oryza sativa.*

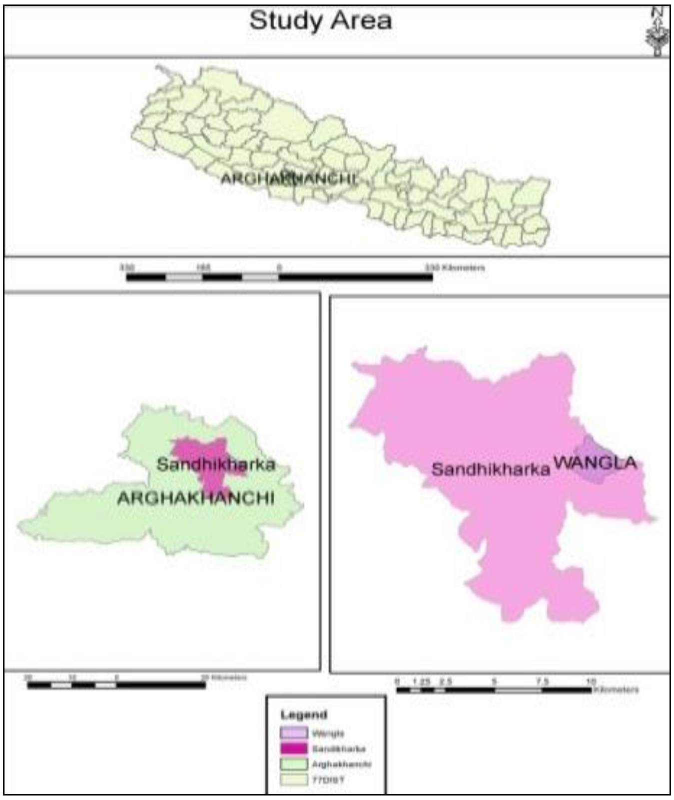

Fig 1: Map of the study are

2.2 Data Collection

Soil samples were taken from a forest (at different slope positions), and agricultural land which are located in Sandhikharka Municipality ward no. 5. Soil samples were collected in the winter season. The dominant tree species in forest land was *Pinus roxburghii* and agricultural land was cultivated with *Zea mays* L. (Linnaeus). Twenty composite soil samples (ten samples from forest land and ten samples from cropland) at three soil depths (0 to 10, 10 to 20, and 20 to 30 cm) were taken at random with an auger for each location for chemical analyses and to determine BD, pH and water content. Three replications from the composite soil samples per depth were used for each chemical analysis.

The soil samples were air-dried in shade for a week and packed in an airtight plastic bag until laboratory analysis. All collected soil samples were well labeled and brought to the laboratory for chemical analysis.

Fig 2: Sampling points for different land use

2.3 Data Analysis

The chemical parameters of soil were SOM, SOC, and soil pH whereas physical parameters were bulk density and soil water content.

The Laboratory analysis was performed at the Environmental Science Laboratory of Tri-Chandra Multiple College, Ghantaghar, and Kathmandu. Before analysis, the soil was passed through a 0.5 mm meshed sieve.

2.3.1 Estimation of Soil Organic Carbon

Though the soil contains both organic and inorganic carbon, only organic carbon was estimated which is the most important source of SOC. SOC was determined by Walkey and Black titrimetric method as follows;

- 0.5 gm of air-dried sieved soil was weighed and transferred to the well-labeled dried 500ml conical flask.
- 10 ml 1 N potassium dichromate solution and 20 ml concentrated sulphuric acid was added and swirled a little.
- The prepared mixture was allowed to cool down for 30 minutes.
- After the 30 minutes or reaction, 200ml of distilled water and 10 ml of phosphoric acid were added, followed by 1ml of diphenylamine indicator.
- The content was titrated with 0.4 N ferrous ammonia sulfate till the color changed from violet-blue to green.
- The blank was also run simultaneously but without a soil sample.

The percentage of SOC was calculated using the following equation (Walkey and Black Method).

2.3.2 Percentage of SOC

Percentage of SOC= $3.951/g * (1- T/S)$

Where,

g= Weight of soil sample taken

S= Volume of ferrous ammonium sulfate for blank titration (ml)

T= Volume of ferrous ammonium sulfate for sample titration (ml)

Percentage of SOM: The percentage of SOM was calculated by multiplying the value of SOC by 1.724.

Bulk Density: Bulk density was determined by using the following formula,

BD (g/cm^3) = Dry soil weight (g)/ Soil volume (cm^3)

pH: For the determination of soil pH, soil and distilled water ration was maintained i.e., 10gm: 25ml, and then the pH meter was suspended in pH water (Brady and Weil, 1996) [7].

Soil Water Content: For the soil water content, the weight of the soil samples was noted before drying. Again, the weight of the sample was noted after the samples were air-dried to a constant weight and the change in the weight of the sample was used to calculate the water content (Anderson and Ingram, 1993) [3].

3. Results

3.1 Soil Organic matter

The SOM for the two land-use types appears in Figure 3. SOM is discovered to be higher in forest land than in agricultural land. The SOM of forest land in the top 10cm soil was discovered to be 26.70% more than that of agricultural land. The SOM in the top 10cm was higher for both land-use types when contrasted with the lower soil depths.

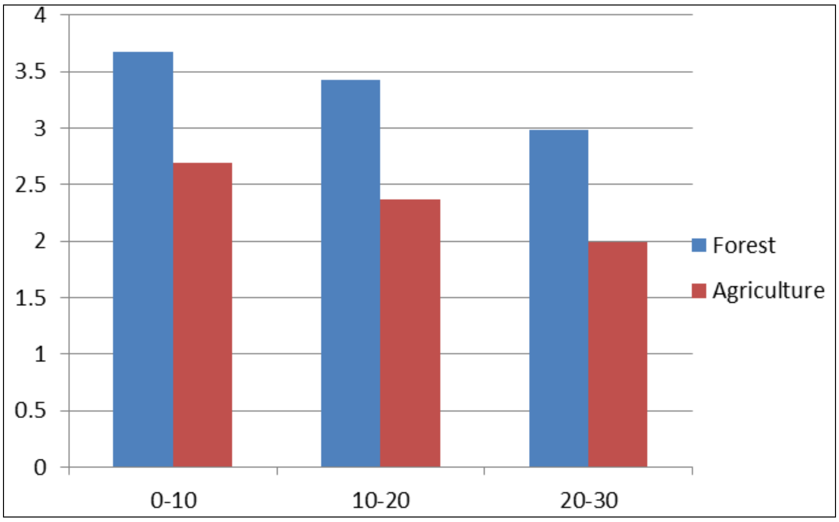

Fig 3: SOM content for the land use types at various depths

3.2 Soil Bulk Density

The SBD for the two land-use types is depicted in Table 1. SBD in Agriculture Area was higher than that of the Forest land for all soil depths. The BD of Agriculture land to 10 cm was 13.63% higher than for the forest land. The SBD for the best 10 cm was lower for both land-use types when contrasted with the 10 to 20 cm and 20 to 30 cm soil depth.

Table 1: Soil Bulk Density (g/cm3) for land use types at various depths

S. N.	Land Use	Soil Depth(cm)		
		0-10cm	10-20cm	20-30cm
1	Forest land	0.38	0.66	0.88
2	Agriculture land	0.44	0.72	0.92

3.3 Soil water Content

The soil water content for forest and agricultural land soil at various soil depths appears in Table 2. Soil water content in the forest land was discovered to be higher than that of agricultural land. Soil water content in the forest for the top 10 cm was 6.41% more than that of agricultural land. The soil water content for the best 10 cm was consistently higher for both land-use types than the 10 to 20 cm and 20 to 30 cm soil depths.

Table 2: Soil water content for land use types at various depths

S. N.	Land Use	Soil Depth(cm)		
		0-10 cm	10-20cm	20-30cm
1	Forest land	18.70	29.20	36.40
2	Agriculture land	17.50	26.50	35.90

3.4 Soil pH

The soil pH for forest and agricultural land soil at various soil depths appears in Table 3. Soil water pH content in the forest was lower than that of the agricultural land. Soil pH of forest land for the top 10cm was 20.07% lower than the pH of cropland.

Table 3: Soil pH for land use types at various depths

S. N.	Land Use	Soil Depth(cm)		
		0-10 cm	10-20cm	20-30cm
1	Forest land	6.41	6.08	5.74
2	Agriculture land	8.02	7.68	7.26

4. Discussion

4.1 Soil Organic Matter

An investigation by (Wang *et al.*, 2008; Bonino, 2006; Breuer *et al.*, 2006; Morisada *et al.*, 2004, Sharp *et al.*, 2011) [31, 5, 8, 17] discovered that forest soils have more SOM than agricultural land soils. In an investigation by Sharp *et al.*, (2011) the examination showed that the SOM content for the forestland, top 15 cm soil was 8.4% than the agriculture land and for 30cm of soil depths it was 23.46% more than the agriculture land. In any case, this investigation showed that the SOM content at the main 10 cm was 26.70% more than the farming area, for the 10-20 cm depth it was 23.32% and for the 20-30 cm it was discovered to be 33.22% more than that of the agriculture land. The higher SOM in the forest land, when contrasted with farming area in this examination, may be on the grounds that geology clarified a lot of change in SOM and furthermore on the grounds that the rise shows a huge positive relationship with SOM (Fu *et al.*, 2004). However, now and again the current examination doesn't completely uphold the hypothesis that "higher heights have higher SOM content". Nath and Deori (1976) [26] saw that OM content expanded from 1.03 to 9.78% in the soil of Andhra Prades as the height increment from 180 to 1800m. The abundance of SOM is additionally directed by the soil sort (Morisada *et al.*, 2004) [17].

4.2 Soil Bulk Density

In this research, the BD in the farming area was higher than in forest land. This investigation relates to the investigation of (Islam and Weil, 2000) [13] for example developed soils have higher mass thickness. The considered zones of forest land and agricultural land have diverse surfaces of soil and were distinctive in shading also. The contrast between the BD in forestland and agriculture land could be on the grounds that; soil mass densities rely upon land use, just as on characteristic boundaries (Alexander, 1980) [1] like organic part (Federer *et al.*, 1993) [11].

4.3 Soil Water Content

The Present study shows the measure of water content is higher in the forest land than that of farming land. It may be on the grounds that the forest land soils stay concealed by the plant species while the agricultural land stays open to the sun. The other purpose behind the low measure of water content in agricultural land additionally could be the grounds that the agricultural land has no irrigation facility but there is a source of water close by the forest study territory.

In contrast to the other research, the water content in the present study continues to increase with the increase in depth, it may be on the grounds that the boundaries like the quality of the OM, texture, and bulk density impact the critical water content (Taumer *et al*., 2005) [30]. The presence of water resources nearby the forest study area could be the reason in the case of the forest whereas in the case of agricultural land upper, the soil surface is prone to sunlight and the evaporation rate is high.

4.4 Soil pH

The current investigation shows the pH of forest land is lower than that of agricultural land. For each top 10 cm, soil pH was less and keeps on somewhat expanding with every depth. This may be on the grounds that an increase in OM led to a marked increase in the cation-exchange limit of the soils, joined by an increase in exchangeable hydrogen and a decline in pH (Williams and Donald, 1957). The pH range is connected with the connection between land use and soil richness (Schreier *et al*., 1995) [25].

The current research shows that the accessibility of soil water content is higher with the soil depth; this can also be the explanation behind the addition of soil pH with soil profundity. Also, the BD is discovered to be expanding with the profundity, which means soil pH shows a positive reaction to the SBD.

5. Conclusion

From the current investigation, the level of SOM is discovered to be higher in forest land than in farming areas. The measure of SOM decline with the expansion in soil depth in both land-use types. SBD is discovered to be higher in agricultural land than in forest land. BD shows a positive reaction to the increase in soil depths. Soil water content was discovered higher in forest areas than in agricultural areas. The soil water content expanded with an increase in soil depth. Soil pH was discovered higher in agricultural land than in forest land. On normal soil pH was expanding with the expanding soil depth. pH shows a positive reaction to BD and soil water content.

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