Original Research Article

COMPARATIVE ANALYSIS OF THE TOP SOIL PROPERTIES UNDER FORESTED AND DEFORESTED ZONES: IMPLICATIONS FOR THE ENVIRONMENT

Abstract

An investigation was carried out to examine the properties of top soils between 0 and 30cm under both deforested and forested zones in Bowen University, Iwo, Nigeria. Top soil samples in the deforested zone was taken from the Main Gate area of the institution while that of the forested zone was taken from the forested area opposite staff quarters of the University. The soil samples were subjected to standard laboratory tests in the University central laboratory. The results showed that deforested soil has sandy, clay and silt contents of 72.4%, 9.2% and 18.4% respectively while forested soil has 65.2%, 10.8% and 24% in the same order. Also it was discovered that deforested soil has organic carbon, organic matter, pH, field capacity, moisture and electrical conductivity of 0.32%, 0.55%, 6.8, 0.72g, 126.9g and 230µʃ/cm respectively while forested soil has 0.45%, 0.77%, 7.1, 0.90g, 0.72g, 129.2g and 275µʃ/cm in the same order. The implications of this results is that removal of vegetation contributes to the release of carbon into the atmosphere which increases atmospheric heat, alkalinity of soil, loss of soil nutrients and also could pose limits to the survival of plants growth and also susceptibility of soil to surface wash. Thus, it is recommended that effort should be made to checkmate the removal of vegetation and if unavoidable, relevant policies should be put in place for edge development and its maintenance and also, shades growth as remedies to ensure sustainable environment.

Key words: Top soil, forested soil, deforested soil, community development, soil properties,

Introduction

Despite the fact that deforestation has been seen as an act that should be avoided because of its negative impact on human environment, the process is still naturally desirable in certain situations and circumstances both in space and time. For instance, Umana (2018) considered that deforestation is unavoidable in view of the increase in population and also urbanization which also implies demand for forest resources including trees and other biodiversities. Furthermore, Sambe *et al* (2018), also added that in view of the need to embark on both industrial and urban development, deforestation can hardly be avoided. Deforestation is the permanent destruction of forests in order to make the land available for other uses (Inyang and Esohe, 2014). An estimated 18 million acres (7.3 million hectares) of forest, which is roughly the size of the country of Panama, are lost each year, according to the United Nations' Food and Agriculture Organization (FAO,World Wildlife Fund (WWF)). Also, in 2016, global tree cover loss reached a record of 73.4 million acres (29.7 million hectares), according to the University of Maryland, deforestation occurs around the world, though tropical rainforests are particularly targeted. If current deforestation levels proceed, the world's rainforests may completely vanish in as little as 100 years, according to National Geographic. Deforestation also has impacts on social aspects of the country, specifically regarding economic issues, agriculture, conflict and most importantly, quality of life. According to data taken over 2000 to 2005 Nigeria, located in the western region of Africa, has the largest deforestation rates in the world, having lost 55.7% of their primary forests (Forest in Nigeria, 2018). Mongabay defines primary forests as forests with no visible signs of past or present human activities.

The annual rate of deforestation in Nigeria is 3.5%, approximately 350,000-400,000 hectares per year (FAO, 2018). The Food and Agriculture Organization of the United Nations lists the requirements of sustainable forest management as: extent of forest resources, biological diversity, forest health and vitality, productive functions of forest resources, protective functions of forest resources, socio-economic functions and a legal, policy and institutional framework (FAO, 2018). Many aspects of the outline are currently not being met and will continue to have detrimental effects if not quickly addressed. A lot of damage has been done to Nigeria’s land through the processes of deforestation, notably contributing to the overwhelming trend of desertification. Desertification is the encroachment of the desert on land what was once fertile (Ojudgo, 2010). A study conducted from 1901 to 2005 gathered that there was a temperature increase in Nigeria of 1.1 °C, while the global mean temperature increase was only 0.74 °C. The same study also found in the same period of time that the amount of rainfall in the country decreased by 81mm. It was noticed that both of these trends simultaneously had sharp changes in the 1970s (Omofonmwan and Osa-Edoh, 2008).

From 1990 to 2010 Nigeria nearly halved their amount of forest cover, reduced from 17,234 to 9041 hectares. The combination of extremely high deforestation rates, increased temperatures and decreasing rainfall are all contributing to the desertification of the country. The carbon emissions from deforestation is also said to account for 87% of the total carbon emissions of the country (Akinbamiji, 2003).

The process of deforestation poses a lot of implications for various natural resources and most importantly, soil resources (Anyanwu, 2015). Deforestation exposes soils to direct surface runoff. Tree roots anchor the soil. Without trees, the soil is free to wash or blow away, which can lead to vegetation growth problems. The WWF states that scientists estimate that a third of the world's arable land has been lost to deforestation since 1960. After a clear cutting, cash crops like coffee, soy and palm oil are planted. Secondly, the initial increase of soil erosion is almost certainly due to the removal of the canopy and surface litter that protects the soil surface from the energy of raindrop impact and surface detachment. Surface cover is probably the greatest single management effect on soil erosion (Nearing et al., 1994). Soil structure is destroyed by the plow and the stabilizing effects of root fibers become insignificant as the roots are shredded by the tillage microbially decomposed following deforestation. As pore space increased due to the mechanical cultivation, the air exchange increased the available oxygen for microbial decay of organic matter, particularly the particulate organic matter (POM) that is highly effective at binding soil particles (Wang, 2002). This factor, coupled with the accelerated erosion rapidly depleted the SOM in the plow layer and weakened the soil WAS (Zhang and Horn, 2001). Other effects of deforestation are loss of species and disturbed water cycle. This work aimed to compare the top soil characteristics under both deforested and forested regions in the southwestern part of Nigeria. Specific objectives are to: examine the characteristics of top soil (0-30cm) in the study area and to evaluate the implication of the result on environmental sustainability.

Methodology

Study Area

This study site for this research is Bowen University (7.61464^{o}N, 4.1372^{o}E), Iwo, Osun State, Nigeria. Bowen University, Iwo, owned by the Nigerian Baptist Convention, became operational in 2002 at the site of the old Baptist College (a proscribed Teachers' Training College). Since its inception, the University has embarked on series of projects to enhance its status in the world of other global institutions. Such projects include, building projects, such as Library, Faculty buildings like Social and Management, Agriculture, Sciences, College of Health Sciences, Hostels, landscaping among others. The implications of all these developmental projects are the clearing of the forest to pave way for the erection of these buildings. Currently, forest trees are being cleared firstly, to give room for the beautification of the institution with ornamental and economic trees, and other horticultural plants from the main Gate of the institution to the Chapel junction and secondly to expand the University Commercial farm of the Faculty of Agriculture. All these projects have led to the loss of various environmental resources including vegetation, soil resources and exposure of watershed. It is on this premise that, even though some of the cleared portions are being regrown, the cleared forest could have had effects on soil conditions including its physico-chemical constituents and on the environment generally. Thus this study aims at assessing the impacts of deforestation on soil conditions. Specific objectives are to determine the effects of deforestation on soil moisture and other physical properties and also to assess the implication of deforestation on the properties of soils in the study area.

Data sources

The data required for this research were soil samples. Soil samples were taken from both deforested areas and forested areas within the University in April, 2019, after the incidence of rainfall events. The samples from deforested zone were taken close to the Main University Gate. This area formerly under forest cover was cleared during the dry season while soil samples under forest cover were taken under the forest adjacent to the cleared zone. The samples were taken simultaneously during the daytime with the use of soil auger in triplicate between 0-30cm and kept in polythene bags. The samples were immediately taken to the laboratory for analysis. Soil parameters analyzed are soil moisture, bulk density, particle size distribution, organic carbon, electrical conductivity and soil microorganisms.

Method of analysis:

Six soil parameters analyzed include soil pH, particle size distribution, organic carbon, organic matter, electrical conductivity, soil moisture contents and the soil bulk density. The analyses of the parameters were carried out following standard laboratory techniques. The selected parameters were based on the analysis facilities available and the time frame. The soil pH of the samples were measured using Testr 2 waterproof digital pH meter with soil as described by Hendershot *et al*, (1993) while the soil moisture contents of the two samples were measured using gravimetric method. Particle size distributions and field capacity were determined with use of hydrometer method (Adepetu et al., 1984). Organic Carbon was measured using the procedure according to Golterman et al., (1978); Electrical Conductivity was determined following Ademoroti (1996) and lastly Bulk Density (BD) was determined using the procedure according to King (1988).

Results and Discussion

Bulk Density

Bulk density reflects the soils ability to function for structural support, water and solute movement and soil aeration. It is also defined as weight of fiber per unit volume, often expressed as g/m^{-1}, and is a good index of structural changes (Sreerama *et al*., 2009). Bulk density increases with compaction and tends to increase with depth. From Table 1, the result shows that forested soil has the higher bulk density of 0.9345 g/m^{-1} compared to 0.9210 g/m^{-1} of the deforested soil. In other words forested soil is more compact than deforested soil, which is due to vegetation found on its surface, because the roots of plants tend to hold soil where it absorbs nutrients from. This finding buttresses the observation made by Tefera *et al*. (2007) that soils with higher bulk density are more compact.

Table1: Summary of the mean soil physical and organic parameters analysis

Sample Name	Bulk Density	Soil pH	Organic carbon (%)	Organic Matter (%)	Soil Moisture content (g/cm^3)	Field Capacity (g)	Soil Electrical conductivity (µ∫/cm)
Deforested	0.9345	6.8	0.32	0.55	126.9	0.72	230
Forested	0.9210	7.1	0.45	0.77	129.2	0.90	275

Soil pH

Soil pH is the degree of acidity or alkalinity of the soil. Soil pH is very important because it directly affects soil nutrients availability. Plant roots can only absorb nutrients after they have been transformed into certain ionic form. Soil pH affects the availability of nutrients and how the nutrients react with each other. At a low pH, beneficial elements such as molybdenum (Mo), phosphorus (P), magnesium (Mg) and calcium (Ca) become less available to plants (Landis *et al* 2003). From Table 1, the result shows that forested soil has 7.1 and deforested soil has 6.8. The result also indicates that deforested soil is slightly acidic and forested soil is slightly alkaline which also implies that forested soil have higher nutrient availability compare to deforested soil because they tend to transform nutrients into ionic form due to its slight alkalinity. Deforested soil tends to have low population of micro-organism because of its slightly acidic nature as some micro-organism cannot survive acidic soil compared to the forested soil which corroborate the findings of Landis *et al*. (2003) an acidic soil is dangerous to human and the ecosystem. The result here indicated that efforts should be made to avoid incessant removal of forest in our ecosystem

Organic Carbon

Organic carbon is part of the natural carbon cycle. World's soil holds around twice the amount of carbon that is found in the atmosphere and in vegetation (Hoyle, 2013). Soil organic carbon is important for all three aspects of soil fertility, namely chemical, physical and biological fertility (Viscarra Rossel et al., 2014). From Table 1, Forested soil has 0.45% and Deforested soil has 0.32%, which means that forested soil has good structure, better biological and physical health of soil, and best buffer against harmful substances compared to deforested soil. This result, however, further ascertain the findings made by Ingram *et al*. (2001) that soil organic carbon promotes soil structure by holding the soil particles together as stable aggregates improves soil and physical properties such as water holding capacity, water infiltration, gaseous exchange, root growth and ease of cultivation. This findings explains the reason behind the depletion of ozone layers in the atmosphere. The situation that has generated the current global warming worldwide.

Organic Matter

Organic matter binds soil particle into aggregates. From Table 1, forested soil has the highest organic matter of 0.77% and deforested soil of 0.55%. Forested soil has better supply of nutrient, better habitat and higher water holding capacity as compared to deforested soil. Deforested is prone to soil erosion compared to forested soil because the higher the organic matter higher the soil particles are binded into aggregates thereby buttressing the findings made by FAO and ITPS,

(2015) that Organic matter improves soil aggregate and structural stability which, together with porosity, are important for soil aeration and the infiltration of water into soil. While plant growth and surface mulches can help protect the soil surface, a stable, well-aggregated soil structure that resists surface sealing and continues to infiltrate water during intense rainfall events will decrease the potential for downstream flooding.

Soil Moisture Content

Soil moisture content refers to the quantity of water contained in the soil which plays great role in soil and plant growth relationship. The result from Table 1, shows that forested soil has the higher soil moisture content of 129.2g compared to 126.9g for deforested soil which may be due to vegetation cover. It also implies that forested soil has higher regulatory tendency of physical, chemical and biological activities in the soil as compared with the deforested. Deforested soil is exposed to direct sunlight thereby losing much of its moisture content. Which confirms Hillel, (1982) findings that soil moisture content contributes o deeper plant root growth, reduced soil run-off/leaching and less favourable conditions for insect and fungal diseases.

Field Capacity

Field capacity as to do with the amount of soil moisture or water content held in the soil after excess water has drained away and the rate of downward movement has decreased. From Table 1, forested soil has the highest value for field capacity 0.90g compared to deforested soil of 0.72g which means forested soil is in good condition due to vegetation cover. This implies reduction in the rate of evaporation and transpiration when compared with deforested soil which is exposed to direct sunlight with no vegetation cover. This supported Kramer's, (1983, p.71) observation that the amount of water retained at field capacity decreases as the soil temperature increases. It also means that forested soil has higher soil organic natter content compared to forested soil because it facilitate soil water holding capacity (Hillel, 1971, p. 165).

Electrical Conductivity

Soil electrical conductivity is a measure of the amount of salts in the soil. It also means the salinity of soils. It is an economically friendly method of calculating available nitrogen for plant growth. Table 1, shows that forested soil has the highest conductivity with value of 275µ∫/cm compared to 230µ∫/cm for deforested soil. This implies that forested soil has higher nutrient composition than deforested soil because the lower the value of conductivity the higher the nutrients availability in the soil. It also implies that forested soil has higher percentage of clay content and higher Cation Exchange Capacity because the higher the Cation Exchange Capacity the higher the soil electrical conductivity (Wiatrak et al., 2009). This study reveals that soil with lower value of sand, higher value of clay and silt have higher electrical conductivity. The farther the soil pH move away from the neutral point the more electrical conductive they become. The amount of nutrient in the soil tells the soil electrical conductivity. The higher the soil nutrient the higher the electrical conductivity. The higher the soil moisture content the higher the soil electrical conductivity.

Particle Size Distribution

Particle size distribution is the proportions by dry mass of a soil distributed over specified particle-size ranges. The physical and chemical behaviors of soils are significantly influenced by particle-size distribution which is important for soil interpretations, determination of soil hydrologic qualities, plant nutrient requirements and classifications (Eshel *et al*., 2004). From the result showed shown in Table 2, forested soil has 65.2% of sand, 10.8% of clay, and 24% of silt, while deforested soil has 72.4% sand, 9.2% clay and 18.4% silt which implies that deforested soils has a better particle size distribution in term of plant growth advantage as compared to forested soil which also means that deforested soil has faster water and nutrient movement in the soil because particle size. This is used to classify soils for agricultural purposes and also influences how fast or slow water or other fluid moves through soil which ascertain the observation made by Sandhage-Hofmann *et al*. (2015) that soils with high sand content do not get compacted which aid the free flow of water or liquid.

Table 2: Summary of soil sample particle size distribution analysis

Sample Name	**Soil Depth (cm)**	**Sand (%)**	**Clay (%)**	**Silt (%)**	**Total (%)**
Sample A (Under forested zone)	0-30	65.2	10.8	24	100
Sample B (Under deforested zone)	0-30	72.4	9.2	18.4	100

Conclusion

The properties of top soils under both forested and deforested zones within the Bowen University, Iwo, Nigeria were analyzed using standard laboratory methods. The results revealed that top soils in the forested area has higher percentage of bulk density, soil moisture, field capacity but lower soil pH, soil carbon and electrical conductivity when compared with same properties of top soils in the deforested areas. However, the results implied that effort should be made to avoid forest removal in order to protect the top soil and also to checkmate the release of carbon into the atmosphere which has consequential effect on the depletion of the ozone layer, which leads to atmospheric heat. Also there is need to protect the top soil for agricultural purposes. Planting of trees as shades and edges should be encouraged in a situation where the removal of forest is unavoidable especially as a result of urban expansion, agricultural and industrial projects.

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