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CLIMATE CHANGE AND THE IMPACT OF DEFORESTATION ON SOIL QUALITY IN THE EASTERN OBOLO REGION OF AKWA IBOM STATE, NIGERIA

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Abstract
Climate change and deforestation will affect soil processes and properties because, soils are connected to atmosphere/climate systems through the carbon, nitrogen and hydrologic cycles. The study analyzed the effects of deforestation on soil quality and its impact on climate change in communities of the Obolo Region in Akwa Ibom State. A sample size of five communities was randomly selected from a total population of thirty-two communities in the region. The experimental research design was used for the research. The nature and sources of data were primary and secondary sources. Soil Auger was used in collecting the soil samples from five deforested communities in the region namely Okoroete, Kampa, Amadaka, Elile, and Okombokwo and a composite control were collected from three locations namely Kampa, Amadaka and Elile at a depth of 0-15cm and 15-30cm in an independent simple random sampling method. A total of six soil samples were collected and analyzed with a standard method for microbial/biological and heavy metals. The data collected from the laboratory was subjected to statistical analysis (t-test and ANOVA) including range, mean, standard deviation and variance. The results of the study indicated that there is significant variation between deforested land and soil properties as there has been a decrease in soil microbial/biological count and an induced heavy metal which degraded the soil properties. This decrease contributed to the reduction of soil fertility, soil erosion, and land degradation which can lower the amount of Co_2 and mitigate the greenhouse effect that contributes to climate change. The study recommended that to reduce the rate of deforestation and soil quality, the government should revive the use of other sources of energy such as biogas and electricity to minimize the use of fuelwood; encourage vegetation cover; develop sustained land use practices, encourage long term sustainability of the farmland system and biophysical settings to preserve soil quality to mitigate greenhouse effect that contributes to climate change; policy on anthropogenic activities and community-based natural resources management (CBNRM) among others.

Keywords: Impact, climate change, deforestation, soil quality, communities, Obolo region

Introduction

The earth is a system where everything is connected. Changes in one area can influence changes in other areas. Climate change and deforestation will affect soil processes and properties because, soils are connected to atmospheric/climatic systems through the carbon, nitrogen and hydrologic cycles (Brevik, 2013). Environmental changes especially those concerning climate changes have been connected to the build-up of greenhouse gases in the earth's atmosphere. At the global level, the adverse impact of climate change affects different facets of life. Some of the implications impact human health, the earth's ecosystems and socio-economic development (Folasade & Olusola, 2019). Climate change has been linked to the transmission of important waterborne diseases by altering their geographic range, thus, bringing them to regions whose populations have weak immunity and a weak public health infrastructure (WHO, 2007). In some cases, food production is affected by climate change thereby resulting in a high rate of food importation, illegal migration, industrial liquidation, and high cost of production among others (Ikporukpoi et al., 2019).

Climate change is a situation in which climate change continues in one direction at a rapid rate and for an unusually long period (Akamigbo, 2011). It is an alteration in the global mean temperature or rainfall (Gavin & Joshua, 2008). It refers to long-term shifts in global or regional climatic patterns that is, rise in temperature and climatic patterns. These shifts may be natural, such as through variations in the solar cycle. But since the 1800s, human activities have been the main driver of climate change mainly through the burning of fossil fuels like coal, oil and gas. (UN, 2020). Burning fossil fuels generates greenhouse gas emissions that act like a blanket wrapped around the earth, trapping the sun's heat and raising temperatures. Example of greenhouse gas emission that causes climate is carbon dioxide and methane. The intergovernmental panel on climate change (IPCC) formed in 1989 by the United Nations and the world meteorological organization reports that the average global temperature is likely going to increase between 1.1 and 6.4ºC by 2090-2099 as compared to 1980-1999 temperatures, with the most increase being between 1.8ºC and 4.0ºC (IPCC,2007). The UN reports that the earth is now about 1.1ºC warmer than it was in the late 1800s. the last decade (2011-2020) was the warmest on record (UN, 2020). Thus, for the last 100 years, the global mean temperatures have increased to more than 15ºC, which is assumed to have not only natural but anthropogenic reasons. Reduced water evaporation from agricultural land in contrast to natural forest, emissions of warmth and carbon dioxide especially in urban-industrial agglomerations and the release of methane and nitrous oxide in agriculture are the most important impacts. It is assumed that in the 21st century, the global mean temperature will rise by another 2-3ºC and this is mainly caused by the higher use of fossil fuels and intensified conventional agriculture (Rajib, et al. 2016). It should be noted that, since the earth is a system where everything is connected, changes in one area can influence changes in all other areas. The consequences of climate change now include among others, intense droughts, water scarcity, severe fires, rising sea levels, flooding, melting polar ice, catastrophic storms, and declining biodiversity (UN, 2020).

The geographic space of the Niger Delta including the Eastern Obolo region of Akwa Ibom State is naturally endowed with luxuriant tropical and equatorial rainforests and mangrove swamp forests (Naluba & Ephraim, 2022). The region can be referred to as the unit area formed by common conditions of geologic structure, soil, surface relief, drainage, vegetation and animal life (Naluba, 2017; Igwe, 2009). Rainforest resources play a major role in the survival of life on the planet Earth by providing a wide variety of highly valuable ecological, economic and social services such as carbon sequestration, conservation of biological diversity, soil and water conservation, agricultural production systems, improvement of urban and rural aesthetic conditions, provision of employment and enhanced livelihoods (Naluba, 2020; Ikporukpo, et al, 2019). In an intricate cycle of life, the forests in the region efficiently recycle all the living materials it contains including plants, animals, insects and microorganisms. It also provides a field for scientific research and tourism (Ugboma, 2014). Unfortunately, these forests are fast disappearing due to the uncontrolled high rate of deforestation. Deforestation is the act or process of clearing forests for a variety of reasons or purposes (e.g farming, lumbering, mining/mineral exploitation, industrial, institutional and residential building, animal grazing, recreational stadium, open fields, etc) without immediate replacement or replanting of trees, shrubs and grasses (Naluba & Ephraim, 2022). Deforestation has been on an increase in tropical regions in recent years and these have been caused mostly by anthropogenic factors such as growing population, the need for agricultural land, expansion in the demand for fuel and changes in social and political situations (Fellman et al., 2005, Fabuji, 2011).

Deforestation raises some principal global concerns. First, at a global level, forests play a major role in maintaining the oxygen and carbon balance of the earth. Human beings and their industries consume oxygen; vegetation replenishes it through photosynthesis and the release of oxygen back into the atmosphere as a by-product. At the same time, plants extract the carbon from atmospheric carbon(iv)oxide, acting as natural retaining sponges for the gas so important in the greenhouse effect (Norton, 2007). The second global concern is also related to climate. Deforestation changes the surface and air temperatures, moisture content and reflectivity. It also brings about the loss of a major part of the biological diversity of the earth (Fellman et al., 2005; Norton, 2007). The effects of deforestation are: it aggravates the problems of climate change and global warming; destruction of the natural forest which is a vital natural resource for the enhancement of our community, regional and national development; leads to soil erosion; leads to loss of soil nutrient due to absence of foliage which improves the organic content of the soil and loss of biodiversities (Anyanwu et al. 2015). The major soil types in the rainforest ecosystem can be related to the factors of climate, vegetation lithology and topography. Climatic factors especially rainfall, influence the rate, depth of weathering and pedogenesis. The soil moisture regime, which is very vital in agricultural productivity is highly correlated with the incidence of rainfall (Kunde, 1995). The density of vegetation cover also controls soil moisture content because it determines the extent to which the soils are protected against intense

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insolation. The humus content of the soil which is important in their productivity and structural stability varies with the nature and density of vegetation cover (Okpor, 2008).

Climate change has an impact on soil quality. The Soil Science Society of America (SSSA) defines soil quality as "the capacity of a specific kind of soil to function within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water quality and support human health and habitation" (Rajib et al., 2016). There are several indicators of soil quality/ health. These indicators can be categorized broadly as: visual (such as runoff, plant response, weed species), physical (such as topsoil depth, bulk density, aggregate stability, crusting, compaction), chemical (such as p^H, salinity, organic matter cation exchange capacity, contaminant concentrations), and biological (such as the activity of micro-organisms) indicators. The micro-organisms concerned mainly with this study is Heterotrophic Bacteria. They derive energy from organic compounds. They are found in food, soil and water. They help in nutrient recycling. And the decomposition of organic matter. They decompose dead and decaying plants and animal remnants and help in biodegradation. They are used in making curd, antibiotics and in nitrogen fixation. Soil carbon is very vital for soil health. Organic matter is also very important because it provides an energy source for microbes, structurally stabilizes soil particles, and stores and supplies plant essential nutrients eg. Nitrogen, phosphorus, Sulphur, etc. Climate change is expected to have impacts on soils and ecosystems as a result of an increase in temperature and changes in precipitation thereby altering biogeochemical and hydrological cycles (Gelibo et al., 2018). Some of the phenomena associated with climate change and anthropogenic activity affect soils indirectly through the functioning of the ecosystem especially through higher atmospheric CO_2 concentration and Nitrogen (N) deposition and on soil chemical, physical and biological functions (Rajib et al., 2016). The concentrations of carbon dioxide, methane, and nitrous oxide are all known to be increasing and in recent years, other greenhouse gases especially chlorofluorocarbons (CFCs), have been added to the atmosphere. Increased concentrations of these gases have raised global mean surface temperatures by 0.5^oC and the projected concentrations could produce warming of about 1.5^oC over the next 30 years. Interactions between climate and soils determine the transformation and transport processes. Gradual and long-term changes in abiotic environmental factors alter naturally occurring soil-forming processes by modifying the soil water regime, mineral composition evolution and the rate of organic matter formation and degradation. The resulting biophysico chemical properties play a vital role in the productivity and environmental quality of the soil. Climate change neatly influences the dominant vegetation types, their productivity, chemical characteristics and decomposition of their litter deposits, and the development of soil reactions . Soil structure can be influenced by climate change in various directions, on different time scales and with different intensities. Changes in climatic factors such as precipitation intensities or seasonal temperatures can to a greater extent influence soil hydro-physical properties. These changes may exert an influence on the soil water regime which may, in turn, impact the environmental and economic development of the region concerned (Horel et al., 2015).

The main sources of energy and moisture for both biological and soil processes are solar radiation and precipitation. Solar radiation is absorbed and remitted by the earth's surface which gradually heats the atmosphere. Precipitation is absorbed by the soil and is in turn being used by the plants and subsequently returned to the atmosphere through the processes of evaporation and transpiration. Thus, a continuous latent heat flux is available between the soil and the atmosphere thereby influencing the hydrothermal regime of the soil (Rey, 2015). Climate change and deforestation have a major impact on the soil quality of the regions concerned (A deteriorating environment of this nature puts man and other living components of the region at risk. The altered soil quality requires scientific attention). The growth and socio-economic development of any nation are largely determined by the soil conditions, which are dependent on the climate in general and on anthropogenic activities in particular. Investigations on the impact of climate and deforestation on soil quality can provide indicative results for the functioning of many aspects of the region and mitigate the negative effects of climate change. Therefore, examining the impact of climate and deforestation on soil quality is a way of monitoring the negative effects of climate change in the region. Despite the works carried out by other scholars, the dearth of information on the impact of climate change and deforestation on soil quality in the Obolo region is lacking. Therefore, this study aims to examine the impact of climate change and deforestation on soil quality in the Eastern Obolo region of Akwa Ibom state.

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Materials and Method

Eastern Obolo region of Akwa Ibom state is located between latitudes 4°33'N and 4°50'N, and longitudes 7°45' E and 7°55' E of the Greenwich Meridian. It is about 650m above sea level. Eastern Obolo (or Obolo agan Mbum-ura in the Local Obolo language) is a Local Government Area (LGA) in Akwa Ibom. It is a coastal area in Akwa Ibom state that is heavily influenced by the Bight of Bonny. The region was carved out of Ikot Abasi Local Government Area on 4th December 1996 by the Federal Government of Nigeria. The region lies in the mouth of the Atlantic Ocean in the tropical mangrove forest belt East of the Niger Delta Region of Nigeria. The coastal water of the region drains into the Atlantic Ocean and it is connected to Qua Iboe River Estuary at the East and the Imo River Estuary at the West. The region is bounded in the North by Mkpat Enin, Onna in the East and Ikot Abasi in the West, and Southeast by Ibeno Local Govt. Area and in the South by the Atlantic Ocean. The region has a total landmass of 117,008km^2 and an estimated coastline of approximately 184km in length. The headquarters of the region is Okoroete. Figures 1.0 and 1.1 shows the study area.

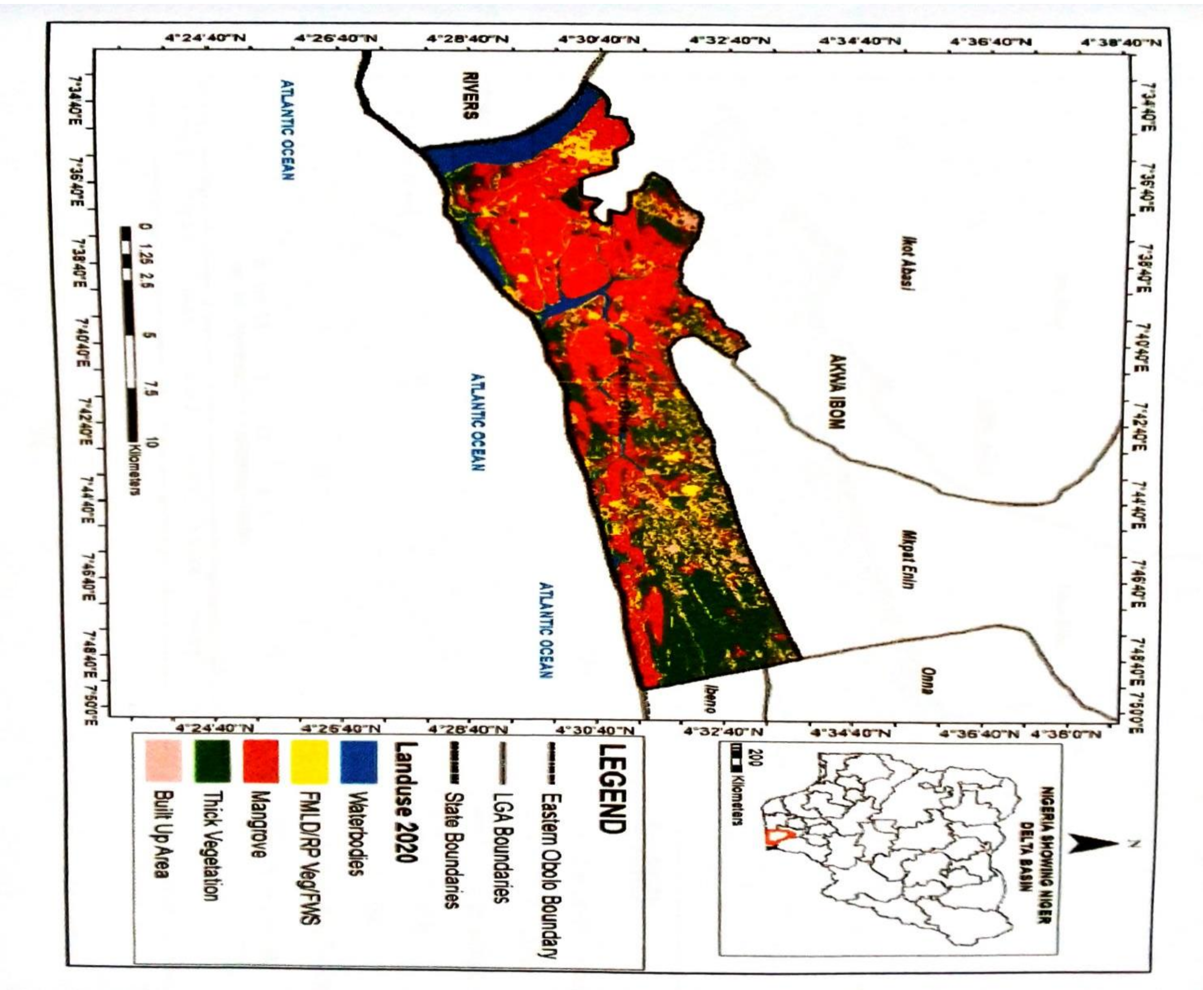

Fig. 1.0: Showing study area

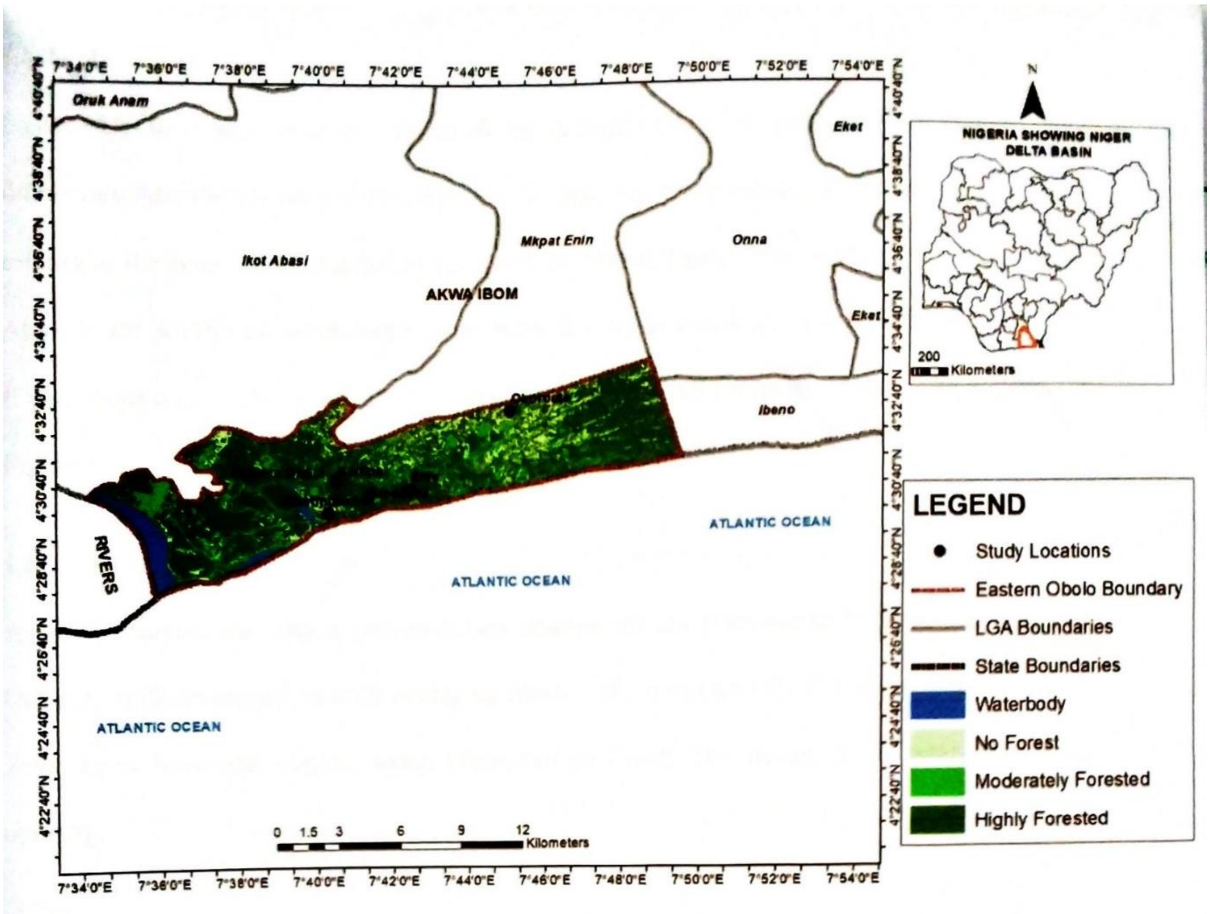

Fig. 2: Showing sampled communities

The climate of the region is tropical and humid. The average temperature for every month is above 18°C. The region experiences two seasons: the dry season (October to May) and the wet season (April to October) with an annual rainfall averaging about 2500mm. The temperature within. The region is constantly high with a mean maximum of approximately 21°C with its peak between April and October. The sun is virtually overhead throughout the year. Daylight hours are the longest because of the long duration of solar radiation. The climatic condition influences the soil quality which in turn affects the growth of plants. The vegetation is dominated by mangrove species (*Rizophora mangle, Avicenia africana*) and the highly invasive raffia palm (*Nypa fruiticans*). The inter-tidal zone bordering the creek when exposed at low tide reveals a clay, peat and/or sandy substratum. Beyond the tidal mud flats are highly elevated lands with soil and luxuriant growth of tangled vegetation fringed with scrambling edges, ferns, and epiphytic ferns such as phymatodes. The dominant trees are cabbage trees, Christmas bush, boundary tree (Dvacaena arborea), blood tree (Harlen gana madas cariensis) and oil palm tree (Elaeis guineenis). Cultivated tree plants such as mango (Mangifera endica), African pear (Dacryodes edulis), coconut palm (Cocos nucifera) and African breadfruit (Trecullia Africana) are common around the communities. The forest in this region has been greatly disturbed naturally or unnaturally characterizing secondary forests (Ephraim 2021). The region consists of Deltaic plain soils which are found in wetland and upland areas. The texture of soil within the region is mostly sandy with 94.00% sand, 0.066% silt and 5.34% clay. The total organic carbon ranges from 0.99% to 3.21%. the low content of organic carbon affects both the soil type and the physical properties of the soil resulting in the poor water-holding capacity of the sandy soil as well as its contribution to the structural stability of clay soil which is also poor. Surface soil colours are well drained having no mottles. The soils are strongly acidic with p^H values of 4.5. the acidity decreases down the profile. Organic matter content is low (2.5%). The carbon-to-nitrogen ratio is fairly high. Generally, the soils of the region consist of reddish-brown sandy clay loam, brown sandy soil, light grey, slightly organic fine sand soils, silt clay and dark organic clay soils (Igwe, 2021; Clifford, 2021). The population of the region is 60542 projected to 2018 (Ephraim, 2021), and presently around 100,361 persons. It consists of 32 settlements which are separated into two clans: Okoroete and Iko. The people are a mixture of Andoni and Iko extractions. The indigenes are predominantly fishermen with over 65% of its inhabitants engaged in active fishing while the rest are farmers. These human activities have resulted in the cutting of trees for fuelwood for the processing of fish. Their traditions contain elements of Bonny, Opobo and Ibibio culture. Their economic activities are characterized by fishing which leads to the constant and eminent utilization of fuelwood for the preservation of their produce. This constant deforestation for various human activities in the region has a significant impact on climate change and soil quality. This situation aggravates the problem of climate change and global warming and also leads to soil erosion which affects the soil quality.

The experimental research design was used for this study. The primary and secondary sources were the nature and sources of the data. The main source of the data which was the primary source involved a field survey in which the samples were collected, tested, and analyzed. The study area covered an area of 538.5km^2 with 32 communities. To obtain the sample frame, soil samples were taken with the help of Soil Auger at 0-15cm and 15-30cm depths of the soil from six (6) communities. All the samples were assumed to be independent of one another. In each of the land, several transects were also established for the identification of the different types of land in the area. This was also done subjectively to ensure that each land across the study area was adequately covered. The sample size was taken from six communities together with a composite control from a non-deforested (Iko) community. The sampling technique used in selecting the six (6) communities from the 32 communities was the simple random technique. The method of data collection and instrumentation was by taking soil samples with a Soil Auger at 0-15cm and 15-30cm depths of the soil. The method used in analyzing the hypothesis was the one-way analysis of variance (ANOVA) and the one-sample T-test. The observed samples were compared with the composite control.

Methods of Analysis of Soil Quality Parameters: Before being taken to the laboratory, each of the samples was properly labelled. The samples collected were analyzed for major soil quality parameters. The study made use of standard procedure instruments like ASTMD7503-10, APHA 4500-NC, ASTMD2974 and APHA4500 P.E. Specifically the methods used for the various parameters are colour (By viewing) p^H (potentiometric p^H meter), organic carbon (wet oxidation), available nitrogen (Alkaline permanganate), Available potassium (Flame photometry), Electrical conductivity (Conductrometry).

Laboratory procedures of p^H analysis: P^H in water (H_2O) (1:1 soil to water ratio) to 20g of air-dried soil was passed through 2mm sieve in a beaker of 500ml, 20ml of distilled water was added and all allowed to stand for 30 minutes with occasional stirring using a glass rod. Next, the electrodes were inserted into the buffer solutions that had p^H values close to that expected of the soil and the needle was to read the buffer p^H. Great care is taken in inserting the electrodes into the buffer solutions because the electrodes are quite fragile and can be easily broken. The electrodes were extended at least 2cm into the solution. The electrodes were then removed, rinsed with distilled water and inserted into the soil. Suspensions with the colonel electrode into the clear supernatant solution and the glass electrodes were supplied separately and the p^H meter reading was recorded to the nearest 0.05 unit. It should be noted that the electrodes were rinsed between each reading. The electrodes were then washed with distilled water and lowered into a beaker of distilled water at the end of the experiment.

Laboratory procedures for Organic carbon: Laboratory procedure for organic carbon was determined using the following procedures: 1g of soil sample was placed into a 250ml Erlenmeyer flask, 10ml of 1-mole potassium dichromate was pipetted into each flask, 20ml sulfuric acid was added and the mixture was titrated with 0.5M potassium permanganate ($KMnO_4$) solution. A black titration was carried out. The percentage of organic carbon was determined using the equation

$$\%OC = N(T-B) + \frac{0.390}{W}$$

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Where:
N = Normality of $KMnO_4$ used;
T = Titre value;
B = Blank reading and
W = Weight of soil.
The organic matter content of the soil sample was determined by multiplying % organic carbon by 1.724.

Methods used for microbial count: The standard method Agar (SMA) was used for the spread plate technique to enumerate heterotrophic bacteria. The total heterotrophic bacteria count was performed for the nutrient Agar (Oxoid) using the spread plate method (Gradi, 1985). Total viable counts of culturable aerobic heterotrophic bacteria were obtained by preparing serial solutions of gram-wet saline (0.89% W/V NaCl).

Methods used for determining Heavy Metals in soils: The concentration of iron (Fe), manganese (Mn), zinc (Zn), and copper (Cu) is determined by treating a 10gram scoop of air-dried soil with 20millilitres of diethylenetriamine-pentaacetate acid extracting solution. After shaking for two hours, the sample is filtered and the extract is analyzed using the Atomic Absorption Spectrometer (ASS). The results obtained are then reported for each metal in the soil. At the laboratory, each sample is assigned an identification number, transferred to a paper bag and then placed in a metal tray. The samples are air dried under forced air at a temperature not exceeding 95^oF. For instance, the procedure for iron (Fe) involves: taking 5g of air-dry soil and adding 50ml of distilled water to make a suspension. Then filter it through the Whatman filter. This is followed by adding 2ml of concentrated Hydrochloric acid and 1ml of Hydroxylamine in the solution. The content is then boiled and allowed to cool. Then 10ml of ammonium acetate buffer solution is added, followed by 1.10 phenanthroline solution, then you make the volume up to 100ml by adding distilled water. The absorbance is recorded at 510mm using distilled water as blank. The standard iron (Fe) solutions of the different concentrations are prepared and the absorbance for each is then recorded. For Manganese, the procedures involved are: Air-dry soil samples from the experimental sites are crushed to pass a 10-mesh sieve. 1 gram of soil is scooped without pressing the soil against the side of the container. The scoop is tapped with a spatula to level off the soil by passing the spatula over the scoop, holding the spatula at 90 degrees. Then, the measured volume of soil is added to a 50ml Erlenmeyer flask, tapping the scoop on the transferred funnel to remove all of the soil from the scoop. 10 ml of the extracting solution is added to each flask and shaken for 10 minutes at 180 ppm. It is then filtered through the Whatman No 1 filter paper. Then, a blank is carried through the entire procedure with each run. Manganese in the extract is being determined with the Atomic Absorption (AA) unit using instrument settings and Mn standards. The results are then reported as ppm in the soil. Ppm in soil = ppm in extract x10. Similar methods are used for copper and Zinc.

Results
The result for analyzing the impact of deforestation in the sampled settlements in the eastern Obolo region of Akwa Ibon State are shown below for the six (6) different settlements including the control. Although previous studies have been carried out on physicochemical parameters such as total nitrogen, available phosphorous, total organic carbon, total organic matter, and cation exchange capacity, our concentration in this study is on total heterotrophic bacteria for the six settlements. Thus, Table 3.1 shows laboratory reports of biological/microbial count and heavy metals under deforested lands in the study area. The methods used are explained in the methodology in 2.3.1-2.3.4 for some nutrients, organic, microbial count and heavy metals.

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Table 3.1: values of biological/microbial counts under deforested lands in the study area.

Microbial count	SD Okoroete	SD Kampa	SD Elile	SD Amakada	SD Okorombakho	Mean	Standard deviation	Control composite
Total Heterotrophic Bacteria cFU/ ml.	6.6 X 107	8.7 X 107	7.4 X 107	6.1 X 107	5.8 X 107	6.9 X 107	11649034.29	1.02 X 108

Source: fieldwork,2022

Table 3.1 shows the values of the biological/microbial content under deforested land for all six observed sampled locations which include the control using standard procedure instruments like APHA9215B. The Microbial count shows a range of values from 6.6 x 107 to 8.7 x 107 when compared with the composite control of 1.02 x 108 for under-forested land. The values give a mean and standard deviation of 6.9 x 107 ± 11649034.29

Table 3.2: Values of heavy metal under deforested land

Heavy metals	SD Okoroete	SD Kampa	SD Elile	SD Amakada	SD Okorombakho	Mean	Standard deviation	Control composite
Iron (mg/kg)	21.69	35.47	24.46	30.08	24.16	27.172	5.563107944	42.19
Manganese (mg/kg)	17.25	31.05	20.7	29.3	24.16	24.492	5.767587884	42.19
Zink (mg/kg)	20.47	26.93	21.19	23.47	21.94	22.8	2.562537805	29.2
Copper (mg/kg)	7.15	10.24	8.66	9.17	8.18	8.68	1.14729391	15.24

Source: Fieldwork, 2022.

Table 3.2 shows the laboratory values of heavy metals under deforested land for the different observed samples. Six (6) different samples were analyzed including the composite control sample. All the parameters were within and less than the composite control for under-deforested land. Iron ranged from 21.69 mg/kg in Okroete to 35.47 mg/kg in Kampa community with a mean and standard deviation of 27.172 ± 5.563107944. Manganese ranged from 17.25 Mg/kg in Okoroete to 31.05Mg/kg in Kampa with a mean and standard deviation of 24.492 ± 5.767587884. Zinc ranges from 20.47Mg/kg to 26.93Mg/kg with a mean standard deviation of 22.8 ± 2.5625378 while Copper's value ranged from 7.15Mg/kg in Okoroete to 10.24Mg/kg in Kampa with a mean value of 8.68 ± 1.14729391.

Testing of Hypothesis

Hypothesis one

Ho 1: There is no significant variation between soil biological/microbial count in deforested area in settlements in the Eastern Oboloo region of Akwa Ibom state.

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Table 3. Determination of the significant variation between soil biological/microbial count on the deforested area in settlements in the Eastern Obolo region.

Locations	**Microbial Analysis**	**Control Composite**
SD Okoroete	6.6 X 107	1.02 X 108
SD Kampa	8.7 X 107	1.02 X 108
SD Elile	7.4 X 107	1.02 X 108
SD Amadaka	6.1 X 107	1.02 X 108
SD Okombokwo	5.8 X 107	1.02 X 108

The one-sample T-test was used as a statistical instrument for analyzing the first hypothesis. From the Analysis, it was noticed that using Excel, the calculated T-test calculated value was -6.2960 while our t-critical (Table) value was 2.1318 at 0.05 level of significance. Since the t-calculated value of -6.2960 is less than the T-critical value of 2.1318, we accept the null hypothesis which states that there is no significant variation between soil biological/microbial count on the deforested area in settlements in the Eastern Obolo region.

Hypothesis two (Ho2): There is no significant variation between soil heavy metals in deforested settlements in the study area.

Table 3.2.3: Determination of the significant variation in the heavy metals from different observed settlements in the study area.

Metal analysis	**SD Okoroete**	**SD Kampa**	**SD Elile**	**SD Amakada**	**SD Okorombakho**
Iron (mg/kg)	21.69	35.47	24.46	30.08	24.16
Manganese (mg/kg)	17.25	31.05	20.7	29.3	24.16
Zink (mg/kg)	20.47	26.93	21.19	23.47	21.94
Copper (mg/kg)	7.15	10.24	8.66	9.17	8.18

From the table, using single factor tabulation Excel, the calculated F-value was 0.73794 while the F-critical value was 3.05557 at 0.05 level of significance. Since the calculated F-value of 0.73794 is less than the table F-critical value of 3.05557, we accept the null hypothesis which states that there is no statistically significant variation between soil heavy metals on the deforested settlements in the study area

Discussion

In the analytical report of biological/microbial counts under deforested lands, the Microbial count (Total heterotrophic Bacteria) for the study locations ranged from 6.6 X 107 to 8.7 X 107 when compared with the composite control of 1.02 X 108 for underforested land with a mean value of 6.9 X 107 and standard deviation of 11649034.29 as in table 3.1. For the said heavy metals (Iron, Manganese, Zinc, and Copper), all the parameters were within the mean and less than the composite control for undeforested land. For Iron, the mean value was 27.172 for the sampled communities, while the control was 42.19; Manganese was 24.492 while the control composite was 42.19; Zinc was 22.8 while the control was 29.2 and Copper was 8.68 while the control composite was 15.24. the T-test and ANOVA statistical tools used in testing the two hypotheses allowed the identification of variations in soil properties in the six sampled settlements. The different soil properties such as micronutrients,

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microbial count and soil heavy metals showed a great statistical variation and the null hypotheses were accepted because the calculated T-test and F-values respectively were less than the critical (table) values at 0.05 significant level. Our findings reveal that deforestation brings about loss of soil nutrients, loss of valuable species of economic and medicinal value, siltation of rivers, species extinction, reduced biological diversity, reduced eco-system stability, reduced plant biomass and broken food chain.

Deforestation is one of the agents of climate change because it reduces the nutrients and the total heterotrophic bacteria (THB) in the soil as revealed in Table 3.1. Deforestation reduced the microbial population as well as degraded the soil quality in the settlements in the study area. It was evident from the findings in Table 3.1 that significant alterations in microbial population have occurred in the soil of deforested land. The microbial count of the controlled settlements blossoms with the increase in plant-bacteria activity. Reduced microbial count in the sampled soil is approximate to the reduced macronutrient observed. In Table 3.2.1. both fungi and bacteria populations significantly lower ($p \leq 0.05$) in the deforested land compared to the forested settlements. In this situation, the habitat of the organisms is destroyed and the organisms are forced to relocate to other places and may even end up dying due to inadequate resources for their survival.

Conclusion

The earth is a system where everything is connected and changes in one affect changes in the other. Climate change and deforestation will affect soil processes and properties because, the soil is connected to atmospheric/climatic systems through the Carbon, Nitrogen and Hydrologic cycles. The growth and socio-economic development of any region are largely determined by the soil conditions which are dependent on the climate in general and on anthropogenic activities. A deterioration of the environment caused by climate change and deforestation puts man and other living components of the region at risk. The altered soil quality caused by climate and deforestation requires scientific attention. Investigation of the impact of climate and deforestation on soil quality can provide indicative results for the functioning of many aspects of the ecosystem and mitigate the negative effect of climate change. The results of the study indicated that there is significant variation between deforested land and soil as there has been a decrease in soil microbial/biological count and an induced heavy metal which degraded the soil quality. These decreases contributed to the reduction of soil fertility, soil erosion, land degradation and a decrease in Carbon (C) sequestration which can lower the amount of Co_2 and mitigate greenhouse that contributes to climate change. Therefore, for the sustainable growth and development of forest resources, to reduce deforestation and improvement on soil quality and to mitigate the negative effect of climate change in the Obolo region and other regions of Nigeria

Recommendations

The study makes the following recommendations.

1. To minimize the use of fuelwood; The government should revive the use of other sources of energy such as biogas, electricity and kerosene and make it available and affordable to the masses.
2. There should be an improvement in soil quality by developing sustainable land use practices to reduce the rate of soil degradation, and to encourage long-term sustainability of the farmland system and similar biophysical settings to preserve soil quality to mitigate the greenhouse effect that contributes to climate change.
3. The government should employ trained field staff that will assist the stakeholders in the region to wisely restore what is altered and predict and manage what can happen to soil and natural resource by anthropogenic and natural perturbations.
4. Laws, policies and legislative and regulatory measures should be effectively enforced and should be such that they encourage local people and institutional participation in forestry management and conservation in the region.
5. The government should encourage Community-based Natural Resources Management (CBNRM) in the region.
6. The government and the communities should encourage reforestation (operation cut one, plant two trees). This would help to mitigate global warming and also improve the sustainability of natural resources as well as provide livelihood opportunities for communities in the region.
7. The government and relevant stakeholders should encourage vegetation cover, avoid burning stubble and avoid erosion in the region. Vegetation cover is the best way to prevent soil and carbon loss. Burning

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creates greenhouse gases as well as exposes the soil to damage from erosion and oxidation. Soil carbon in the topsoil cover is lost through erosion by rain or wind.

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