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Climate change impact and carbon sequestration of agricultural soils around automobile service centers in Southeastern Nigeria.

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Abstract: *Soil carbon sequestration of three agricultural farmlands close to three automobile service centers in Owerri, South Eastern Nigeria was investigated using random sampling technique. Soil samples were collected with the aid of soil auger in July 2014 at the depth of 15cm. Collected soil samples were analyzed using standard laboratory routine analysis. The results showed soil carbon sequestration in the fallow land close to automobile to be higher in both study sites [901.1 – 927.5mM] compared to carbon sequestration in other farmlands. Vegetable farm was [453.1 - 519.5mM] and mixed farmland [805.1 – 853.5mM]. Soil physical and chemical parameters had strong correlation with carbon sequestration in these study areas. Therefore adoption of improved land management practices that protect soil carbon may have additional benefit of providing ways of adapting to and reduce the negative impact of climate change.*
Keywords: *Soil carbon, sequestration, climate change, adaptation, soil management, agriculture.*

I. Introduction

Human activities such as fossil fuel combustion, deforestation and biomass burning; have primarily caused the deposition of large amount of greenhouse gases, which have long residence time and warming potentials into the atmosphere. These gases trap heat closer to the earth's surface and thereby causing warming of the environment. This is the major contributing factor to climate change (IPCC, 2007). The impact of this warming is reported to affect a broad spectrum of physical, ecological and human/cultural system (Serreze*et al.*, 2000;Serreze and Francis, 2006; McGuire *et al.,* 2009). Carbon dioxide is the most persistent of the major atmospheric greenhouse gases that are released due to expansion of the environment. This is due to the fact that humans have interrupted the carbon cycle on a huge scale; they have caused abnormally rapid increase in the concentration of carbon dioxide in the atmosphere. Carbon emitted has exceeded the natural source and its fixation (Weart, 2008). However, carbon dioxide can be removed from the atmosphere or captured at its emission source. This creates opportunity to draw substantial quantities of carbon from the atmosphere back into vegetation and soil to restore terrestrial ecosystem (White, 2012).

Carbon produced from biotic activities is naturally stored as soil organic matter (soil), living biomass (vegetation) and as calcium carbonate in calcareous rocks (Limestone). The oceans can also serve as a sink of inorganic and organic carbon and a source of atmospheric CO_2 (Wali*et al.*, 2009).

Soil represent the largest terrestrial carbon reservoir, containing three times the amount of carbon in the atmosphere (Past *et al.*, 1990) and five times the amount of carbon in the global vegetation (Smith, 2004). The size of the carbon reservoir in the soil depends on the balance between the annual additions of plant, animal, and microbial biomass to the soil and the annual losses by microbial soil respiration and soil erosion (Wali*et al* 2009). When carbon is sequestered, it removes carbon dioxide from the overloading atmosphere; Carbon storage in soilenhancessoilfertility, increases water retention capacity and improves primary production (Denef*et al.*, 2004). However, depletion in soil carbon pool can accentuate as a result of erosion, compaction, depletion of nutrients, acidification, leaching and a general decline in soil biodiversity (White, 2012).

Land use through agricultural and forestry practices bring about degradation of land, these actions have reduced biomass, release soil organic carbon and deposited large amount of carbon dioxide in the atmosphere (Beedlow*et al., 2004*: Sayer*etetal.*, 2012). The IPCC (2007) reported that agriculture and forestry combined were the source of 30.9% of greenhouse gases particularly carbon dioxide in the terrestrial ecosystem, which is associated with climate change. However, clearing of vegetation, tillage and cultivation practices enhance carbon mineralization and carbon dioxide flux in the atmosphere (Paustian*et al.*, 2000; West and Post 2002; Onweremadu, 2009).

In many developing countries including Nigeria, traditional farming system, include land clearing by Slash and-burn; clearing and burning plant debris, all of theseenhance soil carbon loss (Heimann and Reichstein, 2008). The traditional farming methods have been reported to reduce the integrity and productivity of vegetation and soils, which formsnatural sink for carbon dioxide (Onweremadu, and Udebuani, 2012).Carbon dioxide in recent times is continuously recognized as the most abundant of the greenhouse gases, this is because of its emission from different anthropogenic sources particularly from agricultural and forestry activities (IPCC, 2007). The increase concentration of carbon dioxide is a threatnot only towardsaltering the biogeochemical cycle, but also endangering the sustainability of the biosphere especially in agriculture and consequently human health. Presently, the permanence of carbon sequestration in both plants and animals is at risk because of natural disturbances. The increase frequency of wild fires, flooding and drought resulting from all these threatens the stability of terrestrial carbon stores (White, 2012). Soil carbon sequestration is important because the accumulation of carbon in soil has a lasting benefit of improving soil structure and quality (Denef*et al*., 2004; Onweremadu*et al*., 2011). However, the mechanism and factors governing the global uptake and release of carbon from the terrestrial reservoir and their regional importance are still poorly understood.

Anthropogenic activities such as automobile mechanic work generate a lot of hazardous waste. These wastes generated are dumped without proper regulated method of disposal,especially in many developing countries of the world (Udebuani*et al.*, 2011). The environmental impact of automobile mechanic wastes has escalated in recent times due to search of greener pasture. Consequently, ecosystem disturbance through automobile waste disposal, affects soil physical and chemical properties, its spread through run-offs and leaching can affect carbon storage in the soil. The study therefore investigates the carbon sequestration in agricultural soil types near automobile service center in Owerri Southeastern Nigeria.

II. Materials and Methods.

The study was conducted in three agricultural farmsnearautomobile servicing center NekedeOwerri area of Imo state, (Latitude 5.24-5.27^{O}N and Longitude 7.04 - 7.06^{O}W). The land area occupied by the three study sites is over 20km^2 and soils are derived from coastal plain sand (Benin formation). The sites are situated in the humid tropics with mean annual rainfall of about 2500mm and annual temperature range of 27-31^{O}C. The vegetation is a typical rainforest type although highly depleted by increasing population pressure and attendant land use.

Collection of soil samples

Soil samples were randomly collected from a multiple-cropped farm (characteristically dominated by maize, cassava,okra and melon), vegetable farm (pumpkin, garden eggplant), and fallow land (five years). In these farmlands, conventional tillage practices were adopted in farming and inorganic fertilizers were used in augmenting natural fertility of soil. Weeds are removed manually using hoes. The soil samples were collected from the depths of 0 - 20cm using an auger of approximately 7.5cm diameter and taken to thelaboratory for studies. These soil samples were air-dried and sieved using a 2 mm sieve. However 12 core samples were collected for bulk density determination. Macro-morphological attributes, of soil such as; soil color, soil structure, soil consistence, and drainage were determined in the field using peds from the fallow land use (Onweremadu*et al*., 2011).

Soil Studies

Particle size analysis was determined by hydrometer method (Gee and Or, 2002). Bulk density was estimated by core procedure (Grossman and Reinsch, 2002). Soil pH was measured using a pH meter in a soil water ratio 1:25 (Hendershot*et al.*, 1993), cation exchange capacity was determined by ammonium acetate method (Soil Survey Staff, 2003). Soil organic carbon was estimated by wet digestion (Nelson and Sommer, 1982).

Soil carbon sequestration was calculated by multiplying bulk density, soil organic carbon and thickness of horizon that is carbon sequestration; BD (Mg/m^3) x soil organic carbon(SOC) (g/kg) x thickness of horizons in meters (Batjes, 1996).

Data Analysis: Soil data was analyzed using SAS statistics package for analysis of variance (ANOVA) (SAS Institute, 1990). Significant difference between soil organic carbon stocks between three-farmlands was analyzed using simple correlation analysis.

III. Results and Discussion

The morphological properties of the three agricultural soils are shown in Table 1. The three different soil types showed a color range of reddish brown (10YR 1/3 moist) to dark reddish brown (2.5YR 3/2 moist). The soils of multiple-cropped farm, vegetable farmwere slightly sticky, slightly plastic and have weak granular structure compared to the fallow soils was dark brown, non-sticky and non-plastic, well-drained soil. The morphological properties observed in the soil agricultural farmlands were quite different from that observed in automobile waste polluted soil, which was observed sticky, plastic and poorly drained. Variations in the morphological characteristics observed inthe three agricultural soilscould be attributed to land use and management practices. Onweremadu*et al*.,(2011) reported a similar finding and said that the morphological characteristics of the soils have obvious implicationin its property,and that such changes can influence carbon dioxide emission. Poor drainage was observed from the soils in all the soil samples except that obtained from fallow land.

Table 1: General macro morphology of the three agricultural soil.

Morphological characteristics	Vegetable farm Land	Mixed farmland	Fallow land	AWPS
Soil Colour (moist)	Dark brown	Dark brown	Dark red	Brown
Soil Structure	Granular	Granular	Granular	Granular
Soil Consistence	Slightly sticky, non plastic	Slightly sticky, non plastic	Non sticky, non plastic	Sticky and Plastic
Root Abundance	Abundant	Abundant	Abundant	Non abundant
Drainage	Poor drained	Poor drained	Well drained	Poor drained

Key: VFL Vegetable farm Land; MFL Mixed farmland; FL Fallow land; AWPS Automobile waste polluted soil.

Table 2. Shows the physicochemical parameters of agricultural soil types, the soil textural class of the three soil samples was sandy, bulk density was higher in polluted soil than in other soil types. Increase bulk density reduces oxygenation, which affects soil aerobes involved in mineralization of soil organic matter and thus reduces carbon dioxide evolution. Soil moisture were higher in the polluted soil than in other soil types, soil moisture influences the microbial activities, Meixner and Yang, (2006) reported that soil moisture supplies substrate to soil organisms, this way, it can influence carbon dioxide diffusion

Table 2: Selected Soil properties in three agricultural soil (0 – 20cm depth), (mean value) (n=30)

Soil Property	Unit	VFL	MCF	FL	AWPS
Sand	g kg^{-1}	941	916	914	958
Silt	g kg^{-1}	44	38	26	21
Clay	g kg^{-1}	35	35	28	17
Bulk density	mg m^{-1}	1.42	1.39	1.25	1.63
CEC	Cmol kg^{-1}	9.5	8.7	10.7	1.7
pH		5.8	5.7	6.2	4.3
OM	g kg^{-1}	31.4	32.2	19.5	9.1

Legend: VFL Vegetable farm Land; MFL Mixed farmland; FL Fallow land; AWPS Automobile waste polluted soil.

Soil temperature at 5 cm depth was significantly ($P \leq 0.05$) higher in automobile waste polluted soil than all other agricultural soils. The temperature was highest in polluted soils but were lowest in the soils obtained from vegetable farm land

Table 3: Soil moisture content and temperature in three agricultural soils

Soil Types	Soil Moisture (%)	Temperature (^{O}C)
VFL	12.4	28.9
MCF	12.6	30.5
FL	10.07	30.7
AWPS	14.9	32.9

Legend: VFL Vegetable farm Land; MFL Mixed farmland; FL Fallow land; AWPS

Automobile waste polluted soil.

The concentration of total organic carbon in the soil of the study area is shown in Table 4. The concentration of total carbon in the soils of three studied area is presented in Table 4, with the soils of the vegetable farmland having the lowest value (453.1 – 519.5mM) in soils nearer to the two automobile servicing centers. The highest values (901.1 – 927.5mM) were obtained from the fallow land. Previous study found that the potential for different landscape elements to sequester carbon was partly dependent on the changes in soil organic carbon stores that occurred since cultivation began (Bedard-Haughn, 2006). Tillage of soil during farming may have induced a large and rapid loss of soil carbon (Denef, 2004; Gottschalk *et al*., 2010). Onweremadu*et al*., 2011, also obtained similar result, he reported variations in total soil carbon storage in different agricultural soils and the highest value o soil carbon was obtained in fallow soil. The relative permanence of carbon sequestered in the soil depends on some environmental factors such as moisture levels, temperature, canopy cover, soil composition etc. for instance, excessive drainage tends to reduce the ability of soil to hold carbon and it is emitted as carbon dioxide (Smith *et al*., 2007; Onweremadu*et al*., 2011).

Table 4: Concentration (mM) of total organic carbon in three agricultural soils.

	OMV (mM)	NMV (mM)
Vegetable Farmland (VFL)	519.5	453.I
Multiple cropped farm (MCF)	805.1	853.5
Fallow Land (FL)	901.1	927.5
AWPS	211.9	172.06
LSD	54.2***	22.2***

*Key: VFL Vegetable farm Land; MFL Mixed farmland; FL Fallow land; AWPS Automobile waste polluted soil,*** Highly significant*

Several studies reported that changes in the fate of cropping residues (straw and stubble), cultivation and tillage practices have a strong impact on soil organic carbon stocks (Paustian*et al*., 1998, 2000; West and Post, 2002). However, arable soil erosion, which depends on soil organic carbon content, cultivation and tillage practices, causes a significant loss of soil organic carbon in cultivated soils (Eglin *et al*., 2010).

A continuous decline in soil organic carbon levels for a wide scope of agricultural soils has been observed since the 1950s and reported in many countries (Qiu*et al*., 2009). This was mainly explained by the reduction of crop residue incorporation and manure amendments, which have been the major source of soil organic carbon for most of their farmlands (Qiu*et al*., 2009). In addition, intensive agriculture practices, such as application of chemical fertilizer, increased irrigation in arid areas, expansion of straw incorporation, and shallow plowing have also led to an increase in the carbon sequestration of agricultural ecosystems (Huang and Sun, 2006).

IV. Conclusion

This study has revealed that there was great soil carbon storage in fallow soil than other agricultural soil types. However soil physical and chemical properties influences soil organic carbon accumulation in relation to CO_2 emission and these soil properties play key role in global carbon cycle. Intensive agricultural practices and land use influences the production and consumption of gases particularly carbon dioxide gases and its emission in an environment.

Soil carbon sequestration can be achieved by increasing the net flux of carbon from the atmosphere to the terrestrial biosphere by increasing global carbon inputs to the soil (via increasing NPP), by storing a larger proportion of the carbon from NPP in the longer-term pools in the soil, or by reducing carbon losses from the soils by slowing decomposition. For soil carbon sinks, the best options are to increase carbon stocks in soils that have been depleted in carbon that is agricultural soils and degraded soils.

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