Agricultural Research & Technology
Open Access Journal
ISSN: 2471-6774

Research Article
Volume 20 Issue 3 - March 2019
DOI: 10.19080/ARTOAJ.2019.20.556129

Agri Res & Tech: Open Access J

Contribution of Climate Change to Soil Carbon and Nitrogen Storages in Three Parent Materials in Akwa Ibom State, Nigeria

Uduak C Udoinyang*

Department of Soil Science and Land Resources Management, Faculty of Agriculture, University of Uyo, Nigeria

Submission: December 24, 2018, **Published:** March 18, 2019

***Corresponding author:** Uduak C Udoinyang, Department of Soil Science and Land Resources Management, Faculty of Agriculture, University of Uyo, Nigeria

Abstract

A study was conducted to examine the effects of climate change on the Carbon and Nitrogen storages of soils derived from Coastal Plain Sands (CPS), Beach Ridge Sands (BRS) and Sand Stone/Shale (SSS) parent materials in Akwa Ibom State. Secondary soil data of organic carbon, and bulk density as well as climatic data of 2004 to 2014 were used. Organic C stock and SON were calculated as product of soil organic carbon (or total N) contents, bulk density and soil depth. Data were analysed using descriptive statistics, regression analysis and ANOVA at α0.05. Organic C stocks on the surface (0-15cm) soil depth were 44.13±15.91, 43.89±17.39 and 52.40±18.02Mg C ha^{-1} for CPS, BRS and SSS, respectively. The corresponding values for subsurface depth (15-30cm) were 28.30±9.58, 24.83±8.93 and 26.37±5.74Mg C ha^{-1}. However, N stocks at 0-15cm soil depth were 3.37±0.90, 3.19±0.94 and 3.56±1.00Mg N ha^{-1} for CPS, BRS and SSS, respectively. Whereas in the 15-30cm soil depth, SON were 2.07±0.55, 2.00±0.58 and 2.04±0.56Mg N ha^{-1} for the respective parent materials. Highly significant SOC stock of 78.90Mg C ha^{-1} occurred in 2005 in SSS, while the least stock of 23.71Mg C ha^{-1} occurred in 2007 CPS. Across the parent materials, organic C stocks increased as rainfall decreases. Whereas, in. N stocks increased as relative humidity decreases. Change in climate significantly affected soil organic carbon and nitrogen storages.

Keywords: Parent materials; Climate change; Carbon and nitrogen stocks; Rainfall

Abbrevations: CPS: Coastal Plain Sands; BRS: Beach Ridge Sands; SSS: Sand Stone/Shale; SOC: Soil Organic Carbon; SON: Soil Organic Nitrogen; SOM: Soil Organic Matter

Introduction

Climate change refers to a long-term shift in weather conditions. It is measured by changes in a variety of climatic indicators such as temperature, precipitation, and wind. Climate change can be the result of natural processes and/or human activity [1,2]. Like all soils the world over, ultisol found in Akwa Ibom State, Nigeria are strongly affected by climatic gradients in temperature and moisture which in turn affects the storage of soil organic carbon (SOC) and soil organic nitrogen (SON) content. Therefore, to maintain stable carbon (C) and nitrogen (N) stocks within the soils of this vast region, it requires a balance between plant primary productivity and decomposition. This balance is affected by carbon dioxide (CO_2), temperature, and soil moisture, which is further modified by soil texture [3]. Vegetation drives maximum C input to the soil and varies across ecosystems primarily with moisture gradients [4,5]. Consequently, SOC and SON stocks are also highly related to temperature and precipitation gradients [6-8]. Temperature and moisture control soil organic matter (SOM) decomposition and CO_2 respiration driving both global and regional patterns of SOC [4,6].

Soils with greater silt and clay content typically have greater SOC stocks due to physical protection of organic minerals [9,10]. Climate change scenarios predict a 2.2 °C to 3.6 °C (4 °F to 6.5 °F) increase in temperature and increased variability in precipitation across most of the United States by 2040 to 2059 according to Marschner and Bredow [11], will likely alter the distribution and composition of plant biomass. Initial plant responses to changes in temperature and CO_2 observed by Hinzman [12] may not reflect long-term SOC dynamics since increased plant C inputs can lead to increased decomposition [9].

In Nigeria, it is obvious that climate change is equally resulting in variations in temperature and precipitations with its attendant effects on the vegetation. However, evidence of the effects of changes in SOC and SON stocks documentation such as those ascribed to climate change in ultisol is scanty. This study, therefore, attempts to examine the effects of climate change on the soil organic carbon and nitrogen storage of soils on three parent materials in Akwa Ibom State, Nigeria over a ten-year period.

Materials and Methods

Site information

The study was conducted in Akwa Ibom State, Southeastern Nigeria. The State is located between latitudes 4°30′ and 5°30′ N and longitudes 7°27′ and 8°27′E and is characterised by a uniformly hot wet and humid tropical climate [13]. The climate is characterised by two seasons; the wet and dry seasons. The wet or rain season lasts between the months of April and October, during which the rains are heavy and of high intensity. The pattern of rainfall is bimodal with peaks in July and September. The mean annual rainfall varies from 2500 - 4000mm. The dry season lasts from November to March. The average daily temperature varies from 26 °C to 28 °C. Solar radiation falls within 6 to 15mm/day. Relative humidity ranges from 75 to 95%, while evapotranspiration ranges from 4.11 to 4.95mm, partly because of the high values of insolation and temperature.

Vegetation and land use

The hot humid climate favours the luxuriant tropical rainforest [12], which has however been almost completely replaced by secondary forest of predominantly wild palm trees, woody shrubs and various grasses undergrowth [11]. Poor management and improper land use coupled with human population pressure has led to forest depletion with attendant soil degradation and low productivity [10,14-15]. Mangrove ecosystem extends into the estuaries and flood plains of the Imo River at Ikot Abasi, the Qua River at Eket and the Cross River at Mbo and Oron. Large tracts of Riverine Swamp and flood plain environments with wetland characteristics flank the Qua Iboe River valley through Etinan and Abak L.G.A. Farming is very restricted on the beach ridge sands, while agriculture and road network are adversely affected on the narrow-crested sandstone ridges with steep-sided hills and valley which cover much of Itu, Ibiono Ibom, Ikono and Ini L.G.A. The predominant land use is the bush fallow cropping system operated with low productive farming tools. This cropping system leaves more than 80% of the soil surface bare. And this exposed the soil to high intensity rainfall erosivity that is common to this area [5].

Data collection

Secondary soil data spanning from 2004 to 2014 were used. Data were collated from three major parent materials in the area viz: Coastal Plain Sands (CPS), Sand Stone Shale (SSS) and Beach Ridge Sands (BRS). Soil data for each of the three parent materials since 2004 were considered for the study and soil samples of 0-15 and 15-30cm depths were used. The soil data were pulled together and were considered as representative of each parent materials for the years under study.

Procedure for determining soil organic carbon (SOC) stock: Calculating SOC stocks for a given depth consists of summing SOC Stocks by layer determined as a product of bulk density (Db) [16], organic carbon (OC) concentration, and layer thickness for an individual profile with n layers15. Organic carbon stock was determined by the following equation [7].

$$SOC = \sum_{i=1}^{n} Db * Ci * Di * 1000 * 0.0001$$

where, SOC = soil carbon (Mg ha^{-1}); Db = Bulk density (Mg m^{-3}); C*i* = Organic carbon content of depth *i* (g kg^{-1}); D*i* = soil depth *i*

Procedure for determining soil nitrogen (SON) stock: Soil Nitrogen carbon stock was determined by the following equation:

$$SON = \sum_{i=1}^{n} Db * Ni * Di * 1000 * 0.0001$$

where, SON = soil nitrogen (Mg ha^{-1}); Db = Bulk density (Mgm^{-3}); N*i* = soil total N of depth *i* (g kg^{-1}); D*i* = soil depth *i*

Statistical analysis

Data were analysed using descriptive statistics and ANOVA at $\alpha_{0.05}$. The regression analysis was used to determine the association of the climatic variables [8,14] (rainfall, temperature and relative humidity) with SOC and SON over the periods

Results and Discussion

Table 1: Bulk Density of soils of three parent materials in Akwa Ibom State (2004 to 2014).

Year	Bulk Density (Mg m^{-3}) 0 - 15cm			15 -30cm		
	CPS	BRS	SSS	CPS	BRS	SSS
2004	1.43	1.48	1.53	1.58	1.57	1.59
2005	1.43	1.53	1.58	1.69	1.62	1.62
2006	1.51	1.46	1.57	1.56	1.66	1.66
2007	1.55	1.38	1.58	1.68	1.55	1.63
2008	1.48	1.45	1.49	1.55	1.52	1.71
2009	1.54	1.45	1.47	1.61	1.56	1.64
2010	1.42	1.36	1.56	1.52	1.49	1.69
2011	1.46	1.57	1.57	1.59	1.62	1.66
2012	1.45	1.53	1.58	1.57	1.59	1.64
2013	1.38	1.48	1.61	1.54	1.56	1.71
2014	1.52	1.33	1.66	1.63	1.65	1.7
Mean	1.47	1.46	1.56	1.59	1.58	1.66
SD	0.05	0.07	0.05	0.06	0.05	0.04
CV	3.7	5.1	3.4	3.5	3.4	2.4

Results of the soil properties affected by change in climatic factors are summarized in Tables 1-3. Mean bulk density (BD) on the surface soil of CPS, BRS and SSS were 1.47±0.05, 1.46±0.07 and 1.56±0.05 Mg m^{-3}, respectively. The corresponding values in the sub surface were 1.59±0.06, 1.58±0.05 and 1.66±0.04 Mg m^{-3}, (Table 1). The trend of soil compaction on both soil surfaces among the three parent materials was SSS > CPS > BRS. The shale

How to cite this article: Uduak C Udoinyang.Contribution of Climate Change to Soil Carbon and Nitrogen Storages in Three Parent Materials in Akwa Ibom State, Nigeria. Agri Res& Tech: Open Access J. 2019; 20(3): 556129. DOI: 10.19080/ARTOAJ.2019.20.556129

which associated with sandstone consistently characterized with high bulk density. Relatively, bulk density was moderately high on the surface soil compared with subsurface depth. This according to Agbede [17] and Hamarshid [18] is attributed to the organic matter content on the surface soil that promotes good soil aggregation, thus lowering bulk density of the soil [19,20].

Table 2: Organic carbon concentration in soils of three parent materials in Akwa Ibom State (2004 to 2014).

Year	Organic Carbon (g kg^{-1}) 0 - 15cm			15 - 30cm		
	CPS	BRS	SSS	CPS	BRS	SSS
2004	13.04	15.23	23.57	9.46	7.45	10.38
2005	24.67	20.56	33.29	14.57	15.83	7.13
2006	15.65	16.23	32.44	12.25	7.45	12.55
2007	10.2	34.32	20.45	9.21	16.98	11.34
2008	28.22	18.48	18.55	18.2	11.67	14.13
2009	15.21	12.98	14.87	7.43	5.78	9.33
2010	27.49	15.34	31.39	20.6	10.33	10.64
2011	22.9	32.13	16.74	11.5	14.33	13.12
2012	33.23	26.34	10.75	8.76	7.49	7.33
2013	16.9	13.67	18.89	9.89	8.83	10.34
2014	13.87	14.56	24.23	8.95	9.12	10.03
Mean	20.13	19.99	22.29	11.89	10.48	10.57
SD	7.5	7.57	7.48	4.23	3.76	2.19
CV%	37.3	37.9	33.9	35.5	35.9	20.7

Table 3: Total nitrogen concentration in soils of three parent materials in Akwa Ibom State (2004 to 2014).

Year	Total Nitrogen (g kg^{-1}) 0 - 15cm			15 - 30cm		
	CPS	BRS	SSS	CPS	BRS	SSS
2004	1.38	1.43	1.89	0.91	0.67	0.82
2005	1.21	2.22	1.05	0.84	0.83	0.59
2006	1.1	1.26	1.43	0.69	1.34	0.66
2007	2.32	1.06	2.33	1.21	0.88	1.43
2008	1.33	1.38	1.08	0.88	0.76	0.62
2009	1.32	1.37	1.26	0.68	0.79	0.83
2010	1.36	1.22	1.45	0.66	0.69	0.69
2011	2.01	2.02	1.52	1.32	1.17	0.89
2012	1.55	1.54	1.19	0.78	0.77	0.71
2013	2.01	1.23	2.04	0.83	0.66	0.89
2014	1.25	1.18	1.42	0.71	0.68	0.88
Mean	1.53	1.45	1.51	0.86	0.84	0.82
SD	0.4	0.36	0.41	0.22	0.22	0.23
CV	26	24.9	27	25	26.2	28.2

Organic C content of 20.13±7.50, 19.99±7.59 and 22.29±7.48 gkg^{1} on the surface soil of CPS, BRS and SSS were significantly higher compared to 11.89±4.23, 10.48±3.76 and 10.57±2.19gkg^{-1} in the subsurface soil, respectively. The corresponding values for soil nitrogen content were 1.53±0.40, 1.45±0.36 and 1.51±0.41gkg^{-1} on the surface, while soil nitrogen content in the subsurface were 0.86±0.22, 0.84±0.22 and 0.82±0.23gkg^{-1}, respectively. However, SSS parent material recorded significantly high SOC than the other parent materials on the surface, whereas high SOC in the subsurface was noticed in CPS parent material. This result is consistent with the earlier report of Marschner and Bredow [11]. Organic carbon was highly varied (>35%) in both the 0-15 and 15-30cm soil depths of CPS and BRS, but moderately varied in both depth of SSS. Harris [7] noted this high variable distribution of SOC at the field scale both horizontally and vertically. Accordingly, level of SOC variability was attributed to differences in vegetative cover, geomorphic soil position and thermal diffusivity of the soil.

Annual trends of climatic elements in akwa ibom state from

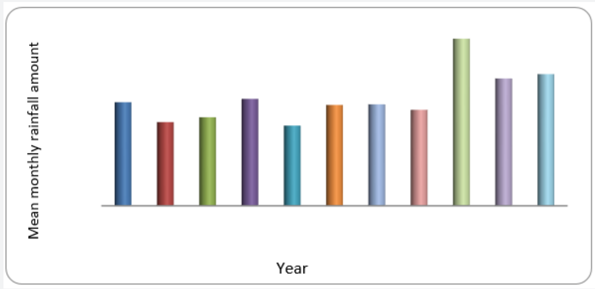

Figure 1: Monthly rainfall pattern in Akwa Ibom State (2004-2014).

The respective yearly rainfall and temperature data are presented in Figures 1 and 2. Significantly high annual rainfall of 319.2mm in the study area was recorded in 2012 while the least annual rainfall of 153.4mm was recorded in 2008. Figure 1 revealed fluctuations in rainfall pattern with stupendous rising in 2012 and significantly drop in 2013 and 2014. Although, the rainfall pattern in 2013 and 2014 were significantly higher compared to the periods preceding 2012.

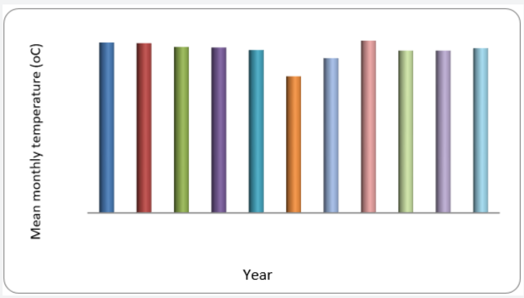

Figure 2: Monthly temperature variations in Akwa Ibom State (2004-2014).

On the other hand, high annual temperature above 26.5 °C was constantly recorded between 2004 and 2008. Conversely, the high

How to cite this article: Uduak C Udoinyang.Contribution of Climate Change to Soil Carbon and Nitrogen Storages in Three Parent Materials in Akwa Ibom State, Nigeria. Agri Res& Tech: Open Access J. 2019; 20(3): 556129. DOI: 10.19080/ARTOAJ.2019.20.556129

temperature regime dropped to 21.8 °C in 2009 and subsequently increased above 26 °C in 2010 and climaxed at 27.5 °C in 2011. From the forgoing, year 2011 was the hottest period and the peak period for water demand for decomposition of organic materials.

Organic C stocks of 44.13±15.91, 43.89±17.39 and 52.40±18.02 Mg C ha^{-1} on the surface soil depth of CPS, BRS and SSS, respectively, were significantly higher than 28.30±9.58, 24.83±8.93 and 26.37±5.74Mg C ha^{-1} recorded in the subsurface soil depth (Table 4). On the surface soil, organic C stocks decreased in the order of SSS > CPS > BRS. Whereas, in the subsurface depth, it decreased in the order of CPS > SSS > BRS. Consistently, BRS stored the lowest C content in the soil. According to Hashamoto and Suzuki [21], differences in biomass production, cropping systems, land use types and soil types could greatly contribute to the variation in SOC stock at an annual time scale.

Table 4: Organic carbon stock in soil from different parent materials.

Organic Carbon Storage (Mg C ha^{-1})						
Year	0 - 15cm			15 - 30cm		
	CPS	BRS	SSS	CPS	BRS	SSS
2004	27.98	33.81	54.09	22.42	17.54	24.75
2005	52.92	47.19	78.9	36.95	38.47	17.33
2006	35.45	35.54	76.4	28.66	18.55	31.25
2007	23.72	71.04	48.47	23.21	39.48	27.73
2008	62.66	40.19	41.46	42.32	26.61	36.25
2009	35.14	28.23	32.79	17.94	13.53	22.95
2010	58.55	31.29	73.45	46.97	23.09	26.98
2011	50.16	75.67	39.42	27.43	34.82	32.67
2012	72.27	60.45	25.48	20.64	17.86	18.03
2013	34.98	30.35	45.62	22.85	20.66	26.52
2014	31.62	29.05	60.33	21.88	22.57	25.58
Mean	44.13	43.89	52.4	28.3	24.83	26.37
SD	15.91	17.39	18.02	9.58	8.93	5.74
CV	36.05	39.62	34.38	33.86	35.97	21.77

Table 5: Mean total N stocks of soils from different parent materials.

Total Nitrogen Storage (Mg N ha^{-1})						
Year	0 - 15cm			15 - 30cm		
	CPS	BRS	SSS	CPS	BRS	SSS
2004	2.96	3.17	4.34	2.16	1.58	1.96
2005	2.6	5.09	2.49	2.13	2.02	1.43
2006	2.49	2.76	3.37	1.61	3.34	1.64
2007	5.39	2.19	5.52	3.05	2.05	3.5
2008	2.95	3	2.41	2.05	1.73	1.59
2009	3.05	2.98	2.78	1.64	1.85	2.04
2010	2.9	2.49	3.39	1.5	1.54	1.75
2011	4.4	4.76	3.58	3.15	2.84	2.22
2012	3.37	3.53	2.82	1.84	1.84	1.75
2013	4.16	2.73	4.93	1.92	1.54	2.28
2014	2.85	2.35	3.54	1.74	1.68	2.24
Mean	3.37	3.19	3.56	2.07	2	2.04
SD	0.9	0.94	1	0.55	0.58	0.56
CV	26.66	29.53	28.1	26.59	28.79	27.59

Similarly, total N stocks of 3.37±0.90, 3.19±0.94 and 3.56±1.00Mg N ha-1on the surface soil depth of CPS, BRS and SSS, respectively, were significantly higher than 2.07±0.55, 2.00±0.58 and 2.04±0.56Mg N ha^{-1} recorded in the subsurface soil depth of the corresponding parent material (Table 5). Total N stocks in the 0-15cm depth decreased in the order of SSS > CPS > BRS while in the 0-30cm depth, it decreased from CPS > SSS > BRS. The highest total N stocks of 5.22Mg N ha^{-1} recorded on the surface soil of SSS was in 2007, while the least storage of 2.19Mg N ha^{-1} was recorded in CPS of the same year (Table 5).

Effect of climate on carbon and nitrogen storages

The effects of climate on C and N storage among CPS, BRS and SSS parent materials were assessed using rainfall and soil temperature. In CPS, BRS and SSS, organic C stock increased with reduction in the amount of rainfall by 30.1, 12.6 and 54.2%, respectively. Organic C stock was highest in SSS parent material and least in the BRS. Hector et al. [22] equally found an increased SOC to the total SOC pool in low rainfall soils. On the other hand, Hinzman [12] reported that soil organic C levels increased with a corresponding increase in mean annual precipitation. This is true for soils with coarse textures soil such as BRS [23]. The significant increase in soil C stock with decreasing rainfalls especially in SSS soil, is therefore, linked to moderation of the biomass loss effects with high decomposition rates in fine textured soil. However, the relationships of organic C stocks and rainfall for CPS (0.301) and BRS (0.126) were not significant. The rainfall effects on N stock in CPS and SSS were significant and directly related, whereas the effect in BRS was inversely related. Across the parent materials, 200mm of monthly rainfall was found to be the peak rainfall amount that contributed to the storage of large quantity of N (4.5Mg N ha^{-1}) in the soil. However, temperature with highest N stock in CPS, BRS and SSS were 26 (4.5Mg N ha^{-1}), 27 °C (4.0Mg N ha^{-1}) and 28 °C (4.7Mg N ha^{-1}), respectively.

Conclusion

It is evident from the study that organic C stock in the surface soil decreased in the order of sand stone/shale > coastal plain sand > beach ridge sand. However, soil nitrogen stock did not follow a definite trend as the organic C stocks obtained in the surface depth. Comparing the three parent materials, organic C stocks in coastal plain sand and sand stone/shale only increased with decrease in rainfall as the temperature increased, whereas in beach ridge sand parent material, N stock increased as rainfall amount decreases. Among the years examined, highest total N stock was

How to cite this article: Uduak C Udoinyang.Contribution of Climate Change to Soil Carbon and Nitrogen Storages in Three Parent Materials in Akwa Ibom State, Nigeria. Agri Res& Tech: Open Access J. 2019; 20(3): 556129. DOI: 10.19080/ARTOAJ.2019.20.556129

obtained in 2007 from sand stone/shale parent material and the least from coastal plain sand. High temperature rate reduced the level of organic carbon and nitrogen storages. Therefore, climatic factors contribute significantly to the variability of soil carbon and nitrogen storages among the three parent materials in Akwa Ibom State, Nigeria.

References

1. Cleland EE, Mooney HA, Schwartz MD (2007) Shifting Plant Phenology in Response to Global change. Trends in Ecology and Evolution 22(7): 357-365.
2. IPCC (International Panel on Climate Change) (2001) Impacts, Adaptation and vulnerability. Summary for Policy Makers. Cambridge University Press, Cambridge, UK.
3. Emmett BA, Beier C, Estiarte M, Tietema A, Kristensen HL, et al. (2004) The Response of Soil Processes to Climate Change: Results from Manipulation Studies of Shrublands across an Environmental Gradient. Ecosystems 7(6): 625-637.
4. Doret SH, Shkesby RA, Walsh RP (2009) Soil Water Repellency. Its Causes, Characteristics and Hydro-geomorphological Significance. Earth science review 51(1-4): 33-65.
5. Edem ID, Edem SO (2008) *In situ* Erosion Variability Management under Vetiver Hedges in Alfisol Assessment of Management Control on Loss and Runoff in the Field with Multi-slot Device. LAMBERT Academic Publishing GmbH and Co. KG. USA.
6. Brady NC, Weil R (2002) The Nature and Properties of Soils, (13th edn). Prentice Hall. Upper Saddle River, New Jersey, USA, pp. 960.
7. Harris D, Pacovsky RS, Paul EA (1985) Carbon Economy of Soybean-rhizobuim-glomus Association. New Phytologist 101(3): 427-440.
8. MacDonald NW, Zak DR, Pregitzer KS (1995) Temperature Effects on Kinetics of Microbial Respiration and Net Nitrogen and Sulfur Mineralization. Soil Science Society of American Journal 59: 233-240.
9. Cookson WR, Osman M, Marschner P, Abaye DA, Clark I, et al. (2007) Controls on soil Nitrogen Cycling and Microbial Community Composition across Land use and Incubation Temperature. Soil Biology and Biochemistry 39(3): 744-756.
10. Frey SD, Lee J, Melillo JM, Six J (2013) The Temperature Response of Soil Microbial Efficiency and its Feedback to Climate. Nature of Climate Change 3: 395-398.
11. Marschner B, Bredow A (2002) Temperature Effects on Release and Ecologically Relevant Properties of Dissolved Organic Carbon in Sterilized and Biologically active Soil Samples. Soil Biology and Biochemistry 34(4): 459-466.
12. Hinzman LD, Bettez ND, Bolton WR, Chapin FS, Dyurgerov MB, et al. (2005) Evidence and Implications of Recent Climate Change in Northern Alaska and other Arctic Regions. Climatic Change 72(3): 251-298.
13. Ogban PI, Ekerette (2001) Physical and Chemical Properties of the Coastal Plain Sand Soils of South-eastern Nigeria. Nigerian Journal of Soil Resources 2: 6-14.
14. Ruttan VW (1993) Agriculture, Environment, Climate and Health, Sustainable Development in 21st Century. University of Minnesita Press, Mineapolis.
15. Watter JT, Bruce CH (1990) Seasonal Rainfall Characteristics and daily Rainfall. Meteorology Society 88: 90-95.
16. Grossman RB, Reinsch TG (2002) Bulk Density and linear Extensibility Core Method. In: Dane JH, Topp GC (Eds.), Method of Soil Analysis Part 4. Physical Method. Madison Wisconsin USA. Soil Science Society of America Journal pp. 208-228.
17. Agbede OO (2009) Understanding the Soil and Plant Nutrition. Published by Petra Digital Press, p. 1-282.
18. Hamarshid NH, Othman Mohamed-Amin HH (2010) Effect of Soil Texture on Chemical Composition, Microbial Population and Carbon Mineralization in Soil. Egypt J Exp Biol 6(1): 59-64.
19. Balser TC, Kinzig AP, Firestone MK (2005) Linking Soil Microbial Communities and Ecosystem Functioning. In: Kinzig AP, Pacala SW, et al. (Eds.), The Functional Consequences of Biodiversity: Empirical Process and Theoretical Extensions. Princeton University Press, New Jersey, USA.
20. Bray RH, Kurtz LT (1945) Determination of Total Organic and Available forms of Phosphorus in Soils. Soil Science 59(1): 39-46.
21. Hashamoto S, Suzuki M (2004) The impact of forest clear-cutting on soil temperature: A comparison between before and after cutting and between clear-cut and control sites. Journal of Forest Research 9(2): 125-132.
22. Hector FC, Aimee TC, Emily EA, Richard JN, Christopher WS (2009) Soil Microbial Community Responses to Multiple Experimental Climate Change Drivers. Journal of Applied and Environmental Microbiology 76(4): 999-1007.
23. Hills RC, Morgan JH (1981) An Interactive Approach to the Analysis of Rainfall records for Agricultural Purposes. Experimental Agriculture 17: 1-16.

How to cite this article: Uduak C Udoinyang.Contribution of Climate Change to Soil Carbon and Nitrogen Storages in Three Parent Materials in Akwa Ibom State, Nigeria. Agri Res& Tech: Open Access J. 2019; 20(3): 556129. DOI: 10.19080/ARTOAJ.2019.20.556129