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Land Degradation: Impacts and Implications on Soil Nutrient Status in South-South Central Nigeria

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Abstract: *The study was conducted in the three geographical zones of south-south central Nigeria represented by Ika North East, Ethiope East and Isoko South Local Government areas of Delta State, Nigeria. The effect of land degradation on the soil nutrient and its implications were examined. Preliminary survey was made in the area of study and two soil profiles pit of 200cm deep were sited in each zone on degraded and un-degraded sites. Samples of soil were taken and analyzed for physical and chemical properties. It was observed that the soils were deep, well drained, coarse medium textured, acidic in nature and generally low in nutrient status. However, the identified forms of land degradation increased the content of heavy metals (Fe^{2+}, Ni^{2+}, Vi^{+} and Pb^{2+}) in all the zone of study, organic matter and carbon in southern zone and exchangeable bases (Na^{+} Ca^{2+} Mg^{2+} and K^{+}) in central zone of study areas by certain percentages. Other nutrient elements analyzed were reduced by certain percentages by the most common forms of degradation identified in each zone of the study.*
Key words: *Degradation, impact, implementation, nutrient.*

I. Introduction

One of the greatest challenges facing mankind today is land degradation. Although the problem is as old as settled agriculture, its extent and impact on human welfare and global environment are now more than before (Lai and Stewart, 2010). Most ancient civilization flourished on fertile soils. However, as the productivity of the soil declined, so did cultures and civilization that depend on it. Archeological evidence has shown that land degradation was responsible for the extinction of the Harappan Civilization in Western Indian, Mesopotamia in West Asia, the ancient kingdom of Babylon in Far East Asia and the Mayan culture in Central American (Olson, 2011). It is estimated that over the millennia as much as two billion hectares of productive land have been rendered unproductive through land degradation (UNEP, 2005).

Barrow (2010) defines land degradation as a decline in quality and utility of land and manifests in various ways such as washing away of soil nutrient/particles, exposure of subsoil surface, exposure of roots of plant/trees and foundation of building, silt deposition in lowland areas and water logging of soil, soil compaction, gully and inter-rill erosion (Lai, 2011). Reduction in yield of most agronomic crops in Africa is due to the degradation of soil. In Nigeria over 35 million tones of soil are lost annually to land degradation (Onyegocha, 2005).

In south central Nigeria, 2-3 million tones of soil are lost annual and this has caused a great decline in agricultural yield (Dike, 2005). It has been observed that land degradation is prominent in south central, Nigeria, but the degree of prominence is not yet known. Hence, it is imperative that the extent of land degradation on soil nutrient status be known. This investigation will gather information on the subject and propose remedial measure for sustained agricultural productivity. Therefore, the objectives of this study were to identify the impact of land degradation on nutrient status in south central Nigeria as well as its implications, and recommend means of reduction of the problem.

II. Materials And Methods

The study was carried out in three different geographical zones in south-south central, Nigeria, represented by Ika North East, Ethiope East and Isoko South located between latitude $5.5^{O}13^{1}$ and $6^{0}22^{1}$N and longitudes $6^{0}03^{1}$ and $6^{0}25^{1}$E as shown in fig (1). The areas of study have average annual rainfall ranging from 2300 to 3500mm and mean annual temperature of 28-30C (Meteorological station, 2012).

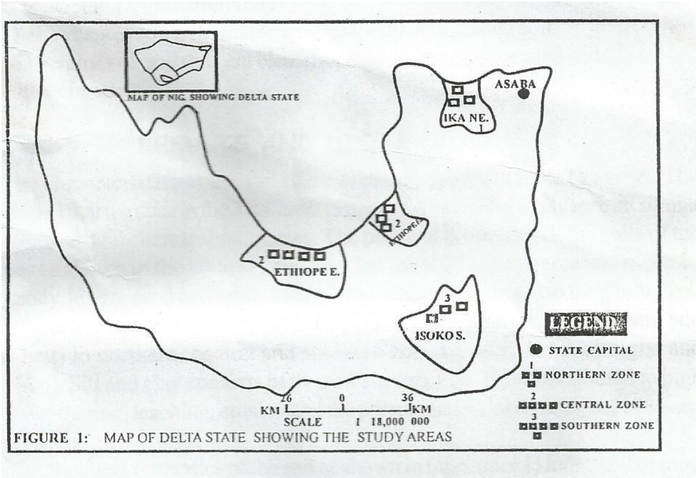

FIGURE 1: MAP OF DELTA STATE SHOWING THE STUDY AREAS

Soil profile pits of 200cm deep were sited in each zone on degraded and undegraded sites; soil samples were collected from different horizons for analysis. The physical and chemical analyses were determined as follows: particle size distribution was determined using the procedure described by Bouyoucos (1951), pH was measured in 0.1 N potassium chloride and distilled water with a soil liquid ratio of 1:2:5 using a Beckman zeromatic pH meter (Peech, 1965), organic carbon was determined by the method of Allison (1965) and total nitrogen by the Kjeldhahl method (Bremma, 1965). Exchangeable bases were determined by the method of Jackson (1958) and exchangeable acidity by the titrimetric method using potassium chloride solution (McLean, 1965). Soil cation exchange capacity was measured by the ammonium acetate method (Jackson, 1958).

Available phosphorus was determined by the Bray 11 method (Bray and Kurtz, 1945). Iron, lead vanadium and nickel were determined using atomic absorption spectrophotometer (AAS). The impact of land degradation on nutrient status was calculated with soil or land degradation index as prescribed by Barrow (2012).

LDI = (D //√D*100)=100-----------Eq (1)

Where:

LDI = Land Degradation Index
D = values of soil nutrient element/property in degraded soil
ND = values of soil nutrient element/property in non-degraded soil.
100 = constant

III. Results And Discussion

The physical characteristics of the soil of the areas are shown in table (1). The result indicates that the soils in the 3 different geographical zones of study are all similar in physical properties. The physical properties of the soils of the study areas as shown in the table (1) indicate that the soils have coarse and medium texture (sandy, loamy, sand and sandy loam). This could be attributed to the geological/parent materials in the area of study (coastal plain sand, deltaic plain, sombreiro and meander belt) in northern, central and southern zone respectively (Akamigbo and Asedu, 2012). Silt and clay contents of the soil are vey low. This is attributed to high degree of weathering, leaching, erosion and the parent materials (Akamigbo, 2008 and Sanchez 2010).

The chemical properties of the soil as shown in (appendix i) indicate that most of the nutrient elements of the soil in the study areas are below the critical levels of agricultural production as pointed out by Odu et al; (2005) in table (2) and low as shown in the table (3). This could be attributed to the geology and local parent material (Enwezor et al; 2001). Generally, the soil is acidic. This could be due to the nature of the economic activities of the study areas (farming and mining). The carbon and organic matter content of the soils apart from crude oil polluted soil are very low. This is due to rapid mineralization of the elements by high temperature as well as high leaching and burning (Sims, 2008).

The exchangeable bases in soils of the study areas are low. This is as a result of high or heavy leaching of soil materials, which can be attributed to the properties inherited from the local parent materials. The inverse effect of theses excessive leaching is the high level of exchangeable aluminium and hydrogen reflected in the pH (Akamigbo, 2005). Akamigbo and Asadu (2010) stated that parent material have strong influence in the total exchangeable bases and total acidity. Also, the apparent cation exchange capacity (ACEC) and the effective cation exchange capacity (ECEC) are both low as show in (appendix 1). King and Juo (2009) referred to this soil as low activity clay (LAC) soils probable as a result of low CEC. These soils are composes of mainly 1.1 lattice clay minerals (Kaolinites) (Akamigbo and Igwe, 2011).

The low CEC value according to Enwezor et al; (2001) is also due to the type of clay minerals. Available phosphorus content of the soil is low as shown in (appendix 1) compared with table (3). This could be attributed to strong weathering as observed by Enwezor (2007). Heavy met al content of the soil analyzed (Fe, Ni, V and Pb) values are depicted in (appendix 1). These values of heavy met also obtained may be attributed to the influence of parent rock, authropogenic activities as well as oil spillage. However, these values have not exceeded the tolerable or critical levels for crop production except nickel as given by Aubent and Pinta (2007). According to them, the critical levels of these heavy met also are 100-400ppm for lead, 50-100ppm for vanadium, 100ppm for nickel and 20,000-60,000 ppm for iron.

The form of land degradation:- soil erosion, bush burning and crude oil spillage most common in northern, central and southern zones of study areas respectively altered the soil nutrient status as shown in table (4). It was observed that land degradation due to erosion in northern zone of south central Nigeria, lowers the values of Carbon by 64.2%, organic matter by 64.1%, Nitrogen by 63.6%, Sodium by 26%, Potassium by 28%, Calcium by 50%, Magnesium by 32%, Phosphorus by 35% Clay by 6.45, silt by 14.2% and Fine Sand by 31.17%. This is attributable to washing away of soil particles and nutrients by erosion and leaching of nutrient as opined by Lai (2011). It was equally noted that erosion has increases the values of pH by 21.6%, Lead by 16.4% and Coarse Sand by 18.54%. From the result, erosion has contributed to the well being of the soil positively by reducing the sodium content by 26% and raising the values of the pH by 21.6%.

In the central zone, land degradation due to bush burning reduces the values of pH by 1.3%, Carbon by 37%, Organic Matter by 35.5%, Nitrogen by 48.8% due to induced volatilization process by burning; silt by 30.0% and Coarse sand by 13.04%. However, the values of Sodium, Potassium, Calcium, Magnesium, Phosphorus, Lead, Iron, Nickel, Vanadium, Clay, and fine Sand were increased by 9.5%, 52.9%, 42.2% and 31.8%, 34%, 19.6%, 0.54%, 27.3%, 16.6% and 29.1% respectively. This is attributed to deposition of mineral nutrients like Calcium, Magnesium, Sodium, Potassium and available phosphorus on the soil as a result of ashes produces during burning (Levine, 2009).

In southern zone, land degradation due to crude oil spillage lowers the values of Magnesium by 77%, Clay by 15%, and Fine Sand by 10.29% but increase the values of pH by 4.8%, Carbon by 478.6%, organic matter by 479.5%, nitrogen by 327%, Potassium by 127%, Calcium by 111%, Sodium by 127%, Phosphorus by 72%, Lead by 44%, Nickel by 11.7%, Vanadium by 60.7%, silt by 66.6% and Coarse sand by 21%. This increment may be the consequence of the component of the petroleum which affects the Organic Carbon, total Nitrogen, Nitrate, Ammonium and Exchangeable cation in the soil as opined by Odu (2010) and inactivation of microbial activities that would have increased mineralization and humification of organic material due to crude oil pollution effect.

High nutrient obtained due to the form of land degradation (bush burning) in the central zone of south-south central, Nigeria, has a positive effect on the well being of crops grown in the area by encouraging rapid and early growth of crops, because the increased exchangeable bases have beneficial effect on plant growth.

However, because of the destruction of the organic matter and the other spongy substances that would have cushioned the effect of leaching, most of these exchangeable bases are lost to percolating water.

Land degradation in its various forms in the zone of study has various implications as observed: pollution of water bodies, making it unfit for survival of aquatic life and limit its used for domestic and agricultural purposes, alteration of plant nutrient element negatively, thereby reducing food availability in the areas affected and increasing of government budget as a result of land degradation control.

IV. Conclusion

Land degradation is a social problem in south-south central, Nigeria. It is, therefore, suggested that vegetative cove through agro-forestry, forestation, cover cropping using mostly leguminous plants and mulching organically using crop waste animal waste and household refuse should be properly practiced and established. Those areas that might not be suitable for forestation should be grassed properly. All burning of bushes and cleared materials if need be done towards the ending of wet season. Laws encouraging good management of pipelines and prevention of oil spillage should be enforced and any defaulter should be punished accordingly.

More so, realistic land use approaches should be adopted to prevent further degradation and make dream of food self sufficiency a reality in south-south central, Nigeria.

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Table 1: Physical Properties of Soil of the Study Area

Sample Description	Depth (cm)	Horizon description	Clay %	Silt %	Fine sand	Coarse sand %	Total Sands %	Textrual Class	Bulk Density	Total Porosity	MWDW	MWDD
1S1	0 – 20	A	12	4	56	28	84	SL	1.25	52.8	0.823	1.121
	20-24	AB	14	4	58	24	82	SL	49.4	1.33	0.941	1.232
	46-83	B+1	16	4	50	30	80	SL	1.32	49.8	0.821	1.032
	83-125	B+2	18	2	50	30	80	SL	1.33	49.4	0.792	0.982
	125-200	B+3	20	4	58	18	76	SL	1.34	49.4	0.785	0.973
1S2	0-15	A	10	6	68	16	84	SL	1.25	52.8	0.721	0.940
	15-36	AB	16	6	50	28	78	SL	1.29	51.3	0.832	1.021
	36-85	B+1	12	8	58	22	80	SL	1.30	50.9	0.711	0.933
	85-120	B+2	14	4	60	22	82	SL	1.31	50.5	0.716	0.920
	120-200	B+3	16	6	60	18	78	SL	1.34	49.4	0.720	0.932
ET1	0-10	A	12	2	20	66	86	SL	1.20	54.7	0.925	1.303
	10-25	AB	10	6	20	64	84	SL	1.23	53.5	0.832	0.991
	25-100	B+1	12	4	34	50	84	SL	1.24	53.2	0.721	0.950
	100-155	B+2	12	4	34	50	84	SL	1.24	53.2	0.90	0.821
	155-200	B+3	14	4	36	82	SL	1.27	52.0	52.0	0.687	0.810
ET2	0-10	AP	8	4	32	56	88	SL	1.20	54.7	0.723	0.921
	10-25	AB	10	4	32	48	54	86	SL	54.7	0.845	0.950
	25-100	B+1	12	2	38	48	86	SL	1.21	54.3	0.713	0.920
	100-155	B+2	14	2	40	44	84	SL	1.21	54.3	0.713	0.810
	155-200	B+3	16	2	44	38	82	SL	1.26	52.4	0.706	0.805
IKI	0-25	AP	6	4	36	64	90	S	1.25	52.8	0.924	1.024
	25-40	AB	8	6	26	60	82	SL	1.27	52.0	0.897	0.987
	40-75	B+1	16	2	40	62	82	SL	1.30	50.9	0.798	0.981
	75-135	B+2	18	2	40	40	80	SL	1.32	50.1	0.873	0.950
	135-200	B+3	18	2	38	42	80	SL	1.34	49.4	0.850	0.930
1K2	0-5	AP	6	3	5	56	91	SL	1.25	52.8	0.821	0.936
	5-35	AB	12	3	33	56	88	SL	1.26	52.4	0.802	0.912
	35-90	B+1	14	2	30	52	82	SL	1.29	51.3	0.798	0.891
	90-150	B+2	14	2	30	50	80	SL	1.32	50.1	0.789	0.901
	150-200	B+3	16	2	30	50	80	SL	1.34	49.4	0.780	0.891

1= unaffected soil, 2 = affected soils, IS = Isoko, ET = Ethiope, S = Sand, SL = Sandy loam, LS = Loamy Sand, IK = IKA, MWDW = Mean weight diameter of wet aggregate, MWDD = mean weight diameter of dry aggregate.

Table 2: Nutrient levels for Agricultural Production

Elements	**Critical values**
Organic matter	2.6%
Carbon	1.513%
Nitrogen	0.15%
Available phosphorus	15ppm
Calcium	2.60 Me/100g
Potassium	0.20 Me/100g
Magnessium	0.40 me/100g
PH	6.5-7.5

Source: Odu et al, 2005

Table 3: Measurement of Soil Property Status Values

S/N	Parameters	Low value	Medium value	High value
1	PH	<5.6	5.6-7.6	>7.6
2	Organic carbon %	<0.8	0.8-1.5	>1.5
3	CEC Me/100g	<16	16-36	>36
4	Nitrogen %	<0.083	0.83-0.16	>0.16
5	Phosphorus Mg/L	<6	6-25	>25
6	Potassium Mg/L	<140	140-450	>450
7	Calcium Mg/L	<1500	1500-6000	>6000
8	Magnesium Mg/L	<190	190-550	>550

Source: FAO Soil Bulletin 48

Table 4: Impact of Land degradation on Soil properties in percentage in the three geographical zones of south-south central Nigeria.

Nutrient elements	Erosion Northern Zone	Bush Burning Central Zone	Oil Spillage Southern Zone
PH	21.6+	1.3-	4.8+
Carbon	64.1-	37-	478.5+
Organic matter	64.1-	35.5-	479.5+
Nitrogen	63.6-	48.8-	327+
Sodium	26-	9.5+	127+
Potassium	28-	52.9+	111+
Calcium	50-	42.2+	17+
Magnesium	22-	31.8	77-
Phosphorus	41-	8-	72+
Lead	16.4-	19.6+	44+
Iron	11.44+	19.6+	21.8-
Nickel	4.5+	0.54+	11.7+
Vanadium	12.7+	27.3+	60.7+
Clay	6.45-	16.6+	15-
Silt	14.2-	30.0-	66.6+
Fine sand	31.18-	29.1+	10.29-
Coarse sand	18.54+	13.04-	21+

+ Grained or added or increased; - Lost or removed or reduced