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ASSESSMENT OF THE STATUS OF SOIL DEGRADATION IN OTUKPO AREA OF BENUE STATE, NIGERIA AND THEIR MANAGEMENT IMPLICATIONS FOR CROP PRODUCTION

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Abstract. The assessment of degradation status of soils of Otukpo Area of Benue state for crop production (Rice, Cassava, and Maize) and its management implications was carried out. A total of thirty-six (36) soil samples were collected from six (6) locations (Upu, Icho, Ojali, Atilo, Okete, and Otobi). The physical and chemical properties of the soil were evaluated in the laboratory and results obtained were compared with the standard indicators and criteria for land degradation assessment according to FAO (1979). The result showed that most of the soils were very highly degraded due to low amounts of total Nitrogen, available Phosphorus, Cation Exchange Capacity (CEC), organic matter and base saturation, while Potassium and total exchangeable base (TEB) are high, showing that they are non-slightly degraded in all the locations. The textural composition of the soils were all sandy-loam, except for Okete1 and Ojali3 that were sandy clay loam and Otobi1 that was loamy sand. Available Phosphorus, and total Nitrogen were identified as serious limitations in those areas. It is recommended that the use of organic manure such as cow dung and poultry droppings to improve the fertility status of these degraded soils since most of these major nutrient elements are not readily available for plant use directly.

Keywords: *soil degradation, crop production, biophysical environment, crusting, erosion.*

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1. Introduction

Land degradation is defined as a reduction in the capacity of the land to produce benefits from a particular land use under a specified form of land Management. Land degradation is the decline in the productive ability of the soil. It is also a change and decrease in the optimum functioning of the soil in ecosystem [12].

For agricultural purpose, land degradation is the actions in land that decreases sustainable crop production overtime. Land degradation is a concept in which the value of the biophysical environment is affected by one or more contribution of human induced processes upon the land. The soil which is very fundamental to agricultural production is a key element of land resource; it is a vital natural resource that is non-renewable on the human time scale [9].

The process of land degradation could be physical, chemical and biological [12]. It could take the form of structural deformation eg. crusting, accelerated erosion, imbalance in water to air ratio which could impede root penetration and development. Chemical degradation could include processes such as fertility depletion, laterization, sodification, aluminium toxicity which can cause serious toxicity or limit the ability of plant to pick up needed nutrients in the soil. The biological degradation could include decline in soil organic matter, soil biomass content and alteration in biological process in the soil [11].

This study therefore, examines the actual level of degradation of the soils, identifies the factors responsible for it and highlights management implications for crop production (Rice, Cassava and Maize).

2. Materials and methods

Study Area

The research was carried out at Upu, Otukpo-Icho, Atilo, Ojali, Okete and Otobi within Otukpo area of Benue State, Nigeria. Otukpo local is located on longitude 8^0 8'47"E and latitude 7^0 11' 35" N.

Soil sampling was carried out in each of the six study sites using an auger at a depth of 0-15cm and 15-30cm. The samples were also collected from soil under fallow condition. The bulked samples were air-dried and gently crushed using mortar and pestle. The samples were then passed through 2mm sieve and packed for laboratory analysis.

Particle size distribution was assessed using the Bouyoucos hydrometer method (1962). The soil pH in water (1:1) was determined by electromagnetic method as described by [5]. The organic carbon content of the soil samples were determined using the Walkley-black wet oxidation method. The cation exchange capacity (CEC) of the soil was obtain through the aluminum acetate (NHOAC) method [6]. Bray-1 method was used to determine the extractable phosphorus [4], while the total Nitrogen was determined by the macro kjeldal wet digestion method [8]. Cations were determined by EDTA titration method [8].The extracts of sodium and potassium were determined with flame photometer.

Soil Degradation Assessment

The actual degradation level of the soils in the various locations was assessed using the standard indicators and criteria for land degradation assessment by Food and Agricultural Organization [7]. Table 1 shows these indicators and criteria. The four degrees of degradation identified include: Class 1: None-slightly degraded. Class 2: Moderately degraded, Class 3: Highly degraded and Class 4: Very highly degraded

Table 1. Indicators and criteria for land degradation assessment

Indicator	Degree of degradation			
	1	2	3	4
Soil bulk density (g/cm^{-3})	<.15	1.5-2.5	2.5-5	<5
Permeability (cm/hr)	<1.25	1.25-5	5-10	>20
Content of Nitrogen (%)	>0.13	0.13-0.10	0.10-0.08	<0.08
Content of Phosphorus element (cmol kg^{-1})	>8	8-7	7-	<6
K content (cmol kg^{-2})	>0.16	0.16-0.14	0.14-0.12	<0.12
Content of ESP (%)	<10	10-25	25-50	<50
Base saturation (%)	<2.5	2.5-5	5-10	>10

Excess salts (Salinization) mmhos/cm/yr)	<2	2-3	3-5	<5
Content of humus (%)	>2.5	2.5-2	2-1.0	<10

Source: FAO (1979)

Key: Class 1: None-slightly degraded. Class 3: Highly degraded
Class 2: Moderately degraded. Class 4: Very highly degraded

3. Results and discussion

Soil Properties of the Study Sites

The results of the physical properties of the soil (particle size distribution) as presented in Table (2) shows that percentage composition of sand is higher than that of clay and silt in all the locations. Also the soils of the six (6) locations (points) are mostly sandy loam. The predominance of sand separates indicates that the water holding capacity of the soil is low. The textural class of the soils indicates that the soils are likely to be well-drained during the wet season and moderately hard during the dry season. Tillage operations should be carried out when the soils are below field capacity. The results of the chemical properties of the soils in the six (6) study areas as presented in table 3 shows that the pH of the soils ranged from 5.41 -7.69 which indicates a lower slightly acidic to neutral conditions of the soils. The soils are however low in organic matter, nitrogen and phosphorus. Thus, the soils were considered to be typical upland soils in the tropics particularly Alfisols. The low organic matter obtained may be partly due to the effects of high rapid mineralization of organic matter. The low cation exchange capacity shows intensely weathered status. Low cation exchange capacity, organic matter, and low total nitrogen are indicators of low inherent fertility status, which underscore the need for improved soil management techniques and a tendency for a positive response of crops to the applied manures. This agrees with the observation of [2] that most Nigerian soils are deficient in nitrogen, phosphorus and potassium with average value of less than 1.5g Kg-1, total N, 8 mg Kg-1 Bray 1- P and 0.2 mol Kg considered to be below critical levels.

Table 2. Physical properties of the study sites

0-15 cm Location	Particle size distribution				15-30 cm Location	Particle size distribution			
	Sand	Clay	Silt	Textural class		Sand	Clay	Silt	Textural class
Upu1	80.80	13.2	6.0	Sandy-loam	Upu1	80.80	15.20	4.00	Sandy-loam
Upu2	80.08	14.2	5.72	Sandy-loam	Upu2	79.80	15.20	5.00	Sandy-loam
Upu3	81.08	12.2	6.72	Sandy-loam	Upu3	75.08	14.20	10.72	Sandy-loam
Tkp1	81.08	13.2	5.72	Sandy-loam	Tkp1	76.80	15.76	7.44	Sandy-loam
Tkp2	77.08	16.92	6.0	Sandy-loam	Tkp2	72.80	16.64	10.56	Sandy-loam
Tkp3	74.08	17.92	8.0	Sandy-	Tkp3	74.80	15.92	9.28	Sandy-

				loam					loam
Atilo1	79.08	14.6	6.32	Sandy-loam	Atilo1	69.80	17.20	13.00	Sandy-loam
Atilo2	78.08	15.6	6.32	Sandy-loam	Atilo2	72.80	16.64	10.56	Sandy-loam
Atilo3	76.80	16.64	6.56	Sandy-loam	Atilo3	70.80	18.64	10.56	Sandy-loam
Ojali1	77.08	17.92	5.0	Sandy-loam	Ojali1	74.08	16.20	9.72	Sandy-loam
Ojali2	74.80	15.92	9.28	Sandy-loam	Ojali2	76.80	18.20	5.00	Sandy-loam
Ojali3	76.80	15.92	7.28	Sandy-loam	Ojali3	72.80	20.92	6.28	Sandy-loam
Okete1	67.08	24.2	8.72	Sandy-loam	Okete1	67.08	24.20	8.72	Sandy-loam
Okete2	70.08	16.20	13.72	Sandy-loam	Okete2	74.08	16.20	9.72	Sandy-loam
Okete3	71.08	17.92	11.0	Sandy-loam	Okete3	71.08	17.92	11.00	Sandy-loam
Otobi1	80.08	15.92	4.0	Sandy-loam	Otobi1	83.08	13.20	3.72	Sandy-loam
Otobi2	79.08	14.92	6.0	Sandy-loam	Otobi2	79.08	14.92	6.00	Sandy-loam
Otobi3	77.80	13.92	8.28	Sandy-loam	Otobi3	77.80	13.92	8.28	Sandy-loam

Textural class: SCL=Sandy clay loam LS=Loamy sand SL=Sandy loam

Table 3. Soil chemical properties of the study sites

S/N	Location	Soil depth (cm)	pH	O.C (%)	P (MgL)	N (%)	K (cmol/kg)	Na	Mg	Ca	E.A	TEB	CEC	B/S
1	UPU1	0-15	7.26	1.18	0.62	0.082	0.41	0.37	3.7	4.20	1.20	8.68	9.88	87.9
		15-30	7.69	1.14	0.48	0.070	0.40	0.38	2.80	3.0	1.01	6.58	7.59	86.7
	UPU2	0-15	7.58	1.08	0.56	0.086	0.34	0.28	3.0	3.21	1.12	6.83	7.95	85.9
		15-30	7.06	1.34	0.53	0.073	0.33	0.25	3.10	3.80	1.10	7.48	8.58	87.2
	UPU3	0-15	7.52	0.98	0.58	0.078	0.35	0.32	3.2	3.90	1.10	7.77	8.87	87.6
		15-30	6.99	1.28	0.51	0.071	0.38	0.30	3.60	4.20	1.12	8.48	9.60	88.3
2	TKP1	0-15	6.76	0.68	0.60	0.081	0.38	0.30	2.91	3.40	1.21	6.99	8.20	85.2
		15-30	6.73	0.76	0.46	0.077	0.32	0.29	2.96	3.42	1.20	6.99	8.19	85.3
	TKP2	0-15	6.60	0.90	0.48	0.079	0.31	0.28	2.82	3.12	1.00	6.53	7.53	86.7
		15-30	6.47	0.72	0.44	0.074	0.28	0.21	3.0	3.12	1.02	6.61	7.63	86.6
	TKP3	0-15	6.56	1.40	0.52	0.077	0.40	0.36	2.60	3.41	1.14	6.77	7.91	90.1
		15-30	6.56	1.12	0.48	0.071	0.39	0.32	2.70	4.0	1.00	7.41	8.41	88.1
3	ATILO1	0-15	5.76	1.10	0.47	0.074	0.36	0.30	2.54	3.10	1.21	6.30	7.51	83.9
		15-30	5.76	0.82	0.40	0.069	0.32	0.24	2.82	3.14	0.98	6.52	7.5	86.9
	ATILO2	0-15	5.67	1.18	0.50	0.076	0.40	0.37	2.50	3.50	1.20	6.77	7.97	84.9
		15-30	5.86	1.38	0.43	0.066	0.38	0.30	3.10	3.60	0.99	7.38	8.37	88.2
	ATILO3	0-15	5.26	0.82	0.48	0.072	0.30	0,24	3.0	3.31	1.08	6.85	7.93	86.4
		15-30	5.41	1.0	0.42	0.068	0.36	0.32	3.10	3.62	1.00	7.4	8.4	88.1
4	OJALI1	0-15	6.12	0.90	0.42	0.068	0.33	0.22	3.30	2.90	1.04	7.75	8.79	88.2
		15-30	6.05	0.63	0.39	0.069	0.030	0.23	2.40	2.70	1.11	5.63	6.74	83.5
	OJALI2	0-15	6.08	0.56	0.38	0.063	0.28	0.25	3.10	3.80	1.03	7.43	8.46	87.2
		15-30	6.06	0.16	0.32	0.070	0.31	0.22	2.20	2.46	1.10	5.19	6.29	82.5
	OJALI3	0-15	6.04	0.14	0.40	0.067	0.34	0.28	3.20	3.70	1.10	7.52	8.62	87.2
		15-30	6.06	0.40	0.39	0.072	0.30	0.21	2.20	2.50	1.03	5.21	6.24	83.5
5	OKETE1	0-15	6.26	1.48	0.54	0.071	0.32	0.33	3.0	3.81	1.10	7.39	8.49	87.0
		15-30	5.95	1.56	0.50	0.073	0.41	0.27	3.40	3.82	1.21	7.96	9.17	86.8
	OKETE2	0-15	6.17	1.72	0.56	0.073	0.33	0.34	3.12	3.70	1.13	7.42	8.55	86.8
		15-30	5.92	1.59	0.52	0.078	0.42	0.35	3.42	3.70	1.20	7.88	9.08	86.8
	OKETE3	0-15	6.12	1.44	0.52	0.070	0.34	0.26	3.10	3.60	1.12	7.30	8.42	86.7
		15-30	6.52	1.0	0.47	0.75	0.32	0.29	2.62	2.92	1.14	6.15	7.29	84.4
6	OTOBI1	0-15	7.26	0.34	0.38	0.068	0.29	0.27	2.80	3.30	1.00	6.68	7.68	87.0
		15-30	7.28	1.20	0.36	0.073	0.28	0.21	2.12	2.52	1.13	5.13	6.26	82.0
	OTOBI2	0-15	7.50	0.60	0.35	0.070	0.34	0.30	3.41	3.82	1.02	7.87	8.89	88.5
		15-30	7.32	1.84	0.36	0.071	0.28	0.25	2.8	3.8	1.00	7.13	8.13	87.7

	OTOBI3	0-15	7.52	1.18	0.40	0.069	0.37	0.34	3.62	3.90	1.11	8.23	9.34	88.1
		15-30	7.32	1.82	0.41	0.073	0.34	0.30	3.6	4.0	1.10	8.24	9.34	88.2

Soil Degradation of the Study Sites

The chemical degradation of the soils of the studied sites were rated as stated by [7] using the indicators and criteria for land degradation assessment. The result is presented I Table 5. Total Nitrogen and available Phosphorus were Very highly degraded in all the locations, as they must have to be changed from their inert state to the form usable by plants (in solution). Also potassium and total exchangeable base are non-slightly degraded across all the locations. Base saturation rating indicated that, the soils were very highly degraded across all the locations which may be due to lack of organic matter content in the soil. These results agree with [1] who observed that more than 50 % of Nigeria soils are moderately to highly degraded. Thus, there is need for the adoption of good management practices for optimum productivity. In order to raise the productivity of the land to optimum (highly suitable) for maize, cassava and rice, application of inorganic and organic manure such as cow dung, poultry droppings to improve the fertility status of these degraded soils must be adopted since most of these major nutrient element are not readily available for plant use directly. Adoption of good management practices such as minimum tillage; appropriate cropping and erosion control will increase the organic matter content of the soil. The input of organic matter is important since it has substantial influence on soil physical and chemical properties that facilitate soil aggregation which in turn modifies soil structure and influences soil water regimes [10]. Management of plant residue will also assist in maintaining soil fertility, reducing soil erosion, increasing water infiltration, reducing soil temperature, suppress weed growth and simulate biological activities of earthworms and sustain a high equilibrium level of organic matter content [10].

Table 5. Soil Degradation of the Study Sites

		N		**K**		**B/S**		**P**		**O.M**		**Na**	
S/N	Location	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm	0-15cm	15-30cm
1	UPU1	NSD	VHD	NSD	NSD	VHD	VHD	VHD	VHD	MD	NSD	NSD	NSD
	UPU2	NSD	VHD	NSD	NSD	VHD	VHD	VHD	VHD	NSD	MD	NSD	NSD
	UPU3	VHD	VHD	NSD	NSD	VHD	VHD	VHD	VHD	NSD	MD	NSD	NSD
2	TKP1	NSD	VHD	NSD	NSD	VHD	VHD	VHD	VHD	NSD	NSD	NSD	NSD
	TKP2	VHD	VHD	NSD	NSD	VHD	VHD	VHD	VHD	NSD	NSD	NSD	NSD
	TKP3	VHD	VHD	NSD	NSD	VHD	VHD	VHD	VHD	MD	NSD	NSD	NSD
3	ATILO1	VHD	VHD	NSD	NSD	VHD	VHD	VHD	VHD	NSD	NSD	NSD	NSD
	ATILO2	VHD	VHD	NSD	NSD	VHD	VHD	VHD	VHD	MD	MD	NSD	NSD
	ATILO3	VHD	VHD	NSD	NSD	VHD	VHD	VHD	VHD	NSD	NSD	NSD	NSD
4	OJALI1	VHD	VHD	NSD	NSD	VHD	VHD	VHD	VHD	NSD	NSD	NSD	NSD
	OJALI2	VHD	VHD	NSD	NSD	VHD	VHD	VHD	VHD	VHD	VHD	NSD	NSD
	OJALI3	VHD	VHD	NSD	NSD	VHD	VHD	VHD	VHD	NSD	VHD	NSD	NSD
5	OKETE1	VHD	VHD	NSD	NSD	VHD	VHD	VHD	VHD	MD	MD	NSD	NSD

	OKETE2	VHD	VHD	NSD	NSD	VHD	VHD	VHD	VHD	MD	MD	NSD	NSD
	OKETE3	VHD	VHD	NSD	NSD	VHD	VHD	VHD	VHD	MD	NSD	NSD	NSD
6	OTOBI1	VHD	VHD	NSD	NSD	VHD	VHD	VHD	VHD	VHD	VHD	NSD	NSD
	OTOBI2	VHD	VHD	NSD	NSD	VHD	VHD	VHD	VHD	NSD	HD	NSD	NSD
	OTOBI3	VHD	VHD	NSD	NSD	VHD	VHD	VHD	VHD	MD	MD	NSD	NSD

NSD=Non-slightly Degraded
MD=Moderately Degraded
VHD=Very Highly Degraded
HD=Highly Degraded

4. Conclusion

The soils of these locations ranged from non-slightly degraded, moderately degraded, and very highly degraded. Soil texture, organic matter content, cation exchange capacity, available Phosphorus and total Nitrogen were identified as serious limitations to the cultivation of the concerned crops. Application of organic manure such as cow dung, poultry droppings to improve the fertility status of these degraded soils is highly encourage. There is also a strong need for the adoption of good management practices for optimum productivity. Adoption of good management practices such as minimum tillage; appropriate cropping and erosion control will increase the organic matter content of the soil. Management of plant residue will also assist in maintaining soil fertility, reducing soil erosion, increasing water infiltration, reducing soil temperature, suppress weed growth and simulate biological activities of earthworms and sustain a high equilibrium level of organic matter content

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