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Evaluation of Soil Degradation Status for Management of Soils of Ogbadibo Local Government Area of Benue State

Wuese, S. T[1*], Ajeh, C. B[2]

[1]*Department of Soil Science, Joseph Sarwuan Tarka University, PMB 2373, Makurdi, Benue State, Nigeria.*

[2]*Department of Soil Science, College of Agronomy, Joseph Sarwuan Tarka University, Makurdi.*

***Corresponding author**

Samuel Terungwa Wuese,
Department of Soil Science, Joseph Sarwuan Tarka University, PMB 2373, Makurdi,
Benue State,
Nigeria.

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Abstract

This study was carried out in Ogbadibo Local Government Area of Benue State during the dry Season of 2019 to evaluate the Degradation status for Management of soils in five (5) locations within Ogbadibo Local Government Area of Benue State. The Locations were Orokam (Olukam), Ipole-Owukpa, Uleke, Ibagba and Itabono (Amala). Soil samples were collected at depths of 0-15cm, 15-30cm and 30-45cm from each location. The samples were analyzed using standard analytical procedures. The evaluated physical and chemical properties of the soils were compared with the Standard Indicator and Criteria for Land Degradation Assessment. The result obtained indicated levels of physical and chemical land degradation. For the physical degradation, most of the soils were moderately to very highly degraded. Chemically, the soils were very highly degraded with respect to Base saturation. Other soil chemical properties like the C.E.C, N.P and K. Biologically, Organic matter was very highly degraded in all locations and depths. Forms of soil degradation observed were actually fertility decline and loss of organic matter. It is recommended that the use of green manure, Organic matter, chemical fertilizer in their right proportion be adopted so as to maintain and improve the soil nutrient status for enhance crop yield.

Introduction

Soil is a fundamental resource for agricultural production and naturally, its continued cultivation leads to loss of nutrients (Oyetunji et al., 2011). Soil degradation can be the loss of organic matter, decline in soil fertility, and structural condition, erosion, adverse changes in salinity, acidity or alkalinity, and the effects of toxic chemicals, pollutants or excessive flooding. It is the lowering in size and quality of land in relation to potential use (Ingevail et al., 2013).

Soil degradation refers to a change in soil health condition that causes a reduction in the ecosystem's ability to provide goods and services for its beneficiaries (Conacher & Sala, 2018). It is also defined as the loss of soil production by either chemical or physical processes (Singer & Munns, 2012). It thus covers the various types of soil degradation as physical, chemical and biological (Brabant, 2010), adverse human impacts on water resources, deforestation, and lowering of the productive capacity of rangelands. Despite, the wealth of literature that exists on the prevalence (Molchanov, 2015), its causes (Babacv et al., 2015), and impacts of soil degradation (Kuznetsova et al., 2009), and the global dimension of the loss of soil fertility from crop fields in most of the major agricultural regions of the world (Mueller et. al., 2010), soil degradation remains a global environmental phenomenon that is interpreted differently in different environments. For the most part, soil degradation is seen as the loss of land productivity, quantitatively and qualitatively, through many processes, such as soil erosion, overgrazing, cultivation, and cropping, leaching, water logging and pollution. Molchanov, et al. (2015), viewed soil degradation as the gradual or complete reduction of soil fertility (quality) through the physical removal of soil by erosion without actual loss of soil or a combination of both with a resultant decline in crop productivity.

Soil degradation processes, or mechanisms, that set-in motion the degradation include physical, chemical and biological processes (Gorobtsova et al., 2016). Prominent among the physical processes are deforestation, desertification, and deterioration of soil structure, leading to crusting, compaction, and erosion (Yusuf et al., 2015). Significant chemical processes include acidification, leaching, soil salinity, and a decrease in cation retention capacity and fertility exhaustion (Ahukaemere et al. 2012). The biological processes include a reduction in the total biomass carbon and a decline in soil biodiversity (Lal, 2013). Numerous studies have been conducted on the effects of the processes of soil degradation, such as cultivation and erosion of soil fertility (Senjobi et al., 2013 & Sotona et al., 2013).

Soil degradation is the decline in soil condition caused by its improper use or poor management, usually for agricultural, industrial or urban purposes. It is a serious environmental problem. Soils are a fundamental natural resource, and are the basis for all terrestrial life. Avoiding soil degradation is very crucial to the well-being of man-kind. It is against this backdrop that an evaluation into the degradation status and management of soil of Owukpa in Ogbadibo Local Government Area of Benue State was conducted to have baseline information that would be used for agricultural planning purposes. This study was carried out to evaluate the degradation status of soils of Owukpa in Ogbadibo Local Government Area of Benue State.

Materials and Methods

Owukpa (derived from the word Awokpa, meaning "people of the water area") is one of three districts that make up Ogbadibo Local Government Area, the other two being Orokam and Otukpa. Situated in the southern end of Idoma West, it is bounded in the North by Okpoga district and in the East by Ichama district, both of Okpokwu local government area. In the south, owukpa shares boundary with Obollo Eke in Udenu local government area of Enugu state while Orokam borders Owukpa in the west. Owukpa is inhabited by a homogeneous community who are descendants of Amuche Onomo.

Owukpa is made up of seven clans, together the seven clans formed Owukpa town. This medium-sized town has a population of about 100, 000 people as at 2006 census. Owukpa people are primarily farmers and are renowned for the quality of their palm wines, palm oil, cashew nuts, kola nuts, yams and cassava.

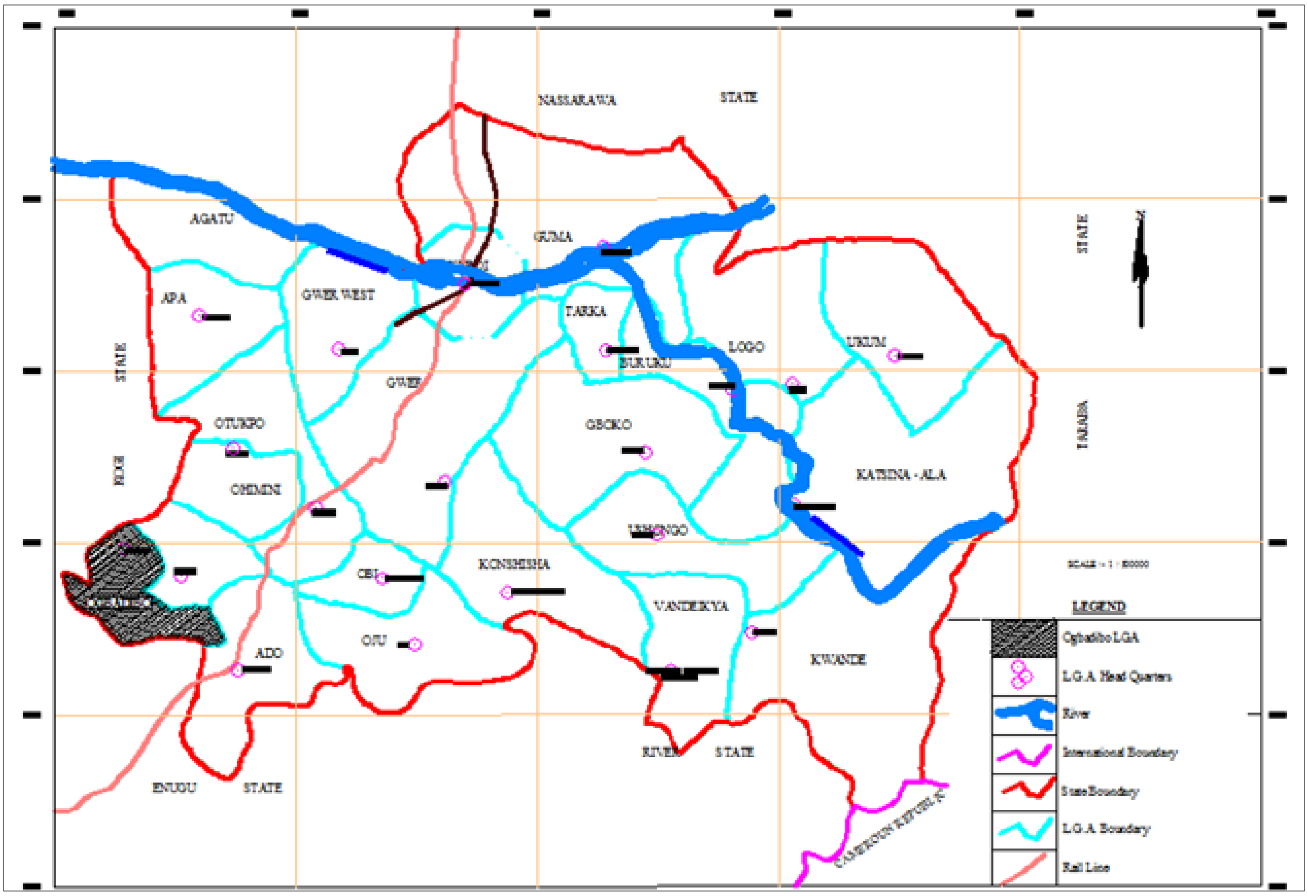

Figure 1: Map of Benue State showing Ogbadibo Local Government Area.
Source: Ministry of Land and Survey (2021)

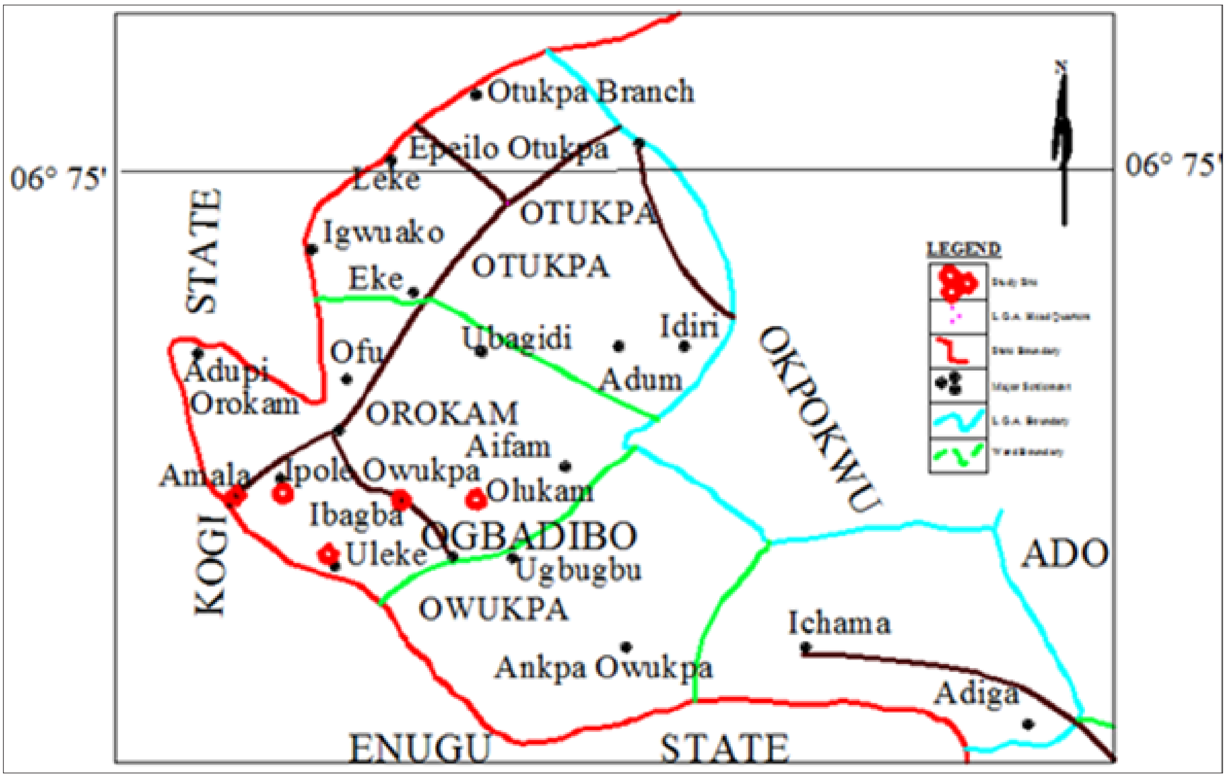

Figure 2: Map of Ogbadibo Local Government Area showing study sites.
Source: Ministry of Land and Survey (2021)

Materials

- Cutlass used for land clearing
- Hoe for digging of soil profile
- Masking tape for sample labeling
- Meter rule for measurement of horizons
- Polythene bags for sample collection
- Compass for location or coordinates

Methods

- Soil samples were taken from five (5) different locations using cutlass and hoe
- Soil samples were taken at 0-15, 15-30 and 30-45 cm depths.
- A total of 15 soil samples were collected from five (5) different locations

Filed Activity

Date of Sample Collection

All the samples were collected on the same day of November, 2019 from five (5) communities namely Ibagba, Amala, Ipole, Uleke and Olukam (Orokam) of Ipole Owukpa in Ogbadibo Local Government Area.

Laboratory Method

Soil analysis was carried out at the Advanced Analytical Soil Testing Laboratory of the Department of Soil Science, Joseph Sarwuan Tarka University, Makurdi using standard laboratory procedures.

Status of Soil Degradation of the Ogbadibo Soils

The level of degradation of soil of Ogbadibo Soils were assessed using the standard indicators and criteria for assessment of land (soil) degradation by the Food and Agriculture Organization (FAO, 1979), as well as the guide for interpretation of analytical data (FAO, 2004). Analytical data from each sample was place in a degradation class by matching the soil characteristics with the land degradation indicators (Table 1 – 2). The four degrees of soil degradation used were: Non to slightly Degraded Soil (NSD) where its productivity ranged from 75 – 100%. Moderately Degraded Soil (MD), where its productivity ranges from 50 – 75%, Highly Degraded Soil (HD) where its productivity ranged from 25 – 50%, and Very Highly Degraded Soil (VHD) where its productivity ranged from 0 – 25%.

Table 1: Indicators and Criteria for Soil Degradation Assessment:

Indicator	Degree of Degradation			
	1	2	3	4
Soil Bulk density (kg/m^3)	<1.5	1.5 – 2.5	2.5– 5	>5
Permeability (cm/hr)	<1.25	1.25 – 5	5–10	>20
Content of N element (Multiple decrease) N(g/kg)	>1.30	1.30-1.00	1.00-0.80	<0.80
Content of Phosphorus Element (mg/kg)	>8	8 – 7	7 – 6	<6
Content of Potassium Element (cmol/kg)	>0.16	0.16 - 0.14	0.14-0.12	<0.12
Content of ESP (Increase by 1% of CEC)	<10	10 - 25	25 - 50	>50
Base saturation (decrease of saturation in more than 50%)	<2.5	2.5 – 5	5 – 10	>10
Excess Salt (Stalinization) (increase of Conductivity mmho/cm/yr)	<2	2-5	3-5	>5
Content of humus (organic matter)(g/kg) soil	>25	25 – 20	20 – 10	<10

Key: Class 1: Non to Slightly Degraded; Class 2; Moderately Degraded; Class 3 Highly Degraded; Class 4 Very Highly Degraded
Source: FAO (1979)

Table 2: Interpretation Guide for Evaluating Analytical Data

Exchangeable cations				
Ca^{3+}	Mg^{2+}	K^+	Na^+ (cmol/kg)	Class
<2	<0.3	<0.2	<0.1	Very Low
2-5	0.3-1	0.2-0.3	0.1-0.3	Low
5-10	1-3	0.3-0.6	0.3-0.7	Moderate
10-20	3-8	0.6-1.2	0.7-2	High
>20	>8	1.2-2	>2	Very High

Cation Exchange Capacity	
Range	**Class**
<6	Very low
6-12	Low
12-25	Moderate
25-40	High
>40	Very High
Percentage Base Saturation (%)	
Range	**Class**
0-20	Very low
20-40	Low
40-60	Moderate
60-80	High
>80	Very High
Hydraulic Conductivity	
Range (cm/hr)	**Class**
<0.13	Very low
0.13-0.15	Low
0.15-2.0	Moderately low
2.0-6.3	Moderate
6.3-12.7	Moderately Rapid
12.7-25.4	Rapid
>25.4	Very Rapid

Organic Matter Rating	
Range (%)	**Class**
<2	Very Low
2-4	Low
4-10	Medium
10-20	High
>20	Very High
Soil pH	
Range	**Rating**
<4.5	Extremely acidic
4.5-5.0	Very strongly acidic
5.1-5.0	Strongly acidic
5.6-6.0	moderately acidic
5.6-6.5	slightly acidic
6.1-6.5	Neutral
7.4-7.8	Slightly alkaline
7.9-8.4	Moderately alkaline
8.5-9.0	Strongly alkaline
>9.0	Very strongly alkaline
Organic Carbon	
Range (%)	**Class**
<0.4	Very Low
0.4-1.0	Low
1.0-1.5	Moderate
1.5-2.0	High
>20	Very high
Total Nitrogen	
Mentson (1961)	
<0.1	Very Low
0.1-0.2	Low
0.2-0.5	Medium
0.5-1.0	High
+0.1	Very high

Available Phosphorus	
Enwezor et al (1989)	
Bray 1 (mg/kg)	
Range	**Class**
<8	Low
8-20	Medium
>20	High
Bray 2	
Range	**Class**
<15	Low
15-25	Medium
>25	High

Source: Special programme for Food Security, Federal Ministry of Agriculture and Rural Development (SPFS FMARD) FAO (2004)

Results:

Physical and chemical properties of the soils of Ogbadibo

The results of the physical and chemical properties of the soils of Ogbadibo is presented on Table 3. It revealed that with regards to pH, at 0-15 cm depth, it varied from 5.63(Moderately acidic) at Ibagba to 6.30 (Slightly acidic) at Ipole-Owukpa. At 15-30 cm, it ranged from 5.61(Slightly Acidic) at Amala to 6.45 (Neutra) at Uleke. At 30-45 cm, it ranged from 5.58 at Amala (Strongly Acidic) to 6.40 (Neutral) at Uleke.

The organic matter: at 0-12 cm ranged from 1.19 % (Very low) at Ibagba to 1.57 % (Very low) at Amala. At 15-30cm, it ranged from 1.05 % (Very low) at Ibagba to 1.33 % (Very low) at Amala, and at 30-45cm, it ranged from 0.80 % (Very low) at Uleke to 1.07 %(Very low) at both Ibagba and Amala.

Nitrogen: at 0-15 cm was highest at Amala with 0.11 % (Low) and lowest at Ibagba with 0.078 % (very low). At 15-30 cm, it was highest at Ipole-Owukpa with 0.097 % (very low) and at 30-45 cm, it was highest at Amala with 0.081 % (low) and lowest at Uleke with 0.064 % (very low).

Phosphorus: at 0-15 cm ranged from 4.60 % (low) at Ibagba to 4.96 % (low) at Orokam (Olukam). At 15-30 cm, it ranged from 4.50 % (low) at Uleke to 4.90 % (low) at Ipole Owukpa. At 30-45 %, it ranged from 4.80 % (low) at both Ipole-Owukpa and Amala.

Potassium: At 0-15 cm ranged from 0.25 Cmol/kg (low) at Ibagba to 0.29 Cmol/kg (low) at Ipole-Owukpa. At 15-30 cm, it ranged from 0.23 Cmol/kg(low) at Ibagba to 0.30 Cmol/kg (moderate) at both Orokam and Ipole-Owukpa. And at 30-45 cm, it ranged from 0.24 Cmol/kg (low) at Ibagba and 0.29 Cmol/kg (low) at Amala.

Sodium: at 0-15 cm ranged from 0.23 Cmol/kg (low) at Amala, to 0.26 Cmol/kg (low) at Ipole-Owukpa. At 15-30 cm, it ranged from 0.21 Cmol/kg (low) at Ibagba to 0.28 Cmol/kg (low) at Ipole-owukpa. And at 30-45 cm, it ranged from 0.22 Cmol/kg (low) at Ibagba to 0.25 Cmol/kg (low) at Amala.

Calcium: at 0-15 cm ranged from 2.66 Cmol/kg (low) Uleke to 3.0 Cmol/kg (low) at Ipole-Owukpa. At 15-30 cm, it ranged from 2.60 Cmol/kg (low) at Uleke to 3.20 Cmol/kg (low) at Ipole-Owukpa. At 30-45 cm, it ranged from 2.70 Cmol/kg (low at Uleke to 3.05 Cmol/kg (low) at Orokam (Olukam).

Magnesium: at 0-15 cm ranged from 2.58 Cmol/kg (moderate) at Uleke to 2.80 Cmol/kg (moderate) at Ipole Owukpa. At 15-30 cm, it ranged from 2.50 Cmol/kg (moderate) at both Uleke and Ibagba to 2.90 Cmol/kg (moderate) at Ipole-owukpa. And at 30-45 cm, it ranged from 2.56 Cmol/kg (moderate) at Uleke to 2.80 Cmol/kg (moderate) at Orokam (Olukam).

Cation exchange capacity: at 0-15 cm ranged from 6.88 Cmol/kg (low) at Uleke to 7.43 Cmol/kg (low) at Ipole-Owukpa, at 15-30 cm, it6 ranged from 6.67Cmol/kg (low) at Uleke to 7.78Cmol/kg (low)Ipole-Owukpa and at 30-45cm, it ranged from 6.08Cmol/kg (low) at Ibagba to 7.48Cmol/kg(low) at Orokam.

Base saturation: at 0-15 cm ranged from 83.58 % (very high) to 85.69 % (very high) at Ibagba. At 15-30 cm ranged from 83.51 % (very high) at Uleke to 86.17 % (very high) at Ipole-Owukpa and at 30-45 cm, it ranged from 84.08 % (very high) to 85.59 % (very high) at Amala.

Organic carbon: at 0-15 cm ranged from 0.69 % (low) at Ibagba to 0.91 % (low) at Amala, at 15-30 cm it ranged from 0.61 % (low) at Ibagba to 0.77 % (low) at Amala. At 30-45 cm, it ranged from 0.46 % (low) at Uleke to 0.62 % (low) at both Ibagba and Amala.

Status of soils degradation of the Ogbadibo soils

The Status of Soil Degradation of the Ogbadibo soils (Table 4) indicated that with regards to organic matter, all of the Soils were very highly degraded at all soil depths and locations. Considering nitrogen, the soils at all depths and locations was moderately degraded. With regards to phosphorus and base saturation, all the soils were also very highly degraded at all depths locations.

Status of pH, nitrogen, phosphorus, organic matter, exchangeable cations and cation exchange capacity

The Status of the pH, Nitrogen, Phosphorus and Organic Matter of the Soils of Ogbadibo (Table 5) indicated that pH at 0-15 cm was neutral in all soils except at Amala where it is slightly Acidic. At 15-30 cm, it was neutral at Orokam (Olukam), Ipole-Owukpa and Uleke, slightly acidic at Ibagba and Amala. At 30-45 cm, it was moderately acidic at Orokam (Olukam), slightly acidic at Ibagba and strongly acidic at Amala. Organic Matter was very low in all soils depths and locations. Nitrogen also were very low across all soil locations and depths except at 0-15 cm Orokam (Olukam), Ipole-Owukpa and Amala. Similarly, Phosphorus was low in all soil depths and locations. The Exchangeable Cations of the Ogbadibo Soils (Table 5) indicated that Potassium, Calcium was low in all soils at all locations and depths. Similarly, Magnesium was moderate in all soil at all locations and depths. The cation exchange capacity (Table 5) was low in all Soils at all locations and depths.

Table 3: Result of Some Physical and Chemical Properties of the Soils of Ogbadibo Soils in 2019

Sample	Depth(cm)	Particule size Distribution			pH	OC (%)	OM (%)	N (%)	P ppm	K	Na	Mg	Ca	Eb	Ea	CEC	BS	Soil Texture %
		Sand (%)	Silt (%)	Clay (%)														
Orokam	0-15	69.80	10.00	20.26	6.33	0.84	1.45	0.100	4.96	0.28	0.25	2.65	2.82	6.00	1.10	7.10	84.51	loam
(Olukam)	15-30	60.08	13.92	26.00	6.32	073	1.26	0.096	4.82	0.30	0.26	2.60	2.80	5.96	1.12	7.08	84.18	clay loam
	30-45	58.80	10.00	31.20	6.00	0.56	0.97	0.077	4.60	0.28	2.24	2.80	3.05	6.37	1.11	7.48	85.16	clay loam
Ipole	0-15	65.36	12.50	22.14	6.30	0.80	1.38	0.100	4.85	0.29	0.26	2.90	3.00	6.35	1.08	7.43	85.46	loam
Owukpa	15-30	62.64	11.00	26.36	6.20	0.73	1.26	0.097	4.90	0.30	0.28	2.61	3.20	6.68	1.10	7.78	86.17	loam
	30-45	60.64	11.36	28.00	6.09	0.51	0.88	0.066	4.80	0.28	0.24	2.58	2.84	5.97	1.13	7.10	84.08	clay loam
Uleke	0-15	69.80	13.00	17.20	6.49	0.70	1.21	0.086	4.70	0.27	0.24	2.50	2.66	5.75	1.13	6.88	83.58	sandy loam
	15-30	65.80	13.00	21.20	6.45	0.64	1.11	0.067	4.50	0.24	0.23	2.56	2.60	5.57	1.10	6.67	83.51	loam
	30-45	61.80	13.00	25.20	6.40	0.46	0.80	0.064	4.60	0.26	0.24	2.50	2.70	5.76	1.12	6.88	84.09	loam
Ibagba	0-15	63.80	9.00	27.20	6.49	0.69	1.19	0.078	4.60	0.25	0.24	2.60	2.90	5.99	1.00	6.99	85.69	loam
	15-30	58.80	10.00	31.20	5.98	0.61	1.05	0.069	4.65	0.23	0.21	2.50	2.75	5.69	1.06	6.75	84.30	clay loam
	30-45	56.08	10.92	33.00	5.94	0.62	1.07	0.070	4.45	0.24	0.22	2.68	2.84	5.98	1.10	6.08	84.46	clay
Itabono	0-15	68.08	12.00	19.92	5.63	0.91	1.57	0.110	4.90	0.26	0.23	2.60	2.83	6.09	1.10	7.19	84.70	loam
(Amala)	15-30	62.80	10.00	27.20	5.61	0.77	1.33	0.093	4.75	0.28	0.25	2.70	2.90	5.93	1.00	6.93	85.57	loam
	30-45	58.08	9.920	32.00	5.58	0.62	1.07	0.081	4.80	0.29	0.25	2.60	2.80	5.91	1.00	6.94	85.59	clay loam

Key: OM = Organic Matter, EA = Exchangeable Acidity, CEC = Cation Exchangeable Capacity, BS = Base Saturation, EB = Exchangeable Base, OC = Organic Carbon

Table 4: Status of Soil Degradation of selected soils of Ogbadibo in 2019:

Locations	Depth (cm)	OM (%)	N (%)	Phosphorus(%)	Base Saturation(%)
Orokam	0-15	VHD	MD	VHD	VHD
(Olukam)	15-30	VHD	MD	VHD	VHD
	30-45	VHD	MD	VHD	VHD
Ipole	0-15	VHD	MD	VHD	VHD
Owukpa	15-30	VHD	MD	VHD	VHD
	30-45	VHD	MD	VHD	VHD
Uleke	0-15	VHD	MD	VHD	VHD
	15-30	VHD	MD	VHD	VHD
	30-45	VHD	MD	VHD	VHD
Ibagba	0-15	VHD	MD	VHD	VHD
	15-30	VHD	MD	VHD	VHD
	30-45	VHD	MD	VHD	VHD
Itabono	0-15	VHD	MD	VHD	VHD
(Amala)	15-30	VHD	MD	VHD	VHD
	30-45	VHD	MD	VHD	VHD

Key: VHD = Very Highly Degraded, MD = Moderately Degraded.

Table 5: Status Chemical Analytical Parameters of the Soils of Ogbadibo in 2019

Location	Depth (cm)	pH	N (%)	P (%)	OM (%)	K	Na	Ca	Mg	CEC
						(Cmol/kg)				
Orokam	0-15	N	L	L	VL	L	L	L	M	L
(Olukam)	15-30	N	VL	L	VL	L	L	L	M	L
	30-45	MA	VL	L	VL	L	L	L	M	L
Ipole	0-15	N	L	L	VL	L	L	L	M	L
Owukpa	15-30	N	VL	L	VL	L	L	L	M	L
	30-45	VSA	VL	L	VL	L	L	L	M	L
Uleke	0-15	N	VL	L	VL	L	L	L	M	L
	15-30	N	VL	L	VL	L	L	L	M	L
	30-45	N	VL	L	VL	L	L	L	M	L
Ibagba	0-15	N	VL	L	VL	L	L	L	M	L
	15-30	SA	VL	L	VL	L	L	L	M	L
	30-45	SA	VL	L	VL	L	L	L	M	L
Itabono	0-15	SA	L	L	VL	L	L	L	M	L
(Amala)	15-30	SA	VL	L	VL	L	L	L	M	L
	30-45	STA	VL	L	VL	L	L	L	M	L

Key: N = Neutral, MA = Moderately Acidic, VSA = Very Slightly Acidic, SA = Slightly Acidic, Strongly Acidic, L= Low, VL = Very Low, M = Moderate.

Discussion

The status of degradation of soils of Ogbadibo revealed that with regards to organic matter, the soils were very Highly Degraded at all the depth and communities studied (Orokam, Ipole-Owukpa, Uleke, Ibaga and Itabono (Amala). Osemsota et al., (2017). also got a very highly degraded soil status in their studies at Ekpoma, Edo State. Oso et al. (2012). in their study of degradation of wetland soil in Ado-Ekiti had organic matter degradation status raging from Slightly Degraded to Highly Degraded Nitrogen was moderately degraded in the soils. Nwite et al. (2012). at Abakaliki Southeast Nigeria obtained a soil test value equivalent of non to slightly degraded to moderately degraded in an acid Ultisol.

Phosphorus and base saturation of some soils were very Highly Degraded which could be due to the low organic matter levels. Ekwue (1990) stated that organic matter is key factor influencing soil stability because it influences soil physical and chemical properties directly. This also agreed with Aruleba (2004) who observed that more than 50% of Nigeria soils are moderately to highly degraded with respect to both phosphorus and base saturation.

Organic matter is actually a very strong indicator of the status of soil fertility. The organic matter of the soils was very low. Ibrahim and Idoga (2013) had similar result at the Teaching and Research Farm of the University of Agriculture Makurdi. They asserted that declining soil organic matter could lead to high level of soil degradation. The low organic matter content according to Harpstead (1973) is a phenomenon associated with Savanna soils which could be as a result of high temperature that rapidly breaks down organic carbon and inhibit nitrogen fixation of rhizo bacteria as a result of vegetative cover depletion and direct solar radiation on the bare soils.

The status of nitrogen in the soils ranged from very low to low. Agbede (2009) confirmed in his work that nitrogen is among the 16 essential plant elements needed for good plant growth and reproduction but because of its volatile nature, it is usually low in most savanna soils.

Phosphorus in the soils was low across all depths and locations. Agber et al., (2017) in their work on assessment of the status of soil degradation in otukpo had similar result. This can be linked to the low status of soil organic matter in the location.
The content of the exchangeable cations ranged from low to moderate while the cation exchange capacity was also low across all depth and locations of the soils. Lombin et al. (1991). reported in his work that organic matter was a major contributor to the cation exchange capacity which implies that low organic matter will give rise to low cation exchange capacity. Akubo (2016) obtained low exchangeable cations at both Karu and Makurdi in his work. Agboola (1975) in his study says that farmers in Africa require adequate soil amendation for good crop production as a result of low inherent soil fertility.

Conclusion

From the result of the study, the degradation status of the soil exhibited a very wide variation ranging from moderately degraded to very highly degraded. It can be concluded that the soils of Ogbadibo have low fertility status.

Recommendations

Based on the result and findings of the study, the following recommendations are made

- That green manure be used to improve soil fertility
- Organic matters should be used to improve the organic matter content and the productivity of degraded soils.
- Application of mineral (chemical) fertilizer is very necessary so as to follow up the organic manure; hence it quickly improves N, P and K as well as cation exchange capacity.

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