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DETERMINATION OF SOIL QUALITY IN A TROPICAL ECOSYSTEM OF ODUKPANI LOCAL GOVERNMENT AREA IN CROSS RIVER STATE.

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ABSTRACT

Soil quality of Odukpani wetland was studied with the aim of classifying the wetland soil in Odukpani LGA in terms of quality, sustainability and fertility indexes. Twenty soils samples were gotten from the surface. The soil was sampled using grid geo-systematic sampling technique. The soil samples were analyzed for the routine physicochemical properties. The results showed that mean composition of sand, silt and clay were 64.65, 15.45 and 19.9 % respectively. The mean composition of organic carbon was 1.85 %, 4.71 for pH, 0.151 % for total Nitrogen, 59.9 mg/kg for available phosphorus. Bulk density ranged from 1.21 to 1.65 g/cm^3 with a mean value of 1.45 g/cm3 while ECEC, Base saturation and SAR had mean values of 8.31 cmol/kg, 48.58 % and 0.047 respectively. The sustainability of the soil was evaluated; the result showed that the soil with index of 26 is sustainable with high input. The result was further evaluated using a modified version of Rattan Lal's Soil Quality Index (SQI) model which is the function of the key indicators. The SQI was equal to 26 showing that the soil is sustainable with high input in Rattan Lal's sustainability classification using SQI. The two models used have proved that the soil is equally sustainable with high input. The study showed that the sustainability status of Mkpara otop wet land was not limited to crop even though some nutrients contents were low and moderate. The soil can be put into good use if there is proper management.

Keywords: Soil Quality, Tropical Ecosystem, Odukpani.

INTRODUCTION

Soil quality is defined as the capability of a soil to function within natural or managed ecosystem boundaries to sustain plants and animal productivity, maintain or enhance water and air quality and support human health and habitation (Anikwe, 2006). Soil quality determination focuses on the dynamic or management affected properties of soil such as nutrient status, salinity and water holding capacity. These properties are assessed in the context of the inherent capability of a particular soil (Doran *et al.*, 1994). Evaluating soil quality include used of soil health card, laboratory analysis and interpretation of the values, use of models in which the values can be fitted to identify the actual quality levels.

Wetland is defined as an area of marsh, fen wetland or water whether natural or artificial, permanent or temporary with water that is static or flowing , fresh, blackish or salt including areas of marine water, the depth of which at low tides does not exceed 6 meters (Coughanowr, 1998). The water logged soil is also known as hydric soils and are low in oxygen which limit plant ability to carry out aerobic root respiration and modify the availability of nutrient. Since the people of Mkpara otop in Odukpani LGA have been utilizing the wetland there is need to assess the quality of the wetlands to scientifically determine what use the land can best be put to. The objectives of the research involves: to determine the physical and chemical properties of soil in this area; determine the soil

quality; and to classify the wetland soils in terms of quality, sustainability and fertility indexes.

MATERIALS AND METHODS

STUDY AREA

The study was carried out at Mkpra otop in Odukpani LGA of Cross River State, Nigeria. Odukpani LGA is in the Atlantic coastal zone of the South Eastern part of Nigeria. It is bounded in the North by Akamkpa LGA, East by Calabar Municipality Government, West by Okurikang LGA and in the South by the Gulf of Guinea of Atlantic Ocean. It is located between longitude 05 ^{0} 10′ 36 N -05 ^{0} 10′ 42 N north of the equator and latitude 05 ^{0} 10′ 42 E - 05 ^{0} 10′ 36 E East of the meridian and altitude 20 m above sea level. The mean annual total rainfall ranges from 2500-3000 mm of rainfall. The peak rainfall occur in June – July and September – November, the short drought period last for 1 – 2 weeks between August break and experiences dry months beginning from December-February. Geo-systematic sampling method was employed in the sampling by following the North to South and East to West transects. A distance of 20 m was measured apart from the first point to the last point and samples were just collected at one depth (0 – 20 cm) making a total of 20 samples. Particle size distribution was determined by Bouyocous hydrometer method (Udo *et al.*, 2009). The soil texture was determined from percent sand, silt and clay using USDA textural triangle. Soil bulk density was determined using the core method (Blake and Hartge, 1986).

Soil total porosity was calculated from the relationship.

$$\% F = (1 - Bd / Pd) \times 100$$

Where F = Porosity

Bd = bulk density g/cm^3

Pd = particle density of the soil estimated at 2.65 g/cm^3

The pH was determined with a pH meter in a 1:2.5 soil: water suspension using a glass-electrode. Total N was determined by Micro-Kjeldahl method (Black, 1965) as modified by Jackson (1989). Available phosphorus was extracted with acidic fluoride using the Bray P 1 method (Bray and Kurtz, 1945), Exchangeable bases (K, Ca, Mg and Na) was extracted with IN NH_4OAc. Potassium and sodium in the filtrate was determined by flame photometer, while calcium and magnesium was determined with an atomic absorption spectrophotometer. The Effective cation exchange capacity was determined by the summation of exchangeable bases and exchangeable acidity. Exchangeable acidity was determined by the successive leaching of the soil with neutral un-buffered IN KCl. The amount of acidity (H and Al) in the leachate was estimated by titration with 0.05 N NaOH (Maclean, 1982). The sum of the exchangeable bases and exchangeable acidity was taken as the effective cation exchange capacity (ECEC). Organic carbon was determined by the dichromate wet oxidation method of Walkley and Black (1934). The result was multiplied by Broadbent's factor of 1.724 (Page *et al.,* 1982) to estimate the soil organic matter content. Evaluation technique: the soils were evaluated using the sustainability index model developed by Lal (1994) where the SQI is a function of soil organic carbon, cation exchange, pH, water content and water stable aggregates.

$SQ = \int 2 \sum$ (SOC, CEC, pH, WC, WSA).

Where: WC = water content

WA= water stable aggregates

RESULTS AND DISCUSSION

Particle size distribution had clay, silt, and sand with means of 19.9 %, 15.45 % and 64.65 % respectively and the texture varies from loamy sand to sandy clay loam. Mean of bulk density was 1.45 g/cm^3 and this is an ideal bulk density for loamy sand and sandy clay loam (Arshad *et al*, 1996). The colour code falls between 10 YR 3/2 to 10 YR 5/4 with very dark grayish brown to yellowish brown colour using the munsel colour chart. The pH values obtained in the soil varies between 4.6 – 4.9, this indicates strongly acidity in the soil. According to Schoeneberger *et al.* (2002), pH less than 5.0 does not support some arable crop production and so in respect to this work. These soils could be lime to reduce the level of acidity in the soil. Organic carbon had mean of 1.85 %, total nitrogen with mean of 0.15 % indicates low level of total nitrogen in the soil (Enwezor *et al*., 1989) while some soils had total N higher than 0.15 %. Available phosphorus mean of 59.90mg/kg indicates that available p was high because it was greater than 20 mg/kg (FMA & NR, 1990). Exchangeable Ca^{2+}, K^+, Na^+ were generally low with mean values of 2.25 cmol/kg^{-1}, 0.92 cmol/kg^{-1} and 0.063 cmol/kg^{-1} respectively, while exchangeable magnesium ranged from low to moderate in the soil (0.4 – 2.2). Exchangeable bases were generally low in the soil. Exchangeable acidity (Al^{3+} and H^+) had means of 3.036 cmol/kg and 1.524 cmol/kg^{-1} respectively; this shows that exchangeable acidity was high in the soil. Effective cation exchange capacity varies from 5.93 - 24.66 cmol/kg shows that limitations range from none to severe limitation for sustainability (Lal, 1994).

SUSTAINABILITY OF THE SOILS IN ODUKPANI WETLAND The sustainability of the soils of Odukpani wetland was evaluated by selecting ten physicochemical properties from the Table 1 below:

Table 1: Physical properties of surface soil of Odukpani wetland.

Location	Clay (%)	Silt (%)	Sand (%)	Tex. class	Bulk density	Total porosity	Depth (cm)	Colour code	Colour name
N1	6	7.4	86.6	LS	0.68	45.0	0 – 20	10 YR 4/3	Brown
N2	0	27.4	72.6	LS	0.69	46.0	0 – 20	10 YR 4/4	Dark yellowish brown
N3	22	7.4	70.6	SCL	0.67	40.0	0 – 20	10 YR 4/4	Dark yellowish brown
N4	26	3.4	70.6	SCL	0.63	46.8	0 – 20	10 YR 4/4	Dark yellowish brown
N5	6	21.4	72.6	SCL	0.57	59.2	0 – 20	10 YR 4/4	Dark yellowish brown
S1	26	13.4	60.6	SCL	1.04	44.0	0 – 20	10 YR 3/2	Very dark grayish brown
S2	22	5.4	72.6	SCL	0.62	38.0	0 – 20	10 YR 4/2	Dark yellowish brown
S3	0	49.4	50.6	SCL	0.77	38.0	0 – 20	10 YR 5/4	Yellowish brown
S4	22	15.4	62.6	SCL	0.65	48.0	0 – 20	10 YR 4/4	Dark yellowish brown
S5	26	21.4	52.6	SCL	0.76	49.0	0 – 20	10 YR 4/4	Dark yellowish brown
E1	26	13.4	60.6	SCL	0.74	48.0	0 – 20	10 YR 4/4	Dark yellowish brown
E2	22	11.4	66.6	SCL	0.72	54.0	0 – 20	10 YR 4/4	Dark yellowish brown
E3	23	9.4	67.6	SCL	0.75	54.0	0 – 20	10 YR 4/3	Brown
E4	20	15.4	64.6	SCL	0.72	43.0	0 – 20	10 YR 4/4	Dark yellowish brown
E5	23	18.4	58.6	SCL	0.74	52.0	0 – 20	10 YR 4/4	Dark yellowish brown
W1	24	21.4	54.6	SCL	0.65	44.0	0 – 20	10 YR 5/4	Dark yellowish brown
W2	6	15.4	58.6	SCL	0.23	38.0	0 – 20	10 YR 4/3	Brown
W3	26	9.4	64.6	SCL	0.67	38.0	0 – 20	10 YR 4/4	Dark yellowish brown
W4	26	9.4	64.6	SCL	0.79	48.0	0 – 20	10 YR 4/3	Brown
W5	26	13.4	60.6	SCL	0.61	51.0	0 – 20	10 YR 5/4	Dark yellowish brown
Minimum	0	3.4	50.6			38.0			
Maximum	26	49.4	86.6			59.2			
Mean	19.9	15.4	64.65			46.5			
Cv (%)	45.08	65.18	12.75			1.30			
S.D	8.97	10.07	8.24			6.04			

Table 2: Chemical properties of surface soil of Odukpani wetland.

Location	pH	O.C(%)	TN(%)	Avail. P(mg/kg)	Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	Al^{3+}	H^{+}	ECEC	BS(%)	SAR	O.M g/kg
					Cmol/kg									
N1	4.7	1.54	0.13	19.5	1.6	1.6	0.07	0.05	6.24	-1.92	7.64	43.46	0.040	2.66
N2	4.7	2.50	0.21	28.25	2.6	2.2	0.10	0.07	2.08	1.04	8.09	61.43	0.045	4.32
N3	4.8	1.82	0.15	34.75	2.0	1.4	0.10	0.08	1.30	0.06	4.94	72.47	0.062	3.15
N4	4.7	2.07	0.17	35.50	3.2	0.6	0.09	0.06	3.20	0.48	7.63	51.77	0.043	3.58
N5	4.6	1.54	0.12	25.75	2.4	0.4	0.09	0.08	3.44	0.40	6.81	43.61	0.068	2.66
S1	4.8	0.78	0.05	27.30	1.6	2.2	0.09	0.06	2.40	0.64	6.99	56.51	0.044	1.35
S2	4.7	0.64	0.05	390.00	2.0	1.0	0.08	0.05	2.60	0.72	6.45	48.53	0.041	1.12
S3	4.7	1.72	0.14	29.75	2.0	0.6	0.08	0.05	2.90	0.46	6.09	44.83	0.044	2.97
S4	4.7	2.07	0.17	51.00	1.4	2.4	0.08	0.05	3.28	1.44	8.65	45.43	0.036	3.58
S5	4.9	2.87	0.24	20.25	2.4	1.6	0.09	0.06	2.80	0.64	7.59	54.68	0.042	4.96
E1	4.7	2.30	0.17	50.25	2.4	1.6	0.11	0.08	3.36	0.48	8.03	52.18	0.057	3.51
E2	4.7	1.94	0.09	68.00	2.8	2.2	0.12	0.09	2.24	1.84	9.29	56.08	0.057	3.35
E3	4.7	2.55	0.22	27.75	3.2	1.2	0.12	0.08	2.56	0.88	8.04	57.21	0.054	4.41
E4	4.5	2.11	0.18	71.68	1.8	1.8	0.08	0.05	2.48	0.56	6.77	55.10	0.037	3.65
E5	4.7	2.11	0.17	64.25	3.4	1.0	0.05	0.06	2.24	17.84	24.66	18.57	0.040	3.65
W1	4.6	1.40	0.12	62.75	2.6	0.6	0.06	0.06	3.76	0.48	7.59	44.14	0.047	2.42
W2	4.7	2.07	0.18	53.30	2.0	1.0	0.06	0.06	3.60	0.64	7.38	42.55	0.049	3.58
W3	4.7	1.76	0.15	49.75	2.4	1.2	0.06	0.07	3.36	2.08	9.21	40.93	0.052	3.04
W4	4.8	1.76	0.16	67.00	2.0	0.6	0.07	0.05	3.52	2.08	8.32	32.69	0.035	3.04
W5	4.8	1.76	0.15	20.75	1.2	1.6	0.08	0.05	3.36	-0.36	5.93	49.41	0.042	3.04
Minimum	4.6	0.64	0.05	19.5	1.2	0.4	0.07	0.05	1.30	-0.36	5.93	18.57	0.035	1.12
Maximum	4.9	2.87	0.24	390.0	3.4	2.2	0.12	0.09	6.24	17.84	24.66	49.41	0.068	4.96
Mean	4.71	1.85	0.151	59.9	2.25	1.34	0.92	0.063	3.04	1.524	8.31	48.58	0.047	3.202
CV(%)	1.8	28.65	3.25	133.06	26.89	46.19	1.74	20.63	32.28	258.53	48.13	23.02	19.15	28.51
S.D	0.085	0.53	0.049	79.7	0.61	0.62	0.016	0.013	0.98	3.94	4.00	11.18	0.009	0.91

O.C= ORGANIC CARBON T.N= TOTAL NITROGEN, BS = BASE SATURATION, O.M = ORGANIC MATTER

AVAIL.P = AVAILABLE PHOSPHORUS ECEC = EFFECTIVE CATION EXCHANGE CAPACITY, SAR = SODIUM ADSORPTION RATIO.

Table 3: Critical level of physicochemical indicator of the Odukpani wetland soil.

Soil indicators	Weighing factor	Limitation
Total porosity	1	None
Texture	3	Moderate
Sodium adsorption ratio	1	None
Soil pH	5	Extreme
Total Nitrogen	3	Moderate
Available Phosphorus	1	None
Exchange potassium	1	None
ECEC	4	Severe
Organic carbon	3	Moderate
Base saturation	4	Severe
Cumulative rating index	26	

From Table 3 the Cumulative rating index of the surface sample (0-20 cm) is 26 comparing this to sustainability of the land use in relation to the Cumulative rating index falls within the range of 25 – 30 which shows that the soil is sustainable with high input.

TABLE 4: Sustainability of the land use in relation to cumulative rating index

	CUMULATIVE RATING INDEX
Highly sustainable	< 20
Sustainable	20 – 25
Sustainable with high input	25 – 30
Sustainable with another land use	30 – 40
Unsustainable	> 40

SOIL QUALITY EVALUATION

The soil quality of Odukpani wetland was evaluated using the soil quality model developed by Lal (1994). Lal developed the soil quality index as a function of soil organic carbon (SOC), cation exchange capacity (CEC), pH, water content (WC) and water stable aggregates. Thus, the model is presented as SQ= ∫ 2 ∑ (SOC, CEC, pH, texture, total porosity) modifying the model would entail replacing WSA, CEC WC with SAR, texture and particle density. The modified equation becomes, SQ= ∫ (SOC, pH, SAR, texture and total porosity). The weighing factor for each indicator according to Lal (1994) is as follows; SOC = 3, pH = 5, SAR = 1, texture = 3 and total porosity = 1. Therefore, SQ= ∫ (2 ∑ (SOC, CEC, pH, texture, total porosity)**.** SQ =2 (3+5+1+3+1) = 2(13) =26. Thus, Odukpani wetland soils could be said to be sustainable with high input according to Lal (1994) sustainability classification which group soil with cumulative rating index (CRI) below 20 as highly sustainable, CRI 20 - 25 as sustainable while soils with CRI > 40 can be sustainable.

SUMMARY AND RECOMMENDATION

The study showed that the sustainability status of Odukpani wetland was not limited to crop even though some nutrients content were low and moderate. The soil can support the growth of many crops like *Telfairia occidentalis* (pumpkin), maize, cocoyam, waterleaves etc. Therefore the wetland soil of Odukpani LGA can be put into good use if there is proper management for crop production. Management practices such as liming should be added to the present activities so that it could boost the soil pH, ECEC, base saturation of the wetland. This could elicit higher productivity of the wetland.

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