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Effects of land-use types on soil quality indices in ughoton community in Ovia north-east local government area, Edo state, Nigeria

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Abstract
The present study was conducted to examine the effects of different land-use types on soil quality indices. Surface soils were collected at 0-15 cm and 15-30 cm depth respectively from three land-use types: Cassava field, Oil palm, and Banana plantation. Samples were subjected to physical, chemical, and microbiological analyses using standard methods, and the result were subjected to descriptive statics. The extent of change in soil quality was assessed using soil quality indices as an index for soil fertility management. The result showed that oil palm plantation was highest in soil quality evaluated as compared to Banana and Cassava field. The fertility differences observed across the land use types were due to inherent soil properties such that farming practices that ensure accumulation of organic matter need to be encouraged in order to improve soil productivity. It is recommended that soil fertility management should be site-specific to enhance optimum yield and productivity.

Keywords: Land-use type, soil quality, indices, ughoton community, Ovia north-east

Introduction

Soil is a fundamental resource base for agricultural production systems. Besides being the main medium for crop growth, soil functions to sustain crop productivity, among other functions and soil quality describe the soil's ability to perform these critical functions (Doran and Zeiss, 2000). It has biological, physical and chemical properties, which are both inherent and dynamic and can change as a result of some natural processes and in response to use. Soil structure can be affected by the intensity of land use and this has an effect on the distribution of microbial biomass as well as microbial processes within the aggregates (Gupta and Germida, 1988) [12]. Changes in soil physical and chemical properties of soils of similar lithological and climatic origin can be ascribed to differences in soil management, and this affects soil quality (Brady and Weil, 2002) [6]. The rate of soil quality degradation depends on land use systems, soil types, topography, and climatic conditions. Among these factors, inappropriate land use aggravates the degradation of soil physicochemical and biological properties (He *et al*., 1999). Land-use change also affects biotic diversity and the ability of natural systems to support human needs. In other words, such changes influence earth system functioning (Lambin, *et al*., 2003) [14]. Land use practices had earlier been reported to affect soil properties (Asadu and Enete, 1997) [3]. The success in soil management to maintain soil quality depends on an understanding of how the soil responds to use and management over time. For this reason, recent interest in soil quality assessment has been stimulated by increasing awareness of the critical functions of the soil in the production of food and fiber, maintenance of environmental quality (Doran and Parkin, 1994) [8]. On the other hand, feeding the increasing human population is most challenging, especially in a developing country like Nigeria of over 140million people (National population census, 2006). Reversing these trends lies in the enhancement of the agricultural sector. Thus, the knowledge about land use and land cover has become increasingly important in ameliorating and improving the quality of degraded soils. Adequate studies of the soils in the various land use types will help generate the information necessary for proper land use planning. Multiple studies have been conducted to assess the effects of land-use changes on soil physical and chemical properties in Nigeria (Adeyolanu *et al.*, 2015, Ndukwu *et al.*,2010, Ande *et al.*, 2009, Awotoye *et al.*, 2011) [4].

However, assessing the effects of different land uses with respect to soil quality indices and how these changes affect soil fertility, and nutrient management has not been given adequate attention. Therefore, this research was initiated to assess the effects of different land-use types (Cassava field, Oil palm plantation, and Banana plantation) on soil quality indices and microbial diversity as a means of ascertaining the fertility status of soils in Ughoton community in Ovia North East Local Government Area of Edo state Nigeria.

Materials and methods

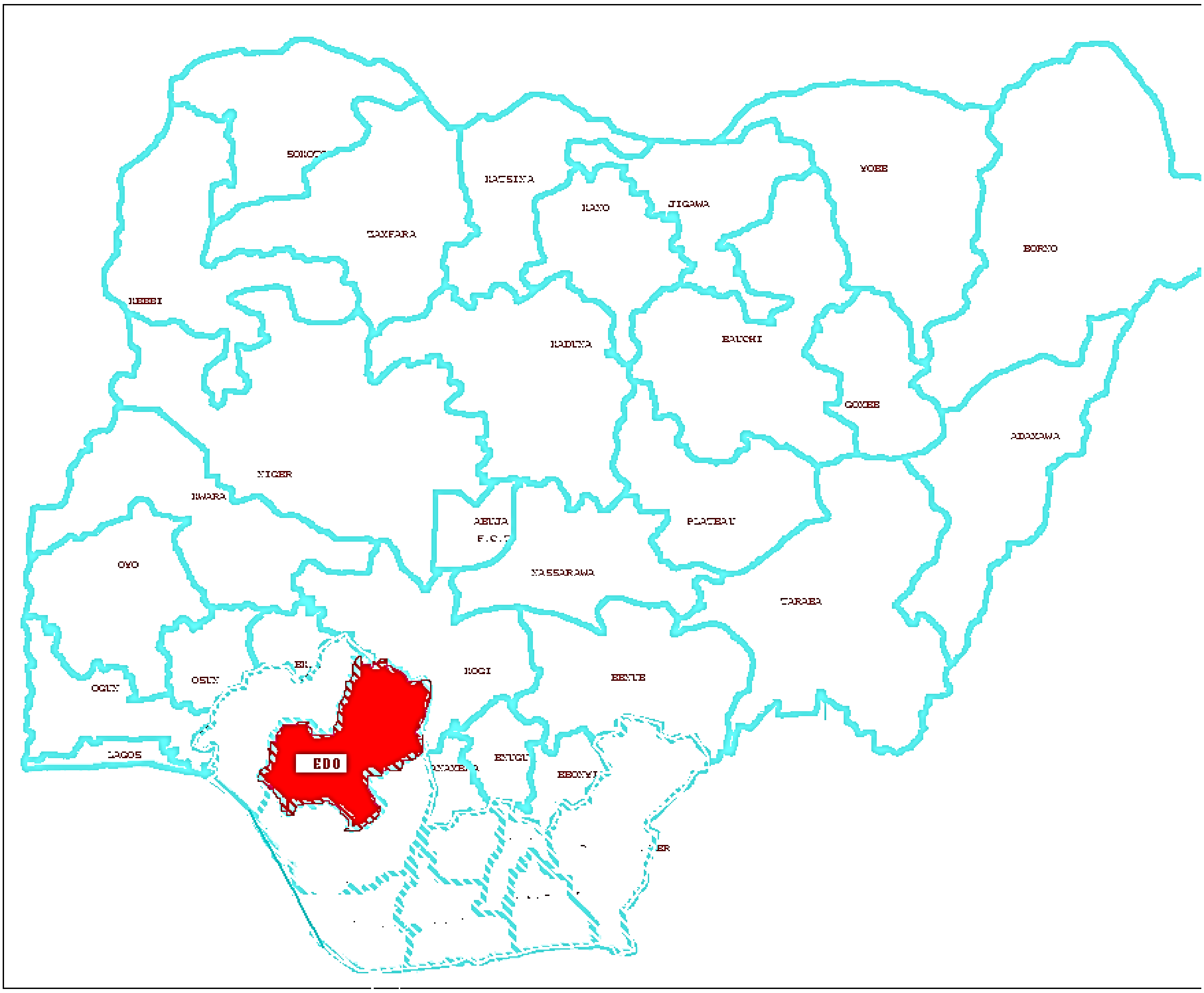

Fig 1.1: Map of Nigeria showing Edo State

Description of the study area

The study was conducted at Ughoton community in Ovia North East Local Government Area of Edo State, South-south Nigeria under three land uses (Cassava field, Oil palm, and Banana plantation). The study location lies between Latitude 6.12-6.25^{0}N and Longitude 5.26-5.63^{0}S with an altitude of 149.4 mASL. The climate of the study sites can be described as the rain forest zone with distinct dry and wet seasons. The dry season runs from early November to the end of March or early April, while the rainy season is from March to November. There are two rainfall peaks in June and September with dry spell in August (August break), which produces the bimodal rainfall pattern in south southern Nigeria. Rainfall ranges from 1500 mm to 2135 mm. The average minimum and maximum temperature during the period of research ranged from (27.2 ^{0}C and 30.1 ^{0}C) over time (NIMET Benin) relative humidity with a mean monthly relative humidity of between (80.5% and 85%) at 9:00 hours.

Vegetation and land use

The study area is dominated by agricultural farmlands, which account for 85% of the vegetation cover. Land use in the entire area comprises farmlands used for the cultivation of food crops, mainly Cassava, which is often cultivated along with maize in a mixed cropping system, Banana, and oil palm plantation. These are mainly subsistence agriculture. There were a few infrastructures for residential and commercial use outside of the farming occupation of the people in the study area.

Soil sampling

Three land uses were chosen for the study; Cassava field, Oil palm, and Banana plantation. This was done to ensure that the study covered the extensive land-use variations in the study area. In each of the land use, five sampling points were located, and soil samples were collected at 0-15 cm and 15-30 cm depth, respectively. The samples were taken for laboratory analysis of the selected soil quality indices.

Laboratory analysis

In the laboratory, the soils were dried at ambient temperature (22-25 ^{0}C), crushed in a porcelain mortar and sieved through a 2 mm (10 mesh) stainless sieve. The air-dried less than 2 mm soils were stored in polyethylene bags for subsequent analysis. The less than 2 mm fraction was used for the determination of selected soil physic-chemical properties. Particle size distribution (sand, silt, and clay) was determined by hydrometer method (Gee and Or, 2002) [10]. Soil pH was measured using 1:2 soil water ratio (Gruhn *et al.*, 2000) [11]. Organic matter was determined by wet oxidation method. (Idigbor *et al*., 2008) [13]. Available P was estimated by Bray–P II method (Olson and Sommers, 1982) [17]. Total Nitrogen was determined by Kjeldah digestion method. (Ndukwu *et al.*, 2009) [15]. Soil exchangeable bases were determined by the neutral ammonium acetate procedure, the K and Na were measured using the flame photometer while Mg and Ca were determined using Atomic Absorption Spectrophotometer perkin Elmer 370 (Model). The cation exchange capacity (CEC) was the summation of the exchangeable bases.

Isolation of bacteria and fungi from soil sample

Microbial parameter includes THB, THF, HUB, and HUF. Tenfold serial dilution procedures were used to get appropriate dilution of the sample. Aliquots (0.1 ml) of the proper dilution of the samples were spread plated onto petri dishes of nutrient agar and potato dextrose agar for enumeration of THB and THF respectively, (Chikere *et al.*, 2009, Orji, 2011) [7, 18]. Inoculated plates were incubated at 28 ºC for 24hours. HUB and HUF of the samples were enumerated on modified Mineral Salt Agar (MSA) using vapour phase transfer method and incubated at 28ºC for 3 to 5 days/1ml of lactic acid was added to the fungal media to inhibit the growth of bacteria (Obire *et al*., 2008) [16]. Discrete bacterial and fungal colonies were further purified by SUB culturing on nutrient agar and malt extract agar, respectively. Pure isolates were identified morphologically, biochemically, macroscopically, and microscopically.

Soil quality indices

Assessment of soil quality involves evaluating numerous properties proposed by Dora and Parkin (1996) [9] for soil quality measurement. But for the purpose of this study the following properties were selected: texture, particle size distribution, soil pH, depth of soil, soil organic matter, microbial biomass, Available phosphorus, total nitrogen, exchangeable bases and cation exchange capacity (CEC).

Results and discussions

Physico-Chemical properties of the soil as influenced by different land use.

Particle size distribution of the soils under different land-use types are shown in (Table 1). The textural classes of the soils ranged from sandy loam to clay loam across the three-land use. The high content of sand ranged from 89.8 to 90.7 g/kg and 89.1 to 90.4 g/kg at 0-15 cm and 15-30 cm depth, respectively. It was observed that high content of sand was recorded in Cassava field followed by oil palm and banana plantation at 0-15 cm depth, whereas in the 15-30 cm depth clay was found to be higher in cassava field followed by Banana and oil palm plantation and increased with depth. The soil texture of the different land-use types at 0-15 cm depth were found to be the same except for that of Banana plantation (15-30 cm depth), which was Clay loam. This suggests that the different land-use types did not have effects on the soil texture in the study area since texture is the inherent soil property that could not be influenced in short period of time. The soils of the study area were slightly acidic to strongly acidic ranging from (4.50 to 5.10 to 4.60 to 4.90) at 0-15 cm depth and 15-30 cm depth across the different land use evaluated, The mean pH in cassava field was found to be highest 4.95 as compared to Oil palm and Banana plantation at both sampling depth (Table 2). However, the pH recorded was within the desirable range for plant nutrient availability (Brandy and Weil, (2002) [6]. The Available P had a mean of 5.66 mg/kg at 0-15 cm depth and 15-30 cm depth, respectively. These values were moderately high at 0-15 cm depth than that of 15-30 cm depth (Table 2). The organic carbon content of the soils observed in the study area was low with mean value of 0.92 g/kg at both sampling points (Table 2). However, these values were relatively high in oil palm at (0-15 cm) and banana plantation (15-30 cm) depth as compared to Cassava field. This result agrees with the findings of Negassa (2001) [18] and Malo *et al.* (2005), who reported less organic carbon in the cultivated soils than uncultivated soils. Similarly, the depletion of organic carbon as a result of intensive cultivation in Cassava field had, therefore, reduced the CEC of the soils as earlier reported by Boke (2004) and Negassa (2001) [18].

Table 1: Some Physical properties of the soils at 0-15 cm and 15-30 cm depth under different land-use.

Soil properties	Land-use type (0-15) cm			Land-use type (15-30) cm		
	Cassava field	Oil palm plantation	Banana Plantation	Cassava Field	Oil palm plantation	Banana plantation
Sand %	90.7	91.6	89.8	90.3	90.4	89.1
Silt %	2.4	2.5	3.2	2.6	2.8	3.6
Clay %	7.3	6.6	6.9 6.9	7.0	6.4	7.5
Texture	LS	LS	LS	LS	LS	CL

Table 2: Mean values of soil quality indicator under different land-use types.

Indicator	Cassava field		Mean	Oil palm plantation		Mean	Banana plantation		Mean
Depth (cm)	0-15	15-30	---	0-15	15-30	---	0-15	15-30	---
pH (H_20)	5.10	4.80	4.95	4.50	4.90	4.70	5.00	4.80	4.90
O.C (g/kg)	1.25	0.58	0.92	1.32	0.89	1.11	1.13	1.06	1.10
Total N	1.10	0.50	0.80	1.14	0.90	1.02	1.12	1.01	1.07
Av. P (mg/kg) Av. P.mg/k	7.24	4.08	5.66	10.2	8.72	9.46	6.84	6.66	6.75
Ca^{2+}	2.28	1.59	1.94	2.60	1.15	1.88	2.75	2.44	2.60
Mg^{2+}	0.75	0.70	0.73	0.32	0.42	0.37	0.75	0.86	0.81

Na^{2+}	1.10	0.92	1.01	1.34	1.03	1.19	1.12	1.20	1.16
K^{+}	2.10	1.60	1.85	1.31	1.60	1.46	1.40	1.00	1.20
CEC	4.29	3.42	3.86	4.39	2.79	3.59	4.75	4.40	4.58
Texture	LS	LS		LS	LS		CL	CL	

Table 3: Distribution of micro-organisms in the soils at 0-15cm and 15-30cm depth under different land use

Land use type	Depth (cm)	THB 10^5cfu/g	HUB 10^3cfu/g	BD %	THF 10^5cfu/g	Most predominant bacteria isolate	HUF 10^3cfu/g	FD %	Most predominant fungal isolates
Cassava and maize	0 – 15	10.1	1.0	0.01	3.7	Bacillus spp, Micrococcus	0.0	0.0	Aspergillius spp., Penicilliumspp
	15 - 30	5.3	0.0	0.0	2.8	Micrococcus spp, Bacillus spp.	0.0	0.0	Aspergillius spp., Penicilliumspp
Oil palm plantation	0 – 15	10.5	1.0	0.0	5.7	Bacillus spp.,	0.0	0.0	Aspergillius spp.
	15 – 30	6.1	0.0	0.1	3.7	Bacillus spp., Enterobacter, Acrogenes	0.0	0.0	Aspergillius spp., Penicilliumspp
Banana plantation	0 – 15	5.2	0.0	0.0	3.0	Bacillus spp., Micrococcus spp.	0.0	0.0	Trichoderma spp. Aspergillius spp.
	15 - 30	4.7	0.0	0.0	2.5	Bacillus spp., Micrococcus spp.	0.0	0.0	Aspergillius spp., Penicilliumspp

Key:
THB = Total heterotrophic bacteria count
THF = Total heterotrophic fungi count
HUB=Total heterotrophic utilizable bacteria
HUF = Total heterotrophic utilizable fungi
% BD = Bacteria Degrader
% FD = Fungi Degrader

The soil N content ranged from 1.00 to 1.20 g/kg and 0.50 to 1.00 g/kg with mean value of (0.80) at 0-15 cm and 15-30 cm, respectively. These values were found to be higher in oil palm and banana plantation as compared to Cassava field. This could be related to the high organic matter content usually found on the top soil. The values of exchangeable bases (Na^+, Ca,$^{2+}$ Mg^{2+} K^+) were relatively low with mean values ranging from 0.74-1.94 cmol/kg across the land-use types evaluated, and these values showed a decreasing trend at 15-30 cm depth. The low values of exchangeable basses observed in Cassava field could be due to the effects of continuous cultivation, leaching or soil erosion and crop removal as was earlier observed by Negassa (2001) [18]. The CEC of the soils in the study area were low with mean of 3.86 cmol/kg. The low values of CEC observed in the study area supported conclusion by Amakhian and Osemwota (2012) [2] who reported low values of CEC in soils of southern guinea savanna zone of Nigeria. The low CEC coupled with low organic matter are indications of low inherent soil fertility status, which increases the need for improved soil management techniques.

Soil microbial density under different Land use

The total heterotrophic bacteria and fungi count distribution are shown in Table 2. It was observed that the total heterotrophic bacteria (THB) population ranged from 4.7 to 10.5 x10^5cfu/g in all the land use types. And total heterotrophic fungi (THF) count varied between 2.5 to 5.7x10^5 cfu/g. and were high in Oil palm plantation at both depths, (Table 2) as compared to Banana, and Cassava field. This corroborates findings by (Aislabie *et al.*, 2012) [1] who earlier reported that soil microbial abundance and diversity are highest in the top 0-15cm depth, and their population decreases with depth (Eilers *et al.*, 2012). The percentage of Bacteria Degrader (% BD) in the soil range from 0.01 to 0.1%. It was observed that the bacterial degraders were more than fungi degraders. This finding is consistent with reports by Anderson (2005) and Prescott (2008), who stated that soil micro-organisms are mainly decomposers of biodegradable wastes.

Conclusion

This study clearly shows that the soil fertility indicators include low to medium pH, total N, exchangeable K and available P. Organic matter, exchangeable bases and cation exchange capacity (CEC) were low such that farming practices that ensure accumulation of organic matter needs to be encouraged in order to ensure improved productivity. This study also reveals that the fertility differences across the land use are due to inherent soil properties. It is recommended that soil fertility management should be site-specific for optimum productivity.

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