Assessment of Soil Quality in Representative Pedons of the Sombreiro Warri Deltaic Plain of the Niger Delta, Nigeria

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ABSTRACT
Assessment of soil quality of the Ogba-Egbema area of the Sombreiro Warri Deltaic Plain was undertaken by morphological characterization and ranking of soil physical and chemical properties. A total of 80 genetic soil samples from 16 soil profiles and one hundred and twenty (120) random surface samples taken from farm plots along eight (8) transects in the area were studied. The ranking of the eight transects in a descending order was: Akabuka/Obite > Umuoru/Ndoni > Omoku/Egbegoro > Obagi/Ogbogu > Obiafu > Aggah/Egbema > Ebocha/Okwuzi > Omoku/Elele. From the results obtained the top three ranked transects: Akabuka/Obite, Umuoru/Ndoni and Omoku/Egbegoro were rated 59.0, 52.0 and 42.7% respectively of the various parameters qualifying for high fertility indices while the three transects with lowest quality (Aggah/Egbema, Ebocha/Okwuzi and Omoku/Elele) had only 28.8, 22.7 and 21.0% respectively of sample stations that qualified them for high soil quality status. Five soil properties: drainage, depth, total organic matter, soil colour and texture, were delineated as the minimum data set needed for soil quality determination in the area. Most of the fertility indices were below critical limits as expressed by low ECEC, low organic matter and low available P. However, the physical properties reflect deep and very productive setting. The pedons are deep and well drained without impermeable layers within the rooting zone. Four soil quality classes (SQ 1 –SQ 4) were delineated in the area with decreasing potentials and productivity in the order of: SQ1 > SQ2 > SQ3 > SQ4. Soils Quality classes 1 and 2 (SQ1 and SQ2) are suited for agricultural use, while soil quality classes 3 and 4 (SQ3 and SQ 4) have varying levels of limitations due to either poor nutrient status or because they are prone to flooding and erosion.

Key Words: *Soil Quality, Binomial Transformation, Critical Limit, ranking*

INTRODUCTION

Soil quality has been defined as the capacity of a specific kind of soil to function within natural or managed ecosystem boundaries to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation (Doran and Parkin 1994; Karlen *et al*., 1997). Gregorich *et al*. (1994) defined soil quality as a composite measure of both a soil's ability to function and how well it functions relative to a specific use or the degree of fitness of a soil for a specific use. The consensus opinion is that soil quality is the ability or capability of the soil to perform specific functions. The quality of a given soil is therefore dependent on place, purpose and time. Soil quality combines several aspects and variables of the soils and cannot easily be measured by any definite single property. This leaves soil scientists with measuring several properties that are known to be indicators of quality. According to the United States Department of Agriculture (USDA) soil quality indicators are classified into four categories that include visual, physical, chemical, and biological. Visual indicators can be obtained through field visits, perception of farmers, and local knowledge. The physical indicators are related to the organization of the particles and pores, reflecting effects on root growth, speed of plant emergence and water infiltration; they include depth, bulk density, porosity, aggregate stability, texture and compaction. Chemical indicators include pH, salinity, organic matter content, phosphorus availability, Cation Exchange Capacity (CEC), nutrient cycling, and the presence of contaminants such as heavy metals, organic compounds, radioactive substances, etc. These indicators determine the presence of soil-plant-related organisms, nutrient availability, water for plants and other organisms, and mobility of contaminants (Mairura *et al.* 2007). The assessment of soil quality requires quantification and qualification of critical soil attributes. The popular and growing view is that soil quality is a holistic concept, which recognizes soil as a system related to management and ecosystem dynamics and diversification using soil attributes (Swift, 1999; Karlen *et al*. 2001; Sanchez *et al*. 2003). Soil quality as a concept differs from conventional approaches that focus exclusively on production functions of soil. However, to make it more functional, the soil quality concept must be integrated with the land-use and other management systems (Karlen *et al*., 1998; Jijo, 2005).

The failure of traditional soil survey techniques to produce accurate results at smaller scales significantly limits the soil information available to programmes that attempt to help small communities and that implement community-based management of resources. Soil quality evaluation has thus become a growing tool for soil resource use and management. Meanwhile, no soil quality evaluation has been documented for the area under study. Concepts and guidelines have been published for soil quality evaluations for several areas (Karlen *et al*. 1998; Karlen *et al*. 2001; Sanchez *et al*. 2003; Jijo, 2005). Soil quality evaluation presents more relevant properties as indicators than the classical soil survey and land capability components. Moreover, soil quality indicators can be easily monitored and trends or changes established over time that would be valuable in ensuring agricultural sustainability in the area (Chen, 1999).

MATERIALS AND METHODS

The Area

The Ogba-Egbema Ndoni Local Government Area (ONELGA) lies between latitude $4^o39'$ and $5^o33'$ and longitude $6^o30'$ and $7^o00'$E and occupies a land area of 1200sqkm with a projected population of 350,000. It is located at the extreme North Western fringe of Rivers State bound on the North by Ogbaru L.G.A. of Anambra State, on the North-East by Oguta and Ohaji/Egbema LGAs of Imo-State, on the West by Sagbama/Yenogoa LGA of Bayelsa State and Ndokwa East LGA of Delta State on the South, and Ahoada West LGA and Emohua LGA of Rivers State on the East. Ogba-Egbema Ndoni area is located on the eastern bank of the River Niger and in the heart of the Niger Delta region (Fig.1.0).

The Sombreiro-Warri Deltaic Plain occupies a transitional position between the Coastal Plains terraces and the Delta proper (Anderson, 1967). The plain lies between the Saint Bartholomeo and Sombreiro Rivers. It extends eastwards to include both Degema and Abonnema Islands and is bounded on the south by Port Harcourt and Ogoni sands. The plain covers the political areas in the present Ogba/Egbema/Ndoni LGA, and part of Akuku-Toru and Degema LGAs, occupying about 30% of the present Rivers State. The area has a flat topography that rarely exceeds 3m above sea level.

Field Description and Sampling Procedures

A total of 80 genetic horizon samples from sixteen soil profiles were studied along eight transects in the Sombreiro Warri Deltaic Plain. Additional 42 surface soil samples randomly selected from the 8 transects or catchments were also studied. The following parameters were employed in the field description: colour, texture, soil structure, porosity, root abundance, effective soil depth (depth to impermeable layer or water table) and horizon boundary.

Qualitative and semi-quantitative approaches were adopted for this study. The first step in this evaluation was to "scope" the soil properties, i.e. arrange soil properties in an order of importance in their contribution to soil quality. The properties considered were: colour, texture, structure, porosity, soil depth, drainage, ECEC, TOC, Available P, pH, bulk density, aggregate stability and hydraulic conductivity.

Data Analysis

To reduce the level of subjectivity on the ranking of these properties as much as eight (8) assessors were made to independently rank them. In the collation, any property that was most ranked was chosen. Soil quality indicators for crop production function were selected using the approach suggested by Cameron *et al.*, (1998) based on the equation: $A = (S + U + M + I + R)$.

Where A = Acceptance score for indicators

S = Sensitivity of the indicators to degradation or remediation process

U = Ease of understanding of indicator value

M = Ease and or cost effectiveness of measurement of soil indicators

I = Predictable influence of properties on soil, plant, animal health, and productivity

R= Relationship to ecosystem processes

Each parameter in the equation was given a score of 1-5 based on expert's opinion and experience. The sum of the individual scores gives the level of the Acceptance (A) Score, which is ranked in comparison to other indicators.

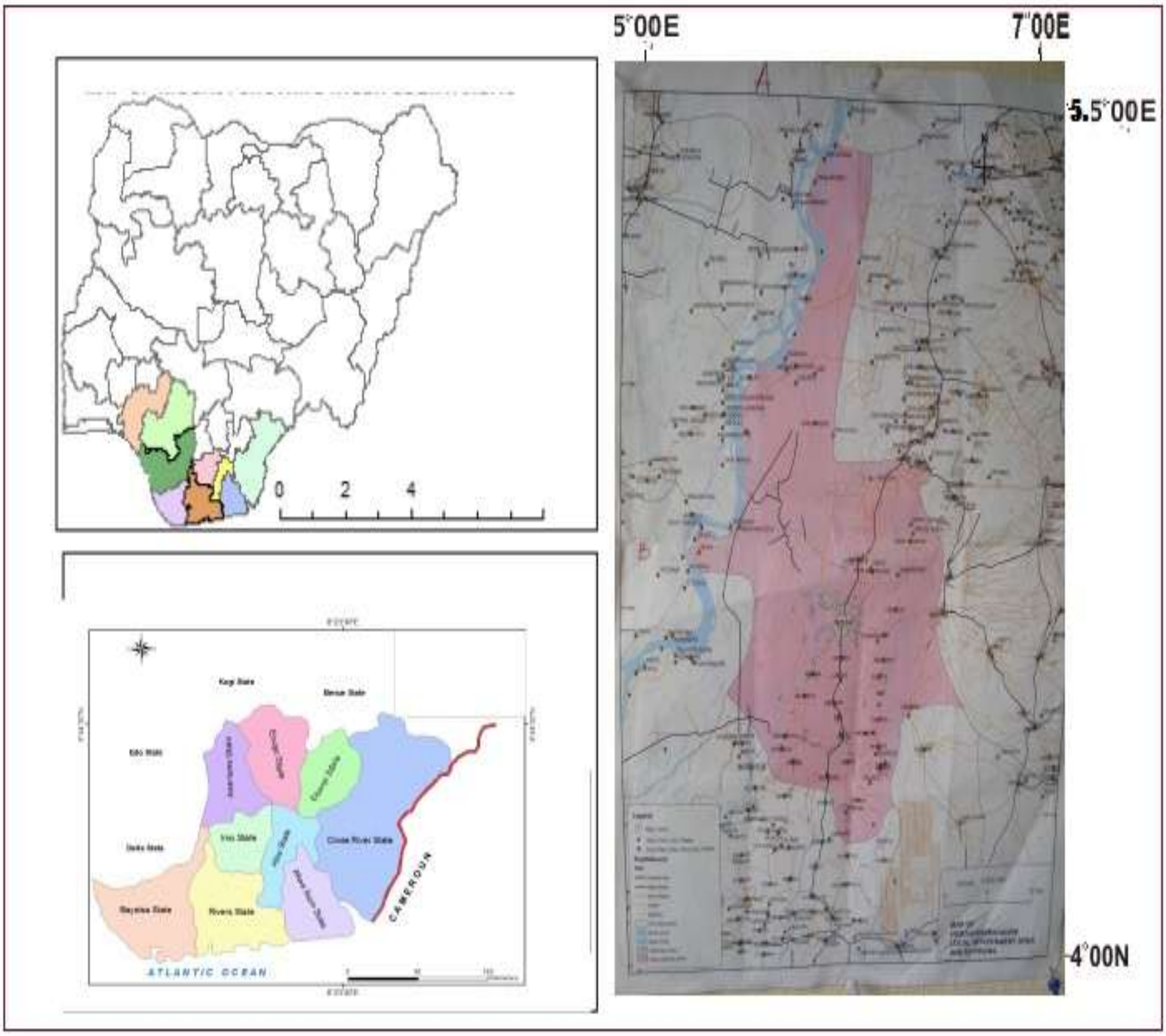

Figure 1: Map of the Niger Delta Showing Sombreiro Warri Deltaic Plain

RESULTS AND DISCUSSIONS

Morphological and Physical Properties of the Soils

The soils of Ogba-Egbema area are well drained and consolidated and formed on flat to almost flat terrain. Detailed morphological descriptions of the various pedons are presented in Table 1. Out of the 16 pedons, 10 were very deep (with no impermeable layer or depth to water table within 0 - 200cm) while the remaining 6 either had concretions at some depths between 120cm and 170cm or had the groundwater within the same depth. The shallow pedons are Obite 2 (<150cm), Obrikom 1 (<140cm), Ebocha 1 (<150cm), Umuoru/Ndoni 1 (<90cm), Aggah 1 (<170cm) and Aggah 2 (<120cm). The rest 12 pedons are all without impermeable layers or water table within 200cm (Table 1). The genetic topsoil horizon in all the pedons were plow layer (AP) and varied in depth from 0 - 14cm to 0 - 25cm with the exception of Ede pedon (0 - 55cm) Egbema pedon (0 - 30cm) and Aggah 2 (0 - 6cm).

The soil texture determined in the field was predominantly sandy loam and loamy sand with little variation between catchment areas or transects. The Umuoru/Ndoni transect was however, an exception with its prevalently loam to silty clay texture. Changes in texture with depth were also minimal usually between loamy sand and sandy loam in the top three

horizons (0 – 75cm). A change in texture from loamy sand to sandy clay loam was observed in three pedons (Akabuka 1, Obite 2 and Omoku 2). A slight increase in clay content with depth was observed in four pedons (Akabuka 1, Obite 2, Omoku 2 and Umuoru 1). The soils are similar to their Coastal Plains counterpart known mainly for sandy textures. Out of the 16 pedons studied, 10 had loamy sand to sandy loam textures throughout the profiles (from the topsoil to 200cm or to the water table). Only six pedons (Akabuka 1, Obite 2, Omoku 2, Ebocha 1, Egbema 1 and Umuoru/Ndoni 1) had sandy clay loam or silty clay loam or clay loam or sandy clay in the subsurface soils (ie between 75 and 200cm). The most clayey pedon in the study area was the Umuoru/Ndoni 1 which was located in the transitional area between the Sombreiro Warri Deltaic Plain (SWDP) and the adjoining Meander Belt.
The structure of the various horizons varied greatly with both depth and location, changing from weak granular and loose structureless on the surface horizons to medium angular and subangular blocky to massive structureless in the subsurface. There was a slight structural development from weak fine to weak medium and moderate medium subangular blocky structure. The structural development from weak to moderate subangular blocky structure may be interpreted as an indication of alteration of the original soil property by pedogenic processes associated with pedoturbation. Dark red mottles were observed at various depths in five pedons (Obagi 1, Obagi 2, Aggah 1, Obrikom 1 and Umuoru/Ndoni 1).

Soil Quality Assessment Using Surface Soil Chemical Properties

The assemblage of soil chemical properties determines the quality of the soil. Soil chemical properties are very important among the factors that determine the nutrient supplying power of soils to plants. The chemical indices for soil quality include pH, organic matter, ECEC, base saturation, total nitrogen and available phosphorus. In this study modal chemical status accepted as critical by several researchers was adopted as the benchmark for high quality (Table 2). The surface soils collected from the various transects or catchments have been compared with this benchmark (critical level) for the topsoil (Table 3).

pH (Soil Reaction)

The soils of the area were generally strongly acid to moderately acid with pH range in the topsoil being 4.09 to 6.90. About 55.5% of the surface soil samples were moderately acidic (greater than 5.5) while 44.5% of the samples were very strongly acidic to strongly acidic (pH less 5.5). Soil reaction affects nutrient availability and toxicity, microbial activity, and root growth. Thus, it is one of the most important chemical characteristics of the soil solution because both higher plants and microorganisms respond so markedly to their chemical environment. Using soil acidity (pH) as quality index, the spatial soil quality trend for the various catchments was of the following order: Akabuka/Obite > Umuoru/Ndoni > Aggah/Egbema > Omoku/Egbegoro > Omolu/Elele > Obiafu > Obagi/Ogbogu > Ebocha/Okwuzi.

Organic matter

The organic matter content of the topsoil of Ogba-Egbema area had a range of 0.24 – 5.42%. From the data the soils are low in organic matter and fertility as most of the soil samples were in the lower range of organic matter level. Using 1.75% TOC (or 3.0% TOM) as bench mark or critical level 56.20% of the soils of the area was low to medium. The spatial trend in organic matter showed that the poorest surface soils were Obiafu, Omoku/Elele and Aggah/Egbema catchment areas where 86.67%, 85.00% and 81.25% of the sample stations respectively had TOC values less than 1.75%. Conversely, the richest soils were from Akabuka/Obite and Omoku/Egbegoro transects where only 19.05% and 26.67% of the surface soils were less than the 1.75% critical level for TOC. Using total organic carbon as fertility or quality index, the soil quality trend for the various pedons or catchments was of the following order: Akabuka/Obite > Umuoru/Ndoni > Omoku/Egbegoro > Ebocha/Okwuzi > Obagi/Ogbogu > Aggah/Egbema > Omolu/Elele > Obiafu.

One of the reasons for the poor status of organic matter in these soils is the continuous cropping and the absence of dressing of organic materials in the agricultural practice of the area. Moreover, there has been complete removal of the biomass from the field. The annual slash and burn system of farming which is generally practiced in the area further discouraged the build-up of organic matter status. These practices result in low organic matter, impaired chemical soil quality and inadvertently low agricultural yield in soils of the area (Assefa, 1978, Yihenew, 2002).

Total N

The soils of Ogba-Egbema area are low in nitrogen. Data obtained for total nitrogen for the surface soils of the study area showed that the range in total Nitrogen was 0.012 – 0.650%. Following the rating of total N of > 1% as very high, 0.5 to 1% high, 0.2 to 0.5% medium, 0.1 to 0.2% low and < 0.1% as very low N status by Landon (1991), the surface soils qualify for very low status of N. Considering total N of the surface as a single soil quality (fertility) index showed that 72.26% of the soils were low to medium leaving only 27.74% of the surface soils qualifying for rich soils (i.e. having high level of total N). Using total N as fertility or quality index, the soil quality trend for the various catchments was of the following trend: Umuoru/Ndoni > Omoku/Egbegoro > Ebocha/Okwuzi > Obagi/Ogbogu > Aggah/Egbema > Akabuka/Obite > Omolu/Elele > Obiafu.

Available Phosphorus

The data for available P (Bray and Kurtz 1945) in the Ogba-Egbema area had a general range of 2.50 – 36.60mg/kg. The critical level for available P (by Bray 1) is 20mg/kg. Considering available P of the surface as a single soil quality (fertility) index showed that 62.04% of the soils are low to medium leaving only 37.96% of the surface soils qualifying for rich soils (ie having high level of available P). Using available P as fertility or quality index, the spatial soil quality trend for the various catchments was of the following order: Akabuka/Obite > Obagi/Ogbogu > Obiafu > Omoku/Egbegoro > Aggah/Egbema > Ebocha/Okwuzi > Umuoru/Ndoni > Omolu/Elele.

ECEC

The data for ECEC in the Ogba-Egbema area had a general range of 1.83 – 8.60Cmolkg^{-1}. The critical level for ECEC is 8Cmolkg^{-1}. The low ECEC of the soils could be attributed to the low organic matter content as well as the low levels of clay in the soils. The status of ECEC in these soils is related to ranges reported by Brady and Weil (2002) and Woldeamlak and Stroosnijder (2003) in sandy textured soils under various land uses.

Considering ECEC of the surface soils as a single soil quality index showed that no soil within the study area was high (i.e. the soils were generally poor or low in ECEC). Only 16.8% of the surface soils qualified for medium status, while 83.2% of the soils have low level of ECEC. The spatial soil quality trend using ECEC status for the various catchments was of the following order: Umuoru/Ndoni > Akabuka/Obite > Ebocha/Okwuzi > Omolu/Elele > Omoku/Egbegoro > Aggah/Egbema > Obagi/Ogbogu > Obiafu.

Ranking of Soil Profiles Using the Chemical Properties

A general soil quality ranking using collated chemical parameters was presented by Esu (1991). He categorized some pertinent soil properties into three levels: low, medium and high. He recommended critical limits for interpreting levels of analytical chemical parameters in arable soils of the tropics (Table 3).

In ranking the soil properties a general soil quality ranking using critical limits presented in Table 3 (Esu, 1991) was used. The fertility index classes of surface soils of the study area is presented in Table 4, while the soil quality ranking of the Transects using collated chemical or fertility parameters is presented in Table 5. The ranking of the transects in a descending order was: Akabuka/Obite > Umuoru/Ndoni > Omoku/Egbegoro > Obagi/Ogbogu > Obiafu > Aggah/Egbema > Ebocha/Okwuzi > Omoku/Elele. From the results obtained the top three transects of Akabuka/Obite, Umuoru/Ndoni and Omoku/Egbegoro had 59.0, 52.0 and 42.7% respectively of the various parameters qualifying for high fertility indices while the three lowest quality transects (Aggah/Egbema, Ebocha/Okwuzi and Omoku/Elele) had only 28.8, 22.7 and 21.0% respectively of sample stations that qualified them for high soil quality status.

Soil Quality Ranking of the Pedons for Crop Production

A general soil quality ranking for crop production was derived by applying a simplified binomial transformation of various soil properties (Table 6). In this assessment the modal class of each soil property was determined and then used to compare with the critical or ideal limit. A transformed value of "1" was given for each parameter that was equal to or greater than the critical (ideal) while a value of "0" was given to each property that was less than the critical.

From the collated data Akabuka 1 Pedon was rated the highest in quality with a score of 72.72%. This was followed by Omoku 1 and Aggah 2 Pedons that scored 63.63% each, while Ede 1, Okwuzi 1 and Umuoru 1 scored 54.54%. The least rated pedon was Obiafu 1 with a score of 27.27%.

Soil Quality Classes in the Area

Four Soil Quality (SQ) Classes were delineated in the area: SQ1, SQ2, SQ3 and SQ4.

Soil Quality 1 (SQ1) is soils with the maximum quality and has the least constraints or limitations to their use and management. The soils are deeper than 200cm. There were no hardpans or any impermeable layers or water table within 200cm. The soils were perfectly well drained and were not seasonally flooded. They also do not have any threat of erosion considering the flat terrain characteristics. The soils that belong to SQ 1 generally have dark brown to black topsoil.

Soil Quality 2 was similar in many ways to those of SQ 1 and occurs in similar terrain features. They were fairly or moderately deep soils without past history of flooding and showed no erosion threat since they occur in terrains that were relatively flat. These pedons were between 140 and 180cm in depth and are moderately to imperfectly drain but without threat of flood.

Soil Quality 3 (SQ 3) were moderately deep soils (effective rooting depth was between 140 and 160cm), were low in organic matter status, were moderately to imperfectly drained but without threat of flood. Most of the soils have dark gray top soils.

Soil Quality 4 (SQ 4) was soils that occurred in depression and natural basins whose effective depth was less than 140cm. They were poorly drained and seasonally flooded. The dominant land use of SQ 4 areas are forestry, wetlands and bare grounds. Soil profile features show impermeable layers or mottles and concretions at depths of 100cm. The soils have predominantly gray soil matrix and gleying.

Screening and Scoping Soil Quality in the SWDP

The screening of soils for quality requires measuring specific variables for physical, chemical, biological properties as well as evaluating interactions between the various properties and processes. This approach is complex and entails considering the place of the various properties on the functions of the soil. The pertinent soil functions considered for screening the soils of the Ogba-Egbema area are potentials for anchorage, nutrient and moisture supply to plants and role as environmental sink or purifier**.** The selection of the appropriate soil quality classification scheme is important because by this operation a link between the evaluation and knowledge of the soils in relation to a specific purpose will be established. In order to screen the soil of the Ogba-Egbema area for quality indices the following aspects are considered: the specific function of the soil, dynamism of soil characteristics, the inter-relationship between various properties, environmental conditions of the area, ease of measurement, etc. The multiple uses of the soil e.g. agricultural production, forest, bush fallow, nature conservation and urban development, were also taken into cognizance in the evaluation.

The following parameters were of utmost consideration in the soil quality assessment: effective soil depth (rooting zone or soil volume), drainage, hydraulic conductivity, organic matter status and soil profile morphological features. Generally, these physical characteristics were weighted much higher than chemical properties like plant nutrients. The productivity and ecological placement of the soils were emphasized above fertility and agronomic potentials. One quick observation even amongst the rural farmer's evaluation or quality placement of the soils is the fact that the soils under very luxuriant tropical vegetation were mostly rated as SQ4. Though soils of the luxuriant vegetation have higher organic matter, total nitrogen and sometimes higher in ECEC, their agronomic ranking and multipurpose evaluation showed that they are considerably poor. Firstly, they are generally waterlogged or poorly drained and prone to flooding in most years or have ground water close to the surface for greater than four months annually. This preference of using productivity and environmental stability functions in ranking soils over fertility and chemical composition agrees with the approach adopted by Fedoroff (1987) for the evaluation of soil degradation. An optimal (or maximum) quality soil is the soil in equilibrium with all the components of the environment. This is seen as a soil where the immediate micro environment has factors or environmental variables that act together to promote performance of crops without compromising on other ecosystem or environmental functions. The soils in the study area delineated as SQ 1 and SQ 2 were located in stable environment, though their fertility functions were comparatively low. The second option considers that the maximum quality reference soils are soils capable of maintaining high productivity and of causing the minimum of environmental distortion or deleterious impacts.

CONCLUSION AND RECOMMENDATIONS

The physical properties reflect deep and very productive setting. Soil depth, terrain characteristics, climatic influences, etc. of Ogba-Egbema area are suitable for agricultural land uses. Most of the fertility indices were below critical limits as expressed by low ECEC, low organic matter and available P. Poor drainage and periodic flooding are also limiting factors in the soils. The soils in the area have low aggregate stability and slow permeability. The study showed four soil quality classes (SQ1 – SQ4). Soils Quality classes 1 and 2 (SQ1 and SQ2) are suited for agricultural use, while SQ3 and 4 have varying levels of limitations due to either poor nutrient status (soils being mainly sandy) or because they are prone to flooding and erosion. The selected five soil indices (drainage, depth, total organic matter, soil colour and texture) agreed with the rural farmers' soil quality determinants.

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Table 1: Morphological Characterization of Representative Pedons in the Study Area

Soil Identity	Depth (cm)	*Colour	Mottles	Texture	Structure	Consistency
Akabuka 1 Ap	0-22	10YR3/2	-	LS	1fgr	Fr
A2	22 – 50	10YR4/4	-	LS	1fgr	Fr
B21	50 – 70	10YR5/4	-	SL	1fsbk	Fr
B22	70 – 93	7.5YR5/6	-	SL	1fsbk	Fr
B23	93 – 125	7.5YR4/6	-	SCL	2mabk	Fr
B31	125– 158	7.5YR5/8	-	SCL	2mabk	Fr
B32	158 - 200	5YR4/6	-	LS	1fsbk	Fr
Obite 1 Ap	0-25	10YR4/3	-	LS	gr	Fr
A2	25 - 40	10YR5/6	-	LS	wsab	Fr
B21	40 - 65	7.5YR5/6	-	LS	wsab	Fr
B22	65 - 110	7.5YR6/8	-	SL	wsab	Fr
B23	110 - 200	5YR5/8	-	SL	msab	Fr
Obagi 1 Ap	0 -20	10YR4/3	-	LS	gr	Fr
A2	20 – 39	10YR5/4	-	LS	wabk	Fr
AB	39 – 47	10YR6/6	-	LS	1wabk	Fr
B2	47 -120	10YR7/6	2.5YR 4/6	LS	1wabk	Fr
BC	120 – 150	10YR7/8	2.5YR 4/6	SL	2mabk	Fi
C	150 - 200	7.5YR6/8	2.5YR 4/6	SL	2mabk	Fi
EDE Ap	0 - 55	10YR5/6	-	LS	gr	Fr
AB	55 – 66	7.5YR7/6	-	LS	1fsbk	Fr
B1	66 – 80	7.5YR5/6	-	LS	1fsbk	Fr
B2	80 – 120	5YR6/8	-	SL	1fsbk	Fr
B3	120 - 200	5YR5/8	-	SL	1fsbk	Fr
Omoku/Obrikom 2 Ap	0 – 20	2.5Y4/1	-	Sil	1gr	Fr
B1	20 – 38	2.5Y6/3	-	Sil	1gr	Fr
B2	38 – 56	2.5Y6/3	2.5YR 4/6	sicl	2msbk	Fi
C1	56 – 110	2.5Y6/3	2.5YR 5/8	Sicl	2msbk	Fi
C2	110 - 150	2.5Y6/3	2.5YR 5/8	Sicl	2msbk	Fi
OKWUZI Ap	0 -14	10YR3/3	-	LS	1fgr	Fr
AB	14 – 37	10YR4/6	-	LS	1fsbk	Fr
B1	37 – 74	7.5YR5/6	-	SL	1fsbk	Fr
B2	74 – 128	5YR5/8	-	SL	1fsbk	Fi
B3	128 - 200	5YR4/6	-	SL	1fsbk	Fi
AGGAH 2 Ap	0 - 6	10YR2/1	-	S	0	0
AB	6 – 50	10YR4/3	-	S	gr	Fr

B2	50 – 80	10YR5/4	2.5YR 3/4	LS	gr	Fr
BC1	80 – 130	10YR5/8	2.5YR 5/4	LS	1fsbk	Fi
C	130 - 160	10YR6/4	2.5YR 3/4	LS	1fsbk	Fi
Egbema 1 Ap	0 – 18	10YR3/2	-	S	0	0
A2	18 – 60	10YR5/2	-	LS	gr	Vfr
B1	60 – 70	10YR7/2	-	SL	1abk	Fr
B2	70 - 120	10YR7/1	-	SL	1abk	Fr
UMUORU-NDONI 2 Ap	0 – 21	2.5Y 4/1		sil	2bk	Fi
B1	21 - 58	(2.5Y 6/3)	-	sil	2bk	Fi
BC1	58 - 90	(2.5Y 6/3)	10 R 5/8	sicl	2bk	Fi
BC2	90 - 150	2.5 Y 6/3	10R 5/8	sicl	2bk	Fi

*All soil Colours were for moist condition; KEY: LS =Loamy sand; SL= Sandy loam; SCL= Sandy Clay Loam; gr= granular; fr = friable; fi = firm; c = clear; s = smooth; g = gradual; w = wavy; 1 = weak; 2 = medium; a = angular; bk = block

Table 2: Critical Limits for Interpreting Levels of Analytical Chemical Parameters

Parameter	**low**	**medium**	**high**
CEC (cmol kg^{-1})	< 6.0	6.0-12.0	> 12.0
Org. C (g kg^{-1})	< 10.0	10.0-15.0	> 15.0
TN (g kg^{-1})	< 0.1	0.1-0.2	> 0.2
Av. P (mg kg^{-1})	< 10.0	10.0-20.0	> 20.0
pH	< 4.0> 7.5	4.5-5.5	5.6 - 7.0

Source: Esu (1991)

Table 3: Mean Values of Key Chemical Properties in the Surface Soils (Wet Season)

Sample Station	**pH**	**TOC**	**ECEC**	**Avail. P**	**Total N**
Umuoru-Ndoni	5.797	2.316	6.136	13.048	0.212
Omoku-Egbegoro	5.829	2.095	4.908	14.547	0.195
Obagi-Ogbogu	5.602	1.982	4.148	21.043	0.170
Akabuka-Obite	5.875	1.702	5.249	23.199	0.147
Aggah-Egbema	5.669	1.539	4.054	13.167	0.169
Obiafu	5.476	0.883	3.735	17.456	0.082
Omoku-Elele	5.321	1.235	4.945	9.753	0.110
Ebocha-Okwuzi	5.146	1.528	5.141	5.794	0.132
LSD ≥) 0.05	0.383	0.586	0.782	4.867	0.060

Table 4: Fertility Index Classes of Surface Soils of the Study Area

		pH			TOC			Total N.			Avail. P			ECEC		
	Sample Size	**L**	**M**	**H**	**L**	**M**	**H**	**L**	**M**	**H**	**L**	**M**	**H**	**L**	**M**	**H**
Obagi/Ogbogu	15	0	12	3	1	11	3	2	10	3	0	1	14	14	1	0
Omoku/Egbegoro	15	1	6	8	0	4	11	1	10	4	5	1	9	13	2	0
Akabuka/Obite	15	0	0	15	0	2	13	0	14	1	0	0	15	13	2	0
Ebocha/Okwuzi	15	4	7	4	1	8	6	6	5	4	9	3	3	12	3	0
Umuoru/Ndoni	15	0	3	12	0	4	11	1	6	8	5	2	8	9	6	0
Aggah/Egbema	15	0	5	10	1	11	3	7	6	2	2	7	6	14	1	0
Omoku/Elele	15	0	8	7	3	10	2	10	5	0	6	3	6	13	2	0
Obiafu	15	0	10	5	8	5	2	9	6	0	0	0	15	15	0	0
TOTALS	**120**	**5**	**51**	**64**	**14**	**55**	**51**	**36**	**62**	**22**	**27**	**17**	**76**	**103**	**17**	**0**

L = Low; M = Medium; H = High

Table 5: Soil Quality Ranking of the Transects Using Collated Chemical or Fertility Parameters

		Low	Medium	High	Ranking
1.	**Obagi/Ogbogu**	23 (23.00%)	41 (41.00%)	36 (36.00%)	4th
2.	**Omoku/Egbegoro**	20 (26.67%)	23 (30.67%)	32 (42.67%)	3rd
3.	**Akabuka/Obite**	14 (13.33%)	29 (27.62%)	62 (59.05%)	1st
4.	**Ebocha/Okwuzi**	32 (42.67%)	26 (34.67%%)	17 (22.67%)	7th
5.	**Umuoru/Ndoni**	15 (20.00%)	21 (28.00%)	39 (52.00%)	2nd
6.	**Aggah/Egbema**	26 (32.50%)	31 (38.75%)	23 (28.75%)	6th
7.	**Omoku/Elele**	43 (43.00%)	36 (36.00%)	21 (21.00%)	8th
8.	**Obiafu**	32 (42.67%)	21 (28.00%)	22 (29.33%)	5th

Table 6: Binomially Transformed Soil Quality Ranking of the Pedons for Crop Production

*Pedon	pH	OC	TN	Av P	ECEC	Tex	Structure	Depth	Drainage	BD	Hydr. Cond.	*Total positive points	% Quality Rating	Ranking of the Pedons
Ak/OB 1	1	1	0	1	0	1	1	1	1	0	1	8	72.72	**1st**
AK/OB 2	0	0	0	1	0	1	1	1	1	0	0	5	45.45	**4th**
OB/OGB 1	0	0	0	1	0	1	1	0	0	0	1	4	36.36	**5th**
OB/OGB 2	0	1	1	1	0	1	1	0	0	0	0	5	45.45	**4th**
OBITE 1	0	0	0	0	0	1	1	1	1	0	0	4	36.36	**5th**
OBITE 2	0	0	0	1	0	1	1	1	1	0	0	5	45.45	**4th**
Ede 1	1	0	0	0	0	1	1	1	1	1	0	6	54.54	**3rd**
OMOKU 1	1	0	0	0	0	1	1	1	1	1	1	7	63.63	**2nd**
OMOKU 2	0	0	0	0	0	1	1	1	1	0	0	4	36.36	**5th**
Obiafu 1	0	0	0	0	0	1	1	0	0	1	0	3	27.27	**6th**
OKWUZI 1	0	0	0	0	0	1	1	1	1	1	1	6	54.54	**3rd**
AGGAH 1	0	0	0	0	0	1	1	0	0	1	1	4	36.36	**5th**
AGGAH 2	0	1	1	1	0	1	1	0	0	1	1	7	63.63	**2nd**
Egbema	0	1	0	0	0	1	1	0	0	1	1	5	45.45	**4th**
UMUORU 1	1	1	0	1	0	1	0	0	1	1	0	6	54.54	**3rd**
OMUORU 2	1	0	0	1	0	1	0	0	0	1	0	4	36.36	**5th**

OC = organic carbon; TN = total nitrogen; Av P = Available phosphorus; ECEC = Effective Cation Exchange capacity; Tex = texture; BD = Bulk density; Hydr. Cond. = Hydraulic conductivity ***Maximum obtainable positive points = 11NOTE: Quality Rating (%) = (Total positive points) / (Maximum obtainable positive point