**INTER-WORLD JOURNAL OF SCIENCE AND TECHNOLOGY VOL. 3. NO. 2: 20-2**

# Application Of Soil Quality Morphological Index In Assessing Soil Health Of Arable Farms On Isophyperthermic Ruptic-Alfic Dystrudepts In Owerri, Southeastern Nigeria.

Onweremadu, E.U, C.C Opara, N.N Oti B.U, Uozoho, A.E Ibe, C.T Tom.
E.M. Nwokeji and Onwubiko N.C

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*Soil quality morphological index (SQMI) was used to assess soil health of arable farms on soils along Otamiri River in Owerri, Nigeria. Sampled points were identified based on physiography and linked using a transect. Three minipedons were dug at equal inter-minipedal distance of 35 metres and sampled. Results showed that soils on a levee had the best quality (SQM1 = 3. 52), followed by Terace (SQMI = 2.83), Backswamp (SQMI 2: 75) and least in Upland soils (SQMI =2.64). Soil quality has a good relationship with organic matter (r = 0.92; r2 =0.84; 1 r2— 0.16; P-0.05). Results of soil properties were used to classify soils of the site as Isohyperthermic Ruptic-Alfic Dystrudepts (USDA. Soil Taxonomy).*

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## INTRODUCTION

Soil degradation has been a topical issue in Nigeria in general and Southeastern Nigeria in particular especially among arable farmers, nomads, environmentalists, governments and the general public. Pimcntal *et al.,* (1995) stated that soil and environmental degradation poses a potential threat to global supplies over a long term. Soil degradation appears in forms of crusting, compaction, sealing, impeded drainage, waterlogging, reduced waterholding capacity, infiltration, salinization, acidification, nutrient leaching, depletion in organic matter, decline in species composition and decline in biodiversity Sell err and Yadav (1996). Major cause Of soil degradation include deforestation, burning of vegetation, increasing intensity of farming, tillage practices, low input agriculture, accelerated erosion by water and wind, road building and other construction works Lai and Okigbo (1990).

Soil degradation negatively influences the capacity of soil to function. These losses attached to soil degradation have sparked off interest in the concept of soil quality and its assessment Karlen *et al.,* (2001). The growing awareness that soil is an important component of tire earth's biosphere especially in the production of food and fibre Doran and Parkin (1994) has caused researchers to attempt definitions of soil quality (Scybokl *et al.,* 1998; Brady and Weil, 1999). Scybold *et al.,* (1998) used the word dynamic soil quality which they defined in terms of human use and

E.U. Onweremadu, B.U, Uzoho and C.C Opara, are lecturers while N.N Oti, is a senior lecturer, Department of Soil Science and Technology while A.E Ibe, C.T Tom, E.M. Nwokeji and N.C Onwubiko are lecturers, Department of crop Science and Technology, Federal University of Technology, Owerri, Nigeria

management on soil functions. Brady and Weil (1999) referred to soil quality as the capacity of a soil to function within its ecosystem boundaries to sustain biological productivity and diversity, maintain environmental quality and promote plant and animal life. Tire relevance of soil quality in its capacity to function of purposes calls for its quantitative assessment using reliable indices. Such indices must be dependent on tire complex interactions of a number of processes and properties Doran and Parkin, (1994). Such indices include soil management assessment framework Andrews, (1998), soil quality index for erosivity Brady and Weil (1999), soil quality morphological index (Grossman ct al Seybold *et al.,* 2004) and the additive index Andrews *et al.*, (2004).

This study used tire soil quality morphological index (SQM1) due to tire simplicity and cheapness of the model. Tire SQMI provides a relative ranking of optimal physical conditions for root growth and development, and free movement of water and air in the pedosphere. Tire index is determined from near-surface soil properties to a depth of 30 cm or to a restrictive layer if shallower Seybold et al., (2004). It combines information from soil texture, soil structure, soil consistence, dry crust strength and thickness and surface connected macropores and cracks Grossman *et al.,* (2001). The index was developed out of the need to characterize tire near-surface attributes in detail for soil survey and to evaluate soil quality in the field using soil morphology. In this index, the higher the value, the better the soil quality Seybold *et al.,* (2004). Changes in near- surface soils due to land use and management are not substantially recognized in soil survey Onweremadu, (2006) hence the need for this index in sustainable soil management for sustainable land use.

Based on the above, the major aim of this study was to evaluate soil quality of an arable farm using soil quality morphological index (SQMI) and relating it to organic matter which is often chosen as a reliable indicator of soil health in tropical soils.

## Methods

### Location

The study site is the, Otamiri River floodplain at Federal University of Technology, Owerri, Nigeria, lying between latitudes 5°20; and5°25;N and longitudes 7°00/ and 7fi5;E. The altitude of the area is 54 metres above mean sea level (Readings of Handheld Global Poitioning System Receiver-Germin Ltd, Kansas USA). The main geological material is Coastal Plain Sands (Benin formation) of the Oligocence - Miocene era Orajaka (1975). However, the geology is influenced by fluvial deposition of alluvium. It is with the lowland areas-of Southeastern Nigeria Ofomata (1975). It is of the rainforest agroecology of the humid tropics characterized by heavy rainfall (Table l) and mean monthly temperature ranging from23.8°Cto29.0°C(Table2). Currently, agriculture is a major socio-economic activity in the study site with the Backswamp physiographic unit being influenced by annual flooding of the Otamiri River.

### Field Studies

Four physiographic units namely backswamp, levee, terrace and upland were identified. A transect was drawn to link all the land units in the area. Aminipedon was sunk in each geomorophic unit and sampling done from the bottommost layer. An inter- mmipedon distance of 35 metres was maintained. Routine and standard physical parameters were used in the determination values for the computation of soil quality morphological index (Brejda *et al.,* 2000a; Brcjda *et al.,* 2000b; Grossman *et al.,* 2001 ; Seybold *et al.,* 2004). Soils were sampled at predetermind depths of 0-10cm, 10-20 cm and 20- 30 cm Grossman *et al.,* (2001).

In addition to four minipedons, four mimipedons, four pedons representing four physiographic units were dug and described. Soil samples were also collected and used in this study.

### Computation of Field Data

Soil quality morphological index (SQMI) was computed using the following formula:

$SQMI = (4\ SRJ_{0-10} + 2SRI_{20.30})7$ where ARI = structure - rupture resistance 4, 3 and 7 = weighting factors

Laboratory analysis

Particle size distribution was determined by hydrometer method according to the procedure of Gee and Bander (1986)-. Soil pH was measured electrometrically in 0.l.N KCl using a soil: liquid ratio of 1:2.5 Hendcrshot *et al.,* (1993). Exchangeable cations were got by the method described by Thomas (1982) and summation of cations gave the cation exchange capacity (CRG): Base saturation was estimated as sum of exchangeable basic cations divided by CKC and multiplied by 100 percent.

Organic carbon was measured by Walkeley and Black Wet digestion method Nelson and Sommers (1982). Values of organic carbon were multiplied by a factor of 1. 724 to obtain organic matter.

### Statistical Analysis

Average values of organic matter from soils sampled from minipedons were correlated with values of SQMI using SAS computer package Little et ah,(1996).

## RESULTS AND DISCUSSION

### Soil Properties and Classification

Results of soil properties arc shown in Table 6. Soil results represent average values of 4 pedons sunk in the 4 physiographic units. Soils were sandy, acidic and moderate base saturation. Base saturation which is a major criterion in the determination of soil taxonomy ranged from 35 - 35%. Organic matter was low (0.09-62%) and decreased with depth. Morphologically, horizons were poorly differentiated except for the weak argillic horizon (Bt)68cm depth. Colour development (Bw) was prominent.

Based on these and climatic data (Tables 1 and 2), soils were classified as Isohyperthermic Ruptic-Alfic Dystrudepts according to the procedure of soil taxonomy (Soil Survey Staff, 2003). The agronomic implication of this is that crops should be subsisting on external inputs for sustainable growth and development in the site as soils arc not « properly formed. Although soils were deep, they were too sandy with very low organic matter and granular which affects mechanical function of soils.

### Soil Quality

Results of soil quality morphological index are presented in Table 7. Soils on the levee have best quality having the highest index value (SQMI= 3.52), followed by those on a terrace and least being those of upland. These results show that soil on the levee have least physical limitations for root growth, development and performance as well and in the soils' ability to 'draw nutrients, air and water in the pedospherc. The influence of Otamiri River via annual overflowing of its banks negatively affects the physical properties of soils of the backswamp hence its low SQMI values. The soils of the upland had the lowest values of SQMI indicating high degree of soil physical infertility. This condition was possibly aggravated by tire anthropogenic activities ranging from farming and construction activities. But the quality of soil of the levee could have been better but for excessive sand mining in the site.

Soil quality morphological index volume were correlated with organic matter at a probability level of'5% and the result shows significant positive correlation coefficient (r = O'. 92; p =0.05; n =9) (Table 8) There was also a very good relationship between SQMI values and soil organic matter (r2 = 0.84; p = 0.05; n=9). Soil organic matter is * regarded as a very reliable and important soil quality parameter Gregorich *et al.*, (1994). If organic matter has correlated well with SQMI, it implies that both arc good indicators of soil health status.

## CONCLUSIONS

Soils of the study site are sandy, acidic and of low organic matter. Base saturation was unique with weak argillic horizon (Bt) and colour development (Bw) hence classified as Isohyperthermic Ruptic – Alfic Dystrudepts considering the moisture and temperature regimes of the site. Soils on a levee had tire best quality while least soil quality in the site was recorded in upland soils using the SQMI. Describing soil structure and rupture- resistance is subjective but requires broad knowledge on soil morphology for a good assessment. Nonetheless SQMI correlated significantly and positively with soil organic matter given the available soil data set.

## REFERENCES

Andrews, S. S. (1998). Sustainable Agriculture Alternatives: Ecological and

Andrews. S .S., Karlen, D.L. and Cambardella, C.A. (2004). The Soil Management Assessment Framework: A Quantitative Soil Evaluation Method. *Soil Sci. Soc. Am.* ,68: 1945-1962.

Brady, N. C. And Weil. R. R. (1999). The Nature and Properties of Soils. 12,hed. Prentice - Hall Inc. New York. 860pp.

Brejda, J. J., And Moorman, T. B., Karlen, D. L. And Dao, T. H. (2000b). Identification of Region Soils Factors and indication: 1. Central and Southern High Plains. So// Sci. Soc. Am. 64:2115-2124.

Brejda, J..I. And Karlen, D.L., Smith, J. L. And Allan, D .L (2000a). Identification of Regional Soil Quality Factors and Indicators: II Northern Mississippi Losses Mils and Palousc Prairie. *Soil Sci. Am. J.,* 64:2125-2135.

Doran, J. Wand Parkin, T. B. (1994). Defining and Assessing Soil Quality for a Sustainable Environment SSSA Special Publication No. 35. pp. 1-21.

Gee, G.W. and Bauder, J. W. (1986). Particle Size Analysis. In: Klute, A. (ed). Methods of Soil Analysis Part 1. *American Society of Agronomy,* Madison WI pp.91-100.

Gregorich, E. G; Carter, M. R. Angers. D. A; Monreal, C. M. and Soil Organic Matter Quality in Agricultural Soils. *Can J. Soil Sci*, 74: 367-385.

Grossman, R, B., Harms, D. S., Seybold, C.A., and Plerrick, J. E. (2001). Coupling Use Dependent and Use- United State, J. *Soil Water Conserv*. 56:63 -68.

Hendersshot, W.H., Lalande, H. and Duquette (1993). Soil Reaction and Exchangeable Acidity. In Carter, M. R. (ed.) Soil Sampling and Methods of Analysis. *Canadian Society of Soil Science,* Lewis Publishers, London, Pp141 -145.

Karlen, D. L., Andrews, S. S, and Doran, J. W. (2001). Soil Quality: Current Concepts and Applications. *Adv. Agron*., 74: 1 -40.

Keeney, D.R (eds). Methods of Soil Analysis Part 2, American Society of Agronomy Madison WI pp. 159-165.

Lai, R. and Okigbo, B.N. (1990). Assessment of Soil Degradation in the Southern States of Nigeria. Environment Working Paper No. 39.58 pp.

Management Alternatives Applied to Agronomic Soils. Ph. D Dissertation

Nelson, D. W. And Sommers, L.E. (1982). Total Carbon, Organic Carbon and Organic Matter. In: Page, A. L. Miler, RH. And Keeney, D. R. (cds) Methods of Soil Analysis, Part 2. *American Society of Agronomy, Madison,* WI pp. 539-579,

Ofomata. G.E.K. (1975). Landform Regions. In: Ofomata, G. E. K. (ed). Nigeria in Maps: Eastern States. Ethiope Publishing House, Benin. pp33 -34.

Orajaka, S.O (1975). Geology. In: Olbmata, G. E. K. (ed.). Nigeria in Maps: Eastern • Slates. Ethope Publishing House, Benin, pp. 5-7.

Pimcntal, D., Harvey, C. Resosudarmo, P., Sinclair, K., Kurz, D., McNair, M., Crist, S. Shpritz, L., Fittony, Economic Costs of Soil Erosion and Conservative Benefits. *Science,* 267: 1117-1123.

Quality Morphological Index Measures in the 1996 NRI Pilot Study. Soil Surv. Horizons, 45(3): 73-110.

Scherr, S.J. and Yadav, S. (1996). Land Degradation in the Developing World: Implications for Food, Agriculture and the Environment to 2010. IFPRI Washington DC. 36 pp.

Seybold, C. A., Mausbach, M. J. Karlen, D. L., and Rogers, H. H. (1998).Quantification of Soil Quality. In: Lai, R. (ed.). Soil Processes and Carbon Cycle.CRC. Press, Boca Raton, F. L. pp. 387 -404.

Seybold, C.A, Drossman, R.B, Llope, H., Muekel, O. and Kullen, D.I (2001). Soil Quality Morphological Index Measures in the 1996 NRI Pilot Study. Soil Surv. Horizons, 45(3): 73-110.

Soil Survey Staff (2003). Keys to Soil Taxonomy, 9th ed. USDA-NRCS, Washington DC. 332 pp.

Thomas, G. W-. (1982). Exchangeable Cations. In: Page, A, L., Miller, R. H, and University of Georgia. Athens.

**Table of 1: Average Rain Fall (1995-2004)**

| Month | Jan | Feb. | Mar | Apr | May | June | July | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average rainfall (mm) | 27.3 | 28.2 | 103.9 | 188.6 | 271.1 | 315.6 | 332.1 | 345.6 | 383.7 | 245.9 | 63.1 | 7.1 |

Source: Owerri Meteorological Station

10 years (1995-2004)

**Table 2: Average Temperature ($^{o}$C) 1995-2004)**

| Month | Jan | Feb. | Mar | Apr | May | June | July | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average Temperature (mm) | 27.4 | 28.5 | 29.0 | 28.8 | 29.2 | 24.7 | 23.8 | 25.8 | 23.9 | 24.9 | 28.6 | 28.4 |

Source: Owerri Meteorological Station

10 years (1995-2004)

**Table 3: Texture – weighting Class Criteria for SQMI**

| Texture Class | Criteria |
|---|---|
| A | Sand, loamy Sand |
| B | Not A and Clay is <18% |
| C | 18-40% Clay |
| D | ≥40% Clay |

**Table 4: Criteria for Placement of Structure Class in the Soil Quality Morphological Index**

| Texture Class | Criteria |
|---|---|
| 1 | All structures with common or many stress surfaces irrespective of other features, massive, platy with firm or stronger horizontal rupture resistance, all weak structure except granular, moderate to very coarse prismatic, all columnar. |
| 2 | All structure with few stress surfaces irrespective of other features, weak granular, moderate to very coarse and coarse blocky; coarse and medium prismatic, play with friable horizontal rupture resistance; strong very coarse and coarse blocky. |
| 3 | No stress surface, moderate to medium blocky, fine, fine and medium prismatic; platy with friable horizontal rupture resistance, strong very coarse and coarse blocky |
| 4 | No stress surfaces, moderate to granular, moderate to very fine and fine blocky; strong fine |
| 5 | No stress surfaces, strong granular, strong very fine through medium blocky and very fine prismatic. |

**Table 5: Rupture – Resistance Classes for the Soil Quality Morphological Index**

| | Moisture rupture resistance | | | | |
|---|---|---|---|---|---|
| **Texture Class** | **Loose** | **Very friable** | **Friable** | **Firm** | **Very firm and stronger** |
| A | 2 | 3 | 3 | 2 | 1 |
| B | 3 | 4 | 3 | 2 | 1 |
| C | 4 | 5 | 3 | 2 | 1 |
| D | 5 | 5 | 4 | 1 | 1 |

**Table 6: Soil Properties**

| Horizon | Depth(cm) | $pH_{(kcb)}$ | $CEC_{(cmo/kg^{-1})}$ | BS(%) | OM(%) | Sand (%) | Silt(%) | Clay (%) |
|---|---|---|---|---|---|---|---|---|
| AP | 0-12 | 4.4 | 3.50 | 38 | 1.62 | 86 | 8 | 6 |
| AB | 12-35 | 4.2 | 4.06 | 35 | 0.71 | 86 | 8 | 6 |
| Bt | 35-68 | 4.6 | 4.23 | 38 | 0.30 | 79 | 9 | 12 |
| Bw | 68-110 | 4.3 | 3.04 | 36 | 0.22 | 86 | 8 | 6 |
| BC | 110-170 | 4.0 | 3.00 | 35 | 0.09 | 85 | 8 | 6 |

CEC = Cation Exchange Capacity – Dabo saturation

OM = Organic Matter

**Table 7: Soil Quality Morphological Index (SQMI) Values**

| Physiography | Origin | SQMI |
|---|---|---|
| Backswamp | Minipedon | 2.75 |
| Levee | Minipedon | 3.52 |
| Terrace | Minipedon | 2.83 |
| Upland | Minipedon | 2.64 |

**Table 8: Relationship Between SQMI and SOM**

| Statistic | **Value** |
|---|---|
| r | 0.92 |
| $r^2$ | 0.84 |
| $1-r^2$ | 0.16 |

$P = 0.05$, $n = 9$

**Figure 1: Map of the Study**