Nigerian Journal of Soil Science

Journal homepage:www.soilsjournalnigeria.com

Impact of land use system on soil quality in Southwest Nigeria

Amosu, S. A.

Department of Fruits and Spices, National Horticultural Research Institute (NIHORT), Ibadan, Nigeria

ARTICLE INFO

Article history:
Received May 12, 2020
Received in revised form August 17 2020
Accepted August 28, 2020
Available online September 7, 2020

Keywords:

Indicators
land use
soil quality

Corresponding Author's E-mail Address:

semeton@yahoo.com

https://doi.org/10.36265/njss.2020.300303

ISSN-1597-4488 © Publishing Realtime.

ABSTRACT

A soil quality (SQ) evaluation was conducted on three different farm locations in the Ijebu-Igbo region of Ogun State Nigeria to ascertain the health status of the soils. The farmlands have been subjected to different land use systems (LUS) for over ten years including plantain/banana orchard, arable farming and fallow/ secondary forest. Soil samples were obtained at 0-30 cm and 30-60 cm depths from each farmland. The SQ of the farms was evaluated quantitatively using the SQ index equation proposed by Bajracharya *et al.* (2006). The results revealed that at 0-30cm depth, the LUS had significant (P<0.05) impact on the SQ indicators with the fallow land recording the highest pH (6.69), zinc (6.12 mg/kg) and ECEC (14.95 cmol/kg) while, high significant (P<0.01) impact was observed on iron with the fallow land recording 21.21mg/kg. At 30-60cm depth, the LUS had high significant (P<0.01) impacts on the SQ indicators with plantain/banana field recording the highest organic carbon (0.79 g/kg) and total N (0.09 g/kg) while the fallow land had the highest pH (6.65), ECEC (13.72 cmol/kg) and iron (31.66 mg/kg). The LUS had no significant (P<0.05) impact on the SQ though the fallow/secondary forest had the highest SQ level (0.56) and plantain/banana field the least (0.52). The results also showed that the land use systems didn't have any significant impact on SQ at both soil depths though the upper soil layer had better mean soil quality (0.54) than the lower layer (0.48). Soil quality declined with depth in the study sites

1.0 Introduction

In Sub-Saharan Africa, land degradation and loss of soil fertility top the significant problems facing agricultural productivity (Sanchez *et al.*, 1997). These problems are primarily caused by poor land use and management practices which directly impact the quality of the soil in question. The concept of soil quality is based on the premise that land use and management systems can deteriorate, sustain or improve soil ecosystem functions. Karlen *et al.* (1997) defined soil quality as the capacity of a 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. Soil quality is assessed both quantitatively and qualitatively, the former involving soil sampling, laboratory analysis to obtain the soil quality indicators and soil quality index calculated from the soil quality indicators. According to Gelaw *et al.* (2015), a soil quality index (SQI) helps to assess the soil quality of a given site or ecosystem. It enables comparisons between conditions at plot, field or watershed level under different land uses and management practices. Ijebu-Igbo is a semi-urban town in Ogun State, Southwest Nigeria known for its agricultural production activities especially with arable crops, plantation crops and fruit crops. Ijebu Igbo is the second largest town in Ogun State in terms of landmass (Nigeria Galleria, 2017) and this landmass extends to and has three important boundary points at Ibadan, Ikire and Ondo (Wikipedia, 2018). The landmass has a lot of arable lands and the majority of the people in the rural areas of the town are engaged in farming. Crops grown include cassava, maize, banana/plantain, oil palm, cocoa, kola nut and citrus. In addition to their farming activities, Ijebu Igbo has other economic activities like gari production, timbering, exploitation of mineral resources, the existence of many sawmills and also a developed quarry. Aromolaran (2012) also sited that Ijebu Igbo is one of the towns in Ogun State, where sand mining is on the increase especially on arable agricultural land. These economic activities and poor land use/management practices by the farming communities have resulted in a potential land degradation threat in the farming communities and a potential decline of soil quality. There is, therefore, need to assess the quality (health) of the soils in the area as a land degradation preventive tool to promote the sustainability of the soil for production for many years to come. The objective of the study was to evaluate the impact of the different land use systems in the Ijebu-Igbo region on soil quality.

2.0 Materials and Methods

2.1 Study Site and Land Use Systems

The study was carried out at Ijebu-Igbo, a semi-urban region in Ogun State, Southwest Nigeria. Ijebu-Igbo lies within latitude 6° 58' 0'N and longitude 4° 0' 0'E, and located within the rain forest agro-ecological zone of Nigeria. It has bimodal rainfall distribution which reaches its maximum in September, with a short dry season of about 2 months. Average annual rainfall is about 1,600mm with about 10 months (February to November) of rain in the year (Weather Spark, 2020). The study area has two temperature regimes during the year with an average maximum and minimum temperatures of 33.9°C and 20.6°C respectively. The length of the day in Ijebu-Igbo does not vary substantially over the course of the year, staying within 31 minutes of 12 hours. Relative humidity varies between 76 and 100%, the highest humidity is experienced during the peak of the rainy period. The site experiences mean monthly sunshine hours that vary between 363.3 hours in December and 375.9 hours in May. The soils of this location are predominantly formed from Sedimentary rocks under forest vegetation and classified as Alfisols and Ultisols (USDA) or Luvisols and Acrisols (FAO/UNESCO). They are non-leached coastal plain soils (Chude *et al.,* 2012). The study was conducted on three different land use systems within the Ijebu Igbo area under use for over a ten year period. The identified land use systems (Table 1) of the study area were: plantain/banana orchard (LU-1), arable farming (LU-2) and fallow/secondary forest (LU-3).

Table 1. Land use systems of the site with coordinate points and mapping units

Units	Land Use Systems	Latitude	Longitude	Elevation (m)
LU-1	Plantain/Banana Orchard	N6° 58.045'	E3° 58.768'	70
LU-2	Arable Farmland	N7° 02.282'	E4° 04.173'	101
LU-3	Fallow/Secondary Forest	N6° 57.873'	E3° 58.873'	94

Soil Sampling, Sample Preparation and Laboratory Analysis

Each farm location/land use type was divided into five blocks, and bulk soil samples were obtained at two (2) depths of 0-30cm and 30-60cm. Each bulk sample was taken from 3 – 4 spots per block. The samples were air-dried, crushed with porcelain mortar and pestle, sieved with a 2mm sieve and bagged for laboratory analysis. Laboratory analysis was done using standard laboratory procedures. Total organic carbon was determined by Wakley and Black method (Wakley and Black, 1934), total nitrogen by the Kjeldahl method (Bremner, 1960), pH was determined using a glass electrode pH meter (Woodruf, 1948), available phosphorus was determined using Bray P-1 extraction method (Bray and Kurtz, 1945), exchangeable bases was determined using 1N ammonium acetate, bulk density was determined using the core method (Blake, 1965) and particle size analysis was determined using Bouyoucos hydrometer method (Bouyoucos, 1951). Available iron and zinc were extracted using 0.1N HCl, filtered and read with an AAS.

Soil Quality Index

The soil quality index was calculated using the soil quality index equation proposed by Bajracharya *et al* (2006) using the equation below:

$SQI = [(a*R_{STC}) + (b*R_{pH}) + (c*R_{OC}) + (d*R_{NPK})]$ ----------------- (1)

Where R_{STC}, R_{pH}, R_{OC}, R_N, R_P, R_K are assigned ranking values for soil textural class, soil pH, soil organic carbon, nitrogen, phosphorus, and potassium, while a=0.2, b=0.1, c=0.4 and d=0.3 are weighted values corresponding to each of the parameters.

Table 2: Soil Quality Index based on an assigned range of values suggested by NARC

Parameters	Ranking Values				
	0.2	0.4	0.6	0.8	1.0
Soil Textural Class	C, S	CL, SC, SiC	Si, LS	L, SiL, SL	SiCL, SC
Soil PH	<4	4.1 – 4.9	5.0 – 5.9	6.0 – 6.4	6.5 – 7.5
Soil Organic Carbon (%)	<0.5	0.6 – 1.0	1.1 – 2.0	2.1 – 4.0	>4.0
Fertilizer (NPK)	Low	Moderately Low	Moderate	Moderately High	High
Soil Quality Index (SQI)	Very Poor	Poor	Fair	Good	Best

Nepal Agricultural Research Council (NARC)

Table 3: Interpretation Table for Soil Fertility (NARC)

OM (%)		TN (%)		AP (kg/ha)		AK (kg/ha)	
Range	Level	Range	Level	Range	Level	Range	Level
<2.5	Low	<0.1	Low	<31	Low	110	Low
2.5-5.0	Medium	0.1-0.2	Medium	31-55	Medium	110-280	Medium
>5.0	High	>0.2	High	>55	High	>280	High

Nepal Agricultural Research Council (NARC)

Legend: OM – organic matter; TN – total nitrogen; AP – available phosphorus; AK – available potassium.

The scoring method used to interpret this SQI was developed by the Nepal Agricultural Research Council (NARC) and is highlighted in Table 2 while the level of soil fertility was determined using a Fertility Interpretation Chart also developed by NARC and is shown in Tables 3

Statistical Data Analysis

The data collected were subjected to statistical analysis using ANOVA while the means were separated using Fishers LSD using SAS Statistical Software

3.0 Results and Discussion

3.1 Impact of Land Use Systems on Physical Soil Quality Indicators

3.1.1 Clay Content

The clay content of the soil from the land use systems varied significantly (P<0.05) at both soil depths (Table 4). At 0-30cm, clay content varied in the order: plantain/banana field < fallow/secondary forest < arable farmland with the mean values of 45.6, 64.8 and 77.6 g/kg respectively. The results also showed that clay content varied significantly (P<0.05) among the land uses with the soil of the arable farmland recording the highest clay and the plantain/ banana orchard with the lowest clay content. At 30-60cm, clay content varied in the order: fallow/secondary forest < plantain/banana field < arable farmland with the mean values of 99.0, 159.4 and 221.6 g/kg respectively. Arable farmland soil recorded the highest clay content while the fallow/secondary forest had the lowest clay content. The high clay content observed in the arable farmland could be due to the continuous cropping of arable crops (maize and cassava). Clay content also increased with depth in all the land use systems as also cited by Belachew and Abera (2010).

3.1.2 Bulk Density

The bulk density in all the land use systems at 0–30cm varied from 1.43 – 1.45 Mg/m^3 in the order plantain/ banana field < fallow/secondary forest < arable farmland with the mean values of 1.43, 1.44 and 1.45 Mg/m^3 respectively. The results showed that bulk density varied significantly (P<0.05) among the land use systems with the highest bulk density found in the soil under arable farming while the lowest bulk density was observed in the plantain/ banana field. The high bulk density of the arable farmland might be as a result of intensive agricultural production practices for arable farmlands (Emadi *et al.,* 2008) of which in this case is the continuous cropping of maize and cassava, which is also consistent with the results of Oguike and Mbagwu (2009). At 30-60cm, the bulk density varied significantly (P<0.05) among the land-use systems in the order fallow/secondary forest < plantain/banana field < arable farmland with mean values of 1.46, 1.49 and 1.51 Mg/m^3 respectively.

3.1.3 Porosity

Porosity in the land-uses varied from 45.21 – 46.12% at 0-30cm and 43.17 – 44.76% at 30-60cm. The results showed that porosity varied significantly (P<0.05) among the land use systems with the highest porosity found in the soil under plantain/banana orchard (46.12%) at 0-30cm and fallow/secondary forest (44.76%) at 30-60cm. The lowest porosities were observed in the soil of the arable farmland at 45.21% and 43.17% for 0-30cm and 30-60cm respectively. The least porosity observed at both depth in the soil of the arable farmland might be due to the higher bulk densities recorded in them as reported by other authors. Osakwe and Igwe (2013) stated that high bulk density is a strong indicator of poor soil porosity and soil compaction. This might cause the restriction of root growth and poor air and water movement through the soil.

3.1.4 Saturated Hydraulic Conductivity

The saturated hydraulic conductivity (SHC) varied significantly (P<0.05) among the land use systems with the soil under the plantain/banana orchard recording the highest SHC of 10.67 cm/hr at 0-30cm while the fallow land recorded the highest SHC of 6.73cm/hr at 30-60cm. The lowest SHC was observed in the soil of the arable farm with

Table 4: Impact of land use on physical indicators at 0-30cm and 30-60cm soil depths

Land Use Types	Clay (g/kg)	BD (Mg/m^3)	Porosity (%)	SHC (cm/hr)
0-30cm				
Plantain/Banana Field	45.6b	1.43b	46.12a	10.67a
Arable Farmland	77.6a	1.45a	45.21b	8.14b
Fallow/Secondary Forest	64.8ab	1.44ab	45.51ab	9.19ab
30-60cm				
Plantain/Banana Field	159.4ab	1.49ab	43.93ab	4.35ab
Arable Farmland	221.6a	1.51a	43.17b	2.33b
Fallow/Secondary Forest	99.0b	1.46b	44.76a	6.73a

BD – bulk density, SHC – saturated hydraulic conductivity

8.14 and 2.33 cm/hr at 0-30 and 30-60cm respectively. The porosity and SHC followed the same trend at both depths and in the land-use systems.

3.2 Impact of Land Use Systems on Chemical Soil Quality Indicators

3.2.1 pH

The pH generally decreased with depth in all the land use systems. The soil pH varied from 6.28–6.69 and from 5.29–6.65 at 0-30 and 30-60cm depths respectively in the different land use systems (Table 5). The fallow/secondary forest had the highest soil pH at both depths while the arable farmland had the lowest at 0-30cm and the plantain/banana field at 30-60cm. The soil pH of the land use systems were in the order: 6.69 < 6.30 < 6.28 for fallow/secondary forest, plantain/banana and arable farmland respectively at 0-30cm. The soil pH in the fallow/secondary forest was neutral while the plantain/banana and arable farmland were slightly acidic according to the rating for soil fertility classes (Chude *et al.,* 2012). The soil pH order of the land use systems at 30-60cm was 6.65 < 5.36 < 5.29 for fallow/secondary forest, arable farmland and plantain/banana field respectively. The soil pH in the fallow/secondary forest was neutral while the plantain/banana and arable farmland were strongly acidic inferring that soil pH (acidity) increased with depth in all the land use systems with the exception of the fallow/secondary forest.

3.2.2 Organic Carbon

Soil organic carbon (OC) for all land use systems at 0–30 cm depth ranged from a minimum in plantain/banana field (1.11 g/kg) followed by fallow/secondary forest (1.25 g/kg) to a maximum in the arable farmland (1.28 g/kg) though OC didn't vary significantly between the fallow/secondary forest and the arable farmland. The high OC in the fallow/secondary forestland might be as a result of decomposed tree leaves, stems, barks, flowers, logs, and fruits while for the arable land, the returns of the plant residues into the soil after every cropping might have accounted for this because microorganisms, animals, and roots contribute to the increase of organic matter and hence OC (Bizuhoraho *et al.,* 2018). At 30–60 cm, the OC reduced in all the land use systems and didn't vary significantly (P<0.05) between the plantain/banana field and arable farmland but varied significantly between them and the fallow/secondary forest. The OC occurred in the order: 0.79 < 0.71 < 0.54 g/kg in plantain/banana field, arable farmland and fallow/seconday forestland respectively. OC reduced with depth.

3.2.3 Total Nitrogen

The results showed that total nitrogen (TN) did not vary significantly among the land use systems. The plantain/banana and arable farmland had 0.11 g/kg TN while the fallow/secondary forestland had 0.12 g/kg at 0-30cm. TN also did not vary significantly among the land-use systems at 30-60cm and ranged from 0.06 – 0.09 g/kg. The plantain/banana field recorded the highest TN concentration (0.09 g/kg) followed by arable farmland (0.07 g/kg) while the fallow/secondary forest had the lowest TN (0.06 g/kg).

3.2.4 Available Phosphorus

The available phosphorus (AP) did not vary significantly (P<0.05) among the land use systems at 0-30cm from 6.00 – 8.08 mg/kg in the order fallow/secondary forest < plantain/banana field < arable farmland with mean values of 6.00, 7.55 and 8.08 mg/kg respectively. At 30-60cm, the AP increased in the plantain/banana (7.61 mg/kg) and arable farmland (9.34 mg/kg) but reduced in the fallow/secondary forestland (3.66 mg/kg). The AP varied significantly among the land use systems at this depth with the arable farmland having the highest AP and the fallow/secondary forest with the lowest.

3.2.5 Exchangeable Potassium

The exchangeable potassium (EP) concentration did not vary significantly (P<0.05) among the land use systems at 0-30cm but varied significantly at 30-60cm. The soil in the arable farmland had the highest EP (0.21 cmol/kg), followed by the plantain/banana field (0.16 cmol/kg) and then the fallow/secondary forest (0.15 cmol/kg) at 0-30cm. EP varied significantly (P<0.05) at 30-60cm among the land-use types from 0.10 – 0.14 cmol/kg in the order: fallow/secondary forest < plantain/banana field < arable farmland with mean values 0.10, 0.12 and 0.14 cmol/kg respectively. The EP reduced with depth in all the land-use systems.

3.2.6 Effective Cation Exchange Capacity

The effective cation exchangea capacity (ECEC) at 0-30cm varied significantly (P<0.05) among the land uses in the order: arable farmland (9.77 cmol/kg) < plantain/banana farmland (10.95 cmol/kg) < fallow/secondary forest (14.95 cmol/kg). The ECEC reduced at 30-60cm and varied significantly among the land uses in the order: plantain/banana (9.42 cmol/kg) < arable farmland (9.54 cmol/kg) < fallow/secondary forest (13.72 cmol/kg). The ECEC also reduced with depth in all the land-use systems.

3.2.7 Available Iron

Iron was deficient in the soil of all the land use systems with the exception of the fallow/secondary forestland. Iron varied significantly (P<0.05) at 0-30cm among the land uses in the order: arable farmland (7.22 mg/kg) < plantain/banana field (9.01 mg/kg) < fallow/secondary forest (21.21 mg/kg). The results also showed a reduction in iron concentrations in the plantain/banana field (7.91 mg/kg) at 30-60cm while the arable farmland and fallow/secondary forest had increased iron concentrations at 8.26 and 31.66 mg/kg respectively. Iron equally varied significantly (P<0.05) among the land-uses at 30-60cm.

3.2.8 Available Zinc

Zinc varied significantly (P<0.05) at 0-30cm among the land uses but did not vary significantly at 30-60cm. At 0-30cm, zinc varied from 4.01 – 6.12 mg/kg in the order plantain/banana (4.01 mg/kg) < arable farmland (5.18 mg/kg) < fallow/secondary forest (6.12 mg/kg). At 30-60cm, zinc did not vary significantly among the land uses and also reduced in concentration. It insignificantly varied from 3.36 – 3.52 in the order: plantain/banana field (3.36 mg/kg) < fallow/secondary forest (3.49 mg/kg) < arable farmland (3.52 mg/kg).

3.3 Impact of Land Use Systems on Soil Quality

The soil quality (SQ) did not vary significantly among the land use systems at both soil depths. Soil quality varied significantly from 0.52 – 0.56 at 0-30cm and did not vary at 30-60cm (0.48). The fallow/secondary forest had the highest soil quality level at 0.56, followed by the arable land (0.54) and the plantain/banana field had the least soil quality (0.52) at 0-30cm. All the land use system had the same soil quality level of 0.48 at 30-60cm. The results further showed that soil quality in all the land use systems declined slightly with soil depth.

Soil quality indicators are soil physical, chemical and biological properties, processes and characteristics that can be measured to monitor changes in the soil (Natural Resource Conservation Service – NRCS, 1996). The results for the physical and chemical soil quality indicators at both depths shows clearly that no single indicator had the best value in the land use type that can be used to determine the quality of the soil. This further supports the submission of the NRCS (1996) that no single property or indicator can be used as an index of soil quality, hence the need for a minimum data set (MDS). The MDS is the smallest set of soil properties or indicators needed to measure or characterize soil quality (Larson and Pierce, 1991; Doran and Parkin, 1996)

Table 5: Impact of land use on chemical soil quality indicators at 0-30cm and 30-60cm soil depths

Land Use Types	**pH**	**OC (g/kg)**	**TN (g/kg)**	**AP (mg/kg)**	**K (cmol/kg)**	**ECEC (cmol/kg)**	**Zn (mg/kg)**	**Fe (mg/kg)**
0-30cm								
Plantain/Banana Field	6.30b	1.11a	0.11a	7.55a	0.16a	10.95b	4.01b	9.01b
Arable Farmland	6.28b	1.28a	0.11a	8.08a	0.21a	9.77c	5.18ab	7.22b
Fallow/Secondary Forest	6.69a	1.25a	0.12a	6.00a	0.15a	14.95a	6.12a	21.21a
30-60cm								
Plantain/Banana Field	5.29b	0.79a	0.09b	7.61ab	0.12ab	9.42b	3.36a	7.91b
Arable Farmland	5.36b	0.71a	0.07b	9.34a	0.14a	9.54b	3.52a	8.26b

OC – organic carbon, TN – total nitrogen, AP – available phosphorus, K – potassium, Zn – zinc, Fe – iron, ECEC – effective cation exchange capacity

Table 6: Impact of land use on soil quality at 0-30cm and 30-60cm soil depths

Land Use Types	**Soil Quality at 0-30cm**	**Soil Quality at 30-60cm**
Plantain/Banana Field	0.52a	0.48a
Arable Farmland	0.54a	0.48a
Fallow/Secondary Forest	0.56a	0.48a

4.0 Summary and Conclusion

This study was conducted to assess the soil quality (health) status of the soils under different land use systems at Ijebu Igbo in Ogun State. The results showed that though some soil quality indicators varied significantly among the land use systems, the land use systems didn't not significantly impact the soil quality at both soil depths.

The SQ varied significantly among the land use systems with the fallow/secondary forest having the best soil quality, followed by the arable farmland and then the plantain/banana field.

The overall soil quality of the three land use systems was relatively moderate at 0-30cm depth but poor at 30-60cm depth. There was also no significant impact of the land use types on soil quality at both depths and soil quality declined with depth for all the land use types.

It is therefore encouraged that the practice of the use of organic soil amendments should be continued in the location and recommended for continued soil quality sustainability in the region. Soil mining should be discouraged as most of the fallow/secondary forest have been degraded by soil mining.

References

Aromolaran, A. K. (2012). Effects of sand mining activities on land in agrarian communities of Ogun State. Continental Jor. Agric. Sci. 6 (1): 41-49, 2012.

Bajracharya, R. M., Sharma, S., Dahal, B. M., Sitaula, B.K. and Jeng, A. (2006). Assessment of soil quality using physicochemical and biological indicators in a mid-hills watershed of Nepal. Conference: Proceedings of the International Seminar: Environmental and Social Impacts of Agricultural Intensification in Himalayan Watersheds. https://www.researchgate.net/publication/233952574. p1-11

Belachew, T. and Abera, Y. (2010). Assessment of soil fertility status with depth in wheat growing highlands of Southeast Ethiopia. World J. Agric. Sci., 6:525-531

Bizuhoraho, T., Kayiranga, A., Manirakiza, N. and Mourad, K.A. (2018). Positive effect of land use systems on soil properties; a case study from Rwanda. Sustainable Agriculture Research, vol. 7, no. 2, pp. 30–40, 2018.

Blake, G. R. (1965). Bulk Density. In: Methods of soil analysis (Black, C.A. (eds)), *America Society of Agronomy.*

Bouyoucos, G. H. (1951). A recalibration of the hydrometer for making mechanical analysis of soils. *Agron. Jour.* 43 434 – 438.

Bray, R. H. and Kurtz, L.T. (1945). Determination of Total Organic and Available Forms of Phosphorus in Soils. Soil Sci. **59**: 39-45

Bremner, J. M. (1960). Determination of nitrogen in soil by Kjeldahl method. *Journal of Agriculture Science.*

59: 39 – 45.

Chude, V.O., Olayiwola S.O., Osho, A.O. and Dauda C.K. (2012). Fertilizer Use and Management Practices for Crops in Nigeria. 4th Edition. Pp. 22-25, 42.

Doran, J. W. and Parkin, T. B. (1996). Quantitative indicators of soil quality: a minimum data set. In: Doran, .W., Jones, A.J. (Eds.), Methods for Assessing Soil Quality. SSSA Special Pub. 49, *Soil Sci Soc. Am., Madison, WI*, pp. 25-37.

Emadi, M., Emadi, M., Baghernejad, M., Fathi, H. and Saffari, M. (2008). Effect of Land use change on selected soil physical and chemical properties in North Highlands of Iran. Journal of Applied Sciences, vol. 8, no. 3, pp. 496–502, 2008.

Gelaw, A. M., Singh, B. R. and R. Lal (2015). Soil quality indices for evaluating smallholder agricultural land use in Northern Ethiopia. *Sustainability,* **2015,** 7. 2322 – 2337.

Guilser, C. (2006). Effect of forage cropping treatment on soil structure and relationship with fracta dimensions," Geoderma, vol. 131, no. 1-2, pp. 33–44, 2006.

Karlen, D. L., Mausbach, M.J., Doran J.W., Cline. R.G., Harris, R.F. and Schuman, G.E. (1997). Soil quality: a concept, definition, and framework for evaluation (a guest editorial). *Soil Science of America Journal 61: 4-10.*

Larson, W. E. and Pierce, F.J. (1991). Conservation and enhancement of soil quality. In: Dumanski, J., Editor, 1991. Evaluation for Sustainable Land Management in the Developing World. Proceedings of the International Workshop, Chiang Rai, Thailand, 15-21 Sept 1991. Technical papers vol 2, int. Board for Soil Res. And Management, Bangkok, Thailand, pp. 175-203.

Nigeria Galleria (2017). Nigeria Galleria: Ijebu Igbo, Ogun State. www.nigeriagalleria.com

Natural Resource Conservation Service (NRCS) (1996). Indicators for Soil Quality Evaluation. USDA- NRCS, Soil Quality Institute, and National Soil Survey Centre: Soil Quality Information Sheet-Soil Quality Indicators. Lincoln NE.

Oguike, P.C. and Mbagwu, J.S.C. (2009). Variations in some physical properties and organic matter content of soils of coastal plain sand under different land use types. World Journal of Agricultural Sciences, vol. 5, no. 1, pp. 63–69, 2009.

Osakwe, U. C. and Igwe, C.A. (2013) "Conversion of forests to arable land and its effect on soil physical properties in Enugu State South Eastern Nigeria," Nigerian Journal of Biotechnology, vol. 26, pp. 33–40, 2013.

Sanchez, P.A. (1997). Soil fertility replenishment in Africa: an investment in natural resource capital. In: Buresh, R.J., Sanchez, P.A. and Calhoun, F., Editors, 1997. Replenishing Soil Fertility in Africa. SSSA Special Publication vol. 51, *Soil Science Society of America, Madison, WI, pp*. 1-46.

Wakley, A.J and Black, I.A. (1934). Estimation of soil organic carbon by the chromic acid titration method. *Soil Science.* 37: 29 – 38.

Weather Spark (2020). Average Weather in Ijebu-Igbo Nigeria.https://weatherspark.com/y/48832/Average-Weathe -in-Ijebu-Igbo-Nigeria-Year-Round

Wikipedia (2018). In Ijebu Igbo. www.wikipedia.com

Woodruf, C. M. (1948). Testing soils for the lime requirement by means of a buffered solution and the glass electrode. *Soil Sci*. 66: 53-63.