Physio-morphological Characteristics of Soil of Akure, Ondo State SW, Nigeria

B. F. Dada*, B. S. Ewulo, M. A. Awodun, T. D. Adebisi and S. O. Ajayi

*Department of Crop, Soil and Pest Management, Federal University of Technology Akure, Ondo State, Nigeria.

Authors’ contributions

This work was carried out in collaboration among all authors. Author BFD designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors BSE and MAA managed the analyses of the study. Authors SOA and TDA managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2020/v32i1130346

1 Prof. Marco Trevisan, Catholic University of the Sacred Heart, Italy.
2 Matheus Souisa, University of Pattimura, Indonesia.
3 K.V. Mohanan, University of Calicut, India.

Received 12 June 2020
Accepted 17 August 2020
Published 29 August 2020

ABSTRACT

Soil physical properties influence soil water infiltration rate, plant rooting depth, amount of available water, air and nutrients which are of utmost importance in agricultural production and, hence there is need to describe in-situ spatial organization and physical properties of soil in Akure. Sixteen profile pits were dug. The soils were characterized and described on the field and samples collected for textural analysis. The area occurs on level plain with little slope gradient, the surface horizons \( A_1 \) and \( A_2 \) were weak medium crumby to moderate medium crumby structures while the subsurface horizons \( Bt_1 \) and \( Bt_2 \) showed moderate medium blocky structure. The soils are generally deep and well drained at the top soil with coarse texture; the subsoils are characterized by prominent presence of mottles, which suggest that the subsoils are poorly drained. The distribution of clay content increased with soil depth for all pedons. Most of the Pedons had reddish gray colour (2.5YR 4/1) and dull reddish brown 2.5YR 4/3 at the surface horizons \( A_1 \) and \( A_2 \), over brownish colour (7.5YR 4/4) and dull reddish brown (5YR 4/4) sub soil. The particle size distribution revealed that sand dominated the particle size fraction of the soil in all the profiles, which could be managed with appropriate organic manure.
1. INTRODUCTION

Research on Akure soil dynamics in relation to agricultural development is scanty. Akure has two local government areas North and South. Agricultural land is becoming a scarce resource in Akure due to massive demographic pressure growing rapidly owing to favourable socio-economic, political, and physical factors. [1] has described the resultant changes in soil nutrients, morphology and physical parameters. This information of land evaluation is essential for determining the origin and fertility of the soils and its distribution in the study area. The result of the study provided updated information on study area using spatial analysis, detailed digital soil maps, data tables and text narratives could be used in land planning programs.

2. METHODOLOGY

2.1 Description of the Study Area

The study was carried out in both Akure North and Akure South Local Government Areas of Ondo State. The areas are agrarian communities located in tropic rainforest zone in Nigeria. The citizens are predominantly farmers and Akure is the trade center for a farming region where cocoa, yams, cassava, and corn are grown. The locations lie within latitude 7°09’ and 7°19’N and longitudes 5°07’ and 5°17’E.

2.2 Topography

The metropolis is located on a gentle undulating terrain surrounded by isolated hills and inselbergs. Topographic elevations vary between 260 and 470 m above sea level [2].

2.3 Climate and Rainfall

The climate of the study areas is hot and humid, influenced by rain bearing Southwest Monsoon winds from the ocean and dry Northwest winds from the Sahara desert. The raining season lasts from April to October with rainfall of about 1524 mm annually. Temperatures vary from 28°C to 31°C with mean annual relative humidity of about 80(%).

2.4 Field Studies and Sampling Techniques

The study was carried out in Akure North and South L.G.A of Ondo State. The sites were divided into Map Grids and pedons established within the grids. Sixteen pedons (1.5 m wide x 1.0 m long x 1.5 m deep) were established. The pedon locations were geo-referenced with Global Positioning System (GPS) (Table 1). Horizons were designated and morphological description carried out on the field in moist condition using Munsell Soil Colour Charts. 500 g soil representative samples were collected from each of the designated horizon. They were packed in polythene bags, neatly labelled and taken to the laboratory for physical and chemical analysis. The soil samples were air dried, gently ground in a mortar and sieved with a 2 mm sieve. Particle size distributions were determined by hydrometer method [3]. Soil pH was determined using a glass electrode in 1:2 soil: water ratio [4] (Thomas, 1996). Soil organic carbon (O.C) was determined using Walkley and Black method and organic matter estimated by multiplying with a factor of 1.724 as was done by [5]. Total Nitrogen was determined by Kjeldahl digestion procedure [6]. Available phosphorus was determined using the Bray-P method and exchangeable acidity by KCl extraction method [7]. Exchangeable bases (Ca, Mg, Na and K) were extracted by leaching with 1N NH4OAC (pH 7.0). Ca and Mg were determined by Atomic absorption spectrophotometer. GIS of the study area and remote sensing were developed with ARC GIS 10.3 and soil position taken by Land meter NF-198. The images were enhanced, geo-referenced, classified and digitized.

2.5 Laboratory Analysis

The soil samples collected were analysed using standard procedures. All the soil samples were air-dried and then sieved using a 2 mm sieve and particle sizes larger than 2 mm were weighed as gravel. Those that were less than 2 mm were used for laboratory analysis and particle size distribution of the soils were determined by the method of [7] and hydrometer method described by [8]. Soil bulk density was determined as per [9].

3. RESULTS

3.1 Pedon 1 (Igoba)

The Pedon was located on nearly level plain with slope gradient 0-2 (%) with elevation 356 above sea level. It was well drained and deep (120cm); colour matrix of the epipedon ranged from dark
brown (7.5YR 3/4) to bright brown (7.5YR 6/8) while the epipedon exhibited orange colour matrix (2.5YR 6/8); prominent mottling colour was brown (2.5YR 3/6) at Btg2 horizon. The top soil (A1) exhibited moderate medium crumby structure while subsurface has strong fine blocky structure. Consistence showed firm in the surface horizon while the endopedons were very firm. Fine, medium to very few root concentration was observed in the top soil.

Fig. 1. Map of Akure south and north local government area of Ondo State showing locations of profile pits dug
Table 1. GPS readings of pedons sites

| Pedon Sites | Longitude (E) | Latitude (N) | Elevation |
|-------------|---------------|--------------|-----------|
| 1 Igoba     | 5.25148       | 7.33326      | 351       |
| 2 Saasa     | 5.25306       | 7.2902       | 347       |
| 3 Airport   | 5.27067       | 7.262        | 323       |
| 4 Oda       | 5.23815       | 7.14666      | 329       |
| 5 Imafo-Irado | 5.28192     | 7.20673      | 327       |
| 6 Iju       | 5.33001       | 7.39464      | 332       |
| 7 Ogbese    | 5.370401      | 7.25791      | 309       |
| 8 Eleyo-owo | 5.28757       | 7.27274      | 336       |
| 9 Aladura   | 5.30886       | 7.34136      | 330       |
| 10 Alagbado | 5.17608       | 7.31883      | 406       |
| 11 Adofure  | 5.17634       | 7.20205      | 356       |
| 12 Olokuta  | 5.13219       | 7.25593      | 354       |
| 13 FECA     | 5.23733       | 7.26462      | 347       |
| 14 Seebi    | 5.176         | 7.29286      | 377       |
| 15 FUTA     | 5.14194       | 7.30134      | 375       |
| 16 Ijoka Olope | 5.20312     | 7.18417      | 345       |

3.2 Pedon 2 (Saasa)

Pedon 2 was formed on a convex topography with a slope gradient of 0-2(%) and an elevation of 351 m above sea level. The pedon was well drained and deep (130 cm). The surface horizons were dark brown (7.5YR 3/4) at A₁ horizon and bright brown (7.5YR 5/6) at Bt₁ horizon while Btg2 exhibited orange colour (2.5YR 6/8) at the endopedon. The pedon had moderate medium crumby structure from the surface horizon while the successive horizons (Bt₁ and Btg₂) had moderate medium blocky and strong fine blocky structure respectively. Consistence was firm in the surface horizon while the endopedon was very firm.

3.3 Pedon 3 (Airport)

Pedon 3 was poorly drained and not deep well. It occurred on nearly planar landscape with a slope gradient of 0-2(%) and an elevation of 350 m above sea level. The pedon exhibited dark brown (5YR 3/4) endopedon. Colour mottling is brown. The surface horizon was strong and very coarse while the endopedon exhibited strong coarse crumby structure. Consistence ranged from very friable, friable to fine firm at the surface. Root was frequent at the surface horizon.

3.4 Pedon 4 (Oda)

Pedon 4 occurred at 331 m above sea level, an almost flat terrain with 0-2 (%) slope gradient. The pedon was well drained and deep (150 cm). The surface horizons of the pedon ranged from reddish gray to dull reddish brown (2.5YR 4/1 to 2.5YR 4/3) while the subsurface horizons ranged from brown color to dull reddish brown (7.5YR 4/4 – 5YR 4/4). Mottling colour at endopedon was yellow to orange (7.5 YR 7/8 YR). The top soil (A₁ and A₂) exhibited weak to moderate medium crumby structure whereas, the sub soil was moderate medium blocky with friable consistence (A₁ and A₂) at the surface whereas it was firm at subsurface. Roots concentrated was high at A₁ and A₂ horizons.

3.5 Pedon 5 (Imafo-Irado)

Pedon 5 was formed on valley bottom topography, with a slope gradient of 0-2(%) with an elevation of 323 m; the horizon colour was dark brown (7.5YR 3/4) and A₂ was bright reddish brown (5YR 5/6). The highest sand percentage was obtained at A₁ and A₂ horizon 50 (%) each) while clay percentage was the highest at Btg2 horizon. Gravel content was the highest at Btg2 horizon with 204 g. Horizon Bt₁ and Btg2 have the highest bulk density of 1.25 g/cm. Soil textures are Sandy Loam (SL) and Clay Loam (CL).

3.6 Pedon 6 (Iju)

Pedon 6 on the landscape was nearly level plain with a slope gradient of (0 – 2 %) and an elevation of 333.9 m above sea level. The soil was deep and well drained with no encounter to water table and impenetrable layer at the depth
3.8 Pedon 8 (Eleyo-owo)

Pedon 8 was well drained and deep with slope gradient of 0-2(%) with an elevation of 336 m above sea level. The colour matrix ranged from dark reddish brown (2.5YR 3/4) A1, red colour matrix (2.5YR 5/6) at Bt1 and strong brown (7.5YR 4/6) subsoil with (2.5YR 3/6) dark reddish colour mottles at the last horizon. The pedon had moderate medium crumb structure from the surface horizon to 30 cm depth while the successive horizons (Bt1 and Btg2) were moderate blocky and fine strong blocky. Consistence condition revealed firm at the surface horizon and very firm subsurface horizon. Presence of root at the upper 30 cm was fine medium to a few roots and very fine and very few roots at the sub horizons (30-90 cm). There was no root at the last horizon Btg2.

3.9 Pedon 9 (Aladura)

Pedon 9 was located on nearly level plain with slope gradient of 0-2(%) with an elevation of 304 m above sea level. It was well drained and deep (> 105 cm). Colour matrix varied from dark brown (7.5YR 3/4) epipedon to reddish yellow (7YR6/8) endopedon. The pedon had moderate medium crumb structure in the epipedon and moderate medium blocky structure in the subsoil. Consistence was firm at the epipedon and very firm at the endopedon. Common to medium roots concentrated found at A1 and A2.

3.10 Pedon 10 (Alagbado)

The results of the morphological properties of the soil of the study area are shown in Table 1. The position of pedon 10 on the landscape was nearly level plain with a slope gradient of 0-2 (%) and an elevation 393 m above sea level. The soil was deep and well drained. The surface horizon (A1 and A2) were brownish black (10YR 2/2) and dull reddish brown (5YR 4/3) underlain by brown colour (2.5YR 4/8). The subsurface horizons (Bt2 and Bt3) exhibited some mottling characteristics with both having 2.5Y 7/8. The surface horizons exhibited moderate crumbly structure from the surface horizon while the successive horizons (Bt2 and Btg3) are blocky, consistence was friable in the surface horizon while the endopedons were firm, very few root concentrated in the upper surface of the pedon. The vegetation of the area is mainly elephant grass, sunflower etc.

3.11 Pedon 11 (Adofure)

The profile was well drained and deep. It occurred on nearly level plain landscape with a slope gradient of 0.2(%) and an elevation of 375 m above sea level. The pedon exhibited dark colour (2.5YR 3/2 – 10R 5/6) (A1 and A2) over red coloured (10R 5/6 – 10R 5/8) endopedon. The surface horizons had weak fine crumby structure while the endopedon exhibited moderate medium angular blocky structure. Consistence varied from very friable to friable at the surface horizons while it varied from firm to very firm at the subsurface horizons, root was firm and common on the surface horizon (A1 and A2) while the subsurface horizons were firm and the few common vegetation found is Titonia dyfasiltiola.
Table 2. Akure North L.G.A: Soil morphology properties of pedon 1-5

| Pedon  | Horizon | Depth(cm) | Colour(Moist) | Mottles | Drainage | Slope (%) | Structure | Consistence | Root | Boundary |
|--------|---------|-----------|---------------|---------|----------|-----------|-----------|-------------|------|----------|
| 1      | Igoba   |           |               |         |          |           |           |             |      |          |
|        | A1      | 0-26      | 7.5YR ¾       | Absent  | Good     | 0-2       | 2.cr.m    | Fm          | f.cm | d, g     |
|        | A2      | 26-47     | 7.5YR 4/5     | Absent  | Good     |           | 2.cr.m    | Fm          | f-m.fw | s, h    |
|        | Bt1     | 47-90     | 7.5YR 5/6     | Absent  | Good     |           | 2 bk.m    | Vfm         | vf.vfw | a, s    |
|        | Btg2    | 90-120    | 2.5YR 6/4     | 2.5YR 3/6 | Good  | 3 bk.f    | Vfm         | Absent     | a, s   |
| 2      | Saasa   |           |               |         |          |           |           |             |      |          |
|        | A1      | 0-30      | 7.5YR ¾       | -       | Good     | 0-2       | 2.cr.m    | Fm          | f-m.fw | c, s    |
|        | Btg1    | 30-70     | 7.5YR 5/6     | -       | Good     |           | 2 bk.m    | Vfm         | vf.vfw | a, s    |
|        | Btg2    | 70-130    | 2.5YR 6/8     | 2.5YR 3/6 | Good  | 3 bk.f    | Vfm         | -           | c, s   |
| 3      | Airport |           |               |         |          |           |           |             |      |          |
|        | A1      | 0-30      | 5YR 3/2       |         | Good     | 0-2       | 3 vc      | vfr-fr      | vf-c. fq-a | d, g |
|        | Btg1    | 30-70     | 5YR 3/4       | 10YR 6/8 | Good  | 3 cr.c    | f.fm         | -           | s, h   |
| 4      | Oda     |           |               |         |          |           |           |             |      |          |
|        | A1      | 0-30      | 2.5YR 4/1     | -       | Good     | 0-2       | 1 cr.m    | Fr          | f-m.cm | a, s    |
|        | A2      | 30-70     | 2.5YR 4/3     | -       | Good     |           | 2 cr.m    | Fr          | f-vfw   | d, w    |
|        | Btg1    | 70-100    | 7.5YR 4/4     | -       | Good     |           | 2 bk.m    | Vmf         | a, s   |
|        | Btg2    | 100-150   | 5YR 4/4       | 7.5YR 7/8 | Good  | 2 bk.c    | Fm          | -           |       |
| 5      | Imafoliado |       |               |         |          |           |           |             |      |          |
|        | A1      | 0-25      | 7.5YR ¾       | -       | Good     | 0-2       | 1 cr.m    | Fr          | Fr     | d, g    |
|        | A2      | 25-70     | 5YR 5/6       | -       | Good     |           | 2 cr.m    | Fr          | Fm     | s, h    |
|        | Btg1    | 70-100    | 2.5YR 4/8     | -       | Good     |           | 2 bk.m    | Fm          | f-m.fw | a, s    |
|        | Btg2    | 100-150   | 2R 7/1        | -       | Good     |           | 2 bk.c    | Fm          | f.cm   | d, g    |

Key: Structure: 1 = Weak, 2 = Moderate, 3 = Strong, M = Medium, C = Coarse, F = Fine, Cr = Crumb, Sbk = Sub-angular blocky. Consistence: s = soft, l = loose, sh = slightly hard, h = hard, vh = very hard, fr = friable, fm = firm, vfm = very firm, ns-np = non sticky-non plastic, s-sp = slightly sticky-slightly plastic, s-p = sticky-plastic. Roots: cc = common coarse, cm = common medium, fm = few medium, cf = common fine, ff = few fine Boundary: a = abrupt, c = clear, g = gradual, w = wavy, s = smooth, h = sharp, d = diffused
**Table 3. Akure North L.G.A: Soil morphology properties of pedons 6-9**

| Pedon | Horizon | Depth(cm) | Colour(Moist) | Mottles | Drainage | Slope (%) | Structure | Consistence | Root | Boundary |
|-------|---------|-----------|---------------|---------|-----------|-----------|-----------|-------------|------|----------|
| 6     | Iju     |           |               |         |           |           |           |             |      |          |
| A1    | 0-23    | 2.5Y 7/2  | Absent        | Good    | 0-2       | 2.Cr.m    | Fr        | cm          | c, s  |          |
| A2    | 23-40   | 10YR 4/3  | Absent        | Good    | 0         | Fm        | f.cm      | g, w        |      |          |
| Btg1  | 40-75   | 7.5YR 6/6 | 7.5R 6/6      | Good    | 2.bk      | Fm        | ff        | a, s        |      |          |
| Btg2  | 75-120  | 2.5YR 4/6 | 2.5YR 7/8     | Good    | 2.bk      | Fm        | vff       | -           |      |          |
| 7     | Ogbase  |           |               |         |           |           |           |             |      |          |
| A1    | 0-20    | 5R 5/1    | Absent        | Good    | 0-3       | 2.cr.m    | Fm        | f-m,fw      | a, s  |          |
| Bt1   | 20-60   | 10YR 7/2  | Absent        | Poor    |           | 2.bk.m    | Vfm       | vf.vfw      | d, w  |          |
| Btg2  | 60-100  | 10YR 6/8  | 2.5YR 3/6     | Poor    |           | 3.sbk.f   | Vfm       | Absent      | a, s  |          |
| 8     | Eleyowo |           |               |         |           |           |           |             |      |          |
| A1    | 0-30    | 2.5YR ¾   | Absent        | Good    | 0 – 2     | 2.cr.m    | Fm        | f-m,fw      | c, s  |          |
| Bt1   | 30-90   | 2.5YR 5/6 | Absent        | Good    |           | 2.bk.m    | Vfm       | vf.vfw      | c, s  |          |
| Btg2  | 90-120  | 7.5YR 4/6 | 2.5YR 3/6     | Good    |           | 2.bk.f    | Vfm       | Absent      | a, s  |          |
| 9     | Aladura |           |               |         |           |           |           |             |      |          |
| A1    | 0-30    | 7.5YR ¾   | Absent        | Good    | 0 -2      | 2.cr.m    | Fm        | f-m.cm      | c, s  |          |
| A2    | 30-70   | 7.5YR 7/2 | Absent        | Good    |           | 2.cr.m    | Fm        | f-m,cm      | g, w  |          |
| Bt1   | 70- 105 | 7.5YR 6/8 | Absent        | Good    |           | 2.bk.m    | Vfm       | vf.vfw      | a, s  |          |

Key: Structure: 1 = Weak, 2 = Moderate, 3 = Strong, M = Medium, C = Coarse, F = Fine, Cr = Crumb, Sbk = Sub-angular blocky. Consistence: s = soft, l = loose, sh = slightly hard, h = hard, vh = very hard, fr = friable, fm = firm, vfm = very firm, ns-np = non sticky-non plastic, s-sp = slightly sticky-slightly plastic, s-p = sticky-plastic. Roots: cc = common coarse, cm = common medium, fm = few medium, cf = common fine, ff = few fine Boundary: a = abrupt, c = clear, g = gradual, w = wavy, s = smooth, h = sharp, d = diffused
Table 4. Akure South LGA: Soil morphology properties. Pedons 10-13

| Pedon | Horizon | Depth(cm) | Colour       | Mottles | Slope (%) | Drainage | Structure | Consistence | Root | Boundary |
|-------|---------|-----------|--------------|---------|-----------|----------|-----------|-------------|------|----------|
| 10    | Alagbado|           |              |         |           |          |           |             |      |          |
| A1    | 0-15    | 10YR 2/2  | Absent       | 0-5     | Good      | 2.cr.m   | Very firm | ff           | Cs   |          |
| A2    | 15-30   | 5YR 4/3   | Absent       | 0       | Good      | 2.cr.m   | Firm      | fvf          | Cs   |          |
| Btg1  | 30-90   | 2.5YR 4/8 | 2.5Y 7/8     |         | Good      | 2.bk     | Firm      | a            | As   |          |
| Btg2  | 90-150  | 2.5YR 4/7 | 2.5YR 7/8    |         | Good      | 2.bk     | Firm      | a            | cs   |          |
| 11    | Adofure |           |              |         |           |          |           |             |      |          |
| A1    | 0-20    | 2.5YR 3/2 | Absent       | 0-2     | Good      | 1.cr.f   | Friable   | cf           | As   |          |
| A2    | 20-30   | 10R 5/6   | Absent       | 0       | Good      | 1.cr.f   | Firm      | fc           | Cs   |          |
| Btg1  | 30-90   | 10R5/8    | 10YR 6/8     |         | Good      | 2.abk.m  | Firm      | ff           | Cs   |          |
| Btg2  | 90-150  | 2.5YR 4/8 | 10YR 6/8     |         | Good      | 2.bk.m   | Firm      | a            | Cs   |          |
| 12    | Olokuta |           |              |         |           |          |           |             |      |          |
| A1    | 0-20    | 2.5YR 3/2 | Absent       | 7-13    | Good      | 1.cr.f   | Firm      | ff           | Cs   |          |
| A2    | 20-30   | 10R 5/6   | Absent       | 0       | Good      | 1.cr.f   | Firm      | fvf          | Cs   |          |
| Btg1  | 30-90   | 10R5/8    | 10YR 6/8     |         | Good      | 2.abk.m  | firm      | a            | Cw   |          |
| Btg2  | 90-150  | 2.5YR 4/8 | 10YR 6/8     |         | Good      | 2.bk.m   | Very firm | a            | Cs   |          |
| 13    | FECA    |           |              |         |           |          |           |             |      |          |
| A1    | 0-30    | 2.5YR 4/1 | Absent       | 0-2     | Good      | 1.cr.m   | Firm      | ff           | Cs   |          |
| A2    | 30-70   | 2.5YR 4/3 | Absent       | 0       | Good      | 2.cr.m   | Very firm | mf           | cs   |          |
| Btg1  | 70-100  | 7.5YR 4/4 | Absent       |         | Good      | 2.bk.m   | Very firm | f            | cw   |          |
| Btg2  | 100-150 | 5YR 4/4   | 7.5YR 7/8    |         | Good      | 2.bk.c   | a          | cs           |      |          |

**KEY:** Structure: 1 = Weak, 2 = Moderate, 3 = Strong, M = Medium, C = Coarse, F = Fine, Cr = Crumb, Sbk = Sub-angular blocky. Consistence: s = soft, l = loose, sh = slightly hard, h = hard, vh = very hard, fr = friable, fm = firm, vfm = very firm, ns-np = non sticky-non plastic, sp = slightly sticky-slightly plastic, s-p = sticky-plastic. Roots: cc = common coarse, cm = common medium, fm = few medium, cf = common fine, ff = few fine. Boundary: a = abrupt, c = clear, g = gradual, w = wavy, s = smooth, h = sharp, d = diffused.
Table 5. Akure South LGA: Soil morphology properties. Pedon 14-16

| Pedon      | Horizon | Depth(cm) | Colour   | Mottles | Slope (%) | Drainage | Structure | Consistence | Root     | Boundary |
|------------|---------|-----------|----------|---------|-----------|----------|-----------|-------------|----------|----------|
| 14 Seebi   | A1      | 0-30      | 2.5YR 4/1| Absent  | 5-7       | Good     | 1.cr.m    | Friable     | cf       | cs       |
|            | A2      | 30-70     | 2.5YR 4/3| Absent  | 0-2       | Good     | 2.cr.m    | Friable     | cf       | cs       |
|            | Btg1    | 70-100    | 7.5YR 4/4| Absent  | 7.5YR 7/8| Good     | 2.bk.m    | Very firm   | mf       | cs       |
|            | Btg2    | 100-150   | 5YR 4/4  | Absent  | 7.5YR 7/8| Good     | 2.bk.c    | Very firm   | a        | cs       |
| 15 FUTA    | A1      | 0-30      | 2.5YR 4/1| Absent  | 0-2       | Good     | 1.cr.m    | Friable     | ff       | cs       |
|            | A2      | 30-70     | 2.5YR 4/3| Absent  | 0-2       | Good     | 2.cr.m    | Friable     | cf       | cs       |
|            | Btg1    | 70-120    | 7.5YR 4/4| Absent  | 7.5YR 7/8| Good     | 2.bk.m    | Firm        | a        | cs       |
|            | Btg2    | 120-150   | 5YR 4/4  | Absent  | 7.5YR 7/8| Good     | 2.bk.c    | Firm        | a        | as       |
| 16 Ijoka-Olope | A1     | 0-15      | 7.5YR ¾  | Absent  | 0-2       | Good     | 2.cr.m    | Friable     | ff       | cs       |
|            | A2      | 15-35     | 5YR 5/6  | Absent  |           | Good     | 2.bk.m    | Firm        | ff       | cs       |
|            | Btg2    | 35-90     | 5YR 4/4  | Absent  | 7.5YR 7/8| Good     | 3.abk.c   | Very firm   | mf       | cs       |
|            | Btg2    | 90-150    | 2.5YR 4/8| Absent  | 10YR 6/8 | Good     | 2.bk.m    | Very firm   | a        | as       |

KEY: Structure: 1 = Weak, 2 = Moderate, 3 = Strong, M = Medium, C = Coarse, F = Fine, Cr = Crumb, Sbk = Sub-angular blocky. Consistence: s = soft, l = loose, sh = slightly hard, h = hard, vh = very hard, fr = friable, fm = firm, vfm = very firm, ns-np = non sticky-non plastic, s-sp = slightly sticky-slightly plastic, s-p = sticky-plastic. Roots: cc = common coarse, cm = common medium, fm = few medium, cf = common fine, ff = few fine. Boundary: a = abrupt, c = clear, g = gradual, w = wavy, s = smooth, h = sharp, d = diffused
3.12 Pedon 12 (Olokuta)

Pedon 12 Occurred on 354 m above sea level, almost flat terrain with 0.2(%) slope gradient. The pedon was well drained and deep (150 cm). The surface horizons of the pedon were dark to reddish brown (2.5YR 3/2 – 10R 5/6) underlain by red colour (10R 5/6 – 2.5YR 4/8) subsoil. The top soil (A₁ and A₂) exhibited weak fine crumby structure while the subsurface exhibited moderate medium angular blocky structure. Consistence varied from very friable to friable at the surface horizons while it varied from firm to very firm at the subsurface horizon. Root was common at the surface but very few at subsurface. Cocoa, banana, yam, oil palm, pawpaw, coconut and mango were the common vegetation.

3.13 Pedon 13 (FECA)

Pedon 13 was located on a plain topography with a slope gradient of 0-2(%) and an elevation of 375 m above sea level; it was well drained and deep (150cm). The pedon had reddish grey colour (10R 5/6) underlain by red grey (10R 4/6) subsoil and A₂ horizon had reddish brown (5YR 4/4) subsoil. The topsoil (A₁ and A₂) exhibited weak fine crumby structure while the subsurface horizons (Btg₁ and Btg2) exhibited moderate medium crumby structure whereas the subsoil showed moderate medium blocky structure. Consistence ranged from friable to firm in all the horizons of the pedon. There were fine, medium and common root concentrations.

3.14 Pedon 14 (Seebi)

Pedon 14 occurred on an almost flat terrain with 2.6(%) slope gradient and an elevation of 388 m above sea level; it was well drained and deep (150cm). The pedon had reddish grey colour (2.5YR 4/1) and dull reddish brown 2.5YR 4/3 at the surface horizons (A₁ and A₂) over brownish colour (7.5YR 4/4) and dull reddish brown (5YR 4/4) sub soil. It was characterized by yellow orange 7.5YR 7/8 mottles. The surface horizons (A₁ and A₂) were weak to moderate medium crumby structure while subsurface horizons (Btg₁ and Btg2) showed moderate medium blocky texture. Consistence was friable in the surface horizon while the endopedons were firm. There were firm, medium and common root concentrations in the top soil.

3.15 Pedon 15 (FUTA)

The surface horizons (A₁ and A₂) of pedon 15 were weak medium crumby to moderate medium crumby structure while the subsurface horizons (Btg₁ and Btg2) showed moderate medium blocky structure. Consistence varied from friable to firm in all the horizons. A few medium to common root concentrations were in the top soil. Pedon 6 (figure) occurred at 387 m above sea level; almost flat terrain with 0.2(%) slope gradient. The pedon was well drained and deep (150 cm). The surface horizons were reddish grey (2.5YR 4/1) to dull reddish brown (2.5YR 4/3) underlain by brown (7.5YR 4/4) and dull reddish brown (5YR 4/4) subsoil. Mottling colour was yellow orange (7.5YR 7/8). The top soil (A₁ and A₂) exhibited weak to moderate medium crumby structure whereas, the subsoil showed moderate medium blocky structure. Consistence ranged from friable to firm in all the horizons of the pedon. There were fine, medium and common root concentrations.

3.16 Pedon 16 (Ijoka Olope)

The pedon was located on a plain topography with a slope gradient of 0.2(%) and an elevation of 347 m above sea level. It was well drained and deep (150 cm). The surface horizons of the pedon were bright reddish (5YR 5/6) and dull reddish brown (5YR 4/4) subsoil. Prominent mottling colour was yellow orange (7.5YR 7/8) at Btg₂ horizon. The top soil (A₁) exhibited moderate medium blocky nature while Btg₁ had strong coarse angular blocky structure and the subsoil surface had moderate medium blocky structure. Consistence ranged from firm to very firm throughout the horizons. Fine and very few root concentration observed in the lower surface of the horizon.

4. PHYSICAL PROPERTIES OF SOILS OF AKURE NORTH AND AKURE SOUTH LOCAL GOVERNMENT AREAS OF ONDO STATE

4.1 Pedon 1 (Igoba)

The highest sand (%) was obtained at Btg₁ and Btg2 horizons 66 (%) each while clay (%) was the highest at Btg₁ and Btg2 horizons (25(%) each). Gravel content was the highest at Btg₁ with 192 g. The Btg2 horizon had the highest bulk density of 1.34 g/cm³. Soil texture was Sandy Clay Loam (SCL).

4.2 Pedon 2 (Saasa)

The highest sand (%) was obtained at A₁ horizon 70 (%) and the clay (%) was the highest at Btg₁ and Btg2 with 30 (%) each. Gravel content was the highest at A₁ horizon with 432 g. The Btg2 horizon had the highest bulk density of 1.31 g/cm³. Soil textures are Sandy Loam (SL) and Sandy Clay Loam (SCL).
4.3 Pedon 3 (Akure Airport)

The highest sand (%) was obtained at $A_1$ horizon 64 (%) while Clay (%) was higher at $Bt_1$ horizon 46 (%). Gravel content was high at $A_1$ horizon with 432 g. Bulk density was higher at $Bt_1$ horizon (1.52 g/cm$^3$). Soil textures are Sandy Loam (SL) and Clay Loam (CL).

4.4 Pedon 4 (Oda)

The highest sand (%) was obtained at $A_1$, $Bt_1$ and $Btg_2$ 20 (%) each while clay (%) was the highest at $A_1$ and $Bt_1$ with 64 (%) each. Gravel content was highest at the $A_2$ horizon with 190 g. The $Btg_2$ horizon had the highest bulk density of 1.35 g/cm$^3$. Soil texture in all the horizons of the pedon was Sandy Clay (SC).

Table 6. Akure North L.G.A: Soil physical properties pedon 1-7

| Pedon     | Horizon | Depth (cm) | Sand ((%) | Silt ((%) | Clay ((%) | Soil Texture | BD (g/cm$^3$) | Porosity ((%) |
|-----------|---------|------------|-----------|-----------|-----------|--------------|---------------|--------------|
| 1 Igoba   | A1      | 0-26       | 56.00     | 14.00     | 30.00     | SCL          | 1.25          | 44.44        |
|           | A2      | 26-47      | 50.00     | 20.00     | 30.00     | SCL          | 1.25          | 44.44        |
|           | Bt1     | 47-90      | 64.00     | 20.00     | 16.00     | SL           | 1.28          | 43.11        |
|           | Btg2    | 90-120     | 64.00     | 20.00     | 16.00     | SL           | 1.31          | 41.78        |
| 2 Saasa   | A1      | 0-30       | 56.00     | 14.00     | 30.00     | SCL          | 1.28          | 43.11        |
|           | Bt1     | 30-70      | 56.00     | 14.00     | 30.00     | SCL          | 1.25          | 44.44        |
|           | Btg2    | 70-130     | 50.00     | 20.00     | 30.00     | SCL          | 1.28          | 43.11        |
| 3 Airport | A1      | 0-30       | 64.00     | 20.00     | 16.00     | SL           | 1.31          | 41.78        |
|           | Bt1     | 30-70      | 40.00     | 14.00     | 46.00     | CL           | 1.52          | 32.44        |
| 4 Oda     | A1      | 0-30       | 20.00     | 16.00     | 64.00     | SC           | 1.25          | 44.44        |
|           | A2      | 30-70      | 20.00     | 20.00     | 60.00     | SC           | 1.25          | 44.44        |
|           | Bt1     | 70-100     | 16.00     | 20.00     | 64.00     | SC           | 1.31          | 41.78        |
|           | Btg2    | 100-150    | 20.00     | 20.00     | 60.00     | SC           | 1.35          | 40.00        |
| 5 Imafo- llado | A1    | 0-25    | 50.00     | 10.00     | 40.00     | SL           | 1.12          | 50.22        |
|           | A2      | 25-70     | 50.00     | 10.00     | 40.00     | SL           | 1.16          | 48.44        |
|           | Bt1     | 70-100    | 30.00     | 20.00     | 50.00     | CL           | 1.25          | 44.44        |
|           | Btg2    | 100-150   | 30.00     | 10.00     | 60.00     | CL           | 1.25          | 44.44        |
| 6 Iju     | A1      | 0-23      | 56.00     | 14.00     | 30.00     | SCL          | 1.28          | 43.11        |
|           | A2      | 23-40     | 50.00     | 20.00     | 30.00     | SCL          | 1.25          | 44.44        |
|           | Btg1    | 40-75     | 64.00     | 20.00     | 16.00     | SL           | 1.25          | 44.44        |
|           | Btg2    | 75-120    | 64.00     | 20.00     | 16.00     | SL           | 1.31          | 41.78        |
| 7 Ogbese  | A1      | 0-20      | 56.00     | 14.00     | 30.00     | SCL          | 1.25          | 44.44        |
|           | Bt1     | 20-60     | 50.00     | 20.00     | 30.00     | SCL          | 1.28          | 43.11        |
|           | Btg2    | 60-100    | 64.00     | 20.00     | 16.00     | SL           | 1.31          | 41.78        |
| 8 Eleyo-owo | A1    | 0-30     | 50.00     | 20.00     | 30.00     | SCL          | 1.12          | 50.22        |
|           | Bt1     | 30-90     | 50.00     | 20.00     | 30.00     | SCL          | 1.22          | 45.78        |
|           | Btg2    | 90-120    | 40.00     | 30.00     | 30.00     | SCL          | 1.27          | 43.56        |
| 9 Aladura | A1      | 0-30      | 56.00     | 14.00     | 30.00     | SCL          | 1.25          | 44.44        |
|           | A2      | 30-70     | 50.00     | 20.00     | 30.00     | SCL          | 1.28          | 43.11        |
|           | Bt1     | 70-105    | 64.00     | 20.00     | 16.00     | SL           | 1.36          | 39.56        |

BD = Bulk Density
4.5 Pedon 5 (Imafo-Ilado)

The highest sand percentage was obtained at A₁ and A₂ horizons 50 (%) each while clay (%) was the highest at Btg 2 horizon. Gravel content was the highest at Btg2 horizon with 204 g. Horizon Bt₁ and Btg2 had the highest bulk density of 1.25 g/cm. Soil textures were Sandy Loam (SL) and Clay Loam (CL).

4.6 Pedon 6 (Iju)

Btg 1 and Btg 2 had a sand percentage of 64 (%) while clay percentage decreased down the profile from 30(%) at A₁ to 16 (%) at Btg2. The soil bulk density also increased down the profile. Porosity increased from down the profile.

4.7 Pedon 7 (Ogbese)

Three horizons were established in Pedon Ogbese. Hardpan was encountered at 1 m down the profile. Percentage of sand increased down the profile while that of clay decreased. Bulk density was 1.25 g/cm³ at A₁ horizons while 1.31 g/cm³ was observed at Btg2.

Table 7. Akure South L.G.A: Soil physical properties pedons 10-16

| Pedon | Horizon | Depth (cm) | Sand (%) | Silt (%) | Clay (%) | Soil Texture | BD (g/cm³) | Porosity (%) |
|-------|---------|------------|----------|----------|----------|--------------|------------|--------------|
| 10 Alagbado | A₁ | 0-15 | 57.00 | 27.00 | 16.00 | SCL | 1.23 | 45.33 |
| | A₂ | 15-30 | 69.00 | 21.00 | 10.00 | SCL | 1.29 | 42.67 |
| | Btg₁ | 30-90 | 55.00 | 21.00 | 24.00 | SCL | 1.32 | 41.33 |
| | Btg₂ | 90-150 | 59.00 | 15.00 | 26.00 | SL | 1.36 | 39.56 |
| 11 Adofure | A₁ | 0-20 | 50.00 | 10.00 | 40.00 | SL | 1.12 | 50.22 |
| | A₂ | 20-30 | 50.00 | 10.00 | 40.00 | SL | 1.16 | 48.44 |
| | Btg₁ | 30-90 | 50.00 | 20.00 | 30.00 | CL | 1.25 | 44.44 |
| | Btg₂ | 90-150 | 30.00 | 10.00 | 60.00 | CL | 1.25 | 44.44 |
| 12 Olokuta | A₁ | 0-20 | 70.00 | 6.00 | 24.00 | SL | 1.11 | 50.67 |
| | A₂ | 20-30 | 68.00 | 14.00 | 16.00 | SL | 1.11 | 50.67 |
| | Btg₁ | 30-90 | 70.00 | 10.00 | 20.00 | SL | 1.14 | 49.33 |
| | Btg₂ | 90-150 | 70.00 | 10.00 | 20.00 | SL | 1.16 | 48.44 |
| 13 FECA | A₁ | 0-20 | 50.00 | 30.00 | 20.00 | L | 1.11 | 50.67 |
| | A₂ | 20-50 | 50.00 | 30.00 | 20.00 | L | 1.14 | 49.33 |
| | Btg₁ | 50-90 | 60.00 | 20.00 | 20.00 | SL | 1.15 | 48.89 |
| | Btg₂ | 90-150 | 60.00 | 20.00 | 20.00 | SL | 1.22 | 45.78 |
| 14 Seebi | A₁ | 0-30 | 70.00 | 14.00 | 16.00 | SL | 1.27 | 43.56 |
| | A₂ | 30-70 | 56.00 | 4.00 | 40.00 | SC | 1.34 | 40.44 |
| | Btg₁ | 70-100 | 40.00 | 10.00 | 50.00 | SC | 1.43 | 36.44 |
| | Btg₂ | 100-150 | 64.00 | 12.00 | 24.00 | SCL | 1.43 | 36.44 |
| 15 FUTA | A₁ | 0-30 | 70.00 | 20.00 | 10.00 | SL | 1.25 | 44.44 |
| | A₂ | 30-70 | 70.00 | 20.00 | 10.00 | SL | 1.27 | 43.56 |
| | Btg₁ | 70-120 | 50.00 | 40.00 | 10.00 | SL | 1.36 | 39.56 |
| | Btg₂ | 120-150 | 70.00 | 20.00 | 10.00 | SL | 1.36 | 39.56 |
| 16 Ijoka Olopo | A₁ | 0-15 | 50.00 | 30.00 | 20.00 | SL | 1.11 | 50.67 |
| | A₂ | 15-35 | 50.00 | 30.00 | 20.00 | SL | 1.11 | 50.67 |
| | Btg₁ | 35-90 | 60.00 | 20.00 | 20.00 | SL | 1.14 | 49.33 |
| | Btg₂ | 90-150 | 60.00 | 20.00 | 20.00 | SL | 1.16 | 48.44 |

BD = Bulk Density
4.8 Pedon 8 (Eleyo-owo)

The textural class was sandy clay loam and bulk density ranged between 1.12 g/cm³ and 1.17 g/cm³. Porosity decreased down the profile from 50.22 (%) to 43.56 (%) at horizon Btg2.

4.9 Pedon 9 (Aladura)

The surface horizons A1 and A2 were classified as sandy clay loam and Btg1 was sandy loam and bulk density was 1.36 g/cm³. Porosity ranged between 44.44 (%) at the surface horizon to 39.56 (%) at the Btg2 at a depth of 70-105 cm.

4.10 Pedon 10 (Alagbado)

The clay (%) in this pedon was the highest at Bt2 horizon 26 (%) and lowest at the surface horizon 16 (%). High sand (%) was recorded at A2 with 69 (%). High gravel content was obtained at the Bt2 horizon with 289 g. The Btg2 horizon has the highest bulk density of 1.36 g/cm³. Soil textures were sandy clay loam (SCL) and Sandy Loam (SL).

4.11 Pedon 11 (Adofure)

The clay (%) in this pedon was the highest at Btg2 followed by Bt1 with 60 (%) and 50 (%) respectively and lowest was recorded at both A1 and A2 with 40 (%) each. High sand (%) was found at A1 and A2 50 (%) each. Also, high gravel content was obtained at Btg2 with 204 g. Porosity was high at Bt1 and Btg2 with 58 (%) each. The horizons Bt1 and Btg2 recorded the highest bulk density of 1.25 g/cm³ each. Soil textures were sandy loam (SL) and clay loam (CL).

4.12 Pedon 12 (Olokuta Ondo Road)

In this pedon, the highest (%) clay was at A1 (24 %) and the lowest at Bt1 and Btg 2 with 20 (%) each; high sand (%) at A1, Bt1 and Btg2 with 70 (%) each and lowest at A2. Also, gravel content was the highest at Btg2 with 252 g content. The horizons had the highest porosity (%) of 58.11(%) at Bt1. The highest bulk density of the horizon was recorded at Btg2 (1.16 g/cm³). Soil texture of all horizons was Sandy Loam (SL).

4.13 Pedon 13 (Federal College of Agriculture, FECA)

All the horizons in this pedon had equal (%) of clay 20 (%). High sand (%) was found at Bt1 and Btg2 horizons with 60 (%) each and the lowest at A1 and A2 with 50 (%) each. Gravel content was the highest at Btg2 with 277 g content. The A1 horizon had the highest (%) of porosity with 56.60 (%). Bulk density was the highest at Btg2 with 1.22 g/cm³. Soil textures were Loam (L) and Sandy Loam (SL).

4.14 Pedon 14 (Seebi)

The clay (%) in this pedon is the highest at the Bt1 horizon 50 (%) and lowest at the surface 16 (%). High sand (%) seen at the A1 70 (%). Gravel content was high at Bt1 horizon with 892 g. Porosity was high at Bt1 with 52.83(%). The highest bulk density was recorded at horizons Bt1 and Btg2 with 1.43 g/cm³ each. Soil textures were Sandy Loam (SL), Sandy Clay (SC) and Sandy Clay Loam (SCL).

4.15 Pedon 15 (FUTA)

The highest sand (%) was obtained at A1, A2 and Bt1 horizon 70 (%) each while all the horizons in the pedon had equal amount of clay (%) of 10(%) each. Gravel content was the highest at Btg2 with 204 g. Horizon Bt1 and Btg2 had the highest bulk density of 1.36 g/cm³ each. Soil texture was Sandy Loam (SL).

4.16 Pedon 16 (Ijoka Olope)

The highest sand (%) was obtained at Bt1 and Btg2 horizons 60 (%) each. Clay (%) was low in all the horizons with 20 (%) each. Gravel content was the highest at Btg2 with 277 g. The horizon Btg2 had the highest bulk density of 1.16 g/cm³. Porosity was also the highest at Btg2 horizon. Soil texture was Sandy Loam (SL).

5. DISCUSSION

5.1 Morphological Properties and Site Description of Soils in Akure North and South Local Government Areas of Ondo State

The soils were generally deep to very deep (70 to 150 cm) and had no restrictions except in pedon 3 where the depth was restricted by hard pans and this posed limitation to crops that can be grown in the study area. It has been reported that hardpans and concretions enhance lateral movement of water in soil body, impede drainage with accumulated water resulting in aeration problems and decrease sharply, the hydraulic conductivity in the direction of hardpans [10]. The justification by [11] was that soil as observed in a
profile at a particular time depended on the interaction of factors and processes of soil formation. The factors are parent materials, climate, organisms, relief time, depth, slope, etc. of the area. The absence of impenetrable layer to the depth of 150 cm from the soil surface indicated for all other pedons shows that the soil in the study area poses no limitation to root development. The occurrence of the soils of the study area on nearly flat to gently undulating landscape will encourage the cultivation of wide range of crops, as the problems of soil erosion will be minimal. The bright colour exhibited by the pedons revealed good drainage condition of the soil, except in Pedon 7 (Ogbese) where the pedon showed very high water volume. Pedon 7 (Ogbese) of the study area will support hydrophilic plants and all other pedons are good for arable and non-arable crops. However, the occurrence of mottles in the lower depth of all the pedons was an indication that there are variations in water table in the soil within and out of season. This could be attributed to the presence of impervious layer (rock) resulting in water stagnation and slow percolation [12].

The structural development of the soil was due to the stabilizing effects of organic matter in the top soil and clay minerals in the sub soil [13]. The friable consistence of the epipedon will ensure good tillage operation and easy penetration of plant roots. [14] reported that friable soil often had the optimum conditions for tillage operations, resulting in better seed bed preparation with good drainage, gaseous exchange and heat conductance.

Generally, the particle size distribution revealed that sand dominated the particle size fraction of the soil in all the profiles. This indicates that the soils of the study area will be less chemically and physically active. [15] have stated that sand has a smaller surface area (0.100-0.01 m²g⁻¹) and it tends to be less chemically and physically active. The coarse sandy texture of the soils (characterized by high infiltration rate) will have good water penetration but the soils can be easily depleted of essential nutrients and moisture through leaching [16]. Therefore, during the dry season, when the water table is low and there is high evapo-transpiration, there will be water stress as ground supply may not be able to recharge through capillary action for the wetter zones at lower depth or from ground water table during this period [17,18] therefore opined that good management practices such as the incorporation of organic matter into the soil (especially, farm yard manure, compost and green manure) will help to bind soil particles together and thus, increase the aggregate stability of the soils. Also, subsurface horizons exhibited higher clay content as compared to the surface horizons, which might be due to illuviation process occurring during soil development as suggested by [19]. This increase in clay was an evidence of eluviation-illuviation soil from the process resulted from high and intense rainfall experienced in the study area, coupled with network of pores of coarse texture of the upper horizons that encouraged easy migration of clay suspension down the profile [20] and [21]. An outstanding feature of these soils across all profiles is moderate to high silt content 4 (%) – 30 (%). [22] opined that the increase in silt content might be due to disturbance of soil aggregate and the washing down of the finer soil aggregates down the profile.

5.2 Evaluation of the Stage of Development of Soils

The assessment of the pedons for in-situ weathering of the profiles showed that all the pedons had ratios of silt: clay above 0.15. This indicates that the soils have not been subjected to severe weathering and may still have some weatherable minerals [23]. This is also in alignment with [24] and [25] who reported that old parent materials usually have silt/clay ratios below 0.15 while silt/clay ratio above 0.15 indicate young parent materials. More so, the soils with silt/clay ratios less than 0.25 are at the advanced stage of weathering while those with ratios greater than 0.25 indicate a low degree of weathering. The implication of this is that, the soils of the study area are made up of young parent materials with low degree of weathering. This might be responsible for coarse texture of the soils and low nutrient status of the soil, as some of the nutrients are locked up in the parent materials.

6. CONCLUSION AND RECOMMENDA-
TION

The results of the study areas have revealed that the soil of Akure North and South Local Government Area occurs on level plain with little slope gradient. The soils are generally deep and well drained at the top soil with coarse texture. The subsoils are characterized by the prominent presence of mottles which suggests that the subsoils are poorly drained also. This study also
revealed that nutrients data acquired from the laboratory could be interpolated using remote sensing integrated with GIS and this would play a vital role in understanding the nature and extent of soil nutrient distribution in the study area. The coarse texture of the soils can be managed through the use of appropriate organic manure especially, farm yard manure, compost and green manure and this will help to bind soil particles together and thus increase the aggregate stability of the soil. So also, maintenance will minimize soil crusting. Bio-organic manure will help bind the soil particles together thereby improving its water holding capacity and nutrient retention in the study area. Thus, and increase usages of organic manure.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Herbert T, Ugochukwu NL, Esan AG. Spatio-temporal analysis of urban land cover growth dynamics in Akure south metropolis, Ondo State Nigeria. American Journal of Earth and Environmental Sciences. 2018;1(1):1-9.
2. Owoyemi FB. A geological-geophysical investigation of rain-induced erosional features in Akure Metropolis. Unpublished. M. Tech Thesis, Federal University of Technology: Akure, Nigeria. 1996;11-18.
3. Sheidrick BH, Wang C. Particle S Analysis. In Carter MR, Ed., Soil sampling and methods of analysis. Lewis Publishers, Boca Raton. 1993:499-517.
4. Thomas GW. Soil pH and soil acidity. In Sparks DL, Ed., Methods of soil analysis part 3 chemical methods, SSSA Book series 5, Soil Science Society; 1996.
5. Nelson DW. Sommers LE. Total carbon, organic carbon and organic matter. In Sparks DL, et al. Eds., Methods of soil analysis. Part 3, SSSA; 1996.
6. Bremner JM. Total nitrogen. In: Sparks DL (Ed). Methods of soil analysis, Part 3, chemical methods, American society of soil science, Book Series 5, Madison, Wisconsin, USA. 1996;1085-1121.
7. McLean EO. Aluminum. In: Black CA. (Ed.). Methods of soil analysis. agronomy. No.9. Part II. American. Soc. Agron, Madison, Wisconsin. USA. 1985;978-998.
8. Gee WG, Or D. Particle-Size Analysis. In: Dane J, Topp GC. (Eds.). Methods of soil analysis. Soil Science Society of America. USA; 2002;5(4):255–293.
9. Miller DD, McPherson JG, Covington TE. Fluviodeltaic reservoir, south belridge field, San Joaquin Valley, California: In Sandstone Petroleum Reservoirs JH. Barwis JG. McPherson, Studlick JRJ, eds, Springer-Verlag. 1990;109-130.
10. Ewulo BS. Soil characterization and classification at Ikaram-Ibaram cluster village in Ondo State, Nigeria. Nigerian Journal of Soil Science. 2012;22(2):1-12.
11. Odunze AC. Effect of short duration grain legume crop inclusion in a ginger-based system on soil quality, growth and yield responses of ginger (Zingiber officinale Rosc) in south eastern Nigeria; 2007.
12. Basina AS, Arueba JO, Omolayo FO, Omotoso SO, Shittu OS. Properties and classification of five soils formed on granite parent materials of humid Southwest Nigeria. Nigerian Journal of Soil Science. 2005;15(2):21-29.
13. Brady NC, Weil RR. The Nature and Properties of Soils. 12th Edition, Prentice Hall Publishers, London, Ojeniyyi. 1999;1-9:453-536,727,739-740.
14. Ojeniyi SO. Soil management, natural resources and environment. Adediran Press. 2002;30.
15. Hazelton PA, Murphy BW. Understanding soils in urban environments. CSIRO Publication. London: Earthscan, Colling wood, VIC; 2011.
16. Chude VO, Malgwi WB, Amapu IY, Ano OA. Manual on soil fertility assessment. Federal Fertilizer Department (FFD) in collaboration with national programme for food security, Abuja, Nigeria; 2011.
17. Ogba PI, Ibia TO. Infiltration characteristics and soil physico-chemical properties of wetlands in Akwa-Ibom State, South-eastern Nigeria. Nigerian Journal of Soil Science Natural Programme for Food and Security, Abuja-Nigeria. 2006(16):62,73-76.
18. Ogban PI, Babalola O. Characteristics of some hydromorphic soils of Southwestern Nigeria. African Soils. 1995;28:147-165.
19. Tripathi SK, Sumida A, Shibata H, Ono K, Uemura S, Kodama Y, Hara T. Leaf litterfall and decomposition of different above-and belowground parts of birch (Betula ermanii) trees and dwarf bamboo (Sasa kurilensis) shrubs in a young
secondary forest in Northern Japan. Biol. Fertility Soils. 2006;43:237-246.
20. Malgwi WB, Ojanuga AG, Chude VO, Kparmwang T, Raji BA. Morphological and physical properties of some soils at Samaru, Zaria, Nigeria. Niger. J. Soil Res. 2000;1:58-64.
21. Ewulo BS, Ojanuga AG, Ojeniyi SO. Nature and properties of soils with kandic Horizon in humid Southwest Nigeria. Bioscience Research Communications. 2002;14(6):693-700.
22. Olatunji OA, Oke SO, Isola EF, Akinyemi DS, Omodara AA. Echafchem. 2011; 1579-4377.
23. Young A. Tropical soils and soil survey. Cambridge University Press, New York. 1980:468.
24. Ayolagha GA. Survey and classification of Yenagoa-meander belt soils in the Niger-Delta. Proceedings of the 27th annual conference of the soil science society of Nigeria, Calabar, Nigeria; 2001.
25. Ayolagha GA, Opene GA. Characterization and classification of selected soils of Ndoni in the meander belt of Niger Delta. Nigerian Journal of Soil Science. 2012; 22(2):50-57.

© 2020 Dada et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/60023