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CHARACTERIZATION, CLASSIFICATION AND ASSESSMENT OF SOIL DEGRADATION CAUSED BY MINING ACTIVITIES IN THE FARMLAND OF COLLEGE OF EDUCATION, MINNA

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ABSTRACT

This study aimed to characterize and classify soils, as well as evaluate the impact mining activities on soil degradation within the College of Education, Minna farm land. A free survey method of an area covering 60-hectare was conducted. Three soil units were identified, two in the upland mapping unit (UL1, UL2) and one in the dissecting valley (DV3). Three pedons were excavated, one from each of the identified soil units. The pedons were described and soil samples from each genetic horizon were collected for laboratory analysis. In addition, six composite soil samples at three different distances away from two mining sites were collected for soil heavy metals determination. Morphological properties revealed that the soils are generally gravel at the surface with texture ranging between sandy loam and sandy clay loam in the subsoil. The presence of a textural horizon (Bt) is common in all the soil units. Buried stone line was identified in UL2 an indication of a lithologic discontinuity. Soil reaction revealed a slightly acid to near neutral pH in the soils. Soil organic matter, Available P and Total nitrogen are rated medium. CEC and the exchangeable bases are low in the soils. Base saturation is generally moderate to high (46 % to 70 %). Low nutrient content in the soils may be attributed to the low activity clay, uptake by plant and little or no addition from fertilizer application. The values of EC, ESP and SAR indicate soils without salinity/sodocity problem. Heavy metals in the soils are generally low according to the limit set by WHO, with the exception of Cd (1.5-5.4 mgkg^{-1}). *The soils could therefore, be referred to as Cd polluted. The farm land soils were classified as Alfisols according to the USDA Soil Taxonomy System and correlates with Lixisols in the WRB system.*

Keywords: Characterization, classification, degradation, mining, assessment
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INTRODUCTION

Soil characterization providesinformation for the understanding of the physical, chemical, mineralogical and microbiological properties of the soils we depend on to grow crops, sustain forests and grasslands as well as support homes and society structures (Ogunkunle, 2005). According to Eswaram (1977), some different uses of soil characterization data include to aid in the correct classification of soils and enable other scientists place the soils in their taxonomies or classification systems and to serve as a basis for more detailed evaluation of the soil as well as gather preliminary information on nutrient, physical or other limitations needed to produce a capability class. A soil characterization study, therefore, is a major building block for understanding the soil, classifying it and getting the best understanding of the environment (Esu, 2005). Soil classification, on the other hand, helps to organize our knowledge, facilitates the transfer of experience and technology from one place to another and helps to compare soil properties. Soil/Land degradation is a process in which the value of the biophysical environment is negatively affected by a combination of human induced process acting upon the land (Lal, 2010). It leads to a temporary or permanent decline in the productive capacity of the land. Degradation of land includes soil erosion, salinization, nutrient depletion and desertification. Soil degradation is a significant environmental problem that can lead to reduced soil productivity, loss of biodiversity, and ecosystem services. The effects of soil degradation can be severe and long-lasting, impacting the environment, society, and economy. It results in the removal of topsoil, alteration of soil structure, and nutrient depletion.

Several studies have investigated the effect of mining activities on soil health, soil erosion, and water quality. For instance, a study by Adebayo, et al., (2017) in Nigeria found that illegal mining activities led to soil erosion, reduced soil quality, and loss of vegetation cover. Another study by Usman, et al., (2018) found that illegal mining activities led to soil degradation, loss of soil fertility, and contamination of water sources. Okonkwo et al., (2021) investigated the contents of selected heavy metals in top soils and sub-soils around the vicinity of artisanal gold mining site in Minna. Ako et al., 2014 investigated the environmental impact of artisanal gold mining in Luku village. Despite existing studies, significant gap remain in our understanding of the areas soils and the college farm land's soil information database, necessitating a study to characterize, classify and assess soil degradation caused by mining within the college farm land. The impact of these activities on the soil's physical and chemical properties is not known, and there is a need for a comprehensive study to characterize, classify and assess the level of soil degradation and recommend possible remediation strategies.

MATERIAL AND METHODS

The Study Site

The study site measuring 60 ha is located within the premises of the Niger State College of Education, Minna of Bosso Local Government Area, Niger State (Figure1b, c, d). Satellite image of the college of education, Minna is depicted in Figure 1d. The college of education, Minna farm landis within the Southern Guinea savanna, and spans between latitudes, 9°34ʾ0''to 9°34ʾ30'' and longitudes, 6°34ʾ30'' to 6°35ʾ30''. The elevation ranges from 230m to 249m above sea level. The terrain is predominantly upland with rolling elevations shaping the landscape with narrow dissecting valleys. Minna experiences a sub-humid tropical climate characterized by two distinct seasons: a dry season and a rainy season. The area has an ustic moisture regime, with an average annual rainfall of 1284 mm, and an isohyperthermic temperature regime, maintaining high temperatures (around 35ºC) between March and June (by Ojanuga, (2006). The vegetation consists of woodlands, short and tall grasses, interspersed with tall dense trees. The primary land use in the area is agriculture, with major crops including maize, sorghum, groundnut, and melon. Mining activities is also predominant in the general area.

Field Study

An initial reconnaissance field visit was undertaken in April and early May 2024 to gain a general understanding of the study site'sconditions and gather information for detailed fieldwork planning. The detailed assessment, using the free survey method, took place covering a 60-hectare area. Physical and Morphological soil properties such as color, texture, depth, drainage condition, and stoniness were evaluated, resulting in the delineation of two mapping units; upland and dissecting valley designated as UL and DV respectively. Three soil units were identified, two in the upland mapping unit (UL1, UL2) and one in the dissecting valley (DV3).

Soil Sampling

One soil profile (pedons) was excavated in each identified soil unit giving a total of three (3) pedons. The pedons were described according to FAO (2006) guidelines, and bulked soil samples from each genetic horizon were collected for laboratory analysis. Apart from the samples collected from the genetic horizons of the three pedons in the soil units (UL1, UL2 and DV3), six composite soil samples (E1a, E1b, E1c, E2a, E2b, E2c) at two sites (E1 and E2) and three different distances 0m (a), 50m (b) and 100m (c) away from the river where the mining is done) were collected for soil chemical degradation studies.

Laboratory Methods

Soil samples collected from the pedons were air-dried and sieved to 2 mm. Physical and chemical properties were determined as follows: Particle size distribution by the Bouyoucous hydrometer method, and textural classes established using the USDA soil textural triangle; bulk density by the undisturbed soil core method (Blake and Hartge, 1986); soil pH in a 1:1 water solution using the electrometric method; soil organic carbon (OC) by the wet dichromate method (Walkley and Black, 1934); total nitrogen by the Macro-Kjeldahl method (Bremner and Mulvaney, 1982); available phosphorus calorimetrically after Bray-1 extraction; exchangeable bases (Ca, Mg, Na, K) using 1N NH4OAc extractant method (Thomas, 1982), with Ca and Mg determined using Atomic Absorption Spectrometry and Na and K by Flame Photometry; cation exchange capacity (CEC) by NH4OAc displacement; and base saturation (BS) calculated accordingly. Samples were analyzed in the laboratory for heavy metals using atomic absorption spectrophotometer (AAS). The heavy metals determined include Iron (Fe), Lead (Pb), Zinc (Zn), Copper (Cu), Chromium (Cr), Cadmium (Cd).

Soil Classification

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The soils were classified using USDA Soil Taxonomy system (Soil Survey Staff, 2022) and World Reference Base for Soil Resources. (IUSS, WRB, 2022).

Result and Discussion

Mapping /Soil Units

The mapping units were delineated through the interpretations of satellite images and field observations by ground truthing. Mapping units were defined as a combination of landform units and soil units. The landform units were demarcated on the basis of relief features in relation to the geomorphology and they were readily recognized on the satellite images. The landform/soil units which formed the basis for mapping/soils units identified are upland (UL1 and UL2) which is an elevated terrain and dissecting valley (DV3), a valley that has been formed by erosive action of a stream which has cut through pre-existing upland landscape (Figure 2a, 2b and 2c). The soil units were identified on the basis of the field observations (auger pits and soil profile pits). The occurrence of the specific soil units is related to surface soil characteristics such as presence or absence of gravel, boulders, soil texture, soil colour, soil structure, etc. The descriptions of the soil units are presented below.

Soil unit UL1 (Pedon 1); This soil body was identified in mapping unit UL on an elevation of about 236m with few gravels on the surface. The soils are well drained with a surface texture of sandy clay loam. Soil unit UL2 (Pedon 2), identified within mapping unit UL (upland) on an elevation of 247m and characterized by boulders on the surface. The soils are well drained with sand texture on the first 20 cm.

Morphological and Physical Properties of the Soils

Morphological properties

Summary of the morphological and physical properties of the soils is presented on Table1 and the description of the three pedons for the different soil units are presented in figure 2. The three soil units though located on different land forms with varying elevations were classified as *Alfisols* with sequence horizons of A-Bt. The Bt horizons in all the soil units are thick and well developed an indication of mature soils. Illuvial phenomena given rise to Bt horizons were clearly evidenced by change in soil colour and soil texture. Soil units UL1 and DV3 have a predominant soil colour of 10YR hue while soil unit UL2 has predominant hue value of 7.5YR with 10YR on the surface. The colour ranged from dull yellow orange to brown on the surface and bright yellowish brown to yellowish brown at subsurface of soil unit UL1. In DV3, the colour is brownish gray at the surface and subsurface with a predominant chroma of 1. Brownish gray (7.5YR 5/1) mottles were observed in the subsurface of DV3. In UL2, the soils are dull yellow orange at the surface to yellowish brown at the subsurface. The soil structure is generally subangular blocky with a strong and moderate grade. However, the soil is structureless at the surface horizon of UL2 because of the predominance of sand. The strong subangular blocky structure of soils of Sokoto has been attributed to good drainage, moulding actions of wetting and drying cycles as suggested by Yakubu and Ojanuga (2013). The consistency is firm in the surface and hard in the subsoil (UL1 and DV3). It is loose and friable at the surface of UL2 and hard at the subsurface. Sufficient clay was identified in the B horizons (an argillic horizon, Bt). Few fine roots were observed in the surface soils of all the soil units. Few and many gravel materials were identified in soil units UL1, DV3 and UL2 respectively. Fe concretions (Figure 3a and 3d) were observed in horizon Bt2 and Bt3 of soil unit UL1. Fe-stone boulders were also observed in horizon Bt4 and IIIBt2 of soil DV3 and UL2 (Fig.3c & 3a) respectively. Buried tone line was observed in horizon IIBt1 of soil unit UL1 (Fig.3b). This is an indication of lithologic discontinuity and an apparent change in parent material.

Physical Properties of the soils of the Study area

The physical properties of the study soils are also presented on Table 1. Particle size analysis indicates a dominance of sandy loam, sandy clay loam and loamy sand textures. The soils have more clay on the subsurface than surface. Soil unit DV3 contains more clay than soil units UL1 and UL2. The clay content increases with increasing depth of soils, an indication of clay movement through illuviation processes. The sand content in the A horizon of soil unit UL2 is high (84.9%) and followed by a sharp increase in clay content in the next horizon. The clay content changed from 5.3 % in A horizon to about 21% giving rise to a B horizon with different parent materials (IIBt1) The silt/clay ratio of the soils ranged between 0.7 and 4.9 with higher values on the surface. It is also used in the evaluation of clay migration, stage of weathering and age of parent material and soils (Nwaka, 1990). The more highly weathered a soil is the lower the silt fraction. Therefore, soils with silt/clay ratio of less than 0.15 are regarded as highly weathered (Van Wambeke,1962). The results of the study show that, all the soils have silt/clay ratio above 0.15 indicating that the soils have high degree of weathering potential. Similar results were found by Yakubu (2006) for soils of Sokoto State.Bulk density ranged from 1.40 Mgm^{-3} in soil unit DV2 to 1.60 Mgm^{-3} in soil unit UL2. Good plant growth is best in bulk densities below 1.4 Mg/m^{-3} for clay soil and 1.6 Mg/m^{3} for sands (Donahue et al., 1990). As a result, the bulk density values of the soils are unlikely to hinder growth. Porosity values ranged from 52 % to 60 % in all the soils. The porosity values are moderate and could favour good aeration and free water movement in the soils.

Chemical Properties of the Soils

Result of the chemical properties of the soils is presented in Table 2. The soil pH (H_2O) varies from slightly acid (6.30-6.58) to near neutral (6.60 to 6.62) in all the pedons according USDA (1996). pH was observed to be irregularwith increasing depths of profile. The variation in soil pH could be attributed to differences in parent materials. The soil pH is favourable for most crops grown around the area.

Organic matter was generally very low to medium in all the soils according Girma et al., (2006) and ranged from 0.7$gkg^{-1}$to 2.4 gkg^{-1} in the soil unit UL1, 1.5 $gkg^{-1}$to 2.1 gkg^{-1} in soil unit DV3, and 0.9 $gkg^{-1}$to 1.5gkg^{-1} in soil unit UL2. Organic matter was observed to decrease as the depth of profile increases in UL1 and UL2. While in DV3 organic matter increases with increasing depth and this could be due annual deposition by flood in the valley bottom.

Total N ranged from 0.39gkg^{-1} to 0.56 gkg^{-1} in soil unit UL1, 0.60gkg^{-1} to 1.19 gkg^{-1} in soil unit UL2 and 0.35gkg^{-1} to 0.53 gkg^{-1} in soil unit DV3. The total nitrogen in the soil was generally medium to high according to the rating by Metson (1961). Available P ranged between 9.09mgkg^{-1}and 9.88mgkg^{-1} in all the soils. It is medium according to the rating by Enwezor et al., (1989). Exchangeable bases ranged between 0.3 cmolkg^{-1} and 1.3 cmolkg^{-1} for Ca, 0.3 cmolkg^{-1} and 1.1 cmolkg^{-1} for Mg, 0.25 cmolkg^{-1} and 1.05 cmolkg^{-1} for K and 0.03 cmolkg^{-1} and 0.17 cmolkg^{-1} for Na. The dominant exchangeable bases in the soil are Ca and Mg. Ca is very low (< 2 cmolkg^{-1}), Mg is very low to moderate, K is very low to high level in the soils, while Na is very low in the soil. CEC in soil unit UL1 range from 2.89 cmolkg^{-1} to 3.43 cmolkg^{-1}, 3.04 cmolkg^{-1} to 6.17 cmolkg^{-1} in soil unit UL2, and 2.04 cmolkg^{-1} to 4.44 cmolkg^{-1} in soil unit DV3. The CEC is generally with values of less than 6 cmolkg^{-1}. Low nutrient content in the soils may be attributed to the low activity clay, uptake by plant and little or no addition from external inputs. Percentage Base saturation range between 46 % to 70 % in all the soils. Base saturation is generally moderate to high. Electrical conductivity is low with values generally less than 4 dsm^{-1}. The values range between 0.06 dsm^{-1} to 0.14 dsm^{-1} in all the soils. Exchangeable sodium percentage (ESP) is generally low with values less than 15% a critical level suggesting salinity/sodocity. The values range between 1.3%- 6.1% in all the soils. SAR range between 0.03 to 0.14 in the soils, suggesting very low values. The values of EC, ESP and SAR are low and indicate soils without salinity/sodocity problems.

Chemical soil degradation (Heavy metals)

Result of the heavy metals in soils of the study area that showed the level of chemical degradation is presented in Table 3. The values of heavy metals in the soils are compared with the permissible limit set by WHO (1996). Iron (Fe) has a concentration range of 6.0 to 17mgkg^{-1}, with mean values of 10.8 (±4.02) in the soil the samples. Findings revealed values less than the value (80000 mg/kg) reported in soil (McGrath et al, 2001**)**. Iron level was relatively higher (17mgkg^{-1}) away (100m) from the mining area in site E1 and relatively higher (13.3 mgkg$^{-1)}$ closer (0m) to mining area in site E2. Lead (Pb) range from 0.1 to 2.5mgkg^{-1} with mean value of 0.1 (±1.42). The values are generally low below the permissible level of 85 mgkg^{-1} . This therefore indicates absence of lead problem in the area. Zinc (Zn) range from 1.4 to 6.1 mgkg^{-1} with mean value of 3.4 mgkg^{-1}(±1.61). The values are generally below the permissible limit of 50 mgkg$^{-1.}$ Copper (Cu) range from 0.3mgkg^{-1} to 4.4mgkg^{-1} with mean value of 1.8 mgkg^{-1} (±1.98). The values in the soils are below the permissible level of 36 mgkg^{-1}. Chromium (Cr) range from 2.0 to 8.1 mgkg^{-1} with mean value of 4.8 mgkg^{-1} (±2.59). The values are below the permissible level of 100 mgkg^{-1}. Cadmium (Cd) range from 1.5 to 5.4 mgkg^{-1} with mean value of 3.4 mgkg^{-1} (±1.07). Cd values are generally higher than the permissible limit of 0.8 mgkg^{-1}. It therefore shows that the area has higher concentration of Cadmium and thus may cause Cd pollution.

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Taxonomic Classification of the Soils

Taxonomic soil classification was performed based on the criteria of the USDA Soil Taxonomy System (Soil Survey Staff, 2022) and correlated with the World Reference Base for soil resources system (WRB, 2022). The summary of the classifications is shown in Table 4. At the soil order category, irrespective of lithology, all the pedons (soil units UL1, UL2 and DV3) qualified as Alfisols because of the presence of textural (Bt) horizon and moderate to high Base saturation. At the suborder, UL1 and UL2 were classified as *Ustalfs* because of the ustic soil moisture regime while DV3 qualifies as *Aqualfs* because of the aquic conditions and redoximorphic features. At the great group, UL1 was classified as *Kandiustalfs* because of the presence of kandic horizon (low activity clay and CEC) characteristics of the environment and clay increase of 3 % or more. UL2 was classified as *Paleustalfs* because the lower part of the argillic horizon has a Hue of 7.5YR and Chroma of 5 or more. DV3 was classified as *Endoaqualfs*because of the Endosaturation (lower water table). In the sub-group, UL1 was classified as *TypicKandiustalfs* having failed to meet the criteria of other *Kandiustalfs*. UL2 was classified as *Kandic Paleustalfs* because of CEC less than 24 cmol(+) kg clay. DV3 was classified as *Typic Endoaqualfs (*Other *Endoaqualfs).* The soils correlate with Lixisols in the World Reference Base for Soil Resources because of the accumulation of low activity clay and high base saturation.

Conclusion

The characterization of soils of the cultivated area of Niger state College of Education, Minna revealed two mapping units (Upland and Dissecting Valley) out of which three soil units were identified, two (UL1 & UL2) on the upland and one (DV3) on the Dissecting valley. The soils are texturally sandy loam, loamy sand, sandy clay loam and clay with a textural B (Bt) in all the soil units. The soils structure is moderately coarsedsubangular blocky in the subsurface and structureless on the surface of UL1. The upland soils are a redder hue of 7.5YR while the dissecting valley soils are dark with predominant hue value of 10YR. The soil reaction range from slightly acid to near neutral. Organic matter and total Nitrogen are generally low to medium in the soils. Exchangeable bases and cation exchange capacity are generally low. Chemical degradation of the soils through heavy metals concentration is not significant. The heavy metals used (Fe, Pb, Zn, Cu, and Cr) to assess the level of degradation revealed values below the permissible level, with exception of Cd which presents values above the permissible level of 0.8mgkg^{-1}. The soils could therefore, be referred to as Cd polluted. The soils were classified as *Alfisols* (USDA Soil Taxonomy System) and correlate with *Lixisols* (low activity clay) in the World Reference Base (WRB) for soil resources.

REFERENCES

Adebayo, O. E., Abosede, T. O., Temitope, O. & Olusegun, O. A. (2017). Effects of Artisanal gold mining activities on soil properties in a part of southwestern Nigeria. Environmental Management &Conservation | Research Article. Cogent Environmental Science (2017), 3: 1305650

Ako, T. A., Onoduku, U. S.**,** Oke, S. A., Adamu, I. A., Ali, S. E., Mamodu, A. & Ibrahim, A. T. **(**2014)**.** Environmental Impact of Artisanal Gold Mining in Luku, Minna, Niger State, North Central Nigeria. *Journal of Geosciences and Geomatics*, *2*(1), 28-37. DOI:10.12691/jgg-2-1-5

Bremner, J.M. & Mulvaney, C.S. (1982). Nitrogen-Total. In: Methods of soil analysis. Part 2. Chemical and microbiological properties, Page, A.L., Miller, R.H. and Keeney, D.R. Eds., *American Society of Agronomy, Soil Science Society of America, Madison, Wisconsin, 595-624.*

Blake, G.R. & Hartge, K.H. (1986). Bulk density. In: Klute, A., Ed., Methods of Soil Analysis, Part 1—Physical and Mineralogical Methods, 2nd Edition, Agronomy Monograph 9, *American Society of Agronomy—Soil Science Society of America, Madison, 363-382.*

Donahue, R.L, Raymond, M.W. & Schick Line, J.C. (1990). Soils: An Introduction to Soils and Plant Growth. Prentice hall of India. 667pp.

Esu, I. E. (2005). Characterization, Classification andManagement Problems of the major soil orders in Nigeria. 26th Inaugural lecture held at the University ofCalabar, Calabar. ISBN 978-007-148-2. Pp 1-66

Eswaran, H. (1977). Soil Analysis for Soil Surveys. In: Soil Resource Inventories. A proceeding of a workshop held at Cornell University, Ithaca, USA, pp 315-324.

FAO, (2006). Guidelines forsoil description. Fourth edition. Food And Agriculture Organization of the United Nations, Rome, 2006. Pp109.

Girma, K., Martin, K.L., Anderson, R.H., Arnall, D.B., Brixey, K.D., Casillas, M.A., Chung, B., Dobey, B.C., Kamenidou, S.K., Kariuki, S.K., Katsalirou, E.E., Morris, J.C., Moss, J.Q., Rohla, C.T., Sudbury, B.J., Tubana, B.S. & Raun, W.R. (2006) Mid-season prediction of wheat-grain yield potential using plant, soil, and sensor measurements. *Journal of Plant Nutrition*, *29*, 873-897.

IUSS WRB. (2022). World Reference Base for Soil Resources. International soil classification system for naming soils and creating legends for soil maps. 4th edition. International Union of Soil Sciences (IUSS), Vienna, Austria.

Lal, R. (2010). Managing soils and ecosystems for mitigating anthropogenic carbon emissions and advancing global food security. *BioScience 60*(9):708-721.

McGrath, S.P., Zhao, F.J. & Lombi, E. (2001). Plant and rhizosphere processes involved in phytoremediation ofmetal-contaminated *soils. Plant Soil. 2001; 232:207–214*. https://doi.org/10.1023/A:1010358708525

Metson, A.J. (1961). Methods of chemical analysis for soil survey samples. Soil Bureau Bulletin No. 12, New Zealand Department of Scientific and Industrial Research, Government Printer: Wellington, New Zealand. 171pp.

Nwaka, G.I.C. (1990). Studies on dune soils of Borno State. Morphology, classification and physical properties. *Annals of Borno 6*(7):198-204.

Ogunkunle, A.O. (2005). Soil Survey and SustainableLand Management. Invited paper at the 29th annual conf. of SSSN held at University of Nigeria, Abeokuta, from 6th to 10th Dec. 2004.

Ojanuga, A.G. (2006). Agro ecological zones of NigeriaManual. National Special programme for foodsecurity and FAO. Pp 124.

Okonkwo, S O., Jacob, J. O. & Iyaka, Y. A. & Inobeme, A. (2021). Assessment of selected heavy metal concentrations in soils from a mining area in Minna, Niger State. Environ Monit. Assess 2021 Feb 22; *193*(3):140. doi: 10.1007/s10661-021-08903-8.

Sharma, S., Nagpal, A.K., & Kaur, I. (2018). Heavy metal contamination in soil, food crops and associated healthrisks for residents of Ropar wetland, Punjab, India and its environs. Food Chem. 2018; 255:15–22. https://doi.org/10.1016/j.foodchem.2018.02.037 PMID: 29571461

Soil Survey Staff, (2022). Keys to Soil Taxonomy, 13th ed. USDA-Natural Resources Conservation Service. Pp410.

Thomas, G. W., (1982). “Exchangeable Cations. Methods of Soil Analysis, Part 2, Chemical and Microbiological Properties”, Second Edition. A.L. Page (editor). Agronomy, No. 9, Part 2, American Society of Agronomy, Soil Science Society of America, Madison, Wl: 159-165

USDA (1996). Soil Survey of Dade Country Area, Florida. “Natural Resources Conservation Service. https:nrcs.app.box.com/s/d0hg4d do8t8otkwaejj131xp7xo0yi9g/file/982460499981. Accessed September 21, 2024.

Usman, L. M., Mahamud, Yusuf M., Usman, Y. & Abdussalam, B. (2018). Limestone as Solid Mineral to Develop National Economy. *American Journal of Physical Chemistry. 7*(2), 23-28. doi: 10.11648/j.ajpc.20180702.13

Walkley, A.J. & Black, I.A. (1934) Estimation of soil organic carbon by the chromic acid titration method. *Soil Sci. 37,* 29-38.

WHO (1996) Permissible limits of heavy metals in soil and plants (Geneva: World Health Organization), Switzerland.

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Yakubu, M. (2006). Genesis and classification of soils over different geological formations and surfaces in the Sokoto plains Nigeria. PhD Thesis. Soil science and Agricultural Engineering Department, UsmanuDanfodiyo University Sokoto (Unpublished). (Donahue *et al.*, 1990).

Yakubu, M. & Ojanuga, A.G. (2013). Pedogenesis, weathering status andmineralogy of the soils on ironstone plateaux (laterites), Sokoto Nigeria. *Bayero Journal of Pure and Applied Science 6*(2): 93-100.

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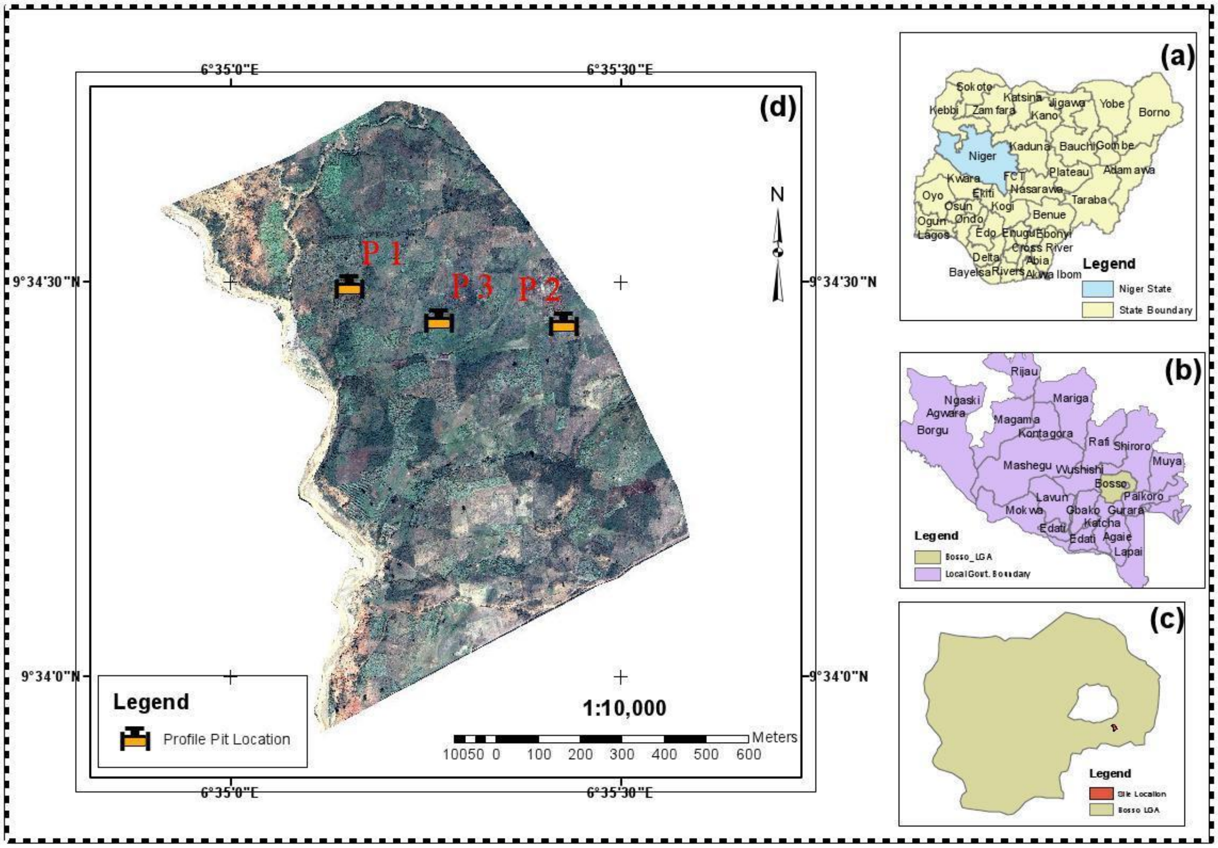

Fig. 1. (a)Map of Nigeria showing Niger State. (b) Map of Niger State showing Bosso LGA (c) Map of Bosso LGA showing the Study Area. (d). Map of the study area showing profile soil sampling points.

Fig. 2a. Upland mapping/soil unitUL1, on an elevation of 236m. Presence of gravelly materials and sandy loam texture at the surface, cultivated to sorghum, maize and

Fig. 2b. Upland mapping units UL2, on an elevation of 247m.Presence of stony boulders with sand texture on the surface. Cultivated to sorghum and cowpea

Fig 2c. Dissecting valley mapping/soil unitDV3. Formed by erosive action of stream on an elevation of 232m. cultivated to rice

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Table 1. Morphological and Physical Properties of the soils of the College of Education, Minna Farm land

Horizon	Depth (cm)	Colour*	Mottling	Structure	Consistence (moist)	Other features	Horizon Boundary	Sand	Silt	Clay	Silt/clay ratio	Textural Class	BD	Porosity
								------------gkg^{-1}------------					Mgm^{-3}	%
Pedon 1 (UL1)				**9º 34' 29.58" N**	**6º 35' 9.10" E**				**Elevation 236M**					
Ap	0-17	10YR 6/4		2CSBK	Fi	ffr,fgr	AW	53.5	37.3	9.20	4.1	SL	1.52	57
Bt1	17-70	10YR 4/4		2MSBK	Hr	ffr,mgr, Fe conc.	CS	57.4	19.7	22.9	0.8	SCL	1.47	55
Bt2	70-120	10YR 5/6		2MSBK	Fi	Fe.conc.	CS	49.6	27.5	22.9	1.2	SCL	1.45	54
Bt3	120-200	10YR 7/6		2MSBK	Fi	Fe.conc	-	55.4	23.4	21.2		SCL	1.45	54
Pedon 2 (UL2)				**9º 34' 26.78" N**	**6º 35'25.63" E**			**Elevation 247M**						
A	0-15	10YR 7/3		0	Ls	mgr, mfr, fcr,	CS	84.9	9.80	5.30	1.8	LS	1.60	60
IIBt1	15-47	7.5YR 6/6		0	Fr	fgr,ffr&, ch, stoneline	AW	57.4	21.6	21.0	1.0	SCL	1.44	54
IIBt2	47-100	7.5YR 5/6		2MSBK	Hr	vffr, ch.	CW	39.8	25.5	34.7	0.7	CL	1.53	57
IIBt3	100-165	7.5YR 6/8		2MSBK	Hr	ffr, Fe stone boulders	-	60.0	26.9	13.1	2.1	SL	1.53	57
Pedon 3 (DV3)			**9º 34' 27.03" N**		**6º 35'16.01" E**					**Elevation 232M**				
Ap	0-20	10YR 5/1	-	3CSBK	Hr	ffr, ch,	AW	45.7	45.1	9.20	4.9	L	1.56	58
Bt1	20-98	7.5YR 2/1	-	3CSBK	Hr	ffr,ch	AS	37.8	25.6	36.6	0.7	CL	1.40	52
Bt2g	98-125	10YR 6/3	7.5YR 5/1 (ff)	3CSBK	Hr	fgr, ffmot.	AS	69.2	21.6	9.20	2.3	SL	1.58	59
Bt3g	125-155	10YR 7/3	7.5YR 5/1 (ff)	2CSBK	Hr	fgr, ff.mot.	AS	57.4	25.5	17.1	1.5	SL	1.55	58
Bt4	155-185	10YR 6/1	-	2CSBK	ss/sp	Fe. stone boulders	-	60.9	15	20.6	0.7	LS	1.57	59

Structure:0- structureless, 2-moderate, 3-strong, CSBK-coarse subangular blocky, MSBK-medium subangularblocky**Texturalclass:**SL- sandy loam, SCL-sandy clay loam, LS-Loamy sand, SCL-sandy clay loam, L-Loam, CL-Clay loam
Consistence: Ls-loose, Fr-Friable, Hr-Hard, ss/sp-slightly sticky,
Other features :ffr-few fine roots, fgr-few gravel, mgr-medium gravel, Fe.conc- Fe concretion, mfr-medium fine roots,vfr-very fine roots, ch-chanel, ffmot-few fine mottles, Fe.stone- Iron stone

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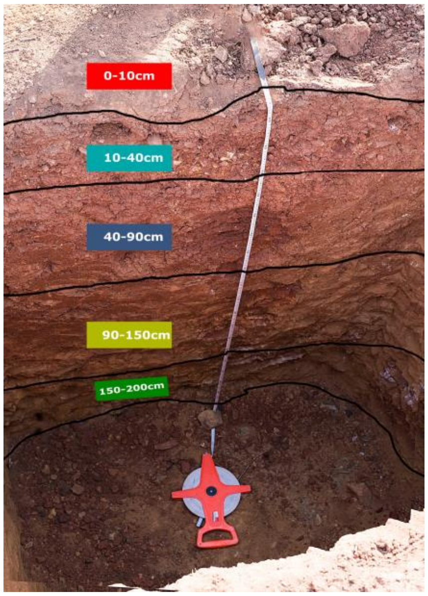

Fig. 3a. Soil unit UL1. Well-drained soils, with gravelly materials, Sandy loam and sandy clay loam on the surface. Fe-concretions between 90-200cm

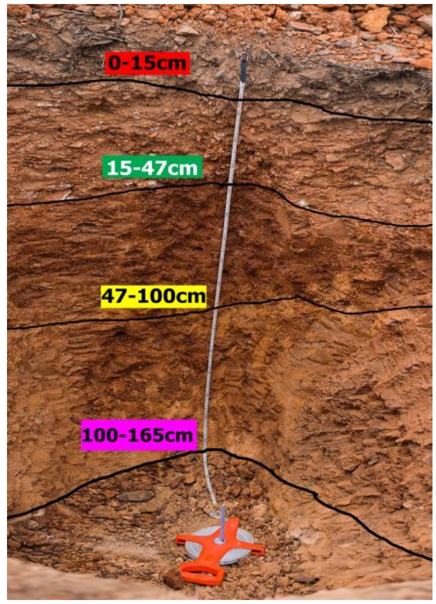

Fig.3b. Soil unit UL2. A well-drained soil, with Loam sand surface followed a sandy clay loam or clay. Gravel material within 50cm. Buried stone line between 15-

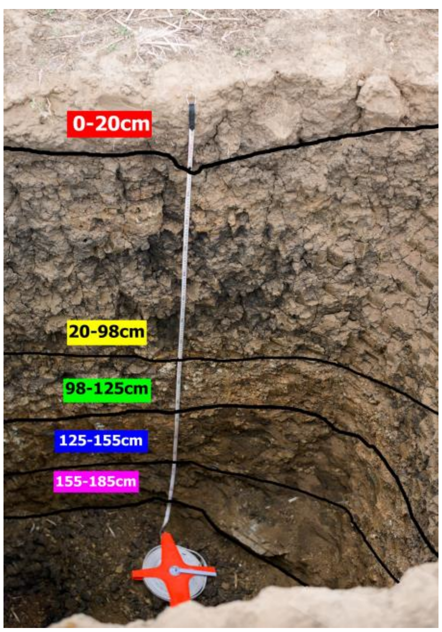

Fig.3c. Well-drained soil. Gravelly material at the surface. Redoximorphic features (20-185cm), gleyic and mottle properties. Fe-stone boulders (185 cm)

Figure.3d. Fe-concretion from Pedon 1 (UL1). Sandy materials impregnated by Fe to form Fe-concretions.

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Table 2. Chemical Properties of the soils of the College of Education, Minna Farm land

Horizon	Depth	pH (H2O 1:1)	O.M	TN	Avail. P	Ca	Mg	Na	K	CEC	BS	EC	ESP	SAR
	(cm)		gkg^{-1}		$mgkg^{-1}$	←---------- $cmolkg^{-1}$	----------→				(%)	dSm^{-1}	(%)	
Pedon 1 (UL1)			**9º 34' 29.58" N**		**6º 35' 9.10" E**						**Elevation 236M**			
Ap	0-17	6.35	2.4	0.56	9.50	0.7	0.5	0.09	1.05	3.34	70	0.11	3.8	0.12
Bt1	17-70	6.60	1.4	0.49	9.44	0.8	0.9	0.13	0.60	3.43	71	0.06	5.3	0.14
Bt2	70-120	6.62	0.7	0.39	9.70	0.5	1.1	0.04	0.25	2.89	65	0.08	2.1	0.05
Bt3	120-200	6.61	1.0	0.44	9.30	0.7	1.0	0.06	0.45	3.34	66	0.07	2.7	0.05
Pedon 2 (UL2)			**9º 34' 26.78" N**		**6º 35'25.63" E**						**Elevation 247M**			
A	0-15	6.44	1.5	1.19	9.66	1.2	0.5	0.17	3.00	6.17	79	0.09	3.5	0.20
IIBt1	15-47	6.62	0.7	0.63	9.60	1.0	0.4	0.04	0.60	3.04	67	0.18	1.9	0.05
IIBt2	47-100	6.66	1.0	0.63	9.40	1.3	0.3	0.04	0.63	4.57	50	0.14	1.8	0.04
IIBt3	100-165	6.61	0.9	0.60	9.60	1.3	0.4	0.03	0.60	5.02	46	0.14	1.3	0.03
Pedon 3 (DV3)			**9º 34' 27.03" N**		**6º 35'16.01" E**						**Elevation 232M**			
Ap	0-20	6.30	1.5	0.53	9.30	0.3	1.0	0.09	1.00	3.39	71	0.14	3.7	0.10
Bt1	20-98	6.49	2.1	0.46	9.09	1.2	1.0	0.09	0.55	4.44	64	0.07	3.2	0.09
Bt2g	98-125	6.60	2.4	0.35	9.88	0.3	0.5	0.04	0.20	2.04	51	0.05	3.8	0.06
Bt3g	125-155	6.58	1.9	0.35	9.28	0.5	0.6	0.09	0.28	2.97	50	0.11	6.1	0.13
Bt4	155-185	6.55	2.1	0.35	9.22	0.4	0.6	0.08	0.25	2.90	46	0.08	6.0	0.11

O.M; Organic Matter, **TN;** Total Nitrogen, **Avail. P;** Available Phosphorus, **BS;** Base Saturation, **EC,** Electrical conductivity, **ESP,** Exchangeable Sodium percentage, **SAR**, Sodium Adsorption Ratio.

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Table 3. Concentration of Heavy Metals in the Soils of the College of Education, Minna

SAMPLES	Iron (Fe)	Lead (Pb)	Zinc (Zn)	Copper (Cu)	Chromium (Cr)	Cadmium (Cd)
			$mgkg^{-1}$			
E1a (0m)	9.5	0.2	2.9	4.4	6.8	2.3
E1b (50m)	6.0	0.1	2.4	1.1	2.5	1.5
E1c (100m)	17	0.3	3.9	2.1	2.0	4.1
E2a (0m)	13.3	2.0	1.4	0.3	3.1	3.3
E2b (50m)	11.9	2.5	3.8	1.5	6.4	3.5
E2c (100m)	7.6	0.9	6.1	1.3	8.1	5.4
Range	**6.0-17**	**0.1-2.5**	**1.4-6.1**	**0.3-4.4**	**2.0-8.1**	**1.5-5.4**
Mean	**10.8**	**0.1**	**3.4**	**1.8**	**4.8**	**3.4**
SD	**±4.02**	**±1.42**	**±1.61**	**±1.98**	**±2.59**	**±1.07**
Reference values (mg/kg)	**80000[a]**	**85[b]**	**50[b]**	**36[b]**	**100[b]**	**0.8[b]**

a. McGrath et al, 2001; b. WHO, (1996)

Table 4. Summary of the Taxonomic Classification of Studied Soils

Pedon	Mapping/ Soil Unit	Order	Sub-order	Great group	Subgroup	WRBSR
P1	UL1	*Alfisols*	Ustalfs	KandicUstalfs	TypicKandiustalfs	LoamicLixisols
P2	UL2	*Alfisols*	Ustalfs	Paleustalfs	KandicPaleustalf	HaplicLixisols