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Assessment of Nutrient Depletion in Mining Sites and Smallholders Farms in the Angwan Doka, Kokona Local Government Area, Nasarawa State Nigeria

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ABSTRACT

This study assessed soil physical and chemical properties in mining sites and farmlands. The aim was to evaluate the level of nutrient depletion in the soil and ascertain the impact of mining sites around farmlands on nutrient depletion. Data were collected using a soil auger to take ten composite soil samples from mining sites and farmlands. Physico-chemical properties of soils were analysed in the laboratory, and the data were analysed using SPSS/10.0 with the results expressed as mean ± SD of five determinations. Statistical evaluations using One-way Analysis of Variance (ANOVA) and values regarded as statistically significant at $p < 0.05$ revealed no significant difference in nutrient depletion between mining sites and farmlands in the Angwan Doka. The F-calculated value for the interaction between nutrient depletion and land use (mining sites versus farmlands) is 0.50876, which is lower than the F-critical value of 4.0471 at a 5% significance level ($P > 0.05$). It indicates that nutrient depletion levels in the soils of mining sites and farmlands in the Angwan Doka area are statistically similar. The analysis highlights that while the overall variance in soil physical-chemical properties is highly significant, with an F-calculated value of 80.40745 ($P < 0.001$), this may be primarily due to variations within other components, rather than between the two land-use types. The total sum of squares (SS = 83952.48) reflects the contribution of all sources of variability, yet the specific contribution of mining sites versus farmlands (SS = 11.16161) is minimal. The mean square (MS) for the mining site versus farmland interaction is also low, at 11.16161, indicating limited variability in nutrient depletion between these two categories.

***Keywords**: Nutrient depletion, Mining sites, Smallholder farms, Angwan-Doka*

1.0 INTRODUCTION

Mining and farming activities are two separate entities that rely on the natural resources of the Earth's surface, and they are essential for socio-economic and industrial development. Both activities involve excavation and cultivation of the Earth's surface, affecting soil nutrients, among critical ecological indices for a sustainable environment and agricultural production. Though both activities involve deforestation, bush burning, and loss of biodiversity, which usually disrupts the ecosystem, the degree to which it varies.

Mining involves all the exploration and extraction of valuable mineral resources from the Earth's surface to get mineral wealth for socio-economic and industrial development. The proper coordination of mining can have a positive socio-economic impact as it provides natural resources for consumption, offers jobs, a source of revenue, and foreign exchange (Unanaonwi and Amonum 2017). The exploitation of mineral resources has assumed prime importance in Nigeria, with abundant mineral resources; this has contributed immensely to the socio-economic status (Adekoya, 2003). Irrespective of the socio-economic importance of mineral resources, Aigbedion and Iyayi (2007) stated that the three stages of mineral development (i.e. exploration, mining and processing) have caused different types of environmental damage, which include ecological disturbance, destruction of natural flora and fauna, pollution of air, land and water, nutrient loss among others.

Smallholders are small-scale farmers who manage farmlands from less than one hectare to ten hectares. They are characterised by family-focused motives such as favouring the stability of the farm household system, using mainly family labour for production and using part of the produce for family consumption (FAO 2013). Smallholder farms supply food to Nigerians. According to Akinsuyi (2011), more than 80% of the farmers, including medium and large ones, are smallholder farmers.

Nutrients are critical elements in the soil that aid productivity and are essential to support life. Soil nutrients are enhanced by plants, environmental factors and soil factors. Nutrients are usually the first link in the food chain; thus, a loss of nutrients in a habitat will affect nutrient cycling and eventually the entire food chain. Nutrient depletion refers to the loss of nutrients and micronutrients in the soil.

Nutrient depletion is one of the major causes of decreased crop yield and a threat to food security and sustainable crop production. Nutrient depletion is the result of a net negative balance between incoming and outgoing nutrients in farm input and output accompanied by low, untimely or inefficient applications of manure or fertilizers with farm management practices that result in leaching and erosion (Van Beek et al., 2008; Hiikyaa 2024), leading to low agricultural productivity and hence a threat to food security and reduced cash income (Kabirigi et al., 2016). Many studies have documented soil fertility decline in Northern Nigeria (Macaulay, 2014), and information on nutrient balances of smallholder farms in the Northern Guinea Savanna of Nigeria is scarce (Hiikyaa, 2024).

The purpose is to ascertain the level of nutrient depletion in mining sites and smallholder farmlands of Angwan Doka, a mining community, where farming is an occupation of the people. The motivation for the study is related to the personal experience during a field trip with some students. We observed environmental degradation due to the mining activities in the Angwan Doka agrarian community. However, this anecdotal evidence was insufficient to assess the ecological impact of mining in the Angwan Doka.

2. MATERIALS AND METHOD

2.1 Description of Study Area

This study was conducted in the Angwan Doka, a smallholder's farm community in Kokona Local Government Area of Nasarawa State, Nigeria. Angwan Doka is an agrarian community in Kokona Local Government Area of Nasarawa State, Nigeria, where mining activities are carried out in the smallholder community and mining sites are about two hundred meters from the farmlands. It is located within latitude 8° 37' 59" North of the equator and between longitude 8°7' 59" E of the meridian with a point location of Lat/Long (dec): 8.63333, 8.13333. The Local Government Area is bounded by Akwanga, Lafia, Nasarawa Eggon, Karu and Nasarawa Local Government Area (Figs 1 and 2). Angwan Doka is within the sub-humid tropical zone. The zone is characterised by two seasons. The dry season starts from November to March, and temperature increases from January to March, between 22^oC – 37^oC. The temperature is moderate in January because of Harmattan. The hottest month is March with temperatures ranging from 33^oC – 36^oC maximum. The wet season begins from April to October, with the wettest months being July and August. The rain comes with high-intensity thunderstorms, particularly at the beginning and end of the wet season. The annual rainfall is 1526mm, with a generally high humidity of about 90% during the rainy season. This figure drops to about 40% during the dry season. (NIMET, 2018).

The topography of Angwan Doka is like that of the Kokona local government area, which is part of the Precambrian-aged basement complex rocks which cover about 60% of the total superficial area of Nasarawa State (Wilson-Osigwe et al., 2020). The area is of basement complex rocks with younger granites intruding and therefore does not occupy any separate landmass of its ·own. Of the basement complex, migmatite-gneisses along with the older granites account for about 70%;

rocks of schistose lithology and other meta-sedimentary series (quartzite, marble, ironstones) in the areas make up the remaining 30% (Obaje et al, 2006; Wilson-Osigwe et al., 2020). The soils are derived mainly from the Basement Complex and old sedimentary rocks (Wilson-Osigwe et al., 2020).

The major solid minerals in Kokona are clay, mica, granite, columbite, and limestone. Land use in the area is mainly agriculture, which forms the mainstay of the people's economy with cash and food crops, which include maize, rice, melon, yam, and cassava being the farm produce (Wilson-Osigwe et al., 2020). From field observation, there are a lot of mining activities in the area, and these mining sites are near the farmlands. Most abandoned mining sites are reclaimed, farming is carried on them and vice versa.

2.2 Site selection and soil sampling

A reconnaissance survey was conducted in Agwan Doka in October 2024 with guidance from some elders in the community to assess the overall geography of the community and identify farmlands and mining sites where soil samples were taken. During the survey, plots were characterised as farmlands and mining sites. Several of these plots (farmlands and mining sites) were found scattered around the study area, barely 200 meters apart.

2.3 Sample Collection and Preparation

Ten (10) plots measuring 30m x 30m were laid within the mining sites and the farmlands to collect soil samples. Four quadrats were marked at each plot and four auger points per site were drilled at random to a depth of 0-25cm, using a soil auger in four directions on a transect line, for Site 1, Site 2, Site 3, Site 4 up till the 10th site, for both the soil in mining sites and farmlands. The soil samples from the four auger points per location were collected and mixed thoroughly to form composite soil samples in a polythene bag, labelled and taken to the laboratory for analysis. The coordinates of the sampling points were recorded in a GPS receiver (Table 1). Foreign materials like plant debris, waste polyethene, metal scraps and plastics were removed from the soil samples. Soil samples were air-dried for a week, ground and sieved through a 2mm sieve. The soil samples were then stored in a dried plastic container for laboratory analysis.

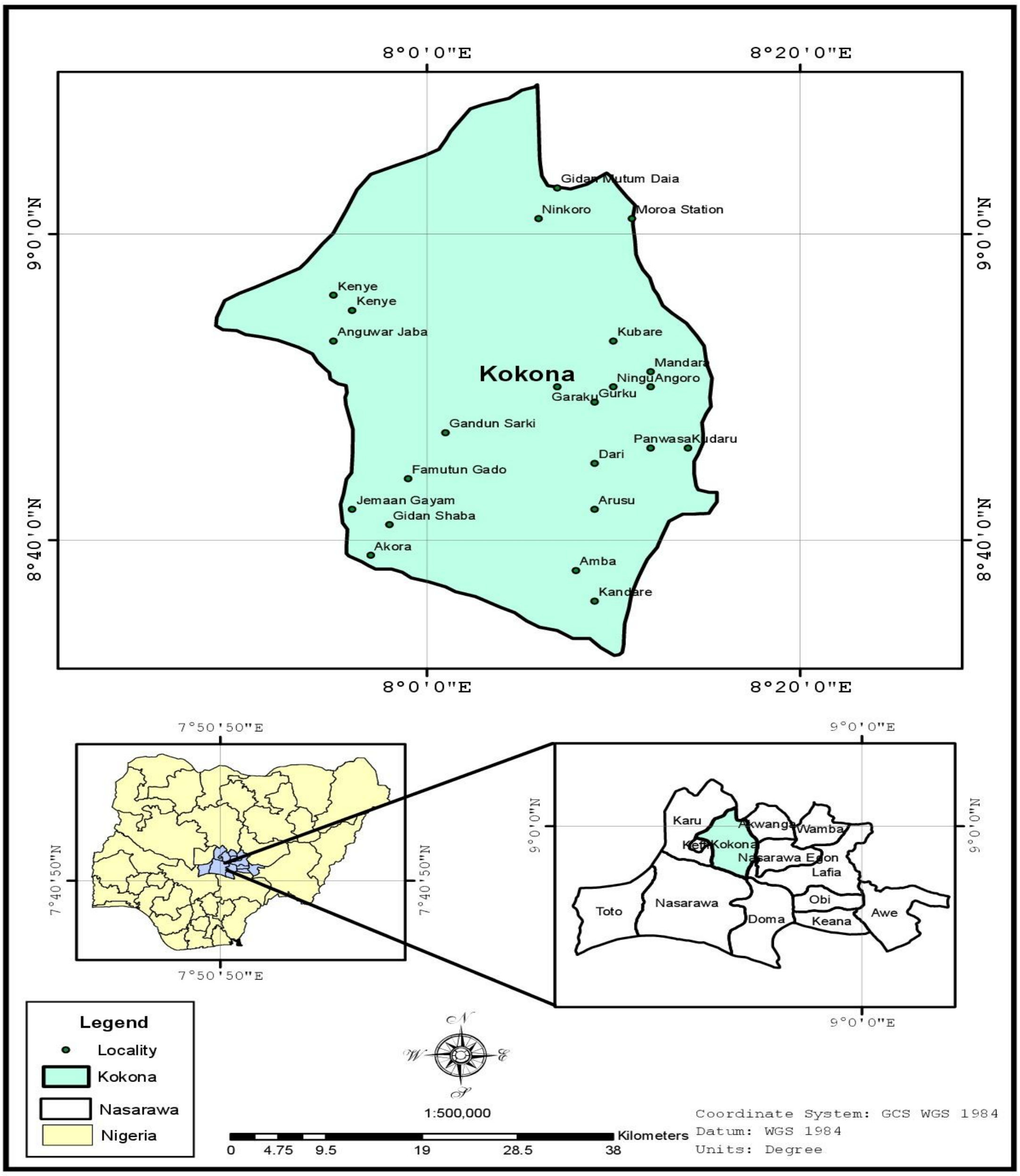

Figure 1: Map of Kokona Local Government Area of Nasarawa State
Source; Map Produced using ARCGIS Pro 2025

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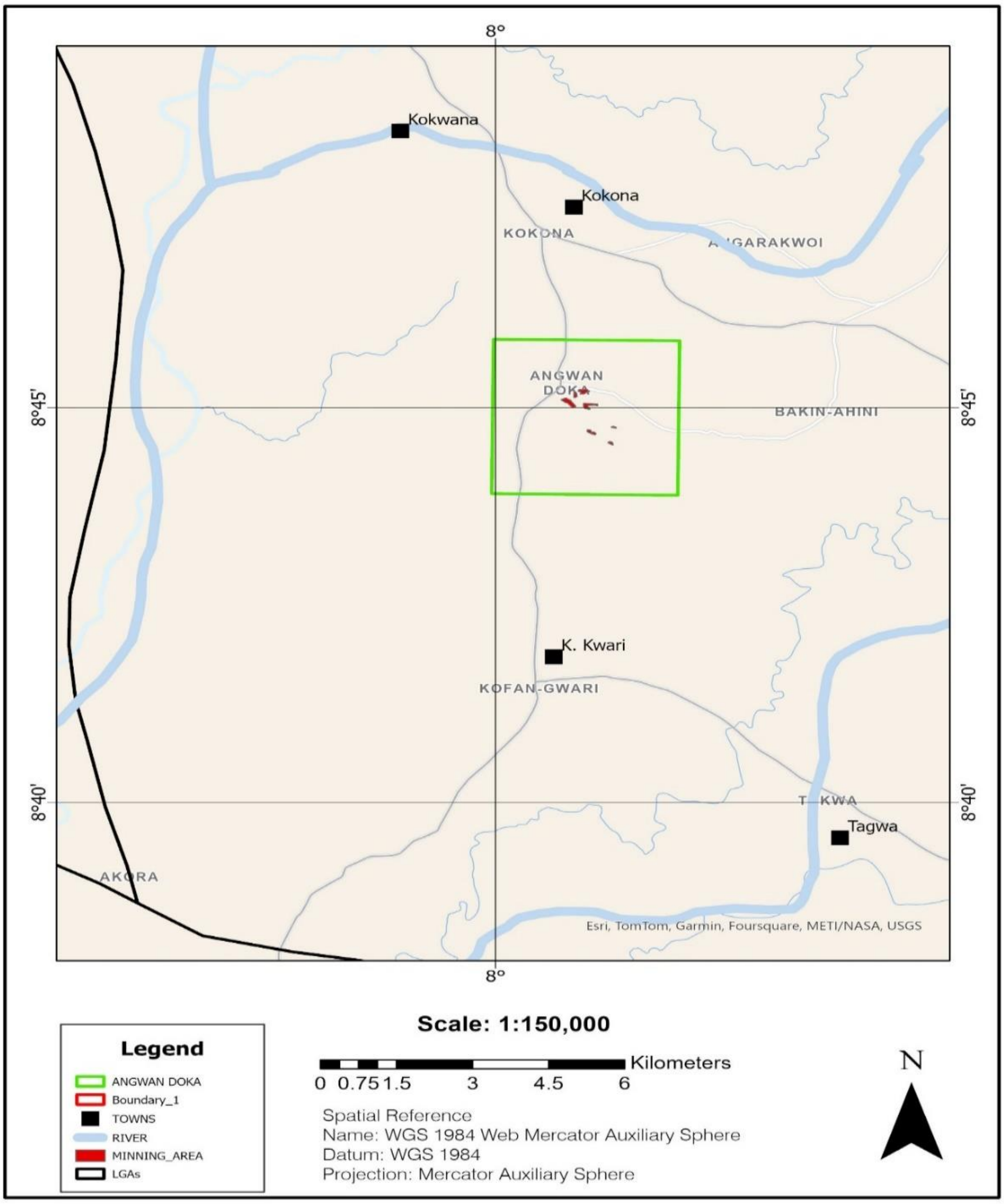

Figure 2: Map of Angwan Doka in Kokona Local Government Area of Nasarawa State
Source: Map produced using ARCGIS Pro 2025

Table 1: GPS Coordinate of Sampling Sites

Angwan Doka Kokona Mining Sites (MS)		**Angwan Doka Kokona farmland (FL)**	
Sampling sites	**GPS Coordinates**	**Sampling sites**	**GPS Coordinates**
MS 1	N08^0 45’ 05.8” E008^0 00’ 41.8”	FL 1	N08^0 45’ 07.0’’ E008^0 00’ 45,2’’
MS 2	N08^0 45’ 07.5’’ E008^0 00’ 50.9’’	FL 2	N08^0 45’ 11.5’’ E008^0 00’ 50.1’’
MS 3	N08^0 45’ 00.2’’ E008^0 00’ 56.3’’	FL 3	N08^0 45’ 02.6’’ E008^0 01’ 05.1’’
MS 4	N08^0 44’ 41.1’’ E008^0 01’01.4’’	FL 4	N08^0 44’ 40.2’’ E008^0 01’ 04.0’’
MS 5	N08^0 44’ 33.8’’ E008^0 01’12.3’’	FL 5	N08^0 44’ 31.5’’ E008^0 01 14.6’’
MS 6	N08^0 44’ 45.4’’ E008^0 00’ 55.4’’	FL 6	N08^0 44’ 44.5’’ E008^0 01’ 17.5’’
MS 7	N08^0 45’ 13.3’’ E008^0 00’ 55.4’’	FL 7	N08^0 45’ 12.4’’ E008^0 00’ 52.7’’
MS 8	N 08° 45' 12.0" E 008° 01' 00.1"	FL 8	N 08° 44' 33.5" E 008° 01' 14.6"
MS 9	N 08° 44' 43.1" E 008° 00' 58.8'	FL 9	N 08° 44' 59.7" E 008° 00' 59.3"
MS 10	N 08° 45' 06.9" E 008° 00' 44.1"	FL 10	N 08° 45' 00.9" E 008° 00' 58.8"

2.4 Sample laboratory Analysis

Soil samples were analysed in the Laboratory, Faculty of Agriculture, Nasarawa State University, Keffi for physical and chemical properties. Soil pH was determined using the Pye Unicam pH meter. The percentage organic carbon (% OC) was determined using the potassium dichromate wet oxidation method of Walkley and Black (Walkley and Black, 1934) and the organic matter (OM) was calculated from the % OC (i.e. % OC × 1.724). Total Nitrogen (TN) was determined by the micro-Kjeldahl technique (Bremner, 1982 and Mulvaney, 1982). Conventional Bray 1 method was used to determine the available phosphorus in the soil samples (Bray and Kurtz, 1945). The particle size distribution, also known as mechanical analysis, was determined by the hydrometer (Bouyoucos, 1962).

2.5 Statistical data Analysis

Data were analysed using SPSS/10.0 with the results expressed as mean ± SD of five determinations. Statistical evaluations were done using One-way Analysis of Variance (ANOVA), and values were regarded as statistically significant at $p < 0.05$.

3.0 RESULTS AND DISCUSSION

Physical and chemical properties of soils

This study seeks to determine whether there is a significant difference in nutrient depletion between mining sites (MS) and farmlands (FL) in the Angwan Doka. Table 2 compares the physical-chemical properties of the soil in these two areas, detailing various soil parameters. The results of the physical and chemical properties of the investigated soil samples are in Table 2.

Soil pH is an indicator of the quality of the soil and an index of biogeochemical processes in terrestrial ecosystems, which serves as a guide for fertiliser recommendations and liming requirements (Kome, Enang, Yerima and Lontsi 2018). Therefore, the availability of nutrients to plants and the type of organism found in the soil are influenced by soil pH because soil pH moderates the availability of plant nutrients (Feng, Wang, Bai and Reading, 2019). The pH values of soil samples under investigation from mining sites (MS) 6.93 ± 0.06 and farmland (FL) 6.93 ± 0.06 showed no variation in the MS and FL locations (Table 2). The pH is neutral, with no discernible difference in acidity or alkalinity. It may be because of the proximity between farmlands and mining sites in the study area. Generally, soil pH 6.0-7.5 is acceptable for most plants because most nutrients become available in this pH range. According to Chude et al (2011), a pH range of 5.5 -7.0 (slightly acidic to neutral reaction) is optimal for the overall satisfactory availability of plant nutrients. Adesemuyi and Dada (2018) observed that the soils in the study area are ideal for most crops to thrive well because soil nutrients will be available for absorption by plants at this pH range. According to Feng, Wang, Bai and Reading (2019), soil pH moderates the availability of plant nutrients. Soil pH was improved after disturbance for farming and mining, probably because of the input of fertiliser application and localised factors, respectively.

The Electrical Conductivity (EC) for mining sites is 91.67 µs/cm, which is lower than the 102.33 µs/cm in farmlands, indicating a difference in salinity between the two locations, with farmlands showing slightly higher salinity. Though the soil type and agricultural management in the study are similar, the higher salinity in farmlands may be because of dissolved salts from fertilisers in the soil of farmlands.

These low EC values indicate the area is not prone to salinity threats, and the soils will support many crops. The slightly acidic nature of the soil will enhance the availability of nutrients and further facilitate the solubilisation of sodium ions, which are the primary agents of salinisation and alkalinisation. Generally, low EC values indicate a low concentration of soluble salts and good soil fertility. EC value 0<2 indicates low salt content, and the ideal range for most plants is generally between 0.8-1.8ds/m (National Resources Conservation Service, (NRCS) Handbook). However, extremely low EC values can also indicate a lack of essential nutrients (P, K, Ca, Mg, Mn, Zn, and Cu) (National Resources Conservation Service, (NRCS) Handbook).

Soil organic Carbon (OC) content is similar in both areas, with 1.87% in mining sites and 1.88% in farmlands, implying negligible variation in the organic matter in the soils. Generally, values <1% are low and 1 – 1.5% are regarded as medium (Adamu, 1997). According to Adamu (1997), the presence of soil organic carbon and its related nutrients contributes positively and effectively to soil resilience. Therefore, SOC is crucial to understanding the availability of nutrients in the soil. According to Hazelton and Murphy (2016), soil organic carbon is an important parameter that shows the effect of the mineralisation of applied crop residues on soil nitrogen levels and the availability of nutrients.

Organic Matter (OM) is almost identical, with 3.22% in mining sites and 3.23% in farmlands, suggesting that organic content does not differ significantly between the two areas. The importance of soil organic matter is a soil degradation indicator; thus the need for preserving the soil carbon pool (Obalum et al., 2017).

Nitrogen content (N) shows a slight difference between the two sites, with mining sites having 0.37% and farmlands at 0.35%. Organic matter and nitrogen are key indicators of soil health, and are usually deficient in mine soils, limiting vegetation establishment and sustained productivity (Xu et al, 2018). However, organic matter and nitrogen are higher under the mine soils, though the difference is minimal, it might indicate that the marginally higher nitrogen content in the mining site soil is possibly due to natural processes or localised factors.

Available Phosphorus (P) is nearly the same for both sites, with values of 4.44 ppm for mining sites and 4.45 ppm for farmlands (Table 2), indicating no substantial difference in phosphorus availability between the two. According to Chude et al. (2011), a phosphorus value <10 ppm is low for Nigerian soils based on the soil fertility manual. The major sources of available phosphorus in the soil may be attributed to crop uptake, leaching and runoff. Considering that in the study area, mining sites and farmlands are barely 200 meters apart, the nearness of mining sites to farmlands may have resulted in similar processes in the soil.

The Cation Exchange Capacity (CEC), which reflects the soil's ability to hold essential nutrients, is the same at 0.61 cmol/kg for both sites. A high soil cation exchange capacity indicates that the soil has a high content of clay and organic matter, and this will cause better retention of water and nutrients in the soil when compared to soils with low CEC. According to Hazelton and Murphy (2007), CEC <6 is very low, which shows that the soil does not have a nutrient reservoir capacity.

Table 2 shows that the textural soil class on mining sites and farmlands is generally sandy loam, with a sand fraction being the dominant particle size. The sand fractions were coarsely textured and attributed to the parent material, the Precambrian basement complex rocks. Soil texture shows that farmlands have slightly more sand (84.80%) than mining sites (83.27%). Mining sites have a slightly higher percentage of clay (10.53%) than farmlands (9.20%), which may affect water retention and nutrient availability in the soil. The higher sand fraction, and lower clay and silt fraction under mining sites and farmlands in the study may be due to continuous excavation and cultivation, which will make the soils more prone to leaching due to the high presence of macro-pores, resulting in the destruction of soil aggregate among other factors in the study area.

Table 2: Summary of Descriptive Statistics for Physical-Chemical Properties of Soil in Mining Site and Farmland

Variable	Mining Site (Mean ± Std)	Farmland (Mean ± Std)
Ph	6.93 ± 0.06	6.93 ± 0.06
EC (µs/cm)	91.67 ± 8.62	102.33 ± 28.88
% O.C	1.87 ± 0.03	1.88 ± 0.02
% O.M	3.22 ± 0.05	3.23 ± 0.04
% N	0.37 ± 0.03	0.35 ± 0.06
Avail P (ppm)	4.44 ± 0.14	4.45 ± 0.14
CEC (Cmole/Kg)	0.61 ± 0.10	0.61 ± 0.10
% BS	8.18 ± 3.10	8.21 ± 2.99
% Sand	83.27 ± 4.50	84.80 ± 2.00
% Silt	6.00 ± 0.00	6.00 ± 0.00
% Clay	10.53 ± 4.16	9.20 ± 2.00

Hypothesis
There is no significant difference in nutrient depletion between mining sites and farmlands in the Angwan Doka.

Table 3: ANOVA Result for the Physical-Chemical Properties of Soil in Mining Site and Farmland

Source of Variation	*SS*	*Df*	*MS*	*F-cal*	*F-crit*	*P-value*	*Decision*
Physical-Chemical Properties by Mining Site by Farmland	82910.19	47	1764.047	80.40745	1.623755	7.84E-33	Sig***
Mining site by Farmland	11.16161	1	11.16161	0.50876	4.0471	0.479203	Not Sig.
Error	1031.126	47	21.93885				
Total	83952.48	95					

($P< 0.05$ = Significant)

Table 3 reveals no significant difference in nutrient depletion between mining sites and farmlands in the Angwan Doka, with emphasis on the soil physical and chemical properties. The F-calculated value for the interaction between nutrient depletion and land use (mining sites versus farmlands) is 0.50876, which is lower than the F-critical value of 4.0471 at a 5% significance level ($P > 0.05$). It indicates that nutrient depletion levels in the soils of mining sites and farmlands in the Angwan Doka area are statistically similar, supporting the null hypothesis.

The analysis highlights that while the overall variance in soil physical-chemical properties is highly significant, with an F-calculated value of 80.40745 ($P < 0.001$), this is primarily due to variations within other components, rather than between the two land-use types. The total sum of squares (SS = 83952.48) reflects the contribution of all sources of variability, yet the specific contribution of mining sites versus farmlands (SS = 11.16161) is minimal. The mean square (MS) for the mining site versus farmland interaction is also low, at 11.16161, indicating limited variability in nutrient depletion between these two categories.

CONCLUSION

These findings suggest that the impact of mining and farming activities on soil nutrient levels in the Angwan Doka is relatively uniform. Despite the differing nature of these land-use practices, their influence on nutrient depletion and soil physical-chemical properties appears to converge in this context. However, the significant overall variability in soil properties highlights the possible influence of other factors, such as climate, soil type, management practices, or external environmental pressures. Upon closer examination, the depletion of soil nutrients and physical properties is notably higher in mining sites than in farmlands. Mining activities are often associated with significant soil disturbance, loss of organic matter, and disruption of soil structure, which can accelerate nutrient depletion. Although the statistical analysis shows no significant difference, practical observations and the context of mining activities suggest that mining sites exhibit higher levels of soil degradation, including the depletion of essential nutrients and alteration of soil physical properties. This indicates the need for targeted soil restoration and sustainable land management practices, particularly in areas subjected to intensive mining activities.

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