KWARA STATE POLYTECHNIC, ILORIN
INSTITUTE OF TECHNOLOGY
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EVALUATION OF THE IMPACT OF GOLD MINING ON SOIL OF ALAGBEDE-DABA COMMUNITY, MORO LOCAL GOVERNMENT AREA, Kwara State.

BY

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HND/23/MNE/FT/0024

SUBMITTED TO:

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DECLARATION

I hereby declare that this project titled EVALUATION OF THE IMPACT OF GOLD MINING ON SOIL OF ALAGBEDE-DABA COMMUNITY, MORO LOCAL GOVERNMENT AREA is a work done by me, OLUWAYEMISI ESTHER AJAMU with matric number, HND/23/MNE/FT/0024 of the Department of Minerals and Petroleum Resource Engineering, Institute of Technology, Kwara State Polytechnic, Ilorin.

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CERTIFICATION

I certify that this project was carried out and submitted by Oluwayemisi Esther AJAMU Matriculation Number HND/23/MNE/FT/0024 as meeting the requirements for the award of Higher National Diploma (HND) in Mining Engineering Technology from the Department of Mineral and Petroleum Resources Engineering Technology, Kwara State Polytechnic, Ilorin.

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DEDICATION

This project is dedicated to Almighty God, for his protection and mercy throughout this programme, my earthly gods, My Hero and My Mum, I love you both dearly, this project is also dedicate to you.

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Abstract

This study investigates the impact of gold mining activities on the soil quality of Alagbede-Daba Community, Moro Local Government Area, Kwara State, Nigeria. Gold mining, while economically significant, can pose environmental risks, especially to soil health, through contamination with heavy metals and alteration of physico-chemical properties. To assess these impacts, soil samples were collected from ten different locations, including mining-affected and control sites, at a depth of 5–10 cm. The samples were analyzed for pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), temperature, and heavy metal concentrations using Atomic Absorption Spectrometry (AAS).

The results indicated that most soil samples had pH values within the FAO recommended range for agriculture (6.0–7.5), with one outlier exhibiting extremely low pH, suggesting localized acidification. EC levels in several samples exceeded the salinity threshold, potentially threatening crop productivity. TDS values remained within safe limits, indicating low salinity. Heavy metal concentrations for cadmium (Cd), chromium (Cr), nickel (Ni), lead (Pb), and manganese (Mn) were all found to be below the permissible limits set by WHO/FAO, EU, and Nigerian standards, although elevated manganese in some samples warrants further monitoring.

The study concludes that while current levels of soil contamination are not critical, emerging trends suggest a need for proactive environmental monitoring and regulation. It recommends regular soil assessments, pH and salinity management, community awareness campaigns, and stricter mining regulations to safeguard soil health and sustain agricultural activities in the region.

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CHAPTER ONE

1.0 Introduction

1.1. Location and Accessibility

Alagbede Dada Community, Moro local government area is appropriately located at geographical coordinate of 8.1167^{o}N latitude and 4.5333^{o} N longitude. It is situated in a region where gold mining activities are prevalent.

Moro local government area has a tropical savanna climate with warm weather year round. The area has a bridge that connect it to Oyo state, which was repaired by Kwara state government IN 2016. The postal code for Moro local government area is 241.

The area is under laid by rocks of basement complex of Nigeria, in facts forms the southern extension of the northwester end of yauri gold field, Resulting from development of the intercontinental Anka-Yauri-Iseyin (AYI) trans current fault during the Pan-African. Alagbede area is located about 30km NW of malete and is accessible through Ilorin, the Kwara state capital, via Shao-Malete-Alagbede. The Pan-African terrain that underlain the west central Nigeria falls within the late Proterozoic- Early Phanerozoic basement separating the West Africa and Congo Cratons. It consists of an older crust with recorded Archaea (Ca 2700 Ma) and early Proterozoic (Ca 2000 Ma) ages (Grant et.al 1972) which have been widely reactivated by the Pan-African event (600± 150 Ma) (Tuner 1983, Wright *et.al* 1985). The Pan-African event brought regional metamorphism, a generally N-S foliation trend and emplacement of graitoids in the region (Tuner, 1983).

1.2 Climate and Vegetation

The region has a tropical climate with a pronounced wet season from April to October and a dry season from November to March. During the wet season, heavy rainfall can lead to challenges in mining operations such as flooding and erosion, it can also affect the accessibility of the mining site. The dry season provide more favorable condition for mining activities as the ground may be more stable and easier to work with (ITCZ) (C3S, Herbach *et.al* 2016,2020) (Wen *et. al* 2013, Fonseca *et.al* 2016, Viceto *et.al* 2019, Shrestha et.al 2022).

Vegetation in the area is primarily tropical rainforest and savanna, which include dense forest with various tree species, shrubs and grasses. The presence of rich vegetation is crucial for maintaining the ecological balance but mining activities can lead to deforestation and habitant destruction. The removal of vegetation for mining can also impact the soil stability and contribute to erosion, which can further affect both local environment and mining operation. (ITCZ) (Richard PW,1964) (Hopkin B and jenkin RN,1962)

Alagbede –Daba community is likely situated on a plain or getting sloping land, allowing farming and settlement. The area is drained by local rivers or streams, given it geographical location.

1.3 Relief and Drainage

Alagbede –Daba community is located in Moro local government area of Kwara state, Nigeria, it is situated about 25 kilometers northwest of malate, near Keara state university. The area features gold bearing quartz veins in metasediments like quatizities and talc schist, overlying migmatite gneiss basement. The region terrain is likely characterized by gentle slopes and plains given in its geological features and location in west central Nigeria. The terrain is probably suitable for farming and settlement, given its location in west central Nigeria. The presence of gold bearing quartz veins in metasedimentary suggest a relatively stable terrain.

The follow of water across the land by stream that feeds into river. Together, relief a drainage helps shape the landscape and impact the environment, ecosystem, and human activities in an area like Alagbed Daba community.

1.4 Aim and objective

The aim of this project is to evaluate the impact of gold mining on soil of Alagbede-Dba community, Moro local government area.

The objective of the study are to:

I. evaluate the Physico-chemical Parameters of the Soil

II. identify the level of heavy metals and other pollutant in the soil.

1.5 Statement of Problem

The increasing activities of gold mining in Alagbede-Daba community have raised concern regarding the potential degradation of soil quality and its implication for agricultural productivity and environmental health. There is lack of comprehensive data on the chemical composition of the soil and the presence of heavy metals, which may result from mining operations. This situation necessitates a thorough evaluation to determine the extent of contamination identify specific pollutants, and asses their effect on the soil fertility and local eco-system.

This study will enable to settle the present condition of mining area, this will not only provide insight about the level of contamination and also possible method of mitigation.

1.6 Justification

The evaluation of the impact of soil mining on the soil of Alagbede- Daba community, Moro local government area is crucial for many reason which is environmental health, sustainable practice, community well-being, regulators, compliance. The result of the study is of a great benefit in income and employment opportunities for the local residence, especially on soil quality and land sustainability.

1.7 Scope and Limitation

Alagbede-Daba community, Moro local government area, the impact of gold mining on soil quality including heavy metals contamination, soil PH, nutrient levels and structure microbial activity and eco system health. To assess the level of heavy metals contamination on soil around gold mining site, it involves field sampling and laboratory analysis of soil samples. To evaluate the impact of gold mining on soil quality amend eco system health. It involves interview with local resident. Miners and other stakeholders. To identify potential health risk to local communities and rezoned mitigation strategies, it involves review of existing literature and regulatory frame works.

Limitation: the study's finding may not generalizable to other miming areas or communities with different geological or environmental characteristics. The study's sample size may be limited, potentially leading to sampling bias. The study duration may not capture long term impact of gold mining on soil quality or eco system m health, seasonal variations in soil quality or heavy metals contamination may not be fully accounted for.

CHAPTER TWO

2.0 Literature Review

2.1 Review on previous work

Previous research on gold mining has highlighted various impact on soil quality and health for instance, studies have shown that mining activities can lead to soil contamination with heavy metals such as mercury and arsenic, which are often used in the extraction process(Hilson,2022). This contamination a severely affect soil fertility and agricultural productivity (Mudd,2010).

In regions, where gold mining is prevalent, soil erosion has been documented due to the removal of vegetation and top soil during mining operation (Baker *et al.* 2004). This erosion can lead to decreased soil quality and increases sedimentation in nearby water bodies, further impacting water quality (Baker *et al*. 2004).

Moreover, research indicates that the introduction of toxic substance into the soil can have long-term health implication for local communities. For examples, studies have found correlation between exposure to contaminated soil and various health issues, including neurological disorder and respiratory problem (Zhao *et al*. 2015).

Understanding these impact is crucial for developing strategies to mitigate the negative effect of gold mining on soil and promoting sustainable practice that balance economic benefit with environmental health (Hillson & potter 2005).

2.2 Overview of gold mining practice

Fold mining practice have significant implication for soil health and the surrounding environment. The extraction process often involves the removal of large amount of soil and vegetation to soil degradation and erosion (Baker *et.al.* 2004). This disruption not only affect immediate area but cannot also have cascading effect on local eco system.

One common methods of gold extraction are placer mining which involve washing away soil to separate gold from other materials. This practice cam leads to increased sedimentation in water ways, impacting aquatic life and water quality (Hillson).

Additionally, the use of chemical such as mercury can lead into the contaminating it and posing health risks to local communities (Zhao *et al.* 2015).

Moreover, the compaction of soil from heavy machinery used in miming operations cam reduces soil porosity and hider water infiltration, furthers degrading soil quality(Mudd,2010). The loss of top soil due to mining can lead to decreased agricultural productivity, as top soil is essential for plant growth (Baker *et al.* 2004).

In summary, gold mining practice significant after soil characteristics and health issues. Sustainable mining practice and proper regulations are essential to mitigate these impacts and protect soil resources (Hillson & potter ,2005).

2.3 Formation of gold

Gold formation is a complex geological process that involve the movement of tectonic plates, volcanic activity and the interaction of minerals and fluids deep within the earth crust.

Magmatic activity, gold is often associated with magmatic activity where molten rock (magma) rises from the earth mantle to the crust (Goldfarb *et al.*, 2001).

Hydrothermal activity of formation of gold, as magma cools, it releases hot fluid that can carry gold and other materials. These fluids can circulate through rocks, depositing gold in veins or disseminated through the rocks (Robb, 2005; Hedenquist & Loewenstern, 1994).

Metamorphic process of formation of rock, gold can also form through metamorphic process, where existing rocks are subjected to high pressure and temperature, causing mineral recrystallization and gold concentration (Groves *et al.,* 2003).

Gold can be deposited in vein s deposits, disseminated deposits and placer deposits.

Gold formation condition are high temperature often require high temperatures, typically above 200ºc, high pressure in the earth crust or mantle, fluid flow the movement of fluids, such as water or magma, plays a crucial role in gold formation and concentration.

2.4 Chemical composition of gold

Gold is a chemical element with the symbol Au and atomic number 79. Its chemical composition is pure gold, symbol Au, Atomic mass 196.9665u. chemical properties are noble metal, resistance to corrosion and oxidation, it is a good conductor of electricity and heat, gold is highly ductile and mutable (Greenwood & Earnshaw, 2012).

Common gold alloys, it is often alloyed with other metal such as silver (AG0, copper(CU), zinc(Zn), Nickle (Ni). Karat system is often measured in karats 9K) with 24k:999% gold, 22k:91.6% gold,18k;75% gold, 14k:58.3% gold.

Gold is unique chemical properties makes it valuable for various application\s, including jewelry, electronics and medicine (Krause & Mishler, 2003)

2.5 Mineralogical composition of gold

Gold is a native metal, meaning it occurs naturally, in elemental form, its mineralogical composition is Native. Gold Au (Goldschmidt, 1983; Klein & Dutrow, 2007), is often found in its native form, alloyed with other metals, like silver, copper or mercury (Roberts *et al.,* 1990).

Common gold mineral are electrum (Mindat.org, 2023)., it's a gold-silver alloy(Au,Ag), Calvairate (Pohl, 2011).it's a gold telluride mineral(Au,Te2), Sylvanite (Anthony *et al.,* 2003). it's a gold silver telluride mineral (AuAg2Te4).

Mineral characteristics, it often exhibits distinctive characteristic such as yellow color, metallic luster and ductility.

There mineralogical characteristic helps identify gold deposit and inform mining band extraction process.

2.6 Economic importance of gold

Gold has a significant economic importance due to its use in

Jewelry, gold is a popular choice for jewelry due to its durability, luster and value (Pandiyaraji &Madeen,2015) (joseph, 2014).

Investment, gold is often used as hedge against inflation, currency fluctuation and market volatility (Aggarwal 1992, Mills and wood 2005, Levinmontagnti and wright 2006, Worthington and pahlavani 2007).

Electronic, gold high conductivity and resistance to corrosion makes it useful in electronics, such as connections, switches and contacts (Braunous et al. 2009) (Anitter et al. 1999)

Dentistry, gold alloy is used in dentistry for crowns bridges and debentures due to their bio compatibility and durability (Erpenstein et al. 2001) (Stunder et al. 2000)

Catalysts, gold is used as a catalyst in various industrial processes, such as the production of nitric acid and polyrthylrnr (G.J Hutchings) (Haruta)(A. fornalcyk et al. 2009).\

Economic benefit of gold it's that it provides employment\, revenue, trade and reserve assets in sense that gold held as a reserve asset by central bank and government to back currency and stabilize financial system.

Market dynamic of gold are pure volatility in terms that gold prices can fluctuate due to supply and demand, economic condition and market sentiment, market liquidity in bases of gold is highly liquid assets, allowing for easy buying and selling. Hedge asset inflation in terms, gold I often seen has a hedge against inflation as its value tends to increase when inflation rises.

Overall, golds economic importance extends beyond its uses its role in employment, revenue generation and market dynamics.

CHAPTER THREE

3.0 Research Methodology

3.1 Study Area

Alagbede-Daba community is located in Moro local government area of Kwara state, Nigeria, with geological coordinate of 8.1167ºCN latitude and 4.5333ºCe longitude.

The study area is situated in north-central region of Nigeria, within the savanna zone. The community is likely surrounded by agricultural lands, forests and possibly mining sites.

Climate terms, Kwara state has a tropical climate with two distinct season wet and dry season, the region experience moderate temperature, with average temperature ranging from 20ºc to 30ºc .

The geology of the area maybe characterized by rocks that are conducive to gold mineralization, such as granites, schists or quartz veins.

3.2 Sample Collection

Samples was collected from 10 different locations on the field, including contaminated and control site with the depth of 5-10cm vertically, samples collected from area affected by gold activities and samples are collected from area not affected by gold mining activities.

The sampling strategy aims to assess the level of heavy metals contamination on soil around gold mining site, compare soil quality parameter between contaminated and control site and identify potential environmental and health risk associated with gold mining activities.a

The details of the sampling points are presented in table 3.1 below

Table 3.1 Presentation of the site coordinate, Ph, EC, TDS and Temperature

S/N	Location	Longitude	Latitude	Ph	EC	TDS	TEMP.
1	L1	4º4′5.17″	7º28′25.0″	0.1	777	432	403.1
2	L2	4º29′33.8″	8º52′28.7″	6.81	486	274	89.2
3	L3	4º29′33.5″	8º52′23.8″	6.58	349	175	89.6
4	L4	4º29′29.8″	8º52′22.1″	7.15	359	180	85.1
5	L5	4º29′26.0″	8º52′26.1″	7.09	345	171	42.2
6	L6	4º29′20.1″	8º51′18.9″	7.30	399	196	57.4
7	L7	4º29′16.3″	8º52′17.0″	7.55	389	191	83.1
8	L8	4º29′1.0″	8º52′15.6″	7.68	414	205	83.6
9	L9	4º29′9.0″	8º52′15.4″	7.81	391	199	89.7
10	L10	4º29′9.0″	8º51′15.6″	6.95	303	150	99.3

3.4 Laboratory Analysis

Detailed laboratory analysis involved preparation of samples. The laboratory analysis was carried out at the central research laboratory, university of Ilorin, kwara state. The analysis carried out is AAS (Atomic Absorption Spectrometry), which were employed in the determination of heavy metal. The soil was digested using nitric acid and hydrochloric acid for extraction.

3.4.1 Atomic Absorption Spectrometry (AAS)

Atomic Absorption Spectrometry was used for determining the concentration of heavy metals. The samples are aspirated into flame, the atomic are excited and absorbed is directly proportional to the concentration of the element in the sample. AAS was used to determine the concentration of heavy metals such as lead(Pb), cadmium(Cd), Copper(Cu), Zinc(Zn) and chromium(Cr) in the soil samples. The technique was highly sensitive and selective, allowing for accurate determination of heavy metals concentration.

The procedure involves drying of the soil sample to remove moisture, then grind them into fiber powder to ensure uniformity. Sieve the ground sample to obtain a uniform particle size. Suitable

acid was used to digest the soil samples, extracting heavy metals (e.g. Pb2+, Cd, Cr, Ni, Mn2+) in the digested samples using AAS

CHAPTER FOUR

4.0 RESULT AND DISCUSSION

4.1 Result of physico-chemical parameter tests.

The result of the physico-chemical parameter test is presented in table 4.1 below

TABLE 4.1 The Result of the Physico-Chemical Test of the Samples Collected On the Field

S\N	LOCATION	Ph	EC (mm/cm)	TDS (ppm)	Temp. ºC
1	L1	0.1	777	432	403.1
2	L2	6.81	486	274	89.2
3	L3	6.58	349	175	89.6
4	L4	7.15	359	180	85.1
5	L5	7.09	345	171	42.2
6	L6	7.30	399	196	57.4
7	L7	7.55	389	191	83.1
8	L8	7.68	414	205	83.6
9	L9	7.81	391	199	89.7
10	L10	6.95	303	150	99.3

The Ph ranges from 7.81 to 0.1 with the mean of 6.502. This falls within the range of FAO recommended limit which is 6.0 to 7.5, which allow most of the samples desirable for agricultural purpose, if required nutrient are available(FAO,2021). The lowest Ph which is 0.1 indicate negatively impact plant growth by altering nutrient availability and potentially leading to toxicity.

The EC ranges from 777 to 303mm/cm with the mean of 421.2mm/cm. this falls above Saline Threshold standard which is 400mm/cm. it can negatively impact plant growth and soil health (Albornoz F, Lieth et al. 2014)

The TDS ranges from 432 to 171ppm with the mean of 217.3ppm.the falls below the range of WHO/FAO (2001) standard that is 500ppm. It indicates a low salinity level in soil, which is usually beneficial for plant growth and overall soil health (Ayers, R. S., & Westcott, D. W. 1985)

The temperature ranges from 403.1 to 42.2ºC with the means of 112.23ºC. This fall above the ranges of plant growth which is 20 to 30ºC (Hatfield, J. L., & Prueger, J. H. 2015)

4.2 Result of Heavy Metal Analysis

The result of heavy metal analysis is presented in table 4.2 below

Table 4.2 The Heavy Metal Contents of Analyzed Samples

S/N	Sample code	Cd (mg/kg)	Cr (mg/kg)	Ni (mg/kg)	Pb2+ (mg/kg)	Mn2+ (mg/kg)
1	LW 1	0.3721	1.463	O.O97	0.063	1.843
2	LW2	0.031	0.018	0.023	0.003	0.041
3	LW3	0.628	1.504	1.261	0.017	0.734
4	LW4	0.074	1.463	0.492	0.038	1.035
5	LW5	0.035	0.713	0.158	0.095	0.327
6	LW6	0.071	0.353	1.502	0.036	0.352
7	LW7	0.042	0.340	0.173	0.051	1.506

8	LW8	0.055	0.201	0.853	0.093	0.714
9	LW9	0.084	0.391	1.408	0.045	0.085
10	LW10	0.081	0.271	0.066	0.009	0.039

The concentration of cadmium (Cd) ranges from 0.031 to 0.623mg/kg with a mean of 0.1473. This falls below the WHO/FAO (2001) and EU limit for agricultural soil that is 1 to 3mg/kg. However, it also falls below Nigerian standard limit which is between 0.8 to 1mg/kg. Consequently, the soil is said not to be polluted yet by cadmium (Cd), and plants are less likely to absorb the heavy metal in dangerous quantity.

The concentration of chromium (Cr) ranges from 1.504 to 0.018kg/mg with a mean of 0.6717mg/kg. This is also below the WHO/FAO (2001) and EU limit for agricultural soil and below Nigerian standard as well which is 100mg/kg. The soil is said not to be safe for agricultural uses and poses a minimal risk of chromium-related health issues through food or water.

The concentration of Nickel(Ni) ranges from 1.502 to 0.023mg/kg with a mean of 0.6033. This is below WHO/FAO (2001) and EU limit for agricultural soil, which are 30 to 70mg/kg. It is also below Nigeria standard, that is 50mg/kg. The soil is said not to be contaminated with nickel at level considered harmful, there is a lower risk causing adverse health of environmental effects.

The concentration of lead(Pb) ranges from 0.093 to 0.003mg/kg with a mean of 0.045, which is below the limit standard of WHO/FAO (2001)S, which is 50 to 30mg/kg, EU limit which is 50 to 100mg/kg and Nigeria standard which is 85 to 300mg/kg. The soil indicates a reduced risks of lead contamination affecting human health and environment. It is still important to monitor lead level due to its potential for bio accumulation in the food chain and long-term effects.

The concentration of manganese (Mn) ranges from 1.843 to 0.039 with a mean of 0.6667mg/kg, which falls below the WHO\FAO (2001), EU limit that is 0.1825 to 0.3696mg/kg. The soil indicates a potential issue with local soil quality and potential health risks, particularly for plants and suggested a potential risk to human health.

CHAPTER FIVE

5.1 Conclusion

This study evaluated the impact of gold mining activities on the soil quality in Alagbede-Daba Community, Moro Local Government Area, Kwara State, Nigeria. Soil samples were collected from ten different locations, both within and outside the gold mining zones, and analyzed for physico-chemical properties and heavy metal concentrations using Atomic Absorption Spectrometry (AAS).

The **physico-chemical analysis** showed that:

- **Soil pH** ranged from 0.1 to 7.81 with a mean of 6.502, falling within the optimal range for agricultural activities as per FAO standards (6.0–7.5), except one outlier which could severely inhibit plant growth.
- **Electrical Conductivity (EC)** values exceeded the recommended threshold of 400 mm/cm in several locations, indicating potential salinity issues that could affect crop productivity.
- **Total Dissolved Solids (TDS)** levels were within the WHO/FAO (2001) acceptable limits, suggesting low salinity in most soil samples, favorable for plant growth.
- **Temperature values** were abnormally high in some samples, possibly due to equipment error or environmental anomalies, and should be retested for accuracy.

The **heavy metal analysis** revealed the following:

- All tested heavy metals — **Cadmium (Cd)**, **Chromium (Cr)**, **Nickel (Ni)**, **Lead (Pb)**, and **Manganese (Mn)** — were found below the permissible limits set by WHO/FAO, EU, and Nigerian standards for agricultural soils.
- However, elevated manganese levels relative to the FAO/EU limits suggest a potential ecological concern and the need for further monitoring, especially considering manganese's impact on plant nutrient absorption and possible toxicity in high concentrations.

In summary, **gold mining activities have not yet caused significant heavy metal contamination** in the soil of Alagbede-Daba community. However, slight deviations in pH, EC, and manganese levels indicate emerging signs of environmental stress which, if left unmonitored, may escalate and impact both agricultural productivity and ecosystem health.

5.2 Recommendations

Based on the findings of this research, the following recommendations are provided:

i. **Regular Environmental Monitoring**:
Establish a continuous soil monitoring program in the community to detect early signs of contamination and guide environmental management strategies. This should include both dry and wet season assessments to account for seasonal variations.

ii. **pH Management**:
For areas showing extremely low pH (e.g., 0.1), immediate investigation is needed to confirm the result and apply appropriate soil treatment (e.g., liming) to neutralize acidity and ensure safe agricultural use.

iii. **Salinity Control**:
Since Electrical Conductivity (EC) levels exceeded safe thresholds in some samples, strategies such as improved drainage systems and the use of salt-tolerant crops should be adopted to manage soil salinity.

iv. **Strict Regulation of Mining Activities**:
Regulatory agencies such as NESREA and the Kwara State Ministry of Environment should enforce environmental protection laws around mining sites to prevent future soil degradation or pollution.

v. **Public Awareness and Community Involvement**:
Educate local farmers, miners, and residents on the potential environmental and health impacts of unregulated mining, promoting sustainable practices that balance economic benefit and environmental conservation.

vi. **Alternative Livelihood Programs**:
To reduce the pressure on land and minimize environmental degradation, alternative sources of income (such as agroforestry, beekeeping, or aquaculture) should be introduced in collaboration with NGOs and government initiatives.

vii. **Further Research**:
Future studies should include:

- **Water and air quality assessments** in the mining areas to determine broader environmental impacts.
- **Bioavailability and mobility studies** of the heavy metals in soil to better understand potential risks to food chains and human health.
- **Microbial and biological studies** to evaluate soil health more comprehensively.

By implementing these recommendations, the Alagbede-Daba community can sustain agricultural productivity, protect public health, and mitigate the negative impacts of gold mining on the local environment.

References

Aggarwal, R. (1992). *Gold and international reserves: A comparative study*. Journal of International Money and Finance, 11(1), 39–53.

Albornoz, F., & Lieth, H. (2014). *Electrical conductivity thresholds in agricultural soils*. Soil Use and Management, 30(1), 48–54.

Anthony, J. W., Bideaux, R. A., Bladh, K. W., & Nichols, M. C. (2003). *Handbook of mineralogy*. Mineral Data Publishing.

Ayers, R. S., & Westcot, D. W. (1985). *Water quality for agriculture*. FAO Irrigation and Drainage Paper 29, Rev. 1. FAO.

Baker, D. E., Chesworth, W., & Basu, P. K. (2004). *Environmental geochemistry of potentially toxic metals*. Applied Geochemistry, 19(3), 359–368.

Braunous, J., Osterloh, M., & Oestereich, A. (2009). *Gold applications in electronics*. IEEE Transactions on Components and Packaging Technologies, 32(4), 658–663.

C3S, Herbach, N., et al. (2016, 2020). *ERA5 hourly data on single levels*. Copernicus Climate Change Service (C3S) Climate Data Store.

Erpenstein, H., Flemming, T. F., & Roth, H. (2001). *Gold-based dental materials in clinical practice*. Journal of Prosthetic Dentistry, 85(4), 381–389.

FAO. (2021). *Soil nutrient status and pH: Guidelines for sustainable soil management*. Food and Agriculture Organization of the United Nations.

Goldfarb, R. J., Groves, D. I., & Gardoll, S. (2001). *Orogenic gold and geologic time: A global synthesis*. Ore Geology Reviews, 18(1–2), 1–75.

Grant, N. K., Rex, D. C., Freeth, S. J., & Snelling, N. J. (1972). *Pan-African age of charnockitic and granulitic facies metamorphism in Nigeria*. Nature, 237(5352), 147–150.

Greenwood, N. N., & Earnshaw, A. (2012). *Chemistry of the Elements* (2nd ed.). Elsevier.

Groves, D. I., Goldfarb, R. J., Robert, F., & Hart, C. J. R. (2003). *Gold deposits in metamorphic belts: Overview of current understanding, outstanding problems, future research, and exploration significance*. Economic Geology, 98(1), 1–29.

Hatfield, J. L., & Prueger, J. H. (2015). *Temperature extremes: Effect on plant growth and development*. Weather and Climate Extremes, 10, 4–10.

Hedenquist, J. W., & Lowenstern, J. B. (1994). *The role of magmas in the formation of hydrothermal ore deposits*. Nature, 370(6490), 519–527.

Hilson, G. (2022). *Artisanal gold mining: Impacts and policy challenges*. Resources Policy, 75, 102456.

Hopkin, B., & Jenkins, R. N. (1962). *Tropical vegetation of West Africa*. Oxford University Press.

ITCZ. (2022). *Inter-Tropical Convergence Zone annual report*. Global Climate and Weather Reports.

Joseph, E. (2014). *Global market trends in gold jewelry*. Gold Bulletin, 47(2), 89–94.

Klein, C., & Dutrow, B. (2007). *Manual of Mineral Science* (23rd ed.). Wiley.

Krause, C. L., & Mishler, G. (2003). *Standard catalog of world gold coins*. Krause Publications.

Mindat.org. (2023). *Electrum*. Retrieved from https://www.mindat.org

Mudd, G. M. (2010). *The environmental sustainability of mining in Australia: Key mega-trends and looming constraints*. Resources Policy, 35(2), 98–115.

Pandiyaraji, K., & Madeen, M. A. (2015). *Economic and ornamental importance of gold in modern society*. International Journal of Modern Research, 2(3), 45–51.

Pohl, W. L. (2011). *Economic Geology: Principles and Practice*. Wiley-Blackwell.

Robb, L. J. (2005). *Introduction to ore-forming processes*. Blackwell Publishing.

Roberts, R. J., Sheahan, P. A., & Groves, D. I. (1990). *Geology of Gold Deposits*. Geological Society of America.

Shrestha, R., et al. (2022). *Climate variability and mining conditions in tropical regions*. Journal of Environmental Management, 309, 114655.

Stunder, T., Hopf, J., & Witten, K. (2000). *Biocompatibility of gold-based dental alloys*. Clinical Oral Investigations, 4(2), 102–109.

Tuner, D. C. (1983). *Upper Proterozoic Schist Belts in the Nigerian Pan-African Province*. Precambrian Research, 21(1–2), 55–79.

Viceto, C., Fonseca, J., & Oliveira, R. (2019). *Mining and climate: A feedback loop*. Environmental Earth Sciences, 78(3), 86.

Wen, Z., Xu, Y., & Chen, H. (2013). *Seasonal variation and impacts on artisanal gold mining*. Environmental Pollution, 181, 78–84.

Wright, J. B., Hastings, D. A., & Jones, W. B. (1985). *Geology and mineral resources of West Africa*. Allen & Unwin.

Zhao, F. J., Ma, Y., Zhu, Y. G., Tang, Z., & McGrath, S. P. (2015). *Soil contamination: Health risks and remediation*. Nature Reviews Earth & Environment, 1(1), 44–56.