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EFFECTS OF ARTISANAL MINING OF GEMSTONES ON SOILS IN ANGWAN-DOKA, KOKONA LOCAL GOVERNMENT AREA OF NASARAWA STATE, NIGERIA.

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ABSTRACT

The effects of mining have been reported in Angwan Doka, Kakona Local Government Area, Nasarawa State. Mining generally deteriorates the environment in numerous ways especially soil. The data used for this study was derived from two sources- the primary and secondary sources. Primary data was collected from the field studies such as field observations and measurements of environmental variables. Data on soil properties such as soil texture, moisture content, total porosity, bulk density, organic matter, PH, N, P, K, Ca, Mg, Na, S, Fe, Al, and CEC. Secondary data was gathered through the review of relevant literatures which include internet, maps, relevant Governmental Journals and extant work on artisanal mining activities. A reconnaissance survey was carried out in the month of January, 2019 at Angwan Doka Kokona LGA, to establish and confirm the most viable sampling technique to be used before collection of primary data and representative soil sample sites were selected and GPs was used to take the coordinates of the points which assisted in the subsequent sample collection at same point. The instruments that was used in sample collection include – Global Positioning System (GPS) used for taking coordinates of the study Area, filed Note book used for recording observations, auger and cone used for taking the soil sample, masking tape, maker and biro pen for labelling the collected samples and field note taking, sterilized bags collection of soil samples and field bags used to carry field equipments sample and lunch packs. A transact line method

was used for collection of soil sample in the study area and total of five (5) soil samples were collected from points located at 60 metres interval within the study area and being the extent of the radius of the artisanal mining site, one soil sample was collected from undisturbed reference site 2km away from the mined site to serve as control for the study. This approach was adopted because undisturbed land was not common and the only visible plot was obviously very small in size. This is to ensure that soil cores are taken to represent the whole sampling area adequately. From each sample point, top soil samples were collected at a depth of 0-30cm considered being cultivated layer justified as the most significant of soil profile which provides the bulk of the plants nutrients Greenland and Kowal (1960). Soil samples were collected with the aid of an auger and cone that has been calibrated so as to collect soil at the required depth. Two (2) kilograms of soil samples were collected and placed inside well labelled sterilized bags and taken to the laboratory for routine analysis for physical and chemical properties of soils. The study shows that moisture content in the study area varies from 9.00% to 13.00% with a mean of 10.80% site value of 54%. Low value of moisture content in the study area can be attributed to the compaction of the soils in the study area by heavy machinery. Also low moisture content in the mine spoilt land can be attributed to lack of organic matter, higher stone content and sandy texture. The total porosity in the study area ranges from 23.00% to 35.00%, with a mean of 29.40% and SD of 5.03 and the control land site has a value of 39%. The gradual increase of total porosity as we move away from the mining site can be attributed to the top soil disturbance caused by the thin layer of particulates initially caused by mining as observed (Ibanga et al, 2005). The inverse relationships between total porosity and moisture content have been extensively discussed by many scientists.

Keywords: *Angwan Doka, deteriorates, artisanal mining*

INTRODUCTION

Mining generally deteriorates the environment in numerous ways. One of the aspects of environment it harms most is the Soil. Thus, estimation of quality of Soil is extremely important for proper assessment of the associated hazards. Due to lack of proper planning and negligence of regulations, an

appreciable amount of environmental degradation and ecological damage to Soil occurs.
Soil quality monitoring is important because the opencast mining operations routinely modify the surrounding landscape by exposing previously undisturbed earthen materials. Erosion of exposed soils, extracted mineral ores, tailings, and fine material in waste rock piles can result in substantial sediment loading to surface waters and drainage ways. In addition, spills and leaks of hazardous materials and the deposition of contaminated windblown dust can lead to soil contamination. To achieve rapid economic development, some natural resource-rich (such as minerals) countries resort to diversify its various economic activities through exploit of its natural resources. One of such activities is artisanal mining. Consequently, mining is an important economic activity which has the potentials of contributing to the development of area endowed with the resource if properly managed. Mining is a major economic activity in many developing countries (Tauli, 1997, UNEP, 1997). Operations, whether small or large-scale, are inherently disruptive to the environment (Makweba, 1994), producing enormous quantities of waste that can have deleterious effects for decades (UNEP, 1997). The environmental deterioration caused by mining occurs mainly as a result of inappropriate and inefficient working practices and rehabilitation measures. Mining has a number of conventional stages/activities, each of which has potentially-adverse effects on the natural environment, socio-cultural heritage, health and safety of mine workers, and communities based in close proximity' to the sites. The need for better environment and health cannot be over emphasized as increasing industrialization, urbanization, population growth, agricultural, mining activities and the global environment has become fragile as this has been an issue of concern (Shivaraju, 2012). In the quest to satisfy his basic needs and aspirations for better living conditions through the exploitation of his immediate resources, man has created an increasing number of environmental hazards. This continuous exploitation of nature has led to natural disequilibrium which in turn has been proved to be harmful to man. Following each use of water and the exploitation of land and water resources, various forms of pollution contributes to the degradation of the environmental quality (Udiba et al, 2012). Surface mining operations are inherently bed-bound as their size and location are determined by the given

geological conditions of the bedding and associated strata. Since major disruption of the earth's surface is unavoidable in line with surface mining operations, the question of tolerability under the prevailing conditions must be given due consideration prior to the commencement of any extractive processes. But this is totally absent in the case of artisanal mining. Although, nearly all countries of the world have one form of regulations or the other governing mining activities and the treatment of cultivable soil (topsoil). The artisanal miners seem to be saying by their actions that such rules and regulations are meant for the educated elites and the registered miners who are most of the time alien to their mining sites and also accountable to the authority that issues the mining leases (Dukiya, 2013).

The history of mining until this century was one of small-scale operations, often crude in terms of technology and hazardous to health and safety but nevertheless providing the necessary mineral raw materials for society. In contrast, resources development in the twentieth century has been marked by the growth of large mining utilizing economics of scale. In recent years, this philosophy has come under increasing criticism in developing countries where the gap between the rich and poor nations seems to have widened. The corporations have grown to awesome levels of power and the industrialization that has taken place has too rarely benefited the majority of the people in the society. Although most attention in the mining industry is focused, on large corporations, but in some parts of the world, particularly in developing countries, minerals are extracted by Artisanal, Small-Scale Mining (ASM), (Hentschel et al, 2002). These activities are carried out by people working with simple tools and equipment, usually in the informal sector outside the legal and regulatory framework. Nigeria being a developing country belongs to where these types of activities have the potential to thrive and indeed are thriving. The government is aware of the importance and potential contribution of artisanal mining (ASM) to her economy thus; it has established an office in the Mines Department of the· Ministry of Mines and Steel Development. The issue remains that ASM and artisanal mining is a crucial segment of mining in Nigeria. Their activities however, have considerable effects on the environment (Down and Stocks, 1977; Hollaway, 1996; Ripley et al, 1996; Warhurst, and Insor, 1996; McMahon et al, 1999; IUCN, 2004). Unlike the big mining corporations, the environmental effects of these minerals are mainly ecological, although they also produce socio-economic effects.

Effective Assessment studies and strategies for managing these effects in line with massive investment in infrastructures such as roads, hospitals, schools, electricity, water supplies etc. have been the means of minimizing some of the cost of mining activities. It is however noted that most of "these communities have been victims of air and water pollution as well as other forms of environmental degradation resulting from mining operations" (Akabzaa & Darimani, 2001). Mining can therefore have "decisive effect on the communities in which or near which the mines are located" (Anyemedu, 1992 cited in Kabzaa & Darimani, 2001).

Statement of the Problem

Nigeria has a variety of mineral resources and has carried out mining activities overtime which could be dated as far back from the pre-colonial era which has now resulted into an unsustainable condition on the land as well as serious disturbances in the ecosystem. This has further resulted to degradation of vegetation, ecological disturbance, destruction of natural flora and fauna, air pollution, land and water pollution, and instability of soil and rock masses. However, the waste materials or mined contaminants resulting from mining activities are capable of rendering the land infertile even where reclamations efforts is made, complete restoration of land is impossible (Paone, 2000). The artisanal mining activities in the study area involved removing the top soil up to the bedrock, which bears the gemstones. The use of machines and explosives causes instability within the earth crust and also affects underground water which serves as source of water to various water bodies in the area through infiltration of toxic materials. In addition, dynamites are used in blasting the large rocks to aid excavation in the study area where the gemstone is extracted and the loud noise with the vibration from the blasts are known to have affected people within the surrounding communities in the study area through shock being experienced by the inhabitants, and cracking of buildings of indigenes especially those very close to the mining sites. The indiscriminate use of explosives can upset the equilibrium in the geological environment, which may trigger off certain geological hazards.

Such as landslides, subsidence, flooding and tremors. Undoubtedly, due to their crude method of mining in the study area, it is evident that streams and soils in the study area are being contaminated and polluted through the use of the dynamite and Ammonium Nitrate Fuel Oil (ANFO) which drain or percolate into the stream and soil in the villages around the study area, consequently, their drinking water is poisoned and soils depleted as miners could carry some pathogenic micro-organism along with them causing morbidity which at times leads to mortality conditions among residents.
Nasarawa State has been appropriately tagged as "Nigeria's Home of Solid Minerals". The State is one of the most naturally endowed states in Nigeria in terms of the availability of economically and commercially viable natural resources which can be sold in the local and international markets. Despite this, Artisanal mining activities have not only made Angwan Doka Village in Nasarawa State bereft of her resources, but has equally caused harm to the state through their activities. Thus, the need to assess the effects that artisanal mining activities exerts on soils and the appropriateness of the measures that can be put in place to control artisanal mining activities in the study area. A lot of studies have being conducted on the effects of artisanal mining activities on soil nutrient in many parts of Nigeria but none has being conducted in the study area, Ishaya, (2016) assessed the impact of copper mining on surface water in Awe Local Government of Nasarawa State, Omeiza, (2016) assessed the air quality around limestone mining site in Obajana, Kogi state, Salami et al, (2000) assessed the impact of illegal mining on soil nutrient. It is on these bases that the study was carried out in the study area to assess the effects of artisanal mining on soils nutrient in Angwan Doka, Kokona Local Government Area of Nasarawa State.

Purpose of the Study.

The general purpose of this research is to assess the effects of artisanal mining activities on soil in Angwan Doka Village of Kokona LGA of Nasarawa state. Pursuant to this purpose the specific objectives of this study includes:

i. To determine the nutrient status of the soils in the study area;
ii. To evaluate the extents of the soil pollution in the study area;

Research Questions

At the end of this research, answers would be provided to the following research
questions:

i. To what extent has mining operation affected soil nutrient in the study area?

ii. Have the activities of the artisanal miners polluting the soils in the study area?

Research Hypothesis.

In order to guide the analysis of the study, the following null (Ho) hypotheses are formulated thus:

Ho: There is no significant variation in the soil quality status of the study area from the control plot.

HI: There is significant variation in the soil quality status of the study area from the control plot.

REVIEW OF RELATED LITERATURES

Conceptual Frameworks

There are several theories that seek to explain the man-environment-development interface. These theories represent a consistent and logical way of explaining the pattern and interrelationship of anthropogenic activities in space (Ikelegbe, 2005). This section looks at some of the sustainability theories that are most applicable to this research under the following sub-headings:

Sustainability

There was a clear shift a few decades ago in the environmentalist movements: the idea that environmental Conservation is not necessarily the opposite of Development (IUEN, 1991) had been first brought up in the early 1980s, acknowledging that the consequence of poverty and misery can be a burden to the environment. The important need for people to enjoy a life of dignity, combined with conservation arguments, gave birth to the concept of 'Sustainable Development' (Nussbaumer, 2006).

Before furthering discussions on the conceptual underpinnings of sustainability, it is appropriate to commence by discussing the different views and definitions of the concept. It is often more tasking to identify one universally accepted, single definition of sustainability. This is because of several reasons. First, its meaning is strongly dependent on one's approach to environmental management. Second, its interpretation varies depending on different assumptions in regards to human nature, society at large as well as the interaction between society and nature (Ozkaynak et al., 2004), which in turn deeply influence its operationalization. Third, Tabara (2002) argues that the polyvalence of sustainability varies in relation to different social groups and practices, their particular beliefs, values or interests.

Nussbaumer, (2006) argues that "sustainability is a relatively hypothetical state compared to the current way-of-life. The concept of sustainability can be interpreted as representing an objective rather than qualifying a state. Also, it helps identifying the trend by evaluating if a socio-economic system is getting closer to or moving away from an ideal". Also, research on the earth ecosystems' history provides numerous examples of changes, progressive or sudden, that occurred naturally; sea level variation; global average temperature change; biodiversity modifications, all Illustrations, that natural systems are dynamic and self-evolving. Hence, it is often argued in some quarters that, sustainability is anything but a static concept, as long-term equilibriums, whether with or without anthropogenic interaction, have never existed. Despite the absence of unanimity in defining sustainability, the notion is clearly away from futility. According to the World Conservation Union (IUCN, 1991), there are three main conditions for society to claim sustainability.

i. Firstly, it must preserve the essential ecological processes that maintain life and biodiversity.
ii. Secondly, it has to guarantee the sustainable use of renewable resources and minimize the use of non-renewable ones;
iii. Thirdly, its activities are required to remain within the carrying ecological capacity.

Meadows et al., (1992) identified a weakness of the IUCN (1991) argumentation which, from the operationalization point of view, is that the concept of carrying capacity remains difficult to reliably quantify because of its dynamic characteristic. Similarly; Martinez- Alier, (1999) also faults the concepts of carrying capacity because it strongly depends on assumptions in regards to social metabolism. Since ecosystems are complex, with innumerable interactions between them, this interdependency, amongst other factors, together with our limited knowledge don't allow for a clear estimation of the anthropogenic burden an ecosystem could handle. As well, minimizing the use of non- renewable resources is arbitrary and a rather fuzzy target.

Land Degradation

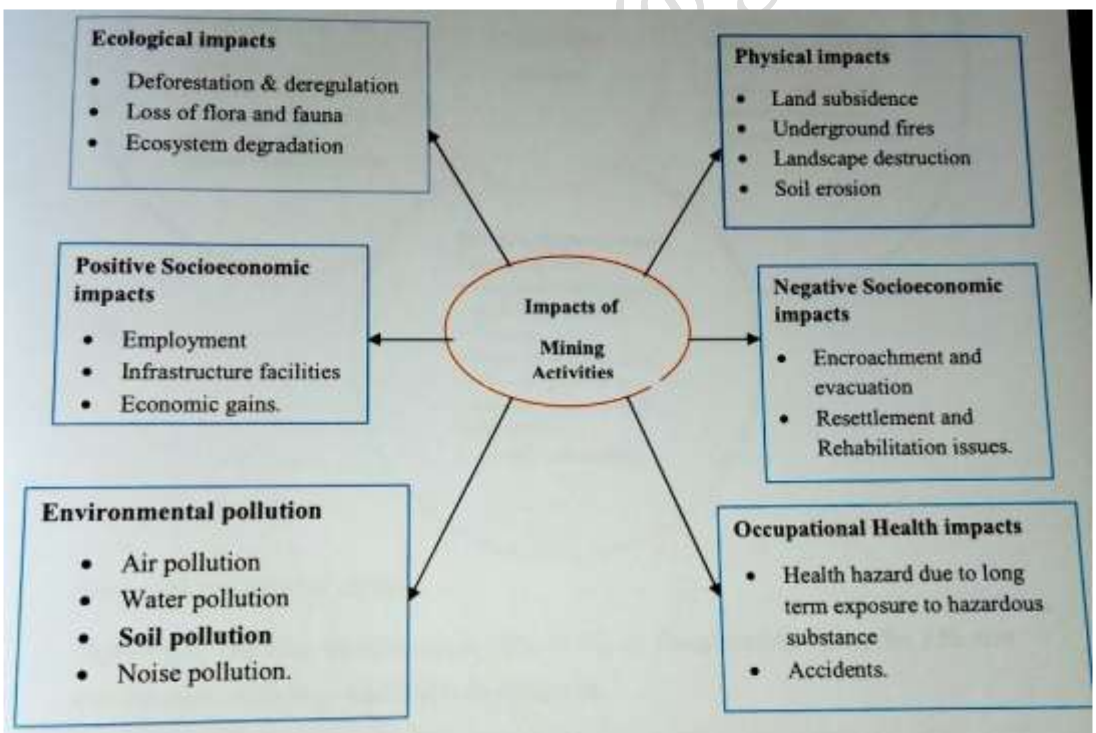
According to Blaikie and Brookfield (1987), sustainability and land degradation are both part of a disequilibrium process between exploitation and resource availability.

Therefore, land degradation should not be viewed as purely a physical process. It should be defined largely as a social problem since the process imply a social criteria which is related to the actual or possible uses to which land can be put Degradation as defined by Blaikie and Brookfield (1987) is a loss in the intrinsic value or capability of land as a result of either one or a combination of natural degrading processes and human interferences less the benefits derived from natural reproduction and from restorative land management practices. The relationship between society and land degradation has three main characteristics, viz:

i. The interactive effect of degradation and society through time;
ii. The crucial consideration of geographical scale and the scale of social and economic organization;
iii. The contradictions between social and environmental changes through time (Blaikie and Brookfield (1987).

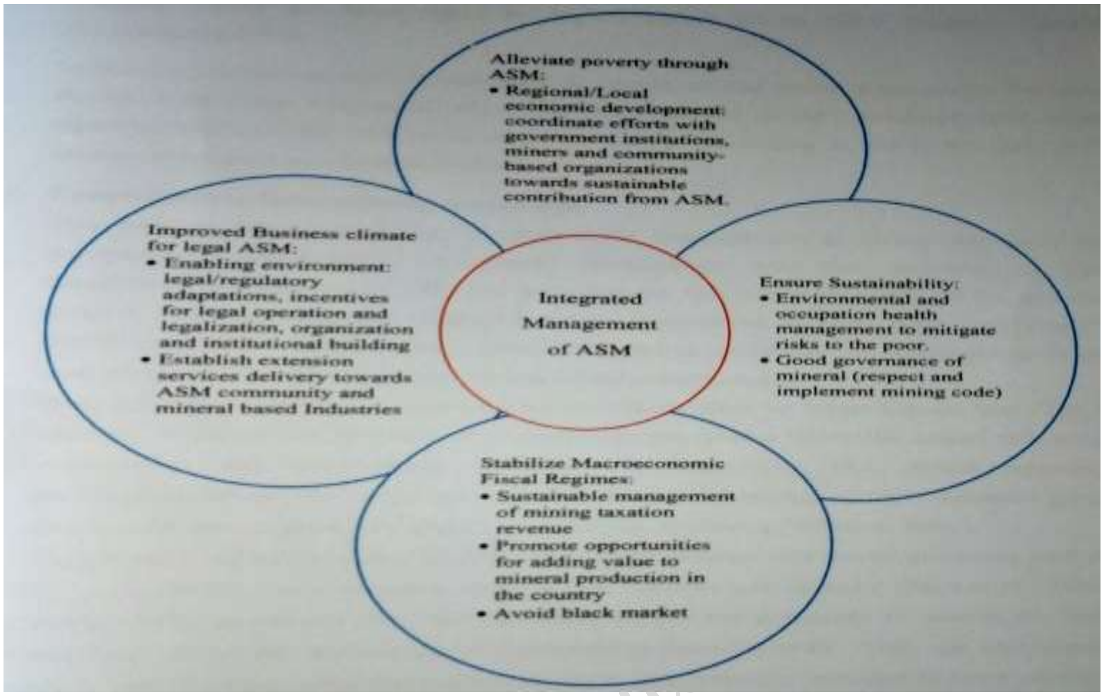
Also, spatial and temporal scales are significant in land degradation analysis. Furthermore, the scale of analysis could also affect the type of explanation made in land degradation. All issues mentioned above have been considered in the analysis of the problem of land degradation in this research.

Although, Blaikie and Brookfield (1987) suggest the inclusion of a historical analysis of sustainability as the cause of present day degradation could possible lie with past activities, this study would not consider that dimension of sustainability as the aim is not on the historical causality. Rather, focus will be on the role of current activities (which is limestone mining and cement production) on environmental degradation. The chief aim of which is to verify the extent to which physical evidences available point to non- compliance of global conventions/principles/standards concerning sustainability and as enshrined in some relevant parts of the UNCED Agenda 21, MDGs documents. The idea of sustainable mining activities in Agwan Doka places a lot of concern on the quality of the soil since quality of soil is as important as its quantity. The current trend of the study area in terms of growth and expansion associated with increased activities of artisanal miners calls for urgent need for sustainable mining to meet up with the challenges in the light of ever increasing population and the desire need for conservation are among other issue that prompted the researcher to investigate the effect of artisanal mining activities in the study area since it is not regulated and Environmental Impact Assessment (EIA) process is not conducted as stated in federal ministry of environment EIA Degree No. 86 section 3 (i) of 1992 Several researches have been conducted on mining and its effects as well as contributions to economic development whereas some researchers highlight the benefits of mining to economic development as shown in Figure 2.2 ; others focus on some of the negative effects of mining on the overall development of such economies as can seen in Figure 2.1



Source: Authors computation 2016

Figure 2.1: General Effect of Mining on the Environment



Source: Hentschel et al (2019)

Figure 2.2: The Four Main Strategic Pillars of good Governmental Policy for Effective Contribution of ASM to sustainable Development. Literarily, mining is as old as man, right from when the 'early man started scrapping the ground in search of sharp edge stone or like which he "Could eventually use as tool to make his life easier. Though evidence of mining has been observed to predate farming and thus mining began right from the time when man was a food gatherer, the oldest identified underground mine, a mine for red ochre at Bomvu Ridge in Swaziland, in southern Africa has been dated to 40,000 before Christ (BC) (Encarta Encarta Encyclopedia 2001). In Nigeria, the earliest miners were the Nok people, skilled artisan from around Jos area, though quite little was known about the first evidence of their existence until when figurines made by the Nok were unearthed during the mining in Jos in the early 20th century (Encarta Encyclopedia 2001).

Understanding Sustainability Assessment

This concept of sustainability, or sustainable development, is clearly the basis of sustainability assessment. Sustainable development was first described by the Brundtland Commission in 1987 as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCELD, 1987). Subsequently, several alternative definitions of sustainability have been proposed and diverse interpretations of the concept made. Many of these definitions are based upon the 'three-pillar' or 'triple bottom line' (TBL) concept. Whereas the Brundtland Commission presented a two-pillar model reflecting environment and development concerns, the three-pillar TBL model separates development issues into social and economic factors, emphasizing that "materials gains are not sufficient measures or preservers of human wellbeing" (Gibs on, 2001). The literature reflects a widely held belief that environment assessment processes such as EIA can, and do, make valuable contributions towards sustainability (Pope et al, 2004). Gibson (2001) points out that "environmental assessment processes are among the most promising venues for application of sustainability-based criteria. They are anticipatory and forward looking, integrative, often flexible, and generally intended to force attention to otherwise neglected considerations" although he also recognizes that, environmental assessments are not the only vehicles for specifying sustainability principles, objective and criteria" (Gibson, 2001).

Marsden and Dovers (2002) highlights the two schools of thought around the relationship between environmental assessment processes and sustainability.

In some cases it is suggested that this contribution arises directly from the integration of environmental consideration into decision-making (as clearly expressed by Wood (1995) and Sheate et al, (2003), while others suggest that ETA provide a sound basis that can be extended to include broader sustainability concerns (Verheem, 1998; Gibson, 2001). Pope et al, (2004; 2013) notes that the two views of the potential contribution of environmental assessment to sustainability often correspond to two different conceptions of sustainability. However, it is pertinent to note that sustainability is a difficult concept to define tin a way that is meaningful and sufficiently practical to allow for its operationalization. The difficulty arises from the arbitrariness of the concept, and as such crating a rather 'fuzzy' outlook until applied in a specific context. This situation is further compounded by the fact that several alternative theoretical formulations and applications of sustainability have been developed, which are founded upon common concerns and principles, but which have different emphases (Gibson, 2001).

In essence, the foregone review provides a detailed analysis of alternative conceptions of sustainability, and also does highlight where appropriate how these alternative views are embedded in the various documented approaches to sustainability assessment. For instance, Sadler (1999) posits that the suggestion that EIA contributes to sustainability reflects the view that environmental impacts are at the core of sustainability concerns. Further, Sheate et al., (2001) adds that integrating the environment into strategic decision-making is an essential pre-requisite for moving towards sustainable development. Gibson (2001) considers this as consistent with a deep green' ecological sustainability model that can be represented as three concentric circles, the outer representing ecology, the middle representing society and the inner representing the economy. According to Sadler (1999), this view of sustainability emphasizes that the source and sink functions provided by natural resources are finite, and that sustainability therefore means finding a way to live within the limits of natural system. Contemporary literature is increasingly suggesting that environment assessment could contribute to sustainability by extending its scope from environmental consideration to include social and economic ones (Devuyst, 2001; Sadler, 1999; Marsden and Dovers, 2002; Pope et al., 2004; Pope et al., 2013). This reflects the 'three-pillar' or TBL model of sustainability, which is often conceptualized as three intersecting circles representing the environment, society and the economy (Gibs on, 20·01), resulting in a form of TBL integrated assessment (Twigger-Ross, 2003).

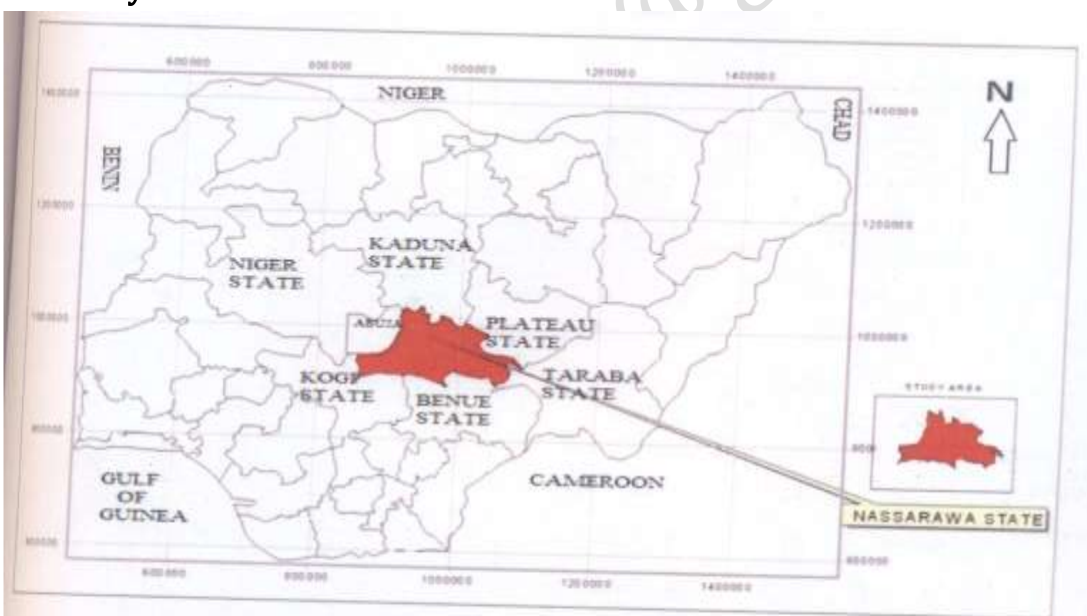
Sustainability in the Context of Non-renewable Mineral Resources: Policy Options;

According to Barrow (1985), Beaumont (1989) and Eriksen (2001), social-economic and ecological arguments against rapid and massive exploitation of non-renewable resources have buttressed the popular view that mining should be looked upon only as a short-term activity which can be capable of providing significant wealth locally and nationally. It would however, be unwise to regard it as a long term component of the national economy in light of the scale and extent of ecological damage it inflicts.

Cordes (1998) opines that "under the circumstances that historically transnational corporations and private big business have captured the natural-resource in mining and considering that the resources at stake are non-renewable and, in some cases, nearing exhaustion, Government of Less Developed Countries (LDCs) in recent decades have increasingly used direct tax and other fiscal instruments for the capture of natural resources rents",. The implication is that rent capture has become the focus of public policy in mining. The central objective/justification of this policy focus is for government to increase its proceeds in rent capture to enable it implement necessary strategies for depletion of mineral resources and post-mining massive environmental destruction. While public instruments for greater rent capture may have increased government revenue, the basic wisdom of encouraging large scale corporate mining with its attendant socio-economic and ecological un-sustainability has largely remained unquestioned. Alternative, environmentally sound mining has not been seriously considered by public policy. Rather, in cases of very serious and immediate environmental disasters, public policies are geared towards either temporarily suspending operations of companies, or cornering more proceeds from the corporate profit windfall. Observation s from literature consulted in the regard reveals suggestion as; re-organization of mining sector and a shift in focus of public policy 'on mining towards emphasis on environmental-friendly technology and harnessing of community-oriented institutions for a more sustainable management of resource-environment. It is in the light of this that EIA is required before commencement of major projects and EA as a follow up to measure environmental performance and EPRP for the rehabilitation of mined sites.

RESEARCH METHODOLOGY

The study Area



Source: Nasarawa State Zip Code Map 2012

Figure 3.1: Map of Nigeria Showing Nasarawa State

The study area lies between coordinates 08° 40' 1l.9" Nand 08° 03' 56.7" E, with an

altitude of 325m and a total population of 9,882 (based on 2006 population estimates)
with land area of 1847.03 kmsq. It is 10.8km off Keffi/Akwanga road and is accessible all year around. The state has a landmass of 27,862.01sqkm, out of this; an estimated figure of 3,885sqkm has been destroyed by mining activities. The State is bounded by Federal Capital Territory, Kogi, Benue, Plateau, Kaduna and Taraba State. Out of which 3,085sqkm has been destroyed by mining activities. However, one-third of the outcrop areas -like Akwanga, Nasarawa Eggon, Nasarawa and Toto Local Government Area were of rocks and hills composition.

Climate

The area is characterised by a tropical sub-humid climate with two distinct seasons. The wet season lasts from about the beginning of May and ends in October. The dry season is experienced between November and April. Annual rainfall figures range from 1100mm to about 2000rrim. About ninety per cent of the rain falls between May and September, the wettest months being July and August. The rain comes with thunderstorms of high intensity, particularly at the beginning and towards the end of the rainy season. Temperatures are generally high during the day particularly between the months of March and April, the mean monthly temperatures in the state range between 20°C and 34°C with the hottest months being March/April, and the coolest months being December/January. (Binbol, 2006).

Soil and Vegetation

The major soil units of the area belong to the category of oxisols or tropical ferruginous soils. The soils are derived mainly from the Basement Complex and old sedimentary rocks. Laterite crust occurs in extensive areas on the plains, while hydromorphic soils (humicinceptisols) occur along the flood plains of major rivers. The area contains a significant proportion of the last vestiges of the country's tropical rainforest and it is characterised by an undulating terrain with magnificent drainage system. The vegetation made of grasses is of 2-4 metres in height. Common species include Andropogongayanus, pannissetumpurpureum and damelliaoliveri. (Ishaya, 2006)

Relief and Morphology

The area fell within the North Central Highland and rocks found in this region are
basically rocks of basement complex. The rocks are mostly igneous and metamorphic in nature. However, sedimentary rocks are also found. The Maloney Hill found in Kokona is a historic relief feature and has an average altitude of S50m above sea level. The settlement is made up of Precambrian basement complex rocks which covered about 60% of the total area while the remaining 40% is made up of sedimentary rocks of the Middle Benue Trough. The younger granites intrude the basement complex and therefore do not occupy any separate landmass of its ·own. Of the basement complex, migmatite-gneisses along with the older granites account for about 70%, while rocks of schistose lithology and other meta-sedimentary series (quartzite, marble, ironstones) in the areas make up the remaining 30% (Obaje et al, 2006). The migmatite gneisses intricately associated with the older granites occupy the areas of the north central and northeast of Nasarawa State. Quartzite, dolomitic marble, marble, banded iron formations phylites, schists and gneisses and genetically and petrologically related to the schist belt occur in Gadabuke, Laminga and part of Nasarawa and Toto in the south western portion of the State. Pegmatites and quartz veins carrying different types of solid mineral lodes are prominent features in rocks of the Basement complex of Nasarawa State.

Hydrology and Drainage

Kokona L.G.A is drained by many rivers most of which is originating from the North Central Plateau and have a dendritic pattern outlook because the streams and rivulets join the main rivers at oblique angles (Samaila and Binbol, 2007).

Socio-Economic Activities of the People

Agriculture 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. Fishing is also one major pre-occupation of the people which is made possible by its location in the Riverine area. Crops are grown primarily for consumption and trade. Some people engage in weaving of mats and blacksmithing. Nomads (Fulani) Supply cattle (beef) and milk is sold in the area. Apprentices such as in tailoring and automobile mechanic are also common among youths. Recently, apart from agriculture, logging is the leading economic activity that is carried out in the study area, and most of the participants are youths. From field observation and inquiry made, about 60% of youths that are not schooling have already take up logging to be their major occupation.

Research Methodology

Research Design

This research was designed in order to assess the effects of artisanal mining of gemstones on soils in Angwan Doka village of Kokona L.G.A of Nasarawa State. This section presented the sources of data and how the data were collected for the purpose of analysis and presentation. The steps taken in the accomplishment of this research work include reconnaissance survey, data collection through primary and secondary source, data presentation and analysis and test of statistical significance as well as drawing conclusion from the research findings.

Sources of Data

The data used for this study was derived from two sources- the primary and secondary sources. Primary data was collected from direct field studies such as field observations and measurements of environmental variables. Data on soil properties such as soil texture, moisture content, total porosity, bulk density, organic matter, pH, N, P, K, Ca, Mg, Na, S, Fe, Al and CEC Secondary data was gathered through the review of relevant literatures which include internet, maps, relevant Government journals and extant work on artisanal mining activities.

Reconnaissance Survey

A reconnaissance survey was carried out in the month of January, 2019 at Angwan Doka, Kokona LGA,to establish and confirm the most viable sampling technique to be used before collection of primary data and representative soil sample sites were selected andGPS was used to take the coordinates of the points which assisted in the subsequent sample collection at same point. The survey equally provided guide on the number of personal field assistant required and gave idea on the safety gadgets and equipment's needed for the field investigation.

Sampling Instrument

The instruments that was used in sample collection include - Global Positioning System (GPS) used for taking coordinates of the study area, Field Note books used for recording observations, auger and cone used for taking the soil sample, Masking tape, maker pen and biro pen for labelling the collected samples and field note taking, Sterilized bags for collection of soil samples and Field bag used to carry field equipment's, samples and lunch packs.

Sampling Technique and Procedures

A transect line method was used for collection of soil sample in the study area and a total of five (5) Soil Samples were collected from points located at 60meters interval within the study area and being the extent of the radius of the artisanal mining site, one soil sample was collected from undisturbed reference site 2km away from the mined site to serve as control for the study. This approach was adopted because undisturbed land was not common and the only visible plot was obviously very small in size. This is to ensure that soil cores are taken to represent the whole sampling area adequately. From each sample point top soil samples were collected at a depth of 0-30cm considered being cultivated layer justified as the most significant of soil profile which provides the bulk of the plants nutrients (Greenland and Kowal, 1960). Soil samples were collected with the aid of an auger and cone that has been calibrated so as to collect soil at the required depth. Two (2) kilogram of soil samples were collected and placed inside well-labelled sterilized bags and taken to the laboratory for routine analysis for physical and chemical properties of soils.

Sampling Area

The areas sampled were the site of artisanal mining activities as shown in plate 3.1 which are characterized by soil belonging to the same series. The samples collected were nearly from the same slopes to avoid or at least minimize the effect of topographical differences. That is to say, if the soils are the same morphologically and belong to the same series, their characteristics before use must be similar.

Plate 3.1 Abandoned Mining Pit at the Study Area

Plate 3.2 New Devastated Site at the Study Area

Methods and Procedures for Laboratory Analysis

The major part of the soil physical and chemical analysis was carried out at a soil Research Laboratory where laboratory procedures were followed in the analysis of the selected physico chemical properties that were considered in the study.

Analysis of soil properties

Soil samples were spread out to air dry on arrival in the laboratory and gently crushed using porcelain mortar and pestle, sieved with 2mm sieve and then subjected to standard method of soil analysis. The soil properties that were analyzed with the description of methods include:

Analysis of soil physical properties

Particle size distribution: the particle size distribution was determined by Bouycous hydrometer method using sodium hexametaphosphate as the dispersant and the textural class determination adopted the USDA textural triangle Bouyoucous (1995) as described by Mocek et- al 1997

Bulk density: Bulk density was determined using core method by collecting soil samples which was oven dried to a constant weight at temperature 105° C for 24hrs the mass of the oven dried soil was divided by the total soil volume

Total porosity: the total porosity was determined by core method as described by (Blake and Hartge, 1986). Soil porosity (%)= (1 bulk density)/2.65xl 0011

Analysis of soil chemical properties

Potential of Hydrogen (pH): The pH was determined in both distilled water and a 0.1 potassium chlorite solution using a soil/liquid ratio of 1:2.5. The pH values were read on Beckrnan Zerometic pH meter as recommended by (Peech, 1965).

Total nitrogen: This was determined by the regular micro Kjeldahl digestion, distillation and titration procedure as described by Jaiswal (2003).

Available phosphorus: This was determined using Bray I method as described by Bray and Kurtz (1995).

Exchangeable Bases (Ca, Na, Mg, and K): Calcium and magnesium was determined by complex metric titration method (Jackson, 1958), while Sodium and Potassium was determined in ammonium acetate leachate using flame photometer as described by Jaiswal (2003).

Cation Exchange Capacity (CEC): The apparent CEC was determined using ammonium acetate method (Jackson, 1958). While the exchangeable bases cation exchange capacity was calculated by summing of the exchangeable bases (cations) and exchangeable acidity determined from IN KCI extract.

Organic matter; The Weight Loss on Ignition method was used and it is based upon measuring the weight loss from a dry soil sample when exposed to high temperatures (360°C). The weight loss that occurs at this temperature is then correlated to oxidizable organic carbon as described by (Reddy et al 1966).

Available Sulphur: Recently, an ion chromatographic method was developed for determination of total S in soils. It involves ignition of a mixture of soil and NaHC03 containing Ag20 at 5500 C for 3 h as described by (Tabatabai, Basta and Pirela, 1988)

Statistical Analysis:
Simple descriptive statistics of the means, standard deviation and coefficient of variation were used to describe each of the soil properties derived from the result of the laboratory analysis and inferential statistics which involves Student Hest was used to determine whether there is statistical significant difference in the means of soil properties or not and also for the study's hypothesis testing. This was done through the use of a statistical software package specifically the Statistical package for social sciences (SPSS) version 17.

DATA PRESENTATION AND ANALYSIS

Physico-Chemical Properties of Soils in the Study Area.

Moisture content and Total Porosity
Table 4.1 shows that moisture content in the study area varies from 9.00% to 13.00%, with a mean of 10.80% and SD of 1.64. The control plot has a value of 54%. Low value of moisture content in the study area can be attributed to the compaction of the soils in the study area by heavy machinery. Also low moisture content in the mine spoil may be attributed to lack of organic matter, higher stone content and sandy texture. While total porosity in the study area ranges from 23.00% to 35.00%, with a mean of 29.40% and SD of 5.03 and the control plot has a value of 39%. The gradual increase of total porosity as we move away from the mining site can be attributed to the top soil disturbance caused, by the thin Iayer of particulates initially caused by mining as observed by (Ibanga et al, 2005).The inverse relationships between total porosity and moisture content have been extensively discussed by many scientists. Aina (1989) found a significant reduction in total porosity of forest fallow (58 %) of an alfisol soil to when the soil was being disturbed (42 %) which was inversely related to soil moisture content. Lal (1985). The macropore volume decreased as a result of soil compaction due to tillage and trampling by

humans coupled with a decline of the soil organic carbon content in the mine spoil (Yimer F, et al., 2008).

Total porosity and bulk density

Table 4.1 shows that bulk density in the study area varies from 1.10% to 1.89%, with a mean of 1.55% and SD of 0.33 the control point has a value of 2.89%. This can be attributed to the mining activities conducted in the study area which involved clearing of top soil and excavation of top soils. Heavy traffic on the top soil within the vicinity of the mining may have contributed to the high bulk density within the mining area (Aina, 1989). Bulk density is the weight of dry soil solids per unit volume of total soil including the pore space. Bulk density normally decreases as minerals soils become finer in texture. It is used to calculate soil pore space. Bulk density increases in cultivated soil or length of time and decrease porosity .it affects porosity, aeration and rate of sedimentation of particles. Soil bulk density is correlated with soil organic matter levels. Soils with a high bulk density are likely to have low organic matter levels and are more prone to nutrient leaching. Soil compaction caused by machinery increased soil bulk density resulting in decreased soil water infiltration capacity, increased erosion risks, reduced porosity and markedly limits root growth. The mining reduced the pore spaces and produces a discontinuity in pore space between the cultivated surface and the subsurface soil.

Table 4.1 Physical and Chemical properties of soils in the study area

PARAMETERS	S1	S2	S3	S4	S5	MIN	MAX	SD	MEAN	CONTROL
Moisture	13	12	10	10	9	9.00	13.00	1.64	10.80	54
Content % Total	35	34	28	23	27	23.0	35.00	5.03	29.40	30
Porosity % Bulk	1.10	1.89	1.67	1.32	1.78	1.10	1.89	0.33	1.55	2.89
Density % Ph	5.4	5.7	6.1	5.7	5.4	5.4	6.1	0.29	5.66	5.5
mg/kg Nitrogen	0.65	0.43	0.51	0.76	0.45	0.43	0.76	0.14	0.56	0.03
mg/kg Iron	0.89	1.01	0.67	0.34	0.97	0.34	1.01	0.30	0.74	0.09
mg/kg	5.60	5.32	5.48	5.11	4.78	4.78	5.60	0.32	5.26	2.29
Potassium	0.32	0.67	0.22	0.34	0.98	0.22	0.98	0.31	0.51	0.31
mg/kg Sodium	4.32	4.54	4.11	4.87	4.98	4.11	4.98	0.36	4.56	2.30
mg/kg	0.56	0.51	0.43	0.39	0.38	0.38	0.56	0.11	0.47	0.31

S2	**73.50**	**19.00**	**7.50**	**Sandy loam**
S3	81.50	11.50	7.00	Loamy sand
S4	65.00	16.75	18.25	Sandy loam
S5	72.25	8.50	19.25	Sandy loam
S6	60.00	23.00	17.00	Sandy clay loam

Source: Field work 2018

Table 4.2 show that the textural class of the study area has a sand particle value of 76%, silt of 6% and clay particles of 18%. This can be attributed to the mining activity in the study area resulting excavation of top soils. In addition, mining dust changes the texture of parents soil as well as add contaminates to the soil. The result shows a Sandy loamy soil which is associated with sub- humid temperate region of Nigeria. This is normal for this type of humid tropical soils that are mostly sandy in nature (Lal, 1985). The present study reveals that mining activities changes the soil texture from silty loam to loamy sand texture. Soil texture influences the rate of organic matter decomposition, water holding capacity, porosity, aeration and nutrient availability of soils.

Chemical properties of soils in the study area

Organic matter:

Table 4.1 shows that organic matter in the study area ranges from 1.34% to 1.87%, with a mean value of 1.55% and SD of 0.l9, the control plot has a value of 2.89%.The low organic matter in the study area can be attributed to the removal of vegetation and excavation of top soils for mining purposes and soil erosion in the study area (Salami et al., 2002). The removal of vegetation and top soil (Agboola, 1982) had been found to have adverse effect on humid tropics. The comparatively low organic matter indicated that it decreases with depth as the topsoil is removed which is an energy source for micro-organisms which drives decomposition and mineralization of plant residues thereby releasing nutrients (Kova et-al, 2005). Intensive tillage increases the loss of organic matter and mining definitely exposes the earth even more. Soils with low levels of organic matter will have a reduction biological activity and a reduction in water holding capacity for plants since high levels of biological activity in a soil require a significant amount of organic matter.

Potential of Hydrogen (pH):

Table 4.1 shows that pH value in the study area ranges from 5.40 to 6.10 that are from slightly acidic to moderately acidic, with a mean of 5.6 and SD of 0.29, the control plot has a pH value of 5.5. The acidic nature of the soil can be associated to the residue of mineral being mined in the study area as observed by Akinnifesi et al., (2005). The pH may have resulted from the quartz rich nature of the underlying geological materials, or a reflection of intensive leaching in the soils. Aluminium found in the minerals mined can also become soluble and increase soil acidity. Excessive disturbance of soil caused high rate of organic turn over and decomposition which involves carbon dioxide and water to form both organic carbonic acid and inorganic acids sulphuric and nitric which are potential suppliers of hydrogen ion. H ion contributes more to soil acidity.

Descriptive terms commonly associated with certain ranges in pH are extremely acidic (pH<4.5), very strongly acidic (pH 4.5-5.0), strongly acidic (pH 5.1 - 5.5), moderately acidic (pH5.6-6.0), slightly acid (pH 6.1 - 6.5), neutral (pH 7.5-8), slightly alkaline (pH 9), moderately alkaline (pH 10-11) strongly alkaline (pH12-13), and very strongly alkaline (pH.14) (Tilahun, 2007).

Nitrogen:

Nitrogen in the soil IS one of the most important elements for plant development. It is required in large amounts and must be added to the soil to avoid a deficiency. Nitrogen is a major part of chlorophyll and the green color of plants.

Table 4.1 shows that Nitrogen in the study area varies from 0.43meg/kg to 0.76meg/kg, with a mean of 0.56meg/kg and SD of 0.14, the control plot has a value of 0.03. The high concentration of nitrogen in the study area can be attributed to the chemicals precipitated from the explosives being used during blasting. Adewale and Adesina (2011) collaborated the findings that soil nitrogen increases as a result of mining in the southern part of Nigeria as also observed by (Agboola, 1982).The low Nitrogen is caused by a reduction in soil microbes induced by stockpiling and excessive leaching to the extent that the soils became biologically unproductive.

Phosphorus:

Phosphorus is one of the most important element in the soil, lack of phosphorus in the soil limit the growth of both cultivated and uncultivated plants (Foth and Ellis, 1997), Table 4.1 shows that phosphorus ranges from 4.78meg/kg to 5.60meg/kg, with a mean of 5.25meg/kg and SD of 0.32, the control plot has a value of 2.29meg/kg. The high concentration of phosphorous resulted from the weathering of soil minerals and the residue of the mineral called Apatite (Tri- calcium phosphate) associated with the gemstones being mined in the study area. The mineral Apatite released excess phosphorous that is immobile in the soil and the diffusion of it into the roots of plants is only above 1/8 of an inch per year. (Wild, 1995). Excessive soil phosphorus interferes and reduces the plant's ability to take up required micronutrients, particularly iron, magnesium and zinc, even when soil tests shows there are adequate amounts of those nutrients in the soil thereby causing bleaching of plant tissue and yellowing of the leaves veins. It is always found in combination with oxygen in phosphate form and plant absorbs it in the orthophosphate form HPO.

Aluminium:

Table 4.1 shows that Al ranges from 0.51meg/kg to 0.83meg/kg, with a mean of 0.71meg/kg and SD of 0.12, the control plot has a value of 0.17. The concentration of Al in the study area can be attributed to the minerals such as topaz and aquamarine that are being mined and acidic nature of the soils in the study area.

In acid soils with a high mineral content, the primary factor limiting plant growth is Al toxicity. The Al released from soil minerals under acid conditions occurs as AI(OH)2+, AI(OH) and AI(H20)3+, the latter commonly referred to as Al (Kinraide, 1991). For most agriculturally important plants, Al ions rapidly inhibit root grow that micro molar concentrations. Excess soluble/available aluminium (At++) is toxic to plants and causes multiple other problems. Some of the more important problems include direct toxicity, primarily seen as stunted roots, Reduces the availability of phosphorus (P), through the formation of Al-P compounds, Reduces the availability of sulphur (S), through the formation of Al-S compounds, Reduces the availability of other nutrient cations through. Competitive interaction.

Sulphur:
Sulphur comes naturally from regional rocks and acid rain. Most sulphur is found in beryllium and organic matter and must be converted to sulphate for crop use.
Table 4.1 shows that sulphur concentration in the study area ranges from 3.30meg (kg to 4.80meg/kg, with a mean of 3.88meg/kg and SD of 0.61, the control plot has a value of 1.23meg/kg. High concentration of sulphur in the study area can be attributed to the minerals that are being mined in the study area and the explosive used during blasting which precipitate sulphur in the soils of the study area. When sulphur is applied to soils, plants may temporarily suffer from lack of nitrogen if the amount of available or in-organic nitrogen is not sufficient to meet both the requirements of the organisms which oxidize the sulphur and the plants which are growing on the land (J.P. Martin i).

Exchangeable bases:
They are commonly defined as the alkali and alkaline earth metals (principally calcium, magnesium, potassium and sodium) attached to the clay and organic constituents of soils and which can be exchanged with each other and with other positively charged ions in the soil solution. Potassium is a key nutrient and plays a vital role in the building of protein and reduction of diseases in plants. Potassium varies from 0.22meg/kg to 0.98meg/kg, with a mean of 0.51meg/kg and SD of 0.31, the control plot has a value of 0.02. This level of potassium improves the overall hardness of the plant by improving the rigidity of the stalks and increasing disease resistance such that the plant can overcome drought stress and survive winter but, excess of this resulting from further mining of pegmatite rich in orthoclase feldspar muscovite mica and sanidine as the case found in the study area can affect the soil and inhibit the absorption of other nutrients by plants. (Brady, et a12002) Calcium ranges from 4.11meg/kg to 4.98meg/kg, with a mean of 4.50meg/kg and SD of 0.36, the control point has a value of 2.30meg/kg. The concentration of calcium in the study area can be attributed to the removal of top soil by the activities of artisanal mining in the study area. Adewole and Adesina, (2011) also observed the same trend in Southern Nigeria. Apatite is the primary source of P and, due to its relatively rapid dissolution rate, can be an important Ca

source in non carbonate soils. The secondary nutrients are essential for healthy plant growth, but are needed in lesser amounts than the primary nutrients.

Magnesium ranges from 3.11meg/kg to 3.76meg/kg, with a mean of 3.50meg/kg and SD of 0.25, the control point has a mean of 2.41meg/kg. The low concentration of Magnesium in the study area can be attributed to the excavation of top soil in the area for mining activities, destruction of soil structure and texture due to the activity of heavy equipment and leaching of soil nutrient. Adewole and Adesine, 2011, one of their observed tendencies is for these soils to become hard, form crusts and become difficult to till. High magnesium soils can prove to be a challenge if crop rotation, manure additions and timely tillage operations are not followed. Moderate rates of K applications are needed when potash is low to medium.

Sodium varies from 0.38meg/kg to 0.56meg/kg, with a mean of 0.47meg/kg and SD of 0.11, the control point has a 0.31meg/kg. Low Sodium in the study area can be attributed to the leaching of soil nutrient, soil aggregate, acidic nature of the soil and low organic matter in the study. Low Sodium affects the internal drainage of the soil. Adewole and Adesina, 2011, also observed the same trend in Southern Nigeria.

Ideal soil should have following saturations of exchangeable cations 65% Ca, 10% Mg, 5% K, and 20% Na. They may be dissolved in the soil solution, from where they can be utilized directly. They may be absorbed into exchange sites, from where they enter soil solution or be directly exploited by tree roots or microorganisms that come in contact with exchange site. 4.2.8 Iron: Table 4.1 shows the concentration of Iron in the study area, it ranges from 0.34ppm to 1.01ppm, with a mean of 0.74ppm and SD of 0.30, the control point has a concentration of 0.09ppm.lt is responsible for the development of chlorophyll of Growing plants Most of the iron in soils is found in silicate minerals or iron oxides. This must have been from the minerals mined in the study area which are predominantly tourmaline. With such high concentration of Fe in the sampled soils; crops in the study area will tend to have a retarded growth. This is evident in the study area as most of the crops have stunted growth and yellow leaves.

Cation Exchange Capacity (CEC):

It is the total capacity of a soil to hold exchangeable cations. CEC is an inherent soil characteristic and is difficult to alter significantly. It influences the soil's ability to hold onto essential nutrients and provides a buffer against soil acidification.

Table 4.1 shows the concentration of CEC in the study area with a minimum concentration of 4.20cmol/kg and maximum concentration of 5.00cmol/kg, with a mean concentration of 4.6cmol/kg, and SD of 0.29 and that of control plot is 6. 74cmol/kg. The low concentration of cation exchange capacity in the study area can be attributed to the low Organic content, acidic pH of the soils resulting from removal of top soil in the study area. Ayuba et al (2000).According to Gaoandchang (1996), CEC is highly correlated with OM content of the soil and said any process that affect soil texture due to land use changes also affects CEC of soils. The cation exchange capacity of a soil is greatly influenced by the organic matter level. A high organic matter soil will have a much higher cation exchange capacity than a low organic matter soil.

Hypothesis Testing

The statement of the research hypothesis is restated thus:

Ho: There is no significant variation in soil quality status of the study area from the control soil.

HI: There is significant variation in the soil quality status of the study area from the control soil. To test the stated hypothesis, the student t-test which is a statistical test that measures the significance of the difference between the means in two sets of data in an investigation was used. To determine this difference, the parameter of the soil sample analyzed in table 4.1 was used as follows.

Table 4.3 Result of the significance difference between mean of the soil sample from the mined area and soil from the control point

	Paired Differences					t	df	Sig. (2-tailed)
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1 Mean - Control	-.84707	3.78299	.97676	-2.94202	1.24788	-.867	14	.400

Source: extracted from SPSS version 17.0

Decision Making Rule.

The decision making rule is, to accept the null hypothesis (Ho) and reject the alternative (HI) if the calculated (t*) is less than the table (critical) t value (t*<t) for two tailed test at U005 level of significance and degree of freedom (df) n-l.

Hence, at U005 level (df) n-l = (14) the critical (table) value was found to be -0.87. Comparing calculated (t*) and critical (t) it was found that t*<t i.e. (0.40 <-0.87).we therefore accept the null hypothesis (Ho) and reject the alternative (HI) and conclude that there is no significant variation in the quality status of soil in the study area from the soils at control point.

We could also use the probability value (P. value) of the test of which in any case we do not need to compare the statistics but rather look at the probability of error we could forgo at either 1 % or 5% level of significance. But for this study we adopted the statistical method of comparing the computed t value and the tabulated t value

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Summary

The findings of the study are summarized below which assisted III making appropriate

conclusion and meaningful recommendations. The study assessed the effect of artisanal mining activity on soils in Angwan Doka, Kokona L.G.A of Nasarawa State where a total of 5 soil samples were collected at interval of 60m along a transect line. The results of physical and chemical properties of soil at artisanal mined area were compared with results of soil at control point that was collected 2 km away from the mining site. Findings from the results revealed that total nitrogen (N) has a mean of 0.056Meg/kg, Fe O.74ppm, P 5.25Meg/kg, K 0.051Meg/kg, (Na) 0.47Meg/kg, Ca 4.5Meg/kg, Mg 3.5Meg/kg, pH 5.6Meg/kg, S 3.88Meg/kg, Al O. Meg/kg, CEC 4.6cmollkg and Organic Matter (OM) 1.55% with deteriorated physical soil parameters such as bulk density l.55%, total porosity 29.40%, and moisture content 10.80%. The study revealed that the physical properties are destroyed due to the activities of artisanal miners in the study area most especially the moisture and CEC of soils declined in the mined areas which is disastrous for soil productivity. Soil CEC is crucial in soil fertility because the total quantity of nutrients available to plants as exchangeable cations depends on it and it influences the degree to which Hydrogen ion (H+) and Aluminium ion (At) occupy the exchange complex and thus affects the pH of soils. Furthermore, the results of the statistical analysis revealed that there is no significant difference from the soil of the study area and that of the control soil, at 95% significance level it was not statistical significant.

Conclusions

The study revealed that artisanal mining activity is responsible for the alteration in the basic physico-chemical properties of the soils and this is causing major adverse environmental effects as a result of changed land use on the soils in the study area. The mining operations being open cast and in the eco-sensitive corridor region of the Northern Ghats, resulting in biodiversity loss, loss of nutrients and microbial properties of the natural fragile soil ecosystems.

The soils are affected by drilling and blasting, removal of natural and stabilized vegetation and excavation of shallow top soil, stockpile of waste spoils and dumping of overburden on natural vegetation, clearing of land for construction of ancillary facilities etc. In all mine soils studied the concentrations of organic matters, available nitrogen, phosphorus, calcium and magnesium changed due to the mining activities.

Iron toxicity is found to be a main factor which limits plant growth in strong acid soil. Toxic effects on plant growth have been found to be dependent on several physiological and biochemical pathways. In present study the mine soils were not highly acidic: though they contained very high aluminium levels which can have a negative effect on the growth of plants. Water holding capacity, soil moisture, Soil nutrients like available nitrogen, phosphorus and potassium also are lower in mining areas with respect to native soils.

Recommendations.

Based on the analysis of the results obtained and the conclusions drawn from the study, the following recommendations are considered appropriate:

- There is the need for the government to review the legislations regulating the access to natural mineral resources and the environmental concerns arising from the operations 'of the artisanal mining. The present legislations to a large degree restrict their ability of meeting the stringent technical and financial requirements for the acquisition of a Small Scale Mining Leases (SSML).

- The policies as a matter of priority should be developed by Government to effectively integrate and mainstream the artisanal miners into the national mining policy framework 'by way of evolving policies plans and programmes that will aid them to easily formalize their mining.
- The artisanal mining operators, land owners, and local authorities need to be organized into cooperative bodies or shareholders .Through such trade associations and co- operative societies, it will be easier for them to mobilize funds, organize trainings, awareness and sensitization programmes and get the attention of the government to assist them. Also, from the rules that govern the associations and co-operative societies, it will be easier to implement environmental and safety measures so as to reduce on environmental and health hazards that affects the environment and constrain the activities of the miners. The Miners can further be assisted by government through importation of simple and easy to operate extractive and processing tools and equipment at subsidized cost. Also, through concern ministries, the government can support research, at tertiary and research institutions to design and provide simple, cost effective and sustainable mining technology.
- The Government need to organize intensive environmental awareness and sensitization campaigns and development of environmental preserving programmes targeting the artisanal mining as part of the national mining policy which should be implemented from the federal down to the states and local government levels.
- The variation in the result of soil physical and chemical properties indicated the risk to the sustainable crop production in the study area. Therefore organic manure should be applied in the soil of the study area during land reclamation to increase the fertility of the soils in the mining site. On the whole, the study underpins the need for strict mining operation policies to improve environmental performance.

Suggestions for further Studies

The following are therefore recommended for further research;

- Analysis of water quality for irrigation purpose.
- Assessment of chemical properties of underground water.
- Assessment of the socio-economic impact of artisanal mining in the study area.

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