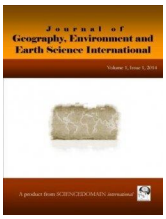

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Environmental Costs of Exploiting Solid Minerals in Nigeria: A Review

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Authors' contributions

This work was carried out in collaboration between all authors. Author SMM designed the study and wrote the first draft of the manuscript. Author NDM handled the literature searches. Author JDD managed the section on the consequences of exploiting mineral resources while author ADB drafted the recommendations and typed the work. All authors read, edited and approved the final manuscript.

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ABSTRACT

Mining of solid minerals has been a long time primary activity in Nigeria. The paper has reviewed a number of related works and discovered that mining of metallic minerals, particularly tin, columbite, iron ore and lead as well as mineral fuel like coal is on the increase in recent times. Those who engaged in mining the mineral resources actually do so, with the sole aim of improving their socio-economic condition through exploiting the products hence government gives support because exportation helps to boost the country's economy and image among comity of nations. The once beautiful landscape of Nigeria suitable for agriculture has now become, not only disfigured but has even lost its ecological outlook as a result of extensive and intensive mining activities. The paper

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has found out that the indiscriminate mining has led to the destruction of vegetation, soil, arable land, pollution of water sources and constitutes death trap to both human beings and animals. The paper has concluded by recommending such measures as embarking on organized tree-planting to stabilize tip-heaps of overburden, conversion of open ponds into fish ponds in order to augment the dietary requirements of the teeming population and the need for companies to prepare and forward statements of EIA to government before mining license could be issued for mining operation. The need for government to strengthen the existing minerals and mining Act of 2007 and the creation of solid mineral commission has also been advocated.

Keywords: Environment; costs; exploitation; solid minerals.

1. INTRODUCTION

Nigeria is located between latitudes 4° and 14° North of the Equator, and longitudes 3° and 15° East of the Prime Meridian. It is bordered on the West, North and East by French – speaking countries: Benin Republic, Niger, Chad and Northern Cameroun respectively, but on the Southeast by English- speaking Western Cameroun [1]. With a landmass of about 923, 768 km^2, Nigeria has been occupied by over 140 million people, comprising 50.78% males and 49.22% females [2]. While the majority of the working class is agrarian, a substantial number is into extractive work of mining minerals from the ground. Mineral resources in the country are associated with rocks and their locations depend to a large extent on the nature of rocks and the geological history of the areas. The country has over 44 solid mineral deposits distributed across the 36 states and the Federal Capital Territory, Abuja which include barites, gypsum, sand, clays, phosphate, iron ore, coal, tin, columbite, tantalite, gold, silver, lead, zinc, and other industrial minerals. Being rich in these minerals, Nigeria has become an important component of the world economic system supplying global markets with the inputs for commercial and industrial activities. Mining activities has impacted positively as evidenced by the growth of settlement, provision of infrastructure, employment of unskilled and semi-skilled Nigerians, promotion of leisure and resorts, boosting of irrigation and fish farming which consequently contribute to the local and national economy through collection of royalties and other dues by federal government [3]. There is no gainsaying that the diversification of the economy by the federal government is a step in the right direction, however, because the main solid mineral areas coincides with the major food production belt of the country, Nigerians are paying dearly as their arable lands are devastated due to overexploitation of the mineral resources. The price which Nigerians are paying is enormous indeed: destruction of vegetation, soil and arable lands that supply the teeming population with food and raw materials; open pits are created and the overburden that have been stockpiled into mounds over the years often near to large settlements now pose significant environmental problems that presently affect plants, terrestrial and aquatic animals, human beings and their economic activities. The questions that readily come to mind begging for answers are: To what extent has the environment been deteriorated and how? How do we understand the reasons for the continued exploitation of solid mineral resources? What are the obvious environmental consequences of mineral exploitation in Nigeria? What steps need to be taken in order to forestall further deterioration of land arising from exploitation of mineral resources?

In answer to the questions posed, the paper undertakes a review of relevant, related works with the aim of recommending appropriate steps to take in order to safeguard the environment from careless destruction. For this purpose, the paper is divided into seven sections. Section **one** is the introduction; section **two** is the methodology; section **three** sets the theoretical framework; section **four** identifies the ways and processes by which land deteriorates due to mining; section **five** presents the trends in exploitation of some solid minerals in the country over the years; section **six** discusses the environmental consequences of mining in Nigeria while section **seven** gives recommendations on what should be done and then concludes.

2. METHODOLOGY OF THE STUDY

The research methodology of this paper involves collection of data from basically secondary sources. Many books and articles in academic journals were read by the authors in the course of preparing this paper. Consequently,

as a lot of ideas and information were derived from such documentary materials, notes were taken and later expanded. The authors gratefully acknowledge all such sources of information obtained during preparation.

3. THEORETICAL FRAMEWORK

The reasons for the continued exploration and exploitation of minerals in Nigeria can best be understood by examining Maslow's Hierarchy of Needs Theory. Humanistic psychologists view needs as deficiencies or anything people perceive as necessary for their overall well-being. Man's needs are diverse and in most cases insatiable, hence Maslow's concept of Hierarchy of Needs can be very relevant in explaining why people in Nigeria go as far as despoiling the environment to bring out minerals embedded underground. Eggen and Kauchak [4] vividly show that Maslow places needs in a hierarchical order to which the very base of the hierarchy is the **primary** or **basic** needs and include food, water, warmth and shelter while other associated needs belonging to **secondary** needs such as security, belonging, self- esteem, intellectual achievement, aesthetic, recognition and appreciation are also necessities that human beings continue to pursue for the attainment of **self-actualization** which he placed at the apex of the triangle. What is glaring in Maslow's chart is that both the primary and secondary needs are interlinked such that as man works towards self-actualization which is placed at the very top of the triangle, he has to meet the lower or secondary needs too because they are also very vital for survival and satisfaction. The secondary needs which include self-esteem, intellectual and technological achievement already possessed by the advanced countries of the world is luring the less economically developed countries like Nigeria to keep struggling in order to uplift the standard of living of its citizens for recognition. As no nation in the world wants to remain dwarf, Nigerians have therefore, decided to embark on the exploration and exploitation of mineral resources which they see as a viable option for the upliftment of standard of living and general well-being. Since a need represents an imbalance or lack of adjustment between a present situation and a new set of conditions assumed to be more desirable, needs therefore elicit observable actions such as exploration, exploitation and processing of mineral resources in order to uplift one's condition of life. In order to improve their standard of living, many Nigerians have therefore taken to mining of mineral resources with the support of both the federal and state governments who have deliberately created solid mineral ministries, charged with the responsibility of granting mining permit to individuals and companies.

Thus, the views of Lamai and Kola [5] can be upheld where they have attributed the general expansion and intensification of mining activities in Nigeria to the arrival of colonialists with their advanced mining equipment, creation of ministry of solid minerals and granting license to prospective miners. The reason for governments' interest in mining of minerals is to boost both the economic and political ego of the country among comity of nations, having been lured by the great achievements of advanced countries of the world like USA, United Kingdom, Japan and Russia.

Mineral resources and human welfare are closely linked in terms of meeting man's secondary needs. For example, tin is required for tin- plating and making cans to preserve food; aluminum is used for aircraft manufacturing to facilitate movement and overcome geographical distances; copper is mined for making electronics to boost communications; uranium is required for electric power generation and weapons of war to defend the citizens against security challenges while columbite is in ardent need for making heat-resistant engines of machinery that manufacture the capital goods we use daily for our comfort.

Minerals provide the materials used to make valuable things of industrial based society including roads, cars, computers, fertilizers and household products. It is in a quest to improve the living condition of humanity that there is increasing demand for minerals to meet those individual needs [6].

It is the desire to meet these needs that have prompted Nigerians to go as far as excavating the earth crust in search of valuable mineral materials which unfortunately, usually leave behind trails of pits and domes that are presently posing health threats, not only to human beings but indeed, the entire ecological set up. Hence, this paper contends that while extracting valuable minerals to meet human secondary needs, it should be done with caution not to deface, disfigure, despoil and degrade the land to the point of dereliction.

4. WAYS AND PROCESSES OF ENVIRONMENTAL DETERIORATION THROUGH MINING

Mineral resources are important source of wealth for the nation but before they are harnessed, they have to pass through the stages of exploration, mining, and processing [7]. Mining is a dirt-generating industry. It has caused some of the largest damage to the environment in the world generally and Nigeria in particular. It takes many procedures to get a particular mineral out of the ground for use by human beings. Asthana and Asthana [8] have succinctly described what mining entails:

> *"It involves the removal of soil and rock overlying the mineral deposits before the actual mining operation commences; the ore is then mined and crushed; the fine powdered ore is run through concentrator which remove unwanted materials and impurities; the concentrated ore is then reduced into crude state at high temperature by various methods; and the crude is finally purified in refineries".*

It should be noted that each step in mining and processing operations produces vast amount of waste materials. Environmental problems are thus, created at each stage of production, upgrading, transportation and utilization of these minerals. In mining, the first task usually undertaken is for the miner to clear the land of any vegetation to survey the area of possible mineral occurrence and determine both the quality and quantity.

Underground mining with a system of shaft and tunnels does not produce much waste materials but in Nigeria open cast is the method usually adopted in mining solid minerals. The waste materials so generated, even if chemically inert do clog streams, get deposited in water bodies and the dust always cloud the air over large areas [8]. The heap of overburden presents additional soil problems. Sediments in nearby streams easily pollute the water. The heaps despoil the landscape for farming and other uses and increases suspended solid load of the waterway. This increase interferes with the ecological habitat and poses silting problems in navigation channels, inhibiting the commercial use of these water bodies. There is need for relevant authorities in the country to address this unscientific method of mining in order to safeguard the environment from further dereliction.

The disposal of waste material produced after concentration of an ore creates yet another environmental problem. As most of the ores at times, columbite, coal and other mineral resources in the country contain large amount of sulphur, its oxidation and leaching results in the formation of acidic leachates. The finely grounded ores are metal pollutants that affect the environment negatively. The pollutants contain appreciable amount of heavy metals and toxic trace elements. Tailings are also not always without residue of organic chemicals such as toluene which causes many other problems.

Ponds full of acidic leachates, covering extensive hectares of land surface can even contaminate underground aquifers which becomes available to human beings through springs or boreholes to cause havoc.

An ugly scene of tip-heap disaster tagged ***Aberfan disaster*** occurred sometimes in the 1970s as reported by Leong and Morgan [9]. An unexpected tip-heap avalanche was said to have buried 116 children at school in Southern Wales mining village in Europe. It is wise not to wait for ***Aberfan disaster*** to occur in Nigeria's mining fields especially, Jos Plateau where heaps of overburden is freely created through the mining of tin and columbite before we take action to reclaim the land. The position of this paper therefore, is that the relevant authorities should as a matter of urgency reclaim the over 316 km^2 of land devastated by the presence of 4000 heaps and ponds produced due to mining of solid minerals around Bukuru, Rayfield, Gana Ropp and Sabon Gidan Kanar – all on the Jos Plateau to forestall further degradation of land [3].

Mining of tin and columbite on the Jos plateau using hydraulic techniques is also known to result in disaster. The method involves blasting the tin-bearing rocks with high pressure jet water and guidingthe sediments through ducts where the tin being heavier settles down from tonnes of non-valuable material. This silt has silted local streams and ponds, thus reducing the fish population along River Dilimi in Jos [5].

Furthermore, the release of sulphur dioxide into the air when fossil fuels, particularly coal and gasoline are burnt in the smelting of ores like tin and coal at their factories located in Jos and Enugu respectively produce a lot of environmental problems too. Research findings, according to Esomonu [10] indicate that sulphur

dioxide slows down ciliary activities in the respiratory track, leading to accumulation of particulate pollutants in the alveoli, causes running nose, easily forms acidic solutions which corrode building materials as well as causes acid rain that lowers soil pH thus, promoting the leaching of aluminum which escapes into water bodies and causes a reduction in the population of fish especially in lakes.

In North America miners use the heap leaching techniques which allow gold extraction from a very low grade ore. As cyanide solution is sprinkled over a heap of low grade ore while trickling down, the solution dissolves gold. It is collected and later gold is recovered from it. However, it is evident, as Asthana and Asthana [8] rightly observed that both the cyanide solution reservoirs and contaminated tailings left behind after the gold extraction pose hazards to wildlife and threaten surface waters as well as underground aquifers. Here in Nigeria illegal gold mining in Zamfara State as reported severally by the national dailies have been responsible for the death of over 400 children between 2009 and 2012 due to lead poison.

5. TRENDS IN SOLID MINERAL EXPLOITATION IN NIGERIA

Exploitation of natural resources has been an ongoing activity for so long that historians mark major periods of human history by reference to mineral materials such as Stone Age, Bronze Age and Iron Age, among others [8]. Searching for rock materials began with a flint which was usually fashioned into tools and weapons during Stone Age. As human beings learnt the science and art of smelting metals, bronze and iron, the resources become very useful for making tools. In essence, our present civilization has no doubt, been ignited to a large extent, by the knowledge and application of metallic minerals which provide the basis of machinery that modern manufacturing industry depends.

In Nigeria organized mining began in 1903 when the Mineral Survey of Northern Protectorate was created by the British Colonial Administration. A year later, the Mineral Survey of the Southern Protectorate was founded. By the 1940s, Nigeria was a major producer of tin, columbite and coal. However, the discovery of oil in 1956 and the Nigerian Civil War of the late 1960s led to many expatriate mining experts to leave the country thus, leading to the decline in non-oil mineral production. The exploitation of non-fuel mineral in Nigeria has been fluctuating over the years. The sector accounted for only 0.3% of its GDP due to influence of the nation's discovery of the vast oil reserves. However, solid mineral production increased in 2008 relative to the preceding year, rising from 35.6 million tonnes in 2007 to 40.2 million tonnes [11,12,13]. The development was accounted for by the substantial increase in the production of stone aggregates, limestone, marbles, sand, gold, lead and zinc where the production of stone aggregates alone was 3.6 million tonnes as against 2.9 million tonnes in 2007.

The production of limestone, sand, marble aggregates, lead, zinc and gold increased by 19.2%, 13.8%, 12.6%, 10.7% and 11.1% respectively. The production of barites, tin, iron ore, shale, columbite, clay and laterite also increased in 2008. The same reports have shown that aggregate output increased from 40.2 million tonnes in 2008 to 41 million tonnes, representing an increase of 20.0%. The increase was accounted for by increased production of limestone. Other minerals such as tin, columbite, clay, marble aggregates, lead-zinc, shale, laterite and iron ore however declined in the period under review compared with 2008 [14]. Table 1 below reveals that solid minerals contributed 0.28% in 2006, 0.34% in 2010, 0.36% in 2011 and 0.6% in 2012 – 2014 (projected) to the real Gross Domestic Product.

The above sources also reported the sectoral growth of solid minerals for 2010 to be 12.29%, 12.30% for 2011, 12.39% for 2012 and 12.40% for 2013. The commercial value of Nigeria's solid minerals has been estimated to run into hundreds of trillions of dollars with 70% buried in the Northern Nigeria [15]. Nigeria is currently the sixth largest producer of tin, with nearly 3 billion tonnes of indicated reserves in 17 identified fields and over 600 million tonnes of proven reserves. Over 7.5 million tonnes of barites have been identified in Taraba and Bauchi States and over 700 hundred million tonnes are in other states. Zinc-lead estimate is put at over 10 million tonnes spread across eight states of the federation [16]. Similarly, over 1 billion tonnes of gypsum are spread around Niger, Ondo and Ekiti States while over 40 millions of talc deposits have been identified in Niger, Osun, Kogi, Ogun and Kaduna States. Table 2 reveals the occurrence and level of development of industrial materials including proven reserves across the federation.

Table 1. Solid mineral contribution to GDP in Nigeria

Year	2006	2010	2011	2012	2013	2014
Percentage (%)	0.28	0.34	0.36	0.6	0.6	0.6

Source: NPC [11]; NBS [12]; NBS [13]

Table 2. Occurrence and level of development of industrial materials in Nigeria

S/N	Metallic mineral	Location	Level of development	Proven reserves ('000 tons)
1	Asbestos	Kaduna	Partial Preliminary exploration	Not yet known
2	Barites	Plateau & Benue	Azara deposit being mined by NMDC	Azara 500, others not yet known
3	Bauxite	Adamawa, Cross- River	Not yet explored	Not yet known
4	Clay ball	Imo, Edo, Delta, A/Ibom, Rivers, Bayelsa, Cross-Rivers, Ekiti, Ondo, Enugu, Ananmbra	Partial Preliminary exploration & evaluation of deposits	Very large up to 50,000
5	Kaolin	Edo, Delta, Imo, Kwara, Kogi, Plateau, Nasarawa, Kaduna, Katsina, Ogun, Kano, Sokoto, Kebbi	Partial/full exploration & evaluation of most deposits, exploration of some	Very large up to 70,000
6	Fire Clay	Anambra, Enugu, Katsina, Ogun, Sokoto	Partial exploration & evaluation, small-scale exploitation of some reserves	Very large up to 20,000
7	Diatomite	Borno	Extensively exploited & evaluated, small-scale exploitation	Very large about 10, 000
8	Dolomite	Kwara, Kogi, Oyo, Niger, FCT	Most exploited, detailed reserve evaluation required	Large quantity not yet known
9	Felspar	Kwara, Oyo, Ogun, Niger, Kaduna	Partial exploration & evaluation	Large quantity not yet known
10	Fluorspar	FCT	Potent Investigation	Quantity not yet known
11	Gypsum	Sokoto, Borno, Anambra	Partial exploration & evaluation, small-scale in Sokoto & Potiskum	Large quantity not yet known
12	Kyanite	Kaduna, Niger	Partial investigation	Quantity not yet known
13	Limestone	Anambra, Enugu, Cross-Rivers, Benue, Ogun, Sokoto, Bauchi, Delta	Most are being exploited	Very large 800
14	Marble	Edo, Kwara, Kogi, Benue, Oyo, Plateau, Kaduna	All are being exploited except Plateau & Kaduna	Very large up to 100, 000
15	Phosphate	Sokoto, Ogun,	Full exploration & evaluation in progree	Quantity not yet known
16	Salt	Benue, Anambra, Imo, Cross-River, Plateau	Partial investigation	Quantity no yet known
17	Soda Ash	Borno, Kano	No systematic studies carried out	Quantity no yet known
18	Talc	Ondo, Oyo, Niger	Partial preliminary investigation	Quantity no yet known

Source: Udeh, [17]

Table 3. Nigeria's solid mineral types, location, and scale of mining

S/N	Mineral	Locality	Current level of exploitation
1	Iron	Itakpe	L
2	Tin	Jos-Plateau, Nasarawa	M, S
3	Niobium/Tantalum	Jos-Plateau, Saki, Idiko, Oro	Won as by-product of tin mining
4	Monazite	Jos Plateau	Dormant
5	Xenotime	Itagunmodi, Birnin Gwari, Dangbala	S
6	Gold	Ishiagu, Enyigba, Ameka, Ameri	Presently dormant
7	Lead	Ishiagu, Enyigba, Ameka, Ameri	M, won as by-product of lead (galena) mining
8	Silver	Kalambaina, Igarra, Dangbala, Ikpeshi, Atte	Won as by-product of lead mining
9	Zinc	Okpilla	Won as by-product of lead mining
10	Limestone	Okpilla, Burum, Ighetti, Igarra, Jakura, Kwakuti, Ikpeshi, Gwoza, Warake	L
11	Marble	Wurno, Fika area, Ikpeshi, warake, Azara, Omi, Adio, Ozubulu, Naragua, Kano, Ikorodu, Ire, Badagry, Igbokoda, Ugheli	M, L (dormant in some part)
12	Feldspar	All parts of the federation	S
13	Gypsum	All parts of the federation	S
14	Barites	All parts of the federation	L
15	Clay	Ijero-Ekiti, Jos Plateau, Saki, Falansa, Iyano	L
16	Glass Sand	Ijero-Ekiti	M, S
17	Construction Sand	Jos Plaeau, Akwanga Area	L
18	Construction stones & laterite	Jos Plateau	S (mainly illegal mining)
19	Beryl	Enugu	S (mainly illegal mining)
20	Tourmaline	Niger Delta	S (mainly illegal mining)
21	Sapphire	Niger Delta	S (mainly illegal mining)
22	Ruby	Niger Delta	S (mainly illegal mining)
23	Topaz	Niger Delta	S (mainly illegal mining)
24	Coal	Enugu	L
25	Oil and Gas	Niger Delta	L

L = Large scale exploitation; M = Medium scale exploitation;
S = Small scale exploitation.
Source: Aigbedion & Iyayi, [7]

Exploitation of solid minerals, which was locally carried out using locally-made tools were not a serious threat to the environment. However, the last century actually witnessed a great expansion and intensification which has been attributed to the arrival of the colonialists with their advanced, sophisticated equipment and recent government interest in the exploitation of solid minerals in the country through the creation of the Ministry of Solid Minerals that always encourage and give mining permits to prospective miners [5].

It could be argued too, that the availability of 44 different kinds of solid minerals in the country being attested to by the Nigerian Extractive Industries and Transparency Initiative and the current slump in the oil price with its attendant declining revenue that continues to impact negatively on the Nigerian economy are certainly additional reasons for government's nod on expanded exploitation of solid mineral resources in Nigeria. Table 3 shows the distribution, scale and intensity of mining which is immensely contributing to environmental devastation in Nigeria.

The Table 3 shows the mineral deposits that are currently being exploited where some of them like tin, columbite, tantalite and coal have been

exploited on a commercial scale since early part of the last century and have made significant contributions to the national wealth and socio-economic development. However, others have been produced in small quantities and exported. At present many minerals are at different level of exploitation as shown in Table 3. To a large extent, the scale of operations involved in exploration, mining and processing of a mineral determines the intensity and magnitude of environmental damage.

The intensive and extensive exploitation of mineral resources being witnessed in recent years in Nigeria is indeed affecting the landscape, quality of air and water negatively and posing great hazards to human beings, their economic activities, animals and useful plants.

Tin ore, which occurs as gravel deposits along ancient river valleys on the Jos- Plateau, was initially exploited by local people before the arrival of British colonialists into the country without causing any significant damage to the landscape, but with the coming of Europeans, commercial mining was intensified. According to Lamai and Kola [5], tin exploitation on Jos Plateau consequently grew and expanded between 1905 and 1962 when production figures rose from 1300 metric tons in 1910 to 17,000 metric tons in 1962.

The exploitation of iron ore in Kogi State which started with the discovery of large deposits at Itakpe in the late 1970s and early 1980s has also increased significantly in recent time. Iron ore which was locally mined and processed in primitive furnaces for making weapons and agricultural implements has today become the basic raw material for the iron and steel factory at Ajaokuta. An estimated 2 billion metric tonnes of high grade iron ore capable of feeding the Ajaokuta iron and steel company has been discovered in different parts of Nigeria [18]. Limestone is a sedimentary rock mineral found in large quantities in different parts of the country. With yearly increase in Nigerian population and the desire to build decent dwelling units, exploitation of limestone and marble is on the increase in an effort to meet up with the demand. Hence Nigerian landscape, air and water courses are being despoiled to the detriment of human health and their economic activities.

Similarly, the quarrying of large quantities of rock, sand, gravel and clay annually for construction of buildings, road and dams is on the increase and is adding to the environmental crises bedeviling the country.

Exploitation of barites and kaolin in Nasarawa and Benue States are reported to have increased recently on a commercial scale where vast expanse of land has been affected [5]. The scene is not different in the case of gypsum. Exploitation of this mineral resource has increased in parts of Nigeria with the discovery of gypsum in states like Gombe and Zamfara. In Gombe, it is being mined at Dukku and even though the mineral is used for making cement, fertilizers and plaster of Paris [19], over-exploitation has left behind large burrow pits, reduced vegetation cover and threatens continued use of the land for food production.

6. CONSEQUENCES OF EXPLOITING SOLID MINERALS

A cursory look at the physical environment would certainly reveal that the extraction of sand, gravel, clay, tin, columbite, limestone and other solid mineral resources has destroyed surface land, vegetation, created noise, and raised dust that pollutes the air and water sources like lakes, rivers and streams. Indeed, the effects of mining activities in mineral producing areas, particularly Jos Plateau is well known. This implies that development in Nigeria always carry along with it environmental consequences that ultimately negate the goals of development process. The harmful effects of mineral exploitation on the environment are discussed as follows:

6.1 Destruction of Vegetation

Since surface mining involves clearing of vegetation, a lot of protective plants are usually removed deliberately in order to lay out surface grids. Such activities require roads, camp sites, excavation and preparation of mining sites, hence the direct impacts include death of plants and animals due to contact with toxic water from mines while the indirect effects are mainly changes in nutrient cycling, increased accumulation of carbon dioxide, accelerated soil erosion and flooding. There is need to plant trees to replace those destroyed as forest provides essential work of protecting the environment from weather effect.

6.2 Destruction of Soil, Arable Land and Crop Yield

The use of heavy machinery in mining usually contributes to soil compaction and a

considerable land is lost due to chemical contamination of the productive layers of the soil. Open cast mining usually result in drastic reshaping of the surface of the earth that affects sub-surface drainage pattern; as large waste materials are removed from some areas and dumped in others.

Over 4000 mine dumps and ponds have been created on the Jos Plateau covering an area of about 316 km^2 of land as a result of nearly a century of open cast mining [3]. Similarly Lamai and Kola [5] have reported the devastation of arable land in Gombe and Nasarawa States, brought about as a result of continued mining of gypsum and Kaolin respectively. The continued exploitation of limestone for cement work in Sagamu has caused a decline in kola nut output from the plantation located within a few kilometers radius [7]. This phenomenon is associated with dust pollution from the cement factory which must have prevented normal photosynthesis of the kola nut leaves.

6.3 Loss of Ecological Balance

The removal of vegetation and the pilling up of overburden combine to produce serious erosion and flooding problems apart from the considerable loss of wildlife habitat. The case of illegal mining of aquamarine in southern Kaduna was said to have resulted in significant loss of wildlife habitat between 1985 and 1989 [5].

6.4 Contamination of Water Courses

Mining operations often pollute the atmosphere, surface and ground water. Rain water seeping through the soil heaps may become heavily contaminated, acidic or turbid with potentially devastating effects on nearby streams and rivers [6]. A study by Ogezi [3] has indicated that there is a high level of radioactive emissions as a result of tin mining of the Jos-Plateau which is believed to affect the brain causing mental problem and death. People in some villages have reported mysterious death arising from the use of monazite-rich sand in building houses on the Jos-Plateau. Trace elements, when leached from mining wastes and concentrate in water, soil and plants could cause diseases to those who consume or use the contaminated objects and food crops. Many of the surface mining activities in river beds are usually washed down into the river which provides water for communities downstream. Heavy metals from mine washing along the Dilimi River in Jos has affected fish population where at the middle course no fish was found and the river water was seen to be heavily suspended with silt, thus unfit for human consumption [5].

6.5 Death Trap

Most of the mining pits in parts of the country have become death traps either in actual act of mining or drowning when they become filled up with water. Often times, the quarry is usually deeper than the water-table hence become dangerous to terrestrial life forms including human beings. Lamai and Kola [5] cited two cases of loss of lives associated with mining of solid minerals in iPlateau and Niger States; where in 1980 some people were drown in some mining pits in Bukuru and in Minna three women were also buried alive in a mining pit. A lot of death traps in the form of ponds and pits exist in the tin mining fields of Jos-Plateau, particularly Naraguta, Kuru, Heipang, Vwang, Du, Foron, Gashish and Ropp [3] There is need for relevant authorities to, as matters of urgency expedite action to reclaim the mined ponds in order to forestall further loss of human lives and their property. The presence of old, deep mines also causes the ground to subside and damage nearby structures and routes.

6.6 Noise Pollution

Blasting and transportation of bulky mineral products cause noise disturbance to the locales and to wildlife. The associated noise can be injurious to the ear if it exceeds 90dB as recommended by health experts. According to Asthana and Asthana [8], human ear is sensitive to sound levels ranging from 0- 150dB, however, sound levels beyond 70- 80dB cause plenty of discomfort, irritation and a variety of physiological disturbances. Noise louder than 120dB is said to constitute a nuisance, hurts the ear, irritates, gives headache and if received continuously may damage the sensory cells of the ear and bring about permanent deafness. Melnikove and Chesnokov [20] averred that if the noise is combined with pulsation as is the case with mining equipment, the heart will also be affected.

6.7 Effects on Climate

Extraction and transportation require huge amounts of energy which can precipitate acid

rain and exacerbate global warming. This is because of the fact that heavy- duty machines are the major emitters of greenhouse gases that trap the outgoing heat from the earth surface. Acid rain makes water acidic which easily destroys buildings, statues, trees and wildlife.

6.8 Destruction of Structures

Some of the solid minerals are mined by blasting followed by crushing to obtain the required minerals. However, vibrations caused by the blasting can damage structures like nearby houses, roads and bridges. It is sometimes very unfortunate that some mining companies hardly pay a good compensation to inhabitants of mining areas to enable them relocate to new, safer site, hence it is not uncommon to find Nigerians still living in such hazardous environment especially the mined fields of the Jos- Plateau [3].

6.9 Effects on Tourism Development

Mines and their associated heaps do occupy level grounds that are otherwise suitable for settlement, agriculture or factory location. People who live at the vicinity of mined areas have no pride in their habitats. Instead, they tend to migrate away from such unpleasant areas thus, leading to urban sprawl in other regions through the general spread of man-made landscapes at the expense of natural landscape [9]. The tin and columbite exploitation on the Jos-Plateau has resulted in the destruction of scenic landscape which is replaced by unsightly large irregular pits and heaps of debris produced through open cast method of mining [7]. Therefore, the ugliness of settlements dominated by tip-heaps and ponds are deterrent to modern tourism development.

7. RECOMMENDATIONS

In order to minimize the negative impact of solid mineral exploitation in Nigeria, it is necessary for federal government to take precautionary measures. Government should provide sound legislation compelling mining companies to take all necessary precautions that will prevent environmental destruction during and after the operations. Such laws already exist as there is the Nigerian Minerals and Mining Act 2007 which was enacted in March 16th 2007 to repel and replace the Minerals and Mining Act of 1999. The new Minerals and Mining Act has addressed the environmental conservation issues, stating unequivocally the method which must be employed in mining and processing operations. However, the current haphazard approach to exploitation of solid mineral resources speaks poorly of the new law which has not made sufficient provision of sanctions against those who fail to comply with the environmental protection regulations [15,7]. The present situation where a few people have 'cornered' the mining licenses and are declaring what they just like as profits and tax with little or no reclamation of the mined lands should not be allowed to continue unabated. The fact that there is a commission for petroleum and none for solid minerals in this country is a misnomer [15]. The wanton destruction of Nigeria's environment arising from exploitation of solid minerals is a surmountable issue. There is the need to strengthen the existing Minerals and Mining Act by taking the following measures.

1. Prospective mining companies should be compelled, through legislation to submit Environmental Impact Assessment, EIA to the relevant authorities for scrutiny before approval can be given to commence operation.
2. Strict legislation on mining activities which affect the landscape should be enacted and enforced.
3. Existing mining companies should be compelled by law to accept the rehabilitation of mined lands after the resources become uneconomical to continue with the exploitation.
4. Individuals should be banned from carrying out illegal mining that exacerbate land deterioration and constitutes death trap to innocent citizens and wildlife.
5. Government should control the activities of the miners through close monitoring to ensure the terms for the approval of Environmental Impact Assessment (EIA) documents are strictly adhered to by the miners.
6. Creation of solid mineral commission would be of immense benefit to Nigerians and Nigeria's environment in this aspect.
7. There is need for both miners and the relevant authorities to provide modern amenities for the people in the mining areas in the form of pipe borne water, good feeder roads, schools, medical facilities and electricity, among others in

order to reduce the problems being faced by Nigerians living in such mined areas.

8. Government should deliberately embark on an organized tree- planting campaign aimed at stabilizing old mined wastes in order to forestall further degradation. In order to accord high value to the mined lands, the ruined landscape should be reclaimed through engineering work for such purposes like fish farming, sports and recreation as well siting of factories and settlements.

8. CONCLUSION

It is no longer news that Nigeria's environment that provides the occupants with all their necessities of life is gradually undergoing obvious destruction through expanded exploitation of such solid minerals like tin, columbite, limestone, marble and iron ore, among others. Although, exploitation of these minerals was done with good intention of meeting the needs of the citizens and to boost the nation's economy, Nigerians are paying the costs dearly. Exploitation of solid minerals in Nigeria has been discovered to result in the destruction of useful plants, arable lands, disruption of ecological balance as well as pollution of air and water courses which in turn is posing threat to human lives. This paper has therefore recommended the use of legislation to forestall further degradation of the environment as well as the need for government and miners to alleviate the suffering of the people in mined fields through the provision of infrastructure and social amenities. Creation of solid mineral commission to perform similar functions like its counterpart Nigerian National Petroleum Corporation (NNPC) has also been advocated.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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