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Keywords: *artisanal mining, acid mine drainage, deforestation, scarification, odagbo.*

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Abstract- Mining as an activity is crucial for economic growth in most countries of the world, but issues of environmental concern are poorly managed by artisanal miners. Artisanal mining is a means of sustaining livelihood that is usually characterized by exploitation of marginal deposits, a very low degree of mechanization, low level of occupational safety and in very dangerous conditions. The objective of this study was to assess the environmental impacts of coal mining at Odagbo and suggestion of useful measures at dealing with these problems for sustainable environmental management. A literature review, field investigations and stakeholder's consultations were used for this study. The environmental problems that were identified are incidence of acid mine drainage (AMD), deforestation, scarification of the entire landscape and decline in agricultural production. This study recommends that government should implement the mining laws that will ensure sustainable development of the artisanal mining sector in Nigeria for the overall growth of the economy and protection of the environment. Also, artisanal miners should be trained to acquire competencies in sustainable mining techniques in order to mitigate these environmental problems. Further, government should consider allocating some mining leases for artisanal mining activities. These will reduce haphazard destruction of the forest in search for productive coal deposit. Coal mining should be carried out with minimal impacts on the environment and steps should be taken to reclaim degraded land by afforestation projects and back filling of exposed land with the overburden.

Keywords: artisanal mining, acid mine drainage, deforestation, scarification, odagbo.

I. Introduction

Mining is an activity that separate useful ore from waste rocks which often impacts the local geological and ecological environment. Research has shown that about 20 million small scale and artisanal miners are in operation across 30 countries of the world (Que et al. 2018; Ericsson 2011). Proceeds from mining are used for construction of infrastructures such as roads, schools and hospitals for the human populace (UNECA 2004).

Coal was discovered in Nigeria in 1909 but exploitation, development and mining started in 1950 when Nigeria Coal Corporation (NCC) was established (MMSD 2014). Nigeria's Federal Government effort at diversifying her economy from a mono economy of oil and gas to exploitation of her abundant solid minerals and agriculture has led to an upsurge in the mining of coal for generation of electricity and export to other countries of the world. Coal is being mined by artisanal miners on a small scale alongside with large scale mining firms such as Dangote Industries, Eta Zuma Nigeria Limited and Weco Nigeria Limited.

Odagbo coal deposit was estimated at about 100 million tones, a paltry of this amount was mined by NCC for rail project and very few tonnages were exported to foreign countries (MMSD 2014). The Odagbo coal mine was abandoned for several years until NCC entered into a production sharing agreement with Nordic Industries Limited and they succeeded in producing 2, 712 tonnes of coal from the mine in 2001 (MMSD 2014).

Till date, total amount of coal that was mined by artisanal miners are not known as they lack basic skills of keeping adequate records of production. Odagbo coal is of sub-bituminous grade which could be used for boiler fuel, production of high calorific gas, domestic heating and production of chemicals such as waxes, resins and dyes (MMSD 2014).

Nigeria's power generating capacity is in the range of about 7000 MW which is far below the country's demand of 30,000 MW. The power output could not sustain most industrial plants in Nigeria hence most cement producing companies in Nigeria notably, Lafarge Cement PLC, Dangote Cement PLC, Sokoto Cement PLC and Ashaka Cement Limited have developed coal- fired power plants to generate electricity for their operations. With these initiatives, artisanal miners were exploiting the abundant coal deposits at Odagbo and other adjoining communities for the supply of coal to these cement companies and export to China, Vietnam and other Asian countries. As the demand for coal to meet the energy requirements of

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these cement plants increases, so also is the destruction of the entire landscape where coal are being mined from.

Artisanal mining is a poverty driven activity which is practiced by poorly educated populace with few employment alternatives (Funoh 2014). It is characterized by a very low level of occupational safety, reduced degree of mechanization (Fig. 1), low level of income and without cognizance of environmental issues from mining operations (World Bank Group 2005; Hentschel et al. 2002).

The objective of this study was to assess the impacts of artisanal coal mining on the environment within Odagbo enclave and to suggest useful strategies that will entrench sustainable environmental management practices.

II. Research Methodology

The data for this study were acquired through a thorough review of documentation from existing reports, a literature review of books, articles and laws relating to mining in Nigeria. Field visits to Odagbo coal mining sites were conducted in March 2019 for visual observation and Focus Group Discussions were organized with artisanal miners on their perceptions and views on impacts of artisanal coal mining on the environment.

III. Geology and Coal Mineralization

Odagbo is situated between latitudes 7° 28′ 30″ N and 7° 29′ 00″ and longitudes 7° 43′30″ E and 7° 44′ 0″ in north central Nigeria (Fig. 2). It has a landmass of about 6 km^2.

The area is a typical example of scarp and valley topography (Momoh, et al. 2017). The soils in the area are loamy and sandy soils, they were derived from Ajali sandstones (Emmanuel 2015). The mean annual temperature is 27° C and annual precipitation is between 1,100 mm and 1,300 mm (Emmanuel 2015). The major land use of the area is farming. Inhabitants of the area and some miners are engaged in the cultivation of cassava, yams, maize, groundnuts and plantain.

The Odagbo coal deposit lies in the Lower Benue Trough, the stratigraphic succession was underlined by Albian Asu River Group (Fig.3).

The Asu River Group is made up of shales, limestones and thin lenses of sandstones (Ameh, 2013). Overlying the Asu River Group is the Turonian Nkalagu Formation, which consists of black shales, limestones and siltstones. The Campanian Nkporo Formation which is predominantly marine shales rests on the Nkalagu Formation. Overlying the Nkporo formation is the Maastrichtian Mamu Formation. The Mamu Formation is often referred to as Lower coal Measures of the Anambra Sedimentary Basin of south eastern Nigeria (Obianuju 2005). The Mamu Formation is made up of shale, carbonaceous shale, sandstones and mudstones with coal at many levels in Mamu Formation (Nwajide 2013). Resting on top of the Mamu Formation is the Ajali Formation which is made up of friable sandstone (Orajaka et al. 1999).

IV. Artisanal Coal Mining Methods

Two mining methods are being used by the artisanal miners for the exploitation of Odagbo coal deposits. Open cast mining (Fig.4). This is a surface mining method of extracting coal from the seam by removing the overburden with an excavator.

Open cast mining method was adopted in areas where the overburden is thin. This method of mining changes the geological and hydrological conditions of the area. Streams are diverted from their normal courses to different routes and this diversion changes the landscape of the entire area. The overburden that was removed is used to build dams around the pits to prevent water from flowing into the mine. The mined coals are carried in sacks to suitable location before they will be loaded into trucks for transportation to designated buyers.

Another form of mining in the area is Lotto mining method (Fig. 5). It is a form of subsurface mining that involves the use of hoe, shovels and diggers to dig holes of several metres into the subsurface layer pending when the artisanal miner will strike the coal seam.

On striking the coal seam, the coal are shoveled into sacks and carried up to the surface by the miners on their head to a loading point (Fig. 6). The miners carry torch and hurricane lamps to illuminate their work places. Pumps are occasionally sent underground to get rid of groundwater in order to prevent flooding of the mining hole.

This form of mining is characterized by low productivity, lack of capital, poor technology and miners work in a very hazardous condition as there are no support pillars to protect the hole from caving in (Emel et al. 2011). The mining holes are uncovered and these can form death traps to man and animals.

V. Impacts of Artisanal Coal Mining on the Environment

Physical, chemical and biological changes in the environment result from mining operations. These are scarification of the landscape, decline in agricultural production, biodiversity and ecosystem loss, deforestation, water and soil pollution (Mishra 2005).

VI. Scarification of the Entire Landscape

Miners excavate large portion of the landscape to extract coal from the seam. Waste matter (Spoils and overburden) were deposited on the edges of the open pit mines (Fig. 7). The spoils and overburden were

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transported downstream and these could have adverse effects on the aquatic habitat because of increased sedimentation and turbidity of the river within the area.

These pits measured up to 50 x 20 m and about 100m deep. Some of the open pit mines that were abandoned are now filled with water. The abandoned mine pits are death traps to cattle, sheep and goats in the area. Research has shown that these ponds were enriched in Pb, As, Hg and U (Momoh et al. 2017).

VII. Decline in Agricultural Production

Most farmers whose farmlands were close to the mines have abandoned agricultural activities because the artisanal miners have taken over quite a large chunk of their arable farmland. Those farmers that are still in the business, acid mine drainage from the mines drains onto their farms, resulting in deterioration of soil quality which significantly reduced agricultural produce from such farmlands (Fig.8). Goats, cattle's and sheep's that normally graze on these lands were malnourished because the grasses which they feed on are very scanty in the area.

Inadequate land for farming activities has significantly reduced the quality of agricultural produce from the area.

VIII. Deforestation and Biodiversity Loss

Odagbo is a densely rain forested area, but around the mines, no single tree was found in the entire area. Miners deliberately cut down the forest to have a very large mining area. The artisanal coal mining also gave room to logging business in the area. Most of the trees that were cut down by the miners are transported to major cities and sold in timber markets. The open cast mining and cutting of trees in the area has exposed the area to landslides and soil erosion. These environmental problems have led to the collapse of the trees within the vicinity of the mines. Several species of grass and herbs were noticed in areas that are very far from the mining fields. However, biodiversity in the mining area were found to be very low or completely absent.

IX. Diversion and Surface Water Pollution

Rivers that run through the mining fields were diverted from their original courses to pave way for mining. Mine tailings and mine spoils were deposited on the fringes of these rivers and leachates from these tailings drains into these rivers. Huge quantities of over burden were left on the banks of these rivers. These overburden were transported down the river courses and these leads to sedimentation of the rivers, this could adversely affect the aquatic habitat in the area. Also, acid mine drainage was observed to have drained from the mining pits into the river channel. This will decrease the pH load of the rivers and it will affect human life as most of the villagers that lives downstream the river courses use this river for their domestic activities.

X. Strategies for Sustainable Mining

Mining is sustainable when it is conducted in a manner that it balances economic, environmental and social considerations (Lawrence 2005) In view of this, a concerted effort should be made by all stakeholders in the allocation of mineable lands, regularization and training of artisanal miners in order to make artisanal mining a tool for sustainable development.

Sections 90 and 91 of the Nigerian Minerals and Mining Act, 2007 clearly spelt out that extension services and training should be provided by Directorate of Mines to artisanal miners in Nigeria. The government should enforce and implement these regulations by training artisanal miners in the management of wastes and disposal of tailings from mining activities. Also, the newly established Solid Minerals Development Fund should assist the artisanal miners to acquire improved tools and equipment for coal mining and protection of the environment.

Donor agencies and International Organizations such as World Bank, Department for International Development (DFID), United Nations Industrial Development Organization (UNIDO) and United States Agency for International Development (USAID) should assist in the area of technological transfer and proffers solution to sustainable development in small scale mining sector of Nigeria's economy.

Artisanal miners should as a matter of policy immediately embark on reclamation of pits after mining is completed, so that mined out pits do not serve as death traps for livestock and breeding grounds for mosquitoes in the area.

Academic institutions in Nigeria should improve miner's livelihood by teaching sustainable mining techniques to mitigate the adverse impacts of coal mining on the environment. Also, they should be able to design appropriate technology in the mining of coal and finding solutions to the problems of achieving sustainable coal mining in Nigeria.

XI. Conclusion

Coal mining has significantly impacted the environment, the observed impacts in this community are deforestation of the landscape, decline in agricultural production, scarification of the landscape and incidence of acid mine drainage. These impacts could be reduced by applications of appropriate mining techniques. Accumulation of large mine spoils and overburden can be avoided by returning these wastes to the excavation when mining ceases. An eco-park project could be embarked upon by the locals and artisanal miners alongside with coal mining by planting economic

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trees such as palm trees and fruit bearing trees in the area. The newly established Artisanal Mining Directorate of the Ministry of Mines and Steel Development should teach Artisanal Miners sustainable mining techniques, this will mitigate the adverse impacts of mining on the environment and they should give them technical assistance by carrying prospection and allocation of specific areas for artisanal mining activities for the overall sustainable development of abundant coal deposits in Nigeria.



Fig. 1: An Artisanal Miner using a digger to excavate a Coal Seam

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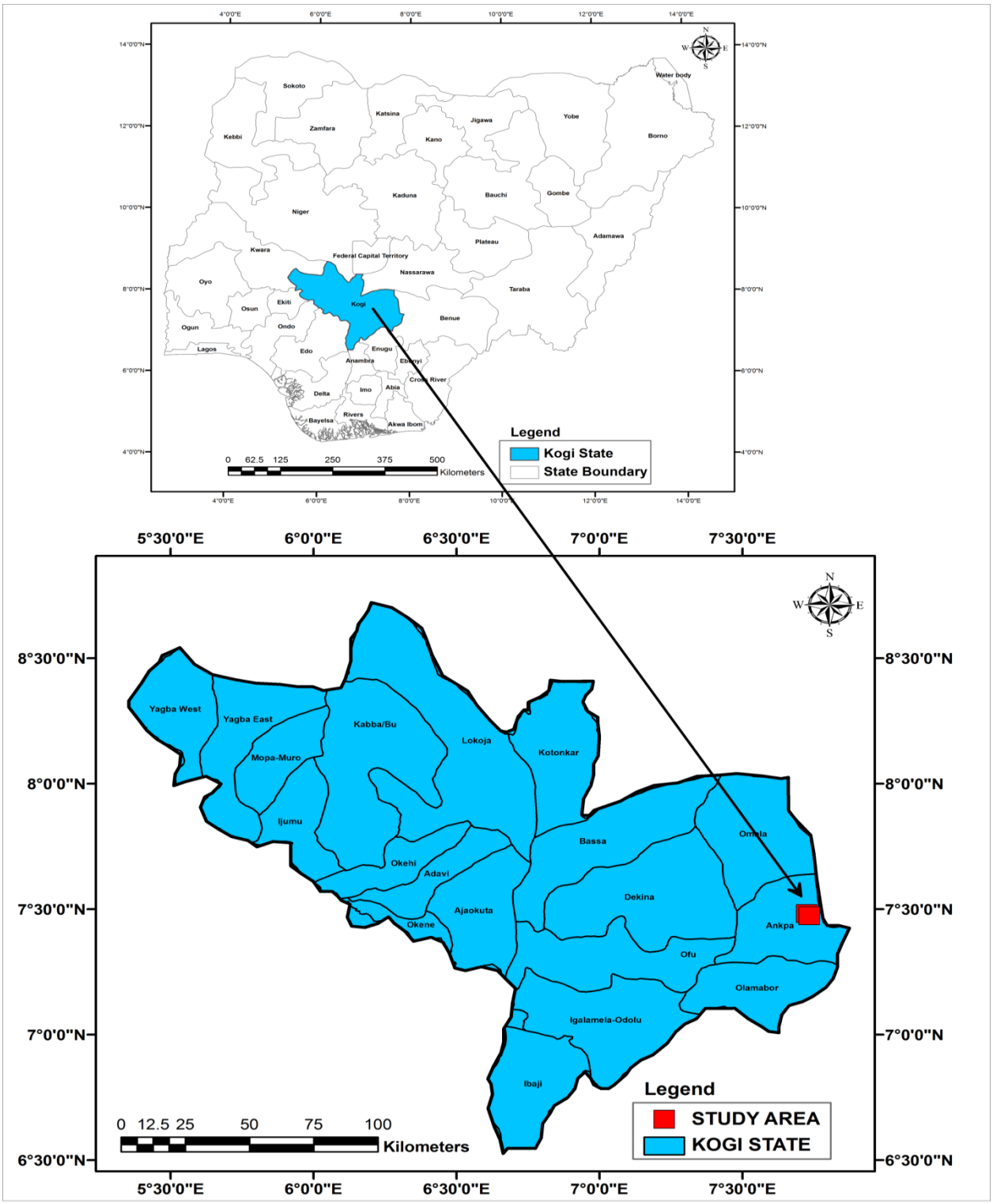


Fig. 2: Location Map of the Study Area

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Fig. 3: Stratigraphic Section of Odagbo Coal Mine

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Fig. 4: An Abandoned Open Cast Mine filled with acid mine drainage

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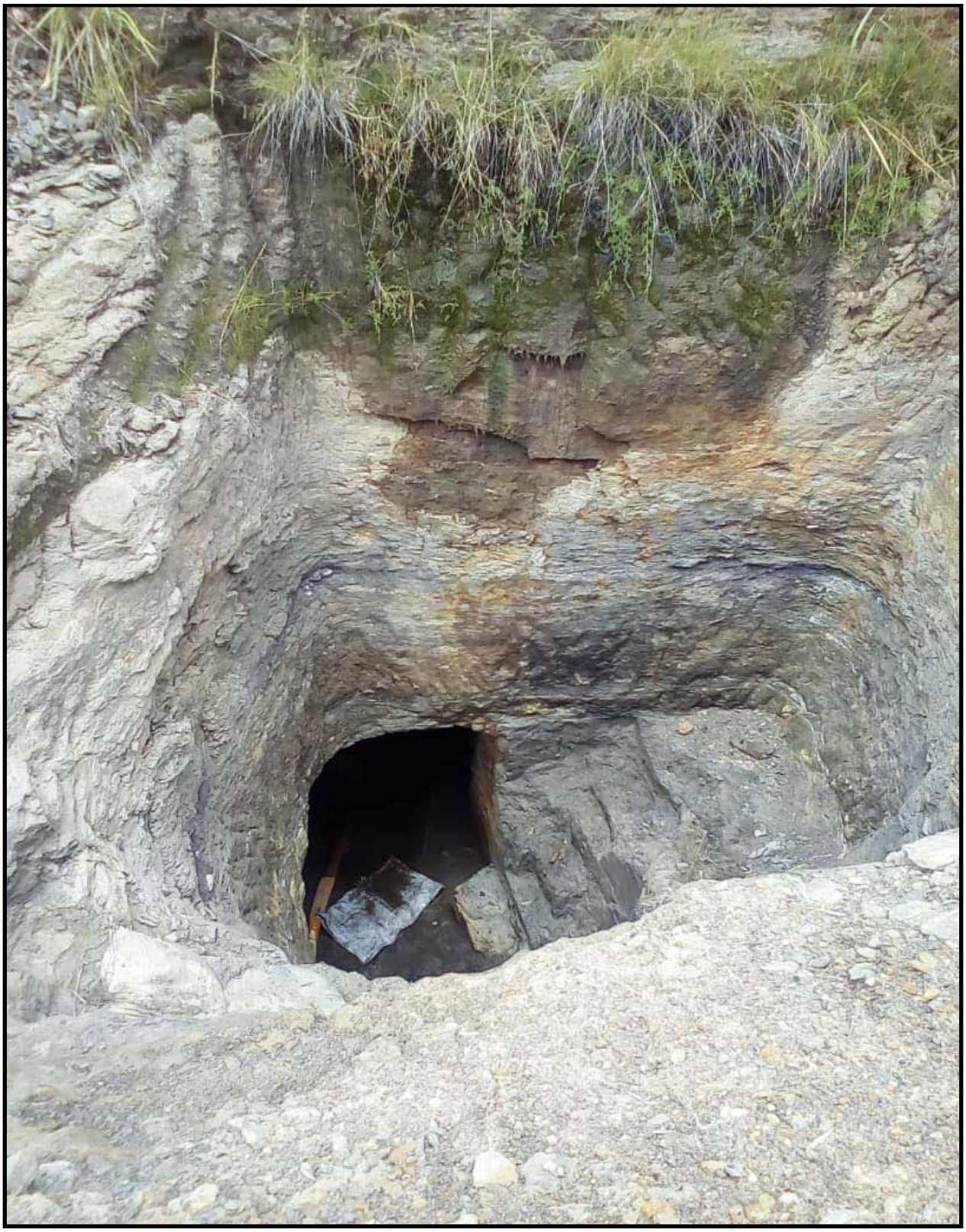


Fig. 5: A Lotto Mining Pit at Odagbo Coal Mine

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Fig. 6: Artisanal Miner carrying Coal from a Lotto Pit

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Fig. 7: Acid Mine Drainage seeping onto Agricultural Land

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Fig. 8: Deforestation of Odagbo Landscape

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