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Analyses of the Effects of Abandoned Mining Pond on Physio-chemical Characteristics of Water Quality

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ABSTRACT: *Tin mining has for decades flourished in Jos, Plateau State, Nigeria and left behind post mining environment scarred by numerous abandon mining ponds and dams surrounded by heaps of mine spoils (dumps/overburden) and a devastated landscape. Due to explosion of population settlement encroached into the area bringing some of the abandon mining pond to the middle of the settlement. This study analyses the effect of abandon mining pond to underground resulting from seepages. To achieve this, three sample of underground were collected from open well and borehole labeled 1, 2, and 3. Two samples from pond and stream was collected to serve as control sample Labeled A, and B. From the analyzed samples. A Manganese and Chromium value of 0.80-0.84 mg/l and 0.65mg/l which is higher than the NSDWQ highest desirable level of 0.2 mg/l was recorded from the mine ponds and stream water respectively. Two other samples, also collected from mine ponds showed chromium (VI) values of 0.1mg/l and 0.12mg/l respectively, which exceeded the maximum admissible concentration of 0.05 mg/l, while the well water samples concentration value falls within the NSDWQ MPL. The turbidity level recorded in all the collected water samples exceed the permissible level of <5NTU set by NSDWQ and the hardness level for the mine pond water is moderately hard, while for the well waters and stream water is soft. On the whole, the water samples did not show any significant pollution of public health concern. The well waters are presently used as source of water for drinking and other domestic purposes and continuous monitoring of the contaminant level in water sources should be carried out periodically to check for any possible high concentration levels beyond the NSDWQ MPL at a later time.*

KEYWORDS: *Tin, mining pond, water quality, Physio-chemical*

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I. INTRODUCTION

Mineral production in Nigeria stated in the early part of 20th Century. Tin and coal were the first set of minerals to be produce while oil came in the late 1950s. Revenue from oil export was high and this has increased oil exploration and exploitation (Adekeye, 1999) cited by (David *et., al.,* 2016). Nigeria has been described as a country that is endowed with abundant solid minerals resources. During the colonial era and the period after the country's independence in 1960, coal and tin ranked high as Nigeria's foreign exchange earners. Other minerals such as limestone, gold, marble, clay etc. were mined to lesser degree mainly for local consumption. A mineral resource is the more general term referring to the geologic endowment of minerals in the earth crust in such concentration that commercial extraction is either presently or potentially feasible (Gentry *et., al.,* 1984). It has also been defined as that as that quantity of minerals contained in deposit which is they were discovered could be produce under stated economic conditions and currently feasible technology or technology which will be feasible in the near future(Harris, 1984). Hence resources are functions of some original endowment, economics and technology. (Gentry *et al.,* 1984) went further to define "reserve" as subset of resource That is, that portion of resource that can be extracted at profit under present mineral price/production coast regime. It would have been discovered by optimum amount of exploration, given the specified economic and unconstrained market.

Tin mining activities which have caused considerable erosion damages to lands arising from active gully equal to 7,240km in length. Apart from tin mining, it is obvious that such human activities like construction

of highways, rail roads, pipelines, airport, industrial sites, sanitary landfills, dam reservoirs, timber harvesting, bush burning and grazing have potential and adverse effects on the environment (Abdulhamid *et., al.*, 2015). To ignore the environment, is to ignore our humanity and surrender its race that is entirely dependent on it. There is the need to manage the ecosystem responsibly so that those coming after will not have to complain, worry or curse their ancestors. Some of the biophysical effects of these human activities on the environment include:
(Interruptions and other changes in natural conditions that cause ponds fluctuations of groundwater level, alterations to stream flow characteristics, and soil Erosion and Siltation.

i. Changes in water turbidity, suspended load and increase in temperature.
ii. Increase in chemical pollutants such as heavy metals, salt and insecticides.
iii. Changes in vegetation caused by site clearing and alterations of the systems in the natural region.

Human activities on land varies, human being exploits land for the purpose of building a house; cultivation of crops; building of roads; grazing of livestock; extraction of solid and non-solid minerals (Twerefou, 2009). These activities may have positive or negative impact on the environment, depending on the nature, type of usage and the manner of exploitation. Mining exploitation is one of such human activities on land that has impact on the residential environment. The scale of operations involved in exploration, mining and processing of a mineral determines the intensity and extent of environmental degradation. For instance, (Aigbedion *et., al.*, 2007) opined that large – scale mining of tin and associated minerals in the Jos, Plateau has resulted in a high degree of degradation of arable land, vegetation and landscape, as well as other environmental problems. Though, these activities are usually not carried out within or around the built – up residential environment but as development and urbanization sets in with passage of time, the areas which hitherto were used for agricultural purposes, mining exploitation and quarrying are gradually enveloped into residential/commercial built –up areas. The desire of miners either illegal or legal is to improve their financial base; hence, the study by (Windle *et., al.*, 2004) presents an idle situation of mining exploitation done within the ambit of the law where mining industries are expected by law to pay royalties to the government which serves as source of revenue to the government. Illegal mining breeds a situation where the income realized remain with the miners and their collaborating companies with little or nothing for the government. The study of (Joseph, 2013) found that illegal mining thrives in Lusaka in which case, the problem of environmental landscape and land degradation ensued. Aigbedion *et al.* (2007) found that mining exploitation contributed to the pollution of air, land and water. It also cause damages to the vegetation, ecological disturbance, degradation of natural landscape, geological hazards, socio-economic problems and radiation hazards arising from by – products of tin etc. More so, it is more terrible if an area used for mining previously is left un-reclaimed. The consequence is more on residents as (Joseph, 2013) found the presence of craters and open pits left after quarrying and mining as great danger to miners and residents of the area.

Mining activities had been a very old practice in many states of Nigeria which include Enugu, Kogi, Zamfara and Plateau among others where different mineral resources had been mined. According to (Ali *et., al.*, 2006) "Mining is the extraction of valuable minerals or other geological materials from the earth's crust, usually from an ore body". While mining activities is also defined by (Osumo, 2001) as "any forms of operations that deals with the excavation of earth's top most soil surface for mineral resources such as coal, tin, diamond, gold, uranium and columbite for economic and industrial development both for the local and export market".

Tin mining flourished in Jos, Plateau state from the beginning of twentieth (20^{th}) century to the early 1980's (Schoeneick, 1998). and left behind a post-mining environment scarred by numerous mine ponds and dams surrounded by heap of mine spoils (i. e. dumps and overburden), leachates and a devastated landscape; the occurrence of these minerals brought about intense mining activities in the state at the beginning of the 20^{th} century and in fact, the early growth and development of the Jos city was closely related to commercial tin mining activities on the Plateau (Schoeneick, 1998).

The quality and changes in factors associated to water have greatly being affected over the years due to tin mining operations in in the area, this can be seen through physical appearance of water reserves in surface and groundwater supply in many mined areas in the Jos Plateau. To extract minerals for use by industries, the earth's crust must be disturbed. On this crust are living things whose life pattern are disturbed when mining is undertaken resulting in loss of biodiversity. Mines both active and inactive are potential water contamination source. The mining excavations create direct connection between groundwater and the surface water; also oxidation of exposed minerals can leads to acid mine drainage - (Osumo, 2001). Leaching of heavy metals and trace element are also a threat, drainage of materials to abandoned mines can act as groundwater contamination source for years after mining operations.

In Jos, Plateau state, mining of tin and columbite had been carried out for many decades now. Many physical conditions of the mined area are visual in Jos, Plateau state. The exploitation of tin ore known to be associated with the alluvial sediments has left behind numerous ponds and prospecting pits as well as heap of mine waste in the course of mining. Since the minerals exploited are commonly associated with variety of others which are not needed, they were simply thrown away or heaped within the tin shed as tailings; among the wastes are minerals like acid mines, manganese, sulphates, nitrates, lead, silica, chlorides, chromates, silica sand and iron. Leachates from mine waste can pollute the surface water and groundwater, while rain could also wash off heavy metals in mine tailings which as surface run-off could pollute the water, leading to health impairment when consumed. This paper analyzes the effect of mining activities on physico-chemical properties of ground-water quality around abandone mining area in Jos Plateau state Nigeria.

Groundwater quality can also be impaired by mining if the outflow of acidic water usually from abandoned mines penetrates or leaches into the underground water table. To extract minerals for use by industries, the earth's crust must be disturbed Howard,(Ransom *et., al.*, 2003). On this crust are living things whose life patterns are disturbed when mining is undertaken, resulting in a loss of biodiversity. Thus, mines both active and inactive are potential water contamination source (Davis *et., al.,* 1966). The mining excavations create direct connection between groundwater and the land surfaces. Oxidation of exposed minerals can lead to "*acid mine drainage*". Leaching of heavy metals is also a threat and drainage of materials from abandoned mines can act as groundwater contamination source for years after mining operations have stopped (Freeze *et., al.*, 1979). The quality of these water sources and indeed that of the underground water with which they may possibly interact are not known.

Leachates from mine waste can pollute the water if the mine ponds, which in turn can infiltrate the ground and pollute the water if it gets at it (Freeman *et., al.*, 1995) while the rains could also wash off heavy metals and radioactive materials in mine tailings, which as surface run-off could pollute the water. It is also possible that the exposed heaps of mine waste and rock formation as a result of mining activities will be subjected to weathering and leaching of some of its element which can contaminate the surface water (mine ponds) and also groundwater in wells and boreholes around the study area. Aigbedion *et al.* (2007) buttress the facts that mining activities in the oil producing areas of Niger Delta cause oil spillages of differing intensity resulting from burst pipelines, tanks, tankers, drilling operations e.t.c is a common phenomenon that causes water pollution with grave consequences of both aquatic and terrestrial life. Also, groundwater pollution has made it impossible for the indigenes of the affected Niger Delta areas to obtain potable water; well water is almost invariably covered with a thin oil film.

II. METHODOLOGY

The Study Area

Jos Plateau state is located at the north central part of Nigeria. The city has a population of about 900,000 residents based on the 2006 census. It is the administrative capital of Plateau state. The city is located on the Jos Plateau at an elevation of about 1,238meters above sea level. During British colonial rule, Jos was an important center for tin mining. Ray filed (The study area) lies between longitude 8^0 50' and 8^0 53' East and Latitude 9^0 45' and 9^0 54' North as indicated in figure 1 below. It is located within the Jos metropolis which is the Capital of Plateau state. Two of the six major mining areas is located in Rayfiled and that is Jos-Bukuru filed and Ray field areas. Tin mining in Jos Plateau state span for more than 80 year. Haruna (2012) reported that the total land area affected by the mining activities is estimated to be 325km^2 out of the 8,689km^2 covered by Jos.

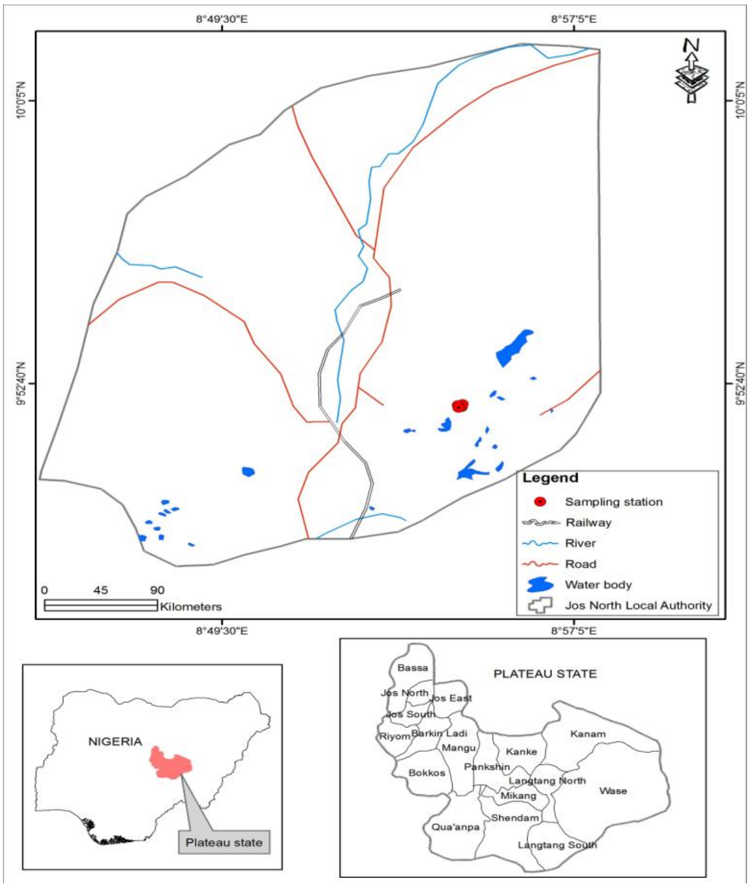

Fig. 1: Map of the Study area and Sample location

III. METHODS

This research encompasses the analysis of the effect of mining activities on the physical and chemical characteristics of water quality in Rayfield settlement of Gold and Base mining quarters. This study intends to assess the quality of the well water been used in this entire area and correlate the findings and information obtained with known established national and international standards for water quality.

Sampling Techniques

The procedure used for this work was systematic sampling of mine pond water, surface water and well water in the study area. All samples were collected with care and stored in sterilized plastic bottles. Prior to sampling, all the sampling containers were washed and rinsed thoroughly to be taken for analysis. The water samples were taken from mine ponds at two point positions *(Plate 1 & 2)* with a distance of 30meters (The mine pond had been excavated of overburden at a depth of about 30-35feet). Surface water sample is collected from the study area at a distance of 110metres from the mine pond point position *(Plate 3),* while underground water sources from well water are collected from two point positions at a distance of 140metres *(Plate 4).* The sample where collected three times at two interval between May and June and the mean of the result was calculated and tabulated in *table 2* below The shortest distance between the well and mine pond is measured to be 40metres. All distance, location and position of samples were determined using a mobile hand-held Global Positioning Systems (GPS).

It is an established fact that one of the most important aspects of sampling process is the care and preservation of the samples prior to analysis; it is thus ensured that sampling techniques used in this project work is selected to prevent changes in water samples between time of collections and analysis. (Aguigwo, 1997) States that if samples of water for analysis have undergone biochemical and physico-chemical changes in the course of storage or transportation, it is of limited value and the changes are time dependent.

A total of five (5) water samples were collected in the study area, two (2) of which are mine pond water samples, while two (2) are groundwater samples (from well water) and one (1) water sample from surface source (stream water). Table 1 shows geo-location of each sample and a brief description of the sampling point.

Table 1: Description and Coordinate Location of Sample Collection Points

Sample	Location	Coordinate	Well Depth	Water Type	Brief Description/Relations between samples
A	Rayfield	9°52´03.25´´N 8°54´39.73´´E	NA	Mine pond	Abandoned mine pond with large surface area.
B	Rayfield	9°52´04.09´´N 8°54´39.94´´E	NA	Mine pond	An abandoned mine pond with large surface area at a distance of 30m to Sample A point position.
C	Rayfield	9°52´07.75´´N 8°54´41.06´´E	NA	Surface water (Stream water)	A small stream flowing in the study area at distance of 110m to Sample B location.
D	Mining quarters, Rayfield.	9°52´06.04´´N 8°54´35.13´´E	20ft	Well water	An old apartment containing 50 blocks of houses with two open hands dug well without concrete lining relatively located besides the mine ponds. The Sample D is at a distance of 40m to the mine pond.
E	Mining quarters, Rayfield.	9°52´01.86´´N 8°54´35.77´´E	24ft	Well water	An old apartment containing 50 blocks of houses relatively located beside the mine ponds. This open hand dug well is without concrete lining and is mostly used for drinking. The Sample E is at a distance of 140m to Sample D.

Water samples collected from the study area were drawn as a representative of the whole and preserved in a plastic container. For proper identification of the Samples, each sample container was identified with a label carrying the sample identification number and location. The samples were analyzed in the laboratory for the physic-chemical parameters index. Laboratory tests were made for conductivity and temperature using E-sticks EC500 conductivity meter and Orion model 520pH meter was used respectively. The temperature of the water samples was determined by using mercury in glass thermometer while turbidity was measured using Secchi's disk turbidity meter. In order to determine total hardness, residual chlorine content and chloride content, fluoride, sulphate, nitrate and manganese concentrations; the titrimetric analysis was used, while the concentrations of iron, chromium, arsenic, lead, copper and zinc were determined using a buck scientific model VGP-210 Atomic Absorption Spectrophotometer (AAS) equipped with a digital read out system.

Table 2: Summary of the Mean Result of physico-chemical composition of collected water samples of the study area

PARAMETERS	UNIT	**Collected Water Samples**					WHO
		A	B	C	D	E	GDWQ/MPL
Iron (Fe^{2+})	mg/l	0.38	0.4	0.31	0.28	0.20	0.3
Copper (Cu^{2+})	mg/l	0.05	0.06	ND	ND	ND	1.5-2.0
Zinc (Zn^{2+})	mg/l	0.07	0.08	0.053	0.03	0.02	3.0
Manganese (Mn^{2+})	mg/l	0.80	0.84	0.65	0.1	0.09	0.2
Lead (Pb^{+})	mg/l	ND	ND	ND	ND	ND	ND
Chromium VI (Cr^{6+})	mg/l	0.1	0.12	0.025	0.1	0.00	0.05
Turbidity	NTU	180	200	70	25.33	22.3	<5
Total Hardness	mg/l	101.15	101.20	61.25	52.83	40.5	150
Chlorides (Cl^{-})	mg/l	81.15	77.65	75.12	73.34	71.61	250
Nitrates (NO_3^{-})	mg/l	2.1	2.3	6.4	20	17	50
Sulphate (SO_4^{2+})	mg/l	5.063	10.15	12.33	4.23	3.23	250-500
Temperature	°C	22.5	23	21	26	24	Ambient
pH		7.25	7.30	6.97	7.12	6.9	6.5-8.5
Conductivity	µs/cm	800	970	340	350	400	1000

(Source: Laboratory Results)

°C = degree celsius
mg/l = milligrams per litre
µs/cm = micro siemens per centimeter
NTU = nephelometric turbidity meter
MPL = maximum permissible/permitted level
ND = not detected
WHO GDWQ= World Health Organization Guideline for Water Quality (WHO, 2004)

From the above table 2, the laboratory tests shows that result of the five (5)collected water samples for 16 parameters shows only five parameters exceeding the maximum permissible limit (MPL) in three (3) water samples while the remaining eleven (11) parameters falls within the maximum threshold limit of the NSDWQ.

IV. DISCUSSION

The five (5) water samples from mine ponds, wells and stream were collected three time at two weeks interval and analyzed to evaluate for possible pollution arising from leachates that can affect water quality in the study area.

1) A manganese value of 0.80-0.84 mg/l and 0.65mg/l which is higher than the NSDWQ highest desirable level of 0.2 mg/l was recorded from the mine ponds and stream water respectively,
2) Two other samples, also collected from mine ponds showed chromium (VI) values of 0.1mg/l and 0.12mg/l respectively, which exceed the maximum admissible concentration of 0.05 mg/l, while the well water samples concentration value falls within the NSDWQ MPL.
3) The iron value of 0.38-0.4 mg/l and 0.31mg/l which is higher than maximum permissible level of 0.3mg/l was recorded from the mine ponds and stream water respectively, while the groundwater (well water) values falls within the NSDWQ.
4) The turbidity level recorded in all the collected water samples exceed the permissible level of <5NTU set by NSDWQ and the hardness level for the mine pond water is moderately hard, while for the well waters and stream water is soft.
5) But all other parameters analyzed in the water samples falls within the NSDWQ Maximum permissible level (MPL).

V. CONCLUSION

Although traces of some metals were found in the analysis of the sample, further research should be conducted that will cover taking samples of all year (January to December) at least monthly. This will give a vivid picture when contamination is high as it is it only gives indication of presence of contamination arising from the mining activities. On the whole, the water samples show significant pollution of public health concern. It can be observed from the results of water analysis that the tin mining activities carried out in the study area may have significantly affect its quality due bioaccumulation resulting from long use of the water for domestic consumption.

The paper recommended that the local communities should be inform on the possible effect of mining activities on water quality that can cause health impairment. Detailed investigation should be carry on what the local communities use the water from the mining pond for thereby treating that fund to be used by the communities.

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Appendix

Plate 1: One of the Open pond resulting from abandoned pond

Plate 2: Open well close to an old apartment

Plate 3: A Stream

Plate 4: A Stream

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