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Environmental Impact of Granite Mining In Tattara Area, North Central Nigeria

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Abstract: *Environmental impact of granite mining in Tattara area, North Central Nigeria was investigated through the analysis of geologic material which includes rocks, soil, water and physical examination of land degradation with the aim of accessing its impact on the environment and public health. These samples were subjected to petrographic and geochemical analysis to determine the concentration of heavy metals in the samples using Atomic Absorption Spectroscopy (AAS). The water from the reservoir and the mine showed concentration of lead (4.48mg/l) and cadmium (1.2mg/l) to be higher than the WHO 2011 and NIS 2007standard guideline for drinking water (which is 0.01mg/l and 0.03mg/l respectively). The result for soil analysis showed that the soil samples from the river and the village were all below DPR, 2002 standard for soil except for cadmium, while soil sample from the reservoir and the mining site showed slightly high concentration of Zinc and cadmium with mean values 47.175mg/kg and 1.2 mg/l respectively. The petrography reveals high percentage of quartz, feldspar and minor accessory and opaque minerals as the basic rock forming and confirms the late stage mineralization of the magmatic fluid which characterized the coarse grain size of the rock. It is recommended that water to use for drinking in the area be treated and regularly monitored to check the concentration of these metals. Health and safety measures should strictly be complied with to maintain an excellent health status of both staff and the inhabitants of the area.*

Keywords: *Granite, Mining, Heavy metals, Microscopic analysis, Water Quality, Soil Quality, Tattara Area*.

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I. Introduction

Nasarawa State is blessed with abundant mineral deposit and its continuous extraction/mining has resulted in leaving degraded lands in the form of Pounds causing loss of lives and properties, and gullies that exposed the communities to erosion menace. Land degradation and chemical poisoning due to mining has been reported over time (Ojo and Adeyemi, 2003, Aigbedion and Iyayi 2007, Adegboye, 2012). The chemical poisoning affects the soil, plants and animal which is due to dispersion of heavy metals and trace metals released into the environment (which has negative impact on water, soil and plants). Mining is defined as the process of extracting valuable minerals or other geological materials from the earth, usually either via open cast or underground method of mining. Mining of rocks (commonly referred to as dimensions stones, slabs, etc.) and metals has been a human activity since pre-historical times. Modern mining process involves prospecting for ore bodies, analysis of the profit potential of the proposed mine, extraction of the desired materials and reclamation of the land after the mine is has been decommission.

Surface or open cast mining is a type mining where by the extraction is achieved by removing the overburden layers of rock and/or top soil. The history of surface or open cast mining is essentially that of mining coal, copper, and iron ores, and the nonmetallic minerals-clays, gypsum, phosphate rock, sand and gravel Marjoribanks, .R. (2010). Changing public policy is exerting strong pressure favoring a reduction or elimination of surface mining; and, since the economic differences between surface and underground mining for the remaining mineral resources is narrowing, this increasing force may become the deciding factor in determining the future trend in surface verse underground mining.

Underground mining consists of digging tunnels or shafts into the earth to reach buried ore deposits. Ore and waste rock are brought to the surface through shaft and tunnels.

Mining operations usually create a negative environmental impact, both during the mining activity and after the mine has closed. Work safety has long been a concern as well, and modern practices have significantly improved safety in mines. Ecosystem and biodiversity can be adversely affected by uncontrolled release of toxic elements and contaminants from mining activities which in most cases can result to irreversible destruction of ecosystem EEb (2000).

Environmental issues resulting from mining includes erosion, formation of sinkholes, loss of biodiversity and contamination of soil, ground water and surface water by chemicals from mining processes. Erosion exposes hillsides, mine dumps, tailings dams and resultant siltation of drainages, creeks and rivers. Mining activities in Nigeria has resulted to soil degradation, dispersion of heavy metals and noise pollution (Oelofse et al., 2008; Adegboye 2012; Oladipo et al., 2013).

Environmental impact assessment was carried out in accordance with the national policy act 2007.Tattara is endowed with granitic rocks. Granite is an igneous rock comprising crystals of quartz, feldspar, mica and/or hornblende or pyroxene. Quartz and feldspar are the dominant minerals in granite, and together make up 90% of the rock. Granite is one of the most abundant, and most widely known, rocks on Earth Myers (1997).Solid waste left from mining of granite can disrupt the soil and water quality because of its chemical composition Gabriela et al.,(2015) this research work was carried out to determine the environmental impact of mining of granite at Tattara, Karu Local Government Nasarawa State in accordance with national environmental policy act 2007. The rock type in the area was mapped and samples Soil, rock and water collected. The water samples were preserved on the site using nitric acid. Rocks are known to compose of heavy and trace metals as part of the rock forming minerals Gribbble(1988) the abundance of these trace and heavy metals in soil and water were determined to ascertain the impact of the mining activity on the health of the individual and to the environment.

II. Study Area

The study area Tattara falls within Latitude 9°13’ 6.504” N and Longitude 7° 59’ 50.7”E, in north central Nigeria and politically is part of Nasarawa State as shown in Fig 1. The area is predominantly covered by granitic intrusion. The inhabitants’ main occupation is farming. The soil is mostly sandy soil. A stream called Maigizo runs through the granitic rock cutting across the village defining the drainage pattern of the area. The stream serves as the main source of water to the village for their daily domestic usage.

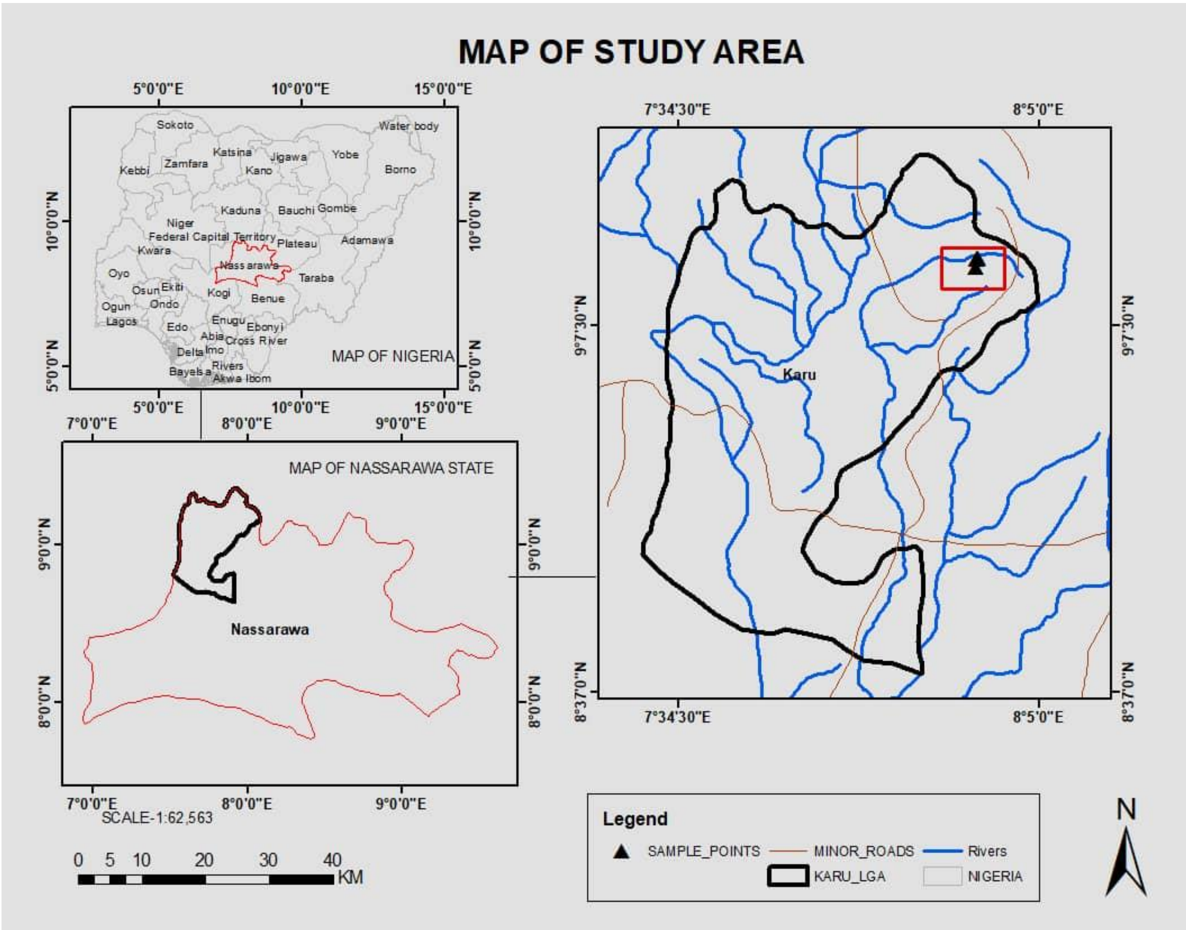

Figure 1 Map of study area

The granitic intrusion forms part of the Mesozoic Younger Granite ring complexes of Nigeria which is believed to form part of a wider province of alkaline anorogenic magmatism Obaje (2009). The extension of the granitic intrusion at the study area is also seen at Afu, Madaand Keffi, where they are associated with other rock types including migmatites, schist and phylittes Ahmed et al., (2008). The granite intrusion of the study area was formed along other rock types of Nigeria younger granite during the Mesozoic age according to (Wright et al.,1985) a mass of granite rises high into the crust (intruding the basement gneiss, migmatites and granites) supplied along ring fracture below (Figure XX). Emplacement is accompanied by doming or swelling of the overlying crust and initial subsidence of the underlying crustal block.

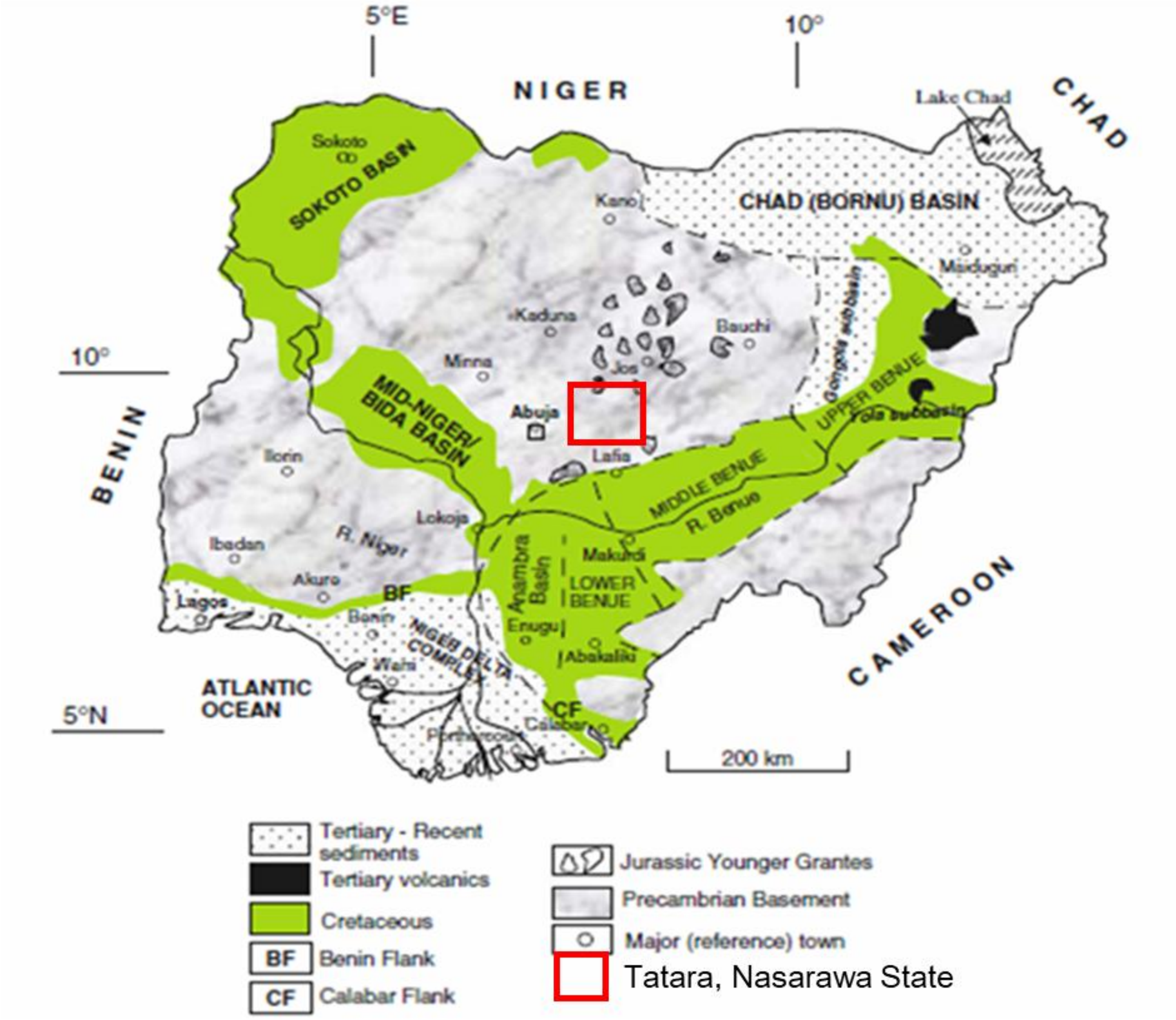

Figure 2: Geological Map of Nigeria (adopted from Obaje, 2009)

The climate of the study is ascribed to that of the state, which is usually referred to as a local steppe climate (NIMET, 2016). There is little rainfall throughout the year. According Kotten et al. (2006), this climate is classified as BSh. The average annual temperature is 28.4°C. About 839mm of precipitation falls annually. The least amount of rainfall occurs in January. The average in month is 226m and also describes as most precipitation month.

The area falls within the Guinea Forest Savanna mosaic zone of the West African Sub-region (Ibeneme et al., 2018). However, patches of rain forest occurring in few areas, especially in rugged terrain to the southern parts of the study area.

III. Methodology

Geological field mapping, sampling and geochemical analyses were undertaken for course of this research work. The field work included mapping out of the rock type and collection of samples (rock, soil and water sample). The water samples were preserved on the site using 1:1 drop of Nitric Acid. The geochemical analysis was carried out at Environmental and Toxicology Laboratory Federal University of Petroleum Resources, Effurun (FUPRE). The heavy metals which included cobalt, zinc, cadmium, cooper and were tested using the Atomic Absorption Technique.

Method of Water Sample Collection and Analysis

The sampling and preservation were carried out as prescribed by APHA (1995) methods. The coordinates of each sampling point were taken (Table 1) and recorded. The area was mapped, and the method of mining noted. Five Rock Samples were collected from the field which is being mined. A hand soil auger (Nickel-plated carbon steel, 3’’ diameter) was used to collect soil sample at the depth of 0 to 15cm which was oven dried at the laboratory before the analysis. The auger was cleaned with de-ionized water after each sampling point. Soil samples were collected, two samples from the mining site, two samples from the Maigizo river, two samples from the reservoir and one sample within the village using a polythene bag making it total of seven samples. Water samples were collected and preserved on the site using 1:1 drop of concentrated Nitric Acid to prevent the growth of micro-organism. A fresh water pre-cleaned polythene plastic kegs was used to collect water samples. The containers were rinsed out at the sampling site with the water to be collected. Water samples were collected from the river, the reservoir, the borehole and well within the village making seven water samples which was tested for abundance of heavy metals and trace metals. In all totals of 18 samples were collected.

TABLE 1: Location of water samples from Tatara Area, North Central Nigeria

S/N	SAMPLE ID	DESCRIPTION OF LOCATION	LONGITUDE	LATITUDE
1	TNW1	MINING QUARTERS	N9◦13’6.504’’	E7◦59’50.7’’
2	TNW2	RESERVOIR	N9◦12’22.74’’	E7◦59’38.244’’
3	TNW3	RESERVOIR	N9◦13’9.714’’	E7◦59’44.55’’
4	TNW4	RIVER	N9◦13’5.08	E7◦59’43.536’’
5	TNW5	RIVER	N9◦13’7.605’’	E7◦59’53.71’’
6	TNW6	WELL	N9◦13’6.517’’	E7◦59’43.78’’

TABLE 2: Location of soil samples from Tatara Area, North Central Nigeria

S/N	SAMPLE ID	DESCRIPTION OF LOCATION	LONGITUDE	LATITUDE
1	TNS1	MINING SITE	N9◦13’6.504’’	E7◦59’50.7’’
2	TNS2	RESERVOIR SITE	N9◦12’22.74’’	E7◦59’38.244’’
3	TNS3	RESERVOIR	N9◦13’9.714’’	E7◦59’44.55’’
4	TNS4	RIVER	N9◦13’5.08	E7◦59’43.536’’
5	TNS5	RIVER	N9◦13’7.605’’	E7◦59’53.71’’
6	TNS6	TATARA	N9◦13’6.517’’	E7◦59’43.78’’
7	TNS7	RESERVOIR SITE	N9◦13’5.24’’N	E7◦59’42.724’’

Water and Soil Samples’ Geochemical Analyses

Determination of abundance of heavy metals for liquid and soil

Procedure

250 ml sample was measure into a beaker and 5ml nitric acid (HNO_3) was added and heated (in hot plate) inside a fume cupboard to about 15-20ml and allowed to cooled, it was filtered through a w2 fitter paper into a 50ml flask and made up with distilled water to 50ml mark.

Dilution factor = 250/50 =5

This means whatever value was given by the AAS will be multiplied by 5 to arrive to accurate concentration of metal present in the sample.

Microscopic Analysis

Microscopic analysis of rocks to elucidate the nature and type of the rock forming minerals was achieved using SMART-POL Polarizing Microscope. The process included identification of rocks, minerals and ores where possible using its optical properties such as cleavage, twining, and reflectance as seen under both plane and cross polarized light sources.

IV. Results and Discussion

Physical examination of the site showed physical degradation of the soil and disruption of the biodiversity by the action of the bulldozer during clearing of the overburden and undesired part of the rock. Because of the large area of land disturbed by mining operations and the large quantities of earth materials, exposed at sites, erosion can be a major concern at the mining sites. Consequently, erosion control must be considered from the beginning of operations through completion of reclamation Mwangi (2014). The Forest and vegetation around the mining area and the rock out crop could have served as habitat for wild life, but due to persistent noise as a result of either power generating plants in the mines or the rock cutting machine, all the wild animals around the area had relocated to new areas which makes the wild animal to feel safe.

Microscopy

Result for microscopic analysis for thin section slides as prepared from rock samples are presented in form of photomicrographs plates (1-8) as seen under both Plane and Cross Polarized Lights (PPL & XPL) respectively.

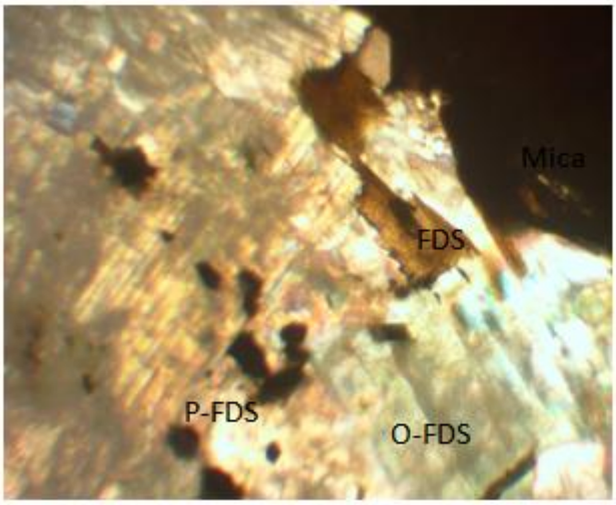

Plate1 Photo-micrograph of TRK 1 from Tattara area, North Central Nigeria under XPL Magnification X40 (QTZ=Quartz, P-FDS=Plagioclase Feldspar, FDs=Orthoclase Feldspar)

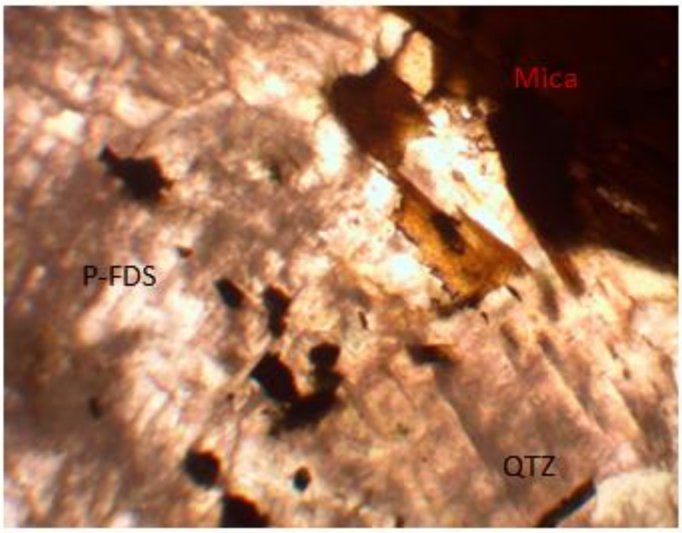

Plate 2: Photo-micrograph of TRK1 from Tattara area, North Central Nigeria under PPL Magnification X40 (QTZ=Quartz, P-FDS=Plagioclase Feldspar, FDs=Orthoclase Feldspar)

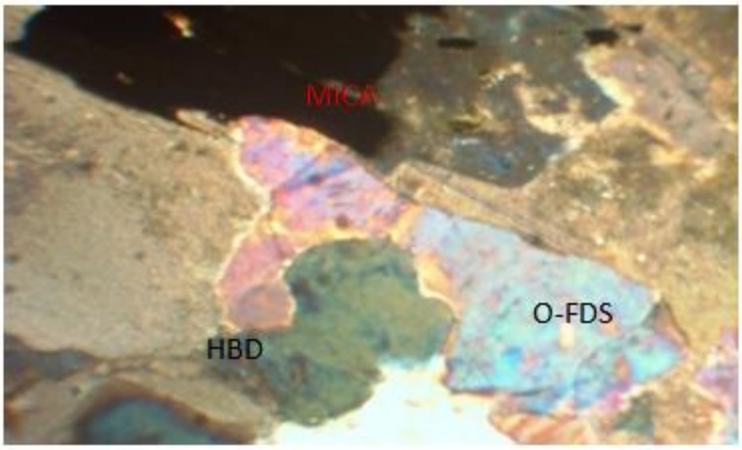

Plate 3: Photo-micrograph of TRK 2 from Tattara area, North Central Nigeria underXXL Magnification X40 (QTZ=Quartz, P-FDS=Plagioclase Feldspar, O-FD=Orthoclase Feldspar, HBD=hornblende)

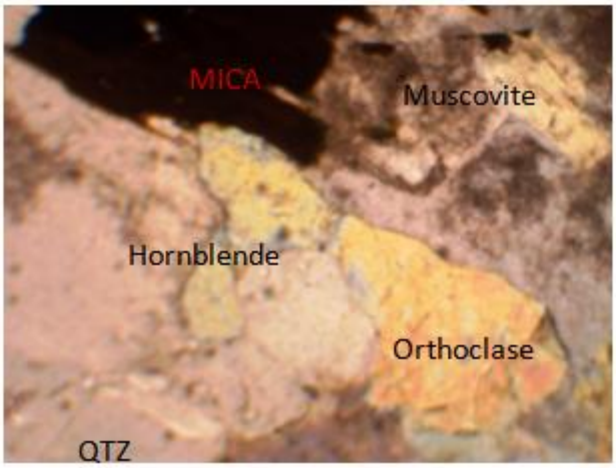

Plate 4: Photo-micrograph of TRK 2 from Tattara area, North Central Nigeria under PPL Magnification X40 (QTZ=Quartz, P-FDS=Plagioclase Feldspar, O-FD=Orthoclase Feldspar, HBD=hornblende)

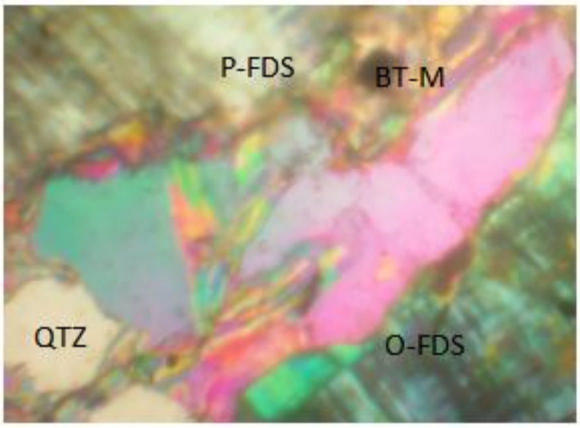

Plate 5: Photo-micrograph of TRK 3 from Tattara area, North Central Nigeria under XPL Magnification X40 (QTZ=Quartz, P-FDS=Plagioclase Feldspar, O-FD=Orthoclase Feldspar, HBD=hornblende, BT-M=Biotite Mica).

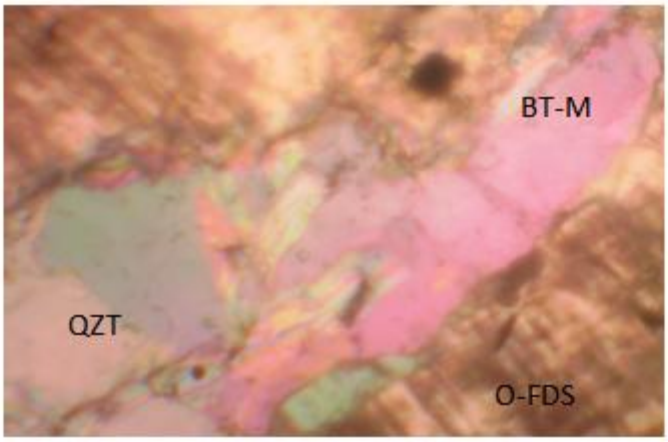

Plate 6: Photo-micrograph of TRK 3 from Tattara area, North Central Nigeria under PPL Magnification X40(QTZ=Quartz, P-FDS=Plagioclase Feldspar, O-FD=Orthoclase Feldspar, HBD=hornblende, BT-M=Biotite Mica).

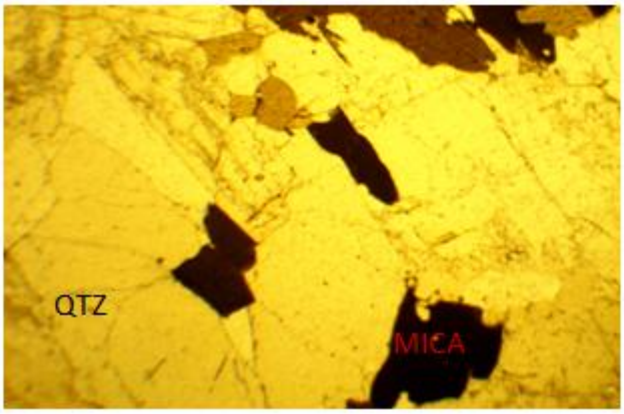

Plate 7: Photo-micrograph of from Tattara area, Nasarawa State under PPL 4 Magnification X40(QTZ=Quartz, P-FDS=Plagioclase Feldspar, O-FD=Orthoclase Feldspar, HBD=hornblende, BT-M=Biotite Mica

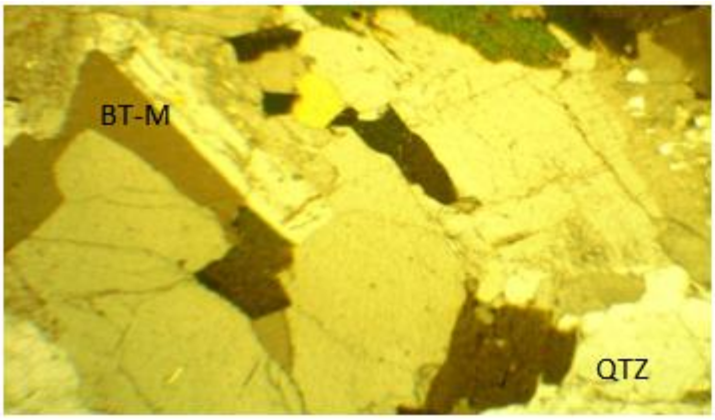

Plate 8: Photo-micrograph of TRK 4 from Tattara area, North Central Nigeria under PPL Magnification X40 (QTZ=Quartz, P-FDS=Plagioclase Feldspar, O-FD=Orthoclase Feldspar, HBD=hornblende, BT-M=Biotite Mica).

The major rock forming minerals observed are captured in the photomicrographs, which were: Quartz, Feldspars and at times opaque minerals.

Feldspar identified within the slide includes both plagioclase and orthoclase feldspar. Orthoclase feldspar was identified as colourless, exhibiting blocky habit and cleavages, grains appear cloudy due to alteration with inclined extintiction exhibiting penetration twining. Orthoclase feldspar was distinguished from the plagioclase because of the absence of striations and pink while the plagioclase feldspar was colourless with presence of Carlsbad twining. The Quartz crystals appear colourless under the thin section with undulatory extinction and uniaxial character. Hornblende was identified as xenomorphic crystals with presence of double cleavage and was strongly green. Biotite constitutes a very small proportion of the major mineral. It was identified by its light brown and pleochroic characteristics from light brown to dark brown under PPL with its crystals occurring as tiny flakes.

Modal composition of the rock based on visual estimation was 40% quartz and 40% feldspar with 5% biotite and 5% muscovite while accessory minerals like zircon make up the remaining percentage. To classify the igneous rocks, the Q-A-P ternary diagram was adopted using the modal composition of the minerals (Quartz, Alkali-feldspar and Plagioclase-Feldspar) as shown in Fig 2.

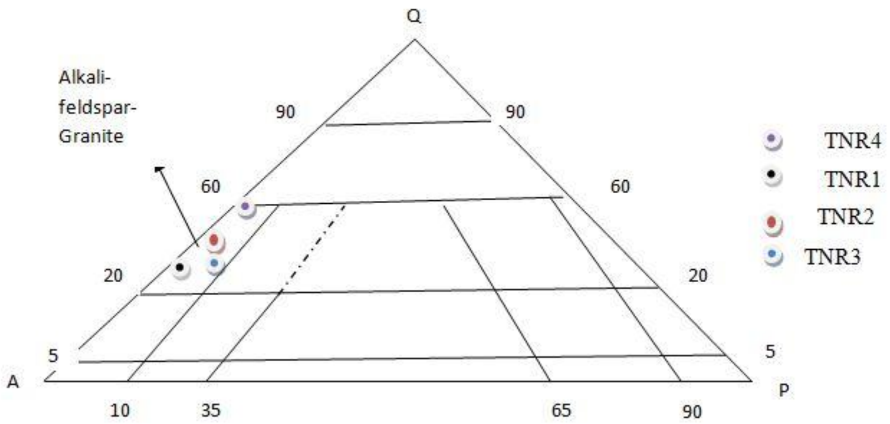

Figure 2: Classification of the rock type using ternary diagram according to the IUGS Systematic classification of igneous rock.

The middle 3 Plutonic rock types (Granites, Granodiorite and tonalite) are together called Granitoids Streckeisen (1991). The samples are plotted on the ternary diagram (Figure 11) fall under alkali-feldspar granite. The mineral composition of the rock as observed in the plate (1-8) above comprises of minerals formed in the later crystallization stage (majorly Quartz and Feldspar) as observed in Bowen's crystallization series. If the early formed minerals are not allowed to separate from melt, Olivine will react with the melt to form pyroxenes and pyroxene if not removed will react again with the melt to form hornblende and it continues like that as the temperature reduces until no silicate mineral is left again to react Plummer et al. (2014). The minerals composition of the late magmatic stage is characterized of low density and are known as felsic. Though no possible mineralization is observed within the outcrop, small traces of trace elements are bound to occur along with the rock forming minerals which forms the basis of our argument in this case and possible source of heavy metal dispersion (Lead and Zinc) in the reservoir and soil.

Results of Physical/Chemical parameters of soil and water sample

Table 3: Heavy metals concentration from soil around Tattara Granite Mine, North central Nigeria.

SOIL SAMPLES											
PARAMETERS	UNIT	TNS1	TNS2	TNS3	TNS4	TNS5	TNS6	TNS7	Average	SD	VARIANCE
PH		6.75	7.50	6.35	7.30	6.33	6.90	6.27	6.77	0.49	0.24
Electrical Conductivity	s/m	11	8.00	7.00	11	10	22	15	12	5.10	26
Zinc(Zn)	mg/kg	36.15	9.93	30.9	11.03	18.38	36.35	47.175	27.13	14.23	202.40
Lead(Pb)	mg/kg	3.80	6.68	2.05	0.83	6.03	5.15	3.5	4.00	2.11	4.45
Cadmium(Cd)	mg/kg	0.98	0.53	1.20	0.35	0.43	0.95	0.725	0.74	0.32	0.10
Copper(Cu)	mg/kg	17.88	0.75	2.80	1.15	1.63	3.3	8.5	5.14	6.18	38.31
Cobalt(Co)	mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			

Table 3: Heavy metals concentration from water around Tattara Granite Mine, North central Nigeria.

Sample Type: WATER										
Parameters	Unit	TNW1	TNW2	TNW3	TNW4	TNW5	TNW6	AVERAGE	SD	VARIANCE
Lead(Pb)	mg/L	<0.001	<0.001	0.7	<0.001	<0.001	<0.001	0.7	-	0.08
Zinc(Zn)	mg/L	0.78	1.23	4.48	1.82	1.08	0.86	1.71	1.41	1.98
Cadmium(Cd)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		-	0
Copper(Cu)	mg/L	0.37	1.06	1.87	0.18	0.35	0.18	0.67	0.67	0.45

Cobalt(Co)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	0

Table 4: Nigerian standard for drinking water quality, (SON, 2007)

Parameter	Unit	Maximum permitted	Health impact
Lead (Pb)	Mg/l	0.01	Cancer, interference with Vitamin D metabolism. Affect mental Development in Infants. Toxic to the central and peripheral nervous system.
Copper	Mg/l	1	Gastrointestinal Disorder
Cadmium	Mg/l	0.003	Toxic to the Kidney
pH	-	6.5-8.5	None
Zinc (Zn)	Mg/l	3	None

Table 5: Guideline and permissible limits for heavy metal concentration in water and soil samples as adopted from (WHO, 2007; DPR (2002) & SON (2007)

Parameter	**WHO 2007 permissible Limits for drinking Water (mg/L)**	**Nigerian Standard for drinking water quality, (SON, 2007) (mg/L)**	**WHO permissible limits for Soil (mg/kg)**	**DPR(2002) limit for soil mg/kg**
Cadmium (Cd)	0.003	0.003	0.8	0.8
Copper (Cu)	2	1	36	36
Lead (Pb)	0.01	0.01	85	85
Zinc	0.05	3	50	140

The concentration of elements like lead, copper, zinc and cadmium when taken in high level by both Human beings and some animals (mammals) may lead to the formation of particular stable bonds in some enzymes and form the basis of metal toxicity in man Chaanda et al. (2008). However, (Buss and Robertson, 1976, Pinmorotu and Oshodi 1993, Adeyeye et al., 2000, Aremu and Inajoh, 1997) emphasized that the human system requires an acceptable proportion of most of the elements to sustain life.

The level of lead for soil samples as observed from the result obtained were found to be within the range of 0.825 to 6.675mg/kg which is below the WHO permissible limit (85mg/kg) for soil. While for water, water samples gotten for tap water, well and the river was below WHO and Nigeria Standard for drinking water Quality with the reservoir water sample showing slight contamination of lead.

Cadmium was observed to be below the WHO (2011), Nigeria Standard for drinking water quality (2007) permissible limit and for soil, the soil samples collected for reservoir and inside the village showed slightly contamination of cadmium. The source of the contamination could have been from anthropogenic source as contamination was also observed in the control sample collected within the village.

The results obtained from this analysis suggested that the concentration of copper in the water samples ranges from 0.35mg/l to 1.865mg/l which below the WHO (2011) standard for drinking water and for soil the analysis result for concentration of copper ranges from 0.75mg/kg to 17.875mg/kg which is below the WHO and DPR standard for soil (36mg/kg). Therefore, there is no possible copper contamination from the mining operation.

The result analysis for zinc concentration in water ranges from 0.78mg/l to 4.48mg/l and for soil it ranges from 9.925mg/kg to 47.175mg/kg which is below the DPR and WHO standard for soil but for water it is higher than the WHO permissible limit but less than Nigerian Standard for Drinking Water Quality (2007) except for sample 3 which was gotten from the reservoir. The sequence of occurrence of heavy metal in soil is Zn>Cu>Pb>Cd>Co and for water the sequences is also Zn>Cu>Pb>Cd>Co correlating with each other. All the value of heavy metal abundance in soil and water were found below the permissible limit except for sample 3 showing slightly high level of cadmium, zinc and lead for water sample collected from the reservoir. The heavy metal contamination is believed to be from the rock residue that is being mined which is not adverse at the present, adequate measures should be taken and the level of the heavy metal in the reservoir monitored from time to time.

V. Conclusion

The implication of granite mining at Tattara village from the analysis result and physical observations showed less impact of mining at Tattara area, North Central, Nigeria. The concentration of heavy metals in water sample analyzed from the study area were below the guide line for drinking water standard WHO and Nigerian Standard Quality for drinking water which means the villagers are not under any risk of exposure to water pollution as a result of the granite mining operations taking place in the area at the moment while the water sample from the reservoir and the mining site showed slightly higher concentration of lead and cadmium. Analysis result for soil also showed that the soil samples from the river and the village were all below DPR, 2002 standard for soil except for cadmium. While soil sample from the reservoir and the mining site showed high concentration of lead and cadmium, therefore the concentration of these heavy metals for both soil and water should be monitored from time to time because there is potential tendency that these concentrations may rise as the mining operation progresses. To have a sustainable mining operation in line with the Mineral Act 2007, the Millennium Development (MDG) Goal 7 of the United Nations, monitoring the concentration of these in the different water regimes should be routine to sustain environmentally friendly operation of granite mining in the area. The issue of land degradation, noise pollution and air pollution were also reported in this work to be at minimum though the noise could be adverse to the workers if necessary safety measures are not taken. Finally, the reservoir which serves as a means of lubrication for the cutting machine has been observed to be situated at a place close to the river with the walls and bottom open to infiltration. If the concentration of the heavy metal within the reservoir increases, the reservoir can serve as a source anthropogenic influence on the river system and the underground water.

VI. Recommendation

It is recommended that the reservoir walls and bottom is cemented as to ensure that the water does not infiltrates through to the underground water or finds its way to the surface water as the concentration of the heavy metals within the reservoir is expected to increase as the mining operation increases with time.

Mine restoration program is encouraged as to reclaim the degraded land areas. According to (Tongway and Ludwig, 2011) restoration process begins from design to aftercare as to enable the dilapidated land to revert to its original use such as Agriculture or the area is transformed to a recreational place as an alternative measure. However, prior to the restoration program, it is also recommended that adequate research is carried out as to determine the best approach to follow.

It is also recommended that the health of the workers working in the mine should be put into consideration. The management should provide hear mask, noise mask and eye goggle for the workers as to minimize the impact of noise and air pollution on the workers.

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