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The Impact Of Mineral Development On Water Resources, Effects Of Tin Mining On Water Quality: Focus On Some Parts Of The Jos Plateau, Nigeria.

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Abstract: *Mineral development which involves exploration, mining and processing, must have caused some damage to water quality in the study area. Active tin mining took place in the study area from beginning of this century to the mid 1980s and no doubt to some extent, has affected the quality of both surface and groundwater in the localities. The waste after the removal of the desired mineral(tin), which often contains acid generating sulphides, heavy metals and other contaminants is usually left on the ground surface in large free drainage piles, can be major sources of water pollution. Water samples were collected from mining ponds, hand – dug wells, boreholes, and analyzed to investigate the possible level of pollution resulting from leaching of the contaminants. Concentration of Arsenic (As) from one of the hand – dug wells is 0.013mg/l, which is above the W. H. O maximum acceptable limit of 0.01mg/l. also, lead (Pb) has a concentration of 0.011mg/l from a borehole, which is slightly above the W. H. O standard of 0.01mg/l. generally, the water samples did not show any significant pollution of public health concern. Although the devastating effect is much on the landscape in the area as seen in form of numerous mine ponds, heaps of excavated overburden, e. t. c the effects of trace elements is mild, except for lead (Pb) and Arsenic (As) concentration. The mining ponds though seen as good sources of water for irrigation reduces the availability of arable land for farming. Lives are reportedly being loss from ponds from time to time.*

I. Introduction

Exploration of mineral resources is of great importance in several developing countries including Nigeria. Mineral resources are important sources of wealth for a nation but before they are harnessed, they have to pass through the stages of exploration, mining and processing (Adekoya, 2003; Ajakaiye, 1985). Theses stages of mineral development are accompanied by different types of damages and hazards including pollution of surface water and groundwater. The purpose of this study therefore, is to present the effect of tin mining on water quality of some parts of the Jos Plateau, Nigeria, and also attempt to examine some precautions and remedies to the effects.

Formal mining started on the Jos Plateau as far back as 1902 with Tin and Collumbite as the major targets (Federal Department of Museum and Monuments, 1979). The occurrence of various minerals in the study area brought about intense mining activities in the state at the beginning of this century, and in fact, the early growth and development of the Jos city was closely related to the commercial tin mining activities on the Plateau (Schoeneick and Aku, 1998). Commercial tin mining activities commenced at about 1914 through the Royal Niger Company and by late 1920s the industry had been established, expanded and linked to the outside World, creating new communities and flourishing mining companies (Gyang and Ashano, 2010).

Varying degrees of pollution of air, water and land occur in the course of mineral development depending on the stage and scale of activities attained. While only minor pollution occur during mineral exploration, more intense air and water pollution emanates from exploitation stages, particularly if carried out on a large scale (Aigbedion and Iyayi, 2007). In study area, the open cast mining method was generally used in predominantly flat plains of the Plateau as tin and collumbite were concentrated in old streams bed (alluvial), having been washed down from the younger outcropping units (Falconer, 1921). The waste, after the removal of the desired minerals (tin and collumbite), which usually contains acid generating sulphides, heavy metals and other contaminants, is usually left on the ground surface in large free drainage piles, and can be major sources of water pollution. The exposed bedrock walls from which it is excavated are also the source of most metal pollution caused by tin mining on the Jos Plateau.

In the study area, the abundant and mine tailings are believed to have negative impacts on the environment in the sense that the mine ponds and Lotto pits are considered to be death traps (Adiuku-Brown, 1999). Leachates from mine waste can pollute the water in mine ponds, which in turn can infiltrate the ground and pollute the ground water if it gets at it (Lindslay, 1975).

Acid mine drainage is another possible negative impact of tin mining in the study area, this is a natural process whereby Sulphuric acid is produced when sulphides in rocks and mine waste, are exposed to air and water. When large quantities of waste rock, containing sulphide minerals are excavated from open pit or open up in an underground mine, it reacts with water and oxygen to form sulphuric acid. The acid will leach from the rock as long as its source rock is exposed to the air and water and until the sulphides are leached out, this process can last hundreds, even thousand years after mining activities (Miningwatch, 2011). Acid is carried off the mine site by rain water or surface run-off into nearby streams, rivers and ground water (boreholes, hand dug wells). Acid mine drainage degrades water quality severely and can kill aquatic life and make water virtually unusable.

Chemical water pollution is also possible in the study area; this must have resulted from the minerals after mining. When chemical agents (such as cyanide, or sulphuric acid) used by mining companies to separate the target mineral (tin) from the ore spill, leak or leach from the mine site into nearby water bodies (streams, mine ponds), hand dug wells, boreholes. These chemicals can be toxic to humans and wildlife (Miningwatch, 2001). Hydrgeological studies revealed three hydrogeological units in the study area; Quaternary sedimentary deposits, weathered zone of crystalline rocks, and tectonically fractured zone of rocks. The fractured crystalline acquifer water relates to tectonically fractured zone and be from open wells, blasted wells and sometimes boreholes. The soft overburden acquifer consist predominantly of clayey materials of alluvial, elluvial and deluvial origin as well as in situ chemical weathered rocks (Schoeneick and Aku, 1998).

In this work, ten (10) samples were collected within the study area and the locations are represented In figure 1.

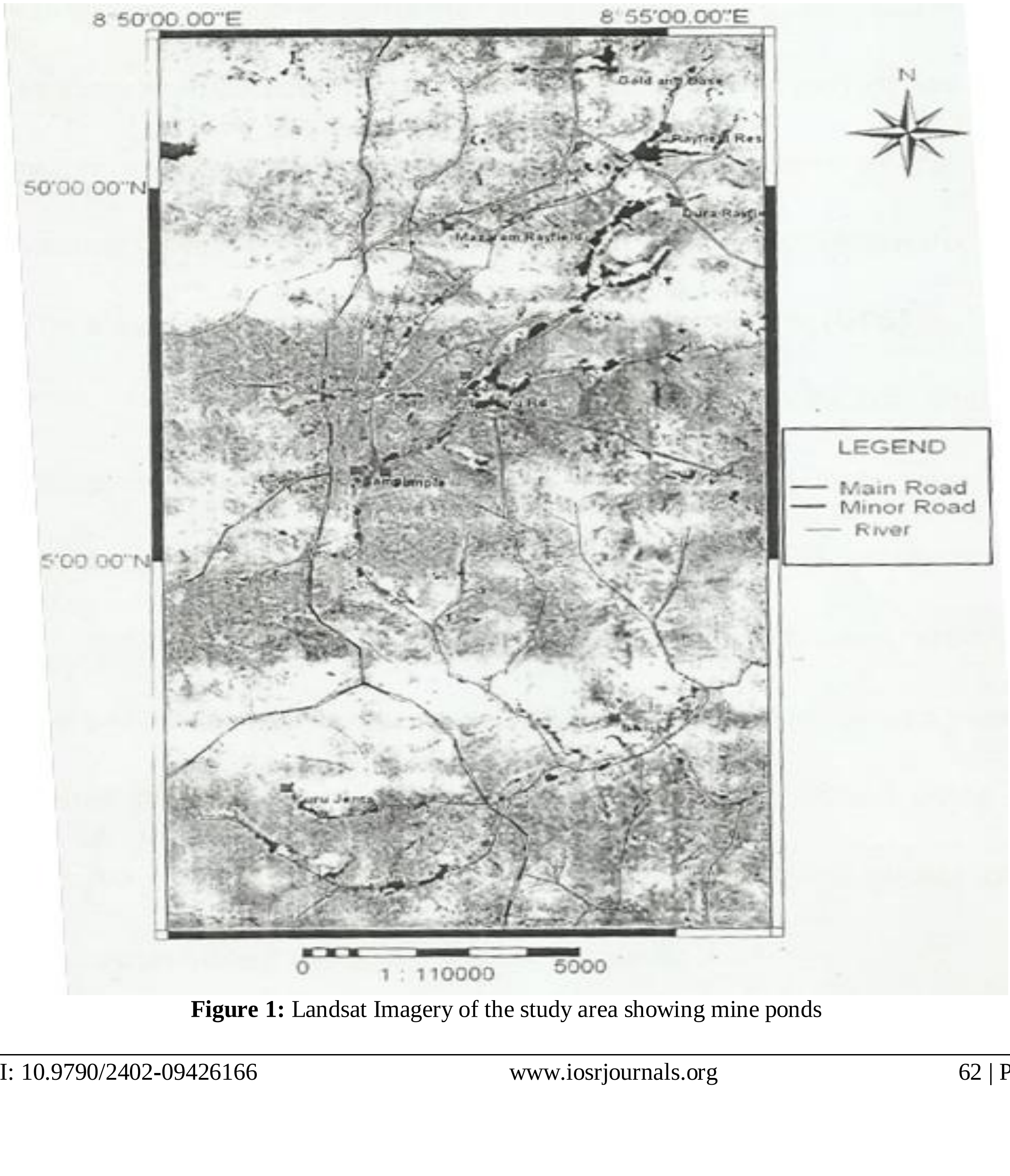

Figure 1: Landsat Imagery of the study area showing mine ponds

II. Methodology

The method carried out for this work was simply collecting water samples from three (3) main sources (mine ponds, hand dug wells and boreholes) in the study area from one point to another (Fig. 2). A total of ten (10) water samples were collected from these sources. The samples were collected in plastic containers. At the point of collection, the containers were thoroughly rinsed with the same water to be collected so as to ensure that correct results are obtained at the end of the analysis, then, the sample collected directly into the container. The locations of the points of collection of samples as well as their elevations were taken using Garmin high sensitivity Global Positioning System (GPS).

The samples were taken for analysis in the laboratory. The P. H of the samples was determined using PH meter while conductivity determined by conductivity meter.

Samples for cations were acidified with concentrated nitric acid to reduce their PH. On the other hand, samples for anions were not acidified. The samples were then filtered and then analyzed using Inductively Coupled Plasma (ICP) (Optional Emission Spectrometry). Hardness of the water samples was determined using titrimetric method.

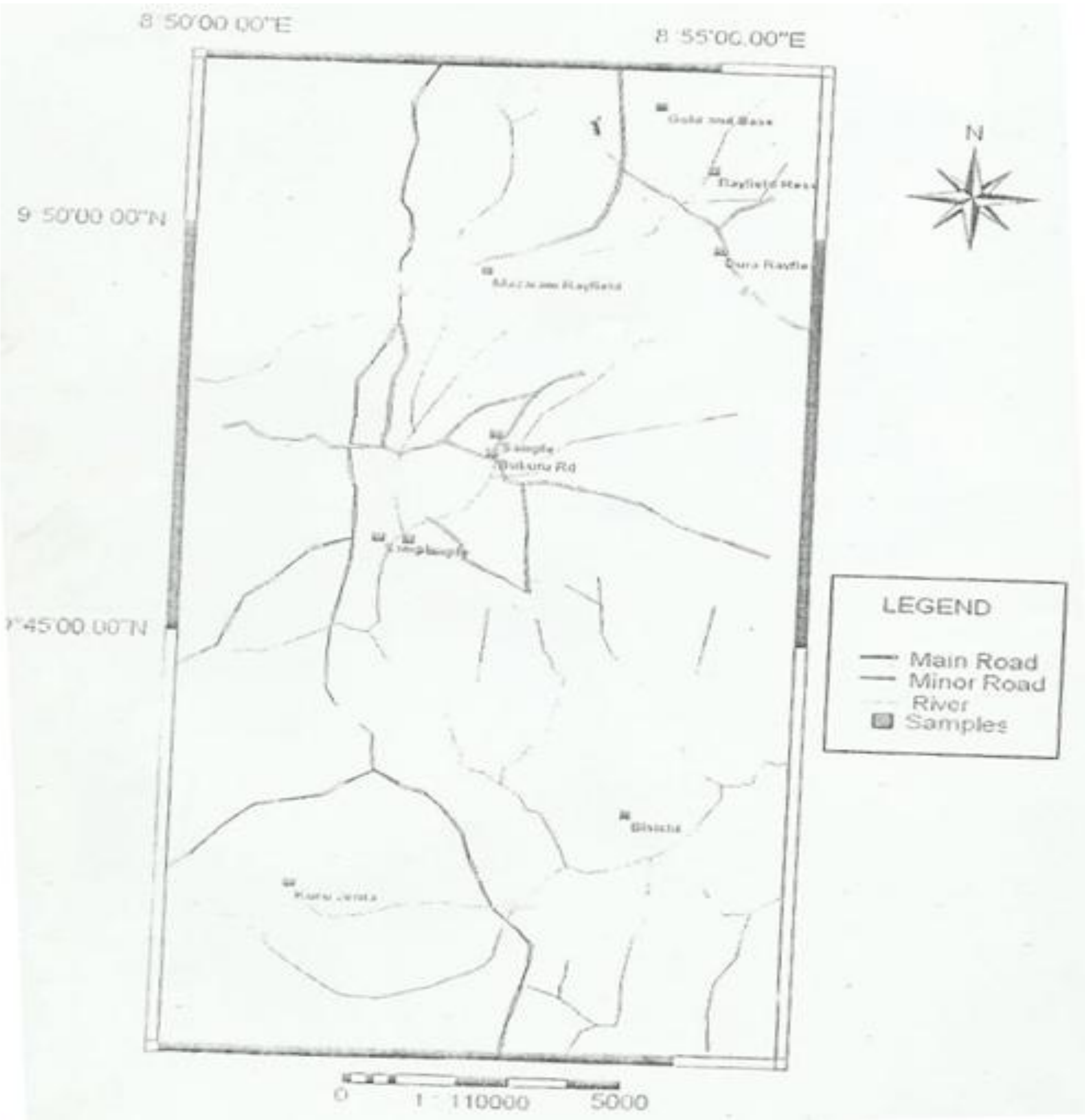

Figure 2: Drainage map of the study area showing samples location.

III. Results

The ten (10) water samples collected in the study area for analysis, seven (7) samples were from mine ponds, two (2) from hand dug wells and one (1) from hand-pumped borehole. The geochemical laboratory analysis of these are shown in tables 2, 3 and 4 while the collection points are given in table below.

Table1. Sample Collection Points And Coordinates

S/N	Sample Identity	Locality	Coordinates
1	MP01	Kuru-Jenta mine pond	N09^{o} 41.971^{1} E008^{0} 51.198^{1} Elevation 1297m
2	MP02	Bisichi mine pond	N09^{0} 42.874 E008^{0}54.363 Elevation 1244m
3	MP03	Bukuru Du road mine	N09^{0} 47.174 E008^{0} 52.898 Elevation 1278
4	MP04	Mazaram Rayfield mine pond	N09^{0} 49.456^{I} E008^{0} 52.803^{I} Elevation 1253m
5	MP05	Rayfield Resort mine pond	N09^{0} 50.772^{I} E008^{0} 54.953^{I} Elevation 1300m
6	MP06	Dura Rayfield mine pond	N09^{0} 49.780^{I} E008^{0} 55.074^{I} Elevation 1308m
7	MP07	Gold and Base Rayfield mine pond	N09^{0} 51.531^{I} E008^{0} 54.435 Elevation 1272m
8	W08	Dorawa Zawan hand dug well	N09^{0} 46.186^{I} E008^{0} 51.876^{I} Elevation 1268^{I}
9	W09	Rahol Kaneng hand dug well	N09^{0} 47.464^{I} E008^{0} 52.965^{I} Elevation 1301m
10	BH10	Du borehole	N09^{0} 46.168^{I} E008^{0} 51.178^{I} Elevation 1268m

Table 2: Geochemical Laboratory Analysis On ICP OES Of Heavy Metals

Sample	Ca317.933	Cd228.802	Cu327.393	Cr267.716	As396.153	Fe238.204	Mn257.610	Pb220.353	Zn206.200	PH	Conductivity	Hardness
MP01	1.813mg/l	0mg/l	0.005mg/l	0.011mg/l	0mg/l	0.050mg/l	0.004mg/l	0.021mg/l	0mg/l	5.2	49.1	126
MP02	3.175mg/l	0mg/l	0.005mg/l	0.005mg/l	0mg/l	0.165mg/l	0.012mg/l	0.012mg/l	0.032mg/l	5.6	26.0	46
MP03	7.793mg/l	0mg/l	0.010mg/l	0.010mg/l	0mg/l	0.886mg/l	0.142mg/l	0.110mg/l	0mg/l	5.8	13.2	42
MP04	7.786mg/l	0mg/l	0.005mg/l	0.005mg/l	0mg/l	0.219mg/l	0.026mg/l	0.016mg/l	0mg/l	6.0	-3.3	2.4
MP05	1.827mg/l	0mg/l	0.005mg/l	0.006mg/l	0mg/l	0.177mg/l	0.012mg/l	0.013mg/l	0mg/l	5.7	25.7	43
MP06	6.732mg/l	0mg/l	0.005mg/l	0.005mg/l	0mg/l	0.198mg/l	0.012mg/l	0.019mg/l	0mg/l	6.5	-23.1	6.0
MP07	4.724mg/l	0mg/l	0.005mg/l	0.005mg/l	0mg/l	0.444mg/l	0.011mg/l	0.017mg/l	0.003mg/l	6.4	-24.8	1.5
W08	13.480mg/l	0mg/l	0.006mg/l	0.015mg/l	0.013mg/l	0.37mg/l	0.040mg/l	0.000mg/l	0.446mg/l	5.7	45.3	62
W09	18.320mg/l	0mg/l	0.010mg/l	0.012mg/l	0.010mg/l	0.065mg/l	0.050mg/l	0.001mg/l	0.442mg/l	5.3	48.7	52
BH10	4.450mg/l	0mg/l	0.005mg/l	0.011mg/l	0.010mg/l	0.080mg/l	0.112mg/l	0.011mg/l	0.042mg/l	5.8	49.3	72

Table 3: Geochemical Laboratory Analysis On ICP OES Of Anions

Sample	SO_4	PO_4	HCO_3	CO_3	NO_3	Cl^-
MP01	50.00mg/l	8.28mg/l	61.00mg/l	0.00mg/l	18.36mg/l	4.47mg/l
MP02	40.00mg/l	4.14mg/l	34.60mg/l	0.00mg/l	15.28mg/l	6.94mg/l
MP03	35.00mg/l	1.69mg/l	45.26mg/l	0.00mg/l	4.09mg/l	3.65mg/l
MP04	N.D	2.79mg/l	79.20mg/l	0.00mg/l	3.91mg/l	2.79mg/l
MP05	N.D	2.25mg/l	85.40mg/l	0.00mg/l	6.33mg/l	2.24mg/l
MP06	30mg/l	2.75mg/l	50.05mg/l	0.00mg/l	5.08mg/l	2.34mg/l
MP07	30mg/l	4.25mg/l	30.12mg/l	0.00mg/l	4.15mg/l	2.62mg/l
W08	N.D	2.24mg/l	60.15mg/l	0.00mg/l	3.50mg/l	4.20mg/l
W09	N.D	1.64mg/l	35.00mg/l	0.00mg/l	6.45mg/l	3.40mg/l
BH10	N.D	4.50mg/l	46.00mg/l	0.00mg/l	7.12mg/l	5.10mg/l

Authors work. ND – Not detected

Table 4: Summary Of Geochemical Analysis Of Water Of The Study Area

Parameter	Mine ponds (Surface water)		Wells (groundwater)		WHO Standard	
	Range	Average	Range	Average	Recommended level	Maximum Permissible Level
PH	5.2 – 6.5	5.9	5.3 – 5.8	5.6	6.5	9.5
Conductivity	(- 24) – 49.1	9.0	35.3 – 49.7	47.8	400	1480
Hardness	1.5 – 126	38.13	52 – 72	62	100	500
Cl^-	2.24 – 6.94	3.58	3.4 – 5.10	4.20	250	600
SO_4	ND – 5.00	27.90	Nil	Nil	250	400
NO_3	3.91 – 18.36	8.17	3.50 – 7.12	5.69	25	50
Fe	0.05 – 088b	0.30	0.065 – 0376	0.17	0.3	1.0

Ca	1.813 – 7.793	4.84	4.450 – 18.320	12.08	-	50
Zn	0.00 – 032	0.005	0.042 – 0.446	0.30	-	3.0
Mn	0.004 – 0.142	0.031	0.04 – 0.112	0.06	0.01	0.2
Pb	0.021 – 0.110	0.020	0.00 – 0.011	0.004	-	0.01
As	Nil	Nil	0.01 – 0.013	0.011	-	0.01
Cd	Nil	Nil	Nil	Nil	-	-

The chemical parameters used in characterizing the water quality in the work are PH, Conductivity, Hardness, Cl^-, SO_4, NO_3, Fe, Ca, Zn, Mn, Pb, As and Cd. **Chlorine (Cl^-):** values ranged from 2.24 to 6.94 for surface water with an average value of 3.58. while the values range from 3.40 – 5.10 with an average of 4.20 for ground water. Both values fall within the WHO's highest desirable limit for drinking water hence does not indicate any danger to water in the area at the moment.

Sulphate (SO_4): Sulphate was not detected in two (2) samples of the surface water but has an averge value of 27.90, which falls below the recommended and maximum permissible level of WHO's standard of 250 and 400 respectively. For ground water (wells) no value of sulphate was detected.

Nitrate (NO_3): The Nitrate values obtained ranged from 3.91 – 18.36 with and average value of 8.17 for surface water. While the range of 3.50 – 7.12 with an average of 5.69 was the value from ground water both values fall far below the (WHO, 2006) recommended value of 25.

Iron (Fe): The values of (Fe) ranged from 0.05 – 0.886 with an average value of 0.30 for surface. For ground water, the values ranged from 0.065 – 0.376 with a value average of 0.17. The average value for surface water was 0.30 exactly the recommended level for WHO standard, but falls below the 1.0 permissible level. A world recorded a value of 0.376 value slightly above the recommended level o WHO standard however falls within the maximum permissible value of 1.0.

Calcium (Ca): The values ranged from 1.813 – 7.793 with an average of 4.84 for surface water. For the ground water the values ranged from 4.450 – 18.320 with an average value of 12.08. Both values fall within the WHO maximum permissible value of 50.

Zinc (Zn): Zinc was detected in only two (2) of the mine ponds MP02 (0.032mg/l) and MP07 (0.003mg/l) with an average value of 0.005 while for the ground water, the value range of 0.30. Both values fall within the WHO permissible value of 0.03.

Manganese (Mn): The value of 0.031; which exceeds the recommended value however falls within the WHO permissible level. For the ground water the value ranged from 0.04 – 112 with an average of 0.06 which though exceed the recommended WHO level, falls within the WHO maximum permissible level of 0.2.

Lead (Pb): The value of lead for the surface water ranged from 0.021 – 0.110 with an average of 0.020. the values of lead in all the seven samples exceed the WHO maximum permissible level of 0.01 which is an indication of pollution of the mine pond by lead overtime. For the ground water, the values ranged from 0.00 – 0.011 with an average of 0.004. Although the average values falls within the WHO permissible level, the value of lead in one borehole (BH10) is 0.011 which slightly exceed the WHO permissible level of 0.01.

Arsenic (As): Arsenic was not detected in any of the mine ponds. For ground water the values ranged from 0.01 – 0.013 with an average of 0.011. The value of 0.013 obtained from one (1) hand dug well exceeds the WHO maximum permissible level of 0.01; therefore an indication of pollution of the ground water by arsenic.

Cadmium (Cd): Cadmium was not detected in neither mine ponds nor wells, from the water samples analyzed

Conductivity values obtained ranged from (-24.8) – 49.1 for the surface water with an average value of 8.87. While the values for ground water ranged from 45.3 – 49.3 with an average value of 47.77. It can be observed that, the values from ground water seem to be higher, and this can be as a result of its closed contact to the earth materials and minerals it comes in contact with (Herm, 1998). However the value falls within the recommended level by WHO.

PH reading recorded for surface water ranged from 5.2 – 6.0 with an average value of 5.6 from the above results, it can be noted that the ground water are acidic which may be due to the breakdown of organic matter

(Gyang and Ashano 2010). However both values fall within the WHO recommended and maximum permissible levels (WHO 2006).

Hardness: The values recorded ranged from 1.5 – 126 with an average value of 38.13 while the ground water value ranged from 52 – 72 with an average values of 62.0. The values recorded fall within the WHO highest desirable value of 100mg/l except in sample MP01 (mine pond) which recorded value of 126mg/l. Excessive hardness affects taste of water and low hardness causes flat taste of water. High total hardness on the other hand, increases soap consumption (Gyang and Ashano 2010).

Precautions and Remedies

In order to minimize the negative effect of mineral development on water quality and environment generally, certain measures must be taken by both the government and mining companies. The government role is to provide the legislation required to make it mandatory for a company to practice all the necessary precautions in their operations that will prevent or minimize environmental damage however, unfortunately such legislation exist in Nigeria as the minerals and mining decree of 1999 (Aigbedion and Iyayi 2007) but it is not being adhere to.

Government should intensify its capacity to administer, monitor and enforce these existing laws and policies. There should remedy to some inevitable environmental damages in the course of development. For the sake of current and future generations we need to safeguard the purity and quality our water and environment against indiscriminate mineral development. There is need to ensure the best pollution prevention strategies are employed in cases where the risk can be managed. There is also need to recognize that in some places mining should not be allowed to proceed because the identified risk to other resources, such as water, are too great (Mining Watch, 2001) that there should be public awareness as regards the use of mine wastes and mine ponds water as these may contain radioactive elements as indicated by the concentration of Lead (Pb) in some mine ponds in the area. The land should be restored or reclaimed in order that the inhabitant can still use the land for agricultural purposes.

IV. Conclusion

Generally, the analysis of the water samples in the area, did not show significant pollution of public health concern, except for the concentration of Lead (Pb) in five mine ponds and a borehole, and also the concentration of Arsenic (As) in a hand dug well which all exceed the WHO maximum permissible level. There is also the fear of bioaccumulation of these trace elements. The major problem in the study area however, is the several abandoned mine ponds and heaps of mine spoils that abound on the project area and are spoiling the scenic beauty of the area as well as serving as contaminants for both humans animals (Adiku-Brown, 1999). Although , the mine ponds seems to be sources of water for irrigation and other purposes today in the study area, they are more of death traps as lives are reportedly being loss from time to time.

References

[1]. Adekoya, J. A. 2003. Environmental Effect of Solid Mining. Journal of Physical Sciences Kenya. 625-640.
[2]. Adiuku-Brown, M. E. 1999. The Dangers Posed by Abandoned Mine Ponds and Lotto Mines on the Jos Plateau. Journal of Environmental Sciences. 3(2) : 258-265.
[3]. Aigbedion, I. and Iyayi, S. E. 2007. Environmental Effect of Mineral Exploitation in Nigeria. International Journal of Physical Sciences. 2(2) : 033-038.
[4]. Ajakiye, D. E. 1985. Environment Problems Associated with Mineral Exploration in Nigeria. A paper presented at the 21st Annual Conference of the Nigeria Mining and Geosciences Society Held at Jos: 140-148.
[5]. Falconer, J. D. 1921. Geology of the Plateau Tin Fields. Bulletin of the Geological Survey of Nigeria. 1.
[6]. Federal Department of Museum and Monuments. 1979. History of Tin Mining in Nigeria .National Antiquities. FDMN: Jos, Nigeria 1:1-50.
[7]. Gyang, J. D. and Ashano, E. C. 2010. Effects of Mining on Water Quality and the Environment. A case study of Parts of Jos Plateau North Central Nigeria. Pacifc Journal of Science and Technology. 11(1): 631-639
[8]. Herm, J. D. 1970. Study and interpretation of Chemical Characteristics of Water, Water Supply. U. S. Geological Survey, Washington, D. C. 254 – 255.
[9]. Lindslay, R. K. 1975. Hydrogeology for Engineers, McGraw-Hill: New York, N. Y. 48.
[10]. Mining Watch, 2001. Mining and Water Pollution in Canada. Newsletter 7/mining Water Pollution.
[11]. Schoeneick, K. and Aku, I. M. 1998. Study of the Degraded Mines Land of Jos, Bukuru, Riyom, Barking-Ladi and Bokkos Area of PlateauState for Development Possibilities. 111.
[12]. World Health Organization, 2006. Guidelines for Drinking-Water Quality, Incorporating First Addendum. Vol.1. Recommendations, 3rd Edition. WHO: Paris, France.