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Evaluation of Arsenic Concentration in Rocks of Kaltungo Area, Upper Benue Trough, Nigeria

M.N Mboringong[1], A.Olasehinde[1]*, R.P.Tabale[1] A.Yusuf[1] and E.C Ashano[2]
1. Gombe State University, P.M.B 127, Gombe, Nigeria.
2. University of Jos, P.M.B 2084, Jos, Nigeria.
* *yinka516@gmail.com*

1. Abstract

This research aimed at investigating the concentration of arsenic (As) due to their potential environmental impact and contamination, in the rocks (Coarse Porphyritic Granite, Biotite Granite, Bima Sandstone and basalt) of the Kaltungo area which is part of the Upper Benue Trough. Eight (8) fresh samples (two from each lithologic unit) were collected and analysed using Inductively Coupled Plasma Optical Emission Spectrometer (ICPOES) for arsenic (As). The results were presented using graphical presentations and this revealed that rocks in the study area host high concentration of arsenic (As) (87.54-237.65 ppm) compared with the average crustal abundance of 2ppm. These values can be attributed to high concentration of the element in the initial magma and/or hydrothermal and weathering processes which acted on the rocks. The high concentration of arsenic (As) in the rocks of Kaltungo area calls for further studies on its distribution and concentration in the soils, stream sediments and ground water.

Keywords: Arsenic, Kaltungo, Upper Benue trough, environment.

2. Introduction

There is a considerable interest in the study of arsenic (As) distribution within the kaltungo area due to their potential environmental impact and contamination. In the study area a lot is known about the tectonic evolution and origin but little has been done on the natural variability of the toxic elements in the rocks. Reasons for this include the interest in the exploration for oil which include sedimentary, stratigraphy and paleontological studies (Allix and Poppof, 1983; Benkhelil, 1982; Benkhelil and Robineau, 1983; Benkhelil, 1986; Benkhelil et al., 1988; Enu, 1980; Guiraud, 1990; Guiraud, 1993; Lawal and Moullade, 1986; Maurin *et al*, 1986; Zaborski, 1990; 1993; Zaborski *et al.*, 1997) and limited value for chemical classification or petrogenitic studies.

The present work tend to study the distribution of arsenic (As) in the rocks of Kaltungo to evaluate its concentration due to their potential for environmental contamination, which will in turn serve as baseline for further studies in its distributions in the soil and ground water respectively.

3. The geology

The Benue Trough of Nigeria is an intracontinental Cretaceous basin about 1000kilometres in length elongated in the NE-SW directions which overlies the Precambrian shield of the West African mobile belt(Maurin *et al.*, 1986; Guiraud, 1990) . Reviews and the origin and the evolution of this linear NE-SW trending megastructure were provided by Benkhelil ,1989; Freeth, 1990; Guiraud and Maurin, 1991; 1992, Genik, 1992, 1993. The sedimentary sequence infilling the Upper Benue Trough includes continental and marine deposits ranging from Upper Aptian to Paleocene in age. The Bima Formation were laid unconformably on the basement in the fitted Wrench – fault basin. The study area consists partly of the basement complex and cretaceous sediments in the Upper Benue Trough (Figure 1). This transgressive episode caused the deposition of Yolde, Dukul, Jessu, Sekule and Numanha sedimentary Formations, all of which outcrop as inliers to Bima Formation in Dadiya syncline (Figure 2). These Formations are shallow marine depositions of limestone, shale and mudstone and they are foundmainly as narrow strips of rocks in the study area, such as Banju, Guyuk, and Shellen. The Longuda Basalt of tertiary age terminates the lithological succession in the area. The Coarse Porphyritic Granite, Biotite Granite, Bima Sandstone and Basalts represent the rocks of the Kaltungo area (Figure 3).

4.Chemistry of Arsenic

Arsenic is situated in the 33rd spot on the periodic table, right next to Germanium and Selenium. It has atomic weight of 74.92, with Electron Configuration [Ar] 4s23d104p3 , Density 5.727 g/cm^3, Oxidation States 5, 3, 2, 1,-3 and Rhombohedral Crystal Structure. It is a chalcophile element being usually found in sulphide minerals. They exhibit similar or identical atomic radii (As, 1.5 Å; Sb, 1.6 Å and Bi 1.7Å), electronegativity (2, 1.9, 1.9) but dissimilar ionic radii (0.47,0.62. 0.77 Å)(Heydemann, 1969).

5. Methodology

Eight (8) Fresh surface rock samples were collected from outcrops of all lithologic units (two per each lithologic unit) in the study area (Figure 3) which includes the Coarse Porphyritic Granite, Biotite Granite, Bima Sandstone and Basalts. Arsenic (As) was determined using the Inductively Coupled Plasma optical Emission Spectrophotometer, (ICPOES), after HF / $HClO_4$ dissolution at the PTDF Geochemistry Laboratory of Department of Geology and Mining, University of Jos. Analytical precision for the instrument was 0.5 – 1% and an accuracy of 2% - 5%. Quality control procedure was by the simultaneous analysis of international standards and blanks and calculated after the method of Ashano (1996).

6. Result and Discussion

The result of the analysis is presented table 1. The concentration Arsenic in all the rock types shows much higher concentration than the Average Crustal Abundant (ACA) of 2ppm. The concentration varies from 87.54ppm in K3 to 235.2 ppm in K1 with mean concentration 194.05ppm in K1, 237.65ppm in K2, 158.120ppm in K3 and 163.10 ppm respectively.

K1 = Coarse Porphyritic Granite; K2= Biotite Granite; K3= Bima Sandstone; K4= Basalts

CA= Crustal Abundant

Arsenic may be lost from soils by two sources, either by streams, which happens rapidly but only low levels of arsenic accumulate, or by groundwater, which is very slow, however comparatively high levels of arsenic may build up. Arsenic is released into ground and surface waters by the erosion, dissolution and weathering of rocks which is highly concentrated in the rocks of the study area. Arsenic can stick to mineral surfaces from circulating groundwater.

7. Human health effects

According to a 1999 study by the National Academy of Sciences, arsenic in drinking water causes bladder, lung and skin cancer, and may cause kidney and liver cancer. The study also found that arsenic harms the central and peripheral nervous systems, as well as heart and blood vessels, and causes serious skin problems. It also may cause birth defects and reproductive problems. According to this same study, an arsenic concentration of 50 ppb, gives you a 1/100 lifetime chance of developing cancer. Even an arsenic concentration as low as 1 ppb gives you a 1/1000 lifetime chance of developing cancer, which is 10 times higher than the EPA standard. Therefore it is necessary that people have access to water which complies with the WHO standard for arsenic of <10 ppb and the arsenic concentration should be kept as low as possible.

8.Conclusion

we have reported the anomalous concentration of arsenic in the rocks of kaltungo area which varies from 87.54-237.65ppm. This work would serve as a baseline for further studies of the concentration of this element in soil, stream sediments and ground water of the area.

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Table 1. Concentration of arsenic (As) within the Rocks of Kaltungo

Samples (ppm)	Coarse Porphyritic Granite (K1)	Biotite Granite (K2)	Bima Sandstone (K3)	Basalts (K4)
1	152.900	232.200	228.700	174.600
2	235.200	243.100	087.540	151.600
Mean	194.0500	237.650	158.120	163.100
Median	194.0500	237.650	158.120	163.100

K1 = Coarse Porphyritic Granite; K2 = Biotite Granite; K3= Bima Sandstone; K4= Basalts

Table 2. Summary of health effect of arsenic (Adopted from Hughes 2002).

System	Effect
Skin	Skin lesions—keratosis, hyperkeratosis
Cardiovascular	Blackfoot disease
Nervous	Peripheral neuropathy, encephalopathy
Hepatic	Cirrhosis, hepatomegaly
Hematological	Bone marrow depression
Endocrine	Diabetes
Renal	Proximal tubule degeneration, papillary and cortical necrosis

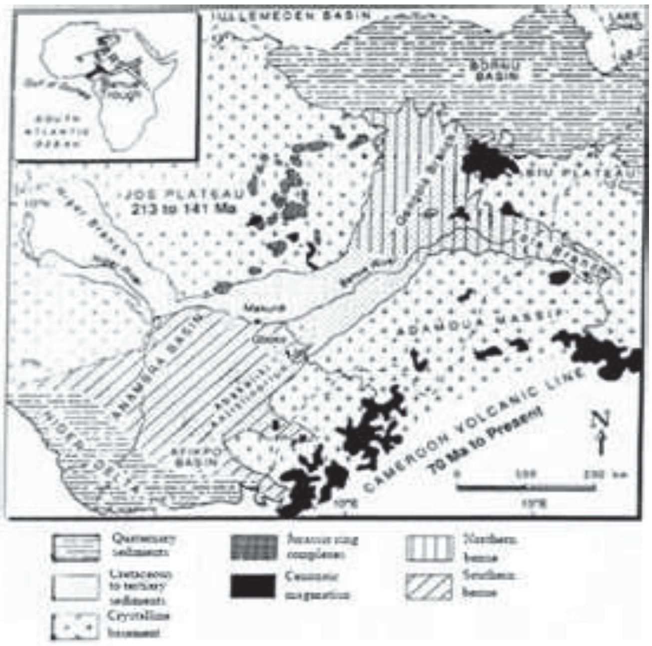

Figure 1.The Benue trough (after Coulon et al 1996)

AGE	PALEO-ENVIRONMENT	GONGOLA BASIN	YOLA BASIN	LAMURDE-LAU BASIN
Quaternary	Continental	Biu Basalts	Longuda Basalts	
Pliocene				
Miocene				
Oligocene		Kerri-Kerri Fm		
Eocene				
Paleocene				
Maastrichtian	Continental/ Transitional	Gombe Sandstone		
Campanian	Marine	Pindiga Formation		
Santonian			Lamja Sandstone	Lamja Sandstone
Coniacian			Numanha Fm	Numanha Fm
Turonian			Sekuleye Fm	Sekuleye Fm
Cenomanian			Jessu Fm	Jessu Fm
			Dukul Fm	Dukul Fm
		Yolde Formation		
Upper Albian	Continental	Bima Sandstone (B_3)		
Late Aptian		Bima Sandstone (B_2)		
Early Aptian		Bima Sandstone (B_1)		
Late Jurassic?				
Pre-Cambrian		Basement Complex		

Figure 2. Stratigraphic succession of the Upper Benue Trough (after Samaila et al, 2007)

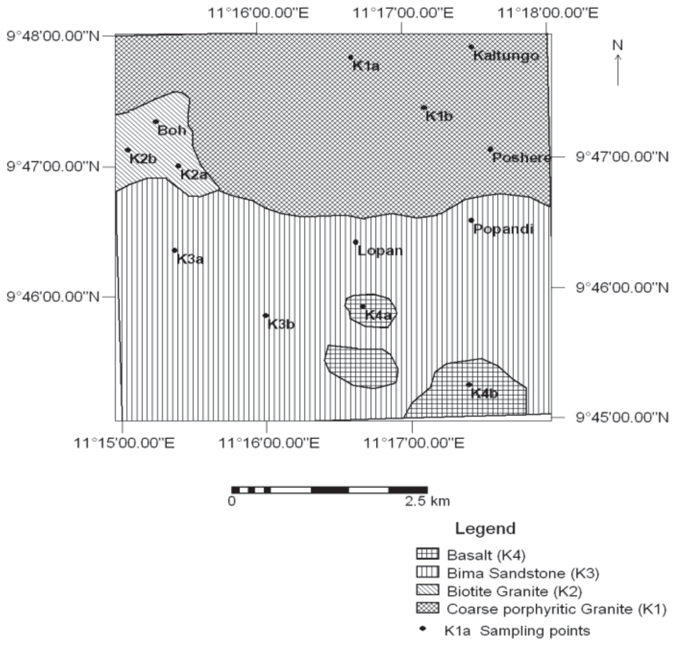

Figure 3. The Geological map of the study area showing sampling location

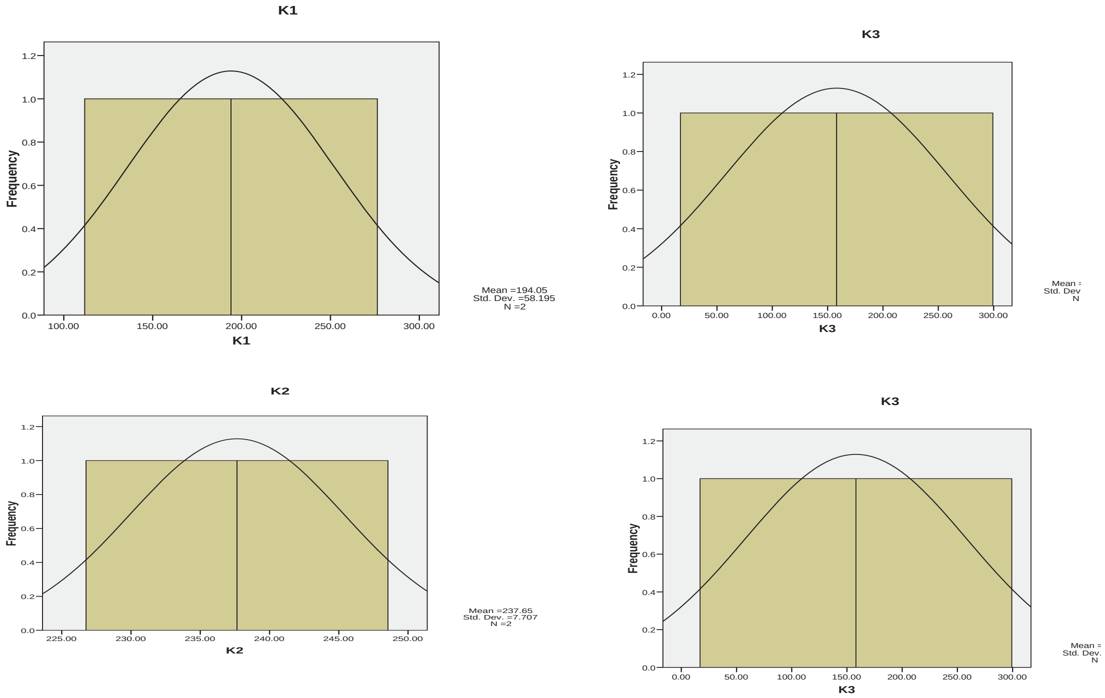

Figure 4. Histogram plots of Arsenic distribution in the rocks of katungo K1, K2, K3, and K4 in ppm

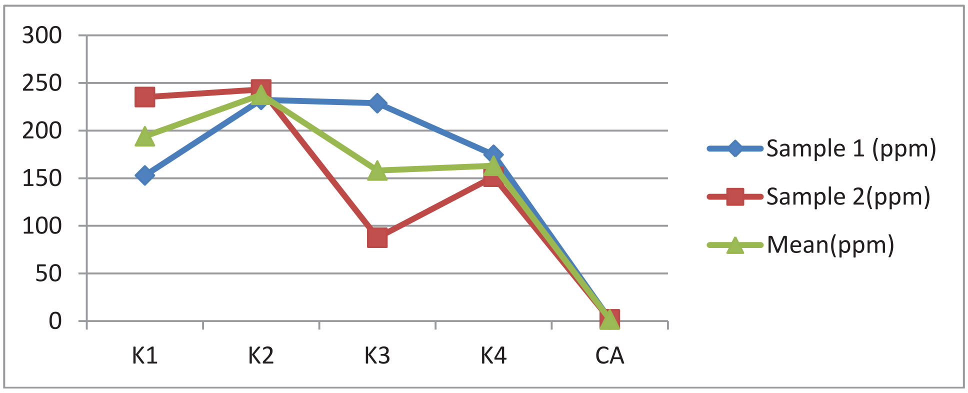

Figure 5. Line plots of the Arsenic concentration in the rock samples of Kaltungo compared with the Crustal Abundant of 2.0 ppm

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