

POLLUTION LEVELS OF HEAVY METALS IN GROUNDWATER SOURCES IN LEAD MINE AREAS OF BUKKUYUM, ZAMFARA STATE, NIGERIA

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ABSTRACT

The uncontrolled illegal mining activities have left a lot of environmental pollution, enormous amount of wastes that have great potentials of polluting groundwater in several communities in Nigeria. The pollution level in groundwater samples from Boreholes and hand dug wells from heavy metals in the mining areas of Bukkuyum local government in Zamfara State was assessed during peak dry season as well as during peak rainy season using atomic absorption Spectrophotometer (AAS 210VG Model). The mean concentration levels of Cr, Cu, Ni, Pb and Zn in boreholes and hand dug wells in the peak dry season are: 0.061mg/L, 0.060mg/L, 0.364mg/L, 0.0273mg/L, 0.035mg/L from Boreholes and 0.035mg/L, 0.041mg/L, 0.035mg/L and 0.150mg/L, 0.014mg/L from hand dug wells respectively. Similarly, the concentration levels recorded in the peak rainy season are: 0.039mg/L, 0.037mg/L, 0.218mg/L, 0.164mg/L, 0.027mg/L from Boreholes and, 0.025mg/L, 0.024mg/L, 0.031mg/L, 0.079mg/L, 0.081mg/L from hand dug wells respectively. The results indicated that the concentration levels of the assessed heavy metals are higher in the peak dry season than in the peak rainy season. The observed higher concentration of Pb in both dry and rainy season in boreholes and hand dug wells are at an alarming level, higher than the safe limit of 0.01mg/L WHO and NESREA standards. This development indicates a significant contamination of groundwater sources in the area especially in the dry season when the demand of water for drinking and other domestic purposes are very high. The present finding is a serious cause for concern to public health particularly consumers of this water sources. The development calls for public education of the public and the government should enact laws to control and regulate mining activities in other to reduce the level of the observed ground water pollution.

Keywords: Heavy metals, groundwater, Bukkuyum, Pollution, Boreholes, Hand dug Wells

1 INTRODUCTION

The uncontrolled and illegal mining activities have left a lot of environmental hazards, enormous amount of wastes and different types of pollutants in both surface and groundwater in several mining communities in Bukkuyum and some mining areas in Zamfara State. The inadequate and uncontrolled handling/disposal of wastes water generated from gold mining activities might infiltrate into the soil to cause groundwater contamination. In March 2010, Medecins Sans Frontiers (MSF- Holland) reported an unusual number of death primarily among children under the age of 5 years in Bukkuyum and Anka local government of Zamfara State to the health authorities. Further study of blood samples revealed that the increase in mortality rate is due to acute lead poison determined to be caused by massive environmental contamination from artisanal mining and processing of gold found in lead rich ore mining areas of Zamfara State. Studies have confirmed high level of lead, cadmium, copper and Zinc levels in human blood, hand dug well waters and soils in Dareta village as reported by [1, 2]. Although, heavy metals are natural components of the environment, but they are of serious concern because of the ability to dissolve/disperse and percolate to contaminate ground water, soil and the atmosphere in increasing amount, leading to alteration of the environmental wellbeing. Exposure to heavy metals in humans and animals are extremely poisonous at comparatively smaller amount, ingesting food or drinking water with greater degree of heavy metals relentlessly irritates the stomach which may result to vomiting and diarrhea, while

greater exposure to lead might be minimizing response period and may result to anemia, a disease of blood in humans. Heavy metals are reported to encourage tumor and mutation at greater amount in animals. They have the capacity of producing harm to germ cells of female and male in animals. They are considered as a growing toxin which when bio accumulates in plant may be transferred into the food chain to affect the health of humans. Heavy metals have the tendency of being non-biodegradable, accumulate in living organisms and have the potential of contaminating ground water resources in the affected areas of Bukkuyum local government in Zamfara state, and therefore there is the urgent need to test and determine the concentration levels of heavy metals in the ground water sources in mining areas of Bukkuyum local government in Zamfara State.

2 THE STUDY AREA

Bukkuyum is one of the 14 Local Governments in Zamfara State. It is located between latitudes $12^{\circ} 08' 00''\text{N}$ and $12^{\circ} 018' \text{N}$, and longitudes $5^{\circ} 28' 00''\text{E}$ and $5^{\circ} 1333^{\circ}\text{E}$. With a land area of $3,214\text{km}^2$, Bukkuyum has a population of 211,633 people according to National Population Census of (2006). The major Communities in the area includes: Gwashi, Kyaram, Masama, Adabka, Nasarawa, Ruwanyashi, Jema and Zurummal respectively. The major income generation of inhabitants are agriculture and Gold mining. The climate of Bukkuyum is warm tropical with temperatures rising up to 38 to 45°C between March and May each year. Rainy season starts in late May to September while the dry season lasts from October to April. There are two major soil types, ferruginous tropical soils and lithosols soils which dominate the local government area [3]. The vegetation of the area consists of northern Guinea Savannah which characterized by short and stringy shrubs as indicated in Figure 1.

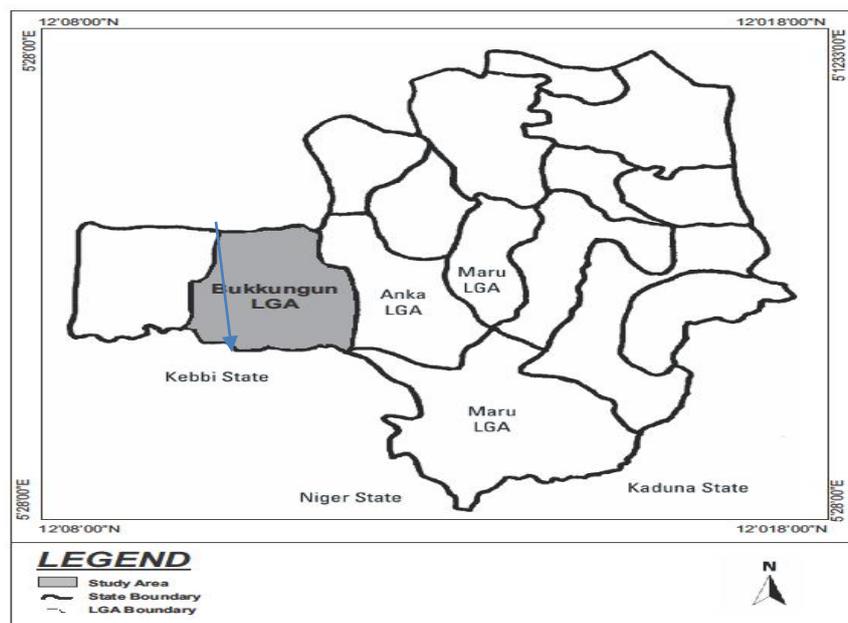


Figure I. Sampling areas of Bukkuyum in Zamfara State

3 MATERIALS AND METHODS

3.1 Water sampling and preservation

Field work begun immediately after the identification of thirty sampling points in five villages labelled as Bukkuyum 1, 2, 3,4 and 5 in the study area during peak period of dry and rainy seasons respectively. glass wares, polyethylene bottles, distilled water, concentrated HCl acid, beakers, hot plate, filter paper, volumetric flask, bucket, rope and clock watch were used throughout the experiment. Groundwater samples from borehole and hand-dug well were collected in April and August, 2017 which were the peak periods during dry and rainy seasons in accordance with standard

procedures by [4] from the study area. 5 borehole waters and 15 hand dug well water samples each were collected from different boreholes and hand dug wells in five endemic villages in Bukkuyum, LGA, this gave a total of 100 water samples all within the study area in Bukkuyum LGA, Zamfara state, Nigeria. The samples were collected in pre-cleaned one litter polyethylene plastic bottles and acidified with concentrated hydrochloric acid (HCl) to less than PH 2.0 and respectively labeled. Similarly, water samples from boreholes were also obtained directly from the water pump and each sample bottle with its cap was rinsed three times with the water sample. These water samples were subsequently stored at 4°C for a short time as possible before laboratory analysis to minimize physio-chemical changes [5]. Thereafter, the samples were transported to the laboratory in soil science department, Bayero University Kano, Nigeria for further analysis of parameters such as Chromium, Copper, Nickel, Lead and Zinc.

3.2 Digestion of prepared water samples

100ml of well mixed acid preserved water sample was transferred into a beaker and 5ml of concentrated HCl was added. The beaker was placed on a hot plate and allowed to evaporate to about 5ml without boiling, the sample was then allowed to cool before it was filtered through Whatman No. 4 filter paper. It was then diluted up to 100ml with distilled water in a volumetric flask which was then used in Atomic Absorption Spectrophotometer machine for analysis of the heavy metals involved.

3.3 Analysis of the prepared water samples

After digestion of the water samples, heavy metals of interest were assayed in the water sample using AAS 210GP in the laboratory. Volume of 25 ml of the prepared sample was aspirated into the electro-thermal device (Nebulizer – spray chamber) of AAS 210VGP machine where it was vaporized and atomized. Ratio of the proper wavelength is then passed through the vapor containing the ground state atoms of the metal where absorption occurs. The magnitude of the AAS absorption signal is directly proportional to the concentration of the analyte metal in the sample solution. This procedure was adopted for all the water samples [6]. The data obtained from laboratory analysis of the heavy metals were analyzed using simple descriptive statistics and the results are presented in the Table 1 and Figures 1 to 5.

4 RESULTS AND DISCUSSIONS

The analyzed results of concentration levels of heavy metals in ground waters (boreholes and wells) in the dry season and rainy season from Bukkuyum local government area of Zamfara State is presented in Table 1.

Table 1. Mean concentration levels of heavy metals in Groundwater samples of Bukkuyum in Zamfara State, Nigeria

Sample Location	Water Sample	No.	Elements (mg/L)	Dry Season Concentration		Rainy Season Concentration		WHO (2011)	NESREA (2011)
				range	mean	range	mean	STD	STD
Bukkuyum 1	Boreholes	5	Cr	0.029-0.072	0.061	0.015-0.059	0.039	0.05	0.05
	Wells	15	Cr	0.028-0.087	0.06	0.015-0.074	0.037	0.05	0.05
Bukkuyum 2	Boreholes	5	Cu	0.027-0.545	0.364	0.091-0.364	0.218	2	1
	Wells	15	Cu	0.091-0.364	0.273	0.091-0.273	0.164	2	1
Bukkuyum 3	Boreholes	5	Ni	0.027-0.082	0.035	0.014-0.055	0.027	0.07	0.06
	Wells	15	Ni	0.014-0.068	0.035	0.014-0.055	0.025	0.07	0.06
Bukkuyum 4	Boreholes	5	Pb	0.022-0.065	0.041	0.011-0.043	0.024	0.01	0.01
	wells	15	Pb	0.011-0.055	0.035	0.011-0.024	0.031	0.01	0.01
Bukkuyum 5	Borehole	5	Zn	0.011-0.027	0.15	0.036-0.143	0.079	5	4
	Wells	15	Zn	0.017-0.250	0.143	0.036-0.179	0.081	5	4

WHO = World Health Organization Standard, NESREA = National Environmental Standards and Regulation Enforcement Agency.

4.1 Levels of Chromium in Groundwater

The concentration levels of chromium in borehole water ranged from 0.029 to 0.072 mg/L with a mean value of 0.061 mg/L in the dry season, while a range value of 0.028 to 0.087 mg/L with a mean of 0.060 mg/L was observed in hand dug wells. In the rainy season, a range value of 0.015 to 0.059 mg/L with a mean value of 0.039 mg/L was observed in borehole waters, while in wells the value range of 0.015 to 0.074 mg/L with a mean of 0.037 mg/L was observed. The chromium concentration level values were observed to be higher in peak dry season than in the rainy season which could largely be attributed to dilution. However, the mean concentration levels of chromium irrespective of the season were observed to be above the World Health Organization limit of 0.05 mg/L indicating that pollution of chromium is evident in the ground water sources of Bukkuyum (Figure 1). The higher concentration of Chromium recorded in this study is far higher than the value of 0.01 mg/L of chromium reported by Mohammed and [7] for pollution of ground water sources of Mumbai and Bead district of India. The findings in our present study is however are in line with that of [8].

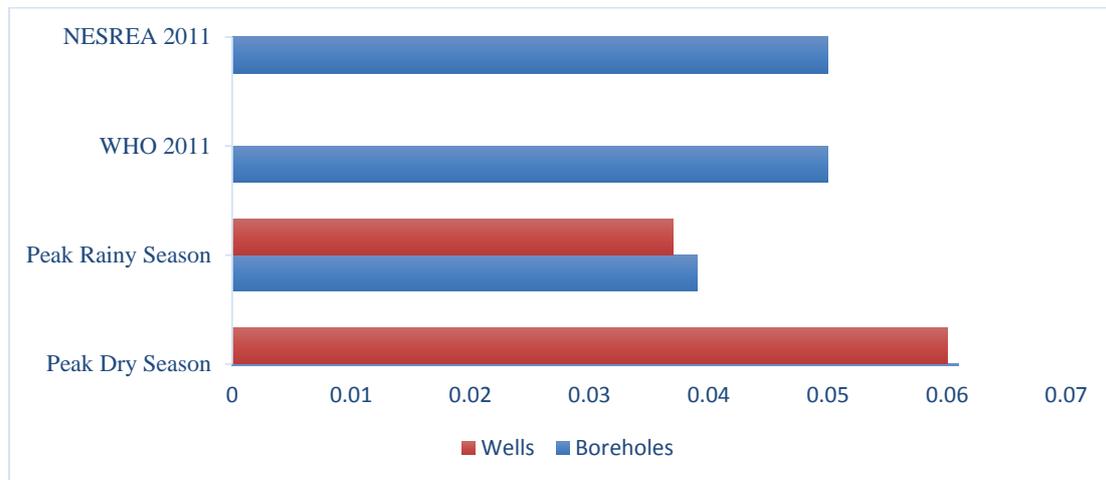


Figure 1. Mean concertation levels of Chromium in Boreholes and Hand Dug Wells in Bukkuyum

4.2 Levels of Copper in Groundwater

The concentration levels of copper recorded in this study for boreholes and wells ranged from 0.027 to 0.545mg/L with mean of 0.364mg/L and 0.091 to 0.364mg/L with mean of 0.273mg/L in the dry season, while during the rainy season, the concentration level range of 0.091 to 0.364mg/L with mean of 0.218mg/L and 0.091 to 0.273mg/L with mean of 0.164 mg/L were recorded respectively. The observed concentration levels of copper in groundwater are slightly lower than the limit of 1.0 mg/L of NESREA Standard indicating that interms of copper, no pollution is likely to be expected, however, in the long run the result is a pointer of a potential pollution unless remedial measures are taken quickly (Figure 2). [9] reported higher concentration of Cu, Cr, Pb and Cd for marine water from Lagos coastal areas to exhibit concentration higher than the acceptable limit of World Health Organization. The sources of copper that might possibly be responsible for the present high level of copper in groundwater could be attributed to anthropogenic activities, small scale iron smelting and industrial operation could increase the level of copper on the soil surface which in the long run percolate into the ground water to cause the possible groundwater pollution. Excessive dumping of wastes, without proper means of good adequate dispersal like a design landfill may also trigger groundwater pollution.

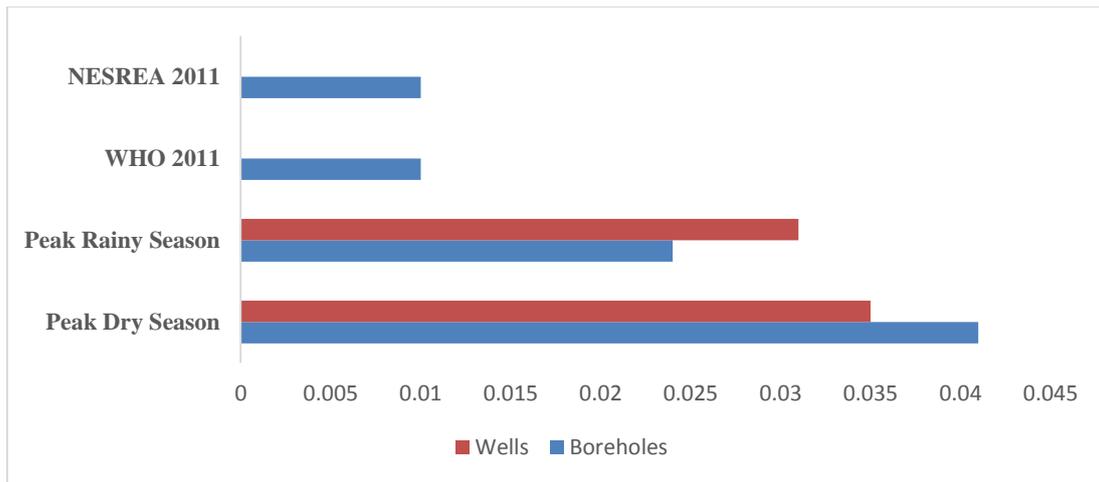


Figure 2. Mean concentration levels of Copper in Boreholes and Hand Dug Wells in Bukkuyum

4.3 Levels of Nickel in Groundwater

The observed concentration levels of nickel in boreholes and hand dug wells ranged from 0.027 to 0.082 mg/L with mean of 0.035 mg/L and 0.014 to 0.068 mg/L with mean of 0.035 mg/L in the dry season, while in the peak rainy season the range of 0.014 to 0.055 mg/L with mean value of 0.027 mg/L and 0.014 to 0.055 mg/L with a mean of 0.025 mg/L recorded. The same mean value of 0.035 mg/L was recorded in both boreholes and hand dug well waters in the dry season, but in the rainy season the concentration of Ni in borehole water are slightly higher than in the hand dug well water. This trend of result is indicating that the Ni pollution is from the same sources which dissolves more during the rainy season. However, the observed results are found below the WHO and NESREA standard of 0.07 mg/L and 0.06 mg/L indicating no nickel pollution for now in the water in respective of the seasonal variation. The results of Ni concentration levels in boreholes and hand dug wells obtained in our present study is lower than that reported by [10] who reported 15.30 mg/L of Ni in water and sediments from Ibadan in Oyo State. [11] also recorded similar lower nickel concentration of 1 to 2 mg/L in private wells in Saudi Arabia.

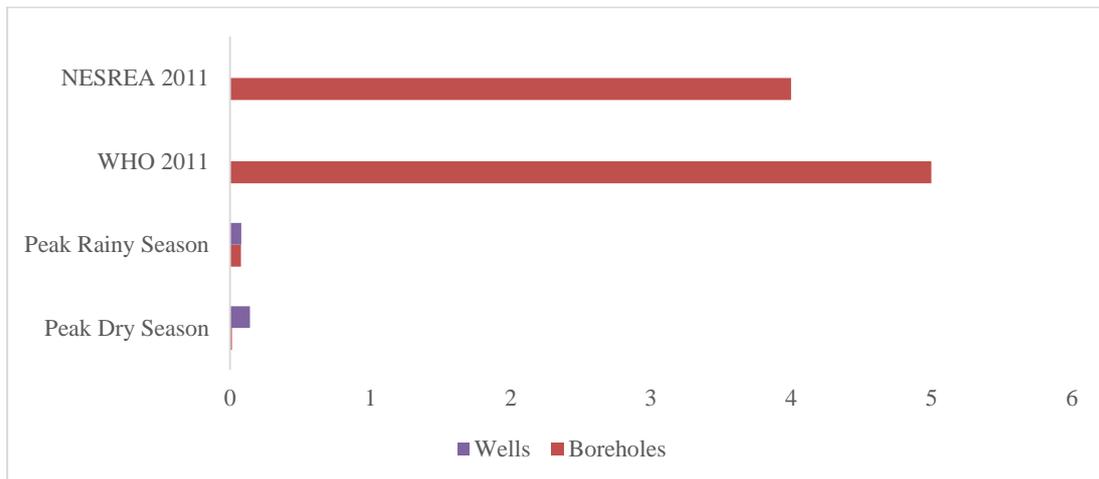


Figure 3. Mean concentration levels of Nickel in Boreholes and Hand Dug Wells in Bukkuyum

4.4 Levels of Lead in Groundwater

The concentration levels of lead in boreholes and hand dug wells in Bukkuyum ranged from 0.022 to 0.065mg/L with mean of 0.041mg/L and 0.011 to 0.055mg/L with mean of 0.035mg/L in the peak dry season, while the concentration range values of 0.011 to 0.043mg/L with mean of 0.024mg/L and 0.011 to 0.024mg/L with mean of 0.031mg/L were recorded in rainy season respectively(Table1). The observed concentration of lead in boreholes and wells in this study area are alarmingly higher than WHO and NESREA safe standard limit of 0.01mg/L concentration level (Figure 4). The

boreholes and hand dug wells waters from our present study indicated that groundwater in Bukkuyum are polluted with lead ions. This development of high concentration of lead in groundwater as noticed from our study is a potential public health hazards which could partly be attributed to the lead mine discovered in Zamfara State by Medecins Sans Frontieres (MSF- Holland) in March, 2010. Similar trend of results was also observed by [12, 13] studied the seasonal variation of heavy metal contamination of groundwater in and around Uyyakodan District of Tamil Nadu and Malwa region of Punjab in India.

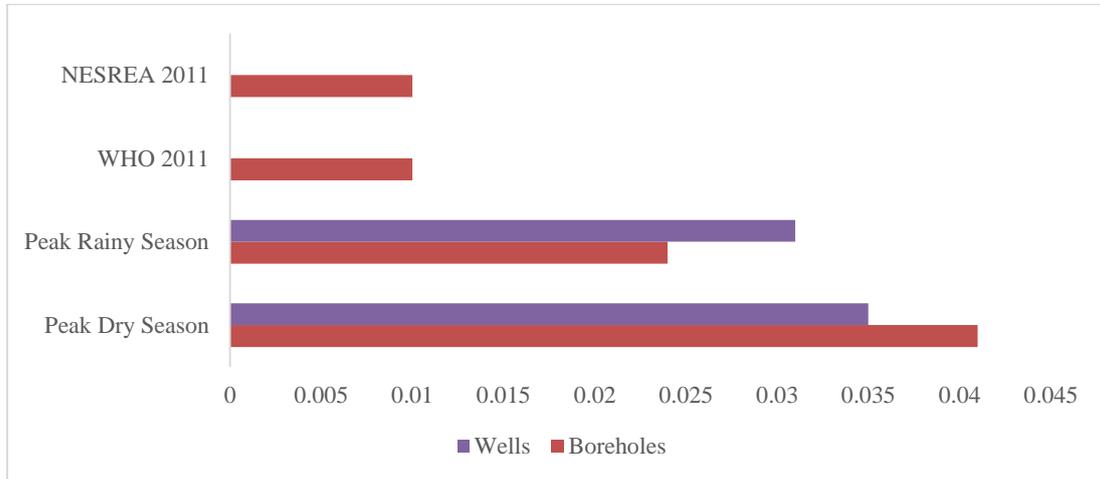


Figure 4. Mean concertation levels of Lead in Boreholes and Wells in Bukkuyum

4.5 Levels of Zinc in Groundwater

The concentration levels of Zn in boreholes and hand dug wells ranged from 0.011 to 0.027 mg/L with mean value of 0.151 mg/L and 0.036 to 0.143 mg/L with mean of 0.079 mg/L was recorded for peak period of dry season, while the concentration value range of 0.017 to 0.250 mg/L with mean of 0.143 mg/L and 0.036 to 0.179mg/L with mean of 0.081 mg/L was recorded for the peak period of the rainy season respectively. The recorded concentration levels of Zn in this study are all found to be below the permissible limit of 5.0 mg/L and 4.0 mg/L WHO and NESREA Standard. This finding in an indication that the study area has no excessive high Zn content in their groundwater sources and hence free of Zn pollution (Figure 5). The study of [14] is in line with our present findings who also reported lower level of Zn in the range of 0.073 to 1.67 mg/L in the study of heavy metal assessment of Zn in groundwater in Kaltungo local government area in Gombe State, Nigeria. Generally, the study area is not under any Zn contamination but might occur in the long run.

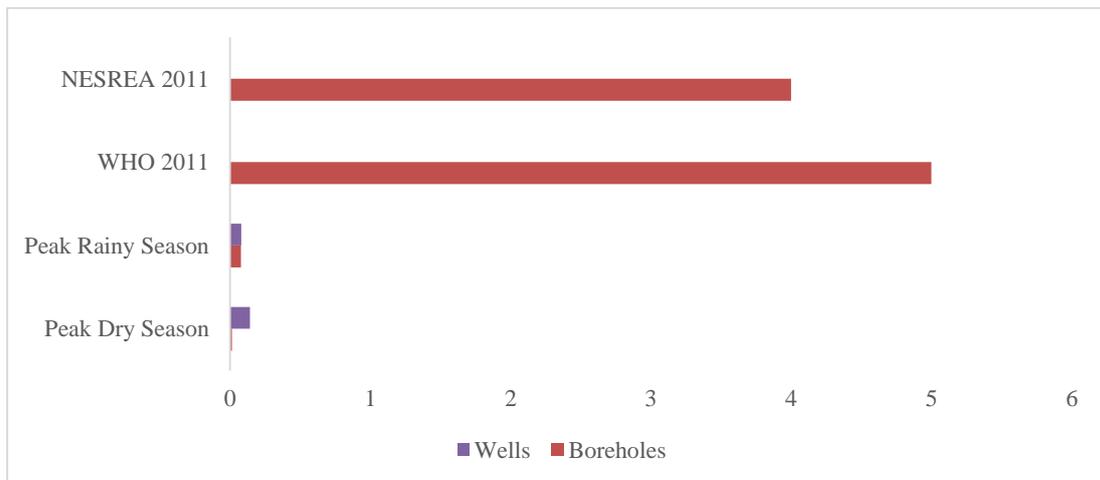


Figure 5. Mean concertation levels of Zinc in Boreholes and Hand Dug Wells in Bukkuyum

5 CONCLUSIONS

The concentration levels of heavy metals in groundwater in the lead mine affected area of Bukkuyum, Zamfara State were analyzed in the peak periods of dry season and rainy season to determine the level of pollution in boreholes and wells waters. The results recorded indicated that boreholes and hand dug wells are seriously tainted with chromium, Copper and lead at an alarmingly high level of pollution in terms of the observed heavy metals studied. The cumulative effect of this development in the long run could be disastrous as groundwater is the major source of water supply to Bukkuyum. The continuous exposure to this heavy metal tainted water through drinking and other household and domestic activities and other uses of the water is a serious cause for concern to the public health as the case of reported lead poisoning was on record from the area affected in Zamfara State. Urgent government intervention is required to provide an alternative mean of water supply to the affected areas of Zamfara State and Bukkuyum in particular to ensure that in the long run human body disorder that is associated with exposure to heavy metals are reduced to a minimum level.

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