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Research Article

Assessment of the levels of Cadmium and Lead in Wells and Boreholes water within Wukari, North-Eastern Nigeria

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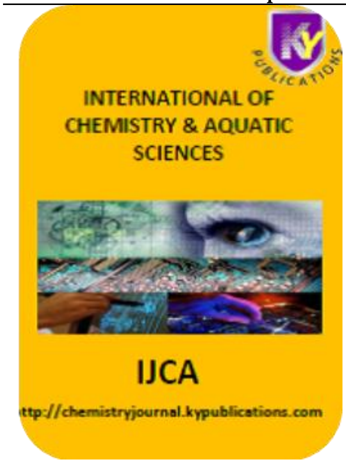

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ABSTRACT

The assessment of the levels of Cadmium (Cd) and Lead (Pb) in borehole and well water samples in Wukari, North-eastern Nigeria is presented in this study. Densely populated areas within the township were selected for this study. Mean values (Pb, mg/L) of 0.48 ± 0.02, 0.08±0.04, 0.46±0.41, 0.03 and 0.12±0.03 were recorded in borehole samples and 1.08± 0.11, 0.44±0.3, 0.214±0.04 and 0.12±0.03 in well water samples (excluding Mamara) for Ambassador(A), Old BB (B), Holy Spirit (H), Mission quarters (M) and Mamara (S) respectively. The mean levels of Cadmium (mg/L) found in borehole water samples were 0.015±0.005, 0.01, 0.026±0.06 and 0.02 in Ambassador, Old BB, Holy Spirit and Mamara areas respectively. Cadmium was not detected in all samples analyzed in borehole water from Mission quarters. For hand dug wells, mean levels were found as 0.10±0.01, 0.09±0.06, 0.22±0.34 and 0.026±0.008 for Ambassador, Old BB, Holy Spirit and Mission quarters respectively. Results obtained were compared with maximum permissible limits of WHO and indicate that some of the borehole water samples in areas some areas only meet up to the allowable limits. Hand dug well were generally found in this study to contain higher levels of lead and cadmium in all study areas.

INTRODUCTION

Contamination of water bodies has increasingly become an issue of serious environmental concern. Potable water is a necessary and limited resource that humans for daily activities (Silderberg, 2003). It is also, an essential requirement for good health (Udom et al., 2002), but it is lacking in many societies. All natural waters contain many dissolved salts and other unknown compounds. Contaminants such as bacteria, viruses, heavy metals, nitrates and salt have polluted water supplies as a result of anthropogenic activities and disposal of waste from humans and live stocks, industrial discharges, and indiscriminate use of limited water resources (Singh and Mosley, 2003).

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Predominant sources of contamination in streams, rivers and underground water arises from anthropogenic activities occasioned by the deplorable and non-compliant practices of factories, industries; leading to the discharge of effluents and untreated wastes. Water pollution affects water quality as well as aquatic biota (Sunnudo-Wilhelmy and Gill, 1999). Ground water pollution could be minimized by siting boreholes and wells far away from sources of potential environmental pollution. In event where no sources of anthropogenic contamination exist, it is likely that natural levels of metals and other chemicals can be injurious to human health. It has been reported that in Bangladesh where natural levels of arsenic in groundwater were found to be harmful to human consuming water from the source (Anawara et al., 2002). Unfortunately, this issue arose due to the lack of details survey or chemical investigations of the quality of the groundwater before being extracted for drinking. Water quality monitoring is quite essential for environmental and human safety, especially in developing countries where access to potable water is limited. Hence, the analyses of various water sources such as boreholes and hand dug wells to ascertain both their physical and chemical properties, including trace elements contents are significantly warranted and imperative for public health and safety (Kot et al., 2000).

Borehole water serves as the major source of drinking water in the local population of Nigeria, since only very few can afford and rely on purified and treated bottled water for consumption. Owners of boreholes capitalize on this opportunity to commercialize their boreholes which many resort to buying the bore holes water for drinking, since it is cheaper for them to afford. Therefore, this brings the imperativeness of examining the water quality parameters of borehole water and hand dug wells with special interest study on Wukari town in Taraba State, Northern Nigeria with a view to accessing their levels of purity from highly toxic heavy metals (Cadmium and Lead). This study tends to x-ray and estimate the levels of Cadmium and Lead only with a view to comparing them with international allowable standards as this will guide our decision on the quality and purity assessment of the bore holes and hand dug wells. We reported recently the assessment of the quality of harvested rainwater in Wukari and its environs (Achadu et al, 2013). This study is an extension of the environment safety assessment researches of the authors with the objective of public awareness and safety.

MATERIALS AND METHODS

Study area

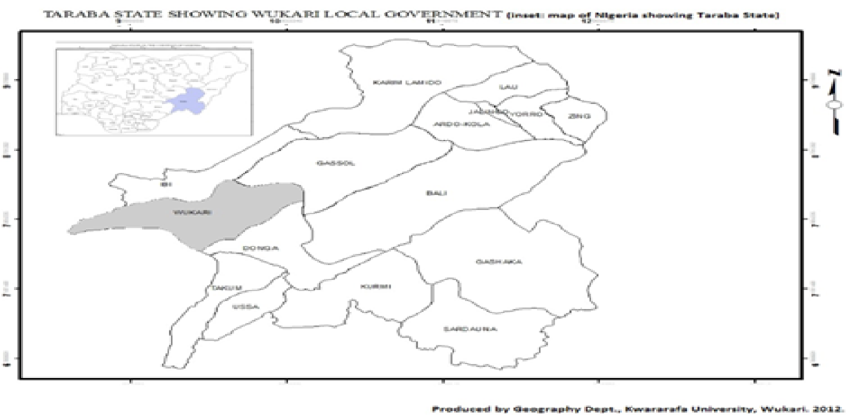

Figure 1. Map of Taraba state, North -eastern Nigeria showing Wukari LGA

Wukari is the study area and the headquarters of Wukari LGA in Taraba State. The town lies within the coordinates $7^{0}15$'N $9^{0}47$'E and 7.850^{0}N9.783^{0}E. It has an area of 4,308km^2 and a population of 214,546 (2006 census). Taraba state is situated in the North-eastern part of Nigeria and lies within the Northern guinea savannah belt. It has an annual rainfall of about 150mm-200mm with a mean temperature of 25^{0}C and a maximum temperature of 39^{0}C. Majority of the houses in Wukari are for residential, clinical, religious and educational purposes. Apart from bakeries and sites for local brewing, the town does not have industries or factories. The study area was chosen because of non-availability of public or private water mains in the area, the major source of water for domestic use are from hand dug wells and boreholes. The community relies extensively on hand dug wells and boreholes and during dry season they rely on the available harvested rainwater.

Sampling and sample locations

Sampling locations were selected based on the population distribution and density of Wukari. The samples areas were **Ambassador (A), Old BB (B), Holy Spirit (H), Mission quarters (M) and Mamara (S)** respectively. These areas were specifically chosen for the study because of the potential ground water pollution sites such as solid waste dump sites and high anthropogenic activities. A total of thirty nine (39) water samples were collected directly from the taps in the boreholes (**B)** and hand dug wells (**W**) into new white polyethylene stoppered bottles cleaned by soaking in 1% HNO_3 after which they were washed with soap solution and rinsed with distilled water and then with the bore hole and well water to be collected. The water samples were stoppered and labelled and other sampling protocol were carefully observed until the samples were analyzed. Samples code was used e.g. **MB1**- denoting Mission quarters borehole 1; **SW1**-Mamara well 1etc.

Heavy metals determination

Analysis for heavy metal determination was achieved by measuring 20 mL of each water sample into a beaker and 5ml of concentrated HNO_3 was added. The solution was evaporated to near dryness on a hot plate, making sure that the sample does not boil. The beaker containing the residue was cooled. 5 mL of conc. HNO_3 was further added and returned to the hot plate until digestion was completed (Ahn et al., 1996). 2 ml of conc. HNO_3 was added and the beaker warmed slightly to dissolve the residue. The digested sample was filtered and the filtrate made up to 50 ml mark with deionized water. The solutions were stored in a refrigerator prior to metal analysis using atomic absorption spectrophotometer (Perkin Elmer AA Analyst (USA)). Blanks were also prepared using the same procedure of digestion of the samples. Cadmium and Lead standards of various concentrations were prepared and used for the calibration of the AAS.

Statistical data treatment

Descriptive statistical analysis was employed for the data obtained. Mean, standard deviation and range were determined.

RESULTS AND DISCUSSION

Cadmium and lead were detected and some undetected in this study. The mean, standard deviations and range of results obtained from study areas for the borehole and hand dug well water are presented in Tables 1-5.

Lead (Pb)

Pb was detected in all samples except for borehole water samples in Mission quarters (MB2-MB5) (Table 4). The trend observed in all sampled locations showed elevated levels of Pb in well water samples as compared to the boreholes samples (Figs 2 and 3). The Ambassador area with high population density gave the highest mean level of 1.08±0.11 of Pb (Table 1). Well water due to their shallow nature often accommodate surface run offs containing leachates of these metals, and as such would usually contain higher levels of these metals and solids as compared with boreholes water.

The poor management of household wastes can be held culpable for these recorded levels of Pb in well water samples and this is very serious especially with regard to children for whom lead poisoning is more dangerous (Peden et al., 2009). Even at low doses may cause deleterious effects. It has been observed Pb poisoning in children causes change in the maturation of the nervous system with delayed motor development (Galaf and Ghannam, 2003), impaired memory and hearing problems (François-Henri et al., 2004). Lead can cause blood disorders, gastrointestinal, reproductive, and immunological and apoptotic disorders (Patrick, 2006; Xu et al., 2008).

The likely long term problems associated with chronic exposure to lead content in potable water are issues of considerable public concerns (Zietz et al., 2007). In this study, results of the water samples collected for Pb indicated that 20 of the well water and 13 borehole water samples contain Pb and of these, 12 of the well water and 3 of the borehole water samples representing 66.21% of the total, contained Pb in levels above the maximum contaminant level (0.1 mg/L) (WHO, 2006), with the maximum concentration detected being 1.23 mg/L. These results are of concern as Pb has been recognized for centuries as a cumulative general metabolic poison (Adepoju-Bello and Alabi, 2005). It is a neurotoxin and is responsible for the most common type of human metal toxicities (Berman, 1980). Also, studies have linked Pb exposures even at low levels with an increase in blood pressure (Zietz et al., 2007) as well as with reduced intelligence quotient (IQ) in children (Needleman, 1993) and with attention disorders (Yule and Rutter, 1985). Its high levels in the blood have been linked to violent behaviour and criminal tendencies (Masters et al, 1998).

Cadmium (Cd)

In the analysis of the water samples collected for Cadmium, nine (9) (**MB1-5** and **BB3-5**) of the collected water samples did not contain detectable levels of Cadmium (Table 2 and 4). However, of the 30 samples containing Cadmium, 36.67% of them were in concentrations above the maximum contaminant level (0.03mg/L) with the maximum concentration being 0.91 mg/L found at Holy Spirit area (H**W5**). Again, the levels of cadmium in well water samples were found to be higher than that for those boreholes water samples in which cadmium was detected (Fig.2). It should be noted that all the cadmium non detected samples were from the boreholes at Mission quarters and Old BB areas (Table 2 and 4).

These recorded levels of cadmium brings a lot of concerns due to the carcinogenic properties of Cd (Lauwerys, 1979) as well as a persistent accumulation in biological tissues (Orisakwe et al., 2006) leading to chronic effects as a result of accumulation in the liver and renal cortex (Hammer and Hammer Jr., 2004). It can result in the impairment of kidneys and other related health effects resulting from over exposure to high concentrations (Orisakwe et al., 2006). The garbage accumulated in dumpsites and leachates from adjacent farmlands where insecticides, herbicides and inorganic fertilizers are utilized produce leachates rich in lead and cadmium (Feuillade et al., 2001). But cadmium, unlike lead adsorbs weakly soil particles (Camobreco et al., 1996). It is easily mobile and leaches freely into the ground and contaminate groundwater (Richards et al., 1998). Excessive exposure to cadmium has been reported to lead to death in humans (Othumpangat et al., 2005). Cd can migrate into cells and accumulates in high concentrations in the cytoplasm where its accumulation is most favored in the livers and kidneys (Cai et al., 2001; Beyersmann et al., 1997).

Table 1. Results for Ambassador area

Sample ID	Pb (mg/L)	Cd (mg/L)
Borehole		
AB1	**0.50**	**0.02**
AB2	**0.46**	**0.01**
Mean±SD/Range	**0.48±0.02/0.04**	**0.015±0.005/0.01**
WELL		
AW1	**1.20**	**0.12**
AW2	**1.04**	**0.09**
AW3	**0.95**	**0.10**
AW4	**1.23**	**0.11**
AW5	**0.99**	**0.09**
Mean±SD/Range	**1.08±0.11/0.28**	**0.102±0.01/0.03**

Table 2. Results for OLD BB area

Sample ID	Pb (mg/L)	Cd (mg/L)
Borehole		
BB1	**0.12**	**0.01**
BB2	**0.10**	**0.01**
BB3	**ND**	**ND**
BB4	**ND**	**ND**
BB5	**0.02**	**ND**
Mean±SD/Range	**0.08±0.04**	**0.1**
WELL		
BW1	**0.20**	**0.02**
BW2	**0.25**	**0.01**
BW3	**0.15**	**0.09**
BW4	**0.40**	**0.15**
BW5	**1.20**	**0.18**
Mean±SD/Range	**0.44±0.3/1.05**	**0.09±0.06/0.17**

Table 3. Results for HOLY SPIRIT area

Sample ID	Pb (mg/L)	Cd (mg/L)
Borehole		
HB1	0.12	0.02
HB2	0.95	0.02
HB3	0.99	0.04
HB4	0.10	0.01
HB5	0.13	0.04
Mean±SD/Range	0.46±0.41/0.89	0.026±0.012/0.03
WELL		
HW1	0.25	0.02
HW2	0.20	0.03
HW3	0.19	0.09
HW4	0.15	0.08
HW5	0.28	0.91
Mean±SD/Range	0.214±0.04/0.13	0.226±0.34/0.89

Table 4. Results for MISSION quarters area

Sample ID	Pb (mg/L)	Cd (mg/L)
Borehole		
MB1	0.03	ND
MB2	ND	ND
MB3	ND	ND
MB4	ND	ND
MB5	ND	ND
Mean±SD/Range	0.03	-
WELL		
MW1	0.15	0.04
MW2	0.9	0.01
MW3	0.12	0.05
MW4	0.10	0.01
MW5	0.95	0.02
Mean±SD/Range	0.44±0.39/0.85	0.026±0.008/0.04

Table 5. Results for MAMARA area

Sample ID	Pb (mg/L)	Cd (mg/L)
Borehole		
SB1	0.15	0.03
SB2	0.09	0.01
Mean±SD/Range	0.12±0.03/0.06	0.02±0.01/0.02

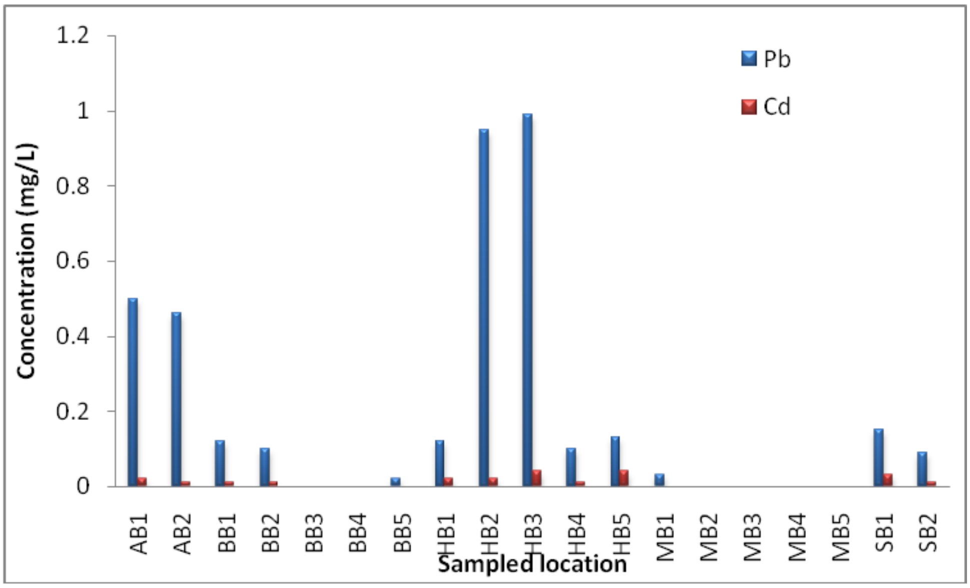

Fig. 2. Borehole water results

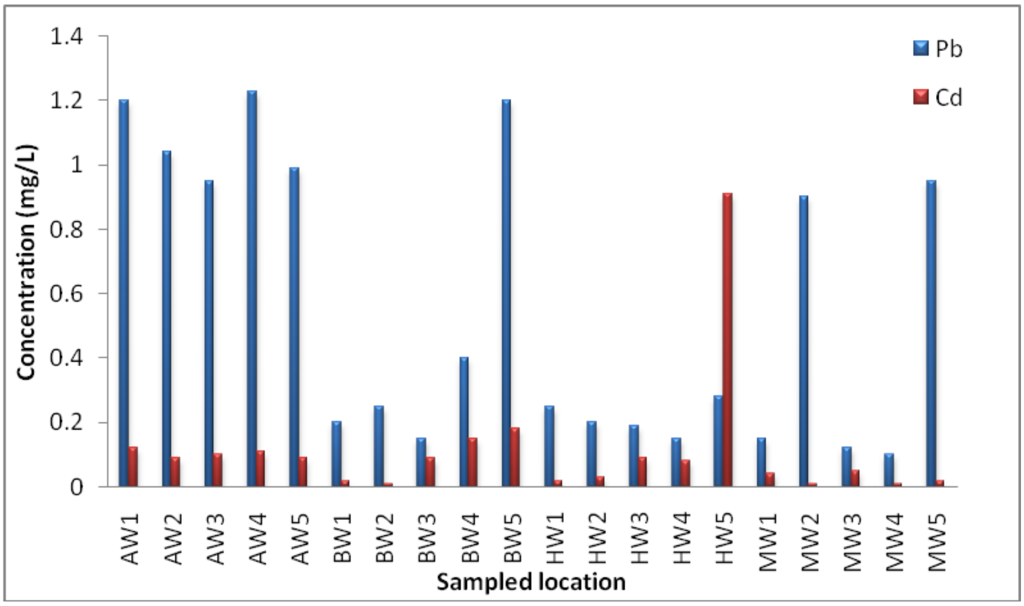

Fig. 3. Hand dug well water results

CONCLUSION

Cadmium and Lead levels in boreholes and hand dug well water within Wukari areas were assessed to evaluate the levels of these highly toxic metals. The borehole water samples were found to contain lower levels of Cd and Pb as compared to the well water samples within the same areas. Results were compared with the WHO and FEPA maximum allowable levels for drinking water showed some relatively higher levels of Cd and Pb in areas such **Holy Spirit** and **Ambassador** which are densely populated, hence high anthropogenic activities. It is therefore suggested and advised as a matter of health importance that the water from the boreholes and hand dug well be subjected to purification and treatment processes to reduce the metals levels before exposure to public use. Also, wells should be dug in strategic locations and be properly covered and shielded from surface run-offs.

RECOMMENDATION

It is recommended that appropriate regulatory agencies should carry out quality assessment of existing boreholes to ascertain their quality level of the water before allowing for public utilization.

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