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ANALYSIS OF HEAVY METALS IN SHALLOW WELLS IN MINNA METROPOLIS, NIGER STATE, NIGERIA

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ABSTRACT

Heavy metals present in groundwater from shallow wells in Minna metropolis, Nigeria, were analyzed. Lead, Cadmium and Chromium levels were determined from 27 water samples collected from nine different settlements within Minna metropolis. Results obtained showed that the average concentrations of the parameters assessed is in the range of 0.011 – 0.036 mg/l for Lead, 0.01 – 0.034 mg/l for Cadmium and 0.012 – 0.028 mg/l for Chromium. When compared to World Health Organization water quality standards, results showed that water from shallow wells in Minna metropolis met these guidelines. This is an indication that the groundwater in the sampled areas of Minna is not polluted and thus, safe for human consumption.

Keywords: Water quality, Shallow wells, Minna.

INTRODUCTION

Water is vital for all humans. It is their birthright. Humans depend on its good quality and quantity for drinking, recreation, use in industry and for the growth of plants and crops. It is also vital in sustaining the natural system on and under the Earth's surface. However, much of the world's population does not have access to safe drinking water. Even though, water covers 70% of the Earth's surface, only 2.5% of this water is fresh water (Ku, 1980; Ipinmoroti, 1993). Two thirds of this 2.5% fresh water are frozen in glaciers and polar ice caps. Of the over 6 billion people on Earth, about 1.5 billion people lack access to safe drinking water (Donald *et al.*, 1997). The problem of scarcity or insufficient potable drinking water is more pronounced in developing or third world countries (Ku, 1980; Bernard and Richard, 1993). In Nigeria for instance, Government can scarcely afford the cost of infrastructural outlay needed for the provision of potable water for her citizens, a teeming population of about 150 million people. The problem is further compounded by limited technology, insufficient technical inputs, poor maintenance culture (for existing water facilities) and poor requisite skills. Given that wells constitute a major source of water to majority of Nigerians, adequate attention must be given to this important source of drinking water. Contamination of water can be as a result of ingression of rain water into wells that are not properly covered or the lateral movement of polluted groundwater from sources of pollution such as pit latrines and septic tanks particularly in areas of high water tables. This gives rise to water borne diseases that kill more than 6 million children each year (Ipinmoroti, 1993; Hiscock, 1995; Okuo *et al.,* (2006; Duruibe *et al.,* 2007). Water from shallow wells must therefore be subjected to acceptable water quality standards. Ipinmoroti worked on the water quality of shallow wells located close to dump sites in Akure, Nigeria (Ipinmoroti, 1993). Okuo *et al*. (2006) carried out physico-chemical studies on surface and groundwaters of the Warri coastal aquifer (Okuo *et al.,* 2006). In a previous study carried out in 1989, the contamination of ground water from different sources arising from farming activities were noted (Headworth, 1989). Heavy metals were also noted to be significant contaminants of water bodies (Robert and Mari, 2003; Wanga *et al.,* 2010).

The provision of safe drinking water must be among the top priorities of any nation. Intake of polluted water kills more people today than other known terminal diseases such as cancer and HIV-AIDS (Gleick, 2002). It is therefore very important that water which will be useful to humans for drinking, domestic, industrial and agricultural purposes must be free of toxic substances and disease causing agents and should be in conformity with WHO standard (Table 1) (Schoeller, 1977; Robins, 1998; Fahad, 2011). This research work focuses on the assessment of water quality in shallow wells in nine major settlements in Minna metropolis of Niger State, Nigeria.

MATERIALS AND METHODS

Materials

The sample containers (50 cm^3 plastic containers) were washed properly with detergent, leached with dilute sulphuric acid and properly rinsed with distilled water. Water samples were collected from three random wells in each settlement giving a total of twenty seven samples from the nine selected settlements in Minna metropolis, Niger state, Nigeria. Collection of the samples was done manually. A transparent polythene material was placed on the top of the container before sealing with a tight fitting lid cover. This was done to prevent contamination of collected samples. Containers were labeled with sticky labels. Samples were collected in the month of March at the peak of the dry season. This is the period at which the highest concentrations of metals in the water bodies are expected.

Method

Lead, Cadmium, and Chromium were determined using Shimadzu 650 Atomic Absorption Spectrometer (AAS). Air – acetylene gas was used as the flame source and the samples were aspirated manually.

RESULTS AND DISCUSSION

Chart 1 shows the bar chart statistical representation of average values of Lead, Cadmium and Chromium that were obtained from the sampled locations, while Tables 2, 4 and

6 give the single factor ANOVA summary for lead, cadmium and chromium respectively, and Tables 3, 5 and 7 give the multiple correlations for lead, cadmium and chromium, respectively.

Table 1: WHO Water guidelines and standards

Parameters	WHO standards
pH	6.5 – 8.5
Conductivity	0- 3200 µs/cm
Total Dissolved Solids	0- 2000 mg/l
Nitrate	0- 100 mg/l
Sulphate	0- 400 mg/l
Alkalinity	< 200 mg/l
Total Hardness	200 – 250mg/l
Iron	< 1.0 mg/l
Magnesium	0 – 120 mg/l
Chloride	0 – 710 mg/l
Fluoride	< 2.4 mg/l
Lead	< 0.05 mg/l
Cadmium	0.01 – 0.1 mg/l
Chromium	< 0.05 mg/l

Source : Schoeller, 1977

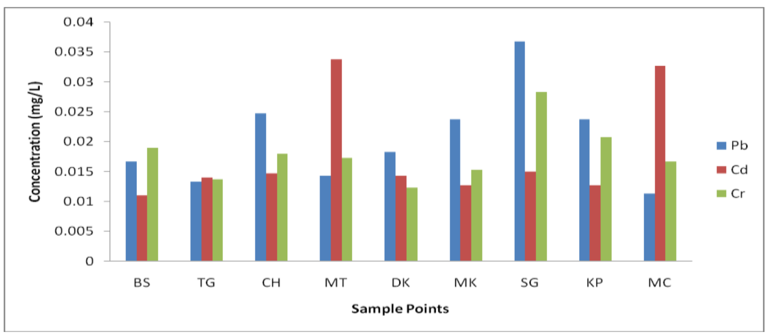

Chart 1: Plot of differences in average concentration of Lead, Chromium and Cadmium from sampled locations.

Table 2: Anova, Single Factor
(LEAD)
SUMMARY

Groups	Count	Sum	Average	Variance
BS	3	0.05	0.016667	3.33333E-05
TG	3	0.04	0.013333	3.33333E-05
CH	3	0.074	0.024667	2.23333E-05
MT	3	0.043	0.014333	2.63333E-05
DK	3	0.055	0.018333	5.23333E-05
MK	3	0.071	0.023667	0.000140333
SG	3	0.11	0.036667	0.000633333
KP	3	0.071	0.023667	3.03333E-05
MC	3	0.034	0.011333	2.33333E-06

ANOVA

Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	0.001474	8	0.000184	1.702087611	0.165911	2.510158
Within Groups	0.001948	18	0.000108			
Total	0.003422	26				

Table 3: Multiple Correlation (Lead)

	BS	TG	CH	MT	DK	MK	SG	KP	MC
BS	1								
TG	0.5	1							
CH	0.305424	-0.67193	1						
MT	-0.95632	-0.22502	-0.57042	1					
DK	-0.55866	0.438948	-0.96039	0.776699	1				
MK	-0.463	0.536107	-0.98542	0.701868	0.993802	1			
SG	-0.11471	0.802955	-0.98097	0.400075	0.888004	0.933617	1		
KP	-0.99587	-0.41931	-0.39061	0.978912	0.63165	0.541557	0.204419	1	
MC	-0.94491	-0.18898	-0.60028	0.999322	0.799368	0.727624	0.433555	0.970725	1

Table 4: Anova: Single Factor (Cadmium)

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
BS	3	0.033	0.011	0.000001
TG	3	0.042	0.014	2.8E-05
CH	3	0.044	0.014667	2.53333E-05
MT	3	0.101	0.033667	3.03333E-05
DK	3	0.043	0.014333	2.63333E-05
MK	3	0.038	0.012667	4.33333E-06
SG	3	0.045	0.015	0.000013
KP	3	0.038	0.012667	6.33333E-06
MC	3	0.098	0.032667	4.93333E-05

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.001847	8	0.000231	11.29528986	1.3E-05	2.510158
Within Groups	0.000368	18	2.04E-05			
Total	0.002215	26				

Table 5: Multiple Correlations (Cadmium)

	BS	*TG*	*CH*	*MT*	*DK*	*MK*	*SG*	*KP*	*MC*
BS	1								
TG	-0.94491	1							
CH	0.993399	-0.90113	1						
MT	-0.90784	0.995082	-0.85375	1					
DK	-0.97435	0.994333	-0.94211	0.978912	1				
MK	0.720577	-0.45392	0.795356	-0.36343	-0.54608	1			
SG	0.27735	0.052414	0.385727	0.151074	-0.05405	0.866025	1		
KP	0.993399	-0.97622	0.973684	-0.94995	-0.99373	0.636285	0.165312	1	
MC	-0.56949	0.807183	-0.47145	0.861685	0.739853	0.159586	0.631798	-0.66003	1

Table 6: Anova: Single Factor (Chromium)

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
BS	3	0.057	0.019	0.000103
TG	3	0.041	0.013667	3.03333E-05
CH	3	0.054	0.018	1.9E-05
MT	3	0.052	0.017333	3.03333E-05
DK	3	0.037	0.012333	1.03333E-05
MK	3	0.046	0.015333	1.43333E-05
SG	3	0.085	0.028333	5.43333E-05
KP	3	0.062	0.020667	0.000110333
MC	3	0.05	0.016667	0.000133333

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.000525	8	6.56E-05	1.169195251	0.368748	2.510158
Within Groups	0.001011	18	5.61E-05			
Total	0.001536	26				

Table 7: Multiple Correlations (Chromium)

	BS	*TG*	*CH*	*MT*	*DK*	*MK*	*SG*	*KP*	*MC*
BS	1								
TG	0.966084	1							
CH	0.689453	0.479028	1						
MT	0.259412	0.5	-0.52068	1					
DK	-0.65902	-0.44245	-0.99915	0.555419	1				
MK	-0.88488	-0.97516	-0.27269	-0.67941	0.232811	1			
SG	-0.98919	-0.99351	-0.57579	-0.39822	0.541609	0.943624	1		
KP	0.980267	0.895975	0.819032	0.063381	-0.7947	-0.77534	-0.94068	1	
MC	-0.76799	-0.57656	-0.9934	0.419314	0.987829	0.381246	0.665771	-0.87944	1

DISCUSSION

The analysis for the presence of some toxic metals in groundwater samples from Minna shallow wells was studied. As observed in Chart 1, results obtained show that there are minimal levels of Lead, Cadmium and Chromium in Minna groundwater samples. The World Health Organization water quality standards for Lead and chromium are < 0.05 mg/l with cadmium having a value in the range 0.01 – 0.1 mg/l. As seen from the statistical analysis in Table 2, Table 4 and Table 6, the highest average concentration of Lead (0.036 mg/l) and Chromium (0.028 mg/l) was observed in well water from Sabongari, and highest average concentration of Cadmium (0.034 mg/l) was observed in Maitumbi. The lowest concentrations of lead (0.01133 mg/l), cadmium (0.01100 mg/l) and chromium (0.01233 mg/l) were observed at Minna Central (MC), Bosso and Dutsen Kura, respectively. The results show that wells in these locations have very little amounts of toxic heavy metals, thus indicating compliance with WHO water quality standards and making the water safe for consumption and for other human, plant and animal use. The multiple correlations tables as given in Table 4, Table 6 and Table 8 also show a correlation between the different sampled locations, attesting to the fact that the quality of ground waters in these locations are possibly affected by the same natural and anthropogenic sources.

It is known that chromium enters the environment from old mining operations runoff and leaching into ground water, fossil fuel combustion, and cement plant emissions, mineral leaching, and waste incinerator. Use in metal plating and as a cooling tower water additive (Gump *et al.,* 2008; Kavcar *et al.,* 2009). Chromium III is a nutritionally essential element while Chromium VI is toxic and causes liver and kidney damage, internal hemorrhaging, respiratory damage, dermatitis, and ulcers on the skin at high concentrations (Kavcar *et al.,* 2009).

Cadmium is found in low concentrations in rocks, coal, and petroleum deposits and enters the ground and surface water when dissolved by acidic waters. It may enter the environment from industrial discharge, mining waste, metal plating, water pipes, batteries, paints and pigments, plastic stabilizers, and landfill leachate. Cadmium replaces zinc biochemically in the body and causes high blood pressure, liver and kidney damage and anemia. It destroys testicular tissue and red blood cells. It is also toxic to aquatic biota (Nordberg *et al.,* 2002; Duruibe *et al.,* 2007). Lead enters the environment from a number of industrial activities, mining, plumbing, gasoline, coal, and as a water additive. It also has a negative effect on the chemistry of the red blood cells. It delays normal physical and mental development in babies and young children, and causes slight reduction in attention span in children. It can cause slight increase in blood pressure in some adults and is a possible carcinogen (Gump *et al.,* 2008; Jusko *et al.,* 2008; Kim *et al.,* 2011).

CONCLUSSION

The geography of Minna metropolis in Niger state, Nigeria, gives a glimpse of possible reasons why the ground water from shallow wells does not indicate the presence these heavy metals. Wherever these heavy metals have been found in reasonable quantities in water, the use of such groundwater becomes perilous or at best difficult (Carpenter *et al.,* 1998). This assessment shows that the measured parameters are all within the limits of WHO water quality standards. This indicates that the geography of Niger state, Nigeria, allows for good groundwater recharge or deep drainage or deep percolation. Chromium, cadmium and lead are known to enter the environment from industrial and anthropogenic activities such as old mining operations, runoffs and leaching into ground water, fossil fuel combustion, cement plant disposals, waste incinerators, plumbing, metal plating and landfill leachates. These all contribute to the amount of the heavy metals that can be found in the environment. Minna is however known to have very few of these industrial activities leading to lower levels of chromium, cadmium and lead contamination.

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