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The Concentration of Cadmium in Borehole and Well Waters in Zaria, Nigeria

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Abstract: The purpose of this study was to investigate whether the level of inorganic chemical cadmium (Cd) in wells and boreholes water in Zaria is sufficient to affect the health of the inhabitants of the area under study. Sixty open wells and 5 boreholes were randomly selected from Zaria and environs. Water samples were collected from the open wells and boreholes using standard techniques. In the study, Cd concentrations of the samples was determined using standard procedures. WHO acceptable limit for drinking water was used in the evaluation. Result obtained shows that Cd concentrations ranged from <0.001 to 0.28 mg L^{-1} with 68% of the samples above the WHO water guideline. Most of the open wells and boreholes water studied were contaminated with abnormal concentration of cadmium sufficient enough to affect the health of the inhabitants of the area.

Key words: Cadmium, open wells, boreholes, Zaria, health

INTRODUCTION

The quality of ground water in an area is highly affected by human activities in the area, rain fall level and natural processes occurring in the area (WHO, 1998a, b; Sajjad *et al*., 1998; Patrick *et al*., 2002). Previous studies have shown possible contamination of ground water in Zaria. Yakasai *et al*. (2004) observed the high level of lead (Pb) in Ahmadu Bello University Dam and also in ground water, open wells and boreholes (Musa *et al*., 2004).

However, human activities have drastically altered the biochemical and geochemical cycles and balance of some heavy metals. The principal man made source of heavy metals are industrial plant sources such as mines, foundries and smelters and diffuse sources such as combustion by-product, explosives, electrical appliances, batteries and traffic emissions. Adequate supply of water which is chemically, physically and microbiologically wholesome is necessary for human and animal survival and health benefits (WHO, 1996; Ejikeme, 2003). In most developing nations, people are not opportuned to have access to safe drinking water (Ejikeme, 2003) in Zaria due to problem of drinking water scarcity, people collect water from surfaces and/or shallow wells.

The tap pumps are mostly not operational where provided. Therefore, most of the populace really heavily on untreated wells groundwater, stream as sources of drinking water and the authorities concern are not taken serious measures in order to address the issue of adequate drinking water for the area, therefore it become necessary to investigate the chemical content of drinking water in our environment.

In this study effort as made to determine the concentration of cadmium in wells and boreholes water in Zaria, Nigeria and environs, to ascertain weather the level of in organic chemical cadmium as contaminant in well and boreholes in selected areas of Zaria is sufficient to effect the health of the people of the area.

MATERIALS AND METHODS

Reagents and chemicals used in this study were of analytical grade. Atomic Absorption Spectrophotometer (AAS) equipped with cadmium hollowed cathode lamp, lamp current 10 mA, wavelength 217.0 nm, Band Pass 0.5 nm with flame type consisting of Air/Acetylene and stochiometric fuel flow at 0.9-1.21 min. The concentration of cadmium was determined by comparison of its absorbance with that of the standard.

Sampling of water: Water samples were collected from 5 boreholes and 60 shallow wells distributed evenly

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throughout Zaria town including Gyallesu, Banzazzau, Magume, Tudunwada, Tukur-Tukur Village, Zaria City and Tudun Jukun area of Zaria, Kaduna State, Nigeria. The samples were collected daily between 10th to 15th February 2003. Established. Preservation and storage were used to ensure that sample were of ground water quality.

The method of analysis was consistent with that of (Musa *et al*., 2004). In evaluating the concentration of cadmium in the ground/well water, World Heath Organization (WHO) permissible limits were applied (WHO, 1996, 1998a, b).

Preparation of calibration graph: Solutions of 0.40, 0.08, 0.12, 0.16 and 0.20 mg L^{-1} of cadmium standards were prepared, so as to obtain a calibration curve, 100 mL of each of this standard solutions was adjusted to pH of between 2.2 to 2.8 by adding 1.0 mL of 1 M trioxonitrate (V) acid (HNO_3). Each standard solution and blank was transferred into an individual 250 mL separatory funnel. One milliliter ammonium pyrolidine dithiocarbamate was added followed by the addition of 10 mL methyl isobutyl ketone (MIBK) and the solution was shaken vigorously for 2 min. The separating funnel was allowed to stand to let it separate into aqueous and organic layers. The aqueous layer was drained off and discarded. The organic layer was then drained into a 10 mL glass stoppered graduated cylinder. The organic extract was aspirated directly into the flame (zeroing the instrument on methyl isobutyl ketone) and the absorbance was recorded. The nebuliser, atomizer and burner was flushed each time with distilled water each sample solution was aspirated before the next. The instrument's stability was also checked at intervals by introducing the highest working standard solution and the blank.

Preparation of samples solution for the determination of cadmium: All samples were collected directly into polyethylene bottles and were not filtered. Samples were analysed for pH immediately after the collection by glass electrode, preserved by acidification to pH<2 with 18.6% w/w HNO_3 and stored in ice-packed coolers. The temperature of all stored samples was maintained at 0 to 4°C until immediately before analysis.

Procedure for pre-treating water sample for the determination of cadmium: The water samples were initially pretreated in the following ways before the final analysis. Beakers were thoroughly washed and dried in the oven and later cooled. The initial weights of empty clean beakers noted, 100 mL aliquot of the water samples was poured into the beaker. The beaker was then placed on a hot plate and the water sample evaporated to dryness. The beaker was then cooled in a desiccators and the final weight of the beaker was recorded. The differences in weight recorded and the residue removed from the beaker, weighed and kept in a desiccators for further analysis. 0.2 g of the pretreated sediment that was kept in a desiccators was taken into 184 plastic beakers. Five milliliter of deionised water was then added to dampen the sample, 6 mL of concentrated nitric acid (HNO_3) was also added followed by 1 mL of perchloric acid. The mixture was heated on a water bath until there was appearance of white fumes then allowed to cool.

After cooling 1 mL of perchloric acid and 5 mL hydrofluoric acid were added and the mixture was heated on a steam bath until evaporated to dryness and then cooled. Six milliliter of 6 M HNO_3 then added after the cooling and the resulting mixture boiled for 10 min. The mixture was then filtered and made up to 100 mL with deionised water in a 100 mL volumetric flask. The sample solutions were then analysed as described under preparation for calibration graph.

RESULTS AND DISCUSSION

Exposure to inorganic chemicals like Cadmium in our environments lead to inadvent poisoning and health hazard. Because the metal is toxic and it has a cumulative effect (Ferrer *et al*., 2000; Klaassen, 2001). The heavy metals are stable and cannot be degraded or destroyed, therefore, they tend to accumulate in soils and sediments. However, human activities have drastically altered the concentration of these metals in the environment. The principal manmade are industrial point source and diffuse sources such as combustion by-products, explosives, electrical appliances, batteries, traffic and a lot of others (Patrick *et al*., 2002; Yakasai *et al*., 2004).

The result of this study indicates the presence of high concentration of Cadmium contaminants in the water samples analysed (Table 1 and 2). It was observed that in areas such as Tudun Wada, Tudun Jukun, BanZazzau and Wusasa, there was high concentration of cadmium in the water samples analysed between 0.02 to 0.28 mg L^{-1} which was very high compared with WHO 0.003 mg L^{-1} permissible limit, the concentrations were as much as more than 10 times the acceptable limit. The result appeared different in Zaria city area where there is low level of Cd compared with Tudun wada and Gyallesu/Kongo area with concentrations of Cd between 0.01 to 0.07 mg L^{-1}. The boreholes and open wells at Tukur Tukur had much higher levels of Cd than the only borehole at Kongo/FCE where Cd was detected.

It was observed that the open wells have much higher concentrations of Cd than the borehole water.

Table 1: Concentrations (mg L^{-1}) of cadmium in selected open wells in Zaria and environs

Areas where samples	Water samples collected	FEPA permissible limit (mg L^{-1})	WHO permissible limit (mg L^{-1})	Mean content of Cd in the samples mg L^{-1} (ppm)
BanZazzau/Unguwan Kaya	1 TO 6	0.01	0.003	0.0817± (0.06)
Gyallesu/Kongo	7 TO16	0.01	0.003	0.0270± (0.02)
Magume	17 TO 20	0.01	0.003	0.0020± (0.00070)
Tudun Jukun/Gaskiya	21 TO 31	0.01	0.003	0.0270± (0.04)
		1.00		
Tudun Wada	32 TO 39	0.01	0.003	0.1230± (0.08)
Wusasa/Tukur Tukur	40 TO 49	0.01	0.003	0.0730± (0.07)
Zaria city	50 TO 60	0.01	0.003	0.0020± (0.001)

Standard deviation in parenthesis

Table 2: Concentration (mg L^{-1}) of cadmium in selected boreholes in Zaria and environs

Borehole sites		FEPA permissible limit	WHO permissible limit	Mean content of Cd in the samples
		(mg L^{-1})		
Kongo/FCE	1	0.01	0.003	0.001± (0.00)
Kongo/FCE	1	0.01	0.003	ND
Nuhu Bamalli Polytechnic	3	0.01	0.003	0.022± (0.00)
Tukur Tukur	4	0.01	0.003	0.002± (0.00)
Wusasa	5	0.01	0.003	0.003± (0.00)

ND: Not Detected, Standard deviation in parenthesis

Samples studied, this might be associated with deepness of the well and the possibility of contaminants getting into the well. In some open wells and boreholes studied, no Cd concentration was detected, this might be due to the nature, processes and anthropogenicity of the area (Patrick *et al.*, 2002; Ejikeme, 2003).

The possible reason for the presence of high concentration of Cd in borehole and open well water in Zaria areas of Tukur Tukur, Tudun Wada, Tudun Jukun and Ban Zazzau are uncertain. It is likely due to natural processes, anthropogenic activities, method of waste disposal, human activities and agricultural practice in the areas (WHO, 1998a, b; Patrict *et al.*, 2002; Ejikeme, 2003).

Occurrence of high concentrations of toxic chemical like Cadmium in drinking water may cause either acute or chronic health problems. Acute toxicity such as nausea, vomiting, dizziness and in the extreme death usually follow large doses of the chemical and occur almost immediately (Klaassen, 2001), accumulation in tissues in proportionate to its consumptions (WHO, 1998a, b; Rhode and Hartmann, 1980). It is a public health danger as its chronic effects can cause renal dysfunction, cancer, testicular necrosis, arteriosclerosis, central nervous system damage, damage to the immune system and the inhibition of growth both in animals and humans (Klaassen, 2001; Shelton, 2002). Also impairment of male fertility (Waakes *et al.*, 1992).

It was observed that Cd and other heavy metals concentrations in ground water depends on the proximity of the water source to roads with high traffic density, industrial processes such as metal melting and refining coal and oil fired power stations, electroplating plants, degree of urbanization of the area concerned, topography, climatic conditions and solid waste disposals (Yakasai *et al.*, 2004).

Sources of cadmium and other heavy contamination in ground water: The possible source of cadmium metal contamination of the wells are uncertain. It is likely due:

- Natural process and anthropogenic activities and open wells are cited indiscriminately in Zaria without proper geological survey.
- Increase in human activities indiscriminately refuse and waste disposal and septic tanks, soakaways and farming habits.
- Industrial point source, mines, smelters.
- Diffuse sources, such as combustion by-products, explosive, electrical appliances, batteries and traffic.

CONCLUSIONS AND RECOMMENDATIONS

Water is life and access to good quality water cannot be overemphasized. The study revealed the presence of high amount of cadmium as impurity in ground water for drinking in areas of Zaria especially Tudun Wada and Kubanni areas, while almost zero concentration in some areas like Zaria city and Magume.

However, it was observed that most boreholes and open wells in the areas of Zaria and environs were contaminated with abnormal levels of Cd. The necessitate urgent attention to the following recommendations:

- There is need for proper monitoring and efficient method of management of waste disposal in the area by the constituted authorities concerned.

- There is need for public health education as regard to environmental sanitation and pollution control.
- Further studies will be very important and necessary to determine the prevalence of diseases associated with Cd and other inorganic chemicals in Tudun Wada, Tudun Jukun and Ban Zazzau as the residence are exposed to health hazards. Studies to determine the prevalence of diseases associated with cadmium and other inorganic chemicals such as kidney diseases, hypertension, anaemia, liver diseases, GIT diseases, reduced fertility, blood and cancer.
- Boreholes and open wells should not be sited indiscriminately in the areas without making proper geological surveys and studies.
- There should be proper placement and localization of small, medium and large scale industries in the area such as industrial layout.
- There should be policies, bye-law and edicts as regard to control and reduction of smokes from exhaust emission by machineries and automobiles in the area in order to reduce pollution from smoke.
- The government must seriously give the desired adequate attention to the supply of potable water to the inhabitants of the city.
- Routine monitoring of the ground and human activities within the city by the relevant government agencies should ensure a reduction of the level of pollution of the waters.
- Urgent need for public enlightenment on the need to treat boreholes and well water before drinking.
- Drilling deeper tubewells and appropriate treatment system.

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