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Determination of Arsenic Concentration in Well and Borehole Waters in Zaria, Nigeria

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Abstract: The objective of this research is to determine the concentration of arsenic in wells and boreholes water in Zaria, to see whether the concentration level is sufficient enough to affect the health of the people living in the area under study. In this study arsenic concentrations of sixty well and five bore hole water samples collected from Zaria and environs were determined using standard procedures. The results obtained shows that arsenic concentrations ranged from <0.002 to 0.51 mg L^{-1} , with 75% of the samples above the World Health Organization drinking water guideline. Bore whole water samples were found to contain less arsenic compared with the shallow well water samples studied. Most wells and boreholes in Zaria were found to be contaminated with abnormal concentration of arsenic sufficient enough to cause serious health hazards to the users.

Key words: Limit, arsenic, well water, borehole water

INTRODUCTION

Arsenic and other heavy metals are toxic and their toxic effects are cumulative (Musa, 2003). It is necessary to put a measure, of reducing heavy metals contamination in drinking water. Adequate supply of water which is chemically, physically and microbiologically wholesome is necessary for man's progress and health benefit (WHO, 1993, 1996, 1998a; Ejikeme, 2003). The chemical quality of drinking water is becoming an increasing cause of concern Globally especially in industrialized nations and urban cities. This is due to environmental pollution from toxic chemicals and wastes from industries, insecticides, smokes from machineries and improper sewage and waste disposals in cities, these discharged drain downwards, polluting underground water supplies, However, the potential or intensity for contaminating drinking water depends upon several factors including rainfall level the method of waste disposal, human activities and agricultural practice in the area (WHO, 1998b).

Water for human consumption should be free from chemicals and microbiological contamination unfortunately in developing Nations most people are not opportune to have access to such safe drinking water, in

Zaria due to chronic drinking water scarcity people normally collect water from surfaces and shallow wells. The tap pumps are mostly not operational where provided. Therefore most of the populace rely 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 was made to determine the concentration of Arsenic in wells and boreholes water in Zaria, Nigeria and environs, to ascertain whether the level of inorganic chemical Arsenic 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 lead hollowed cathode lamp, lamp current 10 mA, wavelength 217.0 NM, Band Pass 0.5 nm with flame type consisting of Air/Acetylene and stoichiometric fuel flow at 0.9-1.21 min.

Sampling of water: Water samples were collected from five boreholes and sixty shallow wells distributed evenly 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 samples were of ground water quality.

Two liters of water samples were in each case taken directly in different plastic containers and preserved. Immediately with 10 mL 1% nitric acid. The samples were kept in a refrigerator while awaiting analysis (Apha, 1995; Storm and Morgan, 1981).

Procedure

Preparation of calibration graph: Solutions of 0.40, 0.80, 0.12, 0.16 and 0.20 mg L⁻¹ of arsenic standard 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 (HNO₃). Each standard solution and blank was transferred into an individual 250 mL separatory funnel. One milliliter ammonium pyrrolidine 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 arsenic: 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 HNO₃ 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 pretreating water sample for the determination of arsenic: 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 one hundred and eighty four plastic beakers. Five milliliter of deionised water was then added to dampen the sample, 6 mL of concentrated nitric acid (HNO₃) 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 hydrochloric acid were added the mixture was heated on a steam bath until evaporated to dryness then cooled. Six milliliter of 6 M HNO₃ 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

Arsenic concentrations in water much depend on source of arsenic contamination which may be as a result of natural processes, anthropogenic activities and increase human activities in the area. It also depend on level of rain fall and method of waste disposal in the area.

In this study about seventy five percent of the samples collected showed high content of arsenic above the 0.01 mg L⁻¹ World Health Organization (WHO) drinking water guideline (Table 1). This indicate that there is high arsenic contamination of well and borehole water in Zaria.

The arsenic distribution in well water analysed followed a pattern of high concentrations (0.02 to 0.51 mg L⁻¹). Since the values obtained are far above the allowable limits in potable water 0.01 mg L⁻¹. The possible sources of arsenic metal contaminants of the open wells in the area are uncertain. It is like due to disposal of arsenic containing materials, burning of solid wastes, natural processes, agricultural activities and other human activities in the area.

The arsenic distribution in borehole water analysed followed a pattern of low concentrations (0.002 to 0.008 mg L⁻¹) despite the fact that the water came from the same area, this might be associated with deepness of the

Table 1: The Arsenic contents of different well waters sample collected

Areas where samples were collected	Water samples collected	WHO permissible (mg L ⁻¹)	FEPA permissible criteria (mg L ⁻¹)	Mean content of Arsenic in the samples mg L ⁻¹ (ppm)
Zaria City	1	0.01	0.05	0.43
	2	“	“	0.48
	3	“	“	0.35
	4	“	“	0.39
	5	“	“	0.08
	6	“	“	0.18
	7	“	“	0.40
	8	“	“	0.45
	9	“	“	0.33
	10	“	“	0.40
Tudun wada	11	0.01	0.05	0.36
	12	0.01	0.05	0.31
	13	0.01	0.05	0.42
	14	0.01	0.05	0.29
	15	0.01	0.05	0.21
	16	0.01	0.05	0.38
	17	0.01	0.05	0.51
	18	0.01	0.05	0.26
Tudun Jukun/Gaskiya	19	0.01	0.05	0.004
	20	0.01	0.05	0.006
	21	0.01	0.05	0.009
	22	0.01	0.05	0.005
	23	0.01	0.05	0.06
	24	0.01	0.05	0.02
	25	0.01	0.05	0.39
	26	0.01	0.05	0.003
	27	0.01	0.05	0.008
	28	0.01	0.05	0.084
Gyellesu/Congo	29	0.01	0.05	0.038
	30	0.01	0.05	0.86
	31	0.01	0.05	0.346
	32	0.01	0.05	0.500
Gyellesu/Kongo	33	0.01	0.05	0.287
	34	0.01	0.05	0.361
	35	0.01	0.05	0.003
	36	0.01	0.05	0.089
	37	0.01	0.05	0.051
	38	0.01	0.05	0.069
	39	0.01	0.05	0.40
	40	0.01	0.05	0.007
Banzazzau/Ungawan Kaya	41	0.01	0.05	0.38
	42	0.01	0.05	0.41
	43	0.01	0.05	0.50
	44	0.01	0.05	0.28
	45	0.01	0.05	0.031
	46	0.01	0.05	0.095
Magume	47	0.01	0.05	0.43
	48	0.01	0.05	0.36
	49	0.01	0.05	0.28
	50	0.01	0.05	0.48
Wusasa/Tukur Tukur	51	0.01	0.05	0.36
	52	0.01	0.05	0.009
	53	0.01	0.05	0.004
	54	0.01	0.05	0.003
	55	0.01	0.05	0.41
	56	0.01	0.05	0.50
	57	0.01	0.05	0.36
	58	0.01	0.05	0.26
	59	0.01	0.05	0.39
	60	0.01	0.05	0.45
Borehole site		WHO permissible criteria (mg L ⁻¹)	FEPA permissible criteria (mg L ⁻¹)	Mean content of Arsenic in the sample (mg L ⁻¹)
Congo/FCE	1	0.01	0.05	0.002
Congo/FCE	2	0.01	0.05	0.008
Nuhu Bamalli Polytechnic	3	0.01	0.05	0.002
Wusasa	4	0.01	0.05	0.007
Tukur Tukur	5	0.01	0.05	0.0053

well, geological survey usually conducted before siting search boreholes wells and the impossibility of impurities getting into the well (Musa *et al.*, 2004).

The highest arsenic concentration observed in the samples were obtained from Magume, Wusasa and Tudun Wada areas of Zaria under study. The areas have high human activities and natural processes.

Generally, toxic chemicals in drinking water may cause either acute or chronic health effects (Patrick *et al.*, 2000). Arsenic is classified as a human carcinogen based on sufficient epidemiologic evidence. High arsenic concentration found in some areas studied is capable of causing chronic and acute health effects such chronic effects, like cancer, birth defects organ damage, disorder of the nervous system and damage to the immune system (Seth *et al.*, 2002).

CONCLUSIONS AND RECOMMENDATIONS

The present study has indicated that most open wells in Zaria were found to be contaminated with abnormal concentration of arsenic sufficient enough to cause serious health hazards to the users, hence proper measures must be taken for the protection of environmental chemical pollution and of proper management of water resources in the area. Protection will ensure high quality standards of drinking water.

Wells should always be dug after making proper and adequate geological survey and should be dug deep down in order to get water with less concentration of arsenic, the importance of safe drinking water, cannot be over emphasized, because water is life.

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