ChemClass Journal, 2004 (14-18)

Determination of lead concentration in well and borehole water in Zaria, Nigeria

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ABSTRACT

In this study, lead concentration of sixty well and five borehole water samples collected from Zaria and environs was determined. Lead concentrations ranged from 0.000786 to 0.0595mg/L, with 91% of samples above the 0.01mg/L WHO drinking water guideline. Borehole water samples were found to contain less lead compared with the shallow well water samples studied. In this study Atomic Absorption Spectrophotometric (AAS) method was used because of its simplicity and accuracy.

INTRODUCTION

Leader contamination of water has occasionally arisen as a result of the use of bad pipes, lead – glazed tanks, metallic lead containers, atmospheric pollution or by addition of water purifying chemicals during water purification [1]. It was found that lead in small catalyses catabolic process while in significant amount. It is poisonous [2]. The World Health Organisation (WHO) [3,4] and Federal Environmental Protection Agency (FEPA) of Nigeria [5] have set standard and desirable limits of some toxic metals and quality criteria for domestic water supplies as shown in Table 1.

Lead occurs in the air a particulate matter. It gets into the atmosphere during the smelting process in industries, and also through exhaust emission motorized vehicles.

Poisoning of the blood is often associated with broad health effects such as inhibition of biosynthesis of heamoglobin, anemia, stomatitis, ulcer, abnormal body movement and reflexes, peripheral neurological effect, peripheral neuropathy, polyneuritis, brain damage, reduced neuropsychological functioning and brain tumour with serious symptoms like joint pain, dizziness, headache, loss of appetite, constipation, abdominal colic paralysis and death [1,6].

In Zaria, due to chronic drinking water scarcity, people collect water from surface sources and shallow wells. The tap where provided are mostly without water. Therefore majority of the populace rely heavily on untreated well water and boreholes.

This study is aimed at investigating the concentration of lead in well water in Zaria and its environs. Atomic Absorption Spectrophotometric (AAS) method of lead determination was used because of its simplicity and accuracy.

MATERIALS AND METHODS

Materials

Reagents and chemicals used in this work were of analytical grade. They were obtained from the Department of Pharmaceutical and Medicinal Chemistry, Faculty of Pharmaceutical Sciences, Ahmadu Bello University, Zaria, Nigeria. Atomic Absorption Spectro- photometer (AAS) equipped with lead hollowed cathode lamp, lamp current 10mA, wavelength 217.0nm, Band Pass 0.5nm with flame type consisting of Air/Acetylene and stochiometric fuel flow at 0.9 – 1.21min.

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 February 2003 to 15th February, 2003. Established, preservation

Table 1: Water quality criteria, domestic water supplies

S/No	Quality criteria	Permissible level (mg/L)	
	Substance	Permissible criteria (mg/L)	Desirable criteria (mg/L)
1	Arsenic (As)*	0.05	Absent
2	Calcium (Ca)	20.0	-
3	Cadmium (Cd)**	0.01	Absent
4	Chromium (Cr)* (hexavalent)	0.05	Absent
5	Copper (Cu)	1.5	Virtually absent
6	Iron (Total Fe)	Less than 0.3	Virtually absent
7	Lead (Pb)*	Less than 0.5	Absent
8	Magnesium (Mg)	150.0	150.0
9	Manganese (Mn)	Less than 0.5	Absent
10	Mercury (Total Hg)	0.0001	Absent
11	Selenium (Se)*	0.01	Absent
12	Zinc (Zn)	15.0	5.0
13	Ammonium (NH_3)	0.5	Less than 0.1
14	Anionic detergent	1.0	Absent
15	Chloride (Cl^-)*	2.50	Less than 2.0
16	Cyanide (CN^-)*	0.50	Absent
17	Flouride (F^-)**	0.9-1.7	1.0
18	Mineral oil	0.3	-
19	Nitrate (NO_3)**	45.0	-
20	Total nitrogen (exclusion of NO_3)	-	1.0
21	Phenol*	0.002	-
22	Plynuclear aromatic hydrocarbon	400.0	-
23	Sulphate (SO_4^{2-})	-	-
24	Radionuclides-gross X acitivity	-	3 pC/l
25	Coliform bacteria	-	30 pC/l
26	Biological Oxygen Demand	-	Not more than 10/1000cm^3
27	Chemical Oxygen Demand	-	1-0
28	pH	6.5-9.2	-
29	Total hardness ($CaCO_3$)	500	-
30	Total Dissolved Solids	1500	-

* Highly Toxic ** Hazardous to health

Source: Report of the committee on protection of water criteria, Federal Environmental Protection Agency, Nigeria (1998)

and storage were used to ensure that samples were of ground water quality.

Table 2: Absorbance measurement of lead standard solutions at 512nm

Conc. of lead standard solutions (mg/L)	Corrected Absorbance
0.04	0.0020
0.08	0.0040
0.12	0.0060
0.16	0.0080
0.20	0.0101

Two liters (2 LTS) of water samples were in each case taken directly in different plastic container and preserved. Immediately with 10ml 1% nitric acid. The samples were kept in a refrigerator while awaiting analysis [7,8].

Preparation of Calibration Graph

Solutions of 0.40, 0.08, 0.12, 0.16, and 0.20mg /L of lead standard were prepared, so as to obtain a calibration curve. 100ml of each of this standard solutions was adjusted to pH of between 2.2 to 2.8 by adding 1.0ml of 1M trioxonitrate (V) acid (HNO_3). Each standard solution and blank was transferred into an individual 250ml separatory funnel. 1ml ammonium pyrrolidine dithiocarbamate was added followed by the addition of 10ml methyl isobutyl ketone (MIBK) and the solution was shaken vigorously for 2 minutes. 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 10ml 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 were flushed each time with distilled water after 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.

Table 3: Showing the concentration (mg/L) of Lead in selected open wells in Zaria and Environs

Well Water Site	Different water samples collected	WHO permissible Limit (mg/L)	FEPA (1978) Permissible criteria	Mean content of lead in the sample (mg/L)
Zaria City	1	0.01	Less than 0.05	0.15
" "	2	0.01	" " "	0.17
" "	3	0.01	" " "	0.25
" "	4	"	" " "	0.04
" "	5	"	" " "	0.15
" "	6	"	" " "	0.12
" "	7	"	" " "	0.08
" "	8	"	" " "	0.23
" "	9	"	" " "	0.24
" "	10	"	" " "	0.08
Tudun Wada	11	0.01	Less than 0.05	0.31
" "	12	"	" " "	0.25
" "	13	"	" " "	0.48
" "	14	"	" " "	0.46
" "	15	"	" " "	0.38
" "	16	"	" " "	0.34
" "	17	"	" " "	0.59
" "	18	"	" " "	0.59
Tundun Jukun/Gaskiya	19	0.01	Less than 0.05	0.03
" " "	20	"	" " "	0.04
" " "	21	"	" " "	0.08
" " "	22	"	" " "	0.24
" " "	23	"	" " "	0.23
" " "	24	"	" " "	0.80
" " "	25	"	" " "	0.06
" " "	26	"	" " "	0.20
" " "	27	"	" " "	0.57
" " "	28	"	" " "	0.08
" " "	29	"	" " "	0.36
" " "	30	"	" " "	0.31
Gyellesu/Congo	31	0.01	Less than 0.05	0.06
" "	32	"	" " "	0.08
" "	33	"	" " "	0.06
" "	34	"	" " "	0.15
" "	35	"	" " "	0.25
" "	36	"	" " "	0.15
" "	37	"	" " "	0.16
" "	38	"	" " "	0.18
" "	39	"	" " "	0.40
" "	40	"	" " "	0.28
Banzazzau/Unguwankaya	41	0.01	Less than 0.05	0.28
" "	42	"	" " "	0.26
" "	43	"	" " "	0.05
" "	44	"	" " "	0.03
" "	45	"	" " "	0.04
" "	46	"	" " "	0.01
Magume	47	0.01	Less than 0.05	0.01
" " "	48	"	" " "	0.02
" " "	49	"	" " "	0.05
" " "	50	"	" " "	0.06
Wusasa/Tukur Tukur	51	"	" " "	0.05
" " "	52	"	" " "	0.03
" " "	53	"	" " "	0.08
" " "	54	"	" " "	0.05
" " "	55	"	" " "	0.03
" " "	56	"	" " "	0.03
" " "	57	"	" " "	0.05
" " "	58	"	" " "	0.05
" " "	59	"	" " "	0.02
" " "	60	"	" " "	0.08

Preparation of Samples Solution for the Determination of Lead

All samples were collected directly into poly-ethylene 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 40^0C until immediately before analysis.

Procedure for Pre-treating Water Sample for the Determination of Lead

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, 100ml 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. 0.2g of the pretreated sediment that was kept in a desiccators was taken into one hundred and eighty four plastic beakers. 5ml of deionised water was then added to dampen the sample, 6ml of concentrated nitric acid (HNO_3) was also added followed by 1ml of perchloric acid. The mixture was heated on a water bath until there was appearance of white fumes then allowed to cool.

After cooling 1ml of perchloric acid and 5ml hydrochloric acid were added the mixture was heated on a steam bath until evaporated to dryness then cooled. 6ml of 6m HNO_3 then added after the cooling and the resulting mixture boiled for ten minutes. The mixture was then filtered and made up to 100ml with deionised water in a 100ml volumetric flask.

The sample solutions were then analysed as described under preparation for calibration graph.

RESULTS AND DISCUSSION

In this study, well water concentration of lead was determined from sixty different randomly collected well water and deep tube wells in Zaria and environs. The minimum, maximum and average reported well and borehole wells depths in this area were 6m, 290m and 40m respectively.

From the results recorded for the sixty well water samples collected in Zaria it was found that lead exceeded the 0.01 mg/L World Health Organization (WHO) drinking water guideline limit in 91% of the samples, this indicate they have completely failed the limit test for lead and such well water samples are not fit for drinking or for human and animals consumption, the fact that if such well water samples are continuously consumed, they may produce lead toxicity after some time as lead accumulation may occur in the body leading to lead poisoning and may be fatal. Lead have a possible carcinogenic effect in human that is ability to cause cancer this is from inconclusive evidence of human and sufficient evidence of animal carcinogenicity [9]. In addition, lead also causes many non-carcinogenic disorders in humans such as headache, joint pains, abdominal colic and paralysis [10]. The drinking water guideline for lead was derived using the lowest measurable retention of lead in the blood and tissues of human infants [9,11]. Drinking water that contains high concentration of lead should always be avoided.

It is the responsibility of the constituted authorities to provide hygienic portable drinking water for the people in order to reduce large expenditure on treatment of diseases that can be prevented by providing hygienic and portable drinking water. According to world health organization, eighty percent (80%) of ill-health in less developed countries like Nigeria occurs from lack of safe water and adequate sanitation [12,13].

It was also observed from the study that deep bore hole well water samples contain very less concentration of lead of between 0.000786 to 0.018mg/L, this might be associated with deepness of the well and the possibility of impurities getting into the well.

CONCLUSION

This investigation/study revealed the presence of excessive amount of lead as impurity in the well water for drinking in some areas of Zaria. The highest concentration of lead was found in Gangaren Kwadi in Tudun Wada Area of Zaria, which indicate that the area have high concentration of lead in the soil, this might be due to stream flowing close to the area which may carry industrial and petrochemical wastes from the mechanic garages and motor parks around the town. The following recommendations are important to obtain and maintain good quality water supply in the areas: waste should always be properly disposed such as

petrochemical wastes, industrial wastes. Industries should be taught and be well informed about the importance of proper waste disposal and should be monitored and prosecuted in the event of non-compliance. Smoke from automobiles should be reduced by using the latest automobiles exhaust scraps or old vehicles and machineries should not be allowed in the area. Wells should always be dug deep down in order to get water with less concentration of impurities.

Drinking water with safe levels of lead could be supplied to the people, by the integrated use of ground water monitoring, drilling deeper wells and appropriate water treatment systems. Mitigation efforts should also be employed. All these in order to provide safe drinking water with limited concentration of lead and other toxin metals from the area; this will improve the health of the people in the area.

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