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The Concentrations of Lead in Ahmadu Bello University Dam Raw, Treated (Tap) and ABUCONS Pure Waters

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ABSTRACT

Raw water samples were collected from 10 different locations of ABU dam between May, 2001 and April, 2002. Similarly, samples of treated (tap) water from the same ABU waterworks were collected from 50 different locations throughout the university community during the same period. Samples of packaged water (ABUCONS water) from the same source were collected during the same period. All these samples were analysed for lead (Pb). Established collection, preservation and storage methodologies were used to ensure that each sample was representative of ABU Dam water quality. This study which involved 20 analytes per sample and 112 samples suggested that the most significant health risk from drinking ABU Dam water was danger of chronic lead poisoning. The lead concentration ranged from 0.0007 to 0.34 mg/L, with 48% of samples above the 0.05 - 0.1mg/L, WHO drinking water guideline. However, there were very low levels of lead concentration ranging from 0.0004 – 0.038 mg/L for the packaged water (ABUCONS water) samples analysed.

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INTRODUCTION

Because of the essential role played by water in supporting human life it also has, if contaminated, great potential for transmitting a wide variety of diseases and illnesses. In the developed world water-related diseases are rare, due essentially to the presence of efficient water supply and wastewater disposal systems. However, in the developing world, perhaps as many as 1.3 thousand million people are without safe water supply and almost two thousand million do not have adequate sanitation [1]. As a result, the toll of water related diseases in these areas is frightening. Millions of people die each year as a consequence of unsafe water or inadequate sanitation.

There is also concern about the possible long-term health hazards which may arise from the presence of trace concentrations of impurities in drinking water. There are several other chemical contaminants, which may be naturally occurring or man-made, having known effects on the health of the consumers. For instance, Arsenic (As) is classified as a human carcinogen based on the sufficient epidemiological evidence [2]. Man- ganese (Mn) is a known mutagen [3]. The accumulation of Mn may cause hepatic encephalopathy [4]. Moreover, the chronic ingestion of Mn in drinking water is associated with neurological damage [5]. Lead (Pb) is a possible human carcinogen because of the inconclusive evidence of human and sufficient evidence of animal carcinogenicity [6]. In addition, Pb causes many non-carcinogenic disorders in humans. The catastrophic health crisis caused by drinking metal contaminated water affects tens of millions of people and requires urgent attention.

The purpose of the present study was to evaluate the presence, if any, of trace concentrations of lead in ABU waterworks raw and treated (tap) waters as well as in pure water (ABUCONS water) produced from the same source.

MATERIALS AND METHODS

Materials

All experiments were performed with analytical grade chemicals obtained from British Drug House (BDH). Measurements were made with a Buck Model 210 Variant Pulses Correction (VPC) system Atomic Absorption Spectrophotometer (AAS) equipped with lead hollow cathode lamp, lamp current 10mA, wavelength 217.0nm, Band Pass 0.5 nm with flame type consisting of Air/Acetylene and stoichiometric fuel flow at 0.9 – 1.21 min^{-1}.

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Reagents

Analytical grade reagents were used. Stock solution of Pb was prepared by dissolving 1.598g of lead nitrate ($Pb(NO_3)_2$) in 100ml of deionised water and diluted to 1 litre in a volumetric flask with deionised water and making up the volume to mark with 5ml of concentrated trioxonitrate (V) acid (HNO_3) to give a 1000 mg/litre solution of lead. The solution was stored in a labeled polyethylene bottle.

Standard working solutions were prepared by suitably diluting the stock solutions to give working standards ranging from 0.05mg/litre to 0.30mg/litre.

Preparation of Calibration Curve for Lead

Five working standard lead solutions of concentrations 0.05, 0.10, 0.15, 0.20 and 0.25 mg/litre 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, while the organic layer was then 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.

Preparation of Sample Solution for the Determination of Lead

All samples (raw, tap and pure water 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 4^0C pending analysis.

Pretreatment and Analysis of Lead in Water Samples

Sediments from the different sources of water samples were analysed. Beakers were thoroughly washed, oven dried and cooled. The weight of the beaker was recorded after which a 1000ml aliquot of each 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 desiccator and the weight recorded. The differences in the weight were recorded and the residue removed from the beaker, weighed and kept in a desiccator until analysis. Triacid digestion method of analysis was employed using nitric acid, perchloric acid and hydrofluoric acid mixture a at ratio of 6:1:5 as follows.

0.2g of the pre-treated sediment sample was treated with 5ml of deionised water to dampen the sample, followed by the addition of 6ml of concentrated nitric acid and 1ml of perchloric acid and then heated on a water bath to the appearance of white fumed and then allowed to cool. After cooling, 5ml of hydrofluoric acid was added and the resulting mixture was boiled for 10 minutes. This was then filtered and made up to the mark with deonised water in a 100ml volumetric flask.

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

The study areas

The areas where water samples were collected within the University community include:

i) ABU Dam Raw Water (RW)
ii) University Residential areas (RA) (Comprising of Areas A, BZ, C, E,F and G);
iii) ABU Waterworks (AWW) treated water
iv) Booster Stations (BS)
v) Academic Areas (AA)
vi) ABU Staff School (ASS) main campus
vii) ABUCONS Pure Water.

Statistical analysis of results

The data generated were statistically analysed using Standard Error of the Sampling Distribution of Mean (SEM).

RESULT

Linear calibration curve with good correlation coefficient (r = 0.993) was obtained for levels of lead in water samples for determination of lead levels in the various water samples.

Similarities as well as differences were observed in the lead concentration levels in the one hundred and

Table 1: Mean Lead Concentrations (mg/L) in Tap water samples taken at Different periods of the year (April, 2001 to March, 2002) within the University community

	Sampling Locations				
Period of the years	AWW	RA	AA	BS	ASS
April	0.018 ± 0.0016	0.284 ± 0.0120	0.038 ± 0.0041	0.024 ± 0.0004	0.128 ± 0.0006
June	0.122 ± 0.0071	0.178 ± 0.0220	0.104 ± 0.0041	0.147 ± 0.0027	0.170 ± 0.0032
August	0.149 ± 0.0140	0.284 ± 0.0112	0.224 ± 0.0022	0.178 ± 0.0018	0.240 ± 0.0111
October	0.104 ± 0.0011	0.147 ± 0.0111	0.134 ± 0.0011	0.138 ± 0.0022	0.149 ± 0.0129
December	0.022 ± 0.0000	0.0164 ± 0.0048	0.018 ± 0.0091	0.036 ± 0.0004	0.034 ± 0.0177
March	0.018 ± 0.0019	0.304 ± 0.0184	0.017 ± 0.0028	0.019 ± 0.0001	0.098 ± 0.0027

Table 2: Lead concentration (mgk) in Raw Water (RW) Samples taken at Different Periods of the Year (April 2001 to March 2002) from A.B.U. Dam

Period of the year	1	2	3	4	5	6	7	8	9	10	Mean ± SEM (%)
April	0.052	0.071	0.082	0.033	0.011	0.009	0.0017	0.0040	0.0127	0.024	0.030 ± 0.037
June	0.125	0.129	0.128	0.138	0.142	0.141	0.138	0.112	0.134	0.131	0.132 ± 0.028
August	0.162	0.142	0.128	0.179	0.133	0.104	0.128	0.111	0.127	0.139	0.135± 0.028
Oct.	0.042	0.039	0.038	0.031	0.029	0.041	0.027	0.042	0.033	0.039	0.036± 0.018
Dec.	0.011	0.012	0.007	0.018	0.009	0.028	0.044	0.108	0.100	0.012	0.035± 0.027
March	0.028	0.011	0.017	0.026	0.009	0.011	0.057	0.022	0.098	0.011	0.029± 0.006

twelve (112) samples of water analysed within the university community.

The water samples analysed demonstrated high levels of lead concentrations ranging from between 0.017 to 0.304mg/L for the tap water samples from residential Areas (RA) (i.e. Areas C, E, F, and G); 0.033 to 0.248mg/L for tap water sample from ABU Staff School (ASS) and Academic Areas (AA); (table 1) 0.007 to 0.189mg/L for Raw Water (RW) from ABU Dam and tap water samples from ABU Water Works (AWW) and Booster Stations (BS) (Table 1 and 2).

However, the water samples for pure potable water (ABUCONS water) analysed demonstrated very low levels of lead concentration ranging from 0.0004 to 0.018mg/L (Table 3). The average lead concentration level in raw, tap and pure waters are shown together with their standard error of distribution mean in Table 4.

DISCUSSION

Lead in water samples was monitored in order to provide a tool for estimating the level of contamination, the source and habitat. Lead concentration in water depends on the proximity of the water source to roads with high traffic density, degree of urbanization of the area concerned, topography, climatic conditions and solid waste disposals [7].

In the present study, the frequency of lead distribution in ABU Dam raw water and treated (tap) waters analysed followed similar pattern of high concentrations (0.007 to 0.189mg/L and 0.017 to 0.304mg/L) respectively. Its burden in these areas is a function of factors such as vehicular emission, disposal of discarded batteries and other lead containing materials, burning of solid wastes and painted woods and weathering of lead containing paints on buildings. It was observed that these areas served both as residential, academic and staff school areas.

The lead distribution in pure potable water analysed followed a pattern of low concentration (0.0004 to 0.018mg/L) despite the fact that the water came from the same source just as the raw and tap water samples. The treatment system applied on the pure potable water through series of micro filtrations and UV sterilization coupled with the adherence to

Table 3: Lead concentration (mg/L) in different batches of pure portable water (ABUCONS water) samples taken at different periods of the year (April, 2001 to March 2002)

Period of collection	1	2	3	4	5	6	7	8	9	10	11	Mean ± SD (%)	Mean ± SEM(%)
April	0.020	0.016	0.018	0.020	0.021	0.019	0.024	0.022	0.019	0.021	0.020	0.022 ± 0.4	0.022 ± 0.9
June	0.029	0.031	0.033	0.030	0.035	0.036	0.031	0.035	0.030	0.032	0.038	0.032 ± 0.42	0.032 ± 0.12
August	0.039	0.037	0.035	0.036	0.039	0.037	0.036	0.035	0.035	0.037	0.038	0.037 ± 0.15	0.037 ± 0.04
Oct.	0.024	0.026	0.028	0.027	0.022	0.029	0.028	0.024	0.027	0.030	0.028	0.027 ± 0.23	0.027 ± 0.07
Dec.	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.004 ± 0.05	0.004 ± 0.01
March	0.000	0.000	0.000	0.001	0.001	0.002	0.000	0.001	0.000	0.001	0.0001	0.0005 ± 0.06	0.0005 ± 0.02

Table 4: Mean lead concentrations of Raw, Tap and pure portable 9ABUCONS) Water samples obtained from ABU Waterworks at different periods of the year (April, 2001 to March, 2002)

	Lead content (mgk)± SEM		
Period of collection	Raw	Tap	Pure water
April	0.030±0.037	0.018±0.0016	0.022±0.0090
June	0.1320±0.005	0.122±0.0071	0.032±0.0012
Aug	0.0135±0.028	0.149±0.0140	0.037±0.0012
Oct	0.0360±0.018	0.104±0.0011	0.027±0.0007
Dec	0.0350±0.027	0.022±0.0000	0.0004±0.0005
March	0.0290±0.006	0.018±0.0019	0.0005±0.0002

Table 5: Mean Lead Concentrations (mgk) Tap water samples obtained from Residential Areas (RA) within the university community at different period of the year

Period of collection	A	BZ	C	E	F	G
April	0.096 ± 0.004	0.106±0.0014	0.194 ± 0.0129	0.168 ± 0.0112	0.174 ± 0.0268	0.198 ± 0.0241
June	0.124 ± 0.0021	0.114 ± 0.0010	0.204 ± 0.0006	0.194 ± 0.0016	0.201 ± 0.0121	0.268 ± 0.0117
Aug	0.164 ± 0.0041	0.170 ± 0.0032	0.247 ± 0.0110	0.234 ± 0.0027	0.281 ± 0.0111	0.304 ± 0.0184
Oct	0.064 ± 0.0028	0.086 ± 0.0006	0.127 ± 0.0024	0.142 ± 0.0012	0.0201 ± 0.007	0.248 ± 0.0042
Dec	0.074 ± 0.0006	0.062 ± 0.0022	0.101 ± 0.0006	0.016 ± 0.0414	0.098 ± 0.0410	0.102 ± 0.0004
March	0.099 ± 0.0011	0.086 ± 0.0077	0.128 ± 0.0004	0.172 ± 0.0048	0.102 ± 0.0009	0.124 ± 0.0007

Good Manufacturing Practice (GMP) guidelines and hygiene in the production, must have contributed to the very low level of lead concentrations in the pure potable packaged water. Also processing methods such as reverse osmosis remove most chemical and micro biological conta- minants.

The Regression Coefficient (r), 0.000468, between pure potable packaged water and raw and tap waters analysed within the university community shows that higher values of lead concentrations are observed in the raw and tap waters than the pure potable water. The lead concentrations in the tap water analysed within the residential areas of C, E, F, and G and that of A and BZ equally gave a positive regression coefficient (r =
0.04872) showing that the concentration of lead in the tap waters sampled within areas C, E, F and G is higher than that of the areas A and BZ (Table 5).

The highest levels of lead observed in all the samples were obtained within the periods of May to September and February to April of the year under study. These periods reflected the peaks of dry and rainy seasons. The dry season is always manifested by irregular or intermittent supply of tap water to especially areas C, E, F and G and this development must have led to eventual drying and rusting of the distribution pipes and pollution of the flowing water due to leaching of dirt and chemicals. While the rainy season is always characterized by erosion and leaching of soil as well as chemicals such as fertilizers, pesticides, herbicides and paints into drainages and eventually into ABU Dam. Areas A and BZ that enjoy regular supply of tap water throughout the year experienced lower levels of Pb concentrations in their water samples analysed (Table 4). This could be as a result of the fact that the distribution pipes connecting these areas do not experience prolong drying and are less likely to leach lead or any dangerous chemical into the flowing water. However, within the scope of this research work, it was found out that all the samples of water analysed with the exception of the pure potable (ABUCONS) water are not safe for human

consumption, since the values obtained are far above the allowable limits in potable water (0.05 - 0.1mg/L [8].

The pathways of lead exposure in ABU community are not different from what one would expect in Samaru and other neighbouring areas that utilise ABU water supply. Our results from the raw and tap waters from ABU waterworks analysed, could serve to draw attention to the fact that these samples when taken for a long time could expose the residence of the university to the danger of being poisoned by lead. This study also adds to the growing pool of scientific data pointing to lead poisoning as being a major public health problem in Africa. Studies in south Africa, for instance, showed that more than 50% of the citizens of Cape Town, Durban, Johannesburg, and possibly other cities have lead blood levels greater than 10mg/dl [9,10,11]. Kamal *et al* [12] found that an average lead blood level for neonates in cairo, Egypt was 14mg/dl. Lead poisoning, which is quite preventable, must now be included among diseases that Africans have to contend with. As long as African countries continue the use of highly leaded gasoline, pesticides, herbicides and paint, lead poisoning will remain an unnecessary health problem among the population.

There is a clear and urgent need for a broader assessment of the magnitude of lead poisoning in Nigeria and other African countries. At the same time, African leaders should begin to implement policies to reduce the risk of lead poisoning in our countries. The scientific evidence is large and conclusive, the principal exposure routes are well known, the health effects are well documented and the scientific and medical information, gathered from all corners of the world cry for programs to protect citizens from lead in their environment. Since automobiles account for most of lead pollution in urban areas of Africa, it would seem morally indefensible to wait for more evidence of lead poisoning before removing lead from gasoline, pesticides, herbicides and paints sold in African continents and Nigeria, in particular.

CONCLUSION

The present study has indicated that all the samples of water analysed with the exception of the pure potable (ABUCONS) water are not safe for human consumption since the values obtained are far above the allowable limits in potable water (0.05 to 0.1mg/L) [8]. This could be a great threat to the inhabitants of the university community and beyond. Hence strategies must be developed for the protection of and proper management of water resources in the university. Protection will ensure high quality standards of drinking water, starting with the catchment area via the reservoir to the consumer. As a rule, priority should be given to the avoidance of contamination directly at their point of origin. Water protection is always cheaper than expensive water-body restoration and water treatment. Rehabilitation and modernisation of A.B.U. Water Works by way of the replacement of the distribution pipes, rehabilitation of the old overhead tanks and construction of new ones, replacement of the vandalized mains and construction of the new ones, construction of new booster stations, revitalization of the water laboratory and drilling of boreholes in especially residential areas become absolutely necessary in providing safe and good drinking water. Also for efficiency and proper monitoring, government should, as a matter of urgency, establish a separate independent agency responsible for monitoring the quality of public water supply systems as well as the packaged water nationwide as well as regulate all drinking water programme. The existing water works law that established the Water Boards in Nigeria should be immediately reviewed and proper legislation put in place to check the degradation of water quality in Nigeria.

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