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JOURNAL FOR THE TROPICS
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**BIOLOGICAL AND ENVIRONMENTAL SCIENCES
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DETERMINATION OF LEAD IN POTABLE WATER OF AHMADU BELLO UNIVERSITY MAIN CAMPUS, ZARIA, NIGERIA

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ABSTRACT

Lead is one of the most ubiquitous toxic metals of concern in urban water supply systems. It is widely distributed and mobilized in the environment. Human exposure to and uptake of this non-essential element has consequently increased. In this study, five drinking water samples from eleven different locations (A, B, C, D, E, F, G, H, I, J, K and L and five packaged water samples from Ahmadu Bello University Main Campus, Zaria were randomly collected, digested with concentrated nitric acid using the AOAC nitric acid digestion method and analysed for lead using atomic absorption spectrophotometer. The results indicated that the mean concentration of lead ranged from $0.0490 \pm 0.0133\text{mg/l}$ to $0.1141 \pm 0.0189\text{mg/l}$ with areas coded D and K having significantly higher concentrations ($P < 0.05$). The mean concentration of lead in all the eleven locations and packaged water were significantly higher than World Health Organisation guideline of 0.01mg/l ($P < 0.05$). Consequently, potable water of Ahmadu Bello University Main Campus, Zaria may pose a threat to the health of the university community.

Keywords: Lead, Contamination, Drinking water, Zaria.

INTRODUCTION

Heavy metals such as lead (Pb) have been widely acknowledged as potential toxic environmental contaminants. Pb is a ubiquitous and versatile metal which has been used since prehistoric times (Smith, 1984). It is used in the production of Pb-acid batteries, solder, alloys, cable sheathing, pigments, rust inhibitors, ammunition, glazes, and plastic stabilizers (WHO, 1989). It has thus become widely distributed and mobilized in the environment and human exposure to and uptake of this non-essential element has consequently increased. Pb toxicity occurs far more often than one would ever expect. We are exposed to Pb on a day-to-day basis in our environment. Those at the greatest risk, even with short-term exposure, are young children and pregnant women (Tong, 2000). In Nigeria, the 2010 tragedy of Zamfara Pb poisoning in which over 165 lives were lost as a result of illegal mining activities is a living example. At high levels of human exposure there is damage to almost all organs and organ systems, most importantly the central nervous system, kidneys and blood, culminating in death at excessive levels. At low levels, haem synthesis and other biochemical processes are affected, psychological and neuro-behavioural functions are impaired, and there is a range of other effects (Goldstein, 1992).

Much research over the last 30 years has demonstrated adverse health effects of moderately elevated blood Pb levels, i.e. below 25 mg/dl . The permissible exposure level in the ambient (air, water,

soil, etc.) environment, as well as in the working environment, has therefore been progressively lowered (WHO, 1995). Although the problems of overt Pb poisoning have largely receded in developed countries, chronic exposure to low levels of Pb is still a significant public health issue, particularly among some minorities and disadvantaged groups. Furthermore, both occupational and environmental exposures have remained a serious problem in many developing and industrializing countries (Tong, 2000).

Pb is present in tap water to some extent as a result of its dissolution from natural sources but primarily from household plumbing systems in which the pipes, solder, fittings, or service connections to homes contain Pb. Polyvinyl chloride (PVC) pipes contain Pb compounds that can leach and result in high Pb concentrations in drinking-water (Schock, 1989). Therefore, Pb concentrations can change as water moves through distribution system and the best way to know is by testing or sampling the water in that facility. Previous research on the concentration of Pb in Ahmadu Bello University dam, treated and ABUCONS package water (Yakasai et al., 2004) revealed that more than 48% of samples have their concentrations above the WHO drinking water guideline of 0.01mg/l (WHO, 1993 and 2011). Similarly Musa et al. (2008) reported presence of Pb in shallow well, borehole and packaged water samples in Zaria. As a follow up, this study determines the mean concentration of Pb in potable water of Ahmadu Bello University Main Campus, Zaria.



MATERIALS AND METHODS

Reagents and equipment

Reagents used were of analytical grade and include: concentrated trioxonitrate (V) acid HNO_3 69%w/w from British Drug House (BDH) Poole. All solutions were prepared using redistilled, deionised water. Potable pH meter model H198107 (Hanna Instruments) and AAS Shimadzu AA-6800- with hollow cathode lamp- for Pb (lamp current at 6mA),

air- C_2H_2 burner (2.0 L/min), slit width 1.0nm were employed.

Sampling sites

The sites sampled include hostel, residential and academic areas, reservoir and a packaged water factory as named and coded below (Table 1). These sites were chosen due to steady supply of running tap water.

Table 1: Sampled sites in Ahmadu Bello University, Zaria main campus with assigned codes

Sites	Codes
Residential Area A	A
Academic Area	B
ABU Staff School	C
Residential Area BZ	D
Booster Station	E
ABU Dam	F
Residential Area E	G
Residential Area F	H
Residential Area G	I
Packaged Water	J
Suleiman Hall	K
Water Works	L

Sample collection

Five two-litre (2L) water samples were randomly collected into plastic containers from each of the sampling sites. The plastic containers were previously cleaned by washing in non-ionic detergent, rinsed with tap water and later soaked in 10% HNO_3 for 24 hours and finally rinsed with deionised water prior to usage. During sampling, sample bottles were rinsed with the sampled water three times before collection. The water when from the taps was allowed to run freely for 1-2 minutes before collecting the samples. The pH of the water samples was taken immediately after collection using portable pH meter. The collected samples were acidified by adding 2-3 drops of concentrated HNO_3 . The samples were coded and labelled (with pH, time, date and place of collection), transported to the laboratory in cooler with ice packs, stored in the refrigerator at about 4°C prior to analysis (DWAf, 1992 and APHA, 1998). All samples were collected in the month of March, 2010.

Sample pre-treatment

Nitric acid digestion method (AOAC, 1990) was used for the pre-treatment of the samples. A 50ml water sample was pipetted into a 100ml beaker. Concentrated nitric acid (10ml) was added with the aid of an acid dropper. The beaker with the content was placed on a hot plate and digested in a fuming cupboard until when brown fumes of nitric acid had escaped. Heating was continued until when content had been reduced to about 10ml volume. The content was allowed to cool and washed into a 50ml volumetric flask through a Whatman® filter paper (Grade 1, size 110mm) supported on a glass funnel

and made to mark with the redistilled, deionised water. The digest obtained was then analysed for Pb using AAS at 283.3nm.

Statistical analysis

All the data were subjected to statistical evaluation. One way analysis of variance (ANOVA) and the post hoc test using the Duncan Multiple Range Test (DMRT) were applied to find the significant difference in the mean concentration of the metals in the different studied areas. The mean concentrations of Pb at each location were compared with the WHO standard using the Independent Sample t-test. The pair-wise linear relationship between Pb and the water pH was also analysed by employing the Pearson's Product-moment Correlation Coefficient using SPSS software.

RESULTS

The mean $\pm$ SEM concentrations of Pb in the samples analysed ranged from $0.0490 \pm 0.0133\text{mg/l}$ to $0.1141 \pm 0.0189\text{mg/l}$ being lowest for areas coded E and H and highest for area coded D, (Table 2). The mean concentration of Pb varied across the sampled locations but the variations were not significantly different ($P < 0.05$). Comparison of the result based on the different sources of potable water is represented in Table 3.

The mean concentrations of Pb in all the sampled locations and for all the sources significantly ($P < 0.05$) exceeded the WHO guideline of 0.01mg/l . The pair-wise correlation studies revealed a weak negative (-0.441) relationship between the pH of drinking water samples and concentration of Pb.



Table 2: Concentration of lead in potable water of Ahmadu Bello University main campus, Zaria

Sample Codes	pH $\pm$ 0.1	Concentration (mg/l)
		mean $\pm$ SE
A	6.8	0.0791 $\pm$ 0.0253
B	6.9	0.0891 $\pm$ 0.0218
C	6.9	0.0691 $\pm$ 0.0222
D	7.1	0.1141 $\pm$ 0.0189
E	6.9	0.0490 $\pm$ 0.0233
F	7.5	0.0839 $\pm$ 0.0385
G	7.7	0.0570 $\pm$ 0.0085
H	7.4	0.0490 $\pm$ 0.0133
I	6.9	0.0746 $\pm$ 0.0255
J	7.6	0.0714 $\pm$ 0.0166
K	5.7	0.1011 $\pm$ 0.0276
L	6.9	0.0741 $\pm$ 0.0266

Sample size n=5 No significant ($p < 0.05$) difference by ANOVA & Duncan post-hoc test

Table 3: Comparison of mean concentration of lead in different sources of potable water of Ahmadu Bello University main campus, Zaria

Sources of water	pH	Concentration (mg/l)
		mean $\pm$ SEM
Packaged	7.6	0.0714 $\pm$ 0.0166
Tap	7.1	0.0728 $\pm$ 0.0255
Raw	7.5	0.0839 $\pm$ 0.0385
Boreholes	5.7	0.1011 $\pm$ 0.0276

Sample size n = 5,

DISCUSSION

From Table 2, the areas coded D and K have the highest concentrations while areas coded E and H have the lowest concentrations. Comparison of the mean concentration of Pb in the different sources of potable water (Table 3) revealed the mean concentrations of Pb are in the order: packaged < tap < raw < boreholes being lowest for packaged water and highest for the boreholes. Though far above the WHO guideline of 0.01mg/l (WHO, 2011), the packaged and tap water being treated contain slightly lower concentrations of Pb as compared to the untreated raw (reservoir) and boreholes water. The concentrations above the concentration from the source, coded L observed in coded areas A, B, D, F, I and K may be attributed to leaching of Pb from corroding pipes and fixtures or Pb containing solder in the distribution systems. Pb pipe are a major source of Pb contamination in drinking water (ATSDR, 2007). Pb most frequently gets into drinking water by leaching from plumbing materials and fixtures as water moves through distribution system (Quinn and Sherlock, 1990). Even though the drinking water from water supplier meets regulatory standards for Pb, facility may have elevated Pb levels due to plumbing materials. The source of the Pb in the reservoir, coded F may be as a result of natural contamination which may originate from weathering of minerals, rocks and aquatic environments. Other probable sources of Pb in the reservoir may be due to water runoff from paints and disposal of wastes (domestic and industrial) such as sewage sludge, and mining effluents (ATSDR, 2007). The source of the potable water, coded K was borehole. The water was untreated and thus acidic with an average pH of 5.7. Therefore plumb solvency may account for the high mean concentration of Pb

observed in potable water of this area. The amount of Pb dissolved from the plumbing system depends on several factors, including the presence of chloride and dissolved oxygen, pH, temperature, water softness, and standing time of the water (WHO, 2011). Soft, acidic water being the most plumbosolvent (Schock, 1990). The low mean concentrations of Pb in areas coded G and H may be as result of the relatively high pH of the drinking water (7.7 and 7.4 respectively) of these locations which may help in reducing the plumb solvency and subsequently the dissolution of Pb in the water. The level of Pb in drinking-water may be reduced by corrosion-control measures such as the addition of lime and adjustment of the pH in the distribution system from <7 to 8-9 (Sherlock and Quinn, 1984). The EPA requires public water distribution systems to reduce the corrosivity of water if >10% of the water samples exceed 15 μ g/L of Pb (ATSDR, 2007). Hence the acidic potable water of the area coded K can be controlled by treating the water to adjust the pH. The one-way analysis of variance (ANOVA) and post-hoc test using the DMRT showed there was no significant difference in the mean concentrations of Pb across the twelve sampled locations at 5% level of significance. The independent sample t- test analysis revealed that the mean concentrations of Pb in all the sampled locations and for all sources of water exceeded the WHO guideline of 0.01mg/l ($P < 0.05$). The result agreed with earlier studies on concentration of Pb in ABU dam, treated and packaged water (Yakasai et al., 2004). The pair-wise correlation studies showed that the correlation between the pH of the drinking water samples and the mean concentration of Pb was -0.441 which implies weak negative relationship.



CONCLUSION

The results of the study showed that the concentration of Pb in potable water of ABU main campus, Zaria significantly exceeded the WHO set limit of 0.01mg/l and may pose a problem to the health of the University community. Thus there is the need for a follow up monitoring and implementation of the following recommendations.

RECOMMENDATIONS

- In-house chemical analyses must be carried-out periodically for the surface and groundwater to ensure suitability of water for drinking purposes.
- The use of polyvinyl chloride (PVC) pipes (free of plasticizers which contain Pb) and engineering practices to minimise plumb

solency in water treatment and water distribution systems should be encouraged.

- A testing protocol for the identification of pipes, and soldered fittings which contribute to Pb contamination in drinking water should be carried out. This program should include measures for reduction or elimination of Pb contamination from pipes and fittings by ensuring that they are repaired, permanently removed or replaced as appropriate.
- Corrosion control to adjust water pH so that it is less likely to damage pipes, solder, fixtures or any combination of the three should be encouraged. This will reduce the release of these metals into the drinking water.

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