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Lead in Potable Water Sources in Abakaliki Metropolis, South-East, Nigeria

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Abstract Lead concentration was analyzed in potable water samples (25 well water, 15 borehole water, 7 tap water and 3 stream/river water samples), collected randomly from 5 zones (Abakaliki urban, Azuiyiokwu, Kpirikpiri, Nkaliki and Onuebonyi/rice mill) in Abakaliki metropolis, South-East Nigeria, using Atomic absorption spectrophotometry. The mean ± SD lead levels of Tap, well, borehole and stream/river water were 0.13 ± 0.08, 1.04 ± 0.19, 0.78 ± 0.19 and 0.83 ± 0.22 mg/L, respectively. There was statistically significant difference ($p = 0.016$) in lead concentrations in well water, compared with tap water. The highest well water lead level was found in Azuiyiokwu whereas the highest level in borehole water was in Abakaliki urban.

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Historically, lead has been used to produce water pipes, to solder iron and copper pipes. It has also been used as a constituent in various products such as face powder, ceramics, gasoline, plumbing, radiation shielding, children's toys and paint. Lead, in form of lead nitrate, is a component of lead haematoxylin, commonly used in histopathology, in the study of gastrin-secreting cells in the stomach (Ochei and Kolhatkar 2008). It is also used in the construction of lead-acid batteries, making of stained glass, lead fishing weights, candles, and also in battery casings. Its long history of use and distribution reveals the global nature of lead exposure and its health effects.

At high levels of human exposure, almost all organs and systems, especially the central nervous system, kidneys and blood, are damaged, leading to death. However, at low levels, heme synthesis and other biochemical processes are affected, in addition to impaired psychological and neurobehavioural functions, and a range of other effects (WHO 2001; Goldstein 2002). Ingestion of small amounts, seem to induce physiological, psychological, biochemical and neurobehavioural responses, many of which are dose-dependent (Lansdown et al. 2004). Much research over the years has demonstrated adverse health effects of moderately elevated lead levels, i.e. blow 25 μg/dl. The permissible exposure level of lead in the ambient (air, water soil, etc.) environment, as well as in the working environment, has therefore been progressively lowered (WHO 2001). Although the problems of overt lead poisoning have largely receded in developed countries, chronic low-level exposure to lead is still a significant public health issue, partially among some minorities, especially in developing countries. Furthermore, both occupational and environmental exposures have remained a serious problem in developing and industrialized countries (Patterson 2001; WHO 2001; Ericson et al. 2009). The natural mobility of lead in the environment is low, owing to the low solubility of this element in water. However, concentrations as high as 100 mg/L of dissolved lead, have been measured in rain and snow in areas of substantial air pollution (Crook 2006).

The various physiological, psychological, biochemical and neurobehavioural responses of humans to lead are of interest and also, most lead contamination of drinking water takes place at some point in the water delivery system, hence the need to assay for the lead concentration in potable water. This work is centered on determining the preponderance and distribution of lead in the different water sources in Abakaliki metropolis, an area with great industrialization in South-East, Nigeria. This work will help to elucidate the possibility of lead poisoning associated to potable water sources in this environment.

Materials and Methods

Potable water samples (tap water, well water, borehole water and stream/river water) were randomly collected from the five regions of Abakaliki metropolis (Abakaliki Urban, Azuiyiokwu, Kpirikpiri, Nkaliki and Onu Ebonyi/Rice Mill) and assayed for lead concentrations. A total of 25 artesian well water, 15 borehole water, 7 tap water and 3 stream/river water samples were randomly collected for the study. All water samples were collected directly from the various water sources into chemically clean, dry and sterile plastic containers and were taken to the laboratory immediately after collection and analyzed within 7 days of collection. Lead concentration was analyzed at 283.3 nm wave length using Buck Scientific Atomic Absorption Spectrophotometer (Model 210 VGP) with 0.7 nm slit. The analysis was done in duplicate and the average used for the calculation. Results were expressed as mean ± standard deviation (mean ± SD). Significant differences between means were determined using student's *t* test at 95% confidence limit. Student's *t* test was analyzed by the use of statistical package for social sciences (SPSS) computer software programme, version 11.

Results and Discussion

The mean (±SD) lead levels of borehole, tap, well and stream/river water samples collected in the five zones of Abakaliki metropolis were 0.78 (±0.09), 0.13 (±0.08), 1.04 (±0.19) and 0.83 (±0.22) mg/L, respectively (Table 1). Tap water was found to contain the least mean lead concentration whereas well water had the highest mean concentration. Table 2 shows the test of difference in mean lead concentrations between tap water and other water sources. From the table, the *T* values and *p* values of well, stream/river and borehole were as follows: (−3.339, 0.016); (−1.474, 0.278); (−1.887, 0.108), respectively. Among the assayed water samples, only well water showed statistically significant difference ($p = 0.016$) in mean lead concentration compared to tap water. Figures 1 and 2 show the mean lead concentrations in well and borehole water respectively, in the different locations of Abakaliki metropolis. Azuiyiokwu locality had the highest mean lead level in their well water while Kpirikpiri area had the least. Also the highest lead concentration in borehole water was obtained in Abakaliki urban while Azuiyiokwu had the lowest. The least mean lead concentration observed in the tap water may be attributed to the treatment it receives in

Table 1 Mean lead concentrations (mg/L), standard deviation and standard errors of potable water sources in Abakaliki Metropolis

Water sources	Mean	SD	SE
Tap	0.13	±0.08	0.22
Well	1.04	±0.19	0.93
Stream	0.83	±0.22	0.38
Borehole	0.78	±0.19	0.72

Table 2 Test of differences in mean lead concentration between tap water and other potable water sources

Water sources	Mean	*T* value	*p* value
Well	1.04	−3.339	0.016[a]
Stream	0.83	−1.474	0.278
Borehole	0.78	−1.887	0.108

[a] Statistically significant

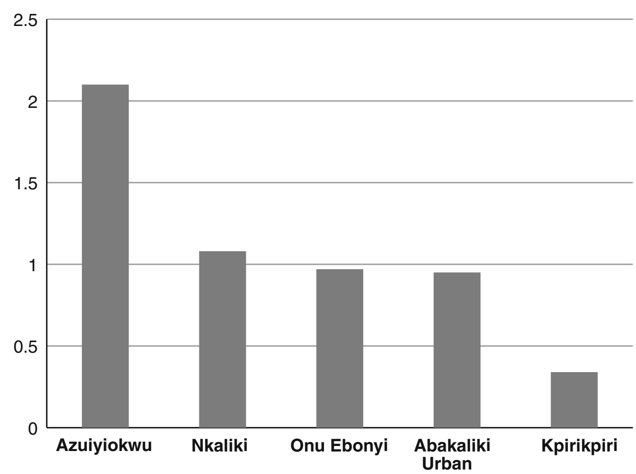

Fig. 1 Mean lead concentration (mg/L) in well water samples in the different parts of Abakaliki Metropolis

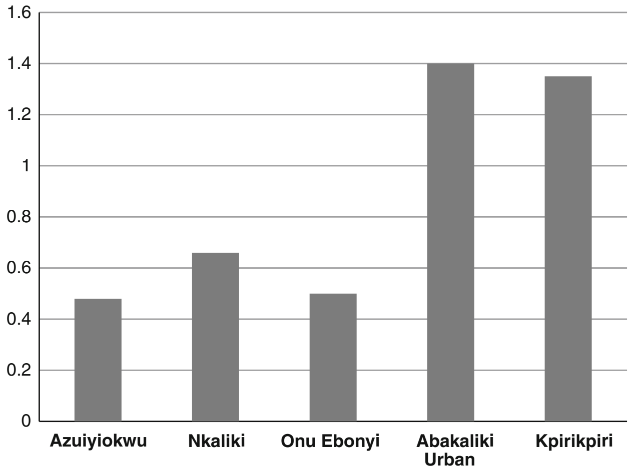

Fig. 2 Mean lead concentration (mg/L) in borehole water samples in the different parts of Abakaliki Metropolis

the municipal water treatment plant. Well water, however, recorded the highest mean lead level possibly due to the nature of the well, which exposes it to improper handling, soil components and activities taking place around the site. Some of such sampled wells were shallow, covered with rusted metal pan, uncovered and dug in areas where run-off water contaminates the well after rain. More so, the wells that are located around refuse dumps, markets and industrial activities, are likely to be contaminated. The increased value of the mean lead concentration of borehole water beyond the U S Environmental Protection Agency's (US EPA)-approved standard value of 0.015 mg/L (WHO 2008), might be as a result of the lead content of metal pipes used in the drilling of such water sources and also for the connection systems. Again, busted pipes in the soil may expose the water content to soil lead contamination, leading to an increased lead level.

For rivers and streams, contamination might be as a result of air or water pollution from industrial effluents produced (WHO 2001) or through water run-off from different areas of commercial activities, refuse dumps and improper disposal of wastes. There was statistically significant difference ($p = 0.016$) in lead concentration in the well water, compared with that of tap water, showing that of all the water sources studied, well water in the region is the most predisposed to lead contamination.

The results of the present study, showed that the mean lead levels in mg/L of the various water sources tested from the different locations of Abakaliki metropolis of Ebonyi State, South-East Nigeria, exceeded the US EPA action level of 15 μg/L (0.015 mg/L) (WHO 2008), and had close relationship with the results obtained in the study by Ahumada et al. (2010). As shown by the study, adequate monitoring in form of periodical screening exercise, to test the lead levels in the municipal drinking (potable) water sources, at least annually, should be put in place by the government, as in most developed countries, and also adequate action taken when acceptable levels are exceeded. This will help checkmate lead exposure which may result to neurodevelopmental effects such as intellectual and other neurologic deficits in children, or lead poisoning in general. Government should enact laws to mandate the use plastic pipes in plumbing works as recommended by UNICEF, to reduce the risk of lead exposure through the use of metal pipes in our water systems.

However, the use of plastic pipes also has its own health implications, since plastic containers have been implicated in bisphenol-A (BPA) exposure to man as a result of the PVC content (Maduka et al. 2010). The solution can only be the use of non-lead metal pipes. For individuals in the region who might have been exposed to the contaminant via various sources, biomonitoring may be necessary. This may be in form of measurement of whole blood lead, however, bone lead measurement is becoming a more robust method of accessing prolonged exposure. Lead has a short residence time of about 30 days in blood, whereas its residence in bone is 10 years (US EPA 2006). Refuse dumps should also be sited away from streams and rivers, and such refuse should be incinerated and buried properly. Alternatively, recycling of waste materials remains the ultimate to combat the issue of lead exposure in our environment. Azuiyiokwu area of Abakaliki municipality had the highest well lead level whereas the highest borehole lead level was from Abakaliki urban locality. Adequate information should be provided to the residents of these areas on the health implications of using those potable water sources, whereas treated tap water should be provided for them.

Finally, tap water, which had the least mean lead level in Abakaliki metropolis after adequate analysis, should be the preferred potable water source for the residents. This will reduce the human exposure to the significant lead concentration in potable water in the area.

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References

Ahumada A, Edel M Tril, Crockett R, Moreno K, Telles C, Rodriguez F, Folgar E, Ramirez-Tril J, Nguyen R, Mogadam S (2010) Lead concentration levels in public water sources in the Fruitvale District of Oakland, California. American Geographical Union, Fall meeting abstract HED 41 A-0606(23)10–15

Crook MA (2006) Clinical chemistry and metabolic medicine, 7th edn. Charon Tee Ltd, Chennai, p 320

Ericson JE, Shirahata H, Patterson C (2009) Skeletal concentrations of lead in ancient Peruvians. N Eng J Med 300:946–951

Goldstein G W (2002) Neurological concepts of lead poisoning in children, Pediatr Ann, 21(6)

Lansdown RG, Clayton BE, Graham PJ, Shepherd J, Delves HT, Turner WC (2004) Blood levels, behaviour, and intelligence: a population study. Lancet 1:538–541

Maduka IC, Ezeonu FE, Neboh EE, Shu EN (2010) Preponderance of bisphenol-A in harvested rain water in Enugu Municipality, South East Nigeria. Res J Environ Earth Sci 2(1):36–38

Ochei J, Kolhatkar A (2008) Medical laboratory science theory and practice, 7th edn. Tata McGraw-Hill publishing Company Limited, India, pp 306–448

Patterson CC (2001) Natural skeletal levels of lead in homosapiens uncontaminated by technology. Sci Total Environ 107:205–230

United States Environmental Protection Agency (US EPA) (2006) Air quality criteria for lead, Research Triangle park, NC, Environmental criteria and assessment office, pp 8–83

World Health Organization (2001) Guidelines for drinking water quality, 2nd edn, vol 1. Geneva, pp 49–50

World Health Organization (2008) Healthy environments for children alliance, lead (issue briefs services), Geneva, pp 304–310