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Research Article

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Zamfara lead poisoning saga: Comparison of lead contamination level of water samples and lead poisoning in Bagega Artisanal gold mining district, Nigeria

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ABSTRACT

Bagega and its environs in Zamfara State (Nigeria) were part of the region where recent acute lead (Pb) poisoning outbreak occurred. In this study, different sources of water samples were obtained from Bagega, Topeki, Tunga-kudeku and Dareta. Pb concentration level in water samples was quantitatively determined using Atomic Absorption Spectrometry (AAS). Pb level in water samples was assessed using Contamination Factor (CF) and the result obtained was compared with the previous investigation conducted on blood Pb levels of the dwellers within the same study area. All the water samples analysed in the study area contained Pb above the 0.01ppm World Health Organization (WHO) drinking water limit for Pb. With the exception of Topeki well water sample (which had a considerable contamination for Pb), all other water samples analysed in the study area showed a very high contamination (C.F > 6) for Pb. There wasa strong link between the Pb level in water samples of the study area and the blood Pb levels of the inhabitant of the locality. Thus, the drinking water source might be one of the major routes of human Pb exposure among the dwellers of the study area.

Key words: Lead poisoning, artisanal, contamination factor, nephropathy and drinking water

INTRODUCTION

Toxicity of lead (Pb) and other heavy metals have been documented throughout history. However, the recent outbreak of acute lead poisoning among the rural dwellers of Zamfara State happened to be the worst heavy metals poisoning incident in Nigeria, which resulted in the death of over 500 children within seven months in 2010 [1]. During the period of Pb poisoning outbreak, a joint research was conducted by Médecins Sans Frontières (MSF), US Center for Disease Control and Prevention (CDC), Blacksmith Institute (BI) and World Health Organisation (WHO). It was revealed that out of about 120 children examined, 96% were found to show life threatening Pb concentrations in their blood [2].

Lead poisoning can have significant effect on human and animals; it can cause permanent brain damage, kidney disease, nephropathy, seizure, coma and even death in some cases [3]. Reports have shown that the major routes of exposure include drinking water, hand to mouth ingestion and inhalation of dust containing lead particulates [3]. Water is regarded as the most precious natural resource which plays essential role in supporting human life. Unfortunately, it has a great potential for transmitting diseases and illnesses if contaminated with toxic pollutants [4].Lead has no biological role in the human body and can be toxic even at a very low concentration in drinking

water. Thus, World Health Organisation [5], has set the maximum permissible limit for Pb in drinking water to be 0.01ppm.
In recent times, scientists have made considerable achievements in the evaluation of heavy metal pollution in environmental samples using mathematical models. One of such models is the Contamination Factor, which is obtained by dividing the concentration of each metal in the environmental sample (e.g. water and soil) by its baseline or background value [6]. The contamination factor may be classified based on its intensities on a scale ranging from <1 to >6. This is given as$Cf< 1$, $1<Cf<3$, $3<Cf<6$, and $Cf>6$ for low contamination factor, moderate contamination factor, considerable contamination factor and very high contamination factor respectively [7].

Bagega and its environs are part of the region where active artisanal gold mining is being carried out in Zamfara State, Nigeria. Thus, the Pb poisoning outbreak was very severe in the region. In response to this problem, Blacksmith Institute (with other international organisations) in collaboration with Zamfara State and Federal Government of Nigeria carried out soil remediation exercise in most of the lead-contaminated villages including Bagega and environ. It was indicated from environmental assessments of Blacksmith Institute [8] that lead exposure could be eliminated by removal and replacement of topsoil and by thorough cleaning/removal of dust from all interior spaces, homes and compounds. It was reported that water sources (as compared to ingestion of soil/ food and inhalation of dust) have lesser significance as lead exposure route to human [9].

However, no any record yet of water remediation exercise for this lead poisoning zone. Does it mean that soil remediation is enough to curb the menace of lead poisoning among the dwellers? Or does the contamination level of the drinking water sources in these communities not high enough to warrant for remediation exercise or to make provision of alternative source of drinking water for the dwellers? To answer these questions, this work was carried out to assess the level of Pb in the drinking water sources of these artisanal gold mining communities and to compare the contamination levels of the different sampling sites. Values obtained for Pb in water would be compared also to the reported cases of Pb poisoning. This is particularly important since previous Pb poisoning investigations were mainly carried out on human samples (e.g. blood), with little or no comparison with environmental samples (e.g. water) which are actually the sources of the pollutant. This work would go a long way in making available data that will be vital in remediation program of lead (Pb) poisoning in the study area.

EXPERIMENTAL SECTION

All experiments were performed with analytical grade chemicals (Sigma-Aldrich) and deionised water was used throughout the entire analysis. Measurements were made using Varian model-AA240FS Atomic Absorption Spectrophotometer (AAS) equipped with a lead hollow cathode lamp.

2.1Study area

The study area (Fig.1) comprises of Bagega and selected neighbouring communities (Dareta, Tunga-kudeku and Topeki). These villages were selected because of their proximity to each other along the same route and to Bagega where major Artisanal gold mining activities are taking place. Bagega being the district headquarters of the entire study area lies on the geographical coordinates of latitude 11^{o} 51' 47" N and longitude 6^{o} 0' 15" E.

2.2Collection and Preservation of Water samples

All Water samples for this research work were obtained on 21^{ist} of April, 2013 between 8.00am- 4.00pm. A total of forty five (45) water samples were collected at Bagega and three (3) other neighbouring communities (Dareta, Topeki and Tunga-kudeku). In each community, ten (10) ground water samples were collected randomly from both borehole and domestic wells. In addition, Five (5) surface water samples were also collected at different points of Bagega Dam (pond). Sampling was done in accordance with APHA [10] standard method of water analysis. Briefly, pre-cleaned 2 litre polyethylene sampling bottles were used. At each sampling point, the bottles were rinsed 3 times with the water before collection. The samples were preserved by acidifying with $2cm^3$ of concentrated HNO_3 in order to achieve a pH of 2. All the samples were returned to the laboratory and the analysis was carried out within 4 days.

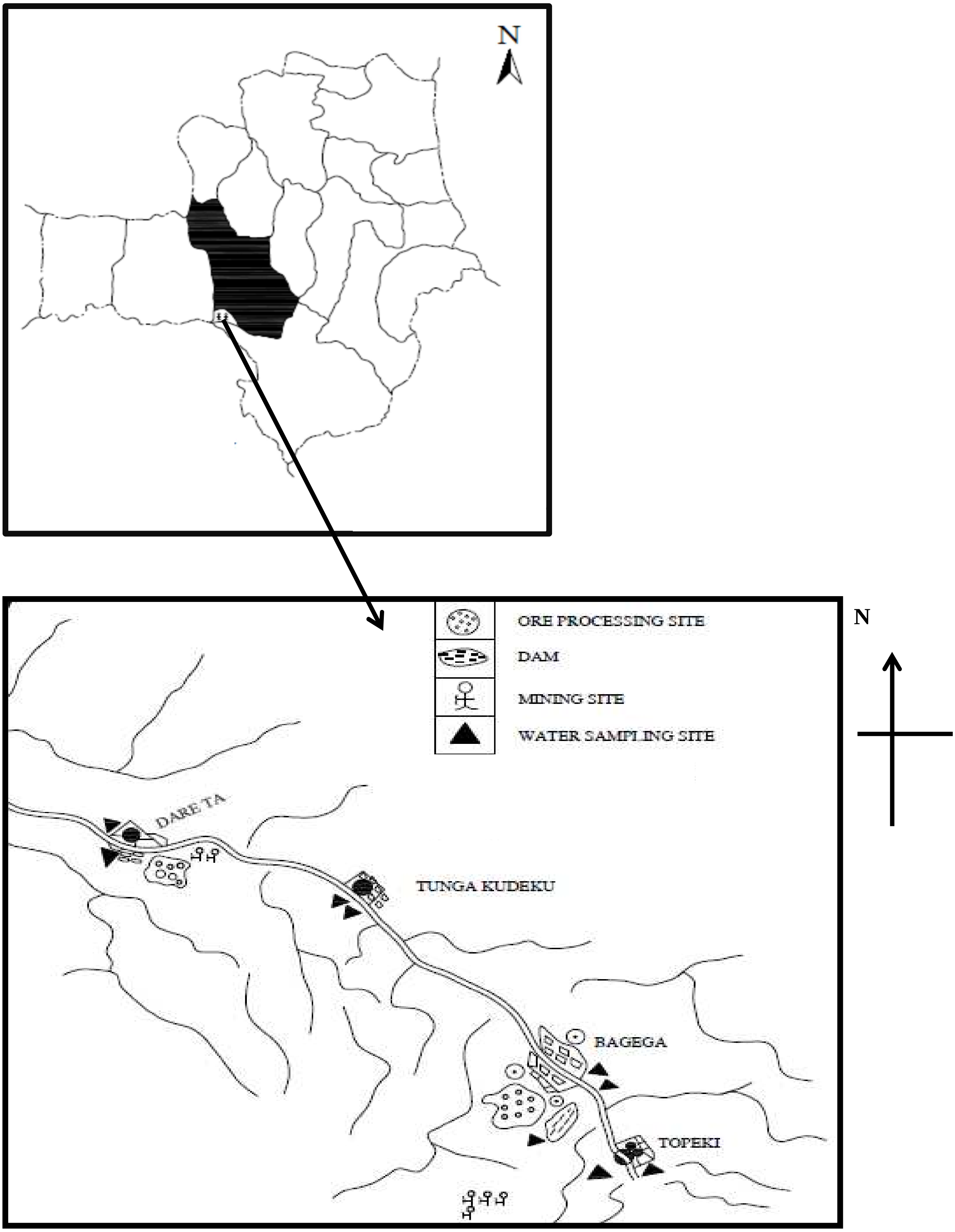

Fig. 1: Schematic map of Zamfara State, Nigeria showing Bagega gold Mining region

2.3 Pre-Treatment of water Samples
Water samples were digested according to APHA [10]. Briefly, 1000cm^3 of well mixed, acid preserved sample was transferred into a beaker. Exactly 50cm^3 of conc. HNO_3 was added and heated to boiling. This was then evaporated on a hot plate to 20cm^3. Heating and addition of conc. HNO_3 continued until digestion was completed as indicated by a light colour, clear solution. The content was then transferred to 100cm^3 plastic bottles, cooled and diluted to mark. Portions of the solution were used for Pb determination.

2.4 Quantitative determination of Pb in water samples
In this work, flame atomic absorption spectrophotometer (Varian model-AA240FS) equipped with a Pb hollow cathode lamp was used for quantitative determination of Pb in water samples. Standard calibration curve for the concentration range of 0.0001ppm-2.0000ppm was used. This was linear with coefficient of determination of R^2 = 0.99

2.5 Contamination factor (C.F) of lead (Pb) in water samples
The contamination factor (CF) was calculated by dividing the concentration level of Pb in each water sample by the background value [6]. In this study, the WHO [11] maximum permissible limit for Pb in drinking water was selected as background level for the calculation of contamination factors of all the water samples.

RESULTS AND DISCUSSION

The result of the Pb concentration (mean ± standard deviations, n = 5) and the contamination factors (C.F) of Pb in water samples are presented in Fig. 2 and Fig 3 respectively.

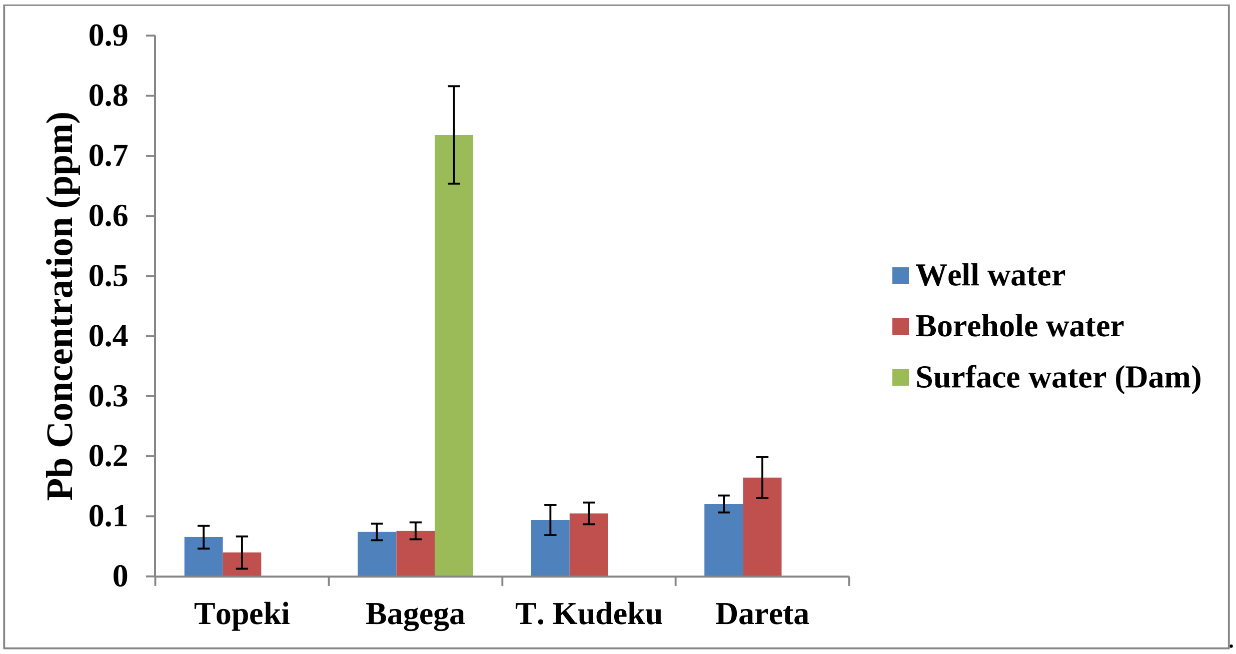

Fig. 2: Concentration of Pb in water samples across different locations in the study area
Error bar represents mean ± standard deviation of five (5) different samples.

The levels of lead (Pb) in well water samples analysed in the study area varied from a minimum of 0.065±0.019 ppm to a maximum of 0.121±0.014 ppm in Topeki and Dareta village samples respectively (Fig. 2). Similarly, the variation of lead (Pb) concentration in Borehole water samples ranged from a minimum of 0.039±0.027 ppm to a maximum of 0.165±0.034 ppm in Topeki and Dareta village samples respectively (Fig. 2). However, the lead (Pb) level of the surface water sample (Bagega dam) was found to be 0.735±0.081ppm (Fig. 2). The values obtained for all the water samples were higher than WHO maximum permissible limit of 0.01ppm [11]. This was expected because there were recent cases of lead poisoning outbreak in the region. Therefore, all ground waters and surface water in the study area may not be fit for domestic and drinking purposes. Student's t- test analysis revealed that there were no significant differences ($P > 0.05$) between well water and borehole water values in each village of the study area.

With the exception of Topeki well water sample which showed a considerable contamination for Pb, all water samples analysed in the study area showed a very high contamination (C.F > 6) (Fig. 3).

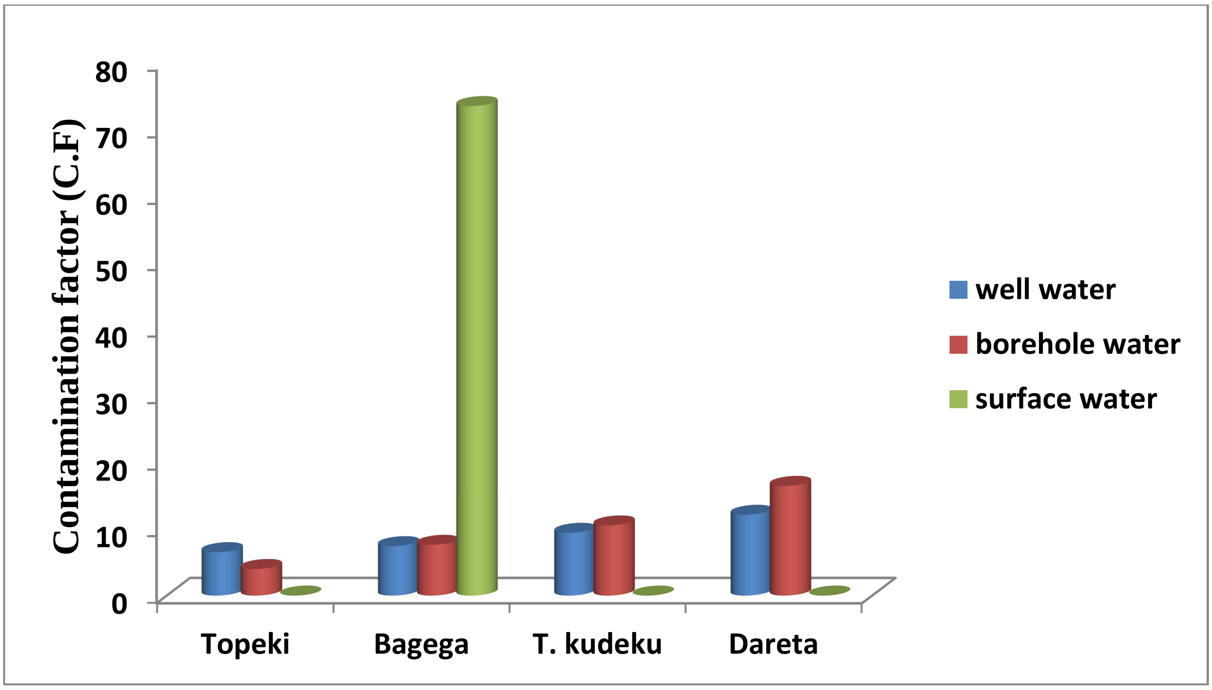

Fig. 3: Contamination factor (C.F) of Pb in water samples across different locations in the study area

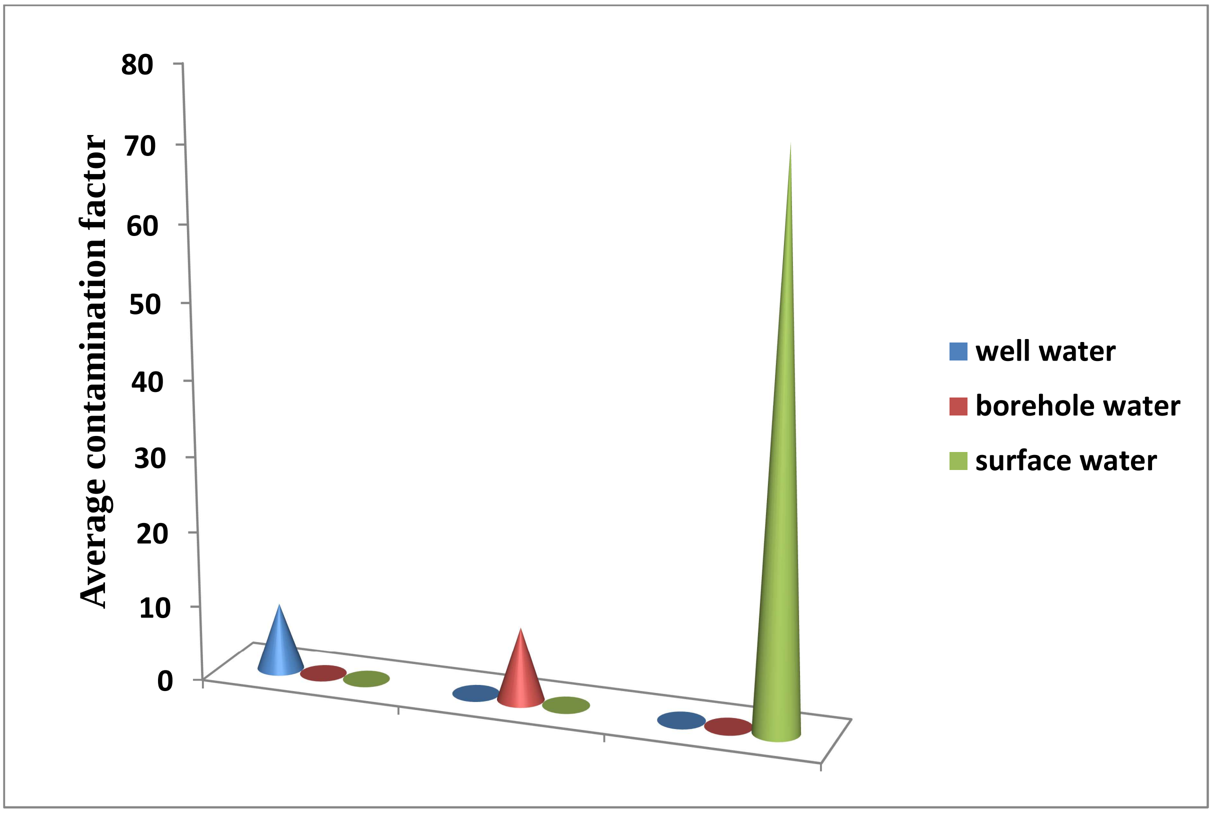

Fig. 4: Average contamination factor (C.F) of Pb in different water sources of the Study area

From the results obtained, it was evident that all the water samples analysed in the entire study area showed Pb levels above WHO maximum permissible limits. These results agreed with a separate investigation conducted by Blacksmith Institute [8] on the blood samples which showed that all the children tested had blood lead (Pb) levels (BLLs) exceeding 10 µg/dl (the international standard for the maximum safe level of lead (Pb) in blood). It was observed that the calculated average contamination factors for well water, borehole water and surface water samples of the study area were 8.85, 9.63 and 73.5 respectively (Fig. 4). This implies that well water, borehole water and surface water recorded approximately 9 times, 10 times and 74 times respectively the maximum permissible limits of WHO [11]. It has been reported that blood lead concentration is increase by about 1 µg/dl for every 0.005 ppm of lead in water consumed; and at this conversion rate, 0.5 ppm of lead in water consumed will produce an unacceptable 10µg/dl of lead in blood [12]. Therefore with the exception of Topeki borehole water, all the water samples within the study area will have a tendency to produce abnormal higher blood lead concentration greater than 10µg/dl.

CONCLUSION

From the comparison above, it is evident that there is a strong link or relationship between the Pb level in water samples of the study area and the blood Pb levels of the inhabitant of the locality. Thus, the drinking water source might be one of the major routes of human Pb exposure among the dwellers of the study area. Therefore, in order to get rid of acute Pb poisoning, there is the need to carry out thorough remediation of all water sources within artisanal gold mining region of the study area.

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