



BLOOD LEAD LEVELS OF MINING COMMUNITIES OF ZAMFARA STATE, NIGERIA

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ABSTRACT

Mining activity in Zamfara State Nigeria is associated with serious health challenges in both children and adults of the mining communities. Deaths due to lead poisoning are common in Zamfara State, Nigeria. This study was aimed to determine the concentration of lead in the blood of dwellers in mining communities of Zamfara State. Blood samples of volunteers from 10 selected gold-mining communities in Zamfara State, Nigeria were collected and analysed for lead levels. Blood samples were collected from 49 children of age bracket (2-6 years) and 43 adult volunteers of age bracket (18 – 60 years). Samples were preserved and digested using the wet digestion procedure for biological samples and analyzed using Atomic Absorption Spectrophotometry (AAS) method. Results indicated that the mean blood lead (BLL) concentration in children ranged from 30.20 ± 7.74 to 159.40 ± 7.45 $\mu\text{g/dL}$, while in adults, the mean blood lead concentration ranged from 38.10 ± 5.62 to 148.20 ± 9.92 $\mu\text{g/dL}$. Within the threshold level of concern, the lower limit of blood lead concentration for children was found in Kwali and the higher limit in Bagega, while in adults the lower limit occurred in Tugar – Kudaku and the higher limit in Magami communities. In all cases, the BLL exceeded the WHO threshold limit of concern (10 $\mu\text{g/dL}$), and the results also indicated that children from 7 out of 10 villages require chelating therapy, as the mean BLL was greater than 45 $\mu\text{g/dL}$, which is the WHO lower limit for chelating therapy. The lead concentrations in children compared to adults were not significantly different ($p < 0.05$) within a community, but the mean blood lead concentration was significantly different ($p < 0.05$) across some communities.

KEYWORDS: Blood lead level, mining communities, gold-mining, lead poisoning, Zamfara State.

INTRODUCTION

The World's attention was drawn to the health and environmental hazard of lead communities in Anka, Bukkuyum, Gusau and Maru Local Government Areas of Zamfara State, Nigeria in 2011 [1,2]. Lead poisoning, especially in children in the mining communities of Zamfara State was as a result of illegal gold mining activity using rudimentary tools [2, 3].

Mining activity is one of the economic activities in developing countries with severe health and environmental consequences. Illegal mining activity in Zamfara State, North-West Zone of Nigeria attracted the world's attention when 400 lives, mostly

children were lost Anka and Bukuyum Local Government Areas of the State [3].

The major source of this contamination was gold mining. And the methods being employed in the processing of the lead-rich ore resulted in direct contamination, ingestion, and inhalation of the lead dust, soil and water contamination. The results of the health and environmental assessment carried out in the affected communities was a worrisome one [3,4]. Up to 50% of inhaled inorganic lead may be absorbed in the lungs. Adults take up 10–15% of lead in food, whereas children may absorb up to 50% *via* the gastrointestinal tract. Lead in blood is bound to erythrocytes, and elimination is slow and principally *via* urine. Lead is accumulated in the bones, and is only slowly released from this body

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compartment. Half-life of lead in blood is about 1 month and in the skeleton 20–30 years [4].

In adults, inorganic lead does not penetrate the blood–brain barrier, whereas this barrier is less developed in children. The high gastrointestinal uptake and the permeable blood–brain barrier make children especially susceptible to lead exposure and subsequent brain damage; this may result in cognitive defect, which affects the Intelligence Quotient (IQ) that would make learning very difficult in children. Organic lead compounds penetrate body and cell membranes. Tetramethyl lead and tetraethyl lead penetrate the skin easily. These compounds may also cross the blood–brain barrier in adults, and thus adults may suffer from lead encephalopathy related to acute poisoning by organic lead compounds. Children may be affected by behavioural disturbances, learning and concentration difficulties. In severe cases of lead encephalopathy, the affected person may suffer from acute psychosis, confusion and reduced consciousness. People who have been exposed to lead for a long time may suffer from memory deterioration, prolonged reaction time and reduced ability to understand [5,6,7].

Lead poisoning in Zamfara State is threatening the lives of more than 5,000 children who are likely to suffer from brain damage [8]. About 73% of the total lead in children is stored in their bones [9]. Children often place objects in their mouth resulting in dust and soil being ingested and, possibly increase the intake of lead [9, 10]. This study was therefore undertaken to determine the level of lead in the blood of the mining communities in Zamfara State.

MATERIALS AND METHODS

Study area

The study was carried out in ten selected communities from four LGAs of Anka, Bukkuyum, Maru and Gusau of Zamfara State. These communities are: Bagega, Kadauri, Kawaye, Kwali, Magami, Sunke, Tsunami, Tungar – Guru, TungarKudaku and Yargalma.

Equipment and Glass wares

- Varian AAS model 240FS machine, with GTA-120 graphite furnace of the Multi-User Science Research Laboratory/ Ahmadu Bello University, Zaria (MUSRL/ABU).
- Geographical Position System (GPS) mobile trackers (Extrex, Garmin, USA).
- Hot plates: Mode HC500, BIBBY.
- Electrical Oven: Model MIR-162, SANYO.

- Refrigerator: Model Casart, HAIER THERMOCOOL.
- Specimen bottles (sterilized and pre-treated) for Blood samples.

Chemicals and reagents

All chemicals used for the analysis are of analytical grade obtained from British Drug House (BDH). The standard stock solution used for the calibration curves for the standards is of standard grade. Other reagents used include the following: hydrochloric acid, HCl (Analytical grade); trioxonitrate (V) acid, 0.5% HNO₃ (Analytical grade); 10% Trioxonitrate (V) acid (Analytical grade); Hydrogen peroxide, 30% H₂O₂ (Analytical grade); and de-ionized distilled water.

Sample collection and preparation

Blood samples of 92 volunteers (49 children and 43 adults) were collected for analysis. Villages were selected by stratified sampling [11,12]. Five sampling units were selected from each village with each sampling unit represents a family compound. Collection and treatment of sample was done under sterilized condition with adequate clinical provision in handling the blood samples. The blood samples were stored in sterilized condition at the Lead Centre of Excellence, Gusau, before it was transferred to the Multi-User Science Research Laboratory (MUSRL)/ABU, Zaria and stored for analysis.

Digestion of the sample

Whole blood samples were digested according to modified procedures described below. A 500 µL subsample of whole blood was removed from the original sample and digested with 2.0 ml trace metal grade concentration HNO₃. The sub-samples were then heated (100°C/2h) until brown fumes were all evolved. The mixture was allowed to cool at room temperature and, once complete digestion was achieved, 300 µL of 30% H₂O₂ was added to each sample followed by heat-instilling until dry. The samples were then reconstituted in 5.0 ml of 0.5 % HNO₃ with deionized water [13].

Preparation of lead stock solution for calibration curve

A 1000 µg/L Pb solution was prepared by dissolving 1.598 g lead nitrate in 5.0 cm³ 10% nitric acid and was diluted with water to mark in a 100 ml volumetric flask.

Calibration curve for lead in blood sample

Approximately 1ml of the stock solution of lead was diluted to 9.0 ppm. And this standard was serially

diluted to 1.0, 3.0, 6.0 and 9.0 ppm and set for analysis. The serially diluted samples were aspirated using the AAS machine (Figure 1).

Analysis of lead in human blood samples

The prepared samples were then aspirated into the AAS machine. The instrument was programmed to take three readings per sample and average the absorbance. Instrument blanks (0.5 % HNO₃) and check standards were processed with all samples. Sample concentrations were then corrected for deviations from the standards, and final wet weight was factored into the calculation of final values. The lead contents of the blood samples were determined from the calibration curve [13].

Statistical analysis

Analysis of Variance (ANOVA) and one-sample t-test using GraphPad Prism 6 statistical tools were used. There was no significant difference between the BLLs for children and adults within the same community, but there was a significant difference across communities. In all cases, P values < 0.05 were considered statistically significant.

RESULTS AND DISCUSSION

The mean blood lead concentrations for children and adults from all the selected mining communities ranged from 32.20 ± 7.33 to 157.60 ± 9.11 µg/dL are above the WHO (10 µg/dL) tolerance limit (Figures 2 and 3). Only three (Kwali, Tungar-Kudaku, and Yargalma) out of the ten villages had children with mean blood lead concentration slightly less than 45 µg/dL, which is the threshold level for chelating therapy treatment in children. At acute level children suffer from impairment of IQ and other cognitive effects, decreased heme synthesis, and interference in vitamin D metabolism[14]. Comparisons in adults' blood lead mean concentration (37.80 ± 5.94 - 146.40 ± 27.40 µg/dL) between Kadauri versus the rest of the mining communities indicated significant difference (P < 0.05) with Kwali, Tungar-Guru, Tungar-Kudaku, and Yargalma. Also, Comparisons

between Kwali versus Magami, Tungar-Guru, Tungar-Kudaku, and Yargalma were statistically significant (P < 0.05). The overall comparison indicated that there was no significant difference (P < 0.05) between children and adults mean blood lead concentration. Adults' involvement in either gold mining or processing made them agents of human transmission of lead from the mining and processing fields to their homes[15]. Often, these adults' activities in mining were the potential routes of re-contamination even after remediation [15,16]. Comparison of the mean blood lead concentration has indicated that the adults had higher mean blood lead level concentration in six out of the ten villages, while in the children mean blood lead concentration was higher in four out of the ten villages (Figure 4). Absorbed lead enters the bloodstream and accumulates in body tissue, particularly the kidneys, bones and nervous system. Adults suffer from reproductive effect, the elevation of blood pressure, headaches, weight loss; nervous system problem, anemia, hypertension, nerve disorders, memory and concentration problems, muscles and joint pains, kidneys, and blood, culminating in death at excessive levels [17]. The fetus, infant and child are especially vulnerable. Damage to the brain, hearing problems, preventing the development of the normal tertiary structure of the brain during the first few years of life, result in permanent abnormality [18]. Children are more vulnerable than adults to the effects of lead exposure because a proportionately greater amount of the lead they ingest is absorbed, more circulating lead enters their brain, and their developing nervous system is more vulnerable to lead's toxic effects of lead. The only treatment available is chelating therapy, and these chelating drugs are not readily available and affordable in developing countries [19,20]. In conclusion, the results of the comparison of blood lead level in children and adults from the selected mining communities in Zamfara State indicated no significant difference in blood levels.

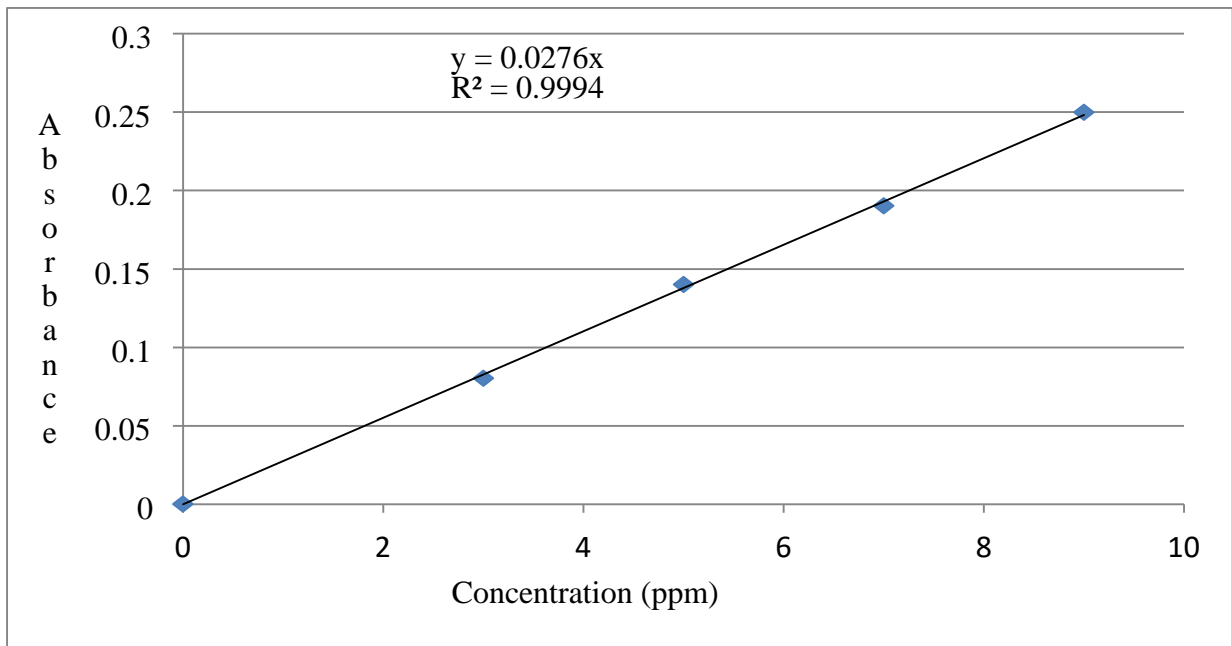


Figure 1: Calibration curve for lead blood samples.

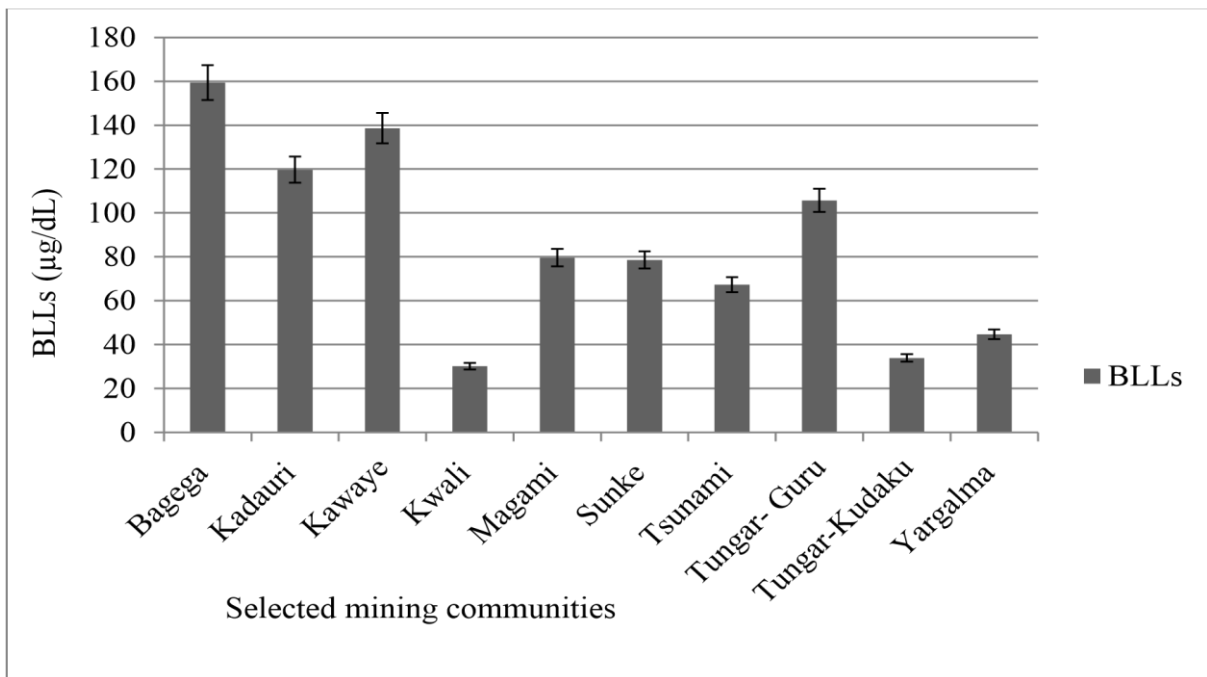


Figure 2: Blood lead levels (BLLs) in Children from the selected mining communities.

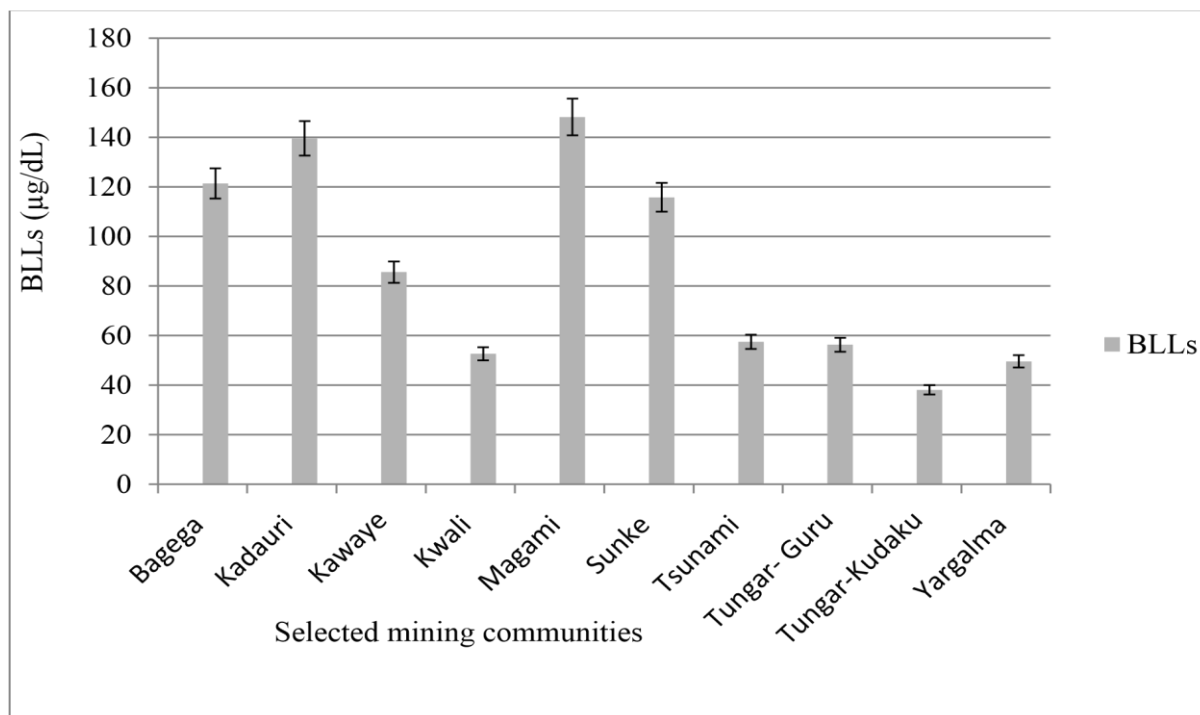


Figure 3: Blood Lead Levels (BLLs) in Adults in the selected mining communities.

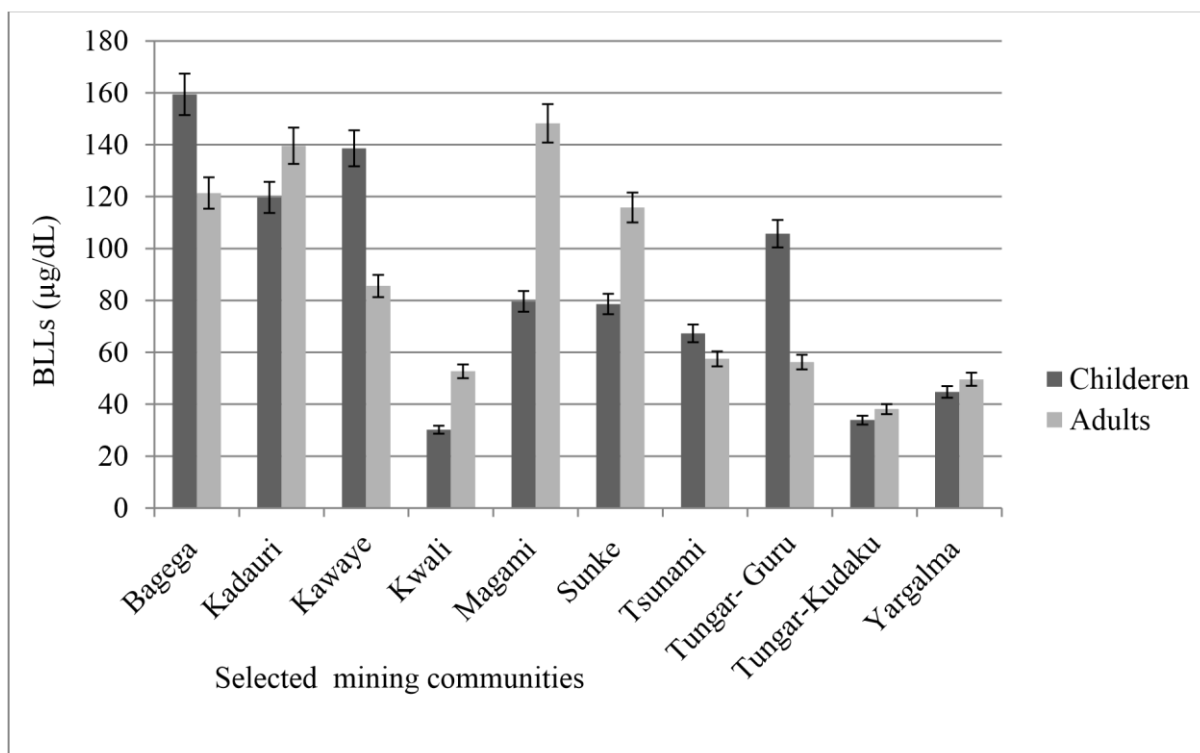


Figure 4: Comparison of blood lead levels (BLLs) in Children & Adults.

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