Is It Safe to Drink Mine Water? A Human Health Risk Assessment of (Lead) Pb Levels in Water Collected from Abandoned Mines in Ebonyi State, Nigeria

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Abstract: ***Lead (Pb) levels were determined in 40 samples of water collected from four abandoned mines scattered across the three senatorial zones of Ebonyi State. The result revealed that Pb concentration in the water samples collected from location 1 varied from 5.1 mg/l to 9.4 mg/l, in location 2, Pb concentration ranged from 2.9 mg/l to 8.0 mg/l. Water samples from location 3 had Pb concentration in the range of 0.9 mg/l to 4.0 mg/l whilst Pb concentration in water samples from location 4 varied from 5.0 mg/l to 9.2 mg/l. These results were compared with the World Health Organisation (WHO), guideline for Pb in drinking-water (0.01 mg/l) and it was observed that even the lowest Pb concentration exceeded the WHO guideline value significantly (200 times in excess). Lead concentrations in excess of WHO guideline could cause Pb poisoning especially in children and pregnant women.***

Keywords: Lead (Pb), water, human health risk, Ebonyi State, abandoned mine

1. Introduction

The amount of water available is as important as its quality. Water is life. It is essential for sustaining basic human functions, health and food production, as well as for preserving the integrity of the world's ecosystems. Access to safe drinking water is a basic right for all human beings. Our well-being is highly dependent on both the quality and the availability of water and how well we manage this precious resource. The provision of safe water for the public is the principal responsibility of every government, whilst, this is no more an issue in developed world, the developing countries are yet to attain this height. The search for drinking and domestic water in Ebonyi State, Nigeria has made many rural dwellers to use any water at their disposal including water collected from mining sites (current mining sites and abandoned mining sites). Though human activities have substantially altered the natural environment, leading to potentially elevated concentrations of contaminants, mining has been described as a major contributor (1). Specifically, opencast mining activities have a serious environmental impact on soils and water streams, having generated millions of tons of sulfide-rich tailings (2). Moreover, acidic drainage resulting from the oxidation of sulphides from metalliferous mine spoils leads to the leaching of large quantities of cations including lead ions (Pb^{2+}) (3). Thus, lead (Pb) contamination and acid mine drainage are very important human health and environmental concerns where open-pit mining has been carried out and abandoned. Unregulated open-pit mining commenced in Ebonyi State, Nigeria in 1952 (4). These have resulted into many abandoned open-pit mines acting as water reservoirs. These open-pit reservoirs are all located in the rural residential arears where the dwellers do not have any other source of water but the abandoned mine water. My interaction with these people revealed that they use the water from the reservoirs (Figure 1) for both domestic and drinking purposes. In addition, children also use the mines as a playground (figure 2). It should be noted that abandoned Pb mines acting as water reservoirs for personal use represents a significant pathway through which Pb could enter the human body.

Figure1: Showing children and adult living within the vicinity of abandoned mines fetching water from a mine reservoir

Figure 2: Showing children fetching water from a mine and also use it as a playground

Thus, contaminated water causes a range of diseases which are often lives threatening and it has been reported (5) that children are the most frequent victims of water related diseases. The burden of morbidity associated with the increasing exposure of neglected populations in the developing countries to chemical pollutants in their environment has generally been ignored. One of the most prevalent and neglected diseases in Nigeria and most of the Sub- Saharan African countries probably is lead poisoning which has affected a large fraction of the childhood population because of the growing multiplicity of potential exposure routes. Recent Pb poisoning in Nigeria which killed over 500 children and made many sick has been reported (6) as theworst outbreak ever recorded. According to the report, hospitalised children were found to have levels of lead in their blood which were 17 to 22 times higher than the minimum international standards. These ugly incident occurred in Zamfara State (North-West of Nigeria) in 2010 (7) and Niger State (North-Central of Nigeria) in 2015 (8) respectively. The short-term effects of lead poisoning include acute fever, convulsions, loss of consciousness and blindness, anaemia, kidney failure and brain damage among the long-term effects.

It is in light of this development that this novel study was undertaken to ascertain Pb levels in mine water being used for domestic and drinking purposes in Ebonyi State, Nigeria. Literature shows that no study has investigated Pb levels in water from these mines.

2. Methodology

2.1 Study Area

Ebonyi State (South-East Nigeria) comprises of three senatorial zones namely; Ebonyi Central, Ebonyi North and Ebonyi South. Each of these zones have at least two Pb abandoned mines. Four abandoned mines serving as water reservoirs for the rural dwellers were randomly selected from the three zones. Mkpumaakpatakpa abandoned mine and Achara Nuhu abandoned mine were selected from Ebonyi North while Ohankwu abandoned mine and Ishiagu abandoned mine were selected from Ebonyi Central and Ebonyi South respectively (Figure 2).

2.2 Sample collection and preparation

Forty (40) water samples were collected from four (4) abandoned mines selected for the study. Ten samples were collected from Mkpumaakpatakpa (Agbaja) abandoned mine (Ebonyi North) on June 10, 2015. 10 samples were collected from Ohankwu Ikwo abandoned mine (Ebonyi Central) on June 15, 2015, 10 samples were collected from Ishiagu Ihetutu abandoned mine (Ebonyi South) on June 20, 2015 and 10 samples were collected from Achara Nuhu abandoned mine (Ebonyi North) on June 25, 2015. In each of the sampling loactions, samples 1 to 5 were collected at 10cm depth while samples 6 to 10 were collected at the surface. They were collected in inert polyvinylchloride (PVC) bottle which were previously soaked in an acid bath for 24 hours, thoroughly washed and then rinsed with ultrapure water of resistivity 18.2 MΩ-cm at 25^0C. All the bottles were allowed to dry before sampling. Collected samples were filtered into 50 ml volumetric flask using a whatman filter paper (grade 41). In order to preserve the integrity of the samples, they were acidified with nitric acid (0.1 M HNO_3).

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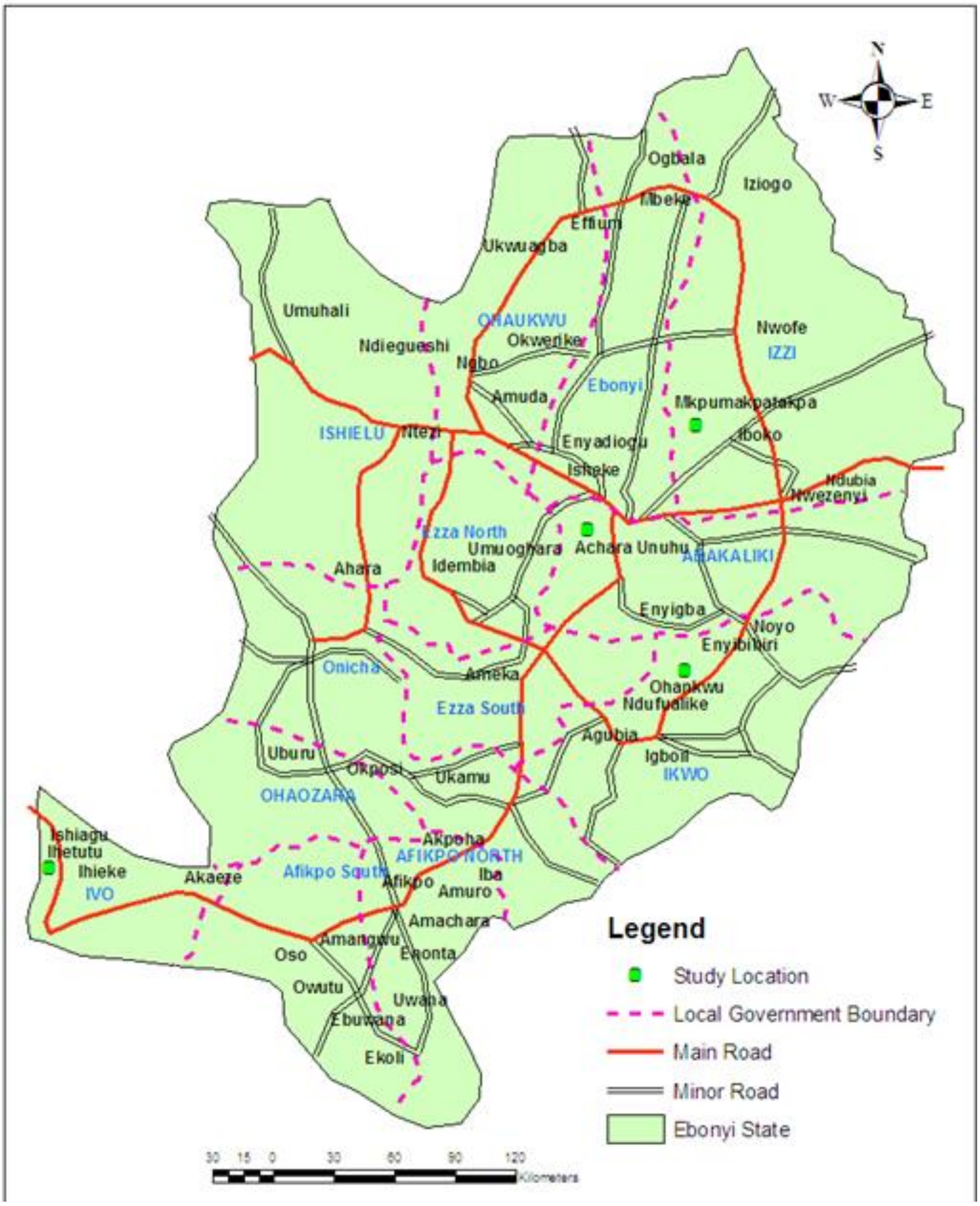

Figure 2: Map of Ebonyi State, Nigeria showing study locations

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2.3 Flame atomic Absorption Spectrophotometer (FAAS) protocol

Samples to be analysed by FAAS were prepared in triplicates in order to ensure reproducibility. Reagent blanks were included to check contamination. Six calibration standards over the range 0-10 µgmL^{-1} (mgL^{-1}) were prepared from 1000 µgmL^{-1} Pb stock solution; this was used to calibrate the instrument and also to plot the calibration graph and the regression coefficient (R^2) obtained was 0.999 (linear graph). Based on the excellent R^2 value, the samples were analysed.

3. Results and Discussion

Table 1 shows the determined mean Pb concentrations for 40 samples collected from 4 abandoned mine reservoirs as well as world Health Organisation (WHO) standard guideline for Pb in drinking water (9) while Table 2 gives the statistical summary of Pb levels in the water samples. From Table 1, it can be seen that Pb concentration in water samples collected from Mkpumaakpatakpa mine varied from 5.1 mg/l to 9.4 mg/l, in Achara Nuhu mine, Pb concentration ranged from 2.9 mg/l to 8.0 mg/l. Water samples from Ohankwu had Pb concentration in the range of 0.9 mg/l to 4.0 mg/l while Pb concentration in water samples from Ihetutu Ishiagu varied from 5.0 mg/l to 9.2 mg/l.

The result showed that the highest concentration of Pb (9.2 mg/l) was found in the water sample collected from Ihetutu Ishiagu abandoned mine while the lowest Pb concentration (0.9 mg/l) was obtained from the sample collected from Ohankwu abandoned mine. Investigations revealed that Ishiagu Ihetutu abandoned mine is the oldest mine while ohankwu abandoned mine is the newest, so it is expected that Pb must have accumulated more in the older mine, especially when it is a reservoir. It has been reported (9) that Pb is immobile in environmental matrices and accumulate over time which may result in elevated concentration. It was also observed that Pb concentration in samples 1 to 5 across the mines collected at a depth of 10 cm were all higher that Pb concentration found in the samples collected at the surface. However, the depth at which the samples were collected not withstanding, it is obvious that high Pb concentration were recorded in all cases. Furthermore, Table 2 gives the statistical summary of Pb levels in the water samples and in line with the raw results, Ihetutu Ishiagu mine with the highest concentration recorded a mean of 7.2 ± 1.6 mg/l while Ohanwu mine with the lowest concentration was found to have a mean of 2.4 ± 1.0 mg/l. Since the inhabitants of the host communities use the water for both domestic and drinking purposes, it was considered necessary to compare these mean values with the World Health Organisation (WHO), guideline for Pb in drinking-water given as 0.01 mg/l (Table 1) (10). It can be seen from the result that even the lowest mean of 2.4 mg/l from Ohankwu abandoned mine exceeded the WHO guideline value significantly (200 times above).

Table 1: Showing sampling locations and Pb levels in the water samples (mg/l)

Sampling locations	Sampling locations and Pb values (mg/l)									
	1	2	3	4	5	6	7	8	9	10
1. Mkpumaakpatakpa (Agbaja), Izzi LGA	7.5	7.8	6.9	7.4	6.7	6.4	5.1	4.9	6.0	5.7
2. Achara Nuhu, AbakalikiLGA	6.7	7.4	6.8	8.0	7.7	3.9	3.1	2.9	3.3	4.0
3. Ohankwu, Ikwo LGA	2.6	3.0	2.5	3.7	4.0	1.5	0.9	1.1	2.0	2.3
4. Ihetutu Ishiagu, Ivo LGA	8.9	9.0	8.7	9.2	8.6	6.7	5.8	4.7	5.1	5.0
Guideline value for lead (Pb) = 0.01 mg/l (WHO)[10]										

Table 2: Statistical summary of Pb levels in the water samples (mg/l)

Sampling locations	*Minimum*	*Maximum*	*Median*	*Mean*	*Standard deviation (n=3)*
Mkpumaakpatakpa (Agbaja), Izzi LGA	4.9	7.8	5.9	6.4	1.6
Achara Nuhu, AbakalikiLGA	2.9	8.0	5.4	5.4	2.1
Ohankwu, Ikwo LGA	0.9	4.0	2.4	2.4	1.0
Ihetutu Ishiagu, Ivo LGA	4.7	9.2	7.7	7.2	1.9

Lead is a highly toxic substance, exposure to which particularly through drinking water can produce a wide range of adverse health effects. Both adults and children can suffer from the effects of Pb poisoning, but childhood Pb poisoning is much more frequent, typically as recorded in Nigeria Pb poisoning. There are many different health effects associated with elevated blood Pb levels. Young children under the age of six are especially vulnerable to lead's harmful health effects, because their brains and central nervous system are still being formed. For them, even very low levels of exposure can result in reduced intelligent quotient (IQ), learning disabilities, attention deficit disorders, behavioural problems, stunted growth, impaired hearing, and kidney damage (11). In adults, Pb can increase blood pressure and cause fertility problems, nerve disorders, muscle and joint pain, irritability, and memory or concentration problems. When a pregnant woman has an elevated blood Pb level, that Pb can easily be transferred to the foetus, as Pb crosses the placenta (12). Considering the high concentration of Pb recorded in these mines and the health effects of Pb, it is obvious that all the people that use abandoned mine water for domestic purposes are at the risk of Pb poisoning.

4. Conclusion

The study has demonstrated that the use of abandoned Pb mine water for drinking and domestic purposes represents an indispensable way through which Pb enters the human body. The author strongly recommends that the Nigeria / Ebonyi State government as well as Non-Governmental Agencies (NGO) should provide portable water in these communities. Furthermore, law(s) restricting people from using such sites should be formulated and implemented.

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Author Profile

Dr. Nwabueze I. Elom took his first degree in Chemical Engineering at the Enugu State University of Science and Technology (ESUT) Enugu State, Nigeria. This was followed by an M.Sc. in Analytical Chemistry at the University of Northumbria at Newcastle, United Kingdom (UK). On his return from the UK, he joined the Department of Industrial Chemistry, Ebonyi State University Abakaliki, Nigeria as an assistant lecturer in 2005. In January 2010, Nwabueze went back to the University of Northumbria at Newcastle, UK and enrolled for a PhD programme under the supervision of Prof John. R Dean (Professor of Analytical and Environmental Science). His edge-cutting PhD research focussed on human health risk assessment of potentially toxic elements (PTEs) from environmental matrices and was successfully completed in record time. While at Northumbria University, Nwabueze alongside with his research colleagues successfully developed an *in-vitro* method (Simulated Epithelium Lung Fluid (SELF)) currently being used to assess the bioaccessibility of PTEs in the human upper respiratory system. He returned to his job in 2013. He had been a senior lecturer in Analytical and Environmental Chemistry since October 2013. His research interest is 'Human health risk assessment of environmental contaminants, with special interest in lead'. Many of his work has been published in reputable journals. He is a member of Royal Society of Chemistry, UK among other professional bodies.