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

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).

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

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