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Physical and Chemical Properties of Soil, Water and Air around Ukawu Pb-Zn Mine, Southeastern Nigeria

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Abstract

In this study, analysis of water, and soil samples, air quality, and noise levels in Ukawu Pb-Zn mine were examined. The pH of the water samples, at 6.7, exceeded permissible levels for potable water established by the National Environmental Standard Regulatory Agency (NESREA), European Union, and World Health Organization (i.e., 7.0-8.5). The soil pH was 5.2, which indicates acidity due to acid mine drainage. Low soil pH is evidence of acid mine drainage. All cations detected in water and soil were below standard limits considered harmful by the NESREA. Measurements of precursor gases, such as O_3, NO_2, CO and SO_2, to determine air quality showed levels below the air quality standards prescribed by the NESREA. Thus, the air quality around the mine is not polluted by these gases. Noise levels around the mine were below the 85dB limit considered deleterious to humans. Comparison of the noise levels detected around the mine with Indian showed that the values obtained in Ukawu mine exceed the permissible daytime values for industrial, commercial, residential, and silence zones. This research could serve as a benchmark for environmental contamination studies at the regional and global scales.

Keywords: air quality, environmental monitoring, noise level, soil, water

Introduction

Mining is a prominent source of environmental pollution by heavy metals. Mining and its related processing operations, together with the disposal of tailings, overburden, and wastewater, create avenues for water, soil, and air pollution [1]. The mining industry could trigger serious environmental pollution because mine waste heaps are sources of prolonged contamination for water and other environmental components [2]. Mine waste heaps contain metal, sulphides, which could generate acid mine drainage (AMD) rich in sulfate ion when in contact with atmospheric oxygen and humidity. Acidic water can dissolve and mobilize heavy metals (e.g., Pb, Zn, Cu, Ni, and Cd) and transport and release them into the environment [2]. Heavy metals pollution may also originate from the natural weathering of minerals and human activities. Such pollutants are persistent, irreversible, and toxic; thus, they are pollutants of enormous environmental concern [3]. Heavy metals in soil may cause fatal diseases through the ingestion of contaminated crops and water these elements easily accumulation in internal organs. Cd and Pb are potential carcinogens that have been associated with the etiology of a number of diseases such as cardiovascular, kidney, blood, nerve and bone diseases. Although Zn is an essential element, its excessive intake through food and plants is of great concern because of its potential toxicity to humans and animals [4]. Abandoned mines and tailings may be sources of heavy metals, which waste out by precipitation and can contaminate various environmental components [5]. Air and sound are components of environmental monitoring in a mine site. Mining activities are among the main sources of soil contamination by heavy metals. The risk may arise from mine spoils, which are often stored in the absence of any environmental management plan.

A review conducted by Yu *et al*. [5] in China revealed environmental contamination by major heavy metals, such as As, Cd, Zn, Pb, and Cu, in Pb-Zn mines. Huang *et al*. [6] performed soil analysis in Pb-Zn mine site and established that Pb > Cd >> Zn and that As, Pb, Cd and Zn levels exceed the safety limits prescribed by the Chinese National soil Environmental quality. Singh and Li [7] and Zhang *et al* [8] studied the environmental impacts of Pb ore mining and showed abnormal concentrations of Cd and Pb in water samples. Johansen *et al*. [9] analyzed water samples from a Pb-Zn mine in Westsvig, East Greenland and found high levels of heavy metals. Analysis of mine spoils in a Pb-Zn mine site Othmani *et al* [10] revealed the clear impact of mining on the environment. Analysis of soils around a Pb-Zn mine in Kabire Zambia and southern China by Shouta *et al*. [11] and Cao *et al*. [12] respectively, showed that Pb, Zn, Cu, Cd, and As levels were higher than the benchmark values. Analysis of heavy metals using ICP-OES in soil and some medicinal plant species collected from the Ahangaran Pb-Zn mine in Iran by using inductively coupled plasma-optical emission spectrometry (ICP-OES) showed high levels of Pb, Zn, Cd, EC and pH. In addition, those recorded at the reference sites and levels of Pb and Cd in soil surrounded by mine were higher than the standards specified by the US Environmental Protection Agency (USEPA). Water samples collected around a Pb-Zn mine site in Iran by Ghadimi *et al*. [13] were analyzed for Fe, Mn, Pb, Hg, SO_4^{2-}, CN, and Cl^- using standard methods and revealed average concentrations of 0.01, 0.60, 0.10, 0.01, 0.40, 35, 0.01 and 5.95 for Fe, Mn, Pb, Zn, Hg, SO_4^{2-}, CN^- and Cl^- respectively.

Clean air is also a fundamental requirement for human health and wellbeing. Various chemicals present in the air are released from natural and anthropogenic sources [14]. In humans, the pulmonary deposition and adsorption of inhaled chemicals from the air can have direct consequences on health [14]. The USEPA has set national ambient air quality standards for six criteria pollutants. These include O_3, PM, CO, SO_2, nitrogen oxide (NOx), and Pb [15].Noise pollution is a major issue that can adversely affect public health and quality of life and often stems from environmental noise, such as roads, rail and air traffic, industrial activities, and public works [16]. Traffic plays a major role in noise pollution [17, 18]. Road traffic generates remarkable levels of noise. In fact, road traffic in Europe may expose civilians to sound levels exceeding those recommended by the European Noise Directive [19]. In mines, workers are exposed to high levels of noise routine machining operations [20].

Individuals exposed to road traffic noise levels between 55 and 60 dB are at increased risk of developing heart disease [21]. The harmful effects of noise on children may begin well before they are born because the auditory system develops at 3-6 weeks of gestation [22].An investigation of traffic noise as a source of noise pollution by Mutalib *et al*. (23) in Taman Muritiara Rimi showed common noise level above 75 dBA, which exceeds the permissible limit recommended by the WHO Department of Environment. Stansfield and Matheson [24] found that individuals chronically exposed to continuous noise at levels of at least 85 dB have higher blood pressure than those not exposed to noise. Indeed, those who are exposed to high noise levels are usually more aggressive and less tolerant than those who are not [25]. Noise pollution also causes nervousness, amnesia and loss of concentration [26]. Occupational noise between 80–100 dB may cause hypertension and increased risk of heart attack [27].

The average ambient noise in Delhi is 80 dB, but thee ambient limit is 55 dB [28]. Noise pollution in a mine site was investigated by Shivdev *et al*. [29], who found that noise levels at the higher side of the core zone exceed the prescribed standard. Measurements of air and noise pollutants in Didar Street and intersections of African and Haggai highways showed NOx and CO levels in the ranges of 0.7- 0.6mg/m^3 and 0.74-0.68 mg/m^3 respectively. The emission standards for particulates, NOx and CO in Europe for passenger vehicles are 0.05 mg/m^3, 0.5 mg/m^3 and 0.64 mg/m^3 for particulates, NOx and CO, respectively [30]. The use of suitable insulators, correct traffic signal timing at intersections and forks, rocks, plant cover and green spaces in building construction can reduce noise pollution [30, 31]. Reduction of noise in the United States by 5 dB saved $3.9 billion in potential costs for treating cardiovascular diseases in 2014 [32].

Aroh *et al*. [33] studied environmental the impact of Pb-Zn mining and effects of Pb-As toxicity on soil collected from Arufu, Northeastern Nigeria, via ICP-OES technique. Result showed levels of As (0.97 - 0.19 ppm), Cd (0 - 4.653 ppm) and Pb (3.357 - 5.9660 ppm) well above the maximum permissible limits of 0.01, 0.01 and 0.003 ppm, respectively set by the Standard Organization of Nigeria. The physicochemical properties of pond water from Ishiagu Pb-Zn mine were employed as an index of mine drainage, and results showed that the mine area is slightly acidic with moderate levels of dissolved constituents. Nnabo [34] analyzed water sources from Enyigba Pb-Zn district Southeastern Nigeria, for heavy metal contamination by using atomic absorption spectroscopy (AAS) and found higher levels of Pb, Zn, Cu, As, Cd, Ni and Mn compared with other metals. Nnabo [35] also examined the constituents of heavy metals (As, Cd, Pb, Cu, Zn, and Ni) in Enyigba soil samples from Pb-Zn mine district and found a trends of As > Cd > Co > Mn > Cu > Ni > Pb > Zn.

Emissions from vehicles are significant contributors to ambient air pollution in Nigeria [36]. Urban areas feature high traffic volumes with the corresponding noise pollution. Examination of noise levels in the Ilorin metropolis by Olayinka [37] showed traffic noise to be a major source of noise. According to WHO guidelines, six locations fall under normally acceptable noise pollution in Ilorin. Assessment of noise pollution and perceived health challenges among residents of Lagos State by Akinnubi. [38], revealed that automobiles are a major source of noise pollution and cause hypertension even among pregnant women.

This research examined noise pollution caused by machinery around Ukawu mine, Pb-Zn ores are excavated from the mine using heavy-duty machines which produce vibrations and excessive noise. Dhole and Kadu [28] defined acceptable daytime and nighttime ambient noise standards for industrial, commercial, residential and silence zones. The study area is characterized by wet and dry seasons. The dry season runs from November to March while the wet season persists from April to October. The study area is located within a tropical rainforest. The surface drainage is irregular and contains some ephemeral streams. Residents of the Ukawu mine area depend on water sources around the mine site for domestic use and farmland cultivation. Water and soil are susceptible to heavy metal contamination due to drainage from active mines. Therefore, environmental monitoring around the mine is of vital importance to evaluate the level of contamination. Vibrations from machinery are a major source of noise; hence, assessment of noise pollution in the study area is also conducted. Emissions of noxious gases from machines highlight the need for sound and noise evaluation in the study area. The outcomes of this research will guide future assessments of levels of pollution in water, soil, and air on the basis of chemical constituents in these environmental media and help formulate remedial measures where necessary. The approach adopted in this study can be applied to not only Nigeria but also other countries for environmental monitoring.

Materials and Methods

The study area is situated in the Ukawu area of Abakaliki between the latitudes of $6^0$4’36’’ and $6^0$4’33.2’’N and longitudes of $7^0$56’42.4’’ and $7^0$56’32.5’’E (Figure 1). The study area lies in a flat topography in the Abakaliki basin, which is a subsidiary depression in the Benue Trough of Nigeria [39]. The study area is characterized by tropical climate with an average rainfall of approxi-mately 980 mm. The streams are seasonal. The vegetation of the area is luxuriant and characterized by trees, shrubs, and a variety of other tree species, such as palm trees.

Geologically, Abakaliki lies within the Asu River Group and consists mainly of poorly sorted bedded shale and occasionally, sandy splintery metamorphosed mudstones. Lenses of sandstone and sandy limestone are highly jointed and fractured. The geologic history of Abakaliki Basin is characterized by compressional tectonic stresses causing metamorphism and faulting of older volcanic rocks. Pyroclastic rocks in the area are deeply weathered, giving rise to shallow aquifers in the area [40, 41].

Sample collection and preparation. Surface water samples were collected in clean prewashed polyethylene bottles during the dry season. The bottles were rinsed thrice with the water at the sampling location to condition the bottle prior to the collection of the actual water sample. The water samples collected for trace element analysis were acidified with three drops of concentrated HNO_3. The water samples for major element analysis were acidified with a single drop of HNO_3 to avoid the loss of ions prior analysis [42]. Soil samples weighing 50 g were collected from around the mine site at a depth of 20–25 cm, kept in clean polythene bags, and then taken to the laboratory for analysis. Water samples were stored in a refrigerator for 24 h and then taken to the laboratory for analysis. Soil samples were dried under the sun, crushed with an agate mortar and pestle and sieved with 80 nm mesh. The sieved soil samples were stored in a sealed envelope and taken to the laboratory for analysis.

Water, soil, air, and sound were sampled at various locations around the mine site. Gaseous emissions into the atmosphere are generated by generators, earth-moving equipment, mining operations and trucks. Dust particulates are generated during the loading and dumping of overburden materials. The constituents of the emissions include CO, NO_2, SO_4, CH_4, NH_3, and soot/fume. Air quality investigations were conducted around facility premises by using Aeroqual Air Quality equipment through direct reading engineering method (DREM). Noise in the facility is mainly generated by two power sets with capacities of 75 KVA and 100 KVA capacities), earth-moving equipment e.g., excavators and Dozers, and trucks. Noise level measurements were obtained from different locations around the mine site by using an Extech digital level sound meter via DREM. Production in the facility is mainly conducted by batch processing, and the production wastes mainly include the overburden/ laterite generated during mining operations.

Laboratory analysis of samples. Field equipment, such as spades, hand trowels, clean polyethylene bottles, and polythene bags, were used to collect the water and soil samples. Noise levels were measured at specific times by using a digital sound level meter via DREM and then calibrated in decibels. The instrument could measure sound levels within the range of 30–130 dB. Physical parameters such as pH, temperature, electrical con-ductivity, and total dissolved solids were measured in the field by using a mercury-in-glass thermometer, digital MV redox pH meter, conductivity meter (WA 3000), and spectrophotometer, respectively [43]. Titration was applied to analyze anions, such as Cl and SO_4^{2-}, biological oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen, phosphate, coliform bacteria moisture, and phenols [44]. Taste, color, and odor were determined by qualitative analysis [45]. The flame test was used to analyze major cations, such as Na, Ca, K, and Mg [46]. Heavy metals in the water and soil samples, such as Pb, Fe, Cu, Hg, Mn, As, and Zn were

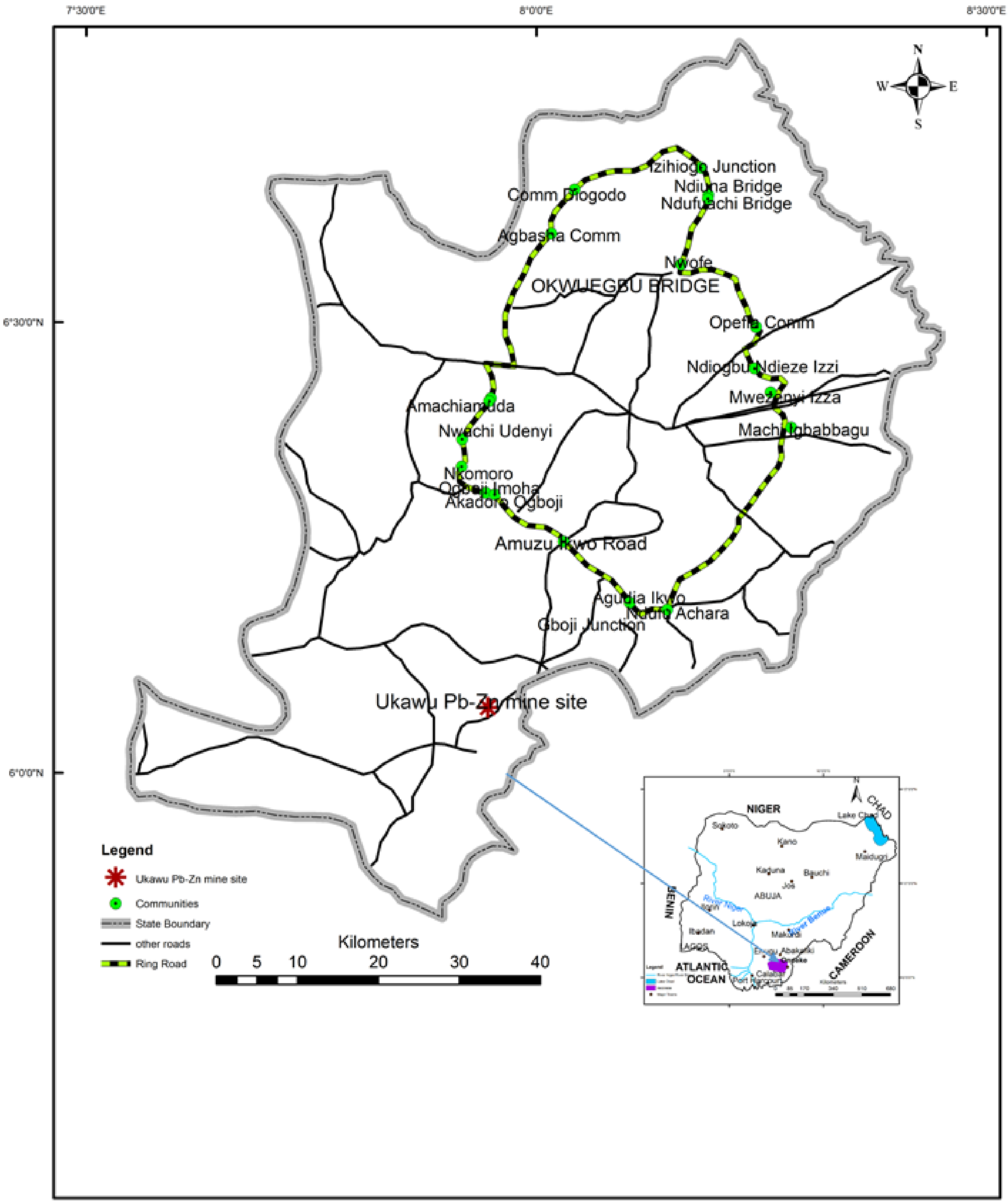

Figure 1. Location of the Study Area. Inset: Map of Nigeria

analyzed using AAS [47]. All analyses were conducted at the University of Nigeria Nsukka laboratory, Enugu State, Nigeria.

Results and Discussions

Tables 1, 2, 3, and 4 respectively present the analysis results of water, soil, air, and sound in the study area.

In Table 1, the temperature and pH of water were 20.7^{0}C and 6.7 respectively. This result indicates that the water is weakly acidic. This, which may be due to the newness of the mine with incipient AMD. The total dissolved solids and total suspended solids were 310.5 and 250 mg/L, respectively. The total dissolved solid is below the NESREA limit of 500 mg/L for potable water. The Cl, SO_4^{2-}, SO_3^{2-}, and NO_3^- levels detected were 3.45, 0.48, 0.28, and 3.35 mg/L respectively. The levels of these anions were well below the standard values for potable water established by the NESREA. The COD was 25.2 mg/L. The pH was below the permissible limit of 7.0–8.5 for potable water specified by the NESREA. These results indicated the occurrence of AMD at the drainage site. The acidity of water could affect its corrosiveness and the speciation of some of its constituents [48]. Temperature and pH affect the solubility, mobility, and dispersion of heavy metals [49]. Temperatures above 15 ^{0}C enhance the growth of pathogenic organisms and may increase issues related to taste, odor, color, and corrosion [50]. The water pH was not much higher than the recommended value of 7.0–8.5 for potable water and, therefore, is not expected to have an adverse effect on water sources. Water organisms can survive in this pH range [51].

Table 1. Analysis Results of Water Samples Collected from Pits within the Mine

S/N	Parameters Tested	Units	Concentration	Nesrea Limit	WHO/EU
1	Temperature	^{0} C	20.7	Ambient	
2	PH	–	6.7	7.0–8.5	$\geq$6.5$\leq$9.5
3	Total Dissolved Solids	mg/l	310.05	500	500
4	Total Suspended Solids	mg/l	250.00	–	
5	Chloride	mg/l	3.45	200	250
6	Sulphate	mg/l	0.48	200	250
7	Sulphite	mg/l	0.28	54.00	
8	Nitrate	mg/l	3.55	50	50
9	COD	mg/l	25.2	–	
10	Zinc	mg/l	0.33	5.0	5
11	Manganese	mg/l	0.38	0.5	0.05
12	Copper	mg/l	0.15	2.0	2.0
13	Iron	mg/l	0.25	0.05–0.3	0.2
14	Mercury	mg/l	ND	–	0.006
15	Aluminum	mg/l	ND	–	0.2
16	Oil and Grease	%	8.2	–	
17	Calcium	mg/l	22.8	50.00	
18	Magnesium	mg/l	23.47	50.00	NS
NS	**Microbial Analysis**				
19	Total Coliform M.agar	cfu/ml	1.4 x 10	1	0/100 ml

Legend: µS/Cm = Micro-Siemens per centimeter
NS = Not specified
Mg/l = Milligram per liter
cfu = Colony forming units.

Table 2. Analysis Results of Soil Samples Collected within the Facility Premises

S/N	Parameters	Units	Concentration	FMENV/NESREA	WHO/USEPA
1	pH (KCl)	–	4.8	6.5–9	–
2	pH (10% solution at 25 ^oC)	–	5.2	6.5–9	–
3	Nitrate	mg/l	0.34	–	–
4	Moisture	–	4.86	–	–
6	Soil Color	–	Brownish Soil	–	–
7	Potassium (K^+)	Meq/100g	0.335	–	–
8	Magnesium(Mg^{2+})	Meq/100g	0.542	–	–
9	Calcium (Ca^{2+})	Meq/100g	0.513	–	–
10	Sodium (Na^+)	Meq/100g	0.330	–	–
11	Iron (Fe^{2+})	mg/kg	2.562	0.03	5
12	Lead (Pb^{2+})	mg/kg	0.157	–	0.2
13	Copper (Cu^{2+})	mg/kg	1.165	–	0.2

The low levels of TDS, TSS, SO_4^{2-}, and NO_3^- detected in this study could be attributed to the low level of materials carried in suspensions, which indicates that the water is not polluted by these water quality indicators. The low level of TDS indicates that high levels of soluble anions and cations are present in the water samples [52]. Low levels of COD are indicative of low abundance of O_2-demanding pollutants [53] or good balance in the use of O_2 by organisms during decomposition in water bodies [54]. Cl compounds are widely distributed in nature, usually in the form of NaCl and KCl. These compounds serve as pollution indicators [55] and exist in all natural waters in variable concentrations. The Cl values in this study (Table 1) did not exceed the permissible values for potable water. Excess NO_3^- is an indicator of pollution. The NO_3^- level in this study was below the NESREA limit of 50 mg/L. NO_3^- could be obtained from the natural degradation of organic matter or nitrogenous fertilizers. SO_4^{2-} emanates from streaming or infiltration into gypsum ground and bacterial action. This activity can oxidize H_2S to toxic sulfate. In this study, the SO_4^{2-} level was lower than the 200 mg/L limit stipulated by the NESREA for water contamination [56] and below the 500–1000 mg/L standard established by the WHO. No health-based guidelines for SO_4^{2-} have yet been published.

Fecal coliform level, an empirical measurement of aerobic and facultative anaerobic bacteria as a group, may be used to assess the overall microbiological quality of water for human consumption. The total coliform in water in this study was 14cfu/ml. While the measurement of total coliform may be considered arbitrary by some researchers, it may be useful as a general indicator of water purity. The oil and grease was 8.2 %, which indicates anthropogenic input.

The levels of Ca and Mg were recorded as 22.8 mg/L and 23.47 mg/L, respectively. The Zn concentration in the soil was 0.33 mg/L. The Cu, Fe, and Mn concentrations were 0.15 mg/L, 0.25 mg/L, and 0.38 mg/L, respectively. None of the metals exceeded the limits established by the NESREA for potable water (Table 2). Low levels of Ca and Mg may be due to the presence of soft water and low concentrations of Ca and Mg salts in water. The Fe in the water samples could be attributed to the leaching of natural deposits into the water body [57]. The Zn concentration was within the NESREA limit for potable water, which indicates that only small amounts of Zn was leached into water bodies [58]. Zn and Pb may have similar levels of toxicity, and Zn poisoning may be mistaken for Pb poisoning [59]. Zn deficiency may trigger anemic in humans. Ca is an important element for good health and levels between 20 and 30 mg/L are desirable in drinking water [60]. Mn occurs naturally in surface water at levels below 0.04 mg/L. The Mn level in Ukawu mine is 0.38 mg/L, which is higher than the normal level found in nature. This finding is common in groundwater because of reducing conditions. Mn an essential element in humans and animals and regarded as the least toxic element. Mn toxicity stems from the uninterrupted inhalation of high levels of Mn from industrial sources [60].

Cu contaminants in drinking water could be attributed to the corrosion or by-products of Cu pipes in prolonged contact with water. The water Cu level detected in this study was 0.15 mg/L. Cu is an essential element but could cause stomach and intestinal distress, liver and kidney damage, and anemia when in excess.

The soil pH was 5.2, which is lower than the range of 6.5–9.0 recommended for agricultural soils by the NESREA. The NO_3 concentration was 0.34 mg/L, and a moisture of 4.86. The concentrations of K, Mg, Ca, and Na in the soil samples were 0.335 mg/L, 0.54 mg/L, 0.513 mg/L, and 0.330 mg/L, respectively. The Fe, Pb and Cu concentrations in the soil samples were 2.56 mg/L, 1.157 mg/L, and 1.165 mg/L, respectively.

Table 3. Air Quality Results

Parameters	Unit	Admin Block (control)	Mining Area (B)	NESREA Limit
NH_3	ppm	0.00	0.2	0.1–0.2
CO	ppm	0.00	16.5	1–5
H_2S	ppm	0.00	0.11	NS
O_3	ppm	0.00	0.14	–
$N0_2$	ppm	0.00	0.025	0.04 – 0.06
SO_2	ppm	0.00	0.07	0.1
CH_4	ppm	3.00	24	NS
VOC	ppm	0.00	0.00	NS

Legend:
Ppm= Parts per million
NS = Not stated.

Table 4. Results of Noise Level Analysis at Selected Points in the Mine Area

S/N	Locations	Result dB (A)	NESREA Limit dB (A)
1.	Administrative Block	54.9	85
2.	Facility Premises	68.1	85
4.	Mechanical Workshop Area	71.5	85
5.	Generator Section (75 KVA)	86.5	85
6.	Equipment Parking Area	66.5	85
7.	Pay Loader	78.4	85
9.	Security Section	50.5	85

Table 5. Ambient Noise Level Guidelines for Different Areas/Zones in India [65]

Area code	Category of area/zone	Limit in dB	
		Daytime	Nighttime
A	Industrial area	75	70
B	Commercial area	65	55
C	Residential area	55	45
D	Silent area	50	40

The permissible levels of Pb, Fe and Cu for agricultural soils established by the WHO are 0.2, 0.2, and 5 mg/kg, respectively. Moreover, the permissible level of Pb for human intake established by the WHO is 10ppb. Pb is deleterious even in small amounts. Pb intake could occur through dust, Pb dye, refuse, and gases from leaded gasoline. High concentrations of Pb cause deterioration of the central nervous system. The permissible level of Zn is 3000ppb. Zn is mainly obtained from zinc salts [61].

The level of NH_3 and CO around the mine were 0.2 ppm and 16.5 ppm, respectively. The CO level was above the NESREA limit 1–5 ppm but the NH_3 level of 0.2ppm was within the acceptable limit of 0.1–0.2 (Table 2). CO is a precursor gas for global warming [62]. The H_2S and O_3 levels recorded around the mine area were 0.11 and 0.14ppm respectively. The NO_2 concentration was 0.025 ppm, which is within the permissible limit of 0.04–0.06 ppm specified by the NESREA. Ground-level O_3 and other photochemical oxidants are pollutants of environmental concern; because their high concentration could cause detrimental effects and threaten human health [62]. Low O_3 concentrations are typical of coastal locations. O_3 and CO are critical pollutants of concern and formed during the transport of precursor gases [61]. The NO_2 and SO_2 concentrations detected in this work were 0.025 and 0.07 ppm, respectively. The NO_2 and SO_2 levels were within the permissible limits of 0.04–0.06 and 0.1, respectively, established by the NESREA. The surface of carbonaceous particles acts as a catalyst for SO_2, photochemical oxidation producing ammonia and alkaline metal sulfide [62].

The noise levels at designated points around the mine area were and the results are shown in Table 4. In general, noise levels at all tested locations were below NESREA permissible limit of 85dBA (Table 4).

Noise levels originated mainly from the generator and mining machinery. High levels of noise are responsible for the increasing incidence of deafness among industrialists using machinery in their operations. Ambient noise levels of ~ 45dBA are considered tolerable [63]. The noise levels recorded in all tested locations in the study area exceeded 45dBA, which is the level recommended for ambient air by Singh and Davar [63]. WHO guidelines recommend noise levels of 30 to 35 dBA for undisrupted sleep [63]. The adverse effects of noise are dangerous enough that noise problem is next crime by certain countries [64].

The ambient levels of noise for different area/zones in India detailed in Table 5 [65]. According to the table, daytime noise level recorded in the mine area exceeded permissible standards at locations around the generator section, pay loader, mechanical workshop and facility premises (Table 4). Thus, these locations show evidence of noise pollution according to Indian standards. Noise pollution causes hearing impairment, negative social behavior and annoyance, interference with spoken communication, cardiovascular disturbances, and sleep and mental health disturbances [64]. Noise pollution, a form of air pollution refers to audibly unwanted sounds that pose a threat to human health and wellbeing [66]. Exposure to noise levels over 75 dB for long periods of time may cause damage to the hearing of an individual. Noise of 120–140 dB may cause pain, noise of 90 dB is considered extremely loud, noise of 60–80 dB is considered very loud, noise of 40–50 dB is considered moderate, and noise of 30dB is considered faint [67]. Given the results above, the mine evaluated in this study does not pollute the environment.

Conclusion

Analysis of water and soil samples, air quality and noise levels around Ukawu mine were conducted for environmental monitoring and pollution assessment. The physicochemical parameters of water samples showed that TDS exceeds standard limit established by the NESREA. All detected anions were below the standard limits of the NESREA for potable water. However, the water pH was also below the permissible limit of 7.0–8.5 for potable water, which means the water around the mine is corrosive. Low levels of BOD, which is evidence of a low oxygen supply were detected. Cation concentrations were all within NESREA limit for potable water.

The pH of the soil sample was 5.2, which is lower than the standard range of 6.5–9.0 recommended for soils. Heavy metal concentrations in the soil were below the standard limits. The air quality around the mine was measured using precursor gases (e.g., O_3, NO_2, CO and SO_2) and found to be below standard limits; thus, the air around the mine is not considered harmful to humans. The noise levels recorded in this study were below the limits of the NESREA (85 dB) considered deleterious to humans. In comparison with Indian standards, the noise levels recorded exceeded permissible daytime limits for industrial, commercial, residential, and silent zones. Environmental monitoring of Pb-Zn levels around Ukawu mine at regular intervals is necessary because mine pollution degrades the environment over time.

Environmental contamination studies around Ukawu mine did not reveal a considerable pollution threat around the mine site. The mine is an incipient and active mine. The geochemical media such as water, soil, noise and air sampled across the study area did not show clear indications of contamination in comparison with the standards of established organizations, such as the WHO, European Union and NESREA. This research provides a solid basis for environmental pollution studies including ambient air quality. The proposed approach may be applied not to Nigeria but also other countries by environmental scientist for environmental pollution monitoring, risk assessment, and control.

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Conflict of Interest

There is no conflict of interest whatsoever.

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