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Water Quality Assessment of Well Water Samples Collected from Ewekoro and Ibeshe Limestone Mines in Ogun State

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Abstract Environment is being polluted by mines with industrial activities that is becoming more harmful by making the environment to be toxic. The aim of this study is to determine the water quality of well water samples around the two limestone mines located in (Ibeshe and Ewekoro) of Ogun State respectively. Physicochemical techniques was carried out to determine the following parameters such as temperature, turbidity, electrical conductivity (EC), dissolved oxygen (DO), acidity, alkalinity, colour, total dissolved solid (TDS) and some selected metals (Cd, Ni, Cr, Pb, Zn, Fe, and Mn) were analysed. The results total suspended solid (TSS) was studied and shows that the TDS of all the samples were found to be within NSDWQ value of 500 mg/L. The concentration of Cr, Pb, Zn, Fe, and Mn detected in the groundwater samples are within the range of 0.007 - 0.012, 0.001 - 0.029, 1.342 - 1.743, 0.13 - 0.20 and 0.17 - 0.22 mg/L respectively. Cd and Ni were not detected in the water samples. In conclusion, limestone mine has impacted negatively on its surrounding well water due to leaching of the metals into the ground and underground water. The pH and EC of the fresh well water from Ewekoro and Ibeshe sites are (6.76 ± 0.02 and 7.46 ± 0.02) and (370 – 675 µS/cm) respectively and it fall within the water quality range for potable water of WHO and NSDWQ. Some of the heavy metals found in the well water were within while others were above WHO and NSDWQ standard limit.

Keywords Well water, Limestone mine, Physicochemical parameters, Heavy metals

1. Introduction

The mining of limestone generates waste which could contaminate both underground soil and well water which is used for domestic purpose. Water and soil are important and valuable resources of the nature. All living things are directly and indirectly dependent on soil for day to day needs and 95% of the human food is derived from the earth. Making plan for having healthy and productive water is essential to human survival.

The environmental pollution as a result of cement industry could be defined as an undesirable process that is responsible to pollute water, air and land through its various activities, right from the mining activity of the raw material (limestone, dolomite etc.) to its crushing, grinding and other associated processes in cement plant [1]. The presence of total solids in the form of salts of Ca, Na, K, Mg, Al as hydroxides sulphates and silicates leads to hardness of water which causes gastro intestinal disorders which have been found as quite common in the area. Soil pollution is developed due to constant fall of cement dust, resulted in the formation of colloidal gels of calcium silicate and calcium aluminate.

The cement dust, produced by cement manufacturing units is considered one of the most hazardous pollutants which affect the surrounding environment. These particles can enter into soil as dry, humid or occult deposits and can undermine its physicochemical properties. The deposit of these particles is complex and it is controlled by the atmospheric stability, the roughness of the surfaces as well as the diameter of the particles. Indeed, it is relevant to mention that in the arid regions, the dry deposits are particularly more important [2].

The atmospheric particles can have as consequence the reduction of biodiversity and the quality of goods and services offered by the ecosystems. The main visible pollution generated by the cement industry corresponds to the dusts. Indeed, the dusts can be emitted at every stage of the manufacturing process of the cement: extraction of the raw material, crushing, production, etc. The impact of the cement dust on soil properties and plant production has been investigated by some researchers [3].

Air pollution has been described as an additional stress on plants since they often respond to atmospheric contamination in the same way as they respond to drought

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and other environment stress. Especially, the role of cement pollutants causing injury to plants either by direct toxic effect or modifying the host physiology rendering it more susceptible to infection [4]. In severe case of pollution, the injury symptoms were expressed as foliar necrosis or completely disappearance of the plant. Samal and Santra, [5] have also reported from their previous study the impact of air pollution on plants with reference to foliar anatomical and biochemical changes by experimenting on various sensitive plants. Increased concentrations of the above pollutants cause progressive reduction in the photosynthetic ability of leaves, closure of leaf stomata and, mainly, a reduction in growth and productivity of plants [6]. These dust particulates are causing large scale deforestation, destruction of Biota [7] and other natural resources. Among these deposition of cement kiln dust in large quantities around cement factories causes changes in soil physical chemical properties [8]. The effect of such deposition affects the growth and biochemical characteristics of field crops has also been widely studied [9].

Water is an essential natural resource for sustainability of life on earth. Humans may survive for several weeks without food, but barely few days without water because constant supply of water is needed to replenish the fluids lost through normal physiological activities, such as respiration, perspiration, urination [10]. Though the hydrosphere is estimated to contain about 1.36 billion Km^3, only about 0.3% of the water, existing as fresh water in rivers, streams springs and aquifers, is available for human use; the remaining 99.7% is locked up in seas and oceans [12].

The geological constraints limit accessibility of many human communities to water that is adequate in terms of quantity, quality and sustainability. Lack of adequate supply of potable water is a critical challenge in developing countries such as Nigeria. Potable water, also called drinking water in reference to its intended use, is defined as water which is fit for consumption by humans and other animals [9].

The usual source of drinking water is the streams, rivers, wells and boreholes which are mostly untreated and associated with various health risks [10]. Paucity of infrastructure for effective treatment and distribution of water accounts for the incidence of high morbidity and mortality rate associated with water borne diseases in developing countries [11]. One of the targets of the millennium development goals (MDG) in terms of healthy living for the masses can be achieved through the supply of safe and convenient water [12].

The quality of water influences the health status of any populace, hence, analysis of water for physical, biological and chemical properties including trace element contents are very important for public health studies. Groundwater is an important water resource in both the urban and rural areas of Nigeria [13]. Pollution of surface water can create health risks because such waterways are often used directly as drinking water sources or connected with shallow well used for drinking water. In addition waterways have important roles for washing and cleaning, for fishing and fish farming and for recreation. Another major source of drinking water is ground water which often has low concentrations of pathogens because the water is filtered during its transit through underground layers of sand, clay or rocks.

However toxic chemicals such as arsenic and fluoride can be dissolved from the soil or rock layers into well waters. The problem associated with mining of limestone production in an environment is the contamination of the surface and underground soil well water. The deposition of limestone wastes within the area of the mining can degrade the soil quality which makes farming difficult for the farmers in that locality. The dust generated during the production of limestone is one of the major causes of heavy metal contamination in soils. Dust pollution has been found to be problematic around limestone mines.

The extent of pollution of water resources in an environment where the mine is situated decreases as the distance from the mine increases. This rate of decrease has not been mapped before or studied. The consistent discharge of wastes in form of dust into the water body around the mine area has led to pollution of the water resources. The pollution of the environment might affect the water and cause hazard to the people using it according to world health organization (WHO).

The rationale of this study is to assess the quality of well water around limestone mining sites that the people use for cooking and drinking so as to provide information on the water quality. The environmental quality deterioration resulting from increase in the level of potentially toxic metals is becoming more rampant, thereby raising the questions on safety status of the environment. The aim of this study is to determine the quality of well water samples around the two limestone mines located in Ogun State.

2. Materials and Method

2.1. Study Area

The mine was first set up fifty five years ago in Ewekoro, Ogun State by extracting and blasting limestone to make cement, West African Portland Cement (WAPCO). The Ewekoro plant of WAPCO is located in Ewekoro local government area Ogun state in the South West Nigeria. The mine is located at Ibeshe and Ewekoro town in Ewekoro local government area of Ogun State. The local government area is bounded in the north by Abeokuta, in the east by Obafemi-Owode, in the west by Yewa South and in the south by Ado-Odo Ota.

Moreover, Ewekoro cement factory is on a latitude 5°.50' N and longitude 3°.17' E. Also, it is approximately 64 kilometers South of Abeokuta. Thus water samples was collected from a season of the year and analysed to determine the quality of the well around the mine. Majority of the inhabitants are farmers and the area is largely rural.

Most of these farmers engaged in the planting of sugar cane, cassava, maize and vegetable. Cash crops such as cocoa, kolanut and oil palm are also cultivated. These farmers also engaged in the rearing of livestock's like small ruminants, poultry and pigs.

Figure 1. Map of limestone mine location in Ogun State Ibeshe = and Ewekoro =

SAMPLING

The main raw materials used for the analysis were well water samples that are randomly selected to represent the study areas. The water samples were collected from hand dug well cement factories Ewekoro and Ibeshe areas in Ogun State respectively. All the bottles were thoroughly cleaned using detergents for washing, rinsed with water and then with distilled water before soaking with 10% nitric acid (HNO_3) overnight. Each water samples were divided into two and 5 mL of (HNO_3) was added to one of it to prevent the metals from undergoing oxidation. The samples were transported to the departmental laboratory, preserved in a refrigerator at a temperature between 0℃ and 4℃. It was cooled to room temperature and stored in the dark for 24 hours before measuring the physicochemical and metal analysis.

EXPERIMENTAL

The techniques used in the measurement of the physico-chemical parameters (pH, EC, TDS, DO, turbidity, suspended solids, alkalinity, acidity, and metals) of the fresh well water samples were studied. The analytical procedures followed the APHA (2008) standard procedure for analyzing water and waste water. The pH was measured with the aid of pH meter, standardized with pH buffer 4.0, 7.0 and 9.0. TDS was estimated by evaporation method at 180℃, D.O, Hardness, Alkalinity, Chloride, CO2 and all these parameters were analyzed by standard procedure mentioned in APHA (2008). The elemental analysis carried out by inductively coupled plasma optical emission spectroscopy (ICP-OES).

TURBIDITY

The turbidity meter (HACH-2100N) was turned on for measurement; the cuvette of the meter was rinsed with de-ionized water. A volume of 10 mL of de-ionized water was dispensed with the cuvette and placed in the meter to calibrate it. A volume of 10 mL of fresh well water sample was dispensed in the cuvette and placed in the meter, reading was recorded and the process was conducted in triplicate.

ELECTRICAL CONDUCTIVITY

A conductivity meter (Jenway 470) was used to measure the conductivity of the fresh well water samples as received. A volume of 20 mL of the well water sample was measured and dispensed into the labeled beaker. The meter was switched on and the probe was rinsed with de-ionized water and immersed the fresh well water sample. The switch on the meter start button was press read to take the reading.

DISSOLVED OXYGEN

This is a test conducted to determine the amount of gaseous oxygen dissolved in fresh well water samples. De-ionized water was in a beaker and used to rinse the dissolved oxygen electrode probe. The dissolved oxygen [DO] meter was switched on. The dissolve oxygen meter was standardized and calibrated by dipping the probe into de-ionized water. Then the probe is dipped into the well water samples and the reading was taken and recorded. The unit is mg/L.

ACIDITY

50 mL of fresh well water sample was measured into the conical flask and three drops of phenolphthalein indicator was added into the well water sample and then, titrate the mixture with 0.1 M sodium hydroxide solution in the burette. A pink colour change indicates the end point. The readings were taken and recorded and the process was repeated in triplicate.

ALKALINITY

Alkalinity of water is its acid neutralizing capacity; the measured value may significantly vary with the end point. It is very important in treatment of fresh well and waste waters because the alkalinity of much surface water is a function of carbonates, bicarbonates and hydroxides content. A volume of 50 mL of water samples was measured into the labelled conical flask. The burette was filled with concentrated hydrochloric acid and take note of the mark for the initial reading. Two drops of indicators was added methyl orange and the mixture was titrated with 0.1M hydrochloric acid in the burette. The colour changed from yellow to orange which indicates the end-point. The final reading was recorded in triplicate.

COLOUR

The filtered samples were kept in a measuring cylinder. About 10 mL of filtered sample was kept in a cuvette, transferred in the UV spectrophotometer. Blank reading at 455 nm wavelength in the UV spectrophotometer was measured.

TOTAL DISSOLVED SOLIDS

The filter paper was placed back in the funnel and moistened with distilled water; 50 mL of well mixed sample water was measured and passed through the filtration system, under suction, thus ensuring all solid in the water trapped in the paper. The filtrate was evaporated to dryness in a dish (already washed, dried and weighed at constant weight), on a stream bath, and dried further in an oven for 1 hour at 105℃, and cooled in the desiccators and weighed. The process was repeated until constant weight was achieved before recording the results. The process was repeated until a constant was achieved [24].

Calculation

Total dissolved solids (mg / L) = [A - B] X 100 / mL sample

A = Weight of dish+ residue

B = Weight of dish

TOTAL SUSPENDED SOLIDS

The filter paper were placed in the oven and dried at 103℃ repeatedly to achieve a constant weight. Then the filter papers were folded and placed inside the different funnels, 100 mL of the well mixed water sample was poured into the different funnels with the filter papers, after the filtration the filter papers were placed in the oven for 103℃ for 30 minutes. Then the filter paper were removed and placed in desiccators to cool after which they are weighed.

Calculation;

SS (mg / L) = mg X 1000 / ml of the sample.

Where SS (mg) = Weight of the filter paper after filtration (mg) - weight of filter paper before filtrating paper.

TRACE METALS ANALYSIS

Spectrophotometer [model 1245] was used to determine the concentration of the trace metals such as calcium (Ca), Magnesium (Mg), Chloride (Cl), Manganese (Mn), Iron (Fe), Zinc (Zn), Lead (Pb), Cadmium (Cd), Nickel (Ni), and Chromium (Cr). These are the metals in most well waters. A volume of 100 mL well water sample was measured into 150 mL griffin beakers and placed on a plate in the fume compound. A volume of 3 mL of concentrated HNO_3 was added when the sample volume reduce to 75 mL. A volume of 1 mL of concentrated HCl was added too when it reduces to 500 mL on reduction to 25 mL, the sample was removed and allowing to cool. The sample was then made up to 100 mL with distilled water, reagent blank was also prepared. The liquid solutions were then taken for analysis using atomic absorption spectroscopy UNICAM 919 AA model and appropriate cathode lamps and resonance wave lengths of the metals.

3. Results and Discussions

3.1. Physical Analysis

The physical parameters of the well water analyzed are pH, EC, TDS, turbidity, odour, taste, and colour. The results of these parameters are presented in Figures 2-3.

Figures 2 and 3 presents the physical parameters of the well water samples collected around the Ibeshe and Ewekoro limestone mines. The pH values of the Ibeshe and Ewekoro limestone site well water are 7.0 and 6.7 respectively which revealed that they are acidic. The low pH shows the well water quality is poor because the values fell below the WHO and NSDWQ specification of 6.7-9. The EC value for Ibeshe and Ewekoro well water samples are 370 and 676.01 µS / cm which show that value of Ewekoro is higher than the Ibeshe and this could be linked to the age of the mining activity. The analysis of the EC for the well water samples collected Ibeshe and Ewekoro mines are 390 and 676 respectively and they fall within the WHO and NSDWQ specification for potable drinking water of 1000 and 900 respectively. The turbidity of Ibeshe and Ewekoro well water samples are 0.04 NTU each which is within the WHO and NSDWQ standard for potable water of 10 and 5 NTU respectively. The TDS of the Ibeshe and Ewekoro well water samples are 195 and 337.48 mg/L which falls within the WHO and NSDWQ standards for potable drinking water of 500 mg/L. The total suspended solids of the well water collected from Ibeshe and Ewekoro mines are 0.00 and 0.02 mg/L respectively in which WHO and NSDWQ have no specific value.

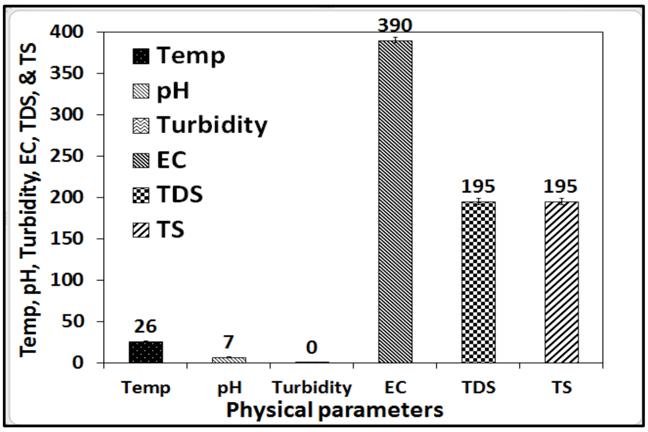

Figure 2. Physical parameters of fresh well water collected around Ibeshe limestone mine residence

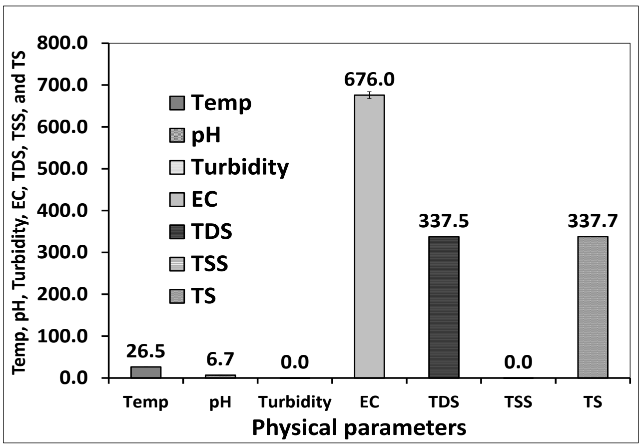

Figure 3. Physical parameters of fresh well water collected around Ewekoro limestone mine residence

3.2. Chemical Analysis

The chemical parameters of the well water analyzed are total acidity, total alkalinity, total hardness, chloride and metals such as Ca, Mg, Mn, Fe, Zn, Pb, Cd, Ni and Cr.

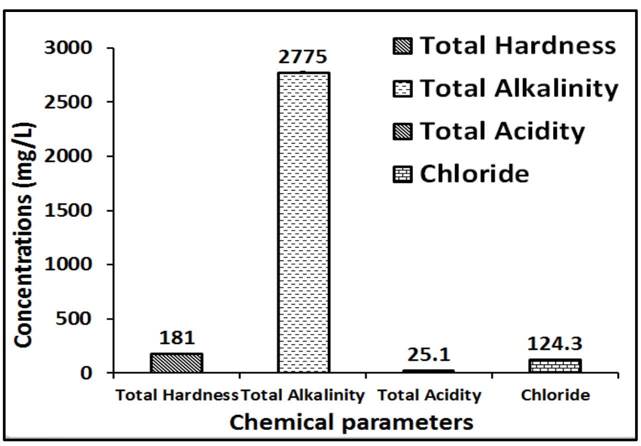

Figure 4. Chemical parameters of fresh well water collected from Ibeshe

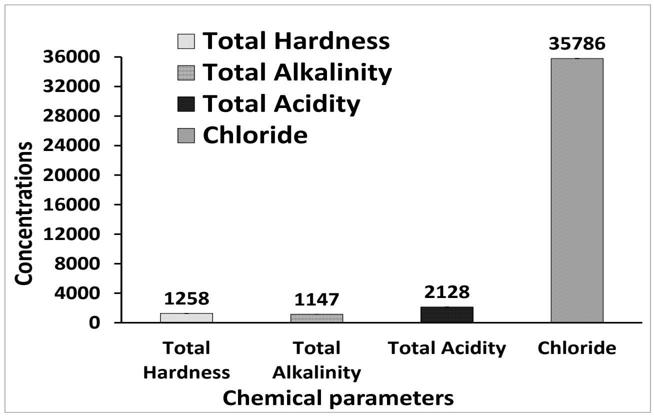

Figure 5. Chemical parameters of fresh well water collected around Ewekoro mine residence

Figures 4 and 5 present the chemical analysis of acidity, alkalinity, hardness and chloride well water samples collected from residence around Ibeshe and Ewekoro limestone mines. The total acidity of the Ibeshe and Ewekoro well water samples around limestone mines are 2125 and 2128 mg / L which is not available in the WHO and NSDWQ standard specification. The values obtained for the total alkalinity of the Ibeshe and Ewekoro well water samples are 1450 and 1147 mg / L which are not available for the WHO and NSDWQ drinking water standards [14,15,16].

The total water hardness of the water samples collected from Ibeshe and Ewekoro limestone mines are 190 and 1258 mg / L which falls above the WHO standard while that NSDWQ is not available. The chloride concentration of the well water samples collected from Ibeshe and Ewekoro limestone areas are 63745 and 35786 mg / L which is far above the WHO and NSDWQ standard potable drinking water limit.

Figures 6 and 7 presents the metal concentrations in the well water samples collected around Ibeshe and Ewekoro limestone mines. The concentrations of Ca are 72.03 and 102.40 mg/L respectively which fall within the WHO standard limit of 200 mg and above the NSDWQ of 50 mg/L. The Mg concentrations of Mg are 26.2 and 47 mg/L respectively which fall within the WHO limit and above NSDWQ limit for potable drinking water. The concentration of Mn present in the well water samples are 0.18 and 20.14 mg/L respectively which indicate that the Ibeshe sample fall within the WHO (0.4 mg/L) and NSDWQ (0.2 mg/L) standards limits of while the Ewekoro sample is above the WHO and NSDWQ standard limits for potable drinking water [16,17,22]. The concentration of Fe present in Ibeshe and Ewekoro limestone mine well water samples are 0.19 and 20.11 mg /L respectively which fall above WHO and NSDWQ standard limits of 0.1 and 0.3 respectively [22,24]. The concentrations of Zn present in the Ibeshe and Ewekoro limestone mine well water samples are 1.38 and 21.51 mg/L which indicate that the Ibeshe sample falls with the limits of WHO and NSDWQ limits of 5 and 3 respectively. The Ewekoro well water sample falls above far above the WHO and NSDWQ for standard limit. The concentration of Pb present in the Ibeshe and Ewekoro limestone mine water samples are 0.02 and 20.00 mg/L respectively which fall above the standard limits of 0.01 mg/L. The concentrations of Cd present in the well water samples collected from Ibeshe and Ewekoro limestone mines are 0.00 and 20 mg/L respectively which indicate that the Ibeshe fall within concentrations of Cd present in the well water samples collected from Ibeshe and Ewekoro limestone mines are 0.00 and 20 mg/L respectively which indicate that the Ibeshe fall within WHO and NSDWQ standard limit 0.003 mg/L while the Ewekoro sample value is above the standard limits. The concentration of Ni present in the Ibeshe and Ewekoro limestone mine well water samples are 0.02 and 20.00 mg/L respectively. The result shows that the Ibeshe sample concentration falls within the WHO and NSDWQ standard limits of 0.02 and 0.07 mg/L respectively while the Ewekoro sample was higher than the standard limits [22]. The concentration of Cr in the well water samples collected from Ibeshe and Ewekoro limestone mines are 0.03 and 20.06 mg/L respectively. The result shows that the Ibeshe sample fall within the NSDWQ while the Ewekoro sample was above the NSDWQ standard potable drinking water limits.

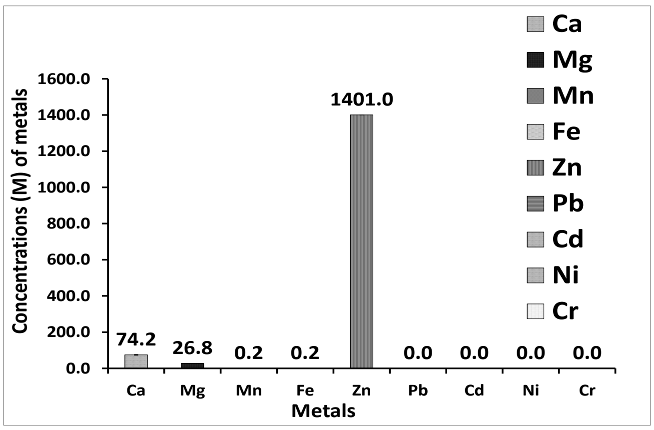

Figure 6. Metal concentrations of fresh well water collected around Ibeshe mine residence

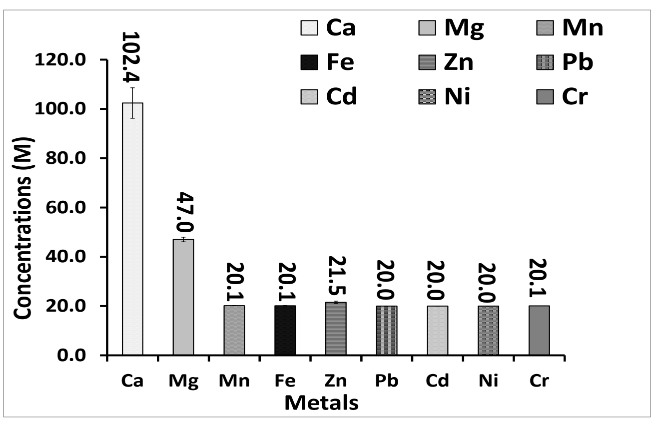

Figure 7. Metal concentration in fresh well water collected around Ewekoro limestone mine residence

4. Conclusions

This study shows that the well water samples collected around limestone mines are contaminated with some metals which are injurious to human health. However, the level of pollution at Ewekoro limestone mine area is much higher than the Ibeshe mine which could be due to the long time existence of the Ewekoro mine. Hence, there is need for strict compliance to environmental rules and regulations by the government to curb the activities of the cement.

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