ISSN: 2634 - 8845

Journal of Earth and Environmental Science Research

Research Article

Open Access

Levels of Some Selected Heavy Metals in Groundwater in Ebubu Community, Eleme, Rivers State, Nigeria

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ABSTRACT

This study was carried out to assess the level of the presence of some selected heavy metals in borehole-drinking water of Ebubu community in Eleme between June and August. Water samples were collected from ten (10) functional boreholes using standard techniques. The levels of the heavy metals in the study area were found to be in the order: cadmium (0.361±0.381 mg/L), > lead (0.117±0.056 mg/L) > nickel (0.042±0.0281 mg/L) > cobalt (0.010±0.009 mg/L) in the water samples. These values were above the WHO and NIS limits. The water quality parameters varied across the sampling periods (June and August); apart from Cd whose mean value was higher during the month of June, but lower during the month of August, all other toxic metals (Ni, Pb, and Co). The groundwater from the community is therefore, unsafe for drinking purpose due to elevated levels of toxic metals. In light of these findings, periodic analysis of samples from boreholes is inevitable. Such analysis will reveal pollution status of groundwater in this area and to determine the best method for water treatment, to intimate consumers and other users of the groundwater, and also to safeguard their health against the subsequent impact that may arise from drinking polluted water.

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Received: November 15, 2019; **Accepted:** November 26, 2019; **Published:** November 29, 2019

Keywords: Groundwater, Pollution, Heavy Metals, Water Quality, Borehole Water

Introduction

The World Health Organization reported that 786 million people in the world do not have access to safe drinking water [1]. This is roughly one in ten of the 7.4 billion world's population. Nigeria is not exempted from the world water crisis which is affecting other countries in many parts of the world. reported that over 63 million Nigerians have no choice but to get water wherever they can, leading to 57 million people not having access to safe water and 25,000 children die every year from diarrhea caused by unsafe water and poor sanitation [2].

Presently, it is estimated that more than 300 million people in Africa live in a water-scarce environment. By 2025, eighteen African countries are expected to experience water stress. The amount of freshwater available for each person in Africa is about one-quarter of what it was in 1950; in many countries, requirements for domestic freshwater use, sanitation, industry and agriculture cannot be met [3]. The situation might get worse as a consequence of population growth, rapid urbanization, increasing agriculture and industrial activities, and lack of adequate capacity to manage freshwater resources [3].

The best standard of purity is required for drinking water as the water we drink is got from different sources like wells, streams, lakes, rivers (surface water), groundwater (boreholes) [4]. Groundwater is water located beneath the surface in soil pore spaces and in permeable geological formations. Adeyemi and Sule gave empirical figures which suggest high groundwater resources potential for Nigeria [5,6]. Olayinka and Adebayo opined that the nation's groundwater resource is abundant and of good quality, estimated at 52,000 Million Cubic Metres (MCM), while MacDonald and Taylor (2012) gave a best estimate of 11,800 km3 as estimated groundwater storage in Nigeria [7]. Groundwater includes all water found beneath the earth's surface in a saturated zone of the aquifer [8]. They are formations that contain sufficient saturated permeable materials to yield sufficient quantities of water to wells and springs [8,9]. Groundwater can be extracted by means of Hand Dug Wells (HDWs) and boreholes at various depths. A large percentage of the world population depends on groundwater as their main source of drinking water [8,10].

Groundwater has various advantages over surface water as it is not exposed to water pollutants associated with surface waters. It is in view of this that the World Health Organization recommended that drinking water supplies should be well analyzed based on their contamination or pollution level [4]. Very few people in small towns have access to safe water supply. Only about 5 percent get water from protected ground sources through boreholes [4].The WHO had stated that it is not sufficient merely to have access to water in adequate quantities, the water also needed to be of adequate quality to maintain good health Such water must be free from toxic biological, physiological and chemical contaminations. The widespread reports on pollutants in groundwater have increased in recent years and have resulted in increased public concern about the quality of groundwater. The importance of potable water, both for domestic and industrial uses, has created concern for water quality analysis [4]. The compounds contained in groundwater, sometimes used as drinking water, are dangerous to human health because of the possibility of a mutagenic and carcinogenic reac¬tion [11,12]. Groundwater bodies are prone to contamination from both anthropogenic and natural activities [13]. Boreholes, though more protected as a result of inherent chemical constituents of permeable rocks through which the water flows can limit the quality of the water as they may have dissolved impurities which came from rock and sand strata through which the water flowed or passed. The seepage of waste buried underground such as pit toilets or leachate from fertilizer applications and debris from erosion can produce harmful effects on ground water quality especially in Ebubu, as it is one of the areas in Rivers State with potential high flooding risk and the residents are mostly farmers. This study was carried out to determine the levels of heavy metals contamination of ten different functional boreholes spatially distributed in Ebubu community in order to assess the potability and usability of their borehole water as domestic water supply. Ebubu is chosen for this research as it is considered a crude oil overburdened site owning to previous oil-spill record in that area.

The result and findings of this research shall provide information on the effect of crude oil spill on groundwater even after years of its spillage

Materials And Methods

Groundwater samples were collected from the different sampling locations within Ebubu community, and were transported in an ice cooler to Fugro international Laboratory, Port Harcourt, Rivers state. Heavy metals were determined in accordance with APHA 3111B, 3112B, 3114B, 3030B and ASTM D3859 (Appendix 2). Samples of groundwater obtained from Ebubu Eleme were subjected to atomic absorption spectrometer (Perkin Elmer 3100 model) for metals analyses. Pb, Cd, Ni and Co were analysed. SPSS version 22 was used for statistical analysis.

Heavy metal contents were calculated as follows.

$$\text{Metal concentrations (mg/L)} = \frac{C \times Y}{X}$$

where C =Concentration of metal determined from calibration curve (mg/l)

Y = Final volume made-up (ml)

X = Volume of sample (ml)

Discussion

These metals were present in all the sampled boreholes, though their values varied. The presence of these metals are often characteristic of municipal landfill leachates and can be harmful to health. The average value of nickel present in groundwater was 0.042 mg/L in groundwater. This value is higher than the WHO and NIS prescribed limit. The minimum value was obtained in BH5 and maximum in BH10 [1,14]. Nickel was however not detected at BH6, BH7 and BH8 (Table 1). The distribution of nickel in groundwater is presented in Figure 1. Water samples from boreholes (BH6, BH7 and BH8) had the same pattern of distribution as their values were below the detection limit. Similarly, in the month of June, Ni level was below the detection level in BH5. Water samples from BH10 had the highest level of nickel for both June and August (sampling periods) followed by water from BH2. The presence of nickel is an indicator of the presence of pollution from petroleum product [15]. This finding is similar to that of Asubiojo, Nkono, Ogunsua, Oluwole, Ward, Akanle, and Spyrou, who in their study had values above the WHO limit within the Niger Delta area [16]. However, this finding is at variance with Akpoveta, Okoh and Osakwe who had values lower than the WHO limit within the Niger Delta area [1,17]. Nickel can result in lung, liver and kidney damage. In high quantities, Ni can also cause cancer, respiratory failure, birth defects, allergies, dermatitis, eczema, nervous system and heart failure [18].

Table 1: Mean Distribution of Toxic metals of the Analyzed Groundwater Samples

	Sample Locations												
Parameters	BH1	BH2	BH3	BH4	BH5	BH6	BH7	BH8	BH9	BH10	Mean	WHO	
(2006)	NIS	0.08	0.05	0.03	0.003	BDL	BDL	BDL	0.013	0.20	0.042±0.0281	0.07	0.02
(2007)	0.68	0.30	0.38	0.27	0.42	0.54	0.35	0.42	0.20	0.05	0.361±0.381	0.003	0.003
Pb	0.11	0.18	0.09	0.09	0.10	0.11	0.09	0.12	0.15	0.13	0.117±0.056	0.01	0.01
Co	0.01	0.02	0.01	0.005	0.01	0.004	0.01	0.0075	0.02	0.003	0.010±0.009	0.0038	NS

*BDL= Below Detection Limit *NS= Not Stated

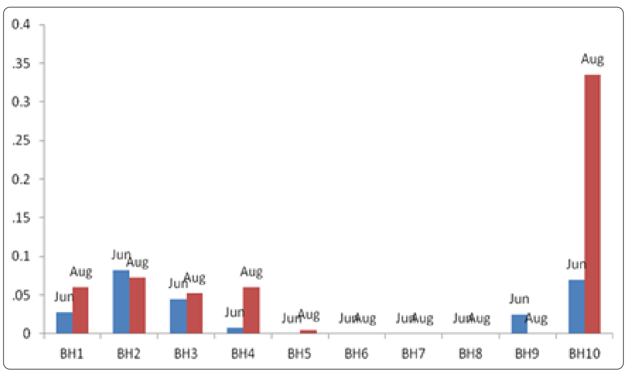

Figure 1: Monthly Distribution of Nickel in boreholes from Ebubu-Eleme

Lead from this study had a mean value of 0.117 mg/L within the study area. This value is above both the WHO and the NIS limits of 0.01 mg/L. These findings confirm an earlier work by Asubiojo et al. who had recorded a mean value of 2.8 mg/L in groundwater within this region, an indication of possible lead pollution with the study area [16]. The distribution pattern of Pb in groundwater from Ebubu community is presented Figure 2 indicates that water samples from boreholes (BH1 to BH8) had the same pattern of distribution as their values in the month of June were more than in the month of August. The reverse case was observed for BH9 and BH10 where the values in the month of August were higher than in the month of June. Although BH9 and BH10 are 768.56m and 929.96m away from the legacy spill site (Table 1, Figure 5), this could be due to more ionic dilution within the aquifer during the month of August. The peak value of lead content was recorded for BH2 first sampling. Lead in drinking water could have significant medical effects on renal functions [19]. Other symptoms of acute lead poisoning are headache, irritability, abdominal pain [20].

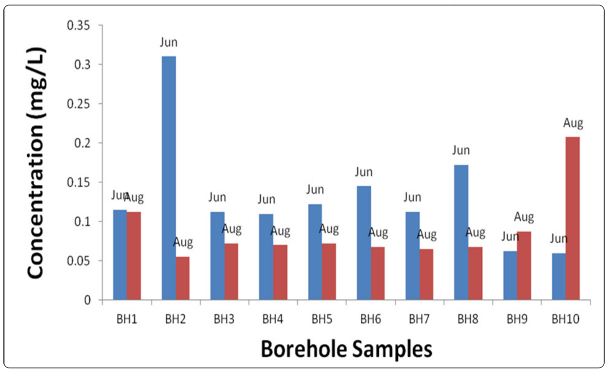

Figure 2: Monthly Distribution of lead in boreholes from Ebubu-Eleme.

Cadmium had a mean level of 0.361 mg/L in this study (Table 1). This value is above the permissible limit of 0.003 mg/L prescribed by both the WHO and NIS [1,14]. Distribution pattern of cadmium in groundwater is presented in Figure 3. Water samples from boreholes (BH1 to BH9) have more levels of cadmium in the month of June than in the month of August (the second sampling period). However, in BH10 cadmium was below detection level during the month of August. This finding from this study is however at variance with Uzoekwe and Oghosanine's submission in their study conducted on water bodies around Warri refinery area in Nigeria, when they reported nil for cadmium [21]. However, cadmium has health effects like hypertension, cancer, cardiovascular diseases and other kidney related effects [22].

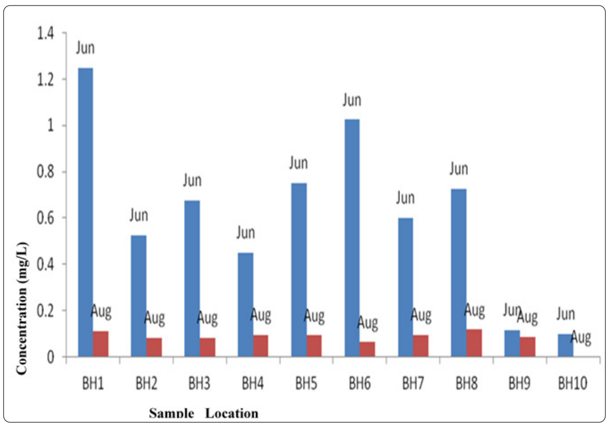

Figure 3: Monthly Distribution of Cadmium in boreholes from Ebubu-Eleme

The mean value of cobalt (Co) observed in this study was 0.010 mg/L. This is above the WHO value of 0.0038 mg/L. This finding collaborates with Asubiojo et al. report that revealed a mean value of 0.60 mg/L within the same area [16]. The distribution pattern of cobalt in groundwater samples is presented in Figure 4. Cobalt was below detection limit in four boreholes (BH4, BH5, BH6 and BH8) in June, and BH10 only in August. However, cobalt was detected in six boreholes (BH1, BH2, BH3, BH7, BH9, and BH10) in June and nine boreholes (BH1, BH2, BH3, BH4, BH5, BH6, BH7, BH8 and BH9) in August. The presence of Co is an indicator of the presence of pollution from petroleum product [15]. Cobalt, when ingested, could lead to vomiting, abdominal pain, allergic reactions in the skin, asthma, inflammation and fibrosis of the lung. Generally, the higher contents of toxic metals recorded in this study indicate higher metal accumulation and this is similar to the findings of Ideriah, Briggs and Stanley within the same region [23].

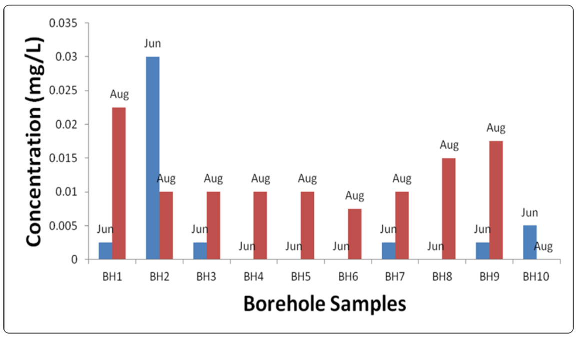

Figure 4: Monthly Distribution of Co in boreholes from Ebubu-Eleme

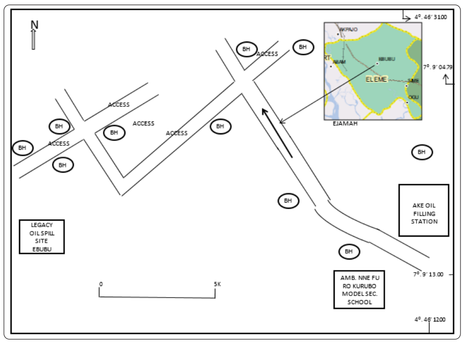

Figure 5: Ebubu town showing the sampling points

Nickel, lead and cobalt had higher mean values of 0.098±0.168; and 0.088±0.085 and 0.011±0.008 respectively (Table 2) during the month of August than during the month of June, while cadmium had higher mean value in August 0.106±0.009. Lower values during the month of August may be due to more ionic dilution within the water aquifer because of increase rainfall and is in agreement with the findings of Iwegbue, Egobuez and Opuene within the Niger Delta area, they also added that the sampling period variations in the levels of the heavy metals could be attributed to the difference in individual metals solubility, pH, leaching by acid rain during the wet season and topography of the area [24]. Toxic metals trend in groundwater samples is in the order Cd (0.106±0.009) >Pb (0.061±0.001) > Ni (0.048±0.023) > Co (0.004±0.001) for the month of June (first sampling), and Ni (0.098±0.168) > Pb (0.088±0.085) > Cd (0.082±0.058)>Co (0.011±0.008) for the month of August (second sampling) (Table 2). It was also observed that both Cd and Pb had values which were higher than the WHO (2013) and NIS (2007) permissible limits during both periods of sampling. While the value for Ni was only higher than the WHO limits for the month of August. Co was within range for both sampling period [1].

Table 2: Summary of Toxic metals in borehole water in Ebubu during the months of sampling

Parameters		Month of Collection	
	Variable	June (BH1-BH10)	August (BH1-BH10)
Nickel	Mean	0.048±0.023	0.098±0.168
	Range	BDL-0.08	BDL-0.005
Cadmium	Mean	0.106±0.009	0.082±0.058
	Range	0.09-1.25	0-0.08
Lead	Mean	0.061±0.001	0.088±0.085
	Range	0.06-0.31	0.055-0.21
Cobalt	Mean	0.004±0.001	0.011±0.008
	Range	BDL-0.003	0.00-0.02

Also, the correlation analysis computed for the four toxic metals (Table 3) indicates that there is a strong positive relationship between cobalt and lead(0.603), indicating a possible common source of contamination to the sampled groundwater possibly the legacy oil spill site within the area of study. A positive relationship is revealed between lead and Nickel (0.500), and a weak positive correlation (0.137) between cobalt and cadmium (Table 3). There was, however, a negative correlation between nickel and cadmium (-0.523) and between nickel and cobalt (-0.036), indicating that they do not have the same source of pollution [25].

Table 3: Correlation between the toxic metals parameters of borehole water in Ebubu

Metals	Nickel	Lead	Cobalt	Cadmium
Nickel	1			
Lead	0.500	1.000		
Cobalt	-0.036	0.603*	1.000	
Cadmium	-0.523	-0.006	0.137	1.000

* Significant level $p>0.05$

Summary, Conclusions and Recommendations

Standard analytical protocols were used to assess the quality of groundwater in Ebubu town, Eleme local government area of Rivers State, Nigeria. The groundwater samples were analysed, toxic metals contents/levels. Statistical tools like mean, standard deviation and correlation analysis were used for data analysis.

The mean values of toxic metals examined: Nickel (0.042 mg/L), Cadmium (0.361 mg/L), Lead (0.117 mg/L) and cobalt (0.010 mg/L) exceeded the WHO regulatory limit of 0.07 mg/L; 0.361 mg/L; 0.01 mg/L and 0.0038 mg/L respectively. These values also exceeded the permissible limit prescribed by NIS [1,14].

The toxic metals levels examined also varied across the sampling periods; apart from Cd whose mean value was higher during the month of June, but lower in August, all other toxic metals (Ni, Pb, and Co). Also, the correlation analysis computed for the toxic metals suggests that there is a strong positive relationship between cobalt and lead (0.603), indicating a possible common source of contamination to the sampled groundwater possibly the legacy oil spill site within the area of study. A positive relationship between lead and Nickel (0.500) was established, while cobalt and cadmium show a weak positive correlation (0.137). There was, however, a negative correlation between nickel and cadmium (-0.523) and between nickel and cobalt (-0.036), indicating that they do not have the same source of pollution.

From the results obtained from this study, the following conclusions and recommendations have been made

The total mean level of cadmium (0.361 mg/L) was observed to be the highest of all heavy metals under study. The mean concentrations of nickel, cadmium, lead, and cobalt in the water samples were higher than the WHO limits for drinking water. The sampled boreholes water is therefore not suitable for human consumption but may be adequate for domestic processes [1].

In light of the findings from this study, the following recommendations are made in an attempt to enhance and promote the quality and suitability of the water sources: Periodic analysis of samples of groundwater taken from boreholes should be routinely carried out as industrialization and population are on the increase in Ebubu town. Such analysis will reveal pollution status of groundwater in such area of interest. If the result of such analysis shows that there is excessive contamination of the water, there is the need to intimate the consumers and other users of the water to guard against the subsequent impact that may arise from such development.

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