Heavy Metal and the Mineral Ions Assessment of Borehole Water Used in Port Harcourt Oil Refinery Host Communities

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ABSTRACT

This study presents the findings of an assessment conducted to determine the levels of heavy metals and mineral ions in borehole water used in the Port Harcourt oil refinery host communities. The study area comprised six selected communities located in the vicinity of the oil refinery in Rivers State, Nigeria. Water samples were collected from various boreholes in each community and analyzed for heavy metal concentrations and mineral ion content within the World Health Organisation (WHO) and National Standard for Drinking water Quality (NSDWQ) standard. The results revealed significant variations in heavy metal and mineral ion levels across the selected communities, with some areas exhibiting elevated concentrations of lead, arsenic, and cadmium. These heavy metals are known to pose health risks to humans, even at low concentrations, and raise concerns about the safety of the borehole water for consumption and agricultural use. It is highly recommended that borehole water in Port Harcourt Refinery be properly and routinely investigated as well as other water parameters checked. And Nigerian government in partnership with Non-governmental organization should conduct water security mapping to help identify vulnerable areas (communities) where there is high water stress such that the areas are given priority in borehole allocation

INTRODUCTION

Water is one of the most important and abundant compounds of the ecosystem. All living organisms on the earth need water for their survival and growth. It rarely occurs in its pure form in nature (Ababio, 2015). It is the only substance that exists naturally on Earth in all three physical states of matter; gas, liquid, and solid. The Earth has oceans of liquid water and Polar Regions covered by solid water and the gaseous water vapour, a greenhouse gas which traps energy radiated from the surface of the planet and provides the planet with warmth. Energy from the sun is absorbed by liquid water in oceans, lakes, and rivers and gains enough energy for some of it to evaporate and enter the atmosphere as an invisible gas, water vapour. As the water vapour rises in the atmosphere it cools and condenses into tiny liquid droplets that scatter light and become visible as clouds. Under the proper conditions, these droplets further combine and become heavy enough to precipitate (fall out) as drops of liquid or, or if the air is cold enough, flakes of solid, thus returning to the surface of the Earth to continue this cycle of water between its condensed and vapour phases. This cycle is known as the Hydrologic cycle. Groundwater is a major source of fresh drinking water. According to the World Health Organization the safety and accessibility of drinking water are major concerns throughout the world (WHO, 2011). According to Chapman (2016), groundwater is easily the most important component of the hydrological cycle, an important source of potable water in Africa and constitutes about two thirds of the freshwater resources of the world. Surface water is not evenly distributed or accessible to large sections of the global population (McDonald & Jones, 2018). Groundwater provides a reasonably constant supply for domestic use, livestock and irrigation, which is not likely to dry up under natural conditions thereby buffering the effects of rainfall variability across seasons (Callow et al., 2017). In many arid and semi-arid areas of Africa borehole water is a means of coping with water deficiencies in areas where rainfall is scarce or highly seasonal and surface water is extremely limited (David, 2017; Omar et al, 2020). Health risks may arise from consumption of water contaminated with infectious agents, toxic chemicals and radiological hazards. Improving access to safe drinking water can result in tangible improvement to health. As a result of frequent outbreak of water borne diseases, the International Small Community Water Supply Network was formed to promote the achievement of substantive and sustainable improvements to the safety of small community water supplies particularly in rural areas as a contribution to the Millennium Development targets related to water sanitation (WHO, 2011).

One of the pollutants that is commonly associated with effluents discharge is heavy metals. These are known poisons or toxicant at certain concentrations on water and food, even though some may be essential at low concentrations (Edori & Kpee, 2016). Heavy metals are dangerous because they tend to bioaccumulation in plant and animal tissues (Wokoma & Edori, 2017). Bioaccumulation results when there is an increase in the concentration of a chemical in a biological organism over time, compared to the natural concentration of chemicals in environment. However, man's increased ability to utilize remarkable properties of metals has always resulted in little or significantly large quantities of these metals being discharged into the surrounding as waste and subsequently the environment (Kpee & Edori, 2014). Heavy metals such as mercury, lead, arsenic and cadmium are harmful and even essential ones like copper, zinc and nickel can be toxic at high concentrations in biological systems (Igbinedion & Oguzie, 2016). The presence of these elements in the environment has been linked with toxicity in man and aquatic organisms (Ndeda & Manohar, 2014). This becomes visible after bioaccumulation over a long period of time since heavy metals cannot be degraded. Diseases related to the heart, kidney and blood have been associated with areas polluted with heavy metals and most importantly inhalation of arsenic, lead and cadmium has been closely linked with lung and skin cancer (Egbe & Ahunanya, 2016). Improper dispersal of industrial effluents which is most common in major African urban and rural centres have led to heavy metal contamination of available fresh water sources reducing the volume of safe agriculture, domestic, irrigation and drinking water (Ozairu et al, 2014). Contamination of water sources often can emerge from leaching of rocks, industrial and agrochemical discharges which are washed into them especially during the raining season (Adewoye et al 2013).

Heavy metals such as lead (Pb), mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), Zinc (Zn), Nickel (Ni), and Copper (Cu) etc., are very toxic and poisonous in small or low concentrations to both human and aquatic organisms. They are hazardous in very minute concentrations thus posing health risk (Peavy et al., 2015). The primary source of lead in drinking water sources is soil containing lead, food growing in contaminated soil, old batteries, atmospheric sources such as combustion of waste oils and fuels with automobile exhaust. High levels of lead contamination in a child can also result in convulsions, major neurological damage, organ failure, coma and ultimately death. Also, moderate to low levels of exposure may alter physical and mental development, inhibit growth, decrease attention span and hearing, and cause learning disabilities. In older men and women, lead can increase blood pressure. Unlike other contaminants, lead do accumulate in the body over a period of time (bioaccumulation) and it will be stored both in brains, kidneys, bones and other organs. In a child's body, it can be stored in the blood for months and in the bones for years.

Arsenic is a semi- metal element and a member of the nitrogen family with atomic mass of 75. It occurs naturally in the earth and in the seas. The major sources of exposure are through consumption of food and water. It may also combine with other element to form organic and in organic arsenicals. Inorganic arsenicals are more toxic than the organic form and they are primarily present in water. Exposure to arsenic poses serious health effects as it is a known human carcinogen. Observable symptoms of arsenic poisoning are thickening and discoloration of the skin, stomach pain, nausea, vomiting, diarrhea, numbness in bands and feet, partial paralysis and blindness (Wilkes Environmental Center, 2018). Cadmium exposure in drinking water sources causes liver and kidney damage, renal dysfunction and bone degeneration. It may be introduced into water source through petroleum refined products, detergents and phosphate fertilizers. High concentration of copper in water sources can causes nausea, diarrhea, eyes, nose and mouth irritation. It may also lead to kidney failure and death as well (Ravindra et al., 2015). Zinc exposure in high concentration causes cholesterol and anemia problems in adults, nausea and vomiting in children etc. Major sources of zinc in water originate from mining and metallurgical processing of zinc ores and its industrial application (WHO, 2017).

Pregnant mothers exposed to toxic mercury either through water or consumption of contaminated fish are liable to born physically and mentally deformed babies. Volcanic eruption, rocks and soils weathering, industrial applications and mining activities etc., all contribute mercury to water sources (Ravindra et al., 2015). Chromium is one of the toxic metals detrimental to human health in small quantity. It can occur from weathering of rocks and soils, volcanic eruptions etc. Burning of fossil fuels and production of plastics are other human activities that contribute chromium to water sources.

The anions which are present in the greatest concentration in most groundwater are Bicarbonate (HCO3-), Sulphate (SO42-), Chloride (Cl-) and Nitrate (NO3-) and they are also introduced to aquifers through rainwater (Younger, 2007). As water travels through the earth surface, sulphates are picked up and dissolved in groundwater during infiltration of rainfall and groundwater recharge (Singh et al., 2017). It is beneficial in irrigation practices especially in the presence of calcium (Nas, 2019). High concentration of chloride indicates high degree of pollution. It originates from natural sources, sewage and industrial effluents; gives a salty taste to water and beverages at high concentration; may cause physiological damages and can be toxic to crops and unsuitable for irrigation and industrial uses. The main source of nitrate in water is from the atmosphere, legumes, plant debris, animal excreta and intensive use of fertilizers for agricultural purposes and higher concentration of it causes illness known as infant methemoglobinemia, i.e., a blood disorder in which too little oxygen is delivered to body cells (Nas, 2019; Balakrishnan et al., 2017).

Gana et al (2021) conducted a study on hydrochemistry and quality assessment of groundwater from constituency water projects, Pategi Local Government Area. The study paper investigated the quality of groundwater samples from these boreholes in terms of their physicochemical, heavy metals and biological parameters and also provides baseline information about the nature of the underground aquifer in this community. Groundwater samples (n=20) were obtained from randomly selected boreholes in the study area and examined for their physicochemical, heavy metal and biological parameters following standard procedures recommended by the American Public Health Association and compared to guideline values. Pearson's correlation test was done to examine the relationship between measured parameters. With the exception of pH (5.58) and total hardness (296.99mg/L), all physico-chemical parameters were within guideline values specified by the WHO and SON. For heavy metals, mean values for Iron (0.32mg/L), Chromium (0.22mg/L) and Nickel (0.4mg/L) were found to exceed the given standard limits as well. The findings revealed that boreholes were mainly acidic which could be of natural origin such as mineral dissolution. Based on correlation analysis, the major mineral groups contributing to total hardness is the K-Cl group (1.00).

In another study by charity et al (2018) on "Health Risk of Consuming Untreated Borehole water from Uzoubi mnna Orlu in Imo State", the researchers noted that among all the water sampled, and investigated, all were contaminated with heavy metals such as cadmium (Cd), Nickel (NI) and Mercury (Hg). The hazard quotient through the of sampled water for both adults and children indicated that the identified metals are capable of posing hazard to presidents and consumers of the water. The researchers icity (Apn) to measure the level of anthrpogenic effects on the sampled borehole water. They noted that Copper, Nickel, Silver as well as Zinc had a very high degree of anthrpogenic effects on some of the sampled. The mean value of the anthrpogenicity for all the metals assesed followed a decreasing order of Cd>Ni>Hg>Cu>Zn>Se>Ag>Ar>Cr>Pb. The researchers could not identify the major source of these metals found in the sampled areas. Also, microbiological parameters of the sampled Borehole Water were not identified by the researchers.

Abdolmajid and Mehraban(2014),conducted a study on evaluation and assessment of drinking water water quality in Iran, using World Health Organisation standard and Iran standard. The researchers noted that the concentration levels of total coliform bacteria exceeded the World Health Organisation and Iran Standard in some of the consumer taps and wells sampled. The Findings also noted that E. Coli, pH, turbidity, total hardness, chloride, sulphate, and total dissolved solid were within the limits hence the samples were of high quality standard for consumption.

Maseke and Vegi (2019) conducted a comparative study of water quality between hot spring and borehole waters of Mara, Shinyanga and Manyara Regions of Tanzania. The study conducted for the comparison of physico-chemical parameters between hot springs and borehole waters. Fourteen samples were collected at Mara, Shinyanga and Manyara in Tanzania. Multimeter used for the analysis of physical parameters pH, EC, TDS, salinity and turbidity. Titrimetric methods were used for the determination of Cl- , total hardness, Ca2+ and Mg2+. UV-Vis. Spectrophotometric method for NO3 - , SO4 2-, F- , Fe2+ and Mn2+ and Flame Atomic Absorption Spectrometer for Cd2+, Zn2+, Ni2+, Cu2+ and K+ . The EC, TDS, salinity, turbidity, Cl- , NO3 - , SO4 2-, F- , Mn2+ and Cu2+ are higher (pH = 7.44-9.42, EC = 4251.33-15334 µS/cm, TDS = 2079-7526.7 mg/L, salinity = 2.2-8.67 ppt, Cl- = 189.3- 3577.6 mg/L, SO4 2- = 11.83-1353.33 mg/L, F- = 4.68-18 mg/L, Mn2+ = 1.03-2.0 mg/L, Cd2+ = 0.01-0.05 mg/L, Cu2+ = 0.37- 0.93 mg/L and K+ = 44-100 mg/L) in hot springs than borehole waters (pH = 6.36-6.58, EC = 270.0-2674.64 µS/cm, TDS = 123.67-1305 mg/L, salinity = 0.03-1.37 ppt, Cl- = 6.25-659.93 mg/L, SO4 2- = 28.92-493.33 mg/L, F- = 0.89-3.0 mg/L, Mn2+ = 0.3-1.70 mg/L Cd2+ = 0 mg/L, Cu2+ = 0.49-0.64 mg/L and K+ = 16-52 mg/L). The t-test at the probability 0.05 showed that there is significant difference of the parameters pH and Ni2+ between hot spring and borehole waters. Some of the parameters are at higher levels than permissible values for both hot spring and borehole waters.

Related empirical studies reviewed reveal a level of microbial, physico-chemical elements and heavy metals in borehole water located in different domestic and industrial environments. Although there are a good number of studies assessing borehole water quality, there are no documented studies that assessed borehole water quality in Refinery activity area in Rivers State. This gap will be addressed by the present study.

STATEMENT OF THE PROBLEMS

The Port Harcourt area plays an essential role in Nigeria's oil and gas exploration and refining activities, serving the nation's petroleum sector. The communities, close to the oil and gas industry, experience growth alongside its success. Due to the absence of reliable quality water distribution networks, this communities heavily rely on groundwater, primarily from boreholes, to meet there daily domestic activities.

Nonetheless, there may be a risk of water contamination due to the proximity of these host communities to the oil refinery facilities. Processes such as petrochemical manufacturing and oil refinement, inherent to the industrial landscape, have the capacity to discharge diverse pollutants into the surroundings. Among these potential contaminants, heavy metals stand out as hazardous agents that possess the ability to inflict significant harm on both human health and ecosystems, even at minimal levels of exposure. Moreover, mineral ions such as calcium, magnesium, sodium, and potassium hold a pivotal role in water quality, serving as indicators that could point to issues related to contamination or increased salinity.

Previous research has highlighted apprehensions regarding the water quality in proximity to oil refineries. The introduction of heavy metals and mineral ions into groundwater, stemming from industrial emissions, accidental leaks, and inadequate waste disposal practices, has been a subject of concern. These factors have the potential to impact the well-being and vitality of communities reliant on borehole water sources

Recognizing the significance of groundwater for the daily sustenance and economic activities of the host communities, it becomes imperative to assess the physical and chemical attributes of borehole water. This evaluation is especially crucial for ensuring its suitability for various essential purposes, notably drinking and agricultural uses. By determining the concentrations of heavy metals and mineral ions present in borehole water, valuable insights can be gained into the potential threats of water contamination and their potential implications on both human health and the local ecosystem. Hence this study seek to investigate heavy metal and the mineral ions assessment of borehole water used in Port Harcourt oil refinery host communities

AIM OF THE STUDY

The aim of this study is heavy metal and the mineral ions assessment of borehole water used in Port Harcourt oil refinery host communities. The specific objectives of the study include assessing:

OBJECTIVES OF THE STUDY

1. The heavy metals in borehole water used in the selected host communities of Port Harcourt oil Refinery.
2. The mineral ions present in the borehole water of Selected host communities of Port Harcourt oil Refinery

Research Questions

The following research questions will be answered in this study:

1. What are the heavy metals properties of borehole water used in Port Harcourt Oil Refinery host communities?
2. What are the mineral ions present in the borehole water used in Port Harcourt Oil Refinery Host communities in Rivers State?

HYPOTHESES

The following hypotheses were tested at 0.05 level of significance:

1. The heavy metals properties of borehole water used in host communities of Port Harcourt Oil Refinery host communities do not significantly differ from the World Health Organization's parameter for safe drinking water.
2. The mineral ions properties of borehole water used in host communities of Port Harcourt Oil Refinery host communities do not significantly differ from the World Health Organization's parameter for safe drinking water.

MATERIAL AND METHODS

THE STUDY AREA

The research was carried out in six host communities near the Port Harcourt Oil Refinery Area in Rivers State, Nigeria. The refinery complex consists of two refineries located in Alesa-Eleme, Rivers State. The older refinery has its utilities, including water boreholes, water treatment, cooling water tower, instrument air, and steam boilers. It generates its own gas for processing, supplemented occasionally with LPG from storage. The new refinery, also known as Port Harcourt II, is a complex refinery with a capacity of 7,500,000 metric tons per year (150,000 barrels per day). Initially intended for export, it now primarily serves the domestic market due to supply interruptions from other refineries in Nigeria. The selected host communities are at varying distances from the refinery, ranging from 3 km to 10 km.

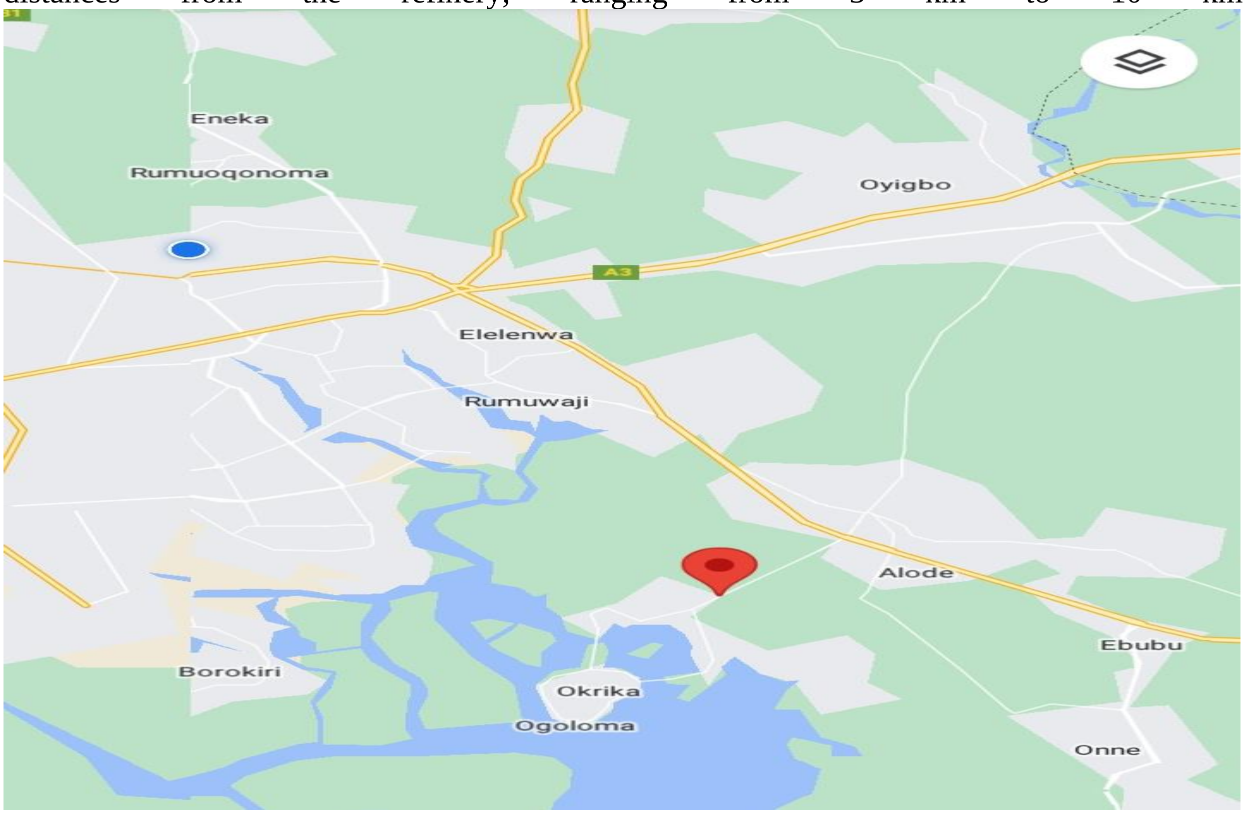

Fig 1: Map showing Port Harcourt Refinery

population for the study

This study was carried out in the six selected host communities of Eleme Port Harcourt Refinery in Rivers State. The selected host communities are : Abam, Darka, Ekereakana, Okochiri, Ogan, and Alesa respectively. The sampling location coordinates are given in the table below :

Sample Location	Latitude	Longitude
ABAM	45.760^0N	5.708^0E
ALESA	46.191^0N	6.158^0E
DARKA	45.006^0N	5.959^0E
EKEREAKANA	45.108^0N	6.175^0E
OGAN	45.288^0N	5.829^0E
OKOROCHIRI	44.968^0N	6.453^0E

MATERIAL AND METHODS

Sample and sampling techniques

In this study, two water samples were taken from each host community for heavy metals and mineral ions test. The samples were collected from boreholes using sterilized plastic water bottles, leaving ample air space for oxygen and mixing. Proper labeling and immediate transportation in an insulated bag ensured that external factors, like temperature, did not alter the parameters. The analysis began within 12 hours of sampling, following the guidelines of APHA 1998.

Determination of Mercury, Candium, Lead And Iron

Mecury (Hg), Cadmium (Cd), Lead (Pb) and Iron (Fe) were determined using analytical procedure for heavy metals. To determine the total metal concentrations, 5 mLs of samples each was first acidified with 10 mLs concentrated aqua regia. He water samples were digested for four hours using HCl: HNO3 of 1:3. Heavy metal concentration determined using GBC 908 Varian Atomic Absorption Spectrophotometer according to Enyoh et ala (2016).

Determination of Mineral ions

The heavy metals intended for analysis include bicarbonate (HCO3-), sulfate (SO42-), nitrate (NO3-), sulfite (SO32-) and phosphate (PO43-). The selection of mineral ions was based on there relevance too industrial activities and there potential toxic effects on human health and the environment..

Mineral ions Quality Assessment

The mineral ion concentrations were assessed based on established water quality criteria for different uses, such as drinking water, irrigation, or industrial purposes. Any deviations from the recommended standards will be highlighted and potential impacts on human health and the environment will be discussed.

Heavy Metals Quality Assessment

The obtained heavy metal concentrations were compared to WHO standard as well as NSDWQ standard guidelines for drinking water, irrigation, and environmental protection. The results were interpreted to assess the level of contamination and potential risks posed to human health and the surrounding ecosystem.

Method of Data Analysis:
Data was be analyzed using Statistical Package for Social Sciences (SPSS) version 25. Descriptive statistics (mean and standard deviation) was used to answer the research questions and one way analysis of variance (ANOVA) was used to test for the hypotheses at 0.05 confidential level

ANALYSIS OF DATA

Research Question 1: What are the heavy metal properties of borehole water used in Port Harcourt Oil Refinery host communities?

Table 1: mean and standard deviation of the heavy metals properties of borehole water used in Port Harcourt Oil Refinery host communities.

		Heavy metals properties heavy/parameters				
Sampled Communities		**Lead**	**Cadmium**	**Nickel**	**Mercury**	**Iron**
ABAM	Mean	.00100	.04750	.01050	.00100	.10500
	N	2	2	2	2	2
	Std. Deviation	.000000	.000707	.013435	.000000	.120208
ALESA	Mean	.00100	.01350	.01500	.00100	.42500
	N	2	2	2	2	2
	Std. Deviation	.000000	.000707	.021213	.000000	.035355
DARKAAMA	Mean	.00150	.03300	.00100	.00150	.19000
	N	2	2	2	2	2
	Std. Deviation	.000707	.001414	.000000	.000707	.000000
EKEREKANA	Mean	.00100	.02350	.00100	.00150	.40500
	N	2	2	2	2	2
	Std. Deviation	.000000	.000707	.000000	.000707	.007071
OGAN	Mean	.00100	.00400	.00100	.00150	.24000
	N	2	2	2	2	2
	Std. Deviation	.000000	.000000	.000000	.000707	.014142
OKOROCHIRI	Mean	.00100	.00100	.00100	.00100	.44000
	N	2	2	2	2	2
	Std. Deviation	.000000	.000000	.000000	.000000	.000000
Reference Points	**WHO 2011**	0.01	0.003	0.07	0.001	0.3
	NSDWQ 2016	0.01	0.05	0.02	0.001	0.3

Table 1 shows the heavy metals properties of borehole water used in Port Harcourt Oil Refinery host communities. The average properties of heavy metals such lead, cadmium, Nickel, Mercury and iron in sampled communities ; ABAM, ALESA, DARKAAMA, EKEREKAN , OGAN and OKOROCHIRI have the range of 0.000 – 0.001,mg/L, 0.01350– 0.04750mg/L, 0.001 - 0.21213mg/L, 0.001 – 0.0015mg/L and 0.105 -0.440mg/L. The following heavy metals properties of borehole water like lead, Nickel, Mercury in the sample communities falls below and within the reference point when compared reference point of WHO (2008) and NSDWQ (2016). The presence of cadmium in the Borehole water in the sample communities was actually far above the reference point of WHO (2008) and NSDWQ (2016),this is similar to the work of Bamigboye *et`at* (2018). Also heavy metals properties of borehole water such iron was also below the reference point when compared reference point of WHO (2008) and NSDWQ (2016) except for communities like ALESA, EKEREKANA and OKOROCHIRI.

Research Question 2: What are the mineral ions present in the borehole water used in Oil Port Harcourt Refinery Areas?

Table 2: mean and standard deviation of the mineral ions present in the borehole water used in Oil Port Harcourt Refinery Areas.

		mineral ions present			
Sampled Communities		**Sulphate**	**Chloride**	**Sulphite**	**Carbonate**
ABAM	Mean	.50000	4.00000	.01000	.00000
	N	2	2	2	2
	Std. Deviation	.707107	.000000	.000000	.000000
ALESA	Mean	.50000	5.00000	.01000	1.50000
	N	2	2	2	2
	Std. Deviation	.707107	.000000	.000000	.707107
DARKAAMA	Mean	1.00000	9.50000	.01500	1.50000
	N	2	2	2	2
	Std. Deviation	.000000	.707107	.007071	.707107
EKEREKANA	Mean	.50000	10.00000	.01000	3.00000
	N	2	2	2	2
	Std. Deviation	.707107	.000000	.000000	.000000
OGAN	Mean	.50000	5.50000	1.00000	1.00000
	N	2	2	2	2
	Std. Deviation	.707107	.707107	.000000	.000000
OKOROCHIRI	Mean	.00000	7.00000	2.00000	1.01000
	N	2	2	2	2
	Std. Deviation	.000000	.000000	.000000	1.414214
Reference Points	**WHO 2011**	100	250	250	-
	NSDWQ 2016	100	250	250	250

Table 2 shows the mineral ions present in the borehole water used in Oil Port Harcourt Refinery Areas. The average properties of mineral ions such Sulphate, Chloride, Sulphite and Carbonate of the borehole waters in sampled communities ; ABAM, ALESA, DARKAAMA, EKEREKAN , OGAN and OKOROCHIRI are 0.000 – 0.500,mg/L, 4.000– 10.0000mg/L, 0.01 – 2.000mg/L and 0.000 – 3.00mg/L. This implies all the mineral ions are below the reference point when compared reference point of WHO (2011) and NSDWQ (2016).

Hypothesis 1: The heavy metals properties of borehole water used in Port Harcourt Oil Refinery host communities do not significantly differ from the World Health Organization's parameter for safe drinking water.

Table 3: ANOVA analysis of the heavy metals properties of borehole water used in Port Harcourt Oil Refinery host communities

	Sum of Squares	df	Mean Square	F	Sig.(p-value)	Decision
Between Groups	.168	5	.034	11.119	.005	Reject H0
Within Groups	.018	6	.003			
Total	.186	11				

Table 3 indicate that heavy metals properties of borehole water used in Port Harcourt Oil Refinery host communities significantly differ from the World Health Organization's parameter for safe drinking water, $F(2,6) = 11.119$, $p = 0.005$. Hence reject the null hypothesis ($p < 0.01$)

Hypothesis 2: The mineral ions properties of borehole water used in Port Harcourt Oil Refinery host communities do not significantly differ from the World Health Organization's parameter for safe drinking water.

Table 4: ANOVA analysis of the mineral ions properties of borehole water used in Port Harcourt Oil Refinery host communities

	Sum of Squares	df	Mean Square	F	Sig.(p-value)	Decision
Between Groups	110.770	5	22.154	18.989	.001	Reject Ho
Within Groups	7.000	6	1.167			
Total	117.770	11				

Table 4 indicate that mineral ions properties of borehole water used in host communities of Port Harcourt Oil Refinery host communities significantly differ from the World Health Organization's parameter for safe drinking water, $F(2,6) = 18.989$, $p = 0.001$. Therefore Reject the null hypothesis ($p < 0.01$)

RESULTS AND DISCUSSION

Table 1 showed that there is difference of heavy metals properties of borehole water used in Port Harcourt Oil Refinery host communities. Table 3 confirmed the difference of heavy metals properties of borehole water used in Port Harcourt Oil Refinery host communities was significant. The difference in heavy metal properties in the sampled communities could be attributed to the differences in individual metals solubility, pH, leaching by acid rain during the wet season and topography of the communities. The concentrations of heavy metals were generally low but some samples fall short of regulatory standards for drinking purpose. The concentration of Iron (Fe) was higher in communities like ALESA, EKEREKANA and OKOROCHIRI with the average heavy metal properties of 0 .42500, 0.40500 and 0.44000 respectively which were above the WHO permissible limit of 0.3 mg/L for human use while other communities average were below. High concentration of Fe in these communities may be due to natural existence iron rivers, lakes and underground water. Iron may also be released to water from natural deposits, industrial wastes, refining of iron ores and corrosion of iron containing metals. When the borehole water with higher concentration of iron is abstracted, it quickly oxidizes to ferric state in the form of insoluble ferric hydroxide, a brown substance. More so, effect of iron overload on some organs such as skin, is trivial, compare to hemosiderotic harm to other organs, like the liver and kidney, which can be fatal. The lead (Pb) content (mg/l) of the borehole water samples average range from 0.000 0.001mg/L, which is also within the limit of WHO (0.01mg/l) (WHO, 2008). The cadmium levels (mg/l) of the borehole water samples assayed from 0.01350 0.04750mg/L in 5 borehole water in the sampled, while it was not detected in the borehole water in OKOROCHIRI. This shows that the Cd levels are very high compared to the limit of 0.003mg/l prescribed by WHO. This high Cd levels could be as a result of the activities going on around the boreholes. Some of the boreholes were surrounded by beer parlour where there is high level of cigarette smoking. Cigarette has been attributed to high level of Cd which could pollute the environment (WHO, 2011). The results also showed that the concentration of Nickel and Mercury is slightly lower than the permissible standard. No health impairment is associated with consumption of water with low Nickel and Mercury. The finding of this agrees with Maseke and Vegi (2019) who reported that some of the parameters are at higher levels than permissible values for both hot spring and borehole waters. The concentration of iron on the sampled water ranges from 0.19-0.45 glml. This could result in an adverse aesthetic and health effects when ingested by the residents of the host communities of eleme refinery.(Nave edulalah, 2016).High concentration of Fe in these communities may be due to leaching of Fe from refineries pipes, it may also be as a result of nitrate leaching in ground water, oxidation and decrease in PH could lead to dissolution of iron thus, increases the iron concentration in ground water (Edokpayi et al.,2018).The deviations of okochiri may be as result of the church that treats their borehole. High concentrations of cadmium affects the nervous system, causes damage of DNA and the immune system as well as damage the development of cancer (charity, 2018).It Can as well cause other non-cancerous diseases that includes; loss of sense of smell and taste, fibrosis, upper respiratory diseases, shortness of breath, skeletal effects, lumbago, hypertension, tubular proteinuria and cardiovascular diseases (Nweke & ukpa 2016). The presence of cadmium in the borehole water occurred when it comes in contact with soil contaminate with discharge from fertilizer industries, petroleum, hydrocarbon through leaching (Emeka et al.,2020).The results showed that the concentration of Nickel and Mercury is slightly lower than the permissible standard. No health impairment is associated with consumption of water with low Nickel and Mercury.

Table 2 showed that the mineral ions properties of borehole water used in host communities of Port Harcourt Oil Refinery host communities differs across the six sample communities. Table 4 revealed that the mineral ions properties of borehole water used in host communities of Port Harcourt Oil Refinery host communities significantly differ from the World Health Organization's parameter for safe drinking water. This implies all the mineral ions are below the reference point when compared reference point of WHO (2011) and NSDWQ (2016). There are no specific guidelines for bicarbonates in WHO(2011). The bicarbonates concentration of the study area however is below the permissible range. Therefore, borehole sources in this study areas can be regarded to be free from biocarbonates pollution. The agrees with the study conducted by (Bashiar and Olaken 2012). The chloride, sulphate and sulphite are also below the WHO(2011) reference point. High concentration of sulphate only has laxative effects on the human organism, it should be recognised that its combination with other ions can introduce discomfort for the consumer (unpleasant taste) and lead to the abandonment of the facility. In addition, the presence of high sulphate content could explain the corrosion of the water storage tank and the high iron concentration obtained. The analyses carried out on the water from sampled communities boreholes showed that they did not have any special characteristics. The sulphate ion content in the water from these boreholes had a maximum value of 0.500,mg/L. Chloride in drinking water is not harmful, however, higher concentration above 250mg/l can cause unpleasant taste and corrosion which results to leaching of metals from the pipes used for water system distribution. The chloride levels in all water sample obtained are below the permissible limit of WHO. This study is line with Ebong et al (2018) whoreported that when the average value of minerals ion values were compared with the World Health Organization (WHO) standard values for drinking water quality. They did not meet the WHO standard, and therefore requires robust purification strategies to ensure a good potable drinking water in the community as to reduce the outbreak of water-borne infections. There are no specific guidelines for bicarbonates in WHO(2011) However,the value of 250-500 cited in the world Health organisation of (1980). The bicarbonates concentration of the study area however is within the permissible range. Therefore, borehole sources in this study areas can be regarded to be free from biocarbonates pollution. The agrees with the study conducted by (Bashiar and Olaken 2012).

CONCLUSION

The assessment of heavy metals and mineral ions in borehole water used in Port Harcourt oil refinery host communities has provided critical insights into the water quality and potential risks faced by the residents in this region. The study revealed significant variations in the concentrations of heavy metals and mineral ions across the selected host communities, indicating the influence of various factors such as proximity to the refinery, industrial activities, and geological characteristics.

The results showed elevated levels of certain heavy metals, including iron lead and cadmium, in some borehole water samples. These findings are of utmost concern, as heavy metals are known to have detrimental effects on human health, even at low concentrations. Long-term exposure to heavy metals through drinking water and agricultural use can lead to serious health issues, including neurological disorders, kidney damage, and cancer. Additionally, high mineral ion concentrations, such as sodium and sulfate, in certain areas may pose challenges for agricultural activities and water usability.

RECOMMENDATION

1. Households should site their borehole far away from industrial pipes, suck-away and sewage dumps.

2. It is highly recommended that borehole water in Port Harcourt Refinery be properly and routinely investigated as well as other water parameters checked.
3. Nigerian government in partnership with Non-governmental organization should conduct water security mapping to help identify vulnerable areas (communities) where there is high water stress such that the areas are given priority in borehole allocation.
4. Environmental awareness associations should regularly organize a program in order to educate members of the communities on the proper disposal of waste, management and Protection of their water resources. These would drastically reduce acute problem of water pollutants and water related diseases that are endemic to the health of man.

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