The Assessment of Physiochemical and Biological Quality of Borehole Water Used in Port Harcourt Oil Refinery Host Communities

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ABSTRACT

The research was carried out assessment of physiochemical and biological quality of borehole water used in port Harcourt oil refinery host communities. The study assessed the level of contamination and of physical and biological quality of the groundwater of randomly selected boreholes. Water quality analysis was performed on samples collected from twelve (12) boreholes within six selected host communities of Port Harcourt Refinery in Rivers State for the following physicochemical parameters: Temperature, pH, turbidity, alkalinity, and total dissolved solid (TDS) using conventional equipment and standard laboratory procedures, also the bacterial analysis were carried out and characterized using standard methods. The results showed that physical parameters such as pH, temperature and turbidity in some communities did not show any reason for concern. The physical parameters measured are within the World Health Organisation (WHO) and National Standard for Drinking water Quality (NSDWQ) standard. Also when the biological qualities was also determined, the results showed that. E. Coli was not detected in any of the water samples. Total coliform count and Fecal coliform count were detected in high rate in Abam, Darka - ana and some parts of Ogan community as it ranges from 0.000-7.000mg/l and 0.000-1150mg/l. Intervention of Government and Non- governmental Organisation is highly recommended.

Keywords : *Water quality, boreholes, physicochemical parameters*

Introduction

Water accounts for about 70% or more of the weight of most organism. In human adults also, total body water account for about 70 % of the lean body mass (Ikeyi and Omeh 2015). Adult slim females have a low water content of about 46 - 60% where as Infants can be in the range of 65 - 77% (Jain *et'al* 2013). The human body temperature of 37°c is maintained mainly because water is expelled by lungs and the skin. A loss of 10% of water in our body is serious while a loss of 20% is fatal in human. No order substance on earth is as abundant as water and it is present almost in air, clouds, oceans, Lakes, rivers, glaciers or Springs. In 5km layer below the sea level on earth water is 6 times as abundant as all other substances put together. And nọ other substance exist in

three states of matter at the same time. (Jain *et'al* 2013). It is water that had conditioned our climates. The water in the oceans, season and the atmosphere (vapour) act as an accumulator of heat. In hot weather, it absorbs, heat and in cold, it gives up heat thereby making the planet warm. Without water our planet will be cold to zero temperature long ago and all forms of life would have perished. Water is the most important possession of humanity and keeping in view the relevance of the role of water in our planet NASA launched a satellite known as "Aqua" to study the effect of water in various forms on climate (Jain *et'al* 2013). Water has the ability to dissolve substances more than anyother known liquid hence it is known as universal solvent. (Obi *et'al* 2016),defined water as a liquid that boils at 100oC, has a pH of 7 and pressure of 760mmHg. Water as well serve as a very useful substance to mankind in many says, for instance: it serve as a means of transportation, serves as a sporting and recreation activity. Electricity is also generated from water, bathing, drinking, washing, cleaning as well as cooking activities are carried out with water (Obi2016).
Water and its quality is a very serious and vital issue for mankind due to its link with human health and welfare. It is one of the most important, valuable and renewable essential resources. Water is one of the essential elements of human life as the body cannot survive longer than few days without adequate water (Alepu *et'al* 2016). The availability of adequate water supply both in quality and quantity is essential for human existence. There is abundance of it on the earth surface but the quality as well as the quantity to serve its intended purpose is where the problem lies. This because, water that may be good for tanning and dyeing of clothes may not be good for domestic purposes. Water can originate from various sources which include rain water, surface water and groundwater. But the most important one is the groundwater which originate as a result of rainfall infiltration into the ground through the pores of rock and soil thus meeting the water table. It is normally abstracted through domestic boreholes and is essentilly used for human consumption. As such, the need to ensure that individuals get access to clean water cannot be ignored. However, improved access to safe water in Nigeria remains slow due to several issues related to corruption that pervades every sector of the economy and this has hindered establishment of legal acts to checkmate water usage in the country (Valipour, 2015). Nigeria is the most populous country in Africa with an estimated population of over 170 million, growing annually at a rate of 2 percent (Al-Zayer, 2020). According to the USAID (2021), the fast-growing population has not been accompanied by increase access to good water supply. The gap between the areas that have access to safe water supply and those without has grown wider.

With the exponential increase in population, access to improved water remains an important pre-condition for sustaining human life, maintaining ecosystems and for achieving sustainable development (Waziri et al, 2022). Accessibility and availability of fresh clean water is a key to sustainable development and an essential element in health, food production and poverty reduction (Adekunle et al., 2014). A water resource such as rain, river, groundwater and sea is one of the major components of environmental resources that are under serious threat from over exploitation or pollution from anthropogenic activities in Olowoyo (2012). Fresh water resource deterioration is now a global problem and is increasing at a faster rate (Mahananda et al., 2015). Discharge of toxic chemicals, over pumping of aquifers and contamination of water bodies with substances that promote algae growth are some of the major causes of water quality deterioration (Awoyemi et al., 2014).

Today there are traces of contamination not only of surface water but also of groundwater, which are susceptible to leaching from waste dumps, mine tailings and industrial production sites (Mahananda et al., 2005). Groundwater is an increasingly important resource all over the world. The term groundwater is usually reserved for the subsurface water that occurs beneath the water table in soils and geologic formation that are fully saturated (Uzomah & Scholz, 2021). Groundwater is generally less susceptible to contamination and pollution when compared to surface water bodies (Zaman 2021). Importantly, groundwater can also be contaminated by naturally occurring sources. The quality of water is substantially affected by domestic, industrial, mining and farming activities. Water is said to be potable if it is colourless, odourless, practically tasteless, as well as devoid of physical, chemical and biological contaminants.

The physicochemical quality of water refers to its characteristics and properties related to both physical and chemical aspects. These properties play a crucial role in determining water's suitability for various purposes, including drinking, irrigation, industrial processes, and ecological support. Monitoring and understanding the physicochemical quality of water are essential for ensuring water safety, protecting ecosystems, and preserving human health. Physicochemical parameters used to assess water quality include temperature which affects various biological and chemical processes in aquatic ecosystems. It can influence the distribution and behavior of aquatic organisms, as well as the solubility and mobility of substances in water. Another one PH, PH measures the acidity or alkalinity. It is important because it affects the chemical behavior of substances dissolved in water and influences the availability of essential nutrients for aquatic life. We also have Total Dissolved Solids (TDS) that measure the total concentration of inorganic and organic substances dissolved in water. It includes minerals, salts, metals, and other dissolved materials. Electrical Conductivity is related to TDS and measures water's ability to conduct electricity. It provides an indication of water salinity and can be used to estimate TDS levels. Turbidity is cloudiness or haziness of water caused by suspended particles. High turbidity levels can affect light penetration and impact aquatic ecosystems. And Dissolved Oxygen (DO) is the amount of oxygen gas dissolved in water. It is essential for supporting aquatic life, as most aquatic organisms rely on dissolved oxygen for respiration.

Biological quality signifies the presence of bacteriological contamination which involves disease causing organisms. Mostly, these organisms are microscopic in nature. They are small living organism inside water which when consumed will create much havoc to the consumer. Bacteriological analysis mainly includes estimation of total coliform and faecal coliform in order to investigate the suitability of water for consumption thereby preventing water borne disease. The quality of the water is determined by the number of coliforms which can be counted in a volume of water. Therefore, emphasis and awareness on water quality needed for consumption purposes, especially for developing country, like Nigeria should be encouraged. Major factors affecting microbiological quality of water are discharges from sewages and run off from informal settlements. Since civilization began, water has been seen as a carrier of diseases and germs (Obi et'al 2016).

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. Odunze and Nwachukwu (2020), access water quality in Diobu community of Rivers State. The study which adopted a descriptive survey designed using questionn ire, the results showed that most private borehole water in the Diobu community is full of little particles and the greenish substances.

Similarly, Bamigboye and Amina (2018) conducted a study on physicochemical and microbiological assessments of newly dug borehole water sources in Rafi local government, Minna, Niger State. The physicochemical and microbiological status of six newly drilled boreholes in Rafi Local Government Area, Minna, Niger State was assessed. Twenty-two physicochemical parameters and coliform count were determined. Water samples were collected from newly drilled borehole water sources in Tsofomension 1, TsofoMension 2, Katako, Tunga Bako, Kagara and Kwana. The colour, odour, taste, temperature, turbidity, conductivity, pH, chloride and copper ions were within acceptable limits. Iron and manganese content of the three regions were highly elevated above the recommended level. It is of concern that the level of hydrogen sulphide (0.2 - 0.27) was far above the permissible level (0.05), being newly drilled sources of water. Only one of the studied boreholes was free of both total and faecal coliforms, other boreholes were contaminated with either total or faecal coliforms or both. The findings in this study necessitate a call for increased hygiene and construction of lined soak-away to eradicate indiscriminate discharge of human and animal wastes.

Palamuleni and Akoth (2015) also conducted a study on physico-Chemical and Microbial Analysis of Selected Borehole Water in Mahikeng, South Africa. The study aimed at determining levels of physicochemical (temperature, pH, turbidity and nitrate) and bacteriological (both faecal and total coliform bacteria) contaminants in drinking water using standard microbiology methods. Furthermore, identities of isolates were determined using the API 20E assay. Results were compared with World Health Organisation (WHO) and Department of Water Affairs (DWAF-SA) water quality drinking standards. All analyses for physicochemical parameters were within acceptable limits except for turbidity while microbial loads during spring were higher than the WHO and DWAF thresholds. The detection of Escherichia coli, Salmonella and Klebsiella species in borehole water that was intended for human consumption suggests that water from these sources may pose severe health risks to consumers and is unsuitable for direct human consumption without treatment.

Edori and Nna (2018) also carried out a study to determine physicochemical parameters of effluents at discharge points into the New Calabar River along Rumuolumeni Axis, Port Harcourt, Rivers State, Niger Delta, Nigeria. Water samples collected from three effluents discharge points into the New Calabar River were analyzed for physicochemical parameters using standard methods. The physicochemical parameters analyzed were colour, odor, temperature, pH, conductivity, total dissolved solids (TDS), turbidity, total suspended solids (TSS), dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), sulphate (SO_4^{2-}), nitrate (NO_3^-), phosphate (PO_4^{3-}) and chloride (Cl^-). The result obtained showed that at Iwofe Jetty the water was colourless and odorless but had slight colour and odor at the police post station and Minipiti station. The range for the parameters obtained in the seasons were: temperature (26.4 ± 1.10-29.0 ± 2.38°C), pH (3.43 ± 0.24-5.06 ± 1.42), conductivity (11.60 ± 2.68-15.61 ± 3.01 μS/cm), TDS (6.53 ± 0.56-8.89 ± 0.98 mg/L), turbidity (9.42 ± 2.68-17.90 ± 3.09 mg/L), TSS (20.53 ± 3.27-33.51 ± 6.25 mg/L), DO (2.62 ± 0.02-5.02 ± 0.31 mg/L), BOD (4.28 ± 1.08-6.11 ± 1.33 mg/L), COD (13.54 ± 3.93-19.16 ± 2.10 mg/L), SO4 2- (65.92 ± 12.50-346.72 ± 23.22 mg/L), NO3 - (0.32 ± 0.01-0.53 ± 0.04 mg/L), PO4 3- (0.34 ± 0.01-0.68 ± 0.03 mg/L) and Cl- (4041 ± 80.50-9411 ± 100.68 mg/L). Generally, the result indicated that colour, odour, pH, turbidity, DO, BOD, COD, and Cl- do not meet the WHO standard for portable water, therefore the water is polluted.

Ebong et al (2018) conducted a study on evaluation of physicochemical and microbiological characteristics of borehole water in Mgboushimini Community of Rivers State, Nigeria. The research was carried out to determine the physicochemical and microbiological characteristics of groundwater in boreholes used as drinking water in Mgboushimini community in Obio Akpor Local Government Area of Rivers State in Nigeria. Eight water samples (n=8) from different boreholes were collected randomly within the community. The total bacterial count and Coliform was determined by using the standard microbiological method and Most Probable Number (MPN) method. A total of four (4) genera of organisms were isolated from the water samples which included Proteus spp, Citrobacter spp, Klebsiella spp, Candida spp. The mean value of Total Heterotrophic Bacterial count ranged from 1.1±0.14 to 7.9±0.07. The mean concentration ofchloride, calcium, magnesium, and salinity were 10.79, 2.11, 0.47 and 0.21, respectively. The recorded pH, total alkalinity, temperature, and turbidity were 4.31 to 4.66, 4.00, 29.6 to 29.9, and 0.00 NTU, respectively. The electrical conductivity, total hardness, total dissolved solids, phosphate and sulphate, showed the mean value of 438±67.14, 7.18±1.99, 284.88±49.48 mg/l, 0.02±0.01 mg/l, 4.15±0.76 mg/l, respectively. These values were compared with the World Health Organization (WHO) standard values for drinking water quality. The study concluded that the microbiological and physicochemical result of the eight borehole water samples analysed did not meet the WHO standard

The assessment of borehole water quality often time seems incomplete without physical and biological quality assessment because once the ground is contaminated; the borehole water is usually affected through natural exchange processes existing between the soil and the groundwater. However, this study focused on the assessment of physical and biological quality of borehole water used in port Harcourt oil refinery host communities. Communities in Rivers State, including those in Port Harcourt, face the risk of water quality alteration due to contaminants from waste. This alteration affects both the physical and biological characteristics of the water, posing a potential health risk to consumers who use the contaminated water. However, there is limited literature available to confirm the speculation about the existence of contamination-free and reliable borehole resources in the host communities. The study therefore assessed the physical and biological quality of borehole water used in port Harcourt oil refinery host communities

Statement of the problem

The availability of clean and safe drinking water is a critical aspect of public health. However, in the Port Harcourt oil refinery host communities, reliance on borehole water raises concerns about the potential contamination of this vital resource. The proximity to industrial activities, including oil refining, introduces the possibility of water pollution, which can have severe consequences for human health and the well-being of the affected communities.

The problem at hand is the lack of a comprehensive assessment of the physiochemical and biological quality of borehole water in the Port Harcourt oil refinery host communities. Existing data may be limited, and there is a need to conduct a thorough and up-to-date study to determine the current state of water quality. This assessment will encompass various parameters, including pH, turbidity, total dissolved solids (TDS) and microbial content.

Addressing the water quality challenges in these communities is of utmost importance. It requires a systematic investigation to identify potential pollutants and contaminants that may be present in the borehole water. Additionally, understanding the microbial quality is crucial as it directly impacts the safety of the water for consumption. Therefore this study seek to assess the physical and biological quality of borehole water used in port Harcourt oil refinery host communities

Aim and Objectives of the Study

1. The biological quality of borehole water used in the selected host communities of Port Harcourt oil Refinary using (total coliform fecal coliform, E. Coli) as reference points.
2. The physical parameters of borehole water in selected host communities of port Harcourt oil Refinery using (PH, Turbidity,Temperature, Total Suspended Solid, Conductivity, alkalinity) as reference points.

Research Questions

The following research questions will be answered in this study:

1. What are the physicochemical characteristics of borehole water used in Port Harcourt Oil Refinery host communities?
2. What are the microbiological characteristics of borehole water used in Port Harcourt Oil Refinery host communities?

Hypotheses

The following hypotheses will be tested at 0.05 level of significance:

1. The physicochemical characteristics 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 microbiological composition 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

MATERIAL AND METHODS

The study area

This study was conducted in the six selected host communities of Port Harcourt Oil Refinery Area of Rivers State, Nigeria. The Refinery Complex comprises two refineries at Alesa-Eleme in Rivers State. The old Refinery has its own utilities and tank farm. The utilities consist of water boreholes, water treatment, cooling water tower, instrument air and steam boilers. The only utilities supplied from the new refinery are power and nitrogen by air. The old refinery is designed to generate its own gas as process fuel. Port Harcourt II has considerable clean fuel capability, including lead-free gasoline. The distance between the selected host communities to the Refinery include : Alesa 5KM, Darka 5.8KM, Abam 10KM,Ekereakana 6 KM, Ogan 6.5km and Okochiri 3km.

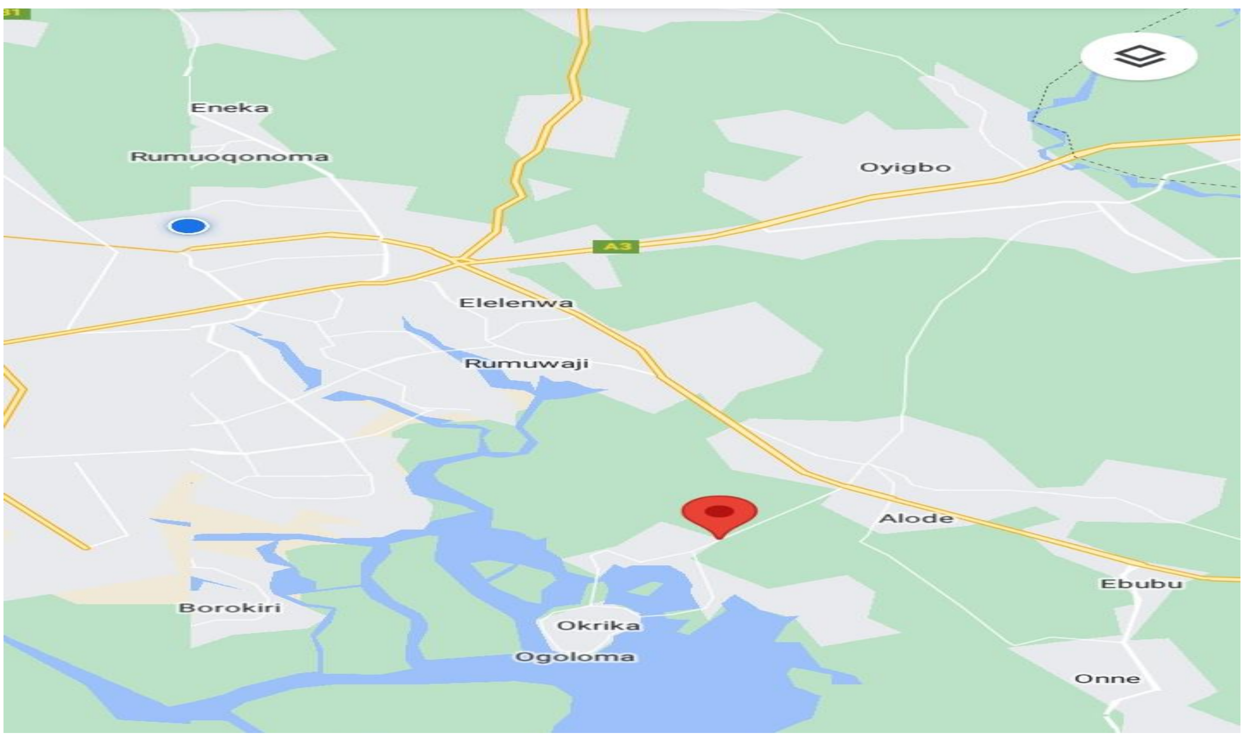

Fig 1 : Map showing Port Harcourt Refinery

Research Design

This study is a descriptive cross sectional survey of borehole waters in Port Harcourt Oil Refinery host communities in Rivers State. In using the research design, borehole water samples will be selected across Port Harcourt Oil host communities in Rivers State

Sample Collection

Two water samples were collected from each of the host communities for physiochemical and biological analysis. The water samples were collected from the various boreholes using sterilaized plastic water bottles (1000ml). before each collection The tap was allowed to run 2-3 minutes and an ample air space of 2.5cm was left in the water bottles to create space for oxygen so that organisms in the water samples will not die before testing and also to facilitate mixing before shaking before testing. The water samples were collected from various communities and were labeled accordingly. The water samples were immediately sent to the laboratory in an insulated bag to prevent external factor like temperature from changing some of the parameters.

pH Determination

This was done using pH meter. The electrode was first standardized and calibrated using the three set of buffer solution at pH 4.00,7.0 and 9.0, the electrode was rinsed thoroughly with distilled water and immersed in distilled water. The electrode was then dipped into the sample to determine the pH. This method is adopted by (APHA 1989).

Determination of Turbidity

This was done by pouring 25ml of distilled water into the cuvette and set at zero in the HACH spectrohotometer and read at 45nm, then 25ml of sample was poured into another cuvette and read in the meter. This method is adopted by (APHA 1989).
Calculation Turbidity (NT) =Instrument Turbidity x Slope Reciprocal.

Conductivity Determination

The electrode was first calibrated and standardized for 15mins. It was then rinsed with distilled water. The electrode was then dipped into the sample and allowed to stabilize then reading was taken. This method is adopted by (APHA 1989).

Determination of Total Dissolved Solid (Tds)

This was done using gravimetric method. 250ml conical flask was dry in an oven. 50ml of sample water was filtered into the weighed flask. The filtrate was evaporated completely by heating on the heating mantle. The conical flask was reweighed and the weight gained was recorded. This method is adopted by (APHA 1989).

Determination of Alkalinity

HCl acid was standardized with sodium carbon ate solution. 20ml of the sample was measured into a conical flask of 500ml capacity. Few drops of methyl Orange (indicator) was added and the sample titrated against the standardized HCl solution to the end-point. This method is adopted by (APHA 1989).

Determination of Temperature

This was done using caibrated mercury in glass thermometer.

Microbiological Analysis
Microbial analysis of the water sample was assayed by testing for total coliform count (faecal indicator bacteria) using the heterotrophic plate counts and the most probable number techniques (MPN).)

Total Coliform Count
Total Coliform count was carried out firstly, to establish the presence of microbial contamination in the water samples using a presumptive test method to identify the most probable value [Azuonwu et'2020)

Data Analysis

The data obtained from the laboratory analysis were used as variable inputs for the descriptive statistics such as mean and standard deviation. Data collected were also subjected to analysis of variance (ANOVA). ANOVA was used to measure the variance between qualities of water from the boreholes.

Research Question 1: What are the physicochemical characteristics of borehole water used in Port Harcourt Oil Refinery host communities?

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

		Physical Characteristics/parameters					
Sampled communities		**PH**	**Turbidity**	**Conductivity**	**Temperature**	**Alkalinity**	**TDS**
ABAM	Mean	5.25000	3.15000	11.50000	26.00000	1.00000	6.00000
	N	2	2	2	2	2	2
	Std. Deviation	.070711	.212132	.707107	1.414214	.000000	.000000
ALESA	Mean	5.75000	3.50000	15.00000	25.00000	2.00000	11.00000
	N	2	2	2	2	2	2
	Std. Deviation	.353553	.707107	1.414214	1.414214	.000000	4.242641
DARKAAMA	Mean	5.30000	3.00000	26.50000	27.75000	3.50000	15.50000
	N	2	2	2	2	2	2
	Std. Deviation	.707107	.000000	.707107	1.060660	.707107	.707107
EKEREKANA	Mean	5.30000	2.50000	31.00000	26.20000	6.50000	17.00000
	N	2	2	2	2	2	2

	Std. Deviation	1.697056	.707107	.000000	1.697056	2.121320	.000000
OGAN	Mean	4.65000	1.00000	15.50000	26.00000	3.00000	8.50000
	N	2	2	2	2	2	2
	Std. Deviation	.070711	1.414214	2.121320	.000000	1.414214	.707107
OKOROCHIRI	Mean	6.80000	.00000	25.50000	27.00000	3.00000	14.00000
	N	2	2	2	2	2	2
	Std. Deviation	.000000	.000000	.707107	.000000	.000000	.000000
Reference Points	**WHO 2011**	6.5 – 8.5	5	900	-	2.00	600
	NSDWQ 2016	6.5 – 8.5	5	1000	20 - 32	20 - 200	500

Table 1 shows the physical characteristics of borehole water used in host communities of Port Harcourt Oil Refinery host communities. The average pH of the borehole water in the sampled Communities; ABAM, ALESA, DARKAAMA, EKEREKAN , OGAN and OKOROCHIRI were 5.25, 5.75, 5.30, 5.30 , 4.65, 6.80 respectively with a range of 5.25 to 6.80. All pH level are below (WHO, 2008; NSDWQ, 2016) except in OKOROCHIRI community. Turbidity average of the borehole water in the communities were ABAM, ALESA, DARKAAMA, EKEREKAN , OGAN and OKOROCHIRI were 3.15, 3.50, 3.00, 2.50, 1.00 and 0.00 respectively which are the reference point of WHO (2008) and NSDWQ (2016). Conductivity in the sampled communities varied widely, from 11.50 to 31.00 s/cm on average which is also below the reference point of which are the reference point of WHO (2008) and NSDWQ (2016). The tempereature and alkalinity average of the borehole water in the sampled communities were 26 – 27^0C and 1- 6.5mg/L. This indicates the temperature falls within reference point of WHO (2008) and NSDWQ (2016). And the Alkalinity far below the reference point of WHO (2008) and NSDWQ (2016). Average TDS concentration of the sampled communities was 6.00 – 17.00 mg/l which also below reference point of WHO (2008) and NSDWQ (2016). Therefore there is no health-based limit for TDS in drinking water (WHO, 2008). The Borehole water in the sample communities was fresh water.

Research Question 2: What are the microbiological characteristics of borehole water used in host communities of Port Harcourt Oil Refinery host communities?

Table 2: mean and standard deviation of the microbiological characteristics of borehole water used in host communities of Port Harcourt Oil Refinery host communities

		microbiological characteristics	
Sampled Communities		**Fecal Coriform**	**Total Coriform**
ABAM	Mean	7.00000	11.50000
	N	2	2
	Std. Deviation	.000000	.707107
ALESA	Mean	1.00000	.50000
	N	2	2
	Std. Deviation	1.414214	.707107
DARKAAMA	Mean	4.50000	4.00000
	N	2	2
	Std. Deviation	.707107	.000000
EKEREKANA	Mean	.00000	.00000
	N	2	2
	Std. Deviation	.000000	.000000
OGAN	Mean	2.50000	3.50000
	N	2	2
	Std. Deviation	3.535534	4.949747
OKOROCHIRI	Mean	.00000	.00000
	N	2	2
	Std. Deviation	.000000	.000000
Reference Points	**WHO 2011**	0	-
	NSDWQ 2016	0	0

Table 2 shows the microbiological characteristics of borehole water used in host communities of Port Harcourt Oil Refinery host communities. The average microbiological characteristics such Fecal Coriform and Total Coriform in borehole water of the sampled communities ; ABAM, ALESA, DARKAAMA, EKEREKAN , OGAN and OKOROCHIRI are of 0.000 – 7.000mg/L and 0.000– 11.500mg/L. This implies microbiological characteristics are above the reference point of WHO (2008) and NSDWQ (2016).

Hypothesis 1: The physicochemical characteristics 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 physicochemical characteristics of borehole water used in Port Harcourt Oil Refinery host communities

	Sum of Squares	Df	Mean Square	F	Sig.(p-value)	Decision
Between Groups	1993.267	5	398.653	21.105	.001	Reject H0
Within Groups	113.335	6	18.889			
Total	2106.602	11				

Table 3 indicate that physicochemical characteristics 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, $F(2,6) = 21.105$, $p = 0.001$. Therefore reject the null Hypothesis ($p < 0.01$)

Hypothesis 2: The microbiological composition 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 microbiological composition of borehole water used in Port Harcourt Oil Refinery host communities

	Sum of Squares	df	Mean Square	F	Sig.(p-value)	Decision
Between Groups	508.750	5	101.750	81.400	.000	Reject H0
Within Groups	7.500	6	1.250			
Total	516.250	11				

Table 4 indicate that microbiological composition of borehole water used in Port Harcourt Oil Refinery host communities significantly differ from the World Health Organization's parameter for safe drinking water, $F(2,6) = 81.40$, $p = 0.001$. Hence reject the null hypothesis ($P < 0.01$)

RESULTS AND DISCUSSION

Table 1 showed that physicochemical characteristics of borehole water used in Port Harcourt Oil Refinery host communities differ from the World Health Organization's parameter for safe drinking water. The average pH of the borehole water in ABAM, ALESA, DARKAAMA, EKEREKAN and OGAN were 5.25, 5.75, 5.30, 5.30 and 4.65 respectively. Table 3 confirmed that the difference was significant. The findings of this agrees with Maseke and Vegi (2019) who reported there is significant difference of the parameters pH and $Ni2+$ between hot spring and borehole waters. This shows that most of the physical parameters that were assesed in the borehole were found to deviate from the normal range of World Health Organisation (WHO) and Nigeria Standard for Drinking Water Quality (NSDWQ) except for Okochiri with the pH level of 6.8).PH (power of Hydrogen) is one of the most important operational water quality determinants. NSDWQ and WHO hay standard of 6.5-8.5(pH unit). The pH range of the analysed samples ranges from 4.10 to 6.80. All the samples were slightly acidic except for Okochiri (6.8) and some part of Ekereakana (6.5). This deviation may be as a result of water treatment usually done by the Anglican Church were Okochiri borehole is located and its distance away from the Refinery activity Area. International Standard for drinking water suggest that pH less than 6.5 or 9. 2 would impair the portability of the water. The weakly acidic nature may may be as a result of some dissolved organic matter in the soil or site of the borehole as well as acid rains (Oram B2009). This is common in the selected in the selected host communities where Refinery activities that release CO2 which combines with rain water to form acid rains. Drinking water with low pH has not been found to have any adverse effect in man; however it can leach metals from plumbing system which can cause health problems (Oram, 2009). This finding corolates with (Bashir and Olaken 2012).

Turbidity ranged from average of 0.000 to 3.1500 . The range indicates wide distribution of turbidity in water of Borehole in the sampled communities. High turbidity in water has both esthetic and health effect. Thus, it is essential to eliminate the turbidity of water in order to effectively disinfect it for drinking purposes.This finding of this study is consonance with Edori and Nna (2018) who reported that colour, odour, pH, turbidity, DO, BOD, COD, and Cl- do not meet the WHO standard for portable water, therefore the water is polluted. The average turbidity of the samples in the study area is below the approved 5NTU of word Health organisation and particles that may originate from organic or inorganic matter (Joshua etal 2018). The alkalinity of the sampled borehole range from 1mgll to 5mgll (Table 1:00) which is lower than the standard of WHO and NSDWQ

The conductivity in water samples ranged from 11.50 to 31.00 s/cm on average. The range indicates wide distribution of conductivity of water samples in dry season. The range of 11.50 to 31.00 µs/cm is relatively low compare to World Health Organisation (WHO) and Nigeria Standard for Drinking Water Quality (NSDWQ) because water of good quality for domestic use should have conductivity of 1500 µs /cm3 and above. The temperatures recorded in the six sampling communities, of the study area, were well within the WHO recommended limits (20 -32) for drinking water quality. Changes in temperature, as noted earlier, affect living organisms. The rates of biological and chemical reactions depend to a large extent on temperature. High water temperature enhances the growth of micro-organisms and this may increase taste , odour and corrosion problems

Total Dissolved Solids (TDS) varied from community to community with a mean range of 6.00 17.00 mg/l. The concentration of TDS is within the regulatory standard for drinking purpose. Thus, all values are below 500 Mg/l limit set by WHO (2008). This may not have negative effects on the consumers of the borehole water in the sampled communities since it is a higher TDS level that affects water quality. High level of TDS may cause an objectionable taste, odour and colours to the water. However there is no health-based limit for TDS in drinking water (WHO, 2011). According to the TDS categorization, all of the groundwater samples were fresh water.

Table 2 showed differences exist microbiological composition of borehole water used in host communities of Port Harcourt Oil Refinery host communities. Table 4 confirmed that microbiological composition of borehole water used in Port Harcourt Oil Refinery significantly differ from the World Health Organization's parameter for safe drinking water. This implies microbiological characteristics are above the reference point of WHO (2008) and NSDWQ (2016). The level of microbiological contaminants obtained differs from level obtained in similar research carried out in other part of the state by (Odunze & Chinonso, 2020). Fecal coliform exceeding the WHO limits in some water samples indicates the presence of bacteria and this could make the water unsafe for certain purposes. The presence of microbiological characteristics in some of the borehole water samples is unacceptable from the public health point of view. These organisms could be pathogenic. Therefore, there is need for caution when using these contaminated borehole water sources for any purposes. The Nigerian Standard for Drinking Water Quality recommends no faecal coliform should be found in any water meant for drinking. Total coliform count obtained was also higher in Abam, Darka - ana and some part of of Ogan. E. Coli was not observed in any of the boreholes. Total coliforms can also originate environmental sources such as soils or from biofilms. A positive total coliform sample should be considered an indication of pollution in the borehole water. Although information on the depth of the sample borehole were not available, another cause of microbial contamination is the depth of borehole (Seth 2014 ; Monyo 2013). Minimum depth of borehole is 40m in a way that microbial contamination is removed within the first 30m as ground water pass through saturated sand and non-fissured rock. During the study, it was observed that most of the pipes used for water disturbution are trusted. Rusting pipes affects the quality of water by allowing seepage of microbial contamination into the borehole (Seth 2014).

CONCLUSION

In many communities, boreholes are considered a valuable natural resource and a suitable alternative to surface water sources that are susceptible to contamination. The study's findings revealed that most of the physical and biological parameters assessed in borehole water samples from the host communities were within acceptable limits. However, the collective result from this study showed a strong need for prompt and regular risk evaluation of physical and microbial contamination of borehole water since citizens residing and those doing all kind of businesses in this area make use of this water ignorantly, not knowing the health implication it could pose in their health. Also, this study reveals that safety of borehole water in the host communities of Port Harcourt Refinery activities area cannot be guaranteed. The activities of the Refinery could be the major source of contamination of borehole water in the sampled area.

RECOMMENDATION

1. Government at all levels should establish effective water control monitoring system.
2. Crude oil spillage and other industrial activities should be regulated by both the government and the Refinery.
3. The Refinery Company should check out for leaching pipes that causes contamination of water with iron.
4. Households should site their borehole far away from industrial pipes, suck-away and sewage dumps

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