Comparative Analysis of Physicochemical, Potential Toxic Metals and Microbiological Properties of Potable Waters in Bonny Island, Rivers State, Nigeria

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Abstract

This research aims to analyze the levels of physicochemical, potentially toxic metals and microbiological properties of drinking water supplied in some selected facilities in Bonny Island, Nigeria. Samples of water were collected from Nigeria liquefied natural Gas(NLNG), Saipem and Shell corporation facilities bimonthly for six months and a total of 21 samples were collected. The samples collected were transported to the laboratory and analyzed for pH, EC, Turbidity, Nitrate, Cl-, Cd, Cu, Fe, Pb, Zn, total coliform and fecal coliform using standard procedure described by APHA and the values obtained were subjected to statistical analysis (ANOVA), and compared with WHO and Nigeria Industrial Standard (NIS) permissible limits for drinking water. The results of pH ranged from (6.60-7.40), EC (20-170), TDS (10-90), SO_4^{2-} (6.11-9.56), Cl^- (3.19 - 4.25), NO_3^- (0.49-0.65), NO_2 (0.01), Mg (< 0.001 - 0.33), Na (2.79-4.21), K (< 0.001 -2.80), Ca (< 0.001 - 0.29), hardness (16-28), while ammonia, turbidity, Zn, Cu, Cd and Pb were < 0.001 mg/L. The levels of total coliform and fecal coliform were < 0.003 ml. The analyzed physicochemical, metal, and microbiological parameters were within WHO and NIS permissible limits, indicating the water quality was good and safe for consumption. Consumption of contaminated water will result in serious health issues such as gastrointestinal problem, liver inflammation, suppression of immune system and kidney failure. Thus, water with low levels of potential toxic metals and coliform is void of these health issues. However, routine check and monitoring on the quality of water supplied for consumption in Bonny island is of essence to ensure residents' health and safety.

Keywords: Clean water, Human health, Sustainability,

1. INTRODUCTON

Water is one of the most invaluable and indispensable natural resources that serves as an essential component of the human diet, which maintains the body system and contributes critically to environmental stability [1]. The United Nations General Assembly in her consideration of the essentiality of water to human existence, has declared access to clean and safe potable water, as a fundamental right and this infers that inaccessibility to safe and clean water is a total infringement and violation of the fundamental right [2].

However, the unabated increase in population has continually placed a greater demand on daily water supply due to the exponential rise in consumption, particularly among the developing countries like Nigeria. In order to meet up with the water demand, several water sources have been employed, both groundwater and surface water, and some are untreated, badly impaired with potentially toxic metals, and microbial impacts while others are with poor physicochemical properties occasioned by anthropogenic activities [3, 2].

Every human use of water, including drinking, irrigation, industrial, domestic, and recreational activities, must meet certain quality standards in order to be considered acceptable. The quality standard of drinking water from different sources can be evaluated using physical, chemical, and bacteriological parameters. Drinking water should be completely free of pathogens that could be harmful to human health and meet standards for physicochemical levels [4].

Water quality must adhere to international criteria for microbiological, chemical, and physical characteristics. Alkalinity, hardness, chloride, total dissolved solids (TDS), and other water quality factors enhance the aesthetic value of water. Negative health impacts may result from pollutants such as ammonia, lead, arsenic, and nitrate [5]. Potable water with very high pH levels, high turbidity, or other undesirable parameters can be harmful. While moderate levels of water hardness and chloride are beneficial, excessive amounts can negatively impact the water's aesthetic quality, making it unfit for human consumption. A high concentration of iron, phosphate, nitrate, and ammonia is also undesirable; this is due to certain additional chemical components, including heavy metals which are harmful, and their presence in drinkable water is restricted [5]. Heavy metals can enter the human body through several pathways once released into drinking water, including direct consumption, skin contact, inhalation, or ingestion [6]. Depending on the element and its chemical form, long-term exposure to heavy metals can damage the brain, liver, and bones, which can pose a major health risk [7].

Additionally, the presence of microorganisms in drinking water is a significant contributor to waterborne diseases in developing countries, including Nigeria. Drinking water does not cause an infectious disease if it is free from indicator organisms [8]. Some of the most reported bacteria in water sources are *Escherichia coli, Salmonella spp., Shigella spp*. and *Staphylococcus aureus*. The presence of coliforms (*E. coli*) bacteria in water samples indicates the presence of feacal matter and the potential presence of harmful bacteria. Feacal contamination of water sources and water treatment is a continuing issue globally, according to [5], and Bonny island is not an exception.

Bonny Island in Rivers State is a well-recognized area that houses major oil and gas companies. According [9], the environment of Bonny Island has suffered badly due to activities of oil and gas which has burdened the Island with phthalates, heavy metals, brominated flames, organo-chlorine pesticides, particulate matter and poly-aromatic hydrocarbons. The presence of these pollutants have consequentially affected plants and contaminated both ground and surface water. Apart from Bonny Island, some other oil producing areas in the Niger Delta have been reported to suffer similar fate. [10], posited that both ground and surface of oil producing area of Ebocha-Obrikom in Ogba/Egbema/Ndoni area of Rivers State is severely polluted. Generally, the discovery of oil in the Niger Delta has resulted in socio-economic disparities and environmental degradation, and this region has continued in the quagmire from bad government years after oil boom, leaving her inhabitants to consume contaminated water and food caused by oil pollution [11]. Conversely, some of the health issues associated with the consumption of contaminated water include Lymphoma, Leukemia, Bladder Cancer, Breast Cancer and Reproductive problems. With the prominent oil and gas activities in bonny Island, the town is faced with the problem of inaccessibility to good and safe drinking water. Potable water is provided to the residents of Bonny Island and the neighboring communities by oil and gas companies operating in the area; this is due to the huge cost of sinking private boreholes and associated water treatment requirements. As a result of high water demand and cost of supply of water to the residents, most water suppliers are in the practice of supplying untreated water. Hence this research aims to analyze and compare the physicochemical, heavy metal, and microbiological properties of the water supplied by selected oil and gas companies operational in the area to the national and international standards as a way of assessing these companies' commitment in their corporate socio responsibility by providing clean and potable water for the host community.

2. MATERIAL AND METHOD

2.1. STUDY AREA

Bonny Island is one of the prominent towns in Niger Delta being an industrial hub that houses key oil and gas firms like NLNG, Shell and Mobil multinational companies. Apart from these companies, the town also houses Federal Polytechnic of oil and gas, and other government agencies. The distance between Port Harcourt and Bonny Island is 48.04 km. This distance is equal to 29.85 miles and 25.92 nautical miles. With GPS coordinates of 4° 26′ 57″ N, 7° 14′ 24″ E. It lies between longitude 70 10' 14.66E and latitude 40 27' 5.76N and the population is estimated to be 270,000 [9]. Bonny Island is bordered in the south with the Atlantic Ocean and North with Opobo, as shown in (Fig 1).

Figure 1. Map of the Sample Stations

2.2. SAMPLING

Samples of water were collected from NLNG, Saipem and Shell cooperation facilities in bonny island, Nigeria, bimonthly for six months and a total of 21 samples were collected. Samples from each site were collected in three sterilized plastic bottles (1.5 liters capacity and 100ml) which has been rinsed several times with distilled water and the water collected. The samples were collected for bacteriological analysis (100 ml sterilized plastic bottle); the second one (100 ml sterilized plastic bottle); acidified and preserved with HNO_3 for major ion analysis of heavy metals and the third one (1.5 liters capacity) for other physicochemical parameter analysis. The collected samples were stored in an ice-chest in a cooler and transported to the laboratory for further analyses [13]. The bacteriological tests were carried out within 6hours of collection to avoid death or growth of organisms in the sample [14]. In- situ parameters like temperature (^{o} C), pH, EC (µS/cm) and TDS were measured in the samples using a multi-probe Hanna portable meter.

2.3. SAMPLE ANALYSIS PROCEDURES.

2.3.1 Physicochemical Analysis of the Water Samples.

Various physicochemical parameters suitable for the assessment of water quality were examined in this study. These parameters include total suspended solids, turbidity, sulphate, ammonia, phosphate, nitrate, nitrite, and color. Temperature was measured on-site using mercury in glass thermometer by inserting into each water sample and allowed to stabilize for two minutes before taking the recording. The process was repeated and mean values were recorded in degree Celsius. Total dissolved solids (TDS) and electrical conductivity (EC), were also measured on-site using Hanna portable conductivity meter which was handheld. The probe was dipped into water sample, switched on and allowed to stabilized for 10 to 15mins, while the values were taken at the stability of the meter and this procedure was repeated with the record of the mean values. Water turbidity was measured on-site as well with the use of turbidity meter (Turner designs Aquafluor 8000-001). For the determination of nitrate concentration, the brucine method was used with 2.5 ml of the sample in a test tube immersed in a cold water bath for 20mins and then 2.5ml (4+1) H_2SO_4 solution was later added and mixed thoroughly by swirling. The mixture was allowed to cool after which 0.2ml brucine sulphate was added and mixed properly. The mixture in a test tube was placed in a boiling water bath for about 25mins for colour development and after which the content was cooled. The absorbance of the resulting yellow coloured mixture was read off on spectronic 21D at 410 nm wavelength. The nitrate level was calculated by reading off absorption level from calibration curve standard and limit of detection was 0.03mg/l. To measure these parameters, a UV spectrophotometer was used at different specific wavelengths. In addition, free chlorine was analyzed using the DPD Colorimetric Method, while chloride and hardness were determined using the Titrimetric method [15].

2.3.2 Heavy Metal Analysis of the Water Samples

Iron, cadmium, lead, and copper, as well as magnesium, sodium, potassium, and calcium anions, were analyzed using an atomic absorption spectrometer (AAS) equipped with standard hollow cathode lamps specific to each element [15]. The samples water was digested thus: 100 ml of water samples were transferred into a beaker and 5 ml concentrated HNO_3 acid added to it. The beaker that had the content was placed on a hot plate and evaporated down to about 20 ml and the beaker was later cooled before another conc. HNO_3 of 5 ml was added. Then the beaker was covered with a watch glass and returned to hot plate for heating. Heating of the content continued and a small portion of HNO_3 was added to a point that the solution appeared colourless. The beaker and watch glass used to cover the beaker were washed with reagent water and the sample filtered to remove some insoluble materials that could clog the atomizer. Then the filtrate was poured into a container and volume made up to 100 ml with reagent water. The concentration of metal was then determined using Perkin Elmer Analyst 200 Atomic Absorption Spectrometer (AAS) with appropriate Lamp and standards.

2.3.3 Bacteriological analysis of the Water Samples

Total Coliform and Fecal Coliform colonies were enumerated following 24 hours of incubation at a temperature of 37°C by employing the most probable number (MPN) technique and the spread plate method, respectively. To ascertain Fecal Coliforms, the spread plate method was utilized, where 0.1 mL and 1 mL of the specimen were plated onto a MacConkey plate, and the ensuing colonies were tallied after a 24-hour incubation period employing a colony counter. The three-tube procedure employing MacConkey broth was employed for assessing the Most Probable Number (MPN) of coliform organisms. These tubes were incubated at 37°C for 48 hours, and the MPN was ascertained in accordance with the standard Methods for the Examination of Water and Wastewater [15].

2.3.4 Quality Control and assurance

The experiment setup used in this research involved the utilization of atomic absorption standard for all the potentially toxic metals which were buck-certified to establish a calibration curve. To ensure reproducibility and reliability of the data, a reagent blank was used after ten runs to mitigate equipment drift. The method used and wavelength (nm) was in conformity with the procedures stated by [2]. Meanwhile, analytical grade reagents were used for all the experiments.

2.3.5 Statistical Analysis

Data collected were analyzed using Statistical Package for Social Science (SPSS version 21). The mean and standard deviation were calculated, while the statistical significant difference was determined using one-way analysis of variance (ANOVA).

Table 1. Mean Results of Physicochemical Properties of Potable Water in the Study Location.

SN	Parameters	Units	Saipem	NLNG	Shell	WHO	NIS
1	pH		7.40 ± 0.10^a	7.30 ± 0.10^a	6.60 ± 0.10^a	6.5 – 8.5	6.5 – 8.5
2	EC.	µS/cm	20 ± 1.00^a	170.00 ± 1.00^a	70.00 ± 1.00^a	1000	1000
3	Total Dissolved Solid (TDS)	mg/L	10.00 ± 1.00^a	90.0 ± 1.00^a	40.00 ± 1.00^a	600	500
4	Temperature	0_C	28.90 ± 1.00^b	29.3 ± 1.00^b	28.30 ± 0.10^a	NS	Ambient
5	Colour	TCU	1.00 ± 0.00^a	1.00 ± 0.00^a	1.00 ± 0.00^a	15	15
6	Free chlorine	mg/L	0.2 ± 0.00^a	0.00 ± 0.00^a	0.00 ± 0.00^a	0.2-0.5	0.2 -0.25
7	Odour	-	Odourless	Odourless	Odourless	Unobjectionable	Unobjectionable
9	Total Suspended Solids (TSS)	mg/L	0.05 ± 0.01^b	0.05 ± 0.01^b	0.10 ± 0.00^a	NS	NS
10	Turbidity	NTU	<0.001	<0.001	<0.001	0.2	5
11	Sulphate (SO_4^{2-})	mg/L	6.11 ± 0.05^a	8.33 ± 0.08^b	9.56 ± 1.00^c	250	100
12	Chloride (Cl^-)	mg/L	3.48 ± 0.03^a	3.19 ± 0.05^b	4.25 ± 0.06^c	250	250
13	Ammonia (NH_3)	mg/L	<0.001	<0.001	<0.001	0.5	NS
14	Phosphate (PO_4^{3-})	mg/L	4.00 ± 0.04^c	4.00 ± 0.20^b	4.00 ± 0.10^a	NS	NS
15	Hardness	mg/L	16.00 ± 1.00^a	28.00 ± 1.00^a	16.00 ± 1.00^a	70	150
16	Nitrate (NO_3^-)	mg/L	0.49 ± 0.01^a	0.65 ± 0.04^c	0.64 ± 0.03^b	50	50
17	Nitrite (NO_2)	mg/L	0.01 ± 0.00^a	0.01 ± 0.00^a	0.01 ± 0.00^a	3	0.2
18	Magnesium (Mg)	mg/L	<0.001	0.33 ± 0.04	<0.001	30	20
19	Sodium (Na)	mg/L	4.21 ± 0.06^c	2.79 ± 0.04^b	3.31 ± 0.03^a	50	200
20	Potassium(K)	mg/L	<0.001	2.80 ± 0.01^a	1.93 ± 0.04^b	NS	NS
21	Calcium (Ca)	mg/L	<0.001	0.29 ± 0.01^a	<0.001	100	NS

WHO: World Health Organisation, NIS: Nigeria Industrial Standard, NLNG: Nigeria Liquefied Natural Gas. The results were presented as mean ± standard deviation. Means in the same row with a common superscript are not significantly different (p>0.05).

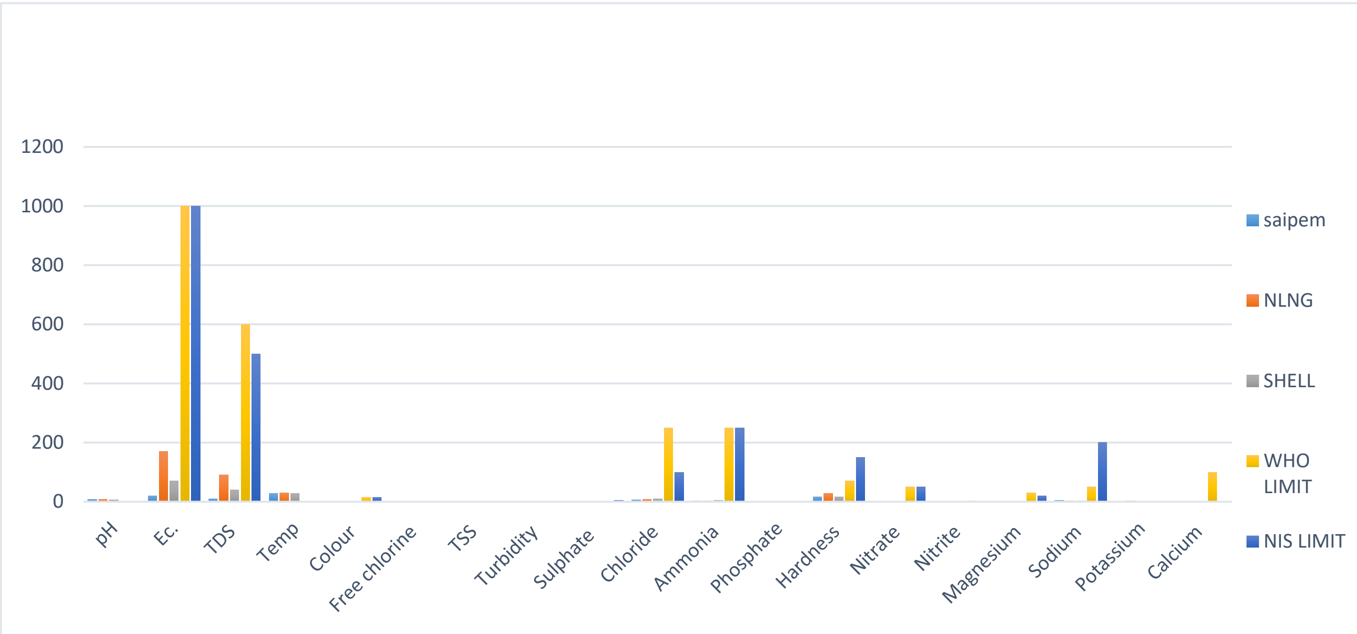

Figure 2: Physicochemical Concentration of potable water in study location

3. Results and Discussion

The physicochemical properties of water samples collected from the three water facilities in Bonny Island at the cause of this study are displayed in Table 1 and Figure 2.

The average concentrations of each of the parameters were compared with the World Health Organization and NIS standards for drinking water. The average pH concentration was found to be 6.60mg/L at the Shell Corporation water facility, being the lowest value and 7.40 mg/L as the maximum pH value being for water sourced from Saipem facility. The pH concentrations for all the water samples were within the W.H.O and N.I.S permissible limits for drinking water. The statistical analysis revealed there was no significant difference (p>0.05) for the average pH concentrations across the sample locations. The average pH concentrations observed in this study is in conformity with the values (6.30 - 6.50) previously reported by [12], from Treatment of Bonny Pipe Borne Water. But these values were below the mean concentration reported by [16]. in drinking water of selected urban areas of a city. Water pH is pivotal in the measurement of the acidity and alkalinity of any water source, and conventionally, the natural water has a pH range of 6.5-8.5 mg/L [12]. Although, the consumption of water with pH below the standard, may not have a direct impact on human health but it is an indication of toxicity and will negatively affect other parameters [7].

The average electrical conductivity concentration of the potable water samples collected for this study, indicated the lowest value (20.10 µS/cm) was found in Saipem water facility, while the maximum concentration of 170 µS/cm was found in water samples collected from Shell. Comparatively, the EC values across the water samples aligned with the international and national standards provided for drinking water. However, the values observed in this study are in conformity with the EC concentrations of drinking water in high and low crude oil- producing communities in the Niger Delta region of Nigeria [18, 3]. Observation in urban groundwater in Southeast Nigeria. Electrical conductivity is a vital physicochemical parameter that determines the degree of ions present in water and can negatively impact the water taste, and as well dissuade people from its acceptance [19,2]. According to [20], reports that the value of EC could be used to assess the purity and freshness of drinking water, and for this study, EC concentrations were low, which ascribe low salt and mineralization in the water sources.

Similarly, the mean concentration of TDS revealed the minimum value of 10 mg/L was observed in water samples collected from Saipem, while the maximum concentration recorded in the study was found in samples collected from the Shell facility. This pattern was seen in EC as well and were within the standard limit recommended by the regulatory agencies for drinking water. The low TDS values generally connote there were low cations and anions in the water sample of the study. Meanwhile, the TDS concentrations recorded in this study are in the same range as the values reported by [19], for domestic water sources in Samaru Community, Zaria Northwest. Higher values of TDS in drinking water can cause undesirable flavour, scaling of water distribution pipelines and resultant health issues like paralysis of tongue, damage of central nervous system and dizziness [17, 16].

The highest mean value (29.3^{o}c) of temperature was recorded in the water sample collected from the NLNG facility, followed by the sample from Saipem (28.90^{o}c) and the least value (28.30^{o}c) was recorded in samples collected from Shell. The samples generally showed no statistical significance ($p>0.05$) from each other. The concentration of water temperature in this study was within permissible limits prescribed by W.H.O and N.I.S. These values are in tune with the mean concentration previously reported in water quality in proximity to oil and gas facilities in Bonny waterways [21], and in drinking water in high and low crude oil producing communities in the Niger Delta Region [17]. The water temperature values in this study indicated the samples were warm, and a further increase in the values will result in changes in flavor, smell, colour and also affect the Microbiological parameters [22,3].

Odour and colour are crucial water quality indicators that need to be regularly watched. Decomposing materials, volatile organic chemicals, or bacterial formation of hydrogen sulphide gas are the main causes of odour [23,24]. The absorption or reflection of light by suspended and dissolved particles determines the colour of water; the greater the concentration of these particles, the more intense the colour [13]. Colour and smell have no negative health consequences on people. Drinking water that has been polluted by bacteria, volatile organic compounds, sewage, or other substances is not advised. [24]. When compared, the results for the three drinking water samples had the same colour and smell values are within the W.H.O and N.I.S recommended allowed limits. The results of colour and odour in this study are in consonance with the report of [17]. Similarly, the level of free residual chlorine in drinking water correlates with the absence of pathogenic microorganisms and serves as a gauge of the water's potability [23,14]. In the current research.

Only samples from Saipem had free chlorine found; samples from the other research sites did not. This is likely because the other locations treat their water with UV light rather than sodium hypochlorite.

Total suspended solids are a very helpful metric that shows the amount of suspended particles (ions) and solids in a body of water and rises in response to an increase in decomposing plant matter [2]. Total Suspended Solids varies from 0.05±0.01 to 0.10±0.01, which is within the WHO and NIS recommended allowable level for drinking water. According to [25], turbidity rises as the amount of suspended particles rises. Any number higher than the 0.2 and 5 NTU suggested allowed limits for turbidity in drinking waters is regarded as harmful. The obtained results demonstrate that there is no turbidity that would declare the water unfit for consumption.

According to [26], dissolved calcium and magnesium salts from soil and aquifer minerals comprising limestone or dolomite are the cause of the water's hardness. The WHO and NIS guidelines allowed any value less than 70 mg/L and 150 mg/L, respectively, whereas the average total hardness for these samples ranges from 16.00±1 to 28.00±1. All three samples from the research locations had hardness values that were within acceptable bounds. According to WHO recommendations, the maximum allowed levels of calcium and magnesium in drinking water are 100 mg/L and 30 mg/L, respectively, whereas the NIS limit for magnesium is 20 mg/L and calcium is unspecified. Only the sample from NLNG had calcium and magnesium in the region under study, and that sample's contents were 0.29±0.01 and 0.33±0.04 respectively as seen in Table 1 and Fig 2. The result from this study aligns with the findings of [27], in drinking ground water resources of southeast Iran. Magnesium and calcium are both necessary for appropriate bodily growth and function. A dearth in any vitamin can potentially yield adverse consequences on an individual's well-being. Owing to its composition in bones and teeth, calcium concurrently assumes a role in diminishing neuromuscular excitability. Magnesium serves as an indispensable co-factor for enzyme activity, encompassing glycolysis, ATP metabolism, and the transportation of elements such as potassium, sodium, and calcium across membranes [28,26].

The major components of the nitrogen cycle, which are naturally present in water, are nitrate (NO_3^-) and nitrite (NO_2). The nitrate reductase enzyme of bacteria, which is abundant in the stomach and saliva, converts nitrate into nitrite without directly affecting human health [23,24]. Because it may interact with amines, amides, and amino acids to form nitric oxide carcinogenic chemicals (nitrosamine) in certain situations (acidic conditions in food and the stomach), high dosages of nitrite are poisonous [29]. According to this study, the value of nitrate as stated in Table 1 and Fig 2 ranges from 0.49±0.01 to 0.64±0.03 mg/L, whereas nitrite is present in all samples at a value of 0.01±0.0 mg/L. The water is safe for human consumption when compared to WHO and NIS acceptable limits.

Potassium concentrations range from <0.001 to 2.80±0.01, whereas sodium concentrations range from 2.79±0.04 to 4.21±0.06. Each water sample is within WHO and NIS acceptable levels. In cells, potassium and sodium keep the osmotic pressure normal. The release of insulin, creatinine phosphorylation, glucose metabolism, and protein synthesis all depend on potassium, a co-factor for several enzymes. A healthy salt intake in people helps them avoid numerous deadly conditions, including renal damage, hypertension, headaches, and more. Most water supplies in most nations have less than 20 mg of sodium per liter, however in certain countries the salt content of the water exceeds 250 mg per liter [30]. However, those with renal illness or other disorders including heart disease, coronary artery disease, hypertension, or diabetes may have substantial health impacts from increased exposure to potassium.

Most waters including the physiologically active chemical ammonia, which is a natural byproduct of the biological breakdown of nitrogenous organic matter (protein). Ammonia interacts with water to produce the ions hydroxyl (OH^-) and ammonium ($NH4^+$). As a consequence of chloramine treatment, drinking water may include ammonia. The [30] states that the maximum amount of ammonia that may be present in drinking water is 0.5 mg/L and not determined by NIS. The obtained ammonia value is far lower than the maximum allowed amount. All sample locations showed identical phosphate concentrations. Despite WHO and NIS not specifying the regulatory limitations.

The concentration of sulphate and chloride ranged from 6.11±0.05 – 9.16±1 and 3.19±0.05-4.25±0.06 correspondingly, with the sample taken from the shell position containing the greatest concentration. The results of a health study showed that prolonged exposure to high levels of sulphate and chloride may have a negative impact on the health of the sample group. This research showed that the levels of chloride and sulphate were within WHO and NIS permitted limits

Table 2. Mean results of heavy analysis of potable water in the study location

S/n	Parameters	unit	Saipem	NLNG	shell	WHO	NIS
1	Iron(Fe)	mg/L	$0.06±0.01^b$	$0.02±0.00^a$	$0.003 ±0.00^a$	0.3	0.3
2	Zinc(Zn)	mg/L	<0.001	<0.001	<0.03	3	3
3	Copper(Cu)	mg/L	<0.001	<0.001	<0.001	2	1
4	Cadmium (Cd)	mg/L	<0.001	<0.001	<0.001	0.003	0.003
5	Lead (Pb)	mg/L	<0.001	<0.001	<0.001	0.01	0.01

Means in the same row with a common superscript are not significantly different (p>0.05).

The concentration trend of Fe in this study as shown in Table 2 revealed there was a significant difference (p<0.05) among the samples collected. The values were generally below 0.3 mg/ L stipulated by the World Health Organization as a standard for drinking water. Previously, [27] reported similar low Fe concentration in drinking groundwater sources of southeast Iran. In contrast, the concentrations observed in this study were lower than the values observed in borehole water [31]. According to [2], Fe is one of the essential metals needed for proper body functions, but consumption of water with Fe values above the permissible limits could result in critical health issues such as liver Cancer, heart and nervous malfunctioning and infertility sometime. The mean concentration of metals (Zn, Cu, Pb, and Cd) is <0.001. Results are below the threshold for detection. The mean amount of all metals is significantly below the highest acceptable limit for drinking water, according to a comparison of these water samples with WHO and NIS limits

Table 3: Mean results of Microbiology Analysis of Potable water in the Study Location.

	Parameters	Unit	Saipem	NLNG	Shell	WHO	NIS
1	Total Coliform	MPN/100ml	<0.003	<0.003	<0.003	Nil/100	10
2	Faecal Coliform.	Cfu/100mL	0.00	0.00	0.00	0.00	0.00

Means in the same row with a common superscript are not significantly different (p>0.05).

Evaluating the bacteriological quality of drinking water, which is one of the key factors that should be taken into account in any monitoring of water quality. Pathogens are common in drinking water, which points to possible origins of human and animal waste [23]. Microorganisms may pollute water at the source, during transit, or during distribution. The most important microbiological indicators for assessing the quality of water are coliforms. They are often discovered in both human and animal digestive tracts and are regarded as indicator organisms that are utilized all over the globe to determine the level of feacal contamination in water [32]. According to the results shown in Table 3 (<0.003 MPN/100ml and 0 Cfu/100ml, respectively), both total and feacal coliforms satisfied WHO and NIS standards for drinking water

4. CONCLUSION

The overall results of this study was compared with the WHO and NIS criteria set for drinking water, and the outcome demonstrates that the concentrations of the physicochemical parameters, heavy metals, and microorganisms examined in the water samples from the different facilities at various locations were within the corresponding recommended permissible limits for a drinkable water quality. This showed that the water has undergone proper treatment and is suitable for drinking by residents of Bonny communities. However, Government (Federal, State and Local) should embark on the construction of similar water treatment facilities to produce good drinkable and quality water for the rising population, especially in the areas that lack good quality water. This will help to improve health statue in rural and Urban areas. Also, due to the impact of oil and gas activities on both ground and surface water, it is important for routine check on water dispense for consumption to forestall water borne diseases in the host communities and oil producing rural communities.

AUTHOR CONTRIBUTION

- Conceptualization: Nwaogbeni Elvis Etumonuwa.
- Methodology: Nwaogbeni Elvis Etumonuwa.
- Data Collection: Nwaogbeni Elvis Etumonuwa and Okanezi Stephen.
- Data Analysis: Nwaogbeni Elvis Etumonuwa and Wokeh Okechukwu Kenneth
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COMPETING INTEREST

The authors declared there were no conflicts of interest among them

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