Investigation Of Water Quality in Proximity to Oil and Gas Facilities in Bonny Waterways

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Abstract- ***Oil facilities are private and state owned assets in the country of study, therefore the study is aim at "Investigating the Water Quality in Proximity to Oil and Gas Facilities in Bonny waterways". This study aimed to assess the water quality near oil and gas facilities in Bonny Island and evaluate potential impacts on the surrounding environment. Bonny Island, located in the Niger Delta region of Nigeria, is known as the oil and gas hub of Nigeria owing to her status in NLNG activities. Understanding the water quality in this area is essential for effective environmental management and safeguarding human health. Water samples were collected from three (3) different locations in proximity to oil and gas facilities along Bonny River in January, February and April, 2024. The collected water samples were tested and compared for possible contaminants. The method of analyzing the data is analysis of variance (ANOVA). The result was compared with regulatory authorities such as World Health Organization (WHO), Federal Ministry of Environment, NSDWQ and DPR.***

Index Terms- ***Bonny Island, Contaminants, Oil and Gas Facilities. Water Quality, Waterways.***

I. INTRODUCTION

Water plays a major role in the life of both humans and plants. Humans, aquatic life and plants cannot do without water. Water is commonplace, two-third of the earth is covered by the ocean, and nearly 4% of the global land mass is inundated permanently with water. (Boyd C laude 2012). Water is also a vital resource for agriculture, manufacturing, transportation and many other human activities. The availability of water resources has a direct impact on the economy of a country and development of the production process from agriculture, irrigation and food production. (Moreno-Pizani, M.A. 2021) Oil and gas activities take place in the waters and their proximity with plants, animals and humans within Bonny Island waterways is of critical importance due to the potential environmental and human health risks associated with these industries. Pollution from oil and gas activities within the study area causes serious environmental challenges. Effluents from oil and gas in Bonny Island waterways has detrimental impacts on the ecosystem including soil, water and air because is a major constituent of hydrogen. For instance, crude oil which consist of hydrocarbon could alter the characteristics of the environment such as soil and water resources (Aigberua et al., 2016a, b, 2017). Currently, hundreds of thousands of people who live in the Niger delta are being exposed to oil contamination near their homes, farm lands, fishing grounds and in their drinking water and foods but the consequences of such exposure on their health are unknown (Nriagu,2011). The study area bonny island southeastern region of Niger Delta within the Atlantic water channels which is the oil and gas hub of Nigeria crude terminal. The Island's proximity to these facilities raises concerns about the potential contamination of surrounding water bodies and the subsequent effects on ecosystems and public health. Understanding the water quality in this area is crucial for developing effective management strategies, ensuring environmental sustainability and safeguarding the well-being of ecosystem.

The potential consequences of water contamination near oil and gas facilities are numerous. Aquatic ecosystems, including rivers, streams and coastal

areas may experience adverse impacts on their biodiversity and ecological balance. Contaminants can accumulate in sediments and aquatic organisms, potentially disrupting food chains and affecting the health of fish, shellfish and other marine life. Furthermore, if the water resources near Bonny Island are utilized for agricultural purposes, contamination may pose risks to human health.

Given the ecological and socio-economic significance of water resources management in the region, it is imperative to investigate the water quality near oil and gas facility in Bonny waterways. The study will provide a scientific basis for understanding the water quality and the impact on the aquatic life, identifying areas of concerns and making recommendations that might be effective.

II. IDENTIFY, RESEARCH AND COLLECT

IDEA

Different researchers in related fields have studied the water quality in proximity to oil and gas facilities in different locations in Niger Delta region. Adebayo, Adesina and Adeniji (2022) investigated the water qualities of open wells located at fuel stations within Ilorin metropolitan communities, Nigeria. They evaluated the quality of water samples collected from twenty-seven open wells located at nine selected fuel stations situated within three Ilorin metropolitan areas. Three stations each, in the three local government areas were selected randomly. They used standard methods to analyze the physiochemical parameters of samples and total petroleum hydrocarbon (TPH) for any possible petroleum product leaking from the station's underground storage tank into the nearby wells. Their findings revealed that two samples were polluted with TPH and their levels were above the values stipulated by WHO.

Investigating the effects of crude oil production activities on surface and groundwater quality in Sapele (Ogbeibu, Akpogheneta and Zagi at el, 2020) Delta State, Nigeria. In their studies, water samples were collected from April to September 2016 from stations 1 and 2 (perturbed locations) and station 3 (control) for analysis of physiochemical parameters including heavy metals. They analyzed their samples using standard procedures and atomic absorption spectrophotometer. Their study revealed that stations 1 and 2 (perturbed stations) had higher mean values than station 3 (control). Also, the results from the study show that the average physiochemical parameters in ground and surface water conformed to World Health Organization (WHO) standard with the exception of temperature, electrical conductivity, dissolved oxygen, colour, biological oxygen demand, iron, cadmium and lead which were slightly higher than WHO and Federal Ministry of Environment permissible level for surface and groundwater indicating some level of pollution due to oil exploration activities.

A study carried out on environmental assessment of river water quality near oil and gas fields in Niger Delta region (Patimah at el 2023). In their study, water samples were collected from January to September 2021 at seven locations along the river segment and tested ex-situ using six parameters, including physical, chemical and microbiological. They used the pollution index formula to calculate, determined and analyze the river water quality status. They further collected and tested samples from three locations with thirteen additional chemical parameters due to potential contamination by other substances as they were located the closest to the production site and office area. From their findings, six parameters showed a pollution index value of 0.558 or within the predefined standard at one location and 1.080 – 2.721 at the other six locations, indicating slight pollution.

This study investigate the water quality in proximity to oil and gas facilities using Bonny waterways as a case study.

III. WRITE DOWN YOUR STUDIES AND FINDINGS

Materials and Methods

Bonny Island falls within the Beach ridges on-shore geomorphic sub-environment of the Niger Delta and lies between $4^{o}52^{I}$N to $5^{o}02^{I}$N and longitudes $6^{o}56^{I}$E $7^{o}04^{I}$E

Geologically, it comprises of Pleistocene to Recent sediments deposited by fluvial and shallow

continental shelf hydrodynamic processes. The area is characterized by strong wave and tidal action, which further compacts the sediments. The water table in the area varies with season. The area has a declining water table during the dry season. Generally, water table in the area is dynamic and ranges between 0.1–3 m depending on the season (Amadi, 2010 in Nwankwaola et al 2012).

Bonny Island has a population of 313,733 as at 2018, with a population projection of 457,843 by 2030 according to National population census. Four (4) habitat types were observed. They are; mangrove swamp (natural habitats), freshwater (natural habitats) and secondary forest (disturbed habitat). Specifically, mangrove swamp can be seen at George Pepple, Alasakiri, Bomu- Bonny Trunk Line, Issille-Ogono and Bonny community, freshwater at Otuokolo and secondary forest at Abalamabie community.

IV. WATER SAMPLE COLLECTION

A total of nine water samples were collected from three different locations along bonny waterways. Every month, three samples were collected from three different location for a period of three months using sterile 150ml plastic bottles for each sample. To ensure that the samples were sterile, the bottles was rinse with the appropriate amount of sample before final sample collection. The samples were transported to the laboratory for the analysis.

- Analysis of water sample

Key parameters such as pH, temperature, turbidity, dissolved oxygen, and electrical conductivity was carried out using HANNA H19829, and total hardness, Alkalinity, BOD, COD, and TSS was carried out using APHA. Magnesium test was carried out using AAS and the presence of contaminants such as hydrocarbons was tested. Total Petroleum Hydrocarbon (TPH) was carried out using Agilent 7890 GC-FID, while Polycyclic Aromatic Hydrocarbons (PAH) was carried out using Agilent GC 7890/5975 MSD.

- Microbiological analysis of water samples

Bacteria Isolation: A total of five bacteria was isolated from the water samples namely Bacillus sp, Enterobacter sp, Pseudomonas sp, Vibrio sp, and Aeromonas app

V. RESULTS AND DISCUSSION

RESULTS

The results of the physicochemical parameters of the bonny waterways are presented in tables. These results are in tables 1 and 3. The physical parameters such temperature, electrical conductivity, total dissolved solids, turbidity, total suspended solids, pH and salinity are presented in table 1, alongside the chemical parameters such as the biological chemical demand (BOD), the chemical oxygen demand(COD), dissolved oxygen (DO), Alkalinity and Total Hardness and Total petroleum Hydrocarbon (TPH) and polcyclic romatic Hydrocarbons are all found on tables 1, while the mean values for all the parameters are found on tables 3. To further determine which of the parameters a key player, ANOVA analysis was done for the parameters. Table 4 is levene's test of homogeneity for the variables while table 5 contains the analysis of variance table. Table 2 is the standards for WHO, FEMENV, NSDWQ and DPR.

DISCUSSION

The physicochemical parameters are presented in table 1.

Table 1: physicochemical parameters

S/N	Months and	pH	Temp	EC	TDS	Total	DO	BOD	COD	TPH	PAH

	sample		°C	µS/cm	M/L	Hardness	mg/l	mg/l	mg/l		
1	Month 1,1	7.5	29.97	31,660	15,870	9950.25	5.38	6.50	84.611	<0.001	<0.001
	Month 1,2	7.5	29.80	31,650	15,870	9950	5.30	6.75	82	<0.001	<0.001
	Month 1,3	7.5	29.80	31,670	15,800	9950	5.30	9.00	81	<0.001	<0.001
2	Month 2,1	7.6	27.0	32,700	16,300	7000	5.15	9.25	64	<0.001	<0.001
	Month 2,2	7.6	27.0	32,720	16,300	7000	5.15	9.50	62	<0.001	<0.001
	Month 2,3	7.6	27.0	32,800	16,300	7000	5.15	9.74	60	<0.001	<0.001
3	Month 3,1	7.50	23.5	33,800	16,898	5000	5.00	12.32	46	<0.001	<0.001
	Month 3,2	7.5	23.4	33,800	16,880	5002	5.00	12.32	45	<0.001	<0.001
	Month 3,3	7.5	23.2	33,800	16,880	5000	5.00	12.3	45	<0.001	<0.001

Table 2: Federal ministry of Environment standard (FMENV), Department of Petroleum Resources (DPR) Standard, and Nigerian Standard for Drinking Water Quality (NSDWQ) Standards of water samples.

Parameters	FMENV	DPR	NSDWQ	WHO
pH	6.5-9.2	6.5-8.5	6.5 -8.5	6.5 – 8.5
Electrical Conductivity	NS	NS	1000	400_{min} – 1000_{max}
TDS	2000	2000	500	400

Temperature	35	30	Ambient	28-30
BOD	NS	10		
COD	NS	10		
DO	NS	NS	5.0	
Total Hardness			150	100
TPH		10		
PAH				0.2

Table 3: Mean values for physicochemical parameters, TPH and PAH showing concentrations of water samples in bonny waterways.

s/n	Parameters	Average for Month 1	Average for Month 2	Average for Month 3	Overall Average for Months 1,2,&3
1	pH	7.5	7.53	7.5	7.5
2	Temp	29.86	27.0	23.37	26.74
3	EC	31,660	32,733	33,800	32,711
4	TDS	15,847	16,300	16,833	16,326
5	Total Hardness	9,950	7,000	5,000.6	7316.6
6	DO	5.33	5.15	5	5.16
7	BOD	7.416	9.50	12.31	9.742
8	COD	82.54	62	45.33	63.29
9	TPH	<O.001	<0.001	<0.001	<0.001
10	PAH	<0.001	<0.001	<0.001	<0.001

Temperature

Temperature defines how hot or cold something is measured. Ambient temperatures ranges from 23.20 to 29.97°C with mean value of 26.74°C (table 1 and 3). A portable water has a better fresh taste at a lower temperature of about 15°C but, higher temperatures do not imply impurities (okurnmeh, O.K and Olashahinde, P.I 1999). From table 2, the temperature is within acceptable limits.

pH

pH is an important parameter for assessing water quality due to its impact on the chemical and biological process that occur in water bodies(shailesh Kumar Dewangan et al 2007). The pH values ranges from 7.5 to 7.6 between month one and month three and between the samples from table 1. The overall average value for pH from table 3 is 7.5, and from table2, the pH value is within the acceptable limits for water samples.

Electrical Conductivity

Electrical Conductivity in water is due to dissolved solute (Bassey S. Okori, Akanimo N. Ekanem 2022). From table 1, electrical conductivity ranges from 31,650 to 33,800µS/cm. The overall average of Electrical conductivity from the samples is 32,711(table 3). The acceptable limit of electrical conductivity of water is 1000µS/cm according to NSDWQ (table 2). From this table, the electrical conductivity of the water sample from bonny waterways is above the recommended standard.

Total Dissolved Solids (TDS)

The total dissolved solids (TDS) recommended by DPR, FMENV and NSDWQ are between 500-2000 (table 2). The total dissolved solids of the bonny waterways sample ranges from 15,870 to 16,898, and the overall average is 16,326 (table 3) showing a significant difference from the acceptable limit.

Total Hardness

Hard water is usually define as water which contains a high concentration of calcium and magnesium ions. The value of total hardness ranges from 5000 mg/l to 9950.25mg/l with a mean value of 7316.6 mg/l (table 1 and 3). All the surface water samples had hardness values above the WHO and NSDWQ permissible limits of 100mg/l and 150mg/l (table 3) respectively.

These suggest that the water is hard. Hardness of water can create problems in laundry and piping system. Hardness of water can also cause alot of diseases such as cardiovascular problems, diabetes and reproductive failure (Dr. Pallav Sengupta 2013) and diseases such as eczema and skin irritation. The analysis of variance (ANOVA) result, shows that there exist a statistically significant difference in the mean contribution of all parameters towards water pollution, and total hardness contributed the highest to the pollution of the water.

Dissolved Oxygen (DO)

Dissolved Oxygen values ranges from 5.00 to 5.38 with a mean value of 5.16 (table 1 and 3). The Nigerian Standard for Drinking Water Quality (NSDWQ) has a limit of 5.0 (table2). From the overall mean result obtained from the test, the value is slight above the threshold of the acceptable limits.

Biological Oxygen Demand (BOD)

The values gotten from the test ranges from 6.50 to 12.32 and a mean value 9.742 (table 1 and 3). Department of Petroleum Resources (DPR) stipulated a limit of 10mg/l. Not all the samples were within the permissible range on individual basis, the three samples from month 3 had a high value of 12.32 per sample, although the mean value shows that biological oxygen demand is within the permissible limit of the standard but slightly on the upper permissible limit. From the mean value, there is an indication that there is no pollution. Whatever purification process is required, the river can efficiently use its self-purification process to handle it.

Chemical Oxygen Demand (COD)

Table 1 and 3 indicates that chemical oxygen demand from month 1 to 3 ranges from 45 to 84.611, with a mean value of 63.29. This result shows that when compared to Department of Petroleum Resources (DPR), permissible limit which is 10mg/l they all tend to be higher than the said limit which indicate that all the sites are polluted and could reduce the dissolved oxygen of the recipient environment leading to the death of aquatic biota.

Total Petroleum Hydrocarbons (TPH)

Values gotten from all sample location is less than 0.001. (table 1 and 3) this result shows that there is no pollution as a result of hydrocarbons.

Polycyclic Aromatic Hydrocarbons (PAHs)

The values obtain from the results shows that, there was no indication of pollution since all the sample location had a value less than 0.001, and this is below the permissible limit of WHO standard.

Table 4: Levene's test

Test of Homogeneity of Variances

Months

Levene Statistic	df1	df2	Sig.
5.770	14	30	290

The Levene's test of equal variance in Table 4 above shows a p-value greater than 0.05. Hence, we conclude that the variance of the dependent variables or samples are similar between our groups. Hence, the assumption of equal variance is met.

ANOVA

Months

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	148768072.493	14	10626290.892	25.513	.000
Within Groups	12495246.349	30	416508.212		
Total	161263318.842	44			

Table 4 above shows the one-way analysis of variance obtained using SPSS version 23 which shows that our result is statistically significant with a p-value less than 0.05 and therefore from this result we can conclude that there is a statistically significant difference in the mean contribution of our variables to the pollution of the water. And to determine the course of this difference, we conducted a multiple comparison test as shown in Appendix 1.

Bacteriological

The microrganisms seen from the microbial analysis are Aureobasidium, Aspergillus sp and Penicillium sp, Bacillus sp, Enterobacter sp, pseudomonas sp, vibrio sp and Aeromonas sp.

Areobasidium pullulans is a rare cause of skin and soft tissue infection, peritonitis and catheter-related fungemia in certain human host (Jorge Verdecia, Chrictopher A. Jankowski, Meredith L. Renolds, Yvett McCarter, Malleswari Ravi 2022)

According to the center for disease control and prevention, Aspergillus sp is a type of fungus that casues aspergillosis. For people with weakened immune systems, breathing in aspergillus spores can casuse an infection in the lungs or sinuses which can spread to other parts of the body

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Penicillium sp can cause invasive diseases such as chronic granulomatous disorder (CGD), superficial infection (keratitis and otomycosis. G Lyratzopoulos et al. j infect 2002 oct.

Anthrax remains the best known Bacillus disease. This disease is a food borne pathogen that can produce toxins, causing two types of gastrointestinal illness – the emetic (vomiting) and diarrhoeal syndrome. so it can be gotten from the sea foods e.g fish. So when the the emetic toxin (cereulide) is produced in the food, vomiting occurs after ingestion of the contaminated food.

Bacillus sp also has other functions, a large number of reports in the literature indicates that bacillus sp are involved in the regulation of plant growth, development, and response to both biotic and abiotic stress factors such as drought, salinity, high and low temperatures, toxic metals, waterlogging etc (Hassan Etesami, Byoung Ryong Jeong, Bernard R. Glick 2023)

Pseudomonas sp can deposit in the lungs and can cause death. People with cystic fibrosis are unable to clear this bacteria efficiently from their lungs. (Barbara H. Iglewski 1996)

Vibrio bacteria are naturally found in salt and brackish (i.e., somewhat salty) waters. Infection with vibrio bacteria can cause two types of illnesses, vibrosis and cholera. The bacteria thrive in warm waters and thus cause more infections during the summer months. Most people become infected by eating raw or undercooked seafood, especially shellfish (including oysters, mussels, and clams). Infection can also occur when the Vibrio bacteria enter the body through a break in the skin while a person is in salt or brackish water or while handling raw fish or shellfish caught from these waters. Certain Vibrio species can also cause ear infections when salt or brackish water enters a person's ear. (Virginia Department of Health- epidemiology (vibriosis- non cholera). Aeromonas sp, are water borne bacteria, they have been isolated from marine waters, rivers, lake, water distribution system and drinking water. They can cause wound infections. (J.M.Tomas 2012)

CONCLUSION

From the research findings, oil and gas activities along bonny waterways in the sample stations, do not impact on the water as the study revealed that it is possible that appropriate control measures are in place as Total Petroleum Hydrocarbon (TPH) and Polycyclic Aromatic Hydrocarbons (PAHs) are within the permissible limits of WHO and DPR. The study rather revealed that the water is hard. As total hardness, in all the samples exceeded the standards set by WHO and NSDWQ. And the Analysis of Variance (ANOVA) shows that total hardness parameter that mostly have impact on the water.

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