Quantification of the Physico-Chemical Parameters and Estimation of Water Quality in Otuoke River During Low Tides, Using Weighted Arithmetic Water Quality Index Analysis

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Abstract
Surrounded by river water, many coastal communities are torn apart by a lack of potable water for basic needs. Over the years, Otuoke community has relied majorly on river for its water needs, without actually knowing its quality status, particularly during the low tides. This research therefore addressed the pressing question of if harvesting water during the low tide is suitable for domestic needs. The study involved the collection of five water samples from different locations along the river reach during the low tides at distances between 150m – 200m apart. A total of eight parameters were analyzed in the laboratory, they included pH, Total Dissolved Solids (TDS), Electrical Conductivity (EC), Turbidity, Hardness, Nitrates, Chlorides, and Biochemical Oxygen Demand (BOD). The results of the water quality analysis were compared with guideline values from the World Health Organization (WHO) and the Nigerian Standard for Drinking Water Quality (NSDWQ), using statistical charts. The Weighted Arithmetic Water Quality Index (WAWQI) method, aided by Microsoft Excel, was used to further evaluate the overall quality of the average samples. The findings showed that the Otuoke River's water quality is significantly of poor quality, with a WAWQI value of 169.62 according to the WAWQI classification table. Based on these findings, the water quality during the low tide in its current study was unfit for domestic consumption without proper treatment. It is therefore recommended that a further treatment of Turbidity and BOD will make the water fit for town supply to meet the water needs of the residents. Actionable policies of waste disposal should be put in place to mitigate against increased BOD and Turbidity of the Otuoke river.

Key Words: *Potable, River Water, Quality, Estimation, Low Tide,*

INTRODUCTION

Although there are minimum requirements for water quality standards used for domestic purposes as prescribed by Public Health institutes and the World Health Organization (WHO) for good hygiene, most coastal communities have lacked the opportunity of knowing the quality status of their sources of water before use. Rivers remain one of the most abundant natural sources of freshwater resources, yet their overall quality, particularly during the low tides is not well documented. Whether documented or not, this freshwater resource serves multiple functions most of which are critical to human settlement and survival of humans (Nwankwola and Ngah, 2014; Nwankwola *et al.,* 2018; Abadom and Nwankwoala, 2018).

This is because water has remained a basic human right and a prerequisite for sustainable development. Nonetheless, as a rising global issue, water scarcity is made worse by pollution, urbanization, population expansion, and climate change (Omole & Ndambuki, 2014; WHO, 2017). Poor access to safe water, low water quality, and unequal resource distribution are just a few of the many water-related issues (Winrock International, 2021). Dam construction and the creation of a National Water Resources Master Plan are only two of the initiatives and methods the Nigerian government has put in place to solve these problems through organizations like the Federal Ministry of Water Resources (FMWR, 2014).
Bayelsa State, where the Otuoke River is located, is a prime example of these challenges. Despite being a major oil-producing state, it has a high rate of poverty and a significant portion of its population lacks access to safe drinking water. The intricate geography of the state makes the construction of conventional water supply schemes difficult and expensive. As a result, many residents depend on a mix of irregular public water supply, expensive privately-sourced water, and contaminated natural water bodies (IIARD Journals, 2025). The Otuoke River, a tributary of the River Nun, is an important natural resource for the Otuoke community and its environs. It serves as a source for various domestic and industrial activities. It is a significant water body in the region, which has the potential to serve as a sustainable source as a result of its abundance, freshness, accessibility etc. Given the pervasive issues with both groundwater and public water supply in the region, the potential of the Otuoke River as a viable source for a large-scale surface water supply scheme is a critical area of investigation.

Previous studies on water quality in Otuoke and its surroundings have highlighted a mix of findings. Some research indicated that certain physicochemical parameters of the river water are within acceptable limits for specific uses like irrigation or industrial processes (ResearchGate, 2018). However, other more recent studies paint a more alarming picture. Investigations into the Otuoke River had found that the water is contaminated by a number of pollutants, including heavy metals, and has a high concentration of pathogenic heterotrophic bacteria, often exceeding the standards set by the World Health Organization (WHO) (Discovery Scientific Society, 2024; Greener Journals, 2025). The presence of these contaminants suggests that the river, in its current state, is not suitable for domestic consumption without significant treatment.

Therefore, this work seeks to build upon existing knowledge to investigate the suitability of accessing water from Otuoke River during the low tide for town supply.

STUDY OBJECTIVES

This study investigated the water quality in Otuoke River during the low tide to ascertain its quality status and suitability as a sustainable source of water supply, through the following objectives.

- To collect water samples from five different sections of the Otuoke River (upstream, midstream, and downstream) during Low tides, with sampling distances of 150m – 200m apart.
- To conduct standard laboratory analyses on the collected samples for parameters such as pH, Total Dissolved Solids (TDS), Electrical Conductivity (EC), Turbidity, Hardness, Nitrates, Chlorides, and Biochemical Oxygen Demand (BOD).
- To compare results with acceptable global World Health Organization (WHO) and Nigerian Standard of Drinking Water Quality (NSDWQ) standards using statistical tools.
- To Analyse the Water Quality Index using Weighted Arithmetic Method (WAWQI).

MATERIALS AND METHOD

This study applied both quantitative and qualitative methods to gather and analyze data. Quantitative methods focused on the number of samples collected for assessment, while qualitative methods involved samples analysis. The laboratory dada was further analyzed using statistical tools and for water quality index, using the weighted arithmetic method.

Study Area

The community is part of a lowland coastal area characterized by a network of rivers, tributaries and creeks. Which has made the community have access to numerous surface water sources, as well as large supply of ground water from aquifers within the delta's geological formations.

Sample Collection and Analysis

A total of Five (5) water samples were collected at different locations along the Otuoke river reach during the low tide period. These samples were labeled as LT1, LT2, LT3, LT4, and LT5. The distances between sampling points were within 150 meters to 200 meters. The samples were preserved and taken to the laboratory for analysis of parameters such as pH, EC, BOD, Turbidity, Nitrates, Hardness, Chloride, and TDS. Statistical charts were used to compare results with standards. An average concentration of the laboratory results was taken for further data analysis.

RESULTS AND DISCUSSION

Table 1.0: Results of Water Samples at Different Sampling Locations Collected During the Low Tide

Table 1.0 above shows the results of the concentrations of considered parameters collected

Sampling Locations		pH	TDS (mg/L)	EC (µS/cm)	Turbidity (NTU)	Hardness (mg/L $CaCO_3$)	Nitrate (mg/L NO_3)	Chloride (mg/L)	BOD (mg/L)
LT1	Lat 4.791126 Long 6.309436	6.4	28	56	33.507	21.33	13.28	25.05	11.69
LT2	Lat 4.788536 Long 6.309997	6.3	27	54	29.891	22.01	13.64	25.39	12.01
LT3	Lat 4.785187 Long 6.309366	6.3	27	54	30.866	22.06	13.55	24.86	11.88
LT4	Lat 4.784455 Long 6.310438	6.4	27	54	31.424	21.41	13.02	25.11	11.84
LT5	Lat 4.784975	6.6	27	54	32.031	21.27	12.97	25.17	11.92
Average Concentration		**6.5**	**27**	**54**	**31.7275**	**21.34**	**12.995**	**25.14**	**11.88**

from five different locations as indicated with coordinates during the low tide. Average values of these parameters were also taken for further data analysis as shown in Table 2.0 below.

Table 2. 0: Average Concentrations of Parameters During the Low Tide as Compared with the WHO and NSDWQ Standards

Parameters	Average Low Tide Concentration	WHO	NSDWQ
pH	6.5	6.5 – 8.5	6.5 – 8.5
TDS	27	≤ 1000 mg/L (palatability decreases above this)	≤ 500 mg/L
EC	54	No strict GV; generally corresponds to TDS	≤ 1000 µS/cm
Turbidity	31.7275	≤ 5 NTU (≤ 1 NTU ideal for disinfection	≤ 5 NTU
Hardness	21.34	No health-based GV; > 500 mg/L often unacceptable taste-wise	≤ 150 mg/L
Nitrate	12.995	<50 mg/L	<50 mg/L
Chloride	25.14	No health limit:<250 mg/L for taste	<250 mg/L
BOD	11.88	< 5mg/L	≤ 5 mg/L

Statistical Comparison of Parameters

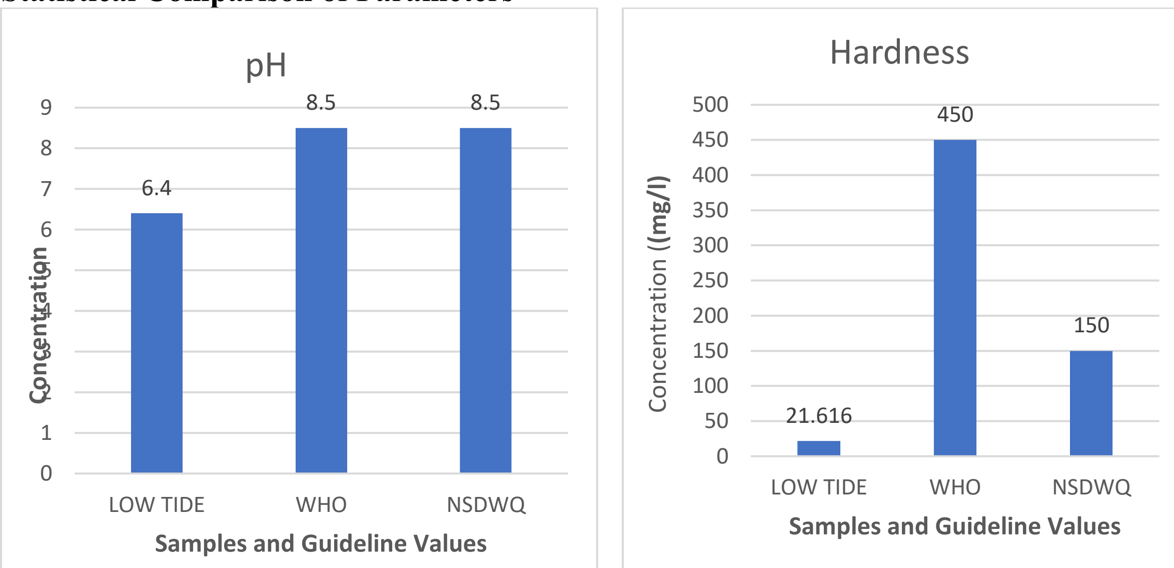

Figure 1.0: Chart Comparing pH and Hardness Levels at Low Tide with WHO, and NSDWQ Standards

Measured pH values were 6.4, while hardness was 21.62mg/l in Otuoke River. pH and hardness at the low tide were observed to be lower than that of the standards, indicating water being slightly acidic during the low tide.

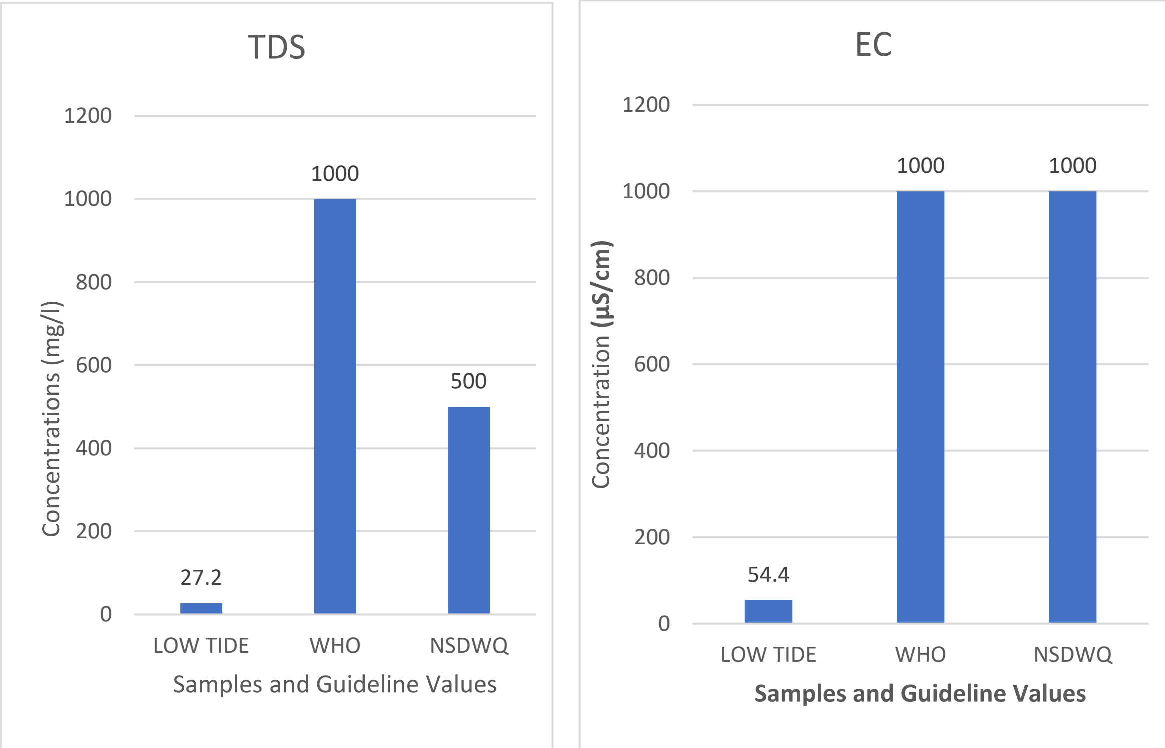

Figure 2.0: Chart Comparing TDS and EC Levels at Low Tide, with WHO and NSDWQ Standards

Similarly, TDS and EC levels were 27.2 mg/l and 54.4 in Otuoke River at the low tide. These values were far below the 500 mg/l desirable and 1000 mg/ permissible limits of WHO (2017) and NSDWQ (2007) respectively. These low values showed that the parameters were within permissible limits.

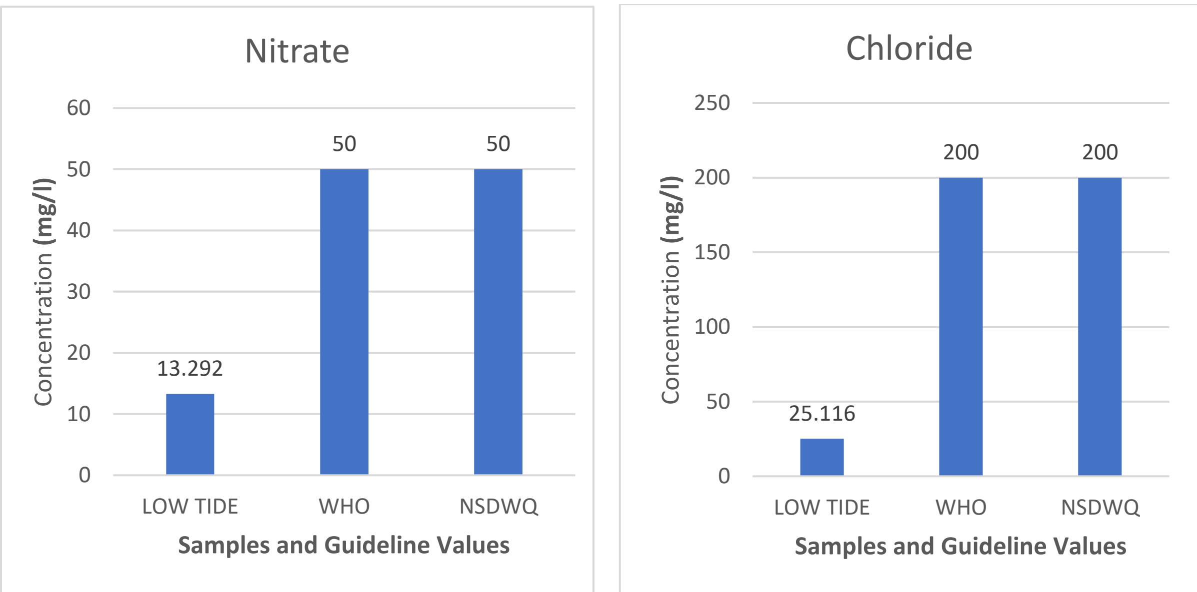

Figure 3.0: Chart Comparing Nitrate and Chloride Levels at Low Tide, with WHO, and NSDWQ Standards

Again, Nitrate and Chloride levels were 13.29 mg/l and 25.12 mg/l in Otuoke River at the low tide. Yet, both of the parameters were well within the safe limits of 50 mg/l and 200mg/l respectively of the guidelines set by WHO (2017) and NSDWQ (2007). These values confirmed that the river poses no immediate nitrate or chloride related health risks.

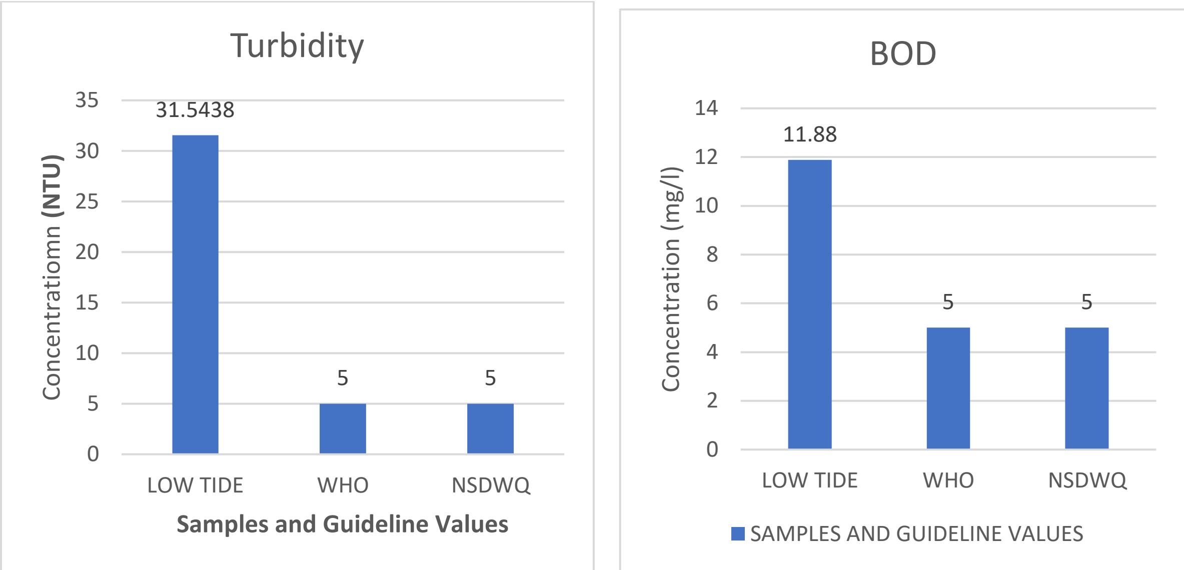

Figure 4.0: Chart Comparing Turbidity and BOD Levels at Low Tide, with WHO, and NSDWQ Standards

However, Turbidity and BOD levels were 31.54 NTU and 11.88mg/l respectively at the low tide. These levels exceeded the 5 NTU and 5mg/l guideline values set by WHO (2017) and NSDWQ (2007). The high levels suggested suspended particles from runoff, erosion, or waste, indicating the water is unsafe for direct consumption without treatment.

Weighted Arithmetic WQI

In this research, the Weighted Arithmetic Water Quality Index (WAWQI) was used to evaluate the quality status of water in Otuoke River during the low tide. The WAWQI method used the Microsoft Excel to help simplify the variables into a single value that was compared with standards provided in their classification chart with ranges from less than fifty to greater than three hundred, (<50 to >300). In this analysis, the calculated values less than 50, were regarded as excellent for drinking. The quality status becomes questionable and eventually get bad as the calculated value progresses towards 300. Scholars like Nta, *et al.* (2020), Mishra and Patel, (2001) and kizar, (2018), all used WAWQI to evaluate their works.

Table 3.0: Water Quality Index Analysis During the Low Tide Analytical Regime

Parameters	WHO (2011) Sn	Average Low Tide Conc.	**Wn = 1/Sn**	$\sum \frac{1}{Sn}$	$K = \frac{1}{\sum \frac{1}{Sn}}$	**Wn = K/Sn**	**Ideal Values (Vo)**	**Mean Conc. Values (Vn) of the Points**	**Sub-index = Vn/Sn**	**Qn = Vn/Sn x 100**	**Wn x Qn**
pH	8.5	6.4	0.11764706	**0.55031373**	1.8171453	0.2137818	7	6.4	-0.4	-40	-4.7058824
TDS (mg/L)	1000	27.2	0.001	**0.55031373**	1.8171453	0.00181715	0	27.2	0.0272	2.72	0.00272
EC (µS/cm)	1000	54.4	0.001	**0.55031373**	1.8171453	0.00181715	0	54.4	0.0544	5.44	0.00544
Turbidity (NTU)	5	31.5438	0.2	**0.55031373**	1.8171453	0.36342906	0	31.5438	6.30876	630.876	126.1752
Hardness (mg/L $CaCO_3$)	150	21.616	0.00666667	**0.55031373**	1.8171453	0.0121143	0	21.616	0.14410667	14.4106667	0.09607111
Nitrate (mg/L NO_3)	50	13.292	0.02	**0.55031373**	1.8171453	0.03634291	0	13.292	0.26584	26.584	0.53168
Chloride (mg/L)	250	25.116	0.004	**0.55031373**	1.8171453	0.00726858	0	25.116	0.100464	10.0464	0.0401856
BOD (mg/L)	5	11.868	0.2	**0.55031373**	1.8171453	0.36342906	0	11.868	2.3736	237.36	47.472
SUM			**0.55031373**			**1**				**WQI =**	**169.617414**

The final results at Table 3.0 above showed that the WQI during the low tide analysis was 169.617414. When this value was compared to the values in the ranking chart, it was observed that the river water quality in this research fell within category 3, indicating that the water was of poor quality.

CONCLUSION

The water quality analysis revealed significant challenges. Results of parameters such as pH, Total Dissolved Solids (TDS), Electrical Conductivity (EC), Hardness, Nitrates, and Chlorides, showed acceptable levels of concentration in the river as compared with WHO and NSDWQ standards. However, Turbidity and BOD levels were exceptionally high, far exceeding the WHO and NSDWQ standards of 5 NTU and 5mg/l respectively, pointing to substantial availability of suspended solids from erosion and waste management as well as organic pollution.

Furthermore, the overall water quality analysis using the WAWQI, showed results with values of 169.62 for low tide, classifying the water as of “poor water.” This value was significantly above the “good water” range (50.1-100) and even higher than the “excellent water” category (less than 50). These elevated values suggested the presence of pollutants from industrial activities, oil spills, and indiscriminate waste dumping, which have been documented as major concerns for the river, similar to the study done by Churchill *et al.,* (2022). This showed that even with one spiking parameter, the overall water quality can be compromised.

Therefore, any plan to use the Otuoke River as a primary water source for domestic use or town supply during the low tides must include substantial and sophisticated water treatment processes to address the high levels of turbidity and organic pollution. The current state of the river poses significant health risks to the population that depends on it for domestic use. This study confirmed the need for immediate action to mitigate pollution and highlight the unsuitability of the river for direct consumption.

Recommendation

It is therefore recommended that a advanced water treatment methods should be implemented, pollution control and regulation should be a concern for the stakeholders, a continuous water quality monitoring programme should be implemented, public awareness should be raised to reduce cases of Otuoke water.

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