

Physico-Chemical and Biological Parameters Assessment of River Otamiri and One Selected Borehole in FUTO Community for Drinking and Domestic Purposes

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DOI: <https://doi.org/10.61165/sk.publisher.v12i7.4>

Abstract: *The importance of water resources on campus of Nigerian universities cannot be overemphasised This research work is aimed at assessing the suitability of one selected borehole (groundwater) and River Otamiri (surface water) qualities in Federal University of Technology, Owerri (FUTO) in Owerri West L.G.A of Imo state, Nigeria for Drinking and Domestic purposes. Samples of water resources (Borehole and River Otamiri) from FUTO Campus were collected and analyzed in accordance with APHA, AWWA and WPCF (2005) guidelines, so as to evaluate their Physico-Chemical and Biological qualities in relation to World Health Organization (WHO) standard. The results from the Physico-Chemical analyses show that the cation and anion concentrations for both the River Otamiri and the selected borehole falls within the WHO (2011) recommended limit. Again, the Total Dissolved Solids (TDS) and the Total Alkalinity (TA) fall within the WHO recommended standard. The Total Hardness (TH) from the upstream of the River Otamiri falls within the threshold limit while the TH for the downstream of the river as well as the borehole are within the WHO stipulated standard. The biological analysis results also show good tidings with WHO standard, except the Total Coliform Count (TCC) which did not show significant growth on the river, but showed absolutely no growth on the borehole. Overall, owing to the slightly alkaline content of these water resources coupled with the relatively hardness recorded from the upstream of the river and the insignificant growth record of the TCC on the river, the water resources from the FUTO borehole source are suitable for both drinking and domestic purposes while the water resources from the River Otamiri are only suitable for some domestic purposes such as washing of cloth, but not suitable for drinking purposes. Therefore, there may be need for proper treatment of the Otamiri River situated in FUTO Community before it can be used for both drinking and all domestic purposes.*

Keywords: *FUTO, River Otamiri, Borehole, Water Resources, Drinking/Domestic Purpose, Physico-Chemical / Biological Parameters/Qualities.*

I. INTRODUCTION

Federal University of Technology, Owerri [FUTO] is one of the foremost universities of technology established by the Federal Government of Nigeria in 1980 with the major aim of providing technology for service. Its land mass is about 4000

hectares of land and its population has risen to about 25,000 including both the students and staff. FUTO is sited in Owerri, which is a metropolitan city located between latitude $5^{\circ}22^1$ N and longitude $6^{\circ}59^1$ E as shown in Figure 1.

FUTO campus, like every other Nigerian university campus has been a place of high activities that cuts across the academic, social-economic and domestic livelihood that requires the use of water every day. Also as a place of study, the campus and its environment are always at home to welcome all sorts of construction works that also require the daily use of water resources. Thus these increases in activities always prompt the increase in water demand for both drinking and domestic purposes

In a nutshell, water resources refer to natural resources of water that are potentially useful as a source of water supply. Water resources, as natural elements are very essential and precious to life. They also represent important stake for the society as water is one of the basic necessity of life. Water resources are majorly classified into two as Groundwater and Surface water. The importance's of each of these classes are duly explained by Akpobori and Nfor (2007) and Agunwamba (2000) and the sources of different classes of water resources have been fully detailed by the works of Nwachukwu and others (2022). For FUTO community, the source of groundwater of interest is borehole water and the source of surface water of interest is the Otamiri River on the campus.

In general, water remains essential for livelihood as well as socio-economic development of FUTO community. In the campus, it is used for domestic, drinking, agricultural and even construction purposes, etc. Thus, there is need for effective evaluation of water resources qualities from FUTO for drinking and domestic purposes, as any state of poor water condition can lead to health challenges.

Water Quality Assessment is the overall process of evaluation of the physical, chemical and biological nature of the water resources which is based on based upon five broad types of monitoring data: biological integrity, chemical, physical, habitat, and toxicity. It is obvious that many professionals have stakes in water quality assessment for different reasons based on professional interests. This explains why the assessment of water qualities is of interest to many researchers across different field of discipline. The Geologists, Biologists, Crop Scientists/Technologists, Chemists, Civil Engineers/Water Resources Engineers, Environmentalists, Agriculturist/Agricultural Engineers, Physicts, Geographers as well as other water resources agencies have different interest and motive for assessment for water resources qualities. But for the Civil Engineer, his interest is mainly for drinking, domestic and construction purposes. The Physico-Chemical and Biological parameters under analysis from the Civil Engineering perspective are the pH , Sodium (Na), Potassium (k), Calcium (Ca), Magnesium (Mg), Chloride (Cl), Nitrite (NO_3), Bicarbonate (HCO_3), Sulphate (SO_4), Total Coliform Count (TCC), Dissolved Oxygen (DO), Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD) as well as the Total Hardness (TH), Total Alkalinity (TA), and Total Dissolved Solids (TDS)

Many researchers have done related works on the subject matter, but none has been able to carry out detailed assessment based on the subject matter. For instance, Ijeh (2014) carried out an assessment on groundwater quality in different parts of Owerri and his work is limited to groundwater water and for domestic purposes only. Olasoji and others (2019) assessed surface and groundwater qualities using Water Quality Index Method. Their area of interest was in the South Western Nigeria. The work of Okoro and others (2016) is limited to only groundwater. Eyankwere and others (2015) carried out both Physico-Chemical and bacteriological assessment of groundwater quality in Ughelli and its environ. The work of Ihenetu and others (2020) majored on the pollution and health risk assessment of groundwater sources around a waste disposal site in Owerri West L.G.A. Nwosu and Nwosu (2016) carried out the physico-chemical analysis of surface water and groundwater systems within Federal University of Technology Owerri (FUTO). Their major interest as researchers from physics department was to obtain the available **geoelectric** survey information. Nwachukwu and others (2020) carried out comparative analysis of water quality from harvested rain and borehole water in Owerri West L.G.A. As expected, their research interest is limited to their field of career, biology. The work of Obi (2017) concentrated only on consumption purposes and in general terms for Owerri west while

The map displays the coastal region of Lagos State, Nigeria. Key features include the Lagos Lagoon, the Lagos Island, and the mainland. Major roads and landmarks are labeled. An inset map shows the location of Lagos State within Nigeria. A legend identifies symbols for study areas, major roads, minor roads, rivers, and buildings.

II. METHODOLOGY

There are two sources of data in this work- the Primary data and the Secondary data. The primary data which comprises of the water resources quality parameters were gotten through laboratory analysis of the water resources samples collected from one selected borehole and Otamiri River (both upstream and downstream), all in the FUTO community of Owerri West L.G.A. of Imo state. These Physico-Chemical parameters/data include the pH, Sodium (Na), Potassium (K), Calcium (Ca), Magnesium (Mg), Chloride (Cl), Nitrite (NO₃), Bicarbonate (HCO₃), Sulphate (SO₄), etc while the biological parameters include the Total Coliform Count (TCC), Dissolved Oxygen (DO), Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD). The secondary data on the other hand were obtained from literature and updated reports from agency like WHO (World Health Organization). Using these reports, the recommended standards for each water resources parameter for a particular purpose was selected as a standard measure.

For assessment of the water resources for drinking and domestic purpose, a 2-litre polythene bottles which is expected to introduce minimal contamination, was used to fetch two samples of water from the borehole (groundwater) and surface water (River Otamiri) respectively. Thus a total of 4 (Four) bottle water was fetched for analysis. Thereafter, the collected water samples were stored in well-drained clean polyethylene bottles already rinsed out with the same water sample in each case and kept in a refrigerator at temperature below 20°C in order to prevent changes in the water sample between the time of collection and analysis.

2.2.1: METHOD FOR PHYSICO-CHEMICAL ANALYSIS

For the Physico-Chemical analysis, the following water resources parameters were analysed: pH, the cations which include Sodium (Na^+), Potassium (K^+), Calcium (Ca^{2+}), and Magnesium (Mg^{2+}), the anions which include Chloride (Cl^-), Sulphate (SO_4^{2-}), Nitrite (NO_3^-), and HCO_3^- . The Total Hardness (TH), Total Alkalinity (TA), and Total Dissolved Solids (TDS) are gotten through important water analysis theoretical concepts and calculations as demonstrated in the next section. The pH was determined insitu at the water resources source using a pH meter. The cation concentrations were determined using atomic

absorption spectrophotometer while Nitrate and sulphate as well as other anion concentrations were determined using the various standard methods for water analysis and in accordance with APHA, AWWA and WPCF (2005) guidelines.

2.2.2: METHOD FOR BIOLOGICAL ANALYSIS

For the biological analysis, the following parameters were analyzed: TCC, DO, BOD and COD. The DO was determined insitu at the water resources sources using Potentiometric method. The BOD is measured by determining the amount of DO consumed by a micro-organisms in a water sample over a period of time, typically five days at a specific temperature, usually, 20⁰c using Electro- Membrane method. The COD was measured using Titrimetric method while the TCC were determined using the Spread Plate method.

2.3: IMPORTANT THEORITICAL CONCEPTS AND CALCULATIONS

2.3.1. THE CORRECTNESS OF THE PHYSICO - CHEMICAL ANALYSIS.

The correctness of analysis of these water resources is ascertained by ensuring that the equality of sum of the cations and anions expressed in terms of Milliequivalents per litre in order to satisfy the principle of Electroneutrality. In a nutshell, below are the steps:

- i. Determine the molecular weight (Mol. Wt.) of each ion.
- ii. Find the ionic valency
- iii. Divide the Mol. Wt by the corresponding valency to obtain the Mg/M_{eq} (ie Mass/Milliequivalents).
- iv. Divide the concentration of each ion by Mg/M_{eq} to obtain the Milliequivalent per litre (Meq/L).
- v. It is important to note that the analysis is correct if:

$$\left(\frac{Meq}{L_C}\right)_i = \left(\frac{Meq}{L_A}\right)_j \quad \text{That is} \quad \sum_{i=1}^{N_C} = \sum_{j=1}^{N_A} \quad (1)$$

Where N_C and N_A are the number of cations and anions respectively. However, the two cannot be equal because of the presence of some undetectable elements or compounds.

- vi. Therefore, the analysis is accepted or rejected if the percentage of the ratio of the difference to the sum of the total Meq is less than or greater than 3% respectively.

2.3.2. CALCULATIONS OF TA, TH, AND TDS

- i. Total Alkalinity [TA] is calculated as follows: TA = Meq/L of HCO₃⁻ x Equivalent Wt. of CaCO₃ (2)
- ii. Total Hardness [TH] = Hardness caused by Ca²⁺ and Mg²⁺ = (Ca²⁺ + Mg²⁺) x Equivalent wt. of CaCO₃ (3)

$$\text{Total Dissolved Solids [TDS]} = \text{Cation Conc.} + \text{Anions Conc. (Expressed in Mg/L)} \quad (4)$$

III. RESULTS AND DISCUSSION

3.1. RESULTS PRESENTATION

3.1.1. THE RESULTS OF PHYSICO - CHEMICAL AND BIOLOGICAL ANALYSIS FOR RIVER OTAMIRI AND ONE SELECTED BOREHOLE WATER RESOURCES SAMPLING

The results of the Physico - Chemical and Biological analysis obtained for the River Otamiri and one selected borehole located in FUTO Community in Owerri West L.G.A of Imo State, Nigeria are presented in Table 1.

Table 1: Presentation Of Results Of Physico-Chemical And Biological Analysis For River Otamiri And One Selected Borehole In FUTO Community

S/NO	WATER RESOURCES PARAMETERS UNDER ANALYSIS				SAM PLE	RIVER OTAMIRI		BOREHOLE
						UPSTREAM	DOWNSTREAM	
	PHYSICO - CHEMICAL			BIOLOGICAL				
	CATIONS	ANIONS	pH					
1	Ca ²⁺ [Mg/L]				A	5.89	5.89	5.05
					B	5.89	5.89	5.05
					AV	5.89	5.89	5.05
2	Mg ²⁺ [Mg/L]				A	27.09	19.53	11.97
					B	27.09	20.16	11.97
					AV.	27.09	19.85	11.97
3	Na ⁺ [Mg/L]				A	7.38	6.43	7.95
					B	7.33	6.43	7.90
					AV.	7.34	6.43	7.93
4	K ⁺ [Mg/L]				A	4.00	3.33	2.67
					B	3.83	3.16	2.33
					AV.	3.92	3.25	2.50
5		HCO ₃ ⁻ [Mg/L]			A	5.99	6.99	4.99
					B	6.99	6.99	4.99
					AV.	6.49	6.99	4.99
6		Cl ⁻ [Mg/L]			A	23.99	25.99	12.00
					B	23.99	25.99	12.00
					AV.	23.99	25.99	12.00
7		NO ₃ ⁻ [Mg/L]			A	9.96	10.06	4.86
					B	9.94	10.04	4.86
					AV.	9.95	10.05	4.86
8		SO ₄ ²⁻ [Mg/L]			A	27.64	20.53	6.05
					B	27.89	20.79	5.79
					AV.	27.77	20.66	5.92
9			pH		A	8.60	8.50	8.70
					B	8.60	8.50	8.70
					AV.	8.60	8.50	8.70
10				DO [Mg/L]	A	7.80	9.70	9.00
					B	7.80	9.70	8.90
					AV.	7.80	9.70	8.95
11				BOD [Mg/L]	A	2.90	4.40	3.50
					B	2.90	4.30	3.50
					AV.	2.90	4.35	3.50
12				COD	A	576.00	176.00	432.00

				[Mg/L]	B	576.00	176.00	432.00
					AV.	576.00	176.00	432.00
13				TCC [cFu/mL]	A	NG	NG	NG
					B	4×10^{-3}	3×10^{-3}	NG
					AV.	NSG	NSG	NG

3.1.2. CHECKING THE ACCURACY OF THE PHYSICO - CHEMICAL ANALYSES

Using the average values, the accuracy of Physico-Chemical Analyses is demonstrated in Table 2 for the borehole water sample in FUTO Community.

Table 2: Checking the Accuracy of the Physico–Chemical Analysis of One Selected Borehole Sample in FUTO Community

CATIONS	CONC. (Mg/L)	Mg/Meq	Meq/L	ANIONS	CONC.(Mg/L)	Mg /Meq	Meq/L
Ca ²⁺	5.05	20	0.25	HCO ₃ ⁻	4.99	61	0.08
Mg ²⁺	11.97	12.2	0.98	Cl ⁻	12.00	35.5	0.34
Na ⁺	7.93	23.0	0.34	NO ₃ ⁻	4.86	62	0.08
K ⁺	2.50	39.1	0.06	SO ₄ ²⁻	5.92	48	0.12
Total	27.45		1.63		27.77		0.62

Note: The above table is obtained as follows:

- For calcium ion, Ca²⁺
 - Mg/Meq = Mol.Wt / ionic valency = $40/2 = 20$
 - Meq/L = Conc. / (Mg/Meq) = $\frac{\text{Mg/L}}{\text{Mg/Meq}} = 5.05 / 20 = 0.25$
- For Mg²⁺, $\frac{\text{Mg/L}}{\text{Mg/Meq}} = 11.97 / 20 = 0.98$
- All other ions are calculated in the same manner and are presented in Table 2
- Then the Total Meq/L for the Cations is

$$\left[\frac{\text{Meq}}{\text{Lc}} \right]_i = \sum_{i=1}^4 0.25 + 0.98 + 0.34 + 0.06 = 1.63$$

5. And the Total Meq/L for the Anions is :

$$\left[\frac{\text{Meq}}{\text{LA}} \right]_j = 0.08 + 0.34 + 0.08 + 0.12 = 0.62$$

6. Based on Eqn.(1) , the correctness of the analysis is ascertained thus :

$$\text{The difference between the two ions is } 1.63 - 0.62 = 1.01 < 3$$

Thus, the result of the analysis is accepted for the borehole . The results are also accepted for both the upstream and downstream sections of River Otamiri as shown in Table 3

3.13. CALCULATING THE VALUES OF TA ,TH AND TDS

Using the borehole as a case study:

a. Total Alkalinity (TA)

From Eqn.(2):

$$\text{TA} = \text{Meq/L of HCO}_3 \text{ * equivalent wt. of CaCO}_3$$

Where Equivalent weight of $\text{CaCO}_3 = 100/2 = 50 \text{ Mg/Meq.}$

Therefore, $\text{TA} = 0.08 \times 50 = 4.0 \text{ Mg/L as CaCO}_3$

b. Total Hardness (TH)

From Eqn.(3)

$\text{TH} = \text{Hardness caused by } \text{Ca}^{2+} \text{ and } \text{Mg}^{2+}$
 $= (\text{Ca}^{2+} + \text{Mg}^{2+}) \times \text{Equivalent Wt. of } \text{CaCO}_3 = (0.25 + 0.98) \times 50 = 61.5 \text{ Mg/L as CaCO}_3$

c. Total Dissolved Solids (TDS)

From Eqn.(4)

$\text{TDS} = \text{Cations Conc.} + \text{Anions Conc. (expressed in Mg/L)} = 27.45 + 27.77 = 55.22 \text{ Mg/L.}$

For the rest, the final results of Physico –chemical analysis of the water resources samples are shown in Table 3

Table 3: Final Results of Physico-Chemical and Biological Analysis of One Selected Borehole and River Otamiri in FUTO Community

S/N	O	TYPE OF WATER RESOURCES SAMPLING	Ca ²⁺ Mg/L (NA/ *100- 300)	Mg ²⁺ (50)	N ^a (NA/ *200)	K ⁺ (NA)	H C O ₃ ⁻ (<600)	Cl ⁻ (250)	NO ₃ ⁻ (50)	SO ₄ ²⁻ (NA/ *250)	TA Mg/ LC aCO ₃ O ₃ (NA/*100-500) (200)	TH Mg/LC aCO ₃ (NA/*100-500)	TDS Mg/L CaCO ₃ (500)	pH	D O [M g/ L] (> 7.50)	BOD [Mg/ L] (NA)	C O D [M g/ L] (NA)	TCC [cFu/ ML]
1.		RIVER OTAMIRI	5.89	27.09	7.34	3.92	6.49	23.99	9.95	27.77	5.73	125.75	112.48	8.60	7.80	2.90	576.00	NSG
		DOWNSTREAM	5.89	19.85	6.43	3.25	6.99	25.99	10.05	20.66	5.73	96.08	99.11	8.50	9.70	4.35	176.00	NSG
2.		BOREHOLE	5.05	11.97	7.93	2.50	4.99	12.00	4.86	5.99	4.0	61.5	55.22	8.70	8.95	3.50	432.00	NG

Note: The values in bracket represent WHO Standard. NA implies that no health based guideline value has been derived. * indicate the taste threshold values. NG implies No Growth. NSG implies No Significant Growth.

3.2. RESULTS DISCUSSION

The results of the Physico–Chemical and Biological analysis of the Surface water (River Otamiri) and the one selected Borehole in FUTO Community are depicted in Tables 1 and 3. The observed pH values are 8.60 and 8.50 for the upstream and downstream sections of the river otamiri respectively and 8.70 for the borehole. These values show slight alkalinity for the two water resources under analysis. Again, the TH, the TDS and the TA values fall within the WHO recommended standard except

the TH from the upstream of the River Otamiri that falls within the taste threshold limit. The values recorded for the cations and anions for both water resources sources in FUTO Community fall within the stipulated limits by the WHO. Similarly, the results of the biological analysis show that the values of DO, COD, and BOD parameters are within the WHO recommended standard. From the TCC results, there is no significant growth recommended for the River Otamiri water resources source, but the values recorded for the borehole water showed absolutely no growth scenario. The implication of these results is that the water resources from borehole source are well suited for both drinking and borehole purposes while the water resources from the River Otamiri can only be used for some domestic purposes, but not necessarily for drinking purposes because of the presence of some hardness.

IV. CONCLUSION

So far in this work, the Physico- Chemical and Biological analyses of the water resources samples from FUTO borehole as well as River Otamiri are presented. Samples of these water resources have been analyzed for both drinking and domestic purposes using state of the art tools within the recommended standard of the WHO (2011). The nature and implication of the results obtained are stated in the result discussion section. Thus, it can be concluded that water resources from the FUTO Campus borehole are suitable for both drinking and domestic purposes whereas there may be need for proper treatment of the water resources from River Otamiri before it can be used for both purposes except only for some domestic purposes.

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Nwachukwu, K. C., Igbokwe, S. C., Onyia, C. J., Boniface, O. V., Orji, C. O., Abanobi, A. F., Nweke, E. C., & Kings-Nwachukwu, B. C. (2025). Physico-Chemical and Biological Parameters Assessment of River Otamiri and One Selected Borehole in FUTO Community for Drinking and Domestic Purposes. SK INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH HUB, 12(7), 39–47.
<https://doi.org/10.61165/sk.publisher.v12i7.4>