

Water Temperature Impact Assessment on Aquatic Ecosystem Water Quality in Response to Oxygen Availability - A River Measurement Approach

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ABSTRACT

Water is a liquid substance comprising of hydrogen and oxygen. Dissolved oxygen in water is highly influenced by temperature, which can increase or decrease the oxygen content of water through various reaction processes that alter its quality properties (H₂O), especially with regard to the oxygen in water, which is of paramount concern in this study. Using scientific water measurement and analysis, appropriate to temperature and dissolve oxygen, the water quality was classified with index values, used in studying water quality response manifested from dissolve oxygen due to temperature features, in the aquatic ecosystem. Obtained results showed that during the morning hours, water temperature was 22°C, and, dissolve oxygen was 8.64 mg/L. In the afternoon hours, they were 27°C and 7.90 mg/L, while in the evening hours were 26°C, and 8.02 mg/L respectively. In all, temperature and dissolve oxygen were 25°C and 8.19 mg/L. Quality index were 90 (excellent) in the three periods of the measurement. From all results, the maximum dissolve oxygen was 8.84 mg/L associated to the lowest temperature of 21°C. The minimum dissolve oxygen was 7.16 mg/L, attributed to the highest temperature of 32°C. It was found that temperature below 26°C excellently improve dissolve oxygen which at above 6.9 mg/L (excellently available) improved water quality. It was concluded that, water temperature upon low alters dissolve oxygen in opposite order, and conversely upon high.

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Introduction

The continuous understanding of the resources of the aquatic ecosystem remain paramount to various concerns, calling on water engineering, agencies and the rest, for advance management and conservatory.

Water temperature refers to the measure of heat or cold exhibition of a quantifiable water. Extremeness in water temperature affect aquatic quality, growth, survival, and, distribution of organisms (St-Hilaire *et al.*, 2021), in a habitated ecosystem. Climate change contribute to changing temperatures, identifiably impounding on agriculture (Okolotu *et al.*, 2024), and other spheres. This is because, temperature affect man and his environment directly and indirectly. Presently projected 100 years future global temperatures pose noticeable risks to some aquatic ecosystems, invariably degrading their

services to human population (<https://doi.org/10.1016/B978-0-12-822373-4.00016-1>" title="Loucks, 2021">Loucks, 2021). Loperfido (2014), emphasized that water temperature influence biological attributes like growth rate and habitational suitability, physical features like infiltration and viscosity, physical reactions like gas exchange involving gas - liquid interface, human involvements in aquaculture, navigation, and pattern of recreation, as well as rate of chemical reactions and equilibrium.

Water quality index refers to a standard method of classification used in quantifying cleanliness of water. It involves quantifying the quality of water, mostly using numbers from zero to hundred (0-100). The atmospherical, hydrological, lithological, topographical, and climatical factors are the natural influencers of water quality (Uddin *et al.*, 2018; Uddin *et al.*, 2021). Water quality index for river assessment was introduced in 1960's (Hamlat *et al.*, 2017; Chidiac *et al.*, 2023). Various other indices have been developed since then. According to Hamlat *et al.*, (2017), most water quality indices are modeled in line with the National Sanitation Foundation, otherwise the first water quality index developed. Chidiac *et al.* (2023) identified the most recent water quality index model produced in literature to 2017.

Aquatic ecosystem is a water ecological system where the water environment and the habitated organisms exhibit established interconnectedness with each other. It interlinks the atmospheric ecosystem with terrestrial, as well as easing the exchange of substances (Okeke *et al.*, 2022). The aquatic ecosystem globally contributes about 80% of the planet earth living organisms, making it the largest ecosystem (Batra *et al.*, 2023). Hence, our aquatic ecosystems demand appropriate management, enhanceable through necessary studies and understanding.

Dissolve oxygen refers to oxygen integrated into liquid water, mostly by immersion. It is a requisite for respiration and survival in water. Dissolve oxygen is used by invertebrates and all organisms found in water like most plants and animals, including fishes (Bozorg-Haddad *et al.*, 2021). Respiration and photosynthesis in water contribute to the rate of concentration of dissolve oxygen (St-Hilaire *et al.*, 2021). Dissolve oxygen presence in an aquatic ecosystem signify readily available oxygen in water for various uses. Its adequacy in water bodies points to the oxygen richness of the aquatic ecosystem.

Materials

The area of study was Otu Ogwu section of the Niger river, in Asaba Nigeria, west africa. The location of the study area is presented in the geographical map in figure one (1) below:



Figure 1: Location of the Otu Ogwu, Asaba in Nigeria

Other materials include: water meter with sensing probe, computerized mobile digital set, satellite sensing software, etc.

Methods

The Results obtained water temperature was obtained using measuring thermometer device with probe. Dissolved oxygen was obtained using hydro indicator resource. Water quality index was obtained from the temperature influenced dissolved oxygen values deployed in the hydro indicator. The outcomes were classified based on the water assessment from the index readings.

Results

Results are presented in tables one (1) to four (4), and figures two (2) to four (4) below:

Table 1: Periodic recording between the hours of 9am - 12pm, for water temperature, dissolved oxygen, water quality index, and water quality classification

SN	Month	Water Temperature, T_w ($^{\circ}\text{C}$)	Dissolved Oxygen Level, DO (mg/L)	Oxygen Availability Status in Water	Water Quality Index, WQI	Quality Classification
1	January	23	8.50	Excellent	90	Excellent
2	February	21	8.84	Excellent	90	Excellent
3	March	23	8.50	Excellent	90	Excellent
4	April	24	8.33	Excellent	90	Excellent
5	May	22	8.67	Excellent	90	Excellent
6	June	22	8.67	Excellent	90	Excellent
7	July	21	8.84	Excellent	90	Excellent
8	August	21	8.84	Excellent	90	Excellent
9	September	22	8.67	Excellent	90	Excellent
10	October	22	8.67	Excellent	90	Excellent
11	November	24	8.33	Excellent	90	Excellent
12	December	21	8.84	Excellent	90	Excellent
Total	Annual	266	103.7	Excellent	1080	Excellent
Average	-	22	8.64	Excellent	90	Excellent

Table 2: Periodic recording between the hours of 12pm - 4pm, for water temperature, dissolved oxygen, water quality index, and water quality classification

SN	Month	Water Temperature, T_w ($^{\circ}\text{C}$)	Dissolved Oxygen Level, DO (mg/L)	Oxygen Availability Status in Water	Water Quality Index, WQI	Quality Classification
1	January	28	7.72	Good	90	Excellent
2	February	29	7.58	Good	90	Excellent
3	March	29	7.58	Good	90	Excellent
4	Apri	26	8.02	Excellent	90	Excellent
5	May	23	8.50	Excellent	90	Excellent

6	June	24	8.33	Excellent	90	Excellent
7	July	26	8.02	Excellent	90	Excellent
8	August	28	7.72	Good	90	Excellent
9	September	32	7.16	Good	90	Excellent
10	October	22	8.67	Excellent	90	Excellent
11	November	24	8.33	Excellent	90	Excellent
12	December	32	7.16	Good	90	Excellent
Total	-	323	96.79	-	1080	-
Average	-	27	7.90	Good	90	Excellent

Table 3: Periodic recording between the hours of 4pm - 6pm, for water temperature, dissolved oxygen, water quality index, and water quality classification

SN	Month	Water Temperature, T_w (°C)	Dissolved Oxygen Level, DO (mg/L)	Oxygen Availability Status in Water	Water Quality Index, WQI	Quality Classification
1	January	29	7.58	Good	90	Excellent
2	February	30	7.44	Good	90	Excellent
3	March	26	8.02	Excellent	90	Excellent
4	Apri	26	8.02	Excellent	90	Excellent
5	May	22	8.67	Excellent	90	Excellent
6	June	27	7.87	Good	90	Excellent
7	July	25	8.18	Excellent	90	Excellent
8	August	28	7.72	Good	90	Excellent
9	September	31	7.30	Good	90	Excellent
10	October	21	8.84	Excellent	90	Excellent
11	November	21	8.84	Excellent	90	Excellent
12	December	28	7.72	Good	90	Excellent
Total	-	314	96.2	-	1080	Excellent
Average	-	26	8.02	Excellent	90	Excellent

Table 4: Water temperature, dissolved oxygen, water quality index, and water quality classification

SN	Month	Water Temperature, T_w (°C)	Dissolved Oxygen Level, DO (mg/L)	Oxygen Availability Status in Water	Water Quality Index, WQI	Quality Classification
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1	January	27	7.93	Good	90	Excellent
2	February	27	7.95	Good	90	Excellent
3	March	26	8.03	Excellent	90	Excellent
4	Apri	25	8.12	Excellent	90	Excellent
5	May	22	8.61	Excellent	90	Excellent
6	June	24	8.29	Excellent	90	Excellent
7	July	24	8.35	Excellent	90	Excellent
8	August	26	8.09	Excellent	90	Excellent
9	September	28	7.71	Good	90	Excellent
10	October	22	8.73	Excellent	90	Excellent
11	November	23	8.50	Excellent	90	Excellent
12	December	27	7.91	Good	90	Excellent
Total	-	301	98.22	-	1080	Excellent
Average	-	25	8.19	Excellent	90	Excellent

The water temperature for the measurement periods are presented in figure two (2) below:

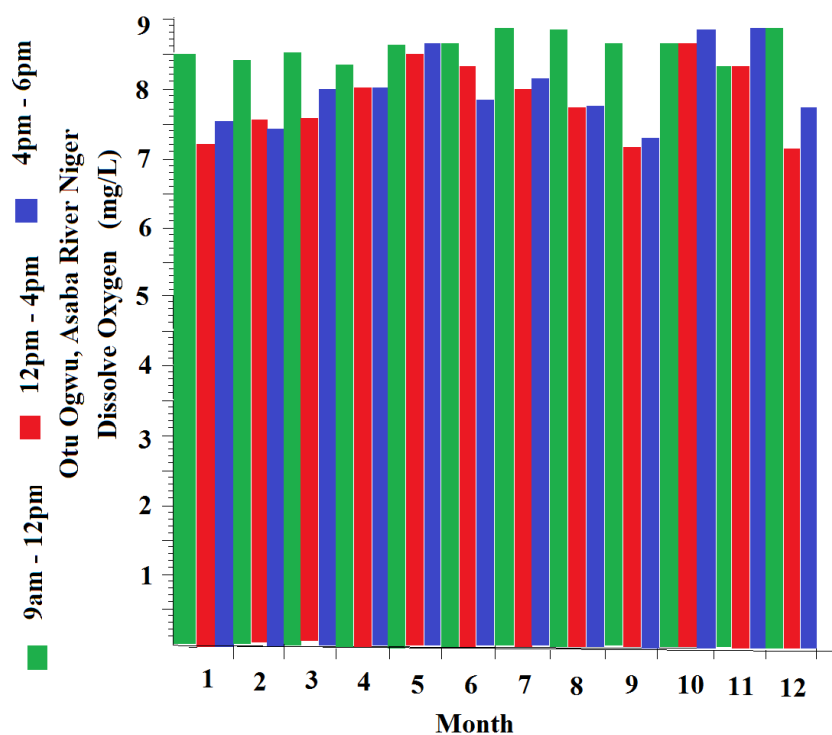


Figure 2: Water temperature for the measurement periods

The dissolve oxygen for the measurement periods are presented in figure three (3) below:

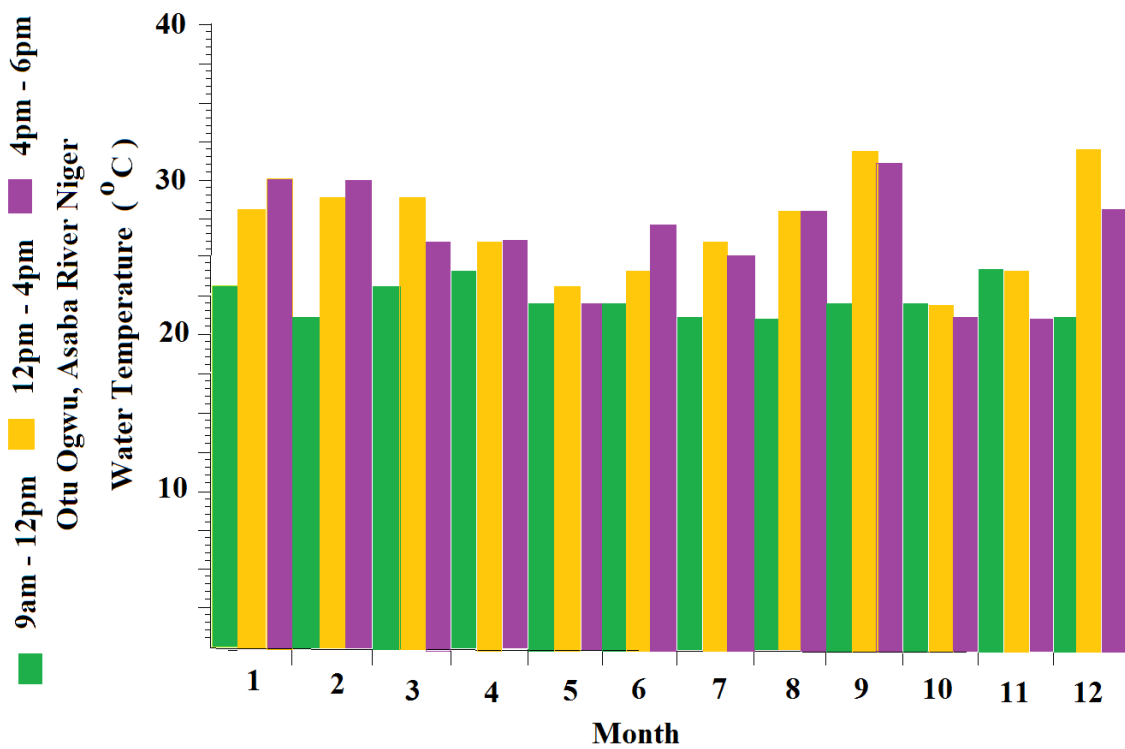


Figure 3: Dissolve oxygen for the measurement periods

The water temperature and dissolve oxygen for the three periods during the river measurement are presented in figure four (4) below;

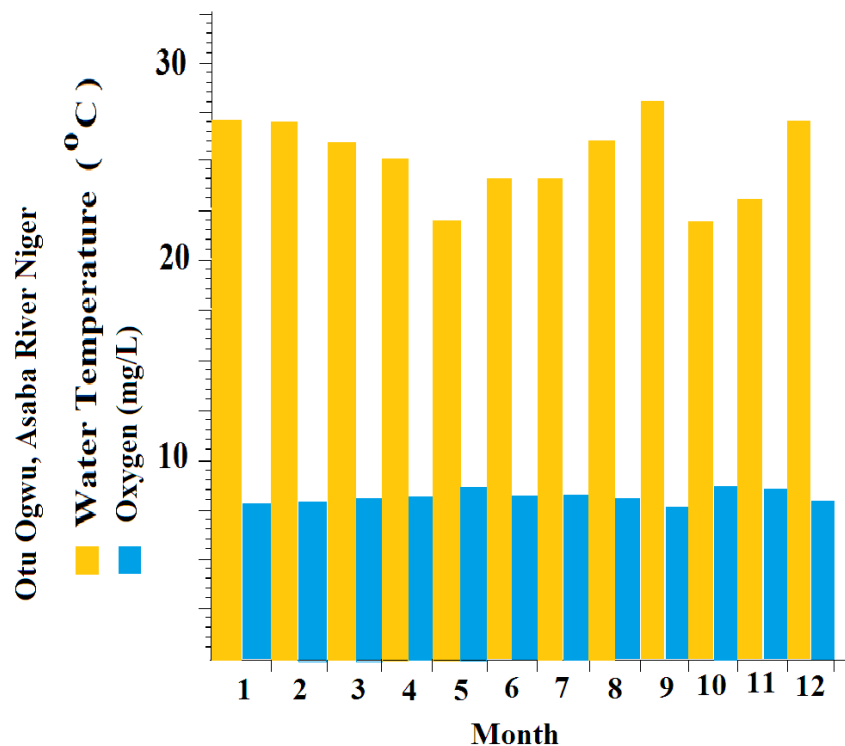


Figure 4: Water temperature and dissolve oxygen for the three periods

Discussion

It was observed that the water oxygen availability status were excellent at temperatures below 27 degree celsius. It was however good above 26 degree celsius. That is, oxygen availability status due to temperature were excellent at <27°C, and good at >26°C. The minimal oxygen level in the water was 7.16 mg/L, associated to high water temperature of 32°C. This minimal oxygen level of 7.16 mg/L, was however possessing good oxygen availability status and even excellent water quality (index) classification, though it only crossed the redline with a very little value of 0.16 mg/L. That is because, it was observed that oxygen availability status changes from 7 mg/L. In other words, <7 mg/L, is associated to not excellent or good, while, >6.9 mg/L, produces excellent water quality classification status.

Conclusion

From results obtained, the maximum dissolve oxygen was 8.84 mg/L, attributed to its lowest temperature of 21°C. This signifies the high oxygen availability in the aquatic ecosystem. The minimum dissolve oxygen was 7.16 mg/L, attributed to its highest temperature of 32°C. In all, temperature and dissolve oxygen were 25°C and 8.19 mg/L. This drew the conclusion that low temperature contribute to high oxygen which contribute to high water quality. On the other hand, high temperature contribute to low oxygen which contribute to low water quality. It was also concluded that temperature impact were positive (excellently good) below 26°C. Within these readings were high values of dissolved oxygen, with very excellent water quality. Moreover, temperature impact above 26°C were still good though with lower dissolve oxygen, with moderate water quality, classifiably good.

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