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Dissolved Oxygen-Based Low-Cost Receptor Model for Rapid Screening of Climate-Driven Freshwater Quality Deterioration

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ABSTRACT

Climate change, such as global warming, has continuously affected freshwater quality, making it one of the most pressing global problems. The scenario is especially severe in low- and middle-income countries due to limited resources to identify pollutant sources and set targeted control measures. Dissolved Oxygen can respond quickly to climate (temperature)-driven water quality deterioration. However, Dissolved Oxygen use as a low-cost, rapid screening method for temperature-driven freshwater quality deterioration remains underexplored due to methodological complexities in isolating temperature effects from other Dissolved Oxygen stressors. This study developed a novel experimental setup in a controlled environment (laboratory), using deionized distilled water aerated with a medical-grade 100% pure oxygen to ascertain the temperature-driven Dissolved Oxygen dynamics, suppressing other confounding Dissolved Oxygen stressors. Linear and segmented regression analysis of Dissolved Oxygen against temperature rise revealed an average Dissolved Oxygen decrease of 0.103 mg/L per unit temperature. Also, Dissolved Oxygen decreased by 0.084 mg/l, 0.068 mg/l, and 0.262 mg/l per unit increase in temperature across temperature ranges of 8-22 ˚C, 23-35 ˚C, and 36-45 ˚C, respectively. It was recommended that the Dissolved Oxygen-temperature regression model should be integrated into rapid screening frameworks for climate-driven water-quality deterioration. The study aligns with SDG 6.3.2 and SDG 13 and contributes to knowledge through a novel experiment.

Keywords: Distilled Water, Temperature, and Water Quality

INTRODUCTION

Freshwater quality deterioration has become one of the most pressing problems of the 21st century, particularly in developing countries. This is exacerbated by the unceasing incidents of climate change (Dahal *et al.,* 2025; Koue, 2025). Increasing air and water temperatures, along with severe or prolonged droughts, are progressively threatening the ecological stability and functional condition of freshwater sources like rivers (Ahmed et al., 2020). For instance, the severe drought of 2003 affected the Rhine and Meuse rivers in Europe, leading to an average increase in water temperature of around 2˚C, decreased Dissolved Oxygen (DO) solubility (Wolff & van Vliet, 2021). The significant change in

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DO has detrimental effects on aquatic life and the overall quality of natural water. In East Africa, algal blooms in some parts of Lake Victoria have been reported to be exacerbated by high temperatures, which deplete DO levels and alter water quality (Griffith & Gobler, 2020). As global temperatures continue to rise, the sensitivity of DO dynamics to climate variability has gained increasing attention, making DO the most vital and immediate indicator of climate-related stress in aquatic systems (Knoll *et al.,* 2025; Ma *et al.,* 2025; Yavuz, 2025).

DO is a fundamental water quality parameter that influences the health and functioning of aquatic ecosystems (Ali et al., 2022; Berry et al., 2023; Qin et al., 2023). Under Sustainable Development Goal 6, Target 3, Indicator 2 (SDG 6.3.2), the international community has recognized DO as a key parameter in water quality monitoring to improve ambient water quality (UN, 2015). Despite its importance, DO has not been thoroughly examined as a low-cost, rapid method for detecting climate-related water quality deterioration. This is because, apart from rising temperature, DO levels in freshwater are also influenced by multiple factors such as physical, biological processes, and other chemical reactions (Breitburg *et al.*, 2018; Deutsch *et al.*, 2024; Garcia-Soto *et al*., 2021; Mahaffey *et al.,* 2020; Rajwa-Kuligiewicz *et al.*, 2015; Woolway *et al*., 2022; Zhang *et al.,* 2015).

Mahaffey et al. (2020) acknowledge that the relative magnitude and net effect of temperature-DO dynamics remain poorly constrained. Highlighting that the distinct impact of temperature on DO dynamics is complex because, as warming reduces oxygen's solubility, biological processes that are not quantified consume DO as well. Mahaffey et al. (2020), argued that while some models sought to address the situation, the capacity of those models to accurately represent DO dynamics remains under debate, given their limited ability to depict biological and physical processes. This condition makes the estimation of the temperature-DO interaction difficult and hence necessitates searching for a novel method to address the gap.

Similarly, the study by Nkwalale *et al*. (2024) highlighted a significant role of temperature in DO dynamics in the lakes. However, it was argued that DO depletion due to rising temperature is complex, partly because the study did not exclude other DO stressors. In fact, many studies (Chapra et al., 2021; Jansen et al., 2024; Johnson et al., 2024; Koue, 2024; Mahaffey et al., 2023; Rajwa-Kuligiewicz et al., 2015) have shown that high temperatures tend to decrease DO levels in water. However, these studies used natural waters with multiple stressors, thereby failing to establish that temperature alone was the sole driver of DO depletion.

Febiyanto (2020) sought to establish the sole temperature-driven DO depletion through a laboratory investigation (in a controlled environment) using a simple water-bath reactor setup. However, Febiyanto (2020) used freshwater collected from the drinking water supply system and then aerated it with a commercial aquarium air pump, thereby introducing unknown air quality, which posed a risk of contamination and limited the methodological rigor. So, previous researchers did not establish any conclusive findings.

In a bid to address the gap, this study has developed a novel experimental setup in a controlled environment (laboratory), which uses deionized distilled water aerated with a medical-grade 100% pure oxygen to ascertain the distinct impact of temperature on DO levels. For quality control and assurance, the aerated deionized distilled water (ADDW) was further tested for Electrical Conductivity (EC), salinity, total dissolved solids (TDS), and total coliform (TC) as an indicator organism. ADDW was well stored throughout the experimentation.

MATERIALS AND METHODS

Materials

As indicated in Figure 1, the study materials include tap water (freshwater) that was further distilled, deionised, and aerated. Equipment used included a laboratory glass water distiller (Merit glass water distiller) for preparation of distilled water, an Elgastat Water Deionizer for deionisation of distilled water, and a 10000 ml blue graduated Aspirator Kautex Textron Carboys HDPE with handle 350-84132 (Kautex™ 2000084133) for handling deionised distilled water. Others include 250 ml Pyrex glass bottles for sample handling, 100% purity nine (9) litres of medical-grade oxygen, a TOL-packed 2000 bar medical oxygen cylinder for aerating deionised distilled water, and a Saffire gas flow regulator (Mubex). There is also a Multiparameter (Hach HQ40d) for measuring DO, temperature, salinity, and pH; an EC meter (Hach HQ30d) for measuring water samples' EC; a water bath (Hach 26PC-2) for controlling and maintaining water samples' temperature, M-Endo Agar for total coliform analysis, and a filtration unit for microbial analysis using the membrane filtration method.

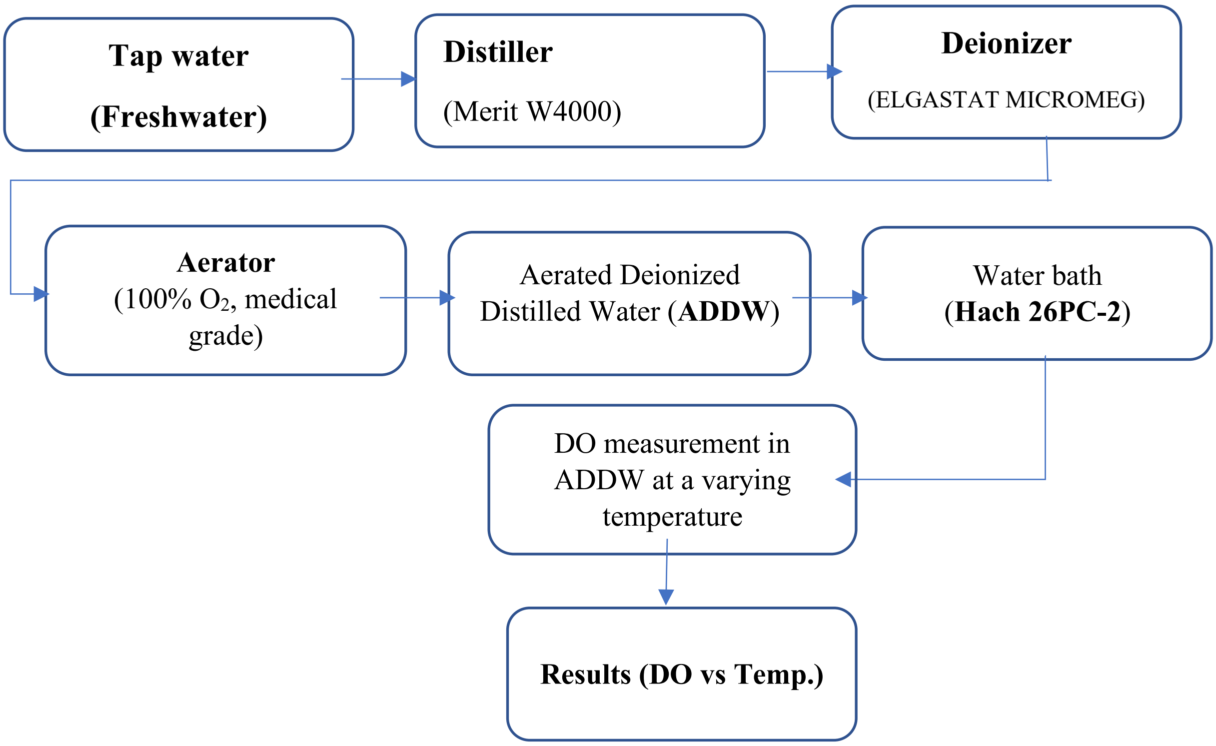

Figure 1: Schematic flow of an experimental setup

Methods

Freshwater was directly collected from the Environmental Engineering Laboratory water tap at Ardhi University. The tap water was passed through the Merit glass water distiller (model W4000) to produce distilled water (distillate). The model W4000 distiller automatically produced distilled water with an electrical conductivity of ≤3 µs/cm. The distillate was then passed through the ELGASTAT MICROMEG deionizer to remove ions and impurities, producing deionised distilled water (DDW). The DDW was stored in the 10000 ml blue graduated Aspirator Kautex Textron Carboys HDPE with handle 350-84132 (Kautex™ 2000084133) for further aeration.

The DDW was aerated by introducing 100% pure medical-grade oxygen from a high-pressure oxygen cylinder through an adjustable Saffire Mubex Single-Stage Oxygen Flow Regulator. This gas flow regulator, which met the EN ISO 2503 pressure standards, provided precise control of oxygen flow and pressure for effective gas transfer into DDW. It is important to note that natural DO saturation at 25˚C and 1 atm (1.01325 bar) is 8.3 mg/L, and increasing oxygen pressure above 1.5 bar could lead to supersaturation, resulting in oxygen degassing (bubble loss). Higher oxygen pressures elevated DO levels, but excessive pressure caused turbulence and gas wastage. The pressure setting on the oxygen flow regulator was critical to optimize gas dissolution while avoiding excessive bubble formation and gas loss. To accomplish this, Henry`s Law of Gases, which states that "the amount of a gas dissolved in a liquid is proportional to the partial pressure of that gas above the liquid," was applied to determine the regulator`s pressure setting, using Equation 1.

$$C = k_H \times P_{O2} \dots\dots\dots\dots\dots\dots\dots\dots \quad (1)$$

Where: C = Dissolved oxygen concentration (mg/L), k_H= Henry's law constant (varies with temperature) and P_{O2}= Partial pressure of oxygen (bar)

Apart from continuously measuring the DO in DDW, Equation 1 facilitated a controlled aeration process, using a desired DO level to set the gas pressure. In this study, 0.5 bar on the Saffire gas regulator effectively controlled the oxygenation of two litres of deionised distilled water within two minutes. The Aerated Deionised Distilled Water (ADDW) was tested for DO, EC, pH, and temperature as baseline data during each experiment.

For quality assurance, ADDW was tested for pH, salinity, and total dissolved solids by using a Hach HQ40d portable multi-parameter meter. The Hach HQ40d supports interchangeable digital IntelliCAL™ probes, enabling simultaneous measurement of water quality parameters, increasing efficiency and flexibility. ADDW was also tested for EC using the Hach HQ30d instrument. The Hach HQ30d is a portable, single-channel water quality meter designed to ensure accurate and reliable EC measurements. It also utilises Hach's IntelliCAL™ digital probes. Furthermore, microbiological water quality was tested for total coliforms (TC) using the membrane filtration method. The M-Endo media was used to determine total coliform, incubated at 35 ± 0.5 ˚C for 24 hours. A triplicate ADDW samples were taken and analysed.

The ADDW was used to investigate DO dynamics by varying temperatures in a controlled environment using a water bath. The 250 ml Pyrex glass bottle was used to handle the ADDW sample for testing. The sample bottles were placed in the water bath (Hach 26PC-2) where the temperature, independent variable (IV), was kept increasing from 8 to 45˚C, and DO levels, dependent variable (DV), were recorded. The water bath's temperature was set to a maximum of 60˚C to facilitate a gradual increase in the sample's temperature. Furthermore, the water bath temperature was continuously monitored with a thermometer to ensure precise, stable conditions during measurements. The DO and water temperature were concurrently monitored. Triplicate (three separate) measurements were conducted for the same ADDW sample to ensure the experiment's accuracy, reliability, and statistical validity. The triplicate DO dynamics measurements were recorded at a temperature range of 8 to 45°C, in which a total of 114 DO and temperature tests were conducted. The DO and temperature values were measured concurrently using a Multiparameter (Hach HQ40d).

Before using it, the multiparameter (Hach HQ40d) was calibrated to ensure accurate DO and other parameter measurements. The DO sensor in the Hach HQ40d was calibrated using an Iodate-Iodide Standard Solution (0.00125 N, equivalent to 10.0 mg/L DO as O_2). As shown in the chemical reactions in Equations 2 and 3, the iodate-iodide (KIO_3 - KI) standard solution undergoes a chemical reaction to produce a precise oxygen concentration. The oxygen produced mimics a known DO level of 10.0 mg/L under controlled conditions, enabling the HQ40D meter to be accurately calibrated.

$$IO_3^- + 5I^- + 6H^+ \rightarrow 3I_2 + 3H_2 \dots\dots \quad (2)$$

$$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-} \dots\dots\dots\dots \quad (3)$$

The chemical reactions (Equations 2 and 3) provide a stable oxygen concentration, useful for DO sensor calibration. The HQ40d was switched on and connected to a dry, clean DO probe. The probe (DO sensor) was rinsed with deionised distilled water to eliminate residual contaminants and shaken off to remove excess water (no cloth to dry it, as lint may affect sensor accuracy). The DO probe was inserted (submerged) into a calibration cup containing the Iodate-Iodide Standard Solution (0.00125 N, 10.0 mg/L O_2) at 20 to 25 ˚C. The HQ40d was navigated to the DO single-point calibration, with 10.0 mg/L selected, corresponding to the standard solution. The probe was left for 2 to 5 minutes for reading stabilisation; measurement was confirmed when the deviation did not exceed 0.2 mg/l. However, where there is a significant deviation above 0.2 mg/L, the HQ40d meter was recalibrated. After the calibration process, the DO dynamics in the deionised distilled water sample were investigated.

Data Analysis

The collected experimental data were analysed using Microsoft Excel for simple linear regression and XLSTAT for segmented linear regression. In this study, simple and segmented linear regression analyses were conducted to provide a comprehensive and insightful understanding of the relationships between temperature and DO. While the simple linear model predicted an average DO level with the overall temperature change, the segmented linear models predicted DO levels at lower, moderate, and higher temperatures.

RESULTS AND DISCUSSION

Aerated Deionised Distilled Water Quality

As shown in the results presented in Table 1, all experiments were conducted using high-purity ADDW with low conductivity less than 3 µS/cm, negligible dissolved solids, and no detectable microbial contamination. The ADDW provides a chemically stable and interference-free medium for controlled experimentation, offering isolated temperature-driven DO variation. The ADDW's average pH was 7.0 to 7.3 at 22˚C, indicating a nearly neutral environment, suggesting the absence or low levels of acidic or basic species. This was considered ideal for experimentation and was frequently monitored to detect any quality changes early.

On the other hand, the ADDW had an average EC value of 2.4 µs/cm, a TDS of 1.4 mg/L, and a salinity of 1.2 ppt, all very low, indicating an extremely low mineral content (akin to pure water). That means ADDW had no or limited amounts of metals, such as iron and manganese, which are also attributed to DO dynamics in water. Absence of minerals and metals makes ADDW ideal for testing the isolated impact of temperature on DO dynamics. Figures 2 to 6 revealed that EC exhibited negligible changes and negligible impacts on DO dynamics.

Total coliforms were not detected in ADDW, corresponding to 0 cfu/100 mL, as reported in Table 1. The absence of coliform bacteria indicated that the water was microbiologically safe, making it free from biological processes that could interfere with DO levels as temperature rises. Apart from experimental requirements, the microbial quality of ADDW also complied with the WHO (2017) guidelines for drinking water specifications.

Table 1: Aerated Deionised Distilled Water Quality

Parameter	Unit	Measured Value	TBS (TZS 789:2018) & WHO 2017
pH	-	7.3	6.5 – 8.5
EC	µS/cm	2.4	1000
TDS	mg/L	1.4	1500
Salinity	ppt	1.2	nm
TC	cfu/100ml	0	Absence

Temperature-Driven Dissolved Oxygen Dynamics

Figures 2 to 6 present the dynamics of DO levels in ADDW driven by temperature without any other confounding stressors, as measured during the experiment. The simple and segmented linear regression analyses revealed that experimental data sets were statistically significant (p-values less than 0.05). The isolated impact of temperature revealed that a unit increase in temperature led to a linear decrease in DO levels of up to 0.096 mg/L, 0.116 mg/L, and 0.127 mg/L per unit increase in temperature in ADDW for experiments 1, 2, and 3, respectively (Figures 2 to 4). The average linear decrease in DO level with average temperature was 0.103 mg/L per unit increase in temperature in ADDW (Figure 5).

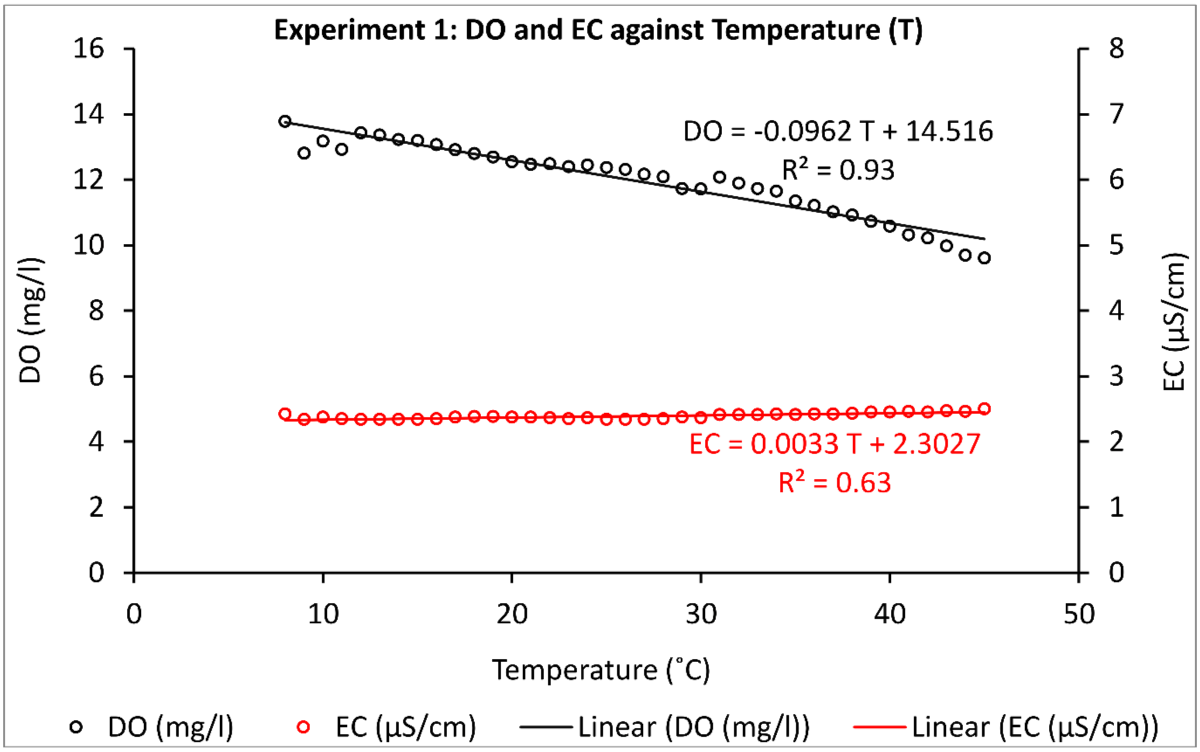

Figure 2: Impact of Temperature on DO-Experiment One

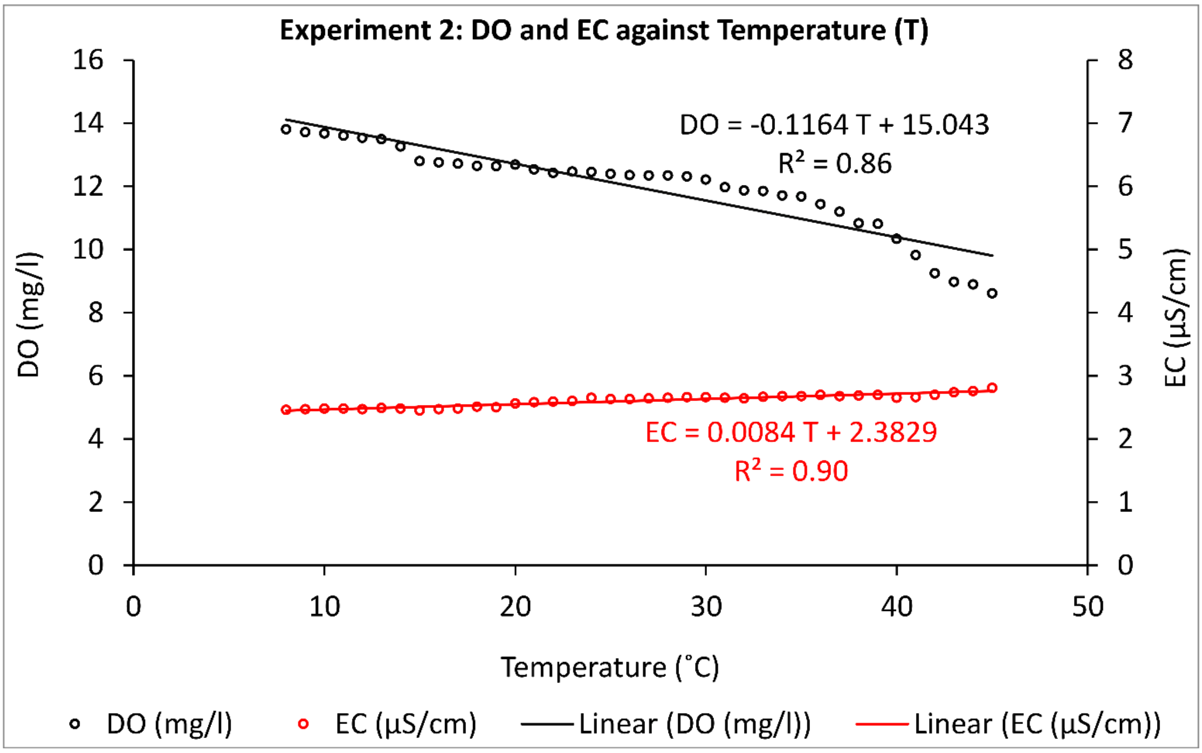

Figure 3: Impact of Temperature on DO -Experiment Two

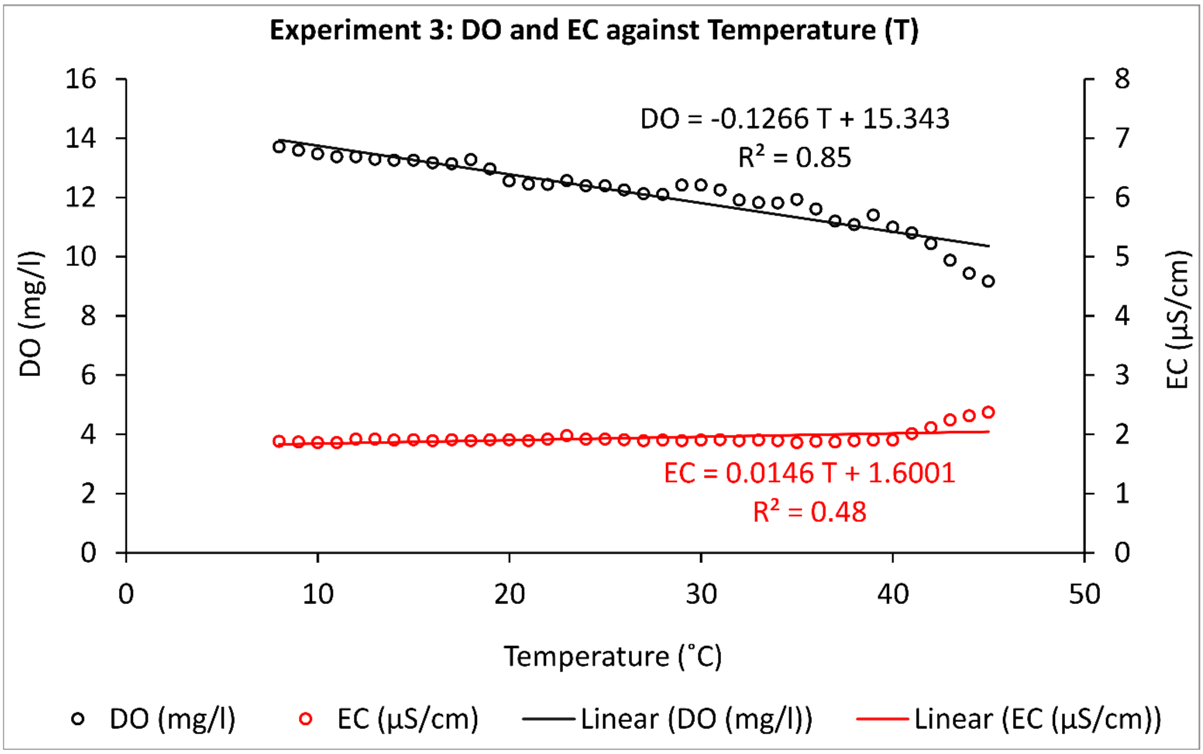

Figure 4: Impact of Temperature on DO-Experiment Three

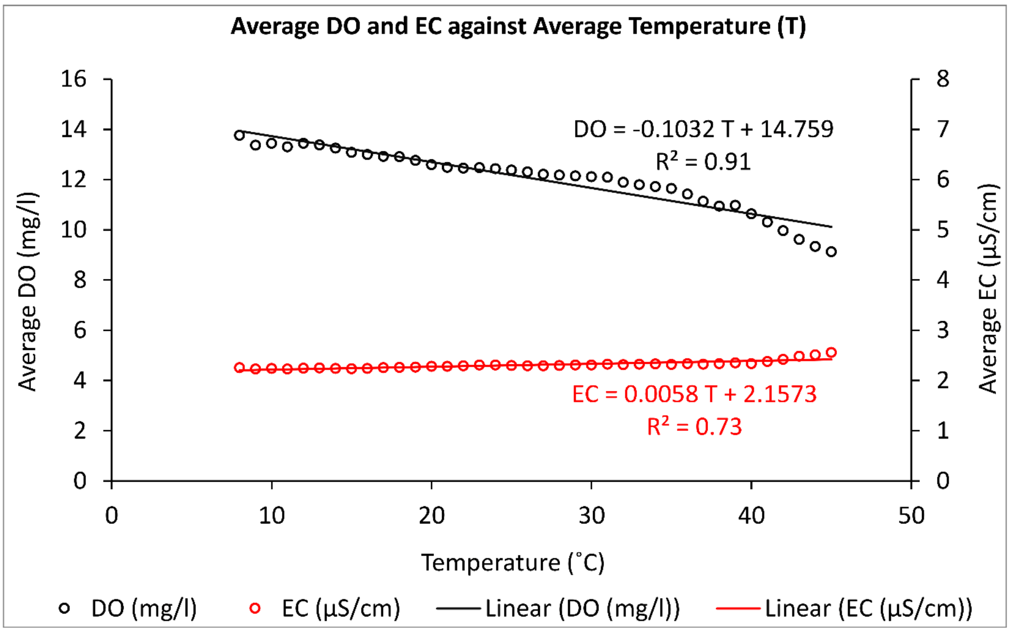

Figure 5: Impact of Temperature on DO -Average of the Three Experiments

Further, the segmented linear regression (at varying temperature gradient) shows that DO depletion was 0.084, 0.068, and 0.262 mg/L per unit temperature increase in ADDW at low temperatures (8-22 °C), moderate temperatures (23-35 °C), and high temperatures (36-45 °C), respectively (Figure 6).

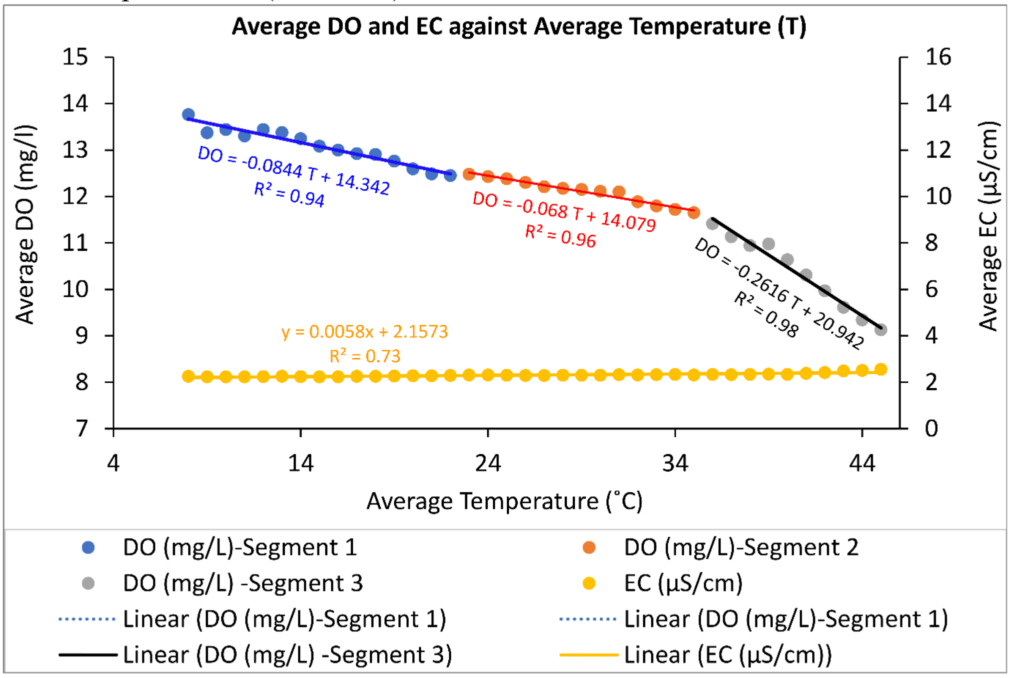

Figure 6: Segmented Regression of the Average Temperature against the Average DO from the Three Experiments

These results demonstrate that while DO levels significantly decreased with rising temperature, electrical conductivity (EC) remained relatively stable (insignificant changes). Figures 2 to 6 indicate that EC exhibited a nearly flat slope, highlighting the successful control of the experimental condition. That means no intrusion of other DO stressors, such as dissolved solids or metals, leaving temperature as the principal, independent stressor on DO dynamics for this study. While EC appears in each experiment, it was not discussed because it was neither a dependent nor an independent variable, only set for experimental quality assurance. Implying that in case significant changes are noticed on EC, that would indicate the possible contamination of ADDW, therefore, call for replacing ADDW. In light of this, since the EC remained below 3 µs/cm throughout the experiment, the discussion has focused on DO against temperature as a central mission of the study.

The findings confirm the inverse relationship between temperature and DO, which has been widely recognized in numerous scientific studies (Zhang et al., 2015; Rajwa-Kuligiewicz et al., 2015; Breitburg et al., 2018; Woolway et al., 2022; Nkwalale et al., 2023; Koue, 2024). Additionally, the findings align with the principle of gas solubility in liquids, indicating that gas solubility decreases as temperature increases. This research has also quantified the extent of temperature's effect on DO, excluding other stressors such as biological and chemical reactions, thereby addressing Mahaffey et al. (2020)'s concern about the difficulty of isolating temperature-driven DO dynamics.

The simple linear relationships in Figures 2 to 5 offer a valuable prediction framework for estimating DO in systems devoid of intricate biochemical interactions, such as pure or low-nutrient environments or laboratory trials, as also highlighted by Mahaffey et al. (2020). Similarly, the segmented linear regression results suggest that the relationship between temperature and DO is nonlinear, with disproportionate oxygen depletion at elevated temperatures (Figure 6). At high temperature ranges (36 to 45˚C), DO depletion was significantly higher (0.262mg/L) as compared to low temperature ranges (8 to 21˚C), which was low (0.084mg/L) per unit temperature increase in ADDW. This is consistent with previous studies indicating that water approaching heat-stress thresholds experiences an accelerated reduction in DO, due, among other factors, to physical stressors such as solubility limitations (Jansen et al., 2024; Johnson et al., 2024). This is especially pertinent for tropical and subtropical freshwater ecosystems, where surface water temperatures may reach or exceed 35°C, rendering them more susceptible to hypoxia and oxygen-depletion events.

The substantial DO depletion at high temperatures indicates that linear models, despite their statistical significance, may underestimate ecological risk under warming conditions. In natural water bodies, where microbial activity and nutrient loading deplete oxygen, interactions with elevated temperatures may synergistically exacerbate DO depletion beyond anticipated linear thresholds (Garcia-Soto et al., 2021; Deutsch et al., 2024). This underscores the role of segmented regression in enhancing the understanding of temperature tipping points for DO depletion across diverse aquatic systems. This is crucial for understanding and managing water quality, as elevated ambient temperatures can intensify hypoxia, threaten aquatic biodiversity, and degrade water quality.

The moderate DO decline of 0.084mg/L per unit of temperature at 8–22˚C reflects typical natural seasonal variability in temperate or cool tropical environments. The further DO decline of 0.068mg/L at 23–35˚C, which matches warm tropical conditions common across Tanzania and East Africa, indicates ongoing sensitivity but with a slight decrease in slope, probably attributed to equilibrium saturation dynamics stabilizing around 30–32°C. Similarly, the sharp increase in the decline rate of DO (0.262mg/L per ˚C) at 36–45˚C signals a threshold at which climate-driven warming results in non-linear worsening of freshwater quality (Jansen et al., 2024). These DO decline patterns per unit of temperature emphasize the usefulness of DO as a quick, inexpensive indicator of climate-related deterioration in freshwater quality, especially when compared to normal DO saturations at a specific temperature. The findings confirm that DO responds strongly and predictably to temperature changes, reinforcing its usefulness as a quick, inexpensive climate-sensitive indicator.

Furthermore, the study findings have significant policy implications. Under SDG 6.3 (Ambient water quality improvement) and SDG 13 (Climate Action), understanding the impact of rising temperatures on DO is essential for developing adaptive water-quality monitoring systems and establishing temperature-dependent water-safety criteria. This is particularly significant for surface freshwater bodies, where shallow depths and limited mixing can exacerbate heat impacts. The long-term monitoring of DO trends in temperate-vulnerable natural water sources can provide early warnings on the pollution load. Given that the magnitude of temperature-derived DO depletion is known, any DO decrease beyond the distinct (isolated) temperature impact indicates the presence of other DO stressors.

CONCLUSION AND RECOMMENDATIONS

Conclusion

Findings reveal a consistent and substantial inverse correlation between water temperature and DO in controlled aquatic environments. Although simple linear regression provides a credible baseline model (average decline of 0.103mg/L/˚C), further data analysis across temperature gradients indicated heterogeneous DO dynamics, driven by a steep decline at elevated temperatures (36 to 45˚C). The findings confirm that DO-based assessment offers a practical, sensitive, and inexpensive method for detecting climate-related deterioration of freshwater quality, supporting its inclusion in routine monitoring programs and early warning systems. This study provides a baseline for understanding how temperature affects net DO dynamics. With known DO saturation in specific temperature ranges, policy and decision-makers can use these findings to predict and address temperature-related impacts by adopting appropriate adaptive measures.

Recommendations

Based on these findings, the following integrated actions are recommended: First, the demonstrated thermal sensitivity of DO justifies its integration as a primary indicator into national water quality monitoring programs and climate policies. This should involve mandating routine, real-time DO monitoring in climate-vulnerable freshwater bodies by installing affordable sensors across diverse climate zones, a strategy that should be formally endorsed within national frameworks like the Water Sector Development Program (WSDP) and the National Climate Change Strategy. A tiered monitoring approach should be adopted, using DO as a rapid, low-cost screening tool to trigger more data-intensive analyses only when DO deviations suggest non-climatic pollution stress. To build comprehensive climate stress profiles, basin institutions must implement protocols for the simultaneous measurement of DO, temperature, salinity, electrical conductivity, and turbidity. These efforts require improved cross-sector coordination, urging water, climate, and pollution control agencies to collaboratively incorporate DO-temperature dynamics into management strategies. Utilizing DO as a quick screening tool will directly accelerate progress toward SDG Indicator 6.3.2 on ambient water quality by detecting early decline, reducing monitoring gaps, and enabling its integration into Early Warning and Early Action systems. Furthermore, the empirical evidence and temperature segments (8–22°C, 23–35°C, 36–45°C) established in this study provide a foundation for developing region-specific, DO-centred rapid screening models. Finally, we encourage the academic community to adopt this novel experimental setup as a standard technique for isolating the impact of specific stressors, such as nutrients and salinity, on DO in future water quality research.

DECLARATIONS

Ethical Approval: Since this study did not include human participants or animal experiments, there was no need for formal ethical approval. All data management and analysis procedures were performed responsibly and in line with standard academic and institutional guidelines.

Declaration of Conflict of Interest: The authors declare that no known conflict of interest or personal relationships exist that could have influenced the work reported in this paper.

REFERENCES

Ahmed, T., Zounemat-Kermani, M., & Scholz, M. (2020). Climate change, water quality and water-related challenges: A review with focus on Pakistan. International Journal of Environmental Research and Public Health, 17(22), 1–22. https://doi.org/10.3390/ ijerph17228518

Ali, B., . A., & Mishra, A. (2022). Effects of dissolved oxygen concentration on freshwater fish: A review. International Journal of Fisheries and Aquatic Studies, 10(4), 113–127. https://doi.org/10.22271/fish.2022.v10.i4b.2693

Berry, K. L. E., Hall, N., Critchell, K., Chan, K., Bennett, B., Mortimer, M., & Lewis, P. J. (2023). Marine Pollution-monitoring, management, and mitigation. In Plastic.

Breitburg, D., Levin, L. A., Oschlies, A., Grégoire, M., Chavez, F. P., Conley, D. J., Garçon, V., Gilbert, D., Gutiérrez, D., Isensee, K., Jacinto, G. S., Limburg, K. E., Montes, I., Naqvi, S. W. A., Pitcher, G. C., Rabalais, N. N., Roman, M. R., Rose, K. A., Seibel, B. A., … Zhang, J. (2018). Declining oxygen in the global ocean and coastal waters. Science, 359(6371). https://doi.org/10.1126/science.aam7240

Chapra, S. C., Camacho, L. A., & McBride, G. B. (2021). Impact of global warming on dissolved oxygen and bod assimilative capacity of the world's rivers: Modeling analysis. Water (Switzerland), 13(17). https://doi.org/10.3390/w13172408

Dahal, D., Bhattarai, N., Silwal, A., Shrestha, S., Shrestha, B., Poudel, B., & Kalra, A. (2025). A Review on Climate Change Impacts on Freshwater Systems and Ecosystem Resilience. 1–25.

Deutsch, C., Penn, J. L., & Lucey, N. (2024). Climate, Oxygen, and the Future of Marine Biodiversity. Annual Review of Marine Science, 16, 217–245. https://doi.org/10.1146/annurev-marine-040323-095231

Febiyanto, F. (2020). Effects of Temperature and Aeration on The Dissolved Oxygen (DO) Values in Freshwater Using Simple Water Bath Reactor: A Brief Report. Walisongo Journal of Chemistry, 3(1), 25. https://doi.org/10.21580/wjc.v3i1.6108

Garcia-Soto, C., Cheng, L., Caesar, L., Schmidtko, S., Jewett, E. B., Cheripka, A., Rigor, I., Caballero, A., Chiba, S., Báez, J. C., Zielinski, T., & Abraham, J. P. (2021). An Overview of Ocean Climate Change Indicators: Sea Surface Temperature, Ocean Heat Content, Ocean pH, Dissolved Oxygen Concentration, Arctic Sea Ice Extent, Thickness and Volume, Sea Level and Strength of the AMOC (Atlantic Meridional Overturning Circula. Frontiers in Marine Science, 8(September). https://doi.org/10.3389/fmars.2021.642372

Griffith, A. W., & Gobler, C. J. (2020). Harmful algal blooms: A climate change co-stressor in marine and freshwater ecosystems. Harmful Algae, 91(May 2019), 101590. https://doi.org/10.1016/j.hal.2019.03.008

Jansen, J., Simpson, G. L., Weyhenmeyer, G. A., Härkönen, L. H., Paterson, A. M., Giorgio, P. A., & Prairie, Y. T. (2024). Climate-driven deoxygenation of northern lakes. Nature Climate Change, 14(August). https://doi.org/10.1038/s41558-024-02058-3

Johnson, M. F., Albertson, L. K., Algar, A. C., Dugdale, S. J., Edwards, P., England, J., Gibbins, C., Kazama, S., Komori, D., MacColl, A. D. C., Scholl, E. A., Wilby, R. L., de Oliveira Roque, F., & Wood, P. J. (2024). Rising water temperature in rivers: Ecological impacts and future resilience. Wiley Interdisciplinary Reviews: Water, 11(4), 1–26. https://doi.org/10.1002/wat2.1724

Knoll, L. B., Fisher, T. J., Vanni, M. J., & Youngblade, E. G. (2025). Long-term Deepwater Dissolved Oxygen Dynamics in a Hypereutrophic Reservoir Following Shifts in Watershed Management and

Lake Warming. Ecosystems, 28(5), 1–18. https://doi.org/10.1007/s10021-025-00996-3

Koue, J. (2024). Assessing the impact of climate change on dissolved oxygen using a flow field ecosystem model that takes into account the anaerobic and aerobic environment of bottom sediments. Acta Geochimica, 0123456789. https://doi.org/10.1007/s11631-024-00711-4

Koue, J. (2025). Assessing the impact of climate change on dissolved oxygen using a flow field ecosystem model that takes into account the anaerobic and aerobic environment of bottom sediments. Acta Geochimica, 44(1), 11–22. https://doi.org/10.1007/s11631-024-00711-4

Ma, B., Dong, F., Peng, W., Liu, X., & Huang, A. (2025). Dynamics of oxygen evolution in a thermally stratified reservoir under climate warming. 1–18.

Mahaffey, C., Hull, T., Hunter, W., Greenwood, N., Palmer, M., Sharples, J., Wakelin, S., & Williams, C. (2023). Climate Change Impacts on Dissolved Oxygen Concentration in Marine and Coastal Waters around the UK and Ireland. MCCIP Science Review, February, 31. https://doi.org/10.14465/2023.reu07.oxy

Mahaffey, C., Palmer, M., Greenwood, N., & Sharples, J. (2020). Impacts of climate change on dissolved oxygen concentration relevant to the coastal and marine environment around the UK. MCCIP Science Review, 2002, 31–53. https://doi.org/10.14465/2020.arc02.oxy

Nkwalale, L., Schwefel, R., Yaghouti, M., & Rinke, K. (2024). A simple model for predicting oxygen depletion in lakes under climate change. 2041. https://doi.org/10.1080/20442041.2024.2306113

Qin, L., Wang, D., Zhang, Z., Li, X., Chai, G., Lin, Y., Liu, C., Cao, R., Song, Y., Meng, H., Wang, Z., Wang, H., Jiang, C., Guo, Y., Li, J., & Zheng, X. (2023). Impact of Dissolved Oxygen on the Performance and Microbial Dynamics in Side-Stream Activated Sludge Hydrolysis Process. Water (Switzerland), 15(11). https://doi.org/10.3390/w15111977

Rajwa-Kuligiewicz, A., Bialik, R. J., & Rowiński, P. M. (2015). Dissolved oxygen and water temperature dynamics in lowland rivers over various timescales. Journal of Hydrology and Hydromechanics, 63(4), 353–363. https://doi.org/10.1515/johh-2015-0041

UN. (2015). Transforming the World: The 2030 Agenda for sustainable development. https://doi.org/10.1201/b20466-7

Wolff, E., & van Vliet, M. T. H. (2021). Impact of the 2018 drought on pharmaceutical concentrations and general water quality of the Rhine and Meuse rivers. Science of the Total Environment, 778, 146182. https://doi.org/10.1016/j.scitotenv.2021.146182

Woolway, R. I., Sharma, S., & Smol, J. P. (2022). Lakes in Hot Water: The Impacts of a Changing Climate on Aquatic Ecosystems. BioScience, 72(11), 1050–1061. https://doi.org/10.1093/biosci/biac052

Yavuz, V. S. (2025). Impact of temperature and flow rate on oxygen dynamics and water quality in major Turkish rivers. 1–16.

Zhang, Y., Wu, Z., Liu, M., He, J., Shi, K., Zhou, Y., Wang, M., & Liu, X. (2015). Dissolved oxygen stratification and response to thermal structure and long-term climate change in a large and deep subtropical reservoir (Lake Qiandaohu, China). Water Research, 75, 249–258. https://doi.org/10.1016/j.watres.2015.02.052