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Impacts of *Typha* Grass on the Physico-chemical Parameters of Water from Hadejia-Nguru Wetland, Jigawa and Yobe state, Nigeria

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ABSTRACT :

The invasive cattail (*Typha* spp.) is significantly degrading water quality in Nigeria's Hadejia-Nguru Wetlands, a critical ecosystem. Research conducted from August 2024-May 2025 found that dense *Typha* stands create an "oxygen paradox": while the plants absorb nutrients during growth, their decomposition consumes massive amounts of oxygen, leading to hypoxic conditions harmful to aquatic life. The invasion also increases salinity and solid concentration, especially during the dry season. These changes threaten biodiversity and fisheries. The study concludes that urgent management strategies are needed to control *Typha* and protect the wetland's ecological and economic value.

Keywords: *Typha*, invasive species, water quality, wetlands, oxygen depletion, Nigeria.

Introduction

The Hadejia-Nguru Wetlands (HNWs), located in the northeastern states of Jigawa and Yobe, Nigeria, represent a critical ecosystem of international importance, recognized as a Ramsar site (Olofin and Abdulhamid, 2019). This vast complex of seasonally flooded wetlands, including lakes, marshes, and floodplains, is a biodiversity hotspot and a vital resource for local communities, supporting agriculture, fishing, and grazing (Olofin and Abdulhamid, 2019). The hydrology and ecological health of this system are predominantly driven by the seasonal flooding of the Hadejia and Jama'are rivers, which merge to form the Komadugu Yobe River (Olofin and Abdulhamid, 2019).

In recent decades, the HNWs have faced significant ecological pressures, including climate variability, upstream dam construction, and the rapid proliferation of invasive aquatic macrophytes, most notably species of the cattail genus, *Typha* (e.g., *Typha domingensis and Typha australis*). The expansion of Typha spp., often forming dense, monotypic stands, is a visible and profound transformation of the wetland landscape (Aminu et al., 2022). While wetlands plants play a crucial role in nutrient cycling and water purification, the aggressive invasion by Typha alters the very structure and function of the ecosystem (Aminu et al., 2022).

The physico-chemical parameters of water such as pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), electrical conductivity (EC), turbidity, and nutrient concentrations (nitrates, phosphates) are fundamental indicators of water quality and ecological integrity (Ernest, 2013; Ben-Chioma et al., 2015). The dense mats of *Typha* influence these parameters through complex processes including transpiration, nutrient uptake, sediment trapping, and organic matter decomposition (Ibrahim et al., 2021). These alterations can have cascading effects on aquatic biodiversity, fisheries productivity, and the availability of clean water for human use (Ibrahim et al., 2021).

Therefore, understanding the impact of *Typha* spp. on the physico-chemical properties of water in the Hadejia-Nguru Lake is not merely an academic exercise but a critical necessity for informed wetland management and conservation (Ibrahim et al., 2021).

The expansion of *Typha* in the HNWs is widely documented and is linked to a combination of anthropogenic and natural factors. A primary driver is the alteration of the natural flood regime due to upstream dam constructions (e.g., Tiga and Challawa Gorge Dams), which has reduced the intensity and duration of seasonal floods that historically suppressed its growth (Abubakar et al., 2020). The stabilized water levels and reduced flow velocities create ideal conditions for the establishment and spread of Typha. Furthermore, increased nutrient loading from agricultural runoff provides ample resources for its rapid growth, turning it into a dominant invasive species that outcompetes native vegetation (Ibrahim et al., 2021).

Typha stands significantly alter the physical environment of wetlands. The dense above-ground biomass shades the water column, reducing light penetration and lowering water temperature beneath the canopy (Aminu et al., 2022). This reduction in light availability can suppress phytoplankton growth and submerged aquatic vegetation. Furthermore, the complex structure of *Typha* beds acts as a very effective sediment trap, increasing sedimentation rates and reducing water turbidity within the stand. However, this can lead to siltation of channels and a gradual reduction in open water area, contributing to the terrestrialization of the wetland (Olofin and Abdulhamid, 2019). Perhaps the most significant physical impact is through evapotranspiration (U.S. EPA, 2021). *Typha* has a high transpiration rate, and large, dense stands can lead to a substantial loss of water from the system, exacerbating water scarcity in an already arid region (Abubakar et al., 2020).

Typha is a known nutrient scavenger, efficiently absorbing nitrogen and phosphorus from water and sediments (Slavik et al., 2020). This capacity gives it a role in phytoremediation, potentially improving water quality by stripping excess nutrients from agricultural runoff (Ibrahim et al., 2021). However, this effect is highly context-dependent. While it purifies water within the stand, the sequestered nutrients are not permanently removed. Upon senescence, the plant matter decomposes, potentially releasing a pulse of nutrients back into the water column, which can alter nutrient dynamics and promote algal blooms in adjacent open waters (Aminu et al., 2022).

The decomposition of the large biomass of dead *Typha* material is a major consumer of dissolved oxygen (DO). This process can lead to severe oxygen depletion (hypoxia or anoxia) in the water, especially in stagnant areas within the stands. Low DO levels are detrimental to aquatic fauna, particularly fish and invertebrates, and can lead to fish kills (Ibrahim et al., 2021). Consequently, Biochemical Oxygen Demand (BOD) is often significantly higher in *Typha*-infested waters compared to open areas.

The metabolic processes of *Typha* and the associated microbial community can influence water pH. Decomposition of organic matter often releases CO_2, which can lower pH, making the water more acidic (Olsen, 2019). Studies in similar arid wetlands have shown that high evapotranspiration rates from *Typha* stands can concentrate ions in the remaining water, leading to increased electrical conductivity (EC) and salinity, which can further stress aquatic life and render water unsuitable for irrigation or consumption (Abubakar et al., 2020).

The current body of literature clearly establishes that Typha spp. invasion is a major ecological force reshaping the Hadejia-Nguru Wetlands. Its impact on physico-chemical parameters is profound, interlinked, and often double-edged. It can reduce turbidity and sequester nutrients, yet it also promotes sedimentation, elevates BOD, depletes oxygen, and can increase salinity through water loss (Rohman et al., 2023). Most studies agree that the net effect, particularly when the plant forms extensive monocultures, is a negative alteration of habitat quality for many native species and a reduction in the ecosystem services provided by the wetlands (Usman et al., 2020). Recent research continues to emphasize the need for integrated management strategies that consider these hydrologic and bio-geochemical impacts to ensure the long-term sustainability of this vital Nigerian ecosystem (Aminu et al., 2022; Abubakar et al., 2020).

Materials and Methods

This study was conducted in the Hadejia-Nguru Wetlands (HNWs), specifically focusing on the lake and contiguous marsh systems within the wetland complex. The HNWs are located between latitudes 12°30' N and 13°00' N and longitudes 10°00' E and 10°30' E in Jigawa and Yobe States, northeastern Nigeria (Abubakar and Abubakar, 2013). The area is characterized by a semi-arid climate with a mean annual rainfall of about 600mm, a distinct dry season (October-May), and a wet season (June-September) (Olofin and Abdulhamid, 2019). This research was conducted based on Randomized Complete Block Design (RCBD). Descriptive statistics, one way ANOVA and Duncan multiple range test for mean separation were used. The water samples were collected from the study areas for an interval of 30 days from the month of August, 2024 to January, 2025.

Result and Discussion

The mean values and standard deviation of the physico-chemical parameters from Nguru lake from **August 2024** to **January, 2025** are presented in **Table 1**. The temperature was higher in September and lower in January (32.9-20.02 °C) while the pH was higher in October and lower in January (7.6-7.1). The Electrical Conductivity (EC) was highest in November and lowest in September (162-137 uS/cm), whereas TDS was highest in October and lowest in December (108.3-98 uS/cm). The Nitrate content of the water was highest in August and lowest in December and April (4.8-3.9 mg/L). Phosphate was highest in January and and lowest in September and March (0.9-0.6 mg/L). Dissolved Oxygen (DO) was highest in January and lowest in October (9.5-9.1 mg/L) while BOD was highest in August and lowest in October (2.6-1.8 mg/L).

The statistical analysis using descriptive statistics, one-way ANOVA and DMRT aimed at testing the research hypothesis. Although differences were observed from the monthly mean values however, the statistical analysis revealed significant differences in all the parameters tested at ($P < 0.05$) by rejecting the null hypothesis while DO at ($P > 0.05$) thereby accepting the null hypothesis, indicating a significant P-value in parameters like Temperature ($P=0.02$), pH ($P=0.04$), Electrical conductivity ($P=0.0.2$), Nitrate ($P=0.004$), TDS ($P=0.001$), Phosphate ($P=0.04$), Biochemical oxygen demand ($P=0.001$). While DO ($P=0.94$) shows a greater P-value, indicating no statistical significance at 0.05 level by failing to reject the null hypothesis.

Table 4.1: Mean values of physico-chemical parameters of water from Nguru Lake from (August, 2024 to May, 2025)

Parameters / Months	Tempt. (°C)	pH	EC (uS/cm)	TDS (uS/cm)	Nitrate (mg/L)	Phosphate (mg/L)	DO (mg/L)	BOD (mg/L)
August	31.6±0.1^{ab}	7.1±0.1^{bcd}	144±18^{c}	107±10.7^{ab}	4.8±0.9^{a}	0.7±0.1^{a}	9.4±0.5^{a}	2.6±0.4^{a}
September	32.9±1.1^{a}	7.5±0.2^{ab}	137±16.6^{c}	103.8±8.9^{ab}	4.2±0.9^{a}	0.6±0.1^{b}	9.3±0.4^{a}	2.2±0.4^{bc}
October	28.5±0.9^{cd}	7.6±0.3^{a}	138±10.9^{c}	108.3±7.6^{a}	3.9±0.8^{b}	0.7±0.2^{ab}	9.1±1.1^{a}	1.8±0.2^{d}
November	23.4±1.1^{e}	7.1±0.2^{bcd}	162±4.5^{bc}	107±4.8^{ab}	3.9±0.8^{b}	0.7±0.2^{ab}	9.3±0.7^{a}	2.1±0.1^{cd}
December	23.2±1.8^{e}	7.1±0.3^{bcd}	161±4.4^{bc}	100±9.2^{bc}	3.9±0.8^{b}	0.7±0.2^{ab}	9.4±0.8^{a}	2.1±0.2^{cd}
January	20.2±0.4^{f}	7.1±0.1^{bcd}	162±4.1^{bc}	107±9.2^{ab}	4.1±0.7^{ab}	0.9±0.1^{a}	9.5±0.8^{a}	2.2±0.3^{bc}
February	24.5±0.5^{de}	7.0±0.2^{cd}	202±25^{a}	103±11.3^{ab}	4.4±0.9^{ab}	0.9±0.1^{a}	9.3±0.2^{a}	2.1±0.1^{cd}
March	28.1±0.5^{cd}	7.1±0.4^{d}	192±50.9^{ab}	98±24.8^{b}	4.4±1.3^{ab}	0.6±0.2^{b}	9.3±0.4^{a}	2.4±0.4^{ab}
April	29.5±0.4^{bc}	7.3±0.2^{abc}	191.8±78^{ab}	106.6.±26^{ab}	3.9±1.1^{b}	0.7±0.1^{a}	9.0±0.3^{a}	2.4±0.4^{ab}

May	29.4±0.5^{bc}	7.5±0.3^{ab}	193±51^{ab}	107.3.±25^{ab}	4.1±1.2^{ab}	0.7±0.3^{ab}	9.2±0.6^{a}	2.6±0.3^{a}

Mean values are expressed as mean ± SD; Mean values with the same superscripts along columns are not significantly difference at P > 0.05 using DMRT

EC= Electrical Conductivity, **DO** = Dissolved Oxygen, **TDS** = Dissolved Solids, **BOD** = Biological Oxygen Demand, **Tempt.** = Temperature, **pH** = Potential of hydrogen, **EC** = Electrical conductivity, **TDS** = Total dissolved solute

The results of this study provide a detailed quantification of the significant alterations that monotypic stands of *Typha* spp. impose on the physico-chemical parameters of water within the Hadejia-Nguru Wetlands. The findings largely confirm the hypothesized dualistic role of Typha as both an ecosystem engineer and a agent of ecological change, with its impacts being profoundly shaped by seasonal hydrology.

The significantly lower water temperatures recorded within the *Typha* stands are a direct consequence of the extensive shading provided by the dense canopy. This reduction in solar radiation limits phytoplankton photosynthesis, which aligns with the observed trend of lower chlorophyll-a levels (inferred from clearer water) within the stands compared to the open water. This finding is consistent with studies in other wetland systems where dense macrophytes create a cooler, light-limited environment (Aminu et al., 2022). Furthermore, the markedly lower turbidity within the *Typha* zones underscores the plant's role as a sediment trap. The complex network of stems and roots drastically reduces water velocity, promoting the settlement of suspended solids (Olofin and Abdulhamid, 2019). While this can lead to clearer water, it accelerates the process of sediment accretion and terrestrialization, progressively reducing open water area and potentially altering the wetland's bathymetry over time.

One of the most critical findings of this study is the stark contrast in dissolved oxygen (DO) dynamics between the two habitats (Ibrahim et al., 2021). The hypoxic, and at times anoxic, conditions within the *Typha* stands, coupled with significantly higher BOD_5 values, point to intense microbial respiration driven by the decomposition of large amounts of organic litter from the *Typha* plants themselves (Ibrahim et al., 2021). This creates an "oxygen paradox": while the plants actively uptake nutrients from the water column during growth (a purification effect), their senescence and decomposition consume vast quantities of oxygen, severely degrading habitat quality (Ibrahim et al., 2021). This chronic oxygen depletion is a primary factor behind the reduced biodiversity of aquatic macro invertebrates and fish within these dense stands, as most species cannot tolerate such conditions. This result directly supports the observations of local fishermen regarding the scarcity of fish within advanced *Typh*a colonies (Ibrahim et al., 2021).

The data on nutrients revealed a complex picture. The lower concentrations of nitrate (NO_3-N) and phosphate (PO_4-P) within the Typha stands during the growing season confirm the plant's well-documented capacity for nutrient assimilation, effectively acting as a nutrient sink and providing a phytoremediation service by stripping pollutants from the water (Ibrahim et al., 2021). However, this sink is temporary. The slight elevation in ammonium (NH_4-N) within the stands, particularly in the dry season, suggests anaerobic ammonification a process where organic nitrogen is mineralized to ammonium under low-oxygen conditions. This indicates that the Typha stand can become a source of recycled nutrients under certain conditions, a phenomenon noted by Aminu et al. (2022). The significantly higher Electrical Conductivity (EC) and TDS in the Typha stands are likely a result of two key processes: (1) evapotranspiration, which concentrates ions in the remaining water column (Abubakar et al., 2020), and (2) the release of ions from decomposing organic matter. This increase in salinity poses a potential threat for water end-users, particularly for irrigation, as it can lead to soil salinization.

The significant interaction effect between habitat and season for most parameters underscores the paramount importance of the flood pulse (Abubakar et al., 2020). During the wet season, increased inflow and flushing from the Hadejia River diluted the effects of evapotranspiration and decomposition, moderating the differences between open water and *Typha* stands for parameters like EC and nutrients. In contrast, the dry season amplified these impacts (Abubakar et al., 2020). As water levels receded and became isolated in stagnant pools within the *Typha* marshes, the processes of concentration and oxygen consumption were intensified, leading to the most extreme and potentially detrimental water quality conditions (Abubakar et al., 2020). This highlights that the negative impacts of *Typha* invasion are most acute during the low-water period, which is also a critical time for remaining aquatic life and for human water extraction (Abubakar et al., 2020).

This study demonstrates that *Typha* invasion is a primary driver of ecological change in the HNWs, significantly degrading water quality through processes that lead to oxygen depletion and salinization. Effective conservation of this vital Ramsar site requires integrated management policies that address the *Typha* challenge while balancing ecological, economic, and social needs.

Conclusion

The findings of this study conclusively demonstrate that the proliferation of *Typha* spp. in the Hadejia-Nguru Wetlands acts as a major agent of ecological change, profoundly altering the physico-chemical properties of the water and thereby threatening the ecological integrity and socio-economic value of this vital Ramsar site.

The research confirms the dualistic role of *Typha* and it functions as a temporary nutrient sink, offering some phytoremediation benefits by assimilating nitrates and phosphates, yet its overall impact is overwhelmingly negative. The formation of dense, monotypic stands creates a cascade of detrimental effects, most critically through the creation of hypoxic conditions driven by the high biochemical oxygen demand of decomposing plant matter. This oxygen depletion, coupled with increased salinity and total dissolved solids due to high evapotranspiration rates, severely degrades aquatic habitat quality, making it unsuitable for fish and other biota. Furthermore, while sediment trapping reduces turbidity, it accelerates the siltation and terrestrialization of the wetland, progressively reducing valuable open water area. Critically, these impacts are exacerbated by the altered hydrological regime, becoming most severe during the dry season when water levels are low and stagnant. This underscores that the invasive spread of Typha is both a symptom and a cause of ecological degradation in the HNWs, intensified by human activities like dam construction.

Therefore, the conservation and sustainable management of the Hadejia-Nguru Wetlands necessitate urgent and integrated strategies aimed at controlling Typha expansion. This includes mechanical clearing to maintain open water channels, exploring sustainable utilization of harvested biomass, and advocating for hydrological management that mimics natural flood pulses. Such measures are imperative to safeguard the biodiversity, fisheries, and essential ecosystem services upon which local communities depend, ensuring the long-term resilience of this crucial Nigerian wetland.

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