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Preliminary Assessment of the Water Physicochemical Suitability for *Macrobrachium vollenhovenii* in the Ovia River, Edo State, Nigeria

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ABSTRACT

Nutrient overloading and agricultural runoff increasingly threaten inland aquatic biodiversity and capture fisheries. To address this environmental degradation, we assessed the water quality of the Ovia River in Edo State, Nigeria. This is an important habitat to study because it houses the commercially important African river prawn (*Macrobrachium vollenhovenii*). In the study, a synoptic sampling event during the 2024 mid-rainy season across four stations was conducted in order to analyze some physicochemical parameters using standard APHA methods. The data was used to calculate a Physicochemical Suitability Index (PSI) which was done by normalizing the physicochemical data values against the established optimal ranges for the species. A high PSI of 0.83 was recorded. It was found out that physical parameters like temperature ($27.68 \pm 0.38^\circ\text{C}$), pH (7.53 ± 0.13), and conductivity showed exceptional high stability ($\text{CV} < 1.73\%$). The nutrient content was different, it was found high. The standard deviation for nitrate ($1.59 \pm 2.39 \text{ mg/L}$) was found to exceed its mean, having a high Coefficient of Variation ($\text{CV} = 150.31\%$) with a peak concentration of 5.12 mg/L . The PSI demonstrates that overall statistical results can mask localized environmental degradation. The study concludes that the Ovia River serves as an excellent natural template for modeling *M. vollenhovenii* habitats and hatchery systems. The study also showed that the localized nitrate peaks may degrade the habitat quality. To protect the *M. vollenhovenii*, the riverbanks should be cleaned and the water studied across different seasons. This will help with a better Physicochemical Suitability Index (PSI) that will invariably sustain aquaculture.

Keywords: *Macrobrachium vollenhovenii*; Physicochemical Suitability Index (PSI); Aquaculture; Nitrate.

Introduction

Nutrient overloading and agricultural runoff increasingly threaten inland aquatic biodiversity and capture fisheries. The inland waters: lakes, rivers, and wetlands are important in research due to their high

biodiversity. They serve as hotspots for many important aquatic flora and fauna (Convention on Biological Diversity, 2004; Funge-Smith & Bennett, 2018). These ecosystems support significant capture fisheries and aquaculture which are important for food security and livelihoods (Funge-Smith and Bennett, 2018). These water sources are important for irrigated agriculture that will enhance global food production (The World

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Bank, 2017). However, they face severe threats from pollution. Human activities, through runoff from farms, can contain excess nitrogen and phosphorus, which can eventually lead to eutrophication and habitat loss (Pericherla and Varal, 2020).

The Ovia River is an important freshwater in Edo State, Nigeria. It is a vital aquatic ecosystem supporting artisanal fisheries and contains different types of aquatic biodiversity. These includes the commercially valuable African river prawn, *Macrobrachium vollenhovenii* (Oguzie & Ehigiator, 2015). This large palaemonid prawn is recognized across West Africa for its high economic importance in capture fisheries and will be good for aquaculture (Bello-Olusoji, 2004; Udo, 2015). *M. vollenhovenii* is a species known for its adaptability to varying environmental conditions, making it a aquaculture animal, which can also sustain fisheries management, according to Jimoh *et al.* (2017). Studies have shown that this animal species is euryhaline, that is, it has the ability to survive in different levels of water salinity (Marioghae, 1990). Successful cultivation of *M. vollenhovenii* can be achieved when all required parameters needed for survival, growth and breeding are met. If this done, livelihood will be enhanced and the conservation of *M. vollenhovenii* will be possible.

The knowledge on the ecology of *M. vollenhovenii* is still limited in spite of the importance of the ecological and economic importance of the animal. The Ovia River is known to support *M. vollenhovenii* populations, and it is providing good income for riparian communities as well as protein, but detailed understanding of some environmental conditions that drive the habitat suitability and the distribution of this animal is limited (Marioghae, 1990). It has been noted that human activities and environmental changes threaten aquatic biodiversity. Thus, the lack of site-specific data on the prawn's environmental tolerances, importantly,

concerning abiotic factors such as pH and temperature (George *et al.*, 2019), hinders effective conservation and resource management strategies. So, there is an urgent need to define the critical physicochemical level of operations for *M. vollenhovenii* within the Ovia River to inform sustainable fisheries and aquaculture development.

In order to provide the required data that will be useful to both artisanal and large-scale fish farmers to rear *M. vollenhovenii*, the habitat suitability for the animal is important. This will also provide helpful information that will help in managing our waters for local fisheries sustainability which will in turn enhance the livelihoods of the communities which depend on the aquatic resources. This research aims to study the important environmental parameters influencing the distribution and abundance of *M. vollenhovenii* in the Ovia River. The study will also provide information about some of the ecological requirements of this prawn species that will aid sustainable management practices that can later enhance its population and habitat conservation. This study, in conjunction with other texts, is intended to provide a template for culturing *M. vollenhovenii* outside the natural water environment.

Materials and Methods

Study Area and Sampling Design

The study was conducted on a defined segment of the Ovia River (Lat. 05°54'36"N and Lon. 05°16'12"E) in Edo State, Nigeria, with four (4) sampling stations established along approximately 1.0 km. The study was limited to a single, synoptic sampling event conducted during the mid-raining season, 2024.

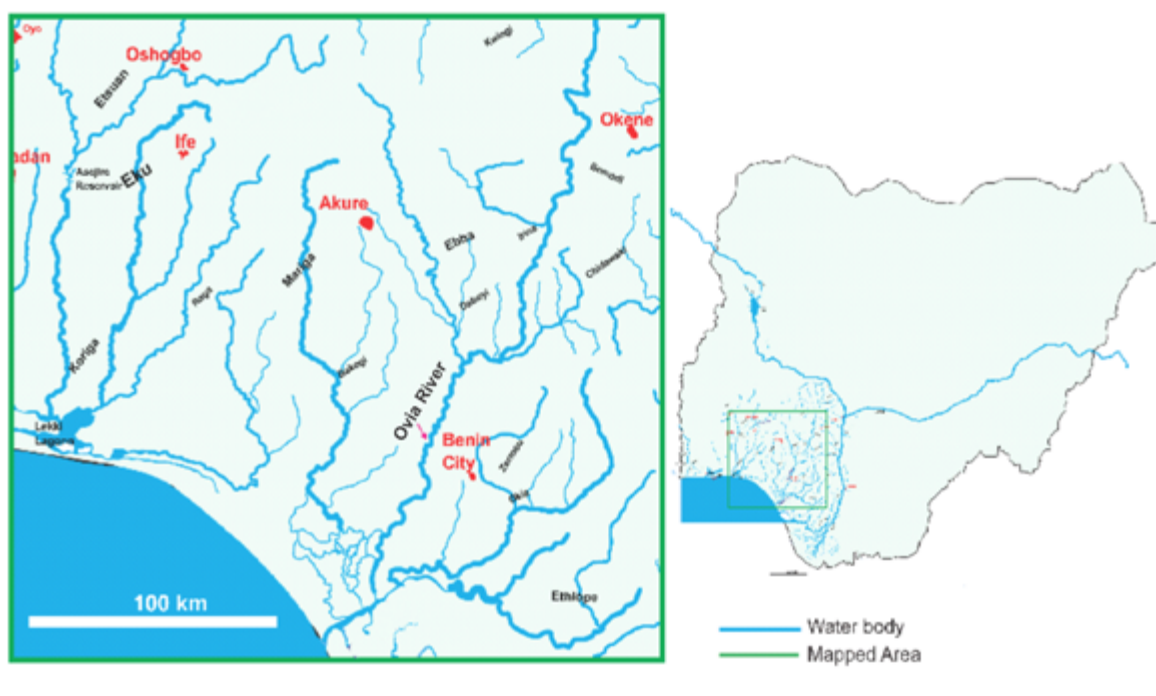


Figure 1: Map of Ovia River among other Southwest Rivers in Nigeria (Source: Adapted from Google Map)

Physicochemical Water Analysis

Water Temperature (°C) was measured *in-situ*. All other parameters were analyzed *ex-situ*. Water samples were stored in an opaque cooler at °C but experienced a transport time of approximately 24 hours before laboratory processing. Analyses were carried out according to APHA (2012).

Prawn Collection and Suitability Index Calculation

A total of 20 specimens of *M. vollehovenii* were collected and reserved for genetic analysis. This collection data was not used for abundance or distribution modeling.

The Physicochemical Suitability Index (PSI) was calculated using an adaptation of the Habitat Suitability Index methodology, which normalizes measured parameters against established optimal ranges for

the species (Hossain and Khan, 2021). The index is calculated as the mean of the individual Suitability Indices (SIB) for *n* measured parameters.

$$PSI = \frac{1}{n} \sum_{i=1}^n SI_i$$

Where SI_i is derived by comparing the measured value (V_i) to the known optimum (V_{opt}) and range (V_{ro}) for *M. vollehovenii* (e.g., Udo, 2015; Jimoh *et al.*, 2017).

Results

The analysis of water samples from Ovia River is summarized in Table 1. The Coefficient of Variation (CV) demonstrates that general parameters like Temperature, pH, and Conductivity were highly stable ($CV < 1.73\%$) when compared with the work of Ogbeibu *et al.* (2014). In contrast, the extremely high CV for Nitrate (150.31%) confirms pronounced

spatial heterogeneity in the nutrient load (Phiri *et al.*, 2005; Rim-Rukeh *et al.*, 2006).

larval and juvenile developmental stages (Dutra *et al.*, 2022).

The spatial patchiness means that habitat suitability in the Ovia River is fragmented (Fahrig, 2003; Schlosser, 1995). While prawns may do well in stable, low-nutrient zones, the localized points with problems of elevated nitrate levels pose serious biological risks. Chronic exposure to high nitrates can impair osmoregulation, disrupt the moulting cycle, and significantly increase mortality rates, particularly during the highly sensitive

Prawns are highly sensitive to sudden thermal or osmotic shocks; therefore, the high stability of temperature and conductivity suggests that the physical environmental condition of the Ovia River does not present immediate physiological stress to *M. vollenhovenii* (Bello-Olusoji *et al.*, 2006; Lawal-Are & Owolabi, 2012).

Table 1: Physicochemical Parameters of the Ovia River Stations During the Mid-Raining Season, 2024 Sampling Event

Parameter	Unit	Mean ± SD	Range (Min - Max)	CV (%)
Temperature	°C	27.68 ± 0.38	27.20 - 28.00	1.37
pH	-	7.53 ± 0.13	7.34 - 7.64	1.73
Conductivity	µS/cm	111.50 ± 1.29	110.00 - 113.00	1.16
BOD	mg/l	2.62 ± 0.42	2.18 - 3.15	16.03
Nitrate (NO ₃ ⁻)	mg/l	1.59 ± 2.39	0.10 - 5.12	150.31
Chloride	mg/l	14.03 ± 3.26	10.28 - 18.29	23.24
Hardness	mg/l	39.53 ± 3.23	35.80 - 42.50	8.17

Physicochemical Suitability Index Calculation

When the Ovia River data was normalized against standard physicochemical water parameters, it gave a Physicochemical Suitability Index (PSI) of 0.83. The score indicates a that the water chemistry and the known physiological requirements of *M. vollenhovenii* are closely aligning (Ukagwu, 2017, Koussovi, 2024).

Discussion

The outcome of this study revealed that most of the physicochemical parameters measured fall withing within the acceptable range when compared with the standard required levels. The calculated PSI of 0.83 also indicates that Ovia River provides a high-quality water template. The mean Temperature (27.68°C) falls within the species’ thermal tolerance range (24°C to 32°C). This condition compares well with that needed for successful *Macrobrachium* culture (Jimoh *et al.*,

2017). The stable pH of 7.53 and low BOD (2.62mg/L) also indicate minimal organic pollution according to Udo (2015). The low Hardness of 39.53mg/L recorded is suspected to have facilitated the osmoregulation and molting processes in the animal (George *et al.*, 2019).

The high coefficient of variation recorded for Nitrate (CV = 150.31%) indicates high concentration. The highest concentration of 5.12mg/L recorded at Station Ovia 1 exceeds the typical NESREA standard, suggesting localized nutrient enrichment which can be linked to human activities on the surrounding land (Pericherla & Varal, 2020).

The observed differences in the Ovia River's nutrient levels (Nitrate CV = 150.31%) become more noticeable when looking at the uneven spread of trees and floating

river plants at the bank of the river (Plate 1). As observed during our fieldwork, parts of the riverbanks were heavily crowded with dense patches of the invasive water hyacinth (*Eichhornia crassipes*). It has been noted that these floating plants act like sponges in tropical rivers and they quickly soak up dissolved nitrogen directly out of the water to grow (Fazal *et al.*, 2018). We also noticed a big shrine where several materials were dropped as sacrifices which eventually will get into the river through runoff. Because of this, the river's nutrients are unevenly spread. Although the grown water plant serves as hiding and feeding spot for *M. vollenhovenii*, their presence in massive quantity quickly depletes the available nutrient too leading to the observed differentiated distribution of nutrients. This could have accounted for the skewed standard deviation of $1.59 + 2.39$ mg/L. This agrees



Plate 1: Picture showing field sampling operations on the Ovia River, Edo State, Nigeria, during the 2024 mid-rainy season. The photograph also shows the use of traditional boat and navigation through the dense riparian vegetation zones and floating macrophyte matrices during our synoptic water quality collection for *Macrobrachium vollenhovenii* habitat modeling.

with what Villamagna and Murphy (2010) found that, when farming waste washes into tropical waters, it causes sharp local changes in the habitat instead of spreading out evenly.

The PSI calculated serves as a pointer to Ovia River potential habitat quality. Nevertheless, the study acknowledges its limitations which is the single synoptic capture of data and the absence of biological abundance data that could prevent the statistical correlation needed for a traditional Habitat Suitability Index.

Conclusion

From the preliminary assessment of the physicochemical parameters of Ovia River, it is resolved that the Ovia River gives a Physicochemical Suitability Index (PSI) of 0.83. This score shows that the water body is a high potential natural template for *Macrobrachium vollehovenii* habitat and a viable model for aquaculture. The study also highlights the critical danger of localized nutrient enrichment as observed in the Nitrate peak. This demands immediate management intervention. Future research should prioritize seasonal monitoring and at the same time evaluate the prawn abundance to validate the PSI and to establish statistically, a definitive Habitat Suitability Index (HIS).

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