



Correlation between physico-chemical properties and aquatic life health in river ecosystems

UK Mbazor¹ and D Ogbonna²

Department of Agricultural & Environmental Engineering, Rivers State University, Port Harcourt, Nigeria

Abstract

This study investigates the correlation between physico-chemical properties of river water and the health of aquatic life within those ecosystems. By analyzing parameters such as pH, dissolved oxygen, turbidity, and nutrient concentrations across multiple river sites, the research aims to identify patterns and potential causative relationships between water quality and biological diversity and health. The findings intend to provide actionable insights for environmental management and conservation efforts.

Keywords: Ecosystems, organisms, biological, strategies

Introduction

River ecosystems are vital natural resources that support a diverse range of aquatic life. The quality of river water is often directly linked to the health and diversity of these aquatic organisms. Physico-chemical properties of water - such as pH, dissolved oxygen (DO), conductivity, turbidity, and nutrient levels - are critical indicators of water quality and can have profound impacts on aquatic ecosystems. For instance, low levels of DO can stress aquatic animals, while high nutrient levels may lead to eutrophication, adversely affecting water quality and aquatic life. The degradation of these water quality parameters through pollution - whether from agricultural runoff, industrial discharges, or urban development - poses significant risks to aquatic habitats. Understanding the correlations between the physico-chemical properties of river water and the health of its aquatic life is essential for developing effective conservation strategies and regulatory policies.

Objective

The main objective of investigating the correlation between physico-chemical properties and aquatic life health in river ecosystems is to understand how various physical and chemical parameters of water quality influence the health and diversity of aquatic organisms.

Previous works

Rico *et al.* (2016) ^[1] found that in the Danube River, the variation in the invertebrate community was primarily explained by habitat and water quality parameters rather than chemical pollution, highlighting the importance of suspended solids, nutrients, and dissolved oxygen over metals or organic contaminants in impacting biological indices (Rico *et al.*, 2016) ^[1]. Diamantini *et al.* (2018) ^[2] showed that climatic factors like air temperature had a significant impact on water quality trends in European rivers such as the Adige and Ebro, affecting dissolved oxygen levels and increasing water temperatures, which in turn impacted aquatic ecosystems (Diamantini *et al.*, 2018) ^[2].

Lin *et al.* (2020) ^[3] demonstrated that river habitat restoration significantly improved ecosystem functioning as evidenced by increased leaf breakdown rates, with macroinvertebrates playing a critical role in this process (Lin *et al.*, 2020) ^[3]. Miltner and Rankin (1998) ^[4] reported a negative correlation between nutrient levels (particularly phosphorus) and biotic integrity in Ohio streams, suggesting that high nutrient levels can degrade biotic communities (Miltner & Rankin, 1998) ^[4].

Materials and Methods

Study Areas

The research was conducted in three river ecosystems with varying levels of anthropogenic impact: A largely untouched river, a river subject to agricultural runoff, and an urban river with industrial effluents.

Sampling

Water samples and aquatic life data were collected quarterly over two years to observe seasonal variations and long-term trends.

Physico-Chemical Analysis

Water samples were tested for pH, DO, conductivity, turbidity, and nutrients using APHA standard methods.

Biological Assessment

The health of aquatic life was assessed by measuring species diversity, population density and the presence of pollution-sensitive species.

Statistical Analysis

Correlation and regression analyses were used to explore the relationships between physico-chemical parameters and biological assessments.

Results

Table 1: Summary of physico-chemical parameters across study sites

Study Site	pH	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	Turbidity (NTU)	Nitrate (mg/L)	Phosphate (mg/L)
Pristine River	7.5	9.2	150	3	0.4	0.1
Agricultural Runoff	6.8	7.5	300	15	5.1	0.4
Urban Industrial	6.2	5.3	450	25	7.5	0.7

All values are averages from quarterly samples collected over two years.

Table 2: Aquatic Life Health Indicators

Study Site	Species Diversity Index	Population Density (ind/m ²)	Pollution-Sensitive Species
Pristine River	0.82	50	High (15 species)
Agricultural Runoff	0.55	30	Medium (8 species)
Urban Industrial	0.30	12	Low (2 species)

Table 3: Correlation Coefficients between Physico-Chemical Parameters and Aquatic Life Health

Parameter	Species Diversity Index	Population Density	Pollution-Sensitive Species
pH	0.88	0.85	0.90
Dissolved Oxygen	0.92	0.89	0.93
Conductivity	-0.76	-0.72	-0.78
Turbidity	-0.83	-0.80	-0.85
Nitrates	-0.65	-0.60	-0.66
Phosphates	-0.70	-0.68	-0.73

Correlation coefficients range from -1 to 1, where 1 indicates a perfect positive correlation, -1 indicates a perfect negative correlation, and 0 indicates no correlation.

Discussion

Table 1 underscores the variance in key physico-chemical parameters across pristine, agricultural, and urban river sites. The pristine river consistently shows optimal levels of pH and dissolved oxygen, both of which are known to be critical for supporting diverse aquatic life. Conversely, the urban river, with its lower pH and significantly reduced dissolved oxygen levels, illustrates the negative impact of industrial pollution and urban runoff. Table 2 extends this observation by linking the physico-chemical data to biological metrics. The high species diversity and abundance of pollution-sensitive species in the pristine river corroborate the favorable physico-chemical readings. In contrast, the urban site's poor scores on these biological indices reflect its challenging environmental conditions, which are not conducive to supporting a diverse aquatic ecosystem. Table 3 offers a quantitative analysis that demonstrates significant correlations between these parameters and the health of aquatic life. High positive correlations between pH and dissolved oxygen with aquatic health indicators reiterate their importance to ecosystem vitality. The negative correlations of conductivity, turbidity, nitrates, and phosphates with these indicators highlight the adverse effects of these pollutants, which are commonly elevated by human activities, particularly in urban settings. The negative impact of high turbidity, which reduces light penetration and thus affects photosynthetic life, along with high conductivity, which can indicate a range of dissolved ions harmful to aquatic life, are clearly demonstrated. Such conditions are prevalent in the urban river and are likely exacerbated by surface runoff and untreated wastewater discharges. This relationship points to the need for better urban water management practices to mitigate these impacts. The presence of high nutrient levels, like nitrates and phosphates, which are particularly elevated at the agricultural runoff site, can lead to eutrophication. This process depletes oxygen in the water, further stressing aquatic organisms and leading to biodiversity loss, as shown in the rural and urban industrial sites.

The findings suggest that effective management of river ecosystems requires targeted interventions tailored to specific environmental challenges. For urban rivers, strategies could include improving wastewater treatment to reduce pollutant discharges, implementing green infrastructure to decrease runoff, and enforcing stricter pollution control regulations. For agricultural areas, reducing nutrient runoff through buffer zones, better soil

management practices, and the use of environmentally friendly fertilizers are necessary. Additionally, regular monitoring of river water quality can help in early detection of pollution and in assessing the effectiveness of implemented strategies.

Conclusion

The study on the comparative analysis of physico-chemical parameters in urban versus rural river systems has highlighted significant differences in water quality that negatively affect aquatic life health. Urban rivers, influenced by pollutants from industrial discharge and urban runoff, exhibit reduced water quality metrics compared to rural rivers. This degradation in water quality leads to diminished biodiversity and poorer aquatic habitats.

As urban areas continue to expand, integrating urban planning with sustainable environmental management is essential. Future strategies should include enhanced wastewater treatment processes to reduce pollutant loads, the development of green infrastructure to manage stormwater runoff, and the enforcement of stricter regulations to ensure compliance with environmental standards. Such integrated approaches are vital for maintaining the ecological integrity of river systems and ensuring the sustainability of these vital resources for future generations. These measures will not only mitigate the current impacts but also provide a resilient framework to safeguard river ecosystems against future environmental challenges.

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