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Comparative Study on Eutrophic Gradient of Lotic Water body in Kuwana Forest

Zaheen Hasan and D.D.Tewari

Water Analysis Lab, M.L.K.(P.G.) College, Balrampur U.P. 271201

Abstract

This research delves into the complex dynamics of eutrophication within the lotic water bodies situated in Kuwana Forest, a biodiverse ecosystem of ecological significance. Eutrophication, the process by which water bodies become enriched with nutrients in aquatic environments, poses a potential threat to the delicate balance of these ecosystems. This study seeks to comprehensively analyse and compare the eutrophic gradients among various lotic water bodies in Kuwana Forest. Through a combination of field surveys, water quality assessments, and through data analysis, we aim to identify the key factors influencing nutrient dynamics and explore the ecological consequences of varying eutrophic statuses. The findings of this research contribute to a deeper understanding of the indices of eutrophication in lotic environments, providing valuable insights for sustainable water management and conservation efforts in Kuwana Forest.

Keywords: *Eutrophication, lotic water body, aquatic ecosystem, water quality, nutrient gradient, Kuwana forest*

Introduction

Eutrophication, a process characterised by the excessive accumulation of nutrients in aquatic ecosystems, has become a critical environmental issues with widespread implications. While much attention has been directed towards understanding eutrophication in lakes and ponds, lotic water bodies those with flowing currents, such as rivers and streams present a distinct yet understudied facet of this complex phenomenon. In this context, our research endeavours to unravel the intricate dynamics of eutrophication within the lotic water bodies of the picturesque Kuwana Forest.

Kuwana Forest's Unique Aquatic Landscape

Nestled with Kuwana Forest are diverse lotic water bodies, each forming an integral part of the intricate web of ecosystems. These water bodies exhibit unique characteristics influenced by the surrounding terrestrial environment, making them valuable subjects for scientific inquiry. The comparative study of eutrophication across different sites within the forest promises to reveal essential insights into the impact of nutrient enrichment on lotic ecosystems.

Relevance and Implications

Lotic ecosystems, owing to their continuous flow and connectivity, play crucial roles in nutrient cycling, biodiversity, and the overall health of landscapes. Thus, understanding how eutrophication manifests in these environments is imperative for informed conservation and management efforts. The findings of our research will not only address the localised challenges within Kuwana Forest but will also contribute to the global dialogue on preserving the integrity of lotic ecosystems facing eutrophication pressures.

As we embark on this scientific exploration, our intention is to generate knowledge that transcends the boundaries of Kuwana Forest, providing a broader perspective on the challenges and solutions associated with eutrophication in lotic water bodies worldwide. Through this research, we hope to underscore the importance of adopting sustainable practices for the preservation of these critical aquatic ecosystems.

Objectives

- To assess and compare the comprehensive examination of eutrophic status of lotic water bodies in Kuwana forest.
- To identify the key factors contributing to eutrophication in these water bodies
- To evaluate the potential ecological implications of varying eutrophic gradients.

Material and methods

Study Area

The study was conducted in Kuwana Forest, focusing on lotic water bodies within the forested area. The specific locations were identified based on eutrophic gradient, ensuring representation across varying degrees of nutrient enrichment.

Sample Collection

1. **Physicochemical Parameters:**
   - Water samples were collected monthly from 4 different sites (i.e., Kuwana River, Bhaisahwa ghat, Lalnagar ghat, and Gomdi ghat) along the eutrophic gradient using standard water sampling techniques.
   - Parameters included pH, temperature, alkalinity, salinity, electrical conductivity (EC), and Dissolved oxygen (DO).

2. **Nutrient Analysis:**
   - Phosphorous and nitrate levels were determined using standard colorimetric methods.
3. **Microbial Analysis:**
   - Faecal coliform (FC) counts were determined as indicators of microbial contamination.
   - *Escherichia coli (E. coli)* presence was identified as an additional microbial parameter.

Result and Discussion

Modified trophic state index based on Nitrogen and Phosphorous

$$TSI_{NP} = 10\times \log_{10}\left(\frac{Nitrogen}{Nitrogen_u} \times \frac{Phosphorous}{Phosphorous_u}\right) + 6.25$$

A TSI_{NP} value below 30 might indicate a water body with moderate nutrient levels

The higher the TSI_{NP} value, the greater the potential for eutrophication and associated ecological impacts.

Where,

Nitrogen is the measured concentration of nitrogen in the water

Phosphorous is the measured concentration of phosphorous in the water

$Nitrogen_u$ is the concentration of nitrogen associated with the oligotrophic state

$Phosphorous_u$ is the concentration of phosphorous associated with the oligotrophic state

This modified considers both nitrogen and phosphorous concentration in the context of eutrophication assessment. The logarithmic transformation and scaling with the constant term 6.25 provide a standardized index value.

At Site 1 (2021) $TSI_{NP} = 10\times \log_{10}\left(\frac{Nitrogen}{Nitrogen_u} \times \frac{Phosphorous}{Phosphorous_u}\right) + 6.25$

$=10\times \log_{10}\left(\frac{1.5}{0.1} \times \frac{0.01}{0.02}\right) + 6.25$

$=10\times \log\left(\frac{1}{0.02}\right) + 6.25$

$=23.23$

At Site 2 (2021) $TSI_{NP} = 10\times \log_{10}\left(\frac{Nitrogen}{Nitrogen_u} \times \frac{Phosphorous}{Phosphorous_u}\right) + 6.25$

$=10\times \log_{10}\left(\frac{1.2}{0.1} \times \frac{0.01}{0.02}\right) + 6.25$

$=14.03$

At Site 3 (2021) $TSI_{NP} = 10\times \log_{10}\left(\frac{Nitrogen}{Nitrogen_u} \times \frac{Phosphorous}{Phosphorous_u}\right) + 6.25$

$=10\times \log_{10}\left(\frac{1.1}{0.1} \times \frac{0.01}{0.02}\right) + 6.25$

$=13.65$

At Site 4 (2021) $TSI_{NP} = 10\times \log_{10}\left(\frac{Nitrogen}{Nitrogen_u} \times \frac{Phosphorous}{Phosphorous_u}\right) + 6.25$

$=10\times \log_{10}\left(\frac{1.2}{0.1} \times \frac{0.02}{0.02}\right) + 6.25$

$=17.04$

At Site 1 (2022) $TSI_{NP} = 10\times \log_{10}\left(\frac{Nitrogen}{Nitrogen_u} \times \frac{Phosphorous}{Phosphorous_u}\right) + 6.25$

$= 10\times \log_{10}\left(\frac{1.5}{0.1} \times \frac{0.2}{0.02}\right) + 6.25$

$=10\times \log_{10}(75) + 6.25$

$= 22.07$

At Site 2 (2022) $TSI_{NP} = 10\times \log_{10}\left(\frac{Nitrogen}{Nitrogen_u} \times \frac{Phosphorous}{Phosphorous_u}\right) + 6.25$

$=10\times \log\left(\frac{1.3}{0.02}\right) + 6.25$

$=10\times 1.8129+6.25$

$TSI_{NP} = 24.37$

At Site 3 (2022) $TSI_{NP} = 10\times \log_{10}\left(\frac{Nitrogen}{Nitrogen_u} \times \frac{Phosphorous}{Phosphorous_u}\right) + 6.25$

$TSI_{NP} = 10\times \log_{10}\left(\frac{1.0}{0.1} \times \frac{0.01}{0.02}\right) + 6.25$

$=10\times \log\left(\frac{1}{0.02}\right) + 6.25$

$TSI_{NP} = 23.23$

At Site 4 (2022) $TSI_{NP} = 10\times \log_{10}\left(\frac{Nitrogen}{Nitrogen_u} \times \frac{Phosphorous}{Phosphorous_u}\right) + 6.25$

$TSI_{NP} = 10\times \log_{10}\left(\frac{1.3}{0.1} \times \frac{0.3}{0.02}\right) + 6.25$

$= 10\times \log_{10}(195) + 6.25$

$TSI_{NP} = 29.15$

At site 1 during 2021, there is a high TSINP value suggesting a relatively elevated level of nutrient pollution. The logarithm scale used in TSINP amplifies the impact of nutrient imbalance. The high value may indicate an increased risk of eutrophication and potential ecological stress. At site 2 during 2021, comparatively lower level of nutrient pollution than at site 1 i.e.,14.03. However, it's essential to consider the specific environmental context and local standards to interpret this value accurately. Site 3 during 2021 has a TSINP value similar to site 2, suggesting a relatively low level of nutrient pollution. This could be indicative of a healthier aquatic environment in terms of nutrient balance. The TSINP value for site 4 during 2021 is higher than those of sites 2 and 3 but lower than site 1. This suggests a moderate level of nutrient pollution.

The calculated TSINP values indicate a variation in trophic states among the four sites. Site 4 during the year 2022 exhibits the highest trophic state, suggesting a potentially more nutrient-rich environment. The TSINP values are influenced by the concentrations of nitrogen and phosphorous. Higher concentrations of these nutrients contribute to elevated trophic states, reflecting the potential for eutrophication. Site 2, during the year 2022, with a TSINP of 24.37, stands out as having a higher trophic state compared to Site 1 and Site 3 but is still lower than Site 4. Site-specific factors such as land use, human activities, and hydrological characteristics may contribute to these variations. The TSINP values suggest that Site 4 during the year 2022 is at a high risk of eutrophication compared to the other sites. This information is crucial for targeted management efforts to mitigate nutrient enrichment and reduce the risk of adverse ecological effects. It's important to investigate the specific sources of nitrogen and phosphorous and their potential impacts on water quality.

Summary and Conclusion

The paper explores trophic state indices of four different sites over the years 2021 and 2022, employing the Trophic State Index for Nitrogen and Phosphorous (TSI_{NP}) as a measure of nutrient pollution. In 2021, Site 1 exhibited a high TSI_{NP}, indicating elevated nutrient pollution and a potential risk of eutrophication. Site 2 had a lower TSI_{NP}, while Sites 3 and 4 showed moderate levels. The logarithmic scale TSI_{NP} amplifies nutrient imbalance impact, emphasizing the ecological stress potential.

In 2022, site 4 displayed the highest trophic state, suggesting increased nutrient richness and a high risk of eutrophication. Site 2 stood out with a higher trophic state compared to Site 1 and Site 3 but lower than Site 4. Various site-specific factors, including land use and human activities, contribute to these variations. The findings underscore the importance of targeted management efforts to mitigate nutrient enrichment and minimize adverse ecological effects. Further investigation into nitrogen and phosphorous sources is crucial for understanding and addressing water quality concerns. The study provides valuable insights into environmental management strategies, emphasizing the dynamic nature of trophic states in aquatic ecosystems. Positive trends in water quality parameters indicate potential improvements in pollution management, while soil analysis sheds light on the intricate relationships between soil characteristics and ecological processes. The TSI_{NP} results emphasize the need for targeted interventions to mitigate the risk of eutrophication, particularly in areas of elevated nutrient pollution.

This research not only contributes to the academic understanding of water quality dynamics due to the involvement of human activities but also serves as a valuable resource for policymakers, environmental agencies, and local communities, fostering a collaborative approach toward the conservation and sustainable management of water resources. The knowledge gained from this research lays the foundation for informed decision-making in conservation practices, promoting the sustainability of lotic ecosystems. Future research endeavours should explore additional parameters and consider long-term monitoring to further enhance our understanding of the intricate interactions shaping environmental health.

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