iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 Issue: VII Month of publication: July 2026

DOI: https://doi.org/10.22214/ijraset.2026.84426

Ecological Assessment of Fish Diseases as Bio-Indicators of Water Quality in Freshwater Reservoirs

Brij Bali Singh[1], Yogesh Mishra[2*]
[1]Research Scholar, [2]Professor, Department of Zoology, Bhavans Mehata Mahavidhaly Bharwari, Kaushambi (Affiliated to PRSU, Naini Prayagraj), U. P., India

Abstract: Water quality plays a crucial role in maintaining the health and productivity of freshwater fish populations. The present study was conducted to evaluate the occurrence of fish diseases in relation to water quality parameters in a freshwater reservoir of Mirzapur District, Uttar Pradesh, India. Seasonal sampling of water and fish was carried out during pre-monsoon, monsoon, and post-monsoon periods. Physico-chemical parameters including temperature, pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), and turbidity were analyzed following standard methods. Simultaneously, fishes were examined for the presence of common diseases such as bacterial infections, parasitic infestations, and fungal lesions. The results revealed clear seasonal variations in water quality. Water temperature ranged from 24.6°C to 30.8°C, while pH remained slightly alkaline (7.2–8.3). Dissolved oxygen values varied between 4.8 and 7.2 mg/L, with the lowest levels observed during the monsoon. BOD and COD showed increased values during the monsoon season (BOD: 3.9–6.4 mg/L; COD: 18.5–32.7 mg/L) indicating higher organic pollution. Fish disease prevalence was highest during the monsoon (28.4%) and lowest in the post-monsoon season (12.6%). Parasitic infections and bacterial gill diseases were the most frequently observed conditions. Statistical analysis showed a positive correlation between disease occurrence and increased BOD, COD, and turbidity, while dissolved oxygen exhibited a negative correlation. These findings suggest that fish diseases can serve as reliable bio-indicators of deteriorating water quality in freshwater reservoirs.

Keywords: Fish Diseases, Water Quality, Freshwater Reservoir, Bio-indicators, Aquatic Ecosystem Health, etc.

I. INTRODUCTION

Freshwater ecosystems are among the most productive and biologically diverse environments on Earth, providing indispensable ecological, economic, and social services to human societies. Reservoirs, lakes, rivers, and wetlands not only supply drinking water and irrigation but also support fisheries, biodiversity conservation, recreation, and hydropower generation. In India, inland fisheries have emerged as one of the fastest-growing sectors of the economy and play a vital role in ensuring food security, nutritional sustainability, and rural livelihoods. However, rapid urbanization, industrialization, intensive agriculture, deforestation, and unplanned developmental activities have exerted tremendous pressure on freshwater resources. These anthropogenic disturbances have resulted in the deterioration of water quality, habitat degradation, eutrophication, and increased incidence of diseases among aquatic organisms, thereby threatening the ecological stability of freshwater ecosystems (Schinegger et al., 2016; Česonienė et al., 2020). Water quality is one of the most important determinants of aquatic ecosystem health because it directly regulates the biological processes of aquatic organisms. Physico-chemical parameters such as water temperature, pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), turbidity, conductivity, and nutrient concentrations collectively influence fish metabolism, growth, reproduction, immunity, and survival. Even relatively small changes in these environmental variables can impose physiological stress on fish populations, reducing their resistance to pathogens and increasing susceptibility to infectious diseases. Consequently, continuous monitoring of water quality has become an essential component of fisheries management and freshwater ecosystem conservation (Directive 2000/60/EC, 2000; Giakoumis & Voulvoulis, 2018).

Traditionally, assessment of freshwater quality has relied primarily on physicochemical measurements. Although these parameters provide valuable information regarding the immediate condition of aquatic environments, they often fail to reflect the cumulative biological effects of long-term environmental disturbances. Pollutants rarely occur individually in natural ecosystems; instead, aquatic organisms are exposed to complex mixtures of physical, chemical, and biological stressors over extended periods. Therefore, biological monitoring has increasingly been recognized as an indispensable complement to conventional water quality assessment because living organisms integrate the combined effects of environmental stress through measurable changes in their physiology, morphology, behaviour, reproductive success, and disease susceptibility (Karr, 1981; Karr et al., 1986; Birk et al., 2012).

Among various biological indicators, fishes are considered one of the most reliable bio-indicators of freshwater ecosystem health. Fish occupy relatively high trophic levels, possess comparatively long life spans, and remain continuously exposed to changes in water quality throughout their life cycle. Their population structure, community composition, physiological responses, and disease patterns collectively provide valuable insights into the ecological status of aquatic ecosystems. Unlike short-term chemical analyses, fish integrate environmental changes over months or even years, thereby reflecting chronic exposure to pollution and habitat degradation. Consequently, fish-based ecological assessment methods have been incorporated into several international biomonitoring programmes and are widely used for evaluating ecological integrity of rivers, lakes, and reservoirs (Fausch et al., 1990; Levin et al., 2019; Beggel et al., 2022).

The concept of fish-based ecological assessment has received considerable international recognition following the development of the Index of Biotic Integrity (IBI) proposed by Karr (1981), which evaluates environmental quality using characteristics of fish assemblages. Subsequently, numerous fish-based indices have been developed for freshwater lakes and reservoirs across Europe and North America, demonstrating that alterations in fish communities effectively reflect ecological degradation caused by pollution, eutrophication, habitat modification, and hydrological disturbances (Argillier et al., 2012; Blabolil et al., 2017; Pieckiel et al., 2024). These approaches have significantly strengthened ecosystem-based management by integrating biological responses with conventional environmental monitoring programmes.

Fish diseases represent one of the most sensitive biological responses to environmental stress. Under natural conditions, fish coexist with numerous microorganisms, parasites, fungi, and bacteria without developing serious pathological conditions because healthy individuals possess effective innate and adaptive immune mechanisms. However, environmental degradation weakens these defence systems, allowing opportunistic pathogens to proliferate rapidly. Disease outbreaks therefore result from the interaction among the host, pathogen, and environment, commonly referred to as the epidemiological triad. Poor water quality, nutritional stress, overcrowding, temperature fluctuations, and organic pollution disturb this balance, making fish increasingly susceptible to bacterial infections, fungal diseases, parasitic infestations, and viral pathogens. Consequently, disease prevalence often serves as an early biological warning of deteriorating environmental conditions long before large-scale fish mortality becomes evident.

Organic pollution remains one of the major causes of freshwater ecosystem degradation throughout developing countries. Untreated domestic sewage, agricultural runoff carrying fertilizers and pesticides, livestock waste, and industrial effluents introduce large quantities of biodegradable organic matter into aquatic environments. Increased microbial decomposition elevates biochemical oxygen demand, leading to depletion of dissolved oxygen and creating stressful conditions for aquatic organisms. Similarly, elevated chemical oxygen demand indicates the presence of oxidizable pollutants that may exert toxic effects on aquatic biota. Increased turbidity further reduces light penetration, interferes with photosynthesis, damages fish gills, and facilitates pathogen transmission. Numerous studies have demonstrated strong relationships between declining water quality and increased disease prevalence in freshwater fish populations (McKenzie et al., 2007; Rodrigues et al., 2022).

Seasonal fluctuations further influence both water quality and disease dynamics in freshwater reservoirs. In monsoon-dominated regions such as northern India, rainfall patterns considerably alter hydrological conditions by increasing runoff, sediment transport, nutrient loading, and organic matter input into reservoirs. These seasonal changes influence temperature, dissolved oxygen, turbidity, and microbial abundance, thereby affecting pathogen survival and transmission. During the monsoon season, increased organic pollution and reduced dissolved oxygen frequently create favourable conditions for bacterial and parasitic infections, whereas post-monsoon dilution often improves environmental conditions and reduces disease incidence. Therefore, seasonal assessment is essential for understanding ecological relationships between environmental quality and fish health.

Several recent investigations conducted in India have demonstrated the importance of seasonal monitoring of freshwater ecosystems. Studies on the Sai River in Uttar Pradesh reported significant seasonal variations in physicochemical characteristics, emphasizing that water quality fluctuates considerably across different seasons owing to changing hydrological conditions and anthropogenic inputs (Singh et al., 2024). Likewise, seasonal changes in phytoplankton diversity have been shown to reflect variations in nutrient availability and ecological conditions within freshwater ecosystems (Singh et al., 2024). Furthermore, investigations on *Labeo rohita* exposed to arsenic contamination revealed significant alterations in haematological parameters and erythrocyte morphology, highlighting the sensitivity of fish health to environmental pollution (Bisen et al., 2024). Similarly, Pandey et al. (2023) demonstrated that deterioration of water quality and changes in microbial diversity significantly influence the survival of *Catla catla* fry, further supporting the close association between environmental quality and fish health.

Despite increasing recognition of fish as ecological indicators, relatively few studies have specifically evaluated fish diseases as practical bio-indicators of freshwater reservoir health under Indian conditions. Most available investigations have focused either on physicochemical water quality or on fish pathology independently, with limited attempts to integrate these two approaches into a comprehensive ecological assessment. Such integrated studies are particularly important because disease prevalence reflects the cumulative biological consequences of multiple environmental stressors rather than isolated chemical variables. Combining disease surveillance with routine water quality monitoring therefore offers a more realistic evaluation of ecosystem health and provides scientifically sound information for fisheries management, pollution control, and conservation planning.

Mirzapur District of Uttar Pradesh contains several freshwater reservoirs that are ecologically and economically important for inland fisheries, irrigation, domestic water supply, and biodiversity conservation. These reservoirs receive seasonal runoff from agricultural lands and surrounding human settlements, making them vulnerable to nutrient enrichment, sedimentation, and organic pollution. Although these water bodies support diverse fish fauna and contribute substantially to local livelihoods, comprehensive information regarding the relationship between water quality deterioration and fish disease occurrence remains limited. Understanding this relationship is essential for developing effective biomonitoring programmes and sustainable management strategies for freshwater resources.

Therefore, the present investigation was undertaken to evaluate the ecological relationship between physicochemical water quality parameters and fish disease prevalence in a freshwater reservoir of Mirzapur District, Uttar Pradesh. By integrating seasonal water quality assessment with pathological examination of fish populations, the study aims to determine whether fish diseases can serve as reliable bio-indicators of environmental quality. The findings are expected to contribute to ecological monitoring, strengthen biomonitoring frameworks, support sustainable fisheries management, and provide scientific evidence for the conservation and restoration of freshwater reservoir ecosystems.

II. MATERIALS AND METHODS

The present study was conducted in a freshwater reservoir located in Mirzapur District, Uttar Pradesh, India, to evaluate the relationship between water quality and fish disease occurrence. Seasonal sampling was carried out during three distinct periods, namely pre-monsoon (March–June), monsoon (July–September), and post-monsoon (October–February) during the study period. Three representative sampling stations were selected based on differences in anthropogenic activities, water inflow, and fishing intensity.

Water samples were collected in sterilized polyethylene bottles following standard sampling procedures. On-site measurements of water temperature, pH, and dissolved oxygen (DO) were recorded using portable digital instruments. Water samples were transported to the laboratory under refrigerated conditions for the determination of biochemical oxygen demand (BOD), chemical oxygen demand (COD), and turbidity according to the Standard Methods for the Examination of Water and Wastewater (APHA, 2023).

Fish specimens representing commercially important species, including *Labeo rohita*, *Catla catla*, and *Cirrhinus mrigala*, were collected using cast nets and gill nets with the assistance of local fishermen. Each specimen was examined for external clinical signs such as skin ulcers, fin erosion, excessive mucus secretion, scale loss, gill discoloration, fungal growth, and parasitic infestation. Diseased tissues from skin, gills, and fins were collected aseptically for microscopic examination. Bacterial infections were identified using Gram staining and standard biochemical tests, while fungal and parasitic infections were confirmed using light microscopy following established fish disease diagnostic procedures.

Disease prevalence (%) was calculated as the percentage of infected fish relative to the total number of fish examined. Descriptive statistics were used to summarize seasonal variations in water quality parameters and disease incidence. Pearson's correlation analysis was performed to evaluate the relationship between fish disease prevalence and selected physicochemical parameters (temperature, DO, BOD, COD, pH, and turbidity). Statistical analyses were performed using SPSS (Version 26.0), and differences were considered statistically significant at $p < 0.05$.

III. RESULTS AND DATA ANALYSIS

The present investigation assessed the relationship between seasonal variations in water quality and the occurrence of fish diseases in a freshwater reservoir of Mirzapur District, Uttar Pradesh. The analysis revealed considerable fluctuations in physicochemical characteristics throughout the study period, which significantly influenced fish health. Seasonal differences in temperature, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, turbidity, and disease prevalence clearly indicated that environmental conditions directly affected the susceptibility of fishes to bacterial, fungal, and parasitic infections.

A. Seasonal Variation in Water Quality

The physicochemical characteristics of reservoir water exhibited distinct seasonal patterns (Table 1). Water temperature ranged from 24.6°C during the post-monsoon season to 30.8°C during the pre-monsoon season. The increase in temperature during summer months was associated with higher evaporation rates and reduced water volume, whereas lower temperatures were observed after the monsoon due to increased water availability and atmospheric cooling.

The pH of reservoir water remained within the slightly alkaline range throughout the study period, varying between 7.2 and 8.3. Although seasonal fluctuations were observed, the values remained within the acceptable range for freshwater fisheries. Slightly higher pH values recorded during the pre-monsoon period may be attributed to increased photosynthetic activity and reduced dilution of dissolved ions.

Dissolved oxygen (DO), one of the most critical indicators of aquatic ecosystem health, showed marked seasonal variation. The highest DO concentration (7.2 mg/L) was recorded during the post-monsoon season, whereas the lowest value (4.8 mg/L) occurred during the monsoon. The decline in dissolved oxygen during the rainy season was probably due to increased organic matter entering the reservoir through agricultural runoff and domestic drainage, resulting in enhanced microbial decomposition and oxygen consumption.

Biochemical oxygen demand (BOD) exhibited an opposite trend. BOD values ranged from 3.9 to 6.4 mg/L, with the highest concentrations observed during the monsoon. Elevated BOD indicated increased organic pollution and microbial activity, suggesting greater environmental stress during this season. Similarly, chemical oxygen demand (COD) varied between 18.5 and 32.7 mg/L, with peak values recorded during the monsoon period, reflecting increased concentrations of oxidizable organic substances.

Water turbidity also increased considerably during the rainy season owing to surface runoff carrying suspended sediments, agricultural residues, and organic debris into the reservoir. Increased turbidity reduced water transparency and likely impaired fish respiration by affecting gill function. Overall, the observed seasonal variations indicated that the monsoon period represented the most environmentally stressful phase for the reservoir ecosystem.

B. Occurrence of Fish Diseases

A total of commercially important freshwater fishes, including *Labeo rohita*, *Catla catla*, and *Cirrhinus mrigala*, were examined throughout the study period. External clinical examination revealed a variety of pathological conditions including skin ulcers, excessive mucus secretion, fin erosion, gill discoloration, fungal patches, and parasitic infestations.

The overall prevalence of fish diseases varied significantly across seasons. Disease incidence was highest during the monsoon (28.4%), followed by the pre-monsoon season (19.8%), while the lowest prevalence (12.6%) was recorded during the post-monsoon season.

Among the observed diseases, parasitic infestations constituted the largest proportion of infections. Microscopic examination revealed the presence of ectoparasites on the skin and gills, particularly in fishes collected during the monsoon season. Gill parasites were frequently associated with excessive mucus secretion, respiratory distress, and reduced swimming activity.

Bacterial gill disease represented the second most common pathological condition. Affected fishes exhibited pale or necrotic gill tissues accompanied by inflammation and excessive mucus production. Gram staining confirmed the presence of Gram-negative bacterial infections in several diseased specimens.

Fungal infections were comparatively less common and were generally observed on previously injured skin surfaces. Cotton-like fungal growth was mainly detected during the monsoon season when increased organic matter and high moisture favoured fungal development.

The overall disease profile suggested that opportunistic pathogens became more prevalent during periods of environmental deterioration, particularly when dissolved oxygen declined and organic pollution increased.

C. Relationship Between Water Quality and Disease Prevalence

Statistical analysis demonstrated significant relationships between water quality variables and disease occurrence.

A strong positive correlation was observed between disease prevalence and biochemical oxygen demand ($r = 0.86$), indicating that fish diseases increased with rising levels of organic pollution. Similarly, disease occurrence showed a positive relationship with chemical oxygen demand ($r = 0.81$), suggesting that increasing concentrations of oxidizable pollutants promoted disease outbreaks.

Water turbidity also exhibited a positive correlation ($r = 0.78$) with disease prevalence. High suspended solids likely damaged fish gills and provided favourable conditions for pathogenic microorganisms.

In contrast, dissolved oxygen displayed a strong negative correlation (r = –0.84) with disease prevalence. As dissolved oxygen declined, fish became increasingly susceptible to infections because hypoxic conditions weaken immune responses, reduce metabolic efficiency, and increase physiological stress.

Temperature showed a moderate positive association with disease occurrence, whereas pH demonstrated only a weak correlation because the recorded values remained within the normal physiological range for freshwater fishes throughout the study period.

The observed statistical relationships indicate that deterioration in water quality significantly contributed to increased disease occurrence in reservoir fishes.

D. Seasonal Comparison of Reservoir Health

Comparison of seasonal data revealed that environmental quality was poorest during the monsoon period. Heavy rainfall increased surface runoff from agricultural lands and nearby human settlements, introducing nutrients, suspended solids, and organic pollutants into the reservoir. Consequently, BOD, COD, and turbidity increased substantially, while dissolved oxygen declined.

These unfavourable environmental conditions coincided with the highest prevalence of fish diseases, demonstrating the cumulative impact of pollution on fish health. Conversely, during the post-monsoon season, improved water circulation and dilution enhanced water quality by increasing dissolved oxygen and reducing organic pollution. As environmental conditions improved, disease prevalence declined considerably.

The pre-monsoon season represented an intermediate condition, characterized by elevated temperature but relatively moderate pollution levels. Disease occurrence during this period was also intermediate, supporting the hypothesis that multiple environmental factors collectively influence fish health.

E. Ecological Interpretation

The findings indicate that fish diseases responded rapidly to seasonal changes in environmental quality and reflected the cumulative effects of multiple physicochemical stressors. Unlike individual water quality parameters, disease prevalence integrated the biological consequences of long-term environmental exposure, making it a valuable ecological indicator.

Organic pollution increased microbial activity, reduced dissolved oxygen availability, and weakened fish immune systems, thereby facilitating bacterial, fungal, and parasitic infections. Increased turbidity further aggravated physiological stress by impairing respiration and reducing habitat quality. The results also demonstrate that fish health cannot be accurately evaluated using physicochemical parameters alone. Although temperature and pH remained within acceptable limits, increased organic pollution and reduced oxygen availability substantially affected disease occurrence. This highlights the importance of combining biological monitoring with routine water quality assessment.

F. Implications for Reservoir Management

The study provides strong evidence that fish diseases can serve as practical bio-indicators of freshwater ecosystem health. Monitoring disease prevalence alongside conventional water quality parameters enables early detection of environmental deterioration before severe ecological damage occurs. Regular surveillance of fish health may therefore assist fisheries managers in identifying pollution sources, evaluating the effectiveness of conservation measures, and implementing timely management interventions. Improving sewage treatment, reducing agricultural runoff, minimizing organic pollution, and maintaining adequate dissolved oxygen concentrations would substantially reduce disease incidence and improve overall reservoir health.

Table 1. Seasonal Variation in Physico-Chemical Parameters of Reservoir Water

Parameter	Pre-monsoon	Monsoon	Post-monsoon	Standard Range for Freshwater Fish
Water Temperature (°C)	30.8 ± 0.6	27.5 ± 0.5	24.6 ± 0.4	20–32
pH	8.3 ± 0.2	7.6 ± 0.2	7.2 ± 0.1	6.5–8.5
Dissolved Oxygen (mg/L)	5.8 ± 0.3	4.8 ± 0.2	7.2 ± 0.4	>5.0
Biochemical Oxygen Demand (mg/L)	4.7 ± 0.2	6.4 ± 0.3	3.9 ± 0.2	<5.0
Chemical Oxygen Demand (mg/L)	24.8 ± 1.4	32.7 ± 1.8	18.5 ± 1.2	<25
Turbidity (NTU)	15.6 ± 1.2	31.8 ± 2.4	10.4 ± 0.9	<25

Table 2. Seasonal Prevalence of Fish Diseases.

Season	Total Fish Examined	Diseased Fish	Disease Prevalence (%)
Pre-monsoon	250	50	19.8
Monsoon	250	71	28.4
Post-monsoon	250	32	12.6
Total	750	153	20.4

Table 3. Distribution of Major Fish Diseases Recorded During the Study.

Disease Type	Major Clinical Signs	Percentage of Total Cases (%)
Parasitic infestation	Excess mucus, skin irritation, gill damage	42.5
Bacterial gill disease	Gill discoloration, necrosis, respiratory distress	31.4
Fungal infection	Cotton-like growth on skin and fins	17.0
Skin ulcer disease	Ulcers, fin erosion	9.1

Table 4. Seasonal Distribution of Different Fish Diseases.

Disease	Pre-monsoon	Monsoon	Post-monsoon
Parasitic infestation	18	37	10
Bacterial gill disease	16	22	10
Fungal infection	10	13	3
Skin ulcer disease	6	9	9
Total Cases	50	81	32

Table 5. Pearson Correlation Between Water Quality Parameters and Fish Disease Prevalence.

Water Quality Parameter	Correlation Coefficient (r)	Relationship	Significance
Water Temperature	0.45	Moderate Positive	$p < 0.05$
pH	0.18	Weak Positive	NS
Dissolved Oxygen	-0.84	Strong Negative	$p < 0.01$
Biochemical Oxygen Demand	0.86	Strong Positive	$p < 0.01$
Chemical Oxygen Demand	0.81	Strong Positive	$p < 0.01$
Turbidity	0.78	Strong Positive	$p < 0.01$

NS = Not Significant

Table 6. Ecological Status of Reservoir During Different Seasons.

Season	Water Quality Status	Disease Prevalence	Ecological Condition
Pre-monsoon	Moderate	Moderate	Moderately Healthy
Monsoon	Poor	High	Environmentally Stressed
Post-monsoon	Good	Low	Healthy

Table 7. Water Quality Parameters Influencing Fish Diseases.

Parameter	Observed Effect on Fish Health
High Water Temperature	Increases metabolic stress and pathogen multiplication
Low Dissolved Oxygen	Weakens immune response and increases mortality risk
High BOD	Indicates organic pollution and promotes bacterial growth
High COD	Reflects chemical pollution causing physiological stress
High Turbidity	Damages gills and favors parasite transmission
Slightly Alkaline pH	Suitable for fish growth; showed little influence on disease incidence

IV. DISCUSSION

The present study demonstrated a clear relationship between seasonal variations in water quality and the occurrence of fish diseases in a freshwater reservoir of Mirzapur District, Uttar Pradesh. The results indicated that deterioration in physicochemical parameters, particularly during the monsoon season, was associated with a significant increase in disease prevalence among freshwater fishes. These findings support the growing consensus that fish health is closely linked to environmental quality and that fish diseases can serve as sensitive bio-indicators of ecological disturbances in freshwater ecosystems (Fausch et al., 1990; Levin et al., 2019).

The observed decline in dissolved oxygen (DO) during the monsoon season, accompanied by elevated biochemical oxygen demand (BOD) and chemical oxygen demand (COD), suggests increased organic pollution resulting from agricultural runoff, domestic wastewater, and suspended organic matter entering the reservoir. Low dissolved oxygen is known to impair fish respiration, suppress immune responses, and increase susceptibility to opportunistic pathogens. Similar observations have been reported in studies evaluating the effects of multiple anthropogenic stressors on freshwater fish communities, where declining water quality significantly altered fish health and ecological integrity (Schinegger et al., 2016; Česonienė et al., 2020).

Parasitic infestations and bacterial gill diseases were the most frequently encountered pathological conditions during the present investigation. Their increased occurrence under conditions of high turbidity and organic pollution indicates that environmental stress favours pathogen proliferation while simultaneously reducing host resistance. McKenzie et al. (2007) suggested that physiological biomarkers in fishes respond rapidly to pollutant exposure and can provide valuable information regarding sub-lethal environmental stress before large-scale mortality occurs. Likewise, Rodrigues et al. (2022) emphasized that biological responses should complement conventional water quality assessment for accurate ecological evaluation of freshwater reservoirs.

The findings are also consistent with previous Indian investigations. Singh et al. (2024) reported significant seasonal variation in the physicochemical characteristics of the Sai River, demonstrating that monsoon runoff substantially influences freshwater quality. Similarly, Pandey et al. (2023) observed that deterioration in water quality and changes in microbial diversity adversely affected the survival of *Catla catla* fry, highlighting the importance of maintaining favourable environmental conditions for fish health. Furthermore, Bisen et al. (2024) demonstrated that exposure to environmental contaminants caused significant haematological alterations in *Labeo rohita*, confirming the sensitivity of freshwater fishes to pollution-induced stress.

The strong positive correlations observed between disease prevalence and BOD, COD, and turbidity, together with the negative correlation with dissolved oxygen, indicate that fish diseases integrate the cumulative effects of multiple environmental stressors rather than responding to a single physicochemical variable. This supports internationally accepted fish-based ecological assessment approaches, including the Index of Biotic Integrity (IBI), which recognize fish health and community characteristics as reliable indicators of freshwater ecosystem quality (Karr, 1981; Karr et al., 1986; Argillier et al., 2012).

V. CONCLUSION AND FUTURE PROSPECTS

The present study demonstrated a significant relationship between seasonal variations in water quality and the occurrence of fish diseases in a freshwater reservoir of Mirzapur District, Uttar Pradesh. The findings revealed that deterioration in physicochemical parameters, particularly reduced dissolved oxygen and elevated biochemical oxygen demand, chemical oxygen demand, and turbidity during the monsoon season, was associated with increased prevalence of bacterial, fungal, and parasitic infections in freshwater fishes. Statistical analysis further confirmed a strong positive correlation between disease prevalence and organic pollution indicators, whereas dissolved oxygen exhibited a strong negative correlation with disease occurrence. These observations indicate that fish health responds sensitively to environmental changes and reflects the cumulative impact of multiple stressors acting within aquatic ecosystems. The study therefore establishes that fish diseases can serve as reliable bio-indicators for evaluating freshwater ecosystem health and complement conventional physicochemical water quality assessment. Integrating fish disease surveillance with routine environmental monitoring can facilitate early detection of ecological degradation, support sustainable fisheries management, and contribute to the conservation of freshwater biodiversity. The findings are consistent with previous studies highlighting the usefulness of fish-based ecological assessment for monitoring aquatic ecosystem integrity (Levin et al., 2019; Argillier et al., 2012; Singh et al., 2024).

A. Future Prospects

Future investigations should include long-term monitoring of fish health and water quality to understand temporal changes in freshwater ecosystems under increasing anthropogenic pressure. Advanced molecular diagnostic techniques such as PCR, DNA sequencing, and environmental DNA (eDNA) analysis may be employed for rapid identification of aquatic pathogens and biodiversity assessment. Studies on heavy metals, pesticides, emerging contaminants, antibiotic-resistant bacteria, and microplastics should also be integrated with fish disease surveillance to obtain a comprehensive understanding of pollution-induced ecological stress. Histopathological, immunological, haematological, and biochemical biomarkers may further improve the sensitivity of biomonitoring programmes. Development of a standardized fish disease-based ecological health index for Indian freshwater reservoirs would strengthen environmental assessment and fisheries management. Additionally, community participation, regular reservoir monitoring, pollution control measures, and watershed management strategies should be encouraged to maintain ecological integrity and ensure the sustainable utilization of freshwater resources for future generations.

Conflict of Interest: Authors have no conflict of interest.

REFERENCES

[1] Anastácio, P.M.; Ribeiro, F.; Capinha, C.; Banha, F.; Gama, M.; Filipe, A.F.; Rebelo, R.; Sousa, R. Non-native freshwater fauna in Portugal: A review. Sci. Total Environ. **2019**, 650, 1923–1934. [**Google Scholar**] [**CrossRef**]

[2] APA; ICNF; CEF; Greenreference. Aplicação Web para o Cálculo do Índice Piscícola de Integridade Biótica para Rios Vadeáveis de Portugal Continental (F-IBIP). n.d. Available online: **https://www.isa.ulisboa.pt/proj/fibip/index.php** (accessed on 15 October 2024).

[3] Argillier, C.; Causse, S.; Gevrey, M.; Pédron, S.; Bertoli, J.; Brucet, S.; Emmrich, M.; Jeppesen, E.; Lauridsen, T.; Mehner, T.; et al. Development of a fish-based index to assess the eutrophication status of European lakes. Hydrobiologia **2012**, 704, 193–211. [**Google Scholar**] [**CrossRef**]

[4] Beggel, S.; Pander, J.; Geist, J. Ecological Indicators for Surface Water Quality—Methodological Approaches to Fish Community Assessments in China and Germany. In Chinese Water Systems: Volume 4: Applied Water Management in China; Dohmann, M., Grambow, M., Song, Y., Wermter, P., Eds.; Springer International Publishing: Cham, Switzerland, 2022; pp. 47–67. [**Google Scholar**] [**CrossRef**]

[5] Blabolil, P.; Říha, M.; Ricard, D.; Peterka, J.; Prchalová, M.; Vašek, M.; Čech, M.; Frouzová, J.; Jůza, T.; Muška, M.; et al. A simple fish-based approach to assess the ecological quality of freshwater reservoirs in Central Europe. Knowl. Manag. Aquat. Ecosyst. **2017**, 418, 53. [**Google Scholar**] [**CrossRef**]

[6] Bobori, D.C.; Ntislidou, C.; Petriki, O.; Chronis, I.; Kagalou, I.; Lazaridou, M. Macroinvertebrate and fish communities in the watershed of a re-constructed Mediterranean water body: Link to the ecological potential. Environ. Monit. Assess. **2018**, 190, 106. [**Google Scholar**] [**CrossRef**]

[7] Bonar, S.A.; Mercado-Silva, N.; Hubert, W.A.; Beard, T.D., Jr.; Dave, G.; Kubečka, J.; Graeb, B.D.S.; Lester, N.P.; Porath, M.; Winfield, I.J. Standard Methods for Sampling Freshwater Fishes: Opportunities for International Collaboration. Fisheries **2017**, 42, 150–156. [**Google Scholar**] [**CrossRef**]

[8] Brijesh Kumar Pandey, Vipin Mishra, Astha Srivastava, Anupam Dikshit, Ravikant Singh and Shashi Kant Shukla (2023) Impact of water quality and microbial diversity in survival of Catla catla fryllings. Biochem. Cell. Arch. 23, 831-838. DOI: https://doi.org/10.51470/bca.2023.23.2.831

[9] Česonienė, L.; Šileikienė, D.; Dapkienė, M. Relationship between the Water Quality Elements of Water Bodies and the Hydrometric Parameters: Case Study in Lithuania. Water **2020**, 12, 500. [**Google Scholar**] [**CrossRef**]

[10] Costa, M.J.; Almeida, P.R.; Domingos, I.M.; Costa, J.L.; Correia, M.J.; Chaves, M.L.; Teixeira, C.M. Present Status of the Main Shads' populations in Portugal. Bull. Fr. Pêche Piscic. **2001**, 362–363, 1109–1116. [**Google Scholar**] [**CrossRef**]

[11] Giakoumis, T.; Voulvoulis, N. The Transition of EU Water Policy Towards the Water Framework Directive's Integrated River Basin Management Paradigm. Environ. Manag. **2018**, 62, 819–831. [**Google Scholar**] [**CrossRef**]

[12] INAG, I.P. Critérios de Classificação do Estado das Massas de Água—Rios e Albufeiras; Ministério do Ambiente, do Ordenamento do Território e do Desenvolvimento Regional: Rua de O Século, Lisbon, 2009; Available online: **https://apambiente.pt/dqa/criterios-classificacao.html** (accessed on 3 December 2024).

[13] Irz, P.; Odion, M.; Argillier, C.; Pont, D. Comparison between the fish communities of lakes, reservoirs and rivers: Can natural systems help define the ecological potential of reservoirs? Aquat. Sci. **2006**, 68, 109–116. [**Google Scholar**] [**CrossRef**][**Green Version**]

[14] Launois, L.; Veslot, J.; Irz, P.; Argillier, C. Development of a fish-based index (FBI) of biotic integrity for French lakes using the hindcasting approach. Ecol. Indic. **2011**, 11, 1572–1583. [**Google Scholar**] [**CrossRef**]

[15] Levin, J.C.; Woodford, D.J.; Snow, G.C. Evaluating the effectiveness of freshwater fishes as bio-indicators for urban impacts in the Crocodile (West) catchment, South Africa. Water SA **2019**, 45, 477–486. [**Google Scholar**] [**CrossRef**]

[16] Minakshee Bisen, Ravikant Singh and P. R. Yadav (2024) Impact of arsenic exposure on erythrocyte morphology and haematological parameters in Labeo rohita. Biochem. Cell. Arch. 24, 229-234. DOI: https://doi.org/10.51470/bca.2024.24.1.229

[17] Mueller, M.; Pander, J.; Knott, J.; Geist, J. Comparison of nine different methods to assess fish communities in lentic flood-plain habitats. J. Fish Biol. **2017**, 91, 144–174. [**Google Scholar**] [**CrossRef**]

[18] Navarro, E.; Caputo, L.; Marcé, R.; Carol, J.; Benejam, L.; García-Berthou, E.; Armengol, J. Ecological classification of a set of Mediterranean reservoirs applying the EU Water Framework Directive: A reasonable compromise between science and management. Lake Reserv. Manag. **2009**, 25, 364–376. [**Google Scholar**] [**CrossRef**]

[19] Pádua, J.; Bernardo, J.M.; Alves, M.H. Exercício De Intercalibração Em Massas De Água Fortemente Modificadas—Albufeiras, No Âmbito Da Diretiva Quadro da Água. 2005, pp. 1–14. Available online: **http://www.apambiente.pt/dqa/assets/exercício-de-intercalibração-em-albufeiras.pdf** (accessed on 4 February 2025).

[20] Paulovis, G.; Kováts, N.; Ferincz, Á.; Acs, A. Fish-Based Assessment of the Ecological Status of the Kis-Balaton–Balaton Reservoir–Lake System, Hungary. Int. J. Des. Nat. Ecodynamics **2012**, 7, 166–172. [**Google Scholar**] [**CrossRef**]

[21] Pieckiel, P.; Kozłowski, K.; Kuczyński, T. Ecological Potential of Freshwater Dam Reservoirs Based on Fish Index, First Evaluation in Poland. Water **2024**, 16, 2169. [**Google Scholar**] [**CrossRef**]

[22] Pinheiro, P. Impactes Ecológicos das Obras Hidráulicas Transversais e as Passagens para Peixes como Medida Mitigadora. 2009. Available online: **https://naturlink.pt/print.aspx?menuid=4&cid=93897&viewall=true&print=true** (accessed on 31 October 2024).

[23] Pinto, I.; Nogueira, S.; Rodrigues, S.; Formigo, N.; Antunes, S.C. Can Zooplankton Add Value to Monitoring Water Quality? A Case Study of a Meso/Eutrophic Portuguese Reservoir. Water **2023**, 15, 1678. [**Google Scholar**] [**CrossRef**]

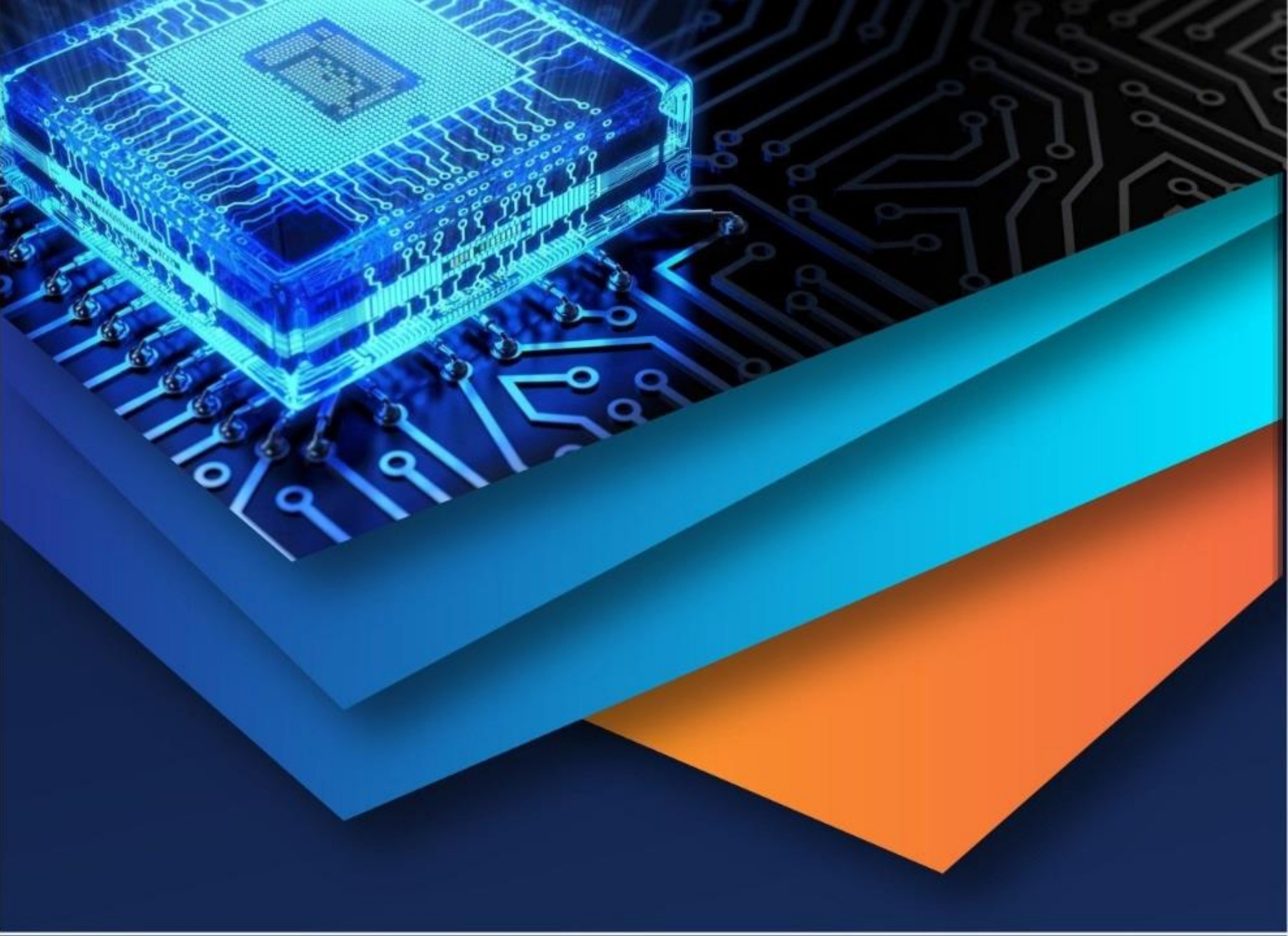
[24] Portela, A.P.; Gonçalves, J.; Cardoso, A.S.; Vaz, A.S.; de Lima, L.T.; Pinto, I.; Rodrigues, S.; Antunes, S.C.; Honrado, J. Landscape functioning in reservoir water quality prediction: Current use and predictive capacity. Ecohydrology **2024**, 17, e2702. [**Google Scholar**] [**CrossRef**]

[25] Pullin, A.S.; Stewart, G.B. Guidelines for systematic review in conservation and environmental management. Conserv. Biol. **2006**, 20, 1647–1656. [**Google Scholar**] [**CrossRef**]

[26] Rodrigues, S.; Pinto, I.; Formigo, N.; Antunes, S.C. Microalgae Growth Inhibition-Based Reservoirs Water Quality Assessment to Identify Ecotoxicological Risks. Water **2021**, 13, 2605. [**Google Scholar**] [**CrossRef**]

[27] Santos, R.M.B.; Sanches Fernandes, L.F.; Cortes, R.M.V.; Varandas, S.G.P.; Jesus, J.J.B.; Pacheco, F.A.L. Integrative assessment of river damming impacts on aquatic fauna in a Portuguese reservoir. Sci. Total Environ. **2017**, 601–602, 1108–1118. [**Google Scholar**] [**CrossRef**]

[28] Shweta Singh, Shikha Singh, B. K. Singh and Ravikant Singh (2024) Analysis of seasonal variation in surface and bottom water quality in Sai river at Pratapgarh, Uttar Pradesh. Biochem. Cell. Arch. 24, 43-49. DOI: https://doi.org/10.51470/ bca.2024.24.1.43



10.22214/IJRASET

INDEX COPERNICUS 45.98

ISRA JIF IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY