International Journal of Research Studies on Environment, Earth, and Allied Sciences (IJRSEAS)
| *Volume-2 Issue-2* | *April-2025* | *ISSN: 3066-0637* | *Website:* https://eesrd.us

Manuscript ID:
IJRSEAS-2025-0202024

OPEN ACCESS

Quick Response Code:

Website: https://eesrd.us

DOI: 10.5281/zenodo.15332262

DOI Link: https://zenodo.org/records/15332262

Volume: 2

Issue: 2

Pp. 105-111

Month: April

Year: 2025

E-ISSN: 3066-0637

Submitted: 27 Feb 2025

Revised: 26 Mar 2025

Accepted: 23 Apr 2025

Published: 30 Apr 2025

Address for correspondence:
S. M Siddiqui
Research Scholar, Department of Zoology, Adarsh College Hingoli (MS) India
Email: shafia4zoology@gmail.com

How to cite this article:
Siddiqui, S. M., Kamble, R. B., & Kharat, P. S. (2025). A Comprehensive Review of Physicochemical Properties and Their Impact on Freshwater Ecosystem. International Journal of Research Studies on Environment, Earth, and Allied Sciences (IJRSEAS), 2(2), 105–111. https://doi.org/10.5281/zenodo.15332262

A Comprehensive Review of Physicochemical Properties and Their Impact on Freshwater Ecosystem

S. M. Siddiqui[1], R. B. Kamble[2], Dr. P. S. Kharat[3]
[1]Research Scholar, Department of Zoology, Adarsh College Hingoli (MS) India
[2]Research Scholar, Department of Zoology, Adarsh College Hingoli (MS) India
[3]Associate Professor Department of Zoology, Nutan Mahavidyalaya, Sailu, Dist parbhani (MS) India

Abstract

Aquatic systems are critical for India's and its people's biological, economic, and ecological health. Floods, lakes, wetlands, and reservoirs provide essential water for supply, irrigation, and are home to diverse species. However, these ecosystems are under increasing threat from pollution, over-exploitation, and climate change, leading to significant alterations in the physicochemical properties of water. This review provides a comprehensive analysis of the published literature from the past decade on Indian water bodies, focusing on parameters such as temperature, pH, DO, turbidity, salinity, and nutrients. The study indicates that pollution and the impacts of global climate change have severely affected aquatic life, ecosystems, and water quality. For example, excessive nutrient input has led to eutrophication, and temperature fluctuations influencing dissolved oxygen (DO) levels have harmed fish populations in the Ganges and Yamuna. Additionally, water quality deterioration has social and economic implications for local communities relying on these water resources. The study underscores the urgent need for sustainable water management, improved monitoring, and the formulation of effective policies aimed at restoring water quality, preserving ecosystems, and enhancing ecosystem services. The physicochemical quality of water is vital for maintaining biodiversity, supporting the provision of ecosystem goods and services, and ensuring water availability. Future research should focus on long-term monitoring, exploring emerging environmental challenges, and identifying innovative solutions to protect and rehabilitate aquatic ecosystems.

Keywords: *Freshwater ecosystems, Physicochemical properties, Biodiversity, Eutrophication, Indian water bodies*

Introduction

Inland water bodies such as rivers, lakes, wetlands, and ponds are important for supporting ecosystems, socio-cultural uses, and economic uses in India. It becomes apparent that they perform other important functions including; water supply, irrigation, sewage treatment, and carbon sequestration. Large rivers like the Ganges, Brahmaputra, and Godavari and the largest freshwater lakes like Vembanad and Chilika are home to a rich biodiversity and are the source of drinking water, irrigation, and fish for millions of people (Nallathiga et al., 2008; Chavan et al., 2010). Water is a crucial input for socioeconomic growth, and out of the total available water, 80% is used in the agricultural sector (Kannaiyan et al., 2023). Ganges and Yamuna are important sources of irrigation and drinking water, and Vembanad and Chilika are important for fish and other aquatic lives and are sources of income from fishing and tourism (Sunkara et al., 2001; Robin et al., 2024). The East Kolkata Wetlands are important for regulating water quality, flood management, and the conservation of biodiversity.

However, these ecosystems are currently under significant pressure from pollution, over-extraction, and climate change. Currently, the largest rivers such as the Yamuna and Ganges receive pollution from industrial effluents, raw sewage, and agricultural drainages that hurt water life (Shukla et al., 2021). The wetlands like the East Kolkata Wetlands are under threat from urbanization hence the loss of important functions such as water purification and flood mitigation (Bunting et al., 2010). Climate change complicates these issues by changing precipitation regimes and water temperatures, and increasing the frequency and severity of extreme events that distort the physical properties of water. Such problems are addressed by national programs like Namami Gange and Swachh Bharat Abhiyan but more scientific studies, proper management, and good policies are needed for the conservation of these ecosystems.

Temperature, pH, DO, turbidity, salinity, and nutrient levels are important physicochemical factors that determine the working of aquatic systems in fresh water. These parameters define the biological activity, water quality, and the state of the aquatic environment in general (Kernan et al., 2010).

High temperatures, associated with climate change, lower DO levels and cause hypoxic conditions that are inimical to the survival of aquatic organisms (Kahlon et al., 2018). Likewise, pH affects nutrient solubility and biological synthesis; water with pH<6 or >8 decreases species richness and yield (Kannaiyan et al., 2023). The low DO levels resulting from pollution or eutrophication affect the aquatic population, especially in the Ganges where variations in DO levels due to seasons influence biological organisms (Singh et al., 2021).

Nitrogen and phosphorus, which are important nutrients, can cause harm, or become pollutants, in large quantities, which causes eutrophication. This process encourages the growth of algae which leads to the formation of layers on the water body which cuts off the oxygen supply to any living thing. Sukhna and Dal Lakes are good examples of how nutrient pollution affects water quality and decreases the number of species (Sunkara et al., 2001). Turbidity, due to suspended particles, reduces light penetration, thus primary production and food chain (Robin et al., 2024). While salinity levels are relatively low in freshwater systems, they are known to affect the distribution of species, especially in such systems as the Sundarbans and Chilika Lake (Sunkara et al., 2001).

These parameters are not mutually exclusive and are influenced by each other most of the time. For instance, high temps decrease oxygen's solubility, increase nutrient availability, and support excess algae growth hence eutrophication. They require the multiple-stressor approach to water quality management in freshwater ecosystems (Kernan et al., 2010). Monitoring the parameters such as temperature, DO and pH is crucial in unfolding the health status of the affected rivers including the Ganges and Yamuna in this situation where extractions and pollution change the properties of water affecting the life of aquatic creatures (Tiwari et al., 2024). Likewise, knowledge of nutrient cycling in lakes like Chilika and Vembanad is equally important to manage eutrophication and to support fish production (Vanni et al., 2006).

These ecosystems need scientific research, monitoring programs, and policy intercessions to control pollution, rehabilitate habitats, and mitigate climate change which will help in the rational utilization and protection of freshwater resources in India.

Overview of Physicochemical Properties in Indian Freshwater Ecosystems

Temperature, pH, dissolved oxygen, turbidity, electrical conductivity, salinity, and nutrients affect the health and species richness of Indian freshwater habitats. Climatic changes by seasons and regions influence metabolic rates and reproduction of the species. For instance, warm-endothermic species replace snow trout in the Ganges, temperature change affects fish reproduction in the Godavari River (Mitra et al., 2023), and changes in pH affect nutrient availability and water quality; pollution changes pH in lakes such as Vembanad (Robin et al., 2024). Likewise, changes in the pH of Chilika Lake influence fisheries by changing nutrient cycling and DO (Sunkara et al., 2001).

DO is important for aquatic life; low DO due to organic pollution affects the bio-diversity of rivers like Yamuna and Cauvery (Kahlon et al., 2018). Sedimentation and urban runoff cause turbidity that in turn limits light penetration and primary production in lakes such as Sukhna (Sunkara et al., 2001). Conductivity, which is an index of pollution, is on the high side in such rivers as the Ganges due to industries discharging effluents/urban sewage into the rivers; the effects on aquatic life are awful (Roy et al., 2020). Changes in salinity levels are common in Chilika Lake and Sundarbans and affect species distribution and ecosystem health, which requires constant assessment (Kannaiyan et al., 2023). Excessive nitrogen and phosphorus promote eutrophication in water bodies including Sukhna and Dal, which reduces oxygen levels and leads to fish kills (Robin et al., 2024).

Interactions among Physicochemical Properties in Indian Water Bodies

The relationships between different physicochemical factors in freshwater systems are intricate and have profound consequences for the biota and processes within these systems. In Indian water bodies, temperature, DO, pH, nutrient availability, turbidity, and light penetration may influence the ecological characteristics and structure of the communities and productivity. This section focuses on major interfaces between these properties in Indian freshwater habitats.

Temperature and Dissolved Oxygen

Temperature and dissolved oxygen (DO) levels are correlated in freshwater ecosystems. With the increase in temperature, DO concentrations decrease because of its solubility and this affects the aquatic organisms. For instance, in Nainital Lake, an increase in summer temperatures reduces DO, which is lethal to cold water fish such as snow trout (*Schizothorax spp.*) (Kamalam et al., 2019). Similarly, in the Godavari River, organic pollutants and increased temperatures enhance DO reduction, which chokes the life of the water (Chavan et al., 2010). Low DO hampers the metabolic activities of fish and invertebrates and leads to fish death and reduced species assemblage.

1. **pH and Nutrient Availability**

pH is one of the physicochemical factors that affect nutrient availability and productivity of an ecosystem. In the Indian FW habitats, changes in pH affect nutrient dynamics and biological productivity. For example, in the Kaveri River, the availability of nitrogen and phosphorus depends on the seasonal changes in pH and agricultural pollution; eutrophication and algal growth are favored at pH 7.5–8.5. Sudden changes in pH in urban rivers and lakes limit nutrient cycling and primary production and hence the availability of food for the higher trophic levels (Robin et al., 2024). In Sukhna Lake the variations in the pH of water and nutrient loading explain the algal blooms affecting the bioavailability of dissolved oxygen (Chaudhry et al., 2013).

2. **Turbidity and Light Penetration**

Turbidity reduces the degree of light transmission in water, because of such things as sediments, organic matter, or pollutants, which reduce the capacity for photosynthesis among phytoplankton and aquatic plants. In

Hussain Sagar, Hyderabad, an increase in turbidity due to sewage and industrial waste hampers the penetration of light to support plants and phytoplankton (Shukla et al., 2021). This cuts on primary production meaning that the food chain is affected and fish in particular. Temperature and oxygen are further affected by turbidity because turbidity causes heat absorption in water leading to a decrease of DO and hypoxia (Khan et al., 2021). In rural reservoirs, water turbidity due to construction activities or agricultural effluents reduces oxygen levels that negatively impact benthos and reproduction.

3. BOD and COD Levels

Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) are critical indicators of water quality, reflecting the level of organic pollution in water bodies. BOD measures the oxygen consumed by microorganisms in decomposing organic matter, while COD quantifies the oxygen required to chemically oxidize organic pollutants. High BOD and COD levels indicate severe pollution, leading to oxygen depletion and stressing aquatic life. For instance, in the Yamuna River, high BOD and COD levels, primarily from untreated sewage and industrial discharge, have significantly reduced oxygen levels, harming fish and other aquatic organisms (Antil et al., 2024). Similarly, in the Godavari River, high COD levels due to organic and industrial waste contribute to hypoxic conditions, impacting biodiversity (Joshi et al., 2022). Monitoring BOD and COD is essential for assessing and managing water quality.

Impact of Physicochemical Properties on Freshwater Organisms in India

Temperature, pH, DO, turbidity, and nutrients are the important physicochemical factors that determine the existence of freshwater organisms in India. The phytoplankton, being sensitive to water quality, are found in nutrient-rich water such as Sukhna Lake where high nitrogen and phosphorus cause eutrophication and oxygen depletion (Robin et al., 2024). While, oligotrophic lakes of the Himalayas have low nutrient concentrations that restrict phytoplankton growth (Mushtaq et al., 2022). Zooplankton and invertebrates are affected by pH and DO; pollution by agricultural activities has an impact on invertebrate fauna in the Godavari River (Chavan et al., 2010). Water quality changes in rivers such as Ganges and Narmada have an impact on fish health and temperature changes mainly affect cold-water fish such as snow trout. Sukhna Lake is affected by algal blooms resulting in fish death, and turbidity affects the predatory fish in urban lakes (Chaudhry et al., 2013).

Human Activities and Alterations to Physicochemical Properties in India

Industrialization, agriculture, urbanization, and climate change affect the physicochemical properties of water bodies in India and thus affect ecosystems. Industrial, agricultural, and domestic effluents pollute rivers including Ganges and Yamuna; causing eutrophication, algal bloom, and oxygen depletion (Sharma et al., 2015). The water quality of the Ganges River is reduced due to the presence of heavy metals, hazardous fecal coliform bacteria, and pesticides (Gupta et al., 2020). Climate change effects include; rising water temperatures, changes in river discharge, and evaporation in high-altitude water bodies leading to water pollution and low dissolved oxygen levels (Mariu et al., 2023). Climate change causes floods that in turn increase pollution as noted by (Agrawal, et al., 2021). Another natural quality of water is influenced by water management practices such as the construction of dams, and water irrigation among others. Hydropower affects the flow and temperature of the water; the Sardar Sarovar Dam for example has led to low oxygen levels and eutrophication (Gupta et al., 2020, irrigation increases the nutrient pollution of river water for instance in the Kaveri (Kumaraswamy et al., 2019).

Case Studies and Examples from Indian Water Bodies

Freshwater habitats of India have been experiencing transformations in the recent past due to anthropogenic pressures, pollution, and climate change. Following are the examples that explain the impact of physicochemical changes on water quality and aquatic life in Indian water bodies.

Case Study 1: Eutrophication in Sukhna Lake, Chandigarh

Sukhna Lake in Chandigarh has been undergoing eutrophication because of high concentrations of nitrogen and phosphorus from domestic, industrial, and agricultural wastes. This results in increased algal growth, low dissolved oxygen, and general upset of the aquatic balance especially during summer. Low DO has a detrimental effect on fish and invertebrates, some fish species have been wiped out due to water pollution (Manzoor et al., 2021). These changes in the physicochemical properties have led to species replacement with species that are more tolerant of the changes replacing those that are sensitive to them (Kumaraswamy et al., 2019). However, nutrient loading is a constant problem, even with management measures such as artificial aeration.

Case Study 2: Impact of Temperature and Oxygen Levels in the Ganges River

The present study has revealed that the temperature and dissolved oxygen (DO) of the Ganges River have been affected by climate change and human intervention. Warmer water holds less dissolved oxygen and thus increases hypoxic conditions in some sections of the river. Sewage and industrial effluents are specific to enhance the deposition of oxides that reduce oxygen levels and impact fish and other creatures such as the endangered and distinctive Ganga Dolphin. Cold-water species like Snow trout (*Schizothorax spp.*) are scarce because of low DO and fluctuating temperatures (Kamalam et al., 2019). Temperature and existing oxygen levels have changed and impacted species, which either move to regions having better oxygen, or species become extinct.

Case Study 3: Water Quality and Biodiversity in Chilika Lake

Chilika is one of the largest brackish water lagoons in Asia and is threatened by changes in salinity, turbidity, and nutrient levels. Fluctuations in the water salinity caused by the discharge of rivers and rainfall

influence the lake's biota, especially fish-eating birds and fish breeding (Kumaraswamy et al., 2019). Contamination from fertilizers and high turbidity resulting from siltation favors eutrophication that hampers penetration of light thus affecting the photosynthesis processes in plants of the water body (Mariu et al., 2023). These changes have resulted in a reduction in species diversity; some of the fish and invertebrates have reduced in number because of poor habitat and food conditions.

Case Study 4: High BOD Levels in Powai Lake, Maharashtra

The cases of pollution of Powai Lake in Mumbai, Maharashtra are tremendously conditioned by the presence of untreated sewage and industrial effluents. High BOD and low DO have been recorded showing that water quality is poor (Ratheeshkumar et al., 2015). Organic eutrophication is a primary cause of algal blooms which decrease DO and disrupt water life due to nutrient pollution. Also, the physical water quality characteristic has recently worsened in the lake because of siltation and runoff increasing water turbidity, thus reducing light penetration and the rate of photosynthesis (Mitter et al. 2016). These physicochemical changes when combined pose a great danger to the aquatic life and overall balance of Powai Lake.

Case Study 5: Industrial discharge and poor biodiversity of Ulhas River, Maharashtra

The Ulhas River in Maharashtra takes its share of pollution from industrial effluents, untreated sewage, and agricultural drains. The concentrations of BOD and DO which are ultimately high and low respectively are typical points of water pollution and dissolved oxygen levels (Mukherjee et al., 2021). Sedimentation and pollution have raised the river's turbidity and consequently, the amount of light that can penetrate through the water and support the life of the organisms. Waste nutrient pollution, especially nitrogen and phosphorus, causes eutrophication that leads to the growth of aquatic vegetation inhibiting aquatic life (Rathod et al., 2009). These physico-chemical changes have affected the river's bio-diversity such as fish stocks and have posed problems to water utilization.

Monitoring and Assessment of Physicochemical Properties in Indian Water Bodies

Supervising the physicochemical parameters of water bodies is very important for the evaluation of water quality and health of the aquatic ecosystems in India. Water sampling is a traditional method of quantifying factors including temperature, pH, dissolved oxygen, turbidity, and conductivity, which are useful in assessing the seasonal changes of rivers like the Ganges and Godavari (Joshi et al., 2022). Furthermore, satellite data is widely used in large-scale water quality monitoring, especially on turbidity, chlorophyll content, and surface temperature. Kumaraswamy et al., (2019) have identified eutrophication and algal blooms in Chilika and Sukhna lakes through remote sensing. In addition, data collection in real-time is made possible by sensors and Automated Water Quality Monitoring Stations (AWQMS) used in water bodies in cities such as Delhi and Mumbai to determine water quality and pollution. These tools and techniques give useful information on the physicochemical quality of water.

Ecological Indicators in Indian Water Bodies

The physicochemical changes in aquatic ecosystems have brought into focus the need for ecological indicators to evaluate the health of the ecosystems in India. There are biotic indicants including Biological Oxygen Demand (BOD) and Fish Health Index (FHI); these identify levels of organic pollutants and the capability of water to support living organisms (Pinnaet al ., 2023). Chlorophyll-a is employed for estimating algal biomass and to determine the extent of eutrophication; the latter was identified in Sukhna. Fish and invertebrate communities indicate water quality; for instance, the Ganges River has been home to many species, including the Ganges dolphin, but the pollution has forced the extinction of many species (Sinha et al., 2014). Fewer numbers of macrophyte species in the water bodies such as Vembanad and Chilika imply a decline in water quality (Kumaraswamy et al., 2019).

Management Strategies for Protecting Freshwater Ecosystems in India

Freshwater habitats of India are under immense pressure due to pollution, over-exploitation, and climate change. This section provides an overview of the major management initiatives in India with special reference to the conservation of water bodies and the development of sustainable practices in agricultural, industrial, and urban sectors.

Restoration and Conservation Efforts

The Yamuna Action Plan (YAP) started in 1993 to control pollution of the Yamuna River through enhanced sewage treatment and industrial effluents, yet untreated sewage continues to be a problem (Nallathiga et al., 2008). Namami Gange or the GAP (Ganga Action Plan) started in 1986 to clean the Ganges and addresses domestic sewage, industrial waste, and other wastes but pollution continues (Balkrishna et al., 2024). In Chilika Lake, wetland conservation strategies are aimed at reducing eutrophication and habitat degradation, and improving species diversity and fish stock (Sunkara et al., 2001***).***

Sustainable Practices

Conservation of freshwater ecosystems is therefore very important to maintain in India. Sustainable agriculture which has been supported by the National Mission on Sustainable Agriculture is efficient in water conservation and soil health and has a low impact on chemical pollution (Stagnari et al., 2016). There are increased environmental laws that promote industrial pollution control, but enforcement is a problem as industries continue to discharge untreated wastes. The Atal Mission for Rejuvenation and Urban Transformation (AMRUT) is for water management and wastewater treatment in urban cities, and Bengaluru is ahead in lake rejuvenation (Doshi et al.,

2021). Such community programs, such as the Ganga Praharis program, promote the active involvement of the community in water quality monitoring and management of the ecosystem (Balkrishna et al., 2024).

Discussion

The complex relationships between physicochemical parameters in the Indian freshwater habitats underscore their importance in sustaining the ecosystem and species diversity. The reviewed studies reveal the dramatic effects of anthropogenic impacts and climate change on water quality and aquatic organisms. High nutrient concentrations particularly nitrogen and phosphorus have promoted eutrophication at Sukhna and Dal Lakes thereby affecting life affecting aquatic life through the depletion of dissolved oxygen and the occurrence of algae blooms. This phenomenon calls for the need to come up with efficient nutrient management in the agricultural and urban environment. Climate change continues to exert more pressure on the temperatures and therefore affects the water bodies. That is; warmer water such as the one in the Ganges has lower DO levels hence; hypoxic conditions that are not suitable for species such as the snow trout. Such changes not only affect species distribution but also affect fish reproduction and their metabolism which is very much affected in rivers such as the Godavari. All these changes call for the inclusion of climate change resilience in water management policies.

Moreover, suspension and sediments from such activities as siltation as well as industrial effluents contribute to high water turbidity which restricts light from penetrating thus; reducing the primary productivity of the water system and hence the supporting food chain. Reservoirs and urban lakes including Powai Lake show the combined impacts of turbidity and nutrient loading that reduce habitats and species richness. Schemes like the Namami Gange and Yamuna Action Plans are good starts but need to be backed up by more science and better public participation to deal with problems that remain constant like untreated sewage and industrial effluents. The application of modern monitoring technologies such as remote sensing and automated water quality stations can further improve those initiatives. The conservation of the freshwater ecosystems of India requires a multi-stressor management strategy that involves scientific research, policy and practice, and community involvement. Further studies should be directed towards the assessment of long-term effects and the identification of potential coping mechanisms as regards combined anthropogenic and climatic pressures.

Conclusion

Freshwater ecosystems in India are vital for biodiversity, food production, and water supply, but they face significant threats from changing physicochemical properties. Research over the past decade highlights the negative impacts of fluctuations in temperature, pH, dissolved oxygen, and nutrient levels on aquatic life. Nutrient enrichment from agricultural runoff and untreated sewage has led to eutrophication, oxygen depletion, and disrupted ecosystems. Climate change exacerbates these issues by altering temperature, water salinity, and precipitation, further affecting oxygen solubility and species distribution. To address these challenges, there is a pressing need for improved management and conservation of freshwater resources. Future research should focus on underexplored lakes, rivers, and wetlands, and integrate climate change impacts into water management systems. Ecosystem-based management approaches, including biodiversity conservation, water quality monitoring, and community involvement, will be essential for protecting India's freshwater resources.

Acknowledgement

All the Authors are thankful to the Principal and HOD, Department of Zoology, Adarsh Education Society's Arts, Commerce and Science College, Hingoli for granting permission to carry out the work.

Financial Support and Sponsorship

Nil.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

References:

1. Agrawal, Kamal & Panda, Chittaranjan & Bhuyan, Mahendra. (2021). Impact of Urbanization on Water Quality. 10.1007/978-981-33-4795-3_60.
2. Antil, Sandeep & Maurya, Swati & Dagar, Jyoti & Bhagat, Pooja & Makhija, Seema & Toteja, Ravi. (2024). Insights into Water Quality of River Yamuna, India: A Comprehensive Spatial-Temporal Analysis Using Advanced Indices and Multivariate Statistical Techniques.. 10.21203/rs.3.rs-4072812/v1.
3. Balkrishna, Acharya & Singh, Sumit & Ghosh, Sourav & Banerjee, Srimoyee & Verma, Sonam & Arya, Vedpriya. (2024). An analytical review on the integrated management of river resources through Namami Gange. Water Policy. 1-18. 10.2166/wp.2024.209
4. Bunting, Stuart & Pretty, Jules & Edwards, Peter. (2010). Wastewater-fed aquaculture in the East Kolkata Wetlands, India: Anachronism or archetype for resilient cultures? Reviews in Aquaculture. 2. 138-153. 10.1111/j.1753-5131.2010.01031.x.
5. Chaudhry, Pradeep & Sharma, Mahendra & Bhargava, Renu & Kumar, S. & Dadhwal, P.J.S.. (2013). Water Quality Assessment of Sukhna Lake of Chandigarh City of India. Hydro Nepal: Journal of Water, Energy and Environment. 12. 10.3126/hn.v12i0.9028.
6. Chavan, Ajay & Sharma, Mahendra & Bhargava, Renu. (2010). Water Quality Assessment of the Godavari River. Hydro Nepal: Journal of Water, Energy and Environment. 5. 10.3126/hn.v5i0.2483.
7. Doshi, Siddh & Sharma, Rutool. (2021). Urban Water Management: Reviewing the Changing Patterns.

8. Gupta, Deepak & Shukla, Reetika & Barya, Mahesh & Singh, Gurudatta & Mishra, Virendra. (2020). Water quality assessment of Narmada River along the different topographical regions of central India. Water Science. 34. 10.1080/11104929.2020.1839345.
9. Joshi P, Chauhan A, Dua P, Malik S, Liou YA. Physicochemical and biological analysis of river Yamuna at Palla station from 2009 to 2019. Sci Rep. 2022 Feb 21;12(1):2870. doi: 10.1038/s41598-022-06900-6. PMID: 35190632; PMCID: PMC8861024.
10. Kahlon, Sharan & Julka, Jatinder. (2018). IMPACT OF TEMPERATURE AND DISSOLVED OXYGEN ON THE MACROINVERTEBRATE DENSITY OF A HILL STREAM IN WESTERN HIMALAYA.
11. Kamalam BS, Mahija J, Baral P, Pandey A, Akhtar MS, Ciji A, Rajesh M. Temperature and oxygen related ecophysiological traits of snow trout (Schizothorax richardsonii) are sensitive to seasonal changes in a Himalayan stream environment. J Therm Biol. 2019 Jul;83:22-29. doi: 10.1016/j.jtherbio.2019.04.014. Epub 2019 Apr 21. PMID: 31331521.
12. Kannaiyan, Neelavannan & Sen, Indra. (2023). Microplastics in Freshwater Ecosystems of India: Current Trends and Future Perspectives. ACS Omega. 8. 10.1021/acsomega.3c01214.
13. Kernan, Martin & Battarbee, Richard & Moss, Brian. (2010). Climate Change Impacts on Freshwater Ecosystems. 10.1002/9781444327397.
14. Khan, Ahmed & Anavkar, Ankur & Ali, Ahmad & Patel, Nimisha & Alim, Hina. (2021). A Review on Current Status of Riverine Pollution in India. Biosciences Biotechnology Research Asia. 18. 9-22. 10.13005/bbra/2893.
15. Kumar, Mukesh & Sharif, Mohammad & Ahmed, Sirajuddin. (2019). Impact of Urbanization on the River Yamuna Basin. International Journal of River Basin Management. 18. 1-27. 10.1080/15715124.2019.1613412.
16. Kumaraswamy, T R & Javeed, Sabiha & Javaid, Maheen & Naika, Kumara. (2019). Impact of Pollution on Quality of Freshwater Ecosystems. 10.1007/978-981-13-8277-2_5.
17. Manzoor, Kaiser & Raj, Pushkar & Sheoran, Rohit & Dey, Swastik & Gupta, Jotesh & Zaman, Bushra & Rao, Chhotu & Students,. (2018). Water Quality Assessment through GIS: A Case Study of Sukhna Lake, Chandigarh, India. 10.13140/RG.2.2.13659.87845.
18. Mariu, Amna & Chatha, Ahmad & Naz, Saima & Khan, Muhammad Farhan & Safdar, Warda & Ashraf, Iqra. (2023). Effect of Temperature, pH, Salinity and Dissolved Oxygen on Fishes. Journal of Zoology and Systematics. 1. 1-12. 10.56946/jzs.v1i2.198.
19. Mitra, Anisa & Barua, Prabal. (2023). Climate Change and Fish Reproduction. Water. 15. 725-750. 10.3390/w15040725.
20. Mitter, C. 2016 Status of Water Quality of Powai Lake.
21. Mukherjee, Bholanath & Rajput, Darshana & Kulkarni, Mrudula & Sonawale, Sanjay. (2021). ASSESSMENT OF ULHAS RIVER WATER TO CHECK ITS QUALITY AND EFFECT ON ENVIRONMENT. 9. a533-a543. 10.1729/Journal.27842.
22. Mushtaq, Fayma & Ghosh, Mili & Mantoo, Afaan. (2022). Trophic State Assessment of a Freshwater Himalayan Lake Using Landsat 8 OLI Satellite Imagery: A Case Study of Wular Lake, Jammu and Kashmir (India). Earth and Space Science. 9. 10.1029/2021EA001653.
23. Nallathiga, Ramakrishna. (2008). River water conservation through Management interventions: A Case Study of Yamuna Action Plan in India. Water Today.
24. Pinna, Maurizio & Zangaro, Francesco & Saccomanno, Benedetta & Scalone, Chiara & Bozzeda, Fabio & Fanini, Lucia & Specchia, Valeria. (2023). An Overview of Ecological Indicators of Fish to Evaluate the Anthropogenic Pressures in Aquatic Ecosystems: From Traditional to Innovative DNA-Based Approaches. Water. 15. 949. 10.3390/w15050949.
25. Ratheeshkumar, R., Purushothaman C, S., SreekanthG, B., ManjuLekshmi, N., Renjith, SandeepK, P., & Pandey, K. (2015). State of Water Quality of Two Tropical Urban Lakes Located at Mumbai Megacity.
26. Rathod, Sudesh & Patil, N. (2009). ASSESSMENT OF SOME HYDROLOGICAL PARAMETERS OF ULHAS RIVER ESTUARY, IN THE VICINITY OF THANE CITY, MAHARASHTRA STATE. Journal of Aquatic Biology. 24. 103-108.
27. Robin, R & Govindasamy, Hariharan & Debasis, T & Bonthu, Subbareddy & Yogeswari, S & Muruganandam, R. & Priya, B & Vijay Kumar, Deepak & Ramachandran, Ramesh & Purvaja, R. (2024). Integrated Coastal Zone Management practices and cumulative environmental impacts: The case of Vembanad Lake, a tropical estuary in India. 10.1016/B978-0-323-95606-2.00002-4.
28. Roy, Misha & Shamim, Farzana. (2020). Research on the Impact of Industrial Pollution on River Ganga: A Review. 1.
29. Sharma, Manju & Chaudhry, Smita. (2015). Impact of Industrial Pollution on Yamuna River: A Review. 10.13140/RG.2.1.3632.8401
30. Shukla, Anoop & Ojha, Chandra & Shukla, Satyavati & Garg, Rahul. (2021). Water Quality Challenges in Ganga River Basin, India. 10.1007/978-3-030-60869-9_1.
31. Singh V, Suthar S. Occurrence, seasonal variations, and ecological risk of pharmaceuticals and personal care products in River Ganges at two holy cities of India. Chemosphere. 2021 Apr;268:129331. doi: 10.1016/j.chemosphere.2020.129331. Epub 2020 Dec 17. PMID: 33359991.
32. Singh, Ajit Pratap & Ghosh, S. & Sharma, Pankaj. (2007). Water quality management of a stretch of river Yamuna: An interactive fuzzy multi-objective approach. Water Resources Management. 21. 515-532. 10.1007/s11269-006-9028-0.
33. Sinha, Ravindra. (2014). Ganges River Dolphin: An Overview of Biology, Ecology, and Conservation Status in India. Ambio. 43. 10.1007/s13280-014-0534-7.

34. Stagnari, Fabio & Jan, Sumira & Galieni, Angelica & Pisante, Michele. (2016). Sustainable agricultural practices for water quality protection. 10.1002/9781119054450.ch6.
35. Sunkara, Narendra Prasad & Ramachandra, T V & AHALYA, N. & Sengupta, Tapti & KUMAR, ALOK & TIWARI, A. & VIJAYAN, V. & Vijayan, Lalitha. (2001). Conservation of wetlands of India - A review. Trop Ecol. 43.
36. Tiwari SK, Yadav JS, Sain K, Rai SK, Kharya A, Kumar V, Sethy PC. Water quality assessment of Upper Ganga and Yamuna river systems during COVID-19 pandemic-induced lockdown: imprints of river rejuvenation. Geochem Trans. 2024 Sep 28;25 (1):8. doi: 10.1186/s12932-024-00092-w. PMID: 39342038; PMCID: PMC11439316.
37. Vanni MJ, Bowling AM, Dickman EM, Hale RS, Higgins KA, Horgan MJ, Knoll LB, Renwick WH, Stein RA. Nutrient cycling by fish supports relatively more primary production as lake productivity increases. Ecology. 2006 Jul; 87(7):1696-709. doi: 10.1890/0012-9658(2006)87[1696:ncbfsr]2.0.co;2. Erratum in: Ecology. 2006 Oct; 87(10):2686. PMID: 16922320.