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Assessment of Environmental Resilience of Surface Water Using Turbidity, Dissolved Oxygen, and BOD with Implications for Plant Diversity in Twin Cities of Gujarat, India

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Abstract

The lightning-fast industrial development and urban expansion in semi-arid areas of India are placing greater demands on freshwater ecosystems. This research examines the environmental resilience of surface water and its connection to plant diversity in the industrial twin cities of Surendranagar and Wadhvan, Gujarat. Water samples were collected seasonally (summer, monsoon, and winter) from the Bhogavo River and Boda Talav. These samples were analyzed for three important water quality indicators: turbidity, dissolved oxygen (DO), and biochemical oxygen demand (BOD), employing standard analytical methods. The findings indicated significant seasonal and spatial differences in water quality. The Bhogavo River displayed significant turbidity, particularly in the monsoon and summer seasons, while both water bodies demonstrated lower dissolved oxygen levels during summer, suggesting heightened organic pollution and microbial activity. Consistently high BOD values observed over the year indicated notable organic pollution, especially in the Bhogavo River. The assessment of plant diversity showed that pollution-tolerant species were predominant in degraded water bodies, whereas sensitive species were mostly missing, suggesting a decline in ecological resilience due to industrial pressures. This research emphasizes the importance of efficient wastewater management and consistent monitoring of surface water quality to safeguard aquatic ecosystems in areas undergoing rapid industrialization.

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Turbidity; Dissolved Oxygen; BOD; Surface water quality; Environmental resilience; Industrial pollution; Plant diversity; Surendranagar–Wadhvan

Introduction

Water stands as a fundamental natural resource that underpins human societies, sustains biodiversity, and maintains ecosystem stability. The quality of water has a direct impact on public health, agricultural productivity, industrial development, and ecological balance. Environmental resilience is the ability of ecosystems to endure disturbances, manage stress, and recuperate while preserving their structure and function. In recent decades, swift industrial growth, urban development, and aggressive farming methods have posed significant risks to water resources, leading to extensive deterioration of water quality.

In India, groundwater is the main source of drinking and domestic water for a significant part of the population. Nonetheless, the discharge of industrial effluents without regulation, improper sewage disposal, and runoff from agricultural activities have resulted in the contamination of groundwater aquifers. Subsurface pollutants frequently endure for extended durations and can disperse across large regions, presenting significant threats to both human health and ecological systems.

Surface water bodies, including rivers and ponds, serve as natural receptacles for pollutants and progressively diminish their ability to self-purify due to ongoing human-induced pressures.

The decline in water quality significantly impacts ecosystems, especially affecting both aquatic and semi-aquatic plant communities. Plant diversity is highly responsive to alterations in water chemistry, nutrient availability, and oxygen concentrations. Species that can tolerate pollution frequently take the place of more sensitive taxa in degraded environments, leading to changes in community composition and a decline in biodiversity. These alterations act as signs of diminishing resilience within ecosystems.

Surendranagar and Wadhvan, the industrial twin cities in Gujarat, have seen significant industrial development in recent decades. The growth of the textile, bearing, oil, and chemical sectors has increased the strain on local water supplies. Although numerous studies have focused on water pollution in industrial areas, there is still a lack of comprehensive evaluations that connect water quality with plant diversity and environmental resilience in these regions. The current study seeks to assess the physical and chemical properties of groundwater, river water, and pond water in Surendranagar and Wadhvan, as well as their impact on the surrounding plant diversity and ecosystem resilience.

Industrial discharges, urban runoff, and agricultural activities are well-established contributors to the contamination of surface and groundwater in urban and industrial areas. A variety of studies indicate that the ongoing release of industrial effluents modifies the hydrochemical properties of water bodies, leading to increased electrical conductivity, total dissolved solids, hardness, and concentrations of major ions. The prolonged infiltration of untreated or partially treated effluents has been demonstrated to introduce enduring organic and inorganic pollutants into aquifers, resulting in a decline in groundwater quality and heightened risks to both human health and aquatic ecosystems (1,2).

Assessments of regional groundwater and surface water in Gujarat and other industrialized areas of India have consistently highlighted the spatial and seasonal variability in water quality, as well as its appropriateness for drinking, irrigation, and fisheries. Surveys of groundwater at the district level and studies on river water quality reveal that industrial discharges, urban runoff, and agricultural practices have a considerable impact on hydrochemical properties. This results in increased levels of total dissolved solids, hardness, alkalinity, chloride, nitrate, and indicators of organic pollution (6,15). Groundwater, a crucial source of drinking and irrigation water in various regions of India, is facing significant threats from over-extraction and the infiltration of pollutants. The presence of excessive minerals and dissolved solids raises potential health concerns, including issues related to renal and gastrointestinal health (16-19, 24-28). Investigations into the hydrochemistry of regions in Gujarat reveal that the quality of groundwater is significantly influenced by geological formations and human activities. Elevated levels of salinity, hardness, and nutrient concentrations are frequently found in proximity to industrial clusters and heavily utilized aquifers (3,4). The collective findings highlight the significance of combining hydrochemical and ecological evaluations to assess environmental resilience in industrial areas like Surendranagar and Wadhvan.

Numerous case studies from India have shown a significant connection between the discharge of industrial effluents and the deterioration of surface water quality. Water bodies such as rivers and ponds that are exposed to industrial and domestic wastewater frequently show elevated levels of biochemical oxygen demand, chemical oxygen demand, and nutrient concentrations, especially in areas downstream from industrial sectors. Seasonal variation is significant, showing elevated pollution levels during the pre-monsoon and summer months, attributed to decreased dilution and heightened evaporation. The results highlight the joint impact of both point and non-point pollution sources on the degradation of surface water throughout India (5,6).

The addition of nutrients, particularly nitrogen and phosphorus, is well acknowledged as a key factor leading to eutrophication and the subsequent alterations in aquatic plant communities. Research and field investigations indicate that nutrient-rich environments promote the rapid growth of macrophytes that respond well to these conditions, including invasive species like Eichhornia crassipes, while hindering the growth of native and sensitive species. Changes in species composition led to a decrease in biodiversity and modify the functioning of ecosystems (7,8).

Research has shown that aquatic plants are crucial in maintaining water quality. The rise in macrophyte biomass and species diversity contributes to better nutrient uptake, stabilization of sediments, and removal of particulate matter, which in turn leads to enhanced water clarity and lower nutrient levels. Nonetheless, when faced with high levels of organic loading, aquatic plant communities frequently transition to species that can tolerate pollution but possess restricted capabilities for purification. This highlights a nuanced and context-sensitive interplay between water quality and vegetation (9,10).

Studies examining the effects of wastewater discharge on riparian and wetland vegetation have indicated a reduction in the richness of native plant species, alongside a rise in opportunistic or invasive species in regions affected by treated or untreated effluents. Changes in vegetation structure can influence habitat quality, trophic interactions, and ecosystem services. Similar patterns have been noted in semi-arid regions of India and in analogous climatic zones across the globe (11,12).

Before 2016, conceptual frameworks for ecosystem resilience focused on the comprehensive evaluation of physical, chemical, and biological indicators to assess how well aquatic ecosystems can endure human-induced stressors. Previous research emphasized the significance of integrating water quality metrics with biological reactions, like variations in plant diversity, to evaluate ecosystem stability and resilience (13,14).

In summary, studies published until 2016 consistently show that (i) inputs from industrial and urban effluents are significant contributors to the decline in water quality, (ii) changes in hydrochemistry have a profound impact on the structure and diversity of aquatic plant communities, and (iii) comprehensive monitoring of both water quality and biological indicators is crucial for evaluating the resilience of ecosystems. The results establish a solid basis for the current research carried out in the industrial twin cities of Surendranagar and Wadhvan.

Materials and methods

Study Area

This study was carried out in the industrial twin cities of Surendranagar and Wadhvan, situated in the central region of Gujarat, India, on the Saurashtra peninsula. Surendranagar district serves as a significant industrial and commercial center, commonly known as the gateway to Saurashtra. The area is marked by a semi-arid climate, featuring very hot summers, some monsoon rainfall, and mild winters. The highest temperature can attain 45.6 °C, whereas the lowest temperature can fall to around 7.8 °C. The typical yearly precipitation is approximately 760 mm, predominantly falling during the southwest monsoon (4,11).

The research area features a diverse array of small- and medium-sized industries, such as textile, chemical, ceramic, food processing, and engineering sectors, with a notable concentration in the Wadhvan GIDC industrial estate (4,11,22). The industrial operations place considerable strain on nearby water resources due to the extraction of groundwater and the release of effluents. Surface water bodies like the Bhogavo River and adjacent ponds are subject to runoff and, in certain areas, may receive either treated or untreated industrial effluents (4,11,22). Figure 1 illustrates the location map of the study area.

Figure.1 Sampling sites of groundwater, river water, pond water in Surendranagar–Wadhawan twin city, Gujarat, India.

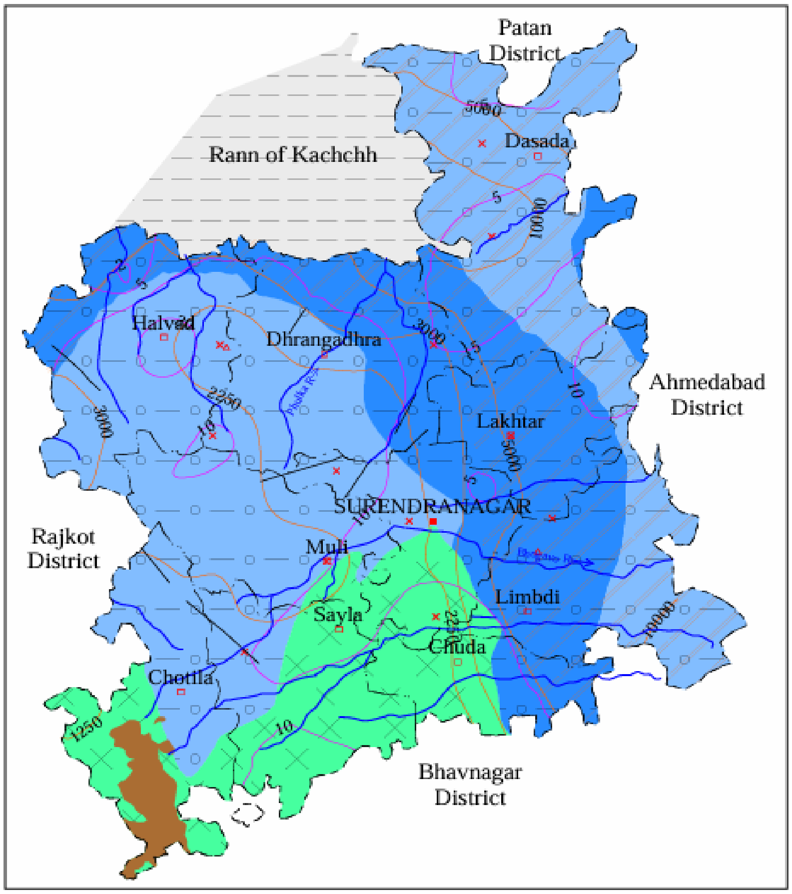

Figure.2 Hydrogeological map of Surendranagar District showing aquifer distribution and groundwater potential: dark blue: Deccan Trap basalt; light blue: fractured basalt; green: alluvial aquifers; brown: hard rock zones; grey: saline groundwater areas influenced by the Rann of Kachchh.(11)

Geological and Hydrogeological Setting

The geological characteristics of the study area significantly affect both the presence and quality of groundwater. The primary lithological units consist of Wadhvan sandstone, Deccan Trap basalts, basic intrusive rocks (dolerite dykes), and alluvial deposits ranging from recent to Pleistocene (4,11). The Wadhvan sandstone is prominently visible in the areas of Wadhvan and Surendranagar, serving a significant function in the storage of groundwater.

The Deccan Trap basalts dominate a significant area of the district, featuring dense, fine-grained lava flows that exhibit well-defined joints and fractures. The structural characteristics promote the flow of groundwater and increase the risk of contamination (4,11,22). The eastern section of the district features unconsolidated alluvial sediments that contain shallow aquifers.

Groundwater exists in both unconfined and semi-confined states, with dug wells and bore wells accessing aquifers at depths between 2 to 30 meters for shallow wells and 60 to 300 meters for tube wells (4,11,22). The heavy extraction of groundwater for both industrial and domestic purposes, along with restricted natural replenishment, has heightened the receptivity of aquifers to quality decline, especially in proximity to industrial areas.

Sampling Strategy and Sample Collection

A systematic sampling approach was utilized to evaluate the impact of industrial operations on various water resources. Samples of water were gathered from groundwater sources (bore wells), river water, and pond water located in and around the industrial areas of Surendranagar and Wadhvan. Sampling locations were chosen due to their closeness to industrial facilities and their ability to represent key water sources utilized for both domestic and agricultural needs (20).

Sampling occurred across three different seasons: summer, monsoon, and winter, to reflect seasonal changes in water quality (20). Samples of groundwater were obtained from bore wells situated in industrial zones and adjacent residential regions. Water samples from the Bhogavo River were gathered at specific locations, especially downstream of industrial areas. Water samples from Boda Pond, located near the border of the twin cities, were collected for analysis.

All samples were gathered in clean polyethylene containers, transported to the laboratory under suitable conditions, and analyzed promptly. Precautions were implemented to prevent contamination during the sampling and handling processes, adhering to established protocols for sample collection and preservation (20).

Analytical Parameters and Methods- Physico-Chemical Analysis

The water samples that were collected underwent analysis for a thorough range of physical, chemical, and organic pollution parameters to assess the status of water quality and environmental resilience. Physical parameters encompassed color, odor, turbidity, dissolved oxygen (DO), and biochemical oxygen demand (BOD) (20,23).

All analyses were conducted in accordance with the standard methods endorsed by the American Public Health Association (APHA) (20), and the results were evaluated against the drinking water guidelines set forth by the World Health Organization (WHO) wherever relevant (21). Seasonal variations and differences among water sources were assessed to comprehend the impact of industrial activities on water quality and the related ecological responses.

Plant Diversity Assessment

Surveys of plant diversity were carried out in and around aquatic environments using systematic field observations. Plant species that thrive in aquatic and semi-aquatic environments were documented, identified through established floras, and categorized according to their ecological traits. The relationship between diversity patterns and water quality conditions was examined to evaluate the effects of pollution on plant communities.

Results and Discussion

Overview of Water Quality Variation

The physico-chemical characteristics of groundwater, river water, pond water, and control (tap water) gathered from the Surendranagar–Wadhawan region exhibited significant spatial and seasonal variations. Seasonal variations were primarily influenced by monsoonal dilution, the intensity of industrial discharge, evaporation in the summer months, and decreased river flow.

Physical Parameters

Colour and Odour

Throughout the study period, the samples of groundwater and dam water exhibited no color or odor. In contrast, the Bhogavo River displayed a light brown to reddish-brown hue and an unpleasant odor during the winter and summer seasons, suggesting the presence of organic pollution and stagnant conditions. The water in Boda Talav exhibited a lackluster hue and unpleasant smell during the summer, indicating the presence of eutrophic conditions.

Turbidity

Turbidity showed notable differences in both space and time at all sampling locations. In the monsoon season, turbidity levels varied from Not Detectable (ND) to 90 NTU, with the peak value observed in River Bhogavo. This suggests a significant presence of suspended particles, probably resulting from surface runoff, industrial discharge, and sediment resuspension. Moderate turbidity levels were recorded at Boda Talav (25 NTU) and Bhavna Way Bridge (3.2 NTU), whereas the majority of groundwater sites exhibited ND values, indicating effective natural filtration via soil layers.

During the winter season, turbidity levels varied from ND to 55 NTU, with the highest measurement observed at River Bhogavo, indicating ongoing human impact. During the summer, turbidity levels varied from ND to 70 NTU, highlighting ongoing particulate contamination in river water, even during dry periods.

Discussion (Turbidity)

Increased turbidity in River Bhogavo throughout all three seasons indicates significant contributions of suspended solids from urban runoff, industrial discharges, and bank erosion. Elevated turbidity limits light penetration, negatively impacting aquatic photosynthesis and, as a result, dissolved oxygen concentrations. Conversely, groundwater samples showed minimal to no turbidity, underscoring the filtering ability of subsurface aquifers. Nonetheless, low turbidity does not automatically signify the lack of dissolved pollutants, necessitating additional chemical analysis.

Oxygen-Related Parameters

Biochemical Oxygen Demand (BOD)(ppm)

Results (BOD)

The BOD values demonstrated different levels of organic pollution. During the monsoon season, the BOD levels varied from 25 ppm in the Control to 70 ppm at Boda Talav. The Bhogavo River displayed elevated BOD levels, peaking at 50 ppm during the monsoon, 80 ppm in winter, and 90 ppm in summer, indicating significant organic pollution.Groundwater locations typically exhibited moderate BOD levels ranging from 40 to 60 ppm, indicating the impact of industrial and domestic discharges.

Discussion (BOD)

The elevated BOD levels in River Bhogavo and Boda Talav indicate a considerable presence of organic matter, probably resulting from untreated sewage and industrial discharges. Increased BOD leads to a decrease in dissolved oxygen levels, negatively affecting aquatic ecosystems. Groundwater BOD levels, while lower than those found in surface water, still reflect human impact in industrial areas. This underscores the necessity for wastewater treatment and more stringent environmental regulations.

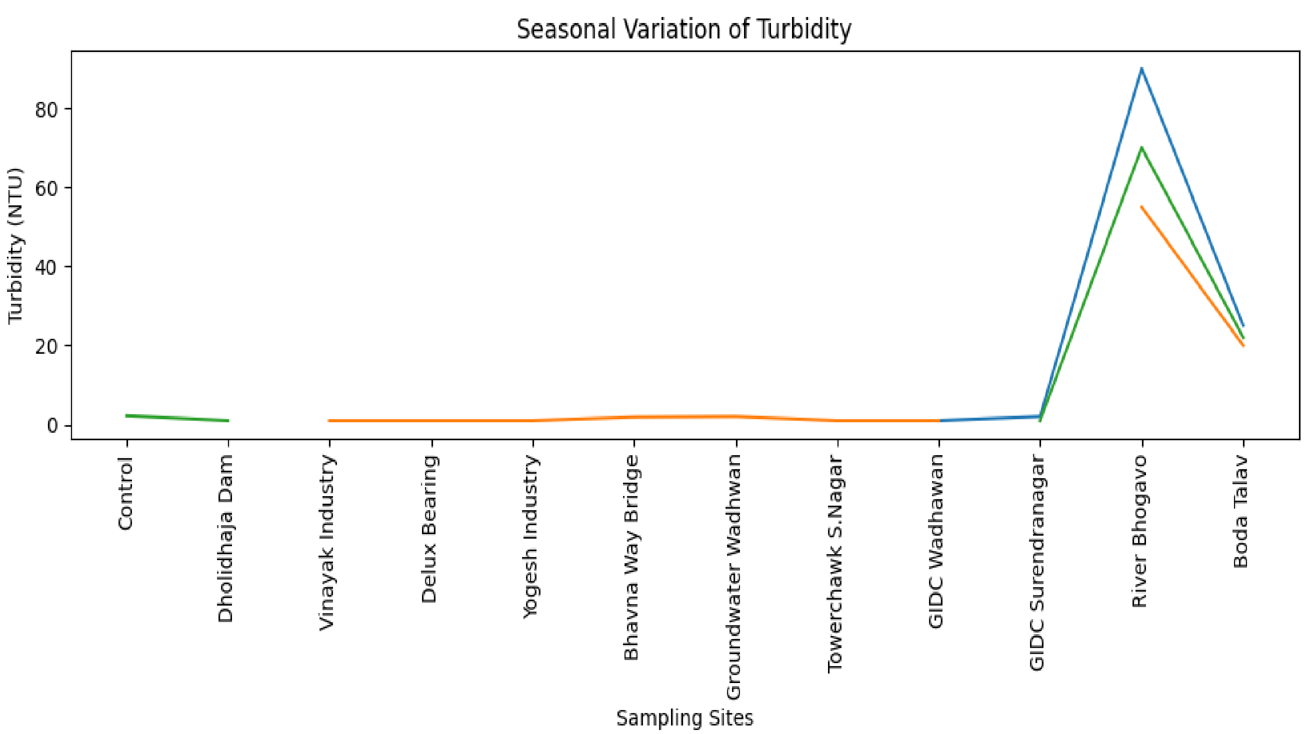

Figure.3 Seasonal variation of Turbidity at different sampling sites.

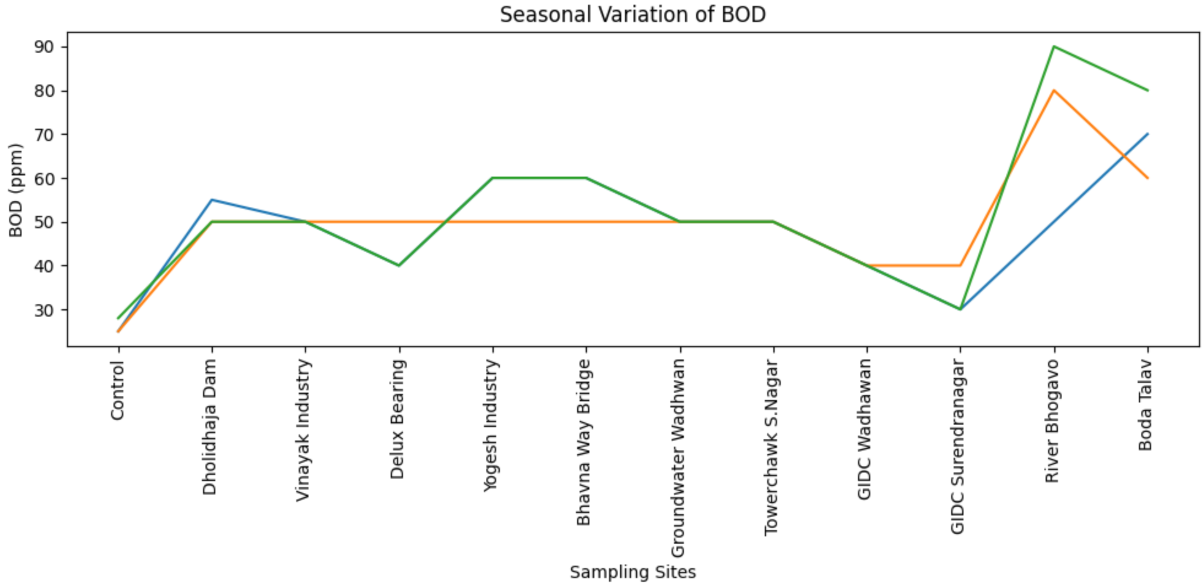

Figure.4 Seasonal variation of BOD at different sampling sites.

Table.1 Range of BOD values across water sources (ppm)

Water Source	Observed Range
Control	25–28
Groundwater	30–60
Bhogavo River	50–90
Boda Talav	60–80

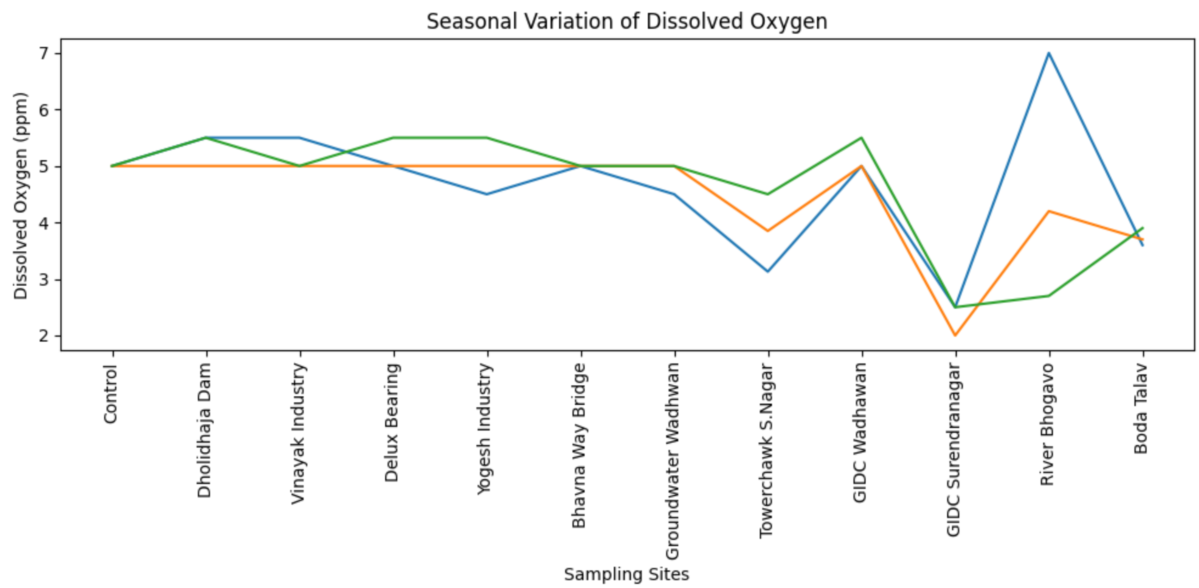

Figure 5: Seasonal variation of Dissolved Oxygen at different sampling sites.

Dissolved Oxygen (DO) (ppm)

Results (DO)

The levels of Dissolved Oxygen (DO) exhibited significant variation across different sampling locations and seasonal periods. During the monsoon season, dissolved oxygen levels varied from 2.5 ppm at GIDC Surendranagar to 7.0 ppm in the River Bhogavo. The majority of groundwater and dam samples exhibited dissolved oxygen levels ranging from 4.5 to 5.5 ppm, suggesting a moderate availability of oxygen.

In the winter season, there was a slight decrease in DO values, recording a minimum of 2.0 ppm at GIDC Surendranagar and a maximum of 5.0 ppm at various groundwater and surface water locations. During the summer months, dissolved oxygen levels at River Bhogavo dropped further to 2.7 ppm, indicating a rise in temperature and organic pollution levels.

Discussion (DO)

Reduced dissolved oxygen levels at GIDC Surendranagar and River Bhogavo during the summer suggest elevated organic pollution and microbial activity, leading to the consumption of dissolved oxygen. This situation could create stress for aquatic organisms and lead to a decline in biodiversity. The relatively stable DO levels in Dholidhaja Dam indicate improved water quality and reduced organic contamination. The levels of groundwater dissolved oxygen were moderate, suggesting limited direct organic contamination while indicating potential mineral effects. During winter, DO values declined slightly, with minimum 2.0 ppm at GIDC Surendranagar and maximum 5.0 ppm at most groundwater and surface water sites. In summer, DO further decreased at River Bhogavo to 2.7 ppm, reflecting increased temperature and organic pollution load.

The findings indicate that the processes of industrialization and urbanization in the Surendranagar–Wadhawan area have had a notable impact on both groundwater and surface water quality. Increased levels of TDS, BOD, COD, nutrients, and hardness in river and pond water suggest significant pollution and eutrophication processes. Seasonal patterns indicate the impact of monsoonal dilution and the increased concentration of pollutants during the summer months.

The investigation focused on turbidity, dissolved oxygen (DO), and biochemical oxygen demand (BOD) distinctly indicates a notable decline in the quality of surface water in the Bhogavo River and Boda Talav. The River Bhogavo displayed consistently high turbidity levels year-round, peaking during the monsoon and summer months. This suggests a significant influx of suspended solids due to factors such as industrial discharge, urban runoff, and the resuspension of sediments. In comparison, Boda Talav exhibited moderate to high turbidity, indicating the buildup of particulates resulting from stagnant water conditions and human activities.

The levels of dissolved oxygen in River Bhogavo exhibited a downward trend from the monsoon to the summer season, ultimately reaching alarmingly low levels during summer. This pattern suggests a rise in organic pollution and heightened microbial activity. In a similar vein, consistently low dissolved oxygen levels in Boda Talav indicate inadequate oxygenation and eutrophic conditions, probably stemming from nutrient enrichment and restricted water circulation.

The biochemical oxygen demand values were notably elevated in both water bodies, especially in River Bhogavo during the winter and summer seasons, indicating significant organic pollution stemming from untreated domestic sewage and industrial discharges. Increased BOD levels in Boda Talav suggest a buildup of organic matter and indicate subpar water quality.

The findings from these three parameters indicate that River Bhogavo experiences greater pollution levels compared to Boda Talav, with both water bodies facing considerable environmental stress. It is crucial to promptly implement measures for controlling industrial effluents, restore rivers, and conduct regular monitoring of water quality to prevent further ecological harm.

Conclusion

This study shows that industrial activities have notably affected the water quality in Bhogavo River and Boda Talav, indicated by increased turbidity, reduced dissolved oxygen, and heightened biochemical oxygen demand, especially in the summer and post-monsoon seasons. The three essential indicators together validate the presence of significant organic and particulate pollution in the surface water bodies of the Surendranagar–Wadhvan twin cities.

Changes in plant diversity patterns, marked by the prevalence of pollution-tolerant species and the reduction of sensitive aquatic and semi-aquatic plants, suggest a diminished resilience of ecosystems in impaired water bodies.

Consistent assessment of turbidity, dissolved oxygen, and biochemical oxygen demand, paired with efficient management of industrial and household waste, is essential for improving water quality and protecting aquatic biodiversity in the examined region.

Conflict of interest statement

Authors declare that they have no conflict of interest.

References

1. Appelo, C. A. J., & Postma, D. (2004). Geochemistry, groundwater and pollution (2nd ed.). CRC Press. https://doi.org/10.1201/9781439833544
2. Lapworth, D., Baran, N., Stuart, M., & Ward, R. (2012). Emerging organic contaminants in groundwater: A review of sources, fate and occurrence. Environmental Pollution, 163, 287–303. https://doi.org/10.1016/j.envpol.2011.12.034
3. Rao, N. S. (2005). Seasonal variation of groundwater quality in a part of Guntur District, Andhra Pradesh, India. Environmental Geology, 49(3), 413–429. https://doi.org/10.1007/s00254-005-0089-9
4. Central Ground Water Board. (2014). Groundwater quality in shallow aquifers of India. Ministry of Water Resources, Government of India.
5. Sirohi, Sandeep & S., P. & Tyagi, Pankaj. (2014). Impact of industrial effluents on water quality of Kali river in different locations of Meerut, India. Journal of Engineering and Technology Research. 6. 43-47. 10.5897/JETR2014.0349.
6. Chauhan, M. B., Patel, R. K., & Shah, P. R. (2016). Physico-chemical assessment of groundwater quality in Wadhvan Taluka of Surendranagar District, Gujarat, India. Journal of Pharmaceutical and Biosciences, 4(3), 185–192.
7. Carpenter, S. R., Bennett, E. M., & Peterson, G. D. (2006). Scenarios for Ecosystem Services: An Overview. Ecology and Society, 11(1). http://www.jstor.org/stable/26267787
8. Yan, S.-H., Song, W., & Guo, J.-Y. (2016). *Advances in management and utilization of invasive water hyacinth (Eichhornia crassipes) in aquatic ecosystems – a review. Critical Reviews in Biotechnology*, *37*(2), 218–228. https://doi.org/10.3109/07388551.2015.1132406
9. Kadlec, R. H., & Wallace, S. D. (2008). Treatment wetlands (2nd ed.). CRC Press. https://doi.org/10.1201/9781420012514
10. Vymazal, J. (2011). Plants used in constructed wetlands with horizontal subsurface flow: a review. Hydrobiologia, 674(1), 133–156. https://doi.org/10.1007/s10750-011-0738-9
11. Tiwari, H. N. (2014). *District groundwater brochure: Surendranagar District*, *Gujarat*. Central Ground Water Board, Government of India.
12. Jha, Poulami & Samal, Alok & Santra, Subhas & Dewanji, Anjana. (2016). Heavy Metal Accumulation Potential of Some Wetland Plants Growing Naturally in the City of Kolkata, India. American Journal of Plant Sciences. 7. 2112-2137. 10.4236/ajps.2016.715189.
13. Holling, C. S. (1973). Resilience and stability of ecological systems. Annual Review of Ecology and Systematics, 4, 1–23. https://www.jstor.org/stable/2096802
14. Folke, C. (2006). Resilience: The emergence of a perspective for social–ecological systems analyses. Global Environmental Change, 16(3), 253–267. https://doi.org/10.1016/j.gloenvcha.2006.04.002
15. Indian Council of Medical Research. (1975). *Manual of standard quality of drinking water supplies* (2nd ed.). ICMR, New Delhi, India
16. Calderon, R. (2000). The epidemiology of chemical contaminants of drinking water. Food and Chemical Toxicology, 38(1 Suppl), S13–S20. https://doi.org/10.1016/s0278-6915(99)00133-7
17. Golterman, H. L., & Meyer, M. L. (1985). The geochemistry of two hard water rivers, the Rhine and the Rhone: Part 3. The relations between calcium, bicarbonate, sulphate and pH. *Hydrobiologia*, *126*(1), 21–24. https://doi.org/10.1007/BF00008382
18. Tyagi, S., Singh, P., Sharma, B., & Singh, R. (2014). *Assessment of water quality for drinking purpose in district Pauri of Uttarakhand*, *India*. Applied Ecology and Environmental Sciences, 2(4), 94–99. https://doi.org/10.12691/aees-2-4-2
19. Patel K. C., Studies on ground water quality of Mehasana district agroclimatic zone of Gujarat state, Ph. D. Thesis submitted to North Gujarat University, Patan (2006).
20. American Public Health Association. (1989). Standard methods for the examination of water and wastewater (23rd ed.). APHA, AWWA, WEF.

21. World Health Organization. (2011). *Guidelines for drinking-water quality* (4th ed.). World Health Organization Press, Geneva.
22. Ground Water Estimation Committee. (1997). *Report of the Ground Water Estimation Committee (GEC-97)*. Ministry of Water Resources, Government of India, New Delhi.
23. Bureau of Indian Standards. (2012). *Indian standard: Drinking water — Specification (IS 10500:2012)*. Bureau of Indian Standards, New Delhi, India
24. Awoyemi, O. M., Achudume, A. C., & Okoya, A. A. (2014). The physicochemical quality of groundwater in relation to surface water pollution in Majidun area of Ikorodu, Lagos State, Nigeria. *American Journal of Water Resources, 2*(5), 126–133. https://doi.org/10.12691/ajwr-2-5-4
25. Trivedy, R. K., & Goel, P. K. (1986). *Chemical and biological methods for water pollution studies*. Environmental Publications.
26. Sharma, D., & Kansal, A. (2011). Water quality analysis of River Yamuna using water quality index in the national capital territory, India (2000–2009). Applied Water Science, 1(3–4), 147–157. https://doi.org/10.1007/s13201-011-0011-4
27. Saravanakumar, A., Rajkumar, M., Serebiah, J. S., & Thivakaran, G. A. (2008). Seasonal variations in physico-chemical characteristics of water, sediment and soil texture in arid zone mangroves of Kachchh-Gujarat. Journal of environmental biology, 29(5), 725–732.
28. Phiri, O., Mumba, P., Moyo, B. H. Z., & Kadewa, W. (2005). Assessment of the impact of industrial effluents on water quality of receiving rivers in urban areas of Malawi. International Journal of Environmental Science and Technology, 2(3), 237–244. https://doi.org/10.1007/bf03325882

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