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Assessment Of Physico-Chemical Parameters And Water Quality In Amlai Lake, Modasa Taluka, Gujarat, India

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ABSTRACT
Water quality assessment is crucial for effective management of aquatic ecosystems, especially in developing nations like India, where water bodies face increasing pollution loads from anthropogenic activities, industrial effluents, and domestic sewage. This study focuses on the determination and interpretation of physico-chemical parameters of water and soil samples from Amlai Lake, a significant wetland in Modasa Taluka, Gujarat, India. Data collected across winter, summer, and monsoon seasons in 2022 and 2023 for parameters such as temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), hardness, chlorides, alkalinity, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), phosphate, and sulphate in water, and pH, total hardness, EC, calcium, magnesium, chloride, sulphate, sodium, potassium, and phosphate in soil, were analysed. The results for Amlai Lake revealed critically high BOD and COD levels in water, indicative of severe organic pollution, and low DO, threatening aquatic life. Soil analysis showed consistent alkalinity and seasonal variations in nutrient and mineral concentrations. This integrated approach highlights the localized impacts of pollutants and emphasizes the urgent need for targeted water quality management and eco-remediation measures for the sustainable health of Amlai Lake.
Key words: *Water pollution, Physico-chemical characteristics, Amlai Lake, Modasa Taluka, Industrial effluent, Domestic waste, Eco-remediation.*

INTRODUCTION:

Water, often referred to as "Jeevan" (life) in Sanskrit, is an indispensable natural resource vital for the sustenance of all living organisms and for various human developmental activities, including drinking, irrigation, and industrial processes. Occupying approximately 70% of the Earth's surface, freshwater resources are increasingly subjected to contamination and pollution, posing a significant global concern, particularly in rapidly developing countries such as India. The quality of water bodies is fundamentally characterized by their physical, chemical, and biological properties, and any adverse alteration in these parameters due to the addition of undesirable materials renders the water unfit for its intended use (Brown, 1970; Patel and Patel, 2012).

In India, river and lake ecosystems, which serve as critical life support systems, are under immense pressure from a multitude of pollution sources. Unplanned urbanization, rapid industrialization, agricultural runoff, and the indiscriminate discharge of untreated domestic sewage and industrial effluents contribute significantly to the degradation of these vital water sources (Chaturvedi et al., 2003). Such pollution not only impacts the ecological balance of aquatic life but also poses severe health risks to human populations relying on these waters. For instance, the presence of pathogens, toxic metals, and chemical compounds like pesticides and industrial waste can lead to waterborne diseases (Abida and Harikrishna, 2008).

Lakes, in particular, play a crucial role in recharging aquifers and regulating hydrological regimes, while also acting as natural traps for sediments and nutrients, thereby influencing the water quality of downstream river systems. However, degradation due to encroachment, eutrophication, and siltation is a widespread issue (Sengupta and Dalwani, 2008). This study specifically focuses on Amlai Lake (Vanzariya), a crucial wetland within the Modasa Taluka of Gujarat, which represents a typical example of such vulnerable aquatic ecosystems. Understanding the physico-chemical characteristics of Amlai Lake's water and soil is fundamental to detecting the effects of pollution and formulating effective management strategies. Changes in water quality are directly reflected in the biotic community structure and overall health of the ecosystem. Therefore, a systematic assessment of these parameters against established standards (e.g., WHO, BIS) is imperative to identify the extent of pollution, pinpoint its sources, and guide remedial actions for this specific lake (Ahipathi and Puttaiah, 2006).

This study aims to investigate the physico-chemical parameters of water and soil samples from Amlai Lake, drawing upon existing methodologies and findings to highlight the challenges faced in maintaining water quality in the context of increasing anthropogenic pressures in semi-arid regions. The objective is to evaluate the suitability of Amlai Lake's waters for various purposes and to emphasize the urgent need for integrated water quality management and restoration efforts (Bharti and Katyal, 2011).

METHODOLOGY

Study Area and Sample Collection

This study focuses on Amlai Lake (Vanzariya), located in the Modasa Taluka, Sabar Kantha district, Gujarat, India. Amlai village is situated 9 kilometres from the sub-district headquarters in Modasa and occupies a total land area of 1159.44 hectares. Amlai Lake represents a typical wetland within this semi-arid region, which experiences distinct seasonal variations affecting its hydrological and ecological characteristics (Chaudhry et al., 2007).

Water and soil samples were collected from Amlai Lake during two distinct seasonal windows over two years (2022 and 2023) to capture temporal variations in its physico-chemical parameters:

- Winter (November-February): Represents cooler, drier conditions following the monsoon.
- Summer (March-April): Represents a period of declining water levels and increased concentration of solutes due to evaporation.
- Monsoon (July-August): Represents a period of maximum water retention and lush aquatic vegetation growth.

For water sampling, surface water samples were collected at 15-30 cm depth in sterilized polyethylene bottles, adhering to standard procedures (APHA, 2005). Field parameters such as temperature, pH, electrical conductivity (EC), and dissolved oxygen (DO) were measured in situ using portable kits. Samples for biochemical oxygen demand (BOD) were collected in dark glass bottles, and chemical oxygen demand (COD) samples were preserved with acid or ice as per standard requirements to prevent degradation prior to laboratory analysis within 1-3 hours of collection.

For soil sampling, representative cores were collected from different zones within the lake, such as the Central Basin Zone (CBZ), Littoral Fringe Zone (LFZ), and Peripheral Upland Zone (PUZ), using stainless steel augers to a depth of 0 to 15 cm. Samples were air-dried, lightly crushed, and sieved (2 mm mesh) for subsequent laboratory analysis according to ICAR soil testing instructions (Costanza et al., 1997).

Physico-chemical Analysis

The following physico-chemical parameters were analysed for both water and soil samples:

Water Parameters:

- pH: Measured potentiometrically.
- Electrical Conductivity (EC): Measured using a conductivity meter to indicate total ionic concentration (mm/cms).
- Dissolved Oxygen (DO): Determined by the Azide modification method (APHA, 2005).
- Total Dissolved Solids (TDS): Measured by the evaporation method (APHA, 2005).
- Alkalinity: Determined by titrimetric methods.
- Turbidity: Measured using a turbidimeter (NTU).
- Bicarbonate (as HCO3): Determined as part of alkalinity.
- Biochemical Oxygen Demand (BOD): Measured by the sodium thiosulphate titration method (APHA, 2005).
- Chemical Oxygen Demand (COD): Measured by the dichromate reflux method (APHA, 2005).
- Chloride (as Cl): Determined by gravimetric methods.
- Magnesium (as Mg): Determined by titrimetric methods.
- Nitrate (as NO3): Measured using standard methods.
- Potassium (as K): Measured using standard methods.
- Sodium (as Na): Measured using standard methods.
- Sulphate (as SO3): Measured using standard methods.
- Fluoride: Measured using standard methods.

Soil Parameters:

- pH: Measured in a soil-water suspension.
- Total Hardness: Determined by standard methods (kg/cm^2).
- Electroconductivity (EC): Measured in a soil extract (mS/m).

• Calcium, Magnesium, Chloride, Sulphate, Sodium, Potassium, Phosphate: Determined by standard soil analytical procedures as outlined by ICAR.

All analytical procedures were performed in triplicate, and mean values were used for interpretation against national (CPCB) and international (WHO) water quality standards.

Results and Discussion

Water Quality Parameters of Amlai Lake

The systematic study of Amlai Lake's water quality during 2022 and 2023 provides a critical overview of its ecological condition, reflecting the combined outcomes of natural processes and human activities. The key parameters, indicating the physico-chemical conditions of the aquatic system and affecting the biotic make-up and ecological processes, were assessed against CPCB and WHO standards (CPCB, 2008; WHO, 1993).

Figure 1: Different graph of water parameters A. Seasonal Water pH Trends in Amlai Lake B. Dissolved Oxygen (DO) Levels in Amlai Lake vs. CPCB Standard C. Water EC and TDS Seasonal Fluctuations in Amlai Lake D. BOD and COD Levels in Amlai Lake vs. Standards E. Key Ion Concentrations in Amlai Lake Water

The electrical conductivity of Amlai Lake water ranged from 330 mm/cms to 350 mm/cms across the study period. The highest values were consistently observed during the winter months of both 2022 and 2023 (350 mm/cms), indicating a higher concentration of dissolved ions. Summer values (330 mm/cms in 2022, 335 mm/cms in 2023) and monsoon values (335 mm/cms in 2022, 345 mm/cms in 2023) were comparatively lower, with monsoon showing slightly higher values than summer in 2023, possibly influenced by initial runoff. While these levels are well within the CPCB standard for irrigation and industrial cooling (<2250µS/cm), they consistently exceed the WHO desirable guideline for drinking water (<400µS/cm), suggesting a higher mineral content than is ideal for potability (Faith, 2006).

Dissolved oxygen concentrations in Amlai Lake varied between 4.0 mg/L and 4.4 mg/L. The highest DO levels were recorded in summer 2022 (4.4 mg/L) and 2023 (4.3 mg/L), likely influenced by temperature, photosynthetic activity, and potential water agitation (Senthilkumar and Sivakumar, 2008). Conversely, winter (4.1 mg/L in 2022, 4.0 mg/L in 2023) and monsoon (4.2 mg/L in both years) seasons generally exhibited lower DO. These observed DO levels consistently fall short of the CPCB standards for Drinking Water Source A (>6 mg/L) and Outdoor Bathing (>5 mg/L). Although they marginally meet CPCB's Drinking Water Source C (>4 mg/L) standard, the persistently low DO is a significant ecological concern, potentially impacting aquatic life (Ganapati, 1943).

The pH of Amlai Lake water showed seasonal fluctuations, ranging from 7.50 to 8.43. The water generally maintained an alkaline character, with the highest pH values observed during monsoon (8.33 in 2022, 8.43 in 2023) and winter (8.26 in 2022, 8.32 in 2023). Summer recorded slightly lower pH values (7.50 in both years). All recorded pH values fall within the permissible range of 6.5-8.5 recommended by both CPCB and WHO, indicating that the water's acidity-alkalinity balance is generally acceptable (Patel and Vaghani, 2015; Shrivastava and Joshi, 2008).

Total Dissolved Solids concentrations in the lake ranged from 230 mg/L to 248 mg/L. The highest TDS values were observed in winter (245 mg/L in both 2022 and 2023) and summer 2022 (245 mg/L), whereas the monsoon season consistently showed the lowest levels (230 mg/L in both years). This pattern suggests a concentration of dissolved solids during drier periods due to evaporation and a dilution effect during the monsoon (Goher, 2002). All observed TDS values are well within the maximum permissible limits set by CPCB (2000 mg/L) and WHO (1000 mg/L), and also below their desirable limits (500 mg/L)(Venkatachalapathy and Karthikeyan, 2013)

Alkalinity levels in Amlai Lake varied from 60 mg/L to 80 mg/L. The highest alkalinity was recorded during the monsoon season (80 mg/L in both years), while the lowest was observed in winter (60 mg/L in both years). These values are consistently within the CPCB desirable standard of 200 mg/L (Montgomery, 2007).

Turbidity remained consistently low throughout the study, ranging from 2 NTU to 4 NTU. Winter and summer recorded the lowest values (2 NTU), with a slight increase during the monsoon (3 NTU in 2022, 4 NTU in 2023). All observed turbidity values are within the CPCB's permissible limit (<5 NTU) and WHO's recommended limit (<5 NTU), indicating generally clear water (Huq and Alam, 2005).

Bicarbonate concentrations ranged from 110 mg/L to 160 mg/L. The highest levels were noted in summer (159 mg/L in 2022, 160 mg/L in 2023), while the lowest occurred in monsoon (110 mg/L in both years). All recorded values are below the WHO desirable limit of 250 mg/L (Bharti and Katyal, 2011).

BOD levels in Amlai Lake were critically high, ranging from 80 mg/L (monsoon 2023) to 96 mg/L (summer 2022 and 2023). These values drastically and consistently exceed the CPCB standards (<3 mg/L for bathing/drinking source C) and WHO guidelines (<5 mg/L). Such elevated BOD indicates severe organic pollution, making the water profoundly unsuitable for direct human use (ReVelle and ReVelle, 1988). COD concentrations mirrored the high BOD levels, ranging from 205 mg/L to 235 mg/L. The highest values were observed in summer (225 mg/L in 2022, 235 mg/L in 2023), with monsoon showing the lowest (205 mg/L in both years). Nearly all COD values significantly exceed the WHO maximum guideline of 100 mg/L. This strongly confirms a widespread high organic and inorganic pollutant load in Amlai Lake, posing a threat to aquatic ecosystems (Sinha et al., 2013; Shekhar et al., 2008).

Chloride concentrations in the lake varied from 24 mg/L to 40 mg/L. Monsoon seasons recorded the highest levels (40 mg/L in both years), while summer showed the lowest (24 mg/L in 2022, 27 mg/L in 2023). All concentrations are well within the CPCB (250 mg/L desirable) and WHO permissible limits, indicating no concerns related to chloride-induced salinity. Magnesium levels ranged from 12 mg/L to 15 mg/L. Concentrations were consistently 15 mg/L in winter and summer, slightly decreasing to 12 mg/L (2022) and 13 mg/L (2023) during the monsoon. These values are well within the CPCB desirable limit of 30 mg/L and WHO permissible limit of 50 mg/L. Nitrate concentrations in Amlai Lake were generally low, ranging from 0.62 mg/L to 1.90 mg/L. Highest values were observed in winter (1.90 mg/L in both years), while summer (0.62 mg/L in both years) and monsoon (0.62 mg/L in 2022, 0.65 mg/L in 2023) showed lower levels. All observed nitrate levels are well within CPCB (45 mg/L) and WHO (50 mg/L) guidelines, suggesting no significant nitrate contamination (Debels et al., 2005). Potassium levels varied from 1.0 mg/L to 4.2 mg/L. The highest concentrations were in winter (3.9 mg/L in 2022, 4.2 mg/L in 2023), and the lowest in summer (1.0 mg/L in both years). While no specific CPCB or WHO standards for potassium are typically provided, these levels are generally considered low. Sodium concentrations ranged from 20.8 mg/L to 30.4 mg/L. The monsoon season recorded the highest levels (30.4 mg/L in both years), while winter showed the lowest (20.8 mg/L in both years). All concentrations are well within the WHO maximum recommended limit of 200 mg/L. Sulphate levels ranged from 1 mg/L to 10 mg/L. The monsoon season consistently showed the highest values (10 mg/L in both years), while summer had the lowest (1 mg/L in both years). These values are well within CPCB (200 mg/L desirable) and WHO desirable (250 mg/L) limits. Fluoride was generally found to be Below Detection Limit (BDL) throughout most seasons. A single detection of 0.10 mg/L occurred in summer 2023. These levels are significantly below the CPCB (1.0 mg/L desirable) and WHO (1.5 mg/L) desirable limits, which might pose a concern for dental health if the water were to be used as a primary drinking source (King et al., 2003; Shaikh et al., 2003).

Soil Quality Parameters of Amlai Lake

The soil quality of Amlai Lake is vital for maintaining its ecological integrity, influencing water holding capacities, nutrient cycling, and supporting plant and microbial life. The analysis reveals seasonal variations crucial for understanding the lake's health (Kumar and Sinha, 2010).

Figure 2: Different graph of soil parameters A. Seasonal Soil pH Trends in Amlai Lake B. B. Soil Total Hardness and EC Seasonal Fluctuations in Amlai Lake C. Seasonal Soil Phosphate Levels in Amlai Lake D. Seasonal Key Cation Concentrations in Amlai Lake Soil

The soil pH in Amlai Lake consistently showed an alkaline character, with values ranging from 7.79 to 8.10. The highest pH was consistently observed during summer (8.10 in both 2022 and 2023), while winter showed slightly lower pH (7.79 in 2022, 8.00 in 2023). Monsoon pH values were intermediate (8.09 in 2022, 8.10 in 2023). While these values fall within the CPCB guideline for effluent discharge on land (6.0-8.5), persistent alkalinity at this range can potentially affect the availability of certain nutrients for plants (Jain et al., 1996; Kumar et al., 2008).

Total Hardness in the soil varied significantly with seasons, ranging from 1.75 kg/cm^2 to 4.50 kg/cm^2. The highest values were consistently found in winter (4.50 kg/cm^2 in both years), suggesting a concentration of hardness-contributing minerals during drier, colder periods. Monsoon recorded the lowest levels (1.75 kg/cm^2 in 2022, 1.90 kg/cm^2 in 2023), likely due to dilution or leaching. Summer values were intermediate (2.25 kg/cm^2 in 2022, 2.35 kg/cm^2 in 2023) (Lal, 1998).

Soil EC values ranged from 20 mS/m to 40 mS/m. The highest EC was consistently observed during summer and monsoon (40 mS/m in both years for both seasons), indicating increased soluble salt concentrations, potentially due to evaporation or increased microbial activity in warmer/wetter conditions. Winter exhibited the lowest EC (20 mS/m in 2022, 28 mS/m in 2023). All observed values are well below thresholds for severe salinity, indicating no major salinity concerns (Prakash, 1982).

Calcium concentrations in the soil ranged from 14 mg/kg to 20 mg/kg. The highest levels were consistently found in summer (18 mg/kg in 2022, 20 mg/kg in 2023) and monsoon (18 mg/kg in both years), suggesting higher concentrations during warmer or wetter periods. Winter consistently showed the lowest calcium levels (14 mg/kg). Magnesium levels in the soil showed a distinct seasonal pattern, varying from 58 mg/kg to 88 mg/kg. The highest concentrations were consistently observed in summer (88 mg/kg in both years), followed by monsoon (78 mg/kg in 2022, 82 mg/kg in 2023). Winter consistently recorded the lowest magnesium levels (58 mg/kg in 2022, 62 mg/kg in 2023). Chloride concentrations in the soil ranged from 9.6 mg/kg to 15 mg/kg. The highest levels were consistently found in summer (15 mg/kg in both years), with winter and monsoon showing lower and similar concentrations (around 9.6-10.0 mg/kg). This suggests higher chloride levels during warmer months, potentially due to evaporation. Sulphate values in the soil varied from 24 mg/kg to 32 mg/kg. The highest levels were consistently observed during the monsoon season (32 mg/kg in both years), while winter (24 mg/kg in 2022, 25 mg/kg in 2023) and summer (28 mg/kg in both years) had lower concentrations (Laskar and Susmita, 2009; Rajkumar et al., 2004). Sodium concentrations in the soil ranged from 1.2 mg/kg to 4.2 mg/kg. The highest levels were consistently found in monsoon (3.9 mg/kg in 2022, 4.2 mg/kg in 2023), with summer showing intermediate values (3.2 mg/kg in 2022, 3.4 mg/kg in 2023). Winter consistently recorded the lowest sodium levels (1.2 mg/kg). Potassium levels in the soil showed significant seasonal variation, ranging from 240 mg/kg to 480 mg/kg (Narsimha and Jaya, 2001; Sahastrabuddhe and Patwardhan, 2003). The highest concentrations were consistently observed in summer (480 mg/kg in both years), while winter (240 mg/kg in 2022, 270 mg/kg in 2023) and monsoon (300 mg/kg in 2022, 315 mg/kg in 2023) showed lower levels. Phosphate concentrations in the soil varied from 20 mg/kg to 70 mg/kg. The highest levels were consistently observed in summer (60 mg/kg in 2022, 70 mg/kg in 2023), suggesting accumulation or increased biological activity during these warmer months. Monsoon values were intermediate (50 mg/kg in 2022, 55 mg/kg in 2023), and winter consistently recorded the lowest levels (20 mg/kg). The elevated phosphate in summer is a minor to moderate concern for potential nutrient runoff into the lake (Pimentel et al., 1995).

Plant Biodiversity in Amlai Lake and Modasa Taluka Wetlands

Amlai Lake, as part of the Modasa Taluka wetlands, supports a diverse array of aquatic and semi-aquatic flora, characteristic of semi-arid wetland ecosystems. The broader floristic assessment of Modasa Taluka wetlands (as referenced in the provided document) identifies 96 unique plant species. This high level of species richness generally indicates healthy and stable ecosystems with diverse habitats.

The dominant plant families in these wetlands are Poaceae (Grasses, 18 species) and Cyperaceae (Sedges, 17 species). These families typically thrive in moist to waterlogged conditions, forming extensive marshy areas, especially along the fringes of water bodies or in seasonally inundated zones. The presence of Hydrocharitaceae (e.g., Hydrilla verticillata, Vallisneria spiralis) and Nymphaeaceae (Nymphaea pubescens, Nelumbo nucifera) are strong indicators of submerged or floating aquatic habitats. Many species are emergent (rooted in submerged soil but growing above water) forming typical "marsh" vegetation and stabilizing shorelines. The prevalence of generalist and pollution-tolerant species, such as Hydrilla verticillata (often found in nutrient-rich waters) and various Cyperus species (many of which tolerate disturbance and nutrient enrichment), biologically corroborates the observed high organic pollution and nutrient loading in the water (Gopal and Junk, 2000). Their unchecked proliferation can sometimes indicate nutrient loading.

Overall Interpretation

The water quality of Amlai Lake presents a critical picture dominated by severe organic pollution (high BOD/COD) and widespread oxygen depletion (low DO). These are the most significant ecological challenges, rendering the water unsuitable for direct human use and stressing aquatic life. While parameters like pH and TDS are generally within acceptable ranges (though pH can be alkaline), the fundamental issue of pollution load needs urgent attention.

For soil, the consistent alkaline pH (up to 8.10) is a notable characteristic. While not as extreme as some other lakes in the region, it indicates potential impacts on nutrient availability. Seasonal fluctuations in EC, calcium, magnesium, and sodium concentrations in soil suggest dynamic processes related to water levels, evaporation, and potentially localized inputs. The elevated phosphate levels in summer are a concern, as this nutrient can leach into the water, contributing to eutrophication.

In essence, Amlai Lake faces significant anthropogenic stress, primarily from organic pollution, which profoundly impacts its water chemistry and threatens its ecological balance. While its soil exhibits generally acceptable characteristics, the pervasive alkalinity and potential for nutrient loading from phosphorus require careful management.

The comprehensive assessment of Amlai Lake's water and soil quality parameters over 2022 and 2023 reveals a wetland under significant ecological stress. The most pressing issues identified are:

• Severe Organic Pollution: Critically high Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) levels in the water consistently exceed national and international standards, indicating a substantial load of organic contaminants.

• Oxygen Depletion: Dissolved Oxygen (DO) levels are pervasively low, falling below the requirements for healthy aquatic ecosystems and rendering the water unsuitable for various human uses.

• Alkaline Conditions: Both water (consistently above 8.0, with summer dips to 7.5) and soil (consistently alkaline, up to 8.10) exhibit high pH, which can negatively impact water chemistry, nutrient availability, and biological processes.

• Nutrient Concerns: Elevated phosphate levels in the soil, particularly in summer, suggest a risk of nutrient runoff into the lake, potentially exacerbating eutrophication.

While some parameters like TDS, chlorides, sodium, and sulphates are within acceptable limits, the fundamental problems of organic pollution and oxygen depletion are paramount. The plant community composition, characterized by pollution-tolerant species, biologically corroborates these findings.

This study underscores the urgent necessity for integrated and proactive management strategies to restore the ecological health and functionality of Amlai Lake.

Suggestions for Wetland Management and Conservation of Amlai Lake:

To address the identified challenges and improve the ecological health of Amlai Lake, the following suggestions are put forth:

1. Implement Strict Pollution Control: Prioritize measures to drastically reduce the inflow of organic pollutants. This includes exploring solutions for diverting or treating sewage from surrounding settlements before it reaches the lake and promoting sustainable agricultural practices to minimize nutrient and agrochemical runoff.
2. Enhance Water Quality: Investigate and implement appropriate artificial aeration techniques to improve dissolved oxygen levels. Regular removal of excessive aquatic vegetation and accumulated organic sediments can also help reduce the biological oxygen demand.
3. Manage Soil Health: Conduct further studies to understand the root causes of high soil alkalinity and explore suitable soil amendments or management practices to bring pH closer to neutral, improving nutrient availability. Control phosphate loading in soil through sustainable agricultural practices and careful waste disposal to prevent further eutrophication of the lake water.
4. Ecosystem Restoration: Once pollution levels are reduced, consider reintroducing sensitive native aquatic plant species to enhance biodiversity and ecosystem services. Foster local ownership and stewardship by involving the Amlai village community in conservation efforts, including clean-up drives, awareness programs, and participatory monitoring.
5. Continuous Monitoring: Establish a robust and frequent monitoring program for both water and soil quality in Amlai Lake to track changes, assess the effectiveness of interventions, and adapt management strategies as needed.

These targeted interventions are crucial for the long-term sustainability of Amlai Lake, transforming it from a stressed ecosystem into a healthy, vibrant wetland serving both ecological and community needs.

CONCLUSION

The comprehensive assessment of Amlai Lake reveals a wetland under significant ecological stress. Critically high Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) levels signal severe organic pollution, coupled with dangerously low Dissolved Oxygen (DO), directly threatening aquatic life. Concurrently, the soil exhibits consistent alkalinity and concerning levels of phosphate, indicating potential nutrient overload that exacerbates water quality degradation. This complex interplay of elevated pollutants and unfavourable physico-chemical conditions profoundly impacts the lake's ecological health. The study underscores the urgent necessity for integrated and proactive management strategies. Implementing stringent pollution control, enhancing water aeration, and addressing soil imbalances are paramount steps. Only through such concerted efforts can Amlai Lake be restored to a healthy, vibrant ecosystem, vital for both environmental and community well-being in Modasa Taluka.

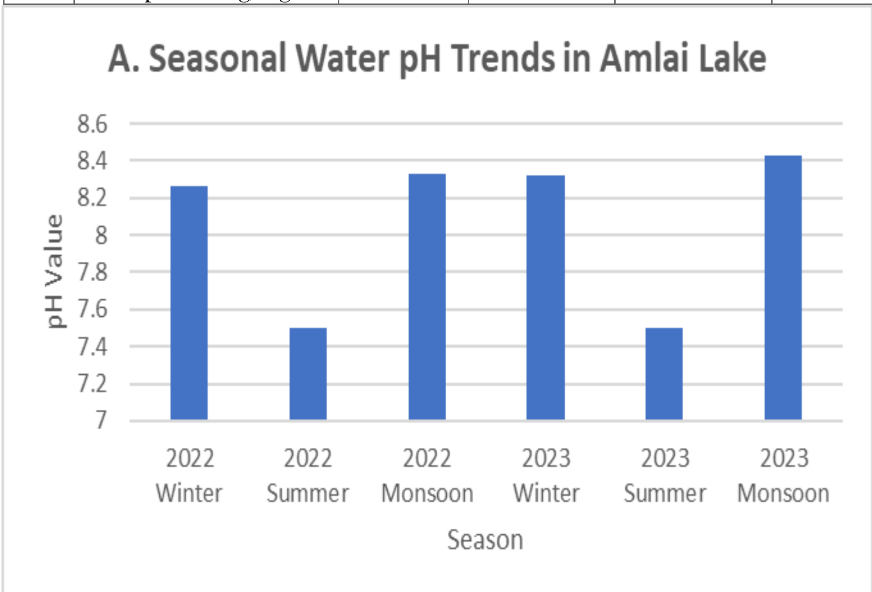
Table 1: Physico-chemical parameters of water of Amlai Lake.

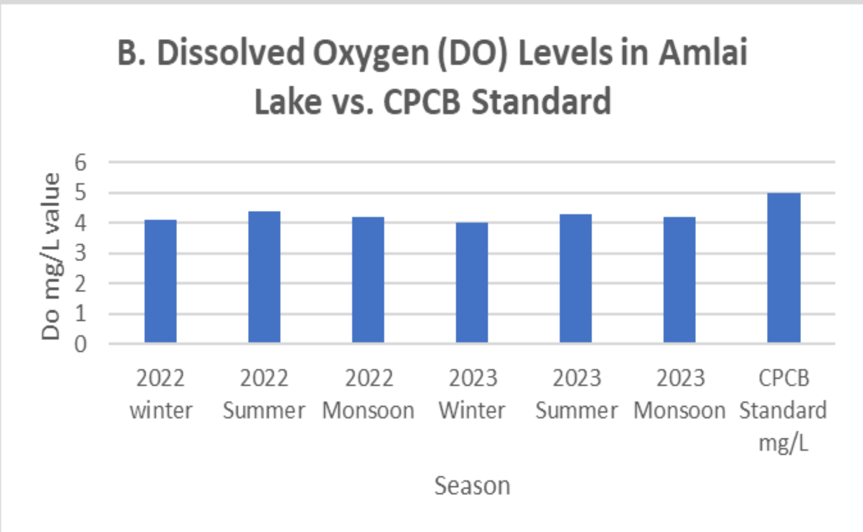
Sr. no	Parameter	2022 Winter	2022 Summer	2022 Monsoon	2023 Winter	2023 Summer	2023 Monsoon
01	Electroconductivity mm/cms	350	330	335	350	335	345
02	Dissolved oxygen mg/L	4.1	4.4	4.2	4.0	4.3	4.2
03	pH at 25°C	8.26	7.50	8.33	8.32	7.50	8.43
04	Total Dissolved Solids mg/L	245	245	230	245	248	230
05	Alkalinity mg/L	60	65	80	60	75	80
06	Turbidity NTU	2	2	3	2	3	4
07	Bicarbonate mg/L	122	159	110	120	160	110
08	B.O.D mg/L	90	96	86	90	96	80
09	C.O.D mg/L	210	225	205	210	235	205
10	Chloride mg/L	32	24	40	35	27	40
11	Magnesium mg/L	15	15	12	15	15	13
12	Nitrate mg/L	1.90	0.62	0.62	1.90	0.62	0.65
13	Potassium mg/L	3.9	1.0	1.1	4.2	1.0	1.5
14	Sodium mg/L	20.8	23.5	30.4	20.8	25.5	30.4
15	Sulphate mg/L	8.2	1	10	8.0	1	10
16	Fluoride mg/L	BDL	BDL	BDL	BDL	0.10	BDL

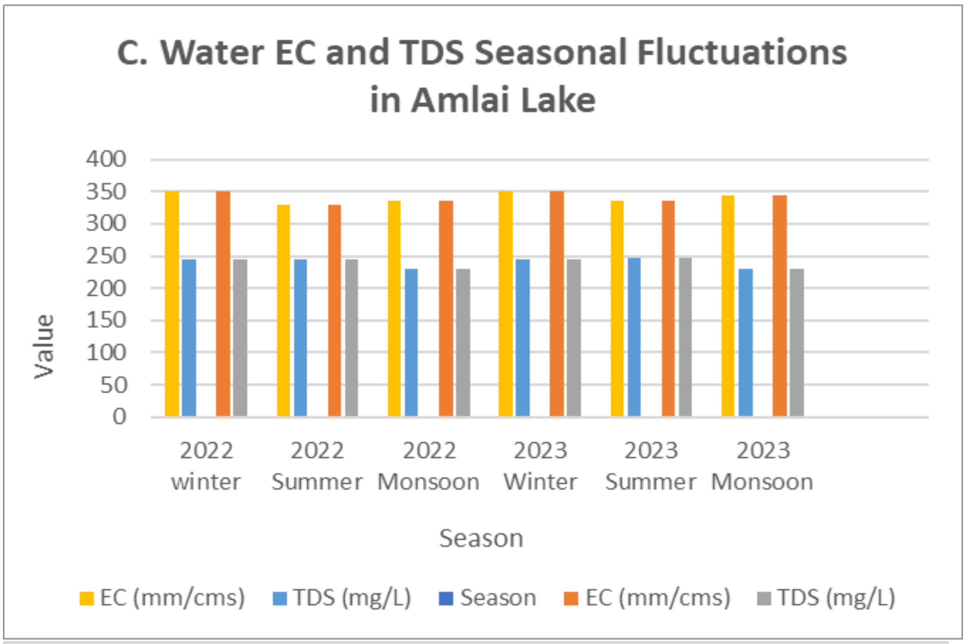
Table 2: Physico-chemical parameters of soil of Amlai Lake.

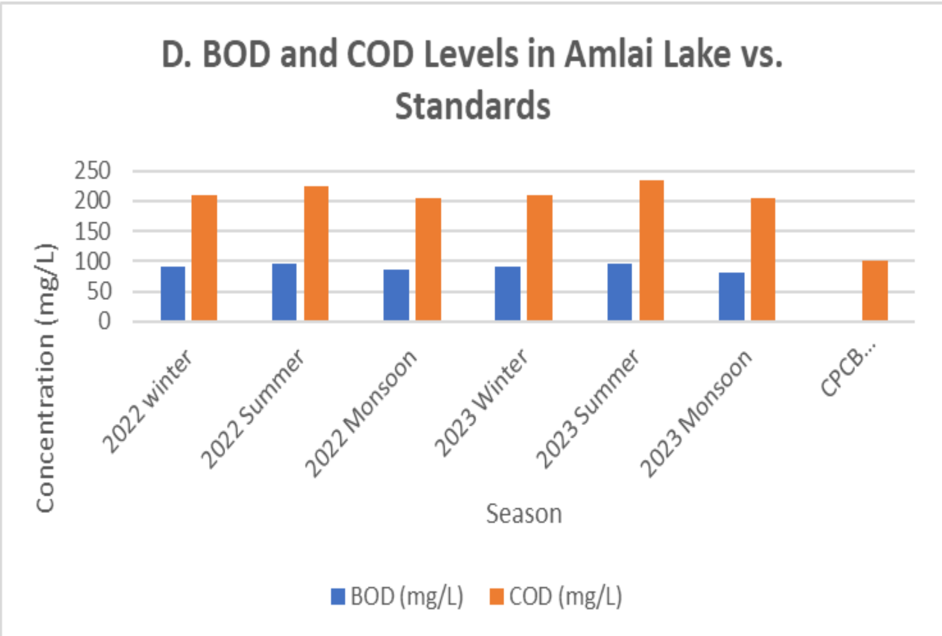
Sr. no	Parameter Unit	2022 Winter	2022 Summer	2022 Monsoon	2023 Winter	2023 Summer	2023 Monsoon
01	pH at 25°C	7.79	8.10	8.09	8.00	8.10	8.10

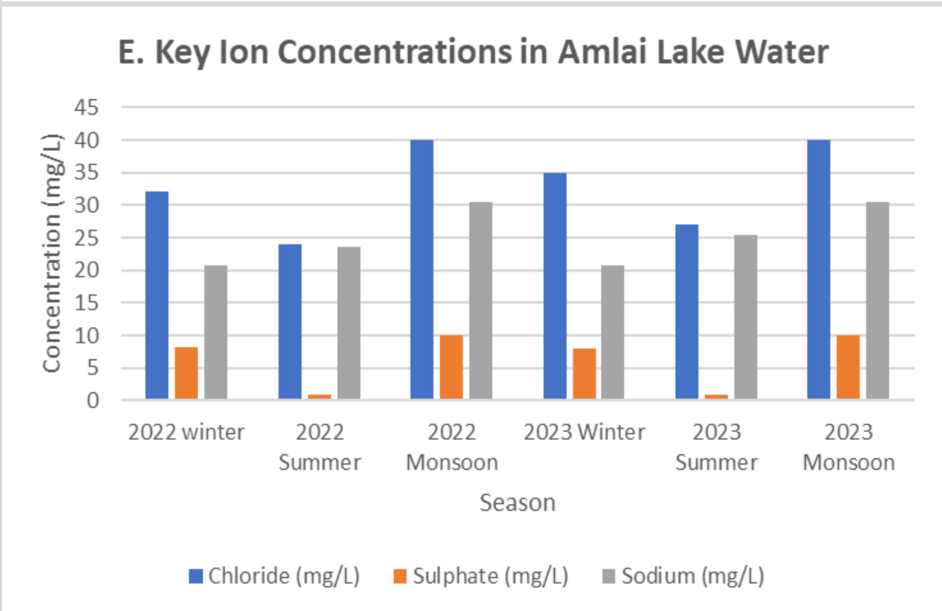
02	Total Hardness kg/cm^2	4.50	2.25	1.75	4.50	2.35	1.90
03	Ec Electroconductivity mS/m	20	40	40	28	40	40
04	Calcium mg/kg	14	18	18	14	20	18
05	Magnesium mg/kg	58	88	78	62	88	82
06	Chloride mg/kg	10.0	15	9.6	10.0	15	10.0
07	Sulphate mg/kg	24	28	32	25	28	32
08	Sodium mg/kg	1.2	3.2	3.9	1.2	3.4	4.2
09	Potassium mg/kg	240	480	300	270	480	315
10	Phosphate mg/kg	20	60	50	20	70	55

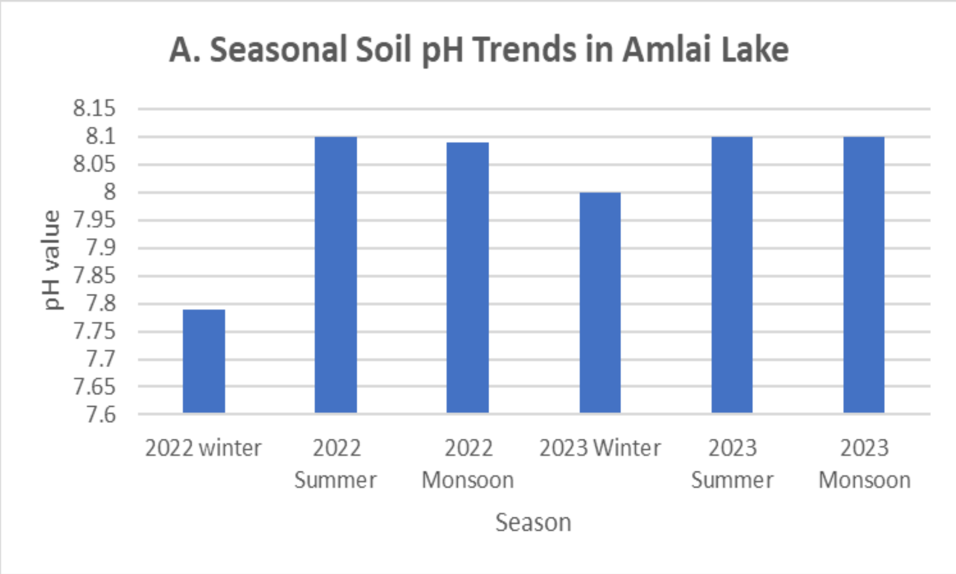


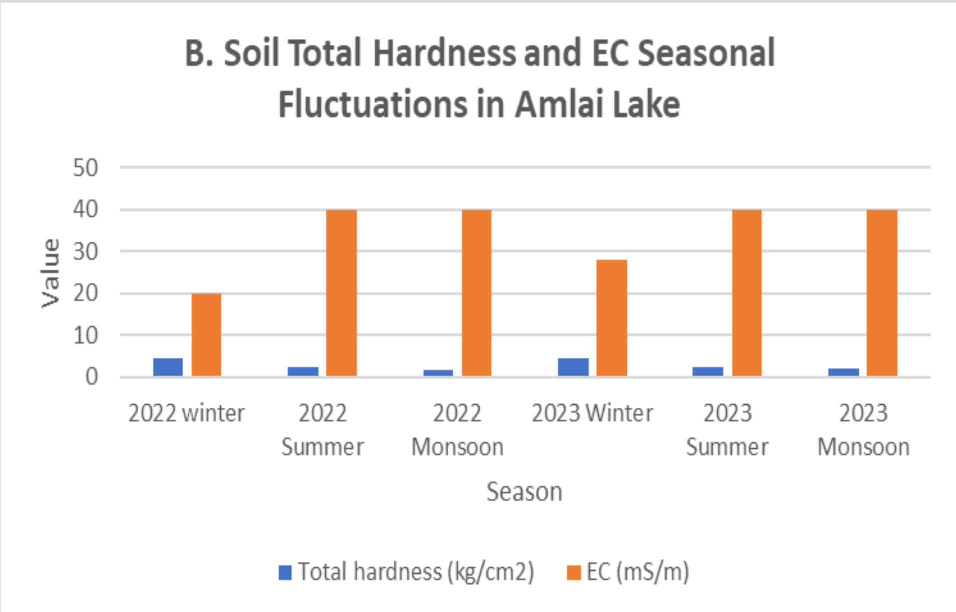


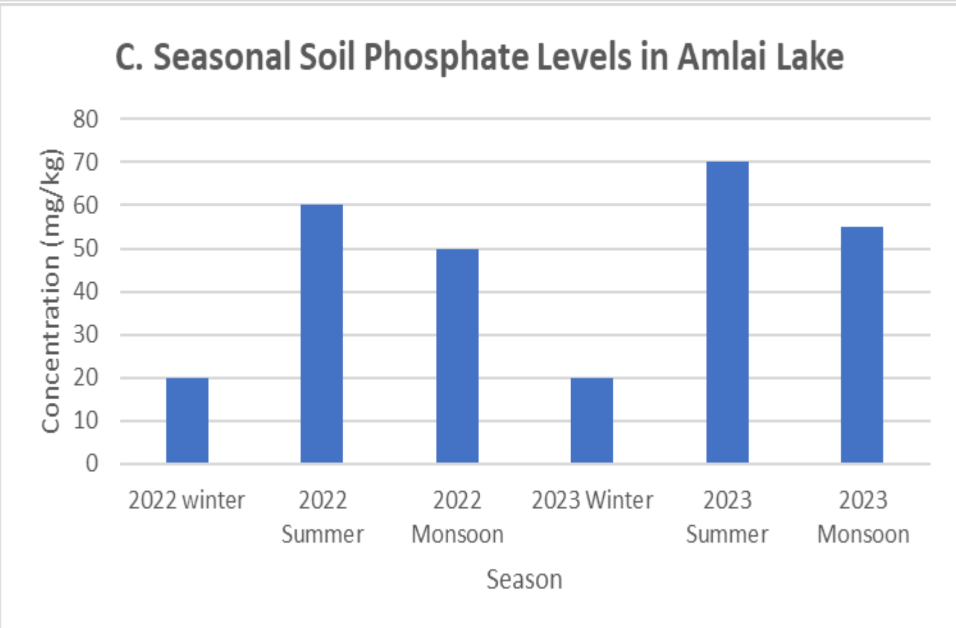

C. Water EC and TDS Seasonal Fluctuations in Amlai Lake
Value
400
350
300
250
200
150
100
50
0
2022 winter
2022 Summer
2022 Monsoon
2023 Winter
2023 Summer
2023 Monsoon
Season
EC (mm/cms)
TDS (mg/L)
Season
EC (mm/cms)
TDS (mg/L)

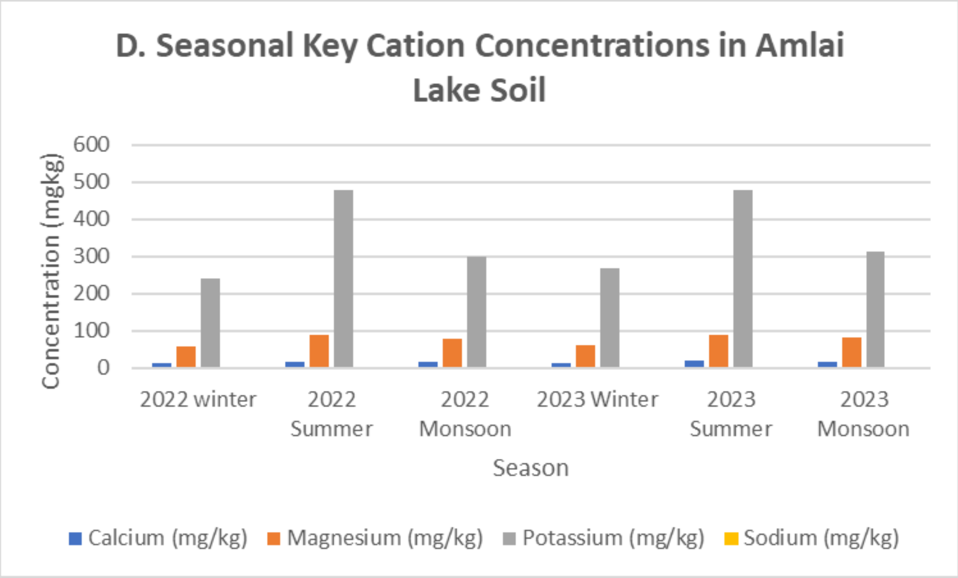

D. BOD and COD Levels in Amlai Lake vs. Standards
Concentration (mg/L)
250
200
150
100
50
0
2022 winter
2022 Summer
2022 Monsoon
2023 Winter
2023 Summer
2023 Monsoon
CPCB...
Season
BOD (mg/L)
COD (mg/L)


E. Key Ion Concentrations in Amlai Lake Water
Concentration (mg/L)
45
40
35
30
25
20
15
10
5
0
2022 winter
2022 Summer
2022 Monsoon
2023 Winter
2023 Summer
2023 Monsoon
Season
Chloride (mg/L)
Sulphate (mg/L)
Sodium (mg/L)


A. Seasonal Soil pH Trends in Amlai Lake
pH value
8.15
8.1
8.05
8
7.95
7.9
7.85
7.8
7.75
7.7
7.65
7.6
2022 winter
2022 Summer
2022 Monsoon
2023 Winter
2023 Summer
2023 Monsoon
Season


B. Soil Total Hardness and EC Seasonal Fluctuations in Amlai Lake
Value
50
40
30
20
10
0
2022 winter
2022 Summer
2022 Monsoon
2023 Winter
2023 Summer
2023 Monsoon
Season
Total hardness (kg/cm2)
EC (mS/m)


C. Seasonal Soil Phosphate Levels in Amlai Lake
Concentration (mg/kg)
80
70
60
50
40
30
20
10
0
2022 winter
2022 Summer
2022 Monsoon
2023 Winter
2023 Summer
2023 Monsoon
Season



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