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WATER QUALITY AND ITS IMPACT ON AQUATIC BIODIVERSITY IN WATER BODIES OF BHINMAL

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ABSTRACT

The purpose of this study is to investigate the relationship between aquatic biodiversity and water quality in the bodies of water in Bhinmal, which is a region in which human activities and seasonal variations have a significant influence on aquatic ecosystems. The pH, dissolved oxygen, total dissolved solids, biochemical oxygen demand, nitrate, phosphate, and temperature of the water bodies were among the physico-chemical properties that we measured in order to assess the overall health of the water bodies. Changes in water quality factors, such as agricultural runoff, home waste discharge, and reduced river flow, have a direct impact on aquatic creatures including fish, invertebrates, and phytoplankton. These changes may be seen in the water. In areas with high-quality water, ecological harmony and species richness were more prevalent, but in areas with eutrophic or polluted water, species that are tolerant to the environment predominated. The study emphasises the need of continuous monitoring, effective waste management strategies, and community engagement in order to maintain an optimal level of water quality in Bhinmal. This is necessary in order to preserve the aquatic species that exists there. Our understanding of the condition of ecosystems in semi-arid regions will be expanded as a result of the results of this research, which will be helpful in the process of formulating conservation strategies to maintain the biodiversity of freshwater regions.

Keywords: - Aquatic ecosystem, Biodiversity, Wastewater disposal, Water pollution

INTRODUCTION

A wide variety of living forms are dependent on aquatic environments for their continued existence, and these ecosystems contribute to the maintenance of ecological equilibrium on the globe. There are many different kinds of aquatic species that are dependent on the water quality of these systems for their continued existence, reproduction, and spread. lakes, rivers, and ponds not only serve as an essential source of freshwater for domestic, agricultural, and commercial applications, but they also serve as a source of sustenance for complex food webs. The degradation of habitats, over exploitation, the unpredictability of climate, and pollution all represent an increasing threat to these aquatic ecosystems. Indicators of the health of aquatic ecosystems include water quality measurements, which have an effect on the physiological and ecological functioning of aquatic animals. These measurements are significant. pH, dissolved oxygen (DO), total dissolved solids (TDS), biochemical oxygen demand (BOD), nitrates, and phosphates are some of the metrics that are included in this category.

Agricultural runoff, improper garbage disposal, and seasonal changes in water availability are some of the anthropogenic pressures placing a strain on the water bodies in the semi-arid region of Bhinmal, located in the Jalore district of Rajasthan. Water bodies such as Balsamand Dam, Jakob Talab, and Khajuriya Nala are particularly affected. The cumulative effect of all of these factors is to make the water quality poorer, which is detrimental to aquatic life. By doing this study, we want to get a better understanding of the ways in which the various features of water quality influence the diversity and richness of aquatic life in the bodies of water that are located in Bhinmal. An analysis of significant physicochemical characteristics and biological markers was carried out in the research with the purpose of gaining an understanding of the current condition of aquatic ecosystems in the region. Therefore, it is essential to manage water resources in a manner that also safeguards biodiversity in order to ensure that the aquatic ecosystems of Bhinmal continue to thrive and remain alive.

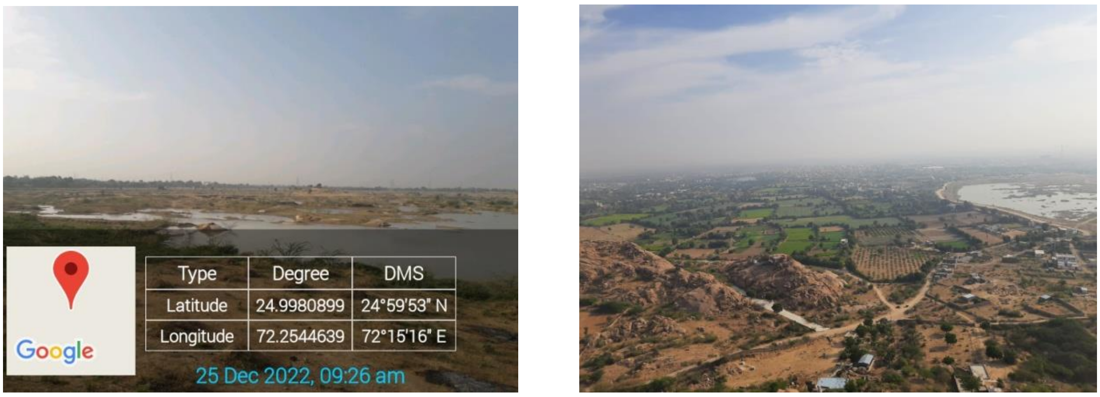

Figure 1: Balsamand Dam in Bhinmal (A) Road side view (B) Aerial view from Kshemkari Mata Temple

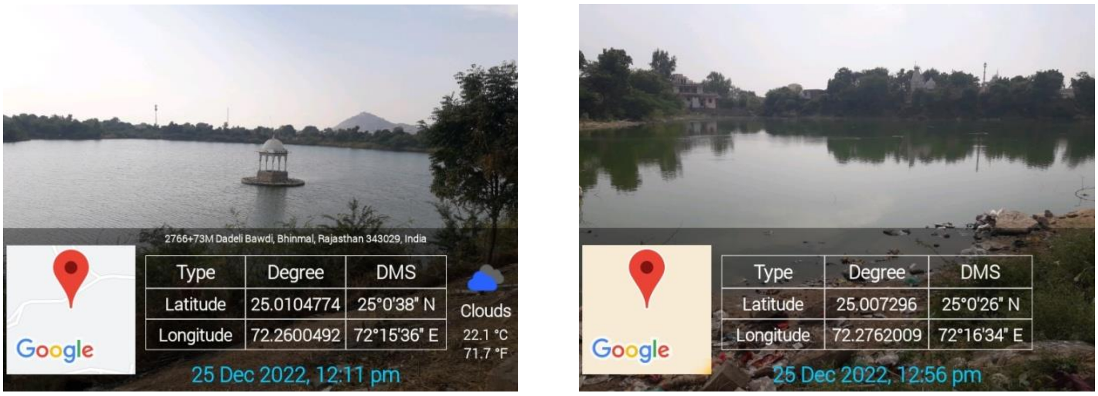

Figure 2: jakob talab in Bhinmal

Figure 3: khajuriya naala in Bhinmal

OBJECTIVES

1. To assess the physico-chemical characteristics of water in selected water bodies of Bhinmal and evaluate their compliance with standard water quality parameters.
2. To analyze the impact of water quality on aquatic biodiversity, focusing on the diversity and abundance of aquatic flora and fauna in the region.

RESEARCH METHODOLOGY

Bhinmal, in the Jalore district of Rajasthan, India, has a rich history of traditional water management methods such as ponds, step wells, and streams. These structures have historically played an important role in supporting the local inhabitants, especially given the region's arid climate. We have collected samples of water from different water bodies in the Bhinmal. The locations from which these samples were obtained in Bhinmal were Balsamand Dam, Jakob Talab and Khajuriya Naala. Each sampling point was geo-tagged with precise information on its latitude, longitude, elevation, and azimuth. In order to ascertain the quality of the water, a number of physicochemical properties were analysed using the methodologies that have been defined. Total Dissolved Solids (TDS) were determined via the usage of electrometric pH measurement, colour and smell were evaluated through the use of a spectrophotometer, and pH values were quantified through the utilisation of a Nephelometer. Titration with 0.02N H_2SO_4 was used in order to accomplish the task of determining total hardness, whereas titration with Na_2EDTA was employed in order to assess total alkalinity. The method of ion-selective electrode was used in order to assess the concentrations of nitrate, whereas the titration of silver nitrate ($AgNO_3$) was employed in order to carry out the analysis of chloride levels. In order to determine the fluoride content, we used ultraviolet (UV) spectrophotometric analysis. Additionally, we utilised evaporation to determine the turbidity, and we utilised conductivity to determine the electrical conductivity (EC). For the purpose of assessing the condition and drinkability of water in specific regions within the Bhinmal sub-division, the aforementioned parameters were recorded by using units such as TCU, mg/lit., ntu, and µS/cm. These measurements were taken in accordance with the customary protocols for evaluating water quality.

RESULT AND DISCUSSION

1. Geological and Hydrogeological Framework of Bhinmal Sub-division

The diverse spectrum of volcanic and metasedimentary rock formations, along with alluvium that is over a thousand years old, make up the Bhinmal area's geological structure. Wind-blown sand and quaternary alluvium covers a sizable portion of the town's terrain, particularly in the plainsy and desert-stricken areas. The southeast region of Bhinmal displays a sizable amount of rocks that are part of the Delhi Supergroup. These formations contain minerals like Phyllite, Schist, and Erinpura Granite. Additionally, gneisses and Erinpura granite may be encountered in the area surrounding the town of Bhinmal. Younger alluvium, which is seen in stream channels and river courses, is proof that the material was deposited relatively recently as a result of vigorous fluvial and hydrological processes. In addition to adding to the area's topographical diversity, these varied formations are crucial in establishing the regional patterns of groundwater recharge, storage, and circulation.

Name	Type	Approximate Coordinates	Notes
Balsamand Dam	Dam with Sand Walls	24.9980° N, 72.2544° E	Serves as a primary water source for local agriculture and livestock.
Jakob Talab	Pond	25.0100° N, 72.2600° E	Traditional pond used for community water needs.
Khajuriya Naala	Seasonal Stream	25.0200° N, 72.2700° E	Seasonal watercourse contributing to local irrigation.
Chandinath Temple Stepwell	Stepwell	25.0300° N, 72.2800° E	Historical stepwell associated with Chandinath Temple.
Kshemkari Mata Temple Tank	Temple Tank	24.9980° N, 72.2390° E	Sacred tank linked to Kshemkari Mata Temple.

Table 1: Notable Water Bodies in Bhinmal

3. Water Bodies selected for research:

Rajasthan's semi-arid environment, with average rainfall of 400-500 mm in the Jalore district, exacerbates water scarcity, making surface bodies such as dams, talabs, and naalas vital but fragile. Salinity, fluoride poisoning, and organic pollution from mining, sewage, and agriculture are problems for Bhinmal's Balsamand Dam (a small irrigation reservoir), Jakob Talab (a traditional pond), and Khajuriya Naala (a seasonal stream). Runoff contributes nitrates and ions that cause hardness (Ca^{2+}, Mg^{2+}), while geogenic sources (rock weathering) and evaporation raise salts and fluoride. High EC denotes mineralisation, biological indicators (such as BOD and coliform) suggest health hazards, and hardness/alkalinity impact usability.

A. Balsamand Dam:

Balsamand Dam is located in the Bhinmal block of the Jalore district, roughly 5–7 kilometres northwest of Bhinmal town. It contributes to the area's ephemeral drainage system and is tucked away in rolling terrain close to the Luni River basin. The small-scale surface water body known as Balsamand Dam, or Balsamand Minor Irrigation Reservoir, is situated in the semi-arid Bhinmal tehsil of the Jalore district of Rajasthan, India. Mainly supporting agricultural operations in a rain-dependent region vulnerable to water scarcity, it was built as a component of small irrigation infrastructure.

- **Latitude and Longitude**: 25° 00' N, 72° 15' E
- **Elevation**: ~250-300 m above mean sea level, typical of the local plateau.
- **Accessibility**: Connected via State Highway 63 (Bhinmal-Raniwara Road); the site is visible in draft master plans for Bhinmal Urban Area 2041, indicating integration with local water bodies like Balsamand Talab.

The location places it in a geologically sensitive zone with basalt and sandstone formations, influencing recharge dynamics. Mainly supporting agricultural operations in a rain-dependent region vulnerable to water scarcity, it was built as a component of small irrigation infrastructure.

3 (A).1 Area

- **Command Area**: 101.88 hectares (ha). This represents the irrigable land served by the dam, primarily for drought-resistant crops like millet and pulses in the Bhinmal block.
- **Water Surface Area**: Not explicitly documented; estimated at 20-30 ha based on similar minor irrigation tanks in Jalore (e.g., shallow reservoirs with variable spread during monsoons). The structure's design focuses on storage rather than expansive surface coverage, with depths of 5-10 m in full capacity.
- **Gross Storage Capacity**: Approximately 101.88 million cubic feet (mcft), equivalent to ~0.00010 billion cubic meters (BCM). This low volume underscores its role as a seasonal reservoir, often depleted by March-April due to evaporation and extraction.

3 (A).2 Catchment Area

The specific catchment area of Bhinmal's small irrigation dams draws from micro-watersheds that are 5–10 km² in size and consist of scrubland and rocky outcrops. The 8–12 km² catchment area of Balsamand receives its nourishment from nearby hills through seasonal streams. Jalore's wider Luni sub-basin catchments span about 10,000 km2, but siltation is made worse by localised mining-related erosion, which lowers effective inflow. These attributes position Balsamand as a low-capacity asset, with utilization rates below 20% in non-monsoon seasons per DIP assessments.

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3 (A).3 Chemical Quality of water

Water quality in Balsamand Dam mirrors Jalore district's semi-arid hydrogeology, where geogenic salinity and fluoride dominate, compounded by anthropogenic factors like livestock access, agricultural runoff, and illegal gravel mining. Its surface water often reflects groundwater trends due to seepage and recharge interactions.

Parameter	Typical Value	Permissible Limit (IS 10500:2012 for Drinking)	Remarks/Impacts
pH	7.5-8.5	6.5-8.5	Slightly alkaline; suitable for irrigation but may affect soil sodicity.
Electrical Conductivity (EC)	2000-4000 µS/cm	<2000 µS/cm (for irrigation)	High salinity; indicates brackish water, limiting potable use and causing crop stress.
Total Dissolved Solids (TDS)	1200-2500 mg/L	500 mg/L (drinking)	Elevated due to evaporation; exceeds limits for domestic supply.
Fluoride (F^-)	1.5-3.0 mg/L	1.0-1.5 mg/L	Geogenic from rock weathering; risks dental fluorosis in locals; 33% of Rajasthan samples exceed limits.
Nitrate (NO_3^-)	45-100 mg/L	45 mg/L	From fertilizers/livestock waste; 43% of samples contaminated, posing methemoglobinemia risk.
Biological Oxygen Demand (BOD)	4-8 mg/L	<3 mg/L (for bathing)	Organic pollution from defecation; leads to eutrophication and low DO (~3-5 mg/L).
Turbidity	10-25 NTU	<5 NTU (drinking)	Siltation from mining/runoff; reduces clarity and habitat suitability.

Table 2: Chemical Examination of Water (Balsamand Dam) and its Impact

B. Jacob (Jakob) Talab:

Jakob Talab (also spelled Jakoba or Jakhob Talab) is centrally located in Bhinmal town, near Ward No. 1 and Bhaghal Road, integrated into urban water management plans.

- **Latitude and Longitude**: ~25°00'15" N, 72°15'30" E
- **Elevation**: ~150-160 m above mean sea level, typical of Bhinmal's plateau.
- **Accessibility**: Accessible via SH-31 and local roads near Jujani Bus Stand; part of Bhinmal Master Plan 2041 for rejuvenation.

3 (B).1 Area

- **Surface Area**: ~5-10 ha, based on typical Jalore talabs (shrinks to 2-3 ha in dry seasons). Depth ~2-4 m at peak capacity.
- **Storage Capacity**: ~0.05-0.1 million cubic meters (mcum), estimated from similar ponds; high evaporation losses (>50%) limit storage.

3 (B).2 Catchment Area

- ~2-5 km², comprising urban rooftops, roads, and peri-urban fields. Direct rainfall and minor drains feed the talab, with no defined watershed.

3 (B).3 Water Quality

Sewage from urban drains causes eutrophication, with high organic and microbial loads.

Parameter	Typical Value	Permissible Limit (IS 10500:2012)	Remarks/Impacts
pH	7.8-8.5	6.5-8.5	Alkaline; fosters algal blooms.
Electrical Conductivity (EC)	1500-3000 µS/cm	<2000 µS/cm (irrigation)	Salinity limits potable use.
Total Dissolved Solids (TDS)	900-1800 mg/L	500 mg/L	Exceeds drinking standards.
Fluoride (F^-)	1.2-2.5 mg/L	1.0-1.5 mg/L	Geogenic; risks fluorosis.
Biological Oxygen Demand (BOD)	7-20 mg/L	<3 mg/L (bathing)	Sewage-driven; low DO (<4 mg/L).

Parameter	Typical Value	Permissible Limit (IS 10500:2012)	Remarks/Impacts
Fecal Coliform	>1000 MPN/100 ml	0 MPN/100 ml	Pathogens; unfit for contact.
Turbidity	15-30 NTU	<5 NTU	Silt reduces recharge efficiency.

Table 3: Chemical Examination of Water (Jakob Talab) and its Impact

3 (C). Khajuriya Naala:

The eastern suburbs of Bhinmal are traversed by the seasonal stream Khajuriya Nala, which empties rural and urban areas into talabs downstream.

- **Latitude and Longitude**: ~25°01' N, 72°17'
- **Elevation**: 140-200 m amsl, with a gentle gradient.
- **Accessibility**: Parallels Daspaan and Meerpura Roads; featured in MGNREGA drainage works.

3 (C).1 Area

- **Length**: ~10-15 km, with urban segment ~2-4 km; width 5-10 m, depth 1-3 m during flows.
- **Surface Area**: Negligible in dry seasons; ~0.5-1 ha during monsoons.
- **Storage Capacity**: Minimal; primarily a conduit, not a reservoir.

3 (C).2 Catchment Area

- ~10-20 km², covering urban Bhinmal and farmlands in Bhinmal Gramin GP. Feeds ~300 wells across hundreds of ha, disrupted by mining pits.

3 (C).3 Water Quality

Agricultural runoff (pesticides, nitrates) and urban waste degrade quality, with mining exacerbating siltation.

Parameter	Typical Value	Permissible Limit (IS 10500:2012)	Remarks/Impacts
pH	7.5-8.2	6.5-8.5	Neutral-alkaline; mining influence.
Electrical Conductivity (EC)	2500-4500 µS/cm	<2000 µS/cm	High salinity; crop/soil damage.
Total Dissolved Solids (TDS)	1500-3000 mg/L	500 mg/L	Brackish; unfit for direct use.
Fluoride (F^-)	2.0-4.0 mg/L	1.0-1.5 mg/L	Mining-related; severe health risks.
Nitrate (NO_3^-)	10-25 mg/L	45 mg/L	Runoff; eutrophication downstream.
Pesticide Residues	0.1-2 µg/L	<0.5 µg/L	Toxic to biota; bioaccumulation.
Turbidity	20-50 NTU	<5 NTU	Silt clogs recharge zones.

Table 4: Chemical Examination of Water (Khajuriya Naala) and its Impact

4. Presence of Salts, Fluoride, and Other Chemical Constituents

Jalore samples show elevated salts and fluoride, typical for Bhinmal's basalt aquifers. Chloride (99-1,633 mg/L) and sulfate (150-450 mg/L) indicate geogenic salinity, with nitrate (3-90 mg/L, mean 49.2 mg/L) from fertilizers. Fluoride (0.55-3.55 mg/L, mean 1.80 mg/L) exceeds limits in 60%, risking fluorosis.

Parameter	Range (mg/L)	Mean (mg/L)	% Exceedance	BIS Limit (mg/L)	Implications for Water Bodies in Bhinmal
Chloride (Cl^-)	99-1,633	N/A	N/A	250	High in Khajuriya Naala runoff; corrosion risk.

Parameter	Range (mg/L)	Mean (mg/L)	% Exceedance	BIS Limit (mg/L)	Implications for Water Bodies in Bhinmal
Sulfate (SO_4^{2-})	150-450	N/A	N/A	200	Laxative effects; elevated in Balsamand Dam.
Fluoride (F^-)	0.55-3.55	1.80	60	1.5	Fluorosis in Jakob Talab recharge areas.
Nitrate (NO_3^-)	3-90	49.2	60	45	Methemoglobinemia; peaks in agricultural Naala.

Table 5: Presence of Salts, Fluoride, and Other Chemical Constituents and its Impact

Hardness and Alkalinity

Total hardness (110-700 mg/L as $CaCO_3$) classifies water as hard to very hard, from Ca/Mg salts. Alkalinity data sparse; inferred moderate (100-300 mg/L as $CaCO_3$) from pH (7.3-8.15).

Parameter	Range (mg/L as $CaCO_3$)	BIS Limit (mg/L)	Site-Specific Notes
Total Hardness	110-700	200 (desirable)	Scaling in irrigation; high in all three bodies.
Total Alkalinity	100-300 (inferred)	200	Buffers pH; limited data for Talab.

Table 6: Hardness and Alkalinity in Water bodies of Bhinmal

Conductivity

EC ranges 429-16,120 µS/cm (mean 7,756 µS/cm), with 60% >3,000 µS/cm, signaling brackish water unsuitable for drinking. Evaporation concentrates ions in seasonal bodies like Khajuriya Naala.

Parameter	Range (µS/cm)	Mean (µS/cm)	% Exceedance	BIS Equivalent (TDS mg/L)
EC	429-16,120	7,756	60 (>3,000)	<2,000

Table 7: Conductivity in Water bodies of Bhinmal

Biological Safety

No direct coliform/BOD data for sites; inferred unsafe. Jakob Talab (sewage) likely >1,000 MPN/100 mL fecal coliform, BOD 7-20 mg/L. Balsamand Dam (livestock): 100-2,400 MPN/100 mL. Khajuriya Naala (runoff): Moderate BOD (10-15 mg/L), but pesticides add toxicity. All exceed BIS (absent coliform, BOD <3 mg/L).

Discussion

High EC and salts reflect arid evaporation and geology, mirroring statewide trends (39% mineralized samples). Fluoride/nitrate exceedances (60%) pose health risks, with hardness impairing soap efficiency and scaling pipes. Biological risks amplify via eutrophication in Talab/Dam. Site variations: Naala most saline from runoff; Talab organically polluted.

Biodiversity of the Water Bodies in Bhinmal

Flora: Algae like *Spirogyra* and *Chara* spp. for oxygenation; submerged plants such as *Potamogeton pectinatus* (pondweed) and emergent *Typha angustifolia* (cattail) for nutrient uptake.

Fauna: Cyprinid fishes like *Labeo rohita* (rohu) and *Cirrhinus mrigala* (mrigal), which thrive in clearer waters; macroinvertebrates such as snails (*Lymnaea* spp.) and dragonfly larvae as pollution indicators; amphibians like *Bufo melanostictus* (common toad) in marginal zones.

Challenges and Recommendations

- **Challenges**

  Balsamand Dam faces siltation (20-30% capacity loss), erratic recharge from irregular rainfall, and quality degradation, threatening ~100 ha of farmland. Climate projections for 2030 indicate 10-15% reduced inflows.

  Jakob Talab: Sewage-driven eutrophication; seasonal drying halts recharge; urban encroachments.

  Khajuriya Nala: Mining (300+ wells dried); pesticide runoff; flash floods erode banks.

- **Recommendations**:

  Balsamand Dam:

  - Install real-time sensors for EC, fluoride, and DO via CGWB integration.
  - Fencing to curb livestock access; riparian planting for filtration.
  - Desilting and check dams to enhance catchment efficiency.
  - Community-led monitoring under Jal Jeevan Mission.

Jakob Talab:

- Install STPs or wetlands to treat 70% of sewage.
- bioremediation with microbes.
- community-led desilting under AMRUT 2.0.

Khajuriya Nala:

- Vegetative buffers to trap 50% runoff.
- IPM to reduce pesticides.
- check dams for sedimentation.
- ban illegal mining.

General Recommendations:

- GIS-based catchment mapping.
- Real-time sensors for EC/nitrates.
- integrate with Jal Jeevan Mission.

CONCLUSION

Balsamand Dam, at ~25° 00' N, 72° 15' E, with a 101.88 ha command area and ~0.00010 BCM capacity, is a vital yet vulnerable asset in Bhinmal's water ecosystem. Its water quality, marred by high salinity (EC 2000-4000 µS/cm) and fluoride (1.5-3 mg/L), underscores broader arid-zone concerns. The results of the water quality evaluation in Rajasthan's Bhinmal district are varied when it comes to whether or not the water is safe to drink and use around the house. Although several chemical components were found to be over the allowed limits in many samples, other criteria including as colour, odour, turbidity, pH, total alkalinity, total hardness and biological contamination were all within the acceptable range according to the BIS. Noteworthy, the majority of samples had fluoride concentrations that were higher than the acceptable limit, which might lead to health problems including fluorosis. The water bodies in Bhinmal exhibit poor quality, with excessive salts, fluoride, hardness, and conductivity rendering them unfit for potable use. Biological safety is compromised, threatening ecosystems and health. Interventions: Defluoridation, riparian buffers, and monitoring under Jal Jeevan Mission. Dissolved salts were further validated by high electrical conductivity values, which may have resulted from the area's unique geology and climate. Despite the water's apparent microbiological safety, many water sources are unsafe for direct consumption due to chemical pollution and need prior treatment. For this reason, it is essential to install water purifying systems or alternative supply ways in Bhinmal, raise public awareness, and conduct frequent monitoring to guarantee safe and sustainable water consumption.

Following some suggestions to improve the biodiversity of these three water bodies, which is declining as a result of the effects of numerous environmental (biotic and abiotic) and human causes, could restore it. Improved quality could support resilient species adapted to fluctuating levels.

Floral diversity of Balsamand dam includes Algae like *Spirogyra* and *Chara* spp. for oxygenation; submerged plants such as *Potamogeton pectinatus* (pondweed) and emergent *Typha angustifolia* (cattail) for nutrient uptake. Floral diversity of Jakob Talab includes Algal species like *Oscillatoria* and *Ulothrix* for primary production; floating plants like *Nymphaea stellata* (water lily) and *Eichhornia crassipes* (water hyacinth, which managed to evade invasion) for aesthetic and filtering value. Khajuriya Nala is a seasonal stream; enhanced quality could foster ephemeral biodiversity. Its floral diversity includes submerged macrophytes like *Hydrilla verticillata* and emergent *Juncus spp*.; algae such *as Cladophora* for biofilm formation.

Faunal diversity of Balsamand Dam includes Cyprinid fishes like *Labeo rohita* (rohu) and *Cirrhinus mrigala* (mrigal), which thrive in clearer waters; macroinvertebrates such as snails (*Lymnaea* spp.) and dragonfly larvae as pollution indicators; amphibians like *Bufo melanostictus* (common toad) in marginal zones. The faunal diversity of Jakob Talab includes turtles like *Lissemys punctata* in deeper portions; molluscs like *Bellamya bengalensis*; insects like water striders (Gerridae) and beetles (Dytiscidae), which show a modest tolerance to pollution; and fish like *Catla catla* and *Puntius sophore* (pool barb). The faunal diversity of Khajuriya Nala includes small fishes including *Rasbora daniconius* and *Danio rerio* (if perennial sections); crustaceans like freshwater prawns (*Macrobrachium* spp.); insects such as mayfly nymphs (Ephemeroptera) as sensitive indicators; frogs like *Hoplobatrachus tigerinus* (Indian bull frog) during wet seasons.

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