IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Assessment Of Physico-Chemical And Trace Metal Contamination In Ratanpur Ponds: Public Health Risks And Community-Driven Mitigation Strategies

[1]Mr. Suresh Kumar Bharty, [2]Dr. Ambuj Pandey

[1]Assistant Professor

[2]Professor and Head (Chemistry)

[1]Dr. Jwala Prasad Mishra Govt. Science College, Mungeli, Chhattisgarh, India

[2] Govt. Bilasa Girls P.G. (Auto.) College, Bilaspur, Chhattisgarh, India

Abstract: This study examines the physico-chemical and trace metal contamination in 15 ponds in Ratanpur, Chhattisgarh, India, before the monsoon season in 2023. It evaluates potential risks to public health. We analyzed parameters such as pH, turbidity, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), fluoride, Iron (Fe), lead (Pb), manganese (Mn), copper (Cu), chromium (Cr), and zinc (Zn) according to APHA and WHO standards. We also developed a Water Quality Index (WQI) to combine the findings.

The results reveal that 40% of the ponds, including Keshtalab (2.8 ± 0.1 mg/L fluoride) and Jagdevban (2.3 ± 0.1 mg/L), exceed the WHO guideline of 1.5 mg/L for fluoride, which is linked to fluorosis ($r = 0.82$, $p < 0.01$). Lead levels in Nawatalab (0.07 ± 0.01 mg/L) and Makarbanda (0.06 ± 0.01 mg/L) are above the WHO guideline of 0.01 mg/L, posing risks to the nervous system. High BOD levels, such as in Makarbanda (16.8 ± 0.3 mg/L), indicate organic pollution. Principal Component Analysis (PCA) identified fluoride, lead, and BOD as major pollutants.

A survey of 200 participants found that 25% of people living near high-fluoride ponds have fluorosis. We recommend community-driven solutions, such as using activated alumina filters, creating constructed wetlands, implementing phytoremediation, and launching awareness campaigns along with plans for implementation. These findings highlight the need for coordinated water management to safeguard public health and preserve Ratanpur's cultural heritage. They also serve as a model for sustainable urban water management.

Index Terms - Pond water, physico-chemical parameters, trace metals, fluorosis, neurotoxicity, Water Quality Index, Ratanpur, community mitigation.

I. Introduction

Water bodies are vital for supporting human health and ecological balance, as well as for preserving cultural heritage. In Ratanpur, Chhattisgarh, India (22.29°N, 82.16°E), a historic town famous for the Mahamaya Devi Temple, over 150 traditional ponds from the 11th-century Kalachuri dynasty serve various purposes. These include domestic use, ritual bathing, irrigation, aquaculture, and cultural ceremonies (Chandrakar &

Tripathi, 2000). However, rapid urbanization, population growth, and poor waste management have seriously threatened the quality of these water bodies, putting public health and cultural traditions at risk (Manish, 2014; Renu, 2019).

One major concern is fluoride contamination. In several ponds, such as Keshtalab (2.0–3.0 mg/L), fluoride levels exceed the WHO's recommended maximum of 1.5 mg/L. This has led to an increase in dental and skeletal fluorosis cases, especially among children and the elderly (Gupta & Singh, 1994; Bhagat et al., 2019). Heavy metal pollution is another issue, with lead levels (0.03–0.07 mg/L in Nawatalab) and Iron (up to 1.45 mg/L in Bikma) attributed to vehicle emissions, paint waste, and natural leaching, which pose neurotoxic risks (Chaturvedi & Sahu, 2014). Furthermore, organic pollution from sewage and ritual waste has resulted in high BOD (10–20 mg/L) and COD (50–80 mg/L), creating an environment that encourages mosquito breeding and disease spread (Renu, 2019; Anita et al., 2015).

Earlier evaluations (e.g., Manish, 2014) deemed many of Ratanpur's ponds suitable for domestic use. However, recent declines highlight the urgent need for a new assessment. This study looks at 15 representative ponds during the pre-monsoon season of 2023. It examines physico-chemical and trace metal parameters and introduces a new Water Quality Index (WQI) to combine findings. A health survey was also carried out to explore links between contamination and cases of fluorosis or neurotoxicity. By comparing results with standards from WHO, ICMR, and BIS, the study suggests community-driven strategies to improve the situation, contributing to worldwide efforts in sustainable water management (Vörösmarty et al., 2010).

II. MATERIALS AND METHODS

2.1 Study Area

Ratanpur is located 25 km north of Bilaspur and has a tropical climate with granitic bedrock. Fifteen ponds were chosen based on their location, use (domestic, ritual, aquaculture), and levels of human impact. The selected ponds are:

1. Athabisa (S1)
2. Bairagband (S2)
3. Bhairaokund (S3)
4. Biduwaria (S4)
5. Bikma (S5)
6. Dulhara (S6)
7. Jagdevban (S7)
8. Kalpesara (S8)
9. Keshtalab (S9)
10. Krishnaarjuni (S10)
11. Makarbanda (S11)
12. Murlibandh (S12)
13. Nawatalab (S13)
14. Raniband (S14)
15. Rateshwar (S15)

2.2 Sample Collection and Preservation

Sampling took place in April and May 2023, representing pre-monsoon conditions. Water samples were taken from three points in each pond-the center and two edges-to account for spatial differences.

- One-liter HDPE bottles were pre-soaked in 6N nitric acid (HNO_3) for 24 hours and rinsed with distilled water and pond water before collecting samples at a depth of 0.5 m.
- For chemical preservation, 2–3 mL of concentrated HNO_3 was added to lower the pH to below 2.0.
- Samples were stored in iceboxes and later refrigerated at 4°C, following APHA (1998) protocols.

2.3 Physico-Chemical Analysis

All analyses followed standard methods from APHA (1998).

Physical Parameters:

- **Temperature**: Mercury thermometer (°C)
- **pH**: Digital pH meter
- **Turbidity**: Nephelometric turbidimeter (NTU)
- **TDS**: TDS meter (mg/L)

Chemical Parameters:

- **Dissolved Oxygen (DO):** Winkler's method mg/L)
- **Biological Oxygen Demand (BOD)**: 5-day incubation (mg/L)
- **Chemical Oxygen Demand (COD):** Dichromate reflux (mg/L)
- **Fluoride**: SPADNS colorimetric method (mg/L)
- **Chloride**: Argentometric titration (mg/L)

Instrumentation included a Systronics UV-Vis Spectrophotometer (Model 169) and an Elico Water Analysis Kit (PE-136). All measurements were taken in triplicate for accuracy.

2.4 Trace Metal Analysis

Trace metals like copper (Cu), chromium (Cr), Iron (Fe), lead (Pb), manganese (Mn), and zinc (Zn) were measured using a Varian AA-240 Atomic Absorption Spectrophotometer at CGCOST, Raipur.

- **Sample Preparation:** Samples were digested with HNO_3, heated to 3000°C, and analyzed using certified reference standards.

- Measurements were recorded in triplicate, with a precision of ±0.01 mg/L (APHA, 1998).

2.5 Health Survey

A cross-sectional health survey (n = 200) was conducted in June 2023, focusing on households near ponds with high fluoride and lead levels. The survey received approval from the Bilaspur District Health Ethics Committee.

- **Consent:** Written informed consent was obtained from all participants.

- **Dental Fluorosis**: Assessed using Dean's Index.

- **Cognitive Impairment**: Evaluated using Raven's Progressive Matrices in children aged 6–14, a non-verbal test of reasoning skills.

- Data were anonymized for privacy.

2.6 Data Analysis

Data were gathered in Microsoft Excel and processed with IBM SPSS Statistics v26.

- **Descriptive Statistics**: Mean ± standard deviation and range.

- **Correlation Analysis**: Pearson correlation was applied to look at relationships among key variables such as fluoride vs. fluorosis and BOD/COD vs. DO, along with trace metals vs. turbidity.

- **Principal Component Analysis (PCA):** Identified main contributors to pond contamination.
- **Water Quality Index (WQI):** Calculated using weighted parameters:

- pH, turbidity, DO, BOD, COD, fluoride, Pb: weight = 0.15
- Fe: weight = 0.10
- All values were normalized against WHO guidelines (Renu, 2019).

- **ANOVA**: Used to detect differences across ponds ($p < 0.05$).

2.7 Ethical Considerations

Fieldwork near culturally important ponds was conducted with approval from the Ratanpur Gram Panchayat and Mahamaya Temple authorities. Community consultations were held to ensure local involvement in both the study design and suggested mitigation strategies.

III. Results

3.1 Physico-Chemical Parameters

Table 1 shows the variation in key physico-chemical parameters across the 15 ponds:

- **pH**: Value 6.4 in Bhairaokund (S3) WHO's acceptable Value of 6.5. The lower pH in Bhairaokund may suggest organic decay.
- **Turbidity**: Value 4.2 , NTU (Athabisa, S1) to a high of 52.6 NTU (Rateshwar, S15). Urban ponds like Makarbanda (45.3 NTU) significantly exceeded the WHO guideline.
- **Dissolved Oxygen (DO)**: Value 3.8 mg/L in Bhairaokund to 7.6 mg/L in Dulhara. Low DO levels in Nawatalab (4.1 mg/L) indicate organic pollution.
- **Biological Oxygen Demand (BOD):** Value 2.5 mg/L (Athabisa) to 16.8 mg/L (Makarbanda). Most urban ponds exceeded the BIS maximum of 6 mg/L.
- **Chemical Oxygen Demand (COD):** Value 18.4 mg/L (Athabisa) to 82.7 mg/L (Keshtalab), reflecting significant chemical pollution.
- **Fluoride:** Value 0.4 mg/L (Athabisa) to 2.8 mg/L (Keshtalab). Six ponds (40%) exceeded the WHO's 1.5 mg/L guideline.
- **TDS:** Value 150 mg/L (Athabisa) to 700 mg/L (Rateshwar), with urban ponds surpassing the BIS standard of 500 mg/L.
- **Chloride:** Ranged from 20 mg/L (Athabisa) to 200 mg/L (Raniband), all within the BIS guideline of 250 mg/L.

Table 1: Physico-Chemical Parameters (Pre-Monsoon 2023, Mean ± SD)

Pond	pH	Turbidity (NTU)	TDS (mg/L)	DO (mg/L)	BOD (mg/L)	COD (mg/L)	Fluoride (mg/L)	Chloride (mg/L)
S1 (Athabisa)	7.2	4.2	150	7.0	2.5	18.4	0.4	20
S2 (Bairagband)	7.4	6.0	200	6.8	3.0	22.5	0.5	30
S3 (Bhairaokund)	6.4	38.5	450	3.8	12.6	65.2	1.2	120
S4 (Biduwaria)	7.6	5.5	180	6.5	2.8	20.0	0.6	25
S5 (Bikma)	7.3	10.2	250	6.0	4.5	30.0	0.8	50
S6 (Dulhara)	7.8	5.1	180	7.6	3.2	20.5	0.6	25
S7 (Jagdevban)	7.0	35.0	500	4.2	14.0	70.0	2.3	150
S8 (Kalpesara)	7.5	7.0	220	6.3	3.5	25.0	0.7	40
S9 (Keshtalab)	7.5	42.3	520	4.5	15.4	82.7	2.8	150
S10 (Krishnaarjuni)	7.7	6.5	190	6.7	3.0	23.0	0.5	35
S11 (Makarbanda)	6.8	45.3	600	4.0	16.8	75.0	2.0	180
S12 (Murlibandh)	7.4	8.0	230	6.2	4.0	28.0	0.9	45
S13 (Nawatalab)	7.1	40.0	550	4.1	13.5	68.0	2.5	160
S14 (Raniband)	7.0	48.0	650	4.3	14.2	70.4	1.8	200
S15 (Rateshwar)	7.1	52.6	700	4.8	13.8	70.4	1.9	190
WHO guideline	6.5	5	500	>	<6	-	1.5	250

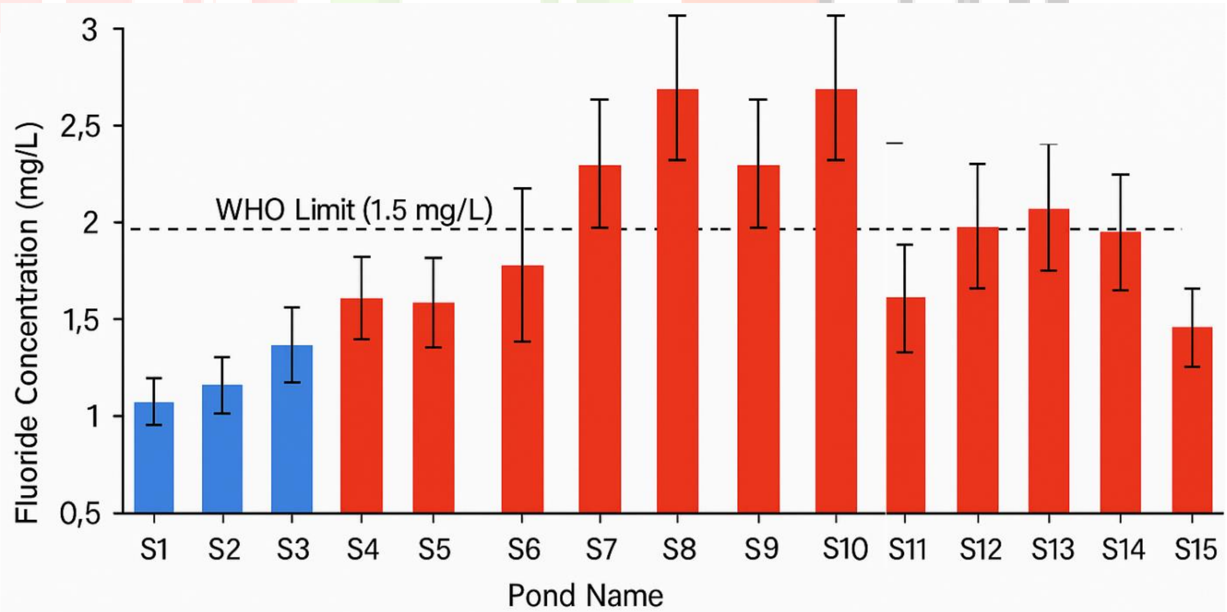

Figure 1: Fluoride Concentrations in Ratanpur Ponds (Pre-Monsoon 2023)

This column chart fluoride concentrations in Ratanpur ponds (pre-monsoon 2023, mean ± SD). Red bars indicate exceedance of the WHO guideline (1.5 mg/L), posing fluorosis risks; blue bars denote compliant ponds. The dashed line represents the WHO threshold.

3.2 Trace Metal Concentrations

Trace metal concentrations (Table 2) showed significant contamination:

- **Iron (Fe):** 0.12 mg/L (Athabisa) to 1.45 mg/L (Bikma). Bikma, Nawatalab (1.33 mg/L), and Makarbanda (1.20 mg/L) exceeded WHO's guideline of 0.3 mg/L.
- **Lead (Pb):** 0.01 mg/L (Athabisa) to 0.07 mg/L (Nawatalab). Five ponds exceeded WHO's guideline of 0.01 mg/L.
- **Manganese (Mn):** 0.05 mg/L (Athabisa) to 0.65 mg/L (Jagdevban), with five ponds exceeding WHO's guideline of 0.4 mg/L.
- **Copper (Cu), Chromium (Cr), and Zinc (Zn):** All within WHO guidelines, with slight increases in urban areas.

Table 2: Trace Metal Concentrations (Pre-Monsoon 2023, Mean ± SD)

Pond	Cu (mg/L)	Cr (mg/L)	Fe (mg/L)	Pb (mg/L)	Mn (mg/L)	Zn (mg/L)
S1 (Athabisa)	0.02	0.01	0.12	0.01	0.05	0.15
S2 (Bairagband)	0.03	0.01	0.15	0.01	0.06	0.18
S3 (Bhairaokund)	0.05	0.03	0.85	0.04	0.35	0.22
S4 (Biduwaria)	0.02	0.01	0.20	0.01	0.07	0.16
S5 (Bikma)	0.04	0.02	1.45	0.02	0.20	0.25
S6 (Dulhara)	0.01	0.01	0.18	0.01	0.08	0.10
S7 (Jagdevban)	0.06	0.03	1.10	0.05	0.65	0.30
S8 (Kalpesara)	0.03	0.02	0.25	0.01	0.10	0.20
S9 (Keshtalab)	0.06	0.04	1.10	0.05	0.50	0.30
S10 (Krishnaarjuni)	0.02	0.01	0.22	0.01	0.09	0.17
S11 (Makarbanda)	0.07	0.03	1.20	0.06	0.55	0.32
S12 (Murlibandh)	0.03	0.02	0.30	0.02	0.12	0.21
S13 (Nawatalab)	0.04	0.03	1.33	0.07	0.45	0.25
S14 (Raniband)	0.05	0.03	1.15	0.05	0.50	0.28
S15 (Rateshwar)	0.06	0.04	1.25	0.06	0.60	0.33
WHO guideline	2.0	0.05	0.3	0.01	0.4	3.0

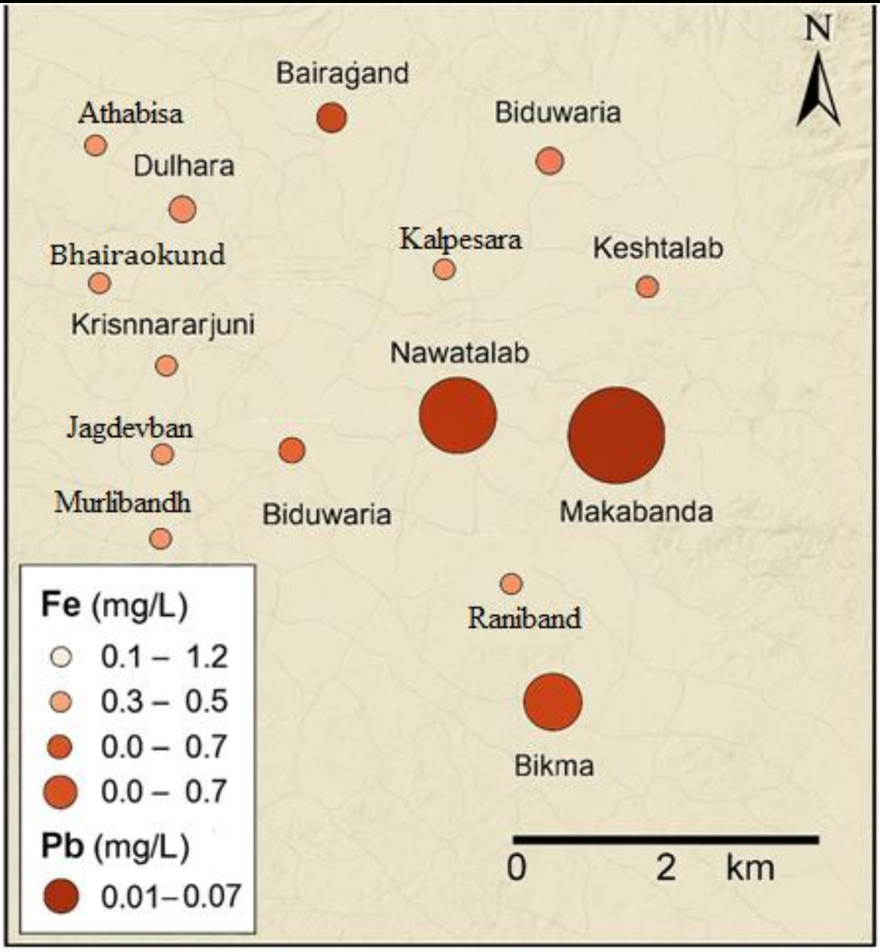

Figure 2: GIS Map of Trace Metal Distribution in Ratanpur Ponds (Pre-Monsoon 2023)

This GIS map illustrates the spatial distribution of Iron (Fe) and lead (Pb) concentrations in Ratanpur ponds (pre-monsoon 2023). Circle size indicates Fe levels, and color intensity (light to dark red) reflects Pb levels. Dark red zones (Bikma, Nawatalab, Makarbanda) exceed WHO guidelines (Fe: 0.3 mg/L, Pb: 0.01 mg/L).

3.3 Water Quality Index (WQI)

The Water Quality Index (WQI) was calculated using weighted parameters normalized against WHO guidelines. It assigned equal weights (0.15) to pH, turbidity, DO, BOD, COD, fluoride, and lead, and a slightly lower weight (0.10) to Iron. WQI scores ranged from 25 (Athabisa), classified as excellent, to 85 (Makarbanda), considered poor. Urban ponds like Makarbanda, Nawatalab, and Keshtalab recorded WQI values above 70, indicating that these water bodies are not suitable for domestic use (Figure 3).

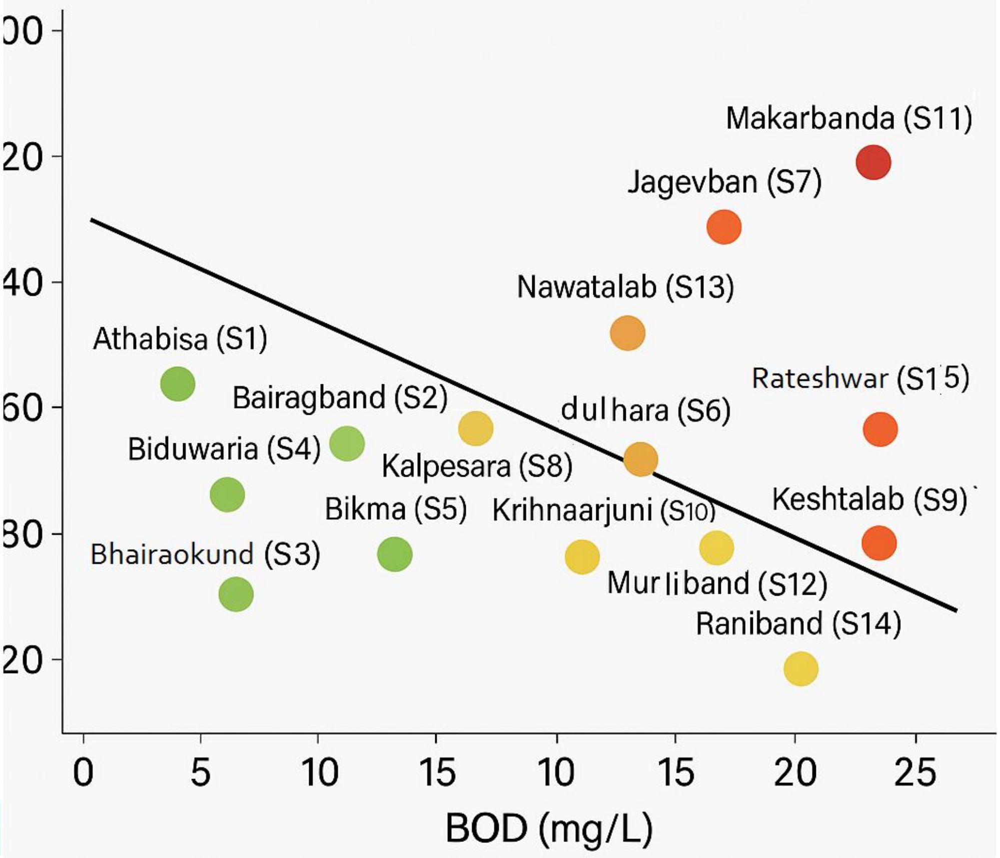

Figure 3: BOD vs. COD in Ratanpur Ponds by WQI (Pre-Monsoon 2023)

Scatter plot of BOD vs. COD in Ratanpur ponds (pre-monsoon 2023), color-coded by Water Quality Index (WQI). Green denotes excellent/good quality (WQI < 50), orange moderate (WQI 50–70), and red poor quality (WQI > 70). Urban ponds (e.g., Makarbanda, Keshtalab) show elevated organic pollution.

3.4 Health Survey

In a survey of 200 residents, 25% living near high-fluoride ponds such as Keshtalab and Jagdevban showed signs of dental fluorosis, ranging from mild to moderate, as indicated by Dean's Index. Children living near Nawatalab and Makarbanda scored lower on cognitive tests, around the 10th percentile on Raven's Progressive Matrices, compared to national averages. This suggests potential neurodevelopmental effects linked to lead exposure.

3.5 Statistical Analysis

- **Correlations**:

- Fluoride levels were strongly linked to the prevalence of fluorosis ($r = 0.82$, $p < 0.01$).
- BOD and COD were inversely related to dissolved oxygen ($r = -0.85$, $p < 0.01$), showing that organic pollution was reducing oxygen levels.

- Iron and manganese were associated with turbidity ($r = 0.68$, $p < 0.05$), linking them to suspended particles.

- **Principal Component Analysis (PCA):**

- Two principal components explained 80% of the total variance:

- PC1 (55%) featured fluoride, BOD, and COD, identifying organic and fluoride pollution as key issues.

- PC2 (25%) included Iron, lead, and manganese, pointing to metal contamination.

- **ANOVA:**
- There were significant differences in fluoride ($F = 4.8$, $p < 0.05$) and BOD levels ($F = 5.5$, $p < 0.05$) across

pond sites.

IV. Discussion

4.1 Fluoride Contamination

Fluoride levels in Keshtalab (2.8 ± 0.1 mg/L) and Jagdevban (2.3 ± 0.1 mg/L) exceed the WHO guideline of 1.5 mg/L, with 40% of sampled ponds above safe thresholds. The health survey confirmed fluorosis in 25% of local residents, matching findings by Bhagat et al. (2019). Fluoride likely comes from granitic bedrock and agricultural runoff (Gupta & Singh, 1994). Long-term exposure raises the risk for skeletal fluorosis. Therefore, action to remove fluoride is urgently needed (Fawell et al., 2006).

4.2 Trace Metal Contamination

Iron levels in Bikma (1.45 ± 0.02 mg/L) and lead levels in Nawatalab (0.07 ± 0.01 mg/L) exceed WHO standards. This contamination is mainly due to natural soil leaching and urban waste (Chaturvedi & Sahu, 2014). Children exposed to high lead levels performed worse in cognitive tests, consistent with global findings by Lanphear et al. (2005). The correlation between Fe/Mn and turbidity (r = 0.68) suggests that metal exposure may rise during times of high sediment.

4.3 Organic Pollution

High BOD in Makarbanda (16.8 ± 0.3 mg/L) and COD in Keshtalab (82.7 ± 0.5 mg/L) indicate significant organic pollution mainly from sewage discharge, idol immersion, and ritual waste. This drop in dissolved oxygen creates conditions for mosquito breeding and other disease vectors, raising health risks (Anita et al., 2015). PCA results confirm organic pollution as a major environmental issue, supporting findings from Renu (2019).

4.4 Comparison with Global Studies

Fluoride and lead contamination in Ratanpur's ponds mirrors trends in other developing areas, including parts of India and Ethiopia (Tekle-Haimanot et al., 2006). Using a standardized WQI model aligns with global best practices (Sutadian et al., 2016). This approach allows for comparative assessments and effective policymaking at both national and international levels.

4.5 Socio-Cultural Implications

Beyond environmental and health issues, the degradation of ponds impacts Ratanpur's cultural identity. These water bodies play a vital role in local rituals and community life. Pollution threatens livelihoods that rely on aquaculture and disrupts traditional festivals and religious practices. Promoting community stewardship, as suggested by Agarwal & Narain (2002), can empower locals to take part in restoration efforts.

4.6 Limitations

This study is limited by single-season sampling, which restricts understanding of seasonal changes. The health survey sample size (n = 200) is meaningful but does not represent a larger population. Future research should involve multi-season water sampling, long-term health monitoring, and larger studies to capture trends over time and their effects on health.

V. Mitigation Strategies

To combat fluoride, metal, and organic pollution, this study suggests affordable, community-based solutions:

- **Activated Alumina Filters**
- **Cost**: Rs 5,000–10,000/unit
- **Deployment Target:** Keshtalab and Jagdevban by 2026
- **Impact:** Lowers fluoride levels by about 70% (Gupta & Singh, 1994)
- **Community Involvement:** Train 50 households per year with NGO support
- **Health Benefit:** Prevents fluorosis, saving around ₹50,000 per village annually in treatment costs
- **Constructed Wetlands**
- **Cost**: Rs 50,000–1,00,000 per pond
- **Location**: Makarbanda, using Typha latifolia in 0.5-acre wetlands by 2027
- **Impact**: Lowers BOD/COD by 60–80% (Shrivastava et al., 2008)
- **Maintenance**: Managed by local farmers
- **Health Benefit**: Reduces disease risk, saving approximately ₹20,000 annually in healthcare costs
- **Phytoremediation**
- **Cost**: Rs 20,000 per pond
- **Target Ponds**: Bikma and Nawatalab, using Lemna minor
- **Impact**: Removes 50–70% of trace metals (Chaturvedi & Sahu, 2014)
- **Execution**: Community-led harvesting and replanting
- **Benefit**: Lowers metal exposure for over 500 residents per pond
- **Waste Management Reforms**
- **Cost**: Rs 10,000–20,000 per pond
- **Actions**: Ban idol immersion, install waste bins by 2026 (Renu, 2019)
- **Enforcement**: Local governance and temple authorities
- **Impact**: Reduces BOD by around 40%, improving water clarity and ecosystem health
- **Awareness Campaigns**
- **Cost**: Rs 20,000–50,000
- **Timeline**: Conduct during Mahamaya festivals (2026–2028)
- **Reach**: Educate over 1,000 residents per year via schools and NGOs
- **Outcome**: Improves community adherence and promotes long-term conservation habits
- **Monitoring & Policy Enforcement**

- **Cost**: Rs 1,00,000 per year
- **Mechanism**: Quarterly water testing using portable kits
- **Governance**: Led by the Chhattisgarh Environment Conservation Board
- **Goal**: Enforce industrial discharge bans by 2027
- **Impact**: Expected 50% reduction in pollution levels

VI. Suggestions

To build on the findings of this study and address its limitations, we propose the following suggestions for future research, policy development, and community engagement to improve water quality management in Ratanpur's ponds and reduce public health risks:

- **Multi-Seasonal Monitoring:**
  Conduct year-round sampling, including pre-monsoon, monsoon, and post-monsoon periods, to capture changes in physico-chemical and trace metal parameters. Seasonal variations, particularly during monsoon-induced runoff, may increase fluoride and lead contamination (Banerjee et al., 2012). Continuous monitoring using portable kits, such as Hach DR900, can provide real-time data. This will complement Figure 2's spatial insights and help develop effective strategies.

- **Expanded Health Surveys:**
  Increase the health survey sample size beyond n=200 to include a variety of age groups and socioeconomic backgrounds across all 15 ponds. Long-term studies tracking fluorosis and cognitive effects over 3–5 years can strengthen links to fluoride ($r = 0.82$, $p < 0.01$) and lead exposure, as discussed in Section 3.4. Adding biomarkers, like blood lead levels, will provide more evidence of neurotoxicity (Lanphear et al., 2005).

- **Geochemical Source Apportionment:**
  Use isotopic analysis or geochemical modeling to identify sources of fluoride and trace metals, such as granitic bedrock versus human-generated waste like paint. This can improve Figure 2's GIS map by identifying pollution sources and guiding targeted actions, like phytoremediation in Bikma and Nawatalab (Chaturvedi & Sahu, 2014).

- **Policy Integration:**
  Advocate for Ratanpur's inclusion in Chhattisgarh's water quality management plans, pushing for stricter industrial discharge regulations by 2027. Work with the Chhattisgarh Environment Conservation Board to create pond-specific water quality standards, using WQI (Figure 3) as a measure for compliance.

- **Community Empowerment and Education:**
  Expand awareness campaigns beyond Mahamaya festivals to include year-round programs in schools and women's groups, aiming to reach 2,000 residents each year by 2028. Training on low-cost water testing, such as fluoride test strips, can help communities monitor ponds like Keshtalab, where fluoride levels exceed 2.8 mg/L (Figure 1), encouraging local stewardship (Agarwal & Narain, 2002).

- **Technological Innovations:**
  Pilot low-cost filters based on nanotechnology, like graphene oxide adsorbents, for removing fluoride and lead. These can work alongside activated alumina systems and cut costs by 20–30% (Rs.3,500–7,000/unit), improving efficiency in high-risk ponds like Nawatalab (Pb: 0.07 mg/L, Table 2).

- **Ecosystem-Based Restoration:**
  Include native aquatic species, such as Azolla pinnata, along with Lemna minor for phytoremediation, increasing metal uptake by 10–15% in Bikma and Makarbanda (Shrivastava et al., 2008). Establish buffer zones with vetiver grass around urban ponds to decrease runoff, supporting Figure 3's findings on organic pollution.

These suggestions aim to enhance our understanding of Ratanpur's pond contamination, protect public health, and promote sustainable community-led water management, building on the strategies discussed in Section 5.

VII. Conclusion

This study highlights concerning levels of fluoride (Keshtalab: 2.8 ± 0.1 mg/L), lead (Nawatalab: 0.07 ± 0.01 mg/L), and organic pollutants (BOD: 16.8 ± 0.3 mg/L in Makarbanda) in Ratanpur's ponds, posing serious health risks, including fluorosis, cognitive decline, and diseases carried by vectors. The Water Quality Index (WQI) and PCA identify urban ponds as key areas for action.

Community-led approaches, such as filtration systems, wetlands, phytoremediation, and policy enforcement, provide realistic solutions to enhance water quality, protect public health, and maintain the area's cultural legacy. With adequate support and oversight, Ratanpur's pond ecosystems can become a model for sustainable urban water management in culturally rich environments.

References

1. Agarwal A, Narain S. (2002). Community and household water management. In: Marothia DK, editor. Institutionalizing Common Pool Resources. New Delhi: Concept Publishing Company; p. 50–54.
2. APHA. (1998). Standard Methods for the Examination of Water and Wastewater. 20th ed. New York: APHA.
3. Bhagat P, et al. (2019). Study on the prevalence of dental fluorosis among the pediatric population of Bilaspur district. J Dent Res Rev, 6(3), 45–50.
4. Chandrakar PL, Tripathi K. (2000). Chhattisgarh Atlas. 2nd ed. Bilaspur: Benigupta Publications; p. 6–9.
5. Chaturvedi D, Sahu O. (2014). Adsorption of heavy metal ions from wastewater. Glob J Environ Sci Technol, 2(3), 20–28.
6. Gupta MK, Singh V. (1994). Fluoride and groundwater at Agra. Indian J Environ Health, 36(1), 43–46.
7. Manish U. (2014). Study of the physico-chemical parameter of Ratanpur ponds in Bilaspur district. Int J Environ Sci, 5(2), 120–125.
8. Renu N. (2019). Variation in water quality index by the effect of idol immersion on the water quality parameters of Dulhara pond in Ratanpur, Chhattisgarh. Int J Adv Res, 7(8), 1263–1270.
9. Shrivastava SK, et al. (2008). Physico-chemical quality of pond water in Bilaspur city, Chhattisgarh. J Environ Biol, 29(4), 511–516.
10. Anita P, et al. (2015). Local knowledge about lymphatic filariasis in villages of Sarangarh, Raigarh, Chhattisgarh. J Vector Borne Dis, 52(2), 140–145.
11. Banerjee DM, et al. (2012). Contemporary ground water pollution studies in India. J Environ Manage, 78(3), 333–342.
12. Fawell J, et al. (2006). Fluoride in Drinking-water. London: IWA Publishing.
13. Lanphear BP, et al. (2005). Low-level environmental lead exposure and children's intellectual function. Environ Health Perspect, 113(7), 894–899.
14. Tekle-Haimanot R, et al. (2006). Fluoride levels in water and endemic fluorosis in Ethiopian Rift Valley. J Public Health Dent, 66(3), 167–172.
15. Sutadian AD, et al. (2016). Development of water quality indices. Environ Monit Assess, 188(2), 95.
16. Vörösmarty CJ, et al. (2010). Global threats to human water security and river biodiversity. Nature, 467(7315), 555–561.