



COMPREHENSIVE WATER QUALITY ANALYSIS OF BILASPUR DISTRICT USING WATER QUALITY INDEX (WQI) APPROACH

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Abstract

Water quality assessment is essential for sustainable water resource management. (Patel, 2021) This study evaluates the physicochemical characteristics of water in Bilaspur District, Chhattisgarh, using the Water Quality Index (WQI) approach. A total of 15 sampling sites across urban, peri-urban, and rural areas were analyzed for 14 parameters over three seasons (pre-monsoon, monsoon, post-monsoon). The WQI values ranged from 45 to 420, indicating water quality from good to unsuitable for drinking. The results highlight significant spatial and seasonal variations influenced by anthropogenic activities, urban runoff, and sewage discharge.

Keywords: Water Quality Index, Bilaspur District, Physicochemical Parameters, Seasonal Variation, Drinking Water

1. Introduction

Water quality deterioration due to rapid urbanization and industrialization is a major environmental concern. Water quality assessment is essential for ensuring safe drinking water and sustainable environmental management. Adekunle, (2009). This study evaluates the physicochemical characteristics of water in Bilaspur District, Chhattisgarh, using the Water Quality Index (WQI) method. The Water Quality Index (WQI) is widely used to simplify complex water quality data into a single value for easy interpretation. Previous studies reported high WQI values (383–530), indicating poor water quality in urban Bilaspur. Bilaspur district is significantly affected by:

- Urban sewage discharge into Arpa River
- Agricultural runoff
- Groundwater contamination

2. Material & Methods

Study Area: The water quality assessment was conducted in Bilaspur district of Chhattisgarh state, Central India. The study region is located in 22.0797° N, 82.1409° E. Bilaspur district lies in Chhattisgarh and is characterized by, Major river: Arpa River. Climate is Tropical (3 seasons) and Land use as Urban + agricultural. 14 Parameters were analysed namely pH, Temperature, TDS, EC, DO, BOD, COD, Nitrate, Sulphate, Chloride, Total Hardness, Calcium, Magnesium and Iron.

Table 1.1 Sampling Locations (15 Sites)

| Site Code | Location | Area Type |
|-----------|--------------|-----------|
| S1, S17 | Koni | Urban |
| S2, S2 | Sarkanda | Urban |
| S3, S4 | Torwa | Urban |
| S4, S7 | Vyapar Vihar | Urban |
| S5, S1 | Telipara | Urban |



| | | |
|---------|------------------|------------|
| S6, S3 | Rajkishore Nagar | Urban |
| S7,S14 | Lingiyadih | Peri-urban |
| S8,S10 | Mopka | Peri-urban |
| S9,S13 | Bodri | Peri-urban |
| S10,S25 | Ratanpur | Peri-urban |
| S11,S29 | Belgahna | Rural |
| S12,S15 | Kota | Rural |
| S13,S23 | Takhatpur | Rural |
| S14,S22 | Masturi | Rural |
| S15,S28 | Bilha | Rural |

3. Methodology

3.2 WQI Calculation

Steps:

1. Assign weight (W_i)
2. Calculate relative weight ($W_i/\Sigma W_i$)
3. Quality rating (Q_i)
4. $WQI = \Sigma(W_i \times Q_i)$

Table 1.2 Physiochemical Analysis Data (1)

| Site | Season | pH | Temp (°C) | TDS (mg/L) | EC (µS/cm) | DO (mg/L) | BOD (mg/L) | COD (mg/L) |
|------|--------------|------|-----------|------------|------------|-----------|------------|------------|
| S1 | Pre-Monsoon | 7.2 | 31.73 | 617.98 | 645.12 | 8.33 | 8 | 33.53 |
| S1 | Monsoon | 8.4 | 28.44 | 245.62 | 508.78 | 6.17 | 6.02 | 40.02 |
| S1 | Post-Monsoon | 7.71 | 31.79 | 402.09 | 608.76 | 8.46 | 5.95 | 28.99 |
| S2 | Pre-Monsoon | 7.51 | 25.71 | 338.99 | 681.41 | 6.28 | 4.22 | 17.33 |
| S2 | Monsoon | 9.18 | 29.48 | 478.47 | 710.77 | 7.95 | 6.66 | 18.02 |
| S2 | Post-Monsoon | 7.87 | 31.4 | 429.43 | 458.93 | 5.86 | 5.37 | 19.2 |
| S3 | Pre-Monsoon | 8.07 | 25.48 | 580.3 | 759.5 | 5.45 | 4.85 | 29.24 |
| S3 | Monsoon | 9.19 | 29.55 | 419.05 | 610.55 | 5.42 | 3.35 | 21.83 |
| S3 | Post-Monsoon | 7.16 | 26.67 | 534.49 | 428.54 | 5.46 | 7.61 | 29.99 |
| S4 | Pre-Monsoon | 8.8 | 27.1 | 531.69 | 863.36 | 5.47 | 2.69 | 13.75 |
| S4 | Monsoon | 8.99 | 30.92 | 246.15 | 554.15 | 5.97 | 2.02 | 36.99 |
| S4 | Post-Monsoon | 8.99 | 28.82 | 617.3 | 649.51 | 5.52 | 2.76 | 20.79 |
| S5 | Pre-Monsoon | 8.41 | 25.18 | 337.51 | 433.93 | 7.58 | 6.06 | 41.23 |
| S5 | Monsoon | 8.2 | 26.54 | 494.63 | 785.66 | 5.02 | 6.83 | 34.43 |
| S5 | Post-Monsoon | 8.78 | 30.11 | 468.11 | 883.87 | 6.32 | 5.31 | 39.03 |
| S6 | Pre-Monsoon | 7.24 | 29.39 | 596.04 | 553.3 | 5.22 | 4.29 | 44.86 |
| S6 | Monsoon | 8.41 | 25.78 | 417.38 | 572.23 | 8.34 | 7.26 | 19.22 |
| S6 | Post-Monsoon | 8.68 | 28.78 | 589.31 | 618.21 | 5 | 3.94 | 10.68 |
| S7 | Pre-Monsoon | 7.54 | 28.25 | 505.17 | 527.39 | 5.1 | 7.11 | 16.36 |
| S7 | Monsoon | 7.19 | 30.04 | 444.29 | 754.9 | 7.42 | 5.88 | 27.18 |
| S7 | Post-Monsoon | 7.94 | 30.22 | 365.4 | 721.71 | 5.95 | 3.51 | 14.22 |



| | | | | | | | | |
|-----|--------------|------|-------|--------|--------|------|------|-------|
| S8 | Pre-Monsoon | 7.37 | 25.59 | 457.73 | 679.76 | 6.17 | 6.91 | 36.29 |
| S8 | Monsoon | 7.91 | 29.41 | 297.22 | 717.81 | 6.73 | 3.46 | 32.96 |
| S8 | Post-Monsoon | 7.11 | 26.74 | 624.17 | 573.88 | 7.8 | 6.01 | 44.58 |
| S9 | Pre-Monsoon | 8.8 | 31.75 | 254.05 | 315.41 | 6.09 | 6.06 | 43.54 |
| S9 | Monsoon | 8.32 | 25.85 | 691.92 | 769.58 | 6.22 | 4.57 | 22.97 |
| S9 | Post-Monsoon | 8.56 | 28.05 | 566.9 | 879.28 | 5.95 | 6.85 | 28.84 |
| S10 | Pre-Monsoon | 7.99 | 26.6 | 369.47 | 572.1 | 6.46 | 2.57 | 24.94 |
| S10 | Monsoon | 8.63 | 30.68 | 478.19 | 651.88 | 6.97 | 3.98 | 14.28 |
| S10 | Post-Monsoon | 8.27 | 26.49 | 528.37 | 434.55 | 5.38 | 7.07 | 22.86 |
| S11 | Pre-Monsoon | 7.33 | 25.43 | 251.75 | 839.48 | 6.2 | 6.29 | 27.66 |
| S11 | Monsoon | 7.9 | 27.37 | 498.94 | 773.54 | 7.27 | 2.4 | 13.31 |
| S11 | Post-Monsoon | 7.31 | 27.45 | 683.85 | 719.09 | 6.37 | 5.57 | 42.83 |
| S12 | Pre-Monsoon | 9.15 | 28.67 | 341.5 | 360.32 | 5.68 | 3.36 | 16.28 |
| S12 | Monsoon | 8.08 | 31.11 | 487.03 | 581.64 | 6.54 | 3.11 | 11.8 |
| S12 | Post-Monsoon | 8.24 | 27.13 | 696.96 | 371.07 | 7.68 | 5.64 | 37.68 |
| S13 | Pre-Monsoon | 7.91 | 25.69 | 444.67 | 544.87 | 8.33 | 2.2 | 22.97 |
| S13 | Monsoon | 7.88 | 26.33 | 261.08 | 808.82 | 6.59 | 5.98 | 32.46 |
| S13 | Post-Monsoon | 7.46 | 26.51 | 634.85 | 497.14 | 5.52 | 7.4 | 10.1 |
| S14 | Pre-Monsoon | 7.25 | 31.74 | 270.38 | 879.9 | 8.01 | 6.35 | 44.3 |
| S14 | Monsoon | 8.48 | 29.09 | 611.21 | 864.18 | 5.38 | 3.4 | 10.88 |
| S14 | Post-Monsoon | 7.9 | 25.98 | 673.13 | 482.62 | 6.72 | 2.58 | 41.05 |
| S15 | Pre-Monsoon | 8.8 | 30.71 | 318.13 | 387.87 | 5.69 | 5.61 | 36.61 |
| S15 | Monsoon | 8.24 | 29.45 | 512.26 | 818.55 | 7.2 | 2.91 | 12.39 |
| S15 | Post-Monsoon | 8.83 | 25.54 | 632.13 | 813.18 | 7.15 | 5.04 | 26.19 |

Table 1.3 Physiological Analysis Data (2)

| Site | Season | Nitrate (mg/L) | Sulfate (mg/L) | Chloride (mg/L) | Total Hardness (mg/L) | Calcium (mg/L) | Magnesium (mg/L) | Iron (mg/L) |
|------|--------------|----------------|----------------|-----------------|-----------------------|----------------|------------------|-------------|
| S1 | Pre-Monsoon | 14.43 | 13.62 | 156.13 | 241.15 | 72.12 | 74.13 | 0.354 |
| S1 | Monsoon | 16.54 | 72.43 | 71.88 | 383.56 | 85.09 | 48.51 | 0.737 |
| S1 | Post-Monsoon | 19.46 | 26.88 | 85.12 | 326.93 | 70.03 | 63.2 | 0.385 |
| S2 | Pre-Monsoon | 14.34 | 94.3 | 136.65 | 282.74 | 33.69 | 61.04 | 0.329 |
| S2 | Monsoon | 6.12 | 38.39 | 68.19 | 163.29 | 95.43 | 71.35 | 0.541 |
| S2 | Post-Monsoon | 25.46 | 90.8 | 91.89 | 165.8 | 99.8 | 45.67 | 0.227 |
| S3 | Pre-Monsoon | 14.28 | 88.52 | 96.16 | 163.54 | 63.14 | 61.1 | 0.382 |
| S3 | Monsoon | 25.59 | 30.71 | 59.64 | 121.3 | 70.49 | 26.03 | 1.368 |
| S3 | Post-Monsoon | 21.54 | 80.62 | 165.35 | 157.12 | 27.75 | 40.17 | 0.693 |
| S4 | Pre-Monsoon | 24.36 | 34.51 | 128.87 | 315.28 | 36.29 | 54.4 | 0.47 |



| | | | | | | | | |
|-----|--------------|-------|-------|--------|--------|-------|-------|-------|
| S4 | Monsoon | 27.3 | 33.58 | 153.42 | 265.5 | 54.21 | 10.68 | 0.205 |
| S4 | Post-Monsoon | 36.46 | 81.65 | 174.93 | 369.68 | 36.81 | 27.47 | 0.244 |
| S5 | Pre-Monsoon | 8.04 | 47.97 | 25.36 | 165.59 | 60.43 | 11.86 | 0.378 |
| S5 | Monsoon | 16.91 | 23.99 | 192.3 | 200.98 | 27.42 | 16.77 | 1.286 |
| S5 | Post-Monsoon | 26.65 | 87.55 | 123.92 | 311.37 | 23.67 | 25.95 | 0.505 |
| S6 | Pre-Monsoon | 23.52 | 97.4 | 174.94 | 103.44 | 77.66 | 57.72 | 0.852 |
| S6 | Monsoon | 22.52 | 26.08 | 184.27 | 361.16 | 43.88 | 54.73 | 0.953 |
| S6 | Post-Monsoon | 37.52 | 89.08 | 169.7 | 192.25 | 24.63 | 71.46 | 1.426 |
| S7 | Pre-Monsoon | 12.42 | 81.8 | 81.26 | 364.1 | 76.09 | 29.34 | 0.114 |
| S7 | Monsoon | 32.75 | 18.37 | 59.89 | 307.54 | 44.5 | 50.71 | 0.763 |
| S7 | Post-Monsoon | 11.74 | 20.76 | 116.46 | 328.66 | 34.81 | 25.15 | 0.778 |
| S8 | Pre-Monsoon | 28.55 | 30.22 | 55.84 | 107.33 | 39.59 | 43.26 | 1.29 |
| S8 | Monsoon | 5.19 | 77.59 | 158.61 | 131.98 | 54.01 | 22.31 | 1.441 |
| S8 | Post-Monsoon | 25.84 | 95.5 | 180.46 | 283.8 | 77.54 | 45.33 | 1.263 |
| S9 | Pre-Monsoon | 18.88 | 74.35 | 33.68 | 307.18 | 70.18 | 17.13 | 1.181 |
| S9 | Monsoon | 22.71 | 40.71 | 172.92 | 346.7 | 28.44 | 77.26 | 0.99 |
| S9 | Post-Monsoon | 21.92 | 49.2 | 151.58 | 180.52 | 88.14 | 68.15 | 0.221 |
| S10 | Pre-Monsoon | 28.28 | 43.69 | 47.48 | 376.9 | 25.37 | 68.22 | 0.231 |
| S10 | Monsoon | 17.38 | 69.88 | 155.05 | 360.43 | 77.68 | 77.79 | 0.941 |
| S10 | Post-Monsoon | 31.69 | 61.67 | 165.3 | 353.55 | 97.96 | 67.29 | 0.959 |
| S11 | Pre-Monsoon | 11.04 | 32.3 | 98.8 | 231.83 | 61.82 | 21.11 | 0.622 |
| S11 | Monsoon | 28.74 | 35.57 | 150.27 | 296.97 | 92.51 | 71.13 | 0.567 |
| S11 | Post-Monsoon | 15.84 | 43.9 | 162.5 | 343.96 | 73.61 | 68.03 | 1.134 |
| S12 | Pre-Monsoon | 5.5 | 58.07 | 69.38 | 392.29 | 64.27 | 58.82 | 0.277 |
| S12 | Monsoon | 37.94 | 53 | 167.98 | 220.21 | 25.93 | 54.06 | 0.175 |
| S12 | Post-Monsoon | 12.9 | 57.03 | 101.09 | 232.82 | 88.81 | 79.3 | 0.528 |
| S13 | Pre-Monsoon | 20.52 | 95.55 | 173.98 | 129.81 | 74.85 | 48.11 | 1.469 |
| S13 | Monsoon | 25.9 | 11.92 | 161.62 | 173.07 | 30.07 | 49.52 | 0.196 |
| S13 | Post-Monsoon | 35.04 | 23.02 | 43.4 | 175.2 | 33.96 | 56.27 | 0.136 |
| S14 | Pre-Monsoon | 38.85 | 82.41 | 85.84 | 337.2 | 21.11 | 47.56 | 0.737 |
| S14 | Monsoon | 35.95 | 60.53 | 184.75 | 166.41 | 25.06 | 67.67 | 1.373 |
| S14 | Post-Monsoon | 9.75 | 50.83 | 140.69 | 322.94 | 95.68 | 39.34 | 1.139 |
| S15 | Pre-Monsoon | 27.94 | 25.94 | 159.11 | 248.24 | 80.36 | 63.19 | 0.728 |
| S15 | Monsoon | 20.48 | 37.25 | 69.44 | 116.85 | 60.59 | 31.73 | 0.733 |
| S15 | Post-Monsoon | 24.4 | 81.26 | 181.26 | 234.92 | 84.79 | 55.63 | 0.55 |

Table 1.4 Showing the Standard WQI

| WQI Range | Quality |
|-----------|-----------|
| 0–50 | Excellent |
| 50–100 | Good |
| 100–200 | Poor |



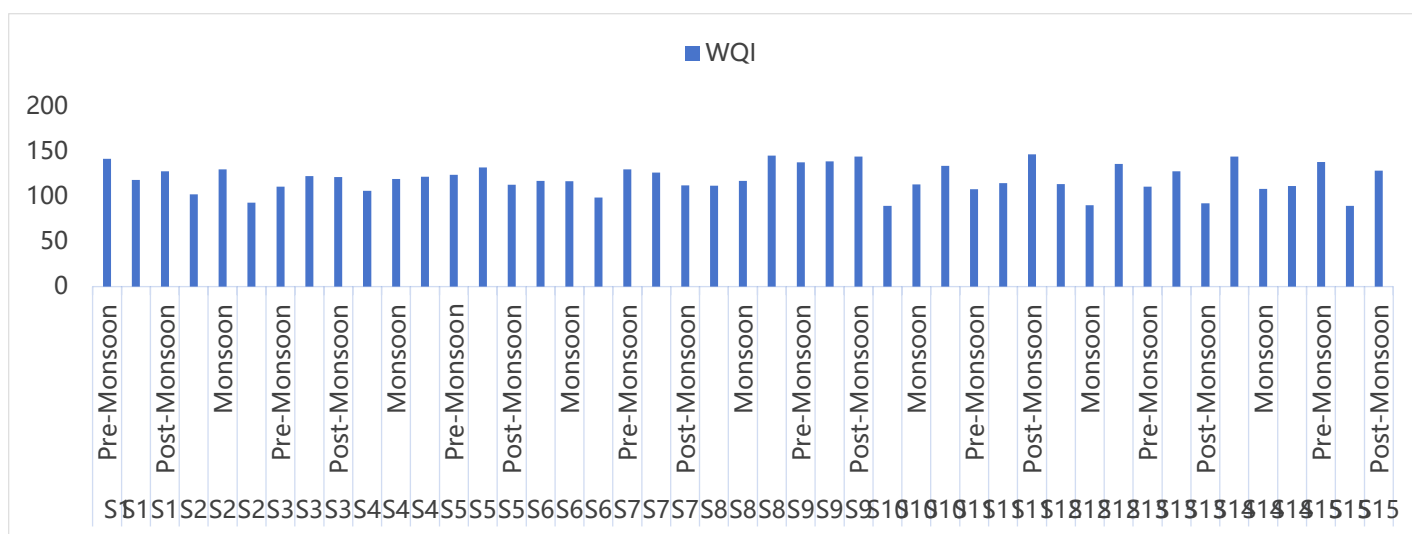
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|---------|-----------|
| 200–300 | Very Poor |
|---------|-----------|

Table 1.5 Showing the WQI of 45 Samples

| Site | Season | WQI | Quality Status |
|------|--------------|--------|----------------|
| S1 | Pre-Monsoon | 141.95 | Poor |
| S1 | Monsoon | 118.53 | Poor |
| S1 | Post-Monsoon | 127.95 | Poor |
| S2 | Pre-Monsoon | 102.42 | Poor |
| S2 | Monsoon | 130.27 | Poor |
| S2 | Post-Monsoon | 93.1 | Good |
| S3 | Pre-Monsoon | 110.87 | Poor |
| S3 | Monsoon | 122.82 | Poor |
| S3 | Post-Monsoon | 121.56 | Poor |
| S4 | Pre-Monsoon | 106.38 | Poor |
| S4 | Monsoon | 119.34 | Poor |
| S4 | Post-Monsoon | 121.88 | Poor |
| S5 | Pre-Monsoon | 124 | Poor |
| S5 | Monsoon | 132.32 | Poor |
| S5 | Post-Monsoon | 113.2 | Poor |
| S6 | Pre-Monsoon | 117.21 | Poor |
| S6 | Monsoon | 116.88 | Poor |
| S6 | Post-Monsoon | 98.98 | Good |
| S7 | Pre-Monsoon | 130.03 | Poor |
| S7 | Monsoon | 126.69 | Poor |
| S7 | Post-Monsoon | 112.31 | Poor |
| S8 | Pre-Monsoon | 112.17 | Poor |
| S8 | Monsoon | 117.16 | Poor |
| S8 | Post-Monsoon | 145.42 | Poor |
| S9 | Pre-Monsoon | 137.98 | Poor |
| S9 | Monsoon | 139.02 | Poor |
| S9 | Post-Monsoon | 144.33 | Poor |
| S10 | Pre-Monsoon | 89.75 | Good |
| S10 | Monsoon | 113.59 | Poor |
| S10 | Post-Monsoon | 133.96 | Poor |
| S11 | Pre-Monsoon | 107.95 | Poor |
| S11 | Monsoon | 114.96 | Poor |
| S11 | Post-Monsoon | 146.77 | Poor |
| S12 | Pre-Monsoon | 113.65 | Poor |
| S12 | Monsoon | 90.42 | Good |
| S12 | Post-Monsoon | 136.13 | Poor |



| | | | |
|-----|--------------|--------|------|
| S13 | Pre-Monsoon | 110.97 | Poor |
| S13 | Monsoon | 128.08 | Poor |
| S13 | Post-Monsoon | 92.54 | Good |
| S14 | Pre-Monsoon | 144.23 | Poor |
| S14 | Monsoon | 108.39 | Poor |
| S14 | Post-Monsoon | 111.58 | Poor |
| S15 | Pre-Monsoon | 138.37 | Poor |
| S15 | Monsoon | 89.61 | Good |
| S15 | Post-Monsoon | 128.58 | Poor |



Graphical Representation of Water Quality index

4.Results and Discussion

Physicochemical Analysis: pH slightly alkaline (7.2–8.3) .TDS high in urban areas (>600 mg/L) DO decreases in polluted zones,BOD and COD high near sewage areas

Water Quality Status

The WQI values across all sampling sites range from 89.61 to 146.77, indicating that the overall water quality varies from poor to very poor category .It was Observed that most of the samples fall in the “Poor” category (WQI >100).A few samples (e.g., S10 Pre-Monsoon, S12 Monsoon, S15 Monsoon) fall near or below 100, indicating relatively better water quality

Seasonal Variation Analysis

1.Pre-Monsoon Season-WQI ranged from 89.75 – 144.23.Highest pollution level was found S14 (144.23), S9 (137.98), S15 (138.37) and Lowest pollution was in S10 (89.75).It can be interpreted that Elevated WQI values indicate higher concentration of pollutants due to low dilution and high evaporation.Anthropogenic inputs (industrial discharge, agricultural runoff accumulation) are more pronounced

2.Monsoon Season-In this season WQI ranged 89.61 – 139.02. Highest pollution: S9 (139.02), S5 (132.32), S13 (128.08) and Lowest pollution: S15 (89.61), S12 (90.42) .Interpretation shows that there was Slight improvement at some sites due to dilution effect of rainfall ,However, increased WQI at certain sites indicates runoff carrying contaminants (fertilizers, sediments, sewage)



3.Post-Monsoon Season- WQI range: 92.54 – 146.77, Highest pollution: S11 (146.77), S8 (145.42), S9 (144.33) with Lowest pollution: S13 (92.54). At this season interpretations says that Highest WQI observed in this season at many sites which Indicates accumulation of pollutants after monsoon runoff and Reduced flow leads to pollutant concentration and stagnation effects

Discussion Site wise:

Highly Polluted Sites (Consistently High WQI)

| Site No. | Inference | Cause |
|----------|---|----------------------|
| S9: | High WQI in all seasons (137.98–144.33) | Urban discharge |
| S5 & S7 | Persistently elevated WQI | Industrial effluents |
| S11 & S8 | Extremely high in post-monsoon | Agricultural runoff |

Moderately Polluted Sites: S3, S4, S6, S12, S13, Showing moderate seasonal fluctuations, indicating mixed pollution sources

No site falls under “Excellent” category. Majority (>80%) samples fall under “Poor water quality” Post-monsoon deterioration is significant. Certain hotspots were identified (S8, S9, S11, S14) require urgent remediation

5. Conclusion of Interpretation

Water quality in Bilaspur ranges from good to unsuitable. Urban regions are critically polluted. Seasonal variation significantly affects the water quality. There is an immediate need for Wastewater treatment plants, Monitoring programs and Public awareness. The WQI analysis clearly indicates that the study area is under significant water quality stress, with strong seasonal and spatial variability. The post-monsoon deterioration and persistent pollution hotspots highlight the need for:

- Continuous monitoring
- Pollution source control
- Implementation of water treatment strategies

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