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# EVALUATION OF SURFACE WATER IN JASHPUR DISTRICT: A COMPARATIVE ANALYSIS USING WEIGHTED ARITHMETIC WATER QUALITY INDEX

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***Abstract :*** Surface water holds immense significance, providing sustenance, transportation, recreation, and supporting life forms. Pollutants in water bodies pose a severe threat to human health as well as aquatic ecosystem. Jashpur district is bestowed with many rivers which are used for irrigation and drinking purposes. Nine physicochemical parameters including pH, turbidiy, alkalinity, total dissolved solids, total hardness, chloride, fluoride, Calcium and magnesium were analysed in surface water samples collected from four different sampling sites of Jashpur district with the objective of evaluating the quality of the water. This paper presents a comparison of water quality across different sampling sites of study area based on calculations using weighted arithmetic water quality index. Result reveals that overall water quality of S2 and S3 is good while S1 and S4 are poor. Although water of S1 and S2 can be used for irrigation and other purposes, implementation of effective water treatment processes along with regular monitoring and testing of water quality are vital for improving water quality and to identify potential issues and take appropriate actions in future.

***Index Terms-*** **water quality, physico chemical parameters, pollutants, weighted arithmetic index**

## I. INTRODUCTION

Surface water plays a significant role in the Earth's hydrological cycle, serving as a resource for various ecosystems, human populations, and industrial activities. It encompasses all forms of water found on the surface of the planet, such as rivers, lakes, streams, wetlands, and oceans. It is a source of drinking water for many communities around the world, particularly in areas where groundwater is scarce or contaminated. Therefore it is crucial to prioritize efforts towards enhancing and preserving the quality of freshwater sources for human health and economic development (Wu et al, 2018). Various types of water pollutants have been classified into different categories, including inorganic pollutants, organic pollutants, pathogens, thermal pollution, and radioactive pollutants (Madhav et al, 2020). The process of urbanization along with a projected population growth, amplifies the occurrence of diffuse pollution entering water bodies (Wehrheim et al, 2020). Water quality is commonly characterized by its physical attributes such as color, odor, and taste, its chemical properties including pH, turbidity, hardness, alkalinity, total solids, presence of metallic or non-metallic salts and its biological properties (Gaur, N., 2022). Aquatic ecosystems face significant vulnerability due to a wide range of pollutants originating primarily from domestic, urban, and industrial sources (Pandey, A., 2014) These pollutants, including those stemming from diverse agricultural practices, pose a considerable risk to river systems by introducing contaminants into their environment (Pinto et al., 2015; Byrne et al., 2015).

The water quality index (WQI) is one of the most widely adopted tools for water quality assessment and decision-making (Munagala et al, 2020). WQI is a concise numerical representation that combines measurements of specific parameters to provide a simplified assessment of overall water quality. It condenses multiple data points into a single dimensionless number, allowing for a straightforward evaluation of water quality (Sutadian, A.D, 2016). The process of evaluating the quality of surface water allows for the implementation of strategies and actions to ensure the provision of safe and uncontaminated water. (Islam et al, 2021). The current work was conducted to examine physico chemical parameters influencing the chemistry of water and assess surface water resources through water quality index.

## II. STUDY AREA

For the assessment of surface water quality four different blocks of Jashpur district namely Jashpur Nagar, Manora, Kunkuri and Duldula were selected as study area, which are shown in fig 1. Jashpur district lies in the north-eastern corner of the state of Chhattisgarh in India. It is between 22° 17′ and 23° 15′ North latitude and 83° 30′ and 84° 24′ East longitude. The north-south length of this district is about 150 km, and its east-west breadth is about 85 km. Its total area is 6,205 km². It is located at an elevation of 779.48 feet above sea level, having a humid subtropical, dry winter climate ( https://jashpur.nic.in/en/). Average rainfall was about 68.350 mm from June 2018 to June 2023.

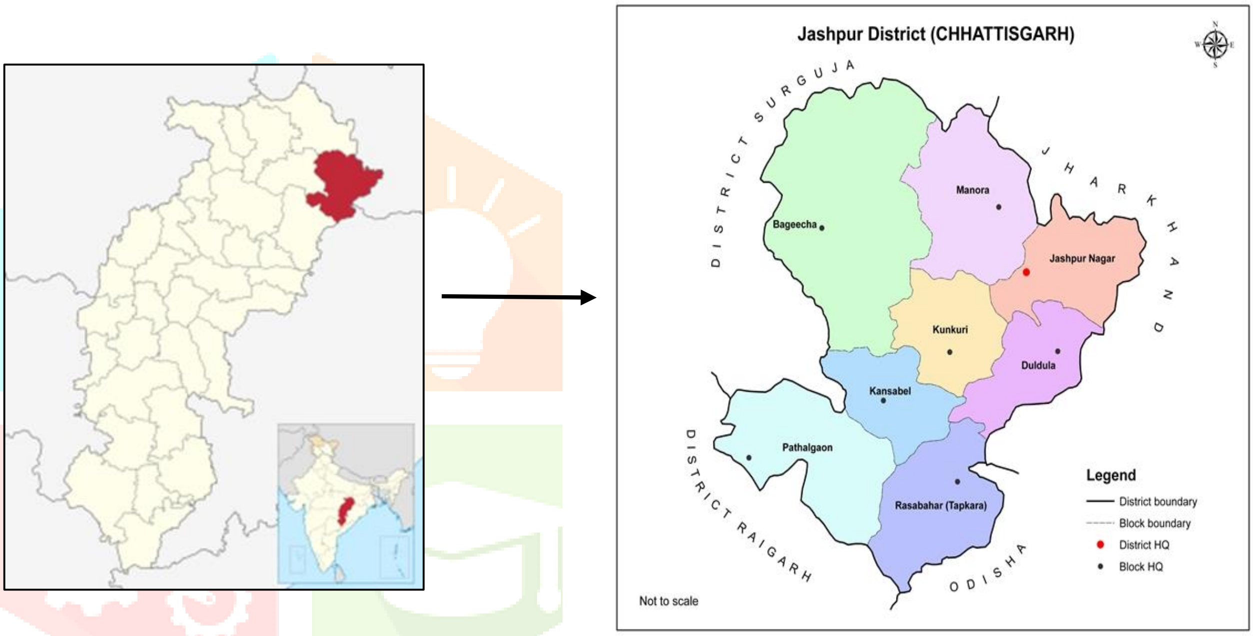


Fig 1. Location map of study area

## II. MATERIAL AND METHODS

### 2.1. Water sample collection and physicochemical Analysis

The surface water samples were collected from rivers of four sampling sites from February 2022 to November 2022. Samples were collected in pre-cleaned one litre capacity plastic polyethylene bottles and rinsed thoroughly with the water to be taken for physicochemical analysis. The collected samples were kept in refrigerator at 4°C for preservation until analysis in laboratory. Each of the water sample was analyzed for nine parameters involving pH, turbidiy, alkalinity, total dissolved solids, total hardness, chloride, fluoride, Calcium and magnesium using standard procedures recommended by APHA. Results were compared with those standards for physical and chemical properties of drinking water recommended by Bureau of Indian Standards(BIS) IS 10500:2012.

Table 1. Details of test methods employed for analysis of different parameters

| No | Parameters | Test Method employed IS: 3025/APHA 23rd ed. | |
|---|---|---|---|
| | | **Method** | **Part No.** |
| 1 | $p^H$ | IS:3025 | Part - 11 |
| 2 | Turbidity | IS:3025 | Part - 10 |
| 3 | Alkalinity | APHA 23rd ed | Part – 2320-B |
| 4 | TDS | APHA 23rd ed | Part – 3540-C |
| 5 | Total hardness | APHA 23rd ed | Part – 2340-C |
| 6 | Chloride | APHA 23rd ed | Part – 4500-Cl-B |
| 7 | Flouride | APHA 23rd ed | Part – 4500-F-C |
| 8 | Calcium | APHA 23rd ed | Part – 3500-Ca-B |
| 9 | Magnesium | APHA 23rd ed | Part – 3500-Mg-B |

**2.2. Water quality index determination**

Water Quality Index (WQI) is widely used due to its capability of full expression of the water quality information and is one of the most effective tools and important parameters for evaluation and management of water quality. In this study weighted arithmetic water quality index developed by (Brown et al,1972) is used. Mean values of pH, turbidity, TDS, total hardness, alkalinity, Ca, Mg, $Cl^-$ and $F^-$ were used in calculation. The weighted arithmetic mean approach employs specific formulae based on the parameters chosen and its recommended standard by WHO, BIS or CCME to calculate the WQI as per the following steps-

1. Calculation of unit weight (Wn) for each parameter using the following formula

$$W_n = \frac{K}{S_n}$$

Where, $K = \frac{1}{\frac{1}{S1}+\frac{1}{S2}+\frac{1}{S3}\dots\dots\dots\frac{1}{Sn}} = \frac{1}{\Sigma\frac{1}{Sn}}$

$W_n$ = Unit weight of each parameter

$S_n$ = Standard desirable value of the nth parameters

2. Calculation of sub-index value ($Q_n$)by using the formula

$$Q_n = \frac{[(V_n - V_o)]}{[(S_n - V_o)]} * 100$$

Where, $V_n$= concentration of nth parameter in the analyzed water
$S_n$ = Standard value of nth parameter
$V_o$ = Ideal value of the parameter in pure water

3. Determination of overall Water Quality Index (WQI) using the formula

$$Overall\ WQI = \Sigma \frac{W_n Q_n}{W_n}$$

4. Determination of water quality by comparing calculated WQI with water quality scale as per the table 2.

Table 2. Water quality index scale (Brown et al 1972)

| WQI | Water quality status |
|---|---|
| 0–25 | Excellent |
| 26–50 | Good |
| 51–75 | Poor |
| 76–100 | Very poor |
| >100 | Unsuitable for drinking |

## III. RESULTS AND DISCUSSION

Surface water collected from four different sampling sites S1,S2,S3 and S4 of Jashpur area during the study period. After analysis mean values and standard deviations of nine physicochemical parameters are presented in Table 1. These parameters (pH, turbidity, alkalinity, TDS, TH, Chloride, Flouride, Calcium and Magnesium) of water samples were used to calculate the WQI value at each site, which is given in the table. Result obtained are discussed as follows-

**pH value -** The pH values of all the sites were found within permissible range, S1,S2,S3 has pH value towards acidic range while S4 has slightly alkaline nature, which might be due to sewage disposal and weathering in sediments. Exposure of living beings to high pH affects the mucous membrane of body cells (Nishtha et al., 2012).

**Turbidity-** According to the WHO (2011), turbidity of water should not be more than 5.00 NTU for drinking purpose. It was found that turbidity of all four sampling sites is higher than permissible limit, which is due to presence of minute soil particles flowing along with surface water.

**Alkalinity –** It is the measurement of concentration of all alkaline substances dissolved in water. It is generally due to the presence of carbonates, bicarbonates and hydroxide ions. It was within prescribed limits by BIS at all sites during the study period.S1 has highest while S3 has lowest alkalinity.

Table 3. Comparison between values of parameters analysed and BIS limits

| No. | Parameters | As per BIS 2012 | | Values | S1 | S2 | S3 | S4 |
|---|---|---|---|---|---|---|---|---|
| | | Acceptable limit | Permissible limit | | | | | |
| 1 | $p^H$ | 6.5-8.5 | 6.5-8.5 | Mean | 6.58 | 6.65 | 6.8 | 7.21 |
| | | | | SD | 0.44 | 0.33 | 0.52 | 0.25 |
| 2 | Turbidity | 1 | 5 | Mean | 10.79 | 9.96 | 11.84 | 15.71 |
| | | | | SD | 1.82 | 5.53 | 1.87 | 2.80 |
| 3 | Alkalinity | 200 | 600 | Mean | 98.8 | 83.65 | 52.5 | 96.03 |
| | | | | SD | 7.76 | 17.83 | 12.15 | 35.07 |
| 4 | TDS | 500 | 2000 | Mean | 120.03 | 78.15 | 60.9 | 101.64 |
| | | | | SD | 10.09 | 9.54 | 19.95 | 6.04 |
| 5 | Total hardness | 200 | 600 | Mean | 94.16 | 48.07 | 32.9 | 35.3 |
| | | | | SD | 5.53 | 19.59 | 2.38 | 5.39 |
| 6 | Chloride | 250 | 1000 | Mean | 14.36 | 15.24 | 13.56 | 7.01 |
| | | | | SD | 3.30 | 2.94 | 5.57 | 0.93 |
| 7 | Fluoride | 1 | 1.5 | Mean | 0.23 | 0.21 | 0.11 | 0.19 |
| | | | | SD | 0.051 | 0.10 | 0.04 | 0.08 |
| 8 | Calcium | 75 | 200 | Mean | 6.01 | 14.09 | 6.4 | 10.62 |
| | | | | SD | 1.16 | 6.50 | 1.98 | 3.45 |
| 9 | Magnesium | 30 | 100 | Mean | 2.9 | 7.16 | 6.04 | 5.58 |
| | | | | SD | 0.79 | 2.21 | 1.70 | 2.02 |

The parameters are determined in mg/L with the exception of turbidity which is expressed in NTU and pH is unitless.

SD means Standard deviation.

Table 3. Calculated water quality index of sample sites

| Sample site | Σ WnQn/Wn | Water quality |
|---|---|---|
| S1 | 51.029 | Poor |
| S2 | 47.073 | Good |
| S3 | 44.144 | Good |
| S4 | 61.345 | poor |

**Total dissolved solids-** The total dissolved solids in the sample water is between the range of 60mg/L to 120 mg/L, which is below the limit of BIS. The low value of TDS indicates less contamination of minerals in the water (S. Sasikala et al., 2015).

**Total Hardness** – It is calculated as the sum of divalent metallic cations $Ca^{2+}$ and $Mg^{2+}$ concentration as $CaCO_3$ equivalent ( Todd, 1980). The value of TH is classified as soft (0-60 mg/L), moderately hard (60-120 mg/L), hard (120-180 mg/L) and very hard (>180 mg/L) as per EPA 1986. Study reveals that S2, S3, S4 has soft water with values 48.01,32.9,35.3mg/L respectively and S1 has moderately hard water (94.16 mg/L)

**Chloride** –The presence of Chloride in natural water can be due to dissolution of salt deposits, discharge of effluents from chemical industries. Chloride concentration was found to be between 7.01 to 15.24 mg/L, which is very low as compare to the set limit. High concentration of chloride in water can be the reason to cause corrosion in distribution systems. (Stets, E. G 2018). Very high chloride concentrations are detrimental to aquatic organisms and can increase the mobility of metals and other bioactive compounds in water (Duan and Kaushal, 2015).

**Fluoride -** Dissolution of fluoride-containing rock minerals, climate, topography and human activities contributes to fluoride contamination in water (Zhang, Z., 2022). S3 has lowest concentration 0.11mg/L while S1 has highest that is 0.23 mg/L, which lies within the permissible limit 1.5 mg/L. Low concentration of fluoride in drinking water has been considered beneficial to prevent dental caries (Kumar, P. S 2019).

**Calcium** – Concentration of Ca in sources of drinking water is due to the composition of bedrock, from which water source originates. Calcium in water is basically found in its ionic form (soluble calcium), which enhances absorption in the gastrointestinal tract (Gaby, K. (2010). Average calcium values varied as follows: 6.01 mg1/L (S1), 14.09 mg1/L (S2), 6.4 mg/l (S3), 10.62 mg/l (S4). Low values in all sites may be due to presence of igneous rocks in this area.

**Magnesium-** The observed values for magnesium ranged between 2.9 mg/L (S1) to 7.16 mg/L (S3), which is within desirable limit. recent research shows that drinking water low in Mg significantly increases the likelihood of cardiovascular mortality. (Kozisek, F., 2020).

**Water quality index** – Results of calculated WQI values as shown in the Table 4. ranges from 44.144 - site S3 to 61.345- S4. The assessment results indicate that S2 and S3 has good water quality due to low physicochemical parameter values contributing to lower composite effect on water quality. Sample sites S1 and S4 has water quality classified as poor for drinking due to comparatively high values of turbidity, TDS, alkalinity and total hardness.

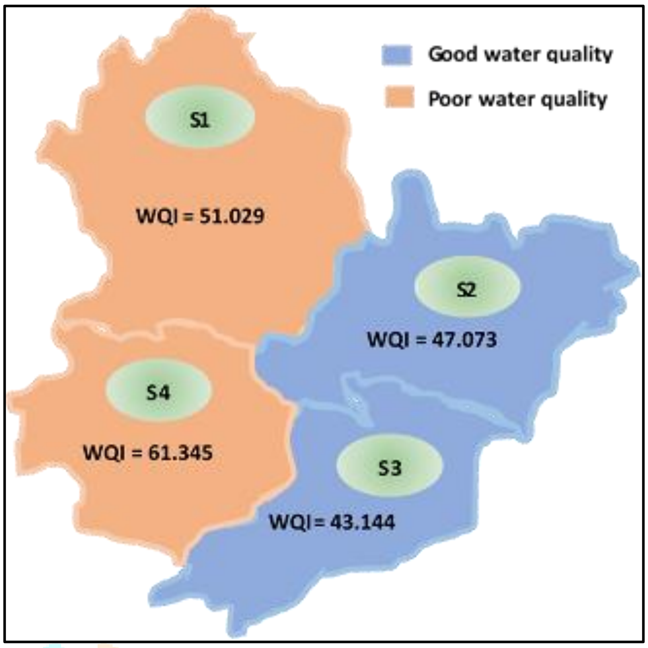


Fig 2. Water quality in different sampling sites as per table 3

## IV. CONCLUSION

In the present study selected water quality indicators were analyzed with the aim of investigating the quality of water for human use and other purposes in Manora, Jashpur nagar, Duldula and Kunkuri of Jashpur district, Chhattisgarh. The water quality index was determined to convert the complex water quality data inJETIR to information that can be understood easily by the community and decision-makers. Results shows that S2 and S3 was under good water quality category, while S1 and S4 under poor category during study period. Based on this study it can be concluded that local community who have been using the water of S2 and S3 should take precautions before using the water for purposes such as drinking. Further effective measures, community engagement, and technological innovations can contribute to safeguarding water resource for present and future generations.

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