ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26mar1882

Physico-Chemical Assessment of Water Quality in the Jaradih Dabri Para & Pachawal Talab Chattishgarh State India

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Publication Date: 2026/04/03

Abstract: Access to safe and clean water is essential for human health and well-being. This study aims to analyze the physico-chemical properties of water in the Jaradih Dabri Para & Pachawal Talab Chattishgarh State India, Balrampur district, Chhattisgarh. Understanding water quality in this region is crucial for evaluating its suitability for drinking, agricultural, and industrial purposes.

The study focused on key physico-chemical parameters, including pH, electrical conductivity (EC), total dissolved solids (TDS), turbidity, alkalinity, hardness, and the concentrations of major ions such as calcium, magnesium, sodium, potassium, chloride, sulphate, and zinc. These parameters provide insights into the chemical composition, overall quality, and potential impacts of water on human health and the environment.

Water samples were collected from pond sources at different depths, representing commonly used water sources in the Jaradih Dabri Para & Pachawal Talab Chattishgarh State India. Standard laboratory methods were employed for analysis. pH was measured using a pH meter; EC and TDS were determined using a conductivity meter; turbidity was assessed with a turbidimeter; alkalinity was measured through titration; and hardness was determined using standard analytical procedures.

The results indicate that the water is slightly alkaline, with pH values ranging from 7.6 to 8.1. EC and TDS values suggest varying degrees of mineralization, indicating the presence of dissolved salts. Turbidity levels ranged from low to moderate, reflecting variations in water clarity. Alkalinity values indicate a moderate buffering capacity against pH changes. Hardness levels varied, suggesting differing concentrations of calcium and magnesium ions. The concentrations of major ions also varied, reflecting the geological and hydrological characteristics of the region.

The findings provide valuable insights into the physico-chemical properties of water in the Aragahi area and can assist local authorities, water management agencies, and community stakeholders in assessing water quality and implementing appropriate treatment strategies. This study also contributes to the existing body of knowledge on water quality in Chhattisgarh and serves as a baseline for future monitoring and research efforts.

Keywords: *Physico-Chemical Properties, Water Quality, Electrical Conductivity, Hardness, Major Ions, Turbidity.*

How to Cite: Dr. Naimish Kumar Verma; Alka Kujoor (2026) Physico-Chemical Assessment of Water Quality in the Jaradih Dabri Para & Pachawal Talab Chattishgarh State India. *International Journal of Innovative Science and Research Technology*, 11(3), 2967-2972. https://doi.org/10.38124/ijisrt/26mar1882

I. INTRODUCTION

Understanding the physico-chemical characteristics of water in this region is essential to ensure the availability of safe and clean water, support public health, promote sustainable water management practices, and protect the environment in the Balrampur district of Chhattisgarh.

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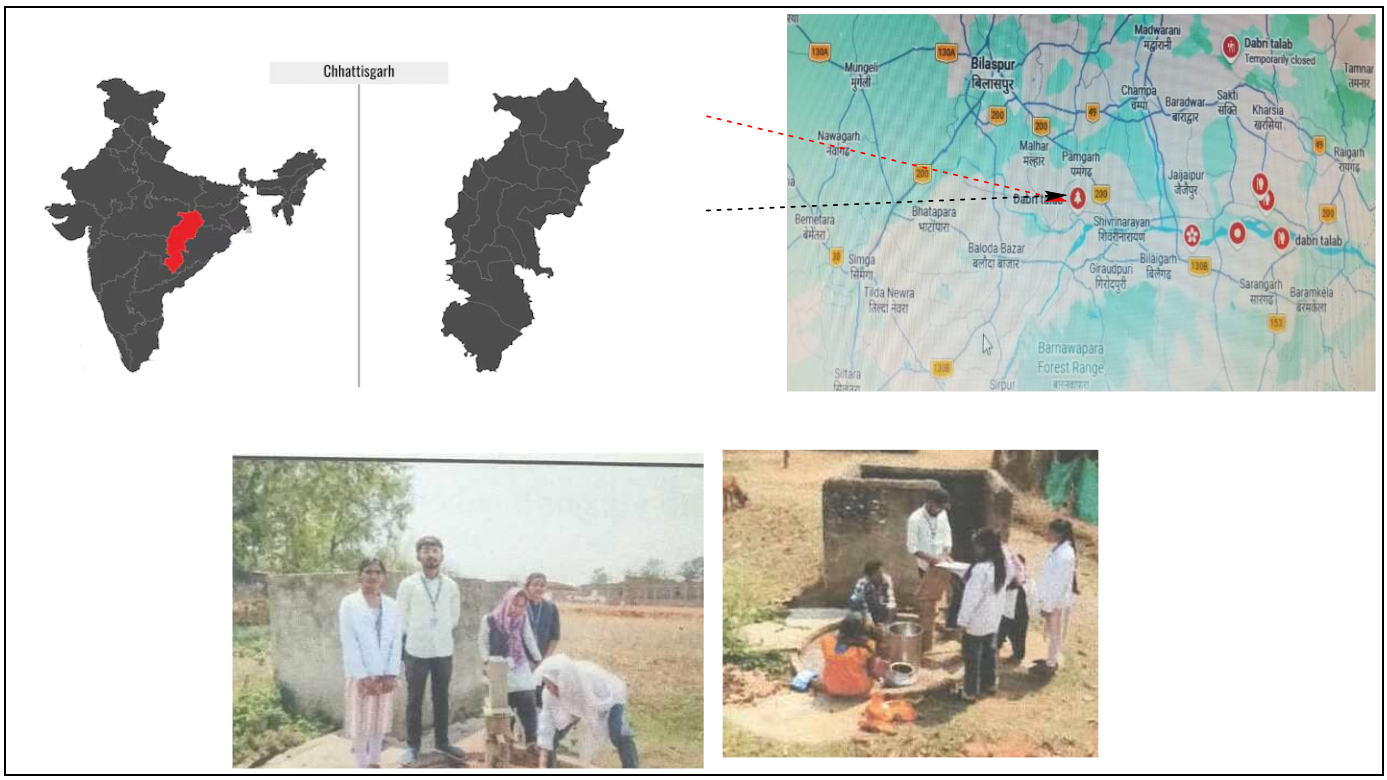

Fig 1 Sample Collection Process from Jaradih Dabri Para & Pachawal Talab Chattishgarh State India

II. LITERATURE REVIEW

Many recent studies have investigated how the density of water changes under different environmental conditions. For instance, Patel *et al.* (2021) used advanced vibrating tube densitometers to measure water density across varying temperatures and pressures. Their findings confirmed that the relationship between temperature and density is nonlinear, with maximum density occurring near 4°C.

➢ *Effect of Temperature on Water Density:*

Temperature is a key factor influencing water density. When water is heated or cooled, molecular expansion or contraction occurs, leading to density changes. Sharma and Gupta (2022) examined water across a wide temperature range and observed that density decreases as temperature increases. They also confirmed the anomalous behavior of water near its freezing point.

➢ *Effect of Pressure on Water Density:*

Pressure significantly affects water density. Li et *al.* (2023) demonstrated that increasing pressure leads to higher density due to molecular compression. However, they noted that the relationship is complex and influenced by temperature and dissolved substances.

➢ *Effect of Impurities and Dissolved Substances:*

Dissolved substances can alter water density considerably. Kumar and Singh (2020) found that increasing salt concentration increases water density due to added mass and changes in intermolecular interactions.

The **viscosity** of water is another important property affecting industrial and natural processes. Several recent studies have explored viscosity under different conditions. Patel *et al.* (2021) studied the effect of temperature on water viscosity using a rotational viscometer and found that viscosity decreases with increasing temperature, consistent with the Arrhenius relationship.

Sharma and Gupta (2022) investigated pressure effects and reported that viscosity increases with pressure, showing a nonlinear trend. In another study, Li *et al.* (2023) examined the impact of dissolved salts using a capillary viscometer and found that viscosity increases with salt concentration. Similarly, Kumar and Singh (2020) analyzed the combined effects of temperature and pressure using a falling ball viscometer. Their results showed that viscosity decreases with temperature but increases with pressure.

Overall, water has relatively low viscosity compared to other liquids, allowing it to flow easily. However, viscosity is strongly influenced by temperature and pressure, affecting water movement in natural systems (Reddy & Verma, 2021).

- *Surface Tension:*

Surface tension arises from cohesive forces between water molecules. This property enables droplet formation and capillary action, which are essential for plant water transport and soil moisture retention (Mehta *et al., 2022).*

- *Solubility:*

Water is considered a universal solvent due to its polarity and hydrogen bonding ability. Its solubility depends on temperature, pressure, and molecular interactions (Das & Roy, 2021).

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- *Heat Capacity:*

Water has a high heat capacity, allowing it to absorb large amounts of heat with minimal temperature change. This helps regulate aquatic environments and climate systems (Nair & Iyer, 2020).

- *Freezing and Boiling Points:*

Water freezes at 0°C and boils at 100°C under standard atmospheric pressure. These phase changes are important in environmental and industrial processes (Reddy & Verma, 2021).

➢ *Chemical Properties:*

- *Calcium:*

Calcium (Ca^{2+}) is a major ion in water derived from rock weathering. It contributes to water hardness and supports bone health. However, excessive calcium can cause scaling (Patel & Shah, 2022*).*

- *Magnesium:*

Magnesium (Mg^{2+}) also contributes to hardness and plays a role in biological functions. Adequate levels are beneficial, but high concentrations may cause scaling *(Kumar et al., 2023).*

- *Fluoride:*

Fluoride (F^-) supports dental health but must be controlled to avoid fluorosis. Its concentration is carefully regulated (Singh & Kaur, 2024).

- *Conductivity:*

Water conductivity indicates the presence of dissolved ions. High conductivity may suggest pollution from industrial or agricultural sources (Gupta & Meena, 2021*).*

- *Iron:*

Iron in water originates from natural and human sources. Excess iron causes discoloration, taste issues, and bacterial growth, requiring proper treatment (Yadav *et al.*, 2022*).*

- *Hardness:*

Water hardness depends on calcium and magnesium levels. High hardness leads to scaling and reduced soap efficiency (Sharma & Patel, 2021*).*

- *pH:*

pH indicates acidity or alkalinity. It affects aquatic life and nutrient availability and is influenced by dissolved substances (Verma & Singh, 2020).

- *Chloride:*

Chloride (Cl^-) is an indicator of salinity and pollution. High levels may result from wastewater or industrial discharge (Rao et al., 2021).

- *Nitrate:*

Nitrate is essential for plant growth but harmful in excess. High concentrations can cause eutrophication and water contamination *(*Kaur & Singh, 2022).

III. MATERIAL & METHODOLOGY

➢ *Sampling*

Water samples will be collected from various sources in the Aragahi area, including groundwater wells, surface water bodies, and domestic taps. Sampling sites will be carefully selected to represent the commonly used water sources in the region. Standard sampling protocols will be followed to ensure accuracy, consistency, and representativeness of the collected samples. Each sample will be collected in clean, sterilized containers, properly labeled, and transported to the laboratory under controlled conditions.

➢ *Laboratory Analysis*

The collected water samples will be analyzed in the laboratory for various physico-chemical parameters. The following analyses will be conducted:

- *pH:*

The acidity or alkalinity of water will be measured using a calibrated digital pH meter. Measurements will be performed at room temperature, and the meter will be standardized with buffer solutions before use.

- *Electrical Conductivity (EC) and Total Dissolved Solids (TDS):*

Water mineral content will be assessed using a conductivity meter. EC provides an estimate of dissolved ions, while TDS will be calculated based on conductivity readings to evaluate overall water quality.

- *Turbidity:*

The clarity of water will be measured using a turbidimeter. Turbidity indicates the presence of suspended particles and is important for assessing water aesthetics and treatment requirements.

- *Alkalinity:*

Alkalinity, which reflects the water's capacity to resist pH changes, will be determined using standard titration methods with acid reagents. This parameter helps in understanding the buffering capacity of water.

- *Hardness:*

Water hardness, due to calcium and magnesium ions, will be measured using titration or the color chart method.

- *Major Ions:*

The concentrations of major ions, including calcium (Ca^{2+}), magnesium (Mg^{2+}), iron (Fe), nitrate (NO_3^-), chloride (Cl^-), and sulfate (SO_4^{2-}), will be analyzed in the laboratory using standard analytical techniques.

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- *Density:*

The density of water samples will be determined using a pycnometer or densitometer to understand the effect of dissolved substances.

➢ *Data Analysis*

The data obtained from laboratory tests will be analyzed and interpreted to evaluate the physico-chemical properties of water in the Jaradih Dabri Para & Pachawal Talab Chattishgarh area. Statistical methods and graphical representations will be used to summarize and present the results. The study will focus on parameters such as turbidity, conductivity, TDS, density, total alkalinity, magnesium (Mg), iron (Fe), calcium (Ca), total hardness, nitrate, and chloride, following the procedures outlined by Dewangan et al. (2022). The results of these analyses will provide insight into the water quality of the sampled sources.

Table 1 Physical Properties of Water Sample Taken from Jaradih Dabri Para (Sample 01) & Pachawal Talab (Sample 02) Chattishgarh State India

S. No.	Parameter (Unit)	Acceptable Value	Sample 01	Sample 02
1	Turbidity (NTU)	1 – 5	0.37	19.4
2	Conductivity (µmho/cm)	NA	213.3	202.8
3	TDS (mg/L)	NA	549	196
4	Density	NA	1.00	0.98
5	pH Value	6.5 – 8.5	8.12	7.66

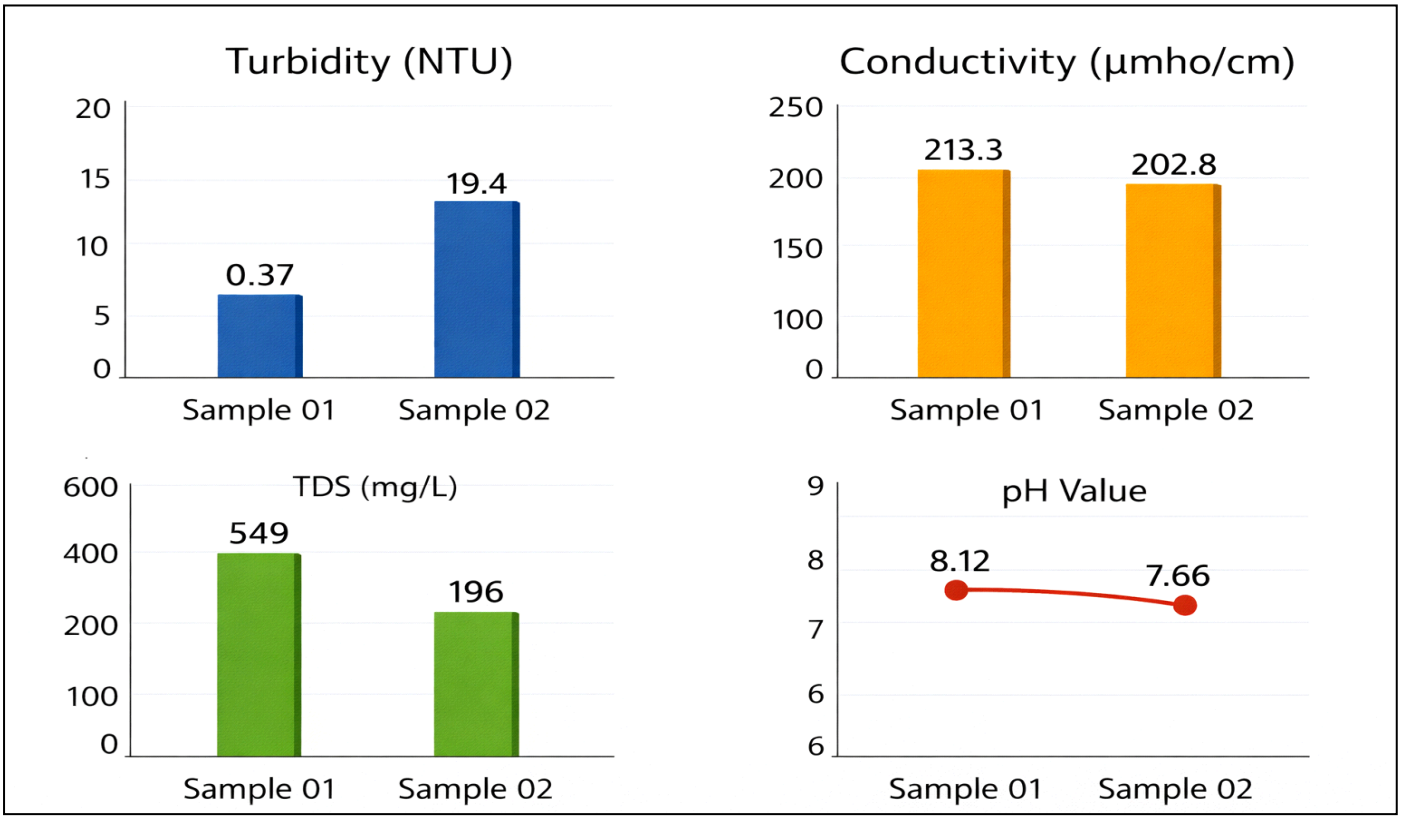

Fig 2 Comparative Analysis of Water Quality Parameters (Turbidity, Conductivity, TDS, and pH) for Sample 01 and Sample 02"

Table 2 Chemical Properties of Water Sample Taken from Jaradih Dabri Para (Sample 01) & Pachawal Talab (Sample 02) Chattishgarh State India

S.No.	Parameter	Acceptable Value	Sample 01	Sample 02
1	Total Alkalinity (ml/l)	200	96	54
2	Chloride (ml/l)	200	19.8	9.9
3	Nitrate (ml/l)	45	5	5
4	Total Hardness ($CaCO_3$) (ml/l)	200	128.64	78.39
5	Calcium (Ca) (ml/l)	75	263.31	110.55
6	Magnesium (Mg) (ml/l)	30	3.2	2
7	Iron (Fe) (ml/l)	0.3	0.04	0.05
8	Fluorides (F) (ml/l)	1	0.422	0.668
9	Sulphates (SO_4) (ml/l)	200	10	10

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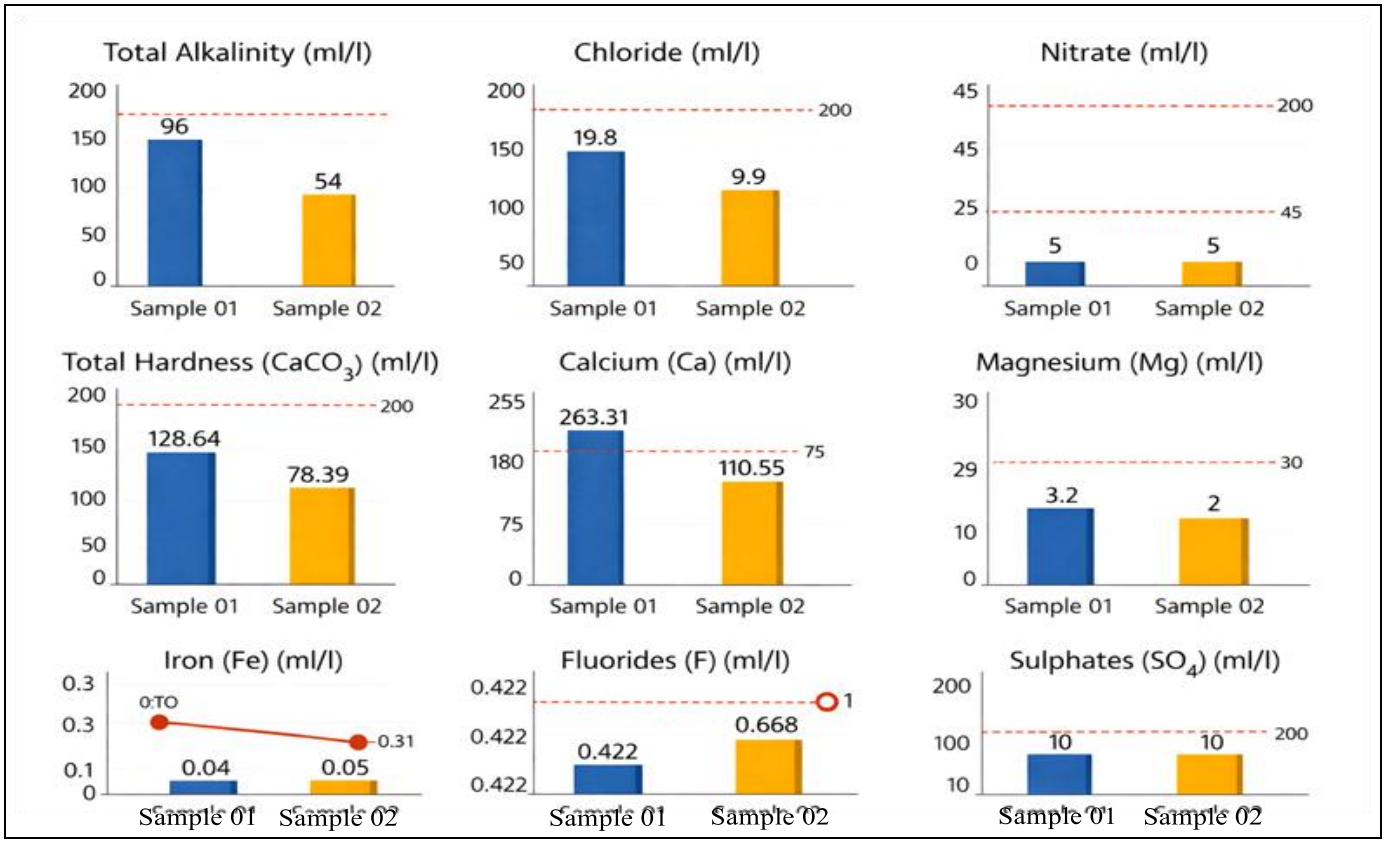

Fig 3 Comparative Analysis of Chemical Water Quality Parameters (Total Alkalinity, Chloride, Nitrate, Total Hardness, Calcium, Magnesium, Iron, Fluoride, and Sulphates) for Sample 01 and Sample 02"

IV. RESULT & DISCUSSION

The present investigation provides a comprehensive assessment of the physicochemical characteristics of water samples collected from Jaradih Dabri Para (Sample 01) and Pachawal Talab (Sample 02). The results reveal notable variations in both physical and chemical properties, which have significant implications for water quality and potability.

Turbidity emerged as a critical parameter influencing water quality. Sample 02 exhibited much high turbidity (19.4 NTU), far exceeding the acceptable range (1–5 NTU), indicating the presence of suspended particulates, organic matter, or possible microbial contamination. Such elevated turbidity levels can hinder disinfection processes and pose health risks.Sample 01 demonstrated very low turbidity (0.37 NTU), indicating relatively clear water.

Electrical conductivity values across all samples were within moderate ranges, reflecting the presence of dissolved ionic species. The comparatively higher conductivity in Sample 01 correlates with its elevated total dissolved solids (TDS) value (549 mg/L), suggesting increased mineralization. Although no strict permissible limit exists for conductivity, it serves as an indirect indicator of water salinity and ionic composition.

TDS analysis further supports this observation, where Sample 01 exhibited relatively high TDS, potentially affecting taste and long-term acceptability. In contrast, Samples 02 showed lower TDS values, indicating better palatability and reduced dissolved impurity levels. The pH values of all samples remained within the acceptable range (6.5–8.5), indicating no immediate concerns related to acidity or alkalinity.

Among chemical parameters, calcium concentration was identified as a major concern. Both Sample 01 (263.31 mg/L) and Sample 02 (110.55 mg/L) exceeded the permissible limit (75 mg/L), indicating significant hardness contribution. Elevated calcium levels can lead to scaling in pipes and may have long-term health implications. Despite this, total hardness values remained within acceptable limits, suggesting that magnesium contribution to hardness was minimal, as confirmed by its low concentration in both samples.

Other chemical parameters, including alkalinity, chloride, nitrate, iron, fluoride, and sulphate, were found to be well within acceptable limits. The low nitrate concentration indicates minimal agricultural runoff contamination, while low chloride and sulphate levels suggest the absence of significant industrial or sewage pollution. Iron and fluoride concentrations were also within safe limits, indicating no risk of staining, taste issues, or fluorosis.

Overall, the results suggest that while chemical contamination is minimal, physical parameters (particularly turbidity) and specific mineral concentrations (notably calcium) are the primary factors affecting water quality in the study area.

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/26mar1882

V. CONCLUSION

The present study concludes that the water samples analyzed from selected locations in Chhattisgarh, India, exhibit varying degrees of suitability for domestic and drinking purposes. While most chemical parameters fall within internationally accepted limits, turbidity and calcium concentration are the principal factors limiting water quality.

Sample 01 is characterized by high TDS and excessive calcium content, indicating the need for water softening treatment before consumption. Sample 02, although chemically safer, exhibits very high turbidity, making it unsuitable for direct use without proper filtration and clarification. In conclusion, none of the samples can be considered fully suitable for direct consumption without treatment. Appropriate water treatment methods, including filtration to reduce turbidity and softening processes to control hardness, are strongly recommended. Regular monitoring of water quality is essential to ensure public health safety and sustainable water resource management.

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