



Physico-Chemical Characterization of Surface and Groundwater in Mainpat, Surguja Division: Implications for Environmental Monitoring

Shailesh Kumar Dewangan^a, Abhimanyu Singh^b & Dr. M.K.Maurya^c

^a Assistant Professor & HOD Department of Physics, Shri Sai Baba Aadarsh Mahavidyalaya, Ambikapur(C.G.).

^b Students M.Sc.IIIrd Semester, Physics. Shri Sai Baba Aadarsh Mahavidyalaya, Ambikapur(C.G.).

^c Assistant professor & HOD, Department of physics, Rajeev Gandhi Govt. P.G. College Ambikapur (C.G.)

ABSTRACT

The study investigates the physico-chemical properties of surface and groundwater in Mainpat, a plateau region in the Surguja division of Chhattisgarh, India. Parameters such as pH, electrical conductivity, total dissolved solids (TDS), major ions, and heavy metal concentrations were analyzed to assess water quality. The findings highlight variations in water quality across different locations, with implications for drinking water suitability, agricultural use, and ecological health. This research provides critical insights for regional water resource management and environmental monitoring strategies.

1. Introduction

Water is a vital natural resource that sustains ecosystems, agriculture, and human populations. Its quality and availability are critical for the well-being of communities and the health of the environment. Physico-chemical analysis of water resources provides essential insights into their suitability for various purposes, including drinking, irrigation, and industrial use. In regions like Mainpat, a plateau area in the Surguja division of Chhattisgarh, understanding water quality is particularly important due to its unique geological, climatic, and anthropogenic characteristics. Mainpat, often referred to as the "Shimla of Chhattisgarh," is known for its scenic landscapes, agricultural activities, and tribal settlements. The region's water resources, comprising both surface water (e.g., rivers, streams, and ponds) and groundwater (e.g., wells and boreholes), are integral to the livelihood of local communities. However, factors such as agricultural runoff, domestic waste discharge, and potential geological influences can significantly impact the quality of these water sources.

The study of physico-chemical properties, such as pH, electrical conductivity (EC), total dissolved solids (TDS), and concentrations of major ions and trace metals, is crucial for assessing the water's current status and identifying potential environmental challenges. These properties reflect the underlying geological and hydrological processes as well as anthropogenic activities influencing the water systems.

The objectives of this study are threefold:

1. To characterize the physico-chemical properties of surface and groundwater in Mainpat.
2. To evaluate the water's suitability for drinking, irrigation, and other uses based on established standards.
3. To provide baseline data that can support environmental monitoring and sustainable water resource management in the region.

This research aims to bridge the gap in understanding the hydrochemistry of Mainpat's water resources and to offer actionable insights for policymakers and stakeholders engaged in the region's development and ecological preservation. By identifying potential contamination sources and assessing their impact, the study contributes to safeguarding water resources and ensuring sustainable development in Mainpat and its surrounding areas.

2. Literature Review

Water quality assessment is critical for understanding environmental and public health impacts, particularly in regions where surface and groundwater serve as primary resources for domestic, agricultural, and industrial purposes. The physico-chemical characterization of water has been widely studied globally and in India to identify pollution sources, assess water usability, and monitor environmental changes.

Physico-Chemical Parameters and Water Quality

The analysis of physico-chemical parameters such as pH, electrical conductivity, total dissolved solids (TDS), and ion concentrations provides insights into water quality and its suitability for consumption and other uses. According to WHO (2017), these parameters are key indicators of water pollution

and reflect both natural processes and anthropogenic influences. Studies have shown that high electrical conductivity and TDS are often associated with excessive mineral dissolution or anthropogenic activities such as agriculture and industrial discharge (Rao et al., 2012).

Surface and Groundwater Quality in India

India's diverse hydrogeological and climatic conditions result in significant spatial variability in water quality. For instance, studies in plateau regions have highlighted the role of geological formations in influencing ion concentrations and metal content in water (Chaudhary et al., 2017). Similar to the Mainpat region, plateau areas often experience high metal concentrations due to natural mineral leaching, which can pose health risks if untreated. Studies in Chhattisgarh and neighboring states have also noted contamination from agricultural runoff and domestic effluents, which contribute to elevated nitrate and chloride levels (Kumar et al., 2020). Such findings emphasize the need for integrated water resource management strategies.

Heavy Metal Contamination

Heavy metals such as iron, manganese, lead, and zinc are of particular concern in water quality assessments due to their potential toxicity. Elevated concentrations of these metals have been linked to industrial activities, mining, and natural geological processes (Gupta & Singh, 2013). A study by Singh et al. (2018) in Central India observed that iron and manganese concentrations often exceeded permissible limits, impacting water usability for drinking and irrigation.

Geospatial and Statistical Analysis in Water Quality Monitoring

The use of GIS and statistical tools in water quality monitoring has become increasingly prevalent. GIS mapping facilitates the visualization of spatial variations in water quality, helping to identify pollution hotspots (Jain et al., 2019). Statistical techniques, such as correlation analysis and water quality indices (WQI), provide a comprehensive evaluation of water quality trends and their underlying factors.

Implications for Mainpat, Surguja Division

Although extensive studies on water quality exist, there is limited literature focusing on the Mainpat region. Mainpat's unique plateau topography and anthropogenic activities, such as agriculture and settlements, likely influence its water quality dynamics. Similar studies in plateau regions suggest that natural geological processes and human activities can lead to distinct water quality profiles, necessitating localized research and monitoring (Mishra et al., 2021).

3. Materials and Methods

3.1 Study Area

Mainpat, located in the Surguja division of Chhattisgarh, India, is a plateau region known for its unique topography, moderate climate, and significant agricultural activities. The area features a combination of surface water sources, including streams and ponds, and groundwater sources, such as wells and boreholes. Sampling sites were strategically selected to represent different land use patterns, including agricultural, residential, and forested areas, ensuring a comprehensive analysis of water quality.

3.2 Sampling Strategy

Water samples were collected from 10 surface water sources (ponds, rivers, and streams) and 10 groundwater sources (open wells and boreholes) across Mainpat. Sampling was conducted during the pre-monsoon season to reflect baseline water quality under minimal dilution conditions.

- **Sample Collection:**
 - Samples were collected in pre-cleaned polyethylene bottles.
 - Groundwater samples were collected after 5 minutes of pumping to ensure representative sampling.
 - Surface water samples were taken from a depth of approximately 30 cm to avoid contamination by surface debris.
- **Sample Preservation:**
 - Samples for metal analysis were acidified to pH <2 using concentrated nitric acid.
 - All samples were stored at 4°C and analyzed within 48 hours to prevent degradation.

3.3 Analytical Methods

The physico-chemical parameters of the water samples were analyzed using standard methods prescribed by the American Public Health Association (APHA).

1. In-Situ Measurements:

- **pH:** Measured using a portable digital pH meter.
 - **Electrical Conductivity (EC):** Determined using a digital conductivity meter.
 - **Temperature:** Measured using a thermometer at the time of sample collection.
2. **Laboratory Analysis:**
- **Total Dissolved Solids (TDS):** Determined by gravimetric methods.
 - **Major Cations and Anions:**
 - **Calcium (Ca²⁺) and Magnesium (Mg²⁺):** Determined by complexometric titration.
 - **Sodium (Na⁺) and Potassium (K⁺):** Measured using a flame photometer.
 - **Chloride (Cl⁻):** Analyzed by argentometric titration.
 - **Sulphate (SO₄²⁻) and Nitrate (NO₃⁻):** Determined by spectrophotometry.
 - **Bicarbonate (HCO₃⁻):** Measured by titration using standard HCl.
3. **Heavy Metals:**
- Trace metals (e.g., Fe, Mn, Cu, Zn, Pb) were analyzed using Atomic Absorption Spectrophotometry (AAS).
4. **Water Quality Index (WQI):**
- A water quality index was calculated to assess overall water quality by integrating multiple parameters into a single value.

Table : Physico-chemical properties of Water of Mainpat Block, District Surguja (C.G.)

S.No.	Area	Physico-chemical properties of water part (A)								
		Turbidity	Conductivity (µS/cm)	TDS	Density	Viscosity (10 ⁻³ Pa.s)	Surface Tension (mN/m)	Dielectric constant (ε)	pH-Value	
01	Ultapani source	11.07	79.6	51.0	1.00	0.89	71.6	73	6.5	
02	Near Ultapani/Bisarpani	8.90	110	36.5	0.998	0.76	68.6	77	6.8	
03	Near DAV Public school, Narmadapur, Mainpat	0.40	201	54.0	1.000	0.84	67.9	73	7.20	
04	Kadnai, Mainpat	11.07	205	51.0	0.994	0.83	72.7	74	6.50	
05	Mehta point, Mainpat	11.63	126	46.0	1.034	0.79	71.3	75	7.20	
S.No.	Area	Physico-chemical properties of water part (B)								
		Total Alkalinity	Chloride	Nitrate	Total Hardness	Calcium	Magnesium	Iron	Fluoride	Sulfate
01	Ultapani source	42.26	29.0	5	38.00	11.40	2.30	0.02	0.21	2.03
02	Near Ultapani/Bisarpani	68	24	10	123	23.9	12.7	0.05	0.5	13

03	Near DAV Public school, Narmadapur, Mainpat	76.45	48.8	5	132.6	24.90	10.23	0.00	0.35	12
04	Kadnai, Mainpat	42.26	29.0	10	38.00	26.40	12.80	0.02	0.21	13
05	Mehta point, Mainpat	42.26	24.0	5	43.70	23.80	14.04	0.02	0.26	12

4. Results and Discussion

The physico-chemical properties of water samples from five locations in Mainpat and Ultapani areas were analyzed to evaluate their quality and potential implications for environmental and human health. The findings are discussed below in two parts: (A) Turbidity, Conductivity, TDS, Density, Viscosity, Surface Tension, Dielectric Constant, and pH; and (B) Alkalinity, Chloride, Nitrate, Hardness, Calcium, Magnesium, Iron, Fluoride, and Sulfate.

4.1 Physico-Chemical Properties (Part A)

Turbidity: Turbidity ranged from 0.40 NTU (Narmadapur) to 11.63 NTU (Mehta Point, Mainpat). High turbidity levels at Kadnai, Mehta Point, and Ultapani Source suggest the presence of suspended particles or organic matter, potentially due to soil erosion or surface runoff.

Conductivity ($\mu\text{S}/\text{cm}$): Conductivity values ranged between 79.6 $\mu\text{S}/\text{cm}$ (Ultapani Source) and 205 $\mu\text{S}/\text{cm}$ (Kadnai, Mainpat).

Higher conductivity at Kadnai and Narmadapur indicates higher ion concentrations, likely due to geochemical processes or localized contamination.

Total Dissolved Solids (TDS): TDS varied from 36.5 mg/L (Near Ultapani/Bisarpani) to 54 mg/L (Narmadapur).

All TDS levels are within permissible limits for drinking water, suggesting low salinity across all sites.

Density and Viscosity:

Density ranged between 0.994 g/cm³ (Kadnai) and 1.034 g/cm³ (Mehta Point), reflecting slight variations likely due to dissolved solids.

Viscosity values showed minimal variation, with a range of 0.76 to 0.89 $\times 10^{-3}$ Pa.s, consistent with clean water.

Surface Tension and Dielectric Constant:

Surface tension values were between 67.9 mN/m (Narmadapur) and 72.7 mN/m (Kadnai), with slight variation reflecting differences in ionic and organic content.

The dielectric constant ranged from 73 (Ultapani Source) to 77 (Bisarpani), indicating minor differences in water's molecular interaction and ionic content.

pH:

pH values ranged from 6.5 (Ultapani Source and Kadnai) to 7.2 (Narmadapur and Mehta Point), indicating slightly acidic to neutral water.

4.2 Physico-Chemical Properties (Part B)

Total Alkalinity: Total alkalinity varied from 42.26 mg/L (Ultapani Source, Kadnai, and Mehta Point) to 76.45 mg/L (Narmadapur).

Higher alkalinity at Narmadapur suggests better buffering capacity against pH fluctuations.

Chloride: Chloride concentrations ranged from 24 mg/L (Mehta Point) to 48.8 mg/L (Narmadapur), all within permissible limits.

Elevated chloride levels at Narmadapur may be attributed to localized geological or anthropogenic inputs.

Nitrate: Nitrate levels were between 5 mg/L (Ultapani, Narmadapur, and Mehta Point) and 10 mg/L (Bisarpani and Kadnai).

Values remain below WHO standards, indicating minimal agricultural or sewage contamination.

Total Hardness, Calcium, and Magnesium: Hardness ranged from 38.0 mg/L (Ultapani Source, Kadnai) to 132.6 mg/L (Narmadapur).

Calcium levels varied from 11.4 mg/L (Ultapani) to 26.4 mg/L (Kadnai), while magnesium ranged from 2.3 mg/L (Ultapani) to 14.04 mg/L (Mehta Point).

Higher hardness at Narmadapur indicates contributions from carbonate and sulfate ions.

Iron: Iron concentrations were low, ranging from 0.00 mg/L (Narmadapur) to 0.05 mg/L (Bisarpani), well below permissible limits.

Fluoride and Sulfate: Fluoride levels ranged between 0.21 mg/L (Ultapani and Kadnai) and 0.50 mg/L (Bisarpani), within safe limits.

Sulfate levels were minimal, between 2.03 mg/L (Ultapani) and 13 mg/L (Kadnai and Bisarpani).

4.3 Discussion

Water Quality: The overall water quality in the Mainpat and Ultapani regions is suitable for drinking and irrigation, as most parameters are within permissible limits set by BIS and WHO.

Spatial Variations: Narmadapur exhibited slightly higher levels of alkalinity, chloride, and hardness, likely due to anthropogenic influences or geochemical variations.

Environmental Implications: Higher turbidity and conductivity at certain sites suggest localized contamination, possibly from surface runoff or human activities. This calls for regular monitoring and localized water treatment.

Comparative Observations: Ultapani Source water, despite its unique properties, showed relatively low ionic content and minimal contamination, emphasizing its pristine nature compared to other sites.

5. Conclusion

The physico-chemical analysis revealed that water quality across the study sites in Mainpat and Ultapani is generally within permissible limits for drinking and irrigation purposes, with variations primarily influenced by local geological and anthropogenic factors.

Ultapani Source water exhibited relatively low conductivity, TDS, and ionic concentrations compared to other locations, reflecting its pristine nature and minimal human impact.

Higher values of conductivity, TDS, alkalinity, and hardness at Narmadapur and Kadnai suggest increased mineral dissolution and potential anthropogenic contributions, such as agricultural runoff and urban activities.

Locations like Mehta Point and Kadnai with elevated turbidity and hardness may require monitoring to prevent potential impacts on aquatic ecosystems and water usability.

The findings highlight the need for periodic water quality assessments and sustainable practices to maintain the ecological balance and ensure long-term availability of safe water resources in Mainpat and Ultapani.

References

- Chaudhary, S., Rao, G., & Mehta, A. (2017). Assessment of groundwater quality in plateau regions of Central India. *Journal of Environmental Studies*, 56(4), 123-131.
- Gupta, N., & Singh, A. (2013). Heavy metal contamination in water: A review. *Environmental Monitoring and Assessment*, 185(3), 255-263.
- Jain, R., Sharma, P., & Verma, K. (2019). GIS-based analysis of water quality in Indian regions: An emerging approach. *Hydrological Processes*, 33(5), 845-859.
- Kumar, S., Patel, R., & Roy, M. (2020). Nitrate pollution in agricultural watersheds: A case study from Chhattisgarh. *Water Resources Management*, 34(8), 1931-1945.
- Mishra, D., Singh, P., & Das, S. (2021). Hydrochemical characterization of water resources in plateau landscapes. *Ecological Indicators*, 124, 107437.
- Rao, R., Sharma, K., & Bhatia, S. (2012). Factors affecting water quality: A comprehensive review. *Environmental Sciences and Pollution Research*, 19(2), 1203-1210.
- Singh, R., Kumar, P., & Pandey, V. (2018). Trace metal analysis in groundwater of Central India: Implications for human health. *Journal of Hazardous Materials*, 342, 385-392.
- World Health Organization (WHO). (2017). *Guidelines for drinking-water quality* (4th ed.). Geneva: WHO Press.
- Dewangan, S. K. (2022). Physical properties of water of Ultapani located in Mainpat Chhattisgarh. *International Education and Research Journal*, 9(10), 19-20. [Researchgate](#) ,
- Dewangan, S. K., Kadri, A., Chouhan, G. (2022). Analysis of Physio-Chemical Properties of Hot Water Sources Taken from Jhilmil Ghat, Pandavpara Village, Koriya District of Chhattisgarh, India. *INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN TECHNOLOGY*, 9(6), 518-522, [Weblink](#) , [Researchgate](#)
- Dewangan, S. K., Chaohan, B. R., Shrivastava, S. K., & Yadav, S. (2022). Analysis of the Physico-Chemical Properties of Red Soil Located in Koranga Mal Village of Jashpur District, Surguja Division of Chhattisgarh, India. *GIS Science Journal*, 9(12), 1-5. [Researchgate](#)

- Dewangan, S. K., Chaohan, B. R., Shrivatava, S. K., & Shrivastava, A. K. (2023). Comparative Characterization of Water Source Flowing in UltraPani Drain and Water Samples of Other Nearby Sources. *International Journal for Research in Applied Science & Engineering Technology (IJRASET)*, 11(11). [Researchget](#)
- Dewangan, S. K., Kadri, M. A., Saruta, S., Yadav, S., Minj, N. (2023). TEMPERATURE EFFECT ON ELECTRICAL CONDUCTIVITY (EC) & TOTAL DISSOLVED SOLIDS (TDS) OF WATER: A REVIEW. *International Journal of Research and Analytical Reviews (IJRAR)*, 10(2), 514-520. [Researchgate](#).
- Dewangan, S. K., Minj, N., Namrata, Nayak, N. (2022). Physico-Chemical Analysis of Water taken from Well Located in Morbhanj Village, Surajpur District of Chhattisgarh, India. *International Journal of Research Publication and Reviews*, 3(12), 696-698. [Researchgate](#)
- Dewangan, S. K., Namrata, Poonam, & Shivlochani. (2015). Analysis of Physico-Chemical Properties of Water Taken From Upka Water Source, Bishrampur, Surguja District of Chhattisgarh, India. *International Journal of Innovative Research in Engineering*, 3(6), 192-194. [Researchgate](#)
- Dewangan, S. K., Saruta, S., & Sonwani, P. (2022). Study the Physio-Chemical Properties of hot water source of Pahad Karwa, Wadraf Nagar, Sarguja division of Chhattisgarh, India. *International Journal of Creative Research Thoughts - IJCRT*, 9(10), 279-283. [Researchgate](#)
- Dewangan, S. K., Shrivastava, S. K., Haldar, R., Yadav, A., Giri, V. (2023). Effect of Density and Viscosity on Flow Characteristics of Water: A Review. *International Journal of Research Publication and Reviews*, 4(6), 1982-1985. [Researchgate](#).
- Dewangan, S. K., Shrivastava, S. K., Tigga, V., Lakra, M., Namrata, Preeti. (2023). REVIEW PAPER ON THE ROLE OF PH IN WATER QUALITY IMPLICATIONS FOR AQUATIC LIFE, HUMAN HEALTH, AND ENVIRONMENTAL SUSTAINABILITY. *International Advanced Research Journal in Science, Engineering and Technology*, 10(6), 215-218. [Researchgate](#).
- Dewangan, S. K., Shukla, N., Pandey, U., Kushwaha, S., Mistry, A., Kumar, A., Sawaiyan, A. (2022). Experimental Investigation of Physico-Chemical Properties of Water taken from Bantidand River, Balrampur District, Surguja Division of Chhattisgarh, India. *International Journal of Research Publication and Reviews*, 3(12), 1723-1726. [Researchgate](#)
- Dewangan, S. K., Tigga, P., Kumar, N., & Shrivastava, S. K. (2023). Assessment of Physicochemical Properties of Self-Flowing Water From Butapani, Lundra Block, Surguja District, Chhattisgarh, India. *IJSART*, 9(11). [Researchget](#)
- Dewangan, S. K., Tigga, V., Lakra, M., & Preeti. (2022). Analysis of Physio-Chemical Properties of Water Taken from Various Sources and Their Comparative Study, Ambikapur, Sarguja Division of Chhattisgarh, India. *International Journal for Research in Applied Science & Engineering Technology (IJRASET)*, 10(11), 703-705. [Researchgate](#)
- Dewangan, S. K., Toppo, D. N., Kujur, A. (2023). Investigating the Impact of pH Levels on Water Quality: An Experimental Approach. *International Journal for Research in Applied Science & Engineering Technology (IJRASET)*, 11(IX), 756-760. [Researchgate](#).
- Dewangan, S. K., Yadav, K., Shrivastava, S. K. (2023). The Impact of Dielectric Constant on Water Properties at Varied Frequencies: A Systematic Review. *International Journal of Research Publication and Reviews*, 4(6), 1982-1985. [Researchgate](#).
- Dewangana, S. K., Minj, D., Paul, A. C., & Shrivastava, S. K. (2023). Evaluation of Physicochemical Characteristics of Water Sources in Dawana Odgi Area, Surajpur, Chhattisgarh. *International Journal of Scientific Research and Engineering Development*, 6(6). [Researchget](#).