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# Physio-Chemical Study of Mandakini River Water at Different Ghat of Chitrakoot District

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***Abstract: This study investigates the seasonal variation in physico-chemical parameters of water quality at four major ghats (Ram Ghat, Mandakini Aartisthal Ghat, Mandakini Jal Ghat, and Satiansuyain Ghat) along the Mandakini River in Chitrakoot. Parameters such as pH, total hardness, alkalinity, chloride, dissolved oxygen (DO), and biological oxygen demand (BOD) were analyzed for both summer and winter seasons. The findings reveal fluctuations in water quality due to religious activities and inadequate waste management, highlighting the need for sustainable water management practices.***
***Keywords: Total hardness (TH), biological oxygen demand (BOD), dissolved oxygen (DO), alkalinity (ALK), chloride ($Cl^-$) and most probable number (MPN),***

## I. INTRODUCTION

The Mandakini River, a tributary of the Yamuna, holds religious and cultural significance in Chitrakoot, attracting thousands of devotees year-round. However, increased human and ritualistic activities—such as bathing, idol immersion, and the disposal of offerings—have led to pollution, especially during festivals. This study focuses on assessing the seasonal variation in water quality at four major ghats by analyzing key physico-chemical parameters such as pH, total hardness (TH), biological oxygen demand (BOD), dissolved oxygen (DO), alkalinity (ALK), and chloride ($Cl^-$), along with microbiological contamination (MPN). The findings highlight the urgent need for sustainable water management practices to preserve river health and ensure safe usage.

## II. OBJECTIVE

Objective of this study is to evaluate the seasonal variation in the water quality of the Mandakini River at various ghats in Chitrakoot, with the ultimate goal of proposing sustainable management strategies to mitigate pollution. To achieve this, field visits and surveys were conducted to identify critical sampling sites, followed by the systematic collection of water samples during the summer and winter seasons.

These samples were analyzed for key physico-chemical and microbiological parameters, including pH, total hardness (TH), biological oxygen demand (BOD), dissolved oxygen (DO), alkalinity (ALK), chloride ($Cl^-$), and the most probable number (MPN) for bacterial contamination. The study further examined how these parameters vary with seasonal changes and increased human and ritualistic activity during festivals. Based on the findings, recommendations have been proposed for eco-friendly worship practices and effective water quality management to ensure the long-term health of the river ecosystem.

## III. LITERATURE REVIEW

The studies by Chourasia and Karan (2015) and Saini et al. (2009) underscore the significant environmental and public health challenges posed by large-scale religious events. Chourasia and Karan (2015) investigated the impact of mass bathing during Amavasya in the Mandakini River, revealing a notable deterioration in water quality, particularly with elevated levels of fecal coliform, reduced dissolved oxygen, and increased biological and chemical oxygen demand. These changes indicate a severe pollution load, making the water unsafe for pilgrims.

Similarly, Saini et al. (2009) examined the unsanitary conditions during the Kanwar fair in Haridwar, which resulted in a surge of waterborne and contagious diseases. Poor sanitation management increased solid waste, elevated noise levels, and contamination of drinking water were major contributors to the health risks observed during the event. Both studies highlight the critical need for improved sanitation, pollution control, and environmental management during such events to mitigate public health risks and protect water quality.

## IV. METHODS AND EXPERIMENTAL CONDITIONS

| S.No. | Specifications | Unit | Approach |
|---|---|---|---|
| 1 | pH | ----- | pH meter with digital electrode |
| 2 | Alkalinity | Mg/l as CaCO3 | With H2SO4, titration |
| 3 | Total hardness | Mg/l as CaCO3 | Using EDTA for titration |
| 4 | Chloride | Mg/l | Argentometric technique |
| 5 | Dissolved Oxygen | Mg/l | Winkler's approach |
| 6 | BOD | Mg/l | BOD approach (Winkler's approach) |

### *A. pH*

Definition: Measure of hydrogen ion activity; $pH = -\log_{10}[H^+]$.
Range: <7 acidic, 7 neutral, >7 alkaline; extreme values may go below 0 or above 14.
Importance: Crucial in biology, chemistry, medicine, agriculture, and water treatment.
Measurement: Commonly measured with a pH meter using a glass electrode.
Relevance: pH affects chlorine disinfection efficiency; becomes ineffective above pH 8.

### *B. Hardness*

Cause: Primarily due to dissolved $Ca^{2+}$ and $Mg^{2+}$ ions.
Sources: Limestone (Ca), dolomite and magnesium-rich formations (Mg).
Measurement: Determined using $Na_2EDTA$ titration with Trichrome Black T indicator at pH 10–10.5.
Note: Higher contact time with rocks = higher hardness; more in groundwater than surface water.

### *C. Alkalinity*

Definition: Water's ability to neutralize acids; buffers pH changes.
Main Components: Bicarbonates, carbonates, and hydroxides.
Sources: $CO_2$ dissolution, rock weathering, organic materials.
Measurement:

- Phenolphthalein endpoint (pH ~8.3) → carbonate alkalinity.
- Methyl orange endpoint (pH ~4.5) → total alkalinity.

Unit: Expressed in mg/L as $CaCO_3$.

### *D. Chloride*

Sources: Natural (rock weathering), anthropogenic (road salt, landfills, septic tanks, fertilizers).
Health/Taste: Taste threshold ($NaCl/CaCl_2$): 200–300 mg/L; rare toxicity in humans.
Measurement: Titration with silver nitrate using a chromate indicator.

### *E. Dissolved Oxygen (DO)*

Importance: Essential for aquatic life; minimum 3 mg/L required for fish.
Factors Affecting DO: Respiration, organic decomposition, temperature, reducing agents.
Measurement: Winkler method in BOD bottles; titration indicates oxygen level.
Units: mg/L or % saturation.

*F. Biochemical Oxygen Demand (BOD)*

Definition: Amount of oxygen consumed by microbes to degrade organic matter over 5 days at 20°C.
Importance: Indicator of organic pollution and wastewater treatment efficiency.
Measurement: Based on Winkler method; samples incubated under controlled conditions.
Storage: Test within 48 hrs; store at ≤4°C if delay is unavoidable.

## V. VIEWS AND ANALYZATIONS

The studies on physio-chemical parameters such as pH, Total Hardness, Alkalinity, and Chlorides D.O. and B.O.D. were followed by the following observations.

pH readings for the several Mandakini River study locations.

| A SAMPLE SITE | pH | |
|---|---|---|
| | SUMMER SEASON | WINTER SEASON |
| Ram Ghats | 6.3 | 6.8 |
| Mandakini Aartisthal Ghats | 6.7 | 7.1 |
| Mandakini jal Ghats | 6.8 | 6.7 |
| Satiansuyain Ghats | 6.8 | 7.1 |

Data on the Mandakini River's Total Hardness

| A SAMPLE SITE | Total Hardness (Mg/l as CaCO3) | |
|---|---|---|
| | SUMMER SEASON | WINTER SEASON |
| Ram Ghats | 180.1 | 178.8 |
| Mandakini Aartisthal Ghats | 198 | 190.8 |
| Mandakini jal Ghats | 157.5 | 165.0 |
| Satiansuyain Ghats | 171.5 | 180.1 |

Mandakini River's Bicarbonate Alkalinity Values

| A SAMPLE SITE | Bicarbonate Alkalinity (Mg/l as CaCO3) | |
|---|---|---|
| | SUMMER SEASON | WINTER SEASON |
| Ram Ghats | 194 | 183 |
| Mandakini Aartisthal Ghats | 191 | 186 |
| Mandakini jal Ghats | 156 | 161 |
| Satiansuyain Ghats | 184 | 191 |

The levels of chloride in the Mandakini River's water

| A SAMPLE SITE | Chloride Content (Mg/l) | |
|---|---|---|
| | SUMMER SEASON | WINTER SEASON |
| Ram Ghats | 14.4 | 15.1 |
| Mandakini Aartisthal Ghats | 15.4 | 17.3 |
| Mandakini jal Ghats | 17 | 17.8 |
| Satiansuyain Ghats | 22 | 21 |

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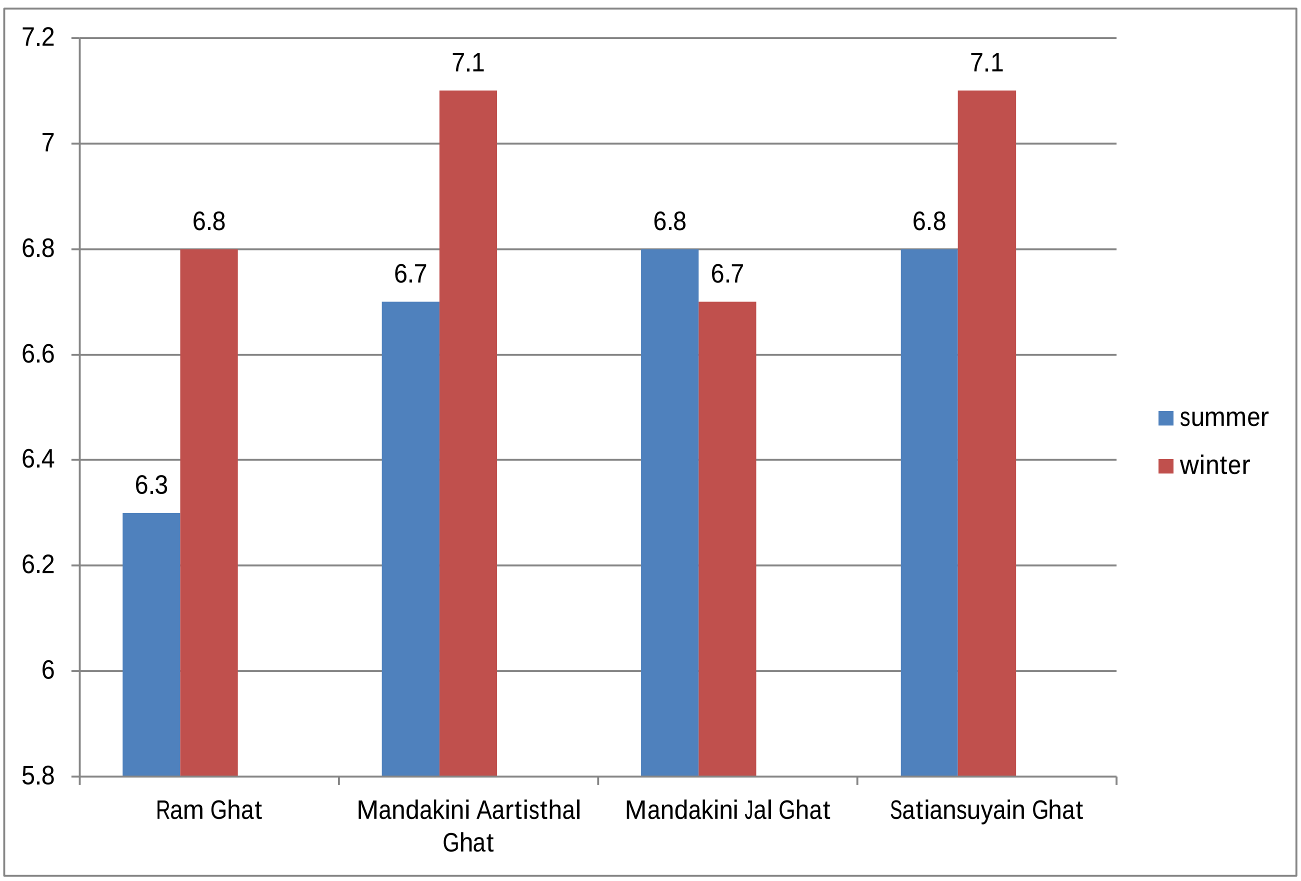
Mandakini River water DO content values

| A SAMPLE SITE | DO content values | |
|---|---|---|
| | SUMMER SEASON | WINTER SEASON |
| Ram Ghats | 6.5 | 9.3 |
| Mandakini Aartisthal Ghats | 7.5 | 10.5 |
| Mandakini jal Ghats | 7.1 | 9.4 |
| Satiansuyain Ghats | 6.3 | 7.3 |

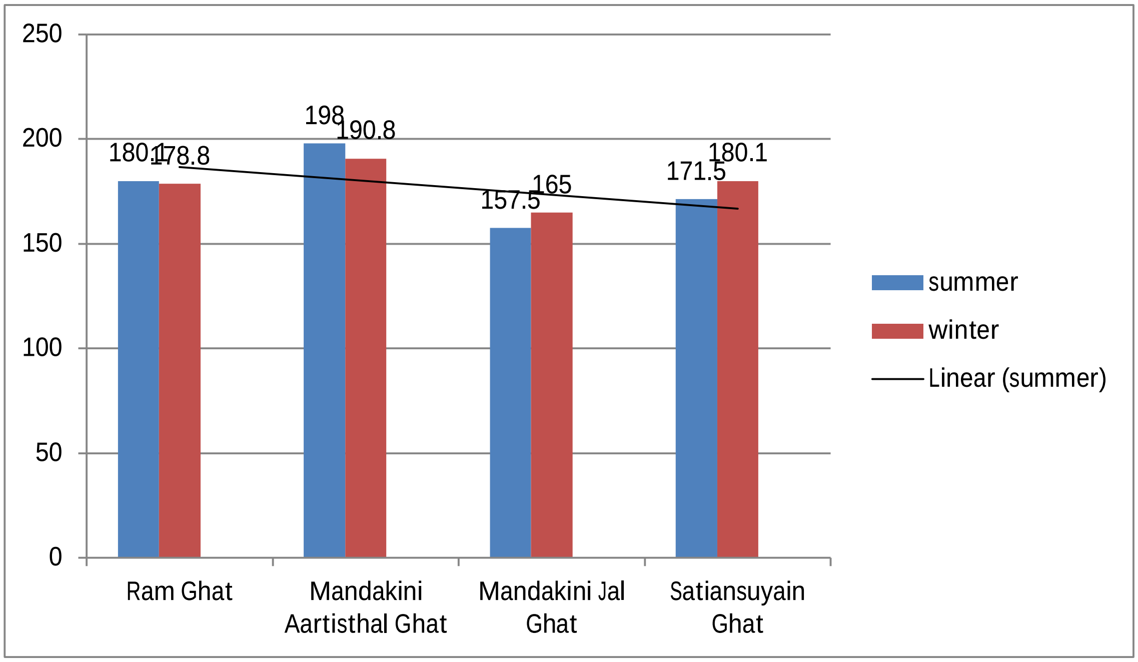
The Mandakini River's BOD Values in Water

| A SAMPLE SITE | BOD Values in Water | |
|---|---|---|
| | SUMMER SEASON | WINTER SEASON |
| Ram Ghats | 5 | 5 |
| Mandakini Aartisthal Ghats | 6 | 5 |
| Mandakini jal Ghats | 5 | 4 |
| Satiansuyain Ghats | 4.5 | 4.8 |

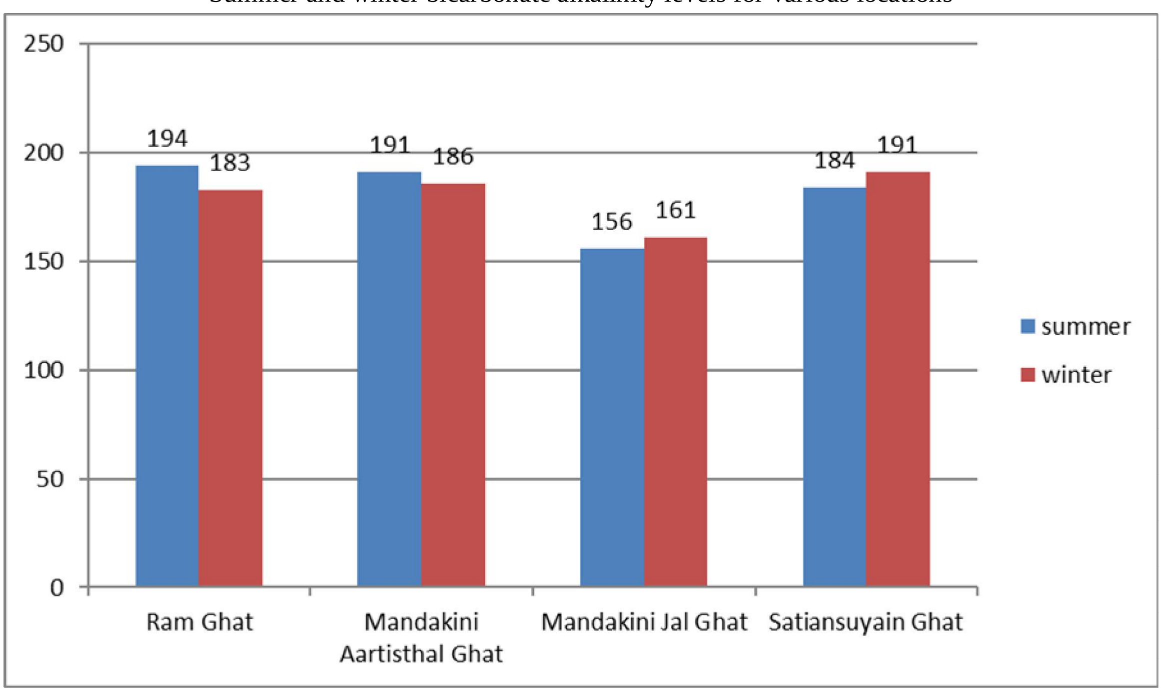
Changes in pH for several locations in the summer and winter



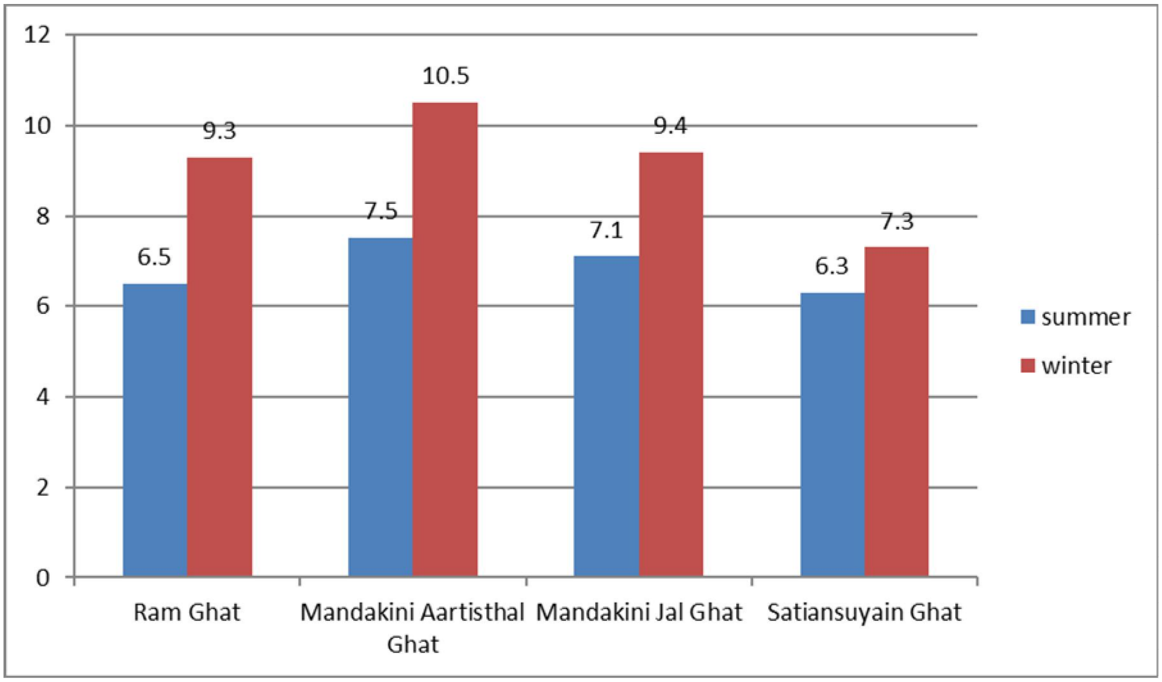
Change in total hardness for several locations in the summer and winter.



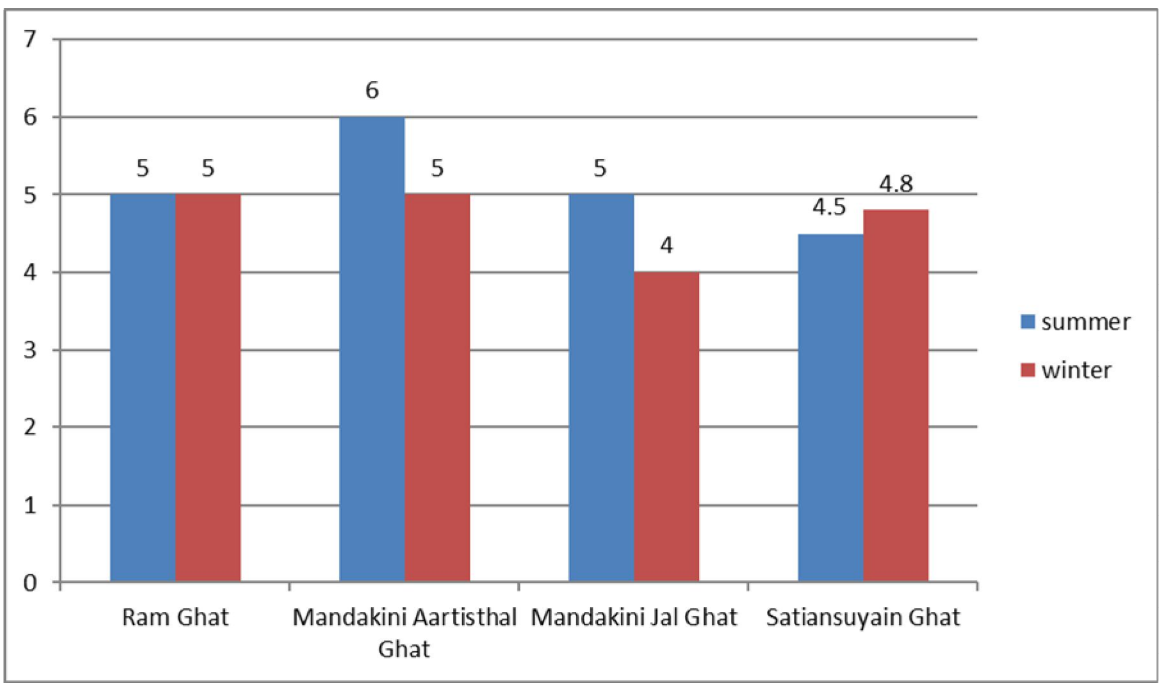

Summer and winter bicarbonate alkalinity levels for various locations



Chloride content values for various locations in the summer and winter




BOD content values for several locations in the summer and winter.




## VI. CONCLUSIONS

The data analysis clearly indicates that religious activities at the major Ghats, including bathing, idol immersion, Jaware visarjan, floating oil lamps, and the disposal of materials such as food waste, leaves, and decorative items, have contributed to the pollution of the river water in the study areas. The present study found that during festivals, the physico-chemical characteristics of several water samples exceeded the maximum permissible limits due to these religious activities. This study highlights the pollution levels at various Ghats of the Mandakini River during different festivals, showing that water quality is significantly impacted. Therefore, it is crucial to implement effective management strategies to maintain water quality during such events.

## VII. RECOMMENDATIONS

The following recommendations are made to establish a sustainable and eco-friendly water management strategy:

1) Sustainable development and management practices should be implemented at all Ghats to create eco-friendly worship areas. One possible approach is to design separate ponds along the riverbanks that simulate the river flow, thereby reducing pollution.
2) The eco-friendly worship areas should be designed with adequate capacity and include proper pumping and filtration systems to manage water flow effectively.
3) Public awareness about proper waste disposal, particularly during festivals, should be raised through various platforms such as posters, media campaigns, and newspapers to promote the conservation of river water bodies.
4) Regular monitoring of water quality at different Ghats is essential to take timely remedial actions when necessary.
5) The development of a computer-based decision support system (DSS) or GIS-based information system could significantly improve the management of events during festivals. Such tools can integrate satellite data with spatial and non-spatial data to enhance decision-making.
6) A comprehensive strategy is needed to mitigate and control the negative impacts of religious and touristic activities in the city. This will help promote eco-tourism, benefiting both the environment and the community.
7) There is an urgent need to create guidelines based on social, religious, scientific, and environmental principles to ensure sustainable management of water resources in terms of both quantity and quality, especially during festivals.

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