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Comparative Study of the Physicochemical Properties of Thermal Springs: Suraj Kund (Hazaribagh), Tatloi (Dumka) and Tattapani (Latehar), Jharkhand, India

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ABSTRACT: Thermal springs are unique geothermal systems characterized by elevated temperatures and distinct hydrochemical compositions resulting from prolonged water-rock interaction. Jharkhand possesses several important geothermal springs along the SONATA (Son-Narmada-Tapti) tectonic lineament, including Suraj Kund (Hazaribagh), Tatloi (Dumka), and Tattapani (Latehar). The present study reviews and compares the physicochemical properties of these three geothermal springs based on published hydrogeochemical investigations. Parameters such as temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), alkalinity, hardness, major ions, and fluoride were compared to understand variations in geothermal processes and groundwater chemistry. The comparison indicates that Suraj Kund exhibits the highest temperature and mineralization, while Tatloi and Tattapani show comparatively moderate physicochemical characteristics. The differences are primarily controlled by geological formations, residence time of groundwater, and water-rock interaction.

KEYWORDS: Thermal spring, Hydrogeochemistry, Physicochemical parameters, Suraj Kund, Tatloi, Tattapani, Jharkhand

I. INTRODUCTION

Thermal springs are naturally occurring groundwater discharges whose temperatures exceed the average ambient temperature due to geothermal heating. These springs provide valuable information regarding geothermal energy potential, groundwater circulation, and geochemical evolution. India contains nearly 340 thermal springs distributed among several geothermal provinces, including the SONATA geothermal belt.

Jharkhand contains several important geothermal springs such as Suraj Kund (Hazaribagh), Tatloi (Dumka), and Tattapani (Latehar). These springs are widely known for their medicinal importance and geothermal significance. Their chemical composition depends on geological structures, lithology, groundwater circulation, residence time, and geothermal gradients. Published studies describe the thermal waters as predominantly alkaline and enriched in sodium and chloride because of extensive interaction with granitic host rocks.

II. OBJECTIVES

- To compare the physicochemical characteristics of Suraj Kund, Tatloi, and Tattapani thermal springs.
- To evaluate similarities and differences in hydrochemical composition.
- To understand the geological factors controlling water chemistry.
- To assess their environmental and geothermal significance.

III. STUDY AREA

3.1 Suraj Kund (Hazaribagh)

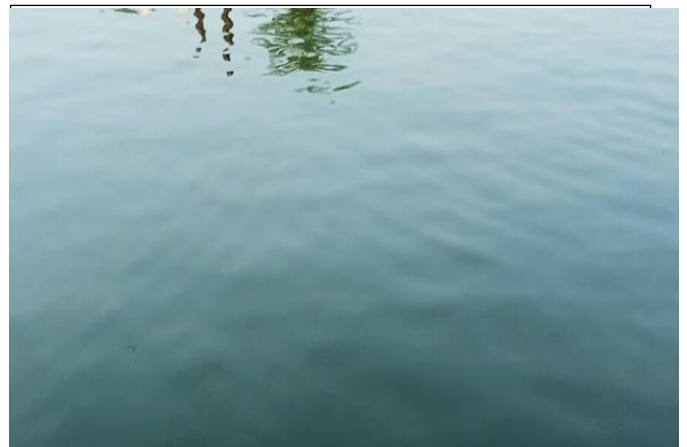
Suraj Kund is located in Hazaribagh district of Jharkhand along the SONATA tectonic lineament. It consists of multiple hot springs with temperatures ranging approximately from **40°C to 89°C**, making it one of the hottest geothermal systems in eastern India. The waters are alkaline and enriched with sodium, chloride, sulfate, and fluoride due to circulation through granitic rocks.

3.2 Tatloi (Dumka)

Tatloi hot spring is situated in Dumka district near the Jharkhand-West Bengal border. It is associated with Precambrian granitic formations and exhibits moderate geothermal activity. Previous hydrochemical studies indicate alkaline water with moderate dissolved mineral content characteristic of geothermal groundwater within the SONATA province.

3.3 Tattapani (Latehar)

Tattapani hot spring is located in Latehar district. The spring emerges through fractured crystalline rocks and exhibits moderate temperatures. Local populations traditionally use the spring for bathing and therapeutic purposes. Hydrochemically, the spring shows alkaline characteristics with dissolved sodium, calcium, magnesium, bicarbonate, chloride, and sulphate.

**Suraj Kund, Hazaribagh, Jharkhand****Tatloi, Dumka, Jharkhand****Tattapani, Latehar, Kharkhand**

IV. MATERIALS AND METHODS**4.1 Study Area**

The present study was conducted on three important geothermal springs of Jharkhand: Suraj Kund (Hazaribagh district), Tatloi (Dumka district), and Tattapani (Latehar district). These springs are situated within the SONATA (Son–Narmada–Tapti) tectonic zone and are associated with fractured Precambrian crystalline rocks. The springs differ in temperature and hydrochemical characteristics due to variations in geological formations, groundwater circulation, and geothermal activity.

4.2 Sample Collection

Water samples were collected from the main discharge points of each thermal spring. Sampling was carried out during the pre-monsoon season to minimize dilution by rainfall and to obtain representative geothermal water. Before sample collection, clean high-density polypropylene (HDPP) bottles of 1 L capacity were washed with detergent, rinsed thoroughly with distilled water, soaked in 10% nitric acid for 24 hours, and finally rinsed again with deionized water. Prior to filling, each bottle was rinsed two to three times with the spring water from the respective site.

Samples for cation analysis were acidified immediately to $\text{pH} < 2$ using ultrapure nitric acid (HNO_3), whereas samples for anion analysis were collected without acidification. All samples were properly labeled with sampling location, date, and time and transported to the laboratory in an insulated ice box. The analyses were completed within 24–48 hours following standard preservation protocols.

4.3 In-situ Measurements

The following parameters were measured directly at the sampling site using portable instruments:

Parameter	Instrument Used
Temperature	Water Analyser 371
pH	Water Analyser 371
Electrical Conductivity (EC)	Water Analyser 371
Total Dissolved Solids (TDS)	Water Analyser 371
Dissolved Oxygen (DO)	Water Analyser 371



All instruments were calibrated before field measurements according to the manufacturers' instructions.

4.4 Laboratory Analysis

Water samples were analyzed following the procedures recommended in the APHA Standard Methods for the Examination of Water and Wastewater (23rd Edition, 2017) and BIS IS 3025 guidelines.

The physicochemical parameters analyzed included:

Parameter	Method
Total Alkalinity	Acid titration method
Total Hardness	EDTA titrimetric method
Calcium	EDTA titration
Magnesium	Calculation from hardness and calcium
Chloride	Argentometric (Mohr's) method
Sulphate	Turbidimetric method
Nitrate	UV-Visible spectrophotometry
Fluoride	SPADNS spectrophotometric method / Ion-selective electrode
Sodium & Potassium	Flame photometry
Iron	Atomic Absorption Spectrophotometer (AAS) or UV-Visible spectrophotometer

In situ Testing with Water Analyser 371

4.5 Quality Assurance and Quality Control (QA/QC)

To ensure the reliability of analytical results:

- All glassware was cleaned with dilute nitric acid and rinsed with deionized water before use.
- Analytical-grade chemicals and reagents were used throughout the study.
- Instruments were calibrated using certified standard solutions before analysis.
- Duplicate samples and reagent blanks were analyzed periodically to check analytical precision and contamination.

- The ionic balance error (IBE) of the analyzed samples was maintained within $\pm 5\%$, indicating acceptable analytical accuracy.



V. RESULTS AND DISCUSSION

Comparative Physicochemical Characteristics

Parameter	Suraj Kund (Hazaribagh)	Tatloi (Dumka)	Tattapani (Latehar)
Temperature (°C)	40–89	50–70	45–65
pH	8.75–9.13	7.8–8.8	7.5–8.5
Water nature	Strongly alkaline	Alkaline	Slightly alkaline
EC	High	Moderate	Moderate
TDS	High	Moderate	Moderate
Na ⁺	High	Moderate	Moderate
K ⁺	High	Moderate	Moderate
Ca ²⁺	Low	Moderate	Moderate
Mg ²⁺	Low	Moderate	Moderate
Cl ⁻	High	Moderate	Moderate
SO ₄ ²⁻	High	Moderate	Moderate
Fluoride	Very high (18.8–24.9 mg/L)	Low–Moderate	Moderate

Temperature

Suraj Kund records the highest spring temperature (up to about 89°C), indicating a stronger geothermal system and deeper groundwater circulation. Tatloi and Tattapani exhibit comparatively lower temperatures, suggesting relatively shallow circulation paths or greater mixing with cooler groundwater.

pH

All three springs are alkaline, with Suraj Kund showing the highest pH values. Alkalinity results from prolonged interaction between groundwater and granitic host rocks containing feldspars and silicate minerals.

Electrical Conductivity and TDS

Electrical conductivity and TDS are highest in Suraj Kund, reflecting greater mineral dissolution during deep circulation. Tatloi and Tattapani exhibit moderate mineralization.

Major Ions

Hydrochemical investigations indicate sodium and chloride dominate the water chemistry of Suraj Kund, whereas Tatloi and Tattapani contain comparatively balanced concentrations of sodium, calcium, magnesium, bicarbonate, and sulphate.

Fluoride

Suraj Kund possesses exceptionally high fluoride concentrations, attributed to dissolution of fluoride-bearing granitic minerals. Elevated fluoride levels may restrict direct drinking use without treatment.

VI. GEOLOGICAL INTERPRETATION

The hydrochemistry of all three springs is controlled by:

- Deep groundwater circulation
- Fractured granitic basement rocks
- Water-rock interaction
- Residence time
- Mixing of thermal water with shallow groundwater

Suraj Kund experiences stronger geothermal heating because of deeper circulation and higher heat flow, whereas Tatloi and Tattapani appear to undergo greater dilution by shallow groundwater.

VII. CONCLUSION

The comparative study reveals significant differences among the three geothermal springs.

- Suraj Kund exhibits the highest temperature and dissolved mineral content.
- Tatloi possesses moderate physicochemical characteristics with alkaline water.
- Tattapani shows moderate geothermal activity and comparatively balanced water chemistry.
- The variations are primarily governed by geological setting, geothermal gradients, and groundwater residence time.
- The three springs possess considerable potential for geothermal research, hydrochemical investigations, and sustainable tourism.

Future investigations should include seasonal monitoring, trace metal analysis, isotopic studies, and microbial diversity assessments for a more comprehensive understanding.

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