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Assessing physical and chemical parameters of the Sone River in Madhya Pradesh, India

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Abstract
This study investigates the physical and chemical parameters (pH, Temperature, Turbidity, Suspended Solids, Total dissolved Solids (TDS), Electrical conductivity, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Alkalinity, Chloride, Calcium Hardness, Magnesium Hardness and Total Hardness) of the Sone River at four distinct sampling stations: Origin point, Anuppur (Sample 1); Bhaturaghat, Shahdol (Sample 2); Bansagar Shahdol (Sample 3); and Chachai Anuppur (Sample 4), over a three-month period from January 2024 to March 2024. The data indicated that water quality deteriorates downstream from the origin point, with the most significant pollution observed at Bansagar (S5). The high levels of suspended solids, total solids, BOD, COD, turbidity, and conductivity at S5 suggest substantial anthropogenic impact and sediment accumulation. S1, the origin point, remains the least polluted, highlighting the importance of monitoring and managing pollution sources to protect river health downstream. These findings highlight significant spatial variations in water quality parameters along the Sone River, indicating localized influences of natural and anthropogenic activities.

Keywords: Sone River, Shahdol, Anuppur, Physico-chemical parameters, water quality

1. Introduction

The most vital fluid for a creature to survive is water, which is a gift from nature to all living things. An estimate states that 97% of the water on Earth is saline water, with freshwater making up the remaining 3%. Merely 0.01% of this 3% is suitable for human consumption. Rivers are the largest freshwater bodies on Earth and are a vital source of drinking water for humans, plants, and animals [1]. Rivers have been central to human history and culture, serving as trading routes, ceremonial sites, and the heart of human settlements [2]. They are essential for agricultural activities and industrial demands [3]. Besides meeting industrial and agricultural needs, rivers are vital for essential daily tasks such as drinking, bathing, and washing [4]. Water possesses a unique ability to dissolve and carry various substances, making it susceptible to contamination. They also become receptacles for significant amounts of waste from industries, domestic sewage, and agriculture, making rivers highly vulnerable as surface water sources [5]. However, the quality of river water is being compromised due to the indiscriminate disposal of sewage, industrial waste, and other human activities [6]. The pollution of river water is significantly impacting the river's ecosystem; leading to an environmental degradation poses serious risks to both aquatic life and human health. This pollution negatively impacts the health and safety of the water, making it crucial to monitor the water quality. Access to clean and safe river water is crucial for preventing waterborne diseases and ensuring good health [7].
Water consumption has increased significantly in recent years due to population growth and rapid industrialization [8]. A large portion of the population of Asia and Africa (800 million) does not have access to clean drinking water and other amenities. These individuals are at risk of exposure to viruses and mineral toxins. Approximately 5.3% die due to unsafe water, sanitation and hygiene. Increasing pollution from industrial and agricultural activities and a growing urban population increases the likelihood of contamination of water resources and therefore life. The population is under threat in many regions of the world. According to the World Health Organization (WHO) and the United Nations Children's Fund (UNICEF), approximately 768 million people depend on highly contaminated water [9].

Therefore, the quality of river water is crucial for various ecological and human activities. Regular analysis of various physico-chemical parameters is necessary to assess the extent of pollution and take appropriate measures to protect and improve water quality for sustainable use.
The Sone River, also known as the Son River, traverses through multiple districts in India. The Son River, stretching over 784 kilometers, is an important tributary of the Ganga River. Its basin extends between 22°37′58.6″ N to 25°43′48.12″ N latitude and 80°5′35.68″ E to 84°58′31.47″ E longitude, covering a geographical area of 68,863 square kilometers. The river flows through the Indian states of Madhya Pradesh, Uttar Pradesh, Bihar, and Jharkhand [10]. The Sone River originates at Sonmuda in the Amarkantak district of Anuppur. Initially flowing underground, it emerges as a surface river near the village of Cholna in Anuppur district. Along its course, it passes through various points such as Jaitahari at Koytar village and Dhurvasin, before reaching Chachai town in Anuppur. It then enters Shahdol district via Amlai village, continuing through locations like Saboo, Bhaturaghat, Nawalpur, Chaka, Jarwahi, Lalpur, Diyapipar, and Kshirsagar (where it meets the Murna River). Further downstream, it passes Dashrathghat, Maseera, and finally reaches Devlond, where the Bansagar Dam is located. The total length of the Sone River from Cholna village in Anuppur district to Devlond in Shahdol district is approximately 209 kilometers. Additionally, six smaller rivers. Kewai, Tipan, Surfa, Murna, Juhila, and Chandas join the Sone River along its course from Sonmuda to Devlond. Furthermore, several nallas including Ghattan, Nargada, Gaibuda, Bagaiha, and Takinalla from Shahdol City flow into the Murna River, which then joins the Sone River at Kshirsagar, approximately 22 kilometers downstream [11]. The water quality index of the Sone River in Madhya Pradesh's Shahdol district has deteriorated due to industrial effluents and domestic sewage [12]. The Sone River in Madhya Pradesh, a vital water source for the region, is subject to various natural and anthropogenic influences that can impact its water quality. This study aims to evaluate the physico-chemical properties of the river water at four different sampling stations over three months to understand these influences better.

2. Materials and Methods

This study is carried out on the Sone River and water samples were collected from the selected five different locations namely Origin point Amarkantak (S1: 20°44'N/ 82°4' E) and Chachai (S2: 23.162146°N/ 81.632816°E) of Anuppur district and Amlai (S3: 23.363147N°/ 81.500876°E), Bhaturaghat (S4: 23.207356°N/ 81.613322°E) Figure 1 and Bansagar (S5: 24°11'30"N/ 81°17'15"E) of Shahdol district of Son River at morning time in the month of January, February, and March. The water samples were collected aseptically in sterile Jerkin bottles from each location, preserved and transported to the laboratory of Madhya Pradesh Pollution Control Board (MPPCB) Shahdol for physico-chemical parameters analysis as per standard methods [13]. The pH and Temperature of each water samples were directly measured by the Digital pH meter (Tecpel Co. Ltd) and Thermometer (Hicks DX 100). All statistical analyses were performed using GraphPad Prism software version 6.0 (San Diego, CA, USA).

Fig 1: Location of Sample 4, Bhaturaghat, Shahdol

3. Results

The evaluation of physical and chemical parameters of the Sone River at different sampling sites provides a comprehensive understanding of the water quality variations from the origin point at Amarkantak (S1) to downstream locations in Anuppur and Shahdol districts. The results, as depicted in Figures 2A to 2M, reveal significant differences across the sampled sites.

3.1 Suspended Solids and Total Solids

Suspended Solids (Figure 2A), the highest concentration of suspended solids was recorded (14 mg/L) at Bansagar (S5). This is likely due to sediment accumulation and runoff in the reservoir area. S2 (Chachai) and S3 (Amlai) exhibited comparable levels, while S1 (Amarkantak) had the lowest concentration, reflecting its relatively pristine condition. Total Solids (Figure 2B), Similarly, S5 had the maximum total solids, indicating higher sediment and dissolved solids in this section of the river. S2 and S3 showed similar total solids levels, with the minimum observed at S1.

3.2 Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD)

BOD (Figure 2C): The lowest BOD was observed at S1, suggesting minimal organic pollution at the source. In contrast, S5 had the highest BOD, indicating significant organic matter pollution likely from agricultural runoff and domestic waste. COD (Figure 2D), COD levels were lowest at S1, increasing downstream. S2 and S3 exhibited comparable

COD levels, while S5 again showed the highest values, pointing to considerable chemical pollutant presence.

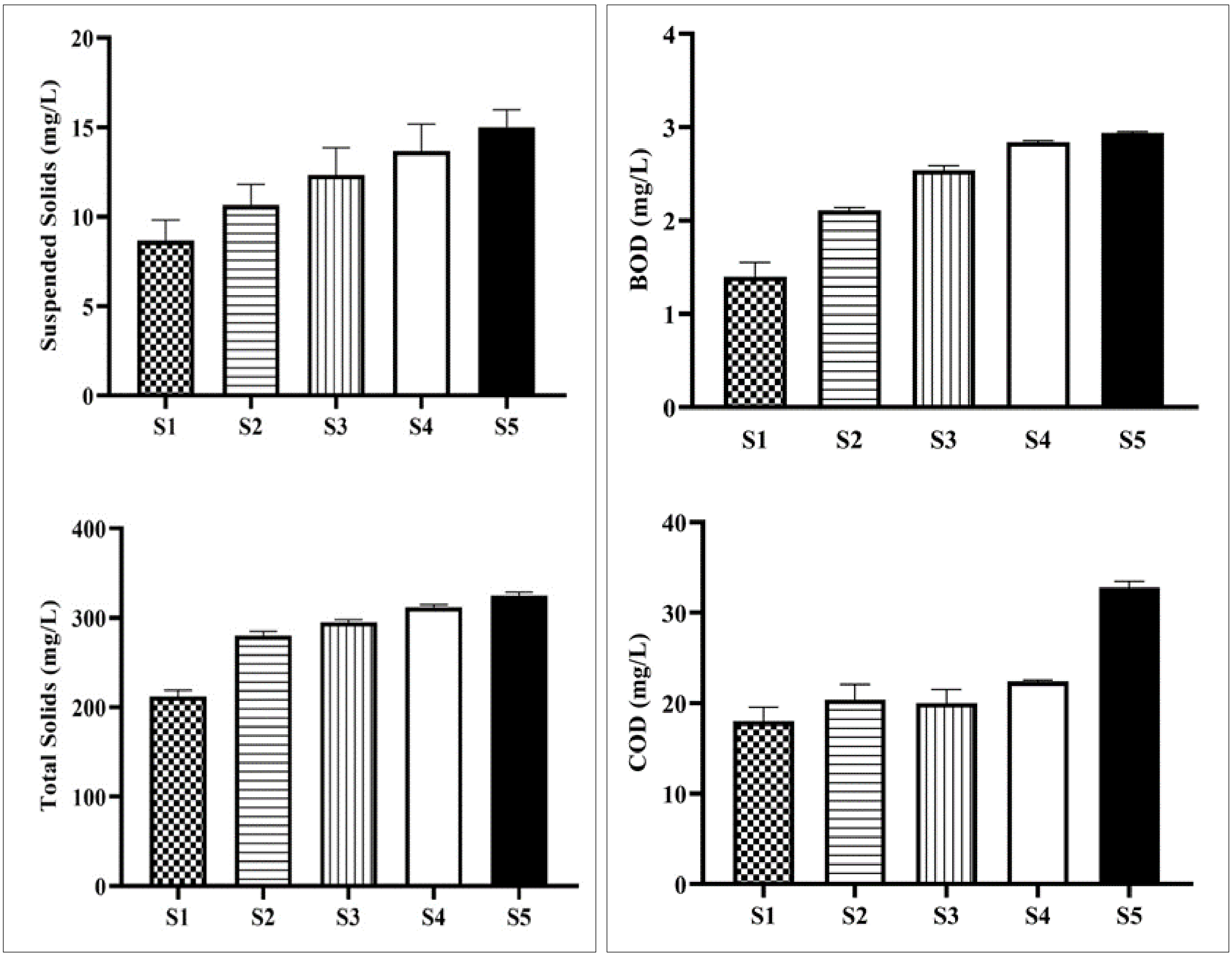
3.3 pH Levels, Temperature and Chloride

PH (Figure 2E), The pH was higher at S2 and S5, indicating more alkaline conditions at these sites. S1 had the most neutral pH, which is typical for a source point with less anthropogenic influence. Temperature (Figure 2F): During January to March 2024, temperatures across the sites varied from 20.77°C to 23.12 °C. These variations are typical for the season, with no extreme deviations observed among the sites. Chloride (Figure 2G): Chloride levels varied across sites, with S4 showing significant values, possibly due to higher pollution levels from anthropogenic sources.

3.4 Calcium Hardness, Magnesium Hardness and Total Hardness: Calcium Hardness (Figure 2H), S5 exhibited the highest calcium hardness, indicating significant mineral content in the water, possibly from geological formations or inflows. Magnesium Hardness (Figure 2I): S2 showed the highest magnesium hardness, suggesting a different mineral composition at this site compared to others. Total Hardness (Figure 2J), Total hardness was maximum at S5, indicating overall high levels of calcium and magnesium ions in the water.

3.5 Turbidity, Alkalinity and Conductivity

Turbidity (Figure 2K), Turbidity was highest at S5, reflecting the high suspended solids and sediment load. Alkalinity (Figure 2L), Alkalinity was lowest at S1 and highest at S5, suggesting different levels of bicarbonate and carbonate ions due to varying geological and environmental factors. Electrical Conductivity (Figure 2L), Conductivity, which indicates the water's ability to conduct electrical current due to dissolved ions, was also highest at S5, correlating with the high total dissolved solids observed.



4. Discussion

The analysis of physical and chemical parameters of the Sone River at different sampling sites (S1 to S5) reveals significant spatial variations in water quality, influenced by both natural and anthropogenic factors [14]. These variations have important implications for the river's ecosystem health, potential uses, and management strategies. Maximum suspended solids and total solids were observed at Bansagar (S5). S1, the origin point at Amarkantak, showed minimum total solids, reflecting its relatively pristine nature and lack of upstream pollution sources. The study's findings consistently indicated total solids levels below the recommended threshold of 500mg/L. This suggests compliance with the recommended value across all samples analyzed. The BOD and COD value ranges from 1.4 to 2.9mg/L and 18 to 32.8mg/L respectively. Lower BOD and COD levels at S1 indicate minimal organic pollution at the river's source. In contrast, the highest BOD and COD levels at S5 suggest significant organic and chemical pollutants, possibly from agricultural runoff, effluents, and other anthropogenic activities near the dam and downstream areas. Comparable levels at S2 and S3 indicate consistent pollution sources affecting these sites. Elevated BOD levels pose a significant threat to aquatic life, leading to stress, asphyxiation, and mortality among organisms due to oxygen depletion [15]. The permissible limits for Chemical Oxygen Demand (COD) are set at 10 mg/l for both drinking purposes and sustaining aquatic life. However, the observed higher values could be attributed to heightened chemical pollutants [16]. The higher pH values at S2 and S5 suggest alkaline conditions, which could be due to the geology of the area or discharges affecting these sites. Alkaline water can influence the solubility of minerals and the toxicity of certain pollutants, impacting aquatic ecosystems. Temperature variations (20.77 to 23.12 °C) across the sites are within the typical range for river systems in this region during the winter months. Temperature influences the solubility of gases (like oxygen) and the metabolic rates of aquatic organisms, thereby affecting overall water quality and ecosystem health. S1's minimum alkalinity reflects its source purity, while S4's maximum alkalinity could be due to the presence of bicarbonates and carbonates from natural and anthropogenic sources. Maximum magnesium hardness at S2 and maximum calcium and total hardness at S5 indicate mineral-rich waters, likely from geological formations or runoff containing these minerals. Increased levels of total alkalinity, total hardness, and turbidity suggest human activities have impacted the water, likely leading to higher concentrations of organic matter [17]. The highest turbidity levels were recorded in the S2 to S5 downstream section of the river, which are above the permissible limit of 5 NTU [18]. Increased turbidity levels downstream could be attributed to the discharge of urban waste originating from Anuppur and Shahdol city, which both converge with the river [19]. The maximum turbidity and conductivity at S5 highlight significant suspended particulate matter and dissolved ion content, respectively. This is indicative of substantial sediment load and potential pollutants entering the water system at this site, affecting its clarity and electrical conductivity [20, 21].

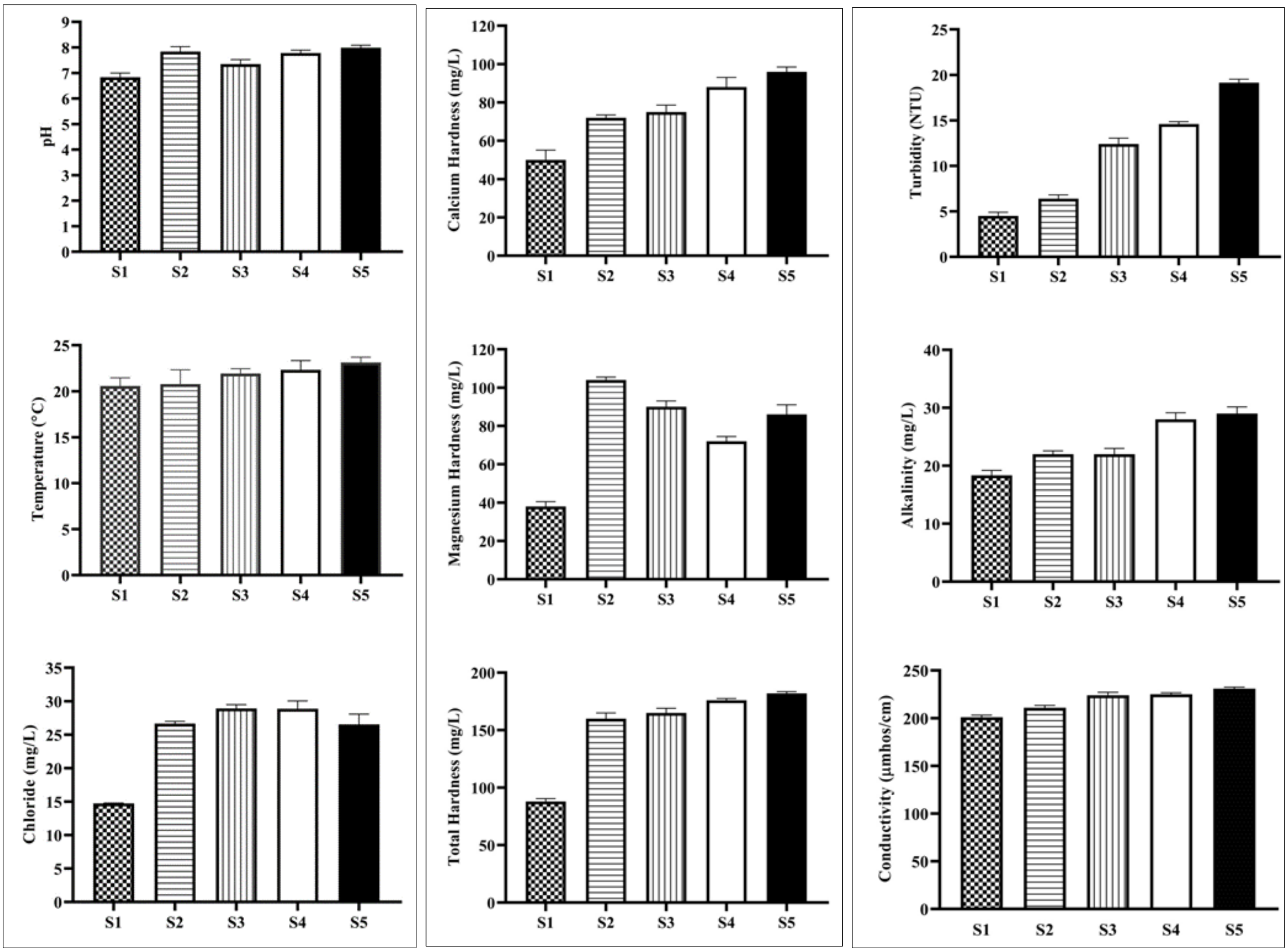


Fig 2: Analysis of Physiochemical Parameters in Sone River Water: (2A) Suspended Solids; (2B) Total Solids; (2C) Biological Oxygen Demand [BOD]; (2D) Chemical Oxygen Demand [COD]; (2E) pH; (2F) Temperature; (2G) Chloride; (2H) Calcium Hardness; (2I) Magnesium Hardness; (2J) Calcium Hardness; (2K) Turbidity; (2L) Alkalinity; (2M) Conductivity

5. Conclusion

The study of the Sone River's physical and chemical parameters across various sites reveals distinct spatial variations attributable to both natural processes and human activities. The origin point at Amarkantak (S1) exhibits the best water quality with minimal pollutants, reflecting its relatively untouched state. In contrast, Bansagar (S5) shows the highest levels of various pollutants, indicating significant environmental pressure from human activities and natural sedimentation processes. To ensure the sustainable management of the Sone River, it is crucial to implement targeted conservation efforts, particularly at sites showing high pollution levels. Strategies could include stricter regulations on effluents, better agricultural practices to reduce runoff, and initiatives to enhance sediment management at dam sites. Continuous monitoring and comprehensive river basin management are essential to protect and restore the river's health, ensuring it can support diverse ecological functions and provide clean water for surrounding communities.

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8. Conflicts of Interest: The authors declare no conflict of interest.

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