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Study of seasonal physico-chemical and macroinvertebrates variations of Sarfa river at Shahdol, Madhya Pradesh

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Abstract
The seasonal variation of Sarfa River at Shahdol district was studied for a period of one year. This study focused on analyzing various physico-chemical parameters across different seasons-summer, monsoon, and winter-from August 2023 to July 2024, along with an assessment of macroinvertebrate diversity in the river surface water. The findings highlighted significant seasonal changes in the physico-chemical characteristics of the water. A total of 17 genera belonging to seven macroinvertebrate orders were identified, namely *Ephemeroptera, Diptera, Coleoptera, Hemiptera, Plecoptera, Odonata,* and *Trichoptera,* all serving as indicators of good water quality. The correlation analysis among hydrological attributes revealed strong interrelationships, with transparency, dissolved oxygen, and pH emerging as key factors influencing benthic faunal composition.

Keywords: Physico-chemical, Macro-invertebrates, Sarfa River, Food chain, Bioindicators, Water pollution

Introduction
Water is a fundamental component of all living organisms, playing a critical role in Earth's ecosystems, the biosphere, and biogeochemical cycles. It supports various unique and indispensable functions essential for sustaining life. The growth and diversity of aquatic microorganisms in river systems are influenced by a combination of physico-chemical and biological factors. As the most basic and vital resource on our planet, water remains crucial for life and development. According to United Nations reports from 1978, only 2.7% of Earth's total water is consumable, with 1% of groundwater now endangered, either directly or indirectly, due to pollution. Rivers often function as the final destination for industrial waste and residential discharge, leading to increased pollution pressure on these vital surface water sources (Belorkar, 2010) [1].

Human activities affecting the environment, particularly freshwater systems, have significantly escalated in recent decades (Khanna *et al*., 2006) [2]. Socio-economic development, urbanization, industrial operations, and agricultural practices have left a profound and widespread impact on water resources (Kurbatova, 2005) [3]. Over the past century, river ecosystems have been subjected to intense human intervention, leading to habitat loss, degradation, and a consequent decline in aquatic diversity—rivers being among the most affected habitats (Chovance, 2003) [4]. Aquatic insects, integral components of aquatic ecosystems, occupy crucial roles at the secondary trophic level. Their type and distribution have often been employed as reliable indicators of water quality and ecological disruption. The macrozoobenthic community is highly responsive to environmental changes and sensitive to disturbances caused by these changes. Factors such as water's physico-chemical properties, sediment or substratum characteristics, food availability, predation dynamics, and other biological interactions determine the distribution, density, and biomass of benthic organisms. Consequently, macroinvertebrate communities are widely regarded as indicators of stream health and ecology. Freshwater macrovertebrates stand out as one of the most endangered taxonomic groups (Darwall, 2005) [5], primarily due to their heightened sensitivity to alterations in both habitat quantity and quality (Sarkar *et al.*, 2008) [6]. Being

vital components of the food chain, their conservation and associated habitat management present growing challenges (Dudhgeon *et al.*, 2006) [7]. However, efforts to curb the pressures threatening these species remain limited and insufficient, leading to a rapid decline in their populations. This study focused on assessing seasonal physico-chemical variations and macroinvertebrates diversity in the River Sarfa, located in the Shahdol District of Madhya Pradesh.

Materials and Methods

Study area

The Sarfa River lies in the northeastern region of Madhya Pradesh extending from 29°39'28" and 24°16'13" North latitude and from 80°32'56" to 82°12'21" East longitude approximately. The Sarfa river originated from village Bodari near Lalpur, Tahsil Burhar district Shahdol. It is a main resource of water for Shahdol town. During its course the river receives all sorts of pollutants *viz*. domestic sewage, agriculture run off and automobile coasts etc.

Collection of sample

Monthly water sampling is planned for three distinct seasons—rainy, winter, and summer—from August 2023 to July 2024. Proper sampling and storage procedures are essential to ensure the collection of reliable and meaningful data. The preservation and analysis of water samples are carried out in accordance with standardized methods outlined by APHA (1998) [8].

Macroinvertebrates were gathered from the shallow bottom regions of the river and preserved using 4% formalin. Identification of benthic fauna samples was conducted using reference materials, including works by Alfred *et al.* (1973) [9], Tonapi (1980) [10], Ward and Whipple (1959, 1992) [11-12].

Results and Discussion

The physico-chemical parameter values of River Sarfa across different seasons in Shahdol district are summarized in Table 1. The highest temperature, 30.4°C, was observed during summer, while the lowest temperature, 20.6°C, occurred in winter. The drop in temperature during winter can be attributed to the lower ambient temperatures, as noted by Gyananath *et al.* (2000) [13]. The pH of the river water ranged from 7.7 to 8.5. Natural water portability standards typically place the pH within the range of 7.2 to 7.6, indicating a noticeable increase in pH values (up to 8.5). This rise can be associated with the dissolution of calcium and magnesium materials originating from the mountainous regions, suggesting that the water has a slightly alkaline nature.

Transparency refers to the ability of light to penetrate through water. The color of the water is influenced by the concentration of suspended organic and inorganic particles within it. Transparency levels ranged from a maximum of 112 cm to 80 cm. Lower transparency was observed during the rainy and summer seasons, whereas during winter, the water displayed relatively higher transparency.

Total dissolved solids consist of salts and various organic compounds that easily dissolve in water, often contributing to water hardness. The measurements of total dissolved solids varied from a maximum of 318 mg/l to a minimum of 212 mg/l. The highest seasonal concentration was recorded during the rainy season, while the lowest was observed in winter. Additionally, Trivedy *et al.* (1988) [14] noted a similar trend, with lower levels of total dissolved solids during summer and higher levels in the rainy season.

The ionic properties of water play a crucial role in determining its conductivity. Higher conductivity levels observed during summer and rainy seasons may result from the increased presence of carbonates and bicarbonates, which often originate from pollutants. In contrast, during winter, the activity of microflora causes the exchange of inorganic ions, leading to moderate conductivity values during this period.

The concentration of hydrogen ions is regarded as a significant ecological factor, influenced by the interaction of various substances in water and numerous biological processes. As noted by Hutchinson (1957) [15], the near-neutral pH of water is primarily regulated by carbon dioxide and bicarbonates. Throughout the study period, the river water consistently exhibited alkaline characteristics, with pH values ranging from 7.1 to 8.3.

The total alkalinity of water primarily arises from cations such as calcium, magnesium, sodium, and potassium. It can also be attributed to the presence of carbonate, bicarbonate, or, in some cases, hydroxides. Seasonal water analysis has revealed that alkalinity tends to be higher during the winter and summer months.

The total hardness in river water typically varies between 125 mg/l and 256 mg/l. Higher levels of hardness are commonly observed during the summer months, whereas lower levels are noted in the winter season. Similar results were documented by Ugale and Hiware (1999) [16]. These findings are further supported by the study conducted by Pratibha *et al.* (2005) [17].

Dissolved oxygen is a key indicator of water quality, playing a significant role in shaping the aquatic life within river ecosystems. Adebisi (1981) [18] highlighted the seasonal variations in dissolved oxygen levels across different water bodies. A comparable trend was noted in the current study, where dissolved oxygen levels dropped during the hot summer months. This decline indicates an inverse relationship between dissolved oxygen and water temperature in river systems.

Biological Oxygen Demand (B.O.D.) serves as a direct indicator of oxygen consumption and an indirect measure of the presence of biodegradable organic matter. In this study, the highest B.O.D. value recorded was 27.2 mg/l during summer, while the lowest was 11.5 mg/l in winter. These results align with similar observations made by Seenaya and Zafar (1979) [19].

Chemical Oxygen Demand measures the level of chemical pollution, predominantly caused by industrial effluents. The observed C.O.D. values tend to peak during winter and reach their lowest during the rainy season. Comparable results were reported by Singh and Roy (1995) [20].

Ammonia naturally exists in surface water and wastewater, but elevated levels often indicate pollution, as noted by Bruce (1958) [21]. During summer, the concentration of organic materials, including religious offerings and other protein-based substances, undergoes microbial decomposition. The higher temperatures during this season accelerate microbial activity, intensifying the rate of decomposition and leading to increased ammonia levels in river water.

The current study revealed that nitrate levels varied from 0.017 to 0.028 mg/l, with the highest concentrations observed during the rainy season and summer, and the

lowest during winter. Gohram (1961) [22] also noted elevated nitrate levels in the rainy season, attributing this to the significant runoff of organic matter from surrounding catchments.

The phosphate concentration in river water varied between 0.072 mg/l and 0.043 mg/l, with higher levels observed during the summer and winter seasons. This increase may be attributed to the deposition of ash and bones from religious activities, as well as the decomposition of organic matter present in the water sediments.

Sulphate is formed through the biological oxidation of the sulphur present in organic matter. The concentration of sulphate varies from 11.3 mg/l to 20.82 mg/l. As noted by Angadi *et al.* (2005) [23], the lowest sulphate levels are observed during winter, while the highest occur in summer.

Macroinvertebrates diversity and their Relationship with hydrological attributes

Benthic aquatic insects serve as crucial indicators of environmental changes in stream ecosystems, reflecting long-term alterations in water and habitat quality rather than momentary conditions, as noted by Johnson *et al.* (1993) [24] and Resh (1995) [25]. The overall density of benthic macroinvertebrate fauna showed a clear increasing trend from the monsoon season to winter (Table 2). These macroinvertebrates were predominantly composed of the immature stages (nymphs) of aquatic insects, classified under various orders, including *Ephemeroptera* (mayflies), *Plecoptera* (stoneflies), *Trichoptera* (caddisflies), *Diptera*, *Coleoptera*, *Hemiptera*, and *Odonata*. From the River Sarfa in the Shahdol district, a total of seven macroinvertebrate taxa, encompassing 17 genera, were documented. Among these, *Ephemeroptera* was the most dominant group with four genera, while *Coleoptera* and *Odonata* were co-dominant, each represented by three genera. *Diptera* and *Hemiptera* comprised two genera each, while *Trichoptera* included only one genus. An in-depth analysis revealed that macroinvertebrate abundance peaked during winter and was lowest in the rainy season. Accordingly, the sequence of macroinvertebrate abundance along the Sarfa River at Shahdol district is as follows: winter > summer > monsoon.

The river Sarfa exhibited its peak macroinvertebrate abundance during the winter season. This trend can be attributed to enhanced growth efficiency of insects during this period, alongside favourable hydrological conditions. The increased dissolved oxygen levels and heightened water transparency during winter further contribute to this abundance. Conversely, macroinvertebrate density experienced a significant decline during the monsoon season. This reduction may be linked to diminished dissolved oxygen levels caused by heightened turbidity, which restricts light penetration and hampers photosynthetic activity. Such disruptions in the food chain likely lead to reduced benthic diversity. Overall, the average macroinvertebrates density showed an inverse correlation with temperature while maintaining a positive relationship with water transparency.

Table 1: Physico-chemical parameters of Sarfa river at Shahdol district

S. No.	Parameters	Rainy season	Winter season	Summer season
1.	Temperature (°C)	26.8	20.6	30.4
2.	Transparency(cm)	80	112	98
3.	T.D.S.(mg/l)	318	212	295
4.	Conductivity	264	281	403
5.	pH	7.1	8.3	7.5
6.	Alkalinity(mg/l)	142	160	189
7.	Hardness(mg/l)	144	125	256
8.	D. O. (mg/l)	8.2	10.1	5.9
9.	B.O.D.(mg/l)	11.5	10.9	27.2
10.	Ammonia(mg/l)	0.016	0.010	0.067
11.	Nitrates(mg/l)	0.028	0.017	0.023
12.	Phosphates(mg/l)	0.043	0.065	0.072
13.	C.O.D.	120.8	151.4	71.7
14.	Sulphate	16.6	11.3	20.82

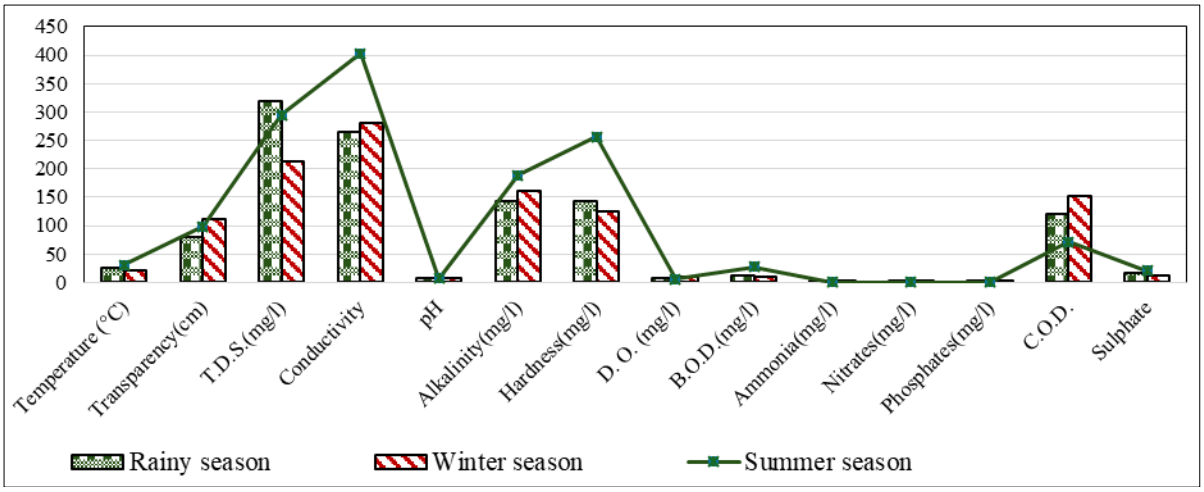

Fig 1: Graph analysis Physico-chemical parameters of Sarfa river at Shahdol district

Table 2: Seasonal Spatial Qualitative and Quantitative Distribution of Macroinvertebrates

S. No.	Macroinvertebrates	Rainy season	Winter season	Summer season
I.	***Ephemeroptera***			
1.	Ephemera	1.27±2.31	30.4±3.25	7.21±6.06
2.	Leptophlebia	8.2±9.13	43.20±11.14	16.5±14.25
3.	Cleon	0.77±2.31	9.65±10.56	7.73±11.98
4.	Heptagenia	7.65±8.18	30.09±6.21	18.35±10.14
II.	***Diptera***			
5.	Chironomous	8.55±5.36	28.47±7.29	11.71±10.07
6.	Bibiocephala	1.32±1.41	14.12±5.39	5.46±4.62
III.	***Coleoptera***			
7.	Hydraticus	1.4±1.46	11.65±2.40	3.35±3.47
8.	Hydrophilus	3.63±3.48	22.2±6.09	7.05±6.23
9.	Dryops	0.79±1.53	13.9±4.15	2.72±3.46
IV.	***Hemiptera***			
10.	Micronecta	1.41±2.37	14.35±7.34	6.63±4.44
11.	Heleoceris	5.3±4.26	16.2±4.73	3.71±3.36
V.	***Plecoptera***			
12.	Perla	5.2±5.67	25.55±8.09	9.05±5.76
13.	Isoperla	3.45±7.1	23.73±4.79	8.1±3.68
VI.	***Odonata***			
14.	Matrona	0.25±0.36	12.6±8.31	2.2±2.56
15.	Agrion	0.0±0.0	5.29±5.12	2.53±3.48
16.	Corixa	0.84±1.42	12.36±4.01	4.81±3.07
VII.	***Trichoptera***			
17.	Hydrosyche	7.35±6.54	28.41±6.07	11.63±5.8

Conclusion

The conclusion suggests that the physico-chemical environmental factors play a significant role in shaping the diversity of macroinvertebrates within the river. The overall condition of the Sarfa River in Shahdol district remains acceptable. However, necessary precautions should be taken to prevent contamination, especially since the water serves as a source for drinking. Currently, the river is well-suited for irrigation and fisheries activities.

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