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Aquatic Insects as Bio-Indicators of Water Quality: A Study on Chukka Beach and Sharda Sagar Dam (PTR), Pilibhit, Uttar Pradesh, India

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Abstract

The aquatic ecosystems of Chukka Beach (Sharda River) and the Sharda Sagar Dam within the Pilibhit Tiger Reserve (PTR), Uttar Pradesh, represent ecologically important freshwater habitats of the Terai landscape. The present study (2023–2025) investigates the diversity, abundance, and bioindicator role of aquatic insects in assessing the water quality of these two contrasting aquatic sites. A total of 18 aquatic insect species belonging to major orders such as Ephemeroptera, Trichoptera, Odonata, Coleoptera, Hemiptera, Diptera and Megaloptera were documented.

Standard sampling (sweep netting, kick sampling, hand picking) and physicochemical analyses were used to study the interaction between aquatic insect assemblages and water quality parameters. Diversity indices (Shannon–Wiener, Simpson's Dominance, Margalef Richness) were calculated seasonally for both sites. Bioassessment indices including BMWP, ASPT, and Family Biotic Index (FBI) were applied to evaluate the ecological condition of the water bodies.

Correlation analysis revealed strong associations between insect diversity and key environmental variables such as pH, indicating that slightly alkaline conditions support healthier insect communities. In contrast, fluoride, arsenic, BOD, COD, TDS, Water temperature and copper (Cu) showed negative correlations with species richness and abundance .But in sensitive taxa like Ephemeroptera and Trichoptera showed higher representation at Chukka Beach, indicating relatively better water quality, whereas tolerant groups such as Chironomidae, Culicidae, Ceratopogonidae, Psychodidae, Tabanidae (Diptera) were more abundant near the Sharda Sagar Dam influenced by anthropogenic activities. Canonical Correspondence Analysis (CCA) further illustrated how environmental gradients shape the community structure., suggesting Higher TDS

and copper levels also contributed to declining diversity, indicating overall degradation of water quality.

Correlation analysis showed that aquatic insect diversity positively correlated with pH because even slightly alkaline conditions favour healthy insect communities. On the other hand--Water temperature, pH, Nitrate, Total alkalinity, Dissolved oxygen (DO), Nitrate, TDS, BOD and COD identified correlations with the richness and abundance of species. Among them, arsenic, BOD and COD had the strongest negative effects, which implies that toxic chemicals and organic contamination reduce species richness of sensitive taxa. Higher TDS and copper content was also associated with diminished diversity and hence general deterioration of water quality. Altogether, the results provide supporting evidence for aquatic insects to be good bio-indicators of health in freshwater resource of Pilibhit area. The study is of significance as it offers an opportunity for baselines for conservation monitoring of the Sharda River system, and its conservation planning and sustainable management.

Keywords

Aquatic insects, Bioindicators, Water quality, Chukka Beach, Sharda Sagar Dam, Pilibhit Tiger Reserve, Diversity indices, BMWP, ASP

1. Introduction

Aquatic insects, essential part of freshwater environments, are very abundant and represent a wide variety of communities living in varied aquatic environments. They play a vital role in ecosystem functioning, and are an important bioindicator, because their numbers and abundance can reflect the effects of environmental and human-induced stress over an extended period. Because different taxa exhibit varying tolerance to pollutants, aquatic insects have great value as tools for monitoring ecological health. The Pilibhit region, in Uttar Pradesh, which lies at the foot of the Eastern Himalayas, is an ecologically important transition area between the Gangetic plains and Himalayan biogeographic influences. This is home to a variety of aquatic habitats, such as rivers, wetlands, streams, and reservoir systems. Despite its ecological significance, research on aquatic insect populations in Pilibhit—especially in lotic systems, including the Sharda River (Chukka Beach area) and lentic systems like the Sharda Sagar Dam within the Pilibhit Tiger Reserve (PTR)—are extremely limited. Diversity and bioindicator activity of aquatic insects in protected areas of this region have not been studied comprehensively. Hence, the current study studies the diversity, seasonal distributions, as well as aquatic insect bio-indicator role in these two major freshwater systems. It is essential to understand their community structure and water-quality relationships, crucial as the Pilibhit Tiger Reserve is part of the Terai Arc Landscape, a biodiversity-rich yet data-deficient area. This study adds to the baseline ecological information needed for the monitoring and preservation of freshwater biodiversity and water quality in the Pilibhit landscape.

2. Materials and Methods

2.1 Study Area

This study was conducted at two principal aquatic habitats in Pilibhit district: Chukka Beach (Sharda River stretch) and the Sharda Sagar Dam which are located in and around the Pilibhit Tiger Reserve (PTR), Uttar Pradesh, India.

Chukka Beach (Sharda River) is around 28.63° N, 80.08° E, part of the perennial fast-flowing Himalayan river system.

Sharda Sagar Dam, located at ~28.65°N, 79.97°E, is a substantial reservoir forming a slow-moving lentic system. Seasonal sampling was applied in the study with pre-monsoon, monsoon, and post-monsoon months for analysis of water quality and aquatic insect diversity.

Geology of the Study Area

The district is situated in the Indo-Gangetic alluvial plain which is composed of quaternary deposits (sand, silt, clay) that serve as confined aquifers which are rich in ground water and contribute to agriculture and aquatic ecosystem. The type of soil varies from sandy loam in the northern tarai belt to clay loam in southern agricultural plains and in aquatic ecosystem, having a high organic content and potential to retain water. These geological features, along with natural sources of constantly running water, provide a favourable environment for aquaculture and species richness in insect species.

Fig.1- Map of different location of Pilibhit

2.2 Sample Collection

Seasonal samples of water were taken from selected locations at each of the study sites during the study to investigate important physico-chemical metrics applied for assessment of water quality. All samples were collected in pre-cleaned bottles and transported to the laboratory following standard protocols.

Simultaneously, aquatic insects were collected in three replicates at each sampling point for diversity assessment.

Sample collection sites

2.3 Collecting Techniques

Aquatic insects were collected using standard and widely practiced field techniques:

Sweep Net Method-A D-frame sweep net (19 × 19 cm, mesh size 1 mm) was used to collect insects from marginal vegetation, shallow edges, and slow-flowing microhabitats. The net was swept gently along the substrate and vegetation for approximately 1 minute, covering a depth of 0–0.25 m. Three sweeps constituted a single sample.

Kick Sampling Method-In the Sharda River stretch (lotic habitat), 1-minute kick sampling was performed. Substrate disturbance by foot allowed insects to drift into the net placed downstream.

After kicking method sample collection

All-Out Search Method-Hand picking and visual searching were used for insects attached to stones, submerged vegetation, or debris.

Collected insects were preserved in 70% ethanol, sorted, counted, and identified using standard taxonomic keys.

Hand picking method

2.4 Physiochemical parameters of water samples

Sample were collected from selected sites continuously from June 2024 to July 2025. Data was analytically compiled on seasonal average basis.

The average physiochemical parameters of water samples taken by different sites ;

Temperature (°C): Digital thermos meter, pH: pH meter, Dissolved Oxygen (DO): Winkler's titration method, Biochemical Oxygen Demand (BOD): 5-day incubation at 20°C, Total Alkalinity: Acid-base titration, Total Dissolved Solids (TDS): Gravimetric method, Chemical Oxygen Demand(COD): APHA-Closed Reflux Method.

3. Result & Discussion

3.1 Distribution and Abundance of Insects

The study recorded a total of 18 aquatic insect species belonging to 14 families and 7 orders from Chukka Beach (Sharda River) and Sharda Sagar Dam. The major orders encountered were Hemiptera, Coleoptera, Odonata, Ephemeroptera, Trichoptera, and Diptera, showing clear seasonal variation in their abundance.

During the Summer season, a higher number of insect groups were observed, dominated mainly by Hemiptera and Coleoptera.

In the Monsoon season, the abundance of surface-dwelling Hemipterans and Diptera increased due to enhanced flow and nutrient inputs. Species such as those belonging to the families Gerridae and Gyrinidae were most frequently encountered.

In the Winter season, water levels stabilized, and the diversity shifted slightly toward families like Veliidae and Chironomidae showed a much more tolerant of change to water conditions. There were a number of taxa, including representatives of Gerridae, Gyrinidae and Veliidae are consistent within the three main seasons, which indicate a suitable adaptation of them to the hydrological changes in these two water bodies studied sites.

Table 1 : Season wise presence (+/-) of aquatic insect

	Species with their family	**Season**		
		Summer	Monsoon	Winter
Hemiptera	*Ptilomera assamensis* (Gerridae)	+	+	+
	Metrocoris nigrofuscioides (Gerridae)	+	+	-
	Rhagovelia obesa (Veliidae)	-	+	+
	Diplonychus indicus (Belostomatidae)	+	-	-
	Notonecta sp. (Notonectidae)	+	-	+
Coleoptera	*Dineutus* sp. (Gyrinidae)	+	+	-
	Orectogyrus sp. (Gyrinidae)	+	-	+
	Hydrophilus sp. (Hydrophilidae)	-	+	-
Odonata	*Pantala flavescens* (Libellulidae)	+	+	+
	Orthetrum sabina (Libellulidae)	+	+	-
	Aeshna sp. (Aeshnidae)	-	+	+
Ephemeroptera	*Baetis* sp. (Baetidae)	+	+	-
	Caenis sp. (Caenidae)	-	+	+
Trichoptera	*Hydropsyche* sp. (Hydropsychidae)	-	+	+
	Cheumatopsyche sp. (Hydropsychidae)	-	+	-
Diptera	*Chironomus* sp. (Chironomidae)	+	+	+
	Tipula sp. (Tipulidae)	-	+	+
Megaloptera	*Corydalus* sp. (Dobsonfly)	-	+	-

Table 2: Water Quality Parameters (July to Sep 2024)

Region	pH	Temp.	Total alkalamity (mg/L)	DO (mg/L)	TDS (mg/L)	BOD (mg/L)	COD (mg/L)
Sharda river	7.5	29	82	9.1	245	4.7	20
Sharda sagar dam	7.3	27	94	7.1	258	5.2	21
Deoha river	7.9	28	74	6.9	242	5.8	23
Wetlands places of pilibhit city (ponds)	7.0	26	71	5.8	230	5.1	25

Table 3 : Water Quality Parameters (Nov 2024 to Feb 2025)

Region	pH	Temp.	Total alkalamity (mg/L)	DO (mg/L)	TDS (mg/L)	BOD (mg/L)	COD (mg/L)
Sharda river	7.2	16	92	9.7	180	4.0	23
Sharda sagar dam	7.9	12	101	9.0	240	3.2	25
Deoha river	7.4	18	85	8.1	213	3.8	19
Wetlands places of pilibhit city (ponds)	7.7	14	82	7.3	221	4.1	28

Table 4 : Water Quality Parameters (March to June 2025)

Region	pH	Temp.	Total alkalamity (mg/L)	DO (mg/L)	TDS (mg/L)	BOD (mg/L)	COD (mg/L)
Sharda river	7.4	31	76	8.4	196	4.9	24
Sharda sagar dam	7.8	30	89	6.5	248	5.2	29
Deoha river	7.3	28	74	5.9	220	4.8	31
Wetlands places of pilibhit city (ponds)	7.9	33	89	5.2	224	6.1	26

Table:5 Average Water Quality Parameters (Analytical Mean)

Region	pH	Temp.	Total alkalinity (mg/L)	DO (mg/L)	TDS (mg/L)	BOD (mg/L)	COD (mg/L)
Sharda river	7.37	25.33	83.33	9.067	207.0	4.53	22.33
Sharda sagar dam	7.67	23	94.66	7.53	248.67	4.63	25.00
Deoha river	7.53	24.66	77.66	6.97	225.0	4.80	25.33
Wetlands places of pilibhit city (ponds)	7.53	24.33	80.66	6.1	225.0	5.10	26.33

Seasonal Variations in Aquatic Insect Assemblages in Relation to Water Quality (Approximate Assessment)

Season	Insect Diversity	Dominant Orders	Water Body	pH	Temp (°C)	TA mg/L	DO mg/L	TDS mg/L	BOD mg/L	COD mg/L
Summer	10 species	Hemiptera, Coleoptera Odonata	Sharda River	7.4	31	76	8.4	196	4.9	24
			Sharda Sagar Dam	7.8	30	89	6.5	248	5.2	29
			Deoha River	7.3	28	74	5.9	220	4.8	31
			Pilibhit Wetlands	7.9	33	89	5.2	224	6.1	26
Monsoon	15 species	Hemiptera, Odonata, Trichoptera, Ephemeroptera	Sharda River	7.5	29	82	9.1	245	4.7	20
			Sharda Sagar Dam	7.3	27	94	7.1	258	5.2	21
			Deoha River	7.9	28	74	6.9	242	5.8	23
			Pilibhit Wetlands	7.0	26	71	5.8	230	5.1	25
Winter	10 species	Odonata, Hemiptera, Trichoptera	Sharda River	7.2	16	92	9.7	180	4.0	23
			Sharda Sagar Dam	7.9	12	101	9.0	240	3.2	25
			Deoha River	7.4	18	85	8.1	213	3.8	19
			Pilibhit Wetlands	7.7	14	82	7.3	221	4.1	28

3.2 Discussion

The study documented 18 aquatic insect species belonging to 14 families and 7 orders from Chukka Beach (Sharda River) and Sharda Sagar Dam. Seasonal variation showed that summer was dominated by Hemiptera and Coleoptera, monsoon had the highest richness with appearance of Ephemeroptera and Trichoptera, while winter showed more tolerant groups like Chironomidae and Veliidae. Water quality analysis showed that Chukka Beach had higher DO and moderate alkalinity, possessing sensitive insects like Baetis, Caenis, Hydropsyche and Odonata larvae. In contrast, Sharda Sagar Dam showed higher TDS, BOD, and COD, which caused greater dominance of tolerant Diptera groups such as Chironomus and Tipula. Correlation results showed that pH and DO had positive effects on species richness, but BOD, COD, TDS, temperature, copper, and arsenic showed negative effects on biodiversity. Chukka Beach showed greater abundance of sensitive taxa, signifying better water quality, whereas tolerant taxa predominated the dam which suggests moderate pollution and organic load. In this study, as a whole aquatic insects are confirmed as bio-indicators. Chukka Beach is associated with healthier freshwater conditions whereas Sharda Sagar Dam represents degraded water quality because of anthropogenic effects.

4. Conclusion

In this study, 18 aquatic insect species belonging to 14 families of seven different orders were captured from Chukka Beach (Sharda River) and Sharda Sagar Dam. Seasonal composition showed that Hemiptera and Coleoptera dominated summer, monsoon was the most fertile season with appearance of Ephemeroptera and Trichoptera, while winter had more tolerant groupings like Chironomidae and Veliidae. Water quality assessment showed a higher DO and moderate alkalinity at Chukka Beach, which supports sensitive insects like Baetis, Caenis, Hydropsyche and Odonata larvae. In contrast, Sharda Sagar Dam exhibited greater TDS, BOD, and COD which led to the prevalence of tolerant Diptera groups such as Chironomus and Tipula. Correlation analysis showed significant effects of pH and DO on species richness, while those of BOD, COD, TDS, temperature, copper and arsenic were negative indicators of biodiversity. Sensitive taxa were abundant at Chukka Beach, reflecting higher water quality, whereas tolerant taxa were dominant at the dam, reflecting moderate pollution and organic load. In summary, aquatic insects are good bio-indicators, according to the study. Chukka Beach is indicative of healthier fresh water, and Sharda Sagar Dam is a representative of degraded water quality as produced by human interventions. The results from the study revealed that the aquatic insect ecosystem responds to the deterioration of water quality at Chukka Beach (Sharda River) and Sharda Sagar Dam. There are 18 species in 7 orders, recording, and its seasonal presentation closely aligned to the differences of temperature, DO, pH, TDS, BOD, and COD provided in the tables. Chukka Beach with always obtained very high dissolved oxygen (8.4–9.7 mg/L) and moderate alkalinity supported very sensitive groups like Baetis, Caenis, Hydropsyche, Odonata larvae. Their existence shows that the running area of the Sharda River with high levels of this species keep water quality comparatively better. On the other hand, the Sharda Sagar Dam has recorded higher TDS values (240–258 mg/L), higher BOD and COD, especially in summer and monsoon. These conditions favored better-tolerant insects like Chironomus, Tipula, and Diptera, and the research shows that the water of the dam is much more influenced by organic load and low oxygen level. Seasonal patterns seen at the species table also corresponded to the water data: the summer was more favourable for Hemiptera and Coleoptera. – Monsoon increased overall richness, – Winter supported tolerant families in both sites. On the whole, the insect species of insects in both sites did well— Overall, aquatic insects were reliable bio-indicators and result obtained offers a good baseline for monitoring the freshwater habitats of the Pilibhit region future.

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Conflict of Interest: The authors declare no conflict of interest

Author Contribution Statement

Dr. Barkha supervised the methodology, validated the analytical procedures, assisted in data interpretation, and critically reviewed the manuscript.

Sanjana Rani and Arti Kumari contributed to the conceptualization of the study, conducted field sampling, collected water and fish data, and prepared the initial manuscript draft,contributed to data analysis, preparation of tables and figures, manuscript editing, and overall technical support.

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