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Preliminary Ecological Investigation of Parvati Stream, Kullu (Himachal Pradesh, India) with Special Reference to Physicochemical Parameters and Fish Faunal Diversity

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Abstract: The present study was conducted for ecological investigation of Parvati Stream Kullu, Himachal Pradesh, India. The study investigated the physicochemical parameters, revealing variations in water quality and their impact on fish species distribution. Water temperature increased during the survey period, with slightly alkaline pH levels of water samples. Total dissolved solids (TDS) were low, indicating good water quality, while alkalinity varied significantly, and dissolved oxygen (DO) levels remained consistently high. The stream's high altitude, turbulent flow, and favorable physicochemical conditions support species such as snow trout (*Schizothorax richardsonii*), brown trout (*Salmo trutta fario*), and rainbow trout (*Oncorhynchus mykiss*). The 2023 flood significantly reduced fish populations, yet exotic trout species were still observed alongside native fish. Principal Component Analysis (PCA) demonstrated that *Oncorhynchus mykiss* and *Schizothorax richardsonii* prefer slightly warmer temperatures and higher DO levels, whereas *Salmo trutta fario* favors high total hardness and well-oxygenated water.

Keywords: Physicochemical parameters, Total dissolved solids, Dissolved oxygen, Snow trout, Brown trout, Rainbow trout

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Introduction

Freshwater ecosystems including lakes, rivers, streams, and wetlands are vital habitats for myriad species, including fish, which are fundamental for ecological balance and human sustenance. These ecosystems support a variety of life forms, each adapted to specific conditions and niches within these waters. The limited distribution of freshwater habitats means that the species within them are often highly specialized and sensitive to changes in their environment (Postel and Richter, 2003). Streams are dynamic components of freshwater ecosystems, they are

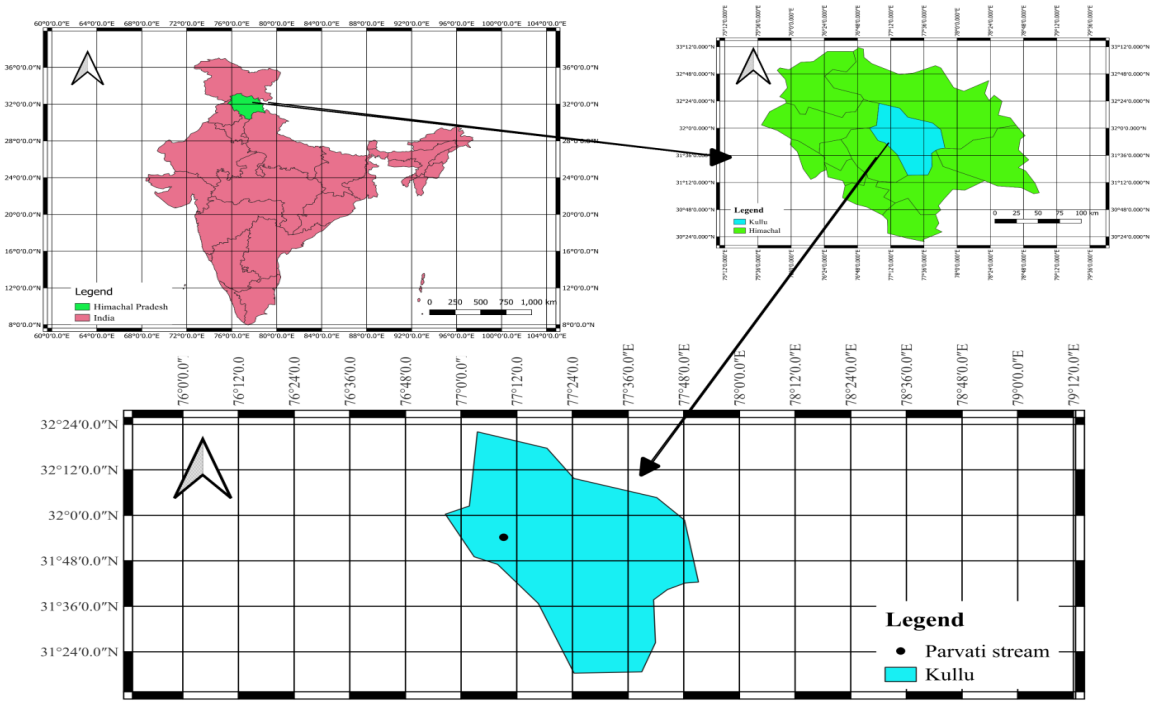

Fig. 1: Map showing area of study.

characterized by their flow regimes and connectivity within the watershed (Wetzel, 2001). These features contribute to the diversity of habitats found within streams, which in turn supports a wide range of aquatic organisms. The physicochemical properties of stream water such as temperature, pH, dissolved oxygen, and nutrient availability are the basis in shaping the biological communities within these habitats. These properties influence metabolic rates, reproductive cycles, and survival rates of aquatic organisms, thereby affecting the composition and diversity of the biological community (Wetzel, 2001). Fish fauna are given particular attention in stream ecology because of their ecological significance and sensitivity to environmental changes. Fish communities are often used as indicators of the health of aquatic ecosystems because they respond quickly to changes in water quality, habitat structure, and other environmental variables. A shift in the pH, salinity, temperature regime, flow clarity, dissolved oxygen, substrate composition, or pollution level is frequently indicated by changes in the makeup of fish communities. They also contribute to the functionality of ecosystems through nutrient cycling, energy flow, and maintaining food web dynamics (Schlosser, 1991). The aquatic system may be more impacted by the changing global climate, which has the ability to modify temperature and precipitation patterns (APHA, 1998).

The present study was conducted for ecological investigation of Parvati Stream Kullu, Himachal Pradesh, India. The present study also investigated the physicochemical parameters, revealing variations in water quality and their impact on fish species distribution.

Materials and Methods

Study Area

The present study was conducted at Parvati stream, largest tributary of Beas River in the Parvati Valley, Kullu, Himachal Pradesh, India (Fig. 1). It rises from the Man-Talai Glacier below the Pin Parvati Pass and flows in a gradual curve from north-northwest to west-southwest past the important temple town of Manikaran and finally drains into the Beas River at Bhuntar, some 10 km

Table 1: Sampling site of Parvati stream

Name of locality	Latitude	Longitude	Altitude (m)
Shat (Upstream)	N 31°58'21.353"	E 77°12'41.263"	1330.80
Seound (Downstream)	N 31°54'24.618"	E 77°9'14.25"	1150

Table 2: Showing range, mean and standard deviation of different physicochemical parameters of stream water

Parameters	Range	Mean	Standard deviation
Water temperature (°C)	8.4-11	9.48	0.87
pH	7.7-8.5	8.07	0.25
TDS (mg/l)	39-50	42.38	4.71
Alkalinity (mg/l)	10-86.7	31.21	25.97
Total Hardness (mg/l)	104-267	222.96	52.13
DO (mg/l)	9.8-11	10.29	0.43

south of Kullu (Negi, 1991).

A field survey of the stream was carried twice in a month from March-June, 2024 from two sampling sites (Table 1). Stream morphology was studied as per criteria given by Rosgen (1994, 1996) and Armantrout (1999). For physicochemical analysis, water samples were collected in 1 L sterilized plastic bottles from the stream. Total of 6 physicochemical parameters were analyzed to assess the water quality of the stream and its impact on local fish-fauna. Water temperature (°C), TDS (mg/l), DO (mg/l), and pH were measured in the field using digital probes. Total alkalinity (mg/l), total hardness (mg/l) were estimated in laboratories according to APHA (1998). Fish specimens were collected mainly with the help of cast net and gill net by local licensed fishermen. Collected specimens were then kept in 5–10% formalin and in laboratory further identification has been done. Identification of fish specimens was done as per Talwar and Jhingran (1991), Jayaram (1999), and Froese and Pauly (2024).

Results and Discussion

The physicochemical parameters of the Parvati stream, monitored over a four-month period from March to June, provide insights into the water quality and its seasonal variations (Table 2).

Temperature gradients in aquatic systems create diverse habitats that support different fish communities. Different fish species have distinct thermal preferences, which directly affect their habitat selection and geographical distribution (John *et al*., 1979). Water temperature also influences fish distribution in an indirect way by interacting with other environmental variables such as dissolved oxygen, pH, salinity etc. (Ficke *et al*., 2007). During the present investigation, the stream's water temperature gradually increases from 8.4°C in early March to 11°C in late June, indicating a seasonal shift from late winter to early summer. Rumana (2001) reported a higher temperature range of 10.7-16.1°C in the same stream. Jindal *et al*. (2022) reported temperature range of 6-13°C in the Beas River in Mid-Himalayan regions.

Aquatic organisms are affected by pH because most of their metabolic activities are pH dependent (Wang *et al*., 2002).

Aquatic ecosystems may also be affected by climate change-related acidification due to the increased uptake of carbon dioxide from the

atmosphere. Humic acid generated from the degrading organic matter can also causes freshwater acidification (Steinberg, 2003). In the present study, the pH levels ranges from 7.7 to 8.5, showing slightly alkaline conditions, consistent with findings of Rumana (2001) and Sharma *et al*. (2021) during the pre-monsoon period in Parvati stream. Jindal *et al*. (2022) reported the pH of Beas river ranging from 7.52-7.84 which is slightly lesser than our findings. pH and alkalinity are two interconnected parameters. Alkalinity varies from 10 mg/l to 86.7 mg/l in current investigation, compared to Rumana's (2001) range of 40 - 70 mg/l. The findings of Jindal *et al*. (2022) show slightly high alkalinity ranging from 45-118 mg/l in Beas river.

Total solids refer to any matter either dissolved or suspended in water. Everything that is retained by a filter is considered to be a suspended solid, while those that passed through filter are classified as dissolved solids, i.e. usually 0.45 µ in size (APHA, 1998). TDS is not regarded as a principal water pollutant however, it is an indicator of water quality. High concentrations of dissolved solids may significantly affect the palatability of drinking water. In addition, high TDS levels can cause scaling and corrosion (Olson, 2017). In the present stream, concentration of TDS was low, ranging from 39 mg/l to 50 mg/l, reflecting good water quality, while Sharma *et al.* (2021) recorded slightly higher TDS level (49.14 - 68.04 mg/l) from the same stream. The range of TDS reported by Jindal *et al*. (2022) in Beas river is between 102.5-120.2 mg/l, which is higher than the recorded values of Parvati stream.

Hardness is a measure of the quantity of divalent ions, such as calcium and magnesium. Calcium has an important role in the biological processes of fish and prawn. Generally fresh water fish do best when hardness is maintained near 100 mg/l. Hardness is important for bone and exoskeleton formation, metabolic reactions and for osmoregulation (William, 1993). Total hardness ranges from 104 - 267 mg/l in present stream during study, was much higher than the 29 - 48 mg/l and 60 - 124 mg/l reported by Rumana (2001) and Sharma *et al.* (2021), respectively. In Beas river, Jindal *et al*. (2022) reported total hardness range from 42-80 mg/l.

The dissolved oxygen concentration of water is one of the vital factors controlling fish habitat quality and a critical measure of stream health (Kramer, 1987). Dissolved Oxygen (DO) levels were consistently high, ranging from 9.8 mg/l to 11 mg/l, exceeding Rumana's (2001) recorded range of 6.33 - 9.09 mg/l, from the current stream. In Beas River Jindal *et al*. (2022) reported slightly lower DO level ranging in between 8.3-8.5 mg/l.

The physicochemical qualities of water such as temperature, pH, dissolved oxygen, and availability of nutrients etc. regulates the biology and physiology of fish species in aquatic bodies. Fishes inhabit in that area which is having optimal physicochemical conditions for sustaining their life activities. Based on the above observations, it is concluded that most of physicochemical parameters of the stream are within the optimum limit, which further support the differential biotic communities including fishes within its channel.

Fish Faunal Diversity

Due to high altitudes having turbulent water flow with high dissolved oxygen and low water temperature, the stream favours snow trout (*Schizothorax richardsonii*), brown trout (*Salmotrutta fario*) and rainbow trout (*Oncorhynchus mykiss*) (Fig. 2). Moreover, due to the devastating flood in 2023, the fish seed in the river has been reduced to greater extent, in the present fish community. The exotic trout fishes *Oncorhynchus mykiss* and *Salmo trutta fario* have also been recorded along with the *Schizothorax richardsonii* from the streams of the Beas River by Sharma (2018).

Diversity Indices

In the current stream, during the study period Dominance Index showed a decrease from 0.52 in March and April to 0.4063 in May, slightly rising to

Fig. 2: Fish fauna of Parvati stream, Kullu (H.P.).

Table 3: Diversity indices of the fish fauna caught during survey

Indices	MARCH	APRIL	MAY	JUNE
Taxa_S	2	2	3	3
Individuals	5	5	8	10
Dominance_D	0.52	0.52	0.4063	0.44
Simpson_1-D	0.48	0.48	0.5938	0.56
Shannon_H	0.673	0.673	0.9743	0.9503
Evenness_e^H/S	0.9801	0.9801	0.8831	0.8621

0.44 in June, indicating a more even distribution of species in May (Table 3). Conversely, Simpson's diversity index increased from 0.48 in March and April to 0.5938 in May and slightly decreased to 0.56 in June, reflecting higher diversity in May. The Shannon-Wiener index also followed a similar pattern, rising from 0.673 in March and April to 0.9743 in May and slightly decreasing to 0.9503 in June, further indicating increased diversity in May. Evenness Index, which measures how evenly individuals are distributed among the species present, was highest in March and April (0.9801), but decreased in May (0.8831) and June (0.8621), suggesting that species distribution became slightly less even as overall diversity increased (Table 3).

Correlation between physicochemical parameters of water and fish fauna

For understanding the correlation between fish fauna and physicochemical properties of stream water, multivariate ordinaton analysis PCA (Principal Component Analysis) was used. The PCA bi-plot of the Parvati stream highlights the influence of physicochemical parameters on fish species distribution (Fig. 3). *Oncorhynchus mykiss* and *Schizothorax richardsonii* prefers slightly warmer temperature as compared to *Salmo trutta fario* and shows moderate tolerance for total hardness and prefers higher dissolved oxygen levels. *Salmo trutta fario* prefers high total hardness and well-oxygenated water, with

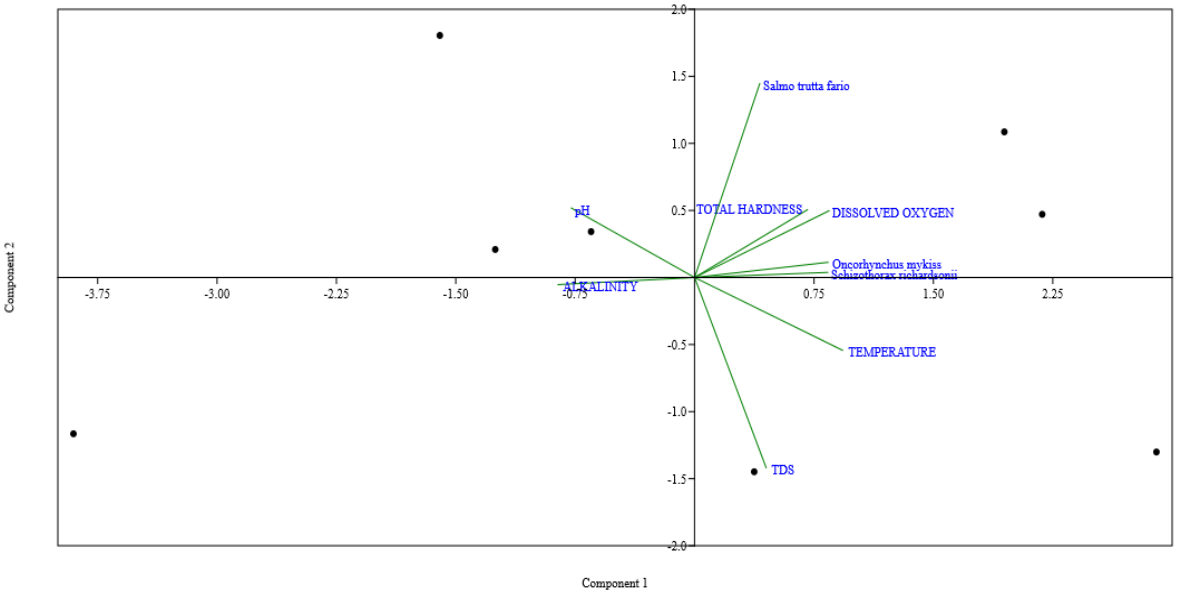

Fig. 3: PCA Bi plot showing the correlation between fish species and physicochemical parameters of stream water.

moderate adaptability to pH and alkalinity.

Conclusion

The study of the Parvati stream's physicochemical parameters revealed a clear connection between water quality and fish species distribution. As the stream transitioned from late winter to early summer, water temperature increases and all other parameters i.e. pH, alkalinity, TDS, DO were in acceptable range. Notably, the stream's high-altitude, fast-flowing waters create an environment conducive to the survival of species such as *Schizothorax richardsonii*, *Salmo trutta fario,* and *Oncorhynchus mykiss*. Despite the significant impact of the 2023 flood, which drastically reduced fish populations, the presence of exotic trout species alongside native ones reflects the stream's resilience. Principal Component Analysis (PCA) further elucidates the relationship between these fish species and the stream's physicochemical conditions, showing overall preference of the three fish species towards lower temperature and higher dissolved oxygen. This study emphasizes the critical role of physicochemical factors in shaping the aquatic ecosystem of the Parvati stream.

Ethical Statement

This study was conducted in accordance with the guidelines of the Research Advisory Committee (RAC) of the Department of Biosciences, Himachal Pradesh University, Shimla, India. Fish sampling was carried out with prior permission from the Director-Fisheries Department, Himachal Pradesh, following all relevant ethical and regulatory standards. All procedures ensured minimal harm to specimens and complied with accepted field research ethics.

Author Contributions

Thakur Sadhana: conducted field sampling, performed laboratory analysis, curated data, and drafted the manuscript; *Banyal Harinder Singh*: supervised the study and conceptualized the research; *Sharma Shivali*: guided the research process and assisted in manuscript review and editing. All authors have read and agreed to the published version of the manuscript.

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Conflict of Interest

The authors declare no conflicts of interest.

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