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Evaluation of ichthyofaunal diversity and physicochemical parameters of Chulla stream in Mandi district, Himachal Pradesh, India

Neha Bains and *H.S. Banyal

Department of Bio- Sciences,
Himachal Pradesh University,
SHIMLA-171005 (HP), INDIA
*Corresponding Author
E-mail : dr.harinderbanyal@gmail.com

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ABSTRACT

A study was carried out to examine the diversity and distribution patterns of fish species in the Chulla stream in Mandi district, Himachal Pradesh. The stream was categorized into upstream and downstream zones according to the altitudinal gradient. Four fish species were identified, belonging to four different genera within the order Cypriniformes. These species were part of the family Cyprinidae and were divided into two subfamilies: Danioninae and Cyprininae, with Cyprininae being the most prevalent. The study analyzed the relationship between fish species and certain abiotic water parameters using Pearson correlation. To assess the stream's biodiversity, various diversity indices were utilized, including Simpson's Index, Simpson's Diversity Index, Shannon Index of Diversity, Margalef's Richness Index and Pielou's Evenness Index. The Water Quality Index values ranged from 41.61 to 45.92, indicating "good" water quality. Results showed greater species diversity in the downstream zone due to lower gradients, increased meandering, and slower current velocity, which enhanced nutrient deposition. In contrast, upstream areas faced significant anthropogenic impacts, altering physicochemical factors and resulting in higher species dominance but lower overall diversity.

Figure : 01 References : 35 Tables : 06
KEY WORDS:Chulla stream, Diversity indices,Ichthyofaunal diversity, Pearson correlation, Physicochemical parameters, WQI

Introduction

Water is foremost substance on globe and is crucial for the survival of all living organisms, including plants and animals. However, this vital resource is increasingly at risk due to growing human populations, which demand more high-quality water for domestic use and economic activities. Safeguarding lake ecosystems is essential not only for protecting the public and economic health of a country but also for preserving and restoring the natural environment for all aquatic and terrestrial life.Aquatic ecosystems serve as habitats for fish, which make up nearly half of all vertebrate species worldwide. India is one of the world's most biodiversity-rich nations, ranking ninth in freshwater biodiversity[26]. Of the approximately 2,500 fish species in India, 930 inhabit freshwater, while 1,570 are found in marine environments[17]. The diversity, community structure, and species assemblages of fish in aquatic bodies are influenced by various living and non-living factors. These factors are pivotal which determine the success or failure of fish species in these habitats[24]. Fish are an integral part of aquatic ecosystems, and any changes in their environment can significantly impact their diversity, distribution, and productivity[13]. Habitat conditions in river systems can vary greatly from the headwaters to the main stream[16,25]. Studies have shown that fish species diversity tends to increase downstream when habitat diversity and stability are enhanced[9,12,29].

Fish perform a significant role in the survival and health of many global populations, as they are a major source of dietary protein and other essential nutrients[8,23] Additionally, fish contribute significantly to the economy and development of nations. However, fish stocks, particularly in freshwater ecosystems, are declining worldwide due to factors such as water pollution, habitat destruction, flow alterations, and the introduction of non-native[19,28].Understanding the current status of fish populations is crucial for global efforts to conserve fish diversity. Natural water bodies provide the conditions under which fish species have evolved, making it important to document the diversity and distribution of fish species over time and space for conservation and management purposes[5].

Himachal Pradesh is home to diverse aquatic ecosystems, including hill streams, rivers, and reservoirs. The exploration of fish fauna in this region dates back

TABLE-1 : Sampling site locations along the Chulla stream

S. No.	Site	Latitude	Longitude	Name of location
1.	Site 1 (Upstream)	31°56’21.49"N	76°47’42.48"E	Near to Chulla village in Joginder nagar region of Mandi district.
2.	Site 2 (Downstream)	31°58’12.70"N	76°46’9.80"E	Near to confluence point of stream with Beas river adjacent to Uhl Hydroelectric Project Stage- 3 in the Mandi district.

to the early 19th century with the arrival of European traders and missionaries. Research contributions from various scholars, including[11,15,18,20-22,32]. have significantly advanced the understanding of fish fauna in different regions of Himachal Pradesh.

The primary aim of the current research is to serve data on the physicochemical parameters and the present status of ichthyofaunal diversity at upstream and downstream locations of the Chulla stream in the Jogindernagar area of Mandi district, Himachal Pradesh. This study was conducted to establish baseline data on the physicochemical characteristics and existing fish populations in the Chulla stream, contributing valuable information for future research on fish diversity in Himachal Pradesh, which will support conservation and management efforts.

Methodology

Study area

The Chulla stream, located in the Joginder Nagar area of Mandi district, Himachal Pradesh, India, is a continuous watercourse that originates in Chulla village and eventually joins the Beas River near the Uhl Hydroelectric Project Stage-3 in Mandi district (Fig.1).

TABLE-2 : List of physicochemical parameters of Chulla stream from February 2023 toJanuary 2024

S. No.	Parameters	Minimum	Maximum	Avg ± S.D.
1.	**Air Temp.(°C)**	16.4	31.8	22.25±4.99
2.	**H_2O Temp.(°C)**	15.2	31.3	20.61±4.37
3.	**pH**	6.7	10.1	8.43±0.93
4.	**TDS (mg/L)**	98	192	146.67±29.67
5.	**EC (ms/cm)**	187	340	258.04±47.59
6.	**D.O. (mg/L)**	4.7	8.3	5.97±1.10
7.	**Alkalinity (mg/L)**	31	78	50.54±14.72
8.	**Total hardness (mg/L)**	30	150	107.81±41.89
10.	**Phosphates (mg/L)**	0.01	0.61	0.19±0.16
11.	**Nitrates (mg/L)**	0.01	0.42	0.15±0.13

TABLE-3 : Composition of freshwater fish species reported from Chulla stream

S.No.	Species Name	Common Name	Upstream	Downstream
Order: Cypriniformes				
Family: Cyprinidae				
Sub family: Danioninae				
1.	*Opsarius bendelisis*	Hamiltons barila	+	+
Sub family: Cyprininae				
2.	*Pethia conchonius*	Rosy barb	-	+
3.	*Garra gotyla*	Gotyla	+	+
4.	*Crossocheilus latius diplocheilus*	Kashmir latia	-	+

Sampling Design

A stratified systematic sampling approach was adopted for this study. Table1 representing the sampling sites.

Physicochemical Parameters of Water

To evaluate the water quality of the Chulla stream, monthly H_2O samples were gathered from selected locations along the stream between February 2023 and January 2024 (Table-2). The samples were thoroughly gathered in aseptic 500 ml bottles. Various abiotic parameters, including EC, TDS, air temperature, water temperature, pH, and dissolved oxygen were measured on-site using digital probes. In the laboratory, further analyses were conducted to determine total hardness, total alkalinity, phosphates, and nitrates, following standardized procedures were outlined[1].

Fish Collection and Preservation

Fish specimens were captured using cast nets and gill nets during the period from February 2023 to January 2024. The specimens were then preserved in a 5-10% formalin solution and carried to the testing lab for detailed scientific examination.

Fish Identification

Fish species identification was carried out using taxonomic criteria and guidelines from the works[14,33].

Data Analysis

Diversity indices were employed to evaluate species diversity at both upstream and downstream locations. The Shannon Index of Diversity (H'), Simpson's Index of Diversity (1-D), Simpson's Index (D), Margalef's Index of Richness (Dmg), and Pielou's Index of Evenness (J) were used to quantify species diversity, evenness, and richness. Pearson's correlation analysis was used to explore the relationship between fish population size and physicochemical parameters. Additionally, CCA was applied to understand the distribution of fish species in relation to selected physicochemical factors. The Water Quality Index was applied to evaluate the overall condition of the stream's water quality.

Results and Discussions

Physicochemical Parameters of Water

Table 2 summarizes the abiotic parameters of the water.

Species Composition

This current analysis documented a total of four fish species—*Opsarius bendelisis*, *Pethia conchonius*, *Garra gotyla*, and *Crossocheilus latius diplocheilus*. These species represent four genera, one order, one family, and two subfamilies (Table-3). Among the two subfamilies, *Cyprininae* was the most dominant. In the upstream area, only two species, *Opsarius bendelisis* and *Garra gotyla*, were found, while all four species were observed in the downstream location.

TABLE-4 : Calculated Fish diversity indices of Chulla stream reported from upstream and downstream locations

INDEX NAME	UPSTREAM	DOWNSTREAM
Simpson¢s Index (D)	0.12	0.09
Simpson¢s Index of Diversity (1-D)	0.88	0.91
Shannon Index of Diversity (H¢)	2.26	2.43
Pielou¢s Index of Evenness (J)	0.87	0.94
Margalef's Index of Richness (Dmg)	2.94	2.96

Fish Diversity Across Different Altitudinal Zones

The diversity indices for the downstream location were D = 0.09, 1-D = 0.91, H' = 2.43, J' = 0.94, and Dmg = 2.96. In contrast, the upstream locations had values of D = 0.12, 1-D = 0.88, H' = 2.26, J' = 0.87, and Dmg = 2.94 (Table 4). The downstream area exhibited higher species richness and evenness, along with lower species dominance. In the upstream area, higher species dominance led to lower species richness and evenness.

In the upstream location, high levels of human activity, such as religious practices, were observed, which altered the physicochemical parameters and resulted in higher species dominance but lower species evenness and diversity.

Distribution of Fish

The differences in species distribution may be attributed to variations in altitude and climate between the upstream and downstream areas. Physicochemical parameters, including air temperature, pH, TDS, EC, DO, and phosphates, were notably higher in the downstream areas, correlating with the observed higher species diversity. Altitude plays a critical role in fish distribution, affecting both diversity and richness, with species diversity increasing as altitude decreases. This is consistent with [35], which reported an inverse relationship between altitude and species diversity. At higher altitudes, rapid environmental changes and steep gradients result in lower air temperatures and faster water currents, which negatively impact fish diversity.

Pearson Relationship Between Fish Population Size and Physicochemical Parameters

Table 5 presents the Pearson correlation analysis, which explores the relationship between fish population size and various physicochemical parameters. There was an important direct correlation between fish population size and pH (rs = 0.606**), while no significant correlations were found with DO, alkalinity, and nitrates (rs = 0.153). The positive correlation with pH, DO, alkalinity, and nitrates suggests that increases in these parameters support fish population growth.

pH is a crucial factor in fish distribution, with optimal growth occurring between pH 6.0 and 9.0, as noted[31]. Similarly, optimal fish growth was recorded at pH 7, while pH levels of 4.3 and 9.2 were associated with lethal effects[34]. This study shows that reduced pH conditions negatively impact fish growth rates.

Dissolved oxygen is vital for water-based life, especially for fish that rely on it. DO levels of 8-8.5 mg/L support optimal growth rates, while levels below 8 mg/L can adversely affect egg and larval development[4,6,10].

In contrast, fish population size exhibited an important inverse relation with air temperature (rs = -0.418**), water temperature (rs = -0.616**), and TDS (rs = -0.095**), with non-significant inverse correlations with EC, TH, and phosphates. This suggests that fish diversity decreases with rising temperatures, TDS, EC, TH, and phosphates. Higher temperatures reduce the oxygen-carrying capacity of water, leading to decreased DO levels and potential fish mortality due to suffocation, as observed[31]. The current study indicates that rising air temperatures contribute to increased water temperatures and deteriorating water quality, accelerating eutrophication in aquatic environments and posing challenges for fish populations, similar to findings[27].

Water Quality Index

WQI is a quantitative tool used to evaluate water

TABLE-5. Pearson correlation between Fish population size and physicochemical parameters.

	Air temperature	water temperature	pH	TDS	EC	DO	Alkalinity	TH	Phosphates	Nitrates	Population size
Air temperature	—										
Water temperature	.859**	—									
pH	-0.607**	-0.739**	—								
TDS	-0.048	-0.016	-0.016	—							
EC	0.003	0.101	0.041	.732**	—						
DO	-0.512*	-0.613**	0.123	0.137	-0.129	—					
Alkalinity	-0.621**	-0.695**	.833**	0.18	0.322	0.196	—				
TH	-0.425*	-191	-0.025	.583**	.616**	0.187	0.276	--			
Phosphates	0.295	0.381	-.477*	.763**	.542**	-0.057	-0.381	.413*	--		
Nitrates	0.201	0.28	-0.312	0.241	0.258	-0.001	-0.317	0.295	.541**	--	
Population size	-.148*	-.616**	.606**	-0.095	-0.236	0.412	0.384	-0.175	-0.344	0.153	--

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

TABLE-6 : WQI of Chulla stream.

			UPSTREAM		DOWNSTREAM	
Parameters	S_n	W_i	Q_i	W_iQ_i	Q_i	W_iQ_i
pH	8.5	0.12	94.59	10.89	103.65	11.94
TDS (mg/L)	1000	0.00	13.43	0.01	15.90	0.02
EC (ms/cm)	2000	0.00	12.70	0.01	13.10	0.01
D.O. (mg/L)	5	0.20	119.00	23.30	119.80	23.46
Alkalinity (mg/L)	120	0.01	39.23	0.32	45.00	0.37
TH (mg/L)	300	0.00	34.87	0.11	37.00	0.12
Phosphates(mg/L)	1.5	0.65	10.67	6.96	15.33	10.01
Nitrates (mg/L)	50	0.02	0.32	0.01	0.28	0.01
WQI				**41.61**		**45.92**

(Sn) Standards for drinking water (WHO, 2011).

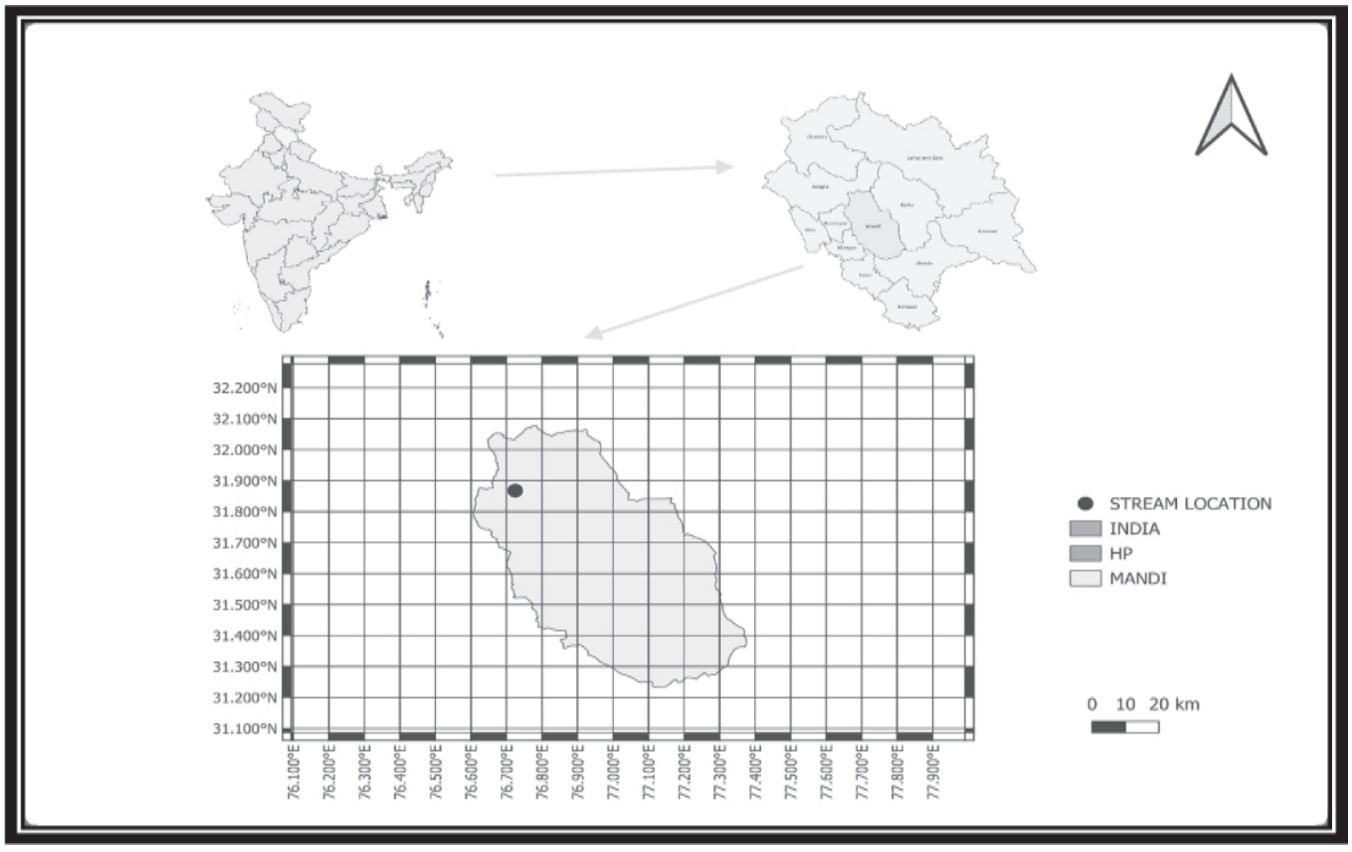

Fig. 1 : The study area of Chulla stream, Mandi (HP) India

quality, usually on a scale from 0 to 100. Values ranging from 0 to 25 signify "excellent" water quality, while values between 25 and 50 indicate "good" quality. Scores from 51 to 75 reflect "poor" quality, and those from 76 to 100 denote "very poor" quality. An index exceeding 100 suggests the water is "unsuitable" for consumption[7].In the case of the Chulla stream, the WQI ranged from 41.61 to 45.92, indicating that the water quality is within the "good" range (Table-6).

Conclusion

In this study, we identified four fish species from the selected hill stream. Using various diversity indices, we found that species diversity is higher at the downstream sampling location. Pearson's correlation interpretation exposed prominent direct links between fish population size and pH, while negative correlations were observed with air temperature, water temperature, and TDS.

WQI assessment indicated that the water quality of the Chulla stream is "good." The study's findings show greater species diversity downstream compared to upstream. The downstream area's low gradient, high meandering, and slow current velocity contribute to increased nutrient deposition in deep pools, which supports higher species abundance. Conversely, upstream locations, affected by high levels of human activity, have altered physicochemical conditions, resulting in higher species dominance but lower species richness and evenness.

This study offers baseline data that provide the present conditions of ichthyofaunal diversity and water quality variables. This information will be essential for refining regulation and safeguarding methods for fish species in the Chulla stream. Consequently, it is vital to implement measures that promote the sustainable endurance of both water quality and fish populations in the watercourse system.

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