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Influence of Physico-chemical Parameters and Plankton Composition on Fish Faunal Diversity of Kuthar Stream, A Tributary of Sutlej River, Himachal Pradesh, India

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ABSTRACT

The current investigations deal with various physico-chemical variables of stream water and its correlation with the ichthyofaunal and planktonic diversity of the Kuthar stream, a tributary of Sutlej River in Solan district, Himachal Pradesh. The results show that the water quality index (WQI) of the stream falls into the category of "very poor" water quality. A comprehensive analysis reports the presence of eight fish species belonging to order Cypriniformes and families Cyprinidae, Danionidae and Nemacheilidae. Various diversity indices are utilized to ensure the fish biodiversity. Additionally, nine species of phytoplankton were observed, most of which belongs to family Bacillariophyceae followed by Zygnematophyceae. CCA (Canonical Correspondence Analysis) was used to elucidate the correlation between fish diversity and physico-chemical parameters as well as between fish diversity and plankton diversity. The stream faces much anthropogenic stress which alters the physico-chemical parameters of the stream water ultimately impacting the floral and faunal diversity.

Keywords Sutlej, Kuthar stream, WAWQI, Diversity indices, CCA.

INTRODUCTION

Water is the most vital, abundant and precious asset on the Earth, covering over 70% of the planet's surface. It is essential for the survival of all living organisms, including humans. With no alternative to replace it, water holds immense value due to its distinct physical and chemical characteristics (Hossain 2015). Only around 2% of the Earth's total water supply is fresh water and of that small portion, nearly 68.7% is entrapped in ice and snow, 29.9% lies beneath the ground as groundwater, just 0.26% exists in rivers, lakes, and swamps, and 0.05% is present in the atmosphere as water vapor (Giordano 2009). The life of people either in bustling metropolis or quiet small village is interconnected with fresh and flowing water from antiquity. A wide range of organisms including phytoplankton, zooplankton, aquatic plants, insects, fish, amphibians, birds, and mammals play a vital role in maintaining aquatic biodiversity. (Irfan and Alatawi 2019). Rivers and streams being a part of freshwater ecosystem, maintain water cycle and transports sediments from the higher elevations to lower lands and ultimately into the sea (Dudgeon *et al.* 2006). Rivers play a major role in shaping the landforms of Earth's continents (Twidale 2004). Rivers and streams configure the emerged surface of

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the earth reaching the base level for geomorphologic systems which is ocean. Streams are water bodies flowing downward through an open channel under the force of gravity. Streams with relatively higher current and water volume are commonly considered rivers (Latrubesse and Park 2017). Himalayas have a relationship of drainages fed with streams and glaciers (Sharma and Mehta 2010). Physico-chemical parameters are crucial in determining the diversity of ichthyofauna and the overall productivity of aquatic ecosystem. These factors affect the composition, structure, and species diversity of both plankton and fish communities (Purushothama *et al*. 2011). Plankton is diverse group of microscopic organisms that form the foundation of aquatic food webs. They are widespread key indicator of water quality (Sharma and Bhardwaj 2011) and derive the productivity of aquatic ecosystems (Davies *et al.* 2009).

The present study was aimed to assess the ecological status of varied biotic communities (fish and plankton) and their correlation with physico-chemical parameters in Kuthar stream, in Solan district of Himachal Pradesh.

MATERIALS AND METHODS

Area of study

The present study has been conducted in Kuthar stream located between 31°01’78” N latitude to 31°02’48” N latitude and 76°96’49” E longitude to 76°95’92” E longitude. Kuthar stream (Fig. 1) is a left

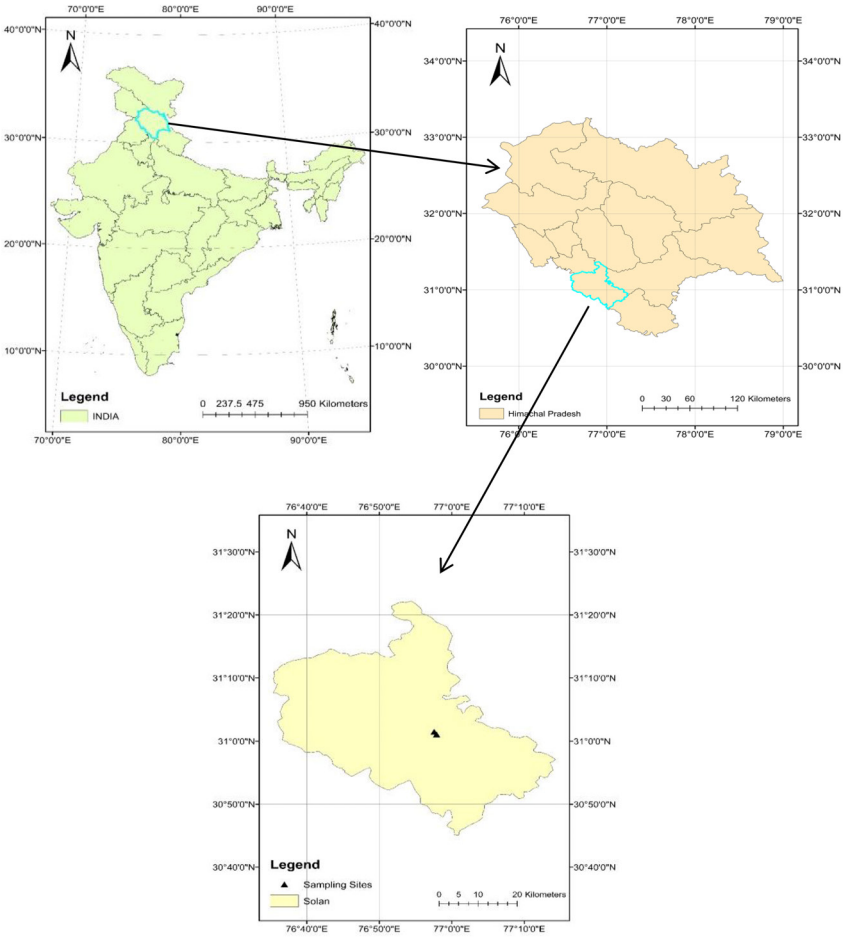

Fig. 1. Map showing the area of study.

Table 1. GPS coordinates of different sampling sites selected for survey in Kuthar stream, Solan.

Sampling sites	Location	Latitude	Longitude	Altitude (meters)
Site I (Upstream)	At Gamberpul	31°01'78" N	76°96'49" E	824
Site II (Downstream)	At Gamjun	31°02'48" N	76°95'92" E	811

bank tributary of Gambhar River in Solan district of Himachal Pradesh, which ultimately flows into Sutlej River. The stream is a spring fed and seasonal stream originating from Dharampur (near Subathu, Solan and flows approximately 20-25 km before joining Gambhar, Solan (HP). The sampling was done at two sampling sites (Table 1).

The survey was conducted in the stream from October 2024 to March 2025. Random sampling was attempted in a selected stream reach of 2-3 km. Different physico-chemical parameters such as water and air temperature, TDS, pH, DO and conductivity were measured at the sampling sites using digital probes. Others including total alkalinity, total hardness, calcium hardness, magnesium hardness, concentration of nitrates and phosphates were tested in the laboratory as per criteria given in APHA (2012). Water quality of the stream was analyzed by using WAWQI method given by Brown *et al*. (1972).

The fish samples were collected by licensed fisherman with the help of cast nets and were preserved in different formalin concentrations (5 – 10%) depending on size of the fish. The identification was done by the references of Talwar and Jhingran (1991), Jayaram (1999) and Froese and Pauly (2024). Fish diversity was analyzed using different diversity indices.

The plankton were collected using plankton nets and then preserved by adding few drops of 2-4% formalin solution in a vial. The qualitative and quantitative analysis of plankton was done by Sedgewick Rafter counting chamber and were identified by the references given by Edmondson (1959) and Ward *et al.* (1963).

The correlation between the physico-chemical variables and ichthyofaunal diversity and plankton and fish diversity was derived using multivariate CCA (Canonical Correspondence Analysis) in PAST software version 4.03.

RESULTS AND DISCUSSION

Kuthar stream is spring fed seasonal stream and riffles were found to be the dominant habitat followed by shallower pools. The bank of the stream was unstable. The upstream site was dominated by large boulders, rubbles and cobbles, while the cobbles, gravel and silt was found in downstream site.

The range and mean values of various physico-chemical parameters were given in Table 2.

Air and water temperature in the stream ranged from 24-33°C and 18.3-32.2°C respectively. Water temperature changes with variation in air temperature, season, water depth and time of the day. pH ranged from 8.1 to 8.8 indicating a well buffered water of the stream. Maximum pH was recorded in February and minimum in November. DO ranged from 8.5 to 10 mg/l. DO increases with decrease in water temperature. Tyor (2002) reported the range of DO in between 5.88 to 10.82 mg/l in Kuthar stream, Solan, which are in line with present findings. Total alkalinity of the stream water ranged from 44-244 mg/l. The heightened value of alkalinity shows the presence of bases such as carbonates and bicarbonates in the water. In the present stream, total hardness ranged from 252-360 mg/l, with calcium and magnesium hardness varied from 178-268 mg/l and 66-148 mg/l, respectively. Total hardness exceeded the normal permissible limit of 200 mg/l standardized by BIS (IS 10500-2012) and the stream comprised of hard to very hard water. Calcium and Magnesium hardness also surpassed the standard value of 75 and 30 mg/l. TDS ranged from 218-263 ppm. Elevated TDS value denotes more anthropogenic activities (Sharma *et al.* 2018). Thakur *et al*. (2013) reported low TDS value

Table 2. Showing different physico-chemical parameters, its range, mean values and calculation of WAWQI.

Parameters	Standard agency	S_n	$1/S_n$	$K=1/(\sum 1/S_n)$	$W_n=K/S_n$	V_0	Range	V_n (Mean value)	V_n/S_n	$Q_n=V_n/S_n*100$	W_n*Q_n
DO (mg/l)	BIS,ICMR	5	0.2	0.0961	0.0192	14.6	8.5-10	9.216	1.84333	55	1.057502
pH	BIS,ICMR	8.5	0.1176	0.0961	0.0113	7	8.1-8.8	8.5	1	100	1.131018
Total alkalinity (mg/l)	BIS	200	0.005	0.0961	0.0005	0	44-244	142.533	0.712	71.266	0.034257
Total hardness(mg/l)	BIS	200	0.005	0.0961	0.0005	0	252-360	320.4	1.602	160.2	0.077005
Ca^{+2} Hardness (mg/l)	BIS,ICMR,WHO	75	0.0133	0.0961	0.0013	0	178-268	218.666	2.915	291.555	0.373722
Mg^{+2} Hardness (mg/l)	BIS,WHO	30	0.0333	0.0961	0.0032	0	66-148	101.733	3.391	339.111	1.086699
TDS (ppm)	BIS,ICMR,WHO	500	0.002	0.0961	0.0002	0	218-263	238.5	0.477	47.7	0.009171
Conductivity (µS/cm)	ICMR,USPHS	300	0.0033	0.0961	0.0003	0	250-350	300	1	100	0.032046
Nitrates (mg/l)	BIS,WHO	45	0.0222	0.0961	0.0021	0	0.7-2.35	1.17666	0.026	2.6148	0.005586
Phosphates (mg/l)	USPHS	0.1	10	0.0961	0.9614	0	0.02-0.17	0.09	0.9	90	86.52291
			$\sum 1/S_n$ =10.402		1						$\sum W_nQ_n / \sum W_n$=90.32992

of 124.08 mg/l in 2008-2009 and 133.09 mg L^{-1} in 2009–2010 due to minimum human interference at Prashar Lake, Mandi, (HP). Conductivity ranged from 250-350 µS/cm. Both TDS and conductivity are directly correlated to each other, as one increases other also increases and vice-versa. Nitrates and phosphates ranged from 0.7-2.35 mg/l and 0.02-0.17 mg/l respectively. The maximum value of phosphate was recorded in the month of March in present findings, while maximum value of nitrate was recorded in the month of February. The Weighted Arithmetic Water Quality Index (WAWQI) (Table 2) in the current stream lied in between 75-100 (WAWQI=90.32992) indicating very poor water quality of stream (Brown *et al.* 1972, Chatterjee and Raziuddin 2002). The WQI values of Beas River (WQI = 60.93) (Kumar *et al*. 2017) and Kunah stream (WQI = 50.50388 – 61.97454) (Sharma and Banyal 2024) was found to be much lower than the present findings due to less human interference.

Fish fauna

A total of 106 individuals were encountered representing eight fish species viz. *Opsarius bendelisis, Opsarius barna, Tor putitora, Schizothorax richardsonii, Tariqilabeo diplochilus, Garra gotyla, Pethia ticto* and *Schistura horai* belonging to order Cypriniformes and distributed across three families: Danionidae,

Table 3. Systematic ichthyofaunal list of Kuthar stream, Solan.

Sl. No.	Fish species	IUCN status
	Order: Cypriniformes Family: Cyprinidae	
1	*Tor putitora* (Hamilton 1822)	EN
2	*Schizothorax richardsonii* (Gray 1832)	VU
3	*Tariqilabeo diplochilus* (Heckel 1838)	LC
4	*Garra gotyla* (Gray 1830)	LC
5	*Pethia ticto* (Hamilton 1822)	LC
	Family: Danionidae	
6	*Opsarius bendelisis* (Hamilton 1807)	LC
7	*Opsarius barna* (Hamilton 1822)	LC
	Family: Nemacheilidae	
8	*Schistura horai* (Menon 1952)	LC

(VU: Vulnerable, EN: Endangered, LC: Least concern, NE: Not evaluated).

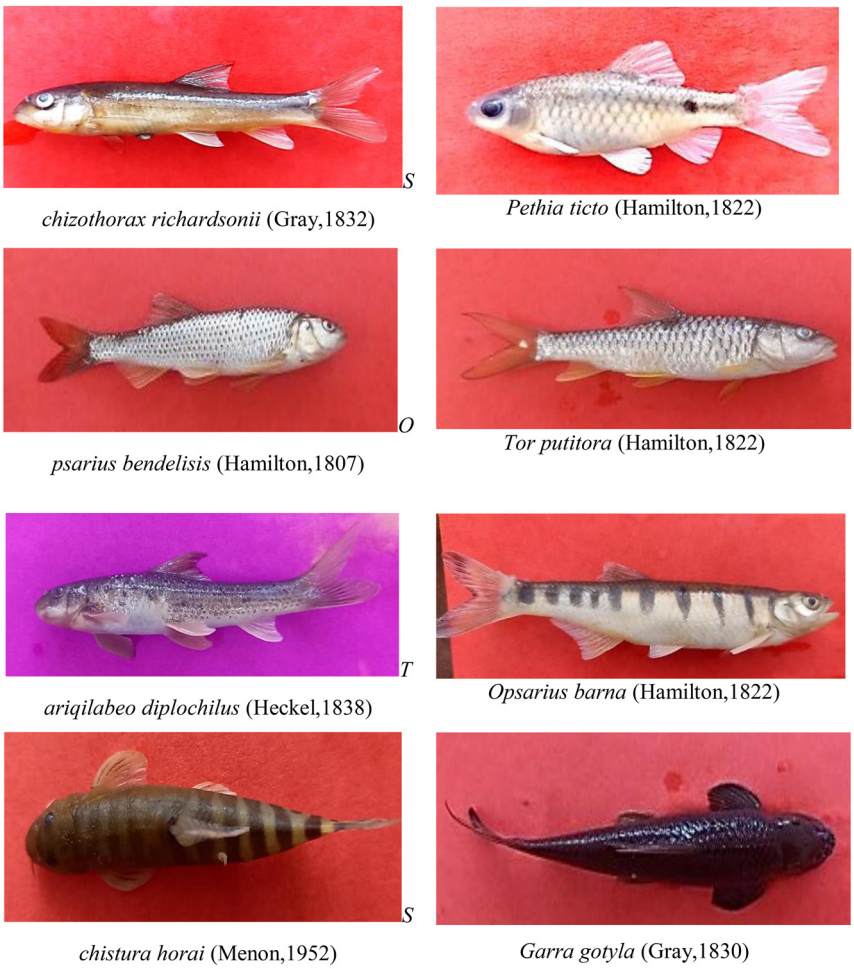

Plate 1. Ichthyofauna of Kuthar stream, Solan (HP).

Cyprinidae and Nemacheilidae consisting 2, 5 and 1 species each (Table 3, Plate 1). Cypriniformes is the only order found in the stream. Also, Singh *et al.* (2025) encountered a total of 35 fish species belonging to 4 orders, 6 families and 25 genera from Sirsa River in Solan district of Himachal Pradesh. Out of which, 29 species belong to Cypriniformes order, representing the dominance of the order in the stream.

Fish diversity

The maximum fish diversity (Table 4) was reported in November month (H′=1.321) (1-D = 1.321) and minimum was in January month (H′= 0) (1-D = 0), because only single species *Opsarius bendelisis* was recorded in the stream during January month showing its dominance. The Simpson and Shannon-Weaver indices reflect greater diversity in the month of October and November. Maximum evenness was observed in January month while minimum was seen in December month.

Correlation between physico-chemical parameters and fish fauna

Canonical Correspondence Analysis (CCA) serves as a significant tool for examining the relationship between physico-chemical variables and fish communities. The length of the arrow depicts the significance of the variable in the plot. Only one individual

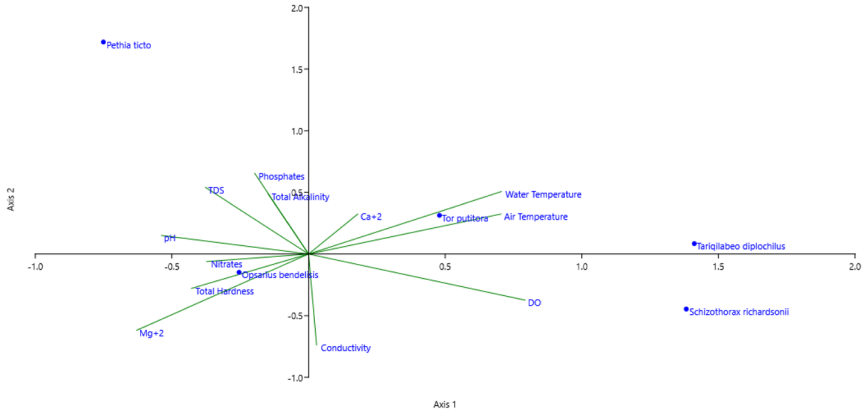

Fig. 2. CCA biplot showing correlation between physico-chemical parameters and fish fauna.

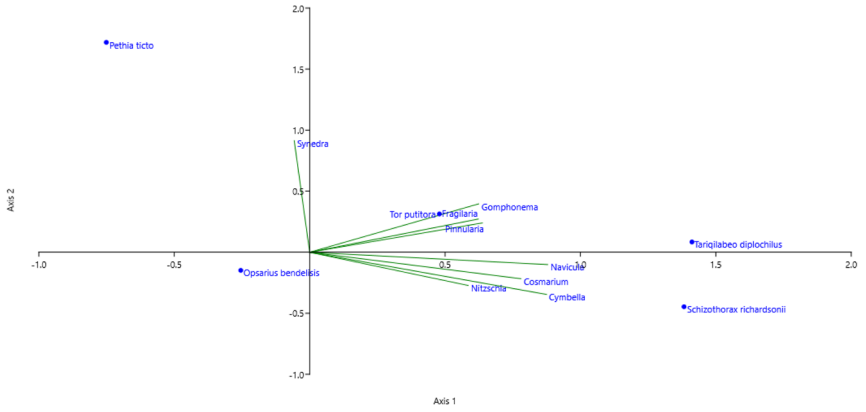

Fig. 3. CCA biplot showing correlation between plankton and fish fauna.

from three species *Opsarius barna, Garra gotyla* and *Schistura horai* have been reported during the current study which would have no significance in deriving correlation, so they were excluded as they affect the analysis.

CCA biplot (Fig. 2) depicts that, *Tor putitora* shows a positive correlation with calcium hardness, air and water temperature while negative correlation with nitrates, total hardness and magnesium hardness. *Opsarius bendelisis* shows positive correlation with magnesium hardness and total hardness, conductivity and nitrates while negative correlation with calcium hardness, air and water temperature.

Table 4. Month wise fish diversity indices of Kuthar stream, Solan.

	Oct-24	Nov-24	Dec-24	Jan-25	Feb-25	Mar-25
Taxa_S	5	5	2	1	2	4
Individuals	19	16	21	13	16	21
Dominance_D	0.3296	0.3281	0.8277	1	0.5703	0.4422
Simpson_1-D	0.6704	0.6719	0.1723	0	0.4297	0.5578
Shannon_H′	1.279	1.321	0.3145	0	0.6211	1.036
Evenness_e^H/S	0.7186	0.7493	0.6848	1	0.9305	0.7043

Schizothorax richardsonii shows positive correlation with DO, while negative correlation with pH, TDS and phosphates. Pal *et al.* (2024) also reported a positive correlation between DO and fish species such as *Schizothorax richardsonii, Tor putitora* and *Tariqilabeo diplochilus* while negative correlation to water temperature. *Pethia ticto* shows positive correlation with pH, TDS, phosphates and total alkalinity while negative correlation with DO and conductivity.

Plankton diversity

Total nine phytoplanktonic genera were observed, out of which eight genera viz., *Nitzschia, Cymbella, Navicula, Gomphonema, Pinnularia, Mastogloia, Fragilaria* and *Synedra belong* to Bacillariophyceae making it the dominant order while 1 genus *Cosmarium* belongs to Zygnematophyceae. Maximum individuals were found in month of October. Kumar *et al.* (2015) recorded maximum planktonic population in February whereas minimum in August in river Beas, Himachal Pradesh. Kumari *et al.* (2024) assessed the abundance and fluctuations in plankton diversity in Ashwani stream, Solan, total of 17 genera were reported and highest plankton abundance was observed in winter season.

Correlation between plankton diversity and fish fauna

CCA biplot (Fig. 3) shows correlation between plankton diversity and fish fauna. From the current plot, it is concluded that *Tor putitora* shows a positive correlation with *Gomphonema*, *Fragilaria* and *Pinnularia* and *Schizothorax richardsonii* shows a positive correlation with *Nitzchia, Cymbella, Cosmarium* and *Navicula. Pethia ticto* shows positive correlation with *Synedra.*

CONCLUSION

Kuthar is a spring fed seasonal stream supporting many floral and faunal diversity. The water quality index (WQI) of the Kuthar stream indicates "very poor quality" of the stream water. Different fish and phytoplankton species are either positively or negatively correlated with the various physico-chemical parameters of the stream water. Many anthropogenic activities like bathing, sewage disposal, agricultural runoff, washing clothes, illegal fishing, religious activities, were reported during the survey. The change in physico-chemical parameters can be due to anthropogenic activities which affect the entire aquatic biodiversity. Hence, it is recommended that authorities should keep a check on the water quality so as to ensure sustenance of fair aquatic faunal diversity.

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