Eco. Env. & Cons. 28 (4) : 2022; pp. (1967-1975)

ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2022.v28i04.046

Variations in water quality parameters and their correlation with fish catch per unit effort of Bhini Stream, a tributary of River Ravi, Jammu and Kashmir, India

Chakshu Gupta[1]*, Seema Langer[2] and Menakshi Dhar[1]

Department of Zoology, University of Jammu, Jammu180 006, J&K, India

(Received 17 April, 2022; Accepted 12 June, 2022)

ABSTRACT

The quality of water is very critical for fish survival and growth in a water body. However, little is known about the state of the Bhini Stream's water quality and its relationship to fish catch. The focus of this study was to evaluate water quality parameters in the Bhini Stream and see if there was a correlation between them and fish catch per unit effort. Monthly samples were gathered using a three-level stratified sampling method. Temperature, depth, transparency, pH, TDS, EC, DO, alkalinity, hardness, chloride, sulphate, phosphate, nitrate, and fish catch (CPUE) were all monitored simultaneously in each of the three strata of the stream. The water quality characteristics were within the permissible range for fish production. There were no significant differences in water quality parameter concentrations between the riverine, transitional, and lacustrine zones ($p>0.05$). TDS and nitrates from fertilisers used on nearby fields and brought to the stream by runoff or floods were significantly and negatively correlated with CPUE ($r=0.84$, $p<0.05$; $r=0.71$, $p<0.05$). 13 fish species all belonging to order Cypriniformes were reported from the stream with *Schistura denisoni* being reported for the first time from the River Ravi.

Key words: *CPUE, Ichthyofauna, Mann-Whitney, TDS,* Schistura.

Introduction

Water is one of the most important and abundant of all the natural resources available on earth which is necessary for the survival and growth of living organisms. The ecological systems, human health, food production and economic development are all dependent on water. So the availability of good quality water is, therefore, a critical factor for preventing diseases and improving quality of life. The nature and health of an aquatic system are an expression of the quality of water and are dependent on the physicochemical properties of water and its biological diversity. The analysis of physico-chemical properties of water help in the identification of the source of pollution, investigation of the ecobiological impacts and initiation of remedial measures for polluted water bodies (Williamson *et al*., 2008; Ekwenye and Oji, 2008). Both natural and anthropogenic activities influence water quality. The increase in the human population has led to an increased demand for food, land conversion, and use of fertilisers causing a faster degradation of freshwater bodies (Singh and Singh, 2008; Rao *et al*., 2012). The fish diversity and their habitat are also affected by anthropogenic activities which in turn leads to

([1*,1] Research Scholar,[2] Professor and Head)

the loss of genetic resources from the gene pool causing irreparable damage to the ecosystem (Tripathy, 2012). Therefore effective management practices are needed which involve a rational knowledge of various components of the water bodies (Mikia *et al.*, 2013). This further needs a complete inventory of fish diversity and the ecology of the fish stock present in the water bodies, especially the distribution pattern, habitat preference, biodiversity status etc (Pethiyagoda, 1994; Dudgeon, 2000).

Any scientific documentation concerning the physico-chemical parameters, their variation with regard to CPUE and the ichthyofaunal diversity of the Bhini stream is completely lacking. The stream has a vast stretch that remained unexplored due to its remote location in the far off forest area. In addition, the extreme diversity of aquatic ecosystems necessitates a constant knowledge of fish species available there. The present study is a maiden attempt a) to assess annual, seasonal and spatial variations in various physico-chemical parameters of the stream, b) to determine the correlation between water quality parameters and catch per unit effort and c) to study the diversity of fish species present in this stream.

Materials and Methods

Description of the study area

The present study was carried out at Bhini stream (32.62°N 75.62°E) (Fig. 1) which is a tributary of River Ravi located in the town of Billawar in Kathua district in the Union Territory of Jammu and Kashmir. The area receives an annual rainfall of 1672-1740 mm during the late post-monsoon (Dec-Jan) and early pre-monsoon (Feb-March) season primarily from western disturbances and monsoon rains from July-September. The Bhini stream is perennial with rain and meltwater as the major source of water. The stream is located in a vegetation-rich area that is comparatively less affected by human endeavours helping the biodiversity to flourish around and within the stream and was selected for the present study owing to the lack of any scientific data.

Study design

Sampling was done at three points chosen randomly across the stream. The first sampling point was characterised by a narrow and channelised basin (Riverine zone); the second sampling point was characterised by a broad and deep basin (Transitional zone), and the third sampling point was characterised by a less deep and lake-like basin (Lacustrine zone). Three hydrological seasons: pre-monsoon (February-May), monsoon (June-September), and post-monsoon (October-January) were also adopted for sampling.

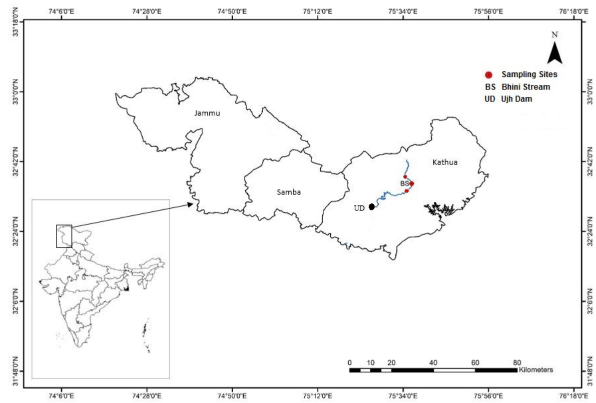

Fig. 1. Location of three sampling stations in the Bhini stream.

Measurement of water quality parameters

Water samples were collected every month for 24 months from January 2020 to December 2021. On-site analysis was done for pH, dissolved oxygen (DO), temperature, depth and transparency, electrical conductivity (EC) and total dissolved solids (TDS) as these parameters tend to change over time due to chemical reactions or biological changes (APHA, 2005). Three readings each at 3 different points per sampling point were taken and the average was calculated and recorded. The sampling point I, II, and III represented the lower, middle and upper portions of the stream respectively. pH was measured using a digital pH metre (Testo 206-pH1). For dissolved oxygen (DO) measurement, oxygen was fixed by the method recommended by APHA (2005) and further analysis was carried out in the laboratory. Water temperature was measured using a mercury bulb thermometer. The depth was measured using metre rods and measuring tape. Transparency was measured using a Secchi disc. EC and TDS were measured using Aquasol TDS/ Electrical conductivity metre.

Laboratory analysis

Three water samples were taken from each sampling point and brought to the laboratory in glass bottles. These samples were analysed in the laboratory using the procedure outlined in the Standard Methods for the Examination of Water and Wastewater (APHA, 2005). Free carbon dioxide (FCO_2), hardness (Ca^{2+} and Mg^{2+}), alkalinity (HCO_3^- and CO_3^{2-}), chloride, phosphate, nitrate and sulphate were analysed within 24 hours in the laboratory.

Fish Identification and Measurement of CPUE

Fish samples were collected by systematic random sampling from the lower/lacustrine zone, middle/transitional zone and upper/riverine zone of the stream using gillnet and cast net for a period of 2 years.

Catch per unit effort of fish was calculated using the following formula:

$$CPUE = \frac{\text{Total catch}}{\text{Sum of efforts}}$$

Fish specimens were preserved in 10% formalin and brought to the laboratory for identification using the identification keys given by Day (1878), Talwar and Jhingran (1991) and Jayaram (1981).

Data analyses

As most concentrations were not normally distributed, non-parametric research using Spearman's correlation to show the association between water quality parameters and CPUE was conducted using Palaeontological Statistics (PAST) v 4.03. The Kruskal-Wallis test was also used to find differences in the means of the seasons and stratum. A multiple comparison study was performed using the Mann Whitney U pairwise test to see the annual changes associated physicochemical parameters. A probability value of 0.05 was considered statistically significant for all tests.

Results

Annual levels of water quality parameters for the study period

The range and mean values of water quality parameters for the study period are presented in Table 1. The mean water temperature varied marginally in the range of 12.9-12 °C in 2020 and 13.3-13 °C in 2021. The mean depth of the stream varied from 4.5-3.6 feet in 2020 and 3.1-2.5 feet in 2021. The range in mean TDS and EC was much higher in 2020 than in 2021. The mean pH fell to a minimum of 7 in 2020 slightly lower than a minimum of 7.1 in 2021 and rose to a maximum of 8.2 in both years. The mean level of dissolved oxygen showed negligible change during both years. Free carbon dioxide was not found in the stream during the study period. The

Table 1. Annual variation of physico-chemical parameters of Bhini stream for the study period 2020 – 2021 using Mann Whitney U test for 2 years.

Parameters	Range		Mean±Standard deviation		p-value
	2020	2021	2020	2021	2020 & 2021
Water Temp (°C)	12.9-12	13.3-13	14.03±1.08	14.89±1.18	0.698
Depth (feet)	4.5-3.6	3.1-2.5	5.5±2.02	5.49±2.92	0.095
Transparency (cm)	36-70	40-72	36.91±22.93	37.83±24.27	0.047*
TDS (ppm)	159-188	162-176	251.33±122.87	228.91±86.7	0.763
EC (μg/m)	302-289	287-273	361.83±43.00	351.66±50.0	0.273
pH	7.7-8.2	7.8-8.2	7.48±0.41	7.5±0.40	0.899
DO (mg/l)	8.2-8.3	8.1-8.2	8.24±0.11	8.14±0.11	0.393
FCO_2 (mg/l)	-	-	-	-	-
HCO_3^- (mg/l)	195.2-207.5	196.4-212.1	245.05±27.08	243.30±31.0	0.537
CO_3^{2-} (mg/l)	9.6-9.3	10.4-10.2	10.97±1.72	11.62±1.50	0.698
Ca^{2+} (mg/l)	8.02-8.11	9.01-9.1	7.52±0.58	8.50±0.70	0.245
Mg^{2+} (mg/l)	2.96-2.89	3.7-4.7	2.24±0.61	3.33±0.72	0.127
Cl^- (mg/l)	13.91-13.98	15.82-15.89	11.64±2.14	13.73±2.04	0.034*
Phosphate (mg/l)	0.87-0.83	0.67-0.64	0.28±0.42	0.65±0.02	0.008*
Nitrate (mg/l)	0.09-0.42	0.07-0.25	0.68±0.58	0.25±0.26	0.029*
Sulphate (mg/l)	33.33-34.02	31.9-34.1	29.47±5.63	29.53±5.62	0.414
CPUE (kg/day)	5.2-6.0	6.1-5.6	6.05±1.62	5.28±1.81	0.506

*Means p-values that are statistically signicant at 5% condence level.

mean values of alkalinity and hardness were found to be higher in 2021 than in 2020. The mean sulphate level was found to vary marginally in the range of 33.33-34.02 mg/l in 2020 and 31.9-34.1 mg/l in 2021. Transparency values were significantly higher (p=0.047) during the year 2020 than in the year 2021. The mean level of chloride was much higher (p=0.034) in 2020 than in 2021. Phosphate and nitrate levels were both significantly higher (p<0.05) in 2020 than in 2021. CPUE was comparatively higher in 2020 than in 2021.

Seasonal variation of water quality parameters

The seasonal variations of water quality parameters for the entire period of study are shown in Table 2. The seasonal variation of water temperature, TDS, EC, pH, DO, alkalinity, hardness and chloride were not signicant (P>0.05). Free carbon dioxide was not found during any of the three seasons. Mean depth (p=0.039), transparency (p=0.022), phosphate (p=0.029), and sulphate (p=0.049) varied signicantly seasonally in the Bhini stream for the study period. Mean depth varied signicantly (p=0.039) mean depth seasonally in the stream with monsoon season (8.37 feet ± 0.29) recording the highest depth mean value than pre and post-monsoon season. The highest mean values of transparency (62.75 cm ± 17.87) were found during the post-monsoon season while the lowest (14.5 cm ± 5.25) was found during the monsoon season. Phosphate and nitrate were signicantly (p<0.05) higher in the monsoon season. Phosphates were not found in any other season while nitrates were found to be lowest during the pre-monsoon season. CPUE was significantly (p<0.05) higher in the post-monsoon season (7.57 kg/day ± 8.55) while the monsoon season showed a decline in the CPUE(3.8 kg/day ± 0.83).

Spatial variation of water quality parameters

For the study period, Table 3 demonstrates the spatial fluctuation of water quality metrics in the Bhini stream. For all of the parameters studied throughout the study period, the results demonstrated no significant difference (p>0.05) in levels of water quality parameters in the lower, middle, and upper regions of the stream.

Association between water quality parameters and CPUE

Table 4 and Table 5 show the associations between water quality parameters and catch per unit effort (CPUE) in the Bhini stream during the years 2020 and 2021. The results showed a strong negative correlation between CPUE versus TDS and nitrate in the year 2020 while EC, water temperature and sulphate depicted a moderate correlation with CPUE.

Table 2. Seasonal variation of physico-chemical parameters of Bhini stream for the study period 2020 – 2021 using Kruskal-Wallis test for test of difference among three seasons.

Parameters	Pre-Monsoon season	Monsoon season	Post-monsoon season	Pre-Monsoon Mean±S.D.	Monsoon Mean±S.D	Post-monsoon Mean±S.D	p-value
Water Temp (°C)	13-14.5	15-15.2	14-12.9	13.77±0.66	15.22±0.17	13.1±0.86	0.394
Depth (feet)	4.5-4.6	8.3-8	3.1-4.5	4.57±0.05	8.37±0.29	3.55±0.68	0.039*
Transparency (cm)	37-31	12-22	73-36	33.5±2.51	14.5±5.25	62.75±17.87	0.022*
TDS (ppm)	319-296	162-164	235-159	396.5±107.18	163.5±1.29	194±31.31	0.287
EC (μg/m)	389-407	313-380	392-302	402.25±9.28	344.25±28.2	339±51.10	0.936
pH	7.4-7.3	7.1-7.1	8.1-7.7	7.35±0.05	7.1±0.08	8±0.21	0.584
DO (mg/l)	8.3-8.2	8.0-8.2	8.1-8.3	8.3±0.08	8.17±0.12	8.25±0.12	0.887
FCO_2 (mg/l)	-	-	-	-	-	-	-
HCO_3^- (mg/l)	262.3-283.7	241.4-245	235.1-195.2	274.85±8.99	243.65±1.98	216.67±18.5	0.778
CO_3^{2-} (mg/l)	10.3-11.09	12.5-13.9	8.8-9.6	10.73±0.39	13.05±0.64	9.15±0.36	0.439
Ca^{2+} (mg/l)	6.95-6.74	7.53-7.8	8.31-8.02	6.84±0.09	7.53±0.18	8.18±0.13	0.621
Mg^{2+} (mg/l)	1.50-1.62	2.07-2.2	3.14-2.96	1.59±0.07	2.12±0.05	3.01±0.11	0.093
Cl^- (mg/l)	12.9-10.5	9.12-9.3	14.12-13.91	11.62±1.05	9.21±0.07	14.07±0.17	0.071
Phosphate (mg/l)	-	0.87-0.83	-	0±0	0.86±0.02	0±0	0.029*
Nitrate (mg/l)	1.1-0.09	1.05-1.25	0.10-0.17	0.58±0.43	1.34±0.26	0.13±0.02	0.046*
Sulphate (mg/l)	31.4-32.92	35.46-33.3	22.01-22.64	32.03±0.93	34.35±0.9	22.02±0.46	0.064
CPUE (kg/day)	6.2-7 .3	3.2-4.9	5.5-6.1	7.57±8.55	3.8±0.83	5.62±0.33	0.026*

*Means p-values that are statistically signicant at p>0.05.

Table 3. Spatial variation of water quality parameters of the Bhini stream for the study period 2020 – 2021 using Kruskal-Wallis test.

Parameters	Mean ± Standard Deviation			p-value
	Sampling point I	Sampling point II	Sampling point III	
Water Temp (°C)	14.03±1.09	14.49±0.41	14.16±0.65	0.785
Depth (feet)	5.49±2.18	6.47±0.17	5.96±0.48	
Transparency (cm)	36.9±20.17	24±3.88	38.62±11.56	
TDS (ppm)	251.33±54.98	280±54.23	295.25±69.24	
EC (µg/m)	361.83±40.62	373.25±18.76	370.62±30.19	
pH	7.48±0.37	7.22±0.06	7.55±0.14	
DO (mg/l)	8.23±0.08	8.21±0.12	8.27±0.10	
FCO_2 (mg/l)	-	-	-	
HCO_3^-(mg/l)	245.05±27.15	259.25±5.48	245.76±13.77	
CO_3^{2-} (mg/l)	10.97±1.66	11.89±0.51	11.1±0.50	
Ca^{2+} (mg/l)	7.51±0.45	7.18±0.13	7.85±0.12	
Mg^{2+} (mg/l)	2.24±0.52	1.85±0.06	2.56±0.08	
Cl^-(mg/l)	11.64±2.19	10.41±1.08	11.64±0.13	
Phosphate (mg/l)	0.49±0.18	0.53±0.02	0.49±0.01	
Nitrate (mg/l)	0.69±0.41	0.73±0.14	0.96±0.34	
Sulphate (mg/l)	29.46±5.62	27.02±0.69	28.18±0.68	
CPUE (kg/day)	5.65±1.72	6.93±1.49	5.25±1.03	

Table 4. Relation between the water quality parameters and CPUE of Bhini stream for the year 2020 using Spearman's correlation.

S. No.	Parameters	Correlation
1.	CPUE/Water Temperature	-0.5359
2.	CPUE/Depth	-0.4797
3.	CPUE/Transparency	0.4518
4.	CPUE/TDS	-0.7482
5.	CPUE/EC	-0.6293
6.	CPUE/pH	0.4393
7.	CPUE/DO	-0.2433
8.	CPUE/HCO_3^-	-0.4405
9.	CPUE/CO_3^{2-}	-0.4335
10.	CPUE/Ca^{2+}	-0.4475
11.	CPUE/Mg^{2+}	-0.4615
12.	CPUE/Cl^-	-0.4125
13.	CPUE/Phosphate	-0.6704
14.	CPUE/Nitrate	-0.7202
15.	CPUE/Sulphate	0.5035

Table 5. Relation between the water quality parameters and CPUE of Bhini stream for the year 2021 using Spearman's correlation.

S. No.	Parameters	Correlation
1.	CPUE/Water Temperature	-0.4895
2.	CPUE/Depth	-0.4195
3.	CPUE/Transparency	0.4299
4.	CPUE/TDS	-0.8461
5.	CPUE/EC	-0.5944
6.	CPUE/pH	0.4436
7.	CPUE/DO	-0.1634
8.	CPUE/HCO_3^-	-0.4965
9.	CPUE/CO_3^{2-}	-0.3636
10.	CPUE/Ca^{2+}	-0.4265
11.	CPUE/Mg^{2+}	-0.4378
12.	CPUE/Cl^-	-0.4916
13.	CPUE/Phosphate	-0.6404
14.	CPUE/Nitrate	-0.7196
15.	CPUE/Sulphate	0.4475

A strong negative correlation was found between CPUE versus TDS and nitrate while EC, phosphate and HCO_3^- showed a moderate correlation during the year 2021.

Fish Diversity of Bhini stream

Fish catch comprised 13 species namely *Barilius vagra, Puntius conchonius, Chela bacaila, Labeo dero, Tor tor, Acanthocobitis botia, Lepidocephalichthys guntea, Badis badis, Crossocheilus latius, Osteobrama cotio, Rasbora rasbora, Danio devario* and *Schistura denisoni*.

Discussion

During the study period, the temperature of the water did not change considerably. The little fluctuation in the three seasons, on the other hand, could have been influenced by excessive rainfall and Western disturbances, making the stream less stratified. The water temperature (12.9-15.2 °C) observed in this study was favourable for cold water fisheries and could support their proper growth and development. During the monsoon season, CPUE fell significantly as the influx of muddy, turbid water hampered fishing activities and reduced productivity, resulting in less food availability for fish (Ghosh and Biswas, 2017). Water temperature showed a moderate negative correlation (r=-0.5127) with CPUE, indicating that an increase in water temperature resulted in a slight decrease in fish catch. This result was in contrast to Dartay *et al.* (2017), who observed that higher temperatures supported higher CPUE values.

The depth of the stream did not vary much throughout the study period while seasonally significant differences occurred in the mean depth values. Excessive downpour during the months of June-Sept. caused a rise in the water level increasing the depth. Consequently, CPUE dwindled which was also reflected in the correlation values (r= -0.4510). This was found in agreement with the results shown by Dartay *et al.* (2017).

Because of the comparatively high water level in 2021, transparency values were higher than in 2020. During the monsoon season, transparency was low, possibly due to runoff impacts resulting in large sediments, silts, debris, and organic and inorganic suspended particles entering the stream. The settling of particles at the bottom of the stream could explain the increased transparency in the post-monsoon season. CPUE showed a positive correlation with transparency as increased transparency implied more light penetration and higher productivity (Kuehl and Troelstrup, 2013).

TDS is a critical metric in defining water quality standards since it accounts for the many types of solids in dissolved form, which might be organic or inorganic (Jayakumar *et al.,* 2009). According to several studies, TDS is related to the degree of pollution (Bharathi and Krishnamoorthy, 1990; Tripathy and Adhikary, 1990). TDS values were higher during 2020 than in 2021. Mean TDS values were maximum during the pre-monsoon season and minimum during monsoon (Narayan *et al.,* 2007). This could be attributed to the fact that high temperatures during the pre-monsoon season increased evaporation and hence the concentration of TDS (Birajdar *et al*., 2017). A strong negative correlation occurred between CPUE and TDS as also studied by Prepas (2011).

The degree to which water conducts electric current as a function of dissolved minerals and salts in water is referred to as electrical conductivity. Dissolution of natural minerals in the stream, as well as unnatural compounds from animal waste, septic systems, and runoff water, may be sources of such compounds. The Bhini stream's conductivity was within the acceptable range of 30-5000 s/cm (Boyd, 2015). However, the electrical conductivity values found in this study were higher than those found in the Neeru stream in Bhaderwah (Kumar *et al.,* 2019). Variations in natural minerals within the water bodies could explain the discrepancy in results. Electrical conductivity was higher in the pre-monsoon season. Higher conductivity levels obtained in this study could be due to the leaching of minerals from agricultural fertilisers used mostly in pre-monsoon farming close to the stream's shore. CPUE showed a negative correlation with EC as also indicated by Rahman *et al.* (2017).

The pH of the water in this study was found to be within the WHO's recommended range (6.5-8.5). Fish adjust to low or high pH by producing a large amount of mucus on their skin and the inner side of their gill covers. Excessively high or low pH values injure fish tissues surrounding the gills, resulting in limited reproduction and mortality (Svobodova 1993). Water pH is related weakly to CPUE in this study.

Throughout the study period, dissolved oxygen levels remained reasonably consistent and high, indicating that the stream was well oxygenated, which is optimal for fish development and survival. The slightly larger amount of dissolved oxygen in the pre-monsoon season than in the monsoon season could be due to Western disturbances generating water turbulence. According to Boyd (1979), dissolved oxygen concentrations of 3.0-12 mg/L in streams and reservoirs enabled fish development and survival. DO had a slight positive correlation with CPUE in this study. Free carbon dioxide had been absent in the stream throughout the study period.

The alkalinity of water is due to the presence of carbonates and bicarbonates in the water. The alkalinity values of the stream were higher during 2020. The highest values of alkalinity were recorded during the pre-monsoon season as the concentration of nutrients increased the alkalinity of water (Arasu *et al.,* 2007), but the alkalinity decreased in monsoon due to dilution by rainwater (Shinde *et al.,* 2010). Higher alkalinity levels buffer acid rain and other acid wastes by storing a surplus amount of free carbon dioxide preventing pH changes that are harmful to fish. A weak negative correlation value was obtained for alkalinity vs CPUE (Ansari, 2018).

Hardness in water is caused by dissolved calcium and, to a lesser extent, magnesium. The values of hardness were higher during 2021. The mean hardness values were low during the pre-monsoon season as high-temperature caused precipitation of Ca^{2+} and Mg^{2+} ions leading to their removal from water (Maheshwari *et al.,* 2011). The weak negative correlation values suggested that a decrease in hardness will lead to high CPUE values as calcium and magnesium are essential in the biological processes of fish (bone and scale formation, blood clotting and other metabolic reactions (Wurts and Durborow, 1992).

The mean chloride concentration of the study period was low, indicating less eutrophication (Kausik *et al.,* 1992). Chloride is a non-reactive element usually leached through the soil and into the groundwater as a result of animal/human waste and potash fertilisers (Yousuf *et al.,* 2012). Fertilisers used for crops on the periphery of the stream and carried by runoff/leached into the Bhini stream could be a source of chloride in the stream. Large quantities of chloride in lotic and lentic habitats may harm the gills of freshwater fish thus signifying a negative correlation between chloride content and CPUE (Subin *et al.*, 2011).

For fish survival and growth, a phosphate range of 0.01-3.00 mg/L is recommended (Boyd, 1998). This signifies that the current study's phosphate concentration was within the acceptable range. Anthropogenic sources of phosphate in the stream include animal dung, washing of clothes with phosphate-based detergents/soaps, bathing with phosphate-based detergents/soaps, as well as nitro phosphate from surrounding farms (Mustapha, 2008). During the monsoon season, erosion and runoff boost the release of nutrients from organic matter, resulting in a rise in phosphate concentration (Nie *et al.,* 2018). In contrast to Ansari's (2018) findings, a negative correlation between phosphate and CPUE was obtained in the present study.

The mean concentration of nitrate was found to be within the recommended limit for fish survival and growth. Nitrate concentration in streams ranged from less than 1.0 mg/l to 5.0 mg/L (Chapman and Kimstach, 1996). A negative correlation was obtained between CPUE vs nitrate similar to the results shown by Duque *et al.* (2020).

The sulphate concentration in this study was found to be within the recommended range. Sulphate concentrations in aquaculture were recommended to be between 5.0 and 100.0 mgl1 (Boyd, 1998). The monsoon season had much greater sulphate concentrations than the pre and post-monsoon seasons, owing to sulphate fertilisers from nearby crops, as well as rain-aided mineral and rock disintegration. A positive association was found between sulphates and CPUE, which was consistent with Tucker's (1991) study, which found that fish could withstand high sulphate concentrations over 500.0 mg/l.

The concentrations of water quality parameters did not differ geographically or longitudinally, i.e. from the stream's lacustrine to riverine zones. The findings of this study concurred with Akongyuure and Alhassan (2021) but differed from Green *et al.* (2015), who found that reservoir nutrient and turbidity levels decrease from the riverine to the lacustrine zone.

Conclusion

All of the water quality parameters measured in this study were within acceptable limits for fish survival and growth. Seasonal changes had a significant impact on depth, transparency, phosphates, nitrates, and CPUE, but not on water temperature, pH, TDS, EC, DO, alkalinity, hardness, chloride, and sulphate. Water quality parameter concentrations and levels did not differ significantly along the reservoir, indicating a homogeneous spatial distribution. TDS and nitrates have a significant and unfavourable impact on CPUE fluctuation. The fish species *Schistura denisonii* was reported for the first time from the River Ujh of which the present stream is a major tributary. Regular monitoring of the water quality of the Bhini stream will be suitable for the conservation and sustainable use of aquatic resources in order to preserve good water quality in the stream for fish survival and growth. The current study can serve as a baseline and reference point for assessing natural and man-made changes in this stream, as well as the investigation of many developmental features of these fish species.

Acknowledgements

The author would like to thank the Department of Science and Technology (DST), Rashtriya Uchchatar Shiksha Abhiyan (RUSA), Government of India for providing necessary facilities under the Fund for Improvement of S and T Infrastructure (FIST) and Promotion of University Research and Excellence (PURSE) programs. The valuable suggestions and help provided by the Head, Department of Zoology, University of Jammu are duly acknowledged.

References

Ansari, N.A. 2018. Assessment of scope for fish biodiversity conservation in relation to environmental variables at Suraj Pur lake, an urban wetland of the upper Gangetic plain, Northern India. *Indian Journal of Fisheries*, 65,16-24. http://dx.doi.org/10.21077/ijf.2018.65.3.66734-02

APHA, 2005. *Standard Methods for the Examination of Water and Wastewater*. Washington, DC, USA: American Public Health Association.

Arasu, P., Hema, S. and Neelakantan, M. 2007. Physico-chemical Analysis of Thamirabarani River Water in South India. *Indian Journal of Science and Technology*. 1(2) : 1-6. doi:10.17485/ijst/2007/v1i2/29211

Bharathi, S.G. and Krishnamoorthy, S.R. 1990. Effect of industrial effluents on river Kali around Dandeli, Karnataka, Part I- Physico-chemical complexes. *Indian Journal of Environmental Health.* 32 : 167-171. https://doi.org/10.1007/s13201-020-1146-y

Birajdar, S., Vedpathak, S. and Chanshetti, U. 2017. The Effect of Seasonal Variation on Physico-chemical Properties of Tubewell Water of Latur District (MS), India. https://doi.org/10.9790/2402-1110015863

Boyd, C.E. 1979. Water quality in warm water sh ponds. Alabama: Craftmaster, Printers Inc.

Boyd, C.E. 1982. Water quality management for pond fish culture. Agricultural Experiment Station, Auburn, Alabama, Birmingham Publishing Company, New York, Department of Fisheries and Allied Aquaculture.

Boyd, C.E. 1998. Water quality for pond aquaculture. Alabama: International Centre for Aquaculture and Aquatic Environments, Auburn University.

Boyd, C.E. 2015. *Water Quality: An Introduction.* New York: Springer.

Chapman, D. and Kimstach, V. 1996. Selection of water quality variables. In: Chapman, D, editor. *Water Quality Assessment - A Guide to use of Biota, Sediments and Water in Environmental Monitoring.* Cambridge: University Press.

Daniel, N.A. and Elliot, H.A. 2021. Variation of water quality parameters and correlation among them and fish catch per unit effort of the Tono Reservoir in Northern Ghana. *Journal of Freshwater Ecology.* 36(1): 253-269. https://doi.org/10.1080/02705060.2021.1969295

Dartay, M., Atessahin, T. and Duman, E. 2017. Effects of Water Temperature and Depth on the Catch Rate and Catch per Unit Effort for Mirror Carp (*Cyprinus carpio*) caught by Gillnets. *Pakistan Journal of Zoology.* 49(3). https://doi.org/10.17582/journal.pjz/2017.49.3.967.971

Day, F. 1878. The fishes of India; being a natural history of the fishes known to inhabit the seas and fresh waters of India, Burma and Ceylon. London.

Dudgeon, D. 2000. Conservation of freshwater biodiversity in Oriental Asia: Constraints, Conflicts, and Challenges to science and sustainability, Asia Oceania Report.

Duque, G., Gamboa-Garcia, E., Molina, S.A. and Cogua, P. 2020. Effect of water quality variation on fish assemblages in an anthropogenically impacted tropical estuary, Colombian Pacific. *Environmental Science and Pollution Research*. 27: 1-2. https://doi.org/10.1007/s11356-020-08971-2

Ghosh, D. and Biswas, J. 2017. Catch per unit efforts and impacts of gears on fish abundance in an oxbow lake ecosystem in Eastern India. *Environmental Health Engineering and Management Journal.* 4 : 169-175. https://doi.org/10.15171/EHEM.2017.24

Green, W.R., Robertson, D.M. and Wilde, F.D. 2015. Lakes and reservoirs – Guidelines for study design and sampling: U.S. Geological Survey Techniques of Water-Resources Investigations, USA.

Hammer, Ø., Harper, D.A.T. and Ryan, P.D. 2001. PAST: Paleontological statistics Software package for education and data analysis. Palaeontologia Electronica.

Jacklin, J.R. and Regini, B.G.S. 2011. Studies on physico-chemical characteristics of freshwater temple ponds in Kanyakumari (South Tamil Nadu). *International Journal of Geology, Earth and Environmental Sciences*. 1(1) : 59-62.

Jayakumar, P., Jothivel, N., Thimmappa, A. and Paul, VI. 2009. Physicochemical characterization of a lentic water body from Tamil Nadu with special reference to its pollution status. *Eco Scan.* 3(1&2) : 59-64.

Jayaram, K.C. 1981. *The Freshwater Fishes of India,* Pakistan, Bangladesh, Burma and Sri Lanka- A Handbook, Calcutta, India.

Kausik, S., Agarkar, M.S. and Sakesena, D.N. 1992. Distribution of phytoplankton in riverine water in Chambal area, Madhya Pradesh. *Bio-nature.* 12: 1-7.

Kennedy, R.H., Thornton, K.W. and Ford, D.E. 1985. Characterization of the reservoir ecosystem. In: Cooke GD, Welch EB, Peterson SA, Newerth PR, editors. *Lake and Reservoir Restoration*. Stoneham: Butterworth Publishers.

Kuehl, L. and Jr, Nels, 2013. Relationships between net primary production, water transparency, chlorophyll-a, and total phosphorus in Oak Lake, Brookings County, South Dakota. *Proceedings of the National Academy of Sciences*. 92 : 67-78.

Maheshwari, A., Sharma, M. and Sharma, D. 2011.

Hydrochemical analysis of surface and groundwater quality of Yamuna river at Agra, India. *Heterocycles.* 2 : 373-378.

Mark, N.M., John, R.S., Alain, F., John, H., Pierre, K. and Shelton, J.H. 2008. Interpreting catch per unit effort data to assess the status of individual stocks and communities. *ICES Marine Science Symposia.* 63(8): 1373–1385. https://doi.org/10.1016/j.icesjms.2006.05.008

Mikia, M., Mady-Goma, D.I., Tsoumou. A., Mabanza, J., Vouidibio, J. and Diatewa, M. 2013. Preliminary Data on the Ichthyofauna of Djiri River (Affluent of the right bank of Congo River). *International Journal of Environmental Science*. 2(10) : 1-6.

Mustapha, M.K. 2008. Assessment of the water quality of Oyun reservoir, Offa, Nigeria, using selected physicochemical parameters. *Turkish Journal of Fisheries and Aquatic Sciences*. 8: 309-319.

Narayan, R., Saxena, K.K. and Chauhan, S. 2007. Limnological investigations of Texi temple pond in district Etawah (U.P.). *Journal of Environmental Biology.* 28(1): 155–157.

Nie, J., Feng, H. and Witherell, B.B. 2018. Causes, Assessment, and Treatment of Nutrient (N and P) Pollution in Rivers, Estuaries, and Coastal Waters. *Current Pollution Reports.* 4 : 154–161. https://doi.org/10.1007/s40726-018-0083-y

Pethiyagoda, R. 1994. Threats to the indigenous freshwater fishes of Sri Lanka and remarks on their conservation. *Hydrobiologia.* 285 : 189-201.

Prepas, E. 2011. Total Dissolved Solids as a Predictor of Lake Biomass and Productivity. *Canadia Journal of Fisheries and Aquatic Sciences.* 40 : 92-95. https://doi.org/10.1139/f83-015

Rao, M.V.S., Rao, D.V. and Andrews, B.S.A. 2012. Assessment of quality of drinking water at Srikurmam in Srikakulam district, Andhra Pradesh, India. *International Journal of Environmental Science.* 1(2): 13–20.

Rahman, M., Hoque, M., Rahman, M. and Nahar, A. 2017. Exploration of fishing gear and fisheries diversity of Agunmukha River at Galachipa Upazila in Patuakhali District of Bangladesh. *Iranian Journal of Fisheries Sciences.* 16 : 108-126.

Kumar, R., Raina, A. and Sharma, N. 2019. Dataset on water quality characteristics of a hill stream in Bhaderwah, Jammu and Kashmir. *Data in Brief.* 26: 104462. https://doi.org/10.1016/j.dib.2019.104462

Shinde, S.E., Pathan, T.S., Raut, K.S., More, P.R. and Sonwane, D.L. 2010. Seasonal variations in physicochemical characteristics of Harsool Savangi dam, Aurangabad, India. *The Eco Scan.* 4(1) : 37–44.

Singh, D.K. and Singh, I. 2008. Interrelationship of certain physicochemical parameters with plankton community of Motipur Ox-bow lakes (Muzaffarpur, Bihar). *Environment and Ecology.* 26(2) : 800-803.

Subin, M.P., Anitha, C.T. and Sidhimol, P.D. 2011. The study of water quality of Tripunithura, a city suburb of Ernakulam district in Kerala, India. *Nature Environment and Pollution Technology.* 10: 583-588.

Svobodova, Z. 1993. Food and Agriculture Organisation of the United Nations and European Inland Fisheries Advisory Commission. Water quality and fish health. Rome: Food and Agriculture Organisation of the United Nations.

Talwar, P.K. and Jhingran, A.G. 1991. *Inland Fishes of India and Adjacent Countries.* Oxford and IBH Publishing Company Pvt. Ltd., New Delhi.

Tripathy, M. 2012. Biodiversity of Chilika and its conservation, Odisha, India, International Research. *Journal of Environmental Sciences.* 1(5) : 54-57.

Tripathy, P.K. and Adhikary, S.P. 1990. Preliminary studies on the water pollution of river Nandira. *Indian Journal of Environmental Health.* 32(4) : 363-368.

Tucker, C.S. 1991. Water quantity and quality requirements for channel catfish hatcheries.

Ekwenye, U.K. and Oji, C.A. 2008. Quality of water from boreholes in Umualia, Nigeria. *Environment and Ecology*. 26 : 543-545.

Williamson, C., Dodds, W., Kratz, T. and Palmer, M. 2008. Lakes and streams as sentinels of environmental change in terrestrial atmospheric processes. *Frontiers in Ecology and the Environment.* 6 : 247-254. https://doi.org/10.1890/070140

Wurts, W. and Durborow, R. 1992. Interactions of pH, Carbon Dioxide, Alkalinity and Hardness in Fish Ponds. Southern Regional Aquaculture Centre Publication. 464.

Yousuf, T., Ibrahim, M., Majid, H., Ahmad, J. and Vyas, V. 2012. Ichthyofaunal diversity of Halali Reservoir, Vidisha, Madhya Pradesh. *International Journal of Scientific and Research Publications.* 2(12) : 1–7.