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Hydrobiological Influences on Ornamental Fish Diversity in Adda-holé and Kempu-holé Rivers, Western Ghats of Karnataka

Pritham Srinivasan* and Usha Anandhi
Department of Zoology, Bangalore University, Bengaluru, India

Abstract:- The *Adda-holé* and *Kempu-holé* rivers are formed by a network of numerous creeks that originate from the dense hilly forests in Gundia region and are an integral part of Western Ghats of Karnataka. Water samples were collected from the two rivers for three consecutive seasons – summer, monsoon and winter for physico-chemical analysis and fish sampling was also done. The results revealed that the hydrobiology of *Adda-holé* is more favourable for supporting the diversity of freshwater ornamental fishes including the endemic species, whereas the attributes of *Kempu-holé* made it less favorable for freshwater ornamental fishes. A total of 24 species under 14 families, 8 orders and 22 genera were recorded from the *Adda-holé* and *Kempu-holé* rivers, of which 4 species are endangered. The study has revealed that the habitat alterations have effects on the fish diversity and population in the given area.

Keywords:- *Western Ghats, Ornamental fishes, Adda-holé, Kempu-holé, Diversity, Endemics.*

I. INTRODUCTION

The hills and the undulating valleys of Western Ghats area gives rise to a large number of torrential hill streams, which lead to formation of bigger rivers. The *Adda-holé* river which is an important tributary to *Kempu-holé* originates from the hills known as Ombathu Gudda (9 hills) and flows downwards about 20 Kms towards the Gundia cross and joins the *Kempu-holé* river (also known as Gundia river). *Kempu-holé* is a tributary of river Kumaradhara which itself is a tributary of major Nethravathi river, a west flowing river of Karnataka State. The average annual rainfall received in this area is recorded to be 5000mm thus Gundia region is also considered as a major catchment which feeds the Nethravathi river. These streams have evolved over time and the form of the channel tends to balance the energy flow that is characteristic of the system, so that the channel is relatively stable even though it may be altered by flood flows (Mount, 1995). Arunachalam (2000, 2007) and Bhat (2003) have studied fish diversity in Western Ghats and Shahnawaz and Venkateshwarlu (2009) have reported the presence of a distinct relationship between fish diversity and water quality in Bhadra river, Western Ghats. The area is very important from the point of view that it comprises of rich ecology with diverse flora and fauna which in-turn supports the sustenance of many indigenous ornamental fishes (Sreekantha, 2013) (Sahyadri- Mathsya (http:// www.ces.iisc.ernet.in/biodiversity/ Sahyadri_enewsnewsletter/issue17/main_index.htm).

Earlier studies on physico-chemical estimations of *Adda-holé* conducted by Anandhi *et al*, (2013) have revealed that *Adda-holé* is an important stream for ornamental fish diversity, but however no comprehensive work has been done yet to explore and compare the fish diversity, seasonal variations and physico-chemical parameters of *Adda-holé* with its adjoining *Kempu-holé*. With the growing threat to the freshwater fishes and habitats in the form of anthropological interventions and growing economy, it is necessary to understand the existing diversity of fishes and their stream health in order to conserve them.

II. MATERIALS AND METHODS:

➢ *Study Area*

Adda-holé river in Kabbinale forest and *Kempu-holé* river in Kombar forest range (both under Hassan District, Sakleshpur range) were selected for the present study. *Adda-holé* river is located along the NH48 main road (12^0 83’ 79 00”N, 75^0 56’ 31 96”E) where it also merges with the larger *Kempu-holé*. *Adda-holé* is formed by the merger of two smaller rivers namely Shishila holé on western side and another unnamed river flowing through the dense hilly forest of Kumarahalli and Mugilagiri hill region. Both these rivers combine to form the *Adda-holé* which flows downwards in the pristine forest for about 10 Kilometers until it merges with the *Kempu-holé* river. The *Adda-holé* is also directly fed by many smaller first order and second order streams (Fig.1) along its entire stretch.

The *Kempu-holé* is an extension of the *Yettina-holé* river which is formed of drainage from the ranges – *Yettina-holé*, *Kadumane-holé*, *Keri-holé* and *Hongada halla* catchment. The *Yettina-holé* river originates at an altitude of 950 meters in Sakleshpura taluk of Hassan district. *Yettina-holé* catchment extends from 12 44’N to 12 58’N Latitude and 75 37’E to 75 47’E longitude and encompasses a total area of 179.68 km^2 (Ramachandra *et al*,2015). Different types of habitat have been observed and assessed as per the methods described by Pusey *et al*, (1993).

➢ *Sampling Methods*

Both the rivers were divided into two portions each comprising of upper portion and lower portion which were considered as study sites. In total 2 sites were made in *Adda-*

holé and were designated as AD-1 & AD-2, where AD-1 was the upstream region and AD-2 was the downstream region. Similarly, 2 sites were designated in *Kempu-holé* as KH-1 & KH-2, where KH-1 was the upstream region and KH-2 was the downstream region (Fig-1). The waters samples were collected from different locations mentioned for three seasons (summer, monsoon and winter) of 2016 - 2018. Water temperature was measured using handheld thermometer in field *per se* at each study site. pH, Turbidity, Total Dissolved Solids, Total Alkalinity, Conductivity, Dissolved Oxygen, Potassium, Phosphate, Biological Oxygen Demand, Chemical Oxygen Demand were estimated by using the standard methods (APHA 1995 and 2012).

The fish sampling was done were done fortnightly by surveying the upstream region of sites AD-1 & KH-1, to the downstream regions of AD-2 & KH-2. Thorough survey was done at multiple points within each portion of the designated site. The survey was also extended to the point where the river *Adda-holé* merges with the larger *Kempu-holé* river. Different types of fishing nets such as dip nets, cast nets, drag nets and sienne nets were used according to the type of fish (Abraham & Kelkar, 2012). Snorkeling methods were used for capture and study of bottom dwellers and scavenging species such as loaches. The fishes were collected, examined and identified by following the keys prescribed by Jayaram (1999, 2010) and Talwar & Jinghran (1991).

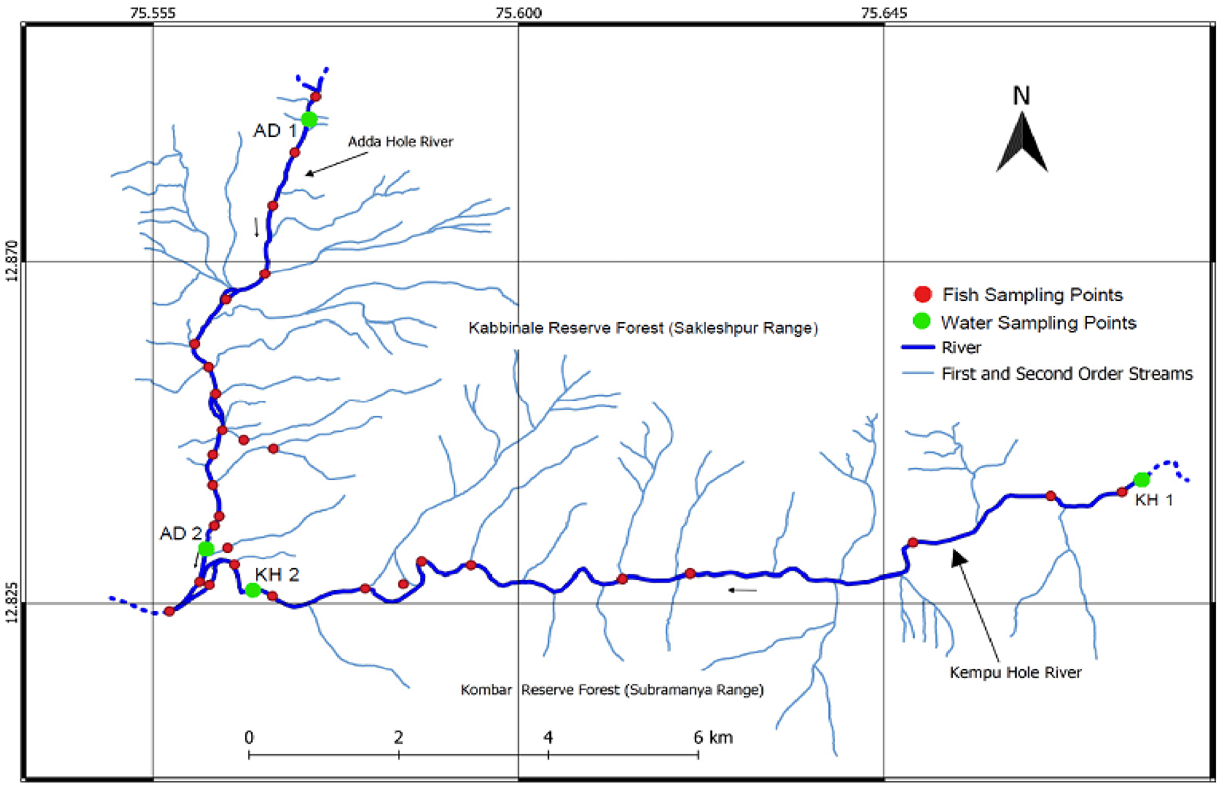

Fig-1: Map showing the location and flow of *Adda-holé* and *Kempu-holé* rivers along with their tributaries.

III. RESULTS AND DISCUSSION

In the present study, a total of 24 species from 8 orders and 14 families have been recorded (Table-1). Among 8 Orders, Cypriniformes (50%) was found to be predominant dominant followed by Perciformes (17%), Siluriformes (13%), while Anguliformes, Beloniformes, Cyprinodontiformes, Synbranchiformes, Tetraodontiformes were found to be 4%. Order Cypriniformes was dominant in the study area and family Cyprinidae showed a significant diversity. Anandhi *et al*, (2013) reported that Cyprinidae family was the predominant species in rivers and streams of Western Ghats. Out of 24 endemic species identified, 4 species *viz, Etroplus canarensis, Mystus irulu, Pseudolaguvia lapillicola and Carinotetraodon imitator* have a restricted range and were found to be having a very narrow range of distribution and hence are endemic to Western Ghats (Britz and Kotellat, (1999), Vijayakrishnan *et al*, (2022). The study has shown that cyprinids were the most widely distributed group throughout the study area. The results are in conformity with Naheed *et al*. (1988) and Jingran (1991). It was observed that the number of fishes per sampling season and the sum total of fishes was higher in the sites AD-1 and AD-2 (*Adda-holé*) when compared to sum total of fishes sampled in sites KH-1 and KH-2 (*Kempu-holé*) as shown in Table-1 and Table-2.

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Table 1: Fishes documented in sampling sites of *Adda-holé* and *Kempu-holé* river.

Sl. No	**Common Name**	**Scientific name**	**Family**	**AD 1**	**AD2**	**KH1**	**KH2**	**IUCN STATUS**
1	Indian longfin eel	*Anguilla bengalensis* (Gray, 1831)	Anguillidae	–	+	–	+	**NT**
2	Freshwater gar fish	*Xenentodon cancila* (Hamilton, 1822)	Belonidae	+	–	–	+	LC
3	Jerdon's Baril	*Barilius canarensis* (Jerdon, 1849)	Cyprinidae	+	+	+	+	**EN**
4	Western Ghats loach	*Bhavania australis* (Jerdon, 1849)	Balitoridae	+	+	–	–	LC
5	Exclamation barb	*Dawkinsia filamentosa* (Valenciennes, 1844)	Cyprinidae	+	+	+	+	**EN**
6	Giant danio	*Devario aequipinnatus* (McClelland, 1839)	Cyprinidae	+	+	+	+	LC
7	Stone sucker	*Garra mullya* (Sykes, 1839)	Cyprinidae	+	+	+	+	LC
8	Melon barb	*Haludaria fasciatus* (Jerdon, 1849)	Cyprinidae	+	+	+	+	LC
9	-	*Mesonoemacheilus petrubanarescui* (Menon, 1984)	Nemacheilidae	+	+	–	–	**EN**
10	Zodiac loach	*Mesonoemacheilus triangularis* (Day, 1865)	Nemacheilidae	+	+	–	+	LC
11	Narayani barb	*Pethia setnai* (Hora, 1937)	Cyprinidae	+	+	+	+	LC
12	Blackline rasbora	*Rasbora daniconius* (Hamilton, 1822)	Cyprinidae	+	+	+	+	LC
13	Razorbelly minnow	*Salmophasia boopis* (Day, 1874)	Cyprinidae	+	+	–	–	LC
14	Denisoni loach	*Schistura denisoni* (Day, 1867)	Nemacheilidae	+	+	+	+	LC
15	Striped panchax / Killi fish	*Aplocheilus lineatus* (Valenciennes, 1846)	Aplocheilidae	+	+	–	+	LC
16	Dwarf snake-head	*Channa gachua* (Hamilton, 1822)	Channidae	+	+	–	+	LC
17	Canara pearlspot	*Etroplus canarensis* (Day, 1877)	Cichlidae	+	+	+	+	**EN**
18	Indian glassy fish	*Parambassis ranga* (Hamilton, 1822)	Ambassidae	+	+	–	–	LC
19	Malabar leaf fish	*Pristolepis marginata* (Jerdon, 1849)	Nandidae	+	+	+	+	LC
20	-	*Mystus irulu* (Vijayakrishnan and Praveenraj, 2022)	Bagridae	–	+	–	–	**Not Evaluated**
21	Wynaad mystus	*Mystus montanus* (Jerdon, 1849)	Bagridae	+	+	–	–	LC
22	Freshwater cat fish	*Pseudolaguvia lapillicola* (Britz, Ali & Raghavan, 2013)	Sisoridae	+	–	–	–	**Not Evaluated**
23	Spiny eel	*Mastacembelus armatus* (Lacépède, 1800)	Mastacembelidae	+	+	+	+	LC
24	Dwarf puffer	*Carinotetraodon imitator* (Britz & Kottelat, 1999)	Tetraodontidae	+	+	+	+	**DD**

(AD – Adda-holé 1 & 2, KH – Kempu-holé 1 & 2; DD-Data Deficient, LC-Least Concern, NT-Near Threatened, VU-Vulnerable, EN-Endangered, + Presence, - Absence)

Table 2: Total numbers of fishes sampled at sites AD-1, AD-2, KH-1, KH-2 between 2016 to 2018:

Scientific name	**2016 AD1**	**2016 AD2**	**2016 KH1**	**2016 KH2**	**2017 AD1**	**2017 AD2**	**2017 KH1**	**2017 KH2**	**2018 AD1**	**2018 AD2**	**2018 KH1**	**2018 KH2**
Anguilla bengalensis	0	0	0	0	0	0	0	0	0	2	1	0
Xenentodon cancila	13	10	0	0	16	22	0	0	10	29	0	3
Barilius canarensis	68	59	23	31	72	80	29	45	60	98	35	36
Bhavania australis	8	0	0	0	5	0	0	0	8	0	0	0
Dawkinsia filamentosa	56	48	30	36	48	57	36	48	53	66	22	40
Devario aequipinnatus	58	55	22	38	62	76	28	33	66	84	29	29
Garra mullya	56	62	29	40	54	59	32	53	62	78	40	59
Haludaria fasciatus	63	58	49	55	60	68	43	60	71	60	34	58
Mesonoemacheilus petrubanarescui	35	28	0	0	26	24	0	0	33	36	0	0
Mesonoemacheilus triangularis	43	40	0	0	51	49	0	0	36	54	0	6
Pethia narayani	52	60	40	51	67	74	40	42	55	61	30	50
Rasbora daniconius	88	93	71	76	106	122	68	93	92	101	55	107
Salmophasia boopis	0	0	0	0	0	5	0	0	0	9	0	0
Schistura denisoni	58	71	28	33	60	59	23	29	73	48	20	32
Aplocheilus lineatus	29	33	0	13	22	25	0	19	33	34	0	16
Channa gachua	22	31	0	37	16	44	0	30	18	33	0	48
Etroplus canarensis	37	41	9	19	44	44	10	22	52	25	8	15
Parambassis ranga	15	10	0	0	10	15	0	0	9	12	0	0
Pristolepis marginata	33	39	8	31	48	37	0	28	22	35	15	41
Mystus irulu	0	1	0	0	0	0	0	0	0	1	0	0
Mystus montanus	6	4	0	0	3	3	0	0	3	2	0	0
Pseudolaguvia lapillicola	0	0	0	0	1	0	0	0	0	0	0	0
Mastacembelus armatus	4	6	2	4	8	16	0	8	4	21	0	12
Carinotetraodon imitator	34	39	0	0	24	24	2	13	39	26	3	16
Total	**778**	**788**	**311**	**464**	**803**	**903**	**311**	**523**	**799**	**915**	**292**	**568**

(AD-1: Adda-holé 1, AD-2: Adda-holé 2, KH-1: Kempu-holé 1, KH-2: Kempu-holé 2).

The results of the physico-chemical parameters provided in Table 3 (a,b,c&d) have revealed that the mean pH of all the four sites varied between the range of 6.5 to 8.4. The high scale pH of 6.5 was recorded from the site AD-1 in winter of 2018, while the lowest scale pH of 8.4 was also recorded in AD-1 during monsoon season of 2017 and 2018. The pH which regulates the acidic or basic characteristics is a vital property of any aquatic ecosystem since all the biochemical functions and retention of physicochemical attributes of the waters greatly depend on pH of the surrounding environments (Jalal and Sanalkumar, 2012).

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Table - 3(a): Mean of physicochemical water parameters of AD-1 for three years:

Sl. No	Year		2016	2016	2016	2017	2017	2017	2018	2018	2018
	Parameters ↓	**Season →**	**Winter**	**Summer**	**Monsoon**	**Winter**	**Summer**	**Monsoon**	**Winter**	**Summer**	**Monsoon**
1	pH		6.9	7.2	8.4	6.9	6.7	8.4	6.5	6.5	8
2	Water Temperature (^{0}C)		24	33	27	25.7	29.8	27	24.2	32	28
3	Turbidity NTU		0.6	0.4	0.8	0.5	0.5	0.6	0.5	0.3	0.6
4	Total Dissolved Solids (mg/L)		35	45	23	33	40	24	34	48	20
5	Total Alkalinity as CaCo3 (mg/L)		19	24	9	20	24	9	19	23	8
6	Conductivity @ 25˚C µmhos/c		43	58	33	56	62	30	43	58	33
7	Dissolved Oxygen (mg/L)		7.1	5	5.8	7.6	6.2	6.8	7.1	6	6.6
8	Potassium as K (mg/L)		2	1	0.7	2.8	2	1.2	2	1	0.7
9	Phosphate as PO4 (mg/L)		0.2	0.3	0.1	0.4	0.6	0.2	0.2	0.2	0.1
10	Biochemical Oxygen Demand, 3 days @ 27˚C (mg/L)		2	3	4.2	1.8	3	3.9	1.8	3	6
11	Chemical Oxygen Demand as O2 (mg/L)		7	10	6	5	8.5	6	4.2	8	3.6

Table - 3(b): Mean of physicochemical parameters of AD-2 for three years:

Sl. No	Year		2016	2016	2016	2017	2017	2017	2018	2018	2018
	Parameters↓	Season →	Winter	Summer	Monsoon	Winter	Summer	Monsoon	Winter	Summer	Monsoon
1	pH		7.2	6.9	7.8	7	6.9	7.7	7.2	6.7	7.8
2	Water Temperature (^{0}C)		24.03	31.9	26.9	25.7	29.9	26.9	24	32	28.1
3	Turbidity NTU		0.5	0.9	0.9	1	0.9	1.1	1.2	1	2
4	Total Dissolved Solids (mg/L)		39	45	22	42	39	20	28	30	25
5	Total Alkalinity as CaCo3 (mg/L)		21	24	9	22	26	8	23	28	10
6	Conductivity @ 25˚C µmhos/c		49	57	32	47	52	38	42	49	36
7	Dissolved Oxygen (mg/L)		6.9	6	6.5	6.1	6.1	7.2	6.1	6	7.8
8	Potassium as K (mg/L)		1	2	0.4	0.5	0.5	0.8	0.8	0.5	0.4
9	Phosphate as PO4 (mg/L)		0.2	0.3	0.5	0.2	0.3	0.5	0.2	0.2	0.4
10	Biochemical Oxygen Demand, 3 days @ 27˚C (mg/L)		2.5	2	3.6	1	2	4.8	0.9	1.8	5.5
11	Chemical Oxygen Demand as O2 (mg/L)		6.3	9	7	6	7	8	5.8	6.5	6

Table - 3(c): Mean of physicochemical parameters of KH-1 for three years:

Sl. No	Year		2016	2016	2016	2017	2017	2017	2018	2018	2018
	Parameters ↓	Season →	Winter	Summer	Monsoon	Winter	Summer	Monsoon	Winter	Summer	Monsoon
1	pH		7.2	7.7	7.6	6.8	7.6	7.7	7	7.5	7.5
2	Water Temperature (^{0}C)		24.07	31.9	26.85	25.5	29.9	27	24.4	32.6	28
3	Turbidity NTU		30.9	3	1.6	31	4	1.8	29	7	2.9
4	Total Dissolved Solids (mg/L)		55	65	24	56	67	23	58	62	26
5	Total Alkalinity as CaCo3 (mg/L)		29	52	10	30	54	13	28	48	11
6	Conductivity @ 25˚C µmhos/c		71	90	37	73	95	41	73	68	40
7	Dissolved Oxygen (mg/L)		1.7	4.9	6.2	4.6	4	7	4	4.9	6
8	Potassium as K (mg/L)		8	2	0.5	9	4	1.3	6.5	2.8	0.5
9	Phosphate as PO4 (mg/L)		0.2	0.2	0.3	0.6	0.6	0.5	0.2	0.5	0.4
10	Biochemical Oxygen Demand, 3 days @ 27˚C (mg/L)		17	6	6.5	15	5	5	10	5	8
11	Chemical Oxygen Demand as O2 (mg/L)		45	13	17	44	12.5	15	17.5	7.6	25

Table - 3(d): Mean of physicochemical parameters of KH-2 for three years:

Sl. No	Year		2016	2016	2016	2017	2017	2017	2018	2018	2018
	Site		KH-2								
	Parameters ↓	Season →	Winter	Summer	Monsoon	Winter	Summer	Monsoon	Winter	Summer	Monsoon
1	pH		7	7.7	7.5	7	7.2	7.3	7	7.7	7.5
2	Water Temperature (^{0}C)		25.03	32.9	26.17	25.5	30	27	25.03	32.5	28
3	Turbidity NTU		4.7	1.8	2.9	4.8	2	3.1	4.7	1.8	2.9
4	Total Dissolved Solids (mg/L)		55	55	26	48	53	24	55	55	26
5	Total Alkalinity as CaCo3 (mg/L)		31	41	11	30	40	9	31	41	11
6	Conductivity @ 25˚C µmhos/c		71	74	40	72	73	44	71	74	40
7	Dissolved Oxygen (mg/L)		6.1	6.6	6	6	4.2	7	6.1	6.6	6
8	Potassium as K (mg/L)		6	2	0.5	6.1	3	1.2	6	2	0.5
9	Phosphate as PO4 (mg/L)		0.2	0.6	0.4	0.3	0.7	0.6	0.2	0.6	0.4
10	Biochemical Oxygen Demand, 3 days @ 27˚C (mg/L)		5	2	8	6.1	2.2	8.4	5	2	8
11	Chemical Oxygen Demand as O2 (mg/L)		16	7	25	14.8	6.5	24	16	7	25

It was observed that the pH of all the four sites were within the norms of a pristine water body. The intense vegetation cover and the organic acids derived from plant roots might be contributing to the slight acidic pH in the AD-1. The mean water temperature of all the four sites (AD-1, AD-2, KH-1 & KH-2) during winter season ranged between 24^0 C to 25.7^0 C and during monsoon it ranged between 26.1^0 C to 28.1^0 C, whereas in summer the temperature fluctuated between 30^{0}C to 32.1^{0}C. Turbidity at the sites AD-1 and AD-2 was found to be very minimal and negligible in comparison with the turbidity values of sites KH-1 and KH-2. The lowest mean turbidity value of *Adda-holé* was found to be at 0.3 mg/l, while the highest mean in the stream was 1.2 mg/L. Whereas the turbidity values of *Kempu-holé* was on a slightly higher side in comparison ranging from the lowest mean of 3 mg/L to 31 mg/L. This could be due to mechanical churning and agitation

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of water in a number of hydro-electric power project dams in the upstream region of *Kempu-holé* which is resulting in cloudiness due to suspended particles. The aquatic plants which are the primary producers in an aquatic ecosystem acts as a measurable indicators of the ecological conditions of surface waters. Thus increase in turbidity leads to decrease in light transmission, which leads to changes in community structure and reduction in aquatic vegetation diversity and depth (Middleboe and Markager, 1997; Duarte *et al*, 1986; Chambers and Kalff, 1985). Notably, the submerged species which are strongly dependent on water quality have proved to be vulnerable to changes in aquatic environment (Robach *et al*, 1996; Dawson *et al*, 1999), leading to reduction of lower aquatic animals such as the invertebrates, zooplanktons and free swimming forms which in turn results in deficiency of food for fishes. The turbidity of *Adda-holé* was found to be within the norms of a healthy aquatic habitat whereas the turbidity of *Kempu-holé* was found to be slightly on a higher side in comparison but yet within the norms. Total dissolved solids (TDS) represents the sum total of solids present in the water which may be either dissolved or suspended. In the present study, the TDS levels of *Kempu-holé* was found to be between lowest mean value of 23 mg/L in monsoon season to the highest mean value of 62 mg/L to 68 mg/L in summer seasons. The TDS in *Adda-holé* was found to be at a lowest mean value of 23 mg/L in monsoon and to a higher mean value of 48 mg/L in summer. The maximum mean of alkalinity of *Adda-holé* stream was found to be 28 mg/L, while the maximum mean alkalinity of *Kempu-holé* stream was found to be 52 mg/L.

Fish diversity in any given water body is directly dependent on the Dissolved oxygen (DO) and any interventions which hamper the DO of water will have adverse effect on the fish population. In the study, the DO of AD-1 and AD-2 in general was found to be between 6 mg/L to 7.8 mg/L which is a good indicator. The highest mean DO of 7.1 mg/L was recorded in *Adda-holé*, whereas in KH-1 & KH-2 the DO ranged between 1.7 mg/L to 6 mg/L which is also on par with that of the *Adda-holé* readings. This could be due to the fact that the waters of *Kempu-holé* river flow along the rocky substrate which aids in influx of atmospheric oxygen into the water. However, the DO values of *Adda-holé* river indicates the stream is supportive for healthy fish population. Similar observation was also made by Adebisi, (1981) and Deshmukh and Ambore, (2006).

The phosphate levels of AD-1 and AD-2 was found to be 0.6 mg/L and sites KH-1 and KH-2 were found to be 0.7mg/L. The entry of Phosphate into a water body may be either by runoff, point source or leaching and weathering of igneous and sedimentary rocks (Robards *et al.,* 1994). The common sources for phosphate include leaf debris and other decaying organic material. In both the streams the phosphate levels were within 1 mg/L. Higher Phosphate levels can contribute to algal blooms and oxygen deficiency. Potassium was predominant in the non-monsoon seasons and the mean values of AD-1 and AD-2 ranged between 0.4 mg/L to 2.8 mg/L whereas the mean values of KH-1 and KH-2 were on a higher side ranging between 0.5 mg/L and 9 mg/L. The mean Phosphate levels in AD - 1&2 and KH - 1&2 were found to be between 0.1 mg/L to 0.7 mg/L. The Potassium levels were found to be within the norms of 10mg/L in all the sites which was also in conformity with the works of Reddy *et al*, (2021) and Thippeswamy *et al*, (2008).

The mean specific conductivity values of sites AD-1 and AD-2 ranged between 32 µmhos/c in monsoon to 62 µmhos/c in summer, whereas the same for sites KH-1 and KH-2 ranged between 40 µmhos/c in monsoon to 95 µmhos/c in summer seasons. The maximum mean Biological Oxygen Demand (BOD) of sites AD-I and AD-2 sites were 5.5 mg/L, whereas the maximum mean BOD recorded for KH-1 & KH-2 sites ranged between 10 mg/L 17mg/L. The maximum mean Chemical Oxygen Demand (COD) of AD-1 and AD-2 was 10 mg/L while the maximum COD of sites KH-1 and KH-2 was found to be 45 mg/L. Higher BOD and COD values of *Kempu-holé* may be due to the presence of human settlements and agricultural activity in the downstream region, in addition to various polluting agents from the NH-47 highway which flows along and just beside the *Kempu-holé*. The maximum mean conductivity of *Adda-holé* stream was found to be 62 mg/L while the maximum mean conductivity of *Kempu-holé* stream was found to be 90 mg/L.

High alkalinity, conductivity, BOD and COD combined with low DO levels at site KH-1 and KH-2 have adverse effect on the fish diversity and hence least number of fishes was recorded in *Kempu-holé* river (Table-2). This could also be due to a number of interventions upon the *Kempu-holé* river such as construction of dams and weirs, pollution from vehicles along the nearby highway, pollution from usage of chemical fertilizers and pesticides in irrigated lands, sewage entry from human settlements, motels and other commercial activities in the downstream region of *Kempu-holé*. Also, sometimes the sudden and abrupt water release from the dams creates turbulent flow resulting in high turbidity due to weathering and erosion of substrate. This also leads to river shelf sliding resulting in creation of physical barriers such as tree logging and buildup of heavy boulders and such accumulations which adds up to further unstable environment in an already turbulent stream. The mean values of the parameters in site KH-2 are mildly towards lower side, this is a notable observation and it is probably because the site gives scope for good influx and mixing of waters from *Adda-holé* with the waters of *Kempu-hole* leading to this change.

On the contrary, the *Adda-holé* was a typical pristine stream with good riparian cover and absolutely no entry of pollutants or sewage. The natural flow of the river is not regulated anywhere hitherto, therefore the fish habitats remain undisturbed and acts as a reservoir of many indigenous ornamental fishes which are endemic to the region, the study highlights the contribution of undammed tributaries in replenishing the catchment scale functional connectivity across regulated stream networks (Johnson, 2002). The reservoirs and streams in the Western Ghats provide hospitable habitats, resulting in structured immigration and emigration of these fish species as observed by Sreekantha *et al*, (2002). The study shows that the endemic and endangered species are mostly clinging to the primeval patches of forests which still persist in these human-river juxtaposing areas.

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