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Impact of water quality on the fish composition in Tunga River, Western Ghats, Karnataka, India

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Abstract
The present study of two years of fish composition data from 7 sites in the Tunga River, Western Ghats, Karnataka, India, were examined for relationships with environmental variables using a multivariate approach including Principle Component Analysis, Jaccard Similarity co-efficient and diversity index packages. 67 fish species were recorded representing 6 orders, 16 families and 40 genera and the family cyprinidae was found to be dominant which contributed 36.73 to 96.64%. The study found that there was a quite difference in fish species richness and abundance in selected sampling sites and species richness varied longitudinally in relation to environmental parameters. The fish species richness and abundance were correlated with water quality parameters and it was shown that pH, turbidity and conductivity influence and structure the fish composition in this river system. Therefore, the study would be helpful in suggesting and adopting the sustainable and effective measures to conserve the fish diversity of this river.

Keywords: water quality, fish composition, Tunga River, Western Ghats

1. Introduction

Landscape changes particularly habitat alterations in an aquatic ecosystem poses a serious threat to flora and fauna at increasing rate (Lecis and Norris, 2003) [13]. Moreover, faunal composition is distinctive to geographical areas and its diversity can be interpreted in terms of habitat features (Belanger and Rodriguez, 2002) [5]. Many rivers in the world are regulated that has caused a decline in spatial and temporal habitat heterogeneity (Shields, 1995) [29]. One of the important areas of hydrobiology is the relationship between fish assemblage and their relationships to biotic and abiotic factors. Fish species richness depends on habitat diversity (Gorman and Karr, 1978) [10]; water chemistry, flow regimes, temperature and channel morphology (Schlosser, 1982) [26]. But unfortunately, fish assemblages face tremendous pressure from threatening factors like habitat alteration or destruction, water pollution, over-exploitation, flow modification and incidental introduction of species or genetic strains, which are the main threats to rare and sensitive species (Postel and Richer, 2003; Revenga et *al*., 2005) [21, 25]. Fish assemblage is a heterogeneous group and is used as indicator for aquatic ecosystem health (Moyle, 1994) [17]. Hence, this fish assemblage could be related to water chemistry which can give a complete concept of water quality (Deacon and Mize, 1997). Therefore, saving fish assemblage would be a challenging factor for conservation ecology based on habitat change or destruction, introduction of exotic species as well as climate change. So, physico-chemical parameters are important factors for fish diversity and composition. In addition, different habitat characteristics viz. water temperature, riparian cover, water velocity, pH, conductivity, substrate types, depth and width, altitude and longitude affect the fish diversity and composition (Shahnawaz *et al*., 2010, Li *et al*., 2012) [27, 15]. Though much of the work has been done on freshwater fish diversity of Karnataka state by various workers and to mention recent studies include Arunachalam, 2000; Bhat (2003, 2004) [3, 7, 8]; Vijaykumar *et al*., (2009) [32]; Shahnawaz *et al*., (2010) [27]; Anandhi *et al*., (2013) [1]. However, the study about the fish composition with relation to water quality of Tunga River in particular is lacking. Hence, the current study discusses the relationship between water quality and fish assemblage of Tunga River, Karnataka. This study would help to formulate sustainable strategies to save the fish diversity of this important riverine system of Southern India.

2. Materials and Methods

2.1 Study Area

The Tunga river (Figure 1) has a source of origin called Gangamulla, near Varaha Hills of Western Ghats, Karnataka. The 130 km river Tunga, which flows for about 64.4 km in Shimoga district (Karnataka) with catchment area of 22, 39.4 square km. Its course is at first north-east passes Shringere town to Baggunji, where it turns north-west direction and then continues up to Thirthahalli. It is a medium, perennial river and for most of the year, the river bed flows thinly. The water of this river is a good source for drinking and irrigation purposes. Its banks are not steep and its streams are generally considered as healthier and less disturbed. The Tunga river goes down with twisted direction and meets the Bhadra river at confluence called Kudli Sangam (KS) where they form a Tunga-Bhadra river basin which is a main source of water for adjacent areas. Seven (7) study sites were selected from Shingere (SG) to Pillangere (PG) and the sites were selected based on forest type, habitat features and canopy cover.

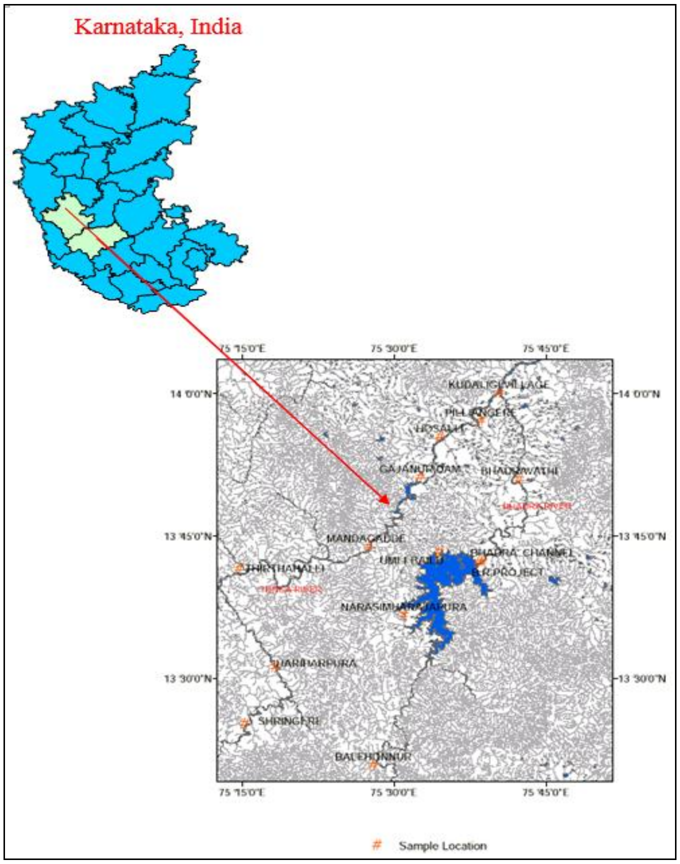

Fig 1: Location of 7 study sites in Tunga river, Western Ghats, Karnataka

2.2 Fish collection and sampling design

Fish sampling and collection was done by using different gill nets of different mesh sizes (10-34 mm) viz. gill nets, cast nets and drag nets and the method of Arunachalam (2000) [3] was used. After collection, fishes were examined and then were released back into the aquatic system after taking few individuals (5-10) which were preserved in buffered formalin (10%) and transported carefully to the laboratory for further analysis. Fishes were identified with the help of keys given by Jayaram (2010) [11] and Talwar and Jhingran (1991) [31]. Water quality characteristics (physico-chemical parameters) were analyzed by using the standard methods (APHA, 1998) [2].

Fish sampling was carried out on 100-150 m stretches of the river at each site. Habitats at each sampling site were analyzed by using Pusey *et al*., (1993) [24] methods. Fish species diversity was analyzed by using different indices viz. species richness (S = number of species); Shannon-Weaver index (1949) [28]; Simpson Dominance Index (Simpson, 1949); Species Dominance Index (Berger and Parker, 1970) [6]; Pielous Evenness (Pielou, 1966) [20].

The mathematical formula of different diversity indices is given as follows:

i) Shannon-Weaver index

H = S/1 = 1 [Sum (Pi) (Log2pi)]

Where, H = Shannon-Weaver index
Sum = Capital epsilon
S = No. of species
Pi = Proportion of individuals of the total sample

ii) Simpson diversity

$$D2 = \sum_{J=1}^{Sn} (nj/n)\ (n-nj/n-1)$$

Where, nj = No. of individuals of the ith species in the sample
$N = \sum_{j} nj$ = total number of individuals in the sample
Sn= No. of species in the sample

iii) Evenness formula

$$V' = \Delta/\Delta\ max$$

Where, V′ = Pielou evenness
V′ = observed value of parameter
Δ max = value parameter would assume if all S species were equally abundant.

The relationship between the water quality parameters and the fish assemblage was analyzed using Principal Component Analysis (PCA) software package.

3. Results

3.1 Fish composition and distribution

During the current study, 67 fish species were recorded in the Tunga river which represents 6 orders, 16 families and 40 genera from 7 study sites (Table 1). The order Cypriniformes was analyzed to be the most dominated group in the fish composition followed by other orders. Fish species represents the family Cyprinidae was observed highest with higher abundance and composition followed by Bagridae (Catfishes), Balitoridae (Loaches) and Siluridae with decreasing order respectively. The fish species have shown remarkable distribution in the river like *Garra mullya* was present in all 7 study sites. While some of the species were present in less abundance and were present only in one site viz. *Tor mussullah*, *Hypsilobarbus lithopidos*, *Amplypharyngodon mola, Etroplus maculatus, Schistura semiarmatus, Aplocheilus lineatus, Puntius sarana subnastus, Lepidocephalus thermalis, Danio rerio, Glyptothorax lonah, Psilorhynchus tenure, Botia straita* and *Danio malabaricus.* While as *Mastacembalus armatus, Mystus armatus* were represented by six sites and *Cyprinus carpio* (exotic species) by 4 sites respectively. Three exotic species like *Oreochromis mossambica, Catla catla* and *Cyprinus carpio cummunis* were found in the lower reaches of the river only.

The comparison of fish species richness between the selected sites of Tunga river is given in Table 1. The high species richness in the river was recorded in the sampling sites viz. Gajanur Dam (GD), Shingere (SG), Hosalli (HS), Pilliangere (PG) and Mandgadde (MG) while as low fish species richness was recorded in the sites like Thirthahalli (TH) and Hariharpura (HH). The different diversity indices are summarized in the Table 2. The higher value for Shannon-Weaver indices was observed at Gajanur Dam (3.368) and lower at Hariharpura (2.788). The evenness value was higher at Hariharpura (0.89) and lower at Thirthahalli (0.65). Similarly, the relative abundance was higher at Gajanur Dam (21.71) and lower at Hariharpura (9.51). Jaccard Similarity Index showed (Table 3) that the species similarity index values were between 0.77 and 0.86. Most of the species in Hosalli (0.86) are similar to the collection from Gajanur Dam followed by Mandgadde (0.84). Mandgadde and Gajanur Dam sites also showed similarity in the species representation (0.77). Shringere and Hosalli sites were dissimilar based on the absence and presence of species in the sample collections. The other sites that were dissimilar from Shringere were Pilliangere and Mandgadde.

Table 1: Diversity, abundance and distribution of fish species in Tunga river, Western Ghats

S. No.	Species	Study Sites							
		1	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
1	*Noptopterus notopterus*	0	0	3	15	20	12	7	57
2	*Xenentodon cancilla*	0	0	0	4	5	2	0	11
3	*Mystus cavasius*	0	0	5	17	23	16	22	83
4	*Sperata (Aorichthys) oar*	0	0	0	7	5	4	2	18
5	*Sperata (Aorichthys) seenghala*	0	0	0	4	10	6	0	20
6	*Osteobrama neilli*	0	10	0	0	4	4	0	18
7	*Osteobrama cotio peninsularis*	0	7	0	4	5	2	0	18
8	*Mastacembalus armatus*	0	3	2	9	10	4	4	32
9	*Puntius chola*	5	10	7	0	4	0	0	26
10	*Puntius sophore*	3	6	9	0	2	0	0	20
11	*Heteropneustus fossilis*	0	0	0	4	9	4	2	19
12	*Mystus armatus*	0	2	1	5	7	6	10	31
13	*Salmostoma boopis*	3	6	7	0	0	0	0	16
14	*Salmostoma sardinella*	8	4	10	35	0	0	0	57
15	*Cyprinus carpio*	0	0	0	7	23	8	4	42
16	*Cirrrhinus fulungee*	0	0	0	26	30	12	10	78
17	*Cirrrhinus reba*	0	0	0	13	12	7	5	37
18	*Ompok bimaculatus*	0	0	0	14	20	19	9	62
19	*Hypselobarbus kolus*	0	0	0	10	14	5	7	36
20	*Ompok pabo*	0	0	2	21	12	7	5	47
21	*Catla catla*	0	0	0	2	10	1	0	13
22	*Rohtee ogilbii*	5	13	3	0	0	0	0	21
23	*Labeo calbasu*	0	0	0	7	9	3	3	22
24	*Labeo rohita*	0	0	0	5	8	5	2	20
25	*Cirrrhinus mrigala*	0	0	0	3	7	2	0	12
26	*Puntius arulius*	11	6	3	0	0	0	2	22
27	*Danio malabaricus*	0	0	46	0	0	0	0	46
28	*Danio aequipinatus*	5	3	17	0	0	0	0	25
29	*Botia straita*	0	0	0	0	0	0	1	1
30	*Clarius batrachus*	0	0	0	9	10	6	4	29
31	*Balitora mysorensis*	5	0	0	0	7	0	0	12
32	*Tor khudree*	10	4	0	0	0	0	0	14
33	*Psilorhynchus tenure*	11	0	0	0	0	0	0	11
34	*Osteochilichthys nashii*	18	11	4	0	0	0	0	33
35	*Osteochilichthys thomassi*	14	7	0	0	0	0	0	21
36	*Garra bicornuta*	0	0	0	4	6	3	8	21
37	*Garra mullya*	14	6	19	5	8	20	26	98
38	*Oreochromis mossambica*	0	0	0	7	13	5	6	31
39	*Channa punctatus*	0	0	4	5	3	3	2	17
40	*Channa marulius*	0	0	0	5	7	4	2	18
41	*Glossogobius guiris*	0	0	0	8	12	4	3	27
42	*Puntius jerdoni*	2	0	0	0	3	0	0	5
43	*Rita gogra*	0	0	0	3	6	5	4	18
44	*Rita pavimentatus*	0	0	0	0	5	4	3	12
45	*Proeutrophichthys taakree*	0	0	0	0	6	5	2	13
46	*Puntius amphibious*	6	0	10	0	0	0	0	16
47	*Puntius ticto*	1	0	4	0	0	0	0	5
48	*Puntius sahyadrensis*	7	4	18	0	0	0	0	29
49	*Barilius canarensis*	13	6	7	0	0	0	0	26
50	*Barilius gatensis*	3	0	2	0	0	0	0	5
51	*Barilius bendelisis*	10	13	16	0	0	0	0	39
52	*Glyptothorax lonah*	5	0	0	0	0	0	0	5
53	*Rasbora daniconius*	19	10	18	0	0	0	0	47
54	*Nemachilichthys rueppelli*	2	4	0	0	0	0	0	6

55	*Danio rerio*	30	0	0	0	0	0	0	30
56	*Lepidocephalus thermalis*	1	0	0	0	0	0	0	1
57	*Puntius filamentosus*	3	4	2	0	0	0	0	9
58	*Puntius sarana sabnastus*	3	0	0	0	0	0	0	3
59	*Aplocheilus lineatus*	2	0	0	0	0	0	0	2
60	*Schistura semiarmatus*	2	0	0	0	0	0	0	2
61	*Etroplus maculatus*	0	0	0	0	0	0	2	2
62	*Amplypharyngodon mola*	2	0	0	0	0	0	0	2
63	*Neotropius khavalchor*	0	0	0	0	0	5	0	5
64	*Hypselobarbus thomassi*	6	3	0	0	0	0	0	9
65	*Hypselobarbus lithopidos*	0	7	0	0	0	0	0	7
66	*Tor mussullah*	4	0	0	0	0	0	0	4
67	*Parambassis thomassi*	0	0	0	4	5	3	2	14

Study sites: 1. Shringere 3. Thirthahalli 5. Gajanur Dam 7. Pilliangere 2. Hariharpura 4. Mandgadde 6. Hosalli

Table 2: Different fish diversity indices of Tunga River, Western Ghats

Indices	Study Sites						
	Shringere (SG)	Hariharpura (HH)	Thirthahalli (TH)	Mandgadde (MG)	Gajanur Dam (GD)	Hosalli (HS)	Pilliangere (PG)
No. of Species (Taxa)	33	23	25	29	35	32	29
No. of individuals	237	149	221	262	340	196	161
Relative abundance	15.13	9.51	14.11	16.73	21.71	12.51	10.28
Dominance_D	0.0533	0.0539	0.0863	0.058	0.0409	0.049	0.0702
Shannon_H	3.18	2.788	3.019	3.098	3.368	3.235	2.999
Evenness_e′H/S	0.7289	0.89	0.65	0.7636	0.8289	0.794	0.6922

Table 3: Jaccard similarity co-efficient of fish density among 7 sites of Tunga river, Western Ghats

Study sites	Shringere	Hariharpura	Thirthahalli	Mandgadde	GajanurDam	Hosalli	Pilliangere
Shringere	0						
Hariharpura	0.47	0					
Thirthahalli	0.45	0.54	0				
Mandgadde	0.03	0.10	0.17	0			
Gajanur Dam	0.07	0.13	0.17	0.77	0		
Hosalli	0.01	0.1	0.14	0.84	0.86	0	
Pilliangere	0.03	0.08	0.17	0.65	0.64	0.69	0

3.2 Environmental Variables

The water quality parameters of 7 study sites in Tunga river is depicted in the Table 4. Air temperature ranged between 28 to 36 °C among the study sites. Water temperature was slightly lower in Gajanur Dam and Shringere sites when compared to other sites. The pH was alkaline in nature in all the study sites (6.8 to 7.4 mg/l). The range of DO varied between 6.5 mg/l (Hosalli) to 9.4 mg/l (Hariharpura). Higher values of hardness as 40 mg/l were recorded in Hosalli and lower values of 16 mg/l were recorded in Mandgadde. The range of alkalinity and conductivity values varied from 12 mg/l (Thirthahalli) to 30 mg/l (Mandgadde) and 0.075 (Shringere) to 0.147 µ/mhos (Hosalli) respectively.

The results of environmental variables were subjected to Principal Component Analysis (Fig. 2) program which showed significant variance between study sites. The first two axes of the PCA accounted for 76% of the variance among study sites (Table 5). Studied water quality parameters showed significant association among study sites. Air temperature has shown variation along the altitude and other unidentified environmental factors. Fish diversity was found to be inversely proportional to turbidity level, lower the turbidity, higher the fish diversity.

Table 4: Water quality parameters of study sites in Tunga river, Western Ghats

Sl. No	Location	Air temp. (C°)	Water temp. (C°)	pH	Dissolved Oxygen (mg/l)	Total Hardness (mg/l)	Alkalinity (mg/l)	Conductivity (mhos/cm)
Tunga river								
1	Shringere	34	24	7.4	6.7	23	28	0.075
2	Hariharpura	28	25	7.2	9.4	32	18	0.078
3	Thirthahalli	35	25	6.9	7.9	31	12	0.132
4	Mandgadde	31	27	6.8	8.2	16	30	0.111
5	Gajanur Dam	33	24	6.8	7.2	35	14	0.076
6	Hosalli	36	26	7.1	6.5	40	13	0.147
7	Pilliangere	34	28	7.3	6.9	17	17	0.104

Table 5: Principal component analysis of water quality parameters studied from Tunga river

Variables	Component I	Component II	Component III
Air temperature	0.36	-0.29	-0.55
Water temperature	-0.03	0	0
pH	-0.12	-0.13	0.06
DO	-0.28	-0.05	0.22
Hardness	0.45	0.2	-0.1
Alkalinity	0.01	0.45	0.42
Conductivity	0.34	0.31	0
Stream mean width	-0.19	0.44	-0.4
Stream mean depth	-0.35	0.18	-0.47
Turbidity	0.23	0.36	0.04
Riparian cover	-0.33	-0.15	-0.05
Mean flow	0.31	-0.39	0.16
Eigen values	2.38	1.50	1.21
% of variance	31.8	20.1	16.2

Note: Values bold are significant

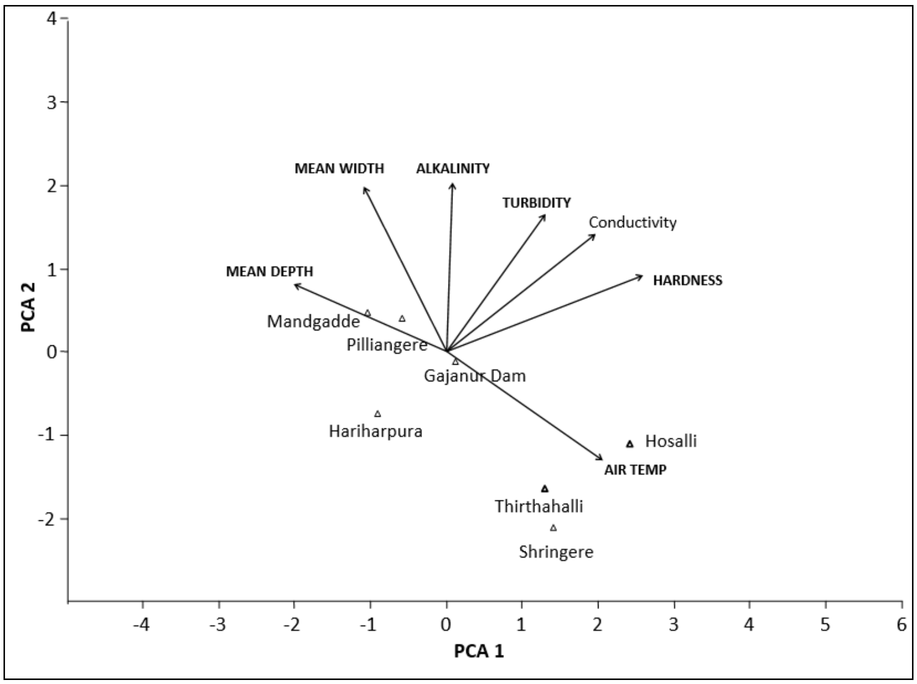

Fig 2: Principal Component Analysis (PCA) for environmental variables and sampling sites in Tunga river

4. Discussion

The high fish diversity in freshwater streams/rivers of Karnataka part of Western Ghats is co-related to the protected areas/sanctuaries (Muralidharan, 2008) [18]. There was a quite difference in fish species richness and abundance in selected sampling sites as they reflect different water chemistry, habitat structure and land use pattern. Species and abundance wise, the family Cyprinidae was observed most dominant. Shahnawaz *et al.*, (2010) [27] made the same and important observations from the Bhadra river of Western Ghats. The dominant nature of cyprinid fishes is because of their extensive use of habitats heterogeneous, (Bhat, 2004) [8] and also adaptive variability (Johnson and Arunachalam, 2009) [12]. During the present study, we found that the family Bagridae and Balitoridae were also dominant but next to family Cyprinidae. The results are in conformity with other studies (Shahnawaz *et al.*, 2010; Bhat, 2003) [27, 7]. Low species richness at HH (23) may be because of physical barrier as it is important for fish movement and it is one of the important factors for fish species richness and abundance (Arunachalam *et al*., 1997) [4]. The retardation in fish species richness may be because of other factors viz. over fishing, dynamiting, habitat destruction etc. The study has also shown a continuous distribution of fish diversity from upstream to downstream but with a gradual increase in taxa composition towards downstream sites. At Shringere (SG) site also, more species richness was found, as this stretch of the river is protected in the form of sanctuary. Such type of observation is evidenced from other studies also. The lower altitudes harbor more species richness (Gaston, 2000) [9]; wider the river size, the higher the species richness (Zalewski and Naiman, 1985) and wider the habitat area, the higher the species richness (Lennon *et al*, 2001) [14].

The environmental variables are important for structuring the fish composition in the riverine ecosystem and have direct impact on fish diversity (May and Brown, 2002) [16]. The mean value of temperature in water was found to be lower than air temperature and it is related to less heating of the river system (Lotic system). The other physical parameters like pH, turbidity and conductivity have direct influence on fish composition but during the current study, all these parameters were under permissive limit except Hosalli (HS). At this sampling site (HS), conductivity value (0.147 mhos/cm) was slightly increased and dissolved oxygen (6.5 mg/l) was also slightly acidic. This could be related to residential sewage as it was noticed at this site. The same observation was made by Oliveira (2004) [19] and Prabhakar *et al.,* (2012) [23]. The alkalinity was under permissive limit at all sampling sites. This might be because of the reason that no industry was located on the river bank. Thus, from the above discussed results, it is evident that water chemistry is co-related to fish distribution and abundance (Pouilly *et al*., 2006) [22]. The present study has shown slight variations in fish species richness at sampling sites. This could be because of altered habitats like pools, riffles, cascades, physical instability (Shahnawaz *et al.*, 2010) [27].

Therefore, it can be concluded from the current study that the River Tunga supports good heterogeneous fish diversity particularly *Tor* and other fish species like loaches. To save such a fish diversity, protection and restoration of natural habitat is mandatory and should be the priority of conservation strategies. Moreover, overfishing, pollution threats, dynamiting etc. should be monitored for sustainable fish diversity.

5. References

1. Anandhi UD, Sharath YG. Study of ornamental fish diversity and water quality of Adda Hole stream, Kabbinale forest range, Western Ghats. Advances in Applied Science Research. 2013; 4(5):158-164.
2. APHA. Standard Methods for the Examination of Water and Wastewater. (20th edition), American Public Health Association, USA. 1998.
3. Arunachalam M. Assemblage structure of stream fishes in the Western Ghats, (India). Hydrobiologia. 2000; 430:1-31.
4. Arunachalam M, Johnson JA, Sankaranarayanan A. Fish diversity in rivers of Northern Karnataka. Int. J. Ecol. Env. Sci. 1997a; 23:327-333.
5. Belangar G, Rodriguez MA. Local movement as a measure of habitat quality in stream Salmonids. Environmental Biology of fishes. 2002; 64:155-164.
6. Berger WH, Parker. Diversity of planktonic Formanifera in deep-sea sediments. Science. 1970; 168:45-1347. Doi:10.1126/science. 168.3937.1345.
7. Bhat A. Diversity and composition of freshwater fishes in river systems of Central Western Ghats, India. Environmental Biology of Fishes. 2003; 68:25-38.
8. Bhat A. Patterns in the distribution of freshwater fishes in rivers of Central Western Ghats, India and their association with environmental gradients. Hydrobiologia. 2004; 529:83-97.
9. Gaston KJ. Global patterns in biodiversity. Nature. 2000; 405:220-227.
10. Gorman OT, Karr JR. Habitat structure and stream fish communities. Ecology. 1978; 59:507-515.
11. Jayaram KC. The freshwater fishes of the Indian region. Narendra Publishing House, Delhi-06. 2010.
12. Johnson JA, Arunachalam M. Diversity, distribution and assemblage structure of fishes in streams of southern Western Ghats, India. Journal of Threatened Taxa. 2009; 1(10):507-513.
13. Lecis R, Norris K. Habitat correlates of distribution and local population decline of the endemic Sardiman newt *Euproctus platycephalus.* Biol. Conserv. 2003; 115:303-317.
14. Lennon JJ, Kloeff P, Greenwood JJ. The geographic structure of British bird distributions: diversity, spatial turnover and scale. J. Anim. Ecol. 2001; 70:966-979.
15. Li J, Huang L, Zua L, Kano Y, Sato T, Ynara T. Spatial and temporal variation of fish assemblages and their associations to habitat variables in a mountain stream of North Tiaoxi river, China. Environmental Biology of fishes. 2012; 93:403-417.
16. May JT, Brown LR. Fish communities of the Sacramento River basin: implications for conservation of native fishes in the central valley, California. Environmental Biology of fishes. 2002; 63:373-388.
17. Moyle PB. Biodiversity, biomonitoring and the structure of stream fish communities. In: S. Loeb, A. Spacie (Eds), Biological monitoring of freshwater ecosystem, Lewis Publications, Inc., Boca Raton, Florida. 1994, 171-186 pp.
18. Muralidharan M. Fish habitats and communities in upland stream of Western Ghats. Unpublished Ph.D. Thesis, submitted to Manomaniam Sundaranar University, Tamilnadu, India. 2008.
19. Olivera EF, Goulart E, Minte-Vera CV. Fish diversity along special gradients in the Itaipu Reservoir, Parana, Brazil. Brazilian Journal of Biology. 2004; 64(3a):447-458.
20. Pielou EC. Ecological Diversity. New York, Wiley. 1966.
21. Postel S, Richer B. Rivers for life: Managing Water for People and Nature**.** Island Press, Washington, D.C, U. S. A. 2003.
22. Pouilly M, Barrera S, Rosales C. Changes of taxonomic and trophic structure of fish assemblages along an environmental gradient in the upper Beni watershed (Bolivia). J. Fish Biol. 2006; 68:137-156.
23. Prabhakar C, Saleshrani A, Tharmaraj K, Kumar VM. Seasonal variations in hydrological parameters of Krishnagiri dam, krishnagiri district, Tamil Nadu, India. Int. J. Pharm. Biol. Arch. 2012; 31:134-139.
24. Pusey BJ, Arthington AJ, Read MG. Spatial and temporal variation in fish assemblage structure in the Mary River, Southestern Queensland: the influence of habitat structure. Environmental Biology of Fishes. 1993; 37:355-380.
25. Revenga C, Campbell I, Abell RD, Villiers P. Prospects for monitoring freshwater ecosystems towards the 2010 targets. Philosophical Transactions of the Royal Society. 2005; 360:397-413.
26. Schlosser IJ. Fish community structure and function along two habitat gradients in a headwater stream. Ecological Monographs. 1982; 52:395-414.

27. Shahnawaz A, Venkateshwarlu M, Somashekar DS, Santosh K. Fish diversity with relation to water quality of Bhadra River of Western Ghats (India). Environ Monit assess. 2010; 161:83-91.
28. Shannon CE, Weaver W. The Mathematical Theory of Communications**.** Urbana, University of Illinois Press. 1949.
29. Shields FD. Fate of lower Mississippi River habitats associated with training dikes. Aquatic Conservation: Marine and Freshwater Ecosystems. 1995; 5:97-108.
30. Simpson EH. Measurement of Diversity. Nature. 1949, 163-668.
31. Talwar PK, Jhingran A. Inland fishes of India and adjacent countries. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi. 1991; 2(19):1158.
32. Vijaykumar K, Vijayalaximi C, Parveen Z. Ichtyofaunal diversity of Kagina river in Gulbarga district of Karnataka. The Ecoscan. 2009; 2(2):161-163.