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Fish Diversity of Anjarakandy River in Kerala, South India

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Abstract

Preliminary documentation of fish diversity of Anjarakandy River in Kannur District, Kerala, South India was conducted along with the assessment of changes in water quality parameters. For the study, eight sampling stations were selected from upstream to downstream of the river. The physico-chemical characteristics of water such as transparency, turbidity, pH, electrical conductivity, total solids, hardness, chlorides, salinity, dissolved oxygen, sulphates, nitrates, sodium and potassium were analysed following standard procedures. From each station, collected fishes were identified with the help of standard keys. Around 63 fish species belonging 40 genera and 28 families were identified. Fish diversity was maximum at the station Mammakunnu, the region with thick mangrove vegetation. In the downstream station of the river Dharmadam, located near to the estuary faces the threat of anthropogenic activities such as sand mining, construction activities, overfishing and solid waste dumping. Due to these threats, less species diversity was observed compared to other down-stream stations. The physico-chemical analysis of river water shows that there is an increase in turbidity, total solids, hardness, chlorides, salinity, sulphates, nitrates, sodium and potassium in the downstream stations. This may be due to saltwater intrusion and sand mining along the down streams of the river. Therefore, the study reveals that sand mining, construction activities and overfishing destroys the fish population in down stretches of Anjarakandy River.

Keywords: Anjarakandy River, Downstream, Fish diversity, Sand mining, Water quality

1. Introduction

Rivers are the most dynamic ecosystems as well as the lifeline of almost all civilisations in India. Rivers are defined as a relatively large volume of water moving within a visible channel, including subsurface water moving in the same direction and the associated flood plain and riparian vegetation. Both streams and rivers as ecological systems are highly variable over space and time and exhibit high degrees of connectivity between systems longitudinally, laterally and vertically (Naiman *et al.*, 1998). The rivers and tributaries form the basis of domestic, agricultural, industrial water supply, hydroelectricity, inland water transport, inland fishing and formation of deltas with fertile soil (Balasubrahmanian, 2007). However, the rivers of Kerala have no delta formation due to the small size and susceptible to environmental changes. The rivers with catchments in areas of high population density are under constant threat. River pollution in India has now reached a point of crisis due to unplanned urbanization and rapid industrialization. The entire array of life in water is affected due to pollution in water. The problem of water quality deterioration is mainly due to human activities such as disposal of dead bodies, discharge of industrial and sewage wastes and agricultural runoff and pose serious health hazards (Meitei *et al.*, 2004). A good number of researchers assessed the water quality of Indian rivers. Despite these factors, Kerala has rich riverine biodiversity, especially ichthyofaunal diversity. Fish diversity of a water body has a very crucial role in the food web and both directly and indirectly in the stability of a particular ecosystem (Polis and Strong, 1996). Several studies were carried out related to fish diversity and water quality in rivers of India and Kerala (Easa and Shaji, 1995; Biju Kumar, 2000; Sheethal Lal *et al.*, 2014; Kisku *et al.*, 2017; Raveendar, 2018).

In the case of Kerala rivers, the industrialisation, agricultural practices and sand mining cause the destruction of rivers. Most of the rivers facing risk due to various anthropogenic activities (Harikumar *et al.*, 2009). These activities make water unfit for domestic purposes due to the altered physico-chemical and biological properties. Aquatic organisms are more prone to these changes, and they can reflect the health of ecosystems. The fish diversity study can be an effective tool for monitoring ecosystem health.

In Kannur district, most of the fish survey studies were concentrated on Valapattanam River, which is the largest river in the district (Sajeevan *et al.*, 2014). Anjarakandy river has a total length of 48 km with an area of 423.763 $km^{2,}$ and it is one of the major sources of municipal water supply (James, 1995). Recent years, sand mining, construction activities, local tourism activities, overfishing were increased and made several environmental issues. From the literature survey it was found that the fish diversity of Anjarakandy river was not yet assessed. In this context, a study on fish diversity along with the water quality of the Anjarakandy river was conducted.

2. Materials and Methods

Study area

The Anjarakkandy River originates from Kannoth forests (600 m height) in Thalasseri taluk and passes through Kannavam, Kadamkunnu and Vemmanal before it joins the Lakshadweep Sea. The main tributaries are Idumbathodu and Kapputhodu. The river has a total length of 48 km, and the navigable length is about 27.2 km. The

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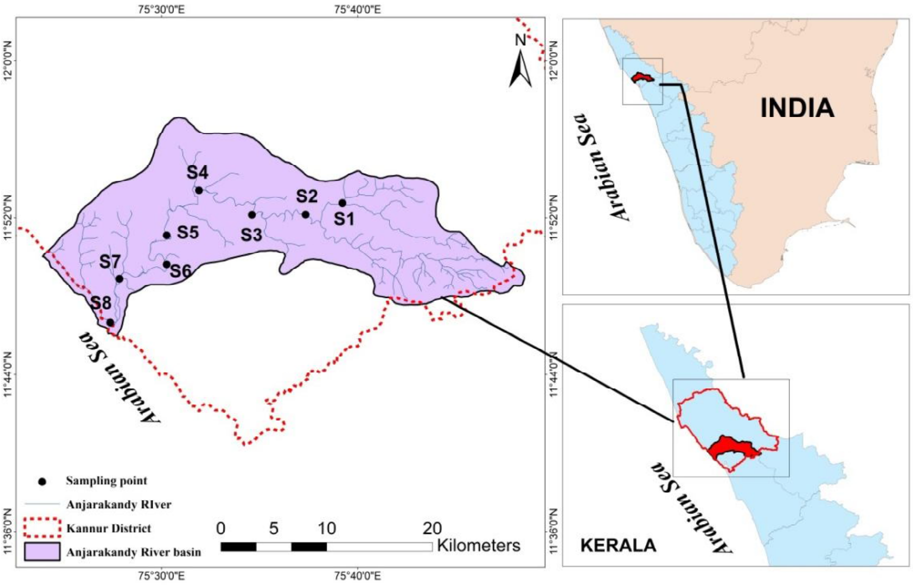

Fig. 1. Location map of Anjarakandy river with sampling stations in Kannur District

average annual streamflow in the river is 433 Mega meters (http://www.kerenvis.nic.in/Database/Anjarakandy_1845.aspx). The location map of the study area and sampling stations are given in Fig. 1.

Sampling stations

A detailed field survey was carried out for the sampling. The water and fish samples were collected from 8 different stations of Anjarakandy river, from upstream to downstream during August 2013 and February 2014. The location of sampling stations was shown in Table 1. Idumba (S1) was the first station located in the upstream of Anjarakandy river, in this station the wild varieties riparian vegetation was found, and there was no human interference except seasonal fishing by native people. Mudapattur (S2) and Meruvembayi (S3) were characterized by bamboo vegetation and other wild vegetation on the banks. The major human activities in these stations include swimming, washing and fishing. There was a constructed water tank and check dam of water authority department of Kerala is located in Kizhallur (S4). The banks of the station were rich in midland vegetation and plantations. The anthropogenic activities include swimming, fishing and irrigation of nearby plantations (coconut, vegetables and fruits). The station Odakkadu (S5) was characterized by the presence of coconut and other agricultural plantations on the banks and water was used for irrigational purposes. Season wise small-scale fishing activities by native peoples can be considered as human interference. Station 6, known as Mambaram (S6), has mangrove vegetation and coconut plantations on the banks. The major anthropogenic activities include swimming, fishing, sand mining, dumping of domestic wastes etc. Station 7, Mammakunnu (S7) has thick mangrove vegetation along the banks, and there is no much human interference except small scale fishing. Dharamdam (S8) located near to the estuary was in the anthropogenic activities like large scale sand mining, unregulated local tourism, fishing boats, construction activities dumping of domestic and other commercial wastes on banks.

Methodology

The water samples were collected in clean plastic containers of 2-litre capacity and transported to the laboratory for doing physico-chemical analysis (APHA, 2012). Selected physico-chemical parameters such as temperature, transparency and pH were analysed at the field itself, and other parameters (turbidity, electrical conductivity, total solids, dissolved oxygen, hardness, chlorides, salinity, sulphates, nitrates, sodium and potassium) were analysed in the laboratory. Collection of fishes were conducted with the help of local fishermen using fish traps, cast nets and gill nets. The morphometric characters of captive fishes were measured, and species identification was carried out using standard keys (Talwar and Jhingran, 1991; Jayaram, 1999).

Table 1. Sampling Stations of Anjarakandy River

Sn No:	Station	Location & Elevation
S1	Idumba	$11^0$52’ 44.7”N; $075^0$39’13.1”E; 39 m
S2	Mudapattur	11^0 52’ 10.0”N; $075^0$37’20.4”E; 34m
S3	Meruvembayi	$11^0$52’ 09.5”N; $075^0$34’36.3”E; 17m
S4	Kizhallur	$11^0$53’ 23.9”N; $075^0$31’54.4”E; 14m
S5	Odakkadu	11^0 51’ 06.3”N; $075^0$30’15.2”E; 13m
S6	Mambaram	$11^0$49’ 37.9”N; $075^0$30’15.2”E; 14m
S7	Mammakkunu	$11^0$48’ 53.8”N; $075^0$27’50.7”E; 14m
S8	Dharmadam	$11^0$46’ 40.2”N; $075^0$27’22.6”E; 14m

3. Results and Discussion

Fish diversity of Anjarakandy river

Based on the survey, sixty-three fish species (S=63) belonging to 28 families and 40 genera were observed and recorded from various sampling stations of Anjarakandy river (Table 2). From the observations (Fig. 3, 4), it was found that family Cyprinidae with 15 species was dominated followed Bagaridae (S=6), Ambassidae (S=6), Mugillidae (S=4), Cichlidae (S=3) and Channidae (S=3). Among the 63 species, one species *Oreochromis mossambicus* was found to be exotic species. The same species was observed in various rivers of Kerala like Achankovil river (Baby *et al*., 2011; Swapna, 2009) of Kerala. Out of the 63 species, *Barilius bakeri*, *Salmophasia boopis*, *Mystus malabaricus*, and *Mystus oculatus* were found to be endemic to the Western Ghats. *Puntius filamentosus*, *Garra mullya* and *Aplocheilus lineatus* were endemic to India. *Devario malabaricus*, *Devario aequipinnatus*, and *Puntius vittatus* were only found in the Indian subcontinent (IUCN, 2011). Among 63 species identified, most of them are the inhabitants of fresh/ brackish water (S=26) followed by 19 freshwater species, 12 fresh/ brackish/ marine species, five brackish/ marine species and one marine species (Fig. 5). From the observations, it was found that most of the fish species were economically important as they are edible and ornamental species (Fig. 6)

The site-specific observations (Fig. 2) showed that more diversity (S=34) of fishes was recorded in Mammakunnu (S7) associated with mangrove vegetation followed by S2 and S6 (S=22), S3(S=17), S1 (S=15), S4 and S5 (S=12) and S8 (S=9). The species diversity was more due to the thick mangrove vegetation in this region and which supports freshwater, brackish and estuarine fishes. Mangroves have a significant role in making the ecosystems as more productive and biodiversity-rich (Radhakrishnan *et al*., 2006). *Avicennia officinalis, A. marina, Sonneratia alba, Rhizophora mucronata,* and *Aegiceras corniculatum* are the common species found in Mammakunnu (S7). The human interference was very less in the station with respect to other sampling stations. In addition to fish diversity, different types of crabs and prawns are also present, and the rural population depend on these fisheries resources. Idumba (S1) located in the upstream, is the meeting point of two tributaries also have high species diversity. Mudapattur (S2) also shows high diversity due to the presence of riparian vegetation and less human disturbances. The stations Kizhallur (S4) and Odakkadu (S5) also shows moderate no. of fish species. Mambaram (S6) also has mangrove vegetation, even though sand mining and local tourism activities destroy mangroves which leads to the deterioration of species diversity. The natives and fishermen report that the fish availability in these regions decreasing year after year. The study supports that it may be due to climate change and anthropogenic activities.

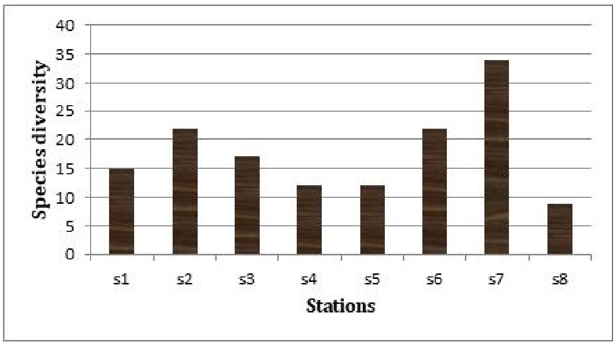

Fig. 2. Station wise diversity of fishes of Anjarakndy river

The station 8, Dharmadam was very near to the estuary and may have more diversity of freshwater, brackish and marine water species. However, in Dharamadam (S8), the declining trend of species diversity was observed because of the human interference such as large-scale sand mining, fishing boats, continuous clams and mussel collection and rearing, bridge construction activities, waste dumping from domestic and commercial sources. Coir and other small-scale industries, intensive shrimp culture practices and large-scale sand mining cause's prodigious threats to the rivers and associated mangrove ecosystems (Radhakrishnan *et al*., 2006). The fish diversity can be used as excellent indicators of water quality and health of the ecosystem (Kar *et al*., 2016). Lowest number species in the station Dharamadam (S8) indicates the unpotable quality of water and irrational fishing. The saltwater intrusion and induced changes in the water quality can cause the migration of marine or estuarine species into inland stretches of the river. Thus, the competition for food and shelter, and predator species among them destroy indigenous species in the inland regions. In addition to this natural threat, the anthropogenic activities like sand mining and fishing boats also cause the destruction of fisheries of Kerala rivers.

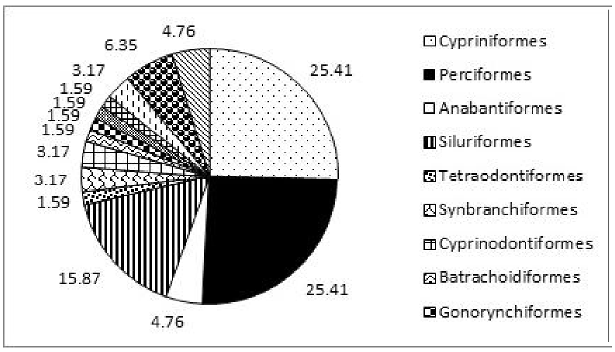

Fig. 3. Percentage contribution of fish species to the orders

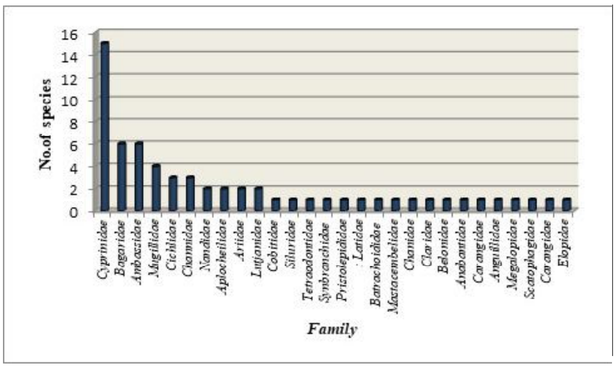

Fig. 4. No. of fish species contributes to various families

Table 2. List of Fish species collected from Anjarakndy River

Sl No.	Species	Habitat	Location
Order: Cypriniformes; Family: Cyprinidae			
1	*Puntius vittatus* (Day, 1865)	Fresh/ brackish water	S1, S2, S4
2	*Puntius filamentosus* (Valenciennes, 1844)	Fresh/ brackish water	S4,S5, S7
3	*Puntius amphibius* (Valenciennes, 1842)	Fresh/ brackish water	S1 S3,S4,S5
4	*Puntius ticto* (Hamilton,1822)	Fresh/ brackish water	S1, S2, S3
5	*Puntius jerdoni* (Day, 1870)	Fresh water	S1, S2, S3
6	*Puntius saranasubnasutus* (Valenciennes, 1842)	Fresh water	S5, S6, S7
7	*Salmophasia boopis* (Day, 1874)	Fresh water	S2, S3, S4
8	*Garra mullya* (Sykes, 1839)	Fresh water	S1, S2, S3
9	*Barilius bakeri* (Day 1865)	Fresh water	S1, S2, S3
10	*Barilius gatensis* (Valenciennes, 1844)	Fresh water	S1, S2, S3
11	*Devario aequipinnatus* (McClelland, 1839)	Fresh water	S1, S2, S3
12	*Devario malabaricus* (Jerdon, 1849)	Fresh water	S2, S3
13	*Osteochilus nashii* (Day, 1869)	Fresh water	S1, S2, S3
14	*Osteobrama bakeri* (Day, 1873)	Fresh water	S2, S3, S4
15	*Rasbora daniconius* (Hamilton, 1822)	Fresh/ brackish water	S4,S5,S6,S7
Order: Cypriniformes; Family: Cobitidae			
16	*Lepidocephalichthys thermalis* (Valenciennes, 1846)	Fresh water	S2, S4
Order: Perciformes; Family: Nandidae			
17	*Badis badis* (Hamilton, 1822)	Fresh water	S1, S2
18	*Nandus nandus* (Hamilton, 1822)	Fresh/ brackish water	S2, S3, S7
Order: Anabantiformes; Family: Channidae			
19	*Channa marulius* (Hamilton, 1822)	Fresh water	S1, S2, S3
20	*Channa striata* (Bloch 1793)	Fresh water	S1, S2, S3
21	*Channa orientalis* (Bloch & Shneider, 1801)	Fresh/ brackish water	S1,S2
Order: Siluriforms; Family: Siluridae			
22	*Wallago attu* (Day, 1878)	Fresh water	S2,S3,S4,S5
Order: Tetraodontiformes; Family: Tetraodontidae			
23	*Carinotetradon travancoricus* (Hora & Nair 1941)	Fresh water	S2,S3, S4
Order: Synbranchiformes; Family: Synbranchidae			
24	*Ophisternon bengalense* (McClelland, 1844)	Fresh/ brackish water	S6, S7
Order: Perciformes; Family: Pristolepididae			
25	*Pristolepis marginata* (Jerdon, 1849)	Fresh water	S4, S5
Order: Perciformes; Family: Latidae			
26	*Lates calcarifer* (Bloch, 1790)	Brackish water	S7
Order: Perciformes; Family: Ambassidae			
27	*Parambassis dayi* (Bleeker, 1874)	Fresh/ brackish water	S6, S7
28	*Parambassis thomassi* (Day, 1870)	Fresh/ brackish/marine	S7
29	*Ambassis gymnocephalus* (Lacepede, 1802)	Fresh/ brackish water	S6, S7
30	*Ambassis dussumieri* (Cuvier, 1828)	Fresh/ brackish water	S6, S7
31	*Ambassis commersoni*(Lacepede, 1802)	Fresh/ brackish/marine	S6, S7
32	*Ambassis nalua*(Hamilton, 1822)	Fresh/ brackish/marine	S7
Order: Cyprinodontiformes; Family : Aplocheilidae			
33	*Aplocheilus lineatus* (Valenciennes, 1846)	Fresh/ brackish water	S5, S6
34	*Aplocheilus blockii* (Arnold, 1911)	Fresh/ brackish water	S7
1. Order: Batrachoidiformes; Family: Batrachoididae			
35	*Batrichthys grunniens* (Linnaeus, 1758)	Brackish/marine	S7
Order: Synbranchiformes; Family: Mastacembelidae			
36	*Mastacembelus armatus* (Lacepede, 1800)	Fresh/ brackish water	S5,S6,S7
Order: Siluriformes; Family: Ariidae			
37	*Arius arius* (Hamilton, 1822)	Brackish/marine	S7
38	*Plicofollis dussumieri* (Valenciennes, 1840)	Fresh/ brackish/marine	S7
Order: Gonorynchiformes; Family: Chanidae			
39	*Chanoschanos* (Forsskal, 1775)	Fresh/ brackish/marine	S7, S8
Order : Siluriformes; Family : Bagridae			
40	*Mystus armatus* (Day,1865)	Fresh/ brackish water	S1,S2
41	*Mystus malabaricus* (Jerdon,1849)	Fresh/ brackish water	S1, S2

42	*Mystus gulio*(Hamilton-Buchanan, 1822)	Fresh/ brackish water	S3, S4, S6
43	*Mystus cavasius*(Hamilton-Buchanan, 1822)	Fresh/ brackish water	S4,S5, S6
44	*Mystus vittatus*(Bloch, 1794)	Fresh/ brackish water	S5,S6,S7
45	*Mystus oculatus*(Valenciennes, 1840)	Fresh/ brackish water	S5,S6,S7
Order : Siluriformes; Family : Claridae			
46	*Clarias batrachus* (Linneaeus, 1758)	Fresh/ brackish water	S5, S6,S7
Order: Beloniformes; Family: Belonidae			
47	*Xenentodon cancila* (Hamilton, 1822)	Fresh/ brackish/marine	S5, S6, S7
Order: Perciformes; Family : Anabantidae			
48	*Anabas testudineus* (Bloch,1792)	Fresh/ brackish water	S6, S7
Order: Perciformes; Family : Carangidae			
49	Caranx carangus(Bloch, 1793)	Brackish/marine	S7, S8
Order : Anguilliformes; Family : Anguillidae			
50	*Anguilla bengalensis*(Gray)	Fresh/ brackish/marine	S5,S6,S7
Order: Perciformes; Family: Lutjanidae			
51	*Lutjanus argentimaculatus* (Forsskal, 1775)	Fresh/ brackish/marine	S6, S7
52	*Lutianus chrysotaenia* (Bleeker, 1851)	Marine	S8
Order : Elopiformes; Family : Megalopidae			
53	*Megalops cyprinoids* (Broussonet)	Fresh/ brackish/marine	S6, S7
Order : Mugiliformes; Family : Mugilidae			
54	*Liza parsia* (Hamilton 1822)	Brackish/marine	S7
55	*Rhinomugil corsula* (Hamilton 1822)	Fresh/ brackish water	S7
56	*Mugil cephalus* (Linnaeus, 1758)	Fresh/ brackish/marine	S6,S7,S8
57	*Liza subviridis* (Valenciennes, 1836)	Fresh/ brackish/marine	S8
Order: Perciformes; Family: Scatophagidae			
58	*Scatophagus argus* (Linnaeus, 1766)	Fresh/ brackish/marine	S7, S8
Order: Cichliformes; Family: Cichlidae			
59	*Oreochromis mossambicus* (Peters, 1852)	Fresh/ brackish water	S6, S7
60	*Etroplus maculatus* (Bloch, 1795)	Fresh/ brackish water	S7
61	*Etroplus suratensis* (Bloch, 1790)	Fresh/ brackish water	S6, S7, S8
Order: Perciformes; Family: Carangidae			
62	*Caranx heberi* (Bennet, 1830)	Brackish/marine	S8
Order : Elopiformes ; Family : Elopidae			
63	*Elops machnata* (Forsskal, 1775)	Brackish/marine	S8

Physico-chemical quality of river water

The results of the water quality parameters are given in Table 3. Water quality has an important role in the fish diversity of water bodies. The most important parameter which can affect the survival of aquatic organisms and temperature can be influenced by riparian vegetation, tributary inflow, water depth and air temperature (Trivedi and Goel, 1986). From upstream to downstream there is no much variation in water temperature. The transparency of water is related to the total depth and is the measure of depth at which sunlight can reach. The suspended and colloidal matter such as clay, silts, finely divided organic and inorganic matter, plankton and other microscopic organisms can cause the turbidity of water (Saxena, 1998). The turbidity was very high at Dharmadam (S8) due to the sand mining, waste dumping and a large number of fishing boats. In other stations like Odakkadu (S5), Mambaram (S6) and Mammakunnu (S7), the riparian vegetation and other plantations contribute organic matter in water and make it turbid.

Water pH also can affect the survival of certain fish species in particular regions. The water pH at station 8 was

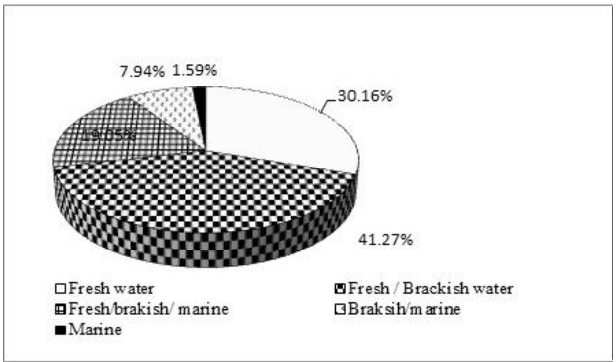

Fig. 5. Percentage contribution of fishes belongs different habitats

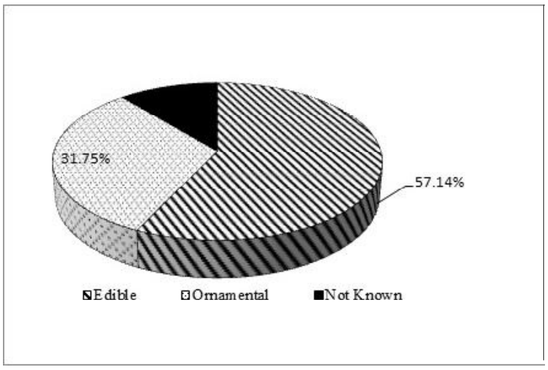

Fig. 6. Percentage contribution of fishes based on economic importance

Table 3. Physico-chemical characteristics of Anjarakandy river water

PARAMETER	STATION								MEAN±SD
	S1	S2	S3	S4	S5	S6	S7	S8	
Temperature (^{0}C)	26.02	27..23	26.05	28.4	28.2	29.1	29	29.5	28.04±1.44
Transparency (cm)	34	31	42	51	57	76	63.5	36.5	48.88±15.86
Turbidity (NTU)	17.15	24.21	27.61	31.5	78.89	92.56	102.4	124.2	62.32±41.87
pH	7.20	7.2	6.9	7.8	7.8	8.4	7.9	9	7.78±0.69
EC (µS)	15.67	21.54	20.92	15.98	67.01	99.03	68.42	448.02	94.57±146.21
Total solids (mg/L)	22.32	26.73	29.06	23.03	92.23	134.67	93.99	496.74	114.85±160.04
DO (mg/L)	6.24	6.83	6.43	6.25	6.03	5.62	6.23.00	4.02	5.96±0.85
Hardness (mg/LasCaCO3)	40	28	38	24	305	480	350	1250	314.38±417.85
Chloride (mg/L)	63.82	63.82	70.91	85.18	115.53	163.22	180.07	861.93	200.56±270.97
Salinity (mg/L)	117.11	117.11	130.13	156.15	215.67	299.25	330.43	1577.33	367.98±495.58
Sulphates (mg/L)	2.12	1.25	4.32	15.32	34.21	94.34	82.32	366.54	75.05±123.29
Nitrates (mg/L)	0.82	0.92	1.43	1.21	4.65	3.21	3.46	3.51	2.40±1.47
Sodium (mg/L)	8.6	6.4	6.7	5.1	154	159	95	782	152.1±263.13
Potassium (mg/L)	1.6	1.7	1.1	0.6	141.1	135	72.3	404	94.68±138.81

alkaline and may be due to the saltwater intrusion and anthropogenic activities in this area. The down streams stations of the river (S5, S6, S7, S8) water showed high values for hardness, chlorides, salinity, sodium, potassium and total solids. It is mainly due to the saltwater intrusion from the sea. Sand mining, construction activities, waste dumping, clearing of the natural vegetation like mangroves, also make water unfit for drinking and irrigation. The water quality also directly affects the fish species inhabiting in particular regions. Dissolved oxygen was high in Mudapattur (S2) followed with Meuvembayi (S3), Kizhallur (S4), Idumba (S1) and Mammakunnu (S7). Declined level of dissolved oxygen was found in Dharamadam (S8). Comparatively dissolved oxygen was less in Odakkadu (S5) and Mambaram (S6). In the case of Odakkadu (S5), there is a chance of agricultural runoff from nearby agricultural lands. In Mambaram (S6) sand mining disturbs the river in a crucial way. The study revealed that compared to the down stretches, the upper stretches (S1, S2, S3 and S4) of the Anjarakandy river was with good quality water. Studies by Harikumar *et al*. (2009) also reported that though the water quality in the upstream stretches of rivers of Kerala is generally good and potable, the quality deteriorates as the rivers traverse through the thickly populated midland and more thickly populated lowland areas. The quality of water determines the other resources like inland fisheries. There should be proper public awareness to control waste dumping and sand mining to conserve river ecosystem.

From the present study, it was confirmed that water quality has a chief role in the survival of fishes in the inhabitant water bodies. The water quality was highly influenced by the anthropogenic activities along with natural causes. In the case of Anjarakandy river, the point source of industrial pollution was not at all observed. However, the water quality analysis points out that the non-point sources also influences the river very crucially along with the salt-water intrusion. The land use pattern in the river banks also affects the water quality and fishes as same as the observations stated by Chattopadhay (2015). The environmental factors affect the abundance and diversity of fishes in an aquatic environment as the permissible limit of dissolved oxygen, pH, salinity and hardness of water exceeds reflected in the species diversity. Similar observations were also made by Ahmad and Venkateshwarlu (2019) in Tunga river of Karnataka State, India. In the present study, the river located in the area with very slow urbanisation and less industrial activities even though the water quality deteriorated. Therefore, the study can point out the threats to the rivers, which are located in thickly populated and urbanised areas. There should be a need for immediate biodiversity documentation and urgent management measures against threatening developmental activities to conserve Kerala rivers.

4. Conclusion

The success and survival of fishes very much depend on the water quality parameters of Inhabitant aquatic bodies. The study revealed that fish diversity was high at Mammakkunu area of Anjarakandy river and is due to the thick mangrove vegetation, good water quality and less anthropogenic activities. Despite the estuarine environment in Dharmadam, fish diversity was found low because of human interference and heavy pollution load in the water. The sand mining and uncontrolled fishing exerted high pressure on the fisheries resources in the Anjarakandy river. So, these adverse activities should be appropriately managed to save rivers and precious fisheries resources.

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