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Variations in fish assemblage with reference to fluctuations in physiochemical parameters in Chettuva Estuary, Thrissur, Kerala

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Abstract
Estuary is an ecosystem in dynamic state which exerts so many stresses on living organisms. This study aims to compare the physiochemical parameters and fish diversity of the Chettuva estuary in the post monsoon months of four years. Fishes were collected from fishermen. Taste and odour, temperature, pH, salinity, TDS, dissolved oxygen and CO_2 were tested. In diversity study about 68 species of fishes belonging to 45 genera were identified. Number of fish species seems to increase by the month of January in all studies because of increase in salinity allowing the entry of more marine fish to this region. The present comparison of four years data reveals that there is notable increase in temperature, decrease in dissolved oxygen and increase in CO_2 content. These changes are all indicators of pollution leading to the deterioration of the water quality parameters which can adversely affect the life sustained by it.

Keywords: Estuary, physiochemical parameters, fish diversity, variations

1. Introduction
Estuary is a semi – enclosed coastal water body, where the sea water and fresh water overlap and mix together [18]. It's an ecotone between freshwater and marine environment - a habitat with variable physical, chemical and biological characteristics. The constant mixing up of seawater and fresh water provide high levels of nutrients in both the water column as well as sediment, making estuaries the most productive aquatic habitats of the world.
Estuary is an ecosystem in dynamic state, and it exerts so many stresses on living organisms. The strong salinity gradient, the abrupt changes in temperature, oxygen content and turbidity and a host of other factors necessitate high physiological tolerance and adjustments on the part of the organisms for survival. Estuarine fish fauna principally comprises of truly estuarine fishes, marine fish species which can tolerate variations in salinity as well as few fresh water fishes which enters the zone when salinity lowers. Estuary has been considered as a 'high way' of marine and freshwater fish species, which move to or from the seas on spawning migrations.
In India about 2.6 million ha brackish water habitat is available in maritime states. A substantial part of Indian fisheries is constituted by estuarine fisheries. Vast stretches of brackish water bodies are present all along the coastal belt of Kerala constituting nearly 70% of the inland water resources of the state. Three wetlands of Kerala included in the Ramsar site are the Vembanad Kol wetlands, Ashtamudi Lake and Sasthamkotta Lake. The Kole lands, a part of Vembanad Kol wetlands spread in the Thrissur and Malappuram districts remains as one of the major fresh water wetlands of the State. The Kole wetlands cover an area of 13,632 ha, extending from the northern banks of Chalakudy River in the south to the southern banks of Bharathapuzha River in the North [11]. Karuvannur, Kecheri and Puzhakkal are the three rivers draining the Kole lands and finally discharge into the Arabian Sea through the estuary.
Several estuarine studies have shown correlations between fish occurrences and specific physicochemical and habitat parameters. Short term studies on fish communities note water temperature [15], salinity [1, 6], dissolved oxygen [13, 14], pH [16], etc., to be the factors structuring fish distributions. Brackish water is well buffered against wide variation in pH [7].
The Kecheri River and Puzhakkal River draining the Kole lands finally discharge into the Arabian Sea through Chettuva estuary. This study aims to compare the physiochemical parameters and fish diversity of the Chettuva estuary in the post monsoon months of four years.

2. Materials and Methods

The study was conducted in the post monsoon months of November, December and January of years 2010 -2011, 2011 - 2012, 2013 - 2014 & 2015 - 2016 in Chettuva estuary. Two visits were conducted for the collection of sample in each month.

Fishes were collected twice for every month from fishermen operating cast nets, scoop nets and traps. For the collection of water sample, plastic bottles of one litre were used. All bottles were washed thoroughly and rinsed with water sample before collecting it. Care was taken not to contaminate the water sample during collection and transportation. Two litres of water were collected for each month's study. Taste and odour of the sample was noted down at the site. Temperature, pH, salinity and TDS were noted down at the site using digital multipurpose meter. Dissolved oxygen was estimated using Winkler's method and dissolved CO_2 was calculated by titration method in the lab.

Fishes collected from sampling locations were preserved in 7% formaldehyde and brought to the laboratory for the identification of species. Standard references such as Day [4], Jayaram [9] and Talwar & Jhingran [24] were used for the classification and identification.

3. Result

The present study is on the six physiochemical parameters of water sample and the fish diversity in the post monsoon months viz., November, December and January of 2010 – 2016 from Chettuva estuary. Results of the physiochemical parameters during this period of study are given in the Table I. The water quality of Chettuva Estuary was found to be varying along with the flow of each month under study. Temperature, pH, salinity, TDS, Dissolved O_2 and CO_2 of the station varied in the post monsoon months of all years are compared and given in the table.

Table I: Physio-Chemical Parameters of Chettuva Estuary During The Study Period

Parameters	Nov-10	Nov-11	Nov-13	Nov-15	Dec-10	Dec-11	Dec-13	Dec-15	Jan-11	Jan-12	Jan-14	Jan-16
Taste & Odour	salty & odourless	salty & odourless	salty & odourless	salty & odourless	salty & odourless	salty & odourless	salty & odourless	salty & odourless	salty & odourless	salty & odourless	salty & odourless	salty & odourless
Temperature ^0C	29	30	30	30	30	31	31	31	30	31	31	32
pH	7.3	7.24	7.2	6.43	7.3	7.17	7.19	6.44	7	7.2	7.21	6.33
Salinity (ppt)	0.7	2.43	2.4	2.43	14.2	12.63	12.65	12.63	24.6	25.7	26	25.7
TDS (ppt)	0.94	3.35	3.33	3.35	12.8	3.36	3.35	3.36	17.8	3.33	3.36	3.33
Dissolved O_2 (ppm)	4	2	2	2	8	6	6	5	6	5	5	3
Dissolved CO_2 (ppm)	7.59	45.5	45.8	25.3	22.77	68.3	68.5	22.7	37.9	68.3	68.5	22.7

The list of fish species recorded from the Chettuva estuary during the study period is given with its systematics in Table II.

Table II: List of Fish Species Recorded From Chettuva Estuary During The Study Period

A	**Order: Beloniformes**
I	**Family: Belonidae**
1	*Xenentodon cancila* (Hamilton)
II	**FAMILY: HEMIRAMPHIDAE**
1	*Hyporhamphus limbatus* (Val)
2	*Hyporhamphus xanthopterus* (Val)
B	**ORDER: CLUPIFORMES**
I	**FAMILY: CLUPIDAE**
1	*Clupea chapra* (Hamilton)
2	*Clupea longiceps* (Val)
3	*Anodontostoma chacunda* (Hamilton)
4	*Escualosa thoracata* (Val)
II	**FAMILY: DUSSUMIERIIDAE**
1	*Dussumieria acuta* (Val)
III	**FAMILY: ENGRAULIDAE**
1	*Engraulis hamiltonii* (Gray)
2	*Engraulis indicus* (Hasselt)
3	*Thryssa dussumieri* (Val)
4	*Thryssa malabarica* (Bloch)
5	*Thryssa mystax* (Bloch & Schneider)
IV	**FAMILY: PRISTIGASTERIDAE**
1	*Pellona ditchela* (Val)
C	**ORDER: ELOPIFORMES**
I	**FAMILY: ELOPIDAE**
1	*Elops saurus* (Linn)
II	**FAMILY: MEGALOPIDAE**
1	*Megalops cyprinoides* (Broussonet)
D	**ORDER: LOPHIIFORMES**
I	**FAMILY: ANTENNARIIDAE**

1	*Antennarius nummifer* (Cuvier)
E	**ORDER: MUGILIFORMES**
I	**FAMILY: MUGILIDAE**
1	*Liza parsia* (Ham-Buch)
2	*Liza tade* (Forsskal)
3	*Mugil cephalus* (Linnaeus)
F	**ORDER: PERCIFORMES**
I	**FAMILY: AMBASSIDAE**
1	*Ambassis commersonii* (Cuv & Val)
2	*Ambassis gymnocephalus* (Lacepede)
II	**FAMILY: CARANGIDAE**
1	*Carangoides chrysophryx* (Cuvier)
2	*Caranx affinis* (Rupp.)
3	*Caranx carangus* (Bloch)
4	*Caranx malabaricus* (Cuv & Val)
5	*Caranx gallus* (Ford)
6	*Caranx ire* (Cuv & Val)
III	**FAMILY: CICHLIDAE**
1	*Etroplus maculatus* (Bloch)
2	*Etroplus suratensis* (Gunther)
3	*Oreochromis mossambica* (Peter)
IV	**FAMILY: DREPANEIDAE**
1	*Drepane punctata* (Linn)
V	**FAMILY: EPINEPHELIDAE**
1	*Epinephelus diacanthus* (Val)
2	*Epinephelus malabaricus* (Bloch & Schneider)
VI	**FAMILY: GERREIDAE**
1	*Gerres filamentosus* (Cuv & Val)
2	*Gerres oyena* (Forsskal)
3	*Gerres setifer* (Gunther)
VII	**FAMILY: GOBIDAE**
1	*Gobioides buchanani* (Day)
2	*Gobius viridipunctatus* (Cuv & Val)
3	*Glossogobius giuris giuris* (Ham -Buch)
VIII	**FAMILY: LEIOGNATHIDAE**
1	*Leiognathus dussumieri* (Val)
2	*Leiognathus equulus* (Forsskal)
3	*Leiognathus splendens* (Cuvier)
4	*Photopectoralis bindus* (Val)
5	*Secutor insidiator* (Bloch)
6	*Secutor ruconius* (Hamilton)
IX	**FAMILY: LUTJANIDAE**
1	*Lutjanus johnii* (Bleeker)
2	*Lutjanus marginatus* (Bleeker)
X	**FAMILY: MENIDAE**
1	*Mene maculate* (Bloch & Schneider)
XI	**FAMILY: NANDIDAE**
1	*Pristolepis marginatus* (Jerdon)
XII	**FAMILY: SCATOPHAGIDAE**
1	*Scatophagus argus* (Cuv & Val)
XIII	**FAMILY: SCIAENIDAE**
1	*Otolithes ruber* (Bloch & Schneider)
XIV	**FAMILY: SILLAGINIDAE**
1	*Sillago sihama* (Gunther)
XV	**FAMILY: SPHYRAENIDAE**
1	*Sphyraena obtusata* (Cuvier)
XVI	**FAMILY: TERAPONIDAE**
1	*Therapon jarbua* (Bleeker)
G	**ORDER: PHYSOSTOMI**
I	**FAMILY: SILURIDAE**
1	*Rita chrysea* (Bleeker)
2	*Arius buchanani* (Ham- Buch)
3	*Arius nenga* (Hamilton)
4	*Arius subrostratus* (Val)
II	**FAMILY: CYPRINIDAE**
1	*Salmostoma boopis* (Day)
H	**ORDER : PLECTOGNATHI**

I	**FAMILY : TRIACANTHIDAE**
1	*Triacanthus brevirostris* (Temm. & Schleg)
II	**FAMILY : TETRAODONTIDAE**
1	*Lagocephalus lunaris* (Bloch & Schn.)
I	**ORDER: PLEURONECTIFORMES**
I	**FAMILY : CYNOGLOSSIDAE**
1	*Cynoglossus dubius* (Day)
2	*Cynoglossus hamiltonii* (Gunther)
3	*Cynoglossus lida* (Bleeker)
II	**FAMILY: PARALICHTHYIDAE**
1	*Pseudorhombus javanicus* (Bleeker)
III	**FAMILY: SOLEIDAE**
1	*Brachirus orientalis* (Bloch & Schneider)
J	**ORDER: SCORPAENIFORMES**
I	**FAMILY PLATYCEPHALIDAE**
1	*Platycephalus macracanthus* (Bleeker)

The variations in their distribution is compared and tabulated in Table III.

Table III: The Distribution of Fishes In Chettuva Estuary During The Study Period

Sl. No	Name of fishes	NOVEMBER				DECEMBER				JANUARY			
		'10	'11	'13	'15	'10	'11	'13	'15	'11	'12	'14	'16
1	*Ambassis commersoni*							+		+		+	
2	*Ambassis gymnocephalus*	+	+		+		+	+	+	+	+		+
3	*Anodontostoma chacunda*					+	+		+		+	+	+
4	*Antennarius nummifer*										+		
5	*Arius buchanani*					+							
6	*Arius nenga*		+				+						+
7	*Arius subrostratus*								+				+
8	*Brachirus orientalis*	+								+	+		+
9	*Carangoides chrysophryx*							+	+				
10	*Caranx affinis*					+				+			
11	*Caranx carangus*			+									+
12	*Caranx gallus*		+			+				+		+	
13	*Caranx ire*						+			+			
14	*Caranx malabaricus*	+			+		+	+	+		+	+	+
15	*Clupea chapra*			+			+						
16	*Clupea longiceps*										+		
17	*Cynoglossus dubius*			+					+	+	+	+	+
18	*Cynoglossus hamiltonii*		+				+	+					
19	*Cynoglossus lida*				+								
20	*Drepane punctata*								+		+		
21	*Dussumeria acuta*			+				+	+				
22	*Elops saurus*									+			
23	*Engraulis hamiltonii*		+		+	+			+	+	+		+
24	*Engraulis indicus*			+			+	+		+		+	
25	*Epinephlus diacanthus*			+								+	+
26	*Epinephelus malabaricus*	+				+	+	+		+		+	+
27	*Escualosa thoracata*		+	+			+		+				
28	*Etroplus maculatus*	+					+	+		+			+
29	*Etroplus suratensis*	+	+			+	+	+	+	+	+		+
30	*Gerres filamentosus*	+	+		+	+	+	+	+	+	+		
31	*Gerres oyena*						+						
32	*Gerres setifer*	+	+		+	+	+	+		+	+	+	
33	*Glossogobius giuris giuris*	+	+			+	+	+		+			+
34	*Gobioides buchanani*						+						
35	*Gobius viridipunctatus*									+			
36	*Hyporhamphus limbatus*	+				+		+			+		
37	*Hyporhamphus xanthopterus*			+					+				+
38	*Lagocephalus lunaris*						+				+		
39	*Leiognathus dussumieri*	+				+				+			
40	*Leiognathus equulus*				+				+		+	+	+
41	*Leiognathus splendens*		+				+						
42	*Liza parsia*	+			+	+			+	+	+		
43	*Liza tade*								+				+
44	*Lutjanus johnii*	+					+				+		+
45	*Lutjanus marginatus*	+				+				+		+	

46	*Megalops cyprinoides*				+				+				
47	*Mene maculata*			+									
48	*Mugil cephalus*	+	+			+	+			+	+	+	
49	*Oreochromis mossambica*	+					+		+		+		+
50	*Otolithus ruber*			+				+				+	
51	*Pellona ditchela*			+								+	
52	*Photopectoralis bindus*		+					+			+		+
53	*Platycephalus macracanthus*	+				+							+
54	*Pristolepis marginatus*					+							
55	*Pseudorhombus javanicus*											+	+
56	*Rita chrysea*	+								+			
57	*Salmstoma boopis*					+							
58	*Scatophagus argus*	+	+			+	+		+	+	+	+	+
59	*Secutor insidiator*			+			+	+		+			+
60	*Secutor ruconius*			+						+			
61	*Sillago sihama*	+				+	+	+		+	+	+	+
62	*Sphyraena obtusata*											+	+
63	*Therapon jarbua*					+	+			+	+	+	
64	*Thryssa dussumieri*								+				+
65	*Thryssa malabaricus*				+							+	
66	*Thryssa mystax*				+				+				
67	*Triacanthus brevirostris*						+			+		+	
68	*Xenentodon cancila*	+		+				+					+

In all the studies the month of January shows highest species count compared to the other months under study. Least number of species was found in November.

5. Discussion

Kerala is rich in estuaries which provide immense fishery resources. Estuarine waters have a rich supply of nutrient salt and are perfectly buffered against abrupt changes in salinity. High fertility of the soil is attributed by the disintegration of the organic matter brought by incoming tides and the fresh water carried by the rivers. Organisms of this region are euryhaline. From the earlier studies it was found out that due to high nutritive content of the estuary, the fishes of the ecosystem predominate in protein content. Estuaries have been called the "nurseries of the sea" because the protected environment and abundant food provide an ideal location for fish and shellfish to reproduce.

Taste and odour of water in the Chettuva estuary is found to be salty and odourless. The salt taste increased from November to January in all study periods. The temperature is slightly less in November and high in January. The temperature of January 2016 seems to be slightly high compared to other years' temperatures which show the impact of climate change. pH of the post monsoon periods in the first two study periods comes in the range of 6.5-8.5 which is at desirable limit. But in the next two periods it is seen to be lowering resulting in an acidic medium. This indicates that there are chances for the water to be more acidic in future. In estuaries, a lot of organic matter is transported from rivers and these organic matters are degraded by the organisms consuming oxygen and producing carbon dioxide that subsequently acidifies the water.

The salinity of the water sample ranged between 0.7ppt to 26 ppt during the study periods. In November has lowest salinity because of the North East monsoon which prevails in Kerala. The heavy inflow of fresh water makes the water equivalent to the riverine water. But drastic variation is seen in the following months of December and January. In January as the water inflow from rivers regress the salinity rises up. The salinity of water has a direct correlation with the temperature too. With increasing temperature, the rate of evaporation also increases which will tend to increase the salinity of water.

The total dissolved solids (TDS) ranged 0.94ppt to 17.8ppt. November 2010 has low TDS value as well as the following December and January showed high TDS values compared to all collections of the periods in study. Remaining all months showed an almost stable TDS value which is around 3.3ppt. Changes in TDS concentration can be harmful because the density of water determines the flow of water into and out of cells of the organisms. If TDS concentrations are too high or too low the growth of much aquatic life may be limited and death may occur.

Oxygen reaches the aquatic system by diffusion from atmosphere and through the photosynthetic activity of the producers. It depends upon physical, chemical and biological activities. The study shows that the amount of dissolved oxygen in this estuary is fluctuating in different months. The dissolved oxygen is a measure of the ability of water to support a well-balanced aquatic biota. The amount of DO is ranged from 2ppm to 8ppm. Throughout the study the amount of oxygen showed least values in November. The month of December indicated values of oxygen which are at desirable range and again January show low values but not as low as in November. Insufficient oxygen, often caused by the decomposition of organic matter and /or nutrient pollution may occur in water bodies tending to suppress the presence of aerobic organisms such as fish. Month of November experiencing the NE monsoon have loads of organic debris brought in by the river inflow into this region resulting in low oxygen content.

Atmospheric air contains only small percentage of carbon dioxide to only very little of this gas enters the water. Enormous amount of CO_2 also exist as carbonates and bicarbonates. A large amount of this is used for photosynthesis. The significant factor is that when oxygen concentration fall through degradation of organic water, the CO_2 concentration rises. The increase in CO_2 makes it more difficult for fish and other organism to use the limited amount of O_2 present. The amount of CO_2 is increased and that of O_2 decreased as we read through consecutive years. This shows that the water body under study is in trouble leading to the degradation of its habitat for supporting the vast majority of

life systems which it supports.

In the diversity study about 68 species of fishes belonging to 45 genera were identified. Fish diversity is rich with fishes representing 10 orders and 34 families. The largest Order is Order Perciformes with 14 families and largest families are Family Carangidae and Family Leiognathidae with six members each. Fishes like *Ambassis gymnocephalus, Caranx malabaricus, Engraulis hamiltonii, Epinephlus malabaricus, Etroplus suratensis, Gerres filamentosus, Gerres settifer, Liza parsia, Mugil cephalus, Scatophagus argus* and *Sillago sihama* are commonly obtained during the study period. Fish diversity was seen high in month of January throughout the study period with more numbers of marine fishes migrating towards the region with the increase in salinity. Fluctuations in the fish diversity can be readily seen with the changes in hydrological parameters. Fishes can be categorized into two based on their primary habitat. Certain fishes found here are of marine origin. Still they are also often found in estuarine waters. The other group consists of brackish water origin. They may be found in fresh water also. Purely fresh water fishes are altogether absent, since they are all stenohaline.

6. Conclusion

Chettuva estuary is a part of Vembanad – Kol wetlands cited under Ramsar sites of Kerala. It carries fishes from both brackish water and marine habitat making its biodiversity more abundant. The nutrients which are brought in by the rivers that drain to this region make it a suitable environment for fast growth of varied life forms. Studies show that the fishes of brackish water origin can provide large amount of protein in human diet. So people depends the estuaries for getting fresh fishes rich in proteins.

The present comparison of four years data reveals that there is notable increase in temperature, decrease in dissolved oxygen and increase in CO_2 content. These changes are all indicators of pollution leading to the deterioration of the water quality parameters which can adversely affect the life sustained by it. Pesticides and fertilizers containing heavy metals and other non-biodegradable wastes from agricultural lands pose a threat to the estuaries. The practices like dumping of wastes and sewage to estuaries are also polluting it. Over exploitation of fishes may reduce the fish diversity of estuaries. Reclamation and sand mining are also badly effects the natural characters of estuaries. All these will decrease the biodiversity in the area gradually. This will ultimately affect the human being. So we should be aware about trends of biodiversity loss of our estuaries and should properly protect it and must make the local people aware about its consequences. Estuaries are the nature's gift for all the generations. So we have no rights to overexploit it, but can utilize sustainably for our needs and protect it for future generations.

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