Applied Ecology and Environmental Sciences, 2015, Vol. 3, No. 2, 42-50
Available online at http://pubs.sciepub.com/aees/3/2/3

DOI:10.12691/aees-3-2-3

Correlation Study of Physico-chemical Parameters and Biodiversity of Poonthura Backwater (Kerala, India)

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Received March 23, 2015; Revised April 05, 2015; Accepted April 16, 2015

Abstract The biodiversity of inland is alarmingly declining primarily due to unsuitable and unethical fishing practices prevalent in the rivers and streams. A variety of destructive type of fishing activities are being practised in the inland water bodies of Kerala such as poisoning using chemicals, insecticides and seeds of plant origin, dynamiting, electric fishing etc. This creates various new and intense pressures leading to decline in species number. The Poonthura backwater in the south west coast of India (Kerala state) is a typical estuary. It is located at a latitude between 8° 25' and 8°3'N and longitude 76° 55' and 77°00'E. This estuary is circular in shape enclosing an island called Edayar. This is separated from the Lakshadweep Sea by a sand bar at Poonthura which opens during the monsoon period consequent to heavy discharge of water from the adjacent rivers. In the present study the biodiversity survey of fish and shellfishes of this backwater was carried on for one year (April 2013 to March 2014). The data on fish community collected during the surveys were correlated with the physico-chemical parameters, nutrients of the water samples, carbon, nitrogen and phosphorous and heavy metals such as copper, lead, manganese, nickel and zinc of the sediments. A total of 32 species were reported during the whole year. All the fish and shellfishes showed seasonal influence with more fresh water species in monsoon months. The marine fishes occur more during pre monsoon. The pre monsoon reported less percentage and non availability of most of the fish species in catches. The analysis of the condition of fishes is of considerable significance in determining the cycle of changes related to other biological aspects of fishes such as feeding and breeding. By virtue of their position at the interface of sea, river and land, estuaries support a distinctive assemblage of birds, fishes, invertebrates as well as characteristic floral communities such as mangrove swamps and salt marshes. The physico-chemical properties in relation to catchment status with condition of the estuary were determined. The correlation analysis proved that, there is a relationship between environmental parameters and survival of the species in those ecosystems.

Keywords: *biodiversity, environment, heavy metal, nutrients, sediment and species*

Cite This Article: Beslin Leena Grace, "Correlation Study of Physico-chemical Parameters and Biodiversity of Poonthura Backwater (Kerala, India)." *Applied Ecology and Environmental Sciences*, vol. 3, no. 2 (2015): 42-50. doi: 10.12691/aees-3-2-3.

1. Introduction

Estuaries are the ecosystems which provide a satisfactory breeding and feeding grounds for a variety of fishes. These highly productive environments require special management and conservational attention since they act as traps for nutrients entering from freshwater flow from land and form nursery areas for many marine species. The fish fauna of Kerala host a total of 50 threatened fishes (Gobi, 2000). Nevertheless, the remote nature and difficulty of monitoring and studying the complex marine environments (due to the three dimensional interchange of mass and energy) create difficulties in quantifying the real level of biodiversity of the area.

The biodiversity of inland is alarmingly declining primarily due to unsuitable and unethical fishing practices prevalent in the rivers and streams. A variety of destructive type of fishing activities are being practiced in the inland water bodies of Kerala such as poisoning using chemicals, insecticides and seeds of plant origin, dynamiting, electric fishing etc. (Kurup *et al.*, 1993). Habitat fragmentation occurring is not related to the changes in a geologic time scale. Instead, fragmentation results from direct modifications such as channelization, dam construction and adverse modification of water quality like chemical spills, siltation and sewage discharges (Yadav, 2000). The major threats to biodiversity conservation as a whole of estuaries are over exploitation and introduction of invasive alien species and aquatic pollution (Khoshoo, 1994). On a daily basis, estuaries present a series of rapid temporal and spatial challenges to the fish that inhabit them. It is known that species becomes rare before becoming extinct. Once rare, the species becomes vulnerable to extinction (Khoshoo 1994). Future efforts to protect species and to prevent rare ones from slipping into extinction will depend on a deeper understanding of the biology of rarity and extinction (Narain, 2000).

Scenario of conserving the ichthyofauna is a hard task, as 70% of water bodies in India are dried and the remaining ones are polluted. So conservation should be deep rooted within the habitat (*in situ*) as well as outside their natural in habitat (*ex situ*). The latter includes the long term preservation of sperms and eggs of fishes in liquid nitrogen (Grace, 2009). The best approach to reduce species depletion is by technological improvements and modifications of gears as well as time and area restrictions on fishing activities (Butchart *et al*., 2010). The *in situ* strategy emphasizes the protection of ecosystems for the conservation of overall diversity of genes, populations, species, communities and the ecological processes which are crucial for ecosystem services (Cai *et al*., 2012).

In order to prevent depletion of biodiversity due to environmental alterations or other ways, it is necessary to understand how the diversity of life particularly at the species level is maintained and it is equally necessary to know how the terminal extinction of species takes place under natural conditions. Moreover, a database on fishery resources of the concerned environment is essential to make decision about specific programmes on conservation of fish germplasm resources. Thus the present exploration aims to quantify the fish and shellfish resources by survey to know the real stocks present in such environment and to observe the conducive and destructive environmental dynamics by the correlation study between the fish community and the environmental variables of the Poonthura backwater.

2. Description of Study Site

The Poonthura backwater is situated about 5.6 km south of the international airport at Thiruvananthapuram (latitude between 8°25' and 8°3'N and longitude 76°55' and 77° 00'E). It is a typical estuary, circular in shape and enclosing an island called Edayar. The total length of the estuary is 4.35 km and the mean width is 0.1 km. This is separated from the Lakshadweep Sea by a sand bar at Poonthura which opens during the monsoon period consequent to heavy discharge of water from the Karamana River. The Parvathy puthanar canal through which the sewage spilled from the sewage farm situated at Muttathara, reaches the Poonthura estuary. The Parvathy puthanar canal connects the Poonthura estuary with the Veli estuary lying further north. The Karamana river which is about 68 km long has its origin in the Agasthyamalai of the western ghats, The Killiar, a small stream, after arising from the Nedumangad hills and flowing for about 24 km joins with the Karamana river, near Nadakara 4.8 km south of Thiruvananthapuram. The Karamana River enters into the estuary at Thiruvallom, where the river is transformed into a sluggish and largely stagnant backwater tract. When the estuary is closed, it is virtually a typical lagoon, largely polluted by sewage. When there is heavy river discharge and land drainage during rainy season, the sand bar between the sea and estuary naturally or manually opened.

- **Station I- Moonatumukku:** It is the reverine zone in which the Parvathi puthanar opens and discharges the sewage directly. The water is dark in colour due to high sewage out fall. It is a fishing zone and the sides are dominated by vegetation.
- **Station II- Chavaripana:** It is the zone where the retting remains are found. The area is shallow with a putrified odour. Flow of water is ensured when the bar mouth opens. Otherwise it is a stagnant water body. It is the most polluted zone of this backwater.
- **Station III- Melatukadavu:** It is the bar mouth region. During opening of the outlet, the area becomes exposed to the sea and less polluted. It is also a fishing zone.

3. Material and Methods

Monthly survey of fishes and shellfishes of the Poonthura backwater were carried out during early morning. The sampling siteswere chosen due to the impairment of water quality by coir retting and pesticide mixed agricultural run-off. All specimens were sorted at the species level and were counted and weighed on board. The same net was used for all sampling; the mesh size for the net opening was 6.3 cm, the depth of the net opening was 6 m, the width of the net opening was 22.6 m, the mesh size of the cod end was 2 cm, and the trawling speed was approximately 4.82 km/h (2.6 knots). The survey was carried out in fresh morning during 4 am. Every month three surveys were taken and made into mean values. Each species was counted separately. The fishes needed for identification were taken as samples. Samples of fishes and shellfishes were preserved in 4% formalin for identification. Identification of fishes was carried out using standard keys (Jayaram, 1981; Talwar and Jhingran, 1991). Stratified random sampling method was followed to assess the count of each species (Krishnaswami, 1993).The survey was carried out for a period of one year (April 2013 to March 2014).

The water and sediment samples were analyzed by standard methods (Trivedy and Goel, 1986). The physico-chemical parameters such as temperature, salinity, dissolved oxygen and nutrients have biological significance and are used as population indicator. Temperature of surface and bottom water was recorded in the site itself using a high quality Celsius thermometer. The hydrogen ion concentration (pH) of water sample was measured in the laboratory using Elico-model L1 – 10 pH meter. The Mohr-Knudsen titration method using potassium chromate indicator was followed to measure the salinity (Grace, 2014). The alkalinity of the sample was estimated by back titration method of Gripenberg modified by Trivedy and Goel (1986).

Dissolved oxygen was determined by classic Winkler's titration method (Grace, 2013). The determination of hydrogen sulphide by Lauth's violet method equalent to methylene blue method was followed (Currie *et al*., 2012). Estimation of ammonia was made by the Colorimetric method of steam distillation by microkjeldahl, distillation unit (Trivedy and Goel, 1986). The Photometric determination of nitrite was followed to estimate the nitrite nitrogen (Grace, 2013).The estimation of Silicate silicon and inorganic phosphate in the water was made by following the modified method of Murphy and Riley (Grace, 2013) and the optical densities were noted spectophotometrically. The total organic carbon from sediment samples were estimated by the Walkley and Black method modified by Trivedy and Goel (1986). Total phosphorous was estimated by modified method of Murphy and Riley and the total nitrogen content was determined by microkjeldahl method (Currie *et al*., 2012). Heavy metals of the Sediment were measured (May and Spears 2012) using atomic absorption spectrophotometer (GBC 932 AA).

In statistical surveys, when subpopulations within an overall population vary, it is advantageous to sample each subpopulation (stratum) independently. Stratified random sampling is a probabilistic sampling option. The first step in stratified random sampling is to split the population into strata, i.e. sections or segments. The percentage of the species and correlation between the environmental parameters and each species were analyzed by Karl Pearson Correlation Coefficient (Kapur, 1981). Statistical analysis for diversity index, diversity richness, evenness and biodiversity dominance were carried out to count the biodiversity criteria (Butchart *et al*., 2010). To understand different biodiversity indices used in the study, they are categorized as follows. Biodiversity is often used as a measure of the health of biological systems. To understand different biodiversity indices used in the study, they are categorized as follows

Diversity Index: A diversity index is a mathematical measure of species diversity in a community. Diversity indices provide more information about community composition than simply species richness (i.e., the number of species present); they also take the relative abundances of different species into account. Diversity indices provide important information about rarity and commonness of species in a community. The ability to quantify diversity in this way is an important tool for biologists trying to understand community structure. Variables:

H Shannon's diversity index
S total number of species in the community(richness)
pi proportion of *S* made up of the *i*th species
EH equitability (evenness)

The proportion of species *i* relative to the total number of species (*pi*) is calculated, and then multiplied by the natural logarithm of this proportion (ln *pi*). The resulting product is summed across species, and multiplied by -1:

$$H = -\sum_{j=1}^{x} P_j \ln P_j$$

Shannon's equitability (*EH*) can be calculated by dividing *H* by *H*max (here *H*max = ln*S*). Equitability assumes a value between 0 and 1 with 1 being complete evenness.

$$E_H = H / H_{\max} = H / \ln S$$

Diversity Richness or Species Richness: It is the simplest measure of biodiversity, and is simply a count of the number of different species in a given area. Species richness is also referred to as alpha-diversity. Species richness is commonly used, along with other factors, as a measure for determining the overall health of different biological ecosystems. High species richness for a given area indicates a high level of ecosystem stability, thus allowing the ecosystem to better withstand natural or anthropogenic disturbance. Richness R simply quantifies how many different types the dataset of interest contains. For example, species richness (usually notated S) of a dataset is the number of different species in the corresponding species list. Richness is a simple measure, so it has been a popular diversity index in ecology, where abundance data are often not available for the datasets of interest. However, if true diversity is calculated with q = 0, the effective number of types (0D) equals the actual number of types (R).

Species Evenness: It refers to how close in numbers each species in an environment are. Mathematically it is defined as a diversity index, a measure of biodiversity which quantifies how equal the community is numerically. The evenness of a community can be represented by Pielou's evenness index:

$$J' = \frac{H'}{H'_{\max}}$$

Where the number is derived from the Shannon diversity index and $H'_{\max}$ is the maximum value of H' equal to:

$$H'_{\max} = -\sum_{i=1}^{S} \frac{1}{S} \ln \frac{1}{S} = \ln S.$$

J' is constrained between 0 and 1. The less variation in communities between the species, the higher is ***J'***.

Biodiversity Dominance or Simpson's Dominance Index: It measures biodiversity based on the probability that two individuals randomly selected from a sample will belong to the same species (or some category other than species). Simpson's dominance index ranges from 0 (all taxa are equally present) to 1.0 (one taxon dominates the community completely).

4. Results

The results of the biodiversity of fishes in percentage and their significance with environmental parameters of Poonthura backwater were presented in Table 1 to Table 5. A total of 31 species were recorded from the Poonthura backwater. The percentage of *Oreochromis* showed a significant negative correlation with temperature, hydrogen sulphide, nitrite nitrogen, nickel and highly significant positive correlation with total nitrogen.The percentage of *Etroplus suratensis* ranged from 2.01 in July to 21.05 in January. It showed a significant positive correlation with nitrite nitrogen and total phosphorus. The percentage of *E. maculatus* ranged from 0.09 in August to 6.97 in December. This species showed positive significance with salinity and negative significance with alkalinity and lead. The percentage of *Terapon jarbua* ranged between 0.48 in August and 4.56 in April. It showed a highly significant negative correlation with lead, manganese and highly significant positive correlation with zinc.

The percentage of *Caranx sehfsciatis* ranged from 0.48 in February to 3.63 in October. It showed a negative significance with hydrogen sulphide, positive significance with zinc, highly significant positive correlation with organic carbon and highly significant negative correlation with total phosphorus. The percentage of *C. ignobilus* ranged from 0.51 in February to 8.25 in December. It showed a negative significance with temperature, ammonia nitrogen, positive significance with copper, zinc, highly significant negative correlation with hydrogen sulphide and total phosphorus. The percentage of *Chanda ranga* ranged from 0.55 in July to 6.6 in September. It showed a negative significance with nitrite nitrogen and nickel, positive significance with zinc, highly significant negative correlation with hydrogen sulphide, ammonia nitrogen and total phosphorus. The percentage of *C. nama* ranged from 2.34 in September to 14.63 in February. It did not show any correlation with any environmental parameters.

Table 1. Species composition of Poonthura Backwater

Sl. No.	Order	Family	Species
1	Elopiformes	Elopidae	*Elops machnata* (Forsskal)
2	Elopiformes	Megalopidae	*Megalops cyprinoides* (Broussonet)
3	Elopiformes	Tachysuridae	*Tachysurus subostratus* (Valenciennes)
4	Siluriformes	Bagridae	*Mystus gulio* (Hamilton)
5	Siluriformes	Hemiramphidae	*Hyphorhampus improvis* (Valenciennes)
6	Siluriformes	Mugilidae	*Mugil cephalus (*Linnaeus)
7	Siluriformes	Mugilidae	*Liza parsia* (Hamilton-Buchanan)
8	Siluriformes	Mugilidae	*Valamugil cunnesius* (Valenciennes)
9	Siluriformes	Teraponidae	*Terapon jarbua* (Forsskal)
10	Siluriformes	Carangidae	*Caranx ignobilus* (Forsskal)
11	Siluriformes	Carangidae	*Caranx sehfsciatis* (Bloch)
12	Siluriformes	Lutjanidae	*Lutjanus johni* (Bloch)
13	Siluriformes	Gerridae	*Gerrus filamentosus* (Cuvier)
14	Perciformes	Cichlidae	*Oreochromis mossambica* (Peters)
15	Perciformes	Cichlidae	*Etroplus suratensis* (Bloch)
16	Perciformes	Cichlidae	*Etroplus maculatus* (Bloch)
17	Perciformes	Gobiidae	*Glossogobius giuris* (Hamilton-Buchanan)
18	Perciformes	Gobiidae	Periophthalmus weberi (Eggert)
19	Perciformes	Anabantidae	*Anabas testudineus* (Bloch)
20	Perciformes	Ambassidae	*Chanda nama* (Hamilton-Buchanan)
21	Perciformes	Ambassidae	*Chanda ranga* (Hamilton-Buchanan)
22	Cypriniformes	Anguillidae	*Anguilla bengalensis* (Gray)
23	Cypriniformes	Cyprinidae	*Catla catla* (Hamilton-Buchanan)
24	Cypriniformes	Cyprinidae	*Puntius filamentosus* (Valenciennes)
25	Cypriniformes	Scatophagidae	*Scatophagus argus* (Bloch)
26	Cypriniformes	Aridae	*Arius arius* (Hamilton-Buchanan)
27	Pleuronectiformes	Soleidae	*Austroglossus pectoralis* (Kaup)
28	Decapoda	Palaemonidae	*Macrobrachium idella* (Heller)
29	Decapoda	Penaeidae	*Penaeus monodon* (Fabricius)
30	Decapoda	Penaeidae	*Penaeus indicus* (Milne Edwards)
31.	Decapoda	Portunidae	*Scylla serrata (Forsskal)*

Table 2. Biodiversity of Fin and Shell Fishes (%) of Poonthura Backwater

Name of fish	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
Oreochromis mossambica	25.33	35.30	39.79	55.59	46.72	65.92	55.46	46.40	27.97	32.62	23.18	26.12
Etroplus suratensis	15.20	13.11	10.47	2.01	9.45	6.60	5.42	7.87	16.47	21.05	9.66	11.05
Etroplus maculatus	5.07	4.54	5.24	5.53	0.09	0.00	0.00	4.36	6.97	0.00	0.00	0.00
Terapon jarbua	4.56	1.58	0.00	0.00	0.48	0.00	2.64	3.65	2.22	1.65	1.30	0.00
Caranx sehfsciatis	0.00	0.00	0.00	0.65	0.00	2.69	3.63	1.33	1.14	1.28	0.48	0.00
Caranx ignobilus	0.00	0.00	0.00	0.65	4.77	6.10	3.94	4.69	8.25	1.14	0.51	0.00
Chanda ranga	0.00	0.00	0.00	0.55	4.27	6.60	6.39	2.30	3.40	0.00	0.00	0.00
Chanda nama	10.13	5.35	0.00	0.00	0.00	2.34	2.66	4.69	5.09	11.21	14.63	0.00
Mugil cephalus	10.72	6.33	7.85	0.65	2.37	0.00	1.92	8.73	4.80	0.00	5.02	0.00
Channa marulius	5.86	5.78	5.24	1.94	0.48	1.32	0.68	1.82	1.03	5.47	2.24	4.02
Channa striatus	0.05	0.00	2.09	0.76	0.58	0.50	0.74	1.33	1.60	0.00	0.00	2.01
Megalops cyprinoides	5.45	2.52	1.05	1.39	0.00	2.64	1.23	0.89	1.29	0.00	2.41	3.01
Gerrus filamentosus	1.52	0.00	5.76	0.74	2.37	0.00	1.25	0.56	0.00	0.00	0.00	0.00
Puntius filamentosus	2.03	3.03	0.00	0.00	0.00	0.00	0.90	1.63	1.98	10.68	4.83	1.00
Anabas testudineus	2.03	0.00	0.00	0.00	0.00	0.66	1.00	0.00	0.00	0.00	0.00	0.00
Mystus gulio	1.52	0.58	0.00	0.00	0.00	0.00	0.22	0.10	0.00	0.00	0.48	0.00
Arius arius	0.71	0.35	0.00	0.28	0.00	0.00	0.00	0.00	0.11	0.00	0.29	0.00
Valamugil cunnaecius	5.50	0.00	5.24	1.39	0.23	4.35	4.32	1.90	2.85	0.00	0.48	0.00
Liza parsia	0.00	2.54	0.00	0.00	2.03	0.00	2.10	2.62	1.79	0.00	0.00	0.00
Elops machnata	2.82	1.23	0.00	0.00	0.23	0.00	0.90	0.00	0.66	0.00	0.50	0.50
Catla catla	0.00	0.10	0.31	0.00	0.00	0.00	0.08	0.06	0.00	0.06	0.05	0.05
Hyphoramphus improvis	0.00	0.00	0.00	0.00	1.32	0.00	0.51	0.00	3.17	4.29	0.00	0.00
Periophthalmus weberi	0.00	0.00	0.00	0.70	0.48	0.00	0.88	1.21	0.58	0.00	0.00	0.00
Gaterius diagramms	0.00	0.00	0.00	0.10	0.00	0.26	0.43	0.06	0.00	0.00	0.00	0.00
Scatophagus argus	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.25	0.69	0.00	0.00	0.00
Lutjanus johni	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Scomfromorus gutatus	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.83	0.34	0.00	0.00	0.00
Scylla serrata	1.52	0.50	0.21	0.17	0.00	0.00	1.07	1.09	2.27	0.02	0.08	1.00
Penaeus monodon	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.00	0.05	0.00
Penaeus indicus	0.00	14.62	13.09	25.16	23.87	0.00	0.00	1.58	3.69	10.52	33.80	51.23
Macrobrachium idella	0.00	2.52	3.66	1.61	0.00	0.00	1.64	0.00	1.58	0.00	0.00	0.00

Table 3. Karl Pearson correlation showing the significance (5%) by relating the number of fishes and physico-chemical parameters of Poonthura backwater

Name of fish	Temperature	PH	Salinity	Alkalinity	Dissolved Oxygen
Oreochromismossambica	-0.50*	0.01	-0.01	-0.18	0.29
Etroplus suratensis	0.31	0.16	-0.18	0.30	-0.44
Etroplus maculatus	-0.25	0.33	0.63*	-0.50*	0.45
Terapon jarbua	0.14	-0.15	0.26	-0.03	-0.44
Caranx sehfsciatis	-0.20	-0.45	-0.15	0.13	-0.44
Caranx ignobilus	-0.54*	-0.39	0.21	-0.24	-0.43
Chanda ranga	-0.48	-0.31	-0.16	0.07	-0.29
Chanda nama	0.40	-0.05	-0.19	0.32	-0.49
Mugil cephalus	-0.13	0.26	0.43	-0.33	0.09
Channa marulius	0.46	0.52*	-0.16	0.23	0.21
Channa striatus	-0.26	-0.35	0.52*	-0.58*	0.11
Megalops cyprinoides	0.51*	0.03	-0.19	0.34	0.07
Gerrus filamentosus	-0.61*	0.35	0.08	-0.32	0.51*
Puntius filamentosus	0.42	0.01	-0.25	0.33	-0.50
Anabas testudineus	0.12	-0.04	-0.30	0.36	-0.08
Mystus gulio	0.38	0.25	-0.19	0.35	0.01
Arius arius	0.38	0.36	-0.10	0.28	0.27
Valamugil cunnaecius	-0.45	-0.03	0.03	-0.11	0.11
Liza parsia	-0.21	0.09	0.32	-0.17	-0.21
Elops machnata	0.41	0.20	-0.24	0.45	-0.04
Catla catla	-0.28	0.35	0.08	-0.22	0.29
Hyphoramphus improvis	-0.05	-0.09	-0.12	0.15	-0.47
Periophthalmus weberi	-0.36	-0.40	0.64*	-0.57*	-0.10
Gaterius diagramms	-0.18	-0.30	-0.25	0.20	-0.15
Scatophagus argus	-0.26	-0.30	0.60*	-0.44	-0.28
Lutjanus johni	-0.36	0.17	-0.17	0.01	0.11
Scomfromorus gutatus	-0.34	-0.34	0.82**	-0.76**	-0.30
Scylla serrata	0.13	-0.36	0.38	-0.11	-0.36
Penaeus monodon	-0.09	-0.45	0.58*	-0.46	-0.47
Penaeus indicus	0.49	-0.11	-0.12	0.12	0.18
Macrobrachium idella	-0.34	0.55*	0.10	-0.12	0.56*

* Significant
** Highly significant

Table 4. Karl Pearson Correlation showing the significance (5%) by relating the number of fishes and nutrients of Poonthura backwater

Name of fish	Hydrogen Sulphide	Ammonia Nitrogen	Nitrite Nitrogen	Phosphate Phosphorus	Silicate silicon
Oreochromis mossambica	-0.67*	-0.27	-0.53*	-0.31	-0.04
Etroplus suratensis	0.46	-0.13	0.52*	-0.07	0.12
Etroplus maculatus	0.21	0.30	0.30	-0.40	0.04
Terapon jarbua	0.03	-0.32	0.23	-0.06	0.02
Caranx sehfsciatis	-0.68*	-0.49	-0.46	-0.02	-0.41
Caranx ignobilus	-0.79**	-0.63*	-0.45	-0.49	-0.20
Chanda ranga	-0.78**	-0.71**	-0.58*	-0.15	-0.06
Chanda nama	0.27	0.00	0.38	0.07	-0.11
Mugil cephalus	0.36	-0.08	0.33	-0.13	0.23
Channa marulius	0.87**	0.32	0.68*	0.20	0.25
Channa striatus	-0.12	0.18	-0.36	0.02	-0.37
Megalops cyprinoides	0.53*	0.18	0.36	0.48	0.09
Gerrus filamentosus	0.08	0.05	-0.32	-0.06	0.22
Puntius filamentosus	0.24	0.04	0.39	-0.06	-0.14
Anabas testudineus	0.076	-0.21	-0.05	0.29	0.11
Mystus gulio	0.53*	0.01	0.47	0.30	0.36
Arius arius	0.56*	0.31	0.53*	0.19	0.33
Valamugil cunnaecius	-0.16	-0.19	-0.36	-0.02	-0.17
Liza parsia	-0.23	-0.62*	0.19	-0.24	0.4
Elops machnata	0.53*	-0.06	0.47	0.41	0.40
Catla catla	0.35	0.10	0.06	0.09	0.05
Hyphoramphus improvis	-0.19	-0.17	0.01	-0.36	-0.14
Periophthalmus weberi	-0.68*	-0.19	-0.41	-0.34	-0.22
Gaterius diagramms	-0.56*	-0.38	-0.47	0.19	-0.21
Scatophagus argus	-0.31	-0.08	-0.03	-0.45	-0.34
Lutjanus johni	-0.26	-0.33	-0.28	-0.17	0.57*
Scomfromorus gutatus	-0.48	-0.34	-0.17	-0.58*	-0.20
Scylla serrata	0.06	-0.12	0.15	0.09	-0.16
Penaeus monodon	-0.25	-0.07	-0.02	-0.28	-0.43
Penaeus indicus	0.36	0.58*	0.09	0.51*	0.01
Macrobrachium idella	0.30	0.17	0.22	-0.00	0.23

* Significant
** Highly significant

Table 5. Karl Pearson Correlation showing the significance (5%) by relating the number of fishes and sediment parameters of Poonthura backwater

Name of fish	Organic carbon	Total Phosphorus	Total Nitrogen	Copper	Lead	Manganese	Nickel	Zinc
Oreochromis mossambica	0.11	-0.73**	-0.29	0.18	-0.06	0.23	-0.65*	0.11
Etroplus suratensis	0.00	0.53*	0.42	-0.08	-0.02	-0.33	0.31	0.15
Etroplus maculatus	-0.45	-0.03	-0.38	-0.15	-0.50*	-0.43	0.08	-0.04
Terapon jarbua	0.35	-0.16	0.30	0.17	-0.77**	-0.72**	0.07	0.73**
Caranx sehfsciatis	0.79**	-0.72**	-0.10	0.48	-0.07	0.18	-0.30	0.65*
Caranx ignobilus	0.24	-0.80**	0.33	0.51*	-0.08	0.18	-0.37	0.57*
Chanda ranga	0.49	-0.86**	0.16	0.46	-0.05	0.18	-0.66*	0.55*
Chanda nama	0.21	0.41	0.29	-0.10	-0.11	-0.31	0.46	0.31
Mugil cephalus	-0.24	0.09	-0.00	0.01	0.81**	-0.77**	0.01	0.33
Channa marulius	-0.22	0.78**	-0.23	-0.36	-0.20	-0.53*	0.25	-0.27
Channa striatus	-0.18	-0.17	-0.18	0.21	0.07	0.33	0.18	-0.16
Megalops cyprinoides	0.07	0.36	-0.06	-0.33	-0.32	-0.62*	0.09	0.01
Gerrus filamentosus	-0.39	-0.04	-0.15	-0.28	-0.19	-0.05	-0.25	-0.16
Puntius filamentosus	0.20	0.49	0.25	-0.04	0.20	0.00	0.49	0.11
Anabas testudineus	0.36	-0.13	0.16	-0.30	-0.53*	-0.65*	-0.25	0.45
Mystus gulio	0.07	0.33	0.12	-0.35	-0.56*	-0.84**	0.00	0.23
Arius arius	-0.17	0.41	-0.05	-0.54*	-0.38	-0.69*	0.12	-0.07
Valamugil cunnaecius	0.18	-0.41	-0.19	-0.13	-0.55*	-0.40	-0.30	0.46
Liza parsia	0.22	-0.50*	0.07	0.73**	-0.42	-0.24	-0.45	0.45
Elops machnata	0.19	0.26	0.14	-0.28	-0.50*	-0.81**	-0.06	0.24
Catla catla	-0.13	0.21	-0.50*	0.10	-0.12	-0.02	0.01	-0.13
Hyphoramphus improvis	0.11	0.03	0.43	0.01	0.31	0.25	0.21	0.17
Periophthalmus weberi	0.17	-0.76**	0.02	0.44	-0.32	0.14	-0.11	0.39
Gaterius diagramms	0.73**	-0.70**	-0.26	0.34	-0.08	0.13	-0.45	0.46
Scatophagus argus	-0.04	-0.35	0.10	0.31	-0.13	0.05	0.22	0.31
Lutjanus johni	-0.34	-0.17	0.59*	-0.10	0.19	0.19	-0.47	-0.17
Scomfromorus gutatus	-0.12	-0.50*	0.30	0.55*	-0.48	-0.08	0.01	0.45
Scylla serrata	0.28	-0.19	0.14	0.23	-0.43	-0.40	0.20	0.46
Penaeus monodon	0.01	-0.16	0.21	0.42	-0.15	0.07	0.45	0.38
Penaeus indicus	-0.30	0.60*	0.02	-0.23	0.70*	0.51*	0.47	-0.77**
Macrobrachium idella	-0.14	0.00	-0.76**	0.03	-0.11	-0.07	-0.19	-0.21

* Significant
** Highly significant

The percentage of *Mugil cephalus* ranged from 0.65 in July to 10.72 in April. It showed highly significant negative correlation with lead and manganese. The percentage of *Channa marulius* ranged from 0.48 in August to 5.86 in April. It showed positive significance with manganese and highly significant positive correlation with hydrogen sulphide and total phosphorus. The percentage of *C. striatus* ranged from 0.05 in April to 2.09 in June. It showed positive significance with salinity and negative significance with alkalinity. Percentage of *Megalops cyprinoides* ranged between 0.89 in November and 5.45 in April. It showed positive significance with temperature, hydrogen sulphide and negative significance with manganese. *Gerrus filamentosus* ranged between 0.56 in November to 5.76 in June. It showed negative significance with temperature and positive significance with DO. The percentage of *Puntius filamentosus* ranged from 0.90 in October to 10.68 in January. No significance was noticed with any environmental parameters.

Percentage of *Anabas testudineus* ranged between 0.66 in September and 2.03 in April. It showed a negative significance with lead and manganese. The percentage of *Mystus gulio* ranged between 0.10 in November and 1.52 in April. It showed a significant positive correlation with hydrogen sulphide, negative significance with lead and highly significant negative correlation with manganese. The percentage of *Arius arius* ranged from 0.11 in December to 0.71 in April. It showed a positive significance with hydrogen sulphide, nitrite nitrogen and negative significance with copper and manganese. *Valamugil cunnaecius* ranged between 0.23 in August and 5.5 in April. It showed a negative significance with lead. The percentage of *Liza parsia* ranged between 1.79 in December and 2.62 in November. It showed negative significance with ammonia nitrogen, total phosphorus and highly significant positive correlation with copper.

The percentage of *Elops machnata* ranged from 0.23 in August to 2.82 in April. It showed a positive significance with hydrogen sulphide and negative correlation with manganese. The percentage of *Catla catla* ranged from 0.05 in February and March to 0.31 in June. It showed negative significance with total nitrogen. *Hyphoramphus improvis* ranged from 0.51 in October to 4.29 in January. The percentage of *Periophthalmus weberi* ranged between 0.48 in August 1.21 in November. It showed positive significance with salinity, negative significance with alkalinity, hydrogen sulphide and highly significant negative correlation with total phosphorus. The percentage of *Gaterius diagramms* ranged between 0.06 in November to 0.43 in October. It showed a negative significance with hydrogen sulphide, highly significant positive correlation with organic carbon and highly significant negative correlation with total phosphorus. The percentage of *Sclatophagus argus* was 0.09 in July, 0.25 in November and 0.69 in December. Rest of the months never reported this species. It showed positive significance with salinity. The percentage of *Lutjanus johni* occurred 0.03 only in August. It showed a positive significance with silicate silicon and total nitrogen. The percentage of *Scomfromorus gutatus* was 0.23 in August, 0.34 in December and 0.83 in November. The remaining months never reported this species. It showed negative significance with phosphate phosphorus, total phosphorus, positive significance with copper, highly significant positive correlation with salinity and highly significant negative correlation with alkalinity. Percentage of *Scylla* *serrata* ranged from 0.02 in January to 2.27 in December. It never showed any significance with environmental parameters. The percentage of *Penaeus monodon* was 0.05 in November, December and February. It showed positive significance with salinity. The percentage of *P. indicus* ranged between 1.58 in November and 51.23 in March. It showed a significant positive correlation with ammonia nitrogen, phosphate phosphorus, lead manganese and highly significant negative correlation with zinc. *Macrobrachium idella* ranged from 1.58 in December to 3.66 in June. It showed positive significant negative correlation with total nitrogen.

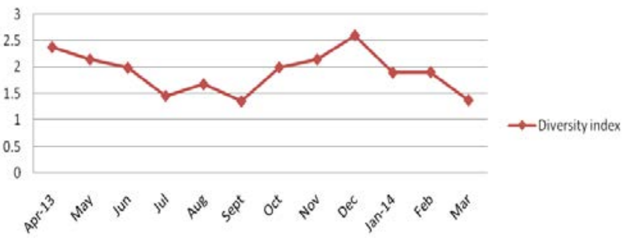

Figure 1. Biodiversity index of the fin and shellfishes present in the Poonthura backwater

In Poonthura backwater, the diversity index ranged between 1.37 in March and 2.59 in December. Species richness ranged between 0.0009 in March to 0.0026 in December. The species evenness of Poonthura backwater ranged between 0.49 in July and 0.84 in April. The diversity dominance of Poonthura backwater ranged between 0.12 in December and 0.45 in September. The biodiversity indices were illustrated in the figure 1 - figure 4.

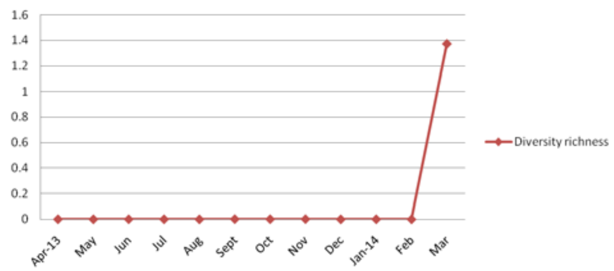

Figure 2. Biodiversity richness of the fin and shellfishes present in the Poonthura backwater

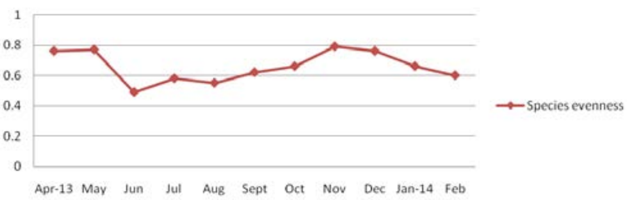

Figure 3. Species Evenness of the fin and shellfishes present in the Poonthura backwater

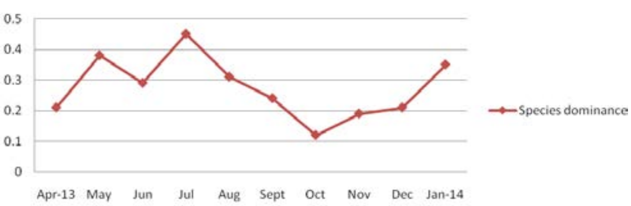

Figure 4. Species Dominance of the fin and shellfishes present in the Poonthura backwater

5. Discussion

The fauna of brackish water system is generally composed of marine and freshwater organisms which are adapted to waters of different salinities besides truly resident estuarine species (Cowley *et al*., 2013). A total of 32 species of fish and shellfish were recorded in the present study. Most of the fish species collected from the environments are transient forms inhabiting the estuarine and riverine environments. Few species are riverine while others are marine forms. Geographically the major parts of the estuarine zone possess the hydro chemical characteristics of river influenced by the occurrence of freshwater species in post monsoon and monsoon seasons. In the dry season, due to seawater mixing and consequent increase in salinity, obvious presence of marine species mostly for feeding purposes (Baran, 2000). The commercially important groups which contribute to the major catches belong to the estuarine habitat are highly seasonal, since the catches depend upon the adjacent sea and river.

According to Grace (2014), the estuarine fauna along the southwest coast of India partially or completely eliminates the estuarine or marine fishes during monsoon and repopulating the species during post monsoon. The present results also showed a partial elimination of the estuarine or marine fishes in monsoon and re-establishment of them during post monsoon. Kennish (2002) suggested that decreased freshwater flow can significantly change the salinity, sediment regimes and nutrient loadings of an estuary, which directly affects the habitat, abundance, distribution of estuarine organisms and trophodynamics of the system. The deficit of species of continental origin is compensated by the presence of larger number of strictly marine ones, whose intrusions are neither limited by the presence of a brackish zone nor by the possible competition with freshwater species (Baran, 2000).

In the present study *Oreochromis mossambica* was the most abundant species in all seasons. Kurup *et al*. (1993) suggested that *Etroplus spp*. and mullets are the most abundant forms having considerable economic importance and contribute appreciably to the catch composition of backwaters in Kerala. But such a trend was not observed during the present study. *Etroplus spp.* once found abundantly in this estuary is no longer available in good numbers. The available reports suggest that the population of *Etroplus spp*. was greatly reduced due to environmental degradation (Khoshoo 1994). A declining catch trend of catfishes such as *Mystus gulio* and *Arius arius* were observed in the present study. Gopi (2000) also reported that certain catfishes were vulnerable to extinction. Grace (2014) reported that the fish *Glossogobius giuris* in the Western Ghats were threatened and the present study also showed that they were very less. Among the mullet species, *Mugil cephalus* and *Liza parsia* contributed considerably to the fishery (Kofi *et al*., 2014). In the present study also these fishes were recorded more or less in higher numbers.

Many interacting physical and biological factors influence the occurrence, distribution, abundance and diversity of estuarine tropical fishes. Among the environmental variables water salinity, temperature, turbidity, dissolved oxygen, and their regular or irregular fluctuations at different time scales, have been identified as determinants in estuarine fish ecology (Marsac *et al*., 2014). Major contributing species for both stations and months are also similar although their percentage of contribution differs from each other. This similarity and dissimilarity is mainly affected by seasonality which is responsible for fluctuation of hydrological and meteorological parameters and thus affecting the fish assemblage in estuaries (Shan *et al.,* 2013). Although there was no evidence to prove that the decline of penaeid prawns and crabs, it was due to intense seed collection and wide spread aquaculture (Kennish 2002). The reasons for the decline of such species can very well be related to intensive coir retting process and the disposal of city sewage through canals in such environments (Grace, 2013). Seasonality also affects the spawning activity of fish and which ultimately influence in catch composition (Shahadat Hossain *et al.,* 2012). In the present investigation also similarity was found in more among the months rather than stations.

Greater evaporation and concentration of pollutants due to increased temperature can limit the distribution of fauna in aquatic ecosystems. Water temperature variation showed less impact on species distribution as value of this parameter was more or less similar throughout the whole station during the study period. Water temperature throughout the year varies according to seasonal variations like sunlight, effect of winds and water currents. Fish communities are highly affected by temperature within estuaries (Marsac *et al.,* 2014). A sudden increase or decrease in water temperature may cause fish mortality (Shan *et al*., 2013). DO generally effect the survival of fishes especially juvenile and fry. Koffi *et al.* (2014) mentioned dissolved oxygen is one of the most important factors for fish abundance and distribution. pH is the most important hydrological factors for species distribution. Villeger *et al.* (2012) found very little impact of this parameter on fish distribution at Bakkhali river estuary. In case of meteorological parameter, rainfall and air temperature is main triggering factors. Rainfall influences salinity distribution. The salt water exclusion is responsible for the remarkable difference in the yield pattern in the upstream and downstream regions of the lake. The depletion of the resources in the upstream is not adequately compensated by natural propagation of freshwater fishes (Kurup *et al*., 1993). This factor also influences the transparency and sediment deposition from surrounding land area.

The distribution of fish and shellfish showed a restricted distribution in the ecosystems studied as the concentration of pollutants particularly H_2S, NH_3, NO_2 and organic carbon was remarkably very high. Heavy siltation, drastic reduction in water volume and loss of breeding grounds are the major factors responsible for the decline in fisheries (Gobi, 2000). Shan *et al*., 2013 reported the presence of various heavy metals, pesticide residues in water, sediments and biotic communities. Their concentration differed in different stretches of the river, but the effluent zone registered relatively higher values. In the present study the distribution of fish showed an inverse relationship with increased concentration of heavy metals, hydrogen sulphide and ammonia, which not only cause stress to aquatic organisms, but also disturb the migratory pattern of the fish (Kennish, 2002).

The diversity index (2.9) in Poonthura backwater overlay the hydrological influence of the species diversity by different criteria such as biogeography, size of the estuarine zone, habitat diversity, and openness to adjacent ecosystem (Koffi *et al.,* 2014). It suggests that extreme climatic variations may results in an alteration of fauna of different origin and increase the global temperature may also results in loss of freshwater species (Baran, 2000). The species richness of estuaries is the number of the particular species which encountered their limits at the particular ecosystem (Cai *et al.,* 2012). The species richness was due to two antagonistic hydrological processes such as penetration of fish fauna from marine or freshwater origin and permanent resident species which make up the bulk of the catches. The concept of hot spots (species richness) largely based on concentration of species in an area plays an important role on nature that result from the exchanges between biotic and abiotic components in various ecosystems (Grace, 2014). The low species evenness (0.84) was due to the dominance of certain species which reduced the chances of survival of more species because of the non-availability of feeding and breeding grounds for all the inhabitants and due to pollution stress. The estuarine species composition and abundance of the fauna depend both on river hydrological regimes and sea water biogeographical regions (Currie *et al.*, 2012). Rarity should not be ignored. The first step to avoid the extinction of the rare species is of course a better knowledge of the biology of a species, correct management and the elimination of the threats.

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