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A study of zooplankton abundance and hydrology of chettuva mangrove

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Abstract
The present study deals with zooplankton abundance and hydrology of Chettuva mangrove, Kerala. Monthly sampling was done in two stations (Station I- non mangrove area, Station II- mangrove area) for a period of seven months from January to July 2013. The zooplankton abundance was influenced by physic chemical factors of water. Their density showed considerable seasonal fluctuation with peak abundance during monsson and pre monsoon.

Keywords: zooplankton, hydrology, mangrove

Introduction
Kerala is gifted with fairly long coastal line and extensive estuaries. Estuarine water contain a rich supply of nutrients. It is a perfectly buffered zone against abrupt change in p^H and salinity. The study of the physic- chemical characteristic is a pre- requisite for the assessment of potentialities of an aquatic ecosystem. Abundance and diversities of biotic community in the shallow water systems such as lakes, back waters and estuaries are influenced to a greater extend by various physic chemical parameters.

An estuary is a semi enclosed coastal body of water which has a free connection with open sea and within which sea water is measurably diluted with fresh water derived from land drainage (Pritchord, 1967) [19]. Estuaries are considered as transition zones between fresh and marine habitat. They have unique physic chemical characteristics. An estuary is a nutrient trap, which is partly physical and partly biological (Odum, 1971) [17]. India has about 1.4 million hectors of estuarine areas (Achary, 1987). The area of estuaries and backwaters in Thrissur district of Kerala is 1.409.7 hecteres (KSLUB, 1993) [14]. The estuarine environment represent an ecotone between fresh and marine water ecosystem and is influenced by both, but is in many ways more complex than either of them (Cearreta *et al*, 2000; Elliott and De Jorge, 2002; Elliott and MCLUSKY,2002) [5, 10, 9]. The word "estuary" is derived from the latin word "aestuarium" meaning tidal intel of the sea, which in itself is derived from the term "aestus" meaning tide. The inflow of both sea water and fresh water provide high levels of nutrients in both the water columns and sediments, making estuaries the most productive natural habitat in the world. Estuary is a dynamic ecosystem which has a free connection with the open sea.

Estuarine variables consist predominantly of, fluctuations in dissolved oxygen salinity and sediment load in the water. There is an extreme spatial variability in salinity at the river end and the estuary mouth. At any one point, the salinity will vary considerably over time seasons, making it a harsh environment for organisms to live. The input of anthropogenic agents and dead and decayed organic matter removes the dissolved oxygen from the water resulting in hypoxic conditions.

Many of the estuaries in Kerala are characterized by mangroves. Mangroves are biologically rich coastal ecosystem, mostly found along the saline marshes near sea shore and back water in tropical and sub-tropical regions. Kerala has 590 km long coast line constituted by long stretches of back waters with mangrove and species of long diverse ecology.

In the 1960 the term "mangal" was used for a community of mangrove plant the term "mangrove" for the plant species making up the forest. Mangrove can be trees, shrubs, palms or ground ferns growing in the zone between high and low tides. The word "Mangrove" is obscurely connected with the Portuguese word "mangue" and the Spanish word "mangle" and the English word "grove". The mangrove vegetation of kerala cover an area of 1671 hecteres

and are found as discrete and isolated patches in different parts of the state (Basha, 1991) [2]. Kerala mangrove are becoming endangered due to the lack of scientific attention (Sunil Kumar, 2002) [29]. There are about 80 species of mangrove plants. All of these plants grow in areas with low oxygen soil, where slow moving waters allow fine sediments to accumulate. Many mangrove forests can be recognized by their dense tangle of prop roots that make the trees appear to be standing on slit above the water. Approximately 15 species of mangroves occurs in South East Asia, 15 species in Africa and 10 species in America. Mangrove are found in regions such as estuaries and broad muddy tidal flats.

The unique family of Rhizophoraceae includes the halophytic (salt tolerant) species of mangrove tree that are endemic to tropical coasts. Like many other species of higher plants, Rhizophora plant release chemical compounds through their roots and leaves, which prevent the growth of invasive plants. Research needs to be conducted to determine the suppressive inhibitory compounds because of the obvious implication for applications with, out of control tumor growth and pathogens in human.

Mangrove canopies and aerial root offer wealth of habitat opportunities to many species of estuarine invertebrates. Mangrove forest stabilize the coast line, reduce erosion from storm surges, currents, waves and tides. The root systems of mangrove also makes these forests attractive to fishes and other organisms seeking food and shelter from predators.

Tropical estuaries are most productive and zooplankton rich ecosystems in the world (Robertson and Blabber, 1992). High zooplankton biomass and productivity may be related to the input of energy and organic matter from mangrove forests, which are of the most frequent coastal vegetation in the tropics (Lugo and Snedaker, 1974) [15]. Zooplankton is an important intermediate component in estuarine food webs, acting as a tropic link between small particle and planktivorous fishes. Zooplankton consist primarily of protozoan, ciliates, rotifers and copepods.

The name plankton is derived from the Greek word “planktos” meaning “wanderer” or “drifter” (Thurman, 1997) [30]. Plankton are primarily divided into the following groups-phytoplankton and zooplankton. Zooplankton are the heterotrophic type of plankton. Many zooplankton are too small to be seen individually with the naked eye.

The study is an attempt to compare the abundance of zooplankton in noon mangrove and mangrove regions along with physical- chemical variations in the two stations and importance of mangrove ecosystem.

Materials and Methods

The present study site, chettuva back water is located in between Orumanayoor panchayath and Pavarti panchayath of Thrissur district in Kerala. The Chettuva back water starts from Enamakkal lake and empties to Arabian sea. The destination is blessed with a vast island in the eastern side of it. The estuary is locally known as Chettuva Manalpuram is also notable for its scenic beauty. Monthly collections were made from January to July (2013), considering January, February & March as Post-monsoon, April& May as Pre-monsoon and June & July as Monsoon. The sampling was done in two stations. Station I is the non-mangrove region and station II is the mangrove zone. The collections were done in the early morning around 6.30 am in the second week of every month.

Water samples were collected using Niskin water sampler. Samples for dissolved oxygen (DO) were fixed on board and the remaining water samples were collected in 1-L plastic bottles kept in ice boxes and brought to the laboratory at the earliest possible time. Temperature and pH of water sample were determined in the field by using thermometer and pH meter. Salinity, dissolved oxygen and carbon dioxide were analyzed by titration methods.

Zooplankton population is distributed in a patchy way due to which both sampling and data interpretation is difficult. Common method for zooplankton sampling is the use of plankton net of 30mm pore size. Plankton nets are pulled through the water vertically for a known depth. Collected sample is then preserved with 5% formalin. The quantitative enumeration of the zooplankton was carried out with the help of a Sedgwick-Rafter (S-R) counting cell which is 50 mm long, 20 mm wide and 1 mm deep. Before filling the SR cell with sample, the cover glasses were diagonally placed across the cell and then samples were transferred with a large bore pipette so that no air bubbles in the cell covers were formed. The S-R cell was let stunned for at least 15 minutes to settle zooplankton. Then plankton on the bottom of the S-R cell was enumerated by compound microscope. By moving the mechanical stage, the entire bottom of the slide area was examined carefully. Number of plankton (Zooplankton) in the S-R cell was derived from the following formula.

$$\text{Number of organisms / ml} = \frac{\text{No of organisms counted in all strips}}{L \times D \times W \times S}$$

Where, L = length of each strip (S-R cell length) in mm; D = depth of a strip (Whipple grid image width) in mm; W=width of strip; S = number of strips counted. The number of cells per mm was multiplied by a correction factor to adjust the number of organisms per liter (APHA 1976).

Result

The monthly and seasonal variations of temperature, p^H, dissolved oxygen, dissolved carbon dioxide, salinity and plankton are represented in Table 1-2 and figure 1-6

Temperature

The average value of water temperature ranged between 25.8 ^{0}C – 35 ^{0}C in station I (Non mangrove) and 25.65 ^{0}C - 32.32 ^{0}C in station II (Mangrove). The highest water temperature was recorded during Pre-monsoon (31.35 ^{0}C) and lowest in Monsoon (25.8 ^{0}C) season in both stations.

p^H

The average p^H value of station I (Non mangrove) ranged between 7.84 – 8.316. In station II (Mangrove) the value lies between 7.92 – 8.156. The maximum p^H (8.31, 8.156) was reported during Post-monsoon in both stations. The minimum values (7.8407.92) were obtained during Monsoon in both stations.

Dissolved Oxygen

The values of dissolved oxygen ranged between 1.64-2.25 mg/l in station I (Non mangrove). In station II (Mangrove) the values were 0.706-1.63 mg/l. the maximum dissolved oxygen was reported during Monsoon season and minimum values were obtained during Post-monsoon season in both stations.

Dissolved Carbon dioxide

The value of dissolved carbon dioxide in station I (Non

mangrove) was ranged between 1.32 to 1.77 mg/l and 2.17-2.88 mg/l in station II (Mangrove). The maximum value (1.77mg/l) was obtained during Pre- monsoon season in station I (Non mangrove) and lowest value (1.32) in Post-monsoon season. In station II (Mangrove), the maximum value (2.88mg/l) was reported during Monsoon season and lowest (2.17mg/l) in Post-monsoon season.

Salinity

The average salinity value was ranged between 23.3-34.69 ppt in station I (Non mangrove) and 23.4-35.7 ppt in station II (Mangrove). The maximum values (34.69, 35.7) was reported during Pre-monsoon season in both stations and lowest (23.3, 23.4) in Monsoon season in both stations.

Zooplankton

The maximum total zooplankton abundance (22.2%) was found in the month of July and minimum (7.3%) in the month of January in station I. In station II maximum value recorded (21.1%) in July and minimum (8.8%) in January. These showed that there is no significant variation of total zooplankton among two stations. The maximum values of zooplankton population was reported during Monsoon season and lowest in Post-monsoon season in both stations.

Table 1: Monthly variations of physic- chemical parameters station I (Non mangrove)

Month	Temperature (^{0}C)	p^H	Dissolved O_2 (mg/l)	Dissolved CO_2 (mg/l)	Salinity (ppt)	Zooplankton (/l)
January	28.2	8.34	1.28	1.32	32.9	15000
February	29	8.39	1.8	1.056	33	17700
March	30	8.22	1.84	1.584	34.21	22000
April	30	8.26	1.6	1.76	34.621	28000
May	32.7	8.13	1.72	1.79	34.72	32000
June	26	7.86	2	1.54	23.5	45000
July	25.6	7.83	2.5	1.51	23.1	45560

Table 2: Monthly variations of physic- chemical parameters station II (Mangrove)

Month	Temperature (^{0}C)	p^H	Dissolved O_2 (mg/l)	Dissolved CO_2 (mg/l)	Salinity (ppt)	Zooplankton (/l)
January	27	8.4	0.64	1.848	34.63	5000
February	28	8.06	0.68	1.584	34.76	5500
March	29.5	8.01	0.8	3.08	35.57	7660
April	32	7.96	1.12	3.12	35.68	7980
May	32	7.97	1.23	2.2	35.72	8800
June	26	7.92	1.61	2.86	23.6	10000
July	25.3	7.93	1.65	2.9	23.2	12000

Discussion

The temperature variations are a function of bathymetry, solar radiation, tidal currents, incidence of up welled waters and atmospheric variations (Alvarez Borrego, 1982). Temperature is a factor of prime importance in the physical environment of organisms. It is one of the important characteristics of water controlling the activities and distribution of animals and plants (Alabaster and uoyd, 1980) [1]. Temperature plays an important role in establishing the water quality criteria.

In the study there was a gradual increase in temperature from Post- monsoon to Pre- monsoon and the temperature declined during the monsoon. similar observation were reported by Dehadral (1970) [8]; Quasim and Sen Gupta (1981) [21] and Rivanker (1991). Temperature was higher during Pre-monsoon with peak value in the month of May (Figure 1). This can be attributed to higher atmospheric temperature prevailing at that time. During monsoon the lowering of temperature may be due to the influx of the cooler fresh water into the estuary. Water temperature in the two stations, was remained almost the same in all the three seasons. Water temperature showed not much fluctuations in the three seasons also.

p^H is an important factor for establishing water quality criteria for inland fisheries. Study of p^H in the two stations revealed that it is comparatively high in station I than station II (7.92-8.156) and it showed a sudden decline in Monsoon season especially in noon mangrove zone (7.84-8.316). p^H generally showed high values during post-monsoon and low values in monsoon in both stations (Figure 2). The high p^H value during post-monsoon season may be due to the influx of sea water. The low value in monsoon may be due to decrease in the level of salinity. Low p^H values during post-monsoon have been reported by various workers (Srinivasan and Pillai, 1973., Singbal, 1985., James and Najmuddin, 1986) [13]. The p^H of water was slightly alkaline during pre-monsoon and post monsoon coincided with high values of salinity. Low value of p^H coincide with high value of dissolved oxygen indicating inverse relationship between p^H and dissolved oxygen. Such relationship has been observed by Ingole and Paralekar (1998) [12] Nagarajaiah and Gupta (1983) [16] reported similar trend in brackish water along Nethravati estuary. Mangrove p^H regulation by soil water interaction besides biological process in rivers and estuaries was suggested by Sarma *et al*., (2009) [25].

Dissolved oxygen in natural water is of prime importance both as a regulator of metabolic processes of plant and animal community and as an indicator of water condition. Depletion of dissolved oxygen is probably the most frequent oxygen values were almost stable in post-monsoon and pre-monsoon season and minimum value was obtained in Post-monsoon season in both stations (figure 3). The variations of dissolved oxygen was in contrast with the variation in salinity. Decreased salinity increase the solubility of oxygen in water. This was reported by Singbal (1976) Quasim and Sen Gupta (1981) [21] and De Souza and Sen Gupta (1986). The high value during monsoon are due to precipitation and influx of oxygen rich fresh water from river mouth.

Dissolved oxygen concentration was always high in the non-mangrove zone (typical estuaries zone) than the mangrove zone. Oxygen concentration in all the three seasons was found to be low in the mangrove area (0.706-1.63). In station II (mangrove) marked depletion in dissolved oxygen leading to

anoxic condition coupled with production of large amounts of H_2S in the water body was a notable aspect of the station II (mangrove).

Free carbon dioxide dissolved in water is essentially the only source of carbon that can be assimilated and incorporated in to the body of all aquatic autotrophs. The concentration of carbonate, bicarbonates and calcium are influenced by the presence or absence of this gas. The dissolved CO_2 content is maximum during the pre-monsoon season. It may be due to relatively high temperature which accelerate bacterial decomposition of organic matter and results in the liberation of CO_2. The amount of CO_2 was found to be comparatively high in the mangrove region than the non-mangrove area. There is a marked variations observed in two different stations.

In the mangrove zone increased concentration of sulphide accompanied with production of CO_2, thereby establishing a positive direct relationship between CO_2 and sulphide values in mangrove zones. This studies were conducted in the Kadinamkulam estuary by Bijoy Nandan (2002) [4].

The relatively high concentration of CO_2 in station II (mangrove) can be attributed to the decomposition of organic matter as suggested by Bijoy Nandan (2004). An inverse relationship between CO_2 and oxygen are evident in this station. Such inverse relationship between CO_2 and O_2 has also been observed by Ganapathi (1943).

Salinity is a measure of the amount of dissolved salts in water. In the study maximum value was obtained during pre-monsoon in both stations. The minimum value of salinity noticed during monsoon (Figure 5).

Salinity is the only factor, which undergoes spectacular change during the year (Qasim, 2005) [20]. In the study period, salinity was high and uniform with minute variation in monsoon. Salinity almost the same in estuary and mangrove zone during pre and post monsoon seasons, but shows great variation during monsoon season. In the mangrove area the salinity is very low during monsoon compared to estuary. This may be due to the rain water dilution during monsoon. Generally the salinity in the estuaries decline during monsoon. This may be due to the influx of fresh water from river. Higher salinity values during major period of study can be attributed to higher temperature. Higher temperature particularly during march, might lead to increased rate of evaporation, which in turn increase the salinity values. Dehandral and Bhargava (1972) [7] reported similar observations. However fall in salinity in this estuary during monsoon was not so high. This could be attributed to the thorough mixing of water resulting from intense tidal actin and influx of fresh water from river, which contributes to more saline nature. The direct effect of the onset of monsoon can be observed in the rapid decline in salinity of the estuary (Padmavati and Goswami., 1996; Ingole and Parulekar., 1998) [18, 12]. Similar trend was reported from Kali Estuary in Karwar by Reddy (1991).

Zooplanktons are generally able to maintain a preferred depth or in some cases, to perform vertical migration from near surface position at night to deeper water in the day time (Riley, 1967) [23]. During the present study a distinct fluctuation of zooplankton population in different months as well as seasons was observed, in station I (Non-mangrove) the density was found in monsoon. The density was found to be decreasing in the post-monsoon (Figure 6). In station II (Mangrove) the numerical abundance of zooplankton was lower. Copepods are the major group in this zones. It may be due to deterioration of water quality parameters like oxygen, temperature and salinity. But mangroves are highly nourished areas, large number of microbes are found within sediments which has a very high oxygen demand and organic decomposition coupled with production of large amount of H_2S gas and CO_2 in the water. Mangroves serve as breeding ground for many fauna like fish, barnacles, oysters, sponges, and bryozoans, Shrimps and mud lobsters. Similar observation was reported by Bijoy Nandan, Abdul Aziz and Natarajan (1994) [3].

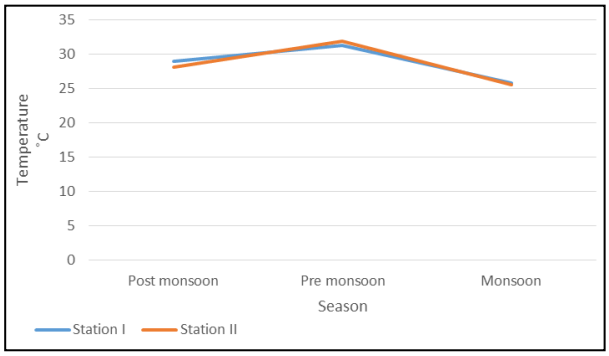

Fig 1: Seasonal variation of temperature recorded from Station I, II

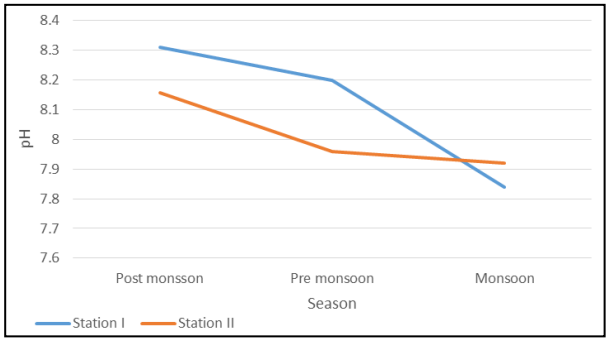

Fig 2: Seasonal variation of pH recorded from Station I, II.

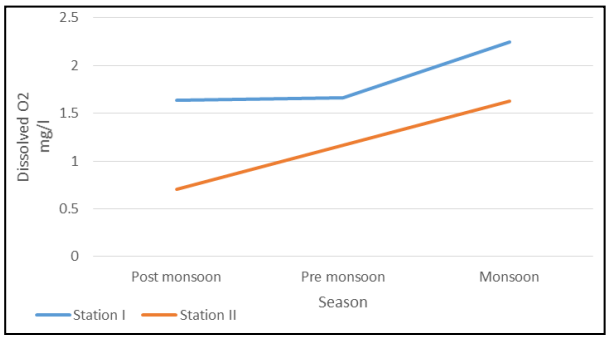

Fig 3: Seasonal variation of dissolved oxygen recorded from Station I, II

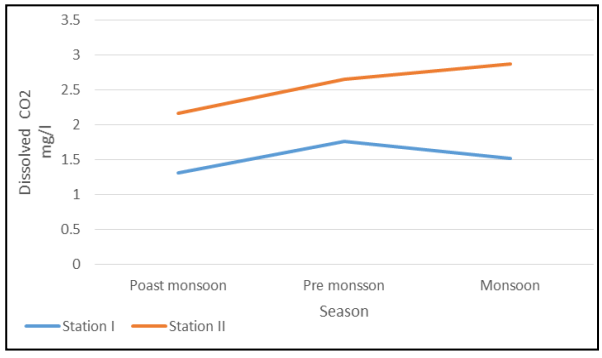

Fig 4: Seasonal variation of dissolved carbon dioxide recorded from Station I, II

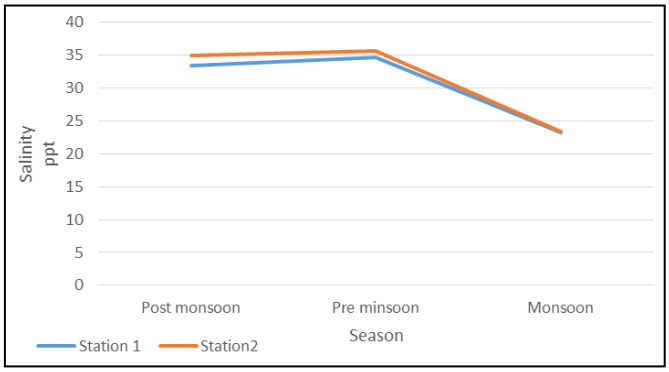

Fig 5: Seasonal variation of salinity recorded from Station I, II.

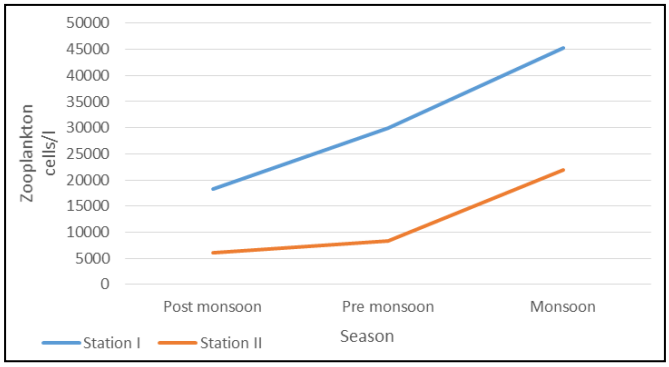

Fig 6: Seasonal variation of zooplankton recorded from Station I, II.

Conclusion

Present investigation revealed that the water quality parameters of estuary showed marked variations in different seasons. Physic-chemical parameters of aquatic habitat play a vital role in the distribution of flora and fauna. Numerical abundance of zooplankton was lower in mangrove zone. It may be due to the deterioration of water quality. In station II (mangrove) showed marked decrease in dissolved oxygen. It may be due to anoxic condition coupled with production of large amount of H_2S gas in the water body. Oxygen in the natural water is prime importance both as a regulator of metabolic processes of plant and animal community and as an indicator of water quality. In station I (Non mangrove) showed increase in population of zooplankton. It may be due to increased oxygen concentration. The water temperature and salinity also has influence on the distribution of zooplankton species.

The present study clearly elucidate that the changes in the water quality parameters have a great impact on organisms living in estuaries. In station II (Mangrove) the numerical abundance of zooplankton was lower. It may be due to the facts that mangrove are highly nourished area, so large number of microbes are found within sediments which has a very high oxygen demand and organic decomposition coupled with production of large amount of H_2S gas in the water. But this area benefits to others. They are breeding, feeding and nursery ground for many estuaries and marine organisms.

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