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A Hydrological Study of Ashtamudi Lake, Kerala, India with Special Reference to its Ecological Difference

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Abstract: ***The life in aquatic system is directly or indirectly depends on the water quality. The alteration of physicochemical parameters of water affects the abundance of biota and their diversity. The Ashtamudi Lake shows differences in ecological conditions and hydrological factors. Hence an attempt was made to evaluate and confirm how far the hydrological parameters influence the different sites of the lake. Different hydrological parameters from five ecologically different areas are studied for three years. Ecological difference have an influence in the hydrological parameters are established and this was discussed with similar works in other lakes.***

Keywords: Ashtamudi, temperature, salinity, back water, pollution

1. Introduction

The life in aquatic system is directly or indirectly depends on the water quality. The alteration of physicochemical parameters of water affects the abundance of biota and their diversity. Fresh water is the most vital resource for all kinds of life. Fresh water system greatly influences the distribution of populations and economic growth; add greatly to the biological and ecological diversity of the landscape. The south west coast of India is blessed with a series of wetland systems popularly referred to as backwaters covering a total area of 46128.94 hectors These back waters are internationally renowned for their aesthetic and scientific values including a repository for several species of fish and shell fish.

Ashtamudi Lake in the Kollam District of Kerala, India, lat 8°59′N 76°36′E is the second largest and deepest wetland ecosystem, a palm-shaped large water body, next only to the Vembanad estuary ecosystem of the state. Ashtamudi wetland is included in the list of wetlands of international importance, as defined by the Ramsar Convention for the conservation and sustainable utilization of wetlands. Kallada River is a major river discharging into the Ashtamudi Lake. This lake has different ecological conditions. Kanjiracode Lake is near to Kundara. The lake at this site now faces the problem of lowering its catchment area due to the deposit of the processed waste clay and major portion of the lake now becomes bare land with white clay, but the pollution rate got reduced to a great extent.

Koivila is the area where the Kallada River joins with the lake. This area has many small islands as a result of the deposit of sand by the river. The lake shows much similarity in ecological characters with a fresh water body. Many small aquatic plants are found in this zone. This area is now facing a problem of deposit of fecal matters from the house boats because of their destination point. Thekkumbhagam near Neendakara is totally different from other sites of the lake, which is abundant of the molluscan species. A good yield of bivalves molluscs gets from this area; however the shell waste is a big problem facing this zone

Towards the central area, the lake shows more diversification in ecology and habitats. Most of the fishing operations are performed in this area. This area has direct opening to estuary. Near to the city the lake is highly polluted, because of the functioning of the city corporation's waste treatment plant. Now it is almost non functioning. During rainy seasons the dumped waste makes this lake a highly polluted zone. Nearby this area many of the fishing boats halt and their repairs and maintenance were carried out, causing the discharge of oily pollutants to the lake. Near to Kollam Bus Station where T S canal opens, is a dumping area of domestic wastes from the city. Moreover, a plastic waste near the city area is another threat faced by this lake. Ashramam area near the city earlier having good population of mangroves, due to encroachment by the tourism department, the population of them was decreased. Kandachira Lake is the only area where coir industry is functions now. Earlier almost all areas of Ashtamudi lake had a good history of coir industry and that the process of coconut retting caused great variation in the flora and fauna of the area.

Ashtamudi is recognized as a coastal estuarine lake of brackish water (salt and fresh water (MOEF Classification). Data available on the ecological and hydrological parameters of the Ashtamudi Lake showed the abundance of phytoplankton (Thresiamma & Nair, 1980). Divakaran et al. (1981) reported seasonal variations in the ecology of the lake. The nature of distribution of major inorganic nutrients in Ashtamudi back water, its general ecology, ecology of grass bed, fishery resources, inorganic nutrients, benthic macro fauna sediments, mineral metals, heavy metals and their seasonal variations were also reported. (Dharmaraj & Nair, 1981; Nair et al., 1983a,b &,c; Nair et al., 1984a, b, & c). The effects of man made changes in mangrove ecosystem of Ashtamudi were reported by Mohandas et al. (1994). Biodiversity status and restoration measures of the Ashtamudi back water systems (BijoyNandan, 2005),

nutrient dynamics of Ashtamudi lake (Sujatha et al., 2009), sedimentary characteristics along the Ashtamudi estuarine system was (Soumya et al., 2011) and analysis the effluents discharged to Ashtamudi lake from China clay industry to the lake (Suma et al., 2012), were also well documented. From the above observations, it is presumed that the lake is now suffering the deterioration of ecosystem and water quality, accumulation of sediments, waste disposal, and above all a loss of the aesthetic value. The Ashtamudi Lake shows differences in ecological conditions and hydrological factors. Hence an attempt was made to evaluate and confirm how far the hydrological parameters influence the different sites of the lake.

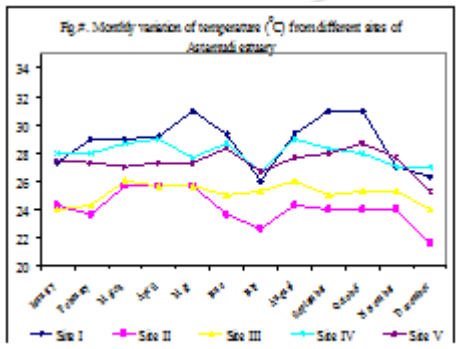
2. Materials and Methods

Water samples were collected for physic-chemical analysis, from sampling sites I Kanjiracode, II Koivila, III Ashtamudi, IV Kavanad, V Kandachira (Figure 1.3) at Ashtamudi Lake. Samples were taken once in every month from February 2007 to January 2010. Water samples were collected during morning hours between 8 am to 11am and the pH, temperature, dissolved oxygen and carbon dioxide were monitored from the sampling sites, whereas salinity, nitrate, phosphate, and total dissolved solids (TDS), were analyzed in the laboratory in accordance with APHA (1989).

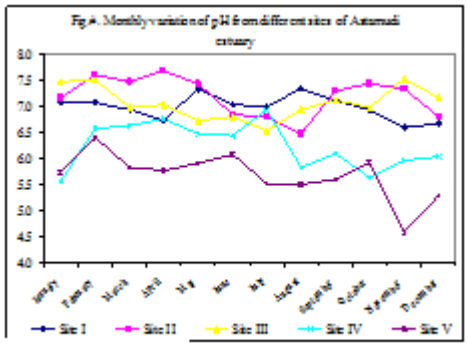
Data obtained were analyzed using SPSS statistical program and the difference between mean was assessed by Duncan's multiple range test (DMRT). All statistical tests were considered significant at 5% level ($P < 0.05$).

3. Results

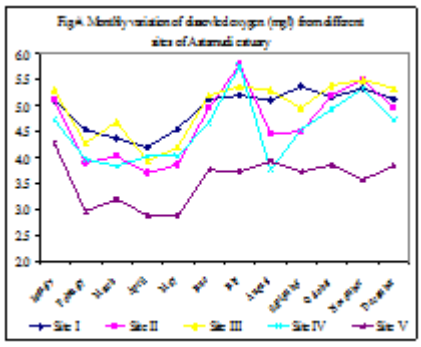
The results of different parameters during 2007 to 2009 are given in figures1.3.1 to 1.3.8



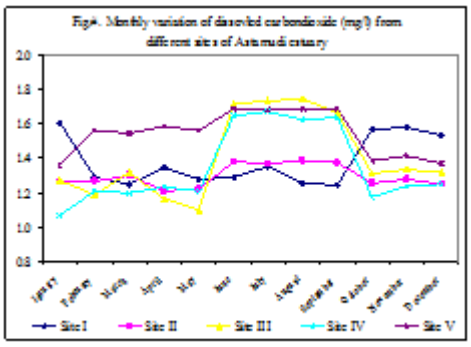
1.3.1. Temperature



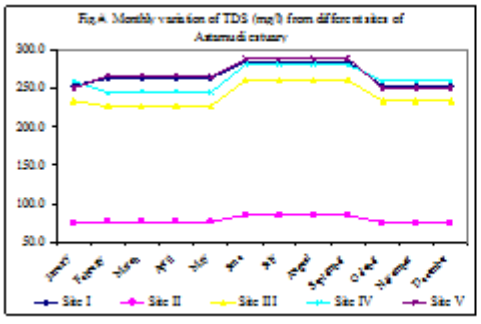
1.3.2.pH



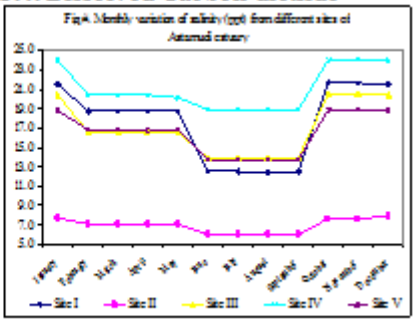
1.3.3. Dissolved oxygen



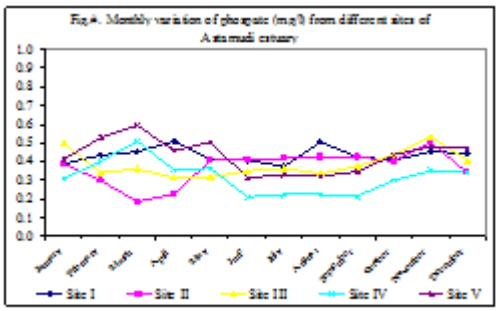
1.3.4. Dissolved Carbon dioxide



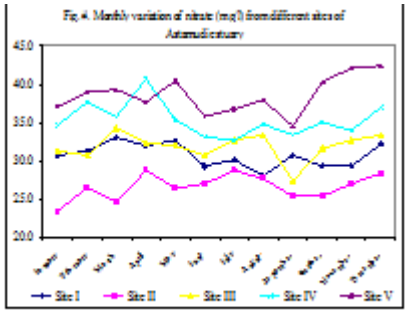
1.3.5 TDS



1.3.6.Salinity



1.3.7. Phosphate



1.3.8. Nitrate

4. Discussion

Average maximum temperature among the sampling sites was most shown by the site I Kanjiracode, which may be due to the climatic and topographical condition of the site. The clayey nature of soil in this site may have the power to hold more temperature, owing to the discharge of the industrial effluent to the lake however, the higher temperature never reduces the fish population of that area. Higher temperatures in summer season recorded from all parts of the lake may be due to the atmospheric conditions such as greater solar radiation and low water level. Moundiotiya et al. (2004) observed similar higher summer temperatures in Ramgarh wetland. Similar conditions were observed in Bangara lake (Swarnalatha & Rai, 1998) and in Rahikhura reservoir (Yogesh & Pendse, 2001). The lower temperature during monsoon period was due to cloudy sky and rainfall that brought down the temperature to minimum. The minimum temperature was observed during all seasons and in the sampling site II, where the Kallada River opens to the lake. Due to the direct river discharge, this site showed minimum temperature. The site III showed moderate temperature during all seasons. This site directly connects with the sea and that the mixing of sea water and fresh water maintains a moderate temperature. The site IV shows higher temperature in some seasons may be due to the oil discharge and waste seepage from waste treatment plant. Discharge of sewage may be one of the principal sources of organic pollution in estuaries.

The observed variations in water temperature at different sites in the present study substantiate with the report of Soumya et al. (2011) and that in the Ashtamudi lake pre-monsoon period showed higher temperature and lower temperature during post monsoon. Available data showed that temperature will lower water quality in lake through, a fall in hypolimnetic oxygen concentration, release of phosphorus, few sediments, increased thermal stability, and altered mixing patterns (Verburg et al., 2003). Higher temperature will negatively affect microorganisms and benthic invertebrates, and distribution of many species of fishes (Mc Kee et al., 2003). In Ashtamudi lake different sites showed variations in temperature which might be due to fluctuations in organic carbon content of the Ashtamudi lake (Nair et al., 1983). The higher concentration of free CO_2 in the retting zones could be attributed to the process of decomposition of organic matter like pectin, phenol, tannin etc. leading to a rise in temperature of the medium, along with the production of the gaseous components (BijoyNandan, 2005).

In the present study the pH of surface water was measured from different sites. In site I, II, &III higher pH were noted.. The range of pH from different sites was 4.1- 8.2. The site I showed a pH range 6.1-7.9 and within this range of pH is a good sign for living organisms in this site. A sharp decrease or increase in pH was not observed in this area. The site II showed almost high pH value throughout the period of study. The pH ranged between 6.1-8.2, the monsoon river discharges might contribute more to this parameter.

The site III showed mixed nature of pH value. This site has a direct contact with sea may influence the pH variation. The water discharge and surface runoff to the site are enough to make the condition of pH. The site IV and V show the lower value of pH. The site IV is heavily polluted by oil discharge from mechanized boats and domestic waste disposal and sewage effluents from waste treatment plant adversely affect the pH of the water. The site V famous for coconut husk retting. This is the only site where the coir industry is working. The activity of coconut husking deposits more organic pollutants to this site that may cause lower pH.

The high pH was earlier recorded by Sujatha et al. (2009) nearly to 8.2, are in agreement with the findings. Geetha (1997) noted a sediment pH range of 3.4-.1 and Vishnu (2005) reported 4.9-6.7 in the estuary. According to Unnithan (2001) low pH could be due to exposure of relatively higher acidic surface basin soil consequent on monsoon turbulence and bottom currents. Low range of pH can also be due to release of biogenic carbon dioxide by bacterial decomposition of organic matter (Berner, 1971). The increase in organic pollution in Ashtamudi estuary must be one reason for lowering of pH in certain area especially sites IV and V. The site V, Kandachira is a major coconut husk retting area of this lake. The observation is in agreement with Bijoynandan and AbdulAziz (1996) in Kadinamkulam estuary. Generally the pH of surface water was slightly higher than that of surface water (Sujatha et al., 2009). Same observation was done by Soumya et al. (2011) from this area. They reported pH up to 3.1 from this area. These results from this area were in agreement with observations by BijoyNandan and AbdulAziz (1996) from Kadinamkulam Lake.

In all the stations low pH value generally observed during monsoon months was due to the heavy freshwater inflow into the lake. Water quality of the station II becomes many time neutral to slightly alkaline. This reason was in accordance with the study of Usha et al. (2006) in Perumal lake. The pH is the most important factor that serves as an index for pollution. The pH range show by this lake may be

due to the high buffering capacity of the system. The pH of water relatively high during post monsoon and summer. The high value during post monsoon could be attributed to increased primary productivity when carbonates, sulphates, nitrates, and phosphates are converted to hydroxyl ions. The lake shows more alkaline to central and eastern areas remain more time above seven. Kandachira and Kavanad sites showed change and low pH in half time of year.

Earlier study shows that range of pH of a majority of lake and reservoirs lies between 6 and 9. This is in accordance with finding of Wetzel (1975) that the values of pH range from 8 to 9 units in Indian waters. The lower pH during monsoon is due to high turbidity, and in summer the high temperature enhances microbial activities causing excessive production of carbon dioxide and reduced pH. Khan and Khan (1985) and Narayani (1990)also reported similar results at Seikha Jhel in Aligarh. Soumya et al. (2011) reported low pH level from the Kandachira site V of this lake because of coconut husk retting. Lowering pH can be due to the release of bio-geneic carbondioxide by bacterial decomposition of organic matter (Berner, 1971). Sugatha et al. (2009) also reported high pH of bottom water than the surface water from Ashtamudi lake.

Oxygen is an important parameter in the wetland which is essential for the metabolism of aquatic organisms. Dissolved oxygen content (DO) indicates water quality and its relation to the distribution and abundance of various algal species. Most of the sites in the lake recorded relatively high values of dissolved oxygen except the last two sites, where a decline in O_2 content was noticed.. The DO value of the lake was found to be in the range of 2.5 – 5.6 mg/L. The lower DO value in the lake may be attributed to the low solubility of oxygen in the saline waters. In the present study it is observed that there is a strong correlation between pH and DO, and that with the lowering of pH, DO was also lowered especially in site IV and V. In the site IV and V the addition of variety of bio-degradable pollutants from the waste treatment plant and city sources stimulates the growth of microorganisms which consume DO. The DO values deplete during summer season because at high temperature the oxygen holding capacity of water decreases. Present observations are in agreement with similar studies on these parameters made by Varghese et al. (1992), Yogesh and Pendse (2001). The low level DO might be due to respiratory activity of the fauna and flora of the lake (Odum, 1971). The high level of DO may be attributed the self purification capacity of flowing water, aquatic plants, photosynthetic efficiency and air flow (Hynes, 1970; Singh & Trivedi, 1979). The seasonal changes in DO concentration indicated that the range of fluctuation is moderate.

Free carbon dioxide showed a range of 1.01 -1.92 mg/l in Ashtamudi Lake. Very low level of CO2 is observed in almost all part of the lake. However high level of CO_2 is observed from Kandachira, site V. Total Dissolved Solids(TDS) value of water sample from the lake ranged between 72 -301mg/L. The concentration of TDS was observed to be high during the monsoon season from different sites, which might be due to the addition of solids from the surface runoff. Marker (1977) has observed that the amounts of total dissolved solids are influenced by the activity of planktons and organic materials. In fresh water ecosystem, dissolved solids originate from natural sources and depend upon the location, geological basin of water body drainage, rain fall, bottom deposits and inflowing water (Gaval et al., 2011). However the TDS value at site II showed relatively very low even though this area receives a heavy runoff from Kallada river.

In the present observation the nitrate content of the lake was in the range of 22.5-41 ppm. The higher value was recorded from site V and minimum from site II. The nitrate level of the lake was increased compared to the earlier studies that this might be due to the anthropogenic influx to the lake. It is reported that the raw sewage is the main source of nitrates and phosphates in the water (Aggarwal et al., 2000). Nitrate concentration of the water bodies is influenced by the geochemical conditions of organic load. The mineralization of rain fall is found to be responsible for the increase in the amount of nitrate content in the lake water. It is also reported that the presence of excessive nitrate of water is due to manmade domestic activities and fertilizers from agriculture field (Krishnaram et al., 2007). Nitrates at high load may cause eutrophication of aquatic body. It is well known that nitrate will be released during oxidation of ammonia (Sharma & Kaur, 1996; Meybeck et al., 1988; Qasim, 2003; Correl et al., 1992). This is produced as digenetic decomposition of organic matter rich in estuarine sediment, (Delange, 1984; Meybeck et al., 1988; Correl et al., 1992) and brought to the sediment water interface during sediment compaction (Lebo, 1990; Froelich, 1988; Mcreau, 1998). The higher values may be due to the nitrification which is the main source of nitrate in sediments as reported by Sujata et al. (2009) from Ashtamudi Lake.

The present study also revealed the phosphate content of the lake which is ranged between 0.1-0.7 from different sites. The concentration of phosphate in the lake does not show any significant change during different seasons. Sujatha et al. (2009) reported lower value of phosphate than the present condition. It is known that Phosphate contents were more seen with silty sediments. The distribution of inorganic phosphate shows significantly higher values in the estuarine area of the lake, caused by discharge of urban sewage and coconut husk retting activities. The observed increase in phosphate content of the lake may be due to rainfall and land runoff as reported by Naih and Mudholker, (1989) and Sujatha et al. (2009).

In lakes phosphate content is often found to be a growth limiting nutrient, because it occurs in the least amount relative to the needs of aquatic flora. Phosphates at high load may cause eutrophication of aquatic habitat. There are various sources of deposition of phosphate to the lake water such as rock deposit, runoff surface catchment and interaction between the water and sediments from dead plant and animals remains at the bottom of the lake. Phosphate is considered to be the most significant amount of the nutrients responsible for eutrophication of lakes, as it is the primary radiating factor. Atmospheric input may account for a significant proportion of influx of nutrients to the lakes (Krishnaram et al., 2007; Savitha et al., 2005)

Salinity value also showed great variation in different parts of the lake. The high saline site IV Kavanad near to the estuarine bar mouth near Neendakara. SiteII showed low saline than any other site often similar to a fresh water body which may due to the discharge of the Kallada River at this site. In the present study it is observed that the salinity of the lake ranged 5.8-24.7 ppm. Even in the site I where there is no direct connection with sea at the eastern part of the lake also showed high salinity. Accordingly the variations in salinity in the lake depended on the tidal input surface run off and also sampling time. It is presumed that the salinity value recorded in different sites of the lake value indicated a mixo haline condition in this lake.

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