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SEASONAL VARIATION IN NUTRIENT CONCENTRATION OF KANDACHIRA KAYAL OF THE ASHTAMUDI LAKE, KERALA

Sachin, S.R.,[1] Benno pereira[1], F.G.*, Sumesh, C.,[2*] Sini Wilson[1] and Jyothilal, C.S.[1]

[1]*Department of Aquatic Biology and Fisheries, University of Kerala, Thiruvananthapuram, Kerala, India*

[2]*Dept. of Aquaculture, St. Albert's College, Ernakulam, Kerala-682018*

**E-mail: bennopereira@gmail.com*

Abstract: Seasonal variation of temperature, pH, salinity and concentration of nutrients such as nitrate-N, nitrite-N, phosphate-P, silicate-Si and sulphate have been recorded from 5 selected stations in the Kandachira Kayal of the Ashtamudi estuary. The kayal is exposed to pollution from human as well as non- human interferences like urban and sewage pollution, coconut husk retting, land reclamation etc. The nature and degree of pollution and its influence on the backwater environment have been discussed. The range of various parameters were, 24 to 31.5°C (atmospheric temperature), 25.5 to 31.5 °C (surface temperature), 24.5 to 31.0°C (bottom temperature), pH 6.01 to 8.86(surface) 6.11 to 8.3 (bottom), salinity 6 to 33 ppt (surface), 7 ppt to 33 ppt (bottom) nitrate-N 4.1 to 11.3µg ml-1 (surface), 3.1to 9.7 µg ml-1 (bottom), nitrite-N 0.3to 5.1µgml-1 (surface), 0.2 to 5.2 µgml-1 (bottom) ,phosphate-P 0.1 to 4.1µgml-1 (surface), 0.2 to 3.8 µgml-1 (bottom), silicate-Si 12.1 to 45 mgl-1 (surface), 12.6 to 57.2 mgl-1 (bottom), and sulphate78.6 to 160.2 mgl-1 (surface), 65.8 mgl-1 to 159.7 mgl-1(bottom). Seasonally, the concentration of nutrients recorded higher during monsoon and lower during pre and post-monsoon season.

Keywords: Nutrients, estuary, Ashtamudi

INTRODUCTION

Water bodies are facing a wide variety of threats viz., urban sewage pollution, pesticide and herbicide from agriculture, sand mining, encroachments, land filling and loss of mangroves. Estuaries may be enriched by nutrients from river water, organic pollution and by entrainment of coastal water in subsurface counter current, transporting nutrients into the estuary Ketchum (1967). Distributions of nutrients are mainly based on the season, tidal conditions and freshwater flow from land source. The most common ways in which man affect aquatic ecosystems is through altering nutrient dynamics (Boostman and Hecky, 1993). Nitrogen, phosphorus and silicate are important elements, especially as nutrients for the growth of aquatic plants which naturally enters into the estuary or lake waters by runoff. Nitrogen and phosphorus are also considered as limiting element as its concentration limits the growth in an aquatic ecosystem. Increased quantity of nutrients acts as a pollutant in the water. This leads to explosive algal blooms that cloud deplete the dissolved oxygen which is critical for aquatic life. Hence nutrients may be considered as one of the key indicators of quality of water. The present study was undertaken to assess the concentration of nutrients in the 5 selected stations of the Kandachira Kayal of the Ashtamudi Lake.

MATERIALS AND METHODS

Study site,

The Ashtamudi Lake, is the second largest and deepest estuary in Kerala, lying between 8°55' to 9°N and 76°33' to 76°37' E and connected to the Arabian Sea, with a water spread area of 61.4 sq.km. Ashtamudi Lake is a Ramsar site and designated as the "wetland of international importance”. It is a palm-shaped extensive water body with eight prominent arms, adjoining the Kollam town. Kandachira kayal is the southernmost arm of the Ashtamudi Lake. Five stations were selected from the Kandachira kayal for this study. Station I- Ashramam, II- Uliyakovil, III- Mangadu, IV- Kandachira and V- Muthathumoolakadavu (Fig.). Two major canals loaded with municipal waste and urban sewage joins on the southern and northern sides of the Kayal. At present the kayal is facing severe threats from human as well as non- human interferences like urban and sewage pollution and land–reclamation. Coconut husk retting is predominant at some areas of the Kandachira Kayal, emitting strong smell of hydrogen sulphide and resulting in black colour of water.

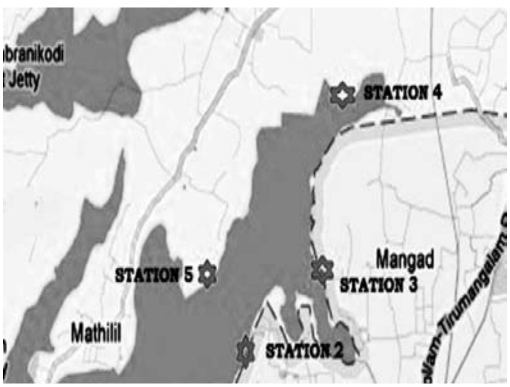

Figure 1. Map of Kandachira Kayal showing the five sampling stations

The nutrient levels were determined over a period of twelve months from February 2009 to January 2010. Five sampling stations were located within the lake and the sampling was done monthly. Both surface and bottom water were taken for the study. Surface water samples were collected by a clean bucket and bottom water by a Van Dorn bottom water sampler. Temperature was measured by using standard mercury thermometer. Salinity was measured using a hand refractometer (ERMA, INC., Tokyo). Water samples collected for the purpose of estimation of nutrients were brought to the laboratory and subjected to analysis immediately as possible. The nutrient parameters such as nitrate-N, nitrite-N, phosphate-P, silicate-Si and sulphate were studied. All these parameters were estimated by internationally accepted standard procedures (APHA, 2005). .

RESULTS AND DISCUSSION

Temperature

Water temperature is an important factor affecting various physico-chemical as well as biological activities (Guptha and Mehrothra, 1991). Atmosphere temperature ranged between 24 - 31°C. Maximum temperature was recorded on summer and minimum during monsoon. Monthly variation in water temperature has been observed due to the influence of atmospheric temperature and mixing up of sea water. Water temperature of the surface and bottom ranged from 25.5 to 31.5 °C and 24.5 to 31.0°C respectively. The average temperature declined from May to July 2009 and slowly increased from August to October 2009 and fell sharply on November. June and July showed the lowest temperature (Fig. 2). Thus indicates the influence of monsoon season contributed by strong breeze and cloudy sky (Karuppasamy and Perumal, 2000). The surface water showed higher than or equal to the temperature of bottom water except on certain occasions. Surface water temperature may be influenced by the solar radiation and evaporation. According to Jayaraman *et al.* (2003) variation in the water temperature may be due to different timings of collection and influence of season. Positive correlation was observed between air temperature and surface water temperature at all stations but statistically significant at station 1 and 2. ANOVA for the water temperature revealed that the variations between stations and seasons were highly significant ($P<0.01$).

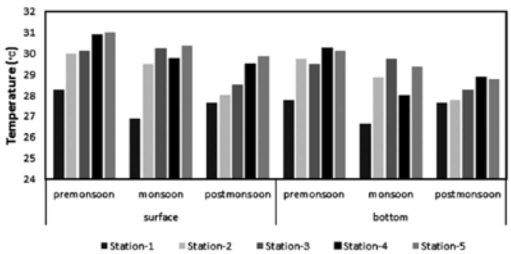

Figure 2. Seasonal variation in temperature at various stations during 2009-2010

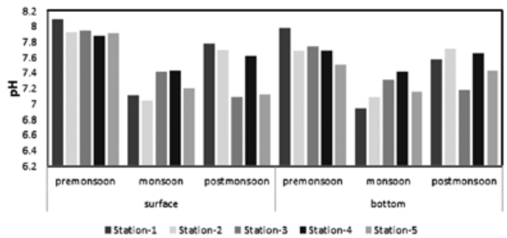

Figure 3. Seasonal variation in pH at various stations during 2009-2010

pH

Aquatic organisms are affected by pH because most of their metabolic activities are pH dependent (Wang *et al.,* (2002). pH value gives an idea about the extent of pollution Verma *et al.* (1984). pH of the surface water ranged from 6.01 to 8.86 and bottom water from 6.11 to 8.3. Higher pH value was observed during pre monsoon followed by postmonsoon months and minimum during monsoon (Fig. 3). Ananthan (1994) has stated that the higher value of pH during summer was due to the uptake of CO2 by photosynthesizing organisms. The low values of pH recorded during monsoon period may be influenced by the flooding and mixing up of fresh water (Prabha Devi, (1986). Similar trend in pH was observed by (Bijoy Nandan, (1991); Shibu, (1991); Reshmi (2004); Radhika, (2005). pH values were found slightly acidic during some months at stations 1, 4 and 5 where station 1 is polluted with anthropogenic activities and sewage and station 4 and 5 intensively polluted with retting activities. But on an average the water remained alkaline at all stations. According to Rajasegar, (2003); and Paramasivam and Kannan, (2005) the fluctuations in pH values during different seasons of the year can be attributed to factors like removal of CO_2 by photosynthesis through bicarbonate degradation, dilution of seawater by freshwater influx, reduction of salinity and temperature and decomposition of organic matter There was no significant difference between seasons and stations.

Salinity

Salinity has been viewed as one of the most important variables influencing the utilization of organisms in estuaries (Marshall and Elliot, 1998). It plays the key role in the dynamics of an estuarine ecosystem. A minor change in salinity will reflect on other physical, chemical and biological parameters (Dehadrai, 1970; Goswami and Singbal, 1974). The surface water salinity ranges from 6 ppt to 33 ppt and bottom water ranged from 7 ppt to 33 ppt. Throughout the study the salinity was low during the monsoon and maximum during premonsoon months (Fig.4). The premonsoon season experienced the highest salinity (33 ppt) may be due to high temperature and increased rate of evaporation. The salinity is greatly influenced by the runoff water, so that the lowest salinity was observed during monsoon season. Salinity at all the stations was high during the summer season and low during monsoon season at both surface and bottom waters. McLusky (1989) reported that rainfall could cause dilution of estuaries and hence cause reduction in salinity, while heat generated by sunlight in dry season months would cause evaporation of the surface water making it saltier and hence more saline. The present observation of low salinity in monsoon and high salinity during premonsoon was similar of that of earlier reports in the estuaries of India, (Ramamritham and Jayaraman, 1963; Sreenivasan and Pillai, 1972; Sarala Devi *et al.,* 1979; Sivakumar, 1982; Jagdeesan, 1986; Shibu, 1991). Positive correlation was observed between temperature and salinity at all stations but significant only at station 5 ($P<0.01$. $r = 0.773$).

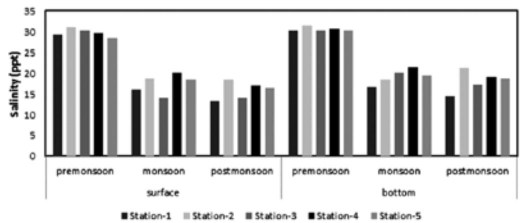

Figure 4. Seasonal variation in salinity at various stations during 2009-2010

Nitrate – Nitrogen

Nitrates are oxidation products of organic nitrogen by the bacteria present in soil and water where sufficient oxygen is present (WHO, 1984). High concentration of nitrates was observed after onset of rains. Higher concentrations of nitrates represent higher pollution load (Kapoor, 1993). The concentration of nitrate nitrogen ranged from 4.1 to 11.3μg ml-1 in the surface water and 3.1 to 9.7μg ml-1 in the bottom water. The concentration was high in monsoon and a decline was noticed during post monsoon (Fig.5). High concentration of nitrate observed during the monsoon season might be due to the heavy rainfall, resultant river run-off, land drainage and input of fertilizers from the adjacent agricultural fields and oxidation of ammonia (Raman, 1995; Mahapatro *et al.,* 2001). Retting of coconut husk might have contributed to the increased nutrient content during the period. This observation was in conformity with the similar type of observation made by Prabha Devi (1986), Balusamy (1988), Geetha Badhran (1997) and Santhanam and Perumal (2003). In the present study, nitrate content was comparatively high at station 1 and 3 which may be due to the direct discharge of sewage which entering into the kayal through the Kollam thodu and Kilikollurthode. Most of the nitrate might have been derived from the decomposition of organic wastes (Satpathy, 1996). The low values recorded during non-monsoon period may be due to utilization by phytoplankton as evidenced by high photosynthetic activity and the dominance of neritic seawater having negligible amount of nitrate (Das *et al.,* 1997). Similar observations are made by Das (2000); Saravanakumar *et al.* (2008) Verma *et al.* (2011). The highest mean values at surface water ranged from (6.36 ± 0.37) μg ml-1 at station 3 to (6.97 ± 0.71) μg ml-1 station 1 and bottom water ranged from (5.68 ± 0.35) μg ml-1 at station 4 to (6.18 ± 0.35) μg ml-1 station 2. Statistical analysis showed that the variations between seasons were significant at 1% level (ANOVA: DF=2, F=24.426).

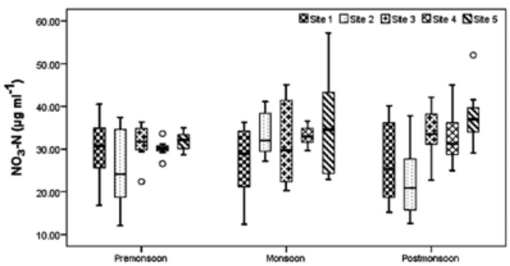

Figure 5. Seasonal variation in nitrate-N at various stations during 2009-2010

Nitrite – Nitrogen

Nitrite is most unstable and it always indicates the fresh input of organic load into water system. Sewage input and organic pollution seems to reduce the availability of nitrite. The high concentration of nitrite at surface water ranged from 0.3 to 5.1μgml-1 and bottom water ranged from 0.2 to 5.2 μgml-1. The concentration of nitrite was high during monsoon season and lowest during post monsoon (Fig. 6). The monsoonal increase in nitrite of the present study was in conformity with the similar type of observation made by (Sarala Devi *et al.,* 1983; Nair *et al.,* 1984; Kahar, 1988). The increased concentration of nitrite observe during the monsoon season may be influence by the seasonal rainfall. Peak nitrite values during monsoon season may be due to the influence of organic matter and drainage effluents (Grasshoff, 1983). Low values of nitrite observed during the pre monsoon and post monsoon may be due to the lesser amount of freshwater inflow and increased utilization by plankton in the coastal waters. Similarly, maximum value in monsoon season and low values at pre/ and post/ monsoon was observed by /Ashok Prabhu *et al.,* (2008), Sundaramanickam *et al., (*2008)/ and Ramalingam *et al.,* 2011). The distribution pattern of nitrite concentration in surface and bottom water is merely similar. Positive correlation of nitrite concentration with nitrate was observed. The highest and value at surface water ranged from (2.84 ± 0.28) μgml-1 at station 4 to (2.32 ± 0.29) μgml-1 station 1 and that of bottom water ranged from (2.39 ± 0.34) μgml-1 at station 4 to (1.89 ± 0.35) μgml-1 station 1. Statistical analysis showed that the variations between seasons and periods within seasons were significant at 1% level (ANOVA: DF=2, F=35.7328) and (ANOVA: DF=9, F=8.58).

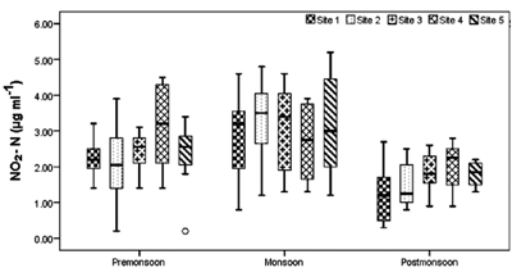

Figure 6. Seasonal variation in nitrite-N at various stations during 2009-2010

Phosphate-P

Phosphate is considered to be the most significant among the nutrients responsible for eutrophication of lakes, as it is the primary initiating factor. The presence of phosphate in large quantities in fresh water indicates pollution through sewage and industrial wastes (Bandela *et al.,*/ (1999). Higher concentration of phosphate shows the higher extent of pollution (Desai *et al.,*/ (1995). The concentration of inorganic phosphate at surface water ranged from 0.1 to 4.1μgml-1 and that of bottom water ranged from 0.2 to 3.8μgml-1. Seasonal values of phosphate at surface and bottom water showed maximum at station 1 and 2 during monsoon season which might be due to the monsoonal land runoff, mixing of freshwater coupled with increased anthropogenic activities. According to Nair *et al.* (1983) rainfall resulting heavy river discharge leads to transportation of sediments in a big way. Thus an increase in the value of phosphate was noticed with the onset of the monsoon rains. The lowest values of phosphate were observed at pre monsoon and post monsoon at surface and bottom (Fig. 7) which may be due to low inflow of fresh water, biological utilization and removal by absorption on to sediment and suspended particles. (De Sousa *et al.,* 1981., Senthilkumar *et al.,* 2002; Rajasegar, 2003). Similar trend in the seasonal variation of phosphate was reported by (Anila Kumari and Abdul Aziz, 1992, other researches Meera and Bijoy Nandan, 2010). The highest mean values at surface water ranged from (1.88 ± 0.26) μgml-1 at station1 to (0.59 ± 0.11) μgml-1 station 4 and bottom water ranged from (1.43 ± 0.31) μgml-1 at station1 to (0.49 ± 0.08) μgml-1 station 4. Statistical analysis showed that the variations between stations, seasons and within periods were significant at 1% level (ANOVA: DF=4, F=14.3), (ANOVA: DF=2, F=8.5376) and (ANOVA: DF=9, F=5.13) respectively.

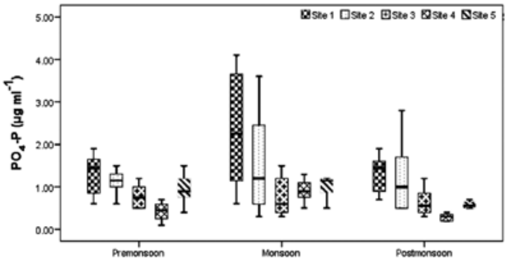

Figure 7. Seasonal variation in Phosphate-P at various stations during 2009-2010

Silicate

Silicate is a naturally occurring compound which is an important element in animal and plant life. Silica is extracted from water by plants, microorganisms, or invertebrates for building structural materials and growth. Primary producers such as Diatoms extract silica from water, which is required for their growth. The high concentration of silicate at surface water ranged from12.1 to 45 mgl-1 and bottom water ranged from 12.6 to 57.2 mgl-1. Seasonal variations in dissolved reactive silicate were apparent in the present study; higher concentration was recorded during monsoon and post monsoon (Fig. 8). During monsoon season all the stations showed similar pattern of increase. This could be attributed to the heavy influx of freshwater from land drainage. This observation was in conformity with the similar type of findings in other Indian estuaries (Sivakumar, 1982; Thangaraj, 1984; Jegadeesan, 1986). During post monsoon season, stations 1, 3, 4 and 5 showed the highest values but it was not in a similar pattern. Higher values of silicate were observed at bottom water, it may be due to sediment exchange with the overlying water due to the turbulent nature of water because of rain, flow and tidal action. A similar observation in seasonal variation was recorded by (Anbazhagan, 1998). The observed low values during premonsoon and postmonsoon seasons may be attributed by uptake of silicates by phytoplankton for their biological activity (Ashok Prabu *et al.,* 2008; Saravanakumar *et al.,* 2008). The highest mean value at surface water ranged from (33.28 ± 1.78) mgl-1 at station 5 to (26.65 ± 2.47) mgl-1 station 2 and bottom water

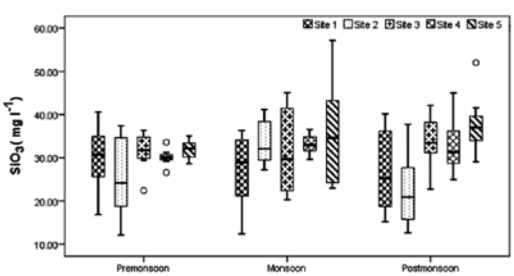

Figure 8. Seasonal variation in silicate at various stations during 2009-2010

ranged from (36.88 ± 2.77) mgl-1 at station 5 to (27.68 ± 2.80) mgl-1 station 2. Statistical analysis showed that the variations between stations and seasons were not significant.

Sulphate

Sulphate is a naturally occurring substance that contains sulphur and oxygen which is present in various mineral salts that are found in soil. Sulphate may be leached from the soil, fertilizers, decaying plant and animal matter commonly released into water. The high concentration of silicate at surface water ranged from78.6 to 160.2 mgl-1 and bottom water ranged from 65.8 to 159.7 mgl-1. The sulphate content was higher than nitrate, nitrite, phosphate and silicate. Higher values of sulphate were observed during premonsoon and monsoon season and the lowest during post monsoon (Fig 9). The seasonal decrease in sulphate has been suggested to be due to reduction to sulphide. According to Essein-Ibbok *et al.* (2010) sulphate showed remarkable seasonal variation with dry season concentrations being significantly higher than wet season concentrations for the different sampling sites. The increased concentration of sulphate observed during the monsoon season may be influence by rain water runoff, sewage waste, soil, fertilizers, decaying plant and animal matter and decomposition of sulphate rich effluents from husk retting grounds. Nath and Sinha, (1996) have reported lowest sulphate content in postmonsoon while Bijoy Nandan (1991) reported this trend during pre-monsoon. The highest mean and standard error at surface water ranged from (123.69 ± 8.61) mgl-1 at station 3 to (106.93 ± 4.45) mgl-1 station 1 and bottom water ranged from (122.88 ± 5.83) mgl-1 at station 1 to (114.73 ± 8.52) mgl-1 station 3. Statistical analysis showed that the variations between seasons and within periods were significant at 1% level (ANOVA: DF=2, F=36.5368) and (ANOVA: DF=9, F=5.41).

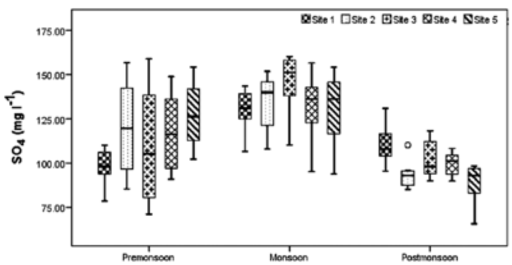

Figure 9. Seasonal variation in sulphate at various stations during 2009-2010

CONCLUSIONS

It can be concluded that seasonally, the concentration of nutrients in Kandachira Kayal recorded higher during monsoon and lower during pre-and post monsoon season.

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