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NUTRIENT COMPOSITION AND PHYSICOCHEMICAL CHARACTERISTICS IN THE DESTINATION SITES OF MIGRATORY WATER BIRDS: A CASE STUDY AT THE SELECTED LOCATIONS OF SEASHORES AND LAKES IN SOUTHERN INDIA

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Abstract

The biodiversity in aquatic systems are indirectly controlled by their nutrient dynamics. The abundance of phytoplanktons and zooplanktons depends on the availability of nutrients such as nitrates, phosphates and silicates since these are the building blocks for their further growth. The phytoplanktons act as prey for the next higher trophic level including various fishes and other small organisms. One of the factors that enchant the migratory birds at some particular locations is the availability of the species of organisms that they prey on. In this paper a preliminary analysis is done to explore the nutrient dynamics of selected tropical aquatic systems in order to correlate the arrival of migratory birds at those locations. Water samples are collected from coastal region of Aleppey, Purakkad and Koonthankulam Bird Sancturay. The latter two sites are the important destination of many migratory water birds including Pallus Gull, Heuglins Gull, Bar-headed goose, Comb Duck and Spot Billed Pelican. The samples are analyzed chemically to trace the nutrient compositions and the related chemical parameters such as temperature, pH, conductivity, primary productivity, chloride, salinity, turbidity, nitrate, phosphate, dissolved oxygen and biochemical oxygen demand. Remarkable differences are observed mainly in the composition of phosphate, organic matter content and salinity. Finally, an attempt has been done to correlate the biodiversity of these locations with the chemical parameters and the prevailing nutrient compositions.

Keywords: Migratory Birds, Nutrient Dynamics, Tropical Seashores, Tropical Lakes, Water Quality

Introduction

The migratory birds move from locations of decreasing resources to sites having increased natural resources where the two primary resources that they seek are food and nesting locations (Alerstam 2001; Andrikovics 2003; Berthold 2001; Bewick1847; Gopal 1995; Sathan and Pandi 2009). Recent studies show that the global climatic changes have an effect on the migratory patterns of birdsincluding time of migration, breeding as well as population variations (Buckland et al. 1993; Karafistan and Colokoglu 2005; Mannay et al. 1994; Roy et al. 2011).

Various species of phytoplankton are responsible for the primary production in the Ocean and lakes and hence it can be considered that they form the foundation stone of aquatic food chain (Saba et al. 2011). Also, they account for half of all photosynthetic activity on Earth and are responsible for much of the oxygen present in the Earth's atmosphere (Leith and Whittaker1975). The local abundance of phytoplankton varies horizontally, vertically and seasonally mainly because of the availability of light which is the source of energy for photosynthesis (RykaczewskiDunne 2011). The secondary variable that determines their abundance is the availability of nutrients such as nitrates, phosphates and silicates which are the building blocks for their further growth. Since these organisms form one of the bases of the aquatic food web the variability in phytoplankton growth influences the higher trophic levels (Boyce et al. 2010). There are many ecological observations supporting this concept and are reported in literature (Henson et al. 2010; Steinacher et al. 2010). For instance, during El Nino periods there are remarkable changes in the temperature and other sea water parameters. It can be observed that phytoplankton levels temporarily decrease rapidly during these periods which in turn influence the populations of zooplankton, fishes, sea birds, and finally marine mammals.

In this work an attempt has been done to correlate the nutrient dynamics of selected locations in the tropical zone with the observed populations of migratory water birds. The tropical ocean zones has characteristic climate patterns comprising Monsoon, moderate winter and summer. The Arabian Sea, one of the study sites is experiencing climatic shifts and shows considerable changes in the distribution of different phytoplankton assemblages. Inorganic nutrients, such as nitrate, phosphate and silicic acid are necessary for phytoplankton to synthesize their cells and cellular machinery. In aqueous ecological systems undergoing eutrophication the concentraion of these nutrients is high and consequently the density of phytoplankton is enhnaced. These species act as prey for the next higher tropic level including various fishes and other small organisms. One of the reasons for the arrival of migratory birds at some particular locations depends on the availability of the species of organisms that they would like to take as food. The biodiversity of all aquatic systems are indirectly controlled by the nutrient dynamics.

Materials and Methods

Study Area

Purakkad Coastal Region

Purakkad is a coastal village (9°21′0″N 76°21′0″E) close to Arabian sea and is situated in the Alappuzha district of Kerala. It can be observed that the seashore of Purakkad beach

contains large amounts of sediments which consist of organic matter, detritus, inorganic matter and numerous living organisms. This characteristic feature catches the attention of lots of life forms such as crustaceans, polychaetes and birds. The birds feed on these smaller life forms found at the shore and in the shallow waters. It is seen that most of the migratory birds visit Purakkad coast during November to April. Owing to the presence of sandy beaches along the Purakkad Coast there are reports that green turtles lay eggs on these regions. (Sashikumar et al. 2004; 2010).

The common migratory birds found at this region are: Grey plover, Sand Plover, Whimbrel, Pacific Golden Plover, Common Redshank, Marsh Sandpiper, Wood Sandpiper, Eurasian Curlew, Ruddy Turnstone, Great Knot, Sanderling, Crab Plover, Pallas Gull, Heuglins Gull, Brown Headed Gull, Black Headed Gull, Gull billed Tern, Sandwich Tern, Lasser Crested Tern, Greater Crested Tern, Saunders Tern and Bridled Tern (Sashikumar et al. 2004; 2010).

Aleppy Coast

Marine water samples are also collected from Aleppy Coast (9°30'N 76°23'E) near the City. This is a city in the Alappuzha District of Kerala. Here the populations of migratory birds are not gathered much in comparison with Purakkad Coast. The purpose of sampling at these sites is to check whether there are any remarkable differences in the water quality parameters in comparison with the former sites were migratory birds are common.

Koonthankulam Lake in the Bird Sanctuary

Koonthankulam Lake is located 38 km away (8.58102°N 77.76123°E) from Tirunelveli in Tamilnadu State**.** This is considered as the largest reserve for breeding water birds in South India. It has been recorded that more than 43 species of resident and migratory water birds visit here every year during January to June. In addition, about 100,000 migratory birds reach by December and return to their northern homes by June or July after they lay and hatch eggs and the little ones mature enough to fly with the older ones.

The most regularly observed migratory birds in this region are: Bar-headed Goose, Pintail Duck, Spotted Sand Piper, Green Sand piper, Green Shank, Coot, White Stork, Large Flamingo, Common Sand Piper, Common Teal, Spot billed Pelican, Painted Stork, Blackwinged Stilt, Spoonbill, White Ibis, Glossy Ibis, Openbill Stork, Grey Heron and Comb Duck.

Chemical Analysis

All the experiments are done according to the standard procedures (APHA, 2005). Six locations are selected at each region, three samples are collected from each sampling point and the mean values of the observations are recorded. The sampling is done during post Monsoon in November. The six locations of Aleppy coast are denoted using codes starting from A01 to A06 and those of Purakkad and Koonthankulam Lake are denoted from P01 to P06 and K01 to K06 respectively.

Results and Discussion

The marine water samples are collected from the predefined locations at the seashore of Aleppy and Purakkad region. Also lake water samples are collected from Koonthankulam Lake which is in the Koonthankulam Birds Sanctuary. The results of the chemical analysis are summarized in Table 1.

The amount of gaseous oxygen (O_2) dissolved in marine water samples and lake water is measured as a part of this study. Gaseous oxygen gets into water by diffusion from the surrounding air by aeration and also from aquatic photosynthesis. Depletion in dissolved oxygen may cause major shifts in the kinds of aquatic organisms found in lakes and seawater. However in all the sampling points the dissolved oxygen level falls in the optimum level of 6-8 mg/L.

The Biochemical Oxygen Demand (BOD) is considered as a measure of how much oxygen is used by microorganisms in aerobic oxidation or for the breakdown of organic matter in aquatic ecosystems.

Table 1.Physicochemical Analysis of the Water Samples from Purakkad Coast (P01-06), Aleppy Coast (A01-06) and Koonthankulam Lake (K01-06)

Sampling Sites	P01	P02	P03	P04	P05	P06	A01	A02	A03	A04	A05	A06	K01	K02	K03	K04	K05	K06
pH	7.44	7.77	7.58	7.65	7.28	7.65	7.68	7.44	7.55	7.64	7.88	7.65	7.28	7.96	7.48	7.37	7.58	7.89
Temperature (Degree C)	23.2	22.1	23.4	22.1	22.4	24.1	22.5	23.3	22.1	24.3	24.1	23.2	20.5	21.3	20.4	22.1	20.3	22.3
Dissolved Oxygen (ppm)	6.31	6.32	6.41	6.32	6.23	6.50	6.92	6.95	6.71	7.31	6.08	6.59	6.92	6.72	6.67	6.52	6.23	6.52
BOD (ppm)	4.31	3.38	3.82	4.11	3.25	4.01	1.23	1.68	2.21	1.62	1.11	2.11	6.61	5.92	6.12	5.93	4.98	5.12
Conductivity (mS/cm)	53.0	53.0	53.0	52.0	53.0	52.0	55.0	55.0	54.0	55.0	54.0	55.0	26.0	27.0	28.0	25.0	26.0	27.0
Chloride (g/L)	17.7	17.4	17.4	17.3	17.9	17.3	18.6	18.5	18.3	18.3	18.9	18.3	11.3	11.5	11.5	11.3	11.4	11.5
Salinity (g/Kg)	31.9	31.3	31.3	31.2	32.2	31.1	33.4	33.3	32.9	32.9	34.0	32.9	20.3	20.7	20.8	20.3	20.5	20.7
Turbidity (NTU)	13.5	11.2	12.3	13.5	11.9	11.2	9.50	9.30	9.40	9.10	9.50	9.30	76.0	75.0	77.0	74.2	73.2	75.3
Nitrate (mg/L)	0.21	0.23	0.24	0.21	0.15	0.18	0.10	0.05	0.04	0.09	0.10	0.12	1.50	2.51	2.60	2.80	2.78	2.56
Phosphate (mg/L)	0.09	0.08	0.09	0.09	0.08	0.07	0.07	0.07	0.06	0.06	0.07	0.06	0.21	0.18	0.13	0.15	0.11	0.12

If the amount of organic matter in the aqueous system is high relatively more amount of oxygen is required for aerobic oxidation. Consequently there is depletion of dissolved oxygen available to other aquatic life. The BOD values of the sampling points are given in Table 1. It can be seen that at Purakkad and Koonthankulam the BOD values are relatively higher indicating more amount of organic matter in the water column. The organic matter includes phytoplanktons, zooplanktons and many floating microorganisms along with soil, plant and animal debris. It helps the growth of a vast number of fishes and other organisms of higher trophic levels which can be considered as a food source for the migratory water birds.

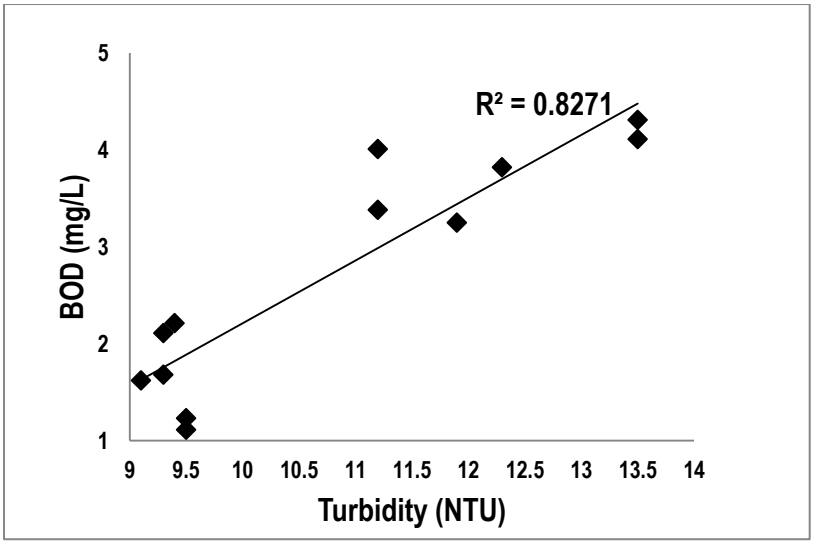

Figure 1. Correlation between BOD and Turbidity

Turbidity in water systems is largely due to the growth of phytoplankton, human activities and soil erosion. Thus it also implies the presence of organic matter. The samples from lake water (K01-06) show relatively higher values of turbidity which imply more concentrations of organic matter. It supports the evidence obtained above by BOD measurements. The values of BOD and turbidity follow a linear relationship especially at the higher values as shown in Figure 1. This is because the organic matter content is responsible for the higher values of BOD and its occurrence in water column can cause turbidity. The elevated concentration of organic matter helps the growth of a vast number of fishes and other organisms of higher trophic levels which in turn acts as a food resource for the migratory water birds.

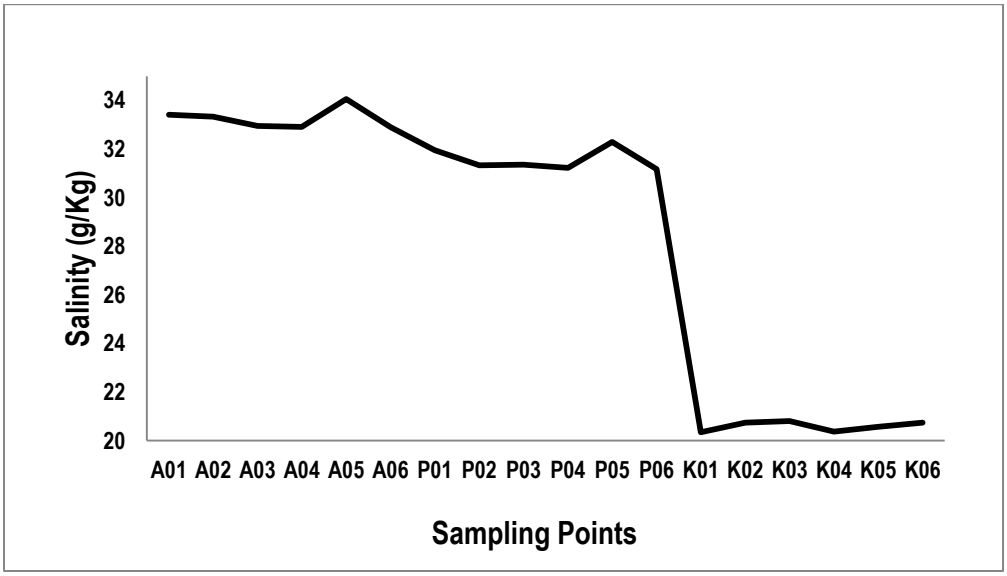

Figure 2.Salinity values at Aleppy (A01-A06), Purakkad (P01-06) and Koonthankulam Lake (K01-06)

Concentrations of metal ions in sea water and lake waters can be correlated with the biodiversity of those aquatic systems (Horsak and Hajek 2003). Conductivity values of a given aquatic system imply the salt content of the corresponding system and the observations

are presented in Table 1 which convey that the lake water is less salty than marine water which is an expected result. The concentration of chloride and the value of salinity in a given aquatic system also determine its salt content. Thus chloride concentrations, conductivity and salinity values convey an idea about the amount of dissolved salts in the corresponding study area. Also, it can be seen in Figure 2 that the marine water samples from Purakkad region (P01-06) has relatively lower salinity values in comparison with those samples from Aleppy region (A01-06). It implies that there is some remarkable difference in the overall concentration of various metal ions such as calcium, magnesium, sodium, potassium and other common metals in the ocean. A detailed analysis is essential to draw a meaningful conclusion which has not yet done. However the concentrations of various salts are indirectly related to the biodiversity of those regions since it is strongly connected to the abundance of the organisms falling in lower trophic levels. This connection reflects in the biodiversity of higher tropic levels via the interactions envisaged through the linkage of various organisms in the food chain. Hence the overall concentration of various metal ions plays a crucial role even in the higher level of organisms including migratory birds. That can be considered as one of the reasons for the arrival of migratory birds at some particular locations. Here Aleppy coast is not a common destination site while Purakkad region is an attractive site for migratory birds.

Phosphate is one of the important nutrients that control the abundance of phytoplanktons and the other small organisms in the water column. In the samples collected from Purakkad(P01-06) and Koonthankulam(K01-06) the phosphate concentrations are relatively higher. Elevated concentrations of phosphate enhance the growth of phytoplankton and consequently a vast number of fishes and other organisms of higher trophic levels which attracts the migratory water birds. It can be observed that there is a logarithmic correlation between phosphate levels and BOD values which is depicted in Figure 3. The phosphate concentration controls the abundance of phytoplankton in the water column. This is only one of the many factors which determine BOD and that is the reason why the curve follows a logarithmic pattern rather than a linear plot.

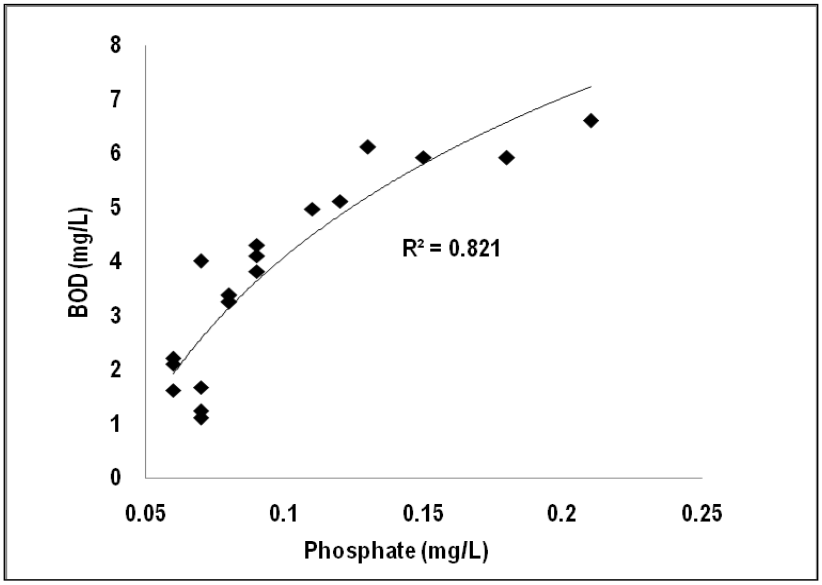

Figure 3. Logarithmic correlation between phosphate levels and BOD values

In addition to the analysis of phosphate, other nutrients such as silicate and nitrates are also important in controlling the growth of phytoplanktons and the other small organisms.Elemental nitrogen can take many forms in the ocean including dinitrogen, ammonia, nitrite, nitrate and a multitude of nitrogen containing organic compounds (Millero, 1996). Among the inorganic species nitrate is often the highest in concentration. Most of the nitrate present in the ocean and lakes originates from the recycling of organic materials such as degradation of planktons (Burkholder et al. 1994). Biological nitrogen fixation done by blue green algae also contributes to the overall concentration of nitrate. Many organisms show increased growth rate at elevated levels of nitrate. Examples include shoalgrass, widgeongrass, marine bacteria, phytoplankton and microalgae (Horrigan et al. 1988; Lapointe and O'Connell 1989; Pedersen and Borum 1996; Touchette and Burkholder 2000).The water samples from Purakkad and Koonthankulam shows relatively higher concentrations of nitrate.Here also we can find a logarithmic correlation between nitrate levels and BOD values which is depicted in Figure 4.

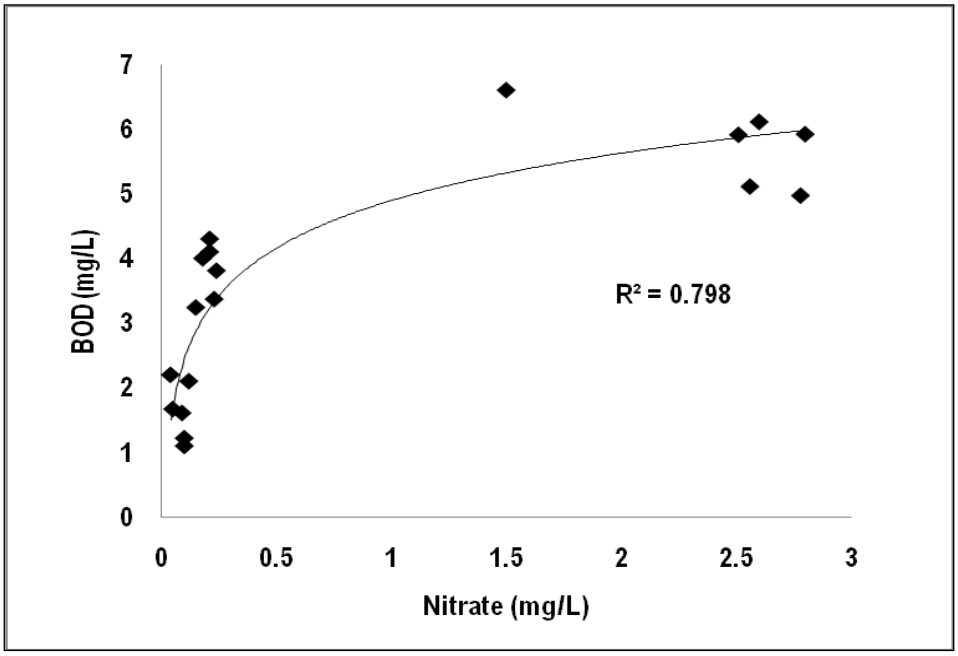

Figure 4. Logarithmic correlation between nitrate levels and BOD values

Experiments are done to determine the rate of aquatic photosynthesis at three locations in each site. The net and gross photosynthetic rates are calculated using the standard procedures. From the values of net photosynthetic rate an estimate of milligram of carbon fixed per m^3 per hour is obtained. The results are plotted in Figure 5. Photosynthetic rate measurements imply that at Koonthankulam Lake and Purakkad coastal zones there is relatively more abundance of phytoplankton.

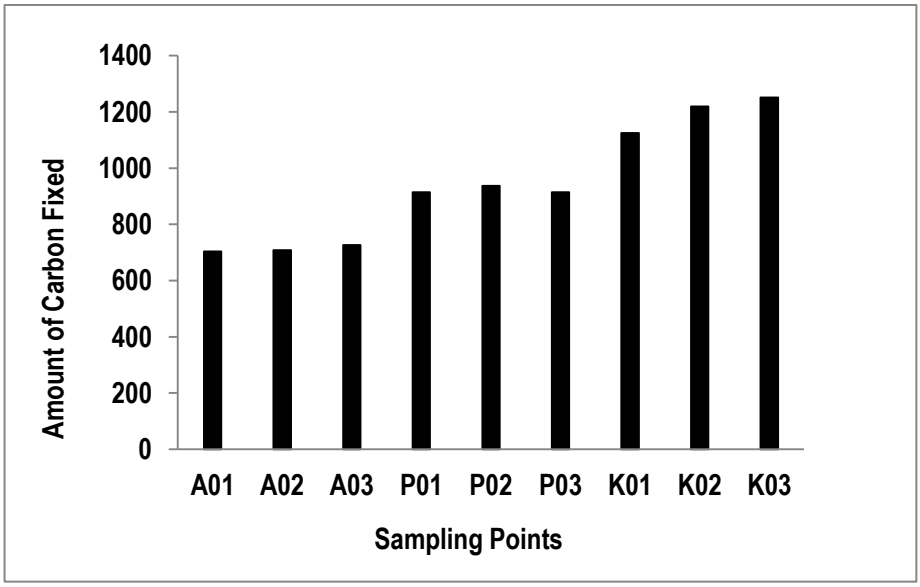

Figure 5. An estimate of milligram of carbon fixed per m^3 per hour at Aleppy (A01-A03), Purakkad (P01-03) and Koonthankulam Lake (K01-03)

Conclusions

As a part of the experimentsanalyses are done to explore the nutrient dynamics of selected tropical aquatic systems in order to correlate the arrival of migratory birds at those locations. The nutrient compositions and the related chemical parameters in the water column of these places are traced. Notable differences are observed primarily in the composition of phosphate, nitrate, organic matter content and salinity. In the end, an effort has been done to correlate the biodiversity of these locations with the chemical parameters and the prevailing nutrient compositions.

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