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Nutrients and Dissolved Gases of Three Backwaters in the South West Coast of India

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ABSTRACT

Irrespective of man's influence, the concentration of nutrients are characteristically higher in river waters than in the surface sea waters and this leads to the general enhancement of nutrients in estuaries and in coastal waters due to land drainage. Knowledge of nutrients and dissolved gasses relating to their contributory sources, utilization levels and their availability will be of great value to asses the productivity potential of an estuary. With a view to understand the level of dissolved gases and nutrients in such estuaries, the present study envisages the nutrients and dissolved gasses in the three backwaters viz. Kadinamkulam, Veli and Poonthura. These three estuaries lie in the Trivandrum city of Kerala in the south west coast of India. Collection of water samples for a period of one year (April 2007-March 2008) was made in a monthly interval. Collected samples from three different stations from each backwater were analyzed using standard methods for nutrients and dissolved gases. The results of the water quality parameters such as dissolved oxygen, hydrogen sulphide, ammonia–nitrogen, nitrite–nitrogen, phosphate–phosphorus and silicate–silicon were interpreted.

Keywords: Kadinamkulam, nitrogen, phosphorous, pollution, Poonthura, silicon, Veli

INTRODUCTION

Estuarine waters are polluted in diverse means and at different rates by the advent of industrialization, modernization, urbanization and the addition of chemical fertilizers and pesticides in agricultural fields. For the most part, physical parameters assess the changes that may take place in well-defined characteristics as a result of the addition of potential pollutants. The chemical parameters assess the concentration levels of persistent pollutants in various environmental compartments (Sundaray *et al.* 2008). Depletion of oxygen with consequent production of hydrogen sulphide (H_2S) is a major threat to living resources of these estuaries (Azis and Nair 1987).

H_2S is produced as a result of the reduction of sulphates by certain bacteria under anaerobic conditions and bacterial decomposition of proteins containing reduced sulfur. Knowledge of nutrients related to their contributory sources, utilization levels and their availability will be of great value to assess the productivity potential of an estuary. Drainage from farm lands, mangroves and some of the sewage effluents are known to enrich estuaries (Sunitha Rao and Rama Sarma 1995).

According to Clark (1992), many of the wastes entering the sea are plant nutrients. Decaying organic matter nitrates and phosphates in sewage enhance plant growth. Another important source of plant nutrients is agricultural fertilizers from areas of intensive farming. Corell (1998) suggested that eutrophication is the over-enrichment of receiving waters with mineral nutrients. The results are excessive production of autotrophs, especially algae and cyanobacteria. This high productivity leads to high bacterial populations and high respiration rates leading to hypoxia or anoxia in poorly mixed bottom.

The seasonal oscillations in the concentration of nutrients have always been an indicator of the fertility of marine and freshwater environments (Azis and Nair 1987). Ammonia is a common and highly toxic pollutant in sufficient quantities adversely affects aquatic organisms. Estuaries and continental shelf waters are the transition zones where excess phosphorous and nitrogen creates problems (Corell 1998). To understand their impact in such water bodies, the present study was framed to assess the level of important nutrients and some gases to predict the water quality of three focused backwaters such as Kadinamkulam, Veli and Poonthura.

DESCRIPTION OF STUDY SITES

1. Kadinamkulam backwater: This backwater (8° 35′ – 8° 40′N lat. and 76° 45′ – 76° 52′E long.) lies almost parallel to the adjoining Laccadive Sea for some distance and has a temporary connection with the sea at the north western region. It is the largest among the backwaters of the Trivandrum district. The Vamanapuram River originating from the Western Ghats, after traversing for about 80 km and covering a drainage area of 540 km empties into the backwater through Lake Anchuthengu. The nature of the mouth depends on the extent of sand bar formation and it normally gets closed completely for varying periods during the pre-monsoon with the diminishing freshwater discharge. In this site three stations were fixed with an interval of 20 m.

2. Veli Lake: It is the smallest among the backwaters of Kerala. It is situated 8 km north west of Trivandrum City at 8° 28′ N lat. and 76° 57′ E long. The system widens from the bar mouth to the eastern part and is 2 km long and 0.3 km broad. It is connected to the Kadinamkulam backwater through the Parvathiputhanar canal. On the southern side it is connected with the Chackai canal and Aakulam. Veli Lake is shallow with a mean depth of 2-3 m. Unlike other large backwaters it has no permanent connection with the sea. During the monsoon season, hydraulic pressure breaks open the bar mouth resulting in maintaining a temporary connection with the adjoining sea. Here also three stations with 20 m interval were fixed.

3. Poonthura backwater: It 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′ to 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

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Research Note

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 Parvathyputhanar canal through which the sewage spilled from the sewage farm situated at Muttathara, reaches the Poonthura estuary. For convenience three different stations were fixed in this site. The interval between the stations was 20 m each.

MATERIALS AND METHODS

Water and sediment samples for a period of one year from April 2007 to March 2008 were collected. Sampling was done during morning hours between 6 and 10 a.m. The year of study was divided into three seasons such as pre-monsoon, monsoon and post-monsoon for convenience of analysis. Pre-monsoon comprises four months from February to May. The monsoon starts from June and ends in September. October to January forms the post-monsoon period. Surface water samples were collected using a clean plastic bucket and the bottom water with a van-don bottom water sampler at a depth of 1 m from the surface. 250 ml of water sample were taken for each collection. The collected water samples were transferred to pre-cleaned, polythene bottles and stored in the refrigerator. Water for the estimation of dissolved oxygen was fixed in the field itself and the samples used for the analysis were filtered by a Millipore filtering unit through Whatman GF/C filter paper of 0.5 µm porosity.

Dissolved oxygen (DO) was determined by classic Winkler's titration method. The determination of H_2S by Lauth's violet method equivalent to methylene blue method was followed (Grasshoff *et al.* 1983). Estimation of ammonia (NH_4) was made by the colorimetric method of steam distillation by a micro Kjeldahl, distillation unit (Trivedy and Goel 1986). The Photometric determination of nitrite (NO_2) was followed to estimate the nitrogen and the estimation of inorganic phosphate (PO_4) in the water was made by following the modified method of Murphy and Riley (Grasshoff *et al.* 1983). Silicate silicon (SO_4) was estimated by adopting the method of Koroleff (1983) and the optical densities were noted spectophotometrically. Student's *t*-test was followed to analyze the data at 1% level.

RESULTS

The mean DO content of Kadinamkulam back water was 4.78 mg/l which ranged from 4.42 mg/l in the bottom of station III to 5.08 mg/l in the surface of station I. The DO in Veli ranged between 5.66 mg/l in bottom of station I and 6.8 mg/l in the surface of station III with the mean value of 6.35 mg/l. In Poonthura waters, the mean DO was 3.95 mg/l which ranged from 1.14 mg/l in station II to 5.38 mg/l in surface of station III (**Table 1**). The mean H_2S content of Kadinamkulam estuary was 0.34 mg/l which ranged from 0.33 mg/l in bottom of station I to 0.35 mg/l in the bottom of station II. The mean H_2S concentration of Veli was 0.34 mg/l with the range of 0.33 mg/l in station I and 0.35 mg/l in surface of station I. In Poonthura back water the H_2S ranged from 0.36 mg/l in the bottom of station III to 0.98 mg/l in surface of station II with the mean value of 0.61 mg/l (**Table 2**). The mean NH_4 of Kadinamkulam backwater was 0.38 mg/l which ranged between 0.3 mg/l in the surface of station III and 0.55 mg/l in bottom of station I. The mean NH_4 of Veli Lake was 0.41 mg/l which ranged from 0.32 mg/l in the bottom of station I to 0.42 mg/l in the surface of station II. The mean value of Poonthura was 0.37 mg/l which ranged between 0.32mg/l in the bottom of station I and 0.42mg/l in the surface of station II (**Table 3**). Mean NO_2 in Kadinamkulam backwater was 0.22 mg/l which ranged from 0.19 mg/l in the bottom of station III to 0.24 mg/l in the surface of station III. In Veli, the nitrite ranged between 0.17 mg/l in the bottom of station III to 0.4 mg/l in the bottom of station I with the mean value of 0.31 mg/l. In Poonthura, the mean NO_2 was 0.27 mg/l which ranged from 0.22 mg/l in station III to 0.39 mg/l in the bottom of station II (**Table 4**).

In the Kadinamkulam backwater, the mean PO_4 was 0.23 mg/l which ranged between 0.22 mg/l in the surface of station II and 0.25 mg/l in the surface of station I. The PO_4 of Veli ranged from 0.55 mg/l in the bottom of station III to 0.69 mg/l in the surface of station II with the mean value of 0.6 mg/l. In Poonthura, the mean PO_4 was 0.47 mg/l and it ranged between 0.26 mg/l in the bottom of station III and 0.78 mg/l in the surface of station II (**Table 5**).

The mean SO_4 distribution of Kadinamkulam backwater was 0.59 mg/l which ranged between 0.48 mg/l in the surface of station I and 0.79 mg/l in the bottom of station II. The mean SO_4 of Veli lake was 1.31 mg/l which ranged from 1.16 mg/l in the bottom of station I to 1.44 mg/l in the surface of station II. The SO_4 content of Poonthura ranged between 1.04 mg/l in the bottom of station III and 1.38 mg/l in the surface of station II with the mean value of 1.28 mg/l (**Table 6**). There was no significance in analysis through t-test at 1% level.

Table 1 Seasonal changes of dissolved oxygen (mg L^{-1}).

Sites/Seasons	Kadinamkulam (± SEM)	Veli (± SEM)	Poonthura (± SEM)
Premonsoon	4 ± 0.03	4.5 ± 0.023	3.8 ± 0.013
Monsoon	5.5 ± 0.041	9 ± 0.056	6 ± 0.023
Postmonsoon	4.5 ± 0.012	5.7 ± 0.015	1.5 ± 0.0012

Table 2 Seasonal changes of hydrogen sulphide (mg L^{-1}).

Sites/Seasons	Kadinamkulam (± SEM)	Veli (± SEM)	Poonthura (± SEM)
Premonsoon	0.6 ± 0.003	0.65 ± 0.005	1.1 ± 0.001
Monsoon	0.1 ± 0.0005	0.09 ± 0.0021	0.39 ± 0.0032
Postmonsoon	0.3 ± 0.0012	0.45 ± 0.0022	0.3 ± 0.0012

Table 3 Seasonal changes of ammonia-nitrogen (mg L^{-1}).

Sites/Seasons	Kadinamkulam (± SEM)	Veli (± SEM)	Poonthura (± SEM)
Premonsoon	0.42 ± 0.003	0.58 ± 0.005	0.44 ± 0.001
Monsoon	0.35 ± 0.005	0.37 ± 0.0021	0.4 ± 0.0032
Postmonsoon	0.34 ± 0.0012	0.28 ± 0.0022	0.25 ± 0.0012

Table 4 Seasonal changes of nitrate-nitrogen (mg L^{-1}).

Sites/Sasons	Kadinamkulam (± SEM)	Veli (± SEM)	Poonthura (± SEM)
Premonsoon	0.23 ± 0.003	0.68 ± 0.005	0.52 ± 0.001
Monsoon	0.02 ± 0.0001	0.01 ± 0.0021	0.05 ± 0.0032
Postmonsoon	0.36 ± 0.0012	0.22 ± 0.0012	0.2 ± 0.0012

Table 5 Seasonal changes of phosphate-phosphorous (mg L^{-1}).

Sites/Sasons	Kadinamkulam (± SEM)	Veli (± SEM)	Poonthura (± SEM)
Premonsoon	0.5 ± 0.003	1.1 ± 0.005	0.7 ± 0.001
Monsoon	0.05 ± 0.0001	0.22 ± 0.0021	0.3 ± 0.0032
Postmonsoon	0.08 ± 0.00011	0.38 ± 0.0012	0.5 ± 0.0012

Table 6 Seasonal changes of silicate-silicon (mg L^{-1}).

Sites/Seasons	Kadinamkulam (± SEM)	Veli (± SEM)	Poonthura (± SEM)
Premonsoon	0.7 ± 0.003	2.4 ± 0.05	1.7 ± 0.001
Monsoon	0.6 ± 0.003	1.2 ± 0.0021	1.6 ± 0.0032
Postmonsoon	0.44 ± 0.0012	0.52 ± 0.0032	0.66 ± 0.0033

DISCUSSION

Respiration and decomposition of bottom fauna in high salinity water leads to the reduction of DO in bottom (Panigraghy *et al.* 1999). In the present study, the mean DO level of Poonthura was very low (3.95 mg/ml) with nil DO in station II during April, when compared to Veli and Kadinamkulam backwaters. This was primarily due to the production of hydrogen sulphide. Anila Kumary (1996) linked the depletion or gradual decrease in oxygen concentration or anoxic condition to the high concentration of H_2S. Ret-ting of coconut husk is a major source of organic pollution in the backwater systems of Kerala. In the present study the pre monsoon season recorded high levels of H_2S due to the concentration of sulphide content through retting process and gradual decline in oxygen concentration. The minimum values in monsoon especially in September was due to the heavy freshwater discharge and dilution of concentrated organic contaminants. In the present study, the formation of high concentration of H_2S during pre monsoon months reflects the dangerous situation, since sulphides are highly toxic and capable of removing all organisms except anaerobic bacteria from ecosystems. Anila Kumary (1996) stated that the high H_2S concentration is an important feature associated with sewage pollution and the nature of mud also indicated high sulphide content.

Chapman and Wang Feiyue (2001) stated that almost half of the nitrogen leaving the estuary is in the form of ammonia, which is not affected by denitrifying conditions. The magnitude of variations in ammonia concentration was nearly identical at the surface and bottom levels. Irregular pattern of distribution regarding different season may be due to excretion by organisms and organic accumulates and oxidation of NH_4 by bacterial, photochemical or by photoplankton. Sunitha Rao and Rama Sarma (1993) reported that there was a steady increase in NH_4 during pre monsoon and almost half of the nitrogen leaving the estuary is in the form of NH_4, which is not affected by denitrifying conditions. Mean NH_4 content observed in Veli lake was high (0.41 mg/l). In other two backwaters the values were nearly the same (0.38, 0.37 mg/l). The station wise relationship also showed high values in station III and station I of Kadinamkulam which can well be related to the greater mixing of sea water. In an intermediate phase of oxidation, the nitrogenous organic compounds attack NH_4 by nitrifying bacteria such as nitrosomonas which absorb ammonia and release nitrite (NO_2) ions (Anila Kumary 1996). In Kadinamkulam estuary the maximum values occurred during monsoon and in shallow estuaries like Veli and Poonthura the maximum concentration of nitrite occurred during pre monsoon. An addition of NO_2 was attributed by its demineralization in the water column or desorption from the bottom sediments and microbial reduction of nitrate or oxidation of ammonia (Sundaray *et al.* 2008). The mean NO_2 content of three backwaters was more or less in equal proportion because they lie in the same topography.

The irregular pattern of seasonal distribution in different stations may be due to the oxidation of ammonia or re-duction of nitrate (NO_3) in the estuarine environment as attributed by Chandran and Ramamoorthi (1984). The maximum concentration during pre monsoon may be due to the high decomposition of nitrogenous organic matter and enhanced microbial activities at high temperature (Bais and Agarwal 1990). Lower values of nitrites observed during monsoon were due to the reduced decomposition of nitrogenous organic matter and low microbial activities at low temperature and dilution of nutrients by rainwater run-off (Geetha Bhadran 1997). The mean PO_4 content of Veli Lake was more (1.31 mg/l) when compared to Poonthura (1.28 mg/l) and Kadinamkulam (0.59 mg/l). The higher values in Veli and Poonthura were due to agricultural run off from neighboring paddy fields and the high organic load. The concentration of phosphorus depends on basin morphometry, geology of the area, introduction of organic matter and organic metabolism within the water body by sedimentation of phosphorus (Sousa *et al.* 2008).

Though distinct stratification was not evident, the surface values of the present study at most of stations in all the seasons were slightly higher than the bottom. This indicated the enrichment of phosphate by terrestrial run off rather than by neritic waters. In contrary to this Fernandez and Bhosale (2002) reported that spatial distribution of phosphorus indicated more phosphorus at the bottom of the estuary. Relatively high removal of PO_4 in monsoon may be due to the combined effects of desorption from suspended particulates and its greater utilization by phytoplankton and adsorption on sediment particulates. During post monsoon when the conditions of the estuary are homogeneous the phosphorus concentration remains low with very little differences in values and the concentration attain its peak during pre monsoon (Ahn *et al.* 2005). Heavy loading of phosphorus during pre monsoon may be due to the concentration of fertilizers, detergents and sewage (Aravind Kumar 1997).

In the present investigation, there was a high concentration of reactive silicon which gradually decreased towards the seaward side. Moreover, the occurrence of higher concentration of SO_4 was always in surface water. This was due to the high saline nature of bottom water and silicate concentration is inversely related to salinity and increases with suspended load (Geetha Bhadran 1997; Padma and Periakali 1999). The concentration of SO_4 was found to be less during post monsoon due to flocculation, and sorption by sediments (Padma and Periakali 1999). Very high levels of SO_4were observed during monsoon period which might be due to river runoff, leaching of silicious materials and desorption from the sediments (Sundaray *et al.* 2008). However the higher mean values noticed in Veli lake and Poonthura, suggests that irrespective of salinity, the effluents discharge from English Indian Clay factory also play a significant role in the increase of SO_4 content.

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