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Seasonal variations of nutrients in Pulicat Lake, Tamil Nadu, India

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Abstract
Seasonal variation in the distribution of nutrients in the surface waters of Pulicat lake, Tamil Nadu, India was assessed from January 2011 to December 2012. The nutrients investigated were nitrate, nitrite, free ammonia, phosphate, sulphate and silica. Data revealed that the amount of nitrate was high during pre monsoon and low during monsoon during the study period. Nitrite content was found to be high during pre monsoon and post monsoon in 2011 and 2012 respectively. High values of free ammonia were recorded during summer in both the years and low values during pre monsoon and post monsoon in 2011 and 2012 respectively. High concentrations of inorganic phosphate were recorded during pre monsoon and low phosphate during summer, post monsoon and monsoon. Minimum sulphate values were observed during post and pre monsoon whereas maximum values were recorded during pre monsoon and summer in both the years. Silica content in the study area showed maximum values during post monsoon and monsoon in 2011 and 2012 respectively and low values were recorded during pre and post monsoon in 2011 and 2012 respectively.

Keywords: Nutrients, Pulicat lake, estuary, eutrophication.

Introduction
Nutrients are considered as one of the most important parameter in the estuarine environment. It influences the growth, reproduction and metabolic activities of living beings. Nutrients are the raw material for the marine trophic chain and estuaries are the main entry for nutrients coming from continental drainage to the marine environment [1]. Agricultural, industrial and urban activities are considered to be major sources of addition of nutrients to aquatic ecosystems [2]. Distribution of nutrients is mainly based on the seasons, tidal condition, freshwater inflow and land runoff, chemical, petrochemical, pharmaceutical effluents and flushing of fertilizer used in paddy fields [3]. Increase in nutrient concentrations in estuarine and coastal water causes several environmental modification, *viz*., increase in productivity and fishing yields. However, anthropogenic inputs frequently cause excessive eutrophication in the environment, especially where the circulation is restricted as in estuaries and coastal regions. Several alterations in chemical characteristics and water quality in such water bodies occur as a result of varying river flows which can lead to various ecological consequences like changes in species composition, blooms of phytoplankton and decrease in oxygen concentrations [4]. Therefore, management of aquatic environment in particular has become a major concern in recent years. In view of the above, the present study was carried out to assess the nutrient content of Pulicat lake.

2. Materials and methods
2.1. Study area
Pulicat lake (latitude 13º 24' and 13º 43'N and longitude 80º 03' and 80º 18E') is the second largest coastal lake in India located 40 km north of Chennai, Tamil Nadu, India. The lake is about 60 km in length and 0.2 to 17.5 km in breadth and separated from the Bay of Bengal by an inland split called the Sriharikota Island. The main source of freshwater is land runoff through three small seasonal rivers that open into the lake *viz*., Arani, Kalangi and Swarnamukhi. The Buckingham canal, which runs parallel to the Bay of Bengal, brings in the industrial and domestic wastes to the lake and eventually to the Bay of Bengal [5].
The hydrology of the Pulicat lake is influenced by local climate, the regime of the inflowing rivers, the Buckingham canal that enters the lake, in addition to the effect of the neritic waters

of the Bay of Bengal. Pulicat lake, harbours many euryhaline species and serves as a nursery for several marine species and a very few secondary freshwater fishes. The industries located around Pulicat lake are discharging effluents indirectly into the lake and the point sources of pollution mainly comes from North Chennai thermal power plant, Ennore port activities, Manali petrochemical industries, other nearby industries and untreated urban wastes from Chennai metropolitan city [5].

2.2. Collection of samples and analysis

Water samples were collected from four stations in the Pulicat lake which are suspected sites of possible local and point source pollution. The water samples were collected undisturbed from the surface water in the study area as the depth of water was very less (< 5m) during early morning throughout the study period. Samples were collected from January 2011 to December 2012 on a monthly basis to study the effects of seasonal variation. The water samples were collected in two litre polyethylene cans which were previously cleaned, rinsed and washed with deionized water and then rinsed with samples several times.

The collected water samples were brought to the laboratory and preserved. The nutrients (in mg/L), nitrate (as NO_3), nitrite (as NO_2), free ammonia (as NH_3), phosphate (as PO_4), sulphate (as SO_4) and silica (as SIO_2) were analyzed by adopting the standard methods of examination of water and waste water [6].

3. Results and discussion

The values for nutrient contents of Pulicat lake during the study period from January 2011 to December 2012 are presented in Tables 1 and 2.

3.1. Nitrate

In 2011 the amount of nitrate varied between 4.02 and 8.01mg/L and in 2012 it varied between 3.75 and 8.75mg/L among the four seasons. High nitrate values were recorded during pre monsoon and low values during monsoon in both these years. The increased nitrate level may also be due to leaching of rocks, fertilizer, domestic and municipal sewage, fresh water inflow and litter fall decomposition during north east monsoon [3, 7]. Another possible way of nitrate input could be through oxidation of ammonia to nitrite and then consequently to nitrate [8]. The recorded low values during non-monsoon period may be due to its utilization by phytoplankton as evidenced by high photosynthetic activity and the dominance of neritic seawater having a negligible amount of nitrate [7, 9].

3.2. Nitrite

Nitrite ranged between 0.05 and 0.08mg/L during pre monsoon and monsoon in 2011 and in 2012 it ranged between 0.06 and 0.010mg/L during summer and post monsoon. Nitrite content was found to be high during pre monsoon and post monsoon in 2011 and 2012 respectively. Minimum values were recorded during post monsoon in 2011 and in summer during 2012. The higher concentration of nitrite and its seasonal variations could be attributed to the variation in phytoplankton, excretion and oxidation of ammonia and reduction of nitrite [10]. The low content of nitrite could be due to less freshwater input, higher salinity, higher pH and also uptake by phytoplankton. Similar values were recorded in Uppanar estuary [11], Vellar estuary [12], Thondi coastal waters [13] and Parangipettai and Cuddalore coasts [14].

3.3. Free ammonia

In 2011 the free ammonia varied between 0.91 and 4.56mg/L among the four seasons. In 2012 it varied between 0.16 and 3.93mg/L. High values of free ammonia were recorded during summer in both the years. Low values were recorded during the premonsoon and post monsoon in 2011 and 2012 respectively. However, Ravaniah *et al*. [15] had recorded minimum ammonia during summer and maximum during monsoon in Pulicat lake. They have also reported similar findings at Pennar estuary, Nellore. Low concentration of ammonia during summer and high during the monsoon may be due to the decomposition of organic matter in the sediments as domestic sewage and industrial effluents leads to an increase in its concentration [16]. Excess utilisation of fertilizer in agriculture and sewage discharge could also be one of the reasons for the increase in ammonia at Pulicat lake. Ammonia is present in both terrestrial and aquatic environment since plants and animals excrete ammonia. Decomposition of organisms and activity of microorganisms also produce ammonia. High concentration of ammonia present in water may be toxic to aquatic organisms [17].

3.4. Phosphate

The amount of phosphate ranged between 0.09 and 0.57mg/L during post monsoon and monsoon in 2011 and in 2012 it ranged between 0.10 and 0.47mg/L during post monsoon and pre monsoon. High concentrations of inorganic phosphate were recorded during pre monsoon. Low phosphate was recorded during summer, post monsoon and monsoon seasons which could be attributed to the limited flow of freshwater, high salinity and utilization of phosphate by phytoplankton [18, 8]. The variations may also be due to the processes like adsorption and desorption of phosphates and buffering action of sediment under varying environmental conditions [8]. Further, the recorded high monsoonal value may be due to heavy rainfall, land runoff, its autochthonous origin and weathering of rocks liberating soluble alkali and metal phosphates, the bulk of which are carried into the estuaries [19]. The addition of super phosphates applied in the agricultural fields as fertilizers and alkyl phosphates used in households as detergents could be other sources of inorganic phosphates [18, 20].

3.5. Sulphate

In 2011 sulphate varied between 831.3 and 2365.5mg/L among the four seasons. In 2012 it ranged between 1328.5 and 1616.5mg/L. Minimum sulphate values were observed during post and pre monsoon whereas maximum values were observed during pre monsoon and summer in both the years. Similar findings were reported by Ravaniah and Murthy [21] at Pulicat lake. The normal amount of sulphate in sea water is 2700mg/L [22]. Sulphate concentration in Pulicat lake was well below the permissible limits. Dimethylsulphide [$(CH_3)_2S$ or DMS] is produced by the decomposition of dimethylsulfoniopropionate (DMSP) from dying phytoplankton cells in the shallow levels of the ocean, and is the major biogenic gas emitted from the sea, which is responsible for the distinctive "smell of the sea" along the coastlines. DMS is the largest natural source of sulphur gas, but has a residence time of about one day in the atmosphere and a majority of it are redeposited in the oceans rather than making it to the land [23].

3.6. Silica

Silica varied between 23.2 and 27.1mg/L during post monsoon and monsoon in 2011 and in 2012 it ranged between 17.58 and 30.3mg/L during monsoon and summer. Silica content in the study area showed maximum values during post monsoon and monsoon in 2011 and 2012. Low values were recorded during pre and post monsoon in 2011 and 2012. The high values of silica observed during monsoon may be attributed to the heavy freshwater influx and land run off which carries silt and other silicon deposits from upper reaches of the rivers flowing into Pulicat lake. Observations similar to the present study were reported earlier by Qasim *et al*. [24] and Ansari and Rajagopal [25] in Cochin back waters, Nair *et al*. [26] in Ashtamudi estuary and by Devi [27] in Coleroon estuary. The decline in silica during summer can be reasonably attributed to its utilization by phytoplankton and bottom algae. Part of silicate content may have been lost to the bottom on mixing with seawater [28].

Table 1: Nutrients present in Pulicat lake in 2011

Nutrients (mg/L)	**Post Monsoon**	**Summer**	**Pre Monsoon**	**Monsoon**
Nitrate	4.25	6.50	8.01	4.02
Nitrite	0.06	0.06	0.05	0.08
Free ammonia	0.91	4.56	2.72	1.17
Phosphate	0.09	0.27	0.41	0.57
Sulphate	831.30	2365.50	2212.50	1756.00
Silica	23.20	24.60	25.30	27.10

Table 2: Nutrients present in Pulicat lake in 2012

Nutrients (mg/L)	**Post Monsoon**	**Summer**	**Pre Monsoon**	**Monsoon**
Nitrate	3.75	6.50	8.75	5.01
Nitrite	0.10	0.06	0.06	0.06
Free ammonia	0.16	3.93	0.49	1.42
Phosphate	0.10	0.41	0.47	0.28
Sulphate	1419.00	1616.50	1370.30	1328.50
Silica	29.80	30.30	29.70	17.580

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