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Assessment of the Physico-Chemical Parameters of Sediment of Adayar Estuary, Tamil Nadu, India

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ABSTRACT: Sediments form one of the complex environments, because of fluctuating physico-chemical characteristics, such as pH, electrical conductivity, salinity, organic carbon, phosphate and nitrate. These parameters are known to manipulate the interactions of pollutants within sediment pattern. Polluted sediment is a major environmental problem affecting freshwater, estuarine and marine environments. The present study aims to assess the pollution load of Adayar estuary of Chennai with reference to the physico-chemical parameters of sediments (pH, Electrical Conductivity, Salinity, Organic carbon, Phosphate and Nitrate).The study was carried for a period of one year (March 2016 to February 2017) at three different sampling stations. Sediments contained very high values of the physico-chemical parameters.

Keywords: Sediments, Physico-Chemical Parameters, Adayar estuary.

1. INTRODUCTION

Chennai, the capital city of Tamil Nadu, is located at the Coromandel Coast of the Bay of Bengal. As the city is located near equator it experiences hot and humid climate for all the three major seasons viz, summer, winter and monsoon. Water quality is a vital phase for the existence and health of the living resources, especially in the coastal and estuarine areas. Estuarine and coastal areas have complex and dynamic aquatic environments (Morris *et al*., 1995). Estuarine ecosystems play an important role in the global economy and biodiversity of the region (Smith and Hollibaugh, 1993) as well as act as a transitional zone between land and sea (Badarudeen *et al*., 1996). A large number of physical and chemical processes occur as the river water mixes with seawater, which may influence water quality (Anitha and Kumar, 2013).

The most important variables which influence the estuaries are, temperature, salinity, pH, rainfall and nutrient (Sampathkumar and Kannan,1998). The seasonal distribution of abiotic and biotic process affects the nutrient cycle of different coastal environments. Seasonal changes on tropical estuaries are mostly based on monsoonal discharge of fresh water (Choudhury and Panigrahy, 1991).

Estuarine sediments and waters are characterized by specific and complex physical, chemical and microbiological properties. These properties depend and interact with each other and collectively constitute a unique environment to the organism. The study of sediments represents a useful tool for determining the actual state of environmental status of a water body. It is well recognized that the primary productivity in shallow marine environment depends on nutrient economy which is known to be governed by the sediment nutrient level. Knowledge on the role of sediments is useful in determining the sediment water interactions which eventually affect the productivity of the overlying water body (Reddy and Hariharan, 1986).

Sediments form a natural buffer and filter system in the material cycles of waters. Sediment strata serve as an important habitat for the benthic macro invertebrates whose metabolic activities contribute to aquatic productivity (Abowei and Sikoki, 2005)

2. MATERIALS AND METHODS

2.1 *Sampling sites*

For collection of sediment samples, three sites were selected in Adayar estuary in Chennai. The sampling sites are shown in Fig.1.

Station I: Adayar River mouth of the estuary served as one of the survey site, measuring around 0.8 square kilometers in area **(13° 0' 45.9756"N & 80° 16' 39.3306"E).**

Station II: Theosophical Society known as the "Huddleston Gardens", lies on the south bank of the Adayar river and covers 1.052 square kilometres. **(13° 0' 51.282"N & 80° 16' 37.0128"E).**

Station III: Srinivasapuram is a slum located between Santhome and Adayar, along the shore of the sea **(13° 0' 59.2632"N & 80° 16' 35.2344"E).**

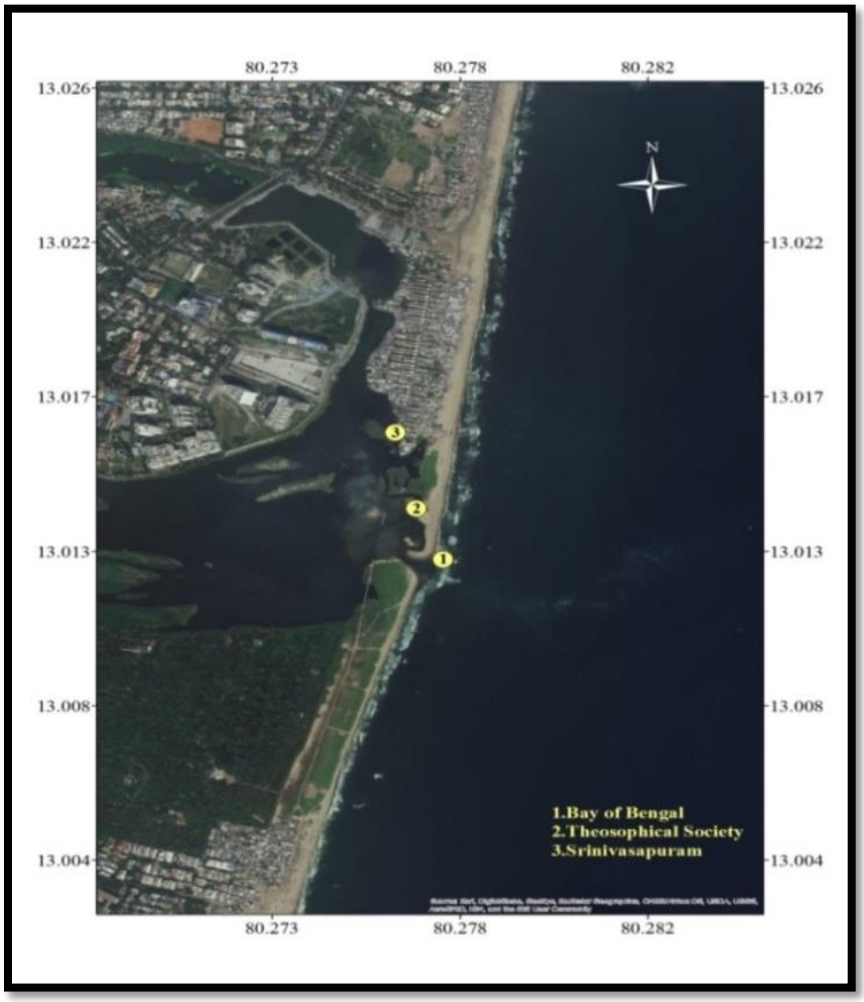


Fig. 1 A Map of Adayar Estuary showing three sampling sites

2.2 ***Sediment sampling***

Sediment samples were collected from selected stations (S1, S2 and S3) from March 2016 to February 2017, using Van Veen Grab sampler. A representative portion of the sediment sample was scooped into whirl pack polythene bags for physico-chemical analysis. The samples were then air-dried for the analysis of physico-chemical parameters. The impurities including decayed wood pieces, shells of Mollusca etc. were removed. The dried sediment was then passed through a 2mm sieve to remove coarse particles. The sieved soil was then sub-sampled and ground to a fine powder by using a mortar and pestle. The fine powder was then used for chemical analysis to perform the following physicochemical analysis except pH and conductivity for which wet samples were used. The standard techniques by APHA

2012 were followed for physical and chemical analysis of sediment samples.

2.3 *Statistical analysis*

To find out the significance in physico-chemical parameters between stations and between seasons, two way ANOVA was performed using the software SPSS,version 18.0.

3. RESULTS AND DISCUSSION

The present study provides a detailed description of the physico-chemical parameters of sediment samples collected from three different sampling stations of Adayar Estuary. The samples collected were analysed for pH, Electrical conductivity, Salinity, Organic carbon, Phosphate and Nitrate and the results are represented in Table 1, 2 and 3 for three seasons.

Table 1: Physico-Chemical parameter of Sediment -Adayar Estuary during Pre Monsoon (March 2016 to June 2016)

S.No	Parameter	Mean ± SD = (n = 6)		
		Station I	Station II	Station III
1	**pH**	6.63 ± 0.36	6.46 ± 0.29	6.22 ± 0.18
2	**Electrical conductivity (μScm^{-1})**	122.87 ± 3.13	123.35 ± 1.11	129.37 ± 3.21
3	**Salinity** (PSU)	7.48 ± 0.37	7.72 ± 0.25	8.05 ± 0.19
4	**Organic Carbon %**	3.4 ± 0.14	3.61 ± 0.38	3.22 ± 0.17
5	**Phosphate (mg/kg)**	431 ± 2.61	430.17 ± 3.18	428.17 ± 1.47
6	**Nitrate (mg/kg)**	22.7 ± 2.47	22.86 ± 2.14	23.1 ± 1.17

Table 2: Physico-Chemical parameter of Sediment -Adayar Estuary during Monsoon (Jul 2016 to Oct 2016)

S.No	Parameter	Mean ± SD = (n = 6)		
		Station I	Station II	Station III
1	**pH**	7 ± 0.25	6.93 ± 0.27	6.71 ± 0.27
2	**Electrical conductivity (μScm^{-1})**	120.9 ± 1.85	121.48 ± 1.89	126.23 ± 2.57
3	**Salinity** (PSU)	4.18 ± 0.64	4.68 ± 0.28	3.95 ± 1.87
4	**Organic Carbon %**	4.48 ± 0.31	4.3 ± 0.14	4.63 ± 0.19
5	**Phosphate (mg/kg)**	440 ± 9.12	444.33 ± 3.27	439.67 ± 5.50
6	**Nitrate (mg/kg)**	30.47 ± 2.39	32.22 ± 1.70	32.78 ± 1.33

Table 3: Physico-Chemical parameter of Sediment Adayar Estuary during Post Monsoon (Nov 2016 to Feb 2017)

S.No	Parameter	Mean ± SD = (n = 6)		
		Station I	Station II	Station III
1	**pH**	6.83 ± 0.21	6.6 ± 0.25	6.3 ± 0.38
2	**Electrical conductivity (μScm^{-1})**	128.02 ± 1.62	132.75 ± 1.45	145.98 ± 0.84
3	**Salinity** (PSU)	8.47 ± 0.14	7.58 ± 0.28	8.82 ± 0.31
4	**Organic Carbon %**	5.21 ± 0.44	5.4 ± 0.37	4.8 ± 0.32
5	**Phosphate (mg/kg)**	450.17 ± 1.72	466 ± 2.37	460.17 ± 1.94
6	**Nitrate (mg/kg)**	41.22 ± 1.69	41.08 ± 2.19	40.97 ± 1.06

3.1 pH of Sediment Samples

pH is a measure of the acidity or alkalinity of water and is one of the stable measurements. pH is a simple but is extremely important parameters, since most of the chemical reactions in aquatic environment are controlled by any change in its pH value. Anything either highly acidic or alkaline would kill marine life. Aquatic organisms are sensitive to pH changes and biological treatment requires pH control or monitoring, Pravin Singare *et al*., 2011.

At Pre-Monsoon, the mean seasonal pH values of sediment were observed to be 6.63 ± 0.29, 6.46 ± 0.29,6 .22 ± 0.18 in station I, station II and station III respectively. For Monsoon and Post-Monsoon it was recorded as 7 ± 0.25, 6.93 ± 0.27, 6.71 ± 0.27 and 6.83 ± 0.21, 6.6 ± 0.25 and 6.3 ± 0.38 respectively, (Figure 2). Negligible difference in pH levels of sediment samples were observed at the three different stations in the study area. The pH levels were found to be low (acidic) in sediment samples, which may be due to the chemical reactions in the sediments. This would definitely pose a serious threat to aquatic organisms. The present findings are in accordance with the works carried out by Suneela *et al*., 2008 and Nnaji *et al*., 2010 Erema Daka and Miebaka Moslem (2013) and Adeola Alex Adesuyi *et al*., (2016).

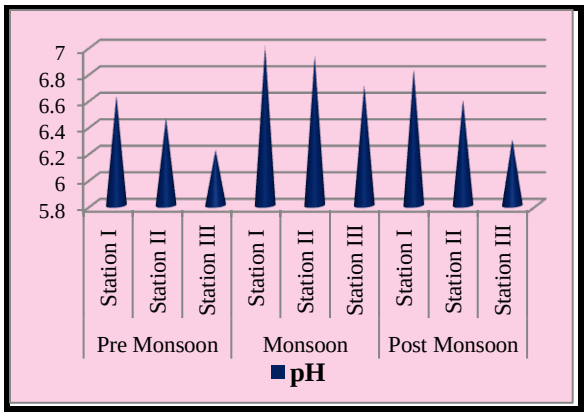


Figure: 2 Seasonal variation in pH - Sediment samples from Adayar Estuary

3.2 Electrical Conductivity of Sediment Samples

Soil electrical conductivity (EC) is a measurement that correlates with soil properties that affect crop productivity, including soil texture, cation exchange capacity (CEC), drainage conditions, organic matter level, salinity, and subsoil characteristics. Electrical conductivity (EC) is the most common measure of soil salinity and is indicative of the ability of an aqueous solution to carry an electric current. The electrical conductivity of soils varies depending on the amount of moisture held by the soil particles. Sands have a low conductivity, silts have a medium conductivity and clays have a high conductivity. Consequently, EC correlates strongly to soil particle size and texture. (NCCP, 2013)

The Conductivity of the sediment samples ranged between 120.9 to 145.98. During Pre monsoon the values were observed to be 122.87 ± 3.13, 123.35 ± 1.11, 129.37 ± 3.21, While during Monsoon and Post monsoon the observed values were 120.9 ± 1.85, 121.48 ± 1.89, 126.23 ± 2.57 and 128.02 ± 1.62, 132.75 ± 1.45 and 145.98 ± 0.84 respectively for three Stations. (Figure 3).The present investigations reveal comparatively high values during post monsoon season. This may be due to the dissolved solids and minerals brought by the effluents and river. The present findings are similar to the results revealed by Vasanthi and Sukumaran 2017 and Mishra and Saksena, 1993. Higher EC indicates the presence of high amount of dissolved inorganic substances in ionized form (Murhekar, 2011).

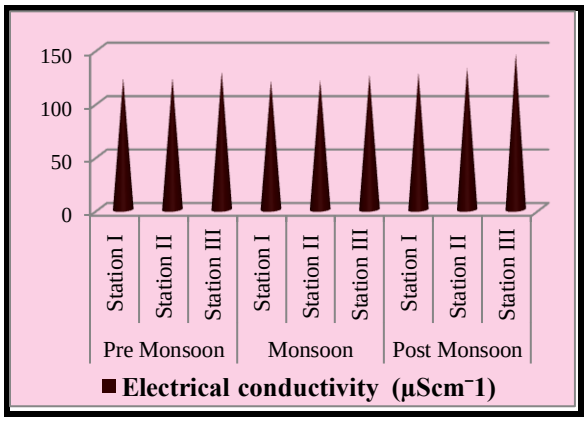


Figure: 3 Seasonal variation in Electrical Conductivity of Sediment samples from Adayar Estuary

3.3 Salinity of Sediment Samples

Salinity in sediments varied from 3.95 ± 1.87 to 8.82 ± 0.31. The values recorded during the Pre monsoon were 7.48 ± 0.37, 7.72 ± 0.25, 8.05 ± 0.19, for Monsoon and Post monsoon it were 4.18 ± 0.64, 4.68 ± 0.28, 3.95 ± 1.87 and 8.47 ± 0.14, 7.58 ± 0.28, 8.82 ± 0.31 respectively for the three stations (Figure 4). High salinity values were observed during Post monsoon season when compared to other seasons.

Salinity of the sediment showed significant relation with salinity of water. Jalal *et al*., (2009) reported higher values of salinity in the sediments of coastal region of Malaysia, and Ashok Prabu *et al*. (2008) reported that the salinity of Pichavaram mangroves ranged from 3 ppt to 33 ppt.

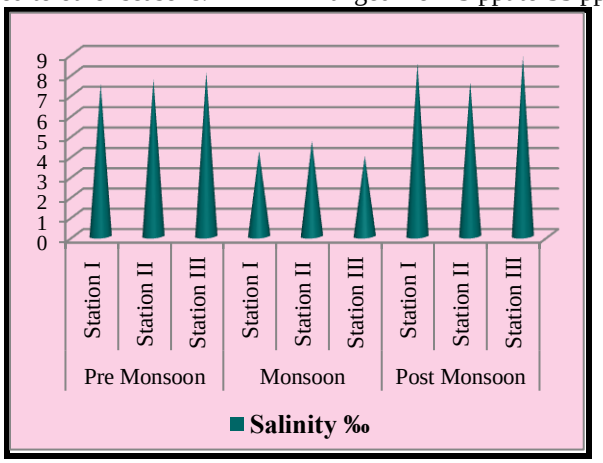


Figure: 4 Seasonal variation of Salinity of Adayar Estuary Sediment samples

3.4 Total Organic Carbon

Total organic carbon is a measure of the carbon content within soil organic matter. Total organic carbon influences many soil characteristics including colour and nutrient holding capacity. The values of total organic carbon observed in the study area significantly varied with space and time. Higher values were observed during the(dry season) Post monsoon season , 5.21 ± 0.44, 5.4 ± 0.37, 4.8 ± 0.32, lowest values were recorded during Pre monsoon season ,3.4 ± 0.14, 3.61 ± 0.38, 3.22 ± 0.17, while during Monsoon ,the values were 4.48 ± 0.31, 4.3 ± 0.14 and 4.63 ± 0.19 (Figure 5). Similar results were recorded by Erema and Miebaka (2013) from Bonny Estuary, Daka and Moslen, (2013) in Azuabie Creek and Ezekiel *et al*., (2011) from Sombrero river.

Sediment is a major site for organic matter decomposition, which is largely carried out by bacteria.

The level of organic matter decomposition may be attributed to the variation in organic carbon content. Fine sediment particles have larger relative surface areas than coarse particles and can absorb colloidal and dissolve organic matter forming sedimentary complexes (Daka and Moslen, (2013), Adeola Alex *et al*., (2016). The variation in organic carbon content may be attributed to difference in deposition of organic matter at the various stations. Adeola Alex *et al*., (2016).

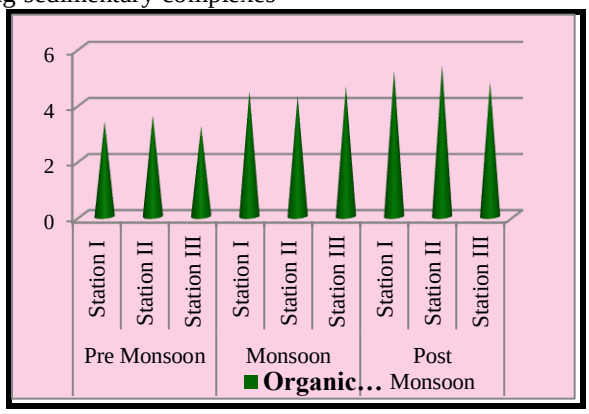


Figure: 5 Seasonal variation of Total Organic Carbon of Sediment samples from Adayar Estuary

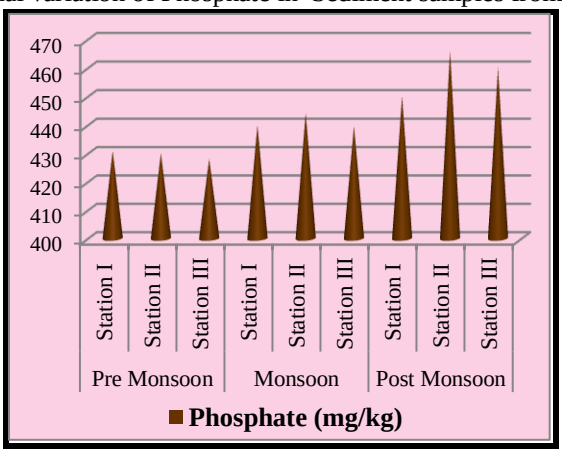
3.5 Phosphate

Phosphorus pollution accelerates a process called eutrophication, which is essentially the process of a rivers biological death due to depleted bioavailable oxygen. Algal blooms caused by excess phosphorus has a serious impact on fisheries. The blooms favours the survival of less desirable fish species over more desirable commercial and recreation species. Excess amounts of phosphorus and nitrogen cause rapid growth of phytoplankton, creating dense populations, or blooms. These blooms become so dense that they reduce the amount of sunlight available to submerged aquatic vegetation. Without sufficient light, plants cannot photosynthesize and produce the food they need to survive. The loss of sunlight can kill aquatic grasses (Pravin *et al*., 2011). The present observations reveal that the level of phosphorus during the Three seasons Pre monsoon , Monsoon and Post monsoon were 431 ± 2.61, 430.17 ± 3.18, 428.17 ± 1.47, 440 ± 9.12, 444.33 ± 3.27, 439.67 ± 5.50 and 450.17 ± 1.72, 466 ± 2.37, 460.17 ± 1.94 respectively for the three selected stations (Figure 6).

The phosphate pollutants will settle down and get accumulated in bottom sediments, under certain conditions and they may get released back to surface water. Such release of phosphate pollutants may result in increase in the phosphate concentration above the permissible limit (5 mg/L) set for inland surface water (The Environment Protection Rules 1986).

The results reveal that the Phosphate concentration was more during the Post monsoon season compared to other seasons. Similar findings were reported by Adeola *et al*., (2016) from Niger creek, Erema R. Daka and Miebaka Moslen (2013) from Bonny estuary, Nair N Balakrishnan (1983) from Ashtamudi estuary.

Figure: 6 Seasonal variation of Phosphate in Sediment samples from Adayar Estuary

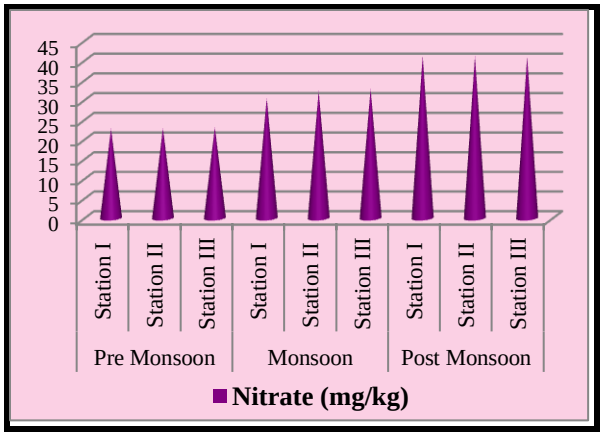


As the seasonal variations have been found to be significant, it can be stated that the impact of rainfall and river discharge on phosphate level changes is indeed prominent. Rainfall resulting in higher river discharge leads to transportation of sediments in a big way. Thus an increase in the value of phosphate was noticed with the onset of the monsoon rains. This ascending trend lasted for several months recording the peak value in the post monsoon period. Sediments in estuaries are reported to trap 80-90 % of phosphorous was reported by Nair N Balakrishnan (1983) in Ashtamudi estuary. Similar conditions were observed in the present study from Adayar estuary.

3.6 Nitrate

The nitrate levels in Adayar estuary were quite high and varied between the selected stations and seasons. The recorded Nitrate values for Pre monsoon, Monsoon and Post Monsoon were 22.7 ± 2.47, 22.86 ± 2.14, 23.1 ± 1.17, 30.47 ± 2.39, 32.22 ± 1.70, 32.78 ± 1.33, and 41.22 ± 1.69, 41.08 ± 2.19, 40.97 ± 1.06 respectively for three selected stations.(Figure 7). Similar results was shown by Nair N Balakrishnan (1983) in Ashtamudi estuary, Daka and Moslen (2013) in Bonny Estuary and Suneela *et al*., (2008).

Figure: 7 Seasonal variation of Nitrate in Sediment samples from Adayar Estuary



The levels of Nitrates and phosphates indicate the nutrient contents in the given area. Significant variations in the levels of Nitrates (nutrients) were observed at all the three selected stations during the period of study. Domestic sewage from human settlements near the selected stations and surface run-offs during Monsoon into the estuary could be the reason for this high levels of nutrients recorded at the three stations. Adeola Alex *et al*., (2016) have reported similar results from Nwaja Creek.

4. CONCLUSION

Sediment quality monitoring befits a very important process in the restitution and protection of the aquatic ecosystems. Sediments contained very high values of the physico chemical parameters. Concentration of these parameters revealed variations with reference to sites and seasons, at Adayar estuary during the study period. The present study would form a baseline information of the physico-chemical parameters of sediments from Adayar estuary, and would be a useful tool for further ecological assessment and monitoring of these significant coastal ecosystems.

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