SEASONAL VARIATION OF PHYSICO-CHEMICAL CHARACTERISTICS OF VELLAR ESTUARY, MUDASALODAI AND MUZHUKUTHURAI AT PARANGIPETTAI COASTAL AREA, TAMIL NADU, INDIA

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Abstract
In the present study, three sampling stations were fixed viz., Vellar estuary, Mudasalodai and Muzhukuthurai coastal waters (St. 1, St. II and St. III). The physico-chemical parameters such as rainfall, air temperature, surface water temperature, salinity, LEC, pH, dissolved oxygen, biological oxygen demand, chemical oxygen demand, nitrate also varied independently. Nutrients also exhibited high values during the monsoon season and low values were recorded during the summer season. It is likely that the river water is enriched by the domestic sewage, agricultural wastes and industrial effluents.

Key words: Physico-chemical characteristics, Nutrients, Vellar estuary, Mudasalodai and Muzhukuthurai.

1. Introduction

Life in aquatic environment is largely governed by physico-chemical characteristics and their stability. Most of the forms exist only within narrow range of conditions. The changes in the water quality may be essential for the existence of some organisms, while for others such changes may not be desirable. Aquatic environment depicts ecological feature that lead to the establishment of a very dynamic system in which the plankton communities play an important role (Pandey and Pandey, 2009).

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In aquatic ecosystems, metallic compounds occur in low concentrations. Heavy metals may come from natural sources, leached from rocks and soils according to their geochemical mobility and also from anthropogenic sources as the result of human land occupation and industrial pollution (Prabhahar et al., 2011). Depending on their solubility, these metals may be eventually associated with suspended particulate matter or accumulate in the bottom sediments. The increase of industrial activities has intensified environmental pollution problems and the deterioration of several aquatic ecosystems, with the accumulation of heavy metals in the organs. Trace elements are essential to life, but at high concentrations, they may become hazardous (Asha and Diwakar, 2007). The coastal water has undergone varying severity of the chemical changes due to human activities like terrestrial
Coastal pollution has seriously affected the exploitable living resources reduction in coastal biological diversity, recreational and commercial uses and overall integrity of coastal ecosystem (Sattler, 2004). Human activities have not only affected the exploitable living resources but have also caused a reduction in coastal biological diversity. These conditions imply, at present, that the coastal zone are either misused or overused. They should however, be managed on a sustainable yield basis (Sharma et al., 2006). This requires a proper understanding of coastal process, biogeoresources and water quality (Goni et al., 1996). Major coastal activities responsible for coastal and marine pollution in Tamil Nadu are discharge and disposal of treated and untreated sewage, industrial wastes, discharge on industrial and coolant waters, harbour activities such as dredging, cargo handling, dumping of ship wastes, spilling of cargoes such as chemicals and metal ores, oil transport, fishing activities such as mechanized fishing vessels movements, draining of waste oil, painting of fishing vessels, scraping of metal lining of fishing vessels, dumping of wastes and trash fishes, oil exploration and oil refining activities, recreation and tourism activities, salt production etc (Kumar et al., 2001).

Among the several characteristics of water quality, the most important factors such as rainfall, atmospheric temperature, surface water temperature, salinity, pH, dissolved oxygen, LEC, biological oxygen demand, chemical oxygen demand and nutrients like nitrate (Wang et al., 2010). Environmental pollution monitoring is essential at strategic point in natural water bodies, as well as in commercial and industrial locations (Iyyappan, 2000). In general, there are two types of monitoring (a) biological monitoring and (b) physico-chemical monitoring.

Biological monitoring is based on the assessment of population of critical species that are sensitive to pollution; while physico-chemical monitoring is based on the actual measurement of physical parameters such as pH, temperature, rainfall, LEC, nitrate, etc. Chemical parameters such as pesticides, insecticides and heavy metals like copper, zinc, cadmium, chromium, lead and iron, cobalt mercury, etc. Biological monitoring directly provides qualitative information with regards to the health, chemical monitoring provides quantitative information about the presence of pollutants in the natural water bodies. Physico-chemical monitoring is also provides stable information with regards to incoming undesirable effluents, which eventually indicate the possible source of such effluents. Biological monitoring does not provide any such hints.

2. Materials and Methods

The study was carried out over a period of 12 months from July 2012 to June 2013. Throughout the study period, sampling of water was carried out on a monthly basis during the last week of every month. Sampling was done usually during the morning hours, between 7 am to 9.00 am. Samples were preserved and analyzed by adopting the procedures outlined by standard methods for various parameters (APHA, 2000). Rainfall and Air temperature data were collected from micrometeorological laboratory at Chennai. Surface water temperature was measured using a mercury thermometer. Care was taken to obtain a constant reading and the temperature was recorded in Celsius scale. pH (Hydrogen ion concentration) was measured using digital pH meter (Elico pH – 131 Digital pH meter) and Salinity (APHA, 2000). Light penetration in water column was measured with the help of Sacchi disc the light extinction co-efficient (LEC) was calculated using the procedure of Pool et al. (1929). Dissolved oxygen (DO) was determined by following the procedure of Parsons et al. (1989). Nutrients nitrate were estimated by titration methods as described by Parsons et al. (1989). Biochemical oxygen demand (BOD) and chemical oxygen demand (COD) were estimated by standard procedures described by Parsons et al. (1989).

3. Results and Discussion

There was no rainfall at the study area during April. Maximum (123.2 mm) rainfall was recorded in the month of November monsoon season. In general, rainfall gradually increased
from the post monsoon season viz., post monsoon, summer, pre-monsoon and monsoon. Bulk rainfall was recorded during the monsoon season. At station 1 (Vellar estuary) there was less water flow in the river between the months of January to April. Air temperature at the study area varied from 27.8 °C to 36.2 °C during October and February to May. All the three stations showed similar trend in the distribution of air temperature. The maximum air temperature (36.2 °C) was observed during the summer season and the minimum air temperature (27.8 °C) was recorded during monsoon season. Water temperature followed a trend similar to that of air temperature. Minimum water temperature (28 °C) at Station 1 was recorded during the pre monsoon season (July and September) and the maximum (33.1 °C) was recorded during post monsoon season. Minimum water temperature (27.9 °C) at station 2 was recorded during the pre-monsoon season and the maximum (30.11 °C) was recorded during summer season. Minimum water temperature at station 3, (27.6 °C) was recorded during the monsoon season and the maximum (34.2 °C) was recorded during the summer season.

In general, all the stations showed more or less similar seasonal changes. Further, station 3 recorded higher values of water temperature during the month of May. Salinity at station 1 varied from 6.1 ‰ to 17.2. Minimum 6.1 was recorded during the monsoon season and the maximum 7.2 was recorded during the summer season. At station 2, it varied from 29.01 to 31.2. Minimum salinity (29.01) was recorded during the monsoon season and the maximum (31.12) was recorded during the summer season. At station 3, it was varied from 12.6 ‰ to 18.5 ‰. Minimum 12.6 ‰ was recorded during the post monsoon season and the maximum 18.5 ‰ was during the pre monsoon season. In general, station 1 recorded minimum salinity, while station 2 recorded the maximum. All the stations showed similar seasonal pattern in salinity distribution and recorded low values during the monsoon season and high values during the summer season. At station 1, minimum LCE 0.22 (K) was recorded during summer and the maximum 5.16 (K) was recorded during monsoon season. At station 2, minimum 2.6 (K) was recorded during summer and the maximum 5.8 (K) was recorded during the monsoon. At Station 3, minimum 3.9 (K) was recorded during summer season and the maximum 7.92 (K) was recorded during the monsoon season. Lowest LEC values were recorded during the summer season indicating higher light penetration in the water column as LEC and transparency were inversely related. In general, LEC showed an increasing trend from summer - monsoon.

Seasonal fluctuation in the pH followed a trend similar to that of salinity. Minimum 6.9 and the maximum 8.83 values of pH were recorded during the monsoon and post monsoon seasons respectively at station 1. Minimum (7.9) and maximum (8.9) values of pH were recorded during the monsoon season and pre monsoon seasons respectively at station 2. At station 3, minimum (8.1) and maximum (8.36) values of pH were recorded during the post monsoon and monsoon seasons respectively. In general, minimum and maximum values of pH were recorded during monsoon and summer seasons respectively at all the stations.

Dissolved oxygen concentration at station 1 varied from 3.2 mg/l to 5.28 mg/l. Minimum dissolved oxygen concentration (3.2 mg/l) was recorded during the summer season and the maximum (5.28 mg/l) was recorded during the monsoon season. At station 2, it was varied from 7.2 mg/l to 8.5 mg/l with the minimum of 7.2 mg/l occurring during summer season and the maximum of 8.5 mg/l during the monsoon season. At station 3, it was varied from 5.2 mg/l to 6.5 mg/l with the minimum 5.1 mg/l occurring during summer season and the maximum 6.5 mg/l during monsoon season. In general, minimum and maximum values of DO were recorded during summer and monsoon seasons respectively at all the stations. The station 1 registered the minimum BOD value of 1.79 mg/l during monsoon and the maximum (3.59 mg/l) was recorded during summer season. The station 2 recorded minimum (3.01 mg/l) value of BOD during the monsoon season and the maximum value (8.92 mg/l) was recorded during summer season. The station 3 recorded minimum (1.1 mg/l) value of BOD.
during monsoon season and the maximum (1.95 mg/l) was recorded during the summer (1.61 mg/l) season. In general, minimum and maximum values of BOD were recorded during monsoon and summer seasons respectively at all the stations.

The Station 1 recorded minimum value of COD 2.01 mg/l during post monsoon season and the maximum 3.45 mg/l during pre monsoon season. The station 2 recorded minimum value of COD 0.13 mg/l pre monsoon season and the maximum crop of (1.21 mg/l) during summer season. The station 3 recorded minimum value of COD (0.59 mg/l) during post monsoon season and the maximum COD of 0.96 mg/l during pre monsoon season. In general, minimum and maximum values of COD were recorded during monsoon and summer seasons at all the stations. Minimum value of (0.83 mg/l) inorganic nitrate was recorded during pre-monsoon season and the maximum value of 1.72 mg/l during monsoon season at station 1. Minimum value of nitrate (5.25 mg/l) was recorded during pre-monsoon season and the maximum of 16.22 mg/l during monsoon season at station 2. Minimum (7.22 mg/l) value of nitrate was recorded during pre-monsoon season and the maximum (36.2 mg/l) was recorded during monsoon season at station 3.

The analyzed parameters in the coastal waters at Parangipettai during different seasons are geographically represented in Figs. 1 to 10. ANOVA between the environmental parameters in the coastal waters showed significant values, whereas within the parameters is significant. The analyzed correlation coefficient values between the environmental parameters in the coastal water during the season July 2012 to June 2013 were presented respectively.

The present study revealed that the water in any ecosystem provides significant information about the available resources for supporting life in that ecosystem (Manikannan et al., 2011). Marine environment as a complex ecosystem is mainly influenced by various physical, chemical and biological processes. Therefore, the environmental conditions play an important role in promoting the abundance of commercially exploitable marine resources (Muraleetharan et al., 2010).

According to Prasanna and Ranjan (2010), when river water mixes with seawater, a large number of physical and Parsons et al. (1989) chemical processes take place, which may influence water quality. The physico-chemical parameters of a natural water body basically determine its suitability for biological organisms and may vary substantially at different seasons of the year. This fact is evidenced in the results of the present study also. The factors that alter the physico-chemical indices include geological parameters of the area, external water inputs into the water body and their sources, atmospheric precipitation by rain and other meteorological forces along with other abiotic and biotic activities taking place in and around the water body. The maximum temperature (both AT and WT) observed during summer seasons can be ascribed to the hot climatic conditions due to the penetration of more solar radiations through the clear sky whereas during the monsoon and winter seasons lesser amounts of solar radiations penetrate the cloudy sky resulting in the reduced water temperature (Ploetz et al., 2007).

The temperature is one of the important ecological factors. It has a universal influence among the living world and is frequently a limiting factor for the growth and distribution of animals and plants. Temperature controls the rate of metabolic and reproductive activities. Temperature also influences the concentration of dissolved oxygen and many other physical and biological factors in a water body. It also controls the diversity, reproduction, migration and behavioral characteristics of animals and plants (Rakhi, 2009). The range of temperature varies greatly in different environments like, terrestrial, fresh water and marine media. The surface water temperature showed an increasing trend from November through June and was influenced by the intensity of solar radiation, evaporation, freshwater influx and cooling and mix up with ebb and flow from adjoining neritic waters (Saravanakumar et al., 2008). The observed low value of October was due to strong land sea breeze and precipitation and the recorded high value during summer could be attributed to high solar radiation (Ashok Prabu et al., 2008; Rajaram and
Das, 2008). The shallow, biologically active waters of tropical or subtropical areas, large diurnal pH changes occur naturally because of photosynthesis. Usually, the pH of river water entering estuaries is high during dry season (summer or post monsoon) and decreases markedly during monsoon (Rao, 2011). The shift towards acidic pH in the polluted site of the present study is happening only during the rainy season and post monsoon season. This might be due to the additional load of pollutants brought in by the rainwater. The low pH observed during the monsoon season may also be due to the influence of rainwater, low temperature and organic matter decomposition as suggested (Rajaram and Das, 2008). Similar trends in hydrogen ion concentration (pH) in surface waters remained alkaline throughout the study period at both stations with maximum value during the postmonsoon and summer seasons and the minimum during monsoon. Generally, its seasonal variation is attributed to factors like removal of CO₂ by photosynthesis through bicarbonate degradation, dilution of seawater by freshwater influx, low primary productivity, reduction of salinity and temperature, and decomposition of organic matter (Paramasivam & Kannan, 2005; Bragadeeswaran et al., 2007). The recorded high summer pH might be due to the influence of seawater penetration and high biological activity (Govindasamy et al., 2000) and due to the occurrence of high photosynthetic activity (Sridhar et al., 2006).

The increase in pH during the summer months may be correlated to the increased utilization of CO₂ by plants and phytoplankton for photosynthesis due to the increased availability of sunlight. Such an increased level of pH during summer season has also been reported by Storelli et al. (2005); Sridhar et al. (2006); Rao (2011). However, decrease in the pH during night time especially in the polluted site of the present study cannot be ruled out. This is because of the fact that the polluted site harbored rich algal and other phytoplankton population and this vegetation even though produce more oxygen during the day time, may be equally utilizing oxygen for respiration during night also. This could result in an overall decrease in the oxygen content and increase in CO₂ during night leading to carbonic acid formation. However, as the pH measurements in the present study are done only during day time such a correlation cannot be made with the available data of the present study. It is well known that the temperature and salinity affect the dissolution of oxygen. In the present investigation, higher values of dissolved oxygen were recorded during monsoon season which might be due to the cumulative effect of higher wind velocity coupled with heavy rainfall and the resultant freshwater mixing (Saravanakumar et al., 2008). The seasonal variation of dissolved oxygen is mainly due to freshwater flow and terrigenous impact of sediments. The amount of oxygen present in the water is called the dissolved oxygen (DO) and its concentration is positively correlated to water temperature (Paramasivam and Kannan, 2005).

Gases like oxygen are more easily dissolved in cold water. It is also proportional to the quantum of photosynthesis done by the aquatic vegetation. DO is very crucial for the survival of aquatic organisms and is also used as a parameter to evaluate the degree of freshness of water (Storelli et al., 2005). It is usually considered as an index of physical and biological processes going on in water (Prakash, 2004; Murugesan and Rajakumari, 2005). Oxygen enters the water by absorption directly from the atmosphere or by the photosynthetic activity of aquatic plants and algae. The oxygen is removed from the water by respiration and decomposition of organic matter. The amount of dissolved oxygen in water depends on several factors including temperature (the colder the water, the more the oxygen can dissolve), volume and velocity of water flow in the water body and the number and diversity of organisms using oxygen for respiration. In addition to all these, anthropogenic activities that affect DO levels include the runoff from roads, sewage, agricultural and domestic discharge and industrial pollution. At lower temperature and salinity water can hold more oxygen (Rajkumar et al., 2009).

Our present study revealed that the maximum oxygen content is seen during monsoon season and winter months. Two important factors
contributing to this increase in oxygen concentration are the turbulent monsoon water rushing into the sea and the decreased atmospheric and water temperature. It is a well-known fact that at lower temperature water holds more oxygen. The rain runoff and flooding even though brings in fresh quantum of pollutants, its turbulent flow causes more atmospheric oxygen dissolution also. Oxygen is poorly soluble in water. As this gas does not react with water, its solubility in water is directly proportional to its partial pressure and varies inversely with temperature (Rakhi, 2009).

Oxygen content is important for organisms and affects the solubility and availability of many other nutrients and therefore it influences the productivity of aquatic ecosystem (Manosathiyadevan, 2009). The biochemical oxygen demand (BOD) is concerned it is the measure of amount of \( \text{O}_2 \) required by the microorganisms to oxidize the organic content in the water. It aids in organic pollution assessment by giving an idea about the quality of biodegradable organic substances present in the water. When any material containing biodegradable organic matter is released into a water body, the process of utilizing the organic matter or sewage by microorganisms causes stress on the dissolved oxygen (DO) content of the water. This happens because microorganisms utilize DO for their respiration and the more the quantity of utilizable organic matter, the more the microbial activity of feeding upon the sewage and consequently, stronger the stress on DO or the demand for it (Ravikumar et al., 2007). The maximum BOD values during summer and minimum in winter season. The higher levels of BOD in the polluted water indicate the presence of higher concentration of organic matter (Saha et al., 2007). The chemical oxygen demand is a measure of the oxidation of reduced chemicals in water. It is commonly used to indirectly measure the amount of organic compounds in water. The measure of COD determines the quantities of organic matter found in water. The COD useful as an indicator of organic pollution of surface water (Rakhi, 2009). The microbial decomposition and depletion of oxygen with high BOD values and eventually form a state of anoxia. The BOD values with high organic load contributed by the direct discharges of domestic, agricultural and industrial wastes in comparison to the reference site. When BOD exceeds the available DO, the DO in the water is also depleted. The correlation matrices also show significant correlations between BOD and DO (Saravanakumar et al., 2008).

Similar results was observed by the nutrients are considered as one of the most important parameters in the estuarine environment influencing growth, reproduction and metabolic activities of biotic components (Saravanakumar et al., 2008). The distribution and behaviour of nutrients nitrate and nitrite in the coastal areas, particularly in the near shore waters and estuaries, would exhibit considerable seasonal variations depending upon their local input, rainfall, quantum of freshwater in flow, tidal incursion and some biological activities like uptake by phytoplankton and their productivity (Sridhar et al., 2006). In general, the removal of nutrients from water bodies may also be attributed to their biological uptake and absorption on suspended solids, mineralisation in the water column and transport across the sediment water interface. The same view has also been expressed (Storelli et al., 2005). The patterns of variations in the nutrients contents in the present investigation, agree with the observations of Wang et al. (2006) that the distribution of nutrients in the coastal environment particularly in the near shore waters and estuaries could exhibit considerable seasonal variation.

The recorded highest monsoonal nitrate value could be mainly due to the organic materials received from the catchment area during ebb tide (Ashok Prabu et al., 2006). Another possible way of nitrate input could be through oxidation of ammonia form of nitrogen to nitrite formation (Shinde et al., 2011). 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 (Govindasamy et al., 2000; Rajaram and
The salinity in turn is determined by a number of interacting factors including local rainfall, river flow, ground water level, winds, currents etc. Salinity is reported to be the most fluctuating parameter with wide range of variations in the estuarine environment. The salinity was found to be high during summer season and low during the monsoon season at both the stations. The recorded higher values could be attributed to the low amount of rainfall, higher rate of evaporation and also due to neritic water dominance.

During the monsoon season, the rainfall and the freshwater inflow from the land moderately reduced the salinity. Statistical analysis revealed highly significant negative correlation of salinity with rainfall. The surface water temperature showed an increasing trend from November through June and was influenced by the intensity of solar radiation, evaporation, freshwater influx and cooling and mix up with ebb and flow from adjoining neritic waters (Rakhi, 2009). The observed low value of October was due to strong land sea breeze and precipitation and the recorded high value during summer could be attributed to high solar radiation (Saravanakumar et al., 2008).

The polluted nature is substantiated by higher levels of BOD very low dissolved oxygen, increased inorganic nitrogen containing compounds etc. The salinity was found to be high during summer season and low during the monsoon season at both the stations. The recorded higher values could be attributed to the low amount of rainfall, higher rate of evaporation and also due to neritic water dominance. During the monsoon season, the rainfall and the freshwater inflow from the land moderately reduced the salinity. Statistical analysis revealed highly significant negative correlation of salinity with rainfall. Waste water for tanneries, paper mill and textile mills contribute the sulphate in natural water along with some agricultural run-off containing residue of fertilizers. It can cause gastrointestinal limitation (Ashok Prabu et al., 2008).

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4. References


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