

Physicochemical analysis of coastal water of east coast of Tamil Nadu (Muthupet estuary)

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Abstract

A study has been undertaken to enlighten the water quality parameters of coastal water of Muthupet estuary and Muthupet east coast was selected as the reference site. The concentration of water quality parameters like temperature, pH, salinity, dissolved oxygen, total hardness, total alkalinity, electrical conductivity, biological oxygen demand (BOD) and chemical oxygen demand (COD) were done triplicate in the laboratory as per the standard methods. The reason for chosen the coastal water level due to the continuous discharge of agricultural, domestic sewage and industrial effluent in the estuary.

Keywords: physicochemical parameters, biological oxygen demand and chemical oxygen demand

Introduction

Estuarine and coastal areas are complex and dynamic aquatic environment. India has a long coastline of 8,129 km and of this 6,000 km is rich in estuaries, creeks, brackish water, lagoons and lakes. The southeast coast of India is an important stretch of coastline, where many major rivers drain into the Bay of Bengal and they are also richer in marine fauna and flora (Rajkumar *et al.*, 2011) [21]. Agricultural, industrial and urban activities are considered to be major sources of addition of nutrients to aquatic ecosystems posing a big threat to fish stocks (Kucuksezgin *et al.*, 2006). Eutrophication is of great environmental distress, leading to diverse problems such as toxic algal blooms, loss of oxygen, fish mortalities and eventually loss of biodiversity (Yadav *et al.*, 2007; Zaggia *et al.*, 2007). The impacts vary relatively minor to major disruptions due to bioaccumulation and biomagnifications processes (Unlu *et al.*, 2007; Altun *et al.*, 2008).

Estuaries, the main contributors of fisheries in India, suffer from severe damage which receive large amount of contaminants due to increased industrialization and urbanization along the coastal areas by continuous discharge of domestic sewage and industrial effluents. Overloading of the estuaries with contaminants for a longer period of time has resulted in the significant buildup of pollutants with a resulting impact on water properties (Padmini *et al.*, 2004) [18]. Paramisivam and Kannan (2005) [4, 19] reported that factors related to water quality such as temperature, pH, salinity, dissolved oxygen, total organic carbon and nutrients are particularly important for determining the biota and ecosystem functions in coastal waters. Hence, the present study was therefore undertaken with a view to provide much needed information on the water quality parameters in the coastal water of Muthupet estuary and Muthupet east coast was selected as the reference site.

Materials and methods

Location of sample Collection

Muthupet is a panchayat town in Thiruvavarur district in the

Indian state of Tamil Nadu. The town lies adjacent to the Bay of Bengal and is in the southernmost part of the Cauvery delta. Muthupet is bounded by Korayar and Bamaniyar rivers to the east and west respectively. The rivers Koriayar and Pamaniyar join near Muthupet, and there is a lagoon, which is rich in fish. Muthupet is an ideal place for fishing, pearl hunting and bird hunting. It is well known for its fishing industries such as finfish (koduva), shrimp and crab. Muthupet estuary (Lat. 11° 42' N, long 79° 39' E) is formed by the tributaries of Cauvery river and opens into estuary on the South East coast of India. The water sample was collected from Muthupet estuary, Muthupet east coast, Muthupet district, Tamil Nadu India. The present study was carried out for Muthupet estuary and the coastal water of Muthupet east coast. During the study period (2015-2016), samples of water were collected fortnightly; the data were pooled seasonally to understand the seasonal effect. The Muthupet estuary (Lat. 11° 42' N, long 79° 39' E) is formed by the tributaries of Cauvery River and opens into estuary on the South East coast of India. The three distinct seasons were monsoon (October to December) post-monsoon (January to March) and pre-monsoon (July to September) periods. The samples were collected from five different points of each site and were mixed together to prepare an integrated sample. The water temperature and pH were analyzed immediately on the spot after collection, whereas the analyses of salinity, dissolved oxygen, total hardness, total alkalinity, electrical conductivity, biological oxygen demand (BOD) and chemical oxygen demand (COD) were done triplicate in the laboratory as per the standard methods.

Physicochemical parameter

The methods used for the analysis of various physico-chemical parameters were the same as given in Standard Methods for the Examination of water (APHA, 1967, 1980; APHA-AWWA-WPCF, 1976) [1, 2, 3]; Golterman *et al.*, (1978) [9] and National Environmental Engineering Research Institute (NEERI, 1986) [16].

Measurement of temperature

This was carried out in-situ at the site of sample collection using a mobile thermometer. This was done by dipping the thermometer into the sample and recording the stable reading

pH

The pH was determined using ELICO-LI 127 pH meter. The pH of water sample was directly determined with the electrode while pH of the sediment sample was determined by preparing (1:5, sediment: water) suspension in distilled water. The contents were stirred well and allowed to settle and supernatant was used to check pH.

Electrical Conductivity (EC)

To determine soluble salts in the sediments. It is preferably to keep the sediment at the field condition and measured at the field condition and measured its conductivity, to get true picture. For this purpose saturated sediment water extract was prepared. Sediment extract is first prepared by taking 20 gms sediment into clean 100 ml beaker, add 50 ml of conductivity water then suspension is stirred for 30 minutes and allowed the suspension was filtered by using ordinary filter paper. EC of the water samples and sediment suspension was measured by using ELICO EC-TDS meter (CM 183, Make-India) where electrode was directly dipped into the respective solutions for the direct display of result on a digital scale. It was reported in micro Siemens (μ S). The clear supernatant used for pH was also used for EC measurement.

Dissolved Oxygen (DO)

Dissolved oxygen content of the water samples was measured by using Winkler's method (modified azide method). The sample was collected in 300 ml bottle and DO was fixed on site by using 1 ml each of Manganous sulphate and Alkaline-iodide-azide. The precipitate formed was dissolved in laboratory by using sulphuric acid and titrated with sodium thiosulphate using starch as an indicator. The end point of titration was blue to straw pale colour.

$$\text{DO (mg/L)} = \frac{\text{Ml of titrant} \times N \times 1000 \times 8}{V_2 (V_1 - V_2) / V_1}$$

V_1 =volume of BOD bottle, V_2 =volume of content titrated and V = volume of MnSO_4 and Alkaline-iodide-azide.

Chemical Oxygen Demand (COD)

COD determination was carried out with dichromate reflux method with the addition of 10 ml of 0.25 N potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$) and 30 ml $\text{H}_2\text{SO}_4 + \text{Ag}_2\text{SO}_4$ reagent in 20 ml diluted sample. The mixture was refluxed for 2h and was cooled to room temperature. The solution was then diluted to 150 ml by using distilled water and excess $\text{K}_2\text{Cr}_2\text{O}_7$ remained was titrated with ferrous ammonium sulphate (FAS) using ferroin indicator.

$$\text{COD (mg/L)} = \frac{(A - B) \times N \times 1000 \times 8}{\text{Volume of Sample}}$$

Where, A is the ml of FAS used for blank; B is the ml of FAS used for sample, N is the normality of FAS and 8 is milli equivalent weight of oxygen.

Biological Oxygen Demand

The dilution method was followed to determine the BOD after three days at 27 oC. For the same dilution water was prepared with the addition of nutrients namely phosphate buffer, magnesium sulphate, calcium chloride and ferric chloride. The diluted sample was transferred to BOD bottles of 300 ml capacity. After determining initial dissolved oxygen (DO), final DO was estimated from the bottles kept for incubation period for three days.

Alkalinity of Water sample

100 ml of water sample was mixed with 2-3 drop of phenolphthalein. The development of pink colour to the solution indicated the presence of alkalinity and was then titrated with 0.02N H_2SO_4 till the colour disappears.

$$\text{Alkalinity} = \frac{B \times N \times 50 \times 1000}{\text{Volume of Sample}}$$

Salinity

Salinity (PSU) was determined by Mohr Knudsen argentometric titration method, using standard solution of silver nitrate (Merck) as an indicator to form silver halides, presence of excess silver ions lead to the formation of red silver chromate (the endpoint of titration).

Total Hardness of Water sample

The total hardness of the water samples was determined by EDTA titration method where 50 ml of well mixed sample was mixed with 1-2 ml buffer of pH 10 and a pinch of Eriochrome black-T indicator. The contents were then titrated with 0.01M EDTA till wine red solution changes to blue.

$$\text{Hardness (mg/L)} = \frac{C \times D \times 1000}{\text{Ml of Sample}}$$

Where C=ml of EDTA for titration, D= mg of CaCO_3 equivalent to 1ml of EDTA

Results and Discussion

Pollution of the aquatic environment and its effects on the living resources, especially the fishery resources, has assumed considerable interest as well as importance in the recent times. Most of the rivers which discharge large quantities of water into the coastal marine environment are polluted and these pollutants obviously end up in the inshore coastal waters. The vast marine environment has long been used as a site for the disposal of wastes. In some cases the polluted material is discharged directly into the sea and in other cases the pollutant reaches the rivers and Estuaries and finally ends up in the sea. Estuaries, the important contributors of fisheries in India, suffer from severe

loss of fish production due to increased industrialization and urbanization along the coastal zone by continuous discharge of industrial effluents (Padmini *et al.*, 2004) [18]. Under the influence of a variety of inter-related biotic and abiotic structural compounds and intensive chemical, physical and biological processes, estuaries are highly variable systems (Madhupratap, 1987) [11]. Data on the range of atmospheric and surface water temperature, pH, salinity, dissolved oxygen, total hardness, total alkalinity, electrical conductivity, biological oxygen demand (BOD) and chemical oxygen demand (COD) are given in the Fig 1 to 6. Temperature is an important limiting factor, which regulates

the biogeochemical activities in the aquatic environment. Generally water temperature correspond with air temperature indicating that the samples collected from shallow zones has a direct relevance with air temperature, shallow water reacts quickly with changes in atmospheric temperature (Rajkumar *et al.*, 2011) [21]. Temperature controls behavioral characteristics of organisms, solubility of gases and salts in water (Vincy *et al.*, 2012) [30]. Surface water temperature varied with the seasons as lowest in monsoon months (26.08 °C) and highest during post monsoon (28.08°C) (Fig 1). Similar findings were also recorded by Ravichelvan *et al.* (2015) [23] and Eshwaralal and Angadi (2002) [7].

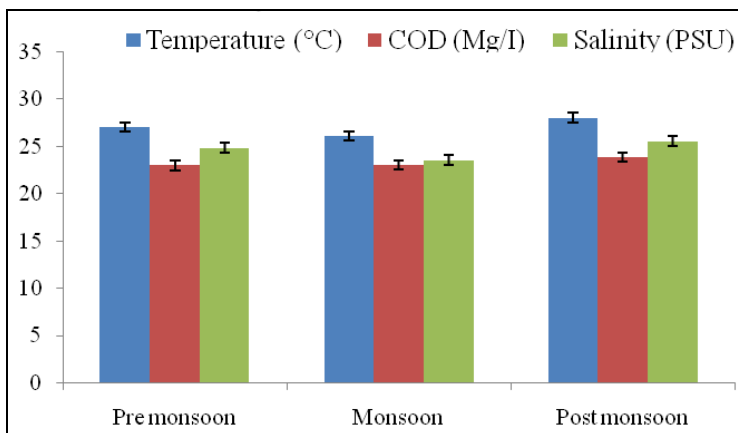


Fig 1: Physicochemical characters temperature, COD and salinity in Pre monsoon, Monsoon and Post monsoon of Muthupet estuary

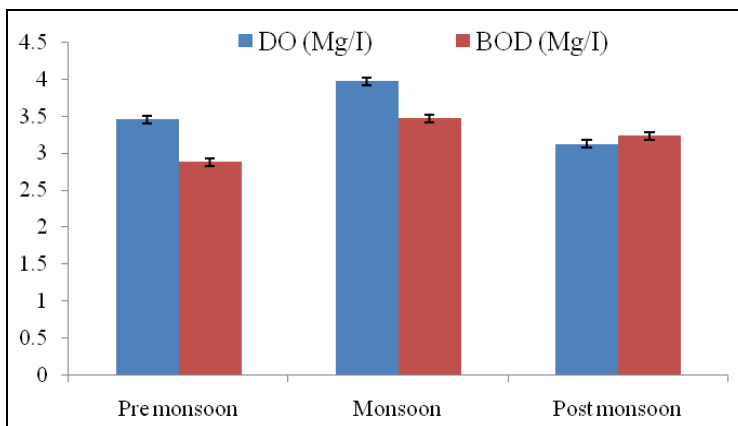


Fig 2: Physicochemical characters Dissolved oxygen and BOD in Pre monsoon, Monsoon and Post monsoon of Muthupet estuary

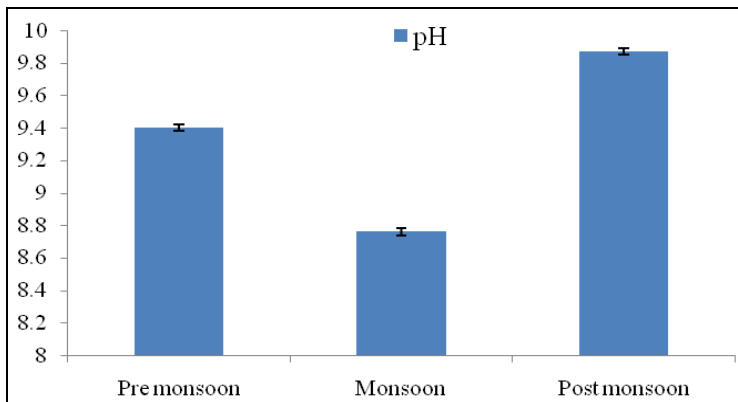


Fig 3: Physicochemical characters pH in Pre monsoon, Monsoon and Post monsoon of Muthupet estuary

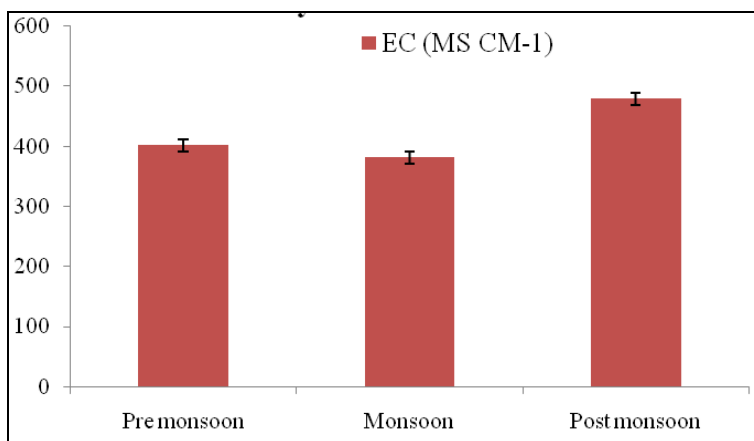


Fig 4: Physicochemical characters electrical conductivity in Pre monsoon, Monsoon and Post monsoon of Muthupet estuary

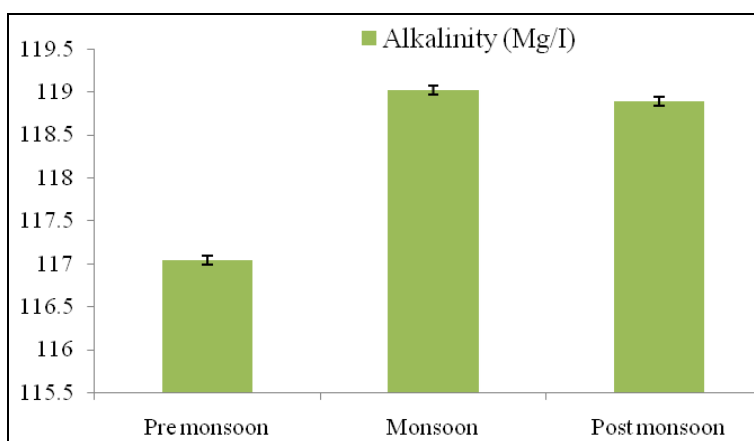


Fig 5: Physicochemical characters Alkalinity in Pre monsoon, Monsoon and Post monsoon of Muthupet estuary

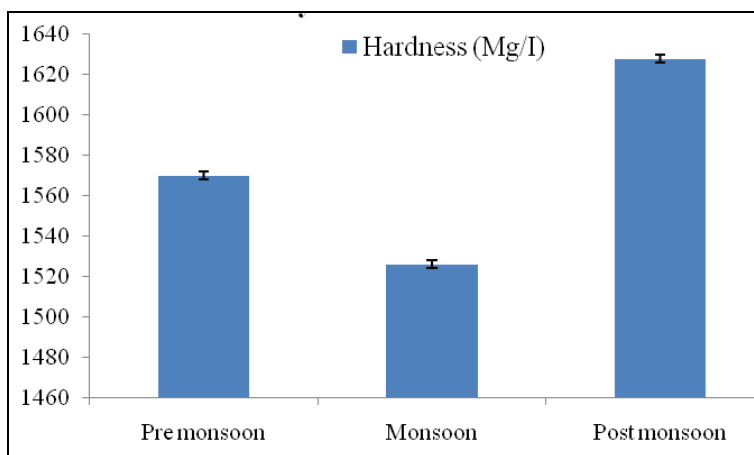


Fig 6: Physicochemical characters hardness in Pre monsoon, Monsoon and Post monsoon of Muthupet estuary

pH of water is an important environmental factor, the fluctuation of pH is linked with chemical changes, species composition and life processes. It is generally considered as an index for suitability of the environment (Rani *et al.*, 2012) [22]. Ellis (1937) [6] has observed that a pH range of 6.7 to 8.4 is suitable for the growth of Aquatic biota. In Muthupet estuary pH ranged from (8.76 to 9.87) indicating slight alkaline nature of water. pH varied with the seasons as lowest in monsoon months (8.76) and highest during post monsoon (9.87) while

pre monsoon pH was 9.40 (Fig 3). Our findings are in concordance with Mohan Raj *et al.* (2013) [14] and Ravichelvan *et al.* (2015) [23]. From the present study the pH result indicating slight alkaline nature which could be due to solutes, shows buffering action, i.e. H^+ ions are compensated with OH^- ions. It has been mentioned that the increasing pH appear to be associated with increasing use of alkaline detergents in residential areas and alkaline material from wastewater in industrial areas (Chang, 2008) [5].

The salinity acts as a limiting factor in the distribution of living organisms, and its variation caused by dilution and evaporation and influence the fauna of the intertidal zone (Gibson, 1982; Balasubramanian and Kannan, 2005) [4, 19]. Generally, changes in the salinity in the brackish-water habitats such as estuaries, backwater and mangrove are due to the influx of freshwater from land run off caused by monsoon or by tidal variations. In the present study, salinity was high during post monsoon (25.56) and low during monsoon (23.56) (Fig 1). Present finding is similar to the Mohan Raj *et al.* (2013) [14] and Ravichelvan *et al.* (2015) [23]. Higher values during post monsoon could be attributed to the heavy tidal influence after monsoon and high degree of evaporation of the study area. In monsoon season due to formation of sand bars and retention of the city domestic sewage water influence the reduction in salinity. Thus the variation of salinity in the study sites could probably be due to mainly freshwater runoff entering the creek systems as reported by Vijayalakshmi *et al.*, (1993) [29].

The value of dissolved oxygen is remarkable in determining the water quality criteria of an aquatic ecosystem. The Dissolved oxygen is regulator of metabolic activities of organisms and thus governs metabolisms of the biological community as a whole and also acts as an indicator of trophic status of the water body (Saksena, 1994) [26]. Maximum dissolved oxygen was recorded during monsoon months (3.97mg/l) which might be due to the cumulative effect of higher wind velocity coupled with heavy rainfall. This could also be because of freshwater mixing from Muthupet estuary

and low metabolic rate of organisms. Minimum dissolved oxygen were recorded (Fig 2) during post monsoon and pre monsoon months (3.12 and 3.97 mg/l respectively) might be due to high temperature, availability of huge quantity of untreated domestic sewage with enriched inorganic reductant and high metabolic rate of organisms. Similar observation were drawn by Ravichelvan *et al.* (2015) [23] and Sahu *et al.*, (2000). Dissolved oxygen is regulator of metabolic activities of organisms and thus governs metabolisms of the biological community as a whole and also acts as indicator of trophic status of the water body (Saksena and Kaushik, 1994) [26].

Tarzell (1957) has suggested that a minimum of 3 mg/l⁻¹ dissolved oxygen is necessary for healthy fish and other aquatic life. The present study showed minimum values of dissolved oxygen during post monsoon and pre monsoon which are not sufficient for most of the aquatic organisms. Interestingly even when DO was much below the optimum level, the rotifers were present in abundance indicating their wide range of tolerance. One of the reasons for the fatality of many teleost's observed during pre-monsoon in Muthupet estuary might be the low level of dissolved oxygen. Dissolved oxygen is the most important indicator of the health of a water body and its capacity to support a balanced aquatic ecosystem of plants and animals. Waste water containing organic pollutants depletes the dissolved oxygen and may lead to impact benthic communities by producing acute changes in their distribution, abundance, and diversity of species (Raffaelli, 2000) [20]. The lower dissolved oxygen also implies that the estuaries were more polluted downstream.

Table 1: physicochemical characterse of muthupet estuary

Parameters	Pre monsoon	Monsoon	Post monsoon
Temperature (°C)	27.03 ± 1.892	26.08 ± 1.825	28.08 ± 1.965
pH	9.4 ± 0.658	8.76 ± 0.613	9.87 ± 0.690
EC (MS CM ⁻¹)	401 ± 28.07	381 ± 26.67	478 ± 33.46
DO (Mg/I)	3.45 ± 0.241	3.97 ± 0.277	3.12 ± 0.218
COD (Mg/I)	23.00 ± 1.61	23.05 ± 1.613	23.86 ± 1.670
BOD (Mg/I)	2.87 ± 0.200	3.46 ± 0.242	3.23 ± 0.226
Alkalinity (Mg/I)	117.04 ± 8.192	119.02 ± 8.331	118.89 ± 8.322
Salinity (PSU)	24.89 ± 1.742	23.56 ± 1.649	25.56 ± 1.789
Hardness (Mg/I)	1570 ± 109.9	1526 ± 106.82	1628 ± 113.96

EC: Electrical conductivity; DO: Dissolved oxygen; COD: Chemical oxygen demand; BOD: Biological oxygen demand. Chemical Oxygen Demand (COD) is a measure of pollution in aquatic ecosystems. It estimates carbonaceous factor of organic matter. In present study obtained in the range of 4.20mg/L and above the permissible limit set by WHO (10mg/L). Biological Oxygen Demand (BOD) is the amount of oxygen required by the living organisms engaged in the utilization and ultimate destruction or stabilization of organic water. It is a very important indicator of the pollution status of a water body. In the conducted experiments, BOD was high in Domestic and Industrial Effluent due to high organic load and excessive growth of total microorganisms (Kandhasamy, and Santhaguru, 1994) [20]. This may be as a result of escape of organic matter (organic) into the river mostly from faecal waste deposition by the surrounding urban area and human settlements. Control Sample revealed BOD value below detection limit, because it was distilled water and had no

organic load. Highest COD values were found in Domestic Effluent which may be due to the incessant inflow of sewages from urban areas (Mishra *et al.*, 1990) [12]. In the present study, COD was lowest in pre monsoon months (23 mg/l) and highest during post monsoon (23.86 mg/l) while monsoon COD was 23.05 mg/l. The BOD was lowest in pre monsoon months (2.87 mg/l) and highest during monsoon (3.46 mg/l) while monsoon BOD was 3.23 mg/l (Fig 1 and 2).

Highest EC was recorded in high during post monsoon (478 Mscm⁻¹) and low during monsoon (381 Mscm⁻¹) while Pre monsoon EC was 401 Mscm⁻¹ (Fig 4). The highest value may be due to the Industrial Effluent because it contained many chemicals, salts and dissolved solids (Mishra and Saksena, 1993) [13]. Higher EC indicates the presence of high amount of dissolved inorganic substances in ionized form (Murhekar, 2011) [15]. Domestic Effluent also showed moderate to high value of EC. Electrical Conductance in monsoon was found below detection limit because it is distilled water and in

distilled water presence of ions and chemicals is in minute quantity so; EC is found below the detection limit.

The alkalinity of water is its capacity to neutralize acids. Alkalinity of water is a measure of weak acid present in it and of the cations balanced against them (Singh *et al.*, 2010)^[27]. Total alkalinity is the total concentration of bases in water usually bicarbonates and carbonates (Ouyang *et al.*, 2006)^[17]. Alkalinity varied with the seasons as lowest in pre monsoon months (117.04 mg/l) and highest during monsoon (119.02 mg/l) while post monsoon Alkalinity was 118.89 mg/l (Fig 5). Total alkalinity depends on the concentration of the substance which would raise the pH of the water. High levels of alkalinity indicate the presence of strongly alkaline industrial waste water and sewage in the estuary (Safari *et al.*, 2012)^[24]. The degradation of plants, living organism and organic waste in the estuary might also be one of the reasons for increase in carbonate and bicarbonate levels, shows an increase in alkalinity value (Wang *et al.*, 2006)^[31]. Our result agrees with the earlier report (Mohan Raj *et al.*, 2013)^[14].

Total hardness is the parameter of water quality used to describe the effect of dissolved minerals (mostly Ca and Mg), determining suitability of water for domestic, industrial and drinking purpose attributed to presence of bicarbonates, sulphates, chloride and nitrates of calcium and magnesium 26 In the present study, salinity was high during post monsoon (25.56 PSU) and low during monsoon (23.56 PSU). The hardness was lowest in monsoon months (1526 Mg/l) and highest during post monsoon (1628 Mg/l) (Fig 1 and 6). Present finding is in agreement with Mohan Raj *et al.* (2013)^[14]. High values of hardness are probably due to regular addition of large quantities of detergents used by the nearby residential localities into lakes which drains into estuaries.

Conclusion

In the present study disrupts normal functioning of the ecosystem, causing a variety of problems such as a lack of oxygen in the water, needed for fish and shellfish to survive. During the rainy season, the increased flow of freshwater results in the appearance of freshwater species. However, the majority of dry season species cannot survive in these low salinities and migrate to higher salinity areas offshore. Salinity is extremely important from the standpoint of monitoring water quality. The purpose of this study has been to determine the effect of drainage system and type of land use on the load of mineral nutrient compounds derived from soil environment and present in water ecosystems. As water originating from rain and snow is the main medium shaping soil processes and transport of minerals, particular attention has been paid to variations in atmospheric precipitation during the analyzed time period. Increased human activities over the recent past are imposing a greater stress on these ecosystems, resulting on changing their water quality and loss of biodiversity. In the present study tidal and diurnal variations in a large spectrum of physico- chemical fraction was irrigates for this coastal environment.

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