



Seasonal Variation in the Physicochemical Parameters in the Estuarine Waters of Gautami Godavari, East Coast of India

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ABSTRACT

Monitoring of river waters are an important in now a days because of increasing industrialization, urbanization and anthropogenic actives from river banks. The industrial effluents, domestic sewage, agricultural wastes and aqua cultural wastes are being discharged into the river waters and finally reaching into coastal waters that causing degradation of coastal water quality. The present study was carried out to determine the water quality in terms of seasonal variability and behaviour of physicochemical parameters for a period of one year during 2015 in the estuarine waters of Gautami Godavari along its longitudinal stretch at seven stations from the head of the estuary to mouth of the estuary. The temperature values in the estuarine waters, varied from 25.60 to 31.80 °C, pH values in the in the range of 7.20 to 8.3, salinity ranged from 0.23 to 31.83 psu, dissolved oxygen values ranged from 2.36 to 6.82 mg L⁻¹. Hydrographical parameters (temperature, pH, salinity, dissolved oxygen) indicated distinct spatial and seasonal variations.

Keywords: Godavari estuary, physicochemical parameters, behavior, seasonal variations.

INTRODUCTION

Estuaries constitute a major interface between land and the oceans and have been regarded as one of the most important aquatic systems. Distribution of chemical constituents in estuarine environment is controlled by physical, chemical, geological and biological processes since they govern the fate and net fluvial transport of weathered materials from continents to the oceans. Studies on the distribution and behavior of physicochemical constituents in estuarine regions are therefore important for assessing riverine inputs into the oceans. Some physico chemical studies such as temperature, salinity and current distributions, diurnal variations of salinity, temperature behavior and their seasonal variations in Godavari estuaries have been reported [1-9]. However, no systemic studies have been carried out so far on the distribution and behaviour of physicochemical parameters in the estuarine waters of Gautami Godavari along its longitudinal stretch. In view of this, the author has therefore been undertaken a detailed study of the behaviour and seasonal distribution of these parameters for a period of one year during 2015.

MATERIALS AND METHODS

The Gautami-Godavari River estuary is the largest estuary in the central east coast of India. The estuary is a drowned river mouth type of estuary ($16^{\circ}41' - 16^{\circ}56'N$, $81^{\circ}.45' - 82^{\circ}21'E$) and covers an area of 330 km^2 in the state of Andhra Pradesh. Godavari is one of the largest rivers in India, after Ganga and Brahmaputra and covers $3.1 \times 10^5 \text{ km}^2$ and opened to the Bay of Bengal on the east coast of India. The river originates at an altitude of about 1600 m near Nasik in the Western Ghats and travels about 1480 km eastwards across the peninsular India and drains into the Bay of Bengal. During its course, it divides into two major distributaries, one flowing towards the east called Gautami-Godavari estuary and the other flowing towards the south termed as Vasista-Godavari estuary. The basin climate is generally dry with an average rainfall of 1512 mm y^{-1} and more than 85% of the annual rain fall received in the catchment during summer monsoon [10]. The river discharge in to the Goutami estuary, downstream of Rajahmundry, is regulated by a century old Dam at Dawleswaram. The river discharge is high during June-September (Indian summer monsoon) and low during October to December and then river discharge is almost negligible. The present study was undertaken in the Gautami-Godavari, which is the major branch of Godavari River. The average range of tides is about 2-2.5 m and current speed is $10\text{-}80 \text{ m s}^{-1}$ at the estuarine location.

Sampling sites: Seven sampling stations are fixed along the stretch of Gautami Godavari estuary, starting from head of the estuary (Kotipalle, St.1, Dangeru, St.2, Yanam St.3, Vrudha Gautami, St.4, Balusuthippa, St.5, Mangrove area, St.6) to the mouth of the estuary (Bhiravapalem, St.7) is shown in Fig. 1.

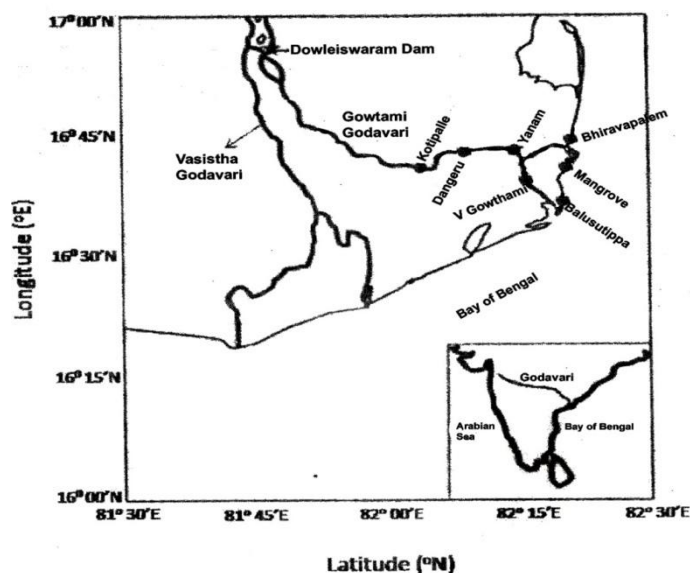


Fig 1. Station locations in the Godavari estuary

Water samples were collected seasonally over a period of one year during the year 2015, starting from premonsoon (March), onset of monsoon (June), monsoon (September) and post-monsoon (December). The average depth of the water column in the study area varied from 5 to 12 m. A hired mechanized boat used to collect water samples.

Sample analysis: The water samples were collected from surface and near bottom with the help of Niskin water sampler. During the sampling time surface and bottom temperature was recorded immediately with a precision thermometer, Dissolved oxygen was fixed with Winkler A and B reagents on the boat itself. After completion of sampling, water samples were filtered through glass fiber filter papers (GF/F of 0.45

μm), the filtered water samples are used to analyze pH, salinity, using standard procedures. Particulate matter was collected on GF/C filter papers in each station, was extracted with 90% acetone and used them for estimation of Chlorophyll-a on spectrophotometrically [11] with a precision of $\pm 4.3\%$. A simple correlation analysis was made taking all the data to know the interrelationships among the analyzed parameters.

RESULTS AND DISCUSSION

The collected water samples during the four seasons in the estuarine waters of the Gautami Godavari were analysed immediately at the shore laboratory of National Institution of Oceanography, Regional center, Visakhapatnam at the shore laboratory of National Institution of Oceanography, Regional center, Visakhapatnam at Yanam. The statistical data on the hydrographic parameters in the study area are given in Table 1.

Table.1. Statistical data on the hydrographic parameters in estuarine waters of Gautami Godavari during 2015

Parameter	Surface				Bottom			
	Min.	Max.	Mean	S.D (\pm)	Min.	Max.	Mean	S.D (\pm)
Temp. ($^{\circ}\text{C}$)	26.50	31.80	29.62	2.01	25.60	31.40	28.84	2.14
pH	7.20	8.20	7.71	0.27	7.43	8.30	7.94	0.21
Salinity (psu)	0.23	31.83	15.43	11.91	4.63	34.26	19.77	10.13
D.O. (mg/L)	4.23	6.82	5.53	0.76	2.36	5.12	3.93	0.77
Chl.a (mg/m^3)	3.45	11.25	6.65	2.18	2.52	6.25	4.30	0.89

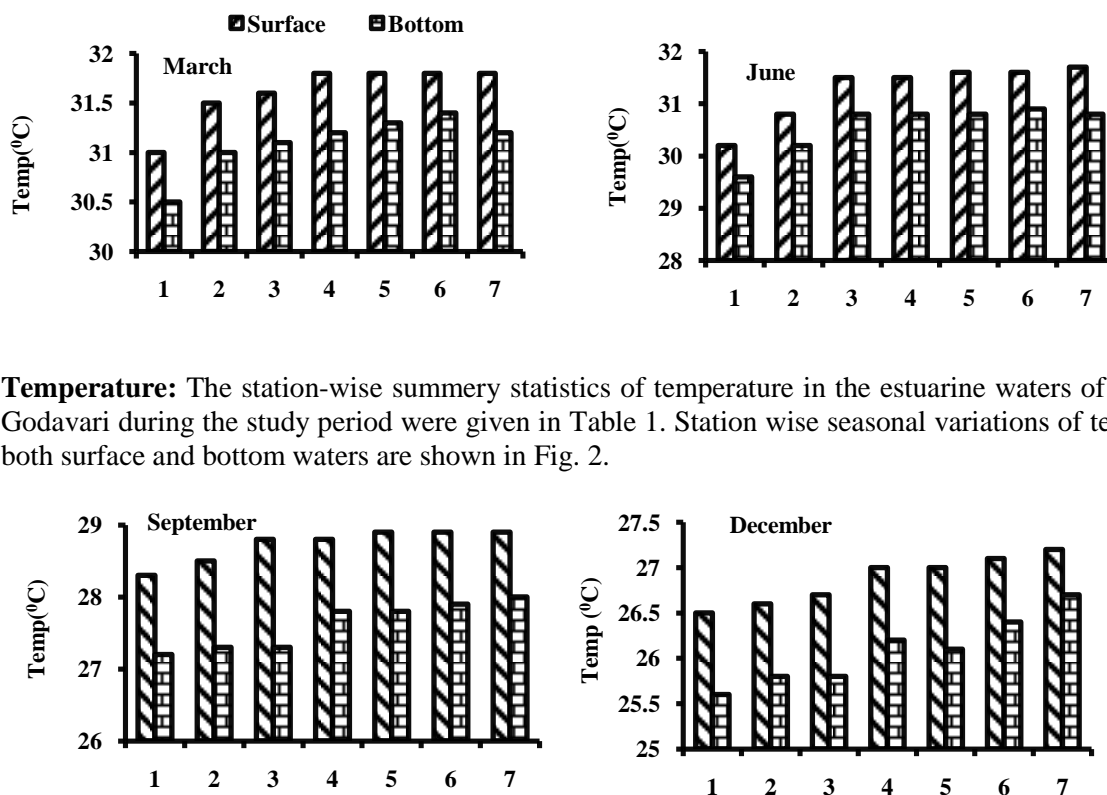


Fig 2. Seasonal and station wise variation of temperature in the estuarine waters of Gautami Godavari during 2015

The temperature values in the surface waters of the Gautami Godavari were in the range of 26.50 to 31.80 °C with an average of 29.62 °C, where as in the bottom waters, the temperature ranged from 25.60 to 31.40 °C with an average of 28.84 °C. The surface as well as bottom water temperatures are high during pre-monsoon and onset of monsoon seasons and low during post-monsoon season in all the stations. The higher temperature observed during pre and onset of monsoon season due to summer heating of the surface waters and the lower temperature noticed during post-monsoon season is due to winter cooling. Similar seasonal variations of temperature were reported earlier in the Godavari estuarine waters [12, 13, 7]. Similar seasonal variations of temperature were also reported in the estuaries of India and elsewhere, are Mandovi estuary [14], Vellar estuary [15] Mahanadi estuary [16] Bahuda estuary [17], Rushikulya estuary [18], Great Quse estuary, England [19], in a tropical estuary of Costa Rica [20], in the northeastern Pacific estuary [21], Pichavaram mangrove waters [22], Kaduviyar estuary, southeast coast of India [23], Ennore estuary [24], estuaries of Khambhat [25], estuaries of Kodungallur-Azhikode, Kerala, India [26], Cochin backwaters [27], Zuari estuary, India [28], in Parangipettai coastal waters and Vellar estuary, southeast coast of India [29] and in Narmada estuary [30]. In general, the surface water temperature was always higher than that of bottom waters. The gradient in temperature between surface and bottom was less during premonsoon ($\bar{x} = 0.51^{\circ}\text{C}$) and onset of monsoon (0.71°C) due to intense tidal mixing, and is high during monsoon ($\bar{x} = 1.11^{\circ}\text{C}$) due to partial mixing in the estuary, as the flooding of estuary and the entire estuary is filled with fresh water when the river discharge and direct precipitation is maximum during this season.

pH: The station wise summery statistics of pH values in the estuarine waters of the Gautami Godavari during the study period were given in table 1. Station wise seasonal variations of pH in both surface and bottom waters are shown in fig. 3. The pH values in the surface waters of the Gautami Godavari were in the range of 7.20 to 8.20 with an average of 7.71, where as in the bottom waters, the pH ranged from 7.43 to 8.30 with an average of 7.94. In general, higher pH values were observed at the mouth of the estuary (Bhairavapalem) due to the dominance of seawater and the lower pH values were observed at the head of the estuary (Kotipalle) due to the dominance of river water. The pH values showed an increasing trend from surface to bottom at all stations may be attributed to the bottom intrusion of seawater in all stations and seasons.

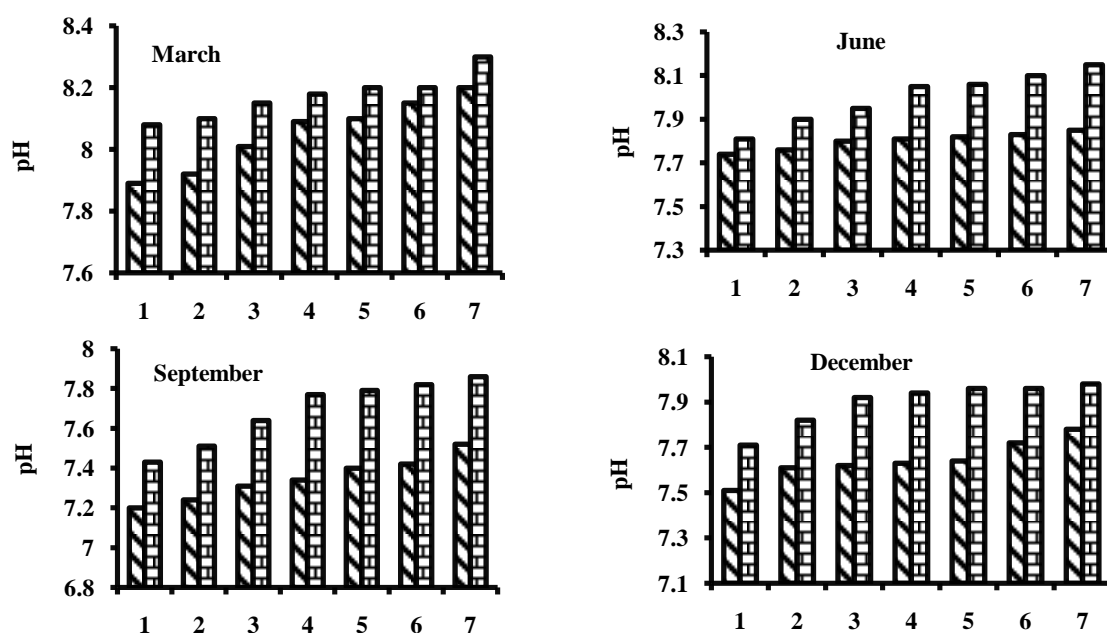


Fig 3. Seasonal and station wise variations of pH in the estuarine waters of Gautami Godavari during 2015

The surface to bottom gradient of pH is more during monsoon ($\bar{x} = 0.35$) due to flooding of fresh water in to the estuary and less during pre-monsoon ($\bar{x} = 0.12$), due to intense tidal mixing. The fluctuations in pH values during different seasons of the year can be attributed to factors like removal of CO₂ by photosynthesis through bicarbonate degradation, dilution of estuarine waters by freshwater influx and decomposition of organic materials [31, 32]. The surface as well as bottom water temperatures are high during pre-monsoon and onset of monsoon seasons and low during post-monsoon season in all the stations. The higher pH values were observed during pre and onset of monsoon season due to summer heating of the surface waters and the lower pH values were observed during monsoon season is due to influx of fresh water in the estuary and slight increase in post-monsoon season. Such a seasonal variations in pH values have also been reported from the Vellar estuary [15], Mahanadi estuary [16], Rushikulya estuary [18], and Kaduviyar estuary [23].

Salinity: Salinity plays a dominant role in influencing chemical constituents in water and sediment and its distribution strongly depends on sea water intrusion through mouth and on influx from the river water into the estuary. Salinity of estuarine waters has been considered as an index of the estuarine mixing processes and tidal effects. The station-wise summery statistics of salinity values in the estuarine waters of the Gautami Godavari during the study period were given in table 1. Station wise seasonal variations of salinity in both surface and bottom waters are shown in fig.4. The salinity values in the Gautami estuary, ranged from 0.23 to 31.83 psu with an average of 15.43 psu in surface waters and 4.63 to 34.26 psu with an average of 10.13 psu in the bottom waters. The salinity showed a decreasing trend from pre-monsoon to monsoon followed by a slight increase in post-monsoon season at all stations. The difference in salinity gradient between surface and bottom varied from 2.43 to 3.00 psu during pre-monsoon, 2.50 to 4.10 psu during onset of monsoon, from 4.40 to 10.4 psu during monsoon and from 2.6 to 3.48 psu during post-monsoon season. Thus, the salinity distribution suggests slight stratification during monsoon and well mixed conditions during pre and post-monsoon seasons prevailed in the estuary [2, 7, 33,8].

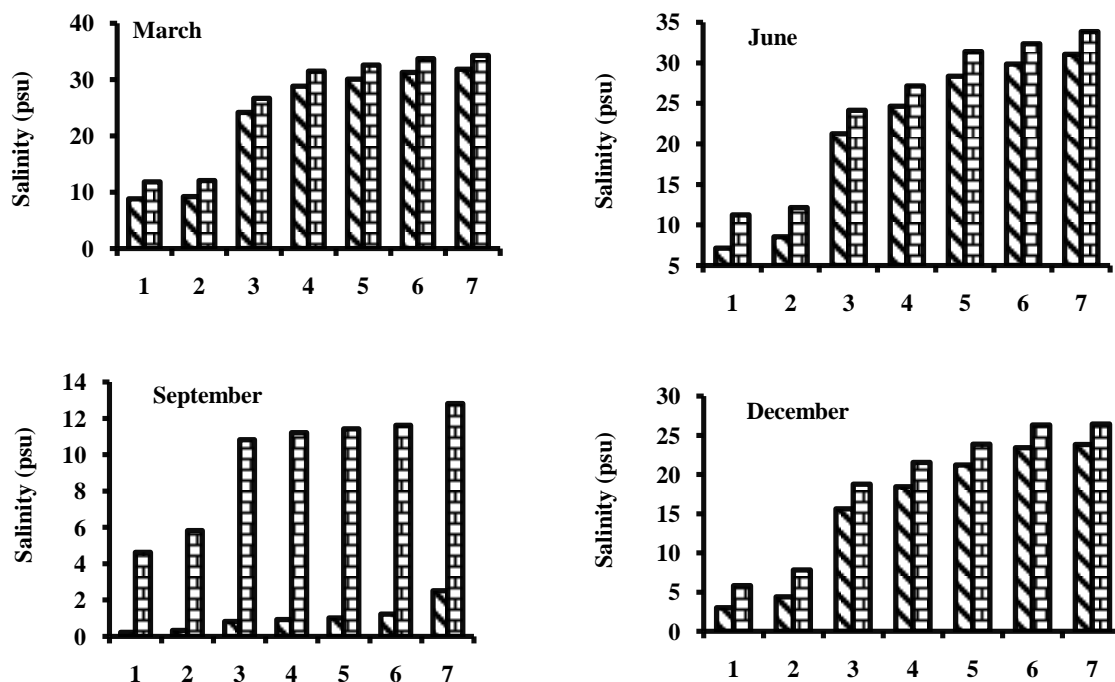


Fig 4. Seasonal and station wise variations of salinity in the estuarine waters of Gautami Godavari during 2015

Similar seasonal variations of salinity were also reported in the estuaries of India and elsewhere, are Mandovi estuary [14], Vellar estuary [15], Mahanadi estuary [16], Bahuda estuary [17] Rushikulya estuary [18], Great Quse estuary, England [19], in a tropical estuary of Costa Rica [20], in the northeastern Pacific estuary [21]. Pichavaram mangrove waters [22], Kaduviyar estuary, southeast coast of India [23], Ennore estuary [24], estuaries of Khambhat [25], estuaries of Kodungallur-Azhikode, Kerala, India [26], Cochin backwaters [27], Zuari estuary, India [28], in Parangipettai coastal waters and Vellar estuary, southeast coast of India [29] and in Narmada estuary [30].

Dissolved oxygen: The station-wise summery statistics of dissolved oxygen values in the estuarine waters of the Gautami Godavari during the study period were given in Table 1. Seasonal and station wise variations of dissolved oxygen values both in surface and bottom waters are shown in Fig. 5.

The dissolved oxygen values in the estuarine waters of Gautami Godavari ranged from 4.23 to 6.82 mg.L⁻¹ with an average of 5.33 mg.L⁻¹ in surface waters and from 2.36 to 5.12 mg.L⁻¹ with an average of 3.93 mg.L⁻¹ in the bottom waters. Higher values of D.O. were observed during pre and post-monsoon seasons due to higher photosynthetic activity and lower values were observed during monsoon due to oxidation of organic matter. More organic waste is entering into the estuarine waters during this season along with huge fresh water runoff. Similar distribution of oxygen was also reported in these waters by Padmavathi and Satyanarayana [7], Sarma *et al.*, [8]. Similar seasonal variations of dissolved oxygen were also reported in the estuaries of India, are in Mandovi estuary [14], in Vellar estuary [15], in Mahanadi estuary [16], in Bahuda estuary [17], in Rushikulya estuary [18], in Pichavaram mangrove waters [22], in the waters of Kaduviyar estuary, southeast coast of India [23], in Ennore estuary [24], in estuaries of Khambhat [25], in the estuaries of Kodungallur-Azhikode, Kerala, India [26], in Cochin backwaters [27] in Zuari estuary, India [28], in Parangipettai coastal waters and Vellar estuary, southeast coast of India [29] and in Narmada estuary [30].

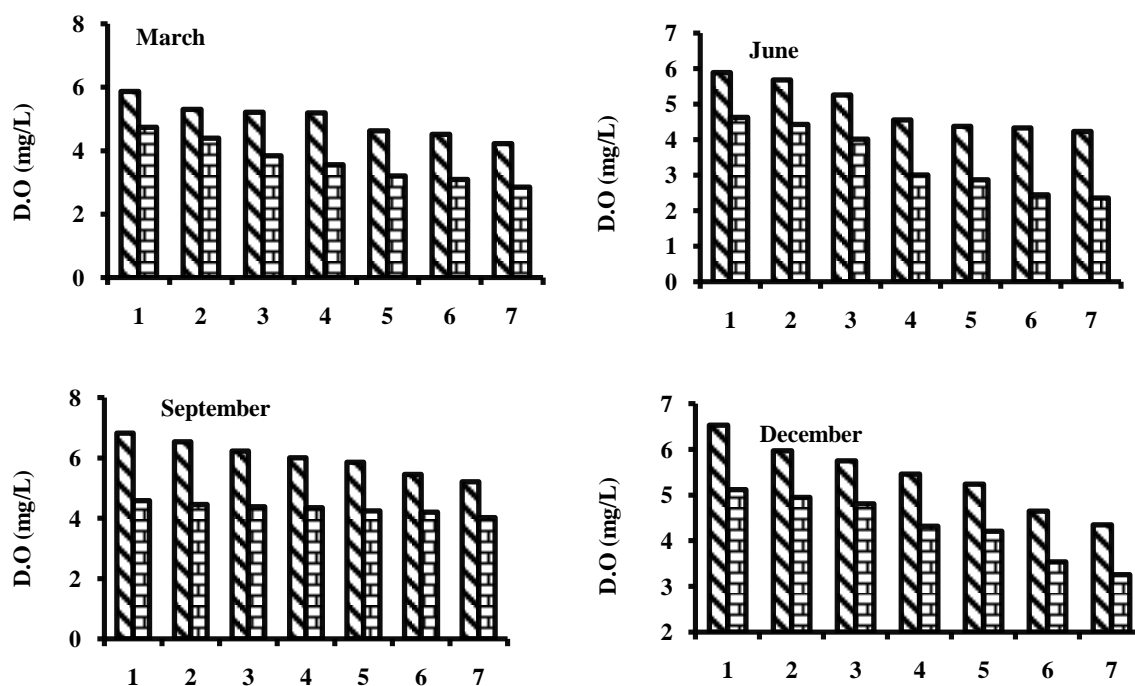


Fig. 5 Seasonal and station wise variations of dissolved oxygen in the estuarine water of Gautami Godavari during 2015.

In general, the surface water dissolved oxygen was always higher than that of bottom waters. Seasonal variation of dissolved oxygen both at surface and bottom in the estuarine waters exhibited a distinct trend

namely (i) decreasing in its concentrations from riverine (head) to mouth (marine) of the estuary, and (ii) decrease in its concentration from surface to bottom in all seasons. The former is due to greater solubility of oxygen in fresh-water region when compared to estuarine and coastal waters, and latter is due to utilization of oxygen in the oxidation of organic matter.

Chlorophyll-a: The station-wise summery statistics of chlorophyll-a values in the estuarine waters of the Gautami Godavari during the study period were given in table 1. Seasonal and station wise variations of Chlo-a in surface and bottom waters are shown in fig.6. The chlorophyll-a values in the surface waters of Gautami estuary, ranged from 3.45 to 11.25 mg.m³ with an average of 6.55 mg.m³ and in the bottom waters, varied from 2.52 to 6.25 mg.m³ with an average of 4.30 mg.m³. Higher values of Chlorophyll-a were observed during onset of monsoon and post-monsoon season. This may be attributed mainly due to the favorable conditions prevailed in the estuarine waters like salinity, temperature, nutrients and light intensity during these periods. Lower values were observed during monsoon season which may be due to high turbulence of flood water and also decrease in isolation during this period. Similar seasonal variations of chlorophyll-a were also observed in the estuarine systems of Goa [33, 34, 35] in the estuarine waters of Auranga and Ambika [36]. Higher values of chlorophyll-a were always observed in the surface waters than that of bottom waters. A longitudinal decrease of chlorophyll-a values were observed in all seasonal, as salinity increases, the values of chlorophyll-a were decreasing towards mouth of the estuary. Similar distribution of chlorophyll-a values were also reported in these waters [7, 8].

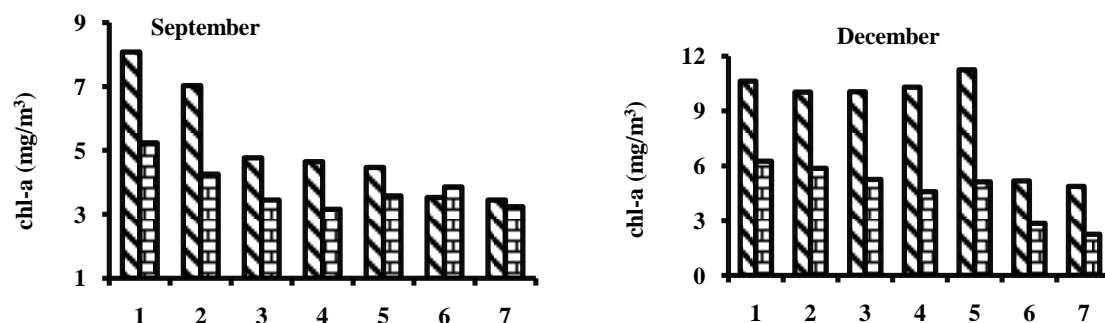


Fig 6. Seasonal and station wise variations of chl-a in the estuarine waters of Gautami Godavari during 2015

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