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HYDROBIOLOGICAL STUDIES IN THE GRADIENT ZONE OF THE VELLAR ESTUARY : 1. PHYSICO-CHEMICAL PARAMETERS*

R. CHANDRAN** AND K. RAMAMOORTHI
Centre of Advanced Study in Marine Biology, Porto Novo - 608 502.

ABSTRACT

The physico-chemical aspects in the gradient zone of the Vellar estuary were studied for a period of two years from January 1977 to December 1978. Water samples were collected at high and low tides of both day and night. Rainfall was very high during the period of investigation and this brought lot of changes in the physico-chemical and biological parameters of this estuary. Tidal range was low (< 2 m). Variation in water temperature was mostly influenced by the atmospheric temperature rather than tidal influence. Variation in salinity was more conspicuous (<1 ppt to 36 ppt) during early postmonsoon, late premonsoon and some collections in monsoon season, but during summer, homogenous conditions prevailed. Dissolved oxygen showed invariably high values during low tides of day time. However, the variation between high and low tide was not significant. Light attenuation coefficient was low during summer when the estuary was dominated by clear neritic water and high during monsoon season owing to the heavy freshwater flow. Although no definite tidal variation in light attenuation coefficient was noticed, the values were generally higher during low tides. pH showed no definite seasonal or tidal variation. The surface-bottom difference in all the parameters was insignificant owing to the shallowness of the estuary.

Key-words : Hydrography, Vellar estuary.

INTRODUCTION

An important aspect in the estuarine hydrography includes the study of dynamic conditions induced by tidal currents and freshwater discharge by the rivers into the estuary. In most of the tropical estuaries, especially those found along the south-west and east coasts of India, the environmental conditions affecting the dynamic nature of the waters are largely governed by two dominant factors, viz. (i) short term changes resulting from tides and (ii) marked seasonal changes induced by the monsoon cycle. Marked changes in the hydrography of estuaries occur during the monsoon months which affect the associated flora and fauna. In the Vellar estuary which falls in the tropical belt, abiogenic processes like monsoon and large scale fluctuations in freshwater effluence play a paramount role by varying the circulation from year to year.

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* Part of the thesis submitted for the degree of Doctor of Philosophy in Marine Biology of Annamalai University.

** Present Address : Prawn Hatchery, Hindustan Lever Limited, Muttukadu - 603 112, Tamil Nadu.

This coupled with a synchronous biological activity and other variable factors, contribute largely to the instability of the environment.

Although, several investigations have been conducted on hydrographical features of the Vellar estuary, most of them are based on short term observations conducted during different periods of the year. This leads to the lack of an uniform profile on the tidal variations in hydrographical features. The present study therefore was conducted systematically over a period of two years from January 1977 to December 1978, to get a clear picture on the temporal variations in the hydrography of Vellar estuary.

MATERIALS AND METHODS

The sampling site for the present investigation was selected in the gradient zone (Ramamoorthi, 1954) at a distance of 1.6 km upstream from the mouth of the estuary (Fig. 1). The location of this station more or less in the

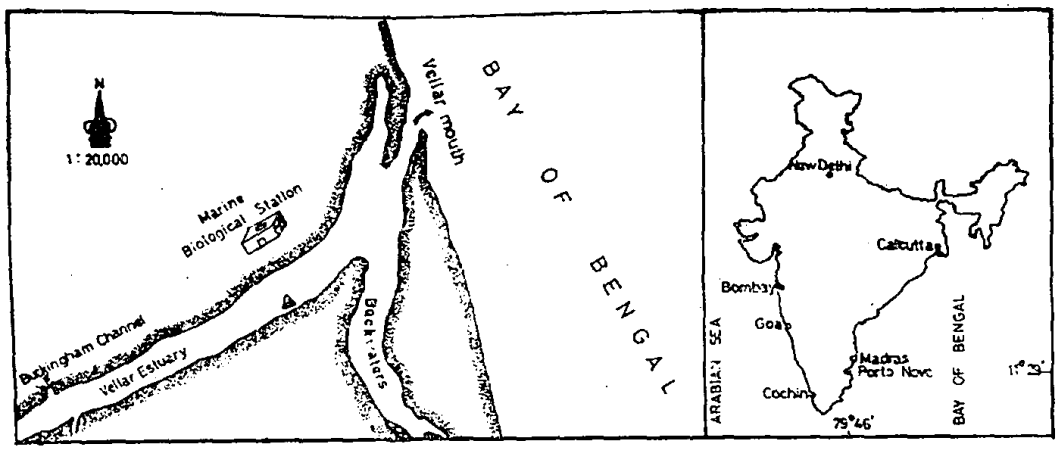

Fig. 1. Map of the Vellar-Colerron estuarine system showing the location of station.

middle of the estuary represented typical estuarine conditions. The average water depth at this station was 2.25 m. Collections were made on every full and new moon days during both high and low tides. Generally the first high water occurred around 0800 hrs, first low water around 1400 hrs, repeating every six hours. Tide level was measured using a graduated wooden pole, while rainfall and wind velocity data were procured from the meteorological department. Light penetration was measured by Secchi disc from which light attenuation coefficient was calculated using the formula of Poole and Atkins (1929). Surface water samples were collected using a clean plastic bucket and bottom water by Meyer's bottom water sampler. Temperature was measured on-board using a thermometer of 0.5 °C accuracy and salinity was calculated by titration method. Dissolved oxygen was measured following Strickland and Parsons (1972). pH was measured with an Elico model EL 10 pH meter. Based on the cyclic phenomena of meteorological events, seasons are classified as (i) post-

monsoon (January to March), (ii) summer (April to June), (iii) pre-monsoon (July to September) and (iv) monsoon (October to December).

RESULTS AND DISCUSSION

Wind velocity: Wind velocity just before the first high and low tide periods varied from 0.5 to 32 km/hr during 1977 and from 0.5 to 20 km/hr. during 1978. In both the years, wind velocity was high from April to September except in July.

Rainfall: In tropical countries, rainfall is a regular cyclic phenomenon and brings about profound changes in the hydrography of estuarine environments (Qasim, 1980). In Porto Novo, which is situated on the south-east coast of India, heavy rainfall occurs during the north-east monsoon. As compared to previous years, heavy rainfall was recorded during 1977–78 especially in 1977 because of a cyclonic storm in November. The average monthly rainfall was high during 1977 (160.1 mm) than during 1978 (129.9 mm).

Tide level: The tidal amplitude varied from 15 to 145 cm. Generally, the tide level was higher in 1978 because of the alteration in the course of estuary near the mouth after the torrential rain in November 1977. The straight course of the estuarine mouth enhanced the exchange of neritic and estuarine waters which adequately reflected in the increased tide level in 1978. Further the increase in the tide level during the monsoon months was mainly due to the large run off and temporal rise in the water level.

Temperature: Tidal and diel variations in temperature are shown in Fig 2. Atmospheric temperature fluctuated from 23.5 to 36.5 °C. Except during the first low tide periods, fluctuations in atmospheric temperature was found to be of a low order. Water temperature varied from 24 to 33.5° C in 1977 and from 26.5 to 33.5°C in 1978. Minimum values were observed during December in both the years and maximum during May in 1977 and in April and October in 1978. In tropical estuaries, the annual variation in temperature would be relatively less (8 to 10° C) when compared to temperate estuaries. The maximum fluctuation in temperature observed at one tidal cycle was 3.5°C (January and August) at the surface and 4 °C at the bottom during July 1977, while it was 5°C (March) at the surface and 3.5°C (June) at the bottom during 1978. It seemed that, changes in the water temperature was mainly induced by variations in the atmospheric temperature rather than variations in tide. Similar findings have also been reported by Qasim and Gopinathan (1969) in Cochin backwaters and Dehadrai (1970a) in Mormugao Bay. Varma, Rao and Cherian (1975) found that the influence of tide was prominent in the downstream region of the Mandovi (near the mouth) while insolation was predominant in the upper reaches, and the present findings substantiate this. In Vellar estuary, vertical stratification in temperature was not prominent because of shallowness. The maximum difference between surface and bottom temperatures was 3°C (August) in 1977 and 2.5°C (April and

September) in 1978. A similar lack of vertical stratification in temperature was reported for Cochin backwaters also and the same was attributed to its shallow nature (Qasim and Gopinathan, 1969). According to Shynamma and Balakrishnan (1973), in Cochin backwaters, the vertical stratification in temperature was prominent only between surface and 8 m depth but the temperature values at 4 m depth showed parity with surface values.

Salinity : Tidal and diel variations in salinity are presented in Fig 3. Salinity values fluctuated from 0.10 ppt (November) to 36.3 ppt (July) in 1977 and from 0.27 ppt (December) to 36.5 ppt (August) in 1978. Such a wide variation in salinity was aslo reported by many workers from Indian estuaries (Jacob and Rangarajan, 1959; Rajendran, 1974; Varma, Rao and Cherian, 1975; Balakrishnan and Shynamma, 1976). In tropical estuaries, it is a common feature since the monsoon and drought conditions represent two extreme situa-

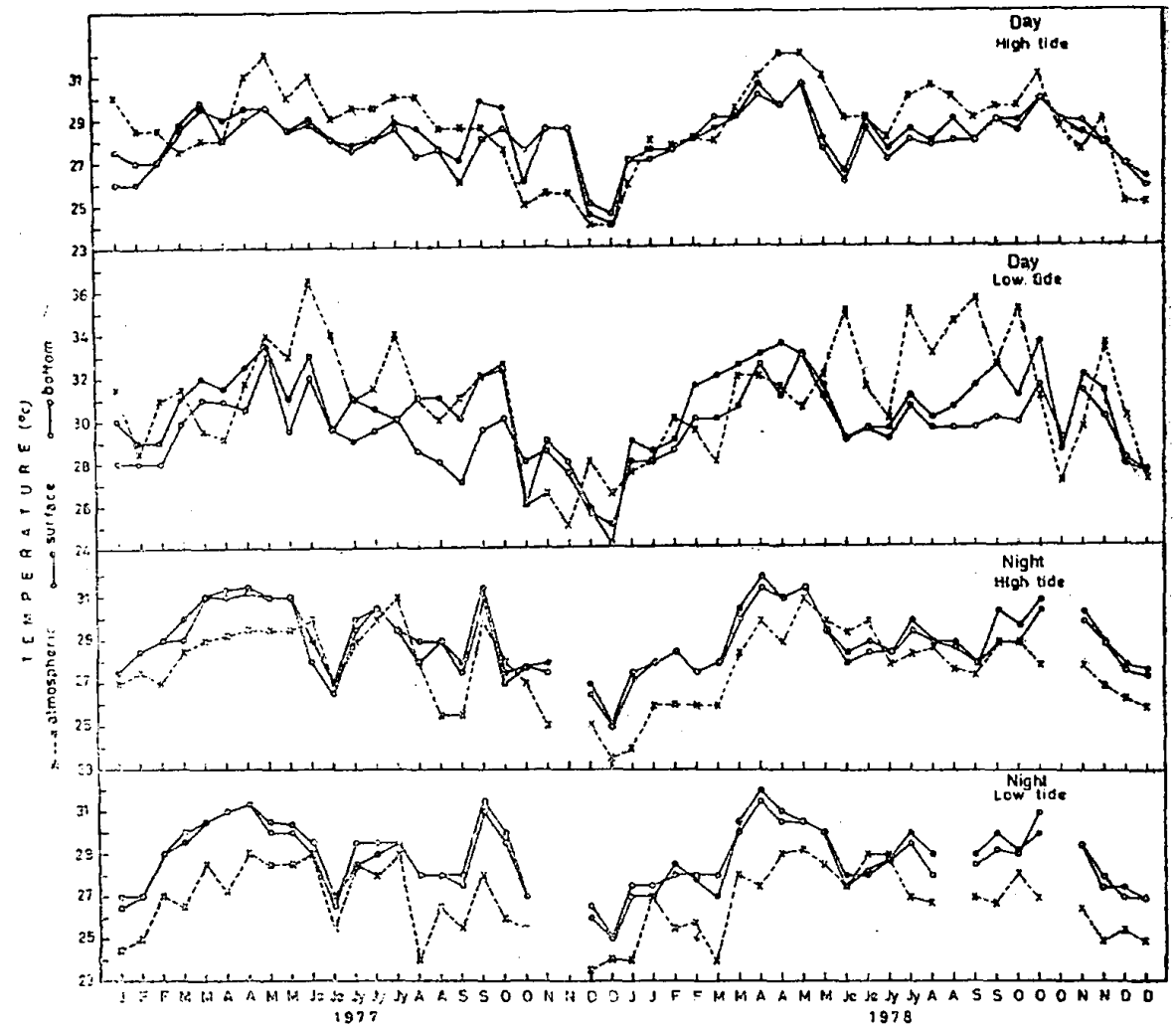

Fig. 2. Tidal and monthly variations in temperature.

tions thus affecting the estuarine environment in dramatically opposite directions.

After the cessation of the monsoon floods, the neritic water was found to penetrate into the estuary along the bottom during high tide periods in post-monsoon (January-March), otherwise known as the recovery phase. Salinity increased steadily during this season with prominent tidal variations. Vertical stratification in salinity was also conspicuous at all tides. However, in 1978, the recovery phase was rapid and high values of salinity (33 ppt) was obtained at high tide periods in January itself. This may be attributed to (i) the cessation of heavy rainfall in November 1977 which facilitated the earlier penetration of seawater into the estuary during high tides as a result of decline in freshwater flow from December onwards and (ii) due to the heavy flood, the mouth of the estuary opened straight to the river stream which was wider and deeper than the previous one, thus exchanging free flow of larger quantum of seawater into the estuary.

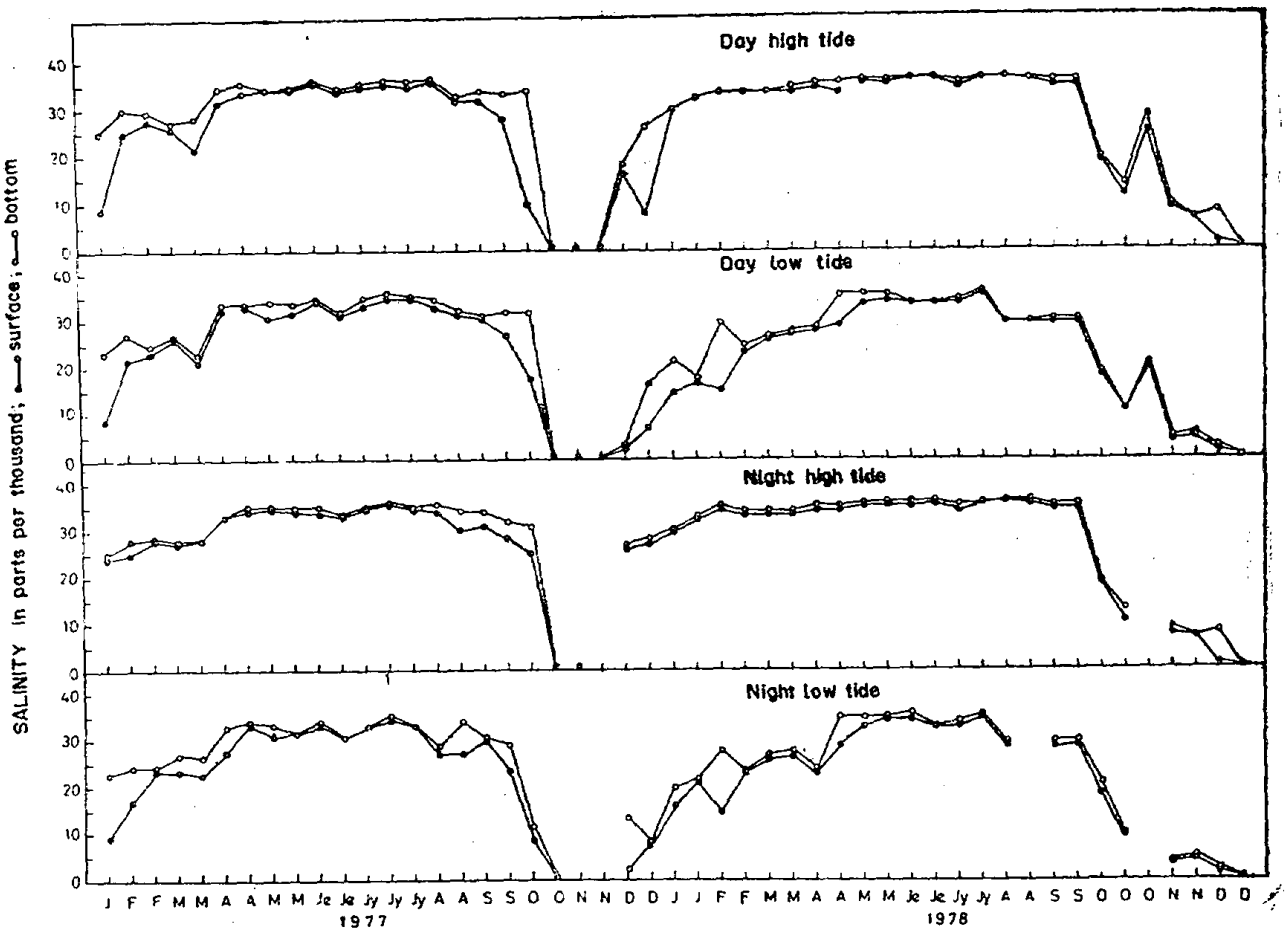

Fig. 3. Tidal and monthly variations in salinity.

During summer (April to June), salinity attained its maximum. The entire estuary was found to be dominated by neritic water and the salinity difference in surface-bottom was negligible even during low tide. The decline in freshwater flow resulted in an increase in surface salinity. Vertical halocline and tidal fluctuations were very low during late summer. Despite the few unprecedented showers recorded in this season, the salinity remained constant.

During the pre-monsoon (July to September), the stable and homogenous conditions continued to prevail till the end of July in 1977 and till September in 1978. The pre-monsoon showers and the release of water from the irrigation canals caused a gradual decline in salinity from August onwards during 1977. However in 1978, the decrease in salinity was observed only at low tides in August and September whereas at high tide periods, the salinity remained high as in summer. Generally during this season, the tidal and vertical salinity gradient was clearly noticed.

With the commencement of the north-east monsoon in October, the extent of freshwater flow became high, resulting in heavy floods and sharp decline in salinity (< 1 ppt) in late October and November in 1977 and in December 1978. During the peak monsoon period, complete scouring of the whole estuarine system took place and the estuary was freshwater dominated. During this prolonged flood period in active monsoon months, river water reaching the sea obliterated the incoming tide completely to an extent that even during high tides, seawater intruding along the bottom was pushed back by the high velocity flood waters. Tidal effect was minimum and vertical salinity gradient was completely absent. Similar observations have also been reported earlier in Vellar estuary (Jacob and Rangarajan, 1959) and Gautami-Godavari estuary (Ganapati and Ramasarma, 1965). On the other hand, in Cochin backwaters and Mandovi and Zuari estuaries, although heavy monsoonal floods were reported, complete scouring did not occur. Instead, during heavy floods, a well marked vertical salinity gradient was noticed (Qasim and Gopinathan, 1969; Shynamma and Balakrishnan, 1973; Cherian, Rao and Varma, 1975). Such difference could be attributed to the nature and bottom topography of these estuaries which were deeper (more than 8 m) than Vellar and Gautami-Godavari estuaries (about 3 m). During 1977, the monsoon ceased in November and the late monsoon period was characterised by a rapid decline in freshwater flow with a gradual resurgence in estuarine conditions whereas in 1978, heavy precipitation occurred only in December. An interesting feature during the early recovery phase was an alteration between freshwater condition during low tides and neritic conditions during high tides. The establishment of estuarine conditions was rather slow in 1977 while it was rapid in 1978.

Maximum salinity fluctuation at one tidal cycle in both surface (18.9 ppt) and bottom water (24.3 ppt) was discernible in December 1977, and at

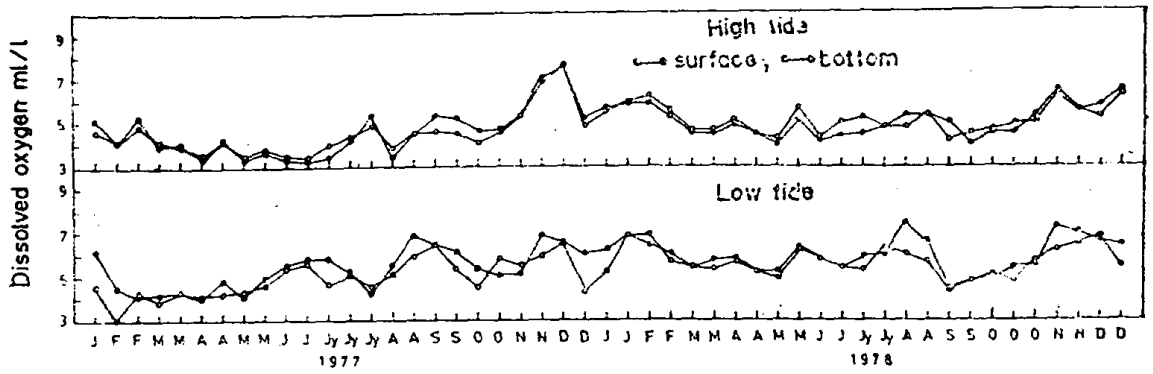

Fig. 4

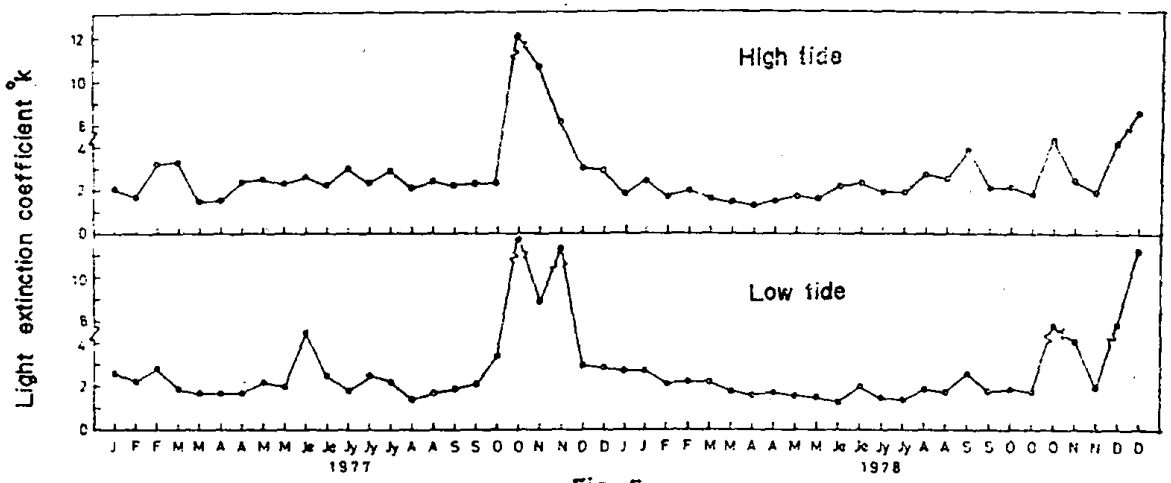

Fig. 5

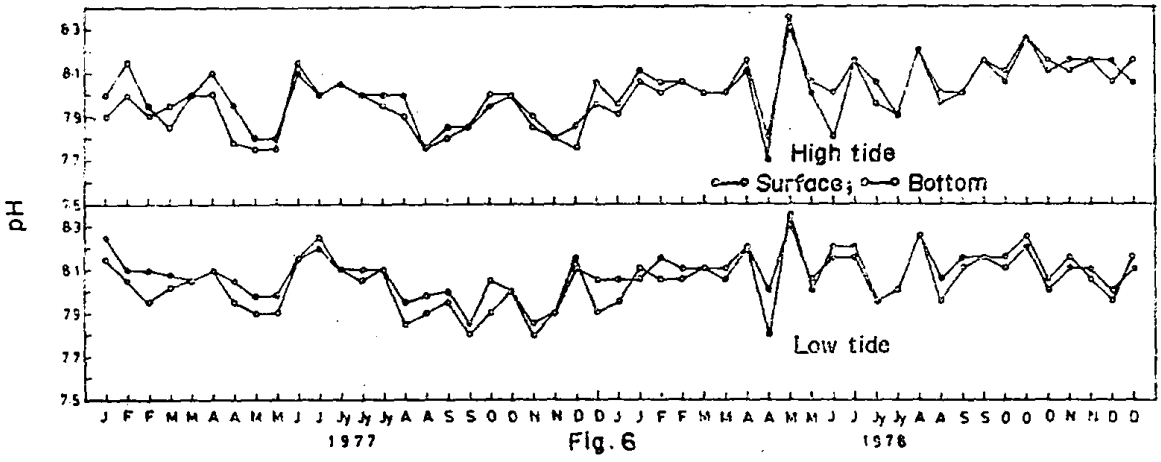

Fig. 6

Fig. 4. Tidal variations in dissolved oxygen concentration.

Fig. 5. Tidal variations in light extinction coefficient (k).

Fig. 6. Tidal variations in pH.

surface in February (10.6 ppt) and at bottom in December (6.9 ppt) 1978. The maximum difference in salinity between surface and bottom was observed to be 21.9 ppt in October 1977 and 14.6 ppt in February 1978.

Dissolved oxygen: Tidal and diurnal variations in the dissolved oxygen content are shown in Fig. 4. The dissolved oxygen concentration varied from 3.30 (June) to 7.62ml/l (December) in 1977 and from 3.95 (June) to 7.35 ml/l (August) in 1978. In general, the dissolved oxygen values were higher during the monsoon and premonsoon seasons in both the years which is in accordance with the findings of Dehadrai (1970a & b) in the Mandovi and Zuari estuaries and Rajendran (1974) in Vellar estuary. The dissolved oxygen showed an inverse relationship with salinity, with high values at ebb tides and low values at flood tides. Similar observations were also made by earlier workers (Qasim and Gopinathan, 1969; Dehadrai, 1970a & b; Vijayalakshimi and Venugopalan, 1973). During high tides, entry of neritic water into the estuary is known to lower dissolved oxygen. Although the vertical difference in oxygen was not conspicuous (which may again be due to the shallowness of this estuary), surface waters showed slightly higher values than bottom waters.

Light penetration: The variations in attenuation coefficient (k) are shown in Fig. 5. The k values varied from 1.4 (August) to 17 (October) in 1977 and 1.3 (June) to 11.3 (December) in 1978. Tropical estuaries are generally characterised by a wide range of light attenuation coefficient in contrast to temperate estuaries (Thayer, 1971). Higher light attenuation values were recorded in the monsoon months especially during flood conditions, due to the increase in turbidity of the water and low intensity of solar radiation. During the other seasons, variation in k values were rather erratic and followed no definite seasonal pattern due to the dominance of clear neritic water and the prevalence of high solar radiation.

pH: Tidal and diurnal variations in pH values are shown in Fig. 6. The pH values fluctuated from 7.75 to 8.25 in 1977 and from 7.70 to 8.35 in 1978. Variations in pH did not show any marked seasonal or tidal pattern. However, the pH values were low during heavy floods which is similar to that reported earlier in this estuary by Rajendran (1974).

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