J. mar. biol. Ass. India, 1987, 29 (1 & 2) : 344-350

CONTRIBUTION OF EDAIYUR — SADRAS ESTUARINE SYSTEM TO THE HYDROGRAPHIC CHARACTERISTICS OF KALPAKKAM COASTAL WATERS

K. K. SATPATHY, P. K. MATHUR AND K. V. K. NAIR

Water and Steam Chemistry Laboratory (WACD, BARC), Indira Gandhi Centre for Atomic Research, Kalpakkam, Tamilnadu-603 102

ABSTRACT

Northeast monsoon plays a vital role in the regulation of physico-chemical characteristics in the Edaiyur - Sadras estuarine system as well as in the adjoining coastal waters. The Edaiyur and Sadras Backwaters get connected to the sea during the NE monsoon period resulting in an estuarine condition in the coastal waters. Surface temperature of these backwaters and coastal waters are characterised by maxima in April and in October and minima in January and duly. Fresh water discharge during NE monsoon period from the backwaters causes considerable dilution of coastal waters resulting in a marked reduction in surface salinity (22 ppt). With the stoppage of monsoon rains a gradual build-up of salinity is found in both the backwaters due to the continuous ingress of sea water. The DO in the coastal waters showed relatively high values (8 ppm) during the monsoon period due to the heavy inflow of fresh water (which is high in DO) from the backwaters. The secchi disc depth in the coastal water decreased substantially (7 m to 0.75 m) during the NE monsoon period due to the heavy runoff of turbid fresh water from the backwaters. The plant nutrient values in the coastal waters also increased during the NE monsoon period following the opening of the sand bar which separates the backwaters from the sea during other periods. The Sadras Backwater is highly rich in nutrients due to the presence of a sewage outfall located upstream in this backwater.

INTRODUCTION

THE EDAIYUR - SADRAS estuarine system is part of a system of backwaters on the east coast of India interlinked by Buckingham Canal which runs parallel to the coast from Nellur in the north to Marakkanam in the south (Fig. 1). The two backwaters do not conform to the common and widely accepted definition of the estuaries. However, some of the dominant characteristics of the estuaries like a substantial mixing of sea water with fresh water and the influence of tides are felt in this aquatic system. Since the chain of backwaters are linked by Buckingham Canal, when any one of these backwaters get connected with the sea, the influence of the tides are felt in the backwaters. Similarly, following periods of heavy rainfall during the NE monsoon period (October to February) and very rarely during the SW monsoon period (June to September) these backwaters open to the sea and remain so sometimes for 2 to 3 months and more often for four to six weeks. During these periods, the discharges of freshwater into the sea are substantial and the backwaters conform to the common definition of an estuary. However, a few weeks after the cessation of heavy precipitation, a sand bar is formed at the opening of the backwaters into the sea by the long shore drift which is predominant on the east coast of India. A close analysis of the hydrological and physiographic characteristics of these backwaters reveals that it belongs to Category-5 of Fairbridge's classification of estuaries, a 'blind estuary' which he defines as a 'low relief estuary seasonally blocked by longshore drift and/or dunes' (Olavsson and Cato, 1980). After the bar mouth is closed by a sand bar the backwaters have the essential characteristics of a lagoon,

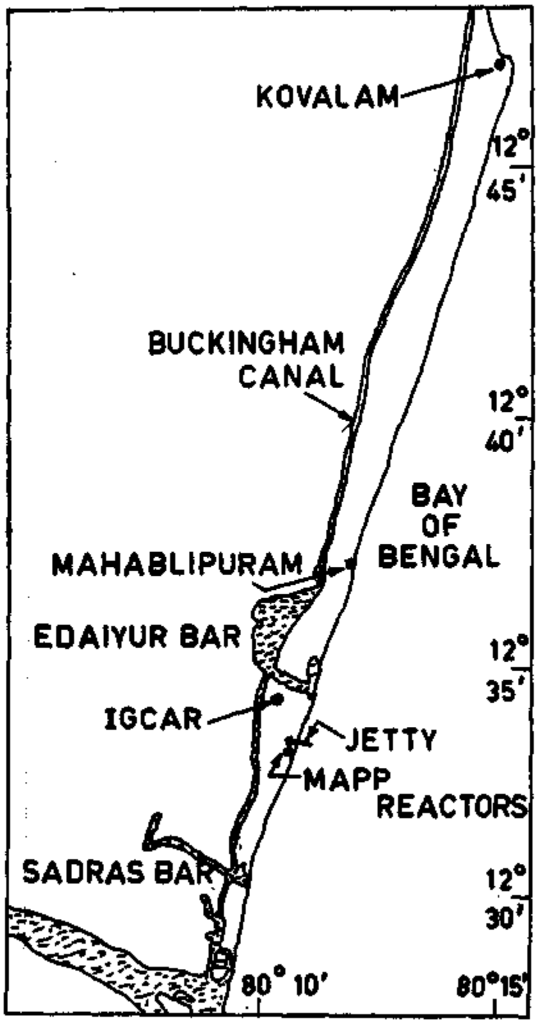

Fig. 1. The Edaiyur - Sadras estuarine system.

although it is often influenced by tides as the backwaters are linked by Buckingham Canal and some of the backwaters like the Kovalam Backwaters 20 km to the north of Edaiyur remains open to the sea for many months. Thus, the Edaiyur—Sadras as well as similar backwater systems, along the east coast of India, although conform to the definition of a blind estuary are unique aquatic systems by themselves.

The Madras Atomic Power Station (MAPS) consisting of two units of 235 Mw(e) each is located about 1.5 km to the south of Edaiyur bar mouth and about 4 km to the north of the Sadras barmouth (Fig. 1). As part of a baseline ecological study of these backwaters and the adjoining coastal waters the hydrochemical and biological characteritics have been studied since 1979. During this study the data were grouped into those belonging to (i) summer (March-May), (ii) SW monsoon (June-September) and (iii) NE monsoon (October-February) seasons as there was a distinct influence of these seasons on the distribution of hydrochemical and biological features (Nair and Ganapathy, 1983). The principal features of the three seasons have been described by Nair (1985). The present paper makes an attempt to summarise the major hydrological features of the coastal waters and assess the impact of fresh water discharges from the backwaters on the chemistry and biology of the coastal waters. These data have also assumed particular significance in the context of the operation of power plant cooling systems using seawater, as bio-fouling in the pre-condenser sections as well as in condenser tubes is considerably influenced by the seasonal variations in the hydrographic characteristics of coastal waters.

Material and methods

All chemical analysis, as well as measurements of productivity chlorophyll and seston were made following the methods described in Strickland and Parsons (1972). Secchi disc measurements were made using a 30 cm diameter, white painted disc. Surface current measurements were made using neutrally bouyant drift bottles. While the data collected on the temperature, salinity and DO for coastal waters, based on weekly samples are continuous from 1979 to 1986, other parameters like PO_4-P, Total P, Silicate, Chlorophyll 'a', primary productivity, seston and secchi disc depth are available only from 1979 to 1984.

For the backwaters, most of the data presented in this paper are those from the period 1979-1981. While the major seasonal features described herein recur every year, the magnitude and the time of occurrence of maxima and minima are governed by the yearly variations in the magnitude and time of onset of rainfal as well as the opening and closure of the bar mouths.

Results and Discussion

Results on the distribution of salinity and temperature in coastal water and data on rainfall are shown in Fig. 2. Results on the vertical distribution of salinity in the coastal waters is shown in Fig. 3. Data (maximum and minimum) on dissolved oxygen, chlorophyll 'a', secchi disc depth and silicate for coastal water are given in Table 1. Similar data (maximum and minimum) on temperature salinity and dissolved oxygen for Edaiyur Backwater are shown in Table 2.

Coastal waters

Hydrography: The coastal waters are characterised by a mean tidal range of 1.2 to 1.5 m for spring tides and 0.3 m to 0.6 m for neap tides. The coastal currents are directed north with a velocity of 0.83 km/hr to 1.9 km/hr during SW monsoon period. During NE monsoon period current directions are reversed and are directed south with velocity ranging from 0.11 to 1.37 km/hr.

Seasonal sea surface temperature data were characterised by two maxima one in April and the other in October alternating with two minima one in January and the other in July. The seasonal distribution of surface salinity is characterised by a minimum which generally falls in the month of November. Salinity values gradually increase thereafter reaching

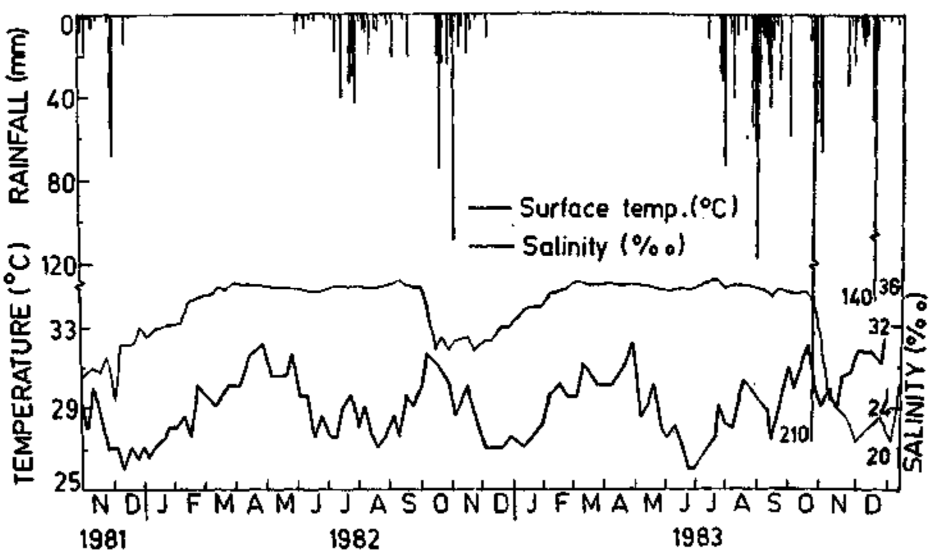

Fig. 2. Seasonal distribution of salinity and temperature along with rainfall data for coastal water at Kalpakkam.

TABLE 1. *Hydrobiological characterisations in coastal waters*

Year	D.O. (mg/l) Max. Nov.	D.O. (mg/l) Min. Feb./March	Chlorophyll 'a' (mg/m^3) Max.	Chlorophyll 'a' (mg/m^3) Min.	Secchi Disc (m) Max.	Secchi Disc (m) Min.	Silicate (μg-at/l) Max.	Silicate (μg-at/l) Min.
1979	8.0	5.9	6.4	0.75	—	—	—	—
1980	6.5	4.7	9.4	1.1	6.0	0.5	29.1	6.4
1981	7.9	4.8	9.2	1 1	7.0	0.5	54.3	1.3
1982	6.8	4.1	11.1	0.61	4.3	0.5	33.9	5.0
1983	7.0	4.8	9.2	1.65	3.5	0.5	75.7	10.7
1984	6.7	4.6	—	0.40	3.4	0.25	31.4	11.1
1985	7.6	4.2	—	—	4.2	0.75	—	—
1986	6.8	4.0	—	—	4.4	0.75	5.7	0.5

a value of around 35‰ by March and remain at the same level till October when the dominant seasonal rainfall sets in. The lowest surface salinity recorded in the coastal waters during the last 7 years was observed in 1979

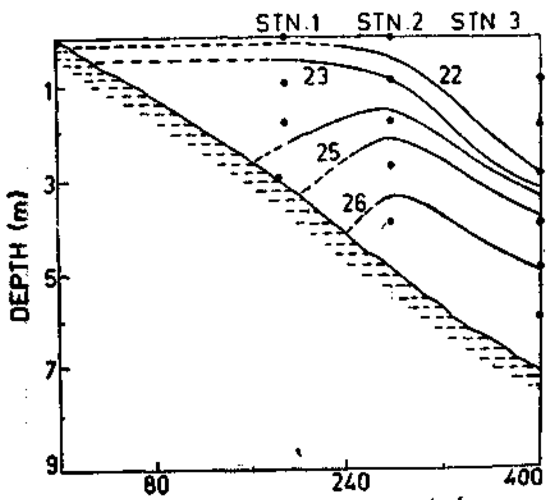

Fig. 3. Density stratification in a section along MAPP jetty during the NE monsoon period.

following an unprecedented very high rainfall during that year. SW monsoon rains in general do not have any marked influence on the salinity of coastal waters (Fig. 2). Observations on vertical distribution of salinity during the period of heavy rainfall (Fig. 3) have shown an increase in salinity with depth indicating vertical stratification in the water column. It was also observed that the salinity values increased from the shore towards the sea.

The dissolved oxygen (DO) levels ranged from 4.0 mg/l to 8.0 mg/l displaying a bimodal distribution with relatively high values occurring during SW and NE monsoon periods, the annual maximum always being recorded during the NE monsoon period.

The chlorophyll 'a' values ranged from 0.61 mg/m^3 to 11.1 mg/m^3. The seasonal distribution was bimodal with maxima in March and in September alternating with minima in August and December. The primary productivity values ranged from 1.6 mg $C/m^3/hr$ to 50.8 mg $C/m^3/hr$ and the seasonal distributions followed a pattern similar to that of chlorophyll 'a'. The period March to September was also marked by an abundance of phytoplankton (44×10^4 cells/mm^3 in March 1980 to 29×10^7 cells/mm^3 in August 1981). The zooplankton standing crop was also found to be relatively high during the period September to November (4.7 to 34.5 ml/m^3).

The seston content ranged from 3 to 58 mg/l during the period 1979 to 1981 characterised by two maxima one in June/July and other in

November/December. The water transparency data as reflected in secchi disc depth were always inversely correlated to seston content, secchi disc depth being maximum in October and minimum in May and November.

Plant nutrients

Inorganic phosphate values were relatively low in all seasons and the values ranged from BDL to 0.6 μg-at/l. The data showed a total depletion of inorganic phosphate during summer months and a corresponding rise of the total phosphorus during the same period. The values during SW and NE monsoon were in general higher than the summer season. The silicate values ranged from 0.50 to 75.7 μg-at/l. Here again relatively high values were observed during SW and NE monsoon periods.

The coastal waters in terms of the influence of rainfall and the distribution of surface salinity essentially fall into two periods October to February and March to September, while the period March to September is characterised by stable salinites, the period October to February is characterised by low and variable salinity regime. This difference in the salinity regime is reflected particularly in the standing crop of phytoplankton which showed an abundance marked by blooms of *Trichodesmium* species, when true marine condition prevailed during the period March to September. Since the period of stable salinity coincides with very high temperature both during April/May and September/October these periods also show relatively high organic productivity. Although significant dilutions of coastal water and influx of nutrients from backwaters occur only during the NE monsoon period the SW monsoon also contribute to an enrichment of nutrients like phosphate and silicates in the coastal waters owing to the turbulant conditions set up by relatively strong winds prevalent during this period.

Sadras Backwater

The seasonal temperature distribution and occurrence of maxima and minima in Sadras Backwater are essentially similar to those of coastal waters, although the maxima are sometimes a little higher. The seasonal salinity distribution show a minimum during the period November/December and the values gradually increase to relatively high values during summer. The salinity values range annually from 2‰ to 26‰. It was found that at no point of time the backwater salinity approached the coastal water salinity and the backwater could thus be considered as a positive estuary throughout the year (Perkins, 1974).

The DO values ranged from 3 mg/l to 10 mg/l and showed very wide fluctuations. The chlorophyll 'a' values ranged from 2.09 to 61.04 mg/m^3 and showed a maximum in March. The primary productivity values ranged from 20 mg C/m^3/hr to 320 mg C/m^3/hr and the annual variation showed a pattern similar to that for chlorophyll 'a' with a well defined maximum in March. The seston content values ranged from 3.2 mg/l to 43 mg/l with a well defined maximum in April. The secchi disc depth showed two maxima in water transparency, one in June and the other in October.

The inorganic phosphate levels varied from BDL to 4.8 μg-at/l and total phosphorus values ranged from 0.23 to 16 μg-at/l. Seasonal distribution of inorganic phosphate was characterised by relatively high values during summer and SW monsoon and low values during NE monsoon season. The pattern was essentially similar for total phosphorus. The silicate concentration ranged from 24 μg-at/l to 374 μg-at/l and the seasonal distributions were characterised by relatively high values during the period August to January and low values from February to August.

The Sadras Backwater thus represent a highly productive, estuarine system during the summer and SW monsoon period, when it has the characteristics of a lagoon. As the backwaters receive sewage effluent from a nearby township the phosphate levels are unusually high. The build-up of nutrients during this period every year is also setting in an ideal condition for eutrophication of these water body, which now sustains extensive growth of the seaweed *Ulva* species.

Edaiyur Backwater

The temperature distributions in Edaiyur is also similar to those of Sadras and coastal waters. The salinity values ranged from 7‰ in December to 40‰ in July. The build up of salinity starts in the month February, after the closure of the barmouth and reaches the very high value of 40‰ in the month of July when the first monsoonal rain sets in. During the period May to July euryhaline conditions prevail in this backwater making it a negative estuary at this time (Perkins, 1974).

TABLE 2. *Temperature, salinity and dissolved oxygen variations in Edaiyur Backwater*

Year	Temperature (°C) Max.	Min.	Salinity (‰) Max.	Min.	Dissolved Oxygen (mg/l) Max.	Min.
1980	33.5	26.2	40.63	7.11	7.6	4.1
1981	32.5	26.0	39.31	4.81	7.8	3·0
1983	32.4	25.5	50.80	1.48	7.2	—
1984	34.0	26.6	37.43	3.55	7.4	—

The DO values ranged from 3 mg/l to 7.8 mg/l. The annual distribution was bimodal with maxima in May/June and November/December with the fluctuations being not as marked as Sadras Backwater. The chlorophyll 'a' values were characterised by a well defined maximum in April/June and a minimum during the period September to November. The values are relatively high during February to July and low during the period August to February.

The annual distribution of gross productivity very closely followed the pattern of chlorophyll 'a' distributions. The values ranged from 3 mg C/m^3/hr to 193 mg C/m^3/hr. The Edaiyur Backwaters thus have the characteristic of a lagoon during the period February to June when the salinity builds up from a value of 20‰ in February to a value of 40‰ in June. With the onset of SW monsoon rains in July the salinity in this backwater shows a sudden fall to a value of around 10‰ and maintains at this level till January. The period July to January is also characterised by low seston, high transparency, high DO, low productivity and low inorganic phosphate, low total phosphorus and high silicates. The period February to July show a significant contrast having high phosphate, high total phosphorus, low silicate, relatively low DO, high seston, low transparency, high chlorophyll 'a' and high productivity.

A comparison of Sadras Backwaters and the Edaiyur Backwaters reveals that the salinity regime in the Sadras Backwaters is distinctly different from those of Edaiyur. While the salinity of Edaiyur Backwaters is influenced by the rain fall alone, that of Sadras is also influenced by the dicharges of domestic sewage into this water body. Thus the Sadras Backwaters are mixohaline (Perkins, 1974) and could be describedas a positive estuary throughout the year whereas, the Edaiyur Backwater is positive during the period of rain fall (July to January) and is negative during the months of April to June.

While the nutrient levels in both the backwaters are relatively high, the levels in Sadras are even higher than what that is normal in most estuarine water. The increased availability of nutrients is also reflected in the very high productivity and standing crop of phytoplankton in the Sadras Backwaters.

Contribution of backwater to coastal water

The most significant and very obvious contribution of backwaters to the coastal waters is the discharge of fresh water following the onset of severe rainfall during the month of October. This fresh water discharge leads to a significant lowering of salinity in the coastal water which takes about five months (October to February) to return to true marine condition. The lowering of salinity in the surface water leads to the development of density stratification in the coastal water particularly when the discharges are very high. The fresh water brings along with it substantial amount of plant nutrients like inorganic phosphate, total phosphorus and silicates into the coastal water as can be seen by the elevated levels of these nutrients in the coastal waters during the period October to February. Another impact of the backwater discharges on the coastal water is an increase in seston content and DO in the latter. The impact of seston is seen in reduced transparency during the months November to February in coastal water. The immediate impact of the fresh water discharge is a reduction in coastal primary productivity and inhibition of macro invertebrate growth, the latter is particularly evident from a low biofouling density observed in sea water cooling system of MAPS during this period (Murugan, Per. Comm.). The impact of backwater discharges in the longer term is a nutrient enrichment of the coastal water which would lead to increased primary as well as secondary and tertiary production during the months March to May when temperature and sunshine are ideal for primary production. The occurrence of blooms of *Trichodesmium* species as well as other phytoplankton species during March to December is also a possible consequence of nutrient enrichment.

The influx of sea water into the backwater system during the period when the barmouth is open also has its own impact on the backwater ecosystem. This is particularly so for the Sadras Backwater which owing to its lagoonal nature and due to the inflow of nutrients becomes eutrophic during the summer months. With the opening of the barmouth the macrophyte biomass as well as nutrients locked up in sediments are washed out into the sea and the estuarine system is restored as a healthy ecosystem once again. This is particularly important as the backwaters are good fishing areas, place of recreation and nursery ground for several important food crustaceans.

REFERENCES

OLAVSSON, E. AND I. CATO 1980. *Chemistry and Biogeochemistry of Estuaries.* John Wiley & Sons, New York.

NAIR, K. V. K. AND S. GANAPATHY 1983. *Mahasagar*, 16 (2) : 143-151.

——— 1985. *Impact of a Nuclear Power Station on the hydrobiological characteristics of Kalpakkam Coastal Waters.* Paper presented at the seminar on SW quality demands, NCML, Naval Dockyard, Bombay, February 20-21, 1985.

PERKINS, E. J. 1974. *The biology of Estuarines and Coastal Water.* Academic Press, London.

STRICKLAND, J. D. H. AND T. R. PARSONS 1972. *A Practical Handbook of Seawater Analysis.* The Alger Press Ltd., Canada.