

DIURNAL VARIATION OF SOME PHYSICO-CHEMICAL FACTORS IN THE MANDOVI ESTUARY OF GOA.

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ABSTRACT

Diurnal changes in temperature, salinity, dissolved oxygen and nutrient salts at two locations in the Mandovi estuary were studied in different seasons as a part of the investigations on ecological conditions of the estuaries around Goa. Temperature and salinity are influenced by tides in all the seasons whereas dissolved oxygen and nutrient salts (phosphates and nitrates) appear to be independent of tidal effects. Silicates, unlike the other two nutrients, follow the tidal change. Probable features governing the diurnal changes in different seasons are discussed.

INTRODUCTION

Tide is one of the important physical factors governing the environmental features of an estuary. Hence it is essential to obtain informations on the range of variations of some of the environmental parameters with the tidal rhythm. The importance of tidal variations, current patterns and magnitude of freshwater discharge at different periods in relation to the environmental parameters is well documented (Cameron and Pritchard, 1963; Qasim and Gopinathan, 1969; Vijayalakshmi and Venugopalan, 1973). Investigations on the general hydrographical and chemical characteristics of the coastal waters of any specific region require a good knowledge of the characteristics of the local riverine and estuarine systems, in order to understand their impact on the near and inshore regions.

Two important estuarine systems in Goa are the Zuari and the Mandovi which have considerable impact on the adjoining coastal waters; they are also important from the point of view of fishery resources and navigation. Earlier, some preliminary investigations were made on environmental features in Mandovi-Zuari estuaries by Dehadrá (1970). Singbal (1973) has reported a detailed account on diurnal variations in Zuari estuary. The present paper gives further information in specific physico-chemical conditions in relation to tidal cycle in Mandovi estuary.

Mandovi is predominantly a normal estuary in which salinities are reduced upstream as a result of considerable freshwater discharge. It runs along the northern boundary of the Panaji Island and flows into the Aguada Bay (Fig. 1). The tides are of semi-diurnal nature with a range of 2 metres (Indian Tide Table 1971 and 1972). The time and range of occurrence of the two highs and two lows show marked variations (Fig. 2).

MATERIAL AND METHODS

Fig. 1 shows the location of two stations in the Mandovi estuary where observations were made. In all, five surveys were conducted, diurnal studies were made at station A in monsoon (August 1971), in post-monsoon (December 1971) and in premonsoon (May 1972) and at station B in December (1971) and May (1972). Samples were collected from surface and bottom at 3 hourly intervals covering an entire tidal cycle in different seasons. A plastic bucket was used to collect water samples from the surface and a Nansen bottle from bottom.

Temperature of the water was measured and the samples were analysed for salinity, dissolved oxygen, phosphates, nitrates, silicates. Standard methods were adopted for the analysis of chemical parameters. (Strickland and Parsons, 1968).

RESULTS AND DISCUSSION

Temperature — The variations in the

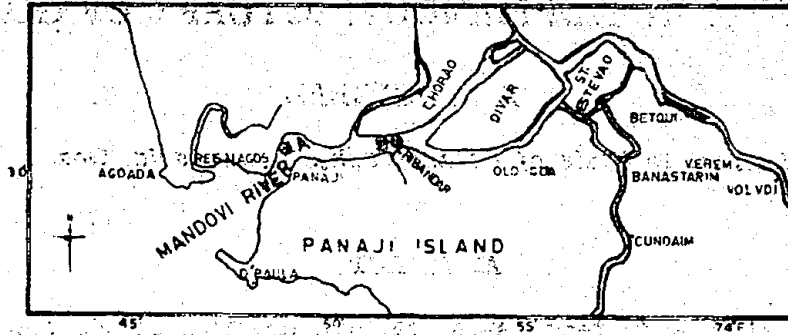


Fig. 1 — Map showing station positions.

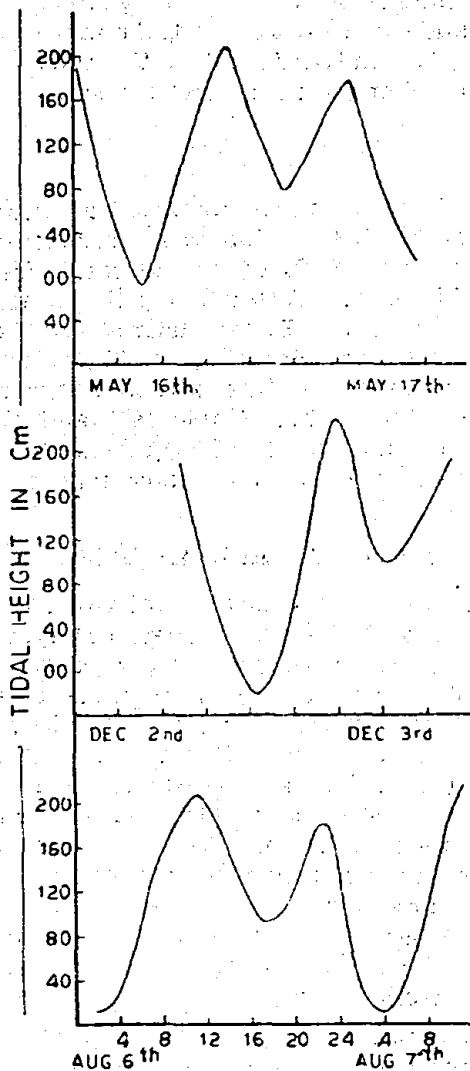


Fig. 2 — Tidal cycle in the estuary during different periods (August 1971, December 1971, and May 1972).

with maximum values at the low tide and minimum during the high tide (Table 1 and Figs. 3-5). However, in the monsoon the conditions were reversed. The temperature differences between the surface and bottom waters during the pre-and post-monsoon seasons were far less than in the monsoon. In general, the surface temperature was higher than the bottom temperature) excepting that few reversals were noticed in the post-monsoon season. The low temperature at the bottom was consistent with the conditions of incursion of sea water and consequent stratification. The high temperature of surface water was due to solar heating of the landlocked estuary. The few reversals in temperature distribution noted during the post-monsoon might be related to the mixing processes. During the tidal cycle a greater variation was observed at station B than at station A. This is because the station A is close to the sea whereas the station B is situated upstream where brackish or freshwater influence is dominant.

Salinity — Maximum salinity variations in the water layers were recorded in the monsoon season during the tidal rhythm (Fig. 3). During this period (at station A) the range of variation in salinity varied from as low as 2.45‰ to 18.69‰ at surface and from 2.45‰ to 28.95‰ at the bottom. During the other seasons even though the range in salinity variation was low (Table 1) the changes were linked with the tides. This feature is obviously related to the extent of river flow during the ebb tide. (Excepting on very few occasions (Figs. 3, 4, 5) the salinity throughout the tidal cycle was low at the surface and high at the bottom). A few exceptions were probably related to turbulence. The salinity

temperature at both surface and bottom waters with tides was more or less similar during the post-and pre-monsoon seasons

Table 1: Variations in physico-chemical parameters at stations A and B in relation to period, tide and depth as observed during each diurnal cycle.

| St on | Date and state of tide. | Height of the tide in meters | Depth in m | Sam-ple | Temp °C | | S % | | O ₂ ml/l | | PO ₄ -P μg-at/l | | NO ₃ -N μg-at/l | | SiO ₂ -Si μg-at/l | |
|-------|-------------------------|------------------------------|------------|---------|---------|-------|-------|-------|---------------------|------|----------------------------|------|----------------------------|------|------------------------------|-------|
| | | | | | max | min | max | min | max | min | max | min | max | min | max | min |
| A | 6.8.71 | HHW 2.10 | 7.0 | S | 29.00 | 27.80 | 18.69 | 2.45 | 5.34 | 4.52 | 1.87 | 1.45 | 1.65 | 0.90 | 119.53 | 57.75 |
| | 7.8.71 (neap) | LLW 0.04 | | B | 28.60 | 26.10 | 29.05 | 2.45 | 4.81 | 3.01 | 2.53 | 1.17 | 1.44 | 0.99 | 100.72 | 60.72 |
| A | 2.12.71 | HHW 2.31 | 12.0 | S | 26.50 | 25.50 | 34.29 | 28.17 | 4.20 | 3.10 | 1.10 | 0.31 | 3.90 | 0.49 | 55.12 | 16.60 |
| | 3.12.71 (neap) | LLW 0.20 | | B | 27.40 | 23.80 | 34.69 | 25.91 | 4.87 | 3.08 | 1.58 | 0.22 | 2.67 | 1.19 | 60.25 | 15.38 |
| A | 16.5.72 | HHW 2.23 | 10.0 | S | 29.90 | 28.00 | 35.38 | 33.24 | 3.70 | 3.02 | 0.78 | 0.26 | 2.94 | 1.64 | 15.38 | 3.85 |
| | 17.5.72 (neap) | LLW 0.11 | | B | 29.80 | 26.70 | 35.75 | 33.43 | 3.47 | 2.58 | 1.38 | 0.40 | 3.15 | 1.50 | 20.15 | 5.13 |
| B | 2.12.71 | HHW 2.31 | 8.5 | S | 26.50 | 25.50 | 33.28 | 20.68 | 4.20 | 2.24 | 1.58 | 0.40 | 3.49 | 1.01 | 26.15 | 6.14 |
| | 3.12.71 (neap) | LLW 0.20 | | B | 27.10 | 24.70 | 33.58 | 20.48 | 4.93 | 3.42 | 1.39 | 0.47 | 2.47 | 1.16 | 44.87 | 19.23 |
| B | 16.5.72 | HHW 2.24 | 8.5 | S | 30.05 | 28.30 | 35.58 | 30.08 | 4.03 | 2.80 | 1.06 | 0.40 | 3.36 | 1.09 | 23.07 | 2.56 |
| | 17.5.72 (neap) | LLW 0.11 | | B | 29.60 | 27.10 | 35.70 | 30.67 | 3.47 | 3.02 | 1.55 | 0.78 | 3.36 | 1.13 | 34.00 | 5.13 |

HHW=Highest high water. LLW=Lowest low water S=Surface. B=Bottom.

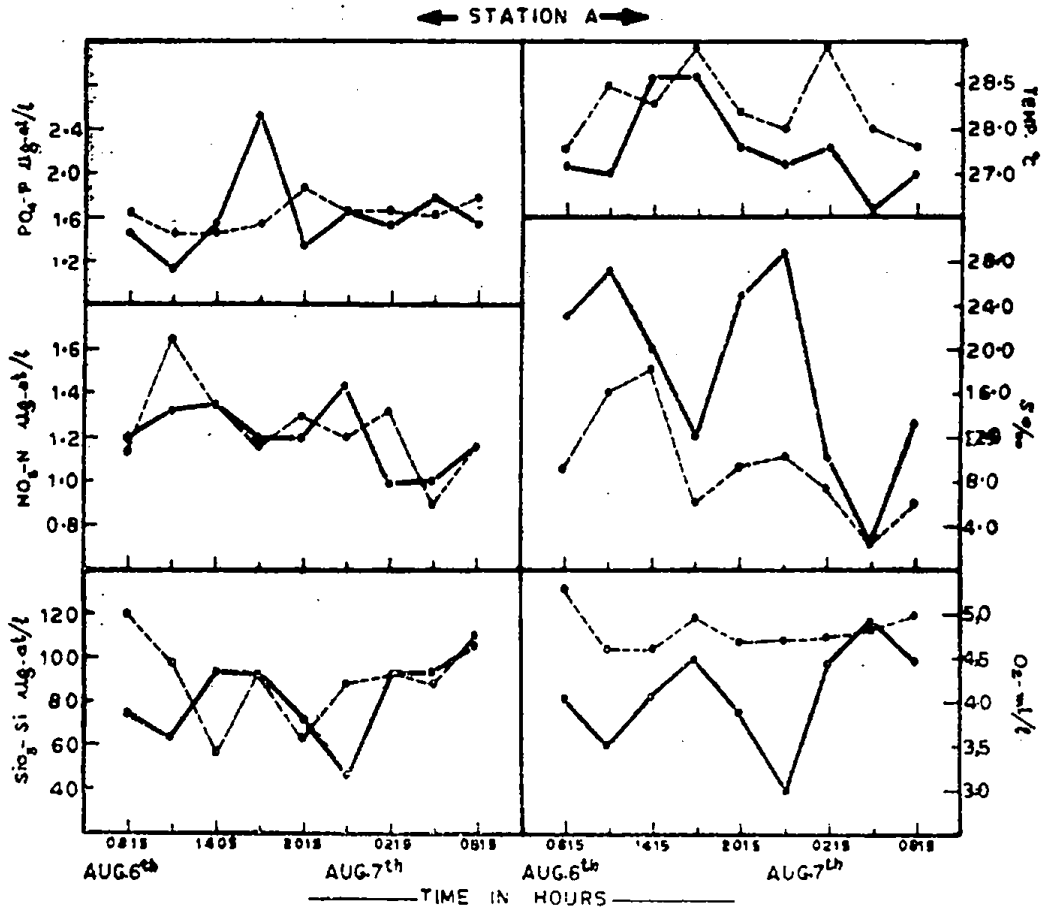


Fig. 3 — Diurnal variations of the physico-chemical parameters in August 1971.
 Surface ——— Bottom

patterns of station A and station B were similar to those of temperature; maximum changes occurred at station B especially during the monsoon. In the pre-and post-monsoon seasons the marine dominance of the estuary is clearly seen from the relatively uniform levels of salinity at the surface and bottom. Broadly, the salinity characteristics in the Mandovi estuary agree well with those of other estuaries (Capstick, 1957; Rangarajan, 1958; Vasisht, 1965; Qasim and Gopinathan, 1969; Singbal 1973).

Dissolved oxygen — The oxygen content of the water appears to be independent of tidal variations especially at the surface. However the tidal influence on the oxygen levels was clearly recorded at the bottom during the monsoon (Fig. 3). In general, the concentration of oxygen was high during the ebb tide and low during the

flood tide. This feature is perhaps related to the solubility of oxygen which is more in fresh or brackish water than in the sea water. It can also be seen that the oxygen levels increased during the day time and decreased during the night hours; marked variations between surface and bottom were probably also due to biological production and utilization. The distribution of oxygen at station A and B during the post-and pre-monsoon seasons seems independent of tides. However, even in this season, variations were noted at station B.

Phosphate — During the monsoon the phosphate content of the waters was found to be very high, due to the effect of excess land drainage. Observations on the diurnal changes do not show a clear relationship with the tides especially in the surface waters. Probably turbulence disturbs the two layer system caused by the large in-

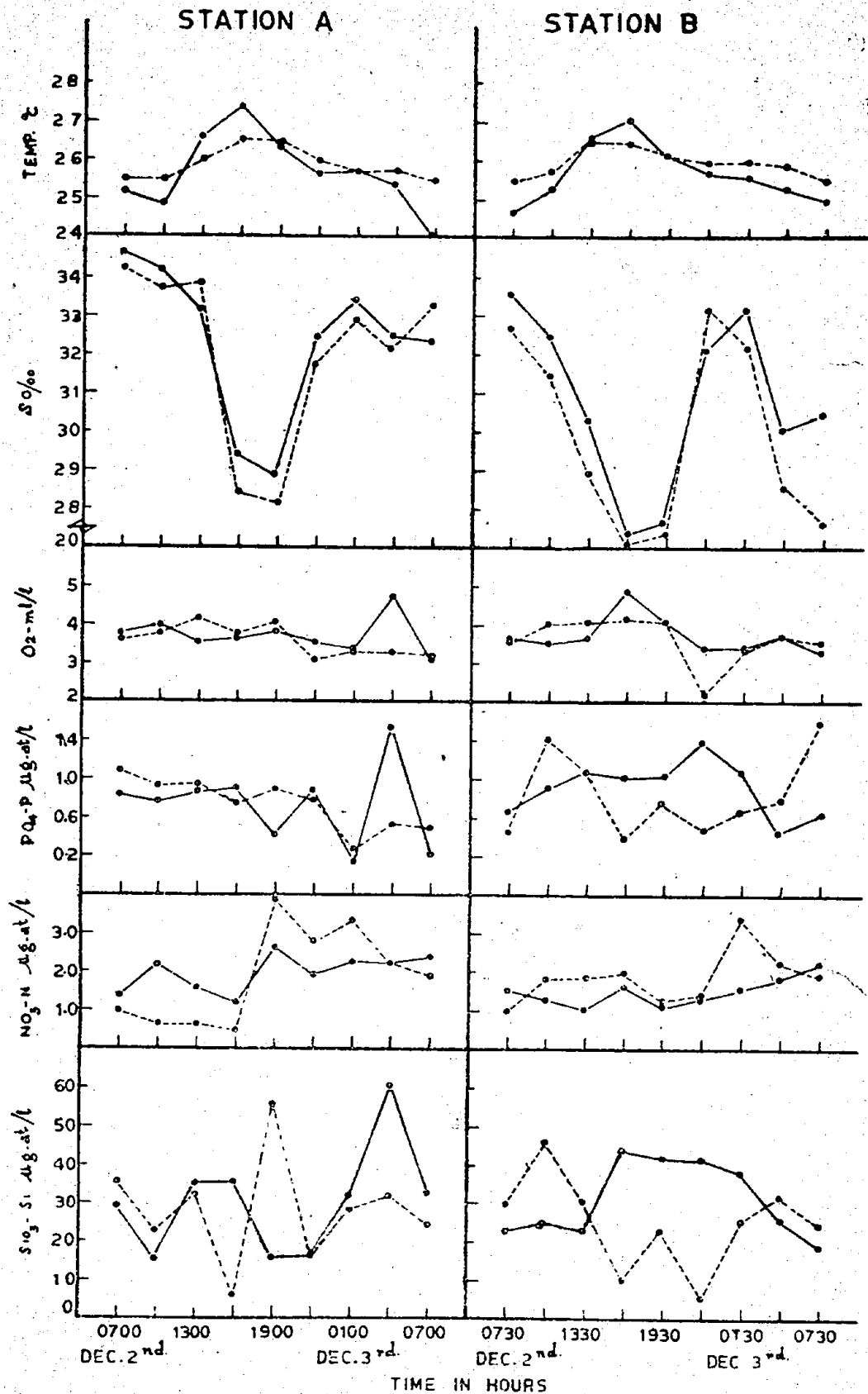


Fig. 4 — Diurnal variations of the physico-chemical parameters in December 1971.
 Surface ——— Bottom

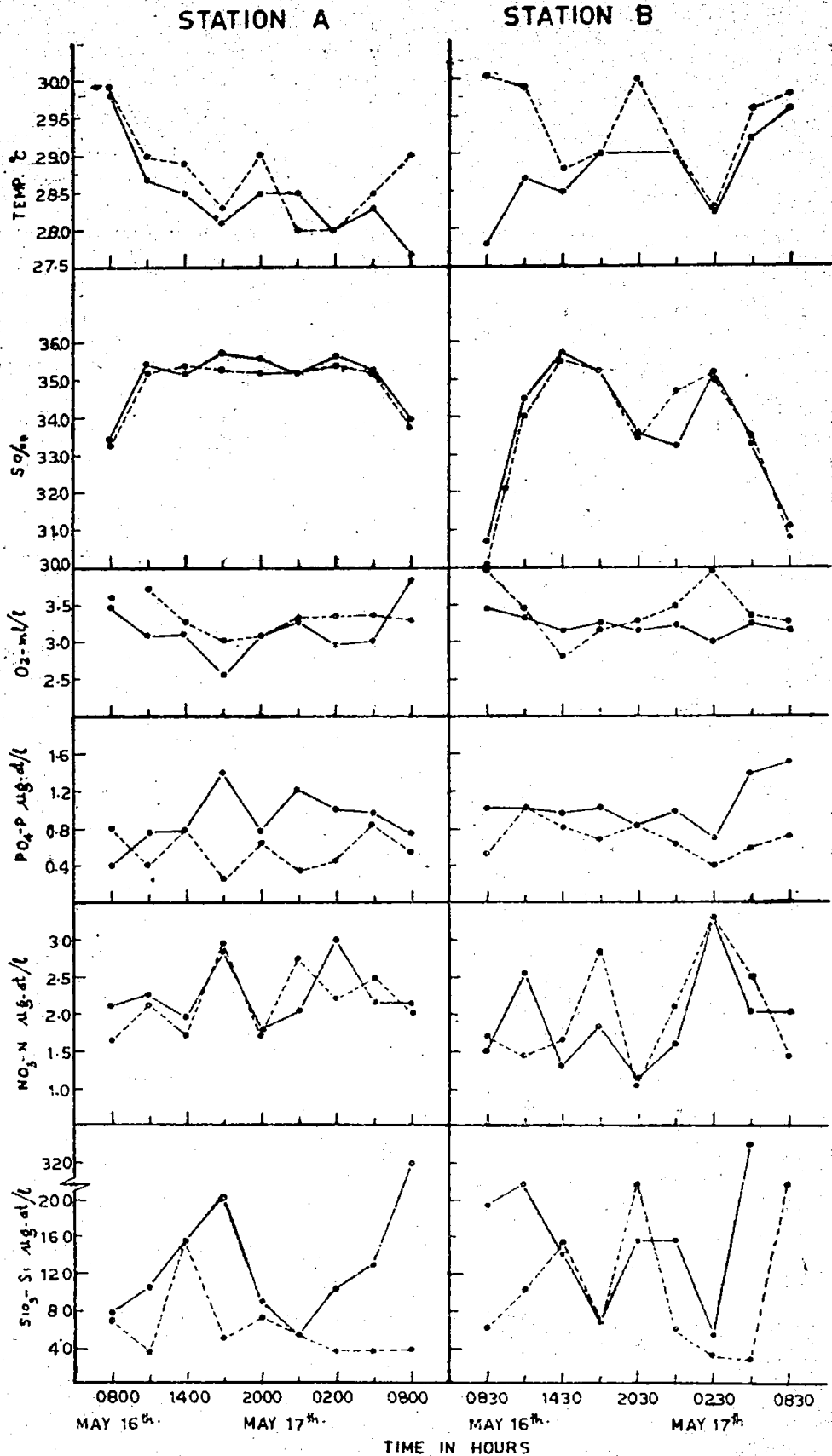


Fig. 5 — Diurnal variations of the physico-chemical parameters in May 1972.
 Surface ——— Bottom

flux of fresh water. Highest concentration recorded at the bottom reflects the effect of strong turbulence releasing more phosphate from the sediments. In the bottom waters low phosphate content was generally associated with the flood tide and high phosphate with the ebb tide. The phosphate concentration of the waters decreased during post-and pre-monsoon months. Diurnal changes were also observed to be more during these seasons than during the monsoon period. The changes appear to be independent of the tides. Phosphate concentration at the bottom was always higher than at the surface during the two seasons excepting on a few occasions. This might be due to the regenerative activity of the bottom sediments releasing a greater phosphate in the bottom layers (Reddy and Sankaranarayanan 1972).

Nitrate — In contrast to phosphate, the nitrate concentration was low during the monsoon month and high during the other seasons. Diurnal changes of nitrate at station A and B do not bear any relation with the tides and were highly erratic.

Silicate — High concentrations of the silicate were observed during the monsoon due to the influx of freshwater bringing large amounts of silicate. Diurnal variations followed the tidal changes, unlike phosphate and nitrate. Diurnal variations were very high in the post-and pre-monsoon months.

From the foregoing account it is clear that significant diurnal variations in physico-chemical parameters occur in the estuary during different seasons. The variations within a short distance (stations A and B)

were found to be considerable. This feature is obviously related to the proximity of the locations in relation to the estuarine mouth and the sediment characteristics. Sankaranarayanan and Qasim (1969) observed large variations in the Cochin backwater at different locations. Reddy and Sankaranarayanan (1972) suggested that such variations within short distances are largely related to the regenerative properties of muds of the estuary. Station A is subjected to relatively stronger influence of the coastal waters as compared to station B where the water remains brackish. Temperature and salinity, changes seem to be linked with the tidal changes whereas the nutrients with the exception of silica, show erratic changes which are due to tides. The changes in silicate however, seem to be controlled by tides. The nutrient concentrations in the estuaries are higher than the coastal waters in all the seasons and reach maximum levels during the monsoon period. This feature of Mandovi estuary is similar to that of the Zuari estuary (Singbal, 1972) and reflects a limited rate of flushing during the tidal cycle.

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