SEASONAL VARIATIONS OF THE HYDROLOGICAL FACTORS OF THE MADRAS COASTAL WATERS

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Introduction

Studies on the hydrological conditions in the coastal waters of India are few compared to similar investigations in the temperate zones. It is an accepted fact that the chemical constituents, especially the nutrient salts, present in the waters act as limiting factors in the distribution and abundance of plankton, which is an important link in the food chain of fishes. Therefore the importance of hydrological studies in a fisheries research programme needs no emphasis. The present paper, embodying the results of investigations carried out at Madras from June 1956 to May 1958, deals with the seasonal fluctuations of pH, salinity, dissolved oxygen, phosphates, silicates and nitrites.

Material and Methods

The samples were collected once a week from a fixed area, having a depth of 8 fathoms, three miles off the Madras Coast at about 6 A.M., using coloured bottles and observing the usual precautions of excluding air bubbles. Only surface samples were collected. The analyses of the samples were carried out within five hours from the time of collection. The pH was determined with the help of a Lovibond Comparator using Thymol Blue as indicator. The salinity was estimated by Mohr's method. Standard seawater supplied from Copenhagen was used for reference. The dissolved oxygen was estimated by Winkler's method. Inorganic phosphates were estimated by Denige's method as modified by Robinson and Thompson (1948 *a*). The silicate content was determined by the colorimetric method of Dienert and Wadenbulcke as modified by Robinson and Thompson (1948 *b*). Nitrites were estimated by using Greiss-Illosway reagent as followed by Orr (1926). Colours were compared in Nesserler's cylinder in bright diffused light.

Results

(*a*) *Hydrogen-ion-concentration.*—The monthly average values of pH are presented in Fig. 1. It showed no marked fluctuations, the average values ranged between 8·42 and 8·65.

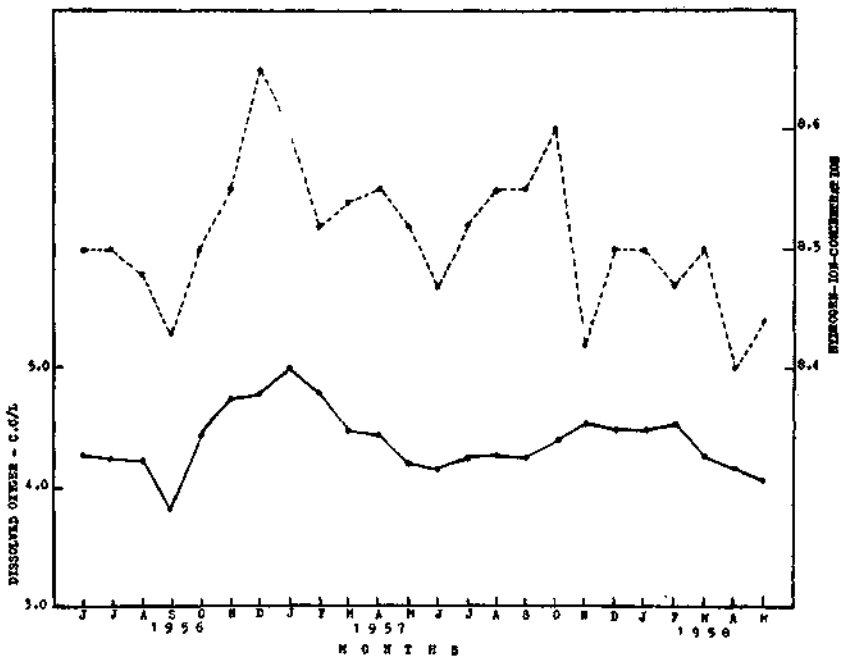

FIG. 1. Seasonal variations of the hydrogen-ion-concentration and the dissolved oxygen content during the period from June 1956 to May 1958. pH values are not corrected for salt error.

(*b*) *Salinity.*—Figure 3 shows the seasonal trends in the variations of the salinity. In 1956, the salinity abruptly fell in October and reached a minimum value in December. From January 1957 onwards it rose gradually and reached maximum values during the period March to October. Again a sudden lowering was found in November 1957. Once again it reached the maximum values during the period March to May 1958. Minimum monthly averages obtained during the period of investigation were 23·90‰ in December 1956 and 24·91‰ in November 1957, and the maximum monthly averages recorded were 34·20‰ in August 1956, 34·18‰ in May 1957 and 34·56‰ in April 1958. Exceptionally low values of 17·77‰ and 18·24‰ were observed on 7th December 1956 and 8th November 1958 consequent on the heavy rains and the influx of freshwater.

(*c*) *Phosphates.*—Figure 3 depicts the seasonal fluctuations in the phosphate concentrations. The waters were rich in phosphates during the period July to November. From December onwards the concentration of phosphates decreased and a minimum value was found in the month of February in both the years 1957 and 1958. It is of interest to note that the maximum values recorded during the period have been in the same month of each

year, *i.e.*, in August of 1956 and 1957. The values were 1·03 μg. at P/L and 1·22 μg. at P/L. Complete depletion of phosphates never occurred in the coastal waters during these two years.

(*d*) *Silicates.*—Figuré 2 illustrates that the silicate concentration has some notable seasonal fluctuations. The highest values were recorded either in November or in December. High values of 61·00 μg. at Si/L and 36·00 μg. at Si/L and were recorded on 7th December 1956 and 8th November 1957 respectively. These dates corresponded to those on which unusual lowering of salinity took place.

(*e*) *Nitrites.*—The monthly average values for nitrites are given in Fig. 3. High nitrite concentrations were found during the periods June to September and November to December. From January onwards a sudden decrease in nitrite content was noticed and waters were impoverished of this nutrient during the period February to April. In the year 1957, even complete depletion occurred during this period. In 1956, the two maximum values recorded were 0·51 μg. at N/L and 0·38 μg. at N/L respectively in the months of September and December. But in 1957 the two maximum values, 0·55 μg. at N/L and 0·43 μg. at N/L, were recorded in July and November respectively. It may be mentioned that the second peak of the nitrite concentration in a year occurs during the north-east monsoon period which starts from November.

(*f*) *Dissolved oxygen.*—The seasonal fluctuations of the dissolved oxygen content are illustrated in Fig. 1. In general the trends were found to be more or less similar during the years 1956, 1957 and 1958. But it may be stated that the high values may be expected in the period from November to February and low values from May to June. It has been found that the coastal waters were not far from the saturation point.

Discussion

It is a common knowledge that salinity is a good indicator of the movements of water masses. The salinity of the Madras coastal waters shows very marked fluctuations. During the months April to August each year, it reaches very high values and during November and December very low values. On 7th December 1956 and 8th November 1957 the two considerably low values recorded have been 17·77‰ and 18·24‰ respectively. Jayaraman (1951) investigating the seasonal trends of the salinity of the waters of the same area observes "by the middle of October, a downward trend is indicated and is continued till the end of December". From Fig. 2 of Ramamurthy (1953), a lowering in salinity of the waters of the same zone

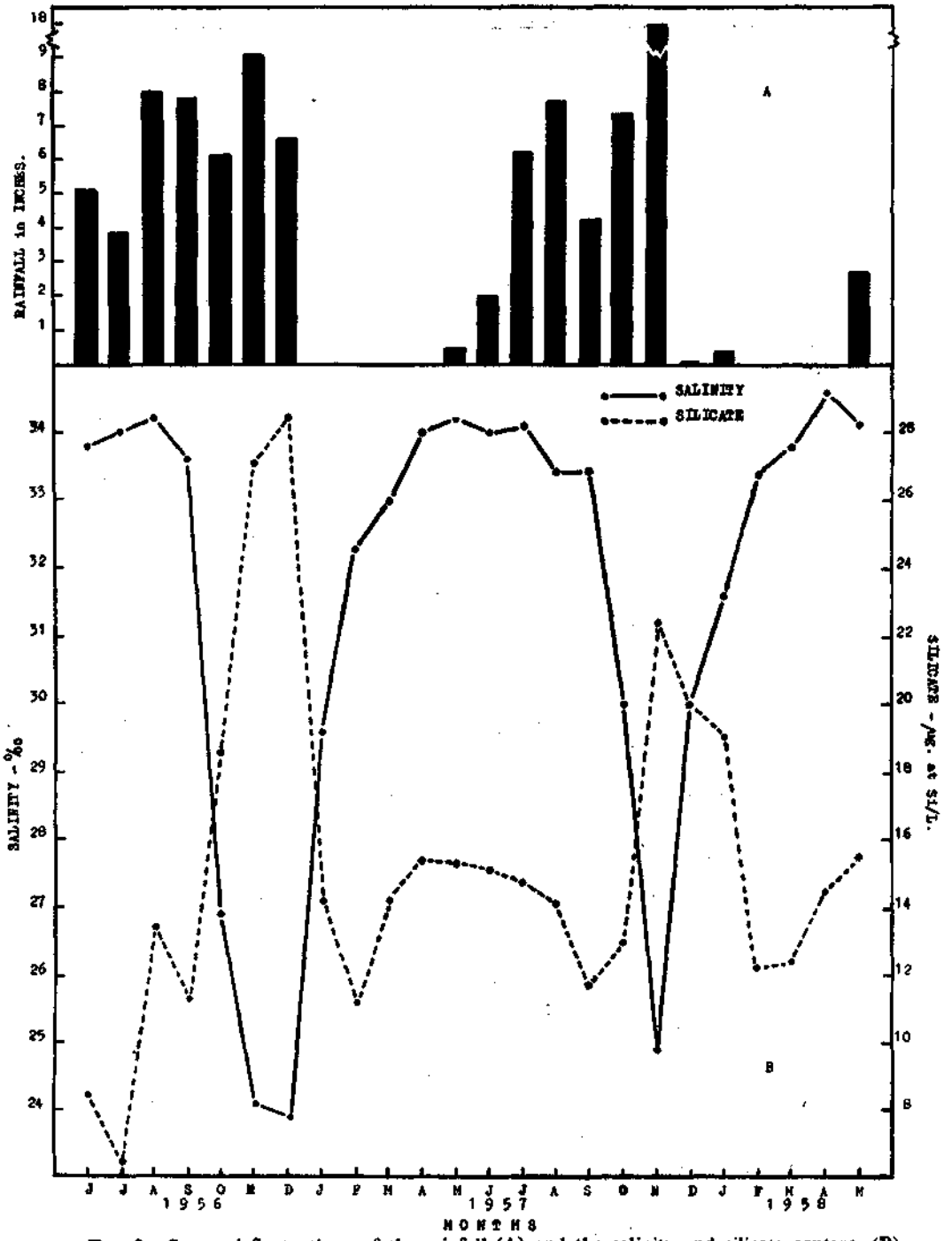

FIG. 2. Seasonal fluctuations of the rainfall (A) and the salinity and silicate contents (B) during the period from June 1956 to May 1958.

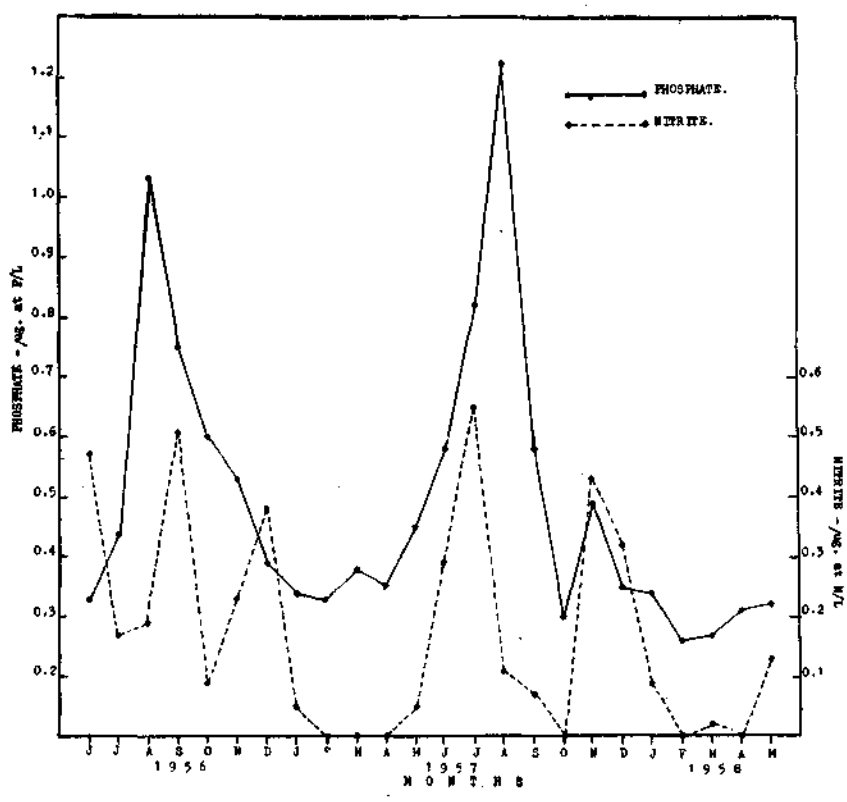

FIG. 3. Seasonal fluctuations of the phosphate and nitrite contents during the period from June 1956 to May 1958.

can be seen during the corresponding period, October to December. In Palk Bay and the Gulf of Mannar, which form a part of the Bay of Bengal, Jayaraman (1954) records salinities as low as 23·90‰ during the months of December and January. In the coastal waters of Visakhapatnam a very low salinity during the period September to October has been observed by many investigators (La Fond, 1954, 1958 *a* and *b*; Ganapathy and Sarma, 1958; Ganapathy and Rao, 1958). From the above observations, the lowering in the salinities during September to October in Visakhapatnam, October to December in Madras, and December to January in Palk Bay and Gulf of Mannar, can only be attributed to the southerly current along the East Coast of India originating from the North, as has been already established by Sewell (1929). La Fond (1954) explains that "the low salinity is caused by discharges from the large rivers (Ganges and Brahmaputra) which dilute the surface layers and flow down the coast". However, exceptionally low salinity values observed in December 1956 and November

1957 may be due to the local influx of freshwater from the rivers, Coum and Adyar, consequent on the heavy rains during this period, the bar remaining open. The gradual increase in salinity observed after the cessation of the north-east monsoon during January to March is perhaps due to the northerly current as has been suggested by Sewell (*loc. cit.*) and inferred by Ramamurthy (1953) and La Fond (1954).

The silicate and nitrite constituents of the Madras coastal waters show a high concentration during the corresponding periods of low salinities. It has been shown by various workers (Nash, 1947; Jayaraman, 1951 and 1954; Ramamurthy, 1953) that river waters are rich in silicates and nitrite, if polluted. During this period polluted freshwaters from the rivers Coum, and Adyar flow into the coastal waters effecting a marked rise in silicates and nitrites. Braarud and Føyn (1951) have observed a direct correlation between the concentration of nitrites in the coastal waters and the polluted water flowing in.

Corresponding to the high salinity values in April to August, the concentrations of phosphates, silicates and nitrities were also high. The dissolved oxygen content was low during this period. Similar observations on the relationship between the salinity and nutrient content of the Madras waters have been made by Ramamurthy (1953). During this period the rivers do not flow to the sea, the bar remaining closed, although there is a certain amount of rainfall. Low dissolved oxygen content, rich nutrient salts and high salinity are the characteristics of upwelled waters. The increase in the nutrient content of the coastal waters during this period can only be attributed to upwelling. Observing high salinities and low temperatures in the coastal waters off Visakhapatnam, La Fond (1954) suggests upwelling along the coast during March to April.

The seasonal fluctuations in the phosphate content have been attributed by numerous workers to the photosynthetic activity. The concentration of phosphate in the Madras coastal waters shows marked fluctuations, reaching high values during July to November and comparatively lower values for the rest of the year. The results compare well with those of Jayaraman (1951). The same author has also indicated a close relationship between the dissolved oxygen content and the concentration of the phosphate. The results obtained here do not indicate any such relationship which is in conformity with the conclusion arrived at by Ramamurthy (1953).

Summary

1. Studies were made on the variation of Hydrogen-ion concentration, salinity, dissolved oxygen and nutrients in the surface-waters

of the Madras Coast for a period of 24 months from June 1956 to May 1958.

2. The salinity of coastal waters showed marked seasonal fluctuations, registering low values during the north-east monsoon period and increasing gradually from January onwards to record the maximum values during the summer months. The coastal waters are influenced by the southerly and northerly currents alternately. During the north-east monsoon period, there is an influx of freshwater from Cooum and Adyar rivers which brings marked lowering in salinity of the coastal waters.

3. The nutrient salts also showed seasonal variations. During the north-east monsoon period the concentration of the silicate and nitrite went up due to the discharge of fresh and polluted waters from the rivers, the Adyar and Cooum. After the cessation of the north-east monsoon the concentration decreased. The high concentration of all the three salts from April to August has been attributed to the subsurface water coming to the surface.

4. The dissolved oxygen content of the coastal waters also showed some variation. The value was high during the north-east monsoon period and was low during April to August.

5. The Hydrogen-ion concentration did not vary considerably.

Acknowledgements

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