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SOME ASPECTS OF THE HYDROGRAPHICAL CONDITIONS OF THE BACKWATERS AROUND WILLINGTON ISLAND (COCHIN)*

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THE Cochin backwaters which form more or less a northward extension of the Vembanad lake have all the characteristics of a typical estuary. On the southern side of the backwaters there is the influx of waters of the Pampa river and on the northern side, the Periyar. The channel to the west opening out into the Arabian Sea is the main area for the exchange between the sea and the estuary. These backwaters thus form a very interesting subject of study not only from the point of view of the seasonal variation in the various hydrographic parameters, but also this is an area where there is considerable scope for a theoretical study of magnitude of exchanges across the transition. The tidal exchanges across the channel are fairly high, as also the influx of freshwater. Apart from the influence of monsoon rains and the considerable amount of evaporation during hot months in this shallow environment, the influence of various types of phenomena in the Arabian Sea such as upwelling, sinking, coastal piling etc. is quite considerable and these result in certain characteristic variations in the hydrographical and associated conditions in this area. The present paper is an attempt to work out the main pattern of distribution of the various parameters—spatial as well as temporal and to indicate the mixing processes which make this area quite interesting not only to the hydrographer but to the biologist as well.

METHODS AND SOURCES OF DATA

With a view to having an adequate sampling schedule which will give a good coverage to this highly complex environment, five stations were established, one in the main channel leading out to the sea, two on the eastern and western sides of the Willington Island in the Ernakulam and Mattancherry channels respectively and two near the northern and southern tips of the island. The locations of stations are indicated in Fig. 1 which also gives an idea of the bottom topography of the area. The variations in the bottom features are mainly caused by the dredging operations connected with the harbour maintenance, but the main point stressed here is that this bottom topography which has a typical upslope from sea inwards exerts a distinct influence on the hydrographical conditions of the backwaters.

The collections were carried out on board the departmental motor launch *CHEMMEEN*, which is well equipped for work in the shallow backwaters. Surface water samples were collected using a surface sampler (fitted with a thermometer), and samples at half meter above the bottom were obtained with the aid of a Nansen reversing bottle provided with two protected reversing thermometers.

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The data which have been collected regularly over a period of two years are presented as distribution charts for the various seasons. The surface and bottom conditions are depicted separately. The stations 3 and 4, at the Sea entrance have

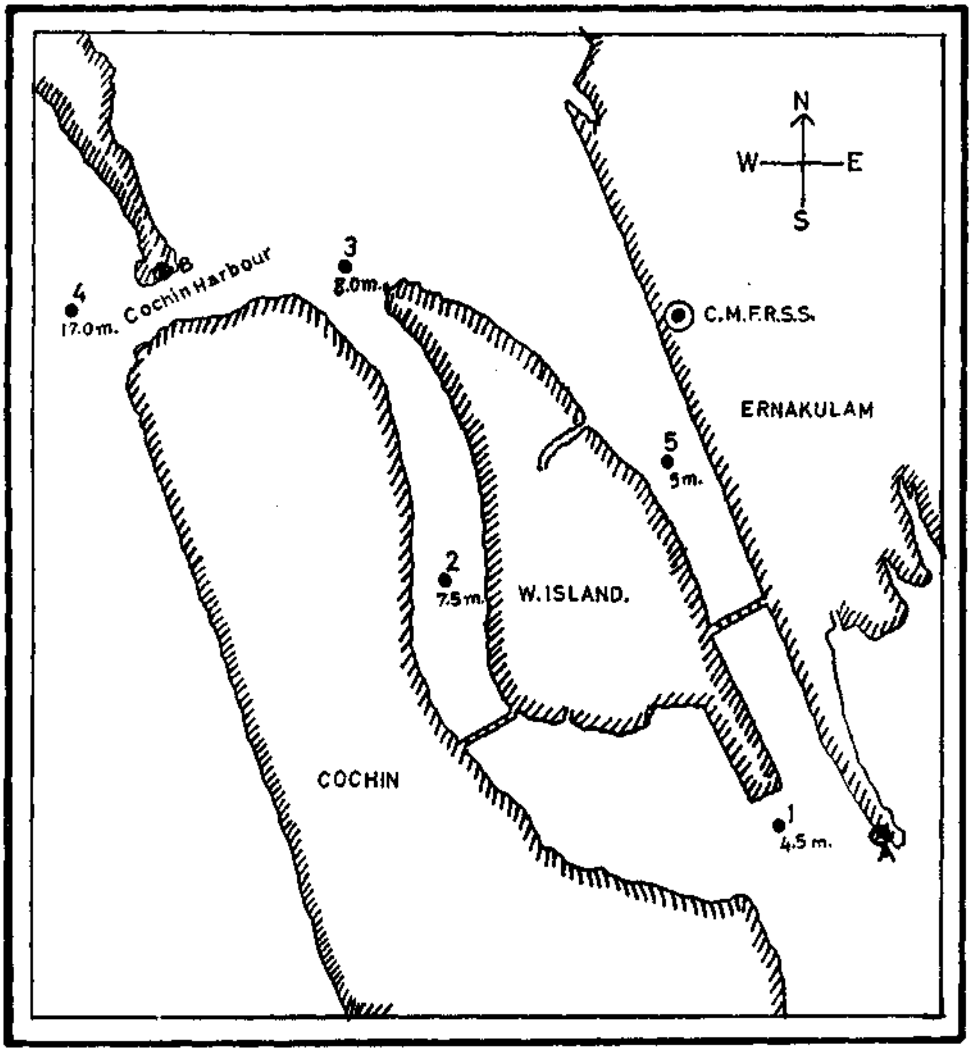

Fig. 1. Map showing the location of hydrographic stations in the backwaters.

been plotted at one end so as to envisage the oceanic intrusions into the estuary. The two seasons chosen for study are the June-October period comprising monsoon and post-monsoon months and November-May period which includes the months of least disturbed conditions with the exception of May. Although this grouping is apparently arbitrary, an examination of the results will indicate the appropriateness of this grouping.

DISCUSSIONS

A. *Period November-May.*

The surface temperatures are found to be quite high throughout the season the range being 29°-32°C. During the interval December-February there has been a decline in the surface temperatures, a difference of more than 2°C occurring between the values, found during November and the period March-May. The linear structure of the isotherms indicates an uniformity in the distribution of parameters in almost all the stations.

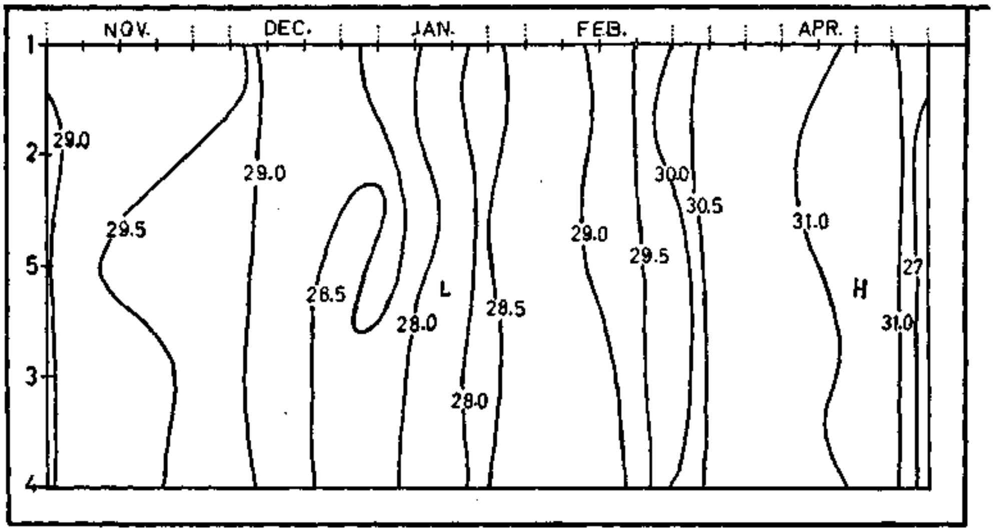

Fig. 2. Seasonal distribution of bottom temperature in the backwaters during the period November—May.

The distribution of bottom temperature is shown in Fig. 2. The range of variation of bottom temperature is found to be 28°-31°C again the lowest occurring during the period December-February. As the season progresses a gradual warming up of the surface and bottom layers is seen and by late April the bottom temperature is as high as 31.45°C at stations 3 and 4. By the time of the onset of monsoon a sudden decrease in the bottom temperature is noticed as can be seen from the position of the 27° C isotherm in the figure.

It may be seen that the vertical thermal gradients in almost all the stations are found to be very weak. Even at station 4, the deepest of the sampling stations the maximum difference between surface and bottom temperature was never greater than 1.2°C, showing good vertical mixing especially during the period December-April, in the backwaters.

The distribution of surface salinity is presented in Fig. 3. during November and early December the surface salinites were low and there is found a sudden increase after December. During January, February and March the surface salinities are found to be quite high as can be seen from the figure, and maximum is noticed during March and April. By late May salinity begins to decrease.

But, the bottom salinity conditions during the whole season are found to be quite uniform, variations being only between 32.5% ? and 34% „ which considering the nature of the environment is not very much. An intrusion of more saline water from the sea into the estuary is perceptible during the period. The salinity stratification is found to be much more distinct than that of temperature during the period.

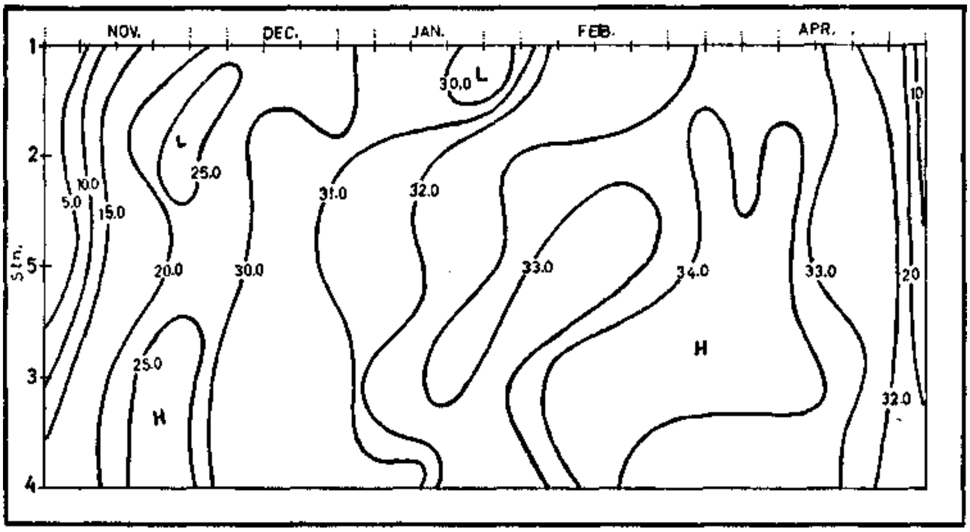

Fig. 3. Seasonal distribution of surface salinity in the backwaters during the period November—May.

Except for the period January-April the vertical salinity gradient is found to be quite steep, there being a difference of more than 20‰ between the surface and bottom values. Although the bottom water has its origin from the sea close by, the temperatures of the waters at corresponding depths in the adjacent sea area are not much different from those encountered within the estuary, while their salinities are much higher. Thus while there are more or less isothermal conditions in the backwaters, there is a distinct salinity gradient from surface to bottom.

The dissolved oxygen values at station 4, the main area of the exchange in the transition zone of the estuary range between 3.5 and 4.5 ml/1 at surface and slightly less than 3.5 ml/1 at the bottom. But the surface bottom differences are never marked during this period. As this was the only station where oxygen sampling was done, comparable values for the other stations are not available. An appreciable degree of oxygenation of the backwaters during this period is however evident from the values at this station.

B. *Conditions during the period June-October.*

The hydrographical conditions in the Cochin backwaters during the period June-October are quite interesting and these provide a much better understanding of the influence of the Arabian Sea on the backwaters.

The distribution of surface temperature during this period is given in Fig. 4. By the onset of monsoon there is found an overall decrease in the surface temperature, a difference of 1.0°-1.5°C occurring during June and July. More or less a constant trend is maintained in the surface temperature throughout the season. A certain

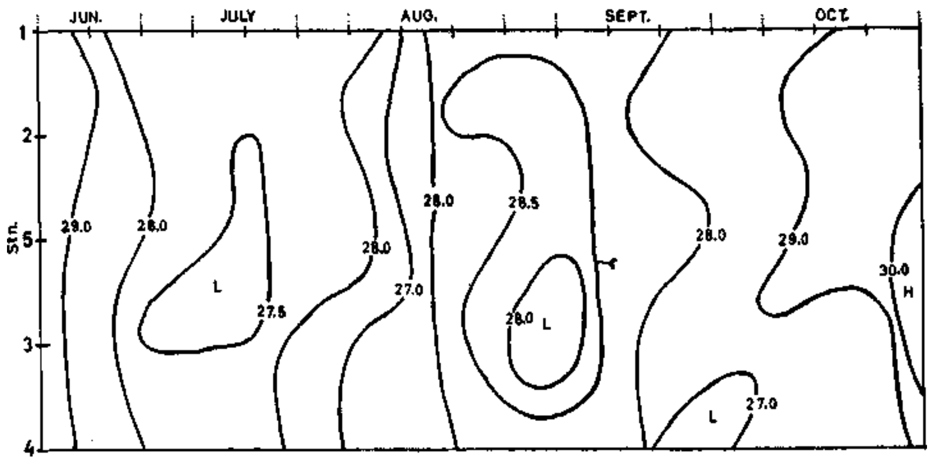

Fig. 4. Seasonal distribution of surface temperature in the backwaters during the monsoon and post-monsoon periods.

amount of uniformity is maintained in the surface temperature in almost all the stations except for two cells of low temperature encountered occasionally during the rainy season. The increase of surface temperature towards the latter part of October is well indicated by the trend of the 30°C isotherm.

The distribution of bottom temperature in the backwaters during the monsoon and post-monsoon seasons furnishes important indications as to the extent of mix-

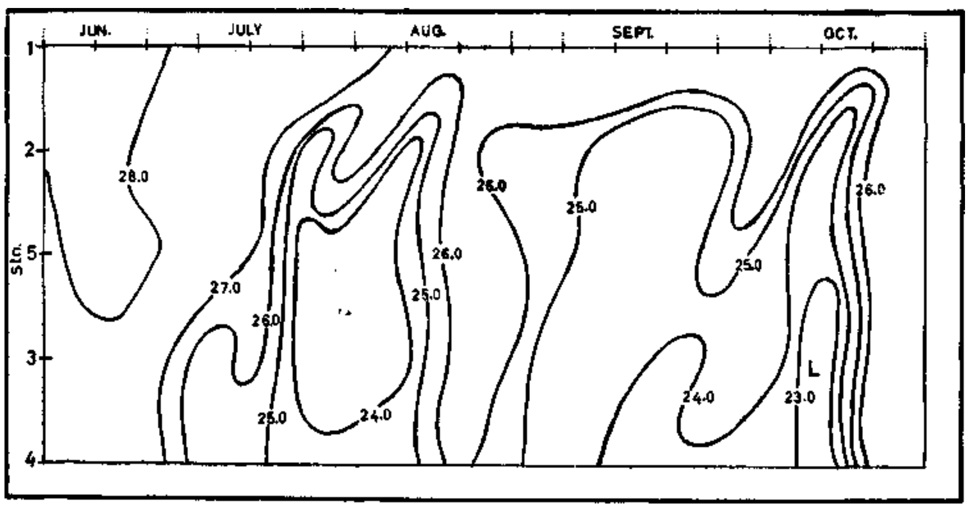

Fig. 5. Seasonal distribution of bottom in the backwaters during the monsoon and post-monsoon periods.

ing with the waters of the Arabian Sea. The pattern of distribution is given in Fig. 5. During June and July the bottom temperatures are not very much different from that of surface, an extension of warmer water being seen to proceed from the southern region to the northern one. But as season progress the bottom temperatures get reduced very much and this reduction seems to occur fairly rapidly. During July and August values of the order of 23.8°C are found to occur at the bottom of stations 3, 4 and 5. A tongue of low temperature is found to extend into the estuary almost near to station 1. It is noted that lowest bottom temperatures occur at station 4 and station 3. Just after August another sharp reduction in the bottom temperature occurs as can be seen from the figure, probably a second intrusion of cold waters from the sea into the estuary.

The vertical thermal gradients in the backwaters are found to be quite steep, there being a difference of nearly 4°-6°C between surface and bottom temperatures during the two intrusions of the oceanic water into the estuary. This steep gradient is maintained more or less throughout the season at all stations except at station 1, which is shallowest. The steep upslope in the bottom topography towards south would probably act as a barrier to the intrusion of this cold water or there may be factors which may not be easily understood.

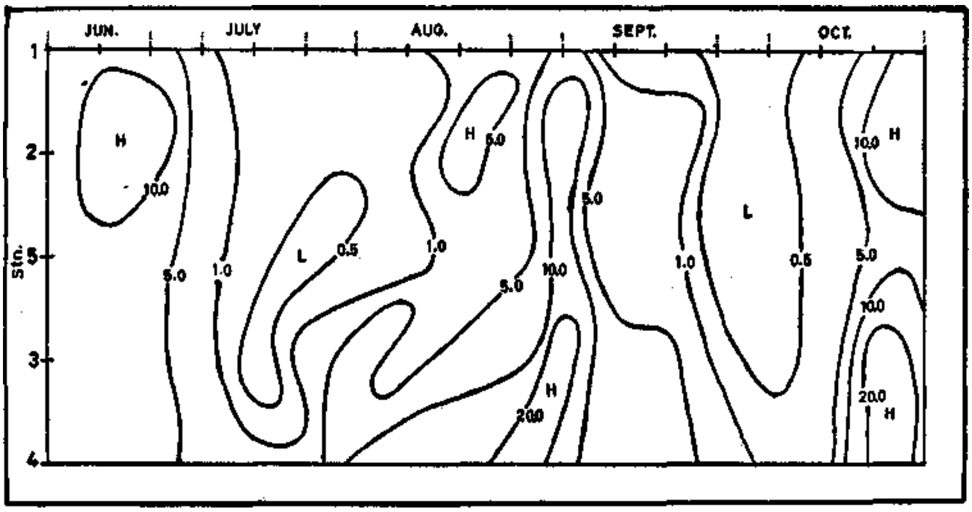

Fig. 6. Seasonal distribution of surface salinity in the backwaters during the monsoon and post-monsoon periods

As regards the distribution of surface salinity the pattern (Fig. 6) presents features which are fairly obvious and which could be expected at this season, especially with the large influx of fresh water. The surface layer consists practically of freshwater. Tongues of low salinity extending seawards at the surface are observed in July to early August and September-October. Although tidal influences tend to bring in large volumes of seawater into the estuary and bring about a considerable degree of mixing, the freshwater influx far surpasses that of saline water and hence surface salinity continues to be low; whereas the influx from the sea remains as a distinct bottom layer in the backwaters.

With high salinities at the bottom and the almost freshwater at the surface, there is a very sharp gradient of salinity resulting from the stratification, during the season (Fig. 7). The layer of cold dense bottom water in the backwaters is not a chance phenomenon and in spite of the turbulent conditions associated with the monsoons, there is considerable resistance to the mixing of these bottom waters with those of the surface. The source of these bottom waters is to be found in the

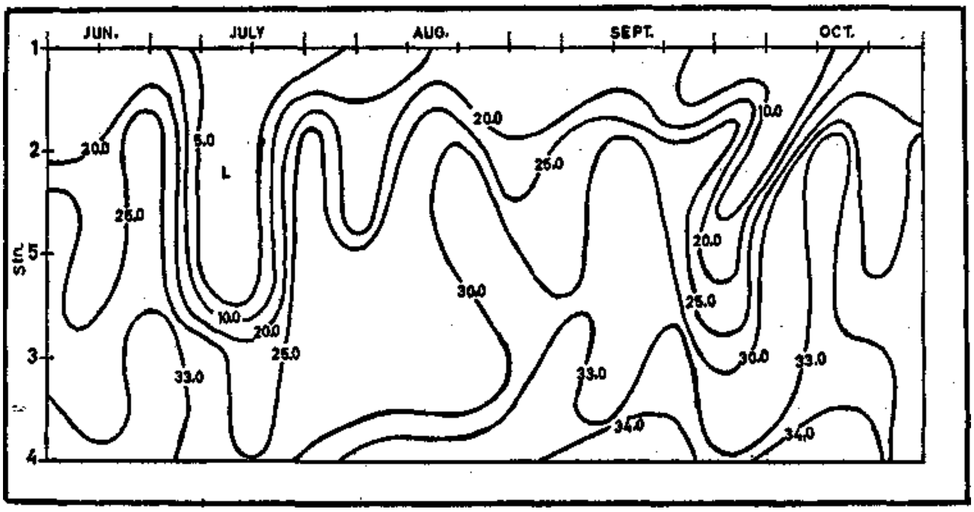

Fig. 7. Seasonal distribution of bottom salinity in the backwaters during monsoon and post-monsoon periods

sea. It has been more or less established (Sastry, 1960; Ramamirtham and Jayaraman, 1960) that duringthis part of the year the continental shelf is pervaded by cold dense waters which have upwelled from subsurface levels and part of this water finds entry into the channel and thence into the backwaters. From all indications the bottom water of the backwaters and the upwelled water of the Arabian Sea are one and the same. Further evidence is obtained from the oxygen content. An analysis of the dissolved oxygen contents at the surface and bottom waters at station 4 has revealed that, whereas the surface oxygen contents were always higher than 3.5 ml/1, the bottom dissolved oxygen contents were always lower than 1.0 ml/1, during late monsoon and post-monsoon seasons till the middle of October.

Towards the end of October a marked change is observed in the hydrographical conditions of the backwaters. The temperature at the bottom is found to increase usually by more than 4°C. The bottom dissolved oxygen contents also are found to exhibit a similar trend. The stratification between surface and bottom waters becomes less pronounced. Such a sudden changeover in conditions is found to take place within a period of about 10 days. After this the conditions remain more or less the same except for warming up as the hot season approaches and the cycle of events is repeated with the onset of monsoon.

SUMMARY

The main features in the hydrographical conditions in the Cochin backwaters are presented and discussed. As in a typical estuary, the conditions in this area are influenced both by the sea and by the freshwater influx. The effects of coastal up-

welling, monsoon piling and sinking in the Arabian Sea are considerable in the backwaters and help to bring about a well-defined seasonal pattern in the backwaters. The intensity of upwelling etc. and also the magnitude of exchanges across the transition could be gleaned from an examination of seasonal patterns of the conditions in these backwaters.

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