Section 2

Ecology

Chapter 1 Physico-chemical parameters of Vembanad Lake
CHAPTER 1
PHYSICO-CHEMICAL PARAMETERS OF VEMBANAD LAKE

1. INTRODUCTION

The Vembanad lake is endowed with all characteristics of a tropical positive estuary (Pritchard, 1967; Qasim et al., 1969; Madhupratap et al., 1977). This water body receives freshwater from five major rivers viz. Pampa, Manimala, Achencoil, Meenachil and Muvattupuzha and is also subjected to strong tidal currents of semi-diurnal type (Wellershaus, 1973) and therefore, the seasonal and diurnal variations of physico-chemical factors are governed by the freshwater run off from the river and tidal currents from the adjoining sea (Josanto, 1971). However, the construction and commissioning of the Thanneermukkam salinity barrier in 1976 has eventually resulted in the severe alterations in the ecological conditions of the lake and resulted in the separation of the lake into two distinctly different ecosystems, retaining estuarine conditions in the downstream part of the lake (Cochin to Thanneermukkam) and transforming the upstream part (Thanneermukkam to Alleppey) to an almost freshwater habitat (Kurup et al., 1992a).

Distribution and abundance of organisms in the estuarine habitat are profoundly influenced by the variation noticed in the physico-chemical conditions.
Physico-chemical parameters of the Vembanad lake were subjected to many detailed studies (Balakrishnan, 1957; Ramamritham and Jayaraman, 1963; George and Kartha, 1963; Cherian, 1967; Qasim and Gopinath, 1969; Sankaranarayan and Qasim, 1969; Silas and Pillai, 1975; Rao et al., 1975; Balakrishnan and Shynamma, 1976; Lekshmanan et al., 1982; Kurup and Samuel, 1987), however, most of them confined to either the barmouth region or the downstream part of the lake. Nevertheless, K W B S P (1989) monitored the water quality parameters of this water body giving more representations to the upstream part of the lake and confluent rivers. Josanto (1971) made a sincere attempt to study the salinity characteristics and factors that influence salt water penetration in Vembanad lake prior to the construction of the barrier. Kurup and Samuel (1987) studied the ecology and fish distribution pattern of the Vembanad lake. In the present study, the pattern of fluctuation of seven major physico-chemical parameters of water is presented and it is hoped that these results would be invaluable in delineating the role of prevailing hydrological conditions of the lake in the distribution and abundance of larvae, postlarvae and stock size of *Macrobrachium rosenbergii* and *M. idella* and also the temporal and spatial variations of morphotypes of *M. rosenbergii* of Vembanad lake.
2. MATERIALS AND METHODS

Water samples were collected at stations 1 - 13 (Fig. 1) for two years (01.03.94 to 28.02.96) during the monthly fishery survey cruises. Surface water samples were collected using a clean plastic bucket and the bottom water samples were collected using a Hytec water sampler. Temperature was recorded at respective collection centres with a sensitive mercury-in-glass centigrade thermometer. pH of water sample was measured in situ using a pH meter (pH scan) having the range from -0.1 to 15 +/- 0.2 and resolution of 0.1. Salinity was measured by the Mohr Knudson method (Strickland and Parsons, 1972) while dissolved oxygen by the azide modification of Winkler method (Greenberg et al., 1992) whereas total hardness, acidity, and alkalinity were estimated following Greenberg et al. (1992).

3. RESULTS

3.1. Rainfall

The annual rainfall in 1994-95 was 2710mm against 2940mm in 1995-96. The pattern of rainfall distribution over the years in the study area is depicted in Fig.1.1. Among the three seasons, monsoon accounted for major discharge of rainfall, registering 65.36 and 67.35% in 1994-95 and 1995-96 respectively while postmonsoon registered 19.06 and 14.10% in the respective years. The premonsoon showers were lowest in 1994-95 (15.04%), however, in 95-96 it was relatively higher (18.54%) when compared to
3.2 Water temperature

Monthly variation in surface and bottom water temperature are presented in Fig. 1.2. In both the years, lowest surface temperature of 25°C was recorded in April while highest of 32°C was in March 1994 and April 1995. The bottom water temperature in all stations were less than that of surface temperature to the tune of 0.5°C in most of months, ranging from 24.5°C (June) to 31.5°C (March) in both the years. Temperature showed a gradual increase from August onwards, however, during November-December another slight fall could be discernible and thereafter a steady increase could be noticed, reaching a value of 32°C in March. The temperature showed strong fluctuations coinciding with onset of south-west monsoon with a pronounced drop in June-July (Fig.1.1) and a sudden rise in the month of September. Difference between surface and bottom temperatures were more pronounced in stations of the downstream part of the lake (Stations 1 to 6) than upstream and riverine stations (Stations 7 to 13), especially in the month of July.

3.3 Salinity

High surface and bottom salinities (>25 ppt) were observed in station 1 and 2 (>20 ppt) in March and April 95 respectively while in 1994, the same was 18.6 and 22 ppt in the months of April and March respectively (Fig.1.3). With the onset of south-west monsoon, the surface salinity lowered to <2 ppt during June to August in all
stations in 1994-95 while in 1995-96 such decrease could be seen in July-September, especially in stations 1 and 2. Conversely, the bottom salinity was in the range of 5-10 ppt in station 1 during 94-95 while in 95-96 it was in the range of 5-25 ppt during June to August, showing the existence of a core of high saline water in these stations. In station 2 also bottom water salinity was relatively high in June 1994 and June-August in 95, showing 6 ppt in the former against 2-24 ppt in the latter period. In the downstream stations (stations 1-4), surface and bottom salinities showed gradual increase from September onwards, however, during October a fall in salinity values were much pronounced in these stations. A steep increase in surface and bottom salinity values were very much pronounced in downstream stations from November onwards, showing >10 ppt in stations 1-4 and >5ppt in stations 5 and 6 during pre-monsoon season (February-May). Lowering of salinity and resultant freshwater conditions were prevalent with the onset of south-west monsoon, converting the entire lake to freshwater conditions and retaining saline conditions only at the bottom part of the stations adjacent to barmouth.

Among the various stations studied in the upstream and riverine regions of the study area, highest surface and bottom salinities recorded was 7 and 8 ppt in the month of April 95 from station 7 whereas it was less than 3 ppt in 1994-95. The saline water incursions in to these parts of the lake could only be recorded in the month of March and persists till April. In station 8, highest
surface and bottom salinities recorded was 4 ppt respectively while in other stations it varied from traces to 2.5 ppt. On the other hand, in station 12, located in river Kaipuzha, surface salinities as high as 6 ppt could be recorded in the month of April 95 while in station 13 which is located at river Muvattupuzha, bottom water salinity up to 7 ppt could be recorded in the month of December 94 and April 95.

3.4 Dissolved Oxygen

Monthly variation in dissolved oxygen concentrations of surface and bottom water are depicted in Fig. 1.4. Dissolved oxygen content of surface and bottom waters in most of the stations fluctuated between 4-8 ml/l during both the years. Highest dissolved oxygen content in surface water estimated during 94-95 and 95-96 were 9.21 ml/l from station 3 in the month of February and 10.64 ml/l from station 12 in July respectively. Similar values in regard to bottom water during the above years were 9.21 ml/l from station 3 in January and 8.34 ml/l from station 11 in July respectively. On the contrary, the lowest dissolved oxygen values in surface water recorded during 94-95 and 95-96 were 3.16 from station 4 in August and 3.96 ml/l from station 1 in May respectively. The bottom water dissolved oxygen content registered in 1994-95 was 2.88 ml/l in station 9 in April against 2.31 ml/l from station 10 in February during 95-96. Generally, the dissolved oxygen values were low in premonsoon months in most of stations.
3.5 pH

pH values of the study area varied from 5.1 to 9.9, showing almost consistent around 7 (Fig.1.5). pH values showed slightly varying results during 1994-95 and 1995-96. In general, high pH values indicating alkaline nature of water, were observed during former year from May to December in most of the stations while in the latter year it remained more or less close to 7 except in downstream stations. During 1994-95, surface water pH values ranged between a maximum of 9.9 in July (station 2) and a minimum of 5.1 in February (station 8) whereas during 95-96 it varied from 9.2 in November (station 6) to 5.1 in April in station 8. Similarly, bottom water recorded a maximum of 9.6 in July (station 2) and a minimum of 5.4 in February (station 12) during 94-95 while in 95-96 it showed variations from 9.3 in station 7 in November to 4.8 in station 12 in April. In general, a gradual increase of the pH values of the lake could be seen from September onwards and this trend continued till January, thenceforth, it declined steeply in February in almost all stations. From March onwards, it again showed an increasing trend, showing slight plummeting in June- July periods, thereafter registered a gradually increasing trend in almost all stations studied. The pH values were invariably high in most of the stations of the downstream part of the lake and this may be due to the intrusion of saline waters, in contrast, in stations 8-12,
low values less than 7 could be observed, especially during 1995-96 and this may be due to the effect of acid soils of Kuttanad.

3.6 Total Hardness

Monthly variation in surface and bottom water hardness in various stations of the lake during March 94 to February 96 are depicted in Fig.1.6. In most of the stations, water hardness was high in bottom water samples when compared to that of surface water. High levels of total hardness could be recorded in both surface and bottom water samples during April 94 to August 94 in almost all stations. Highest values of surface water total hardness during 94-95 was recorded from station 7 in April (94 mg CaCO3/l) whereas in the case of bottom water samples the same was recorded from station 2 in May (143.9 mg CaCO3/l). The values again showed an increasing trend from November 94 to January 95 in most of downstream stations. On the contrary, during 95-96, high values of total hardness during April to August could be recorded only in stations 1 and 2. In these stations, the bottom water samples showed higher values of total hardness than surface water samples and the values gradually increased from September 95 to January 96. The highest values of surface and bottom water hardness recorded during 95-96 were from station 2 in April (44.92 and 53.44 mg CaCO3/l respectively). In all other stations, total hardness was noticeable in both surface and bottom water samples during March to May periods except in station 10.
where only insignificant values of total hardness could be recorded during the same period.

3.7 Alkalinity

Monthly variations in surface and bottom water total alkalinity in various stations of the lake during March 94 to February 96 are shown in Fig.1.7. In general, high alkalinity values were recorded in almost all stations during 94-95 when compared to 95-96. Highest values of surface and bottom water alkalinity during 94-95 were recorded from station 3 in February (160 mg CaCO₃/l) and station 7 in December (148 mg CaCO₃/l). During 1995-96, the alkalinity values of surface and bottom water were found to be very low ranging from 22 mg CaCO₃/l (stations 2, February) to 40 mg CaCO₃/l (station 3, February).

3.8 Acidity

Monthly variation in surface and bottom water acidity in various stations of the lake during March 94 to February 96 are depicted in Fig.1.8. During 94-95 high values of acidity in both surface and bottom water in most of stations could be recorded during August to October. Similarly, very high values of acidity could be recorded during January to June 95 in almost all stations, thereafter it showed a declining trend except in September, 95. In general, acidity values were high in most of months during 95-96 when compared to its previous year. The highest values of surface and bottom water acidity recorded during 94-95 were 180 mg CaCO₃/l (station 1, January ) and 200 mg CaCO₃/l (station 2, January) respectively whereas the same during
95-96 were 190 mg CaCO₃/l (station 3 March) and 270 mg CaCO₃/l (station 3, May) respectively.

4. DISCUSSION

The pattern of fluctuations of surface and water temperatures observed in the present study fully agree with earlier findings (Pillai, et al., 1975; Silas and Pillai, 1975; Kurup and Samuel, 1987; KWBSP, 1989). Temperature showed a steeply increasing trend during premonsoon months (February to May) and during post monsoon period (November to January) whereas during monsoon months (May to October) invariably low values could be observed from the lake. It may also be seen that monsoon months (June to September) contributed to more than 60% of total annual rainfall during both the years under study. The highest and lowest temperatures observed in the present study were in premonsoon and monsoon seasons respectively which fully corroborate with the observations of Haridas et al. (1973), Lekshmanan et al. (1982), Kurup and Samuel (1987) and KWBSP (1989). With regard to the fluctuations of pH, in general, higher values were observed during the first year which also coincided with the high levels of hardness and alkalinity recorded from the study area. As per the data compiled by KWBSP (1989) highest pH of 8.5 was recorded from Punnamada area (station 9 in the present study) while lowest of 5.1 was in Kumarakom (station 8). However, in the present study pH was found to vary from 4.8 to 9.9. Similarly, wide fluctuation of dissolved oxygen content was also observed.
during the present study in contrast to the findings of Silas and Pillai (1975), Kurup and Samuel, (1987) and KWBS (1989). In the present study higher levels of total hardness and alkalinity were observed during the first year when compared to second year. Correspondingly, lower levels of acidity values could also be recorded in the first year.

Salinity is the ecological master factor contributing to the life of estuarine animals (Kinne, 1966). The distribution of salinity is profoundly influenced by a combined action of water movements induced by freshwater discharge and tidal action from the sea. Salinity slowly travels upstream during dry months when there is practically no freshwater discharge and during monsoon months, the freshwater flow pushes salt water down the lake and limits the incursion almost near to mouth of the lake (Josanto, 1971). Among the various physico-chemical parameters studied, salinity appears to be the most fluctuating parameter of the lake. The incursion of sea water through bottom is very much pronounced in stations 1 and 2 where the stratification is clear when compared to other stations. During the monsoon, the entire water body except stations 1 and 2, especially in the bottom, became near to freshwater. This finding is very much similar to that of Wellershaus (1973) who attributed this due to the formation of salinity tongue due to the formation of a bottom reverse current caused by outflow at surface. In all months, the bottom salinity remains higher than surface water in stations 1-6 and this conforms with the finding of Lakshmanan et al.
(1982). The results of the present study when compared against Josanto (1971) revealed that the salinity distribution pattern of this lake has totally been changed over a span of last two decades. Prior to the construction of salinity barrier, the bottom salinity of downstream part of the lake (stations 1-6) ranged from 23 to 31ppt in the month of March, on the contrary, in the present study, it varied from 6-23ppt in 1994-95 and 12-28ppt in 1995-96. Similarly, in upstream part of the lake (stations 7-10) the bottom salinity varied from 18-22ppt, conversely, the variations during the present study was 0-3ppt in 1994-95 and 0-8ppt in 1995-96. It would thus appear that a substantial reduction in the prevailing salinity values have taken place. This transformation was brought about by the human interventions, in the form of constructing the physical barrier across the lake in 1976 in order to arrest the saline water incursion into Kuttanad for facilitating the raising of an additional Punja crop. While the lowering of salinity values in the upstream part of the lake can be attributed to the prevention of tidal action due to the commissioning of the barrier whereas the reduction of salinity values in the downstream part of the lake may be due to the diminishment of tidal action as the same is strongly sensitive to physical obstructions (Josanto, 1971). Kurup and Samuel (1987) reported a maximum salinity from the upstream part of the lake as 3.5ppt while the present estimate, the maximum value recorded is 8ppt and this in comparison with the above is slightly on a higher side.
According to KWBSP (1989), the maximum salinity conditions (6ppt) occurred by March just south of the barrier and salinity in the southern most part of the lake did not exceed 2ppt. Similarly, in the present study, range of surface and bottom salinity in stations 1-5 was in the order of 10-25ppt and 14-31.5 ppt respectively while Lekshmanan et al. (1982) reported that maximum salinity value in these regions varies from 10-30 and 20-32 ppt in surface and bottom waters respectively. It would thus appear that a further reduction in salinity value could be observed in stations which are located in between Cochin barmouth and influxing part of Muvattupuzha river of the lake and this significant variation might be due to the commissioning of the Idukki hydroelectric project and the subsequent diversion of part of Periyar river water in to the Muvattupuzha whereby a perennial flow is being maintained in the Muvattupuzha, the latter influx in to the downstream part of the lake.