CHAPTER - 3

General Hydrography and Mineralogical aspects of sediments

The hydrographical features along with mineralogical characteristics of sediments constitute an essential and useful basis for the partitioning of trace metals among various geochemical fractions being influenced by the parameters like. pH, Eh, salinity, dissolved oxygen, organic matter content, grain size etc., and anthropogenic input. Therefore, a prior knowledge of environmental characteristics and the mineralogy of sediments is essential for the interpretation of trace metal concentrations in various geochemical fractions of the sediments. In this chapter, the data on some important hydrographic parameters like salinity, dissolved oxygen, pH and a brief review on the sedimentological features along with the geological background of the study area are presented and discussed.

3.1 Hydrographical features of Kerala Coast.

Kerala has a number of river openings along its coast line. Some of these drain into the backwaters or lakes prior to emptying into the Arabian Sea (fig. 1). Certain features that most of these rivers share are short length, leanflow during non-monsoon months, connection with backwaters and the tidal nature of mouths (Sarala Devi, et al., 1983). The
FIG. 1. Draining sites of some important rivers of Kerala.
Distribution pattern of salinity, dissolved oxygen and pH of the coastal waters are shown in Figs. 3.1.1, 3.1.2 and 3.1.3.

3.1.1 Salinity.

During the monsoon season the surface salinity is low (<32%) at all stations due to the influence of river runoff and precipitation, as compared to other seasons. The salinity distribution in the area of study is uniform during the pre-monsoon and post-monsoon seasons. The minimum surface salinity was recorded off Calicut at station 1 and (33.03x10⁻³) a maximum of 35.75 at Vizhinjam Station No.2 during the pre-monsoon season and a minimum of 28.36x10⁻³ at Kasargode station No.1 and maximum of 34.4 at Station No.2 off Kannur during the post-monsoon season. The present data shows a well defined horizontal stratification for all the coastal stations during the monsoon and non-monsoon seasons. The spatial variation was found to be more in the post-monsoon than in the pre-monsoon season and it is attributed to the influence of the influx of fresh water. The values are comparable with those recorded by previous investigators for the study area (Sen Gupta et al., 1979).

3.1.2. Dissolved Oxygen

Dissolved oxygen plays a vital role in the marine environment. Oxygen is dissolved directly from the atmosphere at the air-sea interface or is made available
chemically by photosynthetic activity of marine plants. The amount of oxygen present in solution is governed by a number of factors such as temperature, partial pressure of the gas in the atmosphere, biochemical degradation of organic matter, respiration, photosynthesis etc. High photosynthetic activity due to the abundant phytoplankton production enhances the oxygen content of water, especially the surface layers wherein photosynthetic activity is maximum (Tait, 1968).

Dissolved oxygen values of both surface and bottom exhibited significant spatial and seasonal variations. The variation between the surface and bottom values are insignificant during the pre-monsoon season while marked difference was observed during the post monsoon season. The dissolved oxygen values varied from 5.08 ml/l to 2.9 ml/l and from 4.45 ml/l to 1.35 ml/l respectively for surface and bottom waters during post-monsoon period. The low temperature of surface water during the post-monsoon season enhances the solubility of atmospheric oxygen in the surface waters (Riley and Chester; 1971), and the settling of the organic matter rich particulates brought to the coastal region by monsoon flushing causes depletion in dissolved oxygen content of the bottom along with the upwelled water which has low water temperature and dissolved oxygen during the post-monsoon season.

During pre-monsoon season the high surface water temperature reduces the solubility of the oxygen in surface
waters thereby causing a decrease in dissolved oxygen content of the surface waters. The observed data showed that only at four sections along the coast viz. off Kasargode, Ponnani, Cochin and Vizhinjam exhibited the general trend of dissolved oxygen content of the surface waters being more than that at the bottom.

During the pre-monsoon season the dissolved oxygen values for surface and bottom waters ranged from 4.69 ml/l to 3.92 ml/l and 4.69 to 3.51 ml/l respectively, with most of the values falling between 4.69 and 4.25 ml/l. The dissolved oxygen content of the coastal waters were comparatively higher during the pre-monsoon season especially for bottom waters.

During the monsoon season the influence of upwelled water was seen in the dissolved oxygen values of the entire area of study (Bhargava et al., 1973; Rao et al., 1972; Jayaraman and Gogate, 1957; and Banse, 1959).

3.1.3 pH

Eventhough there observed no significant spatial or seasonal variation in pH values of the surface and bottom waters, usually higher values were recorded during the post-monsoon season. The pH of bottom waters were found to be less than that of surface waters during the post-monsoon period, as a consequence of intense upwelling during the monsoon months; (Rao et al., 1970, Jayaraman and Seshappa,
The seasonal and spatial distribution of salinity in the surface and bottom waters of the near shore regions of Kerala Coast. (o) Pre monsoon (●) Post monsoon (—)Surface values, (— —) Bottom values
FIG. 3.1.2. The seasonal and spatial distribution of dissolved oxygen in the surface and bottom waters of the near shore regions of Kerala Coast. (O) Pre monsoon, (●) Post monsoon, (---) surface values, (----) Bottom values
FIG. 3.1.3. The seasonal and spatial distribution of \( P^H \) in the surface and bottom waters of the nearshore regions of Kerala Coast. (O) Pre monsoon, (●) Post monsoon, (—) surface values (---) Bottom values
1957) while a reverse trend was noted during the pre-monsoon season.

3.2 Hydrographical features of Cochin Estuary

3.2.1 salinity

The seasonal and spatial distribution of salinity in the Cochin estuary is depicted in fig 3.2.1. The premonsoon period exhibited relatively stabler environment in the estuary. The influence of the sea water was very much pronounced as the intrusion of saline water was traceable up to the head of the estuary. During monsoon season, the entire estuarine water is flushed out and replaced by fresh water. During the post monsoon period, the estuary behaves as partially mixed one. During the monsoon-post monsoon span, the salinity varied from $0.7 \times 10^{-3}$ to $32 \times 10^{-3}$ at the surface and from $8.2 \times 10^{-3}$ to $35.05 \times 10^{-3}$ at the bottom at the bar mouth. Salinity during the end of premonsoon varied from $29.8 \times 10^{-3}$ (surface) to $32.95 \times 10^{-3}$ (bottom) at the bar mouth. The salinity distribution exhibited a well defined horizontal gradient throughout the entire period of investigation while the vertical stratification was pronounced only during the monsoon season.

3.2.2. Dissolved oxygen

Dissolved oxygen values of both the surface and bottom showed an increasing trend towards the upstream during the entire period of study. This could be attributed to the
shallowness and the high photosynthentic activity in the upper reaches of the estuary. Joseph and Pillai (1975) also has recorded a high phytoplankton production in this region. The vertical gradient was also less in the riverine region. The distribution pattern of dissolved oxygen values (fig.3.2.2.) revealed significant spatial and seasonal variation as was observed by Sarala Devi et al. (1979) and Anirudhan (1988). Generally the surface values were found to be higher than at the bottom except for premonsoon season when the surface values of certain stations were even lower than the bottom ones. This might occur due to the decreased solubility of atmospheric oxygen in the surface waters at higher temperatures. Though the dissolved values were higher during the monsoon season, very low values were noted in the bottom waters of the bar mouth (1.58 ml/l). The intrusion of upwelled water in the south west coast might be the reason for this depletion. (Sankaranarayanan and Jayaraman; 1972; Rao et al., 1970). The depletion in values during the post monsoon season could be attributed to the degradative oxidation of organic matter.

3.2.3 pH

The pH distribution did not exhibit any significant seasonal or spatial variation. In general the pH values showed a decreasing trend towards upstream. Not much variation was observed between surface and bottom values except in certain months during post monsoon season which might be due to the degradation of organic matter at the
The seasonal and spatial distribution of salinity in the surface and bottom waters of Cochin estuary. (O) Pre monsoon, (●) Post monsoon, (X) monsoon, (—)surface values, (—-)bottom values.
FIG. 3.2.2. The seasonal and spatial distribution of dissolved oxygen in the surface and bottom waters of Cochin estuary. (○) Pre monsoon, (●) Post monsoon, (×) monsoon, (—) surface values, (---) bottom values.
FIG. 3.2.3. The seasonal and spatial distribution of $p$H in the surface and bottom waters of Cochin estuary. 
(0) Pre monsoon, (•) Post monsoon, (x) monsoon, (—) surface values, (—) bottom values.
sediment/water interface causing a decrease in pH values. Comparatively the pH values were low during the monsoon season. The seasonal spatial distribution of pH is depicted in Fig. 3.2.3.

3.3 General Hydrography of Chaliyar estuary.

3.3.1 Salinity

Fig. 3.3.1 depicts the seasonal and spatial distribution pattern of salinity in the Chaliyar estuary. The salinity distribution pattern observed in the present studies is similar to that for a typical positive tropical estuary with the surface salinity values ranging from nearly zero during monsoon season to almost marine condition with high and uniform salinity (>34x10\(^{-3}\)) during the pre monsoon season as have been reported by several previous workers (Haridas et al., 1973, Cherian et al., 1975, Balakrishnan and Shynamma, 1976, Saraladevi, 1986, and Nair, et al., 1983). Eventhough Premchand et al. (1987) reported the absence of saline water in Chaliyar river estuary during June and July, the present observations indicate the presence of saline water at the bottom even up to 5 km from the river mouth during June-July at the time of high tide. During heavy monsoon months salinity was limited to 5 km from the river mouth as noticed by Nambudirippad and James (1987) and Natraj et al. (1987). Intrusion of sea water was found even up to 28 km from the river mouth during the premonsoon period (James and
Sreedharan, 1983). During the post monsoon the high saline water extends upto 10 km. upstream.

The absence of vertical salinity gradient during premonsoon season showed the prevalence of well mixed condition probably enhanced by strong tidal currents as stated by Bowden (1967). In the post monsoon season significant variations in salinity from surface to bottom was observed through out the estuary with comparatively smaller vertical gradients in the lower reaches ($2 - 6 \times 10^{-3}$) and the upstream station showed vertical gradients up to $15 \times 10^{-3}$. Thus the estuary varies from a salt wedge type during monsoon to an intermediate partially mixed type during post monsoon and to a well mixed type during premonsoon season.

3.3.2. Dissolved Oxygen

The seasonal and spatial distribution of dissolved oxygen in the surface and bottom waters of Chaliyar estuary is depicted in Fig. 3.3.2. Dissolved oxygen content of the surface waters were found to be slightly higher than that of bottom water. Comparatively higher values of dissolved oxygen content was observed during the monsoon season than in post monsoon and pre monsoon periods. The depletion was more pronounced in the post monsoon season, which could be attributed to the oxidative degradation of organic matter. Lower oxygen values observed in the bottom waters (DO <3ml/l)
during certain months of monsoon period were due to the incursion of high saline low oxygenated upwelled water from the coastal region during these months (Ramamirthm and Rao, 1973; Sharma, 1978; Jayaraman and Gogate, 1957; Banse, 1959). Premchand et al. (1987) have also reported low oxygen values (2.52 ml/l) during the month of August.

3.3.3. pH

In general, monsoon months recorded low pH values and pre monsoon high values especially in the lower reaches of the river. The pH values decreased towards the upstream and the values varied between 7.5 to 8.4. Even though the variation between the surface and bottom values were not so significant, surface values were found to be lower than the bottom values during monsoon period which is attributed to the heavy fresh water discharge. The gradual decrease in pH values towards the upstream and the increased pH values observed during the non-monsoon months showed the influence of incursion of sea water on pH. The relatively higher pH values recorded during the pre and post monsoon months may also be due to the increased photosynthetic activity during these periods (Gnaiger et al. 1978). Saraladevi et al. (1983) have reported for Beypore estuary an average pH value of 7.66 and 7.75 during pre-monsoon. 6.35 and 6.53 during monsoon and 6.68 and 7.63 during monsoon for the surface and bottom waters respectively. Fig. 3.3.3. depicts the distribution patterns.
FIG. 3.3.1. The seasonal and spatial distribution of salinity in the surface and bottom waters of Chaliyar estuary. (O) Pre monsoon, (●) Post monsoon, (X) monsoon. (—) surface values, (---) bottom values.
FIG. 3.3.2. The seasonal and spatial distribution of dissolved oxygen in the surface and bottom waters of Chaliyar estuary (O) Pre monsoon, (●) Post monsoon, (X) monsoon, (—) surface values (---) bottom values.
FIG. 3.3.3. The seasonal and spatial distribution of $pH$ in the surface and bottom waters of Chaliyar estuary. (O) Pre monsoon, (●) Post monsoon, (X) Monsoon, (—) Surface values, (—–) Bottom values.
3.4 Mineralogy of the Sediments.

The sediment composition and texture are related to geology, bathymetry and physical factors of the aquatic environment. The major rock types of the study area belong to crystalline rocks of Archaen age, sediments of Tertiary age, and laterite cappings on crystallines and sediments of sub-recent to Recent age (Mallik et al., 1987). The crystallines include charnockite and Khondalite, granite gneisses and granites traversed by basic rocks. Charnockite is widespread in the hill ranges of the Western Ghats, where from the rivers of Kerala originate. The geology of Kerala is depicted in fig (3.4.1). Mallik et al., (1987) have demonstrated that the minerals both in coastal sediments and river sediments of Kerala are derived mainly from the crystallines of the Western Ghat mountains.

The heavy-mineral suite of the coastal and river sediments of Kerala consists of opaques, horn-blende, hypersthene, tremolite/actinolite, pyroxene, garnet, sillimanite, Kyanite, staurolite, andalusite, epidote, zircon, monazite, rutile, sphene, apatite and tourmaline. The light minerals consists of quartz, feldspar and some mica. The opaque heavy minerals include ilmenite, a little magnetite, rutile, spinel and leucoxene (Mallik et al., 1987).

Veerayya and Murthy (1974) have discussed the distribution of the bottom sediments of Vembanad lake. The minerals of the lake were grouped into allogenic, endogenic
and authigenic by Mallik and Suchindan (1984). The clay mineralogy of innershelf sediments off Cochin was described by Reddy et al. (1992). The major minerals in the sediments of Muvattupuzha was reported to be opaques (39.72%), hornblende (28.92%) and hypersthene (24.1%) (Mallik et al., 1987). They noted high garnet values (7.8%) in the sediments off Calicut. 14.4% of epidote and 5.2% of staurolite was reported in the sediments of Bharathapuzha, which debouches in Arabian Sea at Ponnani. High amounts of Hornblende was reported in the coastal sediments of the northern Kerala (Mallik et al., 1987.)
Fig. 3.4.1 GEOLOGY OF KERALA