4. ECOLOGY

4.1 INTRODUCTION

The marine environment has a complex system mainly influenced by a various of physical, chemical and biological processes. One of the basic goals of ecology is to understand the factors that play a role in the distribution pattern of organisms. The structure and dynamics of biological communities can be better understood only if background information is available on the ecology of the compound species (Underwood, 1979). The hydrological study is inevitable to know the potentialities and to understand the realities between trophic level and food webs. A through knowledge of the hydrography of any biotope is indispensable to estimate the quality of the environment and its influence on the biological fertility. Environmental conditions also play an important role in promoting the occurrence and abundance of commercially exploitable marine resources (Iveler, 1966). In many countries, coastal and marine environs are under special jurisdiction. Hence, It is imperative to know the interrelationships between the organisms and the environmental parameters in order to evaluate the suitability and function of ecosystem.

The environmental conditions are governed by short-term changes due to tides and seasonal changes from monsoonal cycles (Sankaranarayanan and Qasim, 1969). Hydrographical parameters such as rainfall, temperature, salinity and dissolved oxygen determine the distribution and survival of the animals in estuaries, mangroves and in other environments. They directly or indirectly affect the life activities of each and every organism in various levels of their life. The organisms’ habitat adaptations are imperative for their survival. The environment is a selective force of an organism and its population. The organism develops adaptive strategies which enable them to withstand environmental stress. The study of salinity, temperature, dissolved oxygen pH and rainfall are of vital importance since they play a major role in regulating the growth, abundance, recruitment and distribution of the flora and fauna. A knowledge of
the environmental parameters of shallow water area is thus an essential prerequisite to understand the composition of animals inhabitants and their distribution, dispersal and relative zonal abundance within the vast and interior areas of the coastal waters. The distribution of intertidal and other marine invertebrates is limited in locally and regionally by complex of interacting factors, within them temperature is important either directly or for its modifying effects on other factors (Kinne, 1970; Walcott, 1973; Newell; 1979). Marine species have thermal limits both for existence and for reproduction. Temperature is commonly considered the most important single ecological factor in the distribution of marine animals (Gunter, 1957; Hedgepeth, 1957). In terms of molluscan ecology, the limits of shallow water marine habitat may be the best defined on the basis of faunal assemblages, communities that live in water of a certain temperature for an adequate period for reproduction or maturation.

Ecological factors such as salinity, pH, dissolved oxygen, temperature and rainfall may affect the breeding cycle and growth of all organisms. The physico-chemical parameters are involved in determining the distribution of living components of an ecosystem. Knowledge on the environment is of utmost importance to understand the distribution and colonization of most marine benthic organisms. The availability and the distribution of various forms are greatly influenced by environmental parameters such as temperature, salinity, dissolved oxygen and food (Kinne, 1967). The influence of environmental factors stated above was also studied by Sanders, (1956, 58), Thorson (1966), Ansell et al. (1972), Platel and Potter (1996). The distribution pattern of animals in the shore is either individually or collectively influenced by environmental factors.

In Indian waters, studies are limited to very few observations on the distribution and ecology of the molluscan fauna by Kalyana Sundaram et al. (1974) and Harkantra (1975) and Narasimham (1988). The physico-chemical parameters are very important in study of environment, especially aquatic environment; from the cost of India much work (Singbal, 1973; Nair & Ganapathi 1983; Rao & Valasraj 1984 and Patare 1998)
has been done in regard to the hydro biological aspects and valuable studies. Several reports on hydrography (Varadarajulu and Tippu Abdul Khader, 1976), distribution of dissolved oxygen and nutrients (Bhavanarayana and Lafond, 1957; De Sousa et al., 1981). Radhakrishnan et al., (1986) studied the plant pigments and particulate organic carbon in coastal regions of Bay of Bengal. The temperature of tidal variations, current patterns and magnitude of freshwater discharge at different periods in estuaries in relation to the environmental parameters are well documented (Qasim and Gopinathan, 1969; Vijayalakshmi and Venugopalan, 1973; Sarala Devi et al., 1983). Extensive studies have been pertaining to the spatio-temporal distribution and behavior of nitrate-nitrogen, phosphate-phosphorous and silicates-silicon in many estuaries of India (Reddy et al., 1993; Gowda and Panigrahy, 1992; Das et al., 1997).

There is an increasing need for bivalve culture to meet the global nutritional requirement since bivalves are considered to be the valuable source of animal protein. Hence an increased interest to the study on the physical, chemical and biological parameters of the coastal bodies due to their direct effect on the population distribution, growth and reproduction of various animals of culture potential. Previously no attempt has been made in the study of ecology of Gafrarium pectinatum and Gafrarium divaricatum and hence the present investigation was carried out on Physico-Chemical parameters at Thondi coastal waters.

4.2 MATERIALS AND METHODS

The water samples were collected from the study area for a period of one year from Jan.2006 to Dec.2006, 12 months duration, divided, for convenience, into post-monsoon (January – March), summer (April – June), pre-monsoon (July – September) and monsoon (October – December) seasons (Photos5&6). The monthly rainfall data were collected from the metrological observatory unit at Thondi. The water temperature was recorded with a Thermometer; salinity were measured by using of the water by salinometer and the hydrogen ion concentration (pH) was measured with digital pH meter (Biochem model PM – 79). The oxygen content of the water was
estimated standard winkler’s method following the procedure of (Strickland and Parsons 1972).

4.3 ESTIMATION OF PHYSICO-CHEMICAL PARAMETERS

4.3.1 Determination of surface water temperature

Using the standard Celsius thermometer the temperature of the surface water was recorded and the mean temperature was recorded.

4.3.2 Measurement of pH

An Elico LI 120 model pH meter was Precalibrated with standard buffer solutions of pH 4.0, 7.0 and 9.2. Water samples collected from the study area and used to measure pH.

4.3.3 Estimation of salinity

The Classical Mohr Titration method (Strickland and Parsons, 1972), was adopted to estimate salinity of water samples collected from the stations. Initially, chlorinity was estimated. Using Knudsen’s equation, salinity was established.

4.3.4 Estimation of dissolved oxygen

Winkler’s method (Strickland and Parsons, 1972) was adopted to estimate the dissolved Oxygen content in the water samples collected from the station. The water samples were fixed in the station and titrations were done by adopting routine procedures in the laboratory, and the readings were recorded.

4.3.5. Estimation of Nitrite

Nitrite was determined by the Azo Dye method described by Bendschneider and Robinson (1952). The determination of nitrite is based on the classical Greiss’s reaction in which the nitrification at pH 1.5 – 2.0 is coupled with N (1-naphthyl) ethylenediamine to form a highly coloured azo dye. This was measured spectrophotometrically at an absorption maximum of 545 nm.
4.3.6. Estimation of Nitrate

Nitrate is estimated using cadmium reduction column as described by Solyom and Carlberg (1975). The nitrate is reduced almost quantitatively to nitrite by passing through a column containing copperised cadmium filing. The nitrite thus produced is determined by diazotizing with sulphanilamide and coupling with N-(1-naphthyl)-ethylenediamine. Nitrite in the sample passes through the column without quantitative change. Hence the total nitrate plus nitrite was determined by the method. The difference between the two values indicated the total nitrate content of the sample.

4.3.7. Estimation of Inorganic Phosphate

The inorganic phosphate was estimated using the method described by Murphy and Riley (1962). The inorganic phosphate ions in sea water react with acidified molybdate reagent to yield phosphomolybdate complex, which is reduced to molybdenum blue. The colour was measured spectrophotometrically at 880 nm.

4.3.8. Estimation of Silicate

Silicate in the sample was estimated by the method of Strickland and Parsons (1972). The water sample is made to react with ammonium molybdate to form the yellow β-silico molybdic acid, which is then reduced by ascorbic acid to molybdenum blue. The optimum acidity is 0.07 – 0.13 N. To suppress the interferences or phosphate, oxalic acid was added. The absorbance of the blue complex was measured at 810 nm using a spectrophotometer.

4.4. RESULTS

4.4.1. Rainfall

The minimum (0.2mm) rainfall was recorded during May and the maximum (398.6mm) rainfall was recorded during November. In the study area the rainfall was mainly influenced due to northeast monsoon.
4.4.2 Water temperature (Fig.4)

Water temperature varies in accordance with ambient air temperature. In Thondi, the minimum (30 °C) and maximum (34.0°C) water temperature was recorded during monsoon and summer months respectively, with a mean water temperature of 32.0°C (Table 1).

4.4.3 Salinity (Fig.5)

Salinity varied over a narrow range from 31.8‰ to 35.4‰. In the study area, salinity recorded the minimum value of 31.8‰ and the maximum it was recorded 35.4‰ during monsoon and summer months, respectively with a mean salinity of 33.6‰ (Table 1).

4.4.4 pH (Fig.6)

Variations in pH value were very meager during the study period of Jan- Dec along the Palk Strait region. The minimum value of pH (7.8) was recorded during premonsoon and monsoon seasons and the maximum (8.9) pH value was recorded during summer months, with a mean pH of 8.35 (Table 1).

4.4.5 DO (Fig.7)

In Thondi, minimum value of DO (4.8 ml/L) and the maximum value of DO (6.3 ml/L) was recorded during monsoon and post monsoon seasons respectively, with a mean value of DO of 5.55 m/L. (Table 1).

4.4.6 Nitrite (Fig.8)

Nitrite content varied in accordance with total nitrogen content of the seawater. In Thondi, nitrite showed the minimum value of (0.06 µM/L) and the maximum value of nitrite (0.83 µM/L) was recorded during summer and premonsoon seasons, respectively, with a mean value of 0.445 µM/L (Table 1).
4.4.7 Nitrate (Fig.8)

The concentration of nitrate in Thondi showed minimum value (0.14 µM/L) during post monsoon season and maximum value (2.45 µM/L) during premonsoon season. During the study period the mean nitrate value was 1.295 µM/L. coastal waters (Table.1).

4.4.8 Inorganic phosphate (Fig.8)

There was a great fluctuations observed in inorganic phosphate content of Thondi during different seasons of the study period. The minimum (0.75 µM/L) and maximum (1.76 µM/L) value of inorganic phosphate were observed during premonsoon and monsoon seasons respectively with a mean value of 1.255 µM/L (Table.1).

4.4.9 Silicate (Fig.8)

Variations in silicate content was very high during the study period. In Thondi, the minimum value (7.40 µM/L) silicate was recorded during premonsoon and the maximum (14.58 µM/L) silicate content was recorded during monsoon months with a mean value of 10.99µM/L (Table.1).

4.5 DISCUSSION

Coastal ecosystems, especially in the tropical regions, have been known for their richness in biological productivity. The physico-chemical characteristics of an aquatic ecosystem undergo changes due to the action of tides, inflow of domestic and industrial effluents and during rainfall; consequently, the biological characteristics are also likely to change. Rainfall results in the inflow of fresh water from rivers and estuaries. Run-off increases pollution load along the coasts, and wind and wave action can disperse these materials sea-ward. During cyclonic storms, rivers and estuaries express a washed appearance due to flow into the sea and wave action. Seasonal variations brought about by monsoon cycles and tidal rhythms have been known to be
responsible for natural variations in the physical, chemical and biological characteristics of the coastal ecosystem (Keesing and Irvine, 2005).

In addition, anthropogenic inputs have altered the character of the coast adversely and resulted in biodiversity hot-spots. Palk Strait region falls within the temperate subtropical margin that displays limited variation in water temperature. The range of water temperature in the present study is comparable with the earlier records in this area. Among this study area, the lowest (30.0°C) and highest temperature (34.0°C) was recorded at Thondi. The significant positive correlations of water temperature with DO during summer in contrast with the significant negative correlations of the water temperature with DO during monsoon clearly defines the critical role of temperature controlling the water chemistry that increases and decreases DO levels in monsoon and summer seasons, respectively. This is exemplified by conditions during summer when small bubbles, which are always present in the sea associated with organic matter, grow in the presence of high oxygen saturations (Ramsey 1962). Much work has been done in recent years to explore the relationship between economic development and environmental quality (Hale et al., 1998; Hale and Guardia, 2001; Hale et al., 2001).

The distributions of salinity are more prominent in the Palk strait region. Salinity levels in this areas were identical in all the seasons. High salinity, (35.4‰) values recorded during summer seasons and low (31.8‰) values obtained during monsoon seasons. Variations in salinity were observed to be due to rainfall and flow of freshwater into the sea and Canal during changing tides. The low salinity associated with the anthropogenic freshwater inputs (Saunders et al., 2007). Significant negative correlations between salinity, nitrate and inorganic phosphate has been observed. The salinity is lowest at this station is probably due to the huge volume of fresh water, but also an indication that within a saline system the input of considerable freshwater could be considered a pollutant (Saunders et al., 2007). Such characteristics are common in Indian estuaries where nutrient levels are controlled by anthropogenic discharge (De-
Sousa 1999). Grasshoff, (1976) revealed that salinity variation is mainly influenced by anthropogenic fresh water influx rather than prevailing regime.

pH values showed seasonal variations during the study period. In the present study, pH showed minimum during monsoon and maximum during summer. High variations in pH observed specifically during monsoon and summer indicate that the water is often alkaline. Generally, higher pH values may be attributed to sea water mixing and redox variations in sediment and water column; while lower pH values are observed during monsoon may due to influx of freshwater, and tide action (Panigrahy et al., 1999). The values of pH during summer are relatively higher than the recorded levels closest to Dubai [Abu Dhabi creek (Abu-Hilal & Adam 1995) and the UAE coastal waters (Shriadah & Al-Ghais 1999)]. The high pH in Thondi mainly influenced by high and low photosynthetic activities, that contributes to an elevation of the level of pH. The significant difference of pH is attributed to low and high primary productivity zones, respectively. The relationship of high pH and high primary productivity has been defined as the phenomenon of stagnant aquatic environments with examples such as lake (Chilka Lake) and saline reservoirs (Salt pans- Mumbai) in India (Mustafa Deshgooni, 2005 and Nayak et al., 2004).

Dissolved oxygen content in an aquatic system is an essential factor influencing factor for aquatic life. The available DO is derived from the atmosphere and photosynthesis. Organic matter oxidation contributes to the depletion of oxygen in the water body. Changing the balance between the oxygen supply and consumption leads to a characteristic DO profile. Increasing DO values during monsoon are due to high solubility of oxygen in lower water temperatures and increasing turbulence, while the falling DO values during summer are attributed to high water temperature that is increasing the rate of organic matter decomposition in the coastal and creek waters (Shriadah and Al-Ghais, 1999).
Therefore, under aerobic conditions the oxygen content is one of the most suitable measures related to the state of the water body. Current results for DO based on the seasonal variation gives a comprehensive picture of the oxygen behavior in Palk Starit region. The low values of DO due to respiration and chemical reactions, whereas the high DO values were due to air diffusion at the air water interface, high photosynthetic activity and less mixing due to low surface turbulence and anthropogenic contaminants. The observed high monsoonal values might be due to the cumulative effect of higher wind velocity coupled with heavy rainfall and the resultant freshwater mixing (Das et al., 1997). The observed stratification in DO levels correspond to the earlier records that show a high variation (0.02-10.30 mg/L) that is a clear indicative of high stratification (Al-Zahed, 2005).

Nutrients levels have been recorded to increase as a result of monsoons. This increase may be attributed to (i) large-scale discharge from land runoff, and (ii) release of sediment-entrapped nutrients due to monsoon turbulences and wave action (Satpathy, 1996; Prasad and Ramanathan, 2008). Generally nutrients are stable and comparatively low in summer whereas these levels are fluctuating and high in monsoon seasons. During the study period the maximum concentration of Phosphate was observed 1.76µM/l in Thondi during monsoon season. Phosphate concentration will support plankton growth, while concentrations of 1.0-3.2 mg/L phosphate will trigger blooms (USEPA 1986 and Dunne & Leopard 1978). Subramanyan (1959) reported that considerable quantity of phosphate is locked up in the sea bottom mud and this goes into solution during the south-west monsoon season or during the period’s high velocity.

Dissolved nitrogen and phosphorus compounds are present in low concentrations in seawater. Nitrogen is mainly present as NO$_3$-N with low concentrations of (nitrite) NO$_2$-N and NH$_4$-N, while the major inorganic species of phosphorus is PO$_4$-P. Nitrite content in the sea water showed a wide fluctuation due to seasons. In Thondi, the maximum nitrite value was recorded 2.45µM/l during pre
monsoon seasons. High concentrations of these nutrients in water however can lead to excessive growth of algae resulting in eutrophication (Lundberg 2005). However, the nitrate content showed elevated in the sea waters of Palk Strait region. Thondi reported the maximum nitrate value (2.52 µM/l) during premonsoon seasons. These high levels in Thondi could be attributed to the low rate of photosynthesis that requires less nutrient supply. Generally, the nutrient increase from the channel to the lagoon indicates that the lagoon area is heavily vulnerable to eutrophication (El-Sammak, 2001).

In the study area, silicate recorded maximum during monsoon season. The silicate content was higher than that of the other nutrients and the recorded high monsoon values may be due to heavy inflow of monsoonal fresh water derived from land drainage carrying silicate leach out from rocks. Further, due to the turbulent nature of water, the silicate from the bottom sediment might have been exchanged with overlying water in this estuarine environment (Govindasamy and Kannan, 1996; Rajasegar, 2003). The observed low post-monsoonal values (7.40 µM/l) could be attributed to uptake of silicates by phytoplankton for their biological activity (Mishra et al., 1993; Ramakrishnan et al., 1999)
Table 1. Variation of physico-chemical parameters in Thondi during the study period (Jan2006–Dec 2006)

<table>
<thead>
<tr>
<th>Months</th>
<th>Temperature °C</th>
<th>Salinity 0/000</th>
<th>pH</th>
<th>Dissolved oxygen (ml/l)</th>
<th>Nitrite (µM/l)</th>
<th>Nitrate (µM/l)</th>
<th>Inorganic Phosphate (µM/l)</th>
<th>Silicate (µM/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>30.0</td>
<td>31.8</td>
<td>7.8</td>
<td>4.8</td>
<td>0.06</td>
<td>0.14</td>
<td>0.75</td>
<td>7.40</td>
</tr>
<tr>
<td>Maximum</td>
<td>39.0</td>
<td>35.4</td>
<td>8.9</td>
<td>6.3</td>
<td>0.83</td>
<td>2.45</td>
<td>1.76</td>
<td>14.58</td>
</tr>
<tr>
<td>Mean</td>
<td>32.0</td>
<td>33.60</td>
<td>8.35</td>
<td>5.55</td>
<td>0.445</td>
<td>1.295</td>
<td>1.25</td>
<td>10.99</td>
</tr>
</tbody>
</table>
Photo 5. Collection of Water Samples

Photo 6. Water quality analysis
Fig. 4  Temperature

Fig. 5  Salinity

Fig. 6. pH
Fig. 7 Dissolved Oxygen

Fig. 8. Nutrients