CHAPTER II

ENVIRONMENTAL PARAMETERS AND METHODS
ENVIRONMENTAL PARAMETERS

Survival and growth of living organisms depend to a great extent on the nature of their surrounding environment. All organisms have an inherent ability to tolerate the fluctuations in the environment conditions; though the tolerance limit varies from one organism to the other (Kinne, 1970). Unlike planktonic and nektonic organisms, the sedentary organisms have to adjust to the conditions existing in their immediate vicinity and therefore are highly influenced by the surrounding environment. Therefore the fouling communities are influenced by the environmental parameters considerably.

The structure and composition of the fouling complex exhibit wide temporal and regional variations which are governed mainly by varying hydrographical conditions and geographical locations (Dharmaraj and Nair, 1981). Zavodnik and Igic (1968) pointed out that the quantity and intensity of fouling depend on numerous biotic and abiotic factors.

The significance of seasonal variations of environmental conditions on fouling communities have been suggested by many workers such as Coe and Allen (1937); McDougall (1943); Cory (1967); Hanson and Bell (1976); Osman (1977); Sutherland and Karlson (1977); Dean (1977); Goren (1979); etc.

Wilkinson (1980), stated that, variations in
temperature, salinity and available light are the most probable causes for seasonal changes in estuarine algal distribution. Murthy et al (1970) suggested that temperature and dissolved oxygen are the most important environmental factors influencing algal biomass and primary production. Devassy (1983) opined that nutrients are biogenic elements and play a major role in the process of primary production.

Sander (1969), suggested that estuarine environments are "physically controlled" communities, where physical conditions fluctuate widely. Consequently the phenomenon of fouling and the various processes thereof in an estuarine environment need monitoring of environmental parameters, so as to have proper interpretation of the same. Devassy (1983) also suggested that regular monitoring of different environmental parameters is an essential prerequisite for the proper evaluation of the ecosystem.

In India, such investigations have been carried out by Paul (1942); Daniel (1954); Iyengar et al (1957); Antony Raja (1959); Nair (1967); Menon et al (1977); Rao & Ganapati (1978), Meenakumari and Nair (1984); Anil (1986) etc.

The present investigation was carried out in Waghotana estuary at Vijaydurg, Maharashtra and in Mandovi estuary at Panaji, Goa. Along with the observations on biofouling monitoring of environmental parameters was carried out in an effort to correlate the variations found in the settlement to
environmental changes. The analytical methods employed are described in this chapter.

In Mandovi estuary water samples were collected at fortnightly interval because of easy accessibility. However, water samples were collected from Waghotana estuary at monthly interval. At both the stations physical and chemical parameters such as temperature, salinity total suspended matter, pH, dissolved oxygen, transparency, phosphate, nitrate, nitrite, chlorophyll a, phaeopigments were analysed from the water. In Waghotana estuary, however, an additional parameter namely particulate organic carbon (POC) was monitored. Collection of water samples was done by using a plastic bucket.

ENVIRONMENTAL PARAMETERS AND METHODOLOGY - TEMPERATURE

Temperature is the most important single factor as far as marine organisms are concerned (Kinne, 1963; Costlow and Bookhout, 1971). It, according to Connor (1980) affects water density, oxygen and other gas solubility and the biological activities of many organisms. Temperature apparently is the primary factor regulating the daily timing of spore release and the seasonal periods of fertility in many species (Christie and Evans, 1962; Santelices, 1978; Rao & Kaliaperumal, 1983).
Temperature/light interactions are the factors determining timing of maximum algal biomass and diversity (Edwards, 1969; Hodgson and Waaland, 1979; Femino & Mathieson, 1980; Thom, 1980).

This parameter is known to affect morphology (Levinton, 1982), richness and species composition of the community (Quaid and Branch, 1984), and species distribution (Lewis, 1964).

Devassy (1983) opined that temperature is an important factor for determining the abundance and distribution of organisms in the higher latitudes but may not necessarily act as a controlling factor in tropical environment since the fluctuation of temperature in these waters is marginal.

The effects of temperature on fouling organisms were given by Lewis (1963); Southward (1955, 1957, 1958, 1962 and 1964) and Menon (1972).

Temperature of surface water was determined immediately after water collection by using surface thermometer (°C).

SALINITY

Salinity is one of the important factors to be considered in the marine environmental studies as it changes according to seasons as well as depth (Fritsch, 1935; Quasim et al, 1972; Devassy and Bhattathiri, 1974). It is supposed
to be the major environmental factor that controls the nature of the community (Anil, 1986; Meenakumari and Nair, 1984).

Distribution of benthic algae according to Munda (1978) is controlled chiefly by salinity. Most of the changes in species diversity both spatially and temporarily are due to intolerance of marine species to low salinity. According to Wilkinson (1980), lower salinity affects photosynthetic and respiration rates, survival of spores, desiccation resistance, response to light intensity, competitive ability, herbivore grazing pressure, cell division rates and reproductive capacity. Observations at Cochin (Balsubramanyan and Menon, 1983; Nair, 1967) have shown that fouling has been the least in quality and quantity during the monsoon periods which extend from the middle of May to the end of November (Southwest and North-east inclusive) and the cause is reasonably attributed to the fall of salinity. Salinity factor is relatively important in a country like India, where the two prevailing monsoons cause considerable amount of rainfalls over the region. Increased salt concentration in water according to McLachlan (1961) has an effect on chlorophyll synthesis, respiration, cell division and growth in unicellular marine algae.

Diatoms from the estuaries have the widest adaptibility to any change in salinity of the external medium (Williams, 1964). Estuarine algae are euryhaline. In an estuarine
environment where changes in salinity are very large. Maximum abundance of many organisms occurs at exceptionally low salinities. Field studies on horizontal distribution of algae in estuaries in relation to salinity (Conover, 1958; 1964; Druchl, 1967; Nienhuis, 1975; Pomeroy and Stockner, 1976; Mathieson et al, 1981) are supported by experimental results (Norton and South, 1969; Reed and Russel, 1978; Khfaji and Norton, 1979; Yarish and Edward, 1982).

It is generally realised that there is a complex relationship between salinity and temperature and changes in salinity can modify the effects of temperature and vice versa (Kinne, 1963).

The salinity was determined by standard method, described by Strickland and Parsons (1968) which involves the determination of chlorinity of the sample by Mohr-Knudsen titration method.

DISSOLVED OXYGEN

Oxygen is indispensable for the maintenance of life processes of all organisms. Raymont (1963) stated that among the more common gases that are dissolved in natural waters, oxygen is of profound significance since it enters into the normal biological cycle. Dissolved oxygen in seawater plays a very important role with respect to marine life. Oxygen distribution provides a good index of productivity.
characteristics of various environments. Murthy et al (1970) observed that periods of maximum accumulation of biomass tallied with low temperatures coupled with higher values of dissolved oxygen.

Oxygen concentration at any one moment at any given point is the resultant of a series of biological and physical factors (Kinne, 1970). According to Sharma (1978) oxygen content is controlled to some extent by the stagnation of water and biochemical activities such as photosynthesis and organic production also influence the oxicity of waters. Sverdrup (1942) stated that the requirement of oxygen by marine organisms depends upon the temperature of the surrounding environment.

The amount of oxygen dissolved in water was determined by the Winkler method.

pH

Sverdrup et al (1942) have reported that under normal circumstances, pH does not become a critical factor in marine environment. The sea is alkaline with a pH ranging generally from 7.5 to 8.4, though it may be as low as 7.3 (Prescott, 1969). It is generally considered that algae use free CO\textsubscript{2} in photosynthesis but at very high pH i.e. from 9.0 upwards the absence of free CO\textsubscript{2} may be an important ecological factor, the number of species is reduced at this level although many
other factors are involved (Round, 1965).

Changes in pH through photosynthesis may create a situation unsuitable for many algae and hence act as selector, or determine the domination of some species over others (Prescott, 1969).

Effect of pH on the settlement of the organisms was reported by Mor (1968). He reported an intense fouling at a pH range of 8.2 - 8.5 and a gradual decline on rise in pH values.

For pH measurements, a Toa (HM-5ES), pH meter was used.

TRANSPARENCY

Light of proper quantity and quality for photosynthesis is essential for plant survival. The amount and quality of light available to plants in the marine environment is subject to many variables such as reflection, scattering, absorption, the amount of suspended matter, amount of turbulence, amount of dissolved matter, latitude (angle of incidence), and depth (Prescott, 1969). It has been observed that on days when there is choppy water the maximum photosynthesis occurs at or just below the surface, whereas on calm days the best photosynthetic rate is at five meters (Prescott, 1969). Phytoplankton may have an ecological advantage over benthic plants in estuarine system because of
their ability to photosynthesize in surface layers where more light is available (Conor, 1980).

Nair et al (1973) found that transparency is more important than solar radiation which is never a limiting factor in the tropical waters. Very high light intensity could cause photoinactivation and production rates may be affected. Light is a highly critical factor, because of its role in photosynthesis. It has secondary importances, such as influencing the germination of reproductive elements (spores), determining polarity and plane of wall formation in cell division; influencing the rate of cell division in some forms (Cyanophyta according to some studies); movement in Cyanophyta and diatoms etc (Prescott, 1969). Furthermore temperature is also influenced by light.

Secchi disc was employed for determining transparency and the readings were recorded in cms.

SUSPENDED MATTER

Suspended matter is important as one of the major sources of food for the filter feeding sedentary organisms like foulers. Work on food value of suspended matter was carried out by many workers throughout the world (Riley, 1970; Qasim and Sankaranarayanan, 1972; Qasim, 1972; Krishna Kumari et al, 1978).
The waters of estuaries tend to be very turbid, as the silt and clay particles in suspension are carried about. The middle reaches of estuaries are characterised by very turbid waters, with poor light penetration. The presence and magnitude of "turbidity maxima" are controlled by a number of factors, one of which includes the amount of suspended matter in the river or in sea water (Postma, 1967). The suspended matter can cause physiological problems in the life of fouling organisms by clogging their delicate organs.

Total suspended matter in the sample was measured by first weighing GF/C filter which was heated upto 60°C previously. Thereafter, a fixed volume of sample of water was filtered using these filter papers. The difference in weight of the filter paper gave the amount of suspended matter present in water. This was expressed in mg/l.

CHLOROPHYLL a

The major source of nutrition of the fouling organisms is from the plants in the form of chlorophyll. Chlorophyll is an indicator of the primary production in the sea. Food supply is the main factor controlling the biomass and productivity of estuarine organisms (Mc-Lusky, 1981). Devassy (1983) stated that measurement of the most important plant pigment, chl a, gives an indirect estimation of the primary production of the area studied.
Chlorophyll a was extracted with 90% acetone and determined spectrophotometrically (Strickland and Parsons, 1972).

PHAEOPIGMENTS

Phaeopigments being mostly Mg-free decomposition products of chlorophylls, are an index of the physiological state of the phytoplankton and the concentration is governed by the intensity of light (Nakajima, 1973) and grazing pressure (Strickland et al, 1969). Devassy (1983) noted that phaeopigment concentration increased during the monsoon and dissipating stage of blooms and opined that due to high turbidity the transformation of chlorophyll into phaeophytin may be occurring simultaneously during the monsoon.

The phaeopigments were extracted with 90% acetone and determined spectrophotometrically (Strickland and Parsons, 1972).

PARTICULATE ORGANIC CARBON (POC)

The source of particulate organic carbon can be from detritus load, microorganisms etc. Detritus has been defined by Darnell (1967) as "all types of biogenic material in various stages of microbial decomposition, which represents a potential energy source for consumer species". POC gives the total carbon content of the suspended matter present in the seawater which is available as the source of energy for the
filter feeding organisms (Nandakumar et al, 1987).

The concentration of POC have been studied by many workers all over the world. Some of them are Menzel (1974); Wangersky (1976); Qasim (1977); Gordon and Granford (1985); Nandakumar et al (1987).

The values of particulate organic carbon (POC) for Waghotana estuary were found out following the method of Strickland and Parsons (1972).

NUTRIENTS

Rodhe (1948) and Blinks (1951) have cited that availability of nutrients is an ecological factor and that phosphorus and nitrogen are often limiting. The fertility of the sea is determined by the inorganic nutrients such as nitrite, nitrate, phosphate. These nutrients are essential for the primary producers and therefore, the productivity of an area greatly depends on their availability in sufficient concentrations. During active photosynthesis the utilization of these nutrients goes on at a rapid rate and as a result the environment gets depleted of them particularly of phosphate and nitrate. Unless and until this is replenished with fresh stock of nutrients primary production comes to a stand-still. However, the process of microbial regeneration and the physical processes such as vertical mixing,
convection and turbulence help the redistribution of nutrients into the lighted zone and promote primary production.

Ryan et al (1972) have found that increased levels of dissolved nutrients can change the aquatic ecosystem by stimulating algal growth. Most algae are good consumers of N, suggesting that a large quantity of algae will be associated with waters high in N content. Brandt (1929) pointed out the importance of nutrient salts in governing the richness or even barrenness of any locality. Many studies have related inputs and enrichment of nitrogen and phosphorus compounds to macro-algal blooms (Harlin & Thorn-Miller, 1981; Kinding & Littler, 1980; Guist and Humm, 1976; Waite and Mitchell, 1972; Rosenberg, 1985). Qasim (1972) observed succession of diatoms in the Cochin backwater and remarked that the right combination of nutrients may lead to succession in the growth of phytoplankton.

Venugopalan (1987) stated that in ecological investigations dealing with fouling organisms, a study of the distribution of nutrients has to be given due importance as they are the ultimate factors which influence the primary and thereby the secondary production. Changes in nutrient availability and light characteristics have been found to influence the availability of food sources of fouling communities (Levinton, 1972).
PHOSPHATE

Phosphorus plays an importance role in metabolism and in nutrition. Its source is orthophosphates in solution. The importance of phosphorus in metabolism and in population production is illustrated by increments in phytoplankton development following fertilization of lakes. Species of algae which are limited in development by availability of phosphorus have a high content of enzyme alkaline phosphatase. Phosphate deficiency in algae results in the accumulation of large amount of fat.

Allen (1936) stated that the diatoms may be deferred or aborted by lack of usable phosphates. Nasr & Aleem (1948) found that abundance and scarcity of plankton generally correspond with maxima (winter) and minima (summer) of both phosphates and nitrates.

Phosphorus contribution of the estuary is largely dependent upon external sources such as land drainage and freshwater runoff (Sankaranarayan & Qasim, 1969). Phosphorus was indicated to exert a marked influence on algal population (Frink and Machlis, 1968; Sikka and Pramer, 1968).

Determination of phosphate - phosphorus was based on the reaction with acidified molybdate reagent to yield a highly coloured blue compound which was subsequently measured at 885 nm spectrophotometrically.
NITRATE

High on the list of critical elements is nitrogen, which enters into metabolism in a number of ways. The quantity of nitrogen available and the form in which it occurs may be a presence-absence determiner of algal species. Nitrogen is essential in protein synthesis and in pigment construction. As in higher plants the source of nitrogen for algae (macroscopic and microscopic) is mostly nitrates.

It is obvious that the concentration of nitrate in the photic zone is quite high, and can support the observed primary productivity. (Queguiner & Treguier, 1984). Luxury consumption or uptake of nitrogen has been reported in several estuarine species (Asare & Harlin, 1983). Nitrate accumulate in the vacuoles of marine algae, in Valonia to the extent of 2,000 times and in Halicystis 500 times the nitrate value of seawater (Jacques and Osterhout, 1938). Growth experiments with unicellular algae and with Ulva indicated nitrates were one of limiting factors (Borowitzka, 1970). Krishnamurthy (1967) demonstrated that maximum values of total nitrogen content for phytoplankton at Porto Novo, correspond to peak period of phytoplankton.

Nitrate-nitrogen was determined by reducing it quantitatively to nitrite by passing through amalgamated cadmium reduction column.
NITRITE

Nitrite-N is a transitory stage in nitrogen metabolism. Nitrite is a nutrient important next to nitrate. Sankaranarayan and Qasim (1969) noted that values of nitrite-N were much lower than those of nitrate-N. Sankaranarayan & Qasim (1969) stated that nitrite-N may be formed as a result of decomposition of organic nitrogen an explanation which is similar to that of phosphorus cycle. Increase in nitrite and ammonia can be correlated with high zooplankton biomass (Queguiner & Treguier, 1984).

Nitrite-nitrogen was determined by reacting the sample with sulphanilamide solution leading to the formation of an aromatic compound followed by coupling with n-(1-naphthyl) ethylene diamine dihydrochloride to form an azo dye. The absorbance of the compound was measured at 543 nm spectrophotometrically.