General Introduction
1.0. GENERAL INTRODUCTION

Marine environment occupies major portion of the earth’s surface and the future of the world populations depends on this environment for its food and other life-saving wonder drugs. Hence utilization of marine resource for developmental purpose has gained considerable attention in recent times. Much interest has been focused in the biotechnological potential of the microseaweed mainly due to diverse bioactive compounds identified from these marine source. Sea is the source of heterogeneous group of organisms.

Different areas of the sea have different types of marine organisms, including varieties of plants like microalgae or phytoplankton, macroalgae, seagrasses and marine fungi. Among the plants of the sea, the minute planktonic forms are the most abundant and they are passively ‘drifting’ along with water movements. The phytoplankton or microalgae are a large group of microorganisms comprising of various classes of Chrysophyta, Pyrophyta, Cryptophyta, Prasinophyta, Phaeophyta and Rhodophyta. Phytoplankton organisms are autotrophs i.e. they fix solar energy by photosynthesis, using carbon dioxide, nutrients and trace elements. All these autotrophs contain photosynthetic pigments such as chlorophylls and carotenoids. Plankton may be arbitrarily classified by their size as nanoplankton (cells < 20 μm), microplankton (between 20 – 200 μm), mesoplankton, macroplankton and megaplankton (above > 200 μm) (Dussart, 1965, 1966 ; Lenz, 1968 ; Sourhia, 1968).

Biodiversity of marine microalgae in India

The marine algal resources of India are the moderately rich one (Michanech, 1975). Several surveys have been conducted along the Indian
coasts like Gujarat (Chauhan and Krishnamurthy, 1968; Bhandari and Trivedi, 1975; Chauhan and Mairh, 1979), Tamil Nadu (Anon., 1978), Goa (Untawale et al., 1979), Lakshadweep (Anon., 1979) and Kerala (Chennubhotla et al., 1987) indicate that there is very good resource of marine algae at several places. A total of 680 marine algal species has been reported in Indian waters (Anon., 1987). The cultivation of these algae with a proper scientific know how is very essential to improve the hatchery need of fish and shrimp aquaculture. This would also develop the socio-economic status of the people living along the coast.

Uses of microalgae in aquaculture

Sea plants contain more than ten to twenty times minerals and vitamins than the land plants necessary for proper metabolism (Kamimota et al., 1955). Benthic microalgae provides an important link within the food chain as one of the major primary producers. Microalgae directly support diverse communities of small benthic invertebrates such as polychaetes, nematode worms, copepods and soldier crabs.

Microalgae have made themselves a potential food and feed to diverse group of organisms, because of their small size and higher growth rate (Becker and Venkataraman, 1989; Fabregas and Herrero, 1985, 1990). They can also promote larval growth, survival and earlier sexual maturation of fry species (Watanabe et al., 1980; Sorgeloos, 1990). Hence, microalgae are widely used in aquaculture. The demand for microalgae in fish and shrimp hatcheries is increasing everyday because of its major role in aquaculture.

Microalgae is a must in the early stages of any commercially culturing aquaculture species. The early larval stages depend for feed only on
microalgae. Aquaculturists still could not find any alternate for microalgae and even now they depend on the production and use of microalgae as live food for commercially important fish, molluscs and crustaceans during the least part of the life cycle (De Pauw et al., 1984; Laing, 1980).

**Nutrient value of microalgae**

Microalgae border between plant and animal kingdoms and as such offer some distinct nutritional advantages. In their dried state, there is optimal quantities of protein, amino acids, beta-carotene, nucleic acids, pigments, vitamins, polysaccharides, bioactive compounds, biocatalyst and biofertilizer (Bonotta et al., 1989; Richmond, 1990).

Marine microalgae, growing naturally in seawater constitute an essential and huge link in the global food chain and global oxygen production (Berend et al., 1980). The ability of marine microalgae to accumulate trace elements is well documented (Jensen et al., 1974 and Sakaguchi et al., 1981). Most of the researchers on inorganic elements have been confined to osmoregulation and related physiological functions (Azam et al., 1974; Adshead Simonson et al., 1981; Ginzburg, 1981; Rebheen and Ben-amotz, 1984). The nutrient quality of the microalgae needs to be maintained at optimal conditions in order to ensure the maximum growth and survival rate of the culture animals (Volkman et al., 1989).

**Antibacterial activity of marine microalgae**

Marine microalgae produce an incredible diversity of secondary metabolites. An individual species contains more than 1000 unique chemical entities. In order to survive and grow in a highly competitive habitat many organisms must compete for the limited resources. The physiological
manifestations of these defense abilities of marine organisms are in the form of bioactive metabolites. Among the wide range of marine organisms, microalgae also play an important role in the production of bioactive compounds.

Antimicrobial metabolites are present in all algae classes. Very large number of active species were found in the Chlorophyceae, Bonnemaisoniaceae, Rhodophyceae and Phaeophyceae. The metabolites produced by the microalgae are extracted and prepared with lipophilic or hydrophilic solvents. Until the mid sixties final purification and establishment of structures had been achieved in only a few cases (Faulkner, 1977).

The first successful studies for identification of algal inhibitors were carried out with culture solutions of various unicellular Chlorophyceae, especially Chlorella. The antialgal and antibacterial activities increased with the age of the cultures and they were greater in illuminated than in dark cultures (Jorgensen, 1956). An active fraction isolated from such culture was called Chlorellin by Pratt (1944). It has an inhibiting effect on Gram positive and Gram negative bacteria. In spite of many efforts, upto now no definite structure proposal for one or more of the effective principles has been published. They are supposed to be a mixture of fatty acids, in which the more unsaturated compounds are converted by photooxidation into antibiotically active derivatives (Spoehr, 1949).

Similar observations were made with culture solutions and extracts of other algal species (Oschromonas danica, Nitzschia sp., Stichococcus mirabilis, Protosiphon botryoides, Chlamydomonas reinhardtii (Proctor, 1956). The exact investigations of Pesando (1972) with extracts from the diatom Asterionella japonica, the photo-oxidation products of an
Eicosapentaenoic acid develop a strong antibiotic activity after short illumination. Therefore, participation of derivatives of highly unsaturated fatty acids in the antibiosis of algal structures and extracts seems to be investigated.

Acrylic acid is the first antibiotically active compound from algae which was unambiguously identified. It was detected by Sieburth (1967) in Phaeocystis poucheti. Acrylic acid is excreted in low concentration into seawater by Phaeocystis (Guillard, 1971). According to Obota (1951), Phaeocystis inhibits Gram positive, and to a lower degree Gram negative organisms.

In the highly volatile fractions of the genera Asparagopsis, Bonnemaisonia and Ptilonia, belonging to the Bonnemaisoniaceae, a great variety of halogenated alkanes, saturated and unsaturated ketones, aldehydes, alcohols, epoxides and halogenated derivatives of acetic acid and acrylic acid have been detected. A notable antibiotic activity against Bacillus subtilis, Staphylococcus fusarium and Vibrio was shown for the halogenated heptanones (Siuda, 1975).

In the class Rhodophyceae, a great variety of unusual, mostly halogenated, and sometimes aromatic terpenes were found. It shows that the phenolic halogenated terpenes like laurinterol and isolaurinterol are more active than the unhalogenated or the non-aromatic terpene, especially against Staphylococci and Mycobacteria.

Sulphur containing hetero cyclic compounds

In Chondria californica, a species belonging to the Rhodophyceae, various peculiar heterocyclic compounds were found. They are cyclic
polysulfieds and their oxidation products, several thiepanes and thiolanes which are antibiotically active (Wratten, 1976).

**Phenolic inhibitors**

The antimicrobial properties of free phenols are well known. Therefore, phenols are frequently used as antiseptics. Among phenolic substances detected in Chlorophyceae, Rhodophyceae and Phaeophyceae is p-cresol, 3-5 dinitrogualacol (Katayama, 1961; Ohta, 1977).

**Antifungal properties of marine algae**

Burkholder (1960) had tested 131 specimens of marine algae from the Bay of Puerto Rico against pathogenic bacteria, marine bacteria and the yeast *Candida albicans*, and they found that the dinoflagellate *Gonioula tamarensis* showed noticeable activity against *Candida albicans*.

Mauter (1953) reported that marine algae have also been found to be active against the fungi *Trichophyton mentarophytes* and *Trichophyton rubrum, Candida albicans* and a number of other fungal organisms. He tested aqueous homogenates of 22 marine algae belongs to Rhodophyta, Chlorophyta and Phaeophyta against 6 fungi and found that these preparations affected growth, fruiting and colour of the tested organisms.

**Antiviral properties of marine algae**

The marine algae possess antiviral substances was first suggested by Gerber (1958), who observed that polysaccharides extracted from *Chondrus crispus* afforded protection for embroynated eggs against influenza B and mumps virus. Kathan (1965) discovered an inhibitor of bacterial and influenza neuraminidiose in kelp meal. This substance inhibited the replication of
influenza A in embryonated eggs. Chemical characterization of partially purified inhibitor revealed the presence of both polysaccharide and protein.

**Interaction between microalgae and marine bacteria**

Marine benthic algal consortia are organized in multilayered structures that cover the surface of illuminated submerged substrates with a so called biofilm. Biofilms are compact associations of microbenthic algae with bacteria and inorganic particles embedded in polymeric secretions and sustaining an intricate network of functional interactions.

Epibiotic bacteria can produce secondary metabolites which inhibit the settlement of potential competitors such as invertebrate larvae and can antagonistic other bacteria (Holmstrom and Kjelleberg, 1999).

Considering the importance of marine microalgae and its uses, the present investigation was carried out with the following objectives.