I - REVIEW OF LITERATURE

A) Introduction.

Algae are mostly inconspicuous and to the superficial observer, usually less attractive than flowering plants. Nevertheless, they have had for a long time devotees among morphologists, who have appreciated their beauty of form as revealed under the microscope, the variety of structure and life history which they display. More recently physiologists, biochemists, molecular biologists and geneticists have realised that these organisms not only provide ideal experimental material for the investigation of general biological problems, but they possess interesting features peculiar to themselves.

The word "algae" is derived from a Latin word "alga" meaning sea-weeds. Algae are known to be evolved at very low rate among the plant kingdom. They might have evolved quite early on the earth, since the fossil records from the Pre-cambrian period are available (Chapman and Chapman 1981). Marine algae as the name suggest are the algae of seawaters which are popularly known as seaweeds which have rich nutritional value and hence they have been intimately connected, directly or indirectly with human beings as a source of food, fodder and mannure from time immemorial (600 B.C.) especially in densely populated countries.

It has been predicted that within the next few decades civilization will suffer from a shortage of certain commonly used sources of energy. Solar energy is unending and one of the easiest ways to trap solar energy, is to raise large plants both on land and in the sea. Now-a-days, crop lands are being destroyed to build roads, construct houses and to develop industrial complexes and as such, tapping of the solar energy by plants is considerably reduced. The ocean provides unlimited space for capturing sun's radient energy, primarily through the process of photosynthesis by a wide spectrum of plants.

Food resources of the world are not keeping pace with increase in the population. Hence, there is a need to augment the existing food resources of the world. Natural resources are yet to be fully exploited. Among the numerous marine resources available in large quantities for use, sea-weeds are important and may play a pivotal role in the years to come.

Besides, their use as food, seweeds contain more than 60 trace elements and their concentrations are much higher than in terrestrial plants. They also contain vitamins, antibiotics (Brayan and Hammerstone, 1973) They have high nutritive value and

a number of chemical compounds can be extracted from them (Chapman, 1973).

The research on the distribution and utilisation of the marine algae has received much emphasis in recent years. India with long coast line provides optimum conditions for the cultivation of sea weeds. In spite of the tremendous work on the Indian marine algae, most of our coastline remains to be properly evaluated for the resources. West cost ingeneral and Goa cost in particular, has not received much attention from this point of view. Ecological studies on marine algae in India are few and mostly fragmentary, the only contributors are Parija and Parija (1946), Sreenivasan (1946), Krishnamurthy (1954), Prasanna-Verma (1959), Misra (1960) and Umamaheshwar Rao and Sreeramalu (1964) who have studied the ecology of marine algae. Iyengar (1927) published the account on both fresh and marine algal flora of south India and gave a brief account of Krusaday island and other places in the Gulf of Mannar and Palk Bay (areas close to Mandapam). Since then the distribution of marine algae has been reported from other parts of the Indian cost by Boergesen (1933, 35), Dixit (1940), Chalko and Pillai (1958), Sreenivasan (1946) and Krishnamurthy and Joshi (1970). Misra (1965) studied the phaeophyceae of the west coast of India. His study deals with the

species occurring on the littoral regions of Okha port, Dwaraka, Porabandar, Veraval and Bombay, all of which beong to the northern region of the Indian coast. Dixit (1940) who worked with Boergesen has published a paper on the algae of the Malvan harbour.

Along the west coast of India, some areas in Gujarat were studied by Sreenivasa Rao et al. (1964), Desai (1967), Chauhan and Krishnamurthy (1968) and Chauhan and Mairha (1978). Dixit (1933, 1940) studied the algae of the Malvan harbour and Chauhan (1977) surveyed Sargassum species and other brown algae of the Maharashtra coast from Bombay to Vengurla. Recently, Untawale et al. (1979) studied in detail the seaweed resources of the Maharashtra coast and listed 94 species. Untawale and Dhargalkar (1975) and Agadi and Untawale (1978) have surveyed the algal resources of Goa. An ecological study of Ulva reticulata Forsskal from Chapora bay, Goa has been carried out by Untawale and Dhargalkar (1979). Balkrishnan et al (1974) have made extensive study of algal forms at Malvan. Joshi (1976) has also enlisted different algal species found at Malvan. Chougule (1991) reported Derbesia boergesenii for the first time and Bangia fuscopurpurea by Untawale (1980.) from west coast of India at Malvan.

Sea weed utility :

Ahilan and Sujathkumar (1990) have reviewed utilization of seaweeds in natural ecosystem. According to them for ancient people, seaweeds were first of all the source of obtaining salt, next they probably learnt empirically that seaweeds were rich in nutritive substances necessary for good health and thereafter began to eat seaweeds frequently. Thus, seaweeds are become valuable aquatic products which have contributed to human life in large extent.

Marine plants grow as they produce carbonic compounds by photosynthesis using solar energy and nutritive salts dissolved in the water. These representative marine plants are phytoplanktons which serve food for aquatic animals. It is said that in the oceans of the world 10 billion tons (in dry weight) of phytoplankton are produced in a year. Phytoplanktons together with zooplanktons turned to be valuable foods for larva of fishes. There are many fishes feeding mainly on the phytoplankton even in their adult stage.

Seaweeds also protect fish breeding grounds which are used as spawning grounds by fishes and other aquatic animals.

Seaweeds are used as foods in two different ways. They are either eaten raw or agar is extracted from the body of seaweed and supplied to the food industry. The seaweeds which are used directly for food are green, brown and red algae. The species of seaweeds currently used for food are Ulva, Enteromorpha, Laminaria, Porphyra, Gracilaria, Caulerpa, etc. (Ahilan and Sujatha Kumar, 1990).

The seaweeds are rich in carbohydrates, proteins and minerals. Besides, they contain lipids and vitamin and hence are used for nutritional purpose. Almost all kinds of seaweeds are rich in vitamins A, B, B_2, C and niacin. In addition they contain 7 to 34% minerals as well as minor elements necessary for human body such as calcium, sodium, potassium, magnesium, phosphorous, sulphur, Iodine and Iron are also present in sufficient quantity. The digestable nutrient content for live-stock is estimated which is to the tune of 33-35% and hence the seaweed meal is used to feed pigs, chicken, goats etc.. Suitable seaweed used for this purpose are species of Laminaria, Saragassum, Ulva, Gracilaria and Zostera.

Since seaweeds are of great value as a source of potassium, nitrogen and other organic components, are used as

effective fertilizer for agriculture.

Above all the seaweeds are widely used in extracting alginic acids and agar-agar and some seaweeds such as Saragassum thunfragile has a medicinal potential as an expellent for roundworm. Thus, it is vividly clear that the seaweeds are potential sources for food, feed, chemicals, medicine, and fuel. However, the seaweed raw material position in India appears to be not at all promising. Hence it is essential to cultivate or to conserve the seaweed resources of Indian coast, and it is also essential to explore different places of rich algal vegetations for ecological and biochemical aspects.

During the last two decades, information was collected on the potential of Indian seaweeds and their utilization as sources of phycocolloids, human food, animal fodder and fertilizer (Thivy, 1960; Umamaheshwar Rao, 1969, 1970; Untawale et al. 1981). The work done on Indian seaweeds is reviewed by Umamaheshwar Rao (1989) in which he reported the present status of seaweed industry and resources position in the country. According to him the productive seaweeds area and harvesting seasons are to be properly managed and rational exploitation of the existing natural resources is essential.

Several workers have surveyed seaweed resources from different maritime States and estimated the seaweed biomass (Table 1).

It is evident from the table that the densities of total standing crop of useful seaweeds vary in different areas.

Chauhan (1978) in his survey report of marine algal resources of Maharashtra coast reported that Saragassum is dominant seaweed in beds of Malvan area. Agadi et al. (1978) have made extensive survey of marine algal flora along the Goa coast. In all 50 algal species have been recorded by them of which 28 have been reported for the first time.

Most of the marine phycologists have confined their research in studying seasonal variation in organic constituents of seaweeds such as carbohydrates and proteins (Joshi and Gowda, 1975; Dhargalkar, 1986; Penniaman and Mathieson, 1987); polyphenols (Joshi and Gowda, 1975; Ragan and Jensen, 1977, 78, Zavodnik, 1980); chemical constituents (Dhargalkar, 1986; Penniman and Mathieson, 1987; Rao and Indusekhar, 1989), mannitol

Table : 1 Sea weed resources estimated from different maritime States.

Maritime State	Area/length of the coast line surveyed	Standing crop (Tonnes wet wt.)	Reference
Gujarat	548 h	446.2	Chauhan, 1978
Maharashtra	563 km	278.3	Chauhan, 1978a
Goa	?	2000.0	Dhargalkar,1981
Tamil Nadu	9892 h	22044.0	Anonymous, 1977
Andhra Pradesh	1876 h	7493.0	Subbaramiah et al. 1987
Orissa (Chilka)	-	5.0	Mitra, 1946
Lakshdweep	1334 h	7524.0	Subbaramiah et al., 1979

After Umamaheshwar Rao (1989)

and alginic acid content (Umamaheshwar Rao, 1969; Joshi and Gowda, 1975; Mehta and Parekh, 1978; Kalimuthu, ?), agar-agar (Joshi and Gowda, 1975; Yang et al., 1980; Onraet and Robertson, 1987; Penniman and Mathieson, 1987; Mouradi-Givernaud et al. 1992), Growth (Prince and O'Neal, 1979; Kalimuthu et al. ?), Chlorophyll (Patil, 1967; Kulkarni, 1980; Liu et al. 1980).

Besides, screening of some seaweeds from the Indian coast have also been studied for their biological activity such as test for antiviral, antibacterial, antifungal, antiprotozoal and antifertility by Naqvi et al. (1981). significant biological activity was obtained in 13 seaweeds, the most promosing activity being 100% antifertility activity observed in 3 species. According to them diuretic activity was observed in the extracts of Hypnea musciformis, Entermorpha sps. and Trichodesmium erythracum; hypotensive activity in Caulerpa racemosa and Chondria armata; spasmogenic activity in Coralline sps. and Padina tetrastromatica; spasmolytic activity in Stoechospermum marginatium; antiviral activity in Codium elongatum and CNS deprssant activity in Saragassum tenerrimum. Three extracts of Acantophora specifera, Padina tetrastromatica and Gelidiella acerosa showed 100% antifertility activity.

Extensive work has been carried out on the chemical constituents of marine algae. According to Thomas and Krishnamurthy (1976) Mehata and Baxi (1976) algae are the only sources of alginate, agar and carrgeenan. These biochemicals are extensively used in textile, drugs, dairy and paper industries. Besides, the marine algae have been investigated for production of methane gas (Hanisak, 1981), Paper (Kiran et al. 1980), bio-active compounds in pharmacy (Hoppe et al. 1979) dyes (Novak and Rasmussen, 1981) and in human diseases (Stein and Borden, 1984).

Work done in our laboratory

A great deal of work has also been carried out on seaweeds in this department. Patil and Joshi (1970, 1971) have made excellent contribution in the field of algal photosynthesis. They have established metabolic pathways in Ulva lactuca by studying pulse-chase experiment using labelled $NaH^{14}CO_3$. Joshi and Karekar (1973) have studied Pathway of $^{14}CO_2$ fixation in marine algae Enteromorpha tubulosa, Sargassum ilicifolium, Sphacelaria sp. Padina tetrastromatica and Chaetomorpha media. Their study revealed that the above marine algae differ from conventional $^{14}CO_2$ fixation pathway recorded in Chlorella. The early labelling of aspartate and its subsequent utilization

indicated operation of HsK pathway in the marine algae. They have supported these findings by scoring the activities of an enzymes PEPCase and RuBPCase. Further they have reported that appreciable label in PGA is suggestive of the fact that Calvin and Bassham pathway as well as the HSK pathway are simultaneously operating in marine algae. Joshi and Gowda (1975) have also studied seasonal variations in chemical composition of Sargassum ilicifolium and reported that the alga is rich in mannitol and poor in soluble carbohydrates. Shitole (1980) established the path of carbon in Caulerpa racemosa var. Peltata with the help of pulse chase experiment and by scoring the activities of photosynthetic enzymes. His data indicated that Caulerpa racemosa var. Peltata fix carbon via C_4 path.

Kulkarni (1980) studied Gracilria corticata a seaweed of class rhodophyceae. His study mainly dealt with physiological aspects of G. cortceta. Kulkarni and Nimbalkar (1981) have given a good account of seasonal variation in chemical composition of Gracilaria corticata.

Initial products of photosynthetic carbon assimilation and some photosynthetic enzymes in G. carticata have also been studied by Kulkarni and Nimbalkar (1983). The study of

utilization of ^{14}C-aspartate in G. corticata by Kulkarni and Nimbalkar (1983a) is a break through which supported the earlier investigation of the laboratory that in marine algae C_4 path of photosynthesis is more efficient than the convential C_3 path. Joshi (1976) made a brief review on culture of marine algae, seasonal variation in inorganic constituents, initial and steady state products of photosynthesis and carboxylating enzymes in different marine algae.

The foregoing literature survey thus indicated that most of the work is mainly confined to survey report, exploration of the vegetation, seasonal variation in chemical composition and organic constituents, of a particular algae from a particular place. In the present investigation an attempt has been made to study some dominant representative algae of class chlorophyceae, phaeophyceae and rhodophyceae of Malvan coast.