

1. INTRODUCTION

All macroscopic algae occurring in the marine and coastal brackish water habitats are termed as seaweeds. They are autotrophic non-flowering plants and grow either as free floating in the sea surface or attached on rocks, shells or coral in intertidal and subtidal regions. Seaweeds belong to Thallophyta, a group of primitive plants which are grouped under three major classes namely Chlorophyceae (green algae), Phaeophyceae (brown algae) and Rhodophyceae (red algae) based on their morphology and pigmentation of their thallus as well as cell wall polysaccharides (phycocolloids). Seaweeds are valued as one of the important marine living resources as they are the only source of marine polysaccharides known as phycocolloids such as Agar (agar agar), Carrageenan and Algin (alginic acid). These phycocolloids are widely used in various industries such as food, confectionery, textiles, pharmaceuticals, dairy and paper industry mostly as gelling, stabilizing and thickening agents. Seaweeds are also used as animal feed, as manure and as a source of enzymes, dyes, drugs, minerals and vitamins (Chapman, 1970; Deve *et al.*, 1977; Anon., 1987; Joseph and Lipton, 2004) .

World aquaculture production including seaweeds and food fishes in 2008 attained 68.3 million tonnes with a total estimated value of US \$ 7.4 billion. Of the world total production of aquatic plants in the same year, 93.8 % came from aquaculture. The culture of aquatic plants has consistently expanded its production since 1970 with an average annual growth rate of

7.7.% and the production was dominated by seaweeds to the tune of 99.6 % by quantity and 99.3% by value in 2008 (FAO., 2011). Countries in East and Southeast Asia dominate the seaweed culture production(99.8 % by quantity and 99.3% by value in 2008). The People's Republic of China alone produced 62.8% of the world aquaculture production of seaweeds by quantity. Other major seaweed producers are Indonesia(13.7%), the Philippines (10.6%), the Republic of Korea (5.9%), Japan (2.9%) and the Democratic People's Republic of Korea (2.8%). In East Asia, almost all cultured seaweed species are meant for human consumption, although Japanese kelp is also used as raw material in the extraction of Algin and Iodine. On the other hand seaweed farming in Southeast Asia with *Eucheuma* spp. as the major crop, are utilized for carrageenan extraction (FAO., 2011).

India is endowed with a coastline of 8,118 km , an exclusive economic zone (EEZ) of 2.02 mn sq km and a continental shelf area of 468000 sq km spread across 9 maritime States and seven Union Territories. The seaweed wealth of India is estimated to 260876 tonnes wet weight (Kaladharan and Reeta, 2003) comprising 896 species; 228 species from Chlorophyceae, 210 species from Phaeophyceae, 455 species from Rhodophyceae and three species from Xanthophyceae (Umamaheswara Rao, 2011). Rich vegetation of seaweeds can be found in Southern coast of Tamilnadu, Okha and Gulf of Kachchh of Gujarat, Lakshadweep and Andaman -Nicobar archipelagoes. Fairly rich beds of seaweeds occur at Mumbai, Goa, Ratnagiri, Karwar,

Thikkodi, Varkala, Vizhinjam, Kanyakumari and Rameswaram coasts as well as in the Pulicat and Chilka Lakes (Anon., 1987). From the seaweed resource assessment surveys carried out along the Indian coasts by the Central Salt and Marine Chemicals Research Institute (CSMCRI), Bhavangar, Central Marine Fisheries research Institute (CMFRI), Cochin, and National Institute of Oceanography (NIO), Goa; the resources available for the production of phycocolloids in India are just 9% of our total seaweed resources and the major chunk is unutilized or underutilized (Umamaheswara Rao, 2011).

In India seaweeds are harvested from natural beds along the Tamilnadu and Gujarat coasts since 1966 for the seaweed industries. Exploitation of seaweeds from Indian coasts is restricted to species such as *Gelidiella acerosa*, *Gracilaria edulis*, *Gracilaria corticata* for agar production and species of *Sargassum* and *Turbinaria* for algin production (Kaladharan and Kailaperumal, 1999). In India there are several factories manufacturing agar and algin and very recently carrageenan (crude). Seaweed resources in our coastal regions are inadequate to meet the growing demands for agar, carrageenan and algin production. Therefore it has become essential to cultivate commercially important species of seaweeds to augment supply to these seaweed industries. Our efforts to utilize the algal biomass for making value added products are very much limited when compared to other nations.

Agar is the major constituent of the cell wall polysaccharide of certain red seaweed (Rhodophyceae) especially the members of families Gelidiaceae, Gelidiellaceae and Gracilariaceae. "Agar-Agar" is the Malay word for a gelling substance extracted from *Eucheuma* sp., now known to be carrageenan. The term agar is now generally applied to the algal galactan, which have agarose, the disaccharide agarobiose as their repeating units (Duckworth and Yaphe, 1971). The world demand for agar has increased rapidly in recent years and currently the supply of agar containing seaweeds have greatly reduced. It is estimated that the current production of agar in the world is about 7500- 10,000 tonnes/ year and India's share is hardly 130 tonnes/year (Devaraj *et al.*,1999). In food technology agar is used for gelling and thickening in the confectionary and bakery industries. In the pharmaceutical industry agar is used as a laxative for chronic constipation, as drug vehicle (encapsulation) and as a substratum for bacterial and fungal cultures. Agar is an ion-exchanger and is used in the manufacture of ion exchange resins. In cosmetic industry agar is used as a constituent of skin creams and ointments.

Algin or alginic acid is a membrane mucilage obtained from some brown seaweeds (Phaeophyceae) species like *Laminaria*, *Macrocystis*, *Turbinaria* and *Sargassum* and is a major constituent of all alginates such as calcium alginate and sodium alginate. Algin is used in pharmaceutical industry as emulsifiers with fats, oils and waxes as fillers in the manufacture

of tablets, pills and as a base of ointments. As a slimming agent, the alginate forms a jelly in the stomach which produces the satiation. Ammonium alginate wool is used as a filter for microorganisms in laminar flowhoods. In the confectionary, alginates are used for making imitation fruits. Alginates find extensive application in textile industry particularly as thickening agent for printing dyes and paints that prevent smudging and promote quick drying.

Carrageenan is a sulphated galactan obtained from red seaweeds belong to Gigartinaceae, Soliriaceae and Hypneaceae such as *Hypnea valentiae*, *Eucheuma cottonii*, *Chondrus crispus*, *Kapaphycus alvarezii* etc. In food industry, carrageenan finds its use in bakery, dairy, confectionery and culinary purposes in the preparation of whipped creams, ice desserts, cheese etc. Carrageenan improves the quality of wheat flour in *spagethi* and *parotta* making. The food sector accounts for nearly 70% of world market for carrageenan.

The coastline of Kerala extending upto 690 km is intercepted by fishing harbours, ports, tourist resorts, bridges, seaweed and mangrove beds, river mouths, boat yards, sandy beaches, etc. Seaweeds grow abundantly along the coast wherever hard, rocky or coral substrata are available for their attachment. *Chennubhotla et al.(1988) conducted resource assessment survey along the Kerala coast and brought out the details of availability of commercially important resources for the first time. Occurrence of Porphyra*

kanyakumariensis was reported from the southern Kerala coast by Chennubhotla et al (1990). *Gracilariopsis lemaneiformis*, a long thalloid agar yielding red alga has been reported from certain backwaters of Dhalavapuram, (Quilon), Kadalundi (Kozhikode) and Mopla Bay (Kannur) along the Kerala coast (Kaladharan, 2005). Nettar and Panikkar (2009) described two new species from the Family Ralfsiaceae, *Hapalospongidion thirumullavaramensis* and *Pseudolithoderma thangasseriensis*, collected from the Quilon coast of Kerala. The taxonomy of four species of *Feldmannia* collected from different parts of Kerala such as *F. collumellaris*, *F. irregularis* and two new species: *F. sahnienii* and *F. renienii* was also reported by Nettar and Panikkar (2009 a). Nettar and Panikkar (2009 b) reported five species of *Hincksia* collected from different parts of Kerala and these include, *H. clavata* (Krishnamurthy and Baluswami) Silva, *H. ralfsiae* (Vickers) Silva, *H. sandriana* (Zanardini) Silva, *H. mitchelliae* (Harvey) Silva and *H. turbinariae* (Jaasund) Silva. Among these, *H. ralfsiae* is a new report to the Indian marine flora.

The information available on the seaweed resources of Kerala coast is only from the southern coast (Koshy and John 1948; Balakrishnan Nair et al., 1982, 1986, 1986a, 1990 and 1993; Sobha and Nair, 1983 and in 1985; Nettar and Panikkar, 2009, 2009 a, 2000b.) The standing crop of seaweeds along the Kerala coast has been estimated to 1000 tonnes wet weight (Chennubhotla et al., 1988) constituted by 35 species belong to 28 genera (Kaliaperumal and Chennubhotla, 1997) which was brought out from the brief

investigation taken up during May- June 1988. Moreover, information on the distribution of commercially important seaweed resources and any seasonal or regional variations in their phycocolloid content is lacking from the Kerala Coast. In addition to the existing number of seaweed industries many more are also coming up including carrageenan production units. Great demand and competition for raw material are being experienced. In the light of the above, the present study was planned and designed with the following objectives:

1. Identify important seaweed resources occurring along the Kerala coast,
2. Estimate industrially important colloids found on the seaweeds like agar-agar, alginic acid and carrageenan and
3. Study any correlation between the resource availability and their colloid content with their *in situ* environmental conditions.

The outcome of this study might help the entrepreneurs of seaweed based industries on various seaweed resources that can be used as alternative raw materials and their colloid yields along the Kerala coast.