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Seaweed Resources of India

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Seaweeds yield valuable phycocolloids like agar-agar and algin which are widely used in many industries. They are also utilised as food, fodder and fertiliser. Survey of natural seaweed resources and investigation of the chemical composition, methods of extraction, ecology, cultivation and other aspects related to their utilisation are therefore of utmost importance. Majority of the economic seaweeds come under three classes namely the Green algae (Chlorophyceae), the Brown algae (Phaeophyceae) and the Red algae (Rhodophyceae) and they are generally restricted to the relatively narrow littoral and sublittorial belts of the marine environment.

In India several areas along the coast offer suitable environments for luxuriant growth of seaweeds of commercial value. Mandapam, Pamban, Rameswaram, Keelakarai, Tuticorin, Cape Comorin, Muttam and Colachel in Madras State, Visakhapatnam and its environs in Andhra Pradesh, Chilka Lake in Orissa, Okha, Dwarka and Veraval in Gujarat, Bombay and Ratnagiri in Maharashtra, Karwar and adjacent areas in Mysore, Varkala, Kovalam and Vizhingam in Kerala are some of the potential areas along the Indian coast for commercially valuable seaweeds. Laccadives, Andaman and Nicobar Islands are also noted for their rich seaweed resources. Reference is invited to the figure reproduced in the appendix for the general distribution pattern of economic seaweeds along the Indian coast.

On the basis of products obtained, Indian seaweeds may be broadly classified into three groups namely agarophytes, alginophytes and plants used for food, stock feed and ertilizer.

Agarophytes

Gelidiella acerosa, *Gracilaria lichenoides*, *Gracilaria crassa*, *Gracilaria corticata*; *Gracilaria follifera* and *Gracilaria verrucosa* are the principal agar-yielding plants of our country. There is variation among these agarophytes in their distribution and abundance. Considerable quantities of *Gelidiella acerosa* and *Gracilaria foltifera* occur in coral reef areas around Mandapam and also at Okha and Dwarka. *Gracilaria corticata* occurs on many intertidal rocky areas along the coast of India. *Gracilaria lichenoides* is plentiful in the Gulf of Mannar area and *Gracilaria verrucosa* is found growing abundantly in Chilka Lake. Working with some of these agarophytes a method has been developed at the Central Marine Fisheries Research Institute to extract good quality agar. Results obtained on the maximum yield of agar on dry weight basis and gel strength (gm./cm.^{2}) of 1.5% solution of *Gelidiella* and *Gracilaria* species are given below:

Species	Yield	Gel strength
Gelidiella acerosa	45%	300
Gracilaria lichenoides	43%	120
Gracilaria crassa	23%	140
Gracilaria corticata	38%	20
Gracilaria follifera	12%	15

Some algae for example, *Hypnea* and *Spyridia* yield viscous substances with very low gel strength, known as agaroids. These agaroids are soluble in cold water and are useful as stabilizers. Agar with satisfactory gel strength could be obtained from agaroids, especially from species of *Hypnea,* by chemical treatment.

Alginophytes

Sargassum moriocystum, *Sargassum wightii*, *Sargassum swartzii*, *Sargassum johnstonii*, *Sargassum vulgare*, *Sargassum ilicifolium* and other *Sargassum* spp., *Turbinaria conoides*, *T. oronata*, *T. decurrens*, *Cystophyllum muricatum*, *Hormophysa triquetra*, *Padina* spp.; may be mentioned as the representatives of the algin-bearing seaweeds of India. Of these, species *Sargassum* and *Turbinaria* are the valuable raw materials for the production of sodium alginate or alginic acid. Yield of algin from *Sargassum* and *Turbinaria* is about 20 to 25% of the dry weight and from other brown algae the yield is less than 20%. Mannitol and iodine could be extracted as by-products from these brown seaweeds, but yield of these compounds varies considerably with season and stage of development of the plant.

Uses of agar-agar and algin

Agar-agar and algin are colloidal carbohydrates accumulated in the cell walls of red and brown algae. They are used in food, confectionary and dairy industries as gelling, thickening and stabilising agents in the preparation of sweets, gellies, jams, desserts, ice-creams, sherbets etc. Agar is particularly used when firm gel is required and algin is extensively used for soft and viscous products. These seaweed colloids play an important role in pharmaceutical and cosmetic industries as emulsifiers, gel formers and body producers. In textile industry they are often used as sizing materials and as thickeners in dyeing and printing. Other uses of these compounds include the following: adhesives, clarification of liquor and water, leather finishing, dental impression compounds, insect sprays, paints etc. Sodium alginate and other salts are used in the manufacture of synthetic fibre for certain textiles and agar is used as lubricant in drawing tungsten wires and as culture medium for microbiological work.

Edible seaweeds and their nutritive value

Seaweeds form an important part of the diet taken by the people of China, Japan and many other countries of the Western Pacific Region. *Ulva*, *Enteromorpha*, *Codium*, *Caulerpa*, *Hydroclathrus*, *Padina*, *Colpomenia*, *Sargassum*, *Turbinaria*, *Acanthophora*, *Laurencia*, *Gracilaria*, *Hypnea* and *Porphyra* are commonly used for food. These are eaten raw

as salads, and cooked as vegetables. Certain fresh or processed varieties are used in the preparation of pickles with vinegar, soup, porridge and also for garnishing the dishes.

Nutritive value of seaweeds depends mostly on the protein, vitamin and mineral constituents present in them. Green and red algae are rich in proteins and high amounts of protein ranging from 20.12 to 25.48 mg./100 gm., have been found to occur in *Ulva fasciata, Ulva regida, Acanthophora muscoides* and *Centroceras clavulatum.* The Vitamin-C content of fresh Indian seaweeds, *Chaetomorpha brachygonia, Ulva reticulata, Padina, Hypnea musciformis, Gracilaria lichenoides* and *Laurencia papillosa,* has been found to vary from 5.0 to 8.6 mg./ 100gm. and in *Sargassum myriocystum* it exceeds that of lemon. Vitamin-A, Vitamin-B12 and Vitamin-B, are found to occur in many algae and the amounts are generally higher than the other vegetable and animal resources. Utilisation of seaweeds as food is very limited in our country though the natural resources are plentiful. Attempts should be made to popularise the use of edible seaweeds for human consumption.

Among the different edible algae given above, *Porphyra* is the most important seaweed and it contains 30 to 40% protein on dry weight basis. In this connection it may be of interest to note that *Porphyra* is cultivated in Japan on industrial scale to prepare an edible product known as "Asakusa-Nori". About 4000 to 5000 metric tons of dried material of this plant is produced each year for indigenous use and export, which approximately costs 28 million U. S. dollars. *Porphyra vietnamensis,* reported so far from Visakhapatnam coast, could therefore be a dollar-earning edible seaweed in our country. Leafy thallus occurs on this coast during a short period of 5 to 6 months and plants reach harvestable size from February to March or April. Attempts should be made to cultivate this alga following the techniques employed in Japan.

Seaweeds as stock and poultry feed

Experimental work done in other countries has shown the value of seaweed as stock and poultry feed. Because of the presence of vitamins, mineral and trace elements in significant amounts, health of the domestie animals is improved when seaweed meal is added to the daily rations. Washed and dried weeds of *Gracilaria, Hypnea, Sargassum* and *Turbinaria* are useful for the preparation of seaweed meal. The residue obtained after extraction of agar-agar can also be utilised as food for cattle and poultry.

Seaweeds as manure

Use of seaweeds as manure is a common practice in coastal areas throughout the world. They contain high amounts of water soluble Potash and other minerals which are readily absorbed by plants. Recent studies have shown that the carbohydrates and other chemicals present in seaweeds act as soil conditioners by improving the moisture-retaining capacity of the soils and control certain plant diseases. In field trials, conducted at the Central Marine Fisheries Research Institute to study the effect of *Hypnea* compost on Bhindi plants (*Hibiscus esculentus*), 73% increase in yield was observed. Remarkable results were obtained with tuberous crops such as sweet potato, tapioca and other vegetable and garden

plants. In general all seaweeds and seagrasses like *Cymadocea*, *Diplanthera* and *Halophila* growing in littoral and sublittoral areas along the coast line could be utilised as manure. As the seaweeds are generally low in phosphorous and nitrogen, materials rich in these substances should be mixed in order to get a balanced fertilizer.

Seasonal variations in abundance and chemical contents of seaweeds

Ecological investigations carried out in many localities of the east and west coasts of India have revealed the existence of seasonal variations in abundance of different seaweeds. Peak growth periods of green, brown and red algae varied from place to place in relation to the local environmental conditions. It has also been found that the chemical composition of seaweeds alter with the seasonal changes in the vegetation. For instance, distinct monthly variations are reported in the sodium, potassium, calcium, magnesium and chloride contents of eleven species of algae common to Indian coast. In a preliminary study conducted at Central Marine Fisheries Research Institute on three species of *Gracilaria*, the seasonal variation in the yield of agar-agar ranged from 10 to 14%. In view of these seasonal fluctuations both in the availability and chemical content of the raw materials, collection of seaweeds must be done during periods of highest development to obtain maximum yield of raw materials and the end products.

Harvesting of seaweeds

Seaweeds such as *Enteromorpha*, *Ulva*, *Chaetomorpha*, *Padina*, some species of *Sargassum*, *Gracilaria corticata* and *Porphyra* occur in the intertidal region as regular bands from high water to low water and they can easily be harvested during low-tide periods. Other important seaweeds grow at different depths in the sublittoral zone depending upon the availability of light and substratum. These sublittoral seaweeds can be harvested only by skin diving. While harvesting the seaweeds, care should be taken not to destroy the basal portions or hold fasts. Indiscriminate harvesting of seaweeds not only affects the furture yield of raw material but also the quality of the final product. It is therefore necessary to harvest the fully grown plants during the periods of maximum development and sufficient time must be given between the two successive harvests for regeneration and further development of seaweeds.

Detailed investigations have been conducted by the Central Marine Fisheries Research Institute for the past twenty years on the utilisation of Indian seaweeds for the production of agar-agar, algin, seaweed meal and manure and on other problems related to the distribution of seaweeds, their resources survey, systematics, chemical composition and ecology. Valuable data were collected on the properties of Indian agar and agaroids extracted from species of *Gracilaria*, *Gelidiella*, *Hypnea*, *Sarconema*, *Spyridia* etc. A new pulp method was developed on cottage industry lines for the manufacture of agar-agar from *Gracilaria lichenoides* and it was applied to the other Indian agarophytes with considerable success. Alginic acid content of brown algae was determined and a method was worked out for bleaching crude alginic acid extracted from *Sargassum*. Different processes were developed for the preparation of seaweed meal from *Gracilaria lichenoides* and compost

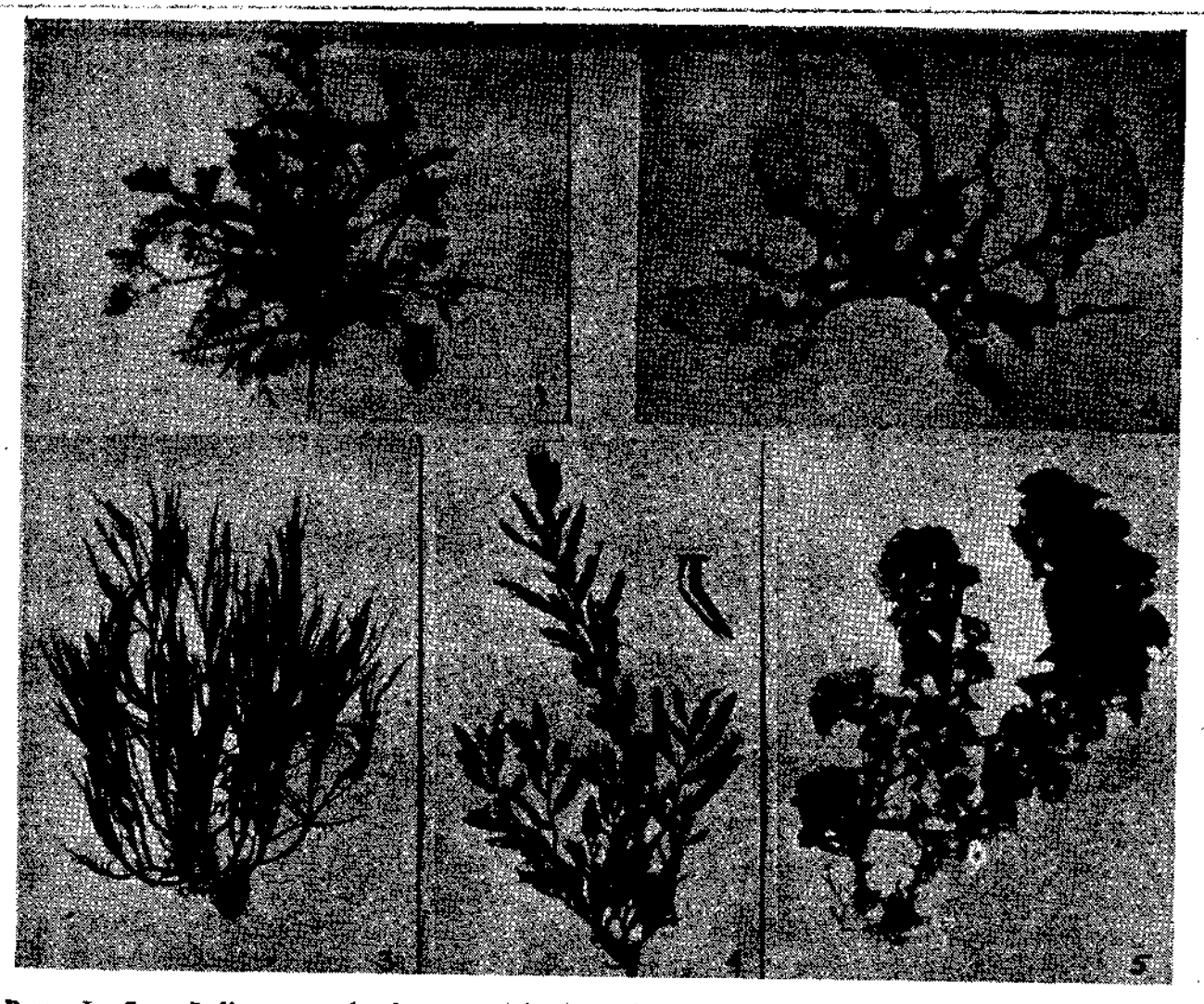

PLATE I. Some Indian seaweeds of commercial value. 1. *Gelidiella acerosa;* 2. *Porphyra vietnamensis;* 3. *Gracilaria lichenoides;* 4. *Sargassum wightii;* 5. *Turbinaria ornata.*

manure from algae cast up in quantities along the sea shore. Experiments were conducted on vegetable crops to study the effect of seaweed manure as mentioned in the earlier section. Distribution and abundance of agarophytes, and other economic seaweeds in the near shore waters of the Indian coast have been studied and quantitative surveys have been made in the Gulf of Mannar and Palk Bay near Mandapam. Detailed observations have been made on the algal flora of pearl beds off Tuticorin and on the morphology of *Padina gymnospora*. Mineral constituents of eleven species of algae common to the Indian coast were estimated. Studies on the water soluble constituents of *Gracilaria lichenoides* and the ionic composition of blue-green algae growing in saline lagoons have been carried out in detail. The colonisation and seasonal succession of marine algae have been followed in Palk Bay. The present studies that are being carried out on autecology and related aspects to cultivate the commercially important seaweeds, will help in increasing the production of raw materials. It may be stated to the credit of this Institute that the investigations on economic seaweeds conducted here have paved the way for the establishment of a seaweed industry in India and in the development of an export trade of seaweeds to foreign countries.