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# SEAWEED RESOURCES, PRODUCTS AND UTILIZATION

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## Abstract

India has extensive seaweed resources and these have been surveyed by several workers. In India, more attention is being bestowed on increasing the production of economically important seaweeds by different culture techniques. The growth rate and production of *Gelidiella acerosa*, *Gracilaria edulis*, *Hypnea musciformis*, *Acanthophora spicifera and Sargassum* spp. in different culture methods have been studied. Considerable data are also available on the commercial exploitation of Indian seaweeds. The important commercial products from seaweeds are agar-agar, algin, mannitol and proteins. The algae are also found to bear bioactive substances such as toxins and antibiotics. Attempts have been made to develop antiviral, antifungal and antimicrobial substances from seaweeds. The use of seaweeds as human food, cattle, poultry and other farm animal feed, manure for land plants, source of energy and in pharmaceuticals are reviewed.

## Introduction

Seaweeds include all macroscopic algae occurring in the marine habitat and in brackish coastal waters. The littoral and sublittoral rocky areas along the Indian coast support a good growth of different seaweeds. Luxuriant growth of several species of green, brown and red seaweeds occur along the Tamil Nadu and Gujarat coasts and around Lakshadweep, Andaman and Nicobar Islands. Fairly rich seaweed beds are present in the vicinity of Bombay, Karwar, Ratnagiri, Goa, Varkala, Kovalam, Vizhinijam, Visakhapatnam and in coastal lakes like Chilka and Pulicat. Information available on the standing crop of seaweeds in Indian waters, production of seaweeds by culture methods, quantity of seaweeds harvested commercially, products obtained from seaweeds and their utilization are reviewed in this paper.

## Natural standing crops of seaweeds

Seaweed surveys have been conducted to assess the resources of Chilka lake (Mitra, 1946) : certain areas of Tamil Nadu (Chacko and Malu Pillai, 1958 ; Thivy, 1960 ; Varma and Krishna Rao, 1962 ; Desai, 1967 ; Umamaheswara Rao, 1973 and Subaramaiah *et al.*, 1979 *a*) ; Kerala coast (Koshy and John, 1948), Gujarat coast (Sreenivasa Rao *et al.*, 1964 ; Desai, 1967 ; Chauhan and Krishnamurthy, 1968 : Bhanderi, 1974 ; Bhanderi and Raval, 1975 ; Bhanderi and Trivedi, 1975 ; and Chauhan and Mairh, 1978) : Maharashtra coast (Chauhan, 1978, and Untawale *et al.*, 1979) ; Goa coast (Untawale and Dhargalkar, 1975) and Lakshadweep (Subbaramaiah *et al.*, 1979 *b*). Of these, the observations of Mitra (1946) Koshy and John (1948), Chacko and Malu Pillai (1958) and Thivy (1960) are of a preliminary nature and the methods adopted

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for estimation were not outlined by them. The total quantities of agarophytes and alginophytes estimated by these workers are given below :

| Locality | Agarophytes (Dry weight) | Alginophytes (Dry weight) | Author |
|---|---|---|---|
| Chilka Lake | 4-5 tons/annum | | Mitra, 1946 |
| Kerala coast (Tranvancore coast) | 10,000 lbs during 1942-46 | | Koshy and John, 1948 |
| Point Calimere to Cape Comorin | 6,000 tons | 60,000 tons | Chacko and Malu Pillai, 1958 |
| Pamban area | 7·1 tons/annum | | Thivy, 1960 |

A detailed survey of the red algae was conducted by Desai (1967) in the Gulf of Mannar in a 10 miles area at Rameswaram and 20 miles area north of Kilakarai. The estimates of dry *Gelidium* and *Gracilaria* were 300 and 3,000 tons respectively per annum.

Varma and Krishna Rao (1962) surveyed a total area of 234·25 sq. km. between Dhanuskodi and Hare Island. The detailed estimates for *Gracilaria* spp., *Gelidiella acerosa* (reported as *Gelidium micropterum*) and brown algae are given below :

| Details | Fresh weight in metric tons | |
|---|---|---|
| | 1958 | 1962-63 |
| *Gracilaria* spp. | | |
| Estimated wet algae | 37,769·00 | 66,979·00 |
| Harvestable wet algae | 188·85 | 334·90 |
| Harvestable dry algae | 18·89 | 34·49 |
| Yield of agar-agar | 2·83 | 5·02 |
| *Gelidiella acerosa* (*Gelidium micropterum*) | | |
| Estimated wet algae | 1,290·00 | 3,775·00 |
| Harvestable wet algae | 6·45 | 18·88 |
| Harvestable dry algae | 0·65 | 1·89 |
| Yield of agar-agar | 0·19 | 0·57 |
| *Brown algae* | | |
| Estimated wet algae | 83,835·00 | 1,31,588·00 |
| Harvestable wet algae | 419·18 | 657·94 |
| Harvestable dry algae | 62·88 | 98·69 |
| Yield of alginic acid | 7·55 | 11·84 |

As a whole the total algin potential in the country is estimated as 500 metric tonnes (refined) annualy and that of agar-agar, 13 metric tonnes (bacteriological grade) annualy with an yield of 19 % (7-30 %) on dry weight basis for algin yielding seaweeds and 28 % (12-43 %) on dry seaweeds for the agarophytes (Thivy, 1964).

Krishnamurthy *et al.* (1967) and Krishnamurthy (1971) gave accounts of a survey of cost up seaweeds occurring on the Indian coasts and concluded that seaweed drift forms a good indication of their distribution and density. In the surveys conducted on Gujarat coast, Sreenivasa Rao *et al.* (1964) estimated 60 metric tons of fresh *Sargassum*

in 0·015 sq. km. area of the Adarta reef near Okha. In the Gulf of Kutch 10,000 tons dry brown algae, 5 tons of wet *Gelidiella* and 20 tons of dry *Gracilaria* can be harvested (Desai, 1967). Chauhan and Krishnamurthy (1968) surveyed Dera, Goosa, Narara, Sika, Karumbhar and Baida areas of Gulf of Kutch and estimated a total of 18765·5 metric tons of fresh seaweeds in 10·65 sq. km. of coastal waters. Of this quantity, *Sargassum* spp. accounted for 12010·5 tons and about 4,000 metric tons of fresh *Sargassum* can be harvested each year in the Gulf of Kutch.

Sample surveys were conducted by Umamaheswara Rao (1973) in a 3·58 sq. km. area between Pamban Bridge and Theedai during the calm seasons of 1965 and 1966. The quantitative data obtained on the standing crop of different seaweeds are shown below :

| Seaweed | Fresh weight in metric tonnes | |
|---|---|---|
| | 1965 | 1966 |
| Agarophytes | 233·15 | 47·92 |
| Alginophytes | 161·83 | 173·43 |
| Edible algae | 188·84 | 245·91 |
| Other algae | 457·87 | 398·51 |

Subbaramaiah *et al.* (1979 *a*) reported on a survey of the marine algal resources of Tamil Nadu coast carried out for 5 years between 1971 and 1976. The area covered was from Athankarai to Rameswaram (45 km distance) and from Mandapam to Colachel (413 km distance) on the mainland India and the adjoining islands in the Gulf of Mannar. The estimated standing crop in the coastal area of 17125 ha is 22044 tons, consisting of 1709 tons agarophytes, 10266 tons alginophytes and 10069 tons other seaweeds. The resources of the commercially important species are presented below :

| Seaweed | Wet weight |
|---|---|
| *Gelidiella acerosa* | 74 tons |
| *Gracilaria* spp. | 974 tons |
| *Hypnea* spp. | 798 ton |
| *Sargassum* spp. | 9381 tons |
| *Turbinaria* spp. | 714 tons |

The resources of iodine yielding seaweed *Asparagopsis delilei* ( = *A. taxiformis*) from some reefs of Sourashtra coast was estimated by Bhanderi (1974). The maximum harvestable quantity from Okha and Boria reef was found to be 12·15 tons (fresh). Bhanderi and Raval (1975) conducted surveys on the tidal region of Okha-Dwarka coastline and estimated 1000 metric tons of fresh *Sargassum*. Bhanderi and Trivedi (1975) have reported an annual yield of 650 tons (fresh wt.) seaweeds from Hanumandandi reef and Vumani reef

near Okha Port. Chauhan and Mairh (1978) estimated standing crop of the seaweeds from Okha to Mahuva and the data collected by them are given below :

| Alga | Wet weight in tons |
|---|---|
| *Sargassum tenerrium* | 238·383—541·984 |
| *Gracilaria corticata* | 15·009—23·086 |
| *Gelidiella acerosa* | 3·047—5·695 |
| *Ulva* | 26·099—39·075 |

The marine algal resources of Maharashtra coast was reported by Chauhan (1978). The total harvestable standing crop of the seaweeds on the coast is given below :

| Seaweed | Weight of the fresh seaweed in metric tons | |
|---|---|---|
| | Lower limit | Upper limit |
| *Sargassum* | 238·417 | 310·097 |
| *Ulva* | 3·483 | 4·516 |

Untawale *et al.*, (1979) estimated an annual yield of 20,000 tons (fresh wt.) of seaweeds from the entire coast of Maharashtra.

The seaweed resources survey of the Goa coast was conducted by Untawale and Dhargalkar (1975). The total standing crop of the coast from Dona Paula to Chapora (0·150 sq. km. area) is 256·6 metric tons fresh weight per year excluding other areas along the Goa coast which are negligible.

The marine algal resources of Lakshadweep was given by Subbaramaiah *et al.* (1979 *b*). Among the 9 islands surveyed, Kavaratti, Agatti Amini, Kadamat, Chetlat, Kiltan, Androth and Kalpeni supported marine algal growth while Bangarem was barren. Out of the total area of 2555 ha surveyed, 785 ha was found to be productive. The total standing crop of the marine algae estimated was 3645-7598 tons (wet weight). The group-wise biomass and their percentage of the standing crop of population are given below :

| | | |
|---|---|---|
| Agarophytes | 961—2074 tons | 27·0 %. |
| Alginophytes | 9—15 tons | 0·2 %. |
| Other seaweeds | 2675—5509 tons | 72·8 %. |

**Seaweed cultivation**

Experimental culture of *Sargassum* was reported by Thivy (1964) who transplanted a young plant into an artificial pond and found it to grow to 52 cm in 40 days. *Gracilaria edulis* was cultured on long line ropes in a sandy lagoon on the eastern side of the Krusadai Island and the fragments grew to a length of 35 to 40 cm in about 5 months after initial planting (Raju and Thomas, 1971). Three harvests were made at the end of 5, 8 and 10½ months after planting and the total harvest during the year was about 3·5 kg from 1 m length of rope. Krishnamurthy *et al.* (1977) cultured *Gracilaria edulis* and *Gelidiella acerosa* on ropes in a lagoon on the southern side of Krusadai Island. In about 5 months the plant of *G. edulis* attained a length of about 30 cm and the average weight of plant increased to about 300 g. Three harvests were made in a period of 10 months. 2 cm fragments of *G. acerosa* were grown to full sized plants of about 10 cm. length with 7 to 8 main branches after 4-5 months.

The cultivation of *G. acerosa* was conducted by Subbaramaiah *et al.* (1975) in shallow lagoon at Krusadai Island by tieing 2 cm fragments to a nylon string which was wound round the rope. Three harvests were made during one year. The maximum growth attained was 6·6 cm and the rate of production was 3·13 g/m/month (wet). In large scale cultivation of *G. acerosa* at Krusadai Island following the above mentioned method and using 5,000 metre coir rope on a half hectare area, the yield was found to be 80 g/m (wet). Patel *et al.* (1979) cultivated *G. acerosa* at Ervadi using coral stones as the substratum. Planting was done on 1764 coral stones in an area of 513 square metre. An annual maximum yield of 115·83 g/m$^2$ (dry) was obtained and it was found to be a 33-fold increase over the seed material. Patel *et al.* (1980) reported a maximum crop yield of 122 g/m$^2$ (dry) in one of their six monthly harvests from the field cultivation of *G. acerosa* carried out at Ervadi for 3 years. Rama Rao and Subbaramaiah (1980) cultured *Hypnea musciformis* in long line rope in a lagoon at Krusadai Island and obtained four-fold increase in biomass in 25 days.

Umamaheswara Rao (1974) cultured *Gracilaria edulis* in the nearshore area of Gulf of Mannar at Mandapam using coir nets of 4 × 2 m size. About 313 g seed material introduced per square metre area of the net yield 4·4 kg (fresh wt.) after 80 days. In *G. edulis* cultured on coir rope frames in the submerged free floating condition in the inshore waters of Gulf of Mannar (Chennubhotla *et al.*, 1978) an yield of 1·985 kg per square metre area of the frame was obtained for an initial seed material of 355 g *G. acerosa* was cultured on coir ropes interwoven around 2 × 2 m size G.I. pipe frames in the inshore waters of Gulf of Mannar (Chennubhotla *et al.*, 1977). From 0·9 kg and 1 kg seed material introduced, 2·5 kg and 3 kg crops were harvested respectively after 76 days. The fragments of *G. acerosa* fastened to coral stones with the help of iron nails reached harvestable size after 5 months and 1·0 kg of seed material yielded 3·1 kg during this period. An average growth of 15·5 cm was recorded from an average initial height of 7·7 cm in *Sargassum wightii* within 60 days, when basal portions of plants with holdfast were inserted into the twists of the coir ropes and cultured in inshore waters (Chennubhotla *et al.* unpublished).

Culture of *G. edulis* and *G. acerosa* was carried out at slightly deeper waters *i.e.* 3-4 metre depth at Palk Bay using HDP rope nets, sinkers and floats. An average of 6·65 kg *G. edulis* introduced in the nets at mid-water in 4 m depth station yielded 16·17 kg after 90 days. In the nets introduced just below the surface of the water, the yield was 25·7 kg for an initial seed material of 7 kg after 70 days growth. For *G. acerosa* an yield of 13 kg after 55 days and 10·6 kg after 60 days was obtained from 6·5 kg seed material from the nets introduced at mid-water level and just immediately below the surface water level respectively. The edible seaweed *Acanthophora spicifera* was cultured on HDP rope nets in a pond with free flow of seawater from the sea and 7-fold increase to the seed material was obtained after 45 days.

## Commercial Harvesting of seaweeds

Commercial harvesting of seaweed is carried out mainly on Gujarat and Tamil Nadu coasts. The seaweeds harvested from these areas are *Gelidiella acerosa* and *Gracilaria edulis* for agar production and species of *Sargassum* and *Turbinaria* for algin production. The quantity of seaweeds harvested (in metric tons) for 3 years from 1966 to 1968 from

Pamban, Periapatnam and Kilakarai of Tamil Nadu coast (Umamaheswara Rao, 1973) is given below. The fresh weight was estimated by him based on 80 % moisture.

| Year | Pamban | Periapatnam | Kilakarai | Total dry weight | Total fresh wt. |
|---|---|---|---|---|---|
| 1966 | 15·19 | — | — | 15·19 | 75·95 |
| 1967 | 18·35 | 65·55 | 58·07 | 141·97 | 709·85 |
| 1968 | 16·59 | 8·00 | 304·65 | 329·24 | 1646·20 |

The species wise seaweed landings data collected by Central Marine Fisheries Research Institute for a period of 7 years from 1978 to 1984 at different collection centres of Tamil Nadu are computed and the total figures are given in the table below :

Total seaweed landings in Tamil Nadu coast (Dry wt. in tons) :

| Species | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 |
|---|---|---|---|---|---|---|---|
| *Sargassum* spp. | 3636 | 4256 | 3090 | 2522 | 3176 | 2070 | 780 |
| *Turbinaria* spp. | 1021 | 1281 | 438 | 222 | 704 | 375 | 215 |
| *Gelidiella acerosa* | 288 | 541 | 247 | 131 | 102 | 293 | 210 |
| *Gracilaria edulis* | 395 | 342 | 213 | 117 | 225 | 291 | 320 |
| *Gracilaria crassa* | — | — | — | — | — | 85 | 96 |
| Total | 5340 | 6420 | 3988 | 2992 | 4207 | 3114 | 1641 |

**Present level of exploitation**

*Gelidiella acerosa* : It is a perennial plant growing on rocks and stones. The collection centres are Rameswaram, Pamban, Kilakarai and Ervadi. Major collection is done around Gulf of Mannar Islands using country crafts and shore collection is done throughout the year at Kilakarai and Ervadi. Shore collection is mainly done by women and children during low tide hours. The ratio between fresh weight and dry weight is 3 : 1 for pure *G. acerosa* plants. *G. acerosa* is essentially required for production of agar and often blended with *Gracilaria edulis* since the availability of *G. acerosa* is not adequate. The plants are dried, bleached and utilized for agar extraction.

*Gracilaria edulis* : This seaweed is collected from five centres namely Rameswaram, Pamban, Vedalai, Seeniappa Dharga and Kilakarai. Around the Gulf of Mannar Islands collection of this seaweed is possible throughout the year which forms the major landings while the shore collection is very meagre. The ratio of fresh and dry weight is 7 : 1. *G. edulis* alone is utilised in some small scale agar industries for preparation of food grade agar, while bigger industries use it in combination with *Gelidiella acerosa* for manufacture of food grade and bacteriological grade agar which is generally used in pharmaceutical and as the culture medium in the laboratories.

*Sargassum* : This brown seaweed forms the major constituent of the total commercial

landings of seaweeds. *Sargassum wightii* is the main species and the rest are *S. myriocystum*, *S. ilicifolium S. plagiophyllum* and *S. tenerrimum*. Shore collection is done only at Pudumadam and Kanyakumari area (Kooduthalai to Leepuram) and the major portion is collected from the Gulf of Mannar Islands. Some algin industries stock the raw material required for one year by procuring the formalin treated *Sargassum* during peak harvesting season. *i.e.* August/September—December/January. Other algin industries procure ordinary dried *Sargassum* plants. The ratio between fresh and dry weight is 5 : 1.

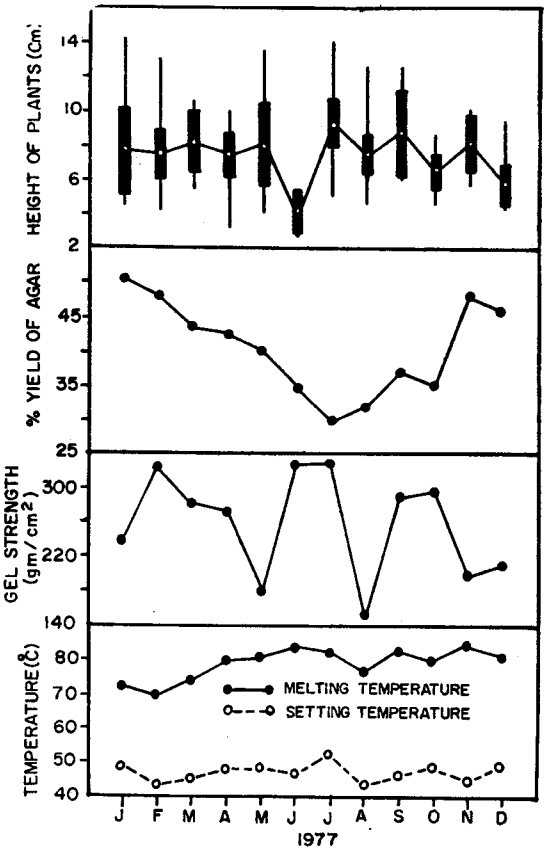
*Turbinaria* : There are three species namely *Turbinaria conoides*, *T. decurrens* and *T. ornata* growing in Mandapam area. The collection of *Turbinaria* spp. is mainly around Rameswaram, Pamban, Vedalai, Seeniappa Dharga, Periapatnam, Kilakarai and Ervadi. The ratio between fresh and dry weight is 7 : 1.

**Products from seaweeds and their utilization**

Seaweeds are the only source of agar and algin which are extensively used in many industries like pharmaceuticals, food, confectionary, textiles, dairy, paper, paint and varnish manufacture. Seaweeds are also used as human food, livestock feed and fertilizer in many parts of the world.

Agar-Agar : It is a carbohydrate extracted from certain red algae such as *Gelidiella*, *Gelidium* and *Gracilaria*. The important and commonly occurring agarophytes of India are *Gelidiella acerosa*, *Gracilaria edulis*, *G. crassa*, *G. verrucosa*, *G. corticata* and *G. foliifera*. In India agar is extensively used in food products and pharmaceutics. The best-known use of agar is as a solidifying agent in culture media in bacteriology.

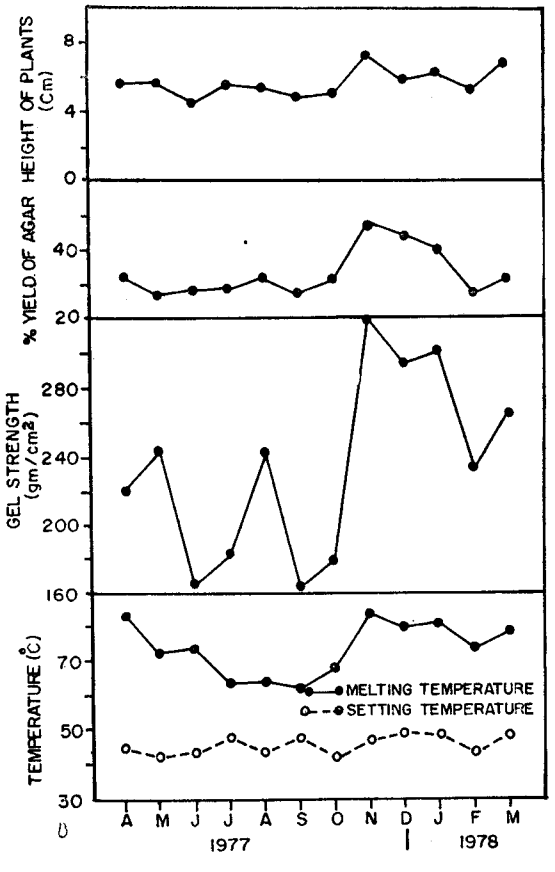
Algin : It is a polysaccharide extracted from certain brown seaweeds such as *Sargassum* and *Turbinaria*. Species of *Sargassum*, *Turbinaria*, *Dictyota*, *Padina*, *Cystoseira*, *Hormophysa*, *Colpomenia*, *Spatoglossum* and *Stoechospermum* are some of the algin yielding seaweeds occurring in Indian waters. Of these, species of *Sargassum* and *Turbinaria* are utilized as raw material for the manufacture of algin in India. Algin is also equally and extensively used in the preparation of various pharmaceutical, food and rubber products, textile products, adhesives, paper products and miscellaneous products.




Other chemicals that can be obtained from seaweeds are Carrageenan, Iodine, Bromine, Mannitol, Ascorbic acid and Protein.

Seaweed as food : Fresh, dried and processed seaweeds are utilized as human food

and the food value depends upon the minerals, trace elements, proteins and vitamins present in them. Species of *Ulva*, *Caulera*, *Codium*, *Hydroclathrus*, *Sargassum*, *Porphyra*, *Gracilaria Eucheuma*, *Halymenia*, *Acanthophora* and *Laurencia* are used as food in Japan, Indonesia, China, Philippines and other countries of Indo-Pacific region (Subba Rao, 1965 ; Levering *et al.*, 1969 ; Michanek, 1975 and Chapman and Chapman, 1980). They are eaten as salads, curries, soup or vegetables.




Some of the edible seaweeds occurring in different localities along the Indian coasts are species of *Ulva*, *Enteromorpha*, *Chaetomorpha*, *Caulerpa*, *Codium*, *Hydroclathrus*, *Sargassum*, *Porphyra*, *Gracilaria*, *Hypnea*, *Acanthophora* and *Laurencia*. The methods of preparing different recipes from seaweeds are given in detail by Chennubhotla *et al.* (1981). The coasta population of Tamil Nadu use *Gracilaria edulis* for making gruel (porridge) and this is the only available report on the use of algae as food in India.

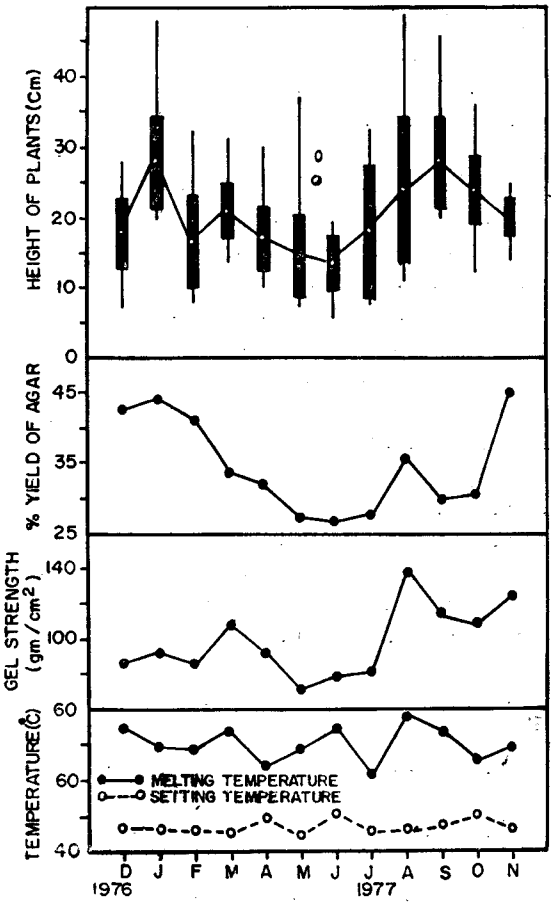
Seaweed meal : Seaweeds are cheap sources of minerals and trace elements. Hence the meals prepared from seaweeds can be given as supplementary to the daily rations of the cattle, poultry and other farm animals. Seaweed meals can be obtained by grinding the cleaned and washed seaweeds of *Ulva*, *Enteromorpha*, *Sargassum*, *Padina*, *Dictyota*, *Gracilaria* and *Hypnea*. Thivy (1960) described a simple method for the preparation of seaweed meal from *Gracilaria edulis*. Seaweed meal can also be mixed with fish meal and used as a poultry feed. Seaweeds have been utilized as animal feed since long back in other countries. But in India the scientific approach to this line of study is scarce. Seaweed meal was prepared from *Sargassum* and feeding trials on chicks, sheep and cattle were reported by Dave *et al.* (1979). Studies on feeding *Gracilaria* meal to white leghorn egg laying birds were made by Chaturvedi *et al.* (1979) to find out the effect of feeding algae on the quality of egg. They concluded that *Gracilaria* meal at the level of 10 % can be included in the ration of laying birds replacing yellow maize. Jagannathan and Venkatakrishnan (1979) likewise concluded feeding trials replacing ragi (*Eleusine coracana*) with 0, 5, 10 and 15 % of seaweed in unsexed day-old white leghorn chicks using six seaweeds commonly available in Tamil Nadu coast.

Seaweed manure : Use of seaweeds is a common practice in coastal areas through the world. In India, it is used for coconut plantations especially in coastal Tamil Nadu and Kerala. The high amounts of water soluble potash, other minerals and trace

elements present in seaweeds are readily absorbed by plants and they control deficiency diseases. The carbohydrates and other organic matter occurring in seaweeds alter the nature of soil and improve the moisture retaining capacity. Hence, large quantities of seaweeds including seagrasses such as *Cymodocea*, *Halodule*, *Enhalus* and *Halophila* can be used as manure directly or in the form of compost. A method for composting the seaweeds with cowdung has been described by Thivy (1958 and 1960). In field trials *Hypnea* compost showed 73 % increase in yield of bhendi than cowdung and wood ash. Good results were also obtained with brinjal, tapioca, *Cyamopsis*, *Dolichos*, gourds, *Amaranthus*, lime, papaya and drumstick when manured with seaweed compost. Crotons and Zinnia also grew well with seaweed treatment (Thivy, 1960).

The nitrifiability of organic nitrogen from *Ulva lactuca* and drift seaweeds from veraval was studied and found to be high as compared to farmyard manure (Mehta *et al.*, 1967). The results of seaweed manurial trials on *Pennisetum typhoides* (pearl millet) and *Arechis hypogea* were reported by Bokil *et al.* (1972). With a view to find out the effect of seaweed manures on the uptake of inorganic nutrients by the wheat plant, Bokil *et al.* (1974) conducted a pot culture experiment. Bhosle *et al.* (1975) studied the effect of seaweed extract on the growth of *Phaseolus vulgaris*. Marine algal extracts obtained from *Spatoglossum asperum*, *Ulva fasciata* and *Enteromorpha intestinalis* were found to promote germination in seeds and growth of seedlings of gram, groundnut and maize (Bukhari and Untawale, 1978). Dilute extracts were found to be more effective than the concentrated extracts. Foliar spray of *Spatoglossum* extract resulted in an increase in the leaf size and better growth in *Hydrangia* sp. The method of preparation and properties of liquid seaweed fertilizer from *Sargassum* was given by Sreenivasa Rao *et al.* (1979 *a*).

Seaweed as source of energy : Sreenivasa Rao *et al.* (1979 *b*) have conducted experiments on production of fuel gas for domestic use utilizing *Sargassum* as raw material. Pharmaceutical uses of seaweeds.




The medicinal uses of seaweeds are given in detail by Mathieson (1969) and Umamaheswara Rao (1970). Seaweeds were considered to be of medicinal value in the Orient as long as 3000 B.C. The Chinese and Japanese used them in the treatment of goitre and other glandular diseases. Although the Romans believed seaweeds to be useless, they also used them to heal wounds, burns, scurvy and rashes. The British used *Porphyra* to prevent scurvy during long voyages.

Various red algae (particularly *Corallina officinalis*, *C. rubens* and *Alsidium helminthocorton*) were employed as vermifuges in ancient times. Dulse is reported to be a laxative and also to reduce fever. Several red algae (including *Chondrus crispus*, *Gracilaria*, *Gelidium* and *Pterocladia*) have been used to treat various stomach and intestinal disorders. The algae aparently absorb enough water to relieve constipation and other associated discomforts. The stipes of *Laminaria cloustoni* have been used to aid in child birth by distending the uterus during labour. A number of species o marine algae have been found to have anticoagulant and antibiotic properties. Carrageenan may be useful in ulcer therapy and the alginates are found to prolong the rate of activity of certain drugs (Mathieson, 1969). Species of *Sargassum* were used for cooling and blood cleaning effect. *Hypnea musciformis* was employed as vermifuge or worm expelling agent and *Centroceras clavalatum* as cathartic agent. The iodine rich seaweed like *Asparagopsis taxiformis* and *Sarconema* can be used for controlling goitre disease caused by the enlargement of thyroid gland (Umamaheswara Rao, 1970).

**Bioactive substances**

A large number of algae have been shown to produce some bioactive substances like toxins and antibiotics. The antibioactivity of the algae is not only widespread but also variable in different strains or collections of the same organism (Pratt *et al.*, 1951).

*Nemacystus decipiens*, *Cladosiphon okamuranus* cause food poisoning (Asano, 1973). Blue-green algae *Microcoleus lyngbyaceus* causes dermatitis in human, due to the resence of a toxin in it (Banner *et al.*, 1960). *Symploca hydnoides*, *Eucheuma muricatum*, *Weberalla nicans* and species of *Dictyota* and *Cladophoropsis* showed toxicity (Hashimoto, 1976). *Ulva pertusa* (Fusetani and Hashimoto, 1975 and 1976) and *Chaetomorpha minima* (Fusetani *et al.*, 1976) were observed to be exhibiting haemolytic activity while *Caulerpa* (Santos and Doty, 1968 and Doty and Santos, 1966) was seen to be toxic to human beings during rainy season, the toxins being caulerpicin and caulerpin. *Alaria crassifolia*, *Cystophyllum hakodatense* and *Laminaria ochotensis* were found to contain some toxins (Shirahama, 1937).

In *Monostroma fuscum* (Tocher and Craizie, 1966) an antibiotic deparine — 18 was found and antibiotic terpenoids were recorded from *Laurencia nipponica* (Ando, 1952) and *Dictyopteris zonarioides* (Fenical *et al.*, 1973). Antibiotic activity was observed by Glombitza *et al.* (1973) for phloroglucinol isolated from brown algae like *Cladostephus*, *Dictyota*, *Fucus*, *Himanthalia*, *Cystoseira*, *Bifurcaria*, *Halidrys*, *Chorda*, *Laminaria* and *Saccorhiza*. It was also noticed that trifuharol in *Halidrys siliquosa* (Glombitza and Sattler, 1973), dipholorethol and bifuhalol in *Cystoseira tamariscifolia* (Glombitza *et al.*, 1975 *a*) and difucol and tetrafucol in *Fucus vesiculosus* (Glombitza *et al.*, 1975 *b*). Many halogenated acetones and butenones of antibiotic activity were isolated from *Asparagopsis taxifomis* (Fenical, 1974 *a* and 1974 *b*) and the presence of antibiotic dichloroacetamide in *Marginisporum aberrans* (Ohta, 1975) was also discovered.

Bromophenol which showed antibacterial activity was found to be present in *Rhodomela larix* and *Symphocladia gracilis* (Mautner *et al.*, 1953) and *Laminaria argustata*, *Lindaria pinnatifida*, *Odenthralia dentata*, *Rhodomela confervoides* etc. (Saito and Sameshima, 1955). Chondriol and cycloeudesmol were found in *Chondria oppositiclada* (Fenical and Sims, 1974) Pacifenol (Sims *et al.*, 1971, 1972, 1973 and 1975) and rhodophytin (Fenical *et al.*, 1974) in *Laurencia pafica* and johnstonol (Sims *et al.*, 1971, 1972, 1973 and 1975) in *Laurencia johnstonii* have shown to have antibacterial activity. The antibacterial activity in the brown alga *Desmarestia* was found to be

sulphuric acid which is accumulated in the cells at a concentration as high as 0·44 N (Ross, 1957 and Eppley and Bovelli, 1958). A red alga *Digenia simplex* has been used as an antihelminthic because of the presence of a bioactive substance celled diganic acid (Murakami *et al.*, 1953) or oc-Kainic acid (Murakami *et al.*, 1954). *Chondria armata* also possessed antihelminthic and insecticidal activity (Daigo, 1959) due to the presence of domoic acid in it. Sargalin a crystallized basic compound from *Sargassum confusum* also was found to be possessing antihelminthic activity (Saito and Nakamura, 1951).

In recent years some attempts are being made to develop antimicrobial, antifungal, antiviral substances from seaweeds. Extracts from *Chondrus crispus* and *Gelidium cartilagineum* have been found to be active against influenza B and mumps virus (Garber *et al.*, 1958). Caccamese *et al.*, (1981) obtained extracts from *Zanardinia prototypus* and *Cystoseira balearica* which were found to be very effective against bacteria and viruses. Blunden *el al.* (1981) extracts from certain marine algae to be having anti-influenza virus activity. Sreenivasa Rao *et al.*, (1979 *c*) have isolated extracts from *Enteromorpha* which effected complete inhibition of growth of the tubercle bacilli in the cultures. Naqvi *et al.*, (1981) in the course of investigations on bioactive substances of some seaweeds have found that *Padina tetrastromatica*, *Gelidiella acerosa* and *Acanthophora spicifera* exhibit 100 % anti-fertilily (anti-implantation) property in mice.

**Natural grazing and balances in ecosystem**

In the natural beds of seaweeds the greatest grazers or predators of the vegetation are the herbivorus vertebrates and invertebrates. These include crabs, amphipods, polychaetes, isopods, copepods, gastropods, bivalves and fishes. The fish *Siganus javus* is supposed to be voracious feeder while the crabs cancause extensive damage to growing parts of the seaweeds by clipping them with their chelipeds (James *et al.*, 1980). Observations carried out by suppressing all the grazing activity, by removing most of the animal life have revealed a luxurious growth of seaweeds.

Though conservation of natural seaweed resources through animal exclusion mechanism s desirable, it may lead to depletion of the valuable fish resources which form an important component of the biota consequently leading to imbalances in the ecosystem.

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