This article is based on a talk prepared for the Bio-Diversity Skills Enhancement Project of **March for Conservation** at Hikkaduwa, in March 1996.

An Introduction to Marine Algae (Seaweeds)

Malik Fernando

Algae are simple plants which, together with ferns, mosses, fungi, and others belong to the group of lower plants also referred to as non-flowering plants. As this name implies, they do not have flowers; neither are the tissues differentiated into roots, stems, and leaves. In those types that have a plant body consisting of many cells, this structure is called a thallus. The thalli of lower plants are usually coloured, the exception being fungi.

Algae are to be found in a bewildering variety of sizes, shapes, and colours: from single cells to giants that measure 40 to 50 metres in height, from unbranched, thread-like plants to those which have branching "stem" systems, "leaves" and "fruit-like" structures. But the "leaves" and "fruits", as well as the "stems" bear only an outward resemblance to those structures seen in the flowering plants and do not serve the same functions.

The flowering plants, also called seed-bearing plants, are more evolved types. They have, for example, developed special supporting tissues which form stems and trunks, leaves for photosynthesis (the process used by plants to convert carbon dioxide and water to starch, using energy from the sun), roots for absorption of water, and specialised reproductive organs, i. e. flowers and fruits. In addition to these structures, the plants possess strands of tissues specially adapted to transport water from the roots up to all parts of the plant, as well as other tissues to transport starch, the product of photosynthesis, from the leaves where it is made to storage areas. A green pigment called chlorophyll acts as a catalyst to facilitate this reaction. It is chlorophyll that colours the leaves green. Chlorophyll is also present in algae, imparting a green colour to some of them, but in many, the green chlorophyll is masked by other pigments, making those plants brown or red or various shades in between.

Algae are divided into several major groups called divisions, based on such characters as, their physical form, the pigment contained in their cells, the form in which they store their energy and the nature of their reproductive cells. They occur in both fresh and brackish water and the sea as well as on land, consisting of unicellular as well as multicellular forms. Those forms that inhabit the sea are called **marine algae**. They are but one member of the plant kingdom found there.

Marine Plants

The plant kingdom is represented in the sea by the seagrasses (which are flowering plants), by unicellular algae (which are single celled planktonic plants) and by the multicellular algae (or macroalgae) commonly referred to as seaweeds. The seagrasses, two classes of unicellular algae and one class of primitive macroscopic forms will be discussed briefly in the following sections, followed by a more detailed description of the three divisions of seaweeds.

Seagrasses

Flowering plants are represented in the sea by several species of seagrasses that grow in shallow sheltered seas. There are beds of them, for instance in the Negombo lagoon and in Colombo where they may be found in certain areas between the shore and the first reef. They look like freshwater aquarium plants, with a creeping stem and roots to anchor them in the sandy or muddy bottoms on which they live, and oval or strap-shaped leaves at intervals along the stem. They are ecologically important in many ways.

Seagrasses grow as large, confluent meadows in shallow water and help stabilise the bottom. They are a source of food for animals like marine turtles and the dugong and provide shelter for myriads of small animals and juvenile forms. *Cymodocea serrulata* and *Cymodocea isoetifolia* are abundant in the Palk Bay and the Gulf of Mannar and are the favourite food of dugongs. Algae may be found in association with seagrasses e.g., *Avrainvillea erecta,* and *Caulerpa sertularioides* are found with the seagrasses *Halophila ovalis* and *Cymadocea* sp. in Colombo. *Halimeda macroloba* is found exclusively in seagrass beds

Seagrass beds at the Bar Reef, Kalpitiya

Left: *Cymadocea serrulata* Right: *Halophila ovalis*

Planktonic algae

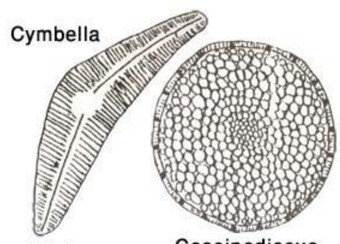
Unicellular algae are found on land, in freshwater and in the sea. Two important classes found in the sea are the diatoms (Bacillariophyceae) and the dinoflagellates (Dinophyceae). The members of both these groups live as plankton—a mass of living organisms drifting with the currents in the oceans.

Plankton consists of microscopic unicellular plants and animals, larvae of animals such as those of fish, crabs, prawns and molluscs (seashells) and other small animals. Larger drifting animals like jellyfish may also be included within the term plankton. Phytoplankton is the name given to the plant forms of the group called algae, of which diatoms and dinoflagellates are the two principal constituents. The animal forms constitute the zooplankton.

Phytoplankton is important in nature, as it is at the bottom of the food web. These little unicellular plants manufacture food from the basic raw materials water and carbon di oxide, using energy derived from the sun. Phytoplankton forms the food of zooplankton, which cannot make their own food. In turn, zooplankton is eaten by larger animals and they, by still larger ones and so on. Filter feeders like oysters and mussels feed on plankton, filtering them out of the water. But it is not only small or primitive animals that feed on plankton—some fish are plankton eaters and so are some whales (the baleen whales). If one considers the size of the large whales that feed exclusively on plankton, one could get some idea of the huge quantity of plankton that must exist in the sea and which is continually renewed. Its importance as a food source should not be undervalued.

Diatoms

Diatoms, like all plant cells, are encased in a rigid cell wall. However, unlike most plant cell walls that are made up of organic substances including cellulose, diatoms are enclosed in a covering of the mineral silica and pectic substances. This covering is in two parts, like a box with a lid, the outer surface being richly ornamented. They are either radially symmetrical (the Centrales) or bilaterally symmetrical (the Pennales).



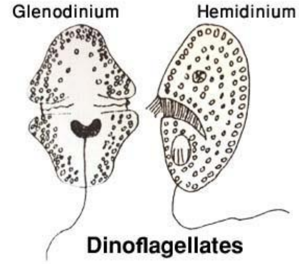
Diatoms

As the cell wall of diatoms consists principally of inorganic silica, it does not perish when the organism dies. The siliceous cases settle to the sea bottom and accumulate. Over many millions of years, large deposits had built up at the bottom of ancient seas and lakes. During the process of continent building, these ancient sea and lakebeds with diatom deposits were thrust up and are now found on land. These mineral deposits (called diatomite, diatomaceous earth or kieselguhr) are mined for a variety of industrial uses. Diatomite is used as a filter medium, as a filler in the manufacture of paints, ceramics etc., for sound and heat insulation, as an abrasive in metal polishes and even in the manufacture of dynamite as an adsorbent for nitro-glycerine. These are only some of its many uses.

Dinoflagellates

Dinoflagellates are a varied group, with characteristics of both animals and plants. They possess pigments for photosynthesis but some feed like animals, others are parasitic. Some are colourless saprophytes. Some are motile unicells, with two threads called flagellae, with which they are able to move locally, an animal characteristic, while others are branched filaments.

In suitable conditions, dinoflagellates are able to multiply rapidly and colour the water, giving rise to the so-called “red tides”. Some produce toxins which may not be harmful to the fish and shellfish that feed on them, and which remain stored in their bodies. These fish and shellfish then become poisonous to other animals which prey on them. There have been reports in Sri Lanka of people dying after eating turtle flesh—it is likely that the turtle flesh was poisonous as a result of feeding on animals contaminated by dinoflagellate toxin.



Dinoflagellates

Paralytic shellfish poisoning is a syndrome which is caused by consuming shellfish which have accumulated and concentrated biological toxins by feeding on plankton and protozoans, including dinoflagellates. The toxins are not destroyed by cooking, nor are they destroyed by stomach acids. Death is due to generalised paralysis of voluntary muscles including those of respiration.

‘Blue-green algae’

‘Blue-green algae’ are now regarded as bacteria—animal rather than plant. They are described here under marine algae because many forms are found in marine habitats and resemble seaweeds. They are principally found in terrestrial and freshwater habitats. Termed Cyanophyta in old literature they are now called Cyanobacteria, a phylum of free-living photosynthetic bacteria.

‘Blue-green algae’ are so called because of the colour imparted to them by the respiratory pigments that are dispersed throughout the filaments. These pigments are chlorophyll, carotin, phycocyanin and phycoerythrin. But they are not all blue-green to the naked eye—some are olive green in colour, others are dark green, and one species commonly seen off Colombo is red.

The Cyanobacteria do not show any great degree of cell differentiation—for example, there is no nucleus, as is found in the cells of other plants and animals. They have low levels of tissue organisation and no clearly differentiated reproductive organs. Many forms produce copious quantities of mucilage, which is seen in the form of sheaths to the cells or filaments. These primitive organisms live as single cells or filaments. The single cells are often aggregated into colonies, bound together by mucilage. The filaments may likewise be found bound together into bundles of characteristic form by mucilage.

Lyngbya majuscula at the Bar Reef, Kalpitiya

They are to be found in a variety of habitats and climatic zones, including hot springs, frigid lakes and on the rocks of rushing torrents and cataracts. They are an important unit in the marine intertidal belt and in salt marshes and are to be found abundantly in freshwater. They are also found on the seabed and in various terrestrial habitats. There are a number of lime boring forms. Others live in association with fungi to constitute lichens, or as symbionts[1] in the cells of animals.

A lichen on a rock-face, Haputale

The blue-green alga (cyanobacterium) *Lyngbya sp*. has been seen in shallow rock pools on the rocky shore at Mount Lavinia, where they form soft carpets consisting of fine, gelatinous filaments 20 to 30 mm long, anchored to the rock at one end. During low tide, the water in these pools, exposed as they are to the full sun, reach a high temperature that other plants cannot tolerate. Cyanobacteria also form slimy scum over rocks and mud etc.

Seaweeds

There are 10,000 or more species of seaweeds, the marine macroalgae, distributed throughout all the oceans, including the polar seas and the tropics. The global distribution of seaweeds is related to water temperature. A few species are cosmopolitan, being found in both tropical and temperate waters, but most have restricted ranges determined by temperature zones. About 320 have been found around Sri Lanka—there are probably many more waiting to be discovered and identified. Factors affecting the local distribution of seaweeds are sunlight and tidal range.

TIDES

Tides are periodic variations in sea level as a result of gravitational forces exerted by the sun and the moon. The sea level variation flows around the earth as two waves on opposite sides. Thus, at any point on the surface there will be two high tides 12 hours apart corresponding to the peaks of these waves and two low tides corresponding to the troughs in between. On a seaside beach this will be observed as waves flowing progressively higher up the beach till a peak is reached following which the waves recede down the beach and the cycle is repeated. Each day, the cycle is 50 minutes later at any one point.

[1] Symbiosis: living together for mutual benefit.

When the sun and the moon exert their gravitational pull together (during the full and new moon phases) higher tides are produced than at times when these gravitational forces oppose each other (during the quarter phases of the moon). The periods of higher tides are known as *spring tides* and periods of lower tides as *neap tides.* During spring tides high tides are higher and low tides are lower than during neap tides. The difference in sea level between high and low water is termed the tidal range—thus the tidal range is greater during springs than during neaps. In Sri Lanka, on account of its proximity to the equator, the maximum tidal range is small (0.8 metre). In higher latitudes, the tidal range is correspondingly greater. The practical effects of tides on seashore life, whether plant or animal, is zonation according to the time that that life form can remain out of water. Various terms are used to denote these ecological zones. The two principal divisions are—

the **littoral zone**, which is that part of the coast that is covered and uncovered by the tides, down to the limits of neap tides and includes the spray zone[2] above high spring tides, and

the **sublittoral zone**, which is that part below the low water mark that remains always under water. The littoral zone is also termed the intertidal zone, and this may be subdivided into high, low intertidal etc. In countries where the tidal range is of the order of several metres, stratification of shore life is more pronounced and terms such as upper/middle/lower shore zone etc are used.

Intertidal zonation as seen at low tide, Mount Lavinia.
Oysters, periwinkles and limpet shells in the supra-tidal spray zone (the white band). Green algae (*Ulva fasciata, Chaetomorpha antennina*) near the high tide line. Red algae (*Gracilaria corticata* and other species) near the low tide line (the dark band).

Sea weeds were earlier classified into three classes—the Chlorophyceae (green algae), the Phaeophyceae (brown algae) and Rhodophyceae (red algae). The current classification has re-assigned the algae to Divisions (Table 1).

[2] The spray zone is that area above the high tide level which is never under water but remains wet from breaking waves. Spray zones are seen on rocky shores with tall rocks. Certain species of oysters and periwinkles are characteristic animals in this zone. Several green algae such as *Chaetomorpha* and *Ulva* (sea lettuces) also grow in this zone.

Table 1: Macroalgae Divisions

Green algae	Brown algae	Red algae
Division Chlorophyta	Division Chromophyta	Division Rhodophyta
Class Ulvophyceae (primarily marine)	Class Phaeophyceae	
Class Chlorophyceae (primarily freshwater unicellular algae)	Class Bacillariophyceae are the diatoms, with silica cell walls	

ECOLOGY OF SEAWEEDS

As the names indicate they are generally coloured green, brown or red. To outward appearances they are similar to each other, but in fact they differ markedly in structure, in the habitats they occupy and in their reproductive tissues—these differences being highlighted in the new classification.

Algae that are able to tolerate varying periods of drying out, grow in the littoral zone. Many green algae live near the high-water mark or above it in the spray zone as they are dependent on many hours of strong sunlight during the day and periodic wetting and drying for survival. Other green algae and some brown and red ones can tolerate shorter periods out of water. They will be found nearer the low-water mark. Most seaweeds are to be found in the sublittoral zone in shallow water, where sunlight penetrates; red algae occur in deeper water than others. The red pigments in them enable them to utilise for photosynthesis the blue and violet light of sunlight which penetrates to these depths.

Rhizoids of the green alga *Caulerpa* attach the creeping stem termed a stolonoid to the substrate.

The algal thallus is usually attached to a firm substrate by the expanded base, which is then termed a holdfast or disc. Such substrates are commonly rock, dead coral or shells of marine snails (both dead and alive). Some algae are epiphytes, living on other seaweeds. Algae that live on soft substrates such as sand (for instance *Caulerpa*) possess root-like extensions of the thallus termed rhizoids which grow down in between the sand grains. In some, (for instance, *Avrainvillea*) the basal filaments of the alga mat together with sand grains to form a cigar-like buried "root" that extends deep into the sand, holding up the expanded photosynthetic green portion. Some algae grow as spreading crusts, closely applied to the rock surface. Many of these are brightly coloured, like the golden-yellow brown alga *Ralfsia* and the red or orange hued red alga *Peysonnelia.*

Most algae are attached, some species are free living as tangled masses. They grow as branched or unbranched thalli, filamentous and narrow or expanded and lobed. The patterns of branching in many algae make them unique in the plant kingdom. Many are microscopic and need to be viewed under magnification to appreciate them fully (and to identify them). Certain red algae (for instance *Lithothamnion*) and some green algae (like *Halimeda*) are able to concentrate calcium carbonate in their tissues. These calcified algae are important reef builders, helping to consolidate the various components of the reef. The three groups of macroalgae are discussed briefly below.

Chlorophyta: Ulvophyceae - Green algae

Green algae contain the same pigments (chlorophyll and others) that are found in the higher plants, colouring them green. The chief food reserve is starch. They are abundant in all the oceans but are more widely represented in fresh water. Some forms are terrestrial. They grow in regions of high light intensity and are therefore found in shallow water all the way up to the beach. In fact, some of them need to have a dry period in bright sunlight for some hours of the day to thrive: e. g. *Ulva, Chaetomorpha*. These algae may be seen on rocks that are periodically washed by waves, as well as on rocks that are perpetually submerged. Green algae are generally small plants. Some are edible.


Halimeda tuna

About 81 species have been found in Sri Lanka of approximately 5, 500 species worldwide.

Chromophyta: Phaeophyceae - Brown algae

In the brown algae, carotenoid pigments predominate in the chromatophores and a brown pigment (fucoxanthin) masks the green pigments. In life, the plants are either brown, or brownish-green or yellowish-green in colour. When dried, they aften turn green. The primary food reserve is a carbohydrate, laminarin, which is in solution in the cell sap. A characteristic feature of this class is the presence of colourless vesicles termed *fucosan vesicles* in the cells.

Brown algae show a higher degree of organisation of the plant body than green algae. They are all multicellular—some are filamentous, usually growing epiphytically, while the majority are more complex, with larger plant bodies. In some orders (e. g. Laminariales) the plant body is very bulky. Some of the largest seaweeds known, for example the giant kelps of California, are brown algae.


Padina boryana

Brown algae are found in all the seas—there are only a few genera that inhabit fresh water. Although certain genera are largely or entirely restricted to the warmer seas, the brown algae are found in their greatest numbers in the colder seas of the northern and southern hemispheres. They are found abundantly in sub-arctic and arctic seas. Most brown algae are found in the littoral zone or in shallow water, those that do live in deep water tend to be very tall so that their photosynthetic tissue is nearer the surface.

The cell wall of all brown algae contains a substance called algin, which is used in the food industry as an emulsion stabiliser, e. g. in ice cream. Brown algae are also harvested for use as fertiliser and some are edible, such as species of *Laminaria* (Tangle - UK, Kombu - Japan), *Alaria* (Bladderlocks - UK, Winged kelp - USA) and *Dictyopteris* (Limu lipoa - Hawaii).

In Sri Lanka brown algae such as *Padina* and *Chnoospora*, may be found intertidally on rocky shores—the former in rock pools or at the level of the lowest tides and the latter on wave-washed rocks. Species of *Sargassum* may also be seen in the littoral zone, but these are abundant only sub-littorally in shallow water, as are the other brown algae. In temperate latitudes, species of the order Fucales (which includes *Sargassum*) are adapted to withstand desiccation and are found in large numbers in the littoral zone.

About 66 species have been found in Sri Lanka of approximately 1500 species worldwide.

Rhodophyta - Red algae

Liagora sp.

Red algae are coloured pink, bright red, purplish, brown or tinged with green. The cells contain little chlorophyll but have in addition two water soluble pigments—a red one (phycoerythrin) and a blue one (phycocyanin). These are the same pigments that are found in the Cyanobacteria ("blue-green algae"), but the two groups are quite unrelated. In addition, other pigments such as carotene and xanthophyll are also present. The products of photosynthesis are stored as a polysaccharide called floridean starch. The reproductive cells in red algae are rather complicated and the division is divided mainly based on the details of reproduction.

The red algae fall naturally into two groups—the Bangioideae and the Florideae. These share common characters but are quite different from each other.

The Bangioideae are simple forms, with diffuse growth, the thallus consisting of a blade with one or two layers of cells. Most species are marine, with a few freshwater forms. Only about four species, in three genera have been reported from Sri Lanka.

The Florideae comprise the vast majority of the red algae. They are filamentous forms, usually with the filaments aggregated with varying degrees of compactness to form the macroscopic thalli. Thalli may be formed from the branch systems of a single filament or from those of many filaments, all with apical growth. A characteristic feature of the Florideae is the occurrence of pit connections between adjacent cells. These are perforations in the cell walls between adjacent cells through which cytoplasmic strands pass. They maintain their continuity even when the cells are pushed apart by growth, sometimes resulting in cells with characteristic form (stellate cells and elongated cells). The range of morphological forms seen is limited—in other words, many Florideae, otherwise unrelated, have the same appearance. Some are impregnated with calcium salts. These algae occur as red or pink coloured patches or crusts. These are important constituents of reefs as they help bind together loose rocks. The vast majority of Florideae are marine, with few freshwater forms. Most red algae are small to medium sized.

Most species of marine red algae are sub-littoral with many growing in deep water, especially where the water is clear. Certain Florideae in the temperate zones form extensive littoral belts. Bangioideae (*Porphyra*) are also seen in the littoral zone. Red algae are present in all seas, even polar, but predominate in the algal flora of the tropics. On rocks that line the beach, the low tide level is indicated by a fringe of red algae.

A number of red algae are used as food. Agar, also called moss jelly, is extracted from certain red algae (*Gelidium* and *Gracilaria*). Such algae have been harvested from the Puttalam lagoon.

About 171 species of red algae have been found in Sri Lanka of approximately 3000 species worldwide.

Uses of Seaweeds

Seaweeds are rich in minerals and other substances and many varieties are exploited commercially for industrial use and as food. However, this potential has not been fully utilised in Sri Lanka, apart from some seaweed which has been harvested and exported. There is little domestic consumption as food. In the sections on the three groups of seaweeds mention was made briefly of uses to which various types of seaweed are put. This section discusses in greater detail specific products obtained from algae which have relevance to seaweeds that grow in Sri Lanka, as well as edible seaweeds.

Industrial uses of seaweeds

Two substances that have many uses, algin and agar-agar, are extracted from seaweeds—one from brown and the other from red algae, respectively. Species of Sri Lankan algae that yield these substances in quantities that justify commercial exploitation have been identified and processes for extraction worked out by the Ceylon Institute for Scientific and Industrial Research (CISIR)—now re-named the Industrial Technology Institute of Sri Lanka.

Algin (alginic acid)

Algin, in the form of alginic acid, forms gels of high viscosity with good heat and chemical stability. It has wide application in the textile, food pharmaceutical and cosmetic industries. Added to ice cream it imparts a smooth texture by preventing the formation of ice crystals. In car polishes it suspends the abrasives. It is used as an emulsifier in cosmetics, water-based paints and salad creams. It is also used in the rubber latex and printing industry as a stabilising agent.

In Sri Lanka it is used mainly in the textile industry as a carrier for the dye in textile printing, as it gives an extremely sharp, well-defined print and subsequently washes off easily. The local pharmaceutical industry too, uses algin.

All brown seaweeds contain alginic acid, but not all can be used for the manufacture of alginates on a commercial scale for technical reasons. The kelps of the Pacific Ocean (*Laminaria digitata, Macrocystis pyrifera*) are some of the seaweeds used for alginate production. Few other brown seaweeds are suitable, but among those that are, is the genus *Sargassum*, with many species in Sri Lanka.

Surveys of the availability of *Sargassum* in Sri Lanka have shown that exploitable resources are present, at least for a small industry. The dominant species in the south coast, *Sargassum cervicone* (Greville) was found to give a high yield. Many other species of *Sargassum* and the related *Turbinaria* and *Cystophyllum* are to be found off the west and south coasts of the island as well as in the Mannar/Jaffna area.

Although the raw material and the technology exist in Sri Lanka for alginate production, an industry has not been established. Attempts have been made in the past to set up commercial production units to provide alginate for the textile industry, but these have not succeeded for a number of reasons—inability to maintain an adequate supply of seaweed has been one. It is reported that inquiries have been made from several importing countries, such as Japan, for purchase of *Sargassum*, but uncertainties regarding supply and difficulty in identification of the plants have posed difficulties.

Agar-agar

Agar-agar is manufactured principally from red algae of the genera *Gracilaria* and *Gelidium.* Agar forms a gel of high strength and is principally used as a stabilising, thickening and gelling agent in the food industry. It can be used as a substitute for gelatine (an animal product) in the preparation of rapid-setting jellies and desserts. As an anti-drying agent in bread and pastry. In the manufacture of frozen dairy products and in improving the slicing quality of processed cheese. It is also used in such diverse processes as the manufacture of water-proof paper and cloth, photographic film, shoe polish, shaving soap and hand lotions, and as a lubricant (mixed with graphite) for drawing hot tungsten wire for electric bulbs.

Carrageen is a similar substance obtained from the red algae *Chondrus crispus* and *Gigartina stellata*, collectively called Irish moss, as well as from a number of other types, none of which are found in Sri Lanka.

The dried seaweed from which agar is prepared is commonly called "China Moss" in Sri Lanka, but it has been exported to Britain and America as dried "Ceylon Moss", under which name it may be found in various literature. In 1840 15,000 lbs were exported (Subasinghe and Jayasuriya). In more recent years, annual dried seaweed exports have varied much—31,250 kg was exported in 1991, less in the next two years, none in 1994 and 20 kg in 1995. The importing countries were Japan, Taiwan, South Korea and Australia. No seaweed was exported to Japan in 1994 and '95 (Sri Lanka Customs, External Trade Statistics).

Two out of the many species of *Gracilaria* in Sri Lanka are used for export and for local consumption. They are *Gracilaria verrucosa* (synonym *G. confervoides*) and *G. edulis* (synonym *G. lichenoides*). Wild *Gracilaria* has been harvested in the Trincomalee area and in the Puttalam lagoon, where trials have been conducted in cultivation. The current status of seaweed cultivation is not known to the writer. Seaweed harvesting has been a parttime activity of fishermen, done at the request of the exporters or middlemen. The harvested seaweed is sundried, bagged and sent to Colombo. Little is done in the way of cleaning before export. The industry is very dependent on the receipt of export orders, as only a small percentage of that harvested is sold domestically. The CISIR (ITI-SL) has found that *G. verrucosa* gave a higher yield of agar than *G. edulis.*

Edible seaweeds

Seaweeds have been used as food for many years in Europe and Asia, as well as in North America. They are eaten raw or cooked, either fresh or dried. All three varieties (green, brown, and red) are used. We are familiar with seaweed use in Chinese and Japanese cuisine, but it may be surprising to learn that seaweeds are also consumed in European countries, as well as in the USA, albeit in smaller quantities. The Philippines, Hawaii, Korea, Vietnam, Myanmar and Thailand are other countries where seaweeds are consumed.

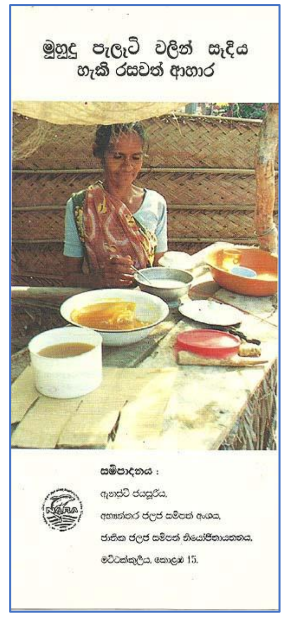
A number of genera are used for food (see table below), and those with representatives in Sri Lanka are marked with an asterisk (*):

Edible seaweeds	
Species name Common name	Country of use/Form of use
*Porphyra umbilicalis** Purple laver (pronounced 'lava')	Wales, England/Boiled and fried
Porphyra tenera, P. yezoensis Nori	Japan, sold dried as sheets
*Ulva lactuca** Sea lettuce, Green laver	Europe, with lemon juice Boiled, the Welsh laver bread
Laurencia pinnatifida Pepper Dulse	Scotland, as a condiment
Gracilaria spp.* Ceylon moss	To prepare agar-agar, jellies
Enteromorpha prolifera (= *Ulva prolifera*)* Green nori	Japan, a dried powder used as a condiment
Caulerpa, Codium, Gracilaria, Porphyra and Sargassum	Are reported eaten in the Philippines
*Gracilaria verrucosa** (lipu manauea), *Enteromorpha* (*Ulva*)* (limu 'ele 'ele), *Polyopes** (opihi limu), *Grateloupia* (opihi limu) and *Dictyopteris* (lipu limoa)	Are among those seaweeds consumed in Hawaii

- Alan Major, The Book of Seaweeds, 1977

Gracilaria spp. has been consumed by the people living around the Puttalam lagoon. A socio-economic survey conducted by the National Aquatic Resources Agency (NARA) in 1988 had shown that 9 out of 10 people living in this area consumed seaweed, usually in the form of a *kende* (porridge) made by boiling the seaweed and adding coconut milk and lime to the strained water. This preparation was also said to be available for sale in boutiques in Kalpitiya. Another preparation sold in this area was seaweed jelly cubes. Packets of dried Gracilaria was said to be available in the market.

NARA produced Sinhala language pamphlets in an attempt to popularise seaweed as food. Among their recipes are two salads using "ulva" and "caulerpa". The fresh seaweed is washed in fresh water, mixed with chopped onions and tomatoes, and sprinkled with lime juice. The pamphlets also briefly describe methods of *Gracilaria* propagation and cultivation.



BIBLIOGRAPHY

Anon, 1979. Useful Products from Marine Algae. *CISIREACH*, The Quarterly Newsletter of CISIR. Vol. 1 No. 4, 1979: 1-3.

Anon, 1981. The Processing, Harvesting and Cultivation of Seaweeds, in *Pilot Survey of the World Seaweed Industry & Trade*, International Trade Centre, UNCTAD/GATT, Geneva, 1981.

Ariyananda, P.L., and Fernando, S.S.D., 1987. Turtle Flesh Poisoning, *Cey Med J* Vol 32, pp 213-215, 1987.

Auerbach, Paul S., 1991. *A medical Guide to Hazardous Marine Life* - 2nd ed. Moseby Yearbook, St. Louis, USA.

Børgesen, F., 1936. Some Marine Algae from Ceylon. *Cey J Sci (A)* Vol. XIX, pt 2, pp 51-96.

Chhapgar, B.F., 1991. *Seashore Life of India*. Oxford Univ Press for World Wide Fund for Nature-India, Bombay.

Durairatnam, M., 1961. Contribution to the Study of the Marine Algae of Ceylon. *Bull Fish Res Stn Ceylon*, No 10, Colombo.

---------------------, 1962. Some Marine Algae from Ceylon - 1. *Bull Fish Res Stn Ceylon*, No 15, Colombo.

Fritsch, F.E., 1935. *The Structure and Reproduction of the Algae,* Vol I. Cambridge University Press, London, 1975.

---------------------, 1945. *The Structure and Reproduction of the Algae*, Vol II. Cambridge University Press, London, 1972.

Major, Alan, 1977. *The Book of Seaweeds*. Gordon & Cremonesi, London.

Subasinghe, S. & Jayasuriya, P.M.A., 1989. *Seaweed Industry in Sri Lanka: A Study of the present status of the seaweed industry in Sri Lanka*. National Aquatic Resources Agency, Colombo.