



Determination of elemental composition of selected seaweeds using SEM-EDS method

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Abstract

Seaweeds are macroscopic algae growing in the environments like marine and shallow coastal waters and on rocky shores. The major industrial products of seaweeds are as a source of agar, agarose and carrageenan. Seaweeds contains various pharmacologically important bioactive compounds like carotenoids, flavonoids, fibre, protein, essential fatty acids, vitamins and minerals. The present study mainly focus with the analysis of elemental composition of five species of red seaweeds (Rhodophyceae) and five species of brown seaweeds (Phaeophyceae) using SEM-EDS. The collected seaweed species were washed, shade dried and then grinded into a fine powder. The elements present in the seaweed species were determined by SEM-EDS in central instrumentation laboratory, Department of physics, Annamalai University. Various elements present in the seaweeds are N>Na>Mg>Al>Si>Cl>S>B>K>Ca>Mn>Fe>Cu>Zn. Among these various elements in all seaweeds, maximum amount of nitrogen and potassium are observed in the *Gracilaria corticata* and *Sargassum wightii* followed by *Kappaphycus alvarezii* and *Turbinaria ornata*. Based on the results, the *Gracilaria corticata* and *Sargassum wightii* can be used as a liquid fertilizer, which will improve the crop growth and productivity and hence these two seaweeds namely *Gracilaria corticata* and *Sargassum wightii* are analysed for further studies.

Keywords: seaweeds, bioactive compounds, SEM-EDS, elements, crop

Introduction

Seaweeds are macroscopic algae growing in the environments like marine and shallow coastal waters and on rocky shores. So far, around 844 species of seaweeds have been reported from Indian seas, and their standing stock is estimated about 58,715 tonnes on wet weight basis. Out of the 844-seaweed species, India possess around 434 species of Red algae, 194 species of Brown algae and 216 species of Green algae. Seaweeds are wonder plants of the sea, the new renewable source of food, energy, chemicals and medicines with manifold nutritional, industrial, biomedical, agriculture and personal care applications. The major industrial products of seaweeds are as a source of agar, agarose and carrageenan used in laboratories. In India, there are about 46 seaweed-based industries (21 for agar and 25 for alginate production) but they are not functioning upto their rated capacity due to short-supply of raw materials. Yaich *et al.*, 2013 have reported that the seaweeds are valuable sources of macro nutrients such as protein, fibre, carbohydrates and lipids and micronutrients such as minerals and vitamins and also have a important bioactive compounds. More than 60 trace elements are present in marine algae which are higher than the commercial terrestrial plants. Balakrishnan *et al.*, 2013^[1] suggested that the trace elements stabilize the living system for biochemical and nutritional aspects and seaweeds contains trace elements such as S, Ca, Mg, Si, Na, K which are necessity for our daily functions and defence system. Seaweeds contains various pharmacologically important bioactive compounds like carotenoids, flavonoids, fibre, protein, essential fatty acids, vitamins and minerals. Niranjana and Se-Kwon Kim, 2011^[4] revealed that the minerals present in seaweed can account for up to 36% of its dry mass and the macro minerals present are magnesium,

calcium, potassium, sodium, phosphorus and the micro minerals are zinc, copper, nickel, cobalt, iodine, manganese, iron, molybdenum, boron. Seaweed could be used as a food supplement which provides macro minerals and trace elements (Ruperez, 2002)^[6]. Most of the environmental parameters may differ according to the change in ecological condition and season that can stimulate or inhibit the biosynthesis of several nutrients. Hence, the present study mainly focus with the analysis of elemental composition of five species of red seaweeds (Rhodophyceae) and five species of brown seaweeds (Phaeophyceae) using SEM-EDS (Energy Dispersive Spectroscopic) by standard protocol.

Materials and methods

Collection and processing of seaweeds

Five seaweed samples from different species of red algae viz., *Gracilaria corticata*, *Jania rubens*, *Acanthophora spicifera*, *Kappaphycus alvarezii*, *Halymenia dilate* and five species from brown algae viz., *Hydroclathrus clathratus*, *Stoichospermum marginatum*, *Padina gymnospora*, *Sargassum wightii* and *Turbinaria ornata* were collected from the coastal region of Mandapam, Rameswaram in Tamilnadu, South India. The collected seaweed samples were washed thoroughly with seawater and cleaned with running water to remove the salt, sand and other impurities. Then, cleaned seaweeds were shade dried and grinded into fine powder and the powdered samples was stored at room temperature and used for further analysis.

Preparation of SEM studies in seaweed

The samples of seaweeds were examined using JOEL JSM-56010 LV with INSA-EDS and the photomicrographs were taken selectively from the computer screen at central

sophisticated instrumentation laboratory, Department of Physics, Annamalai University, Annamalai Nagar, Tamil Nadu, India. EDS analysed the elements present in the cell wall of the five seaweeds. Sundari and Selvaraj, 2009^[7] said that the energy dispersive X-Ray microanalysis provides a unique approach for obtaining qualitative and quantitative compositional analysis of individual cell and intra cellular compartment to localize distribution of elements of leaf differed not only by quality but also in quantity.

Results and discussion

Collection of the different species of the seaweeds

The collected seaweed species from the coastal region of mandapam in Rameswaram were done and designated as SW₁, SW₂, SW₃, SW₄, SW₅, SW₆, SW₇, SW₈, SW₉ and SW₁₀ were represented in the table 1.

Table 1: Location and designation of isolated seaweeds

S.No	Location	Designation
1.	Mandapam, Rameswaram	SW ₁
2.		SW ₂
3.		SW ₃
4.		SW ₄
5.		SW ₅
6.		SW ₆
7.		SW ₇
8.		SW ₈
9.		SW ₉
10.		SW ₁₀

Identification of the seaweeds

The seaweed samples obtained were identified based on their morphological characters such as size, shape, colour, growth etc. Out of ten isolates five of the seaweeds were belongs to red algae (SW-1-SW-5) and remaining five seaweeds are coming under brown algae (SW-6 – SW-10) and the results were represented in the table-2.

Analysis of different element components in seaweed

The presence of various elements in collected seaweeds are analysed by EDS and the results were represented in the

table -3. The elements present in the cell wall of all seaweeds are normally in the order of N>Na>Mg>Al>Si>Cl>S>B>K>Ca>Mn>Fe>Cu>Zn. The mass of the elements in samples are given as percentage (%). The red algae *Gracilaria corticata* showed nine elements and they are N, Na, Mg, Al, S, K, Ca, Mn, Cu. Among these various elements 'Potassium' (23.39) shows the maximum amount followed by 'Sulphur' (18.98%). The minimum amount of the element is 'Manganese' (0.42%). When compared to other red algae species, the *Gracilaria corticata* contains a highest amount of 'N' (18.28%) followed by *Kappaphycus alvarezii*. The *Kappaphycus alvarezii* contains 12 elements viz., B, N, Na, Mg, Al, Cl, K, Ca, Mn, Fe, Cu. Among these elements, the highest amount shows in 'Potassium' (43.91%) and followed by 'Chlorine' (37.20%) and this species contains a 'Nitrogen' in the amount of (10.10%).

Among the brown algae, *Sargassum wightii* showed the elements viz., Na, Mg, Si, Cl, K, Ca, Fe, Cu. Among these elements, the highest amount was recorded in 'Calcium' (27.32%) followed by 'Copper' (25.56%) and the lowest value was recorded in 'Iron' (1.76%). The 'Potassium' content in *Sargassum wightii* shows the maximum amount when compared to other brown algal species. It shows (23.92%) amount of 'Potassium' followed by *Turbinaria ornata* (22.84%) amount of 'Potassium'. These are represented in a graphical presentation in figure 1.

Discussion

Seaweeds are traditionally consumed in different parts of the world. Nowadays, human consumption of brown algae (64.5%), red algae (34%) and green algae (6%). Soriano *et al.*, (2006) reported that seaweeds are often consumed as marine vegetables. Seaweeds contain many nutrients and elements. The techniques in EDS can give a valuable input in estimating the presence of various elements over the surface of seaweeds are reported by Figueria *et al.*, 1999. The present study detected the elemental composition in the cell wall of selected seaweeds by SEM-EDS and reported the elements such as N, K, Ca, Si, Mg, Mn, Cl, Ca, Fe, Cu.

Table 2: Morphological identification of different seaweeds

S.No	Designated code	Morphological characters	Tentative identification of seaweeds	Type
1.	SW ₁	Plants grow in dense tufts, thallus reaching 10-15cm high, rigid, width of segments 1-2mm or 2-3mm in some cases even up to 3-4mm.	<i>Gracilaria corticata</i>	Red algae
2.	SW ₂	Plants saxicolous, erect, articulate, 2-5cm high.	<i>Jania rubens</i>	Red algae
3.	SW ₃	Plants bushy, erect and 15 and 20cm tall, cartilaginous, reddish to greenish.	<i>Acanthophora spicifera</i>	Red algae
4.	SW ₄	Plants are fleshy, firm up to 2 meter tall, thallus coarse with axes and branches 1-2cm diameter.	<i>Kappaphycus alvarezii</i>	Red algae
5.	SW ₅	Plants are erect, rose to red in colour and gelatinous in consistency, small disc, variable in shape.	<i>Halymenia dilate</i>	Red algae
6.	SW ₆	Plants brownish in colour, clathrate, spongy and net-like.	<i>Hydroclatharus clathratus</i>	Brown algae
7.	SW ₇	Plants are large, 30-50cm in height, bushy, leaves alternate, 0.5-1.2cm long.	<i>Turbinaria ornate</i>	Brown algae
8.	SW ₈	Plants are brown, darker at the base, robust, upto 200mm across, fan shaped lobes are present.	<i>Padina gymnospora</i>	Brown algae
9.	SW ₉	Plants are large tufts, 15-25cm or high. Thallus erect, segments of thallus 1-2cm broad,	<i>Steochospermum marginatum</i>	Brown algae
10.	SW ₁₀	Root expanded and disc like, stem erect, 30-60cm high or more, branches are several, leaves 2.5 to 5cm or more long.	<i>Sargassum wightii</i>	Brown algae

Hannan *et al.*, have revealed that the *Ulva lactuca* species has huge amount of calcium. The major elements found in seaweed (*Sargassum wightii* & *Gracilaria corticata*) are Na, Mg, Si, Cl, K, Mn, N, Ca, Fe, Cu. The macro molecules such as nitrogen, potassium, calcium, sodium, magnesium

are present in significant amounts in marine algae (Nisizawa, 2006) [6]. The seaweeds show great variation in nutrient contents which are related to several environmental factors such as water, temperature, salinity, light and nutrients (Dawes, 1998) [2].

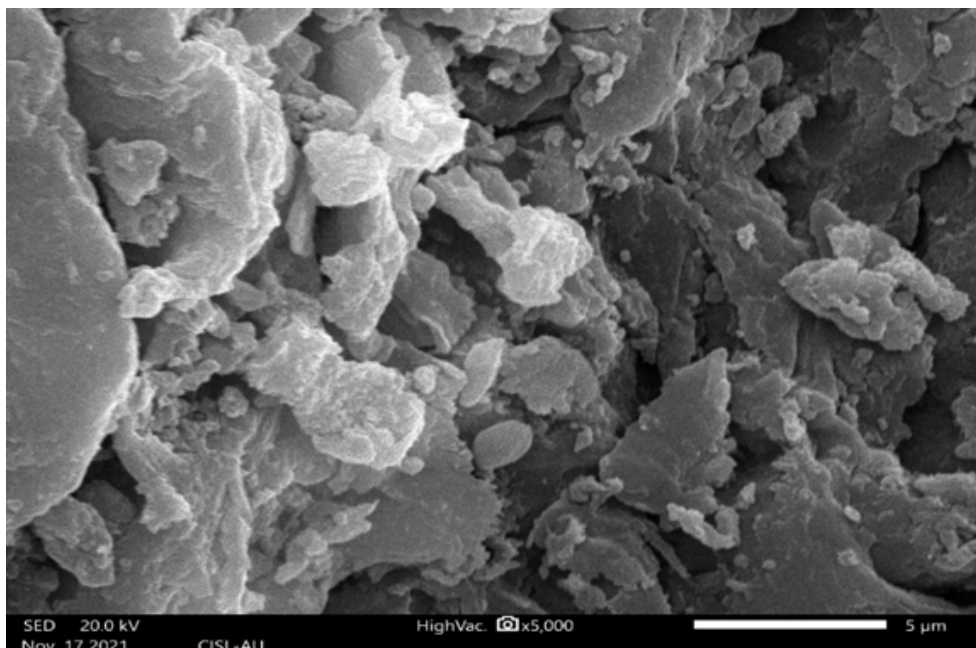


Fig 1: SEM image of *Sargassum wightii*- Brown algae

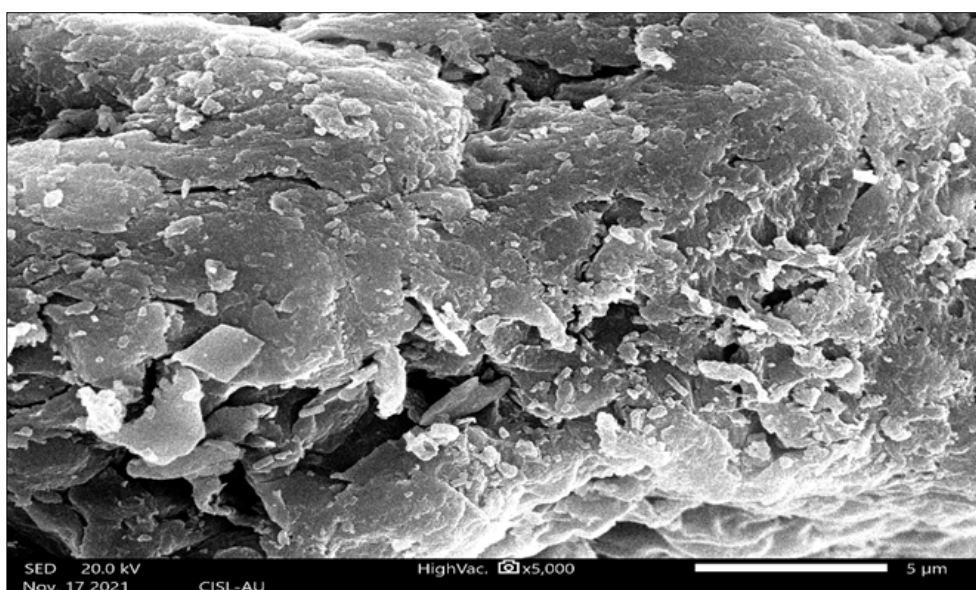


Fig 2: SEM image of *Gracilaria corticata*- Red algae

Table 3: Elemental composition of seaweeds as analysed by SEM-EDS

Seaweed species	N	Na	Mg	Al	Si	Cl	K	Ca	Mn	Fe	Cu	B	S	Zn
<i>Gracilaria corticata</i>	18.28	12.05	3.13	3.19	-	-	23.39	6.60	0.42	-	13.96	-	18.98	-
<i>Jania rubens</i>	6.99	0.48	3.40	1.70	3.55	-	0.28	65.99	0.26	1.49	10.85	-	-	5.02
<i>Acanthophora spicifera</i>	16.54	1.65	0.83	0.40	0.59	0.70	0.72	76.65	0.02	-	1.38	-	-	0.52
<i>Kappaphycus alvarezii</i>	10.10	12.34	0.45	0.62	-	37.20	23.01	1.30	0.14	0.36	2.67	0.89	-	-
<i>Halymenia dilatata</i>	-	16.57	11.17	-	-	-	8.54	7.61	0.20	1.23	13.42	-	33.66	7.59
<i>Hydroclathratus clatharus</i>	-	2.62	5.97	11.62	29.07	-	5.77	29.24	-	8.35	7.35	-	-	-
<i>Turbinaria ornata</i>	-	16.80	8.53	-	-	18.12	22.84	26.36	-	0.28	7.07	-	-	-
<i>Padina gymnospora</i>	-	-	10.13	-	7.81	-	2.73	35.08	-	4.88	23.65	-	-	15.71
<i>Stochospermum marginatum</i>	3.48	1.81	0.95	8.80	7.48	-	5.54	28.31	-	-	43.64	-	-	-
<i>Sargassum wightii</i>	-	5.05	3.95	-	2.70	9.74	23.92	27.32	-	1.76	25.56	-	-	-

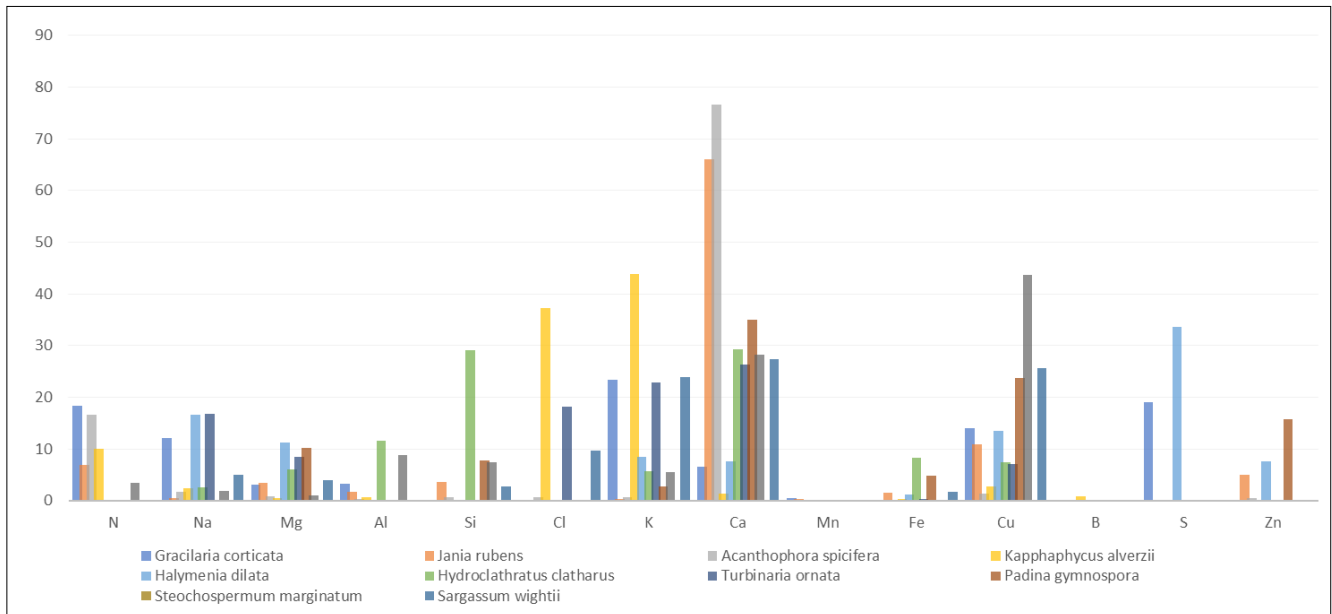


Fig 3: Graphical representation of the elements in seaweed species

Conclusion

The result of the present study revealed that the brown algae *Sargassum wightii* and red algae *Gracilaria corticata* showed many nutrients especially large quantity of nitrogen and potassium. So, it may be used as liquid biofertilizers which will improve the crop productivity and quality. The seaweed extract formulation with the addition of PGPR microorganisms will increase the nutrient uptake of crop plants and enrich the soil in eco-friendly way.

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