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Trace metals and mineral contents of some green algal seaweeds from Vadakadu (Rameswaram) coastal regions, Tamil Nadu, India

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Abstract
The present study focused on the trace metal and mineral composition analysis of fiver green algal seaweeds such as *Caulerpa racemosa*, *Caulerpa sertularioides*, *Ulva reticulate*, *Ulva lactuca* and *Codium tomentosum* were collected from Vadakadu (Rameswaram) coastal regions, Tamilnadu, India. Among this group of seaweeds, *Caulerpa sertularioides* showed the maximum contents of mineral elements such as chromium, copper, and magnesium and *Ulva lactuca* observed the minimum level of mineral content such as cobalt, iron, magnesium, manganese, nickel, lead and zinc.

Keywords: Green algal seaweeds, Vadakadu, trace metals and minerals

Introduction
Seaweeds are traditionally eaten in the orient as part of the daily diet currently, human consumption of green algae has comparatively lower than brown and red algae [1]. Yet the demand for seaweed as food has now extended to North America, South Africa and Europe [2]. The different species consumed at present hold a great nutritional value as source of proteins, sugars, minerals and vitamins.

Marine algae is an important source of dissolved organic carbon in coastal waters. Carbohydrates, polysaccharides, nitrogen and polyphenolic materials, represent the organic carbon [3, 4]. Utilization of algae in food supplements was also studied by Ahmed and Hamza [5].

Around 10% of the green algae are marine in habitat and mostly found in the tropics. They are a direct source of food, fertilizer, medicine and fodder. Among the various species of green algae *Ulva* and *Enteromorpha* are used for human consumption in Japan, East Asia, West and South-East Asia, North and South America and Oceania. Other species of green algae are also finding their application as human food and medicine in certain regions [6, 9]. Considering the commercial importance of the green algae, the trace metals and mineral composition was analyzed and the results obtained on this aspect are presented in this paper.

The seaweeds are also recognized to contain bioactive products that display antibacterial, antiviral and antifungal properties [10]. Furthermore, they are utilized for animal nutrition as feed are as fertilizers and soil conditioning agents [11].

The seaweed shows great variation in nutrient contents which are connected to several environmental factors are water temperature, salinity, light and nutrients [01]. Most of the environmental parameters vary according to season and the changes in ecological conditions can induce of inhibit the biosynthesis of various nutrients [12]. The nutritional properties of seaweeds are poorly experienced and normally are evaluated from the chemical composition. The food composition of seaweed varies and is affected by species, geographic region and season of the year and temperature of water [14]. Approximately, 25% of all food eaten in Japan consists of seaweed prepared and assisted in many phases and has become the primary origin of income for the fisherman there. Nevertheless, at present this seaweed is just eaten in certain coastal areas, particularly on the east coast of peninsula Malaysia and in East Malaysia, where it is occasionally eaten as a salad dish.

Seafood including seaweeds is known to be one of the most fertile sources of minerals. The most common minerals found in seafood are iodine, magnesium, calcium, phosphorus, iron, potassium, copper and fluoride [15]. Minerals are very important for the biochemical reaction in the body as a co-factor of an enzyme. For examples, Ca, P, and Mg build and preserve bones and Mg build and preserve bones and teeth, whereas, Na and K help maintain balance of water, acids and bases in fluids outside of cells, an involve in acid-base balance and transfer of nutrients in and out of individuals cells, respectively [15].

Defects in mineral are capable of producing severe impairment of health. For instances, Ca malnutrition causes abnormal bone formation, namely Osteoporosis and anemia caused by Fe deficiency [16, 17]. Deficiency in magnesium can result in a form of metabolic abnormalities, such as K depletion and clinical presentations.

Seaweeds are major coastal resources which are valuable for human consumption and the environment in many countries. Edible seaweeds were widely consumed, especially in Asian countries as fresh, dried, or ingredients in prepared foods. Compared to land plants, the chemical composition of seaweeds has been poorly investigated and most of the available information only deals with tradition Japanese seaweeds [18, 19]. The chemical composition of seaweeds varies with species, habitat, maturity and environmental conditions [20]. In general, seaweeds are rich in non-starch polysaccharides, minerals and vitamins [29]. As seaweed polysaccharides cannot be entirely digested by human, they are regarded as a new source of dietary fiber and food ingredient. Together with their low lipid content, seaweeds only provide a very low amount of energy. Consumption of seaweeds can increase the uptake of dietary fiber and turn down the natural event of some chronic diseases [22].

Eating patterns of people all over the world have recently undergone marked changes, due to the globalization of markets along with innovation in food technology. The macrobiotic diet, which came to Europe technology. The macrobiotic diet, which came to Europe from Japan, contributed to the introduction of sea vegetables in their staple diet. Fresh seaweeds have been used directly as food stuff in the Asian countries for centuries and are considered under-exploited resources [23]. About 221 seaweeds are utilized commercially world-wide of which 65% is used for human food [24]. Most recently seaweeds have been used in Japan as raw materials in the fabrication of many seaweed food products, such as jam, cheese, wine, tea, soup and noodles [19] and in Western countries, primarily as a source of polysaccharides (agar, alginates, carageenans) for the food and pharmaceutical industries [25]. Seaweeds are a rich source of minerals, especially macro and micronutrients necessary for human nutrition; however, the nutritional properties of seaweeds are usually determined by their biochemical composition alone viz, proteins, carbohydrates, vitamins, amino acids, etc. [21]. The mineral fraction of some seaweed even accounts for up to 40% of dry matter [26], however, in some cases the mineral content of the seaweeds is recorded even higher than that of land plants and animal products [20]. Consumption of seaweeds can increase the intake of dietary fiber a lower the occurrence of some chronic diseases (diabetes, obesity, heart diseases, cancers, etc.) which are associated with low fiber diets of the Western countries [22].

The present work focuses on mineral constitution of different group of seaweeds from Mandapam coastal regions along Southeast coast of India.

Materials and Methods

Collection of Seaweeds

Five species of green algae such as *Caulerpa racemosa*, *Caulerpa sertularioides*, *Ulva lactuca*, *Ulva reticulate* and *Codium tomentosum* were collected from Vadakadu (Rameswaram) coastal regions, Tamilnadu, India (Lat 8° 35' – 9° 25'N; Long 78° 08' – 79° 30' E). The collection was made during low tide from the upper littoral zone of the above mentioned locations in January 2014. The seaweeds were handpicked and collected with the help of scalpel then immediately.

The collected samples were cleaned with seawater to remove sand and epiphytes. Then the seaweeds immediately transported to the research lab and cleaned thoroughly using tap water to transfer the saltiness along the airfoil of the sample. Then it was spread on blotting paper to take out excess amounts of water and shade dried at room temperature until constant weight obtained.

Samples were subjected to acid digestion and analyzed according to the process described by Farias *et al.* [27]. Mineralogical analysis was carried out using inductively coupled plasma atomic emission spectrometry – ICP-AES. All determinations were done in triplicate and data represented on dry weight basis as mean values (Mean ± standard deviation).

Result

Cadmium attained from *Ulva reticulata* and *Caulerpa racemosa* (0.30 ± 0.001 ppm). Cobalt content varied from 0.02 ± 0.005 ppm to 0.04 ± 0.002 ppm; he maximum content was recorded from *Codium tomentosum* and a minimum level attained from *Ulva lactuca*. Chromium content was varied from (0.15 ± 0.010 ppm to 0.89 ± 0.004 ppm; in that the green seaweed *Caulerpa sertularioides* and the minimum content were recorded at *Codium tomentosum* 0.15 ± 0.010 ppm. Copper made the highest level in *U. reticulata* (1.38 ± 0.018 p.m.) and the lowest level were observed at *Codium tomentosum* (0.77 ± 0.008 ppm). Iron was observed the highest level from alga *Ulva reticulata* (58.5 ± 2.021 ppm) and the lowest level was observed at *Ulva lactuca* (16.8 ± 0.305 ppm) (Table 1).

Magnesium content varied from 30.9 ± 0.51 ppm to 16 ± 7.17 ppm); the maximum content was recorded from *Caulerpa sertularioides* (161 ± 7.17 ppm) and the minimum level attained at *Ulva lactuca* (30.9 ± 0.51 ppm). Manganese content varied from (0.63 ± 0.01 ppm to 3.31 ± 0.05 ppm) in that the maximum level was obtained (3.31 ± 0.05 ppm) from *Caulerpa racemosa* and the minimum content was recorded at *Ulva lactuca* (0.63 ± 0.01 ppm) (Table 1).

Nickel was observed at *Ulva lactuca* (0.03 ± 0.004 ppm). Lead content varied from (0.13 ± 0.02 ppm; 0.26 ± 0.076 ppm) from *Ulva reticulata* and the minimum content was recorded at *Ulva lactuca* (0.13 ± 0.02 ppm).

Table 1: The trace metal and mineral composition analysis of five green algal seaweeds.

Elements / Minerals	*Caulerpa racemosa*	*Caulerpa sertularioides*	*Ulva reticulata*	*Ulva lactuca*	*Codium tomentosum*
Cd	0.030±0.001	0.031±0.001	0.60±0.004	0.03±0.001	0.01±0.010
Cr	0.029±0.002	0.89±0.004	0.37±0.014	0.14±0.002	0.15±0.010
Cu	0.19±0.003	0.19±0.058	1.38±0.018	0.53±0.001	0.77±0.008
Mg	0.27±0.002	161±7.17	2.88±0.030	30.9±0.51	21.1±0.301
Co	0.25±0.001	5.12±0.036	0.98±0.021	0.04±0.002	0.02±0.005
Fe	1.11±0.050	2.36±0.001	58.5±2.021	16.8±0.305	10.3±0.052
Mn	3.31±0.05	7.36±0.005	3.12±0.002	0.63±0.01	0.53±0.001
Ni	2.05±0.001	13.26±0.001	1.00±0.003	0.03±0.004	0.23±0.003
Pb	1.75±0.001	11.31±0.023	0.26±0.076	0.13±0.002	0.24±0.001
Zn	2.11±0.003	0.94±0.007	0.73±0.004	0.36±0.04	0.46±0.002

Note: Cd – Cadmium, Cr – Chromium, Cu – Copper, Mg – Magnesium; Co – Cobalt; Fe – Iron; Mn – Manganese; Ni – Nickel; Pd – lead; Zn – Zinc.

Zinc content was attained the maximum level from *Ulva reticulata* (0.73 ± 0.004 ppm) and the lowest level was observed at Ulva lactuca (0.36 ± 0.04 ppm) (Table 1).

Discussion

Seaweeds are potentially good sources of proteins, polysaccharides and fibre [29, 21]. Surveys on the biochemical constituents such as protein, carbohydrate and lipid in green marine algae have been conducted out from different portions of Indian coast [30, 31, 32].

The vitamin and mineral contents of edible seaweeds make them nutritionally valuable. Much work has been done on algal fatty acids, both micro algae as well as on the fatty acid composition of seaweeds. Seaweeds are known as an excellent source of vitamins and minerals, especially sodium and iodine, due to their high polysaccharide content which could dietary fiber Muthuraman and Ranganathan [31] selected six species of marine macro algae viz., *Caulerpa scalpelliformis, Cladophora vagabunda, Enteromorpha compressa, Ulva reticulata, Ulva fasciata* and *Chaetomorpha antennina* to investigate protein, amino acids, total sugars and lipid contents. Mineral content is shown to vary according to species, wave exposure, seasonal, annual, environmental and physiological factors and the type of processing and method of mineralization [33, 34, 13].

Manivanna *et al.* [28] reported the mineral composition of green algal seaweeds such as *Ulva lactuca* and *Enteromorpha intestinalis* from Mandapam coastal regions, and they found that the maximum content of mineral composition such as copper, chromium, iron, lead, sulphur, calcium content and potassium. In the present study also *Caulerpa sertularioides* showed the maximum content of mineral compression chromium, copper and magnesium and the lowest level of mineral, content were present in *Ulva lactuca* cobalt, magnesium, manganese, lead and zinc.

In contrast with the earlier investigations, the present study only concentrated on mineral composition and trace metal concentration accordance with species level. Based on the results; minerals are influenced by the varying species level. Furthermore, studies are necessary to evaluate the nutritional value of different seaweed for food ingredients.

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