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Economic Potential of Seaweed Resources in the West Bengal Coast, India

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ABSTRACT

Under the Sustainable Development Goals (SDG) of the United Nations, *the life below water* is recognised as one of the important components. Therefore, proper explorations and documentation of the marine bioresources of any region is essential for its conservation and sustainable utilization. The state of West Bengal is endowed with a coastline of about 220 km in length and lies in east coast in the Bay of Bengal. It also harbours the Sundarban Biosphere Reserves, which is a globally recognized UNESCO site. Seaweeds are the marine macro algae and constitute an integral part of the marine flora, along with micro algae, mangroves, seagrasses etc. Besides its ecological role in the marine food chains, seaweeds are of great economic potential in the form of food, fodder and in industries. Globally, about 11,000 taxa of seaweeds are reported, of which about 221 taxa are recognized as economically important in various forms. In the present study, the coastline of the West Bengal was explored during 2019-2022 and 28 taxa of seaweeds, comprising of 20 Chlorophyceae (71%) and 8 Rhodophyceae (29%) were recorded. Among these, 11 taxa are recognized with economical potential in the form of food, fodder and for industries. The important genera include *Ulva, Chaetomorpha, Cladophora, Gelidium, Gracilaria* and *Catenella*. The present paper deals with the economic potentiality of these seaweeds towards *Blue economy* for posterity and welfare of the mankind.

Keywords: Seaweeds, Economical potential, Coastline, Blue economy, Sundarban

The term '*Seaweed*' refers to the marine macro algae. The word '*Seaweed*' is a misnomer, and should not be considered a *weed at all*, rather it is one of the potential marine living resources in the World. Therefore, it may be alternatively termed as 'Sea-Plant' or 'Sea-vegetable' (Bast, 2014). Taxonomically, it includes the members of classes Rhodophyceae, Phaeophyceae and Chlorophyceae, which are exclusively growing in the marine habitats, usually on rocks, pebbles, molluscs, coastal wastes, epiphytes etc. in the benthic, shallow, intertidal and sub–tidal zones and even in deep waters of sea, up to a depth of 150 m or up to a depth that can receive more than 0.12% of the incident light (Markager and Sand–Jensen, 1992).

Seaweeds are economically one of the most potential marine natural living resources and used by human beings in various forms such as food and fodder as early as 2500 years ago in Chinese literature (Tseng, 2004). Globally, *c.* 7.5 – 8 million tons of wet seaweeds are being produced every year (McHugh, 2003). In India, the research on the *Algology* got momentum only during the end of 19th century by Prof. M.O.P. Iyengar (1886–1966), *the Father of Indian Algology* (Iyengar, 1927). Globally, among the reported 45,000

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taxa of algae (Guiry, 2012), about 11,000 taxa are seaweeds, which is comprising of *c.* 7,200 taxa of Rhodophyceae, *c.* 2,000 taxa of Phaeophyceae and *c.* 1,800 taxa of Chlorophyceae (http://www.seaweed.ie/). Worldwide, about 221 taxa of seaweeds economically important and utilised in various forms by many maritime countries, particularly the south east Asian countries. India, endowed with a coastline of about 7500 km length, harbours *c.* 865 taxa of seaweeds, consisting of 442 taxa of Rhodophyceae, 212 taxa of Chlorophyceae and 211 taxa of Phaeophyceae (Rao and Gupta, 2015).

The state of West Bengal is the only state in India which touches the Himalayas in the north and Sea in the south. It has a coastline of *c.* 220 km in length and lies in the northern part of the East coast of India, in the Bay of Bengal. The coastline touches 3 coastal districts *i.e.* East Midnapore, South 24 Parganas and North 24 Parganas and also harbours the Sundarban Biosphere Reserves, which is a globally recognized UNESCO heritage, RAMSAR site and renowned Mangrove forests (https://rsis.ramsar.org). The pneumatophores, barks, branches of the mangroves in the Sundarban area act as suitable substrata (Fig. 1) for many species of seaweeds (Yadav *et al.* 2020, Yadav and Majumdar, 2020), whereas in the mainland localities like Digha, Udaypur, Mohana, Tajpur, Shankarpur, Mandarmoni, Namkhana, Bokkhali etc, the natural and artificially laid stones, scattered rocks, cement blocks, and various types of coastal wastes act as substrata for the seaweeds (Fig. 2).

The study of literature reveals that though considerable works have been done on the taxonomic aspects of the algal diversity of the West Bengal coast (Naskar and Santra, 1985; Santra and Pal, 1988; Pal *et al.* 1988; Chattopadhyay and Pal, 1995; Pal, 2000; Naskar *et al.* 2000; Mukhopadhyay and Pal, 2002; Sen and Naskar, 2003; Sen *et al.* 2003; Saptati *et al.* 2012, 2013; Sengupta and Pal, 2016; Sinha *et al.*, 2016; Yadav and Majumdar, 2020; Yadav *et al.* 2020). However, the information on the economic aspects of these important seaweed resources are meagre and sporadically explored. Therefore, an attempt has been made here to explore the economic potentiality of seaweed resources in the West Bengal coast.

MATERIALS AND METHODS

The present study is mainly based on the field exploration and study of the relevant literature on the economic aspects of seaweeds. All the relevant literature were scrutinised and the economic potentials of seaweeds in respect to Indian scenario and present study area were analysed.

Survey, collection and study of seaweeds

During the study period (2019-2022), total 23 coastal localities, starting from the Udaypur coast (21° 36′ 59.2′′ N & 87° 28′ 93.1′′ E) in the southern end of West Bengal-Odisha border to various islands in the Sundarban Biosphere Researches (21° 59′ 33.5′′ N & 88° 45′ 24.4′′ E) were explored and fresh seaweed samples were collected and studied (Figs. 1 and 2). Besides, important field observations such as habit, habitats, nature of the field, vegetation pattern, association mangroves, GPS position (GARMIN 12 channel XL) etc. were recorded and photographed using digital camera (Nikon COOLPIX L120). After thoroughly washing, the collected seaweed samples were poisoned in 4% Formalin and 1% Ethyl Alcohol and were preserved in wet and dry forms *i.e.* Herbarium specimens ((Fig. 3) following the standard protocol (Srinivasan, 1969; Dhargalkar and Kavlekar, 2004). Identification of the studies samples were confirmed based on the field observation and following standard references such as (Srinivasan 1969, 1973; Desikachary *et al.* 1990, 1998; Silva *et al.* 1996; Krishnamurthy, 2000; Kraft, 2007; Palanisamy *et al.* 2020, and many recent reference from the study area and other online resources. The freshly collected specimens are deposited at the Central National Herbarium (CAL), Botanical Survey of India, Howrah, India.

RESULTS AND DISCUSSION

Seaweed resources

The present study revealed 28 taxa of seaweeds under 13 genera, 9 families and 8 orders and includes 20 taxa of Chlorophyceae (71%) and 8 taxa of Rhodophyceae (29%). However, no any Phaeophyceae was recorded. The genera recorded are *Ulva, Chaetomorpha, Cladophora, Rhizoclonium, Codium, Gelidium, Gracilaria, Catenella, Ceramium, Bostrychia, Polysiphonia* and *Compsopogon.*

The thorough scrutiny of literature revealed

Table 1: List of seaweeds with economic potential recorded from the West Bengal coast

Sl. No.	Name of the taxa	Distribution	Economic potential	References
CHLOROPHYCEAE (GREEN ALGAE)				
1	*Ulva compressa L.*	Sundarban BR, Digha, Mohana, Tajpur, Mandarmoni, Junput, Shankarpur.	Edible, Fodder, Medicinal (Antioxidant Activity)	Kaliaperumal *et al.* 1995
2	*Ulvaflexuosa Wulfen*	Sundarban BR, Digha, Tajpur, Mohana, Mandarmoni, Junput, Udaypur, Tajpur	Edible, Fodder	Jha *et al.* 2009
3	*Ulva intestinalis L.*	Sundarban BR, Mandarmani.	Edible, Fodder	Jha *et al.* 2009
4	*Ulva lactuca L.* *[Ulva fasciata Delile]*	Sundarban BR	Edible, Fodder, Medicinal (antibacterial)	Sobha *et al.* 2008; Chakraborty *et al.* 2010
5	*Ulva linza L.*	Digha, Mohana, Tajpur, Udaypur, Sundarban BR	Fodder	Jha *et al.* 2009
6	*Ulvaprolifera O.F. Muell.*	Sundarban BR, Udaypur, Digha, Mohana, Dheusagar, Shankarpur, Mandarmani, Tajpur, Gangasagar Island	Edible, Medicinal, Industrial (cosmetics)	Zhao *et al.* 2016
7	*Chaetomorphaaerea (Dillwyn) Kuetz.* *[Chaetomorphacrassa (C. Agardh) Kuetz.]*	Digha, Sundarban BR, Mohana, Tajpur, Mandarmoni, Udaypur, Shankarpur	Medicinal, Paper industry	Jha *et al.* 2009
8	*Cladophora glomerata (L.) Kuetz.*	Sundarban BR Mukherjee & Pal (2018)	Edible, Medicinal Industrial (Bioethanol production)	Munir *et al.* 2019; Surayot *et al.* 2016.
RHODOPHYCEAE (RED ALGAE)				
9	*Gelidium pusillum (Stackh.) Le Jolis*	Sundarban BR (Satpati e*t al.* (2012)	Industrial (Agar)	Kaliaperumal *et al.* 1995
10	*Gracilaria gracilis (Stackh.) Steentoft, L.M. Irvine & Farnham*	Sundarban BR (Canning)	Antioxidant activities, biotechnological, nutraceutical and pharmaceutical applications.	Francavilla *et al.* 2013.
11	*Catenellacaespitosa (With.) L. Irvine* *[Catenellarepens]*	Sundarban BR	Industrial (Carrageenan source)	Jha *et al.* 2009

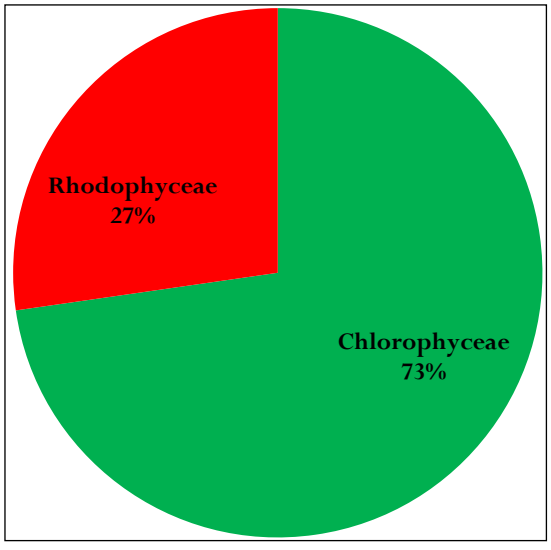
that among the recorded seaweeds, 11 taxa, comprising of 8 green seaweeds (chlorophyceae) and 3 red seaweeds (rhoodphyceae), were found with economic potential in various forms such as food, fodder and in industries (Table 1, Graph 1 & 2). Among these, 6 species like *Ulva compressa* L., *U. flexuosa* Wulfen, *U. intestinalis* L., *U. lactuca* L., *U. prolifera* O.F. Muell. and *Cladophora glomerata* (L.) Kuetz. are recognized as edible seaweeds in various forms like *salads, soups, jellies* and *vinegar dishes*. Likewise, 5 species of seaweeds like *Ulva compressa* L., *U. flexuosa* Wulfen, *U. intestinalis* L., *U. lactuca* L. and *linza* L. are suitable as fodder for animals and poultry farms and used in various parts of the world. Similarly, species like *Ulva compressa* L, *U. lactuca* L., *U. prolifera* O.F. Muell., *Chaetomorpha aerea* (Dillwyn) Kuetz. and *Cladophora glomerata* (L.) Kuetz. are known with pharmaceutical values in the form of antioxidants, nutraceuticals, food supplements etc. Besides, 5 species of green and red seaweeds like *Ulva prolifera* O.F. Muell., *Chaetomorpha aerea* (Dillwyn) Kuetz., *Cladophora glomerata* (L.) Kuetz., *Gelidium pusillum* (Stackh.) Le Jolis and *Catenella caespitosa* (With.) L. Irvine are known with industrial values and used as raw materials for Carrageenan production, Agar-agar production, Bioethanol, paper, textiles, and cosmetic industries.

Fig. 1: Seaweeds in Sundarban Biosphere Reserves: **(1)** Panoramic view of Mangroves vegetation; **(2-3)**. A mangrove stem with dense growth of *Catenella caespitosa* (With.) *L. Irvine* and *C. nipae* Zanardini; **(4-6)**. Luxuriant growth of green and red seaweeds in mangroves forests

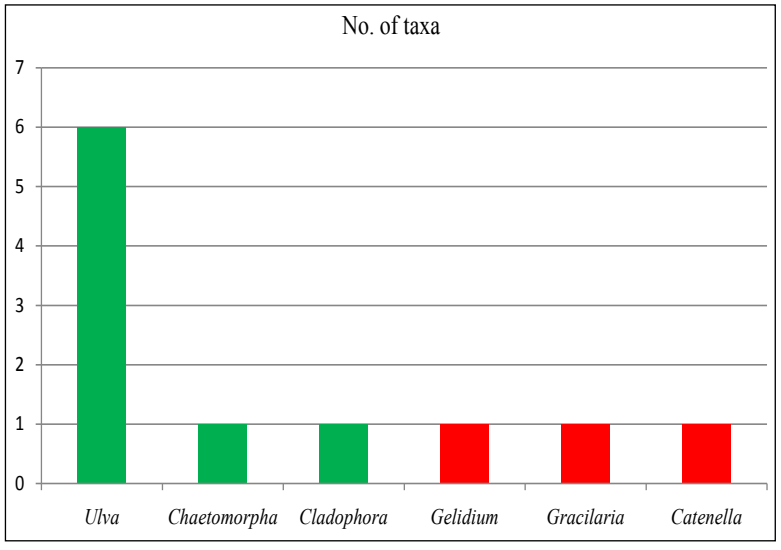
Fig. 2: Seaweeds in various coastal localities: **(1)** Scattered rocks supporting seaweeds at Udaypurcoast (West Bengal – Odisha border); **(2-3)** Panoramic view of seaweeds biomass on artificially laid stones and cement blocks at Digha coast; **(4)** Seaweeds on cemented constructions at Shankarpur coast; **(5)** Coastal waste net supporting seaweeds (young stage) at Mandarmoni; **(6)** *Ulva flexuosa* Wulfen growing on coastal wastes at Mohana coast

Fig. 3: Processing and preservation of seaweeds: **(1)** Collection of seaweed samples; **(2)** Cleaning of collected samples; **(3-4)** Preserved samples (in wet form) and dry form (herbarium specimen)

Fig. 4: (1-2) Rich biomass of seaweeds in Sundarban mangroves, exposed during low tides



Graph 1: Showing percentage diversity of seaweeds with economic potential



Graph 2: Showing number of taxa of green and red seaweeds with economic potential

Discussion

During the present study, it was observed that as unlike the southern maritime states like Tamil Nadu, Kerala, Karnataka, Goa (Palanisamy, 1988; Palanisamy and Yadav, 2018, 2019, Yadav and Palanisamy, 2019, 2021; Palanisamy *et al*. 2020) the diversity of seaweeds in the West Bengal coast is very limited. It is possibly because of the lack of suitable rocky substrata and smaller coastline in the West Bengal coast. However, the study also revealed that there are many economic important species of seaweeds, which were found growing in high biomass at many places in West Bengal in a particular season. During the post monsoon and winter seasons, the species of *Ulva* were found growing abundantly at places like Digha (rocky areas), Shankarpur, Tajpur and in the Sundarban Biosphere Reserves (Amlamethi, Jhorkhali, Dobanki, Canning etc.). Due to the influx of many fresh water bodies in the Bay of Bengal, the diversity and biomass of green seaweeds were more in the mangrove forests of Sundarban Biosphere reserves ((Fig. 4). It was observed that species of *Ulva* such as *U. compressa* L., *U. flexuosa* Wulfen, *U. intestinalis* L., *U. lactuca* L., *U. prolifera* O.F. Muell., *Chaetomorpha* aerea (Dillwyn) Kuetz., *Catenella caespitosa* (With.) L. Irvine, *Catenella nipae* Zanardini etc. were found in more biomass on the pneumatophores, barks, branches of the mangroves in the Sundarban Biosphere Reserves. Similarly, an economically important red seaweed *Gracilaria gracilis* (Stackh.) Steentoft, L.M. Irvine & Farnham (Gracilariaceae) was found in abundant quantity in the stagnant waterbodies in the estuariry region. However, because of the lack of sufficient information on the economic potentiality of these natural living resources, the biomass of these seaweeds remain unutilized and goes in vain. Therefore, these marine resources should be explored well and promoted for cultivation and harvested in sustainable manner by the local communities and fishermen so that it may support as an additional sources of income and boost their economy.

The perusal of literature also reveals that the annual production of the marine algae along the Indian coast has increased from 2,60,876 tonnes (Chennubhotla, 1977, 1992, 1996) to 3,01,646 tonnes (Chennubhotla *et al.* 2011, 2013). Among maritime states, the bulk production of seaweeds comes from Tamil Nadu and Andaman & Nicobar Islands amounting to nearly 60%, while the rest from the coast of Maharashtra, Goa and Kerala. A red seaweed *Kappaphycus alvarezii* is cultivated artificially at large scale by the local communities especially in the Gulf of Mannar region of Tamil Nadu (Chennubhotla *et al.* 2011, 2013; Ganesan *et al.* 2019). Besides, it was reported in a national daily newspaper (Times of India, 25th December 2014) that a group of people can harvest up to 400 kg (150-200 kg in dry wt.) of fresh seaweeds

after 8 hours of diving. The dried seaweeds are sold in market at the rate of ₹ 8 to 25/kg.

Therefore, considering the economic prospectives of the seaweeds, the cultivation, harvesting, quantitative evaluation and marketing of the seaweeds as raw materials from the field to the industries are the areas which need to be focused for the sustainable utilisation, conservation and support the livelihood activities of the coastal communities in the region.

CONCLUSION

Seaweeds are not the '*weeds*', rather they are one of the important living marine natural resources and integral component of the marine biodiversity and life below water. Economically, seaweeds have great potentiality to be utilised in the form of food, fodder and as raw materials in the industries such as pharmaceuticals, biochemical, cosmetics, biofertilizers, papers etc. Globally, about 221 taxa of seaweeds are utilised by many maritime countries, particularly the south east Asian countries. Although, presently the coastline of West Bengal support very limited diversity of seaweeds, however the occurrence of 11 taxa, which are recognized with economical potential, may be promoted for artificial cultivation, harvesting, industrialisation and connected with the blue economy in sustainable manner to boost the additional income, other than fishing for the livelihood of the coastal communities and welfare of the mankind.

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