POLICY
PAPER
22

Seaweed Cultivation and Utilization

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Introduction

The earliest record of use of seaweeds dates back to 2700 BC in the compilation on 'Chinese Herbs' by Emperor Shen Nung. Reports show that seaweeds have been a part of the Japanese diet since 300 BC. Seaweeds are mainly eaten in the Oriental countries like Japan, China, Korea and more recently, in USA and Europe. The Republic of Korea has the highest per capita consumption of seaweeds in the world. After human food consumption, the next most valuable commercial use of seaweeds is as raw material for extraction of phycocolloids (agar, alginate and carrageenan), which are used in several industries. With 20,000 species of seaweeds in the world, India possesses 434 species of red seaweeds, 194 species of brown seaweeds and 216 species of green seaweeds. Traditionally, seaweeds have been collected from natural stocks or wild populations. However, these resources were being depleted by over-harvesting and hence, the need for their cultivation. Today seaweed cultivation techniques are standardised, perfected and made economically favourable. Besides, industry prefers a greater stability through sustained supply of quantity and quality of raw materials. In order to prevent overexploitation of natural seaweed habitats and to meet the needs of industry in an uninterrupted manner, nearly all brown seaweeds, 63 per cent of red seaweeds and 68 per cent of green seaweeds are being cultivated. Top five cultivated seaweeds in the world are *Laminaria, Porphyra, Undaria, Eucheuma* and *Gracilari.* These together account for 5.97 million metric tonnes of seaweed production. Top 10 countries producing seaweeds are China, Korea, Japan, Philippines, Indonesia, Chile, Taiwan, Vietnam, Russia and Italy. The current phycocolloids (seaweed gels) industry stands at over US$ 6.2 billion. The world production of commercial seaweeds has grown by 119 per cent since 1984 and presently, 221 species of seaweeds are utilised commercially including 145 species for food and 110 species for phycocolloid production.

Seaweeds and Their Uses

Macroscopic marine algae, popularly known as seaweeds, form one of the important living resources of the ocean. Agar, carrageenan and alginate are popular examples of seaweeds—these have been used as food for human beings, feed for animals, fertilisers for plants and source of various chemicals. In the recent past, seaweeds have also been gaining momentum as new experimental systems for biological research and integrated aquaculture systems. Seaweed products are used in our daily lives in one or the other way. For example, some seaweed polysaccharides are employed in the manufacture of toothpastes, soaps, shampoos, cosmetics, milk, ice creams, meat, processed food, air fresheners and a host of other items. In several oriental countries like Japan, China, Korea, etc., seaweeds are a staple part of the diet. Some typical examples of seaweed applications are narrated below.

Agar is widely used in paper manufacturing, culture media, packaging material, photography, leather industry, plywood manufacturing, preservation of foodstuffs, dairy industry, cosmetics industry and pharmaceutical industry. Carrageenan is employed in food industry. Its value in the manufacture of sausages, corned beef, meat balls, ham, preparations of poultry and fish, chocolates, dessert gels, ice creams, juice concentrates, marmalade, sardine sauces is well known. It is also used in the manufacturing of non-food items like beer, air freshners, textiles, toothpastes, hair shampoos, sanitary napkins,

tissues, culture media, fungicides, etc. The applications of alginate find place in frozen foods, pastry fillings, syrups, bakery icings, dry mixes, meringues, frozen desserts, instant puddings, cooked puddings, chiffons, pie and pastry fillings, dessert gels, fabricated foods, salad dressings, meat and flavour sauces.

Indian Scenario

Although, India has a coastline of more than 8,000 kms and harbours about 844 species of seaweeds, commercial cultivation is yet to take place in India. R&D efforts over the years have resulted in valuable information regarding biodiversity, ecological conditions suitable for farming, species that could be incorporated in the cultivation, etc.

India is rich in algal biodiversity, has large stretches of suitable areas for cultivation and has communities of traditional fisherfolk. However, Indian seaweed industry suffers from absence of commercial cultivation practices, lack of infrastructure for commercial cultivation and absence of policy support. Since, seaweed is not an important aspect of Indian diet, its cultivation remains a low priority area. Contrary to that, seaweed cultivation presents several opportunities such as carbon sequestration through seaweed farming, provision of nursery grounds for fish and shellfish, medium for pollution abatement and diversified uses as animal feed and fertilisers. Multiple and conflicting uses of coastal areas, grazing by fish and illegal exploitation of seaweeds are some of the threats in the area.

Distribution of seaweed species in India are, Gujarat 202; Maharashtra 152; Goa 75; Karnataka 39; Kerala 20; Lakshadweep 89; Tamil Nadu 302; Andhra Pradesh 78; Orissa 1; West Bengal 6 and Andaman & Nicobar Islands 34. India presently harvests only about 22,000 tonnes of macro-algae annually compared to a potential harvest of 870,000 tonnes, a mere 2.5 per cent. Commercial cultivation of macro-algae has barely begun and is facing continuous regulatory hurdles. Processing of macro-algae is limited to lower grades of agar-agar and alginate and is modest in quantity. Manufacturers of agar-agar are working at less than 50 per cent of their capacity and there is no manufacturer of carrageenans. Instead of being a major global producer and exporter, India remains an importer of macro-algal products. The principal cause for this gap between the potential and the actual results achieved with respect to commercial cultivation and processing of macro-algae is the lack of clearly enunciated policy on cultivation and utilisation of seaweeds.

The National Academy of Agricultural Sciences organised a Round Table on ‘Seaweed Cultivation and Utilisation’ to discuss various aspects of seaweed cultivation and utilisation in India pertaining to their resources and diversity, biomass estimation, sustainable exploitation, commercial cultivation and processing, herbaria and algal cryopreservation, introduction of exotics and problems faced by the industries. About 50 participants representing research institutes, public and private sector undertakings took part in the deliberations. Recommendations emerging out of the discussions are given below.

Recommendations

General

Commercial cultivation and processing of macro marine algae should be a national priority and taken up as a mission mode project. A new nodal cell for promotion of

commercial cultivation, processing and marketing of macro-algae should be set up in the Ministry of Agriculture, similar to Bureau of Aquatic and Fisheries Resources, in Philippines and Indonesia. It will be responsible for coordinating with other concerned ministries and departments, such as Environment and Forests, Ocean Development, Biotechnology, Industry, Commerce, Coast Guard, Port Authorities, Cooperatives, Customs and Excise as well as the state governments. It will resolve issues of overlapping jurisdictions and certain anomalous regulations. The Cell would also formulate detailed policies for the promotion of commercial cultivation, processing and marketing of macro-algae.

Commercial Cultivation and Processing

- The nodal agency shall give clearance for cultivation of specific species of macro-algae as ecologically safe and maintain a list of such species. All indigenous species of macro-algae are considered as ecologically safe for mass cultivation. *Kappaphycus alvarezii* which was introduced to Indian coastal waters more than 10 years ago and has since been domesticated, is considered ecologically safe.

- Recently, natural incidence of *Kappaphycus alvarezii* has also been reported from Andaman islands. Ecological studies have been undertaken regarding the cultivation of the species and no adverse effects to the ecosystem by the species have been reported. Large-scale cultivation of *Kappaphycus alvarezii* can be undertaken in Andaman islands.

- Clearance for use of specific coastal waters shall be obtained from state coastal zone management authorities. In giving the clearances, SCZMAs shall consider the multipurpose utilisation of the coastal areas and the prevalent regulations.

- As long as the method of cultivation of macro-algae does not envisage construction of permanent structures and the cultivation is done below the low-tide mark, CRZ regulations should not be applicable to seaweed farming.

- As the cultivated macro-algae has to be globally competitive in its pricing, the levy for the use of coastal waters shall be similar to that charged by other major global producers of macro-algae, such as Philippines, Indonesia and China.

- Cultivation of macro-algae and the wet and dried macro-algae so produced shall be treated as agricultural cultivation and agricultural produce for the purposes of fiscal levies such as sales tax, income tax, excise, octroi, etc.

- Integrated cultivation of shrimps and seaweeds should be encouraged in aquaculture as seaweeds act as scrubbers in reducing nutrient load and cleaning the environment.

- Seaweed cultivation should be encouraged and undertaken all over the Indian coasts including Chilika Lake, Palk Bay, Andaman islands as well as Lakshadweep islands as seaweed cultivation is ecologically safe and does not damage the marine ecosystems.

- Agar-agar processors have depended solely on naturally occurring beds of *Gracilaria* for supply of raw materials, that have been overexploited. Similarly, processors of alginates depend on naturally occurring sources for their raw materials and no carrageenan industry exists in India. To ensure dependable supply of raw material, high priority should be accorded to cultivation of agarophytes, alginophytes and carrageenophytes.

- Proper scientific methods should be devised and used for harvesting seaweeds so that sustainable utilisation can be done without damaging the ecosystem.

- The anamoly in classification of agar under central excise tariff and customs tariff needs to be corrected.

- In view of the problems encountered in dealing with wastes, proper waste treatment methods should be used by the industries.

R&D Priorities

- Creation of a biodiversity database on seaweeds.

- Taxonomical studies, both classical and molecular, for cataloguing as well as improvement.

- Improvement of strains through biotechnological interventions (tissue culture, genetic transformation by protoplast fusion and hybrid strain production, embryogenesis and regeneration, gene mapping and molecular mapping).

- Standardisation of techniques for large-scale tank cultivation as well as open water cultivation.

- *In situ* conservation of germplasm and establishment of herbaria.

- Periodic resource evaluation and biomass estimation on a national basis.

- Diversified uses of seaweeds as feed, fodder, feed additives, fertilisers, biocides and antimicrobials.

- Refinement of processes of preparation of agar, alginate and quality control.

- Ecological and EIA studies pertaining to introduction of exotic species.

At times it is desirable to import exotic species/strains to improve quality/yield of indigenous strains. Exotic species/strains may also be introduced to widen the range of macro-algae that are cultivated and for the nation to derive economic benefits from the introduction. A specific example is that of high valued species of *Eucheuma* and countries where commercial eucheumatoids have been introduced for cultivation or experimental purpose and where commercial quantities are currently being produced for the carrageenan industry include Fiji, Philippines, USA (Hawaii, California, Florida), Kiribati

(Christmas and Tarawa Islands), Tuvalu, Samoa, Malaysia, French Antilles, Tonga, Japan, Indonesia, Federal States of Micronesia, French Polynesia, Guam, China, Maldives, Solomon Islands, Tanzania, India, Cuba, Vietnam, Brazil, Venezuela, Kenya and Madagascar. However, introduction of exotics should not be done indiscriminately as it carries the risk of pathogen invasion, parasites, epiphytes and undesirable changes in the ecosystem. ICAR has considerable experience with introduction of terrestrial exotics and could lay down a policy for the purpose, including time and duration of testing and certification procedures for the introduction of exotic species of marine macro-algae. Before the species is introduced into open waters, three years of R&D work is recommended in the laboratory and field, to prove the species to be ecologically safe.