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A Review on Potentiality of Marine Algae in Environmental Sustainability

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ABSTRACT

Marine algae are substantial in their natural habitats and even more now in the world of green technology. The essential products extracted from marine algae are highly analyzed areas in impulsive product research. The diverse development in the employment of algae to conquer the environmental complications has stimulated the assurance of achieving the sustainability. The word sustainability represents the comprehensively productive improvements of the environment that encircle an amble compelling and their management. The hasty growth of the population and rapid civilization has led mankind to the exhaustive exploitation of nature and its vibrant resources. However, today humans have realized the catastrophes instigated because of their preceding errors and have already been facing future sustenance challenges. Today, it has turned out to be a challenging task to discover and to develop an eco-friendly, cost-effective and cutting-edge strategies to encounter the current sustainability glitches like, sustainable agriculture solutions, feedstock crisis, pollution, carbon neutrality, industrial effluents and waste water treatment, energy crisis and xenobiotic components that contaminates the natural ecosystem. Marine algae are very good source of bioactive compounds as it is rich in dietary fiber, omega 3 fatty acids, carotenoids, vitamins and minerals. They are effectively crucial due to its extensive spectrum of applications as food,fodder, pisciculture, fertilizer etc. Thus the present review discusses the far ranging opportunities of using marine algae for environmental sustainability.

KEYWORDS: Marine algae, Environmental sustainability, Macroscopic, Green technology, Bioactive compounds

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INTRODUCTION

Plants are predominantly photosynthetic eukaryotes of the kingdom Plantae. Algae are defined as a group of predominantly aquatic, photosynthetic, and nucleus-bearing organisms that lack the true roots, stems, leaves, and specialized multicellular reproductive structures of plants.Marine energy systems have the capacity to be interspersed into and cobuilt with algal developing and harvesting structures. Recent findings have indicated that indigenous marine algae exist with inside the ocean and are broadly unfold in exclusive marine eco systems. Environmental sustainability plans to improve human welfare through the preservation of natural capital (e.g. land, air, water, minerals etc.). Programs are represented environmentallysustainable when they assure that the needs of the population are satisfied without hamming the future generations at risk to meet their needs. Marine macroalgae or seaweeds are plants tailored to the marine surroundings, typically in coastal regions. There are a huge quantity of species across the world, belonging to numerous phylogenic groups. Broadly, 3 forms of seaweeds are differentiated consistent with their pigments e.g. the brown seaweeds (e.g.: *Laminaria, Fucus, Sargassum*), the red seaweeds (e.g. *Gelidium, Palmaria, Porphyra*) and thegreen seaweeds (e.g. *Ulva, Codium*). Microalgae include unicellular plants that may be grownhastily below natural or synthetic light. Cyanobacteria are unicellular organisms that take a seat down on the junction of micro organism and flowers; they may be grown in a way just like different microalgae. Large-scale microalgal operations are none the less below development,favoring boom in raceways or ponds on land.. For seaweed aquaculture, opposition for area with different marine industries, covered conservation regions and different precise land-makes use of should be taken into account. Microalgae may be grown at sea in semiporous containersnearshore, largely to save space on land, reduce the need for supplemental artificial nutrients, and take advantage of natural sunlight for growth (Hoffman *et al.*, 2017). Algae basically harness power through photosynthesis. They seize CO_2 and remodel it into natural biomass which may be transformed to power. Like different biomass sources it's miles theoretically a carbon impartial supply of power .

Algae processing to any type of commodities generates leftovers and waste , thatare typically disposed. Nowadays we should pave way for sustainable bioeconomy and a manufacturing device in which no waste float is created. Algae grown at sea has a aggressive gain over terrestrial-entrenched crops grown for biofuels as it no longer require land, irrigationsystems, introduced nutrients, or fertilizers. Macroalgae grown in farms for human and animalintake are usual across the world, however farms committed to crop manufacturing for biofuels are at the experimental stage. Marine biomass is attracting a amazing deal of industrial and political attentiveness as a feedstock for biofuel production. By changing fossil fuels with marine electricity called as renewable electricity, the biofuels production may bring down thedamage to air and water quality; lessen supply chain and shipping risks; and doubtlessly decrease the operational costs.

The seaweed biorefinery concept presents a conceptual model for high value added product production along with production of biofuels. Biomass is used with maximum efficiency and expenses related to fuel production are reduced. It is important when planning production process and units, to use capable biorefinery concept where all biomass and energyfrom production processes would be used to the fullest extent. Conversion processes (physical,chemical, biological and thermal) used in production of products should work in symbiotic way, individually or in system to create economically sustainable products The various uses of products obtained from algal biorefineries include transport fuels, therapeutics, food additives and biofertilizers (Laurens *et al.*,2017). The commercialization of bio-base compounds on a large scale has been facing many problems in the last decade . Therefore, microalgae can be a potentially better biomass source for bioplastic production since it does not compete with food sources, has the ability to grow on waste resources, and can achieve high lipid accumulation (Senem *et al.*,2020). In addition, bioplastic production from microalgae can be more sustainable and contributes to the circular economy as well as the bioeconomy. Bioplastics can be used in food packaging, pharmaceuticals and cosmetics. (Mohan *et al.*,2019).

Most of the marine algae found in marine environment, these marine algae produce distinctive kind of secondary metabolites. Many of those metabolites have bioactivityand has the capability to be advanced as healing agents. Macroalgae (seaweed) and a few microalgae may be grown at industrial scale offer biofuels, animal feed, and different co- products. Micro and macroalgae have excessive tiers of structural polysaccharides ,concentrations of lignins that may be made into feedstocks for the manufacturing of liquid biofuels. Many algal species comprise natural chemical compounds which are used in lots of commercial and agricultural processes, starting from foodstuff processing to supplementing animal feed.Thus the present study is mainly focussed on the potentiality of marine algae in environmental sustainability.

2. REVIEW OF MARINE ALGAE CONTRIBUTION TO ENVIRONMENTAL SUSTAINABILITY

2.1 .A notion on marine algae biorefinery

Seaweed aquaculture is highly gaining attention in Asian countries. Raw seaweeds andseaweed-based food products in Asian countries have been consumed for centuries.(Newton *et al.*,2016).When developed and implemented in industry ,practical impacts of biorefineryconcept ,can be relevant at different levels:within the seaweed farming and industry ,as employment increase in the sectors of the bioeconomy ,triggering new investments ,unlock incentive and favouring the integration of renewable energy within the overall energy systems (Blumberga *et al.*,2016). Seaweed biorefinery concept is mainly addressed to use particular seaweed species whose overgrowth as result of eutrophication , is causing ecological damagesand affects the sustainability of coastal environments. Instead seaweeds can be used for remediation of environment since together with seaweed biomass certain amount of nitrogen and phosphorous is removed from water ,nevertheless the identification of the thresholds affecting the overall ecosystem service provide by the depletion of a natural resources is a sensitive issue. Seaweed biorefinery concept can have a major impact by showing different aspects for utilizing seaweed to produce a wide range of value -added products ,biofuel and bioenergy concept rather than focusing in a single product.(Karina balina *et al.*,2017) .

2.2 Biofuel and sustainable energy

Microalgal biofuels primary include bio oil and biodiesel which have utility in internal combustion engines in the transportation sector. Triacylglycerols are storage lipids in microalgae that are prime candidates for biofuel production(Johnson Matthey *et al* ., 2017).. Growing microalgae and macroalgae can provide several types of biofuels,including biogas produced by anaerobic degradation of biomass ;biodiesel produced from lipids accumulated in cells of algae ;ethanol;hydrogen from photobiological transformation ;or algae biomass thatmay be used for direct combustion. (Debowski *et al.*,2013).Marine algae biomass can also be used as a feedstock can also be used as a feedstock for energy purpose.They can be transformedin different types of biofuels such as biogas,bioethanaol and biodiesel ,replacing a part of fossilfuels (Laurens *et al.*,2017).

2.3. Bioplastics and its applications

Bioplastics are the form of plastics derived from renewable biological sources such as plants,bacterial and algal sources. Algae have also been used to make bioflocculants and biodegradable polymers(DOE ,2016) They can be degraded by microorganisms present in thesoil such as bacteria and fungi without any release of pollutants. Moreover, the use ofrenewable sources in their manufacturing plays a key role in maintaining the health of the environment. There are many advantages of bioplastics over conventional plastics such as reduced dependence on fossil fuels, non-toxic, easier to recycle, require less energy toproduce,renewable and eco-friendly. The component of seaweeds used in the making of bioplastics is polysaccharides. Some of the polysaccharides of seaweeds are carrageenan, agar,floridean starch and alginate. Quality control of polysaccharides extract begins at the harvest. The seaweed is systematically gathered, quickly dried and then baled to maintain its quality and freshness. At the manufacturing site, the dried seaweed is mechanically ground and sievedto eliminate impurities such as sand and salt which is followed by extensive washing to ensureadditional quality. Seaweeds undergo a hot extraction process to separate the polysaccharides which is a two-step clarification process. First the dissolved polysaccharide mixture is centrifuged to eliminate the dense cellulosic particles, filtered to remove the smaller particles and then, the solution is concentrated (Rajendran, N. *et al.*,2012).The applications of bioplastics are as follows,

Applications of bioplastics

- Packaging industry

The use of bioplastics is popular in packaging sector ,because of their biodegradable property.

- Catering products

Bioplastics has application in disposable crockery, bowls and spoons as catering materials.

- Gardening

In the agricultural economy and the gardening sector mulch foils and flower pots made of biodegradable bioplastics are used, due to their adjustable lifespan and the advantage that theydo not leave residues in the soil.

- Medical products

Bioplastics made of thermoplastic starch (polystarch) absorbs humidity which is applied in theproduction of drug capsules.

- Automobiles

It has been reported that Toyota Company is working on eco car made from seaweed biomasswhich is officially marked as the pioneer of Green automotive movement. The company hopesto replace the oil-based carbon fibre which are now used in many modules with a seaweed based bioplastic.

2.4. Chemicals

Microalgae contain a wealth of organic compounds that are important for the production of certain antibiotics and pharmacologically active compounds like docohexanoic acid (Oilgae,2017).Marine algae ,an important source of bioactive metabolites has a key role in drug development area inside pharmaceutical industry.Production of bioactive compounds by greenalgae is a fortunate thing to pharmaceutical research (Amer *et al.,* 2016).The clinical value hasbeen established for these microalgae due to its application in curing fistula and also certain types of cancer (Temina *et al.*,2007).Green algae are applied as natural anti-fouling agent in the recently developed plants. *Asparagopsis* ,*Laurencia* (red algae),and *Sargassum* (brown algae) act as an important source of antifouling compounds.At present ,one omaezallene and four polyether triterpenoids are reported with anti-macrofouling activity from *Laurencia sp*. and *L.viridis* respectively (Umezawa T *et a*l.,2014).The pigments found in algae (eg., carotenoids phycobillins and chlorophylls) can be used as coloring agents in natural dyes for food,cosmetics and research ,or as pigments for animal feed (DOE ,2016).Alginate can be used in textile printing as a food additive ,in pharmaceuticals and for medicinal purposes;and carrageenan which can be used as food additive ,in pet food and in toothpaste (DOE ,2016).Dainippon Ink and chemical company from Japan extracted a blue phycocyanin from *S.platensis* and sold to the market as a natural blue pigment called " lina blue"which is commercially used in food preparation and cosmetic products.Other applications are confectionaries ,candid ices and sherbets.(Branen *et al.*, 2002).

2.5. Algae in Agriculture and Biotechnology

The naturally existing soil microorganisms can help in maintaining the soil and support in thegrowth of plant.With the biotechnological tool in rice field the nitrogen fixing ability ability of the crop can be enhanced by the presence of cyanobacteria in crop environment and pest resisting cyanobacteia that have the capability of nitrogen fixation in the presence of syntheticnitrogen .Hence ,with the ethical consent ,genetic engineering or mutational studies on these cyanobacteria can be a possible sustainable way to better agriculture. The genetic engineering approach in manipulating the algal genome for the amplification of algal productivity can be defined as transgenic algal biotechnology. Transgenic algal biotechnology can troubleshoot thepresent complications associated with algal utilization and biomass enhancement and productivity complexities etc. The conventional method of algal handling and obtaining the useful productivity from algae is called non transgenic algal biotechnology. (Umar *et al.*,2020)Seaweeds are effectively used as bio-fertilizers because they include high levels of organic matter, which leads to soil nutrient enrichment. In addition, they were found to be a better andmore suitable alternative to chemical and mineral fertilizers when used in adequate quantities.*2.6.Marine Algae as food*

Algal cultivation for human consumption started from more than 370 years ago. Algaculture is a form of aquaculture involving the farming of species of algae. Marine algae or seaweeds aretraditional Asian foods particularly common in Japan and Korea. It is consumed as a snack oras ingredients in dishes or soups. Marine algae have two major bioactive compounds: sulfatedpolysaccharides (SPs) and polyphenol. The major SPs include Fucoidan and Laminaran. The most commonly consumed macroalgae include the red algae *Porphyra* (nori, kim, laver), *Asparagopsis taxiformis* (limu), *Gracilaria*,*Chondrus crispus* (Irish moss) and *Palmaria palmata* (dulse), the kelps *Laminaria* (kombu), *Undaria* (wakame) and *Macrocystis*, and the green algae *Caulerpa racemosa*,*Codium* and *Ulva*.

2.7. Algae as a feedstock

Various algae have been reported for their rich content of protein and is an expensivesupplement for the animal feed (Rezaei *et al.*,2013).Certain microalgae acted immensely not only on the physiological supplementations but have effectively supported the growth and health of the organs in the animals fed by them. According to the earlier and current reports the leftover biomass obtained after biofuel extraction can be used for the purpose of feedstockin the case of chicken ,cow and other animals because of the deflated nature of leftover material

2.8. Algae as a Bioindicator

Water quality can be assessed by the growth of phytoplankton's, which grow on polluted water bodies (Willams,1964). There is a need of effective assessment strategies needs to be designedbecause assessing environment fitness is laborious and time consuming by the virtue of presentmethods Organic pollution of water in reservoirs and large water bodies results in the degradation of water quality that is assessed and evaluated by the use of diatoms . Eco-toxicological studies and toxicity level assessment in case of water bodies and soil may utilizediatoms, algae for effective risk assessment for a sustainable environment.(Prygiel *et al.*,1993).*2.9.Algae for Waste water management*

The presence of the toxic chemicals, metals, organic and inorganic wastes in the effluents posea danger to the aquatic life forms. As well as these effluents become a source of spreading health issues (Abdel-Raouf *et al.*,2012).A typical wastewater is composed of various concentrations of organic pollutants and inorganic components such as calcium, magnesium, sulfur, nitrogen, heavy metals etc., (Lim *et al.*,2010). Macro algal species like *Ulva* and *Monostroma spp*. are effective in reduction of the nitrogen and phosphor content in drainage waste flows from various sources .Algal ability to grow naturally in waste waters of municipalwaste, industrial waste, farm and agriculture waste water itself is a major advantage over wastewater treatment (Umdu *et al.*,2009).

Future scope and capabilities

Rich microbial diversification displayed enormous capacity in satisfying the requirements of humankind. Especially, the Algae have found out their Capabilities in turning into the promising bio potential tools. However there may be an incredible necessity of intented studieswith inside the area of phycology and implemented phycology disciplines to discover the possibilities of the algal resource. Algal network has a remedy for the numerous sustainable Challenges viz. Biofuel Production, bio mining and infected soil remediation, agriculture and natural residues recycling, etc. The present study, efficiently elucidates the multifariouspossibilities of exploring and exploiting algal useful resource for the forthcoming possibilities.

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