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The Inherentpotential of Algaefor Forth coming Future: A Comprehensive Review

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ABSTRACT

Algae are anextensive and varied community of microbes that can take out photosynthesis as they absorb sunlight. Blue-green algae are a well-known source of renewable energy and exhibit an enormous diversity in terms of morphology and metabolism.Algae, mainly marine algae theoretically have the potential as fertilizers. This could result in a lesser amount of nitrogen and phosphorous overflowwhen compared to theutilization of livestock fertilizers. This, successively, raises the quality of water. These organisms are grown all over the world and used as supplements for human nutriment.Algae have a vast perspective as a bioresource for different sectors like biofuels, pharmaceuticals, nutraceuticals, and the food industry. This interesting cluster of organisms also has relevance in cultivation. This can facilitate improved nutrient accessibility, keep up the organic carbon and fertility of the soil, and improving plant development and crop yields. Biofuels have emerged as a safe, nature-friendly, cost-effective alternative to other fuels. Many government agencies and companies are putting efforts for bringing down the capital and operating cost and thus make the production of algal biofuel commercially feasible. This review addresses applications of algae in agriculture, food, and other industries. It is found that further research work is required to optimize algae production and to assess the possibility of more environmentally friendly goods with higher added value.

KEYWORDS: Blue-green algae, Agriculture, Biofuel, Wastewater treatment, Food industry, Medicinal application.

1.INTRODUCTION

Algae are omnipresent and they grow in pretty much every livable environment on earth, in soils, ice, snowfields, underground aquifers, and warm and cold deserts. Biochemically and physiologically, algae are comparable in numerous viewpoints to otherflora(Lee et al.1989). The algae are of various shapes and sizes. The tiny algae are referred to as phytoplankton and perceptible ones as seaweeds (Dhargalkar and Pereira2005). Because of the strange increment in algal biomass, especially that of green kelp, coming about because of the dynamic eutrophication of some coastal ecosystems, the interest in the agricultural use of seaweeds as composts have been increased in the last decades(Morand and Briand 1996).Recent studies have demonstrated that algae have an important role in securing plants against various biotic and abiotic stresses and offer the potential for field application. At present, the growing interest in natural strategies for crop production, as well as the diminishing number of chemical products allowed for use in the fields,is rousing the quest for new bioformulations(Colavita et al.2011).

In general, microalgae are categorizedinto Chlorophyta, Rhodophyta, Phaeophyta, Euglenophyta, Pyrrophyta, and Chrysophyta.The only photosynthetic prokaryotesable to generate oxygen is Cyanobacteria (Singh et al.2015). There are around 30,000 species ofboth unicellular microalgae as well as progressively complex multicellular organisms (Rath et al.2012).

The structural attributes of eukaryotic microalgae and prokaryotic cyanobacteria take after a thallus, i.e. not separated into roots or shoots.The filamentous cyanobacteria are divided into heterocystous and non-heterocystous structures. Most algae play a significant job in sequestrating natural carbon and are liable for half of the whole photosynthesis process on the globe(Moroney and Ynalvez 2009). Besides, current studies have uncovered the possible utilization of green microalgae as organic fertilizer, for upgraded fertility of the soil, plant development, quality ofthe organic product, and nourishing attributes, and grain yield(Coppens et al. 2016). Microalgae, especially cyanobacteria are likewise measured as possible biocontrol operators as they show adversarial impact against several plant pathogens, for example, microscopic organisms, parasites, and nematodes, chiefly as an aftereffect of the creation of hydrolytic chemicals and biocidal mixes, for example, benzoic acid, majusculonic acid, etc (Chandel 2009; Chaudhary et al. 2012; Prasanna et al.2008b; Gupta et al.2013). Microalgae are alluring as fuel sources because numerous species grow relatively fast compared to terrestrial plants and can be developed on brackish or saline water, in this way avoiding the utilization of unsustainable amounts of freshwater (Dismukes et al.2008).Microalgae also have potential applications in the field of the food industry, medical field,wastewater treatment, etc (Jayachitra et al, 2021).

2. APPLICATION OF ALGAE

2.1 In Agriculture:

Presently utilized conventionalfarming management practices intensely depend on the use of chemical composts and pesticides, and practices like rigorous tillage and excess irrigation which or else lead to expanding farming cost, excess abuse of soil and water,make pollution (Kumar et al.2012).

Algae areproven for positive effects on the quality of the soil. Algae improve the fertility of the soil by expanding the general soil activity and improve microbial interactions as they maintain the development of usefulmicroorganisms(Leloup et al.2013; Thomas 2012; Yan-Gui et al.2013).

Cyanobacteria are suitable organic fertilizers for rice-based cropping methods. It'sa significant part of wetland rice ecosystems and serves as the least expensive source of natural biofertilizers(Omar 2000; Ladha and Reddy 2003). For carbon and nitrogen fixation diazotrophic cyanobacteria need daylight as a solitary energy resource.They have the incredible possibility of using as biofertilizers, and their utilization will diminish fuel requirement for fertilizer production The agronomic capability of heterocystous cyanobacteria, both free-living or in a symbiotic relationship with Azolla, has been accepted(El-Zeky et al.2005).

Inoculation of cyanobacteria in soil has been analyzed to support the plants in multiple points of view, for example, improving germination of seeds, growth of plants, grain yield, and nutritional enhancement(Karthikeyan et al.2007; Prasanna et al.2016a; Prasanna et al.2016b).Cyanobacteria have some phosphate solubilizing variety. Phosphorus (P) is the second significant supplement after nitrogen for plant life and microbes. P and N are limiting supplements for most aquatic systems (Silke et al.2007).

While dealing with the algae of Indian rice fields, Gupta et al(2013) noticed that cyanobacteria quickened the germination of seedsand enhanced sprout development. Likewise, they additionally noticed that both the yield and the quality of the grains were enhanced in terms of protein content. The positive effect of the algae on the rice yield may not be limited to their capability to fix atmospheric nitrogen alone; also they have addedadvantageous roles like releasing bioactive matter.It is also clear that the co-inoculation of cyanobacteria with wheat improved root dry mass and chlorophyll content (Obreht etal.1993). In 1995 Gantaret al (1995)noticed that extracellular substances discharged by cyanobacteria that inhabiton roots of wheat plants indicated a noteworthy impact on plant growth. The quick cyanobacterial cell development and simple nutritional necessities primarily water, sunlight,and CO_2give a wide degree to the commercial utilization of cyanobacterial species as plant growth promoters(Ruffing 2011).

Algae are well-knownfor the presence of plant hormones (Tarakhovshaya et al.2007; Khan et al.2009).On the other hand, their concentration is not oftenanalyzed particularly in algal concentrates acquired by supercritical fluid extraction. The supercritical concentrate acquired from Baltic seaweeds consists of plant hormones, for example, phenylacetic corrosive (PAA) from the auxin group and 6-benzyl amino purine (6-BA) from the cytokinin group (Michalak et al.2016). Intheworkof Amin et al. [2009],several phytohormones were found in an aqueous extract of spirulina.

2.2 Biofuel Production

Biofuel refers to any kind of solid, liquid, or gaseous fuels.This can be resultantof renewable resources.Microalgal biomass for the biodiesel makingprocess has been done using either pure or mixed cultures. Autotrophic cultivation can be done in either open or closed systems and heterotrophic growth is kept in fermentors (Singh et al.2011).

Developing microalgae on various sorts of wastewaters like rural run-off, intenseanimal feedstocks, and waste streams have been analyzed over the previous years. The achievement of those investigations intensely relies upon the strains of microalgae. Numerous microalgae strains, for example, Chlorella sp., Scenedesmus sp., Micractinium sp., Actinastrum sp., Heynigia sp., Hindakia sp., Pediastrum sp.,etc have been tried and found to use for evacuating N and P components in the wastewaters (Woertz et al.2009; Wang et al.2010; Oswald et al.1957).For the production of biofuels, collectedlow-priced algal biomass could be used as the best input. There is a vast requirement for more healthystrains of microalgaethat are resistant to particular types of sewage water. Many researchers found that microalgae modified to various culture conditions can grow well than those obtained from algae banks Zhou et al.2012; Li et al.2010).

The steps involved in the biomass processing system are microalgae culturing, collection, dewatering, and drying. For the algal oil conversion process, two methods are generally following. A two-stage technique that is split intothe extraction of oil and oil transesterification and one step, in

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situ transesterification. Three kinds of conversiontechniques exist, chemical, thermochemical, and enzymatic (Maurycy et al.2013).

2.3 Wastewater Treatment

Microalgae are universally perceived for their capacity to expel minerals and heavy metals and thus, collect lipid and starch molecules. The fixation of Carbon, Nitrogen, and Phosphorous (C, N, and P) in sewage water empowers the development of microalgae on a higher amountsince they need 358, 63, and 9 mg L-1 for delivering 1kg of algal biomass (Kong et al.2010). Algae can cultivate in sewage water by using nitrate and phosphate as supplements (Shobana et al.2017).

Cyanobacteria and microalgae are additionally useful in the deprivation of oil and oil mixes (Abed 2010; Abed and Koster 2005). Abed and Koster (2005) assessed five cyanobacteria- Aphanothece halophyletica, Dactyolococcopsis salina, Halothece sp., Oscillatoria sp., and Synechocystis sp. fit for degradation of n-alkane.This study indicated that the deprivation was associatedwith petroleum degrading aerobic microbes(Abed 2010; Abed and Koster 2005).

Green microalga Scenedesmus sp. gave maximal algal biomass with 106 cells mL-1 with half market sewage water (98.54 mg L-1 day-1) and high expulsion of total nitrogen (TN), phosphorous (TP), and total organic carbon (TOC) at 85, 90, and 65 % correspondingly(Apandi et al.2018).

Treatment of wastewater using microalgae not just decreases the contamination rate in the sewage but also considerably builds the biomass grouping of microalgae. This is significant to the research did by Ammar et al. (2018) where effluent treatment and biomass development by Nannochloropsis oculata and Isochrysis galbana in oilfield produced water (PW) were analyzed.

2.4 InFood Industry

Algae have been used as food for many years in diverse cultures (Wells et al., 2017). Archeological records in Chile show utilization of algae dating to 14,000 years back, This is marked as the most seasoned known utilization of algae (Dillehay et al., 2008). They can essentially fulfill the requirement for protein, particularly from the viewpoint of a rising populace.Microalgae protein (MP) can sometimes be superior to the present overwhelming protein sources, particularly in light of the fact that they need low land requirement for cultivation.

Because of the gelling and thickening properties, the foodstuffs like agar, alginates, and carrageenans are considered the most significant items which can be obtained from algae. In past years, noteworthy development has been seen in areas of algae research. Progress in variousareassuch as protoplast fusion, macroalgal cell cultures, transgenic algae are also notable (Bhattacharjee 2016). Alginate, a brown alga derivative is utilized in the textile business for sizing cotton yarn.It also has significance in the food industry because of its gelling nature. Alginate is well known for its chelating property and capacity to make anextremelythick solution. This makes it a goodnominee for food and drug industries(Ververis et al.2007).

Seaweeds are utilized in human and animal nutrition.Customers are captivated towards particular variety, for example, *Porphyra* sp., *Chondrus crispus, Himanthalia elongate,* and *Undaria pinnatifida,* and towards the food industry as a result of their low calory content and high nutrients content, minerals and dietary fiber (Plaza et al.2008). Algal biomass is available as a powder, tablets,

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fluids, etc. it can be fused into various food items and the most significant algal varities in human nutrition are Spirulina and Chlorella sp. Consumable algae are the main source of dietary fiber, minerals, and proteins (Kuda et al.2002).

Group/species	**Extract**	**Use/application**
Aphanizomenon flos-aquae	Protein, essential fatty acids, β-carotene	Health foods, food supplements
Arthrospira maxima	Omega 3 PUFAs	Health foods
Arthrospira platensis	Protein, fiber, mineral content.	Health foods
Chlorella spp.	Biomass, carbohydrate extract.	Animal nutrition, health drinks, food supplement
Crypthecodinium cohnii	DHA	Infant health and nutrition
Diacronema vikianum	Omega 3 PUFAs	Health foods
Dunaliella sp.	Protein content	Health foods
Haematococcus pluvialis	Carotenoids, astaxanthin	Health food, food supplement, feeds
Himanthalia elongate	PUFAs, a-Tocoferol, Sterols, Soluble fibres.	Health food, food supplement
Isochrysis galbana	Omega 3 PUFAs	Health foods
Schizochytrium sp.	DHA and EPA	Food, beverage, and food supplement
Ulva spp	Sterols	Health foods

Table 1: Microalgae species suitable for food products (Arkadiusz and Joanna, 2020)

2.5 Medicinal Applications

One of the microalgae focused compound is a bioactive compound with anticancer activities. About 1000 extracts of various cyanobacteria sp. were screened out for antineoplastic property.Poteriochromonas malhamensis has demonstrated inhibition of protein tyrosine kinase activity because of the existence of a novel chlorosulfolipid compound. Many cyanobacteria are promising producers of bioactive compounds.These can destroy cancer cells by the apoptosis process, affecting cell signalingby inducing protein kinase C family signaling enzymes. Preliminary studies have shown that certain antioxidants like β-Carotene, may be beneficial in the treatment of precancerous conditions (Boopathy and Kathiresan 2010).

Specific extracts from 600 Cyanobacteria cultures were analyzed for cellular inhibition of infection such as HIV-1 and HSV-2.But this shows only a 10 percent rate of success. Patterson et al., (1993)isolated a new cyanobacterial compound called cyanovirin-N,which is an effective virucidal agent against HIV. Cyanovirin-N can block the contact of viral glycoprotein gp120 with CD4 (Dev et al.2000). Rinehart et al. (1981) stated the antiviral activity of 5% Cyanobacteria extracts against

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Herpes simplex virus type II. Under 5% of the extract has proven for activity in opposition to Respiratory syncytial virus (Patterson et al.1991).

The microalgal cell has antibacterial activity both against gram-positive and gram-negative bacteria.There are also antifungal occurrences in green algae, diatoms, and dinoflagellates. Microalgal toxins obtained from blue-green algae, Ochromonas sp., and Prymnesium parvum are applied in pharmaceutical sector(Katircioglu et al.2006; Borowitzka et al.1988). Various strains of Cyanobacteria generate intra and extracellular metabolites. These strains were alsoproven for antifungal, antialgal, antiviral,and antibacterial properties.Antimicrobial agent creation is influenced by several factors like incubation temperature, pH of culture medium, incubation period, light intensity, and medium composition (Noaman et al.2004).

3.CONCLUSION

The widely used metaphoric concept of algal biomass is an "untapped resource" that suggests that natural products and related benefits to the economy and human well-being will flow until the correct valve is found and opened. Genetic and metabolic modifications of Cyanobacteria play significant roles in enhancing the economy of Cyanobacteria-mediated bio-fuel production in the future.This review highlighted the use of a variety of algae in limitless sectors or applications such as bioenergy, wastewater treatment,medical sector, food industry, and agriculture.

The effect of blue-green algae has been studied in paddy fields under flooded surroundings, which are perfect for the development of blue-green algae, but their impact on dry crops such as wheat, maize, etc needstoexplore and will additionally improve their use in agriculture.Since algal biomass is a significant tool for developing environmentally responsible approaches to cultivation in addition to constituting the basis of food webs. There is a high need to raise attentiveness and encourage in-depth research work to expand their applications inthe coming years.

The latest advances in the use of consortia or biofilms of green algae and cyanobacteria as biofertilizers have been proved to be promising. The use of algae for the development of biofuels provides many advantages compared with higher plants, i.e., least land for farming, fast growth rate, high productivity of lipids, and biomass. Furthermore, the full use of algae would create zero waste. Algae is an all-rounder in the medical, farming, and bioremediation sectors.The rich algal variety needs to be harnessed for various futile applications.In summary, algae are gifted sources of biofuels, high-value molecules, nutraceuticals, and a variety of bioactive metabolites for exploring out novel drugs in terms of their market applicability.

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