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The Potential Significance of Algae in Agriculture Field

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Abstract:- As a vast and varied collection of microbes, algae are capable of photosynthesis, which allows them to convert energy from sunlight into chemical compounds. The agricultural sector relies heavily on algae due to their usefulness as biofertilizers and soil stabilizers. The use of algae, especially seaweeds, as fertilizers leads to a decrease in nitrogen and phosphorus discharge compared to that produced by animal dung. The water that eventually makes its way into rivers and seas is therefore of higher quality. As dietary supplements for humans, these creatures are farmed all over the globe. They need very little water to grow, and they may be cultivated on desert and abandoned land, producing food that is both clean and carbon neutral. Iodine is abundant in seaweeds. The dietary intake of the milking cow determines the milk's iodine content. If you want more iodine in your milk, feed your cows seaweed. Incorporating algae into chicken feed speeds up the egg-laying process. This article provided a concise overview of algae and its agricultural applications, covering the essentials for anyone involved in this field.

Keywords:- *Algae, Agriculture, Biofertilizer, Soil Stabilizers.*

I. INTRODUCTION

Algae are an incredibly diversified group of creatures that consist of several plant-like forms. Sizes of algae may vary greatly, from single cells measuring less than a millimeter to enormous seaweeds reaching lengths of more than fifty meters. There are a lot of protozoa-integrating unicellular forms, and a lot of them are motile. In addition to soils, permanent ice, snow fields, hot springs, and both hot and cold deserts, algae may be found practically everywhere on Earth. When compared to other plants, algae have many similarities in their biochemistry and physiology. They are all related to one another biochemically; they all contain chlorophyll-a, and they all have carbs, proteins, and products that are similar to higher plants.[1] Additionally, aquatic food webs are largely dependent on algae because of their status as the principal manufacturers of organic substances. In addition to providing the primary fuel for these food webs, they also provide the oxygen that the creatures that eat them need to function metabolically. The primary goal of this piece is to reaffirm the idea that dry and semi-arid environments rely on algae. The distribution and condition of these organisms may also provide clues about the state of the ecosystem. Furthermore, since algae control the water flow into soils, their presence also reduces erosion. Soil fertility, soil reclamation, bio-controlling agricultural pests, microbiological crust development, treatment of agricultural wastewater, and recycling treated water are all areas where they work similarly [2]. Agrarian practices are fundamental to human civilisation. The soil's fertility is a major factor in agricultural success or failure. Algae, which inhabit a variety of soil types, may, like other species, contribute to the soil's improvement of properties including carbon content, texture, aeration, and nitrogen fixation [3]. The soil's physical and chemical properties impact the makeup of the algal population, which in turn determines the amount of these improvements.[4]

Fertilizers made from marine algae are applied to fields that are near the water. One kind of marine algae is the big brown and red algae, which are organic fertilizers. These algae are often higher in potassium content but lower in nitrogen and phosphorus. Whether it's a solid fertilizer or a liquid one the weed is often applied directly and worked into the soil. Seaweeds are most often used as liquid fertilizers in farming [5]. The high concentration of trace elements and growth regulating chemicals, especially cytokinins, in liquid fertilizers is the major reason for their beneficial impact. Soil acidity may be decreased in the UK and France with the help of calcareous red algae called maerl. Most people don't know how economically significant and diversely used algae are, especially marine algae. Food, medicine, textiles, paper, and paint are just a few of their many uses. Chemical extracts from bigger marine algae, like alginic acid, carrageenan, or agar, are utilized in food manufacturing. Diatomaceous earth, which is made up of deposits of diatom frustules, is used extensively as a material for filtration and polishing. Additionally, algae may be used for wastewater treatment and are significant surface-binding agents that decrease erosion. The prokaryotes associated with cyanobacteria are quite varied. Similar to algae and higher plants, they all engage in oxygenic photosynthesis.[6]. Because they use water and sunlight as fuel, they produce oxygen when exposed to light. Carbon dioxide reduction typically makes use of the energy and reductants produced by photosynthesis. These microscopic organisms are found all over the world and help plants thrive in their shared environments. This is because they do three things: 1) increase soil fertility in many ecosystems, 2) create a wide variety of substances with biological activity, and 3) biosorb heavy metals more efficiently.

II. METHODOLOGY AND DISCUSSION

A. Identification and Assay of Nitrogen Fixation Method:

Many methods are used for estimating nitrogen in the soil and water samples

- *Kjeldahl Method:*

This is most commonly used method for routine analysis and no require no special equipment. The Basic Principle is to convert the nitrogen in the sample to ammonium by digestion with concentrated sulphuric acid and to estimate the nitrogen by alkaline distillation. A full discussion of the procedure details can be found in Hesse’s Text book of Soil Chemical Analysis.

- *Enhancing Soil Fertility*

Although oxygen created from photosynthetic activity in the same cell is deleterious to nitrogen fixation, certain cyanobacteria are able to convert ambient nitrogen to ammonia. Nitrogen fixation and oxygen evolution may occur at separate times in many unicellular and filamentous, non-heterocyst strains, whereas filamentous cyanobacteria use spatial separation and cellular differentiation into nitrogen fixing heterocysts as a strategy to avoid oxygen.[7].The terminally differentiated cells known as hemocysts undergo anaerobic cellular respiration, which permits the oxygen-sensitive nitrogen fixation process to persist. Extensive research on the heterocyst system's control of dinitrogen fixation has been conducted(Fig.1).

For diazotrophic cyanobacteria to fix carbon and nitrogen, sunlight is their only energy source. Thus, their usage will reduce the fuel need for fertilizer production, and they have significant potential as biofertilizers. It has long been recognized that heterocystous cyanobacteria, whether they live independently or form symbiotic associations with water ferns, have agronomic promise.[8]. As a result, biofertilizers made from paddy soils containing the right kinds of cyanobacteria were developed and used on a smaller scale in rice fields.

Fig 1 Enhancing Soil Fertility Cyanophyceae Algae

Cyanobacteria are highly compatible biofertilizers for rice-based cropping systems. They are the primary constituents of wetland rice ecosystems, which are readily accessible and serve as the most cost-effective sources of natural biofertilizers [9].While the integration of genes into rice plants through tissue culture and contemporary genetic techniques continues to be a challenging research objective, the utilization of cyanobacterial diazotrophic technology in rice cultivation presents a viable and potentially sustainable substitute for synthetic nitrogen fertilizers, particularly in developing nations and globally. Nevertheless, a notable limitation of this technique lies in the extensive use of various harmful agrochemicals, particularly herbicides. These substances are often identified as inhibitors of cyanobacterial diazotrophic development and, in some instances, as mutagenic agents. Hence, the achievement of effective biotechnology necessitates the careful choice of appropriate diazotrophic strains as biofertilizers capable of withstanding the high concentrations of herbicides seen in the field [10].

- *The Nitrogen Fixation*

Many agricultural soils rely on algae, particularly cyanobacteria, as their primary nitrogen-fixing agent. Numerous researchers have examined their significance as nitrogen fixers in rice fields. Although most nitrogen-fixing cyanobacteria are likely hetero-cystous, there are certain non-heterocystous species that are capable of fixing nitrogen [11].Plants at a higher level are able to reabsorb the nitrogen that the algae fixed. The nitrogen-fixing capabilities of cyanobacterial species are well-documented, and their use in enhancing soil fertility for environmentally responsible rice farming is widely acknowledged. Despite the great potential of cyanobacteria as a biofertilizer for rice fields, its application is now restricted owing to regional variations in inoculum quality, quantity, and physiological characteristics. The efficiency with which rice plants use fixed nitrogen is generally low, so researchers are trying to find cyanobacteria strains that are good at fixing nitrogen from the air and also excreting it continuously, so that the growing rice plants can use it.

As an alternative to N-rich fertilizers, cyanobacteria are used extensively in Asian rice fields to improve soil fertility via biological nitrogen fixation, also known as algalization. However, their usefulness extends beyond this. Researchers found that inoculating rice fields with the cyano-bacterium Tolypothrix tenuis at a rate of around 250 g dry mass ha-1 increased yields by 19.5% compared to a dressing of 25 kg ha-1 of ammonium sulfate, which increased yields by 16.6%. Quickly multiplying water fern Azolla in Japan includes the symbiotic blue-green algae Anabaena, which fixes gaseous N2, and thereby fertilizes rice fields[12,13]

- *The Origin of Organic Matter*

Algae play a significant role as a source of organic matter in soil. The decomposition of algae may result in the incorporation of organic matter into the soil. Mucilage, which functions as a binding agent, enhances the soil texture, leading to an increase in humus content. This, in turn, improves the suitability of the soil for other plants over time [14]. The significance of filamentous forms of the Cyanophyceae, particularly Oscillatoria, Schizothrix, and Plectonema, in soil formation was seen in the U.S.S.R. The primary contributions of algae to the soil are the assimilation of organic carbon via photosynthesis and the fixing of organic nitrogen through nitrogen fixation. Additionally, they function as a storage facility for inorganic nutrients.

- *Fodder for Milk Cattle and Hens*

Livestock and hens can be fed algae. One significant source of iodine is seaweed. The diet given to the cow that produced the milk affects the amount of iodine in the milk. Seaweeds can be fed to milk cows to raise the iodine content of the milk. Algae feed additives also boost hens' egg-laying rates.

- *Plant Growth Accelerators*

In their study on the algae found in Indian rice fields, that cyanobacteria had a significant role in expediting seed germination and facilitating the development of seedlings. Furthermore, it was noted that there was an improvement in both the production and quality of the grains in terms of protein content. It is very probable that the advantageous impact of algae on rice cultivation extends beyond their ability to only fix atmospheric nitrogen. These algae may also possess other useful functions, such as the release of bioactive compounds. Microbial organisms employ various mechanisms to promote plant growth, such as biofertilization, which involves augmenting the availability of essential mineral nutrients to the plant. Additionally, microbes employ biological control strategies to eliminate plant enemies, including microbial pathogens, insects, and weeds. Furthermore, microbes facilitate direct plant growth by delivering plant growth hormones, as documented by[15].the use of cyanobacteria in biofertilization methods is suggested as a means to enhance the rate of seed germination and improve various growth characteristics in several plant species.

Despite being the predominant microbial photosynthetic agents of the soil, the ecological importance of microalgae and cyanobacteria remains incompletely elucidated. Nevertheless, it is evident that some desirable features and positive impacts of these substances have an impact on plant and soil systems. Soil microalgae have two significant potential applications in agricultural production: as biofertilizers and as soil conditioners. Lately, there has been a growing fascination in their antibacterial and PGR compounds. The impact of diverse extracellular compounds produced by algae, such as cyanobacteria, is significant in aquatic environments [16]. Additionally, these molecules have a crucial role in promoting the development and germination of higher plants. Due to the release of a significant proportion of bioactive chemicals from their nitrogen assimilation outside their cells, cyanobacteria algae have been suggested as a viable biofertilizer [17].The nitrogenase and nitrate reductase activities of cyanobacteria have been previously linked to the influence of plant surface, as well as the presence of amino acids and peptides in algal filtrate and other substances that promote the development of agricultural plants.

Microalgae are a varied collection of microorganisms that may be easily formed and cultured in large quantities. Microalgae, which include cyanobacteria and other eukaryotic groups, exhibit a diverse range of chemicals that possess biological activity. In addition, cyanobacteria possess the capability to release hormones that promote plant growth, such as auxins [18], cytokinin-like substances, gibberellins or gibberellic-like substances , antibiotics, algicides, toxins, organic acids, and pharmaceutically active compounds. [19] have successfully isolated a gibberellin-like compound from the cyanobacterium Phormidium foveolarum, which has shown activity in GA-bioassays. In addition, the chromatographic analysis of a compound secreted by Nostoc muscorum, which was isolated from paddy fields in Argentina, showed that it had auxinic activity and shares comparable features with indole acetic acid.The presence of growth-promoting chemicals was observed via the impact of N. muscorum extracts on the growth of Panicum miliaceum seedlings. All the extracts resulted in an increase in both the height and dry weight of millet plants. There is a lack of information on the incorporation of cyanobacterial biomass or their compounds into plants other than rice [20]

Microalgae are a genetically heterogeneous collection of microorganisms that may be effectively cultivated and cultivated on a large scale. In addition to cyanobacteria and other eukaryotic groups, microalgae exhibit a diverse range of chemicals that possess biological activity. The aforementioned substances include nitrogenous compounds amino acids, vitamin B12, and biotin [21]. In addition, cyanobacteria possess the capability to release plant growth hormones such as auxins, cytokinin-like substances , gibberellins or gibberellic-like substances, antibiotics, algicides, toxins, organic acids and pharmaceutically active compounds [22]. The researchers [23] successfully extracted a compound like gibberellin from the cyanobacterium Phormidium foveolarum. This material has shown activity in GA-bioassays. Furthermore, the process of chromatography was used to identify a molecule that was secreted by Nostoc muscorum, which was isolated from paddy fields in Argentina. This material was shown to have auxinic activity and had comparable properties to indole acetic acid. The impact of N. muscorum extracts on Panicum miliaceum seedlings revealed the presence of growth-promoting chemical extracts tested resulted in an increase in both the height and dry weight of millet plants. The available literature on the incorporation of cyanobacterial biomass or their components into plants other than rice is limited [24].

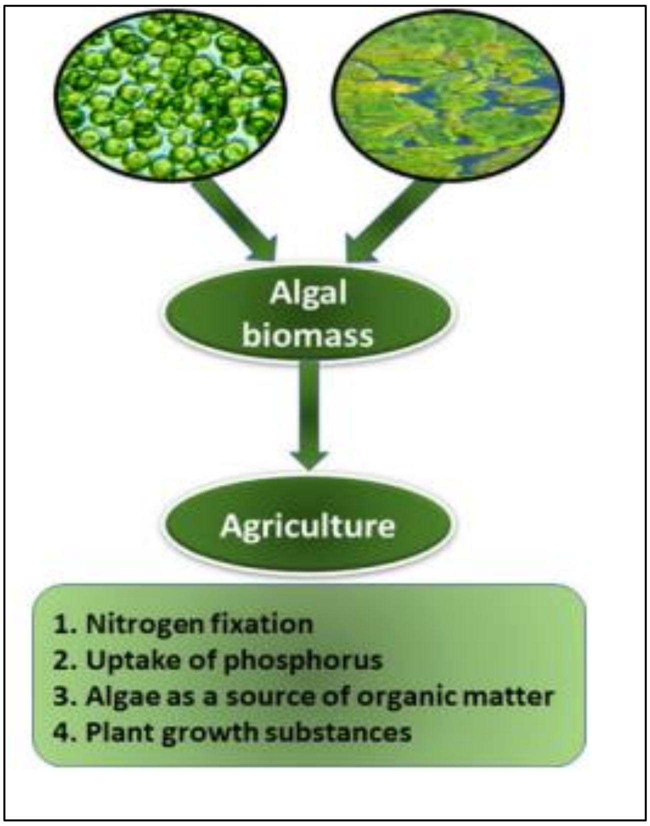

Fig 2 Representation of Algal Biomass

B. *Biocontrol of Phytopathogens*

- *The use of Chemical Insecticides*

The soil is a complex system characterized by the existence of a balanced state of equilibrium among its physical, chemical, and biological components. The use of pesticides without taking into account the other components of the soil disrupts this balance, leading to a negative impact on soil production. The preservation of soil biota, in addition to the control of detrimental pests, contributes to enhanced crop nutrient management and the preservation of soil health. Insecticides often demonstrate inhibitory or stimulatory properties on the development or other physiological processes of microorganisms, whether in controlled laboratory settings or in natural field environments. A limited number of studies were conducted to examine and summarize the distributions, kinds, toxicity, mechanisms of action, degradations, tolerance of pesticides by organisms, and other physiological processes[25] . The primary microorganisms that enhance soil fertility are blue-green algae, particularly the nitrogen-fixing cyanobacteria. The aforementioned organisms have a significant impact on this system as they provide a consistent supply of fixed nitrogen and perform other advantageous functions, as previously mentioned .The majority of soil and aquatic microscopic algae are susceptible to pesticides because they are involved in photosynthesis, which is disrupted by several insecticides. Insecticides, fungicides, and carrionicides derived from a wide variety of synthetic and chemical sources have been in use for quite some time [26].Dispersal patterns of animals in their native habitats are altered by these chemicals. Furthermore, other harmful compounds accumulate in crops due to the inappropriate and risky use of these pesticides, which may be an even more significant indirect contributor to human illnesses.

- *The Exopolysaccharide*

In order to promote microbial development, which in turn improves soil structure and exoenzyme activity, cyanobacteria create extracellular polymers with a wide range of chemical compositions. One such polymer is exopolysaccharide. The precise composition of this perishable organic material remains incompletely understood, however a significant proportion of it may consist of microbial bio[27]. The stability of soil aggregates is influenced by the reduction of organic matter. The introduction of organic materials into soil facilitates the proliferation of microorganisms and enhances enzymatic activity inside the soil. Certain species of cyanobacteria secrete a substance known as slime or mucilage, which disperses throughout the organism and, to a certain degree, dissolves in the culture medium or soil solution. One potential strategy for enhancing nutrient composition and soil structure involves the introduction of cyanobacteria. Reclaiming marginal soils, including saline-alkaline and calcareous soils, is another promising use of algae biofertilizers [28].

Soil aggregation is increased mostly by microorganism exopolysaccharide or by exopolysaccharide supplied to soil after cell death and lysis; N. muscorum may enhance the aggregate stability of salty soil. As an organic matter source and an enzyme producer, cyanobacteria may infiltrate soil with their acid and alkaline extracellular phosphatases, which are either active in solution or found in the periplasmatic region of the cell wall. Incorporating biomass and exopolysaccharides into soil helps other microbes flourish and boosts the activity of soil enzymes that help plants get the nutrients they need[29].

- *Heavy Metal Treatment*

Cyanobacteria are only one of several microbes that may concentrate metal ions found in their natural habitat. There are three parts to the process by which cyanobacteria and microalgae are able to withstand heavy metals: 1) external causes; 2) cellular defence mechanisms that are not species specific; and 3) defence mechanisms that are species specific and evolved in reaction to hazardous metal species. In cyanobacteria, mucilaginous sheaths serve as a "external vacuole" and, in addition to internal protective systems, ion exchange in the outside cell wall is the primary mechanism for biosorption of heavy metals. The capsular polymer likely has its metal-binding characteristics from its high concentration of anionic charges, particularly carboxyl. When grown in a contaminated environment or using dried non-living biomass, this microbial community may be able to remove heavy metals more effectively by biosorption. Also, some of them can fix nitrogen in the air. A more cost-effective way to produce biomass for use as inoculum in environmental remediation operations is to use certain diazotrophic cyanobacteria that accumulate heavy metals.[30] Lead polluted soils and water sources may be remediated by using M. tenera.

➢ *Treatment of Agricultural Wastewater*

The contamination of agricultural water drains is a result of human activities, which may occur due to either elevated levels of naturally occurring chemicals or the introduction of non-natural manufactured compounds (xenobiotics) into the ecosystem. Domestic, agricultural, and industrial activities discharge organic compounds into the environment, resulting in inorganic pollution [31]. Several instances persist where municipal and rural home wastewater is immediately released into rivers, often without undergoing any kind of treatment. The annual increase in these discharges may be attributed to the implementation of water supply networks in several communities as part of the current strategy. Moreover, the current proliferation of water networks in several municipalities, without concurrent implementation of new sewage systems or restoration of the preexisting ones, exacerbates the issues and contributes to water body contamination and heightened public health risks. [32] the components of residential and urban input to water resources include pathogens, nutrients, suspended particles, salts, and oxygen-demanding compounds.

The contaminated rivers, lakes, and oceans were visually unappealing to humans and posed a significant public health danger. They served as reservoirs for human infections and heightened the likelihood of transmitting illnesses associated to excrement via water. To mitigate such issues, the design of sewage treatment systems was undertaken. Throughout the majority of human history, agriculture has served as a significant means of biological water treatment by using the possible contaminants present in human and animal waste to facilitate the development of plants. Municipal sewage, once treated, is sometimes used as a fertiliser supply for land that is inhabited by natural vegetation or other crops[33]. These waste materials remain significant in global agriculture, particularly in regions where commercial fertilisers are not easily accessible.(Fig.3)

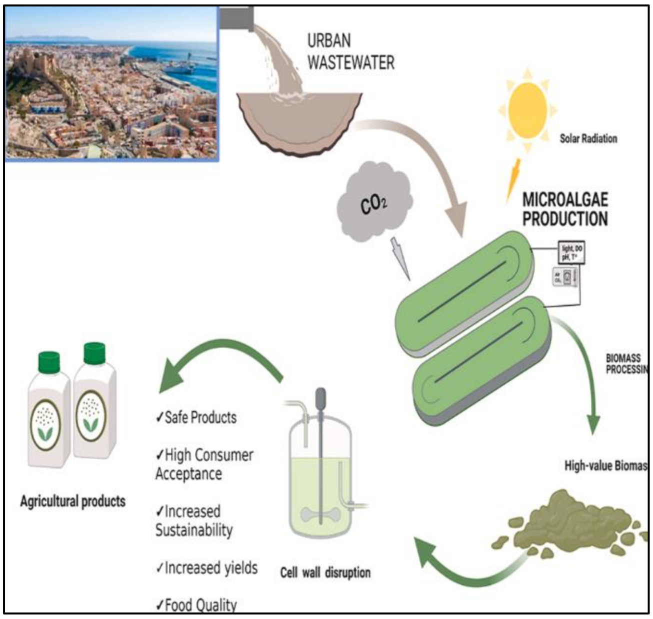

Fig 3 Algae Treatment in Agriculture & Urban Wastewater

Various strains of algae, including Chlorella and Dunaliella, have been mass-produced and used for wastewater treatment for the last 55 years or more in industrial settings. Some industrialised countries, like Mexico, Australia, the United States, Thailand, and Taiwan, are now showing a lot of interest [34].Factoring into the development and management of high-rate algal cultures for the production of valuable goods like pharmaceuticals and genetically modified items is the expertise of biologists in these countries regarding the ecology and biology of large-scale algal cultures, as well as the engineering of such systems and methods of algal harvesting. Many additional physiologically useful compounds fall under this category as well, including those with antibacterial, antiviral, antitumor, anti-cancer, antihistamine, and antihyperlipidemic properties. According to [35] many industrial and agricultural wastewaters have nitrogen and phosphorus concentrations that are up to three orders of magnitude more than those found in natural water bodies. The implementation of primary and secondary treatment methods has become more prevalent in various locations. These techniques aim to remove readily settling substances (primary treatment) and oxidise the organic matter found in wastewater. The ultimate outcome is a transparent and seemingly uncontaminated effluent that is released into natural aquatic environments. However, this secondary effluent contains high levels of inorganic nitrogen and phosphorus, leading to eutrophication and long-term issues due to the release of persistent organic compounds and heavy metals. An all-encompassing wastewater treatment technique designed to eliminate ammonia, nitrate, and phosphate from various sources. Microalgal cultures present a viable approach to tertiary and quinary treatments owing to their utilisation of inorganic nitrogen and phosphorus for growth. Additionally, microalgae possess the capability to effectively eliminate heavy metals [36] and certain toxic organic compounds. Consequently, it does not result in the occurrence of secondary contamination. One of the advantageous attributes of these organisms is their ability to generate oxygen and exhibit a disinfecting impact as a result of the elevation in pH during the process of photosynthesis.

III. CONCLUSION

In this study, we looked at the connection between crop plants and algae in an effort to shed light on the many ways in which algae benefit agriculture. Ecosystems in dry and semi-dry regions rely on algae. Additionally, their dispersion can be a sign of environmental well-being. Many people have been thinking about the idea of using algae as biological conditioners instead of artificial or chemical conditioners recently. This would be because algae not only improve the properties of soil and plants, but they also reduce the pollution that comes from using them. On every continent, you may find some kind of algae, the most common of which being microalgae and cyanobacteria. Their ecological function is still up for debate, despite the fact that they are the soil's principal microbial photosynthetic agents. Soil fertility and reclamation are two areas where algae, and microalgae in particular, play an important role, and this research highlights a few ways in which these organisms benefit the plant-soil system: (1) The excretion of organic acids that improve P-availability and P-uptake (2) Nitrogen supplied by biological nitrogen fixation, (3) Soil organic matter increased, and (4) Bioactive extracellular chemicals produced and released that may affect plant development and growth. Vitamins, amino acids, polypeptides, antibacterial or antifungal compounds that perform phytopathogen biocontrol, and polymers, particularly exopolysaccharides, that enhance soil structure and exoenzyme activity are among these purported substances.Soil aggregation stabilisation via extracellular polysaccharides (5), crust formation (6), and environmental metal ion concentration (7). In addition, the assessment reaffirmed algae's function in wastewater treatment and agricultural recycling. The goal of a comprehensive wastewater treatment procedure is to eliminate ammonia, nitrate, phosphate, and some heavy metals.

- *Compliance with Ethical Standards:*

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- *Disclosure of Conflict of Interest*
  The authors declare no conflict of interest

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