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Biodiversity of Microalgae With Emphasis on Practical Importance — A Review

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Abstract: Microalgae are a very diverse and important group of microscopic aquatic plants that have wide applications in biotechnology today. These microscopic photosynthesizers, which play an effective role in the production of oxygen on the planet, due to their high distribution and abundance, are found in almost all waters on earth and even exist in terrestrial ecosystems. These organisms have attracted the attention of many researchers in recent years to create bioactive compounds and products with high added value and have been widely used in various industries. Therefore, it is very necessary to discover and better understand the biodiversity and ecophysiological characteristics of microalgae to increase their use for practical purposes. This article aims to review the biodiversity of marine microalgae and to express their importance in various fields. The literature that was reviewed for clarifying the issue and writing this article, was conducted using Google Scholar, PubMed, Scopus and Research Gate. The results of this study state that microalgae have anti-viral, anti-cancer, anti-HIV, antioxidant, anti-inflammatory and anti-microbial activities. Due to their unique abilities, they have many applications in various industries such as feed (nutritional additives for livestock and aquatic animals and the production of food supplements for humans), fertilizers, medicine, and cosmetics. Also, biological treatment of wastewater, removal of heavy elements from the environment, moderation of global warming, production of biofuels and environmental measurement of pollutants are their environmental applications.

Key words: microalgae, biodiversity, bioactive compounds, marine environment

1. Introduction

Biodiversity is the variety of different forms of life on earth, including the different plants, animals, and micro-organisms, the genes they contain and the ecosystem they form. It refers to genetic variation, ecosystem variation, species variation (number of species) within an area, biome or planet [1]. The biological and chemical diversity of the marine environment helps provide almost unlimited sources of new bioactive compounds [2]. Marine species comprise almost half of the world's biodiversity [3]. Marine organisms as a rich source of functional substances such as polyunsaturated fatty acids (PUFA), collagen, gelatin, polysaccharides, minerals, vitamins, antioxidants, enzymes and bioactive peptides that they act as valuable food-medicinal, medicinal and cosmetic potential [4]. Microalgae are a very diverse and important group of microscopic aquatic plants that play an effective role in oxygen production on Earth. Due to their high distribution and abundance, these plants are found in almost all waters and even exist in terrestrial ecosystems [5]. These organisms have attracted the attention of many researchers in recent years to create bioactive compounds and products with high added value and have been widely used in various industries. [6]. Therefore, it is very necessary to discover and better understand the biodiversity and ecophysiological characteristics of microalgae to increase their use for scientific purposes. This research aims to review the biodiversity of marine microalgae and to express their importance in various fields.

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2. Materials and Methods

The literature we reviewed for clarifying the issue and writing this article, was conducted using: Firstly, the Google Scholar search engine, one of the most common applicable databases that indexes published articles and books on numerous scientific fields and helps researchers of approximately all majors to search for their essential sources. Moreover, we applied the Semantic Scholar research tool which is used to find various scientific publications and manuscripts and makes it easy to understand their goals in very fast way. Scopus was the next valid database for completing the review literature of the current paper.

We also used PubMed, a well-known search engine, that focuses particularly on life sciences and has been active for 25 years. Furthermore, we took a look at the Europe PubMed Central literature database. Finally, the Research Gate network was our last database to look up the papers and extract the required data and it is said to be the largest academic social network for all researchers.

The whole time that we have spent reviewing the scientific sources and researching our subject is 3 months and the papers that we explored, were written between the years 1990 and 2022 so far. In addition, the following key terms helped us to perform an appropriate search for the papers: Algae, Microalgae, Biodiversity, Bioactive Compounds, and Marine Environment.

3. Algae

Algae and seaweed are valuable sources of bioactive compounds with diverse structures [7]. Algae are divided into two main groups: macroalgae and microalgae [8-9]. In other words, seaweeds are divided into two types microalgae, such as diatoms, dinoflagellates, and cyanophyta, and macroalgae, such as green, brown, or red algae, based on their shape. Microalgae are a microscopic photosynthetic group consisting of eukaryotic organisms and prokaryotic cyanobacteria [10]. Algae are plant species that, unlike higher plants, do not have structures such as roots, stems, and leaves, and are eukaryotic in terms of cell structure, and in terms of size diversity, they Include a wide range from picoplankton dimensions to species with sizes of more than 10 meters in kelp forests. According to estimates, about 10 million species of algae have been identified to date, most of which are in the group of microalgae with microscopic dimensions [11].

4. Microalgae

Microalgae are autotrophic organisms that use light to synthesize high-value bioactive compounds such as polysaccharides, carbohydrates, proteins, and lipids [12]. It should be noted that although microalgae have a wide biological diversity, they are almost unused resources. The number of species of microalgae is estimated to be around 200,000 to 800,000 species, and so far 50,000 of them have been fully identified. They play a vital role on Earth and constitute the world's largest biomass, responsible for at least 32% of the world’s photosynthesis [13].

Marine microalgae have attracted attention due to their abundance, relatively cheap process, and rich source of proteins and peptides with biological functions. The main functions of these active proteins with physiological functions include diazotrophic, antitumor, antioxidant and immune system stimulating activities [14-15].

5. Habitat of Life

Microalgae have remarkable flexibility and adaptability to environmental stresses and can grow in a wide range of habitats with high levels of biodiversity [16]. Due to the fast growth rate and the ability to survive in harsh environments, today microalgae are used in various industrial areas. The process of obtaining microalgae-based biomolecules begins with the selection of a suitable microalgae strain, and cultivation, followed by downstream processing of the biomass (e.g., pretreatment, harvesting, extraction, and

purification). The final products of the processes are biofuels and other valuable biological products [17]. One of the most important features of microalgae is that they are plankton and epiphytes and are present in the deep sea. Microalgae live in different sub-habitats [18], such as benthic microalgae found in sedimentary habitats, epiphytic microalgae are attached to substrates such as mangrove roots seaweed [19] and planktonic microalgae found in the water column. Deep-sea microalgae, called microphytobenthos, are microscopic and capable of photosynthesis in sediments. This type of microalgae can grow in low light levels using a high concentration of nutrients in the sediment. These microalgae are widely distributed in nature, are adapted to different environments, and have high diversity in terms of size, morphology, life cycle, pigmentation, and metabolism [20]. In fact, microalgae can live in different habitats with high levels of biodiversity. Microalgae habitats have different environmental conditions in different regions.

6. Life Requirements

Environmental parameters such as physical, chemical and biological parameters significantly affect the living conditions of microalgae [21]. Microalgae need three main components to grow, including sunlight, water and carbon sources [22]. They obtain nutrients from aquatic habitats, absorb sunlight, absorb CO_2 from the air, and produce about 50% of atmospheric oxygen [23]. These creatures have an efficient biological system that can use sunlight to produce organic compounds [24]. Furthermore, they have commercial importance, which shows their unique features. A wide variety of microalgae species with different biochemical and physiological characteristics have been identified.

7. Applications of Microalgae

The potential of microalgae as an alternative energy source has been sufficiently studied. However, the exclusive use of microalgae as energy raw materials cannot guarantee their scalability and economic sustainability due to the high cost of biomass processing. Participatory processing of microalgal biomass with other related biorefinery applications can offset their cost and improve their sustainability. Also, they have unique abilities to use them for industrial and environmental purposes. The use of microalgae as animal and aquatic feed, fertilizer, medicine, cosmetic, environmental and other biotechnological applications has been thoroughly investigated [25].

8. Application in the Food Industry

One of the most important challenges facing humanity today is feeding the growing human population with limited natural resources. With the establishment of microalgae as a new food and feed platform, there is an opportunity to increase the supply of these essential products to meet the global nutritional demand in a more efficient and environmentally friendly way. Many types of algae are complete foods nutritionally, their performance is better than most plant-based products. The development of high-performance and more nutritious and sustainable food would be of great benefit to the planet, and algae represent an opportunity for new product development [26]. For instance; Microalgae *Chlorella vulgaris*, *Haematococcus pluvialis*, *Dunaliella salina* and *Spirulina maxima* are currently widely used in the world to produce food supplements for humans and as nutritional additives to animal feed [27-28]. These plants are a rich source of proteins and peptides with biological functions, which have been of great interest due to their abundance and relatively cheap production process.

Microalgae not only play an important role in human nutrition, but they are very suitable food sources for aquaculture industries and feeding farmed aquatics. Microalgae can be used as live food in feeding oysters (oysters, clams and mussels) as well as sea cucumbers and Sea urchins. Also, they are used for raising fish fry and increasing the biomass of zooplankton in breeding

centres [29]. On the other hand, microalgae such as *Spirulina sp.* and *Chlorella sp.* are used as natural food supplements to provide active compounds needed by humans as well as feed and grow domestic animals and aquatic animals [30-31]. In addition, microalgae are imported to market as human nutrition in the form of tablets, capsules and liquids. Similarly, they are also added to snack foods, candies or gums, pasta and beverages [32-33].

9. Medicinal Application

Studies have shown that marine microorganisms have a high potential in the production of natural medicinal compounds [34]. Recently, studies have focused on new medicinal bioactive substances from algae, especially those with anti-viral properties that may be useful for protection against COVID-19 [35]. In general, microalgae have anti-viral, anti-cancer, anti-HIV, antioxidant, anti-inflammatory and antimicrobial activities [36-37].

The research results have shown the extract of the microalgae species *Spirulina platensis* with significant antimicrobial and antioxidant activities seems to be a successful candidate for safe and reliable medical applications [38]. Also, it has been found that high doses of spirulina may support duodenal growth and intestinal health [39]. Some algae are considered a source of antibiotics and prevent the growth of other bacteria, for example, we can mention the antibiotic chlorellin, which is found in *Chlorella* algae [40]. Also, in one study, Dawczynski et al. (2018) investigated clinical parameters in patients with rheumatoid arthritis fed microalgae oil from *Schizochytrium sp*. containing 2.1 g DHA per day. The results showed that DHA microalgae oil supplements can improve the condition of patients with rheumatoid arthritis [41]. It has also been proven that microalgae are capable of reducing oxidative damage by inhibiting free radicals and reducing active oxygen, thus preventing the formation of cancer cells [42].

10. Biofuel

It is increasingly clear that biofuels can be a viable source of renewable energy in contrast to the finite nature, geopolitical instability, and deleterious global effects of fossil fuel energy [43]. The results of studies have shown that the microalgae *Chlorella sp.* Considering the cell density, dry cell weight, fat content, lipid yield and fatty acid composition in environmental conditions, it is a very suitable raw material for the production of biodiesel (biofuels) and other high-value products [44-45]. Also, *Dunaliella tertiolecta* microalgae can be a source of clean fuel [46]. On the other hand, the cultivation of microalgae to produce biofuel itself causes the production of oxygen, therefore, today, the use of biofuels is considered the best alternative to fossil energies [47].

11. Biological Treatment of Wastewater

Microalgae have become essential for biological wastewater treatment. The ability of microalgae in the biological treatment of wastewater of different origins shows great potential as a sustainable and economic wastewater treatment method. Microalgae from wastewater have also been recognized in research as an important source of bioproducts and biomaterials with added value [48]. It has been stated that the use of small and green microalgae species such as *Euglena*, *Chlamydomonas* and *Chlorella* in the outlet channel of large and shallow sewage tanks (sewage oxidation) is the fastest and cheapest method for wastewater treatment. These microalgae act as a catalyst and effectively convert rotten and dangerous materials into valuable and odourless fertilizers. The growth of these algae is also important as a purifying agent in sewage channels. To carry out their metabolic activities, microalgae consume these materials such as nitrates and phosphates and release oxygen by carrying out the process of photosynthesis, and the released oxygen helps aerobic bacteria to be active in the decomposition of raw materials of sewage. Industrial and municipal wastewaters contain many organic and inorganic

compounds that are dissolved and suspended in them. [49].

Heavy metals such as arsenic (As), cadmium (Cd), chromium (Cr), lead (Pb) and mercury (Hg) are carcinogenic and show toxicity even in small amounts and are a threat to environmental ecology and human health. Due to several advantages including high availability, cheapness, excellent metal removal efficiency and environmentally friendly nature, there is an emerging and growing trend in using microalgae in phytoremediation (Biorefinery) of heavy metals. This review presents recent advances and mechanisms involved in the removal and bio-absorption of these toxic heavy metals using microalgae [50]. In this regard, reports on the effectiveness of Spirulina and Chlorella species in removing heavy elements from the environment have been published so far [51-52].

12. Modulation of Global Warming

With the increasing threat of global warming to the planet Earth, efforts to reduce carbon emissions in the atmosphere have become inevitable. Carbon emission reductions can be achieved through carbon capture and substitution technologies. In this regard, microalgae and ammonia (NH3) are known as options for carbon absorption and carbon replacement, respectively [48].

13. Pollution Index

Microalgae are regularly used for the environmental assessment of pollutants. For example, *Pseudokirchneriella subcapitata*, *Dunaliella tertiolecta*, *Isochrysis galbana* and *Chlorella sp.* are known microalgae for this purpose [53-54].

14. Conclusion

Nowadays, biodiversity has gained a lot of importance in the research of scientists. The sea environment is a very important and numerous source of renewable compounds that can play a very important role in identifying bioactive compounds. Marine microalgae are autotrophic organisms that can live in different habitats with high biodiversity due to their rapid growth and adaptation to harsh environments, and a wide range of them have been identified with different biochemical and physiological characteristics. The results of this study state that microalgae have anti-viral, anti-cancer, anti-HIV, antioxidant, anti-inflammatory and anti-microbial activities. Due to their unique abilities, they have many applications in various industries such as feed (nutritional additives for livestock and aquatic animals and the production of food supplements for humans), fertilizers, medicine, and cosmetics. Also, biological treatment of wastewater, removal of heavy elements from the environment, modulation of global warming, production of biofuels and environmental measurement of pollutants are their environmental applications.

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