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Role of Microalgal Biotechnology in Environmental Sustainability-A Mini Review

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Sustainability is a main rule in environmental resource management, and it included operational productivity, minimization of natural effect and socio-economic contemplations; which are all related. Many research projects have been conducted on finding alternative of energy from renewable sources and utilization of waste materials. Based on the previous studies one of the most environmentally friendly and sustainable methods for biofuel sources is using microalgae for the production of lipids and wastewater as its nutrient source. Microalgae are maintainable sources of biomass for fuel, food, and feed likewise as contaminant elimination from wastewater. Light, CO_2, and inorganic nutrients like nitrogen and phosphorous are vital for microalgae growth. The aim of this study is thus to introduce an optimum conditions of microalgae cultivation for nutrient removal from wastewater which may impact the bioenergy production like biodiesel production. Utilizing wastewater is a common method to reduce environmental impacts, recycle water and nutrients, and decrease the volume of wastewater being transported and treated. Therefore, developing microalgae production systems would help reduce greenhouse gas emissions by capturing CO_2 and producing an alternative for fossil fuels would be valuable and sustainable.

1. Introduction

Microalgae are prokaryotic or eukaryotic photosynthetic microorganisms that can develop quickly and live in brutal conditions (Mata et al., 2009). Ecologists have classified microalgae in a diversity of classes, primarily eminent by their pigmentation, life cycle and fundamental cellular structure (Khan et al., 2009). Microalgae are one among the foremost photosynthetic living groups beside plants and bacteria. They are usually found in freshwater and marine with the size extending from a couple of micrometers to a couple of many micrometers (McHugh, 2003). The most frequently used microalgae are Cyanophyceae (blue-green microalgae), Chlorophyceae (green microalgae), Bacillariophyceae (including the diatoms) and Chrysophyceae (including golden microalgae). All cells require wellsprings of carbon and energy for growth. Chemoorganotrophs, chemolithotrophs, and phototrophs utilize natural chemicals, inorganic chemicals, or light, as their wellspring of energy. Autotrophs utilize CO_2 as their carbon source, while heterotrophs utilize natural compounds. Numerous microalgae species could change from phototrophic to heterotrophic growth. As heterotrophs, the green microalgae growth depends on glucose or other utilizable carbon sources for carbon digestion and energy. Limited microalgae can also grow mixotrophically (Xu et al., 2006). Microalgae are available in all current earth biological systems, not only aquatic but also terrestrial, instead of a major assortment of groups living in an extensive variety of ecological conditions, such as lakes, rivers, ponds, wetlands, deserts and even living in the north and south poles (Barsanti and Gualtieri, 2006). It is assumed that above 50,000 species living, nevertheless only a few number, of around 30,000 have been investigated and

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examined (Khan et al., 2009). Like plants, microalgae require basically three parts to develop: daylight, carbon-dioxide and water. Photosynthesis is an imperative bio-compound process in which plants, microalgae, and a few microorganisms change over the vitality of daylight to synthetic energy. Among other, microalgae consist of lipids and unsaturated fats as membrane segments, stockpiling items, metabolites and wellsprings of energy (Barsanti and Gualtieri, 2006).

Microalgae have been the focus and interest of researchers, government, and industries because of; (i) their growth rate and simple structure; (ii) cellular components such as proteins, carbohydrate and lipids which can be utilized for biotechnological applications like creating biofuel, product of pharmaceutical, nutritional, and cosmetic value; and (iii) The shift toward the development of green processes. Microalgae have been generally utilized for different applications such as biofuels, animal feed, food supplements, cosmetics, pharmaceuticals, nutraceuticals, CO_2 capture and etc. Microalgae are a promising source of biofuel production such as bioethanol, biodiesel, biogases, biohydrogen and syngas (Nesamma et al., 2015). Biofuels have attracted increasing attention because of the sustainable production and environment-friendly approach.

Plentiful wastewater release from industries in tropical regions being a precious resource of biodiesel need appropriate investigation (Kamyab et al., 2016). In addition, microalgae are additionally utilized as a part of wastewater treatment for toxin and supplement expulsion. Microalgae may be used to rectify wastewater for concurrently biomass production and nutrient removal, thus suggestively dropping the costs of microalgal feedstock. There is significant attention in coupling biological waste treatments to bioenergy production. One method uses a microalgae-based technique to treat wastewater and then uses the harvested microalgal biomass to generate biofuels (Salma et al., 2017). Microalgae construct wastewater treatment depends with respect to the capacity of phototrophic microorganisms to sparging oxygen to vigorous natural toxin degraders and upgrade the evacuation of supplements and pathogens. It is commonly recognized that microalgae assume an imperative regulation in self-sanitization of in self-purification of organic waters, and hence offer an elective means as a tertiary treatment of natural wastewater (Venkatesan et al., 2015).

Microalgae were previously considered in the treatment of several wastewaters (domestic and industrial), including palm oil mill effluent (POME) (Kamyab et al.,2016), municipal wastewater (Pittman et al., 2011), dairy manure wastewater (Wang et al., 2010), artificial wastewater (Aslan and Kapdan, 2006) . Even though findings by previous researchers indicate the ideal growth of microalgae, the extant literature does not provide the prime condition for cultivating microalgae; consequently, still there is a lack of knowledge on wastewater treatment and bioenergy production through microalgae cultivation.

The objective of this study is to introduce an optimum conditions of microalgae cultivation for nutrient removal from wastewater which may impact the bioenergy production like biodiesel production. The robustness of microalgae allows them to thrive even in harsh conditions and has verified to be a benefit in the treatment of these wastewaters. Although removal of nutrients and contaminants by microalgae types has been investigated since 1953 by Oswald et al. (1953), microalgae cultivation in wastewater still faces several barriers. In this review, a description of several microalgae cultivation which effect on microalgae growth for wastewater treatment approaches was carried out. This review aims to assess the present literature on microalgae sustainability with regards to concurrent microalgae cultivation and wastewater treatment.

2. Culture parameters

2.1 Temperature

Most of the microalgae are able to survive at a temperature range between 16 to 27 °C. *Chlorella sorokiniana* had an upper growth restrain at 38 to 42 °C (Oswald,1953). For a multi specific microalgal biomass, as studied by (Golueke et al.,1957), the rate of microalgae biodegradability from 5 to 10 % can be enhanced by a temperature increase from 35 to 50 °C. However, greatest methane productivity at 40 °C was found by (Chen et al.,1957) confirms most mesophilic temperatures recorded to be ideal conditions.

2.2 Nitrogen concentration

Nitrogen restrictive situations were in fact described to expressively rise the lipid fraction of several microalgae (Illman et al., 2000). Nitrogen is vital for peptides, proteins, enzymes, chlorophylls, ATP, DNA and other cellular constituent's synthesis. The increment of lipid fraction in both species due to the decrease of the concentration of nitrate in the growth medium, although of a nearly steady growth rate, consequently doubling the efficiency of the oil (Converti et al., 2009).

2.3 Light intensity

The limiting factor for microalgal growth is light intensity. Consequently, a suitable light intensity for microalgal cultivation needs about 1/10 of quantity of light from direct sunlight. This photosynthetic microorganism produces microalgal biomass by utilizing the sunlight, water and carbon dioxide. 25 % consumption of the biomass produced during daylight might be consumed during the night to sustain the cells until sunrise (Chisti, 2007). Some microalgae are fit for heterotrophic development on monosaccharide or natural acids. This method of development offers the likelihood of extraordinarily enhancing the profitability of microalgal culture using fed batch and high cell density strategies, which cannot be connected to photosynthetic frameworks.

2.4 pH

Acid or basic condition is the suitable pH for microalgal growth. Carbon dioxide consumption may lead to the increasing of pH in the medium. Therefore, CO_2 sparging maintains the pH of the medium (Barsanti and Gualtieri, 2006). Culture pH was not affecting *Chlorella sorokiniana* when the ratio was higher than pH 4.0, and the growth ratio was prevented tremendously at pH 3.0 (Morita et al., 2001).

2.5 Culture parameters

The most critical parameters controlling algal growth by methods for photosynthesis are ecological condition, for example, light power, pH, temperature, turbulence, saltiness (Barsanti and Gualtieri, 2006) and supplements (Kayombo et al., 2003). The range ideal condition and additionally the toleratable scope of working conditions are species particular and different components might be associated (Barsanti and Gualtieri, 2006).

2.6 Nutrients

Production of microalgae needs high concentrations of vital ingredients (C,P,N,K,S,Fe, etc.). The main focus is on the three most significant nutrients, i.e. carbon, nitrogen and phosphorus; Supplements are normally taken up in the inorganic shape, however a few natural types of them are additionally assimilable. A few supplements are not show any restraint impact on microalgal development, while others, for example, NO_2 or NH_3 have inconvenient impacts when exhibit in high focuses. Supplements in the vaporous frame, for example, NO and CO_2 face a noteworthy impediment that is connected basically to their mass exchange from the vaporous to the fluid state (Markou et al., 2014).

2.7 Carbon sources

According to the mode of cell growth (heterotrophic, autotrophic, or mixotrophic), microalgae can utilize organic and/or inorganic carbon sources for cell growth (Feng et al., 2011). From the perspective of microalgae cultivation, the most common organic carbon sources for heterotrophic and mixotrophic cultivation of microalgae are glucose, sucrose, lactase, lactose, acetate, glycerol, ethanol (Liang et al., 2009) and other sugars derived from starch, sugar cane, lignocellulosic biomass, and other sugar sources (Perez-Garcia et al., 2011).

2.8 Phosphorus

Phosphorus is alternative component that has huge pertinence to the cell development and metabolism of microalgae. It is one of the basic components containing RNA, DNA, ATP and cell layer materials, and so on. It is significant that, as a constituent component of ATP, phosphorus is fundamental to the cell forms identified with vitality exchange (e.g., photophosphorylation). On another pertinent idea, photosynthesis requires a lot of proteins and the proteins are orchestrated by phosphorus-rich ribosomes (Ågren, 2004). Phosphorus containing ATP/ADP are fundamental for photophosphorylation. As a result, confinement of development by phosphate starvation may sever affect different parts of microalgal digestion, including lipid and photosynthesis aggregation. Phosphorus is specially absorbed as inorganic phosphates as H_2PO_4 - and HPO_4^{2-}(Martinez et al., 1999).

3. Culture of microalgae

The growth qualities and arrangement of microalgae are known to essentially rely upon the cultivation conditions (Chen et al., 1996). There are four noteworthy sorts of development conditions for microalgae: heterotrophic, photoautotrophic, mixotrophic and photoheterotrophic cultivation. Every sort of advancement is examined about in detail in the going with sub-sections. Microalgae, however developed under pressure conditions, for example, supplement starvation, high saltiness, high temperature and so forth aggregate extensive sums (up to 60– 65 % of dry weight) of lipids or sugars alongside a few auxiliary metabolites (Chen et al., 1996).

3.1 Microalgae versus wastewater

Numerous types of microalgae can viably exist in wastewater conditions through their capacity to use copious natural carbon and inorganic N and P in the wastewater (Kamyab et al., 2015). Furthermore, the utilization of microalgae in the wastewater manufacture is still genuinely constrained. Microalgae growth are utilized all through the world for wastewater treatment but on a generally minor scale (Kamyab et al., 2017a). This is either using regular oxidation (adjustment) ponds or the more created suspended microalgal lake frameworks, for example, high-rate microalgal lakes which are shallow raceway-type oxidation ponds with mechanical blending and have been observed to be exceedingly successful for treatment of wastewater (Kamyab et al., 2017b). A noteworthy necessity of wastewater treatment is the need to expel high convergences of supplements specifically P and N, which generally can prompt dangers of eutrophication if these supplements aggregate in river and ponds (Pittman et al., 2011). Microalgae are proficient in evacuating P, N and poisonous metals from wastewater (Kamyab et al., 2018a) and in this manner can possibly assume a critical remediation part especially during the last (tertiary) treatment period of wastewater (Pittman et al., 2011). The noteworthy preferred standpoint of algal procedures in treatment of wastewater over the regular substance-based treatment strategies is the potential cost sparing and the lower level innovation (Mallick, 2002).

3.2 Microalgae growth in municipal and agricultural wastewater

Contrasted with municipal local agricultural wastewater, sewage-based wastewater, which is frequently resulted from compost, containing of N and P high (Pittman et al., 2011). Despite these high supplement fixations, previous scholar investigated that effective development of microalgae on rural waste, and additionally municipal wastewater, microalgae are proficient at expelling P and N from manure-based wastewater (Pittman et al., 2011). Investigations of microalgal-intervened supplement recuperation from dairy manure have surveyed the capability of benthic freshwater green growth (microalgae) instead of planktonic (suspended) microalgae growth because of the potential higher supplement take up rates in a few types of benthic microalgae (Wang et al., 2010). These species incorporate *Microspora willeana*, *Ulothrix sp*. also, *Rhizoclonium hierglyphicum*. Using a semi- continuous cultivation technique where the benthic microalgal growth was developed in reusing wastewater with new fertilizer included day by day, microalgal cultivation rates and supplement take up were observed to be high and identical to values from microalgae growth cultivation on municipal wastewater with fertilizer outcome (Kamyab et al., 2017b).

3.3 Microalgae growth in artificial wastewater

A few investigations have analysed microalgae cultivation and supplement expulsion characteristics utilizing artificial wastewater (Aslan and Kapdan, 2006). Usage of a simulated medium has advantages, for example, usability for starting research facility-based examinations. It additionally takes into account a streamlined examination of the significant segments in a wastewater medium without one expecting to consider obscure factors, for example, biotic parts. Most manufactured wastewater media are made out of inorganic constituents including high concentrations of particular supplements and will lack solid natural material and other potential poisons. Hence, there might be a few disadvantages in utilizing manufactured wastewater to survey conditions in actual wastewater. Real examinations of municipal wastewater with artificial wastewater have discovered that albeit supplement expulsion rates are comparable, microalgae growth rates are higher in simulated wastewater (Ruiz-Marin et al., 2010). This is likely because of expanded poisonous quality of the actual wastewaters, inhibitory or aggressive impacts of indigenous microorganisms and protozoa, and by the distinctive synthetic organization of the wastewaters (Pittman et al., 2011).

3.4 Microalgae growth in industrial wastewater

There is critical enthusiasm for the utilization of microalgae for remediation of mechanical determined wastewaters, principally for the evacuation of substantial metal contaminations (cadmium, chromium, zinc, etc.) and natural compound poisons (biocides, hydrocarbons, and surfactants), instead of P and N. Because of for the most part low P and N focus and high poison fixations, algal development rates are bring down in numerous modern wastewaters. Therefore, there is less potential for using modern wastewaters for expansive scale age of microalgae biomass (Pittman et al., 2011). The wastewater incorporates process chemicals and shades utilized as a part of the mills, plus a range of inorganic components including low concentrations of metals, and generally low concentrations of aggregate P and N. This wastewater was appeared to be sufficiently low in poisons and had enough P and N to help microalgae growth, with three freshwater microalgae *Chlamudomonas incerta* (Kamyab et al., 2015) *Botryococcus braunii* and *Chlorella saccharophila*, and a marine alga *Pleurochrysis carterae*, ready to become especially well on the untreated wastewater (Chinnasamy et al., 2010). With the huge measure of wastewater accessible from this industry a lot of biomass and possibly likewise biodiesel could be produced from this asset (Pittman et al., 2011).

3.5 Microalgae production

Microalgae grow naturally in a wide range of environments. Typical requirements for phototrophic microalgae include sunlight, CO_2, temperatures between 20 and 30°C, water and nutrients (primarily N, P, and K). In industrial microalgae production, the ideal conditions may be provided, such as artificial light with the appropriate photoperiod and wavelength, consistent CO_2 supply, optimal temperature and essential nutrients like nitrogen (N) and phosphorous (P). Providing optimal conditions improves the microalgae growth rate and potentially improves the composition (oil, starch, protein) of the microalgae, although it increases the costs of the production. Measuring the microalgae concentration and growth rate during cultivation are critical parameters for evaluating the feasibility of microalgae production (Kamyab et al., 2018b). Carbon sources are essential for microalgae growth. Photoautotrophic organisms are the organisms that derive their energy for food synthesis from light and are capable of using carbon dioxide as their principal source of carbon. Hence, photoautotrophic cultivation implies that inorganic types of carbon (CO_2 or bicarbonates) are provided to the cultures while light energy is changed into compound energy through photosynthesis (Ren et al., 2014). Other microalgae strains can utilize natural carbon as both energy and carbon source (heterotrophic cultivation); this cultivation framework is however practiced for the creation of high- value items as it were. Mixotrophic nutrition mode is the mix of both autotrophic and heterotrophic.

4. Conclusion

In this review, microalgae have been broadly discussed for different purposes such as, biofuels, nourishment supplements, CO_2 capture. In addition, microalgae is likewise utilized as a part of wastewater treatment for contamination and supplement evacuation. That is due to microalgae growths are subject to supplement focus and in addition light, temperature, and pH. Microalgae mainly wastewater treatment depends in light of the capacity of phototrophic microorganisms to supply oxygen to vigorous natural contamination degraders and improve the evacuation of supplements and pathogens. The natural habitat and climate are the main aspects which regulate the passable growth of microalgal strains in the specific region. Despite having higher lipid content, microalgae cannot be utilized to produce biodiesel if it does not grow well in the specific region. Furthermore, indigenous species have acclimatization for a longer time to the dominant area abiotic and biotic aspects, which basically contribute to the higher biomass production and production of lipid.

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