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Review

Applications of Microalgae in Wastewater Treatments: a Review

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Abstract

Water is the most important resource for mankind existence and development. Therefore, maintaining the water to a high quality is crucial. Wastewater treatment technologies are constantly evolving. Nowadays, the focus has shifted to the use of microalgae cultures, an interesting step for wastewater treatments, which can improve the treatment process in order to get a clean and healthy water. Microalgae by definition are unicellular algal species that can survive individually or in chains or clusters. They exist in both suspended forms (that free-float in a water body) and attached forms (that adhere to a submerged surface) and are one of the most important groups of organisms on the planet. Microalgae cultures offer a modern solution of wastewater tertiary treatment together with the production of potentially valuable biomass, which can be used for several purposes (biogas and biofuel production, composting, as animal feed or in aquaculture and production of fine chemicals). The microalgae use the nutrients (inorganic nitrogen and phosphorus) for their growth and have the capacity to remove heavy metals and some toxic organic compounds (dyes and antibiotics) and to reduce, also, the chemical and biochemical oxygen demand. In the present review we will focus on the application of microalgae in the wastewater treatment.

Keywords: microalgae, wastewater treatment, heavy metals, toxic compounds, COD, BOD, biomass.

1. Introduction

It is estimated that microalgae produce approximately half of the atmospheric oxygen on earth, while consuming vast amounts of the greenhouse gas carbon dioxide.

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The biodiversity of microalgae is also enormous. It has been estimated that as many as 200,000 to 800,000 species exist, of which only about 35,000 species have been identified and described [1].

Algae play many roles in the aquatic systems such as:

1. primary producers;
2. indicators for water quality (some algae being stenobionts);
3. trophic values for both man and animals consumers

4. obtaining biofuels, medicine, dyes etc.
5. fossils algae used to reconstitute the lakes evolution, climate etc.

The concept of using algae in water treatment was first introduced by Oswald and Gotaas in the paper "Photosynthesis in sewage treatment"[2]. The concept is not difficult to understand - algae use nutrients derived from the aquatic environment, while wastewater contains a huge amount of nutrients that algae can use. Therefore, in aquatic ecosystems, in spring or summer, the phenomenon of "flowering" takes place. Biological wastewater treatment systems with micro algae have particularly gained importance in last 50 years and it is now widely accepted that algal wastewater treatment systems are as effective as conventional treatment systems. From 1957 until now, there has been extensive research in this area, with constantly evolving technologies. The research was oriented to the removal of nutrients, of chemical and biochemical oxygen demand, of heavy metals, dyes and antibiotics and radioactive substances, microorganisms from wastewater and also for the production of biodiesel.

2. Removal of Wastewater Nutrients (N and/or P) by Microalgae

The wastewater nutrients (nitrogen and phosphorus in different forms), if discharged improperly, are the main pollutants which contribute to eutrophication of surface water bodies and thus threaten the balance of aquatic ecosystem and safety of drinking water. Many studies demonstrated that microalgae are excellent nutrients stripper as they require nutrients for development [3-8].

The nutrient removal efficiencies are usually high for wastewaters of different sources. It has been proved that microalgae can reduce nitrogen up to 84% [8]. The widely used microalgae cultures for nutrient removal are species of *Chlorella* [9-13], *Scenedesmus* [14-16] and *Spirulina* [17, 18]. Nutrient removal capacities of *Nannochloris* sp. [19-22] and cyanobacterium Phormidium bohneri [23-24] have also been investigated. Different species of algae were used and were obtained different percentages of nutrient removal. Several studies have been conducted to investigate nutrient removal potential of *Chlorella* sp., revealing feasibility of 80.0%–100.0% nitrogen and 83.2%–92.0% phosphorus removal, respectively [11-13, 25-28]. In an earlier study [29] there were reported lower elimination rates of nitrogen (50.2%) and phosphorus (85.7%) in industrial wastewater treatment and elimination of phosphorus (97.8%) in domestic wastewater treated by algae.

3. Reduction of Chemical and Biochemical Oxygen Demand by Microalgae

Regarding the attack blight in potato variety semitârziu Redsec within four graduations trifactorial experience extending over three years, 2012-2014, it notes that were recorded the highest values in the experimental field located in Jucu, that had been read 17 28% report which identified a humidity/temperature equal to 3.92 (Fig. 1).

The lowest values were recorded in the experimental field of Poieni, 13.26% respectively compared equal to the higher humidity/temperature, which is equal to 4.38 (Fig. 142). Intermediate values Microalgae can be used for BOD and COD removal [11, 45-49]. When used *Scenedesmus acutus*, COD was reduced with 77% [50].

Excess BOD can deplete the dissolved oxygen of receiving water leading to fish kills and anaerobiosis, hence its removal is a primary aim of wastewater treatment. Colak and Kaya (1988) investigated the possibilities of biological wastewater treatment by algae. They found that, in domestic wastewater treatment, elimination of BOD and COD were 68.4% and 67.2%, respectively [29].

4. Removal of Heavy Metals from Wastewater

Heavy metals discharged into waterbodies through wastes have an incorrigible impact on the aquatic system and destroy the self-purification ability of an aquatic body [30]. Therefore, the scientific community is under tremendous pressure to develop new, innovative, cost-effective, efficient and sustainable methods for the removal of heavy metals from aquatic bodies as well as wastewaters.

There is a growing impulse for the production of cheaper adsorbents to replace costly wastewater treatment methods; there by non-conventional heavy metals remediation technologies have been gaining popularity. Researchers have intensified their efforts in developing suitable technologies for prevention of heavy metals pollution, decreasing heavy metals concentrations to a lower level (by decreasing the efflux of heavy metals into the receiving bodies such as rivers, sewer and lake etc.), and removal of heavy metals from contaminated media. Microalgae have been studied for their ability to embed the heavy metal ions in the cell vacuole.

A continuous development of research has been made, with more species of algae that can be used being discovered [4, 34].

It is known that microalgae may bind heavy metal ions. From the reaction of peptides with heavy metal ions and form organic metallic complexes, which are being stored in the cell vacuole. Research proved that the addition of heavy metal ions in the cell activates the synthesis of metallothionein. These complexes can bind heavy metal ions such as Cd2+, Ag+, Pb2+, Zn2+, Hg2+ and Au2+.

Algae from culture are able to absorb zinc ions [51]. Species, such as Spirogyra sp. decrease the concentration of zinc ions by 90-95% in the first 30 minutes [34, 52]. Other species, such as those from the genus Chlorella, are able to absorb uranium and lead ions [35].

Many algae are known to absorb pollutants. Synechocystis salina was used to remove heavy metal ions from water. After 15 days of treatment, approximately 60% of Cr ions, 66% of Fe ions, 70% of Ni ions, 77% of Hg ions, 65% of Ca ions, 63% of Mg ions were reduced [36].

Species from Micractinium were used for Cd ions removal from water (http://www.oilgae.com/ref/downloads/Wastewater_Treatment_Using_Algae_Report_Preview.pdf). Species of Spirulina were used successfully for Cr ions bio absorption [37].

Microalgae can sequester heavy metal ions by the same adsorption and absorption mechanisms as other microbial biomass [41]. Algae are a renewable natural biomass that proliferate ubiquitously and abundantly in the littoral zones of the world and have attracted the attention of many investigators as organisms that can be tested and used as new adsorbents to adsorb metal ions. Several advantages in applying algae as a biosorbent include its wide availability, low cost, high metal sorption capacity, and reliable quality [39-40]. There is much research about the metal biosorption using algal biomass. Examples of recent reports include the biosorption of Cu and Zn using Chlorella minutissima [41]; the biosorption of Cu, Cd, Pb, and Zn using Caulerpa lentillifera [42]; the biosorption of Cr from wastewater using Ulva lactuca [43]; and the biosorption of lead(II) from wastewater by Cladophora fascicularis [44].

5. Conclusion

1. Wastewater treatment systems used are massive and present huge costs.
2. Systems used in present are using different substances that endanger human health and all biological entities.
3. Algae used for wastewater treatment are a better fit for both costs and efficiency.
4. Algae are proven to be able to include in their cell heavy metals, radioactive elements or antibiotics.
5. Many species of algae can be used in the wastewater treatment system.

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