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Phycoremediation in Wastewater Treatment

Divya Srivastava[1], Om S. Srivastava[2]

[1,2]Department of Civil Engineering, Amity University Uttar Pradesh, Lucknow, India
[1]dsrivastava4@lko.amity.edu, [2]om1807srivastava@gmail.com

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Abstract

The simplest definition of phycoremediation is the use of algae to treat wastewater. Water as a commodity is very scarce and follows a downward trend with every passing day. The Middle East and North Africa region accommodates almost 5% of the world's population but contain less than 1% of the world's annual renewable freshwater. The cities are growing at a rate of 4% every year, so this is only going to worsen the demand and supply of water. Hence the use of algae (microalgae and marine macroalgae, commonly known as seaweeds) particularly microalgae can help treat the water efficiently and cater to the demand of the growing population. The omnipotent stature of algae and their adaptation to multifarious habitats makes them tolerant to a wide range of environmental conditions, including nutrient levels. The algae can work as a carbon-reducing system that can convert carbon dioxide into oxygen through photosynthesis, due to its handling of adverse conditions we can use microalgae for bioremediation of wastewater and the biomass produced during the process can serve as food, fertilizers, and late, biofuels.

Keywords

Phycoremediation, Microalgae, Wastewater, Removal, Trace Metals, Nitrogen, Treatment

1. Introduction

As population increases the demand of water also increases, although water covers almost 70% of the earth yet the shortage of water is very evident. In the year 1960 the annual per capita availability was about 3300 cubic meters that fell by 60% to about 1250 cubic meters and the predicted to go further down to 650 cubic meters by the year 2025, hence now is the time to utilize every single drop of water on this Planet starting with wastewater.

Finding a solution to treat water is a difficult task in terms of economics so a less money intensive process to treat the water efficiently is the need of the hour, a potential process can be the used is phycoremediation that uses the help of microalgae for the removal or the biotransformation of the pollutants [2][3]. Microalgae are microorganisms that consume carbon dioxide and colonize in the presence of moisture and nutrients through photosynthesis, a lot of research on the treatment of wastewater is being done to provide an alternative to the conventional cost-intensive treatment processes.

In this paper, we will review the replacement of conventional secondary treatment along with the removal of coliform bacteria, N or P, and heavy metals from water by the use of phycoremediation or using algae.

2. Microalgae for wastewater treatment

The biologists in the countries like USA, Thailand, Australia, Mexico and Taiwan have been studying the potential use of microalgae in treating wastewater. The main attraction of bio-treatment with micro-algae is its incredible capacity to convert solar energy into useful biomasses. The algal systems are now known to be effective in treating human sewage, livestock wastes, industrial, agricultural, waste from food processing factories, the algal systems effectively remove toxic minerals such as lead, cadmium, mercury, scandium, tin, arsenic, and bromine are under development.

Algal systems are proposed as a potential tertiary and secondary treatment process. In the tertiary process removal of organic ions, takes place biologically and chemically that adds to the cost of treatment, hard implementation, secondary pollution, wastewater treatment is altogether a costly affair each additional step in treating the water increases the cost multi-folds, generally, it has been observed that the cost of treatment doubles for each additional step[4].

Tertiary bio-treatment that aims at removing nitrate phosphate or ammonia is about four times more expensive than primary treatment, hence bio-treatment with microalgae provides a cheap yet elegant fix to the tertiary process by utilizing the inorganic nitrogen and phosphorus for their growth. They can also curb down the secondary pollution by removing heavy metals and some basic organic compounds, the most useful characteristic of bio-treatment with microalgae is that it produces oxygen and increases the pH during photosynthesis eventually leading to a disinfecting effect.

3. Removal of coliform bacteria

It has been observed that the environmental factors favorable for the growth of algae were unfavorable for the survival of coliforms, the removal of total coliform organisms is an important parameter to determine the efficiency of disinfection of sewage, in this regard a few systems like sewage stabilization ponds and high-rate sewage stabilization ponds have been more effective than conventional sewage treatment.

A few reports in the literature have revealed the reduction of coliform bacteria in stabilization ponds, some reports have revealed a reduction of 88.8% in 11.4 days while some reports reported a reduction of 99.6% [5].

4. Removal of Nitrogen and Phosphorus

Wastewater after treatment has little amount of nutrients left, when it is allowed to discharge in water bodies, it causes eutrophication. The main forms of nutrient that exist in water are NO_2^{2+} (nitrite), NO_3^- (nitrate), PO_4^{3-} (orthophosphate) and a combination of all these forms nutrients and the process that is used to remove these nutrients, is called nutrient stripping.
The microalgae utilize its high capacity for inorganic uptake and can be grown in mass culture in outdoor solar bio-reactors, microalgae culture here again gives a cheap fix and efficient performance when compared to the money demanding physical and chemical process [6].

Lau et al (1996) studied the ability of *Chlorella Vulgaris* in the removal of nutrients, the conclusion that study led to was an efficient removal of inorganic N (86%) and inorganic P (78%), some earlier studies by Colak and Kaya (1988) reveal the efficiency of *Chlorella Vulgaris* to efficiently remove nitrogen (50.2%) and phosphorus (85.71%) in industrial wastewater and phosphorus (97.8%) in domestic wastewater.

The removal of N by biological treatment offers some advantages over tertiary chemical and physicochemical treatments, some studies have used cultures of *Phormidium bohneri* for removing nitrates from the effluents obtained by the anaerobic digestion of swine manure.

The use of a thermophilic cyanobacteria *Phormidium laminosum* has been reported to remove nitrogen having a wastewater purification as the contamination can be avoided because cyanobacteria are tolerant to high temperatures (45°C). The metabolism of phosphorus and nitrogen are very closely related so this means an abundance of phosphorus is of no use if there is no nitrogen and vice versa [8].

5. Removal of Heavy Metals

Since algae are efficient and economical in absorbing heavy metals so the process of bioaccumulation can be used to create a feasible method to eliminate wastewater contamination with metals [7]. If utilized to full potential this treated wastewater can also be used in concrete applications [12].

Microalgae have an effective role in the detoxification of mine wastewater, reports suggest that 99% of dissolved and particulate metals can be removed. It has been reported that *Coelastrum proboscide*an absorbs 100% of lead from 1.0 ppm solution in 20h at 23°C and about 90% in 1.5h at 30°C [9]. Experimental results suggest that the microalgae is a little less efficient in absorbing Cadmium, about 60% Cadmium were absorbed from a 40 ppb solution after 24hrs, algae when used in rice paddles accumulate and concentrate Cd^{2+} by a factor of 1000 times when compared to ambient.

The studies on *Cladophora glomerata* in artificial freshwater channels have shown that it is an excellent accumulator of zinc and some authors have suggested that algae can accumulate a wide range of trace metals like Ni^{2+}, Cd^{2+}, Fe^{2+}, and Mn^{2+} [11,13,14].

6. Conclusion

Treating wastewater is a cost-intensive task, wastewater treatment by the use of microalgae seems to be the suited alternative with huge potential to meet demand and supply of drinking water. Algal-based systems are also known to remove nutrients as well as heavy metals and the sludge produced is very less or negligible in the quantity that gives this treatment process an edge over the conventional systems. The carbon-reducing system can also be used to generate a decent number of biofuels and can assist in creating a sustainable power source, these systems are the need of the hour and should be incorporated in the current technology wherever it is feasible.

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