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MICROALGAE BASED SUSTAINABLE BIOREMEDIATION OF CONTAMINATED WATER: RECENT TOOL TO RESURRECT POLLUTED RIVER

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The sole author designed, analysed, interpreted and prepared the manuscript.

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Review Article

ABSTRACT

Nature has endowed us by a number of things. It is also equally true carelessness by human being caused a great loss to the earth. Pollution is one of such carelessness. But it is the beauty of nature that has given the treatment of every such carelessness. The technique "bioremediation" is nothing just a remedy by the nature that recycles wastes and makes them harmless and to some extent beneficial. It is found to be one of the most effective methods for restoring polluted river water and preserving the affected ecosystem. With the help of all-inclusive microorganisms, bioremediation involves the degradation, elimination, restriction and reclamation of numerous chemical and physical hazardous elements from the environment. It also involves disintegration as well as the transmutation of contaminants like as heavy metals which is the core premise of bioremediation. Different microorganisms such as algae are found to be game changer in the bioremediation process. Bioaugmentation, Bio stimulation, Biofilters, Bioreactors, Biopharming, Bioventing, Composting, Land farming are various Bioremediation techniques. All bioremediation processes have their own set of advantages and disadvantages. Above all, using bioremediation to resurrect a dirty river will result in significantly less contaminated, safe, and ship-shape waterways.

Keywords: Bioremediation; biodegradation; polluted river; water treatment, contamination, bio stimulation; bio augmentation.

1. INTRODUCTION

1.1 Mechanism of Bioremediation

Bioremediation is an Eco-friendly method which is applied to microorganisms to enhance the rate of degradation or transformation of a variety of poisonous substances into less dangerous forms. Bioremediation is a cheap and highly-efficient technique that is getting fame day by day as a way to minimize pollution in the environment. Sewage

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dumping has become an ecological issue in urban and semi-urban countries. The main source of water pollution is waste from residential and industrial outflow. Industrial wastes were dumped into open sewers, which eventually met up with rivers [1]. Industry effluents is the chief cause of water pollution, it causes oxygen demand and eutrophication resulting in poisonous, unstable aquatic ecosystems [2,3]. Disproportionation of hydrogen ion concentration levels in a water is found to be to disrupt aquatic kingdom, causing change in toxicity of pollutants in some way [4]. The solubility of some critical elements such as selenium decreases as pH levels decreases while the solubility of a number of elements like Al, Cu, Cd, Hg etc. increases [4].

The interactions of aqueous medium with environment determine the water quality. Anthropogenic activities disrupt the balance of aquatic ecosystems, resulting in pollution, which manifests itself in the death of fishes, in addition to other problems. Several heavy metals, including Pb, Cd, Hg, etc. have been identified as toxicants that can create serious poisoning [5]. Access to safe, high-quality water is critical for preventing disease and raising living standards [6]. Metals are involved into aquatic ecosystems by rocks weathering and soils leaching. Metals may be taken up by fauna and plants after being introduced to water, and eventually amplify in marine species that are fed by humans through the food chain [7].

The Gomati is an important river in India. It is utilized for drinking and irrigation. Nowadays drinking river water directly causes a number of health problems [8]. The manufacturing business like of fertilizers caused a great extent of water pollution [9]. The majority of effluent is released into nearby water bodies, disrupting biological ecology and degrading water quality further [10]. Textile mill effluents contain a variety of chemicals including various dyes etc. [11], and a large no of peasants utilize these for irrigation which is a matter of deep concern. Though, now a days, industrial effluents have been used for irrigation following treatment [12]. To gain access to waste water treatment, new methods are being proposed. Algae are a crucial component of these new methods and Ryther [13], Romero-Gonzalez [14], and Wang have investigated algal bioremediation extensively over the last 40 years (2011).The involvement of algal biomass as bio sorbents to reduce environmental contaminants notably heavy metals, has received a lot of attention (Hubbe, 2011).

Algae are usually found to be perfect for such problems from long time. Blue green algae are primordial photosynthesizing prokaryotes and are thought to have first arisen from Pre-Cambrian period [15], supposed to be the first photosynthetic organism, which survived for 2 to 3 billion years and played a crucial role in the evolution of higher animals. Blue green algae are a unique collection of microorganisms, can be used in wide variety of environments [16, and 17]. Blue green algae extremely sensitive for changes in light, salinity, temperature, and nutrient composition, both physical and chemical [18, and 19]. Blue green algae have tremendous potential for such problems, chemical manufacture, biofertilizers, nutrition, feedstuffs, and fuels among other things.

Spirulina sp. is fast-growing blue green algae that possess noticeable extents of mercury and lead (Slotton et al., 1989) when grown in polluted conditions, it can absorb metals from the environment. Several blue green algae species, like *Oscillatoriasalina, Plectonematerebrans, Aphanocapsa* sp., and *Synechococcus* sp., settled in the form of mats in polluted aquatic habitats and effectively utilized in bioremediation of oil spills [20,21,22]. Microalgae have earlier been employed for wastewater problem, either single species such as *Chlorella*, *Scenedesmus*, or *Arthrospira* [23,24,25, 26], or as mixed [23-26,25,27,28] for various types of effluents and the elimination of nitrogen, phosphorus, and chemical oxygen demand. These microbes may also extract and incorporate harmful elements from polluted water, such as Pb [29], Cd, Ni, or Hg [30, and 31]. *Chlorella* is one of the microalgae used to remediate dirty water that grows in a mixotrophic environment. *Spirogyra* sp. has been found to have great capacity of accumulating harmful metals such as copper, chromium, zinc, and fluoride, according to research undertaken by many researchers (Bisnhnoi et al, 2005).

Some marine algae species like *Ascophyllum* and *Sargassum*, are particularly successful for biosorption [32]. The main significance is due to the great tendency to decrease heavy metals in the contaminated environment. Recently, the application of immobilized enzymes for the manufacturing of a variety of metabolites has attracted a lot. The use of immobilized microalgae to remove hazardous metals is effective and suggests great significances in bioreactors [33]. Massive amounts of trash of industry, home sewage and agriculture areas finally move into rivers and ponds, caused widespread spoilage of water properties and a lack of potable water. The need to monitor and create effective algae species for bioremediation of polluted water is critical.

2. BIOREMEDIATION BY ALGAE

Water is regarded as an inexhaustible scarce resource in the twenty-first century. Contaminated water is a significant challenge for natural resources as well as fundamental tactical distinctions related to a country's economic development and long-term stability (Zeng et al.2013). As a result, strengthening water-related resources, managing consumption and efficiently restoring polluted water has become one of the world's most pressing concerns today. To restore the quality of water in contaminated rivers, three sorts of procedures have been used: physical, chemical, and biological processes. Physical approaches, for starters, take into account artificial aeration, water diversion, sediment dredging, and mechanical algae removal. These techniques are both simple and old-fashioned, and they cost a lot of time, as well as a lot of labor, material, and monetary resources (Wu et al. 2015).Second, secondary contaminants are unavoidably produced by these processes, posing hidden dangers to ecosystem persistence (Margeta et al. 2013).

Finally, biological remedies like plant purification (Sun et al. 2009), combinatorial biotechnology approaches (Sheng et al. 2013; Bosso et al. 2015; Ravikumar et al. 2017), bioremediation (Hashim et al. 2014; Hechmi et al., 2016; Mani et al. 2017), biofilm techniques (Boltz et al. 2017), and artificial wet (Zheng et al. 2016) which are all environmentally safe and designed to increase the water's self-refinement quality, re-establishing the aquatic ecology. Among all of the procedures listed above, bioremediation is seen to be the most suitable due to its several advantages, including high degradation capacity, low energy consumption, lack of secondary pollutants, technological simplicity, extended viability, and the absence of additional assemblies [34]. Bioremediation is primarily concerned with strategies for cleaning toxins using live organisms. The bioaccumulation approach is recognized as a dynamic method for metals by living cells that relies on many metabolic processes [35].

Microalgae are not unique in that they have the ability to naturally remove contaminants; nonetheless, they are more beneficial over other biological instruments in terms of conceptual bio removal schemes. Heavy metals biosorption by specific types of biomasses has previously been discovered to be extremely cost-effective, therefore new approaches of decontaminating metal-containing discharge are necessary [36]. Adsorption of hazardous metals using algae is likely to be a very successful method for removing and recovering metal ions from aquatic environments [37].

During the bioremediation of secondary effluents from industrial wastewater, *Chlorella vulgaris* and *Scenedesmus dimorphus* are superbly effective for removing ammonia and phosphorus [38]. The ability of dried *Chlorella vulgaris* to bind with bivalent Cu, Cd, and Pb ions from their aqueous form has already been examined. It was revealed that the percentage uptake of cadmium ions decreased with the decrease in dielectric constant values, whereas the percentage uptake of Cu and Pb ions decreased with the increase in donors [39].

Because of their high-performance activity, low cost, and availability in huge quantities algae are considered highly effective for heavy metal removal and recovery [40]. Although *S. incrassatulus* was capable of removing most of the tested metals to desired level. Continuous cultures eliminated chromium (VI) more efficiently than batch cultures, possibly due to algae's preference for chromate absorption [41]. The increase in pH facilitated by algae also takes into consideration phosphorus precipitation and ammonia removal, sanitizing the wastewater [42].

Under various metal concentrations, the biosorption potential of *Spirogyra* sp. and *Spirulina* sp. observed [43]. Utilization of living and dead Spirulina sp. for the absorption of metals. Living Spirulina sp. is expected to be an effective control agent for industrial effluent [44].

Biodegradation rates of alkyl benzene sulfonate LAS by *Spirulina platensis*rose with Zn (II) and stretched to the maximum, according to Huijuan Meng [45]. The cumulative effect of LAS and Zn (II) was found to be synergistic in this study. Zn (II) sorption is increased by LAS, and Zn (II) biodegradation is increased by LAS. Bindiya et al. [46] investigated the bioaccumulation of Cd in *Spirulina Indica*.

According to Deng et al. [47], the alga *Cladophora fascicularis* is particularly efficient at absorbing copper (II) from the aquatic environment. Previous researches have shown that the biomass of the green algae *Spirogyra* sp. may sorb Pb (II) from aquatic environments [48]. Khalaf [49] used biomass from *Aspergillus niger* and *Spirogyra* sp. to detect the sorption of dye produced from textile industries.

According to Monteiro et al. [50], the *Scenedesmus obliquus* microalga is particularly good at removing a hazardous heavy metal from the aqueous environment, which helps them choose bioremediation solutions for industrial effluents. For the first time, it was confirmed that this species of wild microalgae can adsorb Zn quite effectively, indicating a promising future for bioremediation. Its performance is far superior, particularly near neutrality even after heat treatment [51].

After employing uni-algal and bi-algal systems, Kaushik et al. [52] investigated the chromium (VI) tolerating capacity of algal strains *Nostoc linckia* and *Nostoc spongiaeforme* obtained from salt-affected soils. It was also discovered that cyanobacterial efficiency is of importance since they color and moderate the quality of the aquatic environment into which these algae are dispersed. *Oscillatoria's* bioremediation effectiveness for textile effluents was active [53]

In saline conditions, Prado et al. [54] discovered the rate of cadmium and copper biosorption by biomass of the alga *Sargassum sinicola*. It has been found that salt has no effect on their biosorption. *Chlorella* is frequently present in the various forms of contaminated water for treatment among the several algae used to clean dirty water. Raposoet colleagues [55] discovered that *Chlorella vulgaris*, as well as the autochthonous flora of polluted water, has ability to remove some harmful chemicals. Cecal et al. [56] investigated UO2 2+ ion biosorption in *Chlorella vulgaris*. They compared the biosorption of *Chlorella vulgaris* and *Dunaliella salina*, and found that *Chlorella vulgaris* had a higher biosorption than *Dunaliella salina*.

Kannan [57] discovered that certain microorganisms particularly blue green algae have detoxifying abilities. They gathered tannery waste and mixed it with blue green algal growth media in various amounts. *Anabena flosaquae* had its photosynthetic pigments and nitrogen status assessed before and after the treatment. *Anabena flosaquae* was found to be a potential bio remedial agent for polluted water in an experiment.

The presence of *Oscillatoria* sp., *Synechococcus* sp., *Nodularia* sp., *Nostoc* sp., and *Cyanothece* sp. in contaminated and mixed cultures suggested varying sensitivity. These species were used to remove pollutants as single organisms or in mixed cultures [58]. Lee and Chang [59] discovered that algae species *Spirogyra* and *Cladophora* had biosorption potential for lead and copper in aquatic environments. Miranda et al. [60] isolated two algae from effluent, *Oscillatoria laetevirens Gomont* and *Oscillatoria trichoides Szafer*, and investigated their ability to remove Cr^{6+}.

Pithophora sp. of alga was found to be the most effective at removing Cd, Cr, and Pb from industrial effluent by Brahmbhatt et al. [61]. When compared to cadmium, the amount of mercury in *Dunaliella* alga is higher. *Dunaliella* is also found to be particularly resistant to rising metal concentrations and their sorption in the aquatic environment. This supports *Dunaliella's*use as a potent agent for removing harmful metals from a polluted environment [62].

Gao and Yan [63] investigated role of *Chara globularis* and *Hydrodictyon reticulatum* in lead contamination, finding that *H. reticulatum* was more resistant to lead than *C. globularis*. One of the most compelling reasons to use microalgae in environmental biotechnology is for the elimination of heavy metals [64]. A significant use of bioreactors is the involvement of immobilized algae for effluents and the subsequent elimination of heavy metals [33]. Tam et al. [65] used *chlorella vulgaris* cells immobilized on alginate beads to extract N and P from effluent and achieved significant ammonia and phosphate reductions.

The resistance to cadmium of *Spirulina platensis*, an economically important blue green alga, was examined. *Spirulina platensis* was shown to be more effective in absorbing hazardous metals when it was immobilized [66]. For the simulated chrome liquor in the concentration range of 100–4500 ppm, the biosorption process of trivalent chromium (Cr^{3+}) through a live culture of *Spirulina platensis*, as well as the sorption efficiency of dried biomass, in both free and immobilized conditions has been investigated. Both live and dried biomasses were found to be excellent biosorbents, capable of removing large quantities of chromium [67].

Several operations related with petrochemicals have released a large amount of petroleum pollutants in recent decades. The use of adsorbents as a means of removing organic contaminants has got a lot of interest in the environmental industry [68]. Cyanobacteria have a great deal of potential as a source of fine chemicals, as a biofertilizer and as a source of renewable fuel. [68,69].

3. CONCLUSION

Bioremediation is an Eco friendly and appealing option for cleaning, managing, and recovering polluted river water utilizing microbial applications. Although due to competition among biological agents, a lack of necessary nutrients, hostile exterior abiotic conditions, wetness, and changed pH, the speed of these bioremediation processes is limited. The process of bioremediation in natural circumstances is not as successful as expected, which makes it less favorable, yet it can be used where the environment supports microbial growth and efficiency. Microbes can also be genetically modified to boost their ability to bio remediate a larger range of toxicants in a variety of environments. The bioremediation procedure has been used in a variety of river locations around the world and it has been noted that the benefits outweigh the drawbacks, resulting in an increase in demand over time. Several microbe species have been discovered in diverse locations that are effective in the pollution control system. As a result, there is no question that bioremediation processes will offer a way for safe, clean, and cleaned rivers if sufficient study is conducted in this area.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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