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HEAVY METAL PHYCO- REMEDIATION EFFICIENCY OF BLUE GREEN ALGAE IN PERIYAR RIVER, KERALA: A REVIEW

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Review Article

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ABSTRACT

Heavy metal pollution has drawn increasing attention worldwide owing to a dramatic increase in anthropogenic heavy metals in ecosystems through air, water and soil. Mainstream land and water area in Kerala are polluted with heavy metals due to industrial effluents. Periyar River is the longest river and the river with the largest discharge potential in the Indian state of Kerala. Marine micro and macro organisms contains numerous bioactive compounds and those organisms were involved in the bioaccumulation . Cyanobacteria or Blue green algal cells have developed natural methods of responding to metals such as copper, lead, and cadmium through passive accumulation in cells and through surface binding to various functional groups. They have also been found to remove harmful metals from the environment. The present review article mainly focused on the Phycoremediation potential of blue green algae based heavy metal removal in Periyar River which will be a promising tool in waste water treatment on further study.

INTRODUCTION

Environmental pollution and contamination have become a key focus of global concern. One of the major problems of Periyar river, Kerala is the management of solid waste materials including farm animal manure, agricultural wastes, industrial wastes such as Chemicals, garbage and other metals resulting from demolition of buildings, dead animals etc. Huge quantities of unwanted materials cause serious disposal problems. Some of the present methods of environmental cleanup result in the production of certain harmful by-products. These chemicals may also have significant effects on plants and animals causing a disruption in species composition of communities. Kerala being one of the hot-spots of biodiversity in the world, its bloomed waters are expected to be rich of algal diversity.

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STUDY AREA

The Periyar river, the longest river of the Kerala Originates from Sivagiri group of hills in Sundarmalai at an elevation of about 1830m above .The total length is about 244Km in Kerala with a catchment area of 5284 sqKms in Kerala. The river with the width of 405 m and is located between latitude 9015'50'' and longitude 7607'38" .Tributaries of Periyar river includes Kattapanayar, Muthayar, Peruthurayar, Chinnar and Edamalayar. At Aluva, the river bifurcates into the Mangalapuzha branch and the Marthanadavarma branch. The former joins river Chalakudy and finally drains into the Lakshadweep Sea and the latter bisects the industrial belt at Eloor before discharging into the backwaters adjoining the Arabian Sea.

Harmful Effects of Heavy metals

Heavy metals are one of the major threats to the environment and a serious problem due to their incremental accumulation in the food chain. Unlike most organic wastes, metal contaminants are not biodegradable, tending to accumulate in living organisms, thus they become a permanent burden on ecosystems [23]The livestock systems are prone to general problem of pollution originating from industrial activity. Trace amounts (µgL- 1) of some metal ions such as copper, cobalt, iron, nickel are required by living organisms as cofactors for the enzymatic activities. On the other hand, heavy metal ion concentrations at ppm (mgL-1) level are known to be toxic to the organisms because of irreversible inhibition of many enzymes by the heavy metal ions. Excessive accumulation of Lead causes impaired kidney functions, multiple sclerosis, anemia neurological diseases and encephalitis. Excess Cadmium leads to nephritis and wrong bone metabolism. Wilson's disease is caused by excess Copper and excess Zinc causes the disease of metal fume fever.

Discharge of industry effluents to the land of irrigation influences the physico-chemical properties of soil [18][14]. The release of industrial and municipal wastewater poses serious environmental challenges to the receiving water bodies [17].Wastewater is usually rich in contaminants in the form of nutrients, heavy metals and hydrocarbons. The presence of nutrients especially nitrogen (N) and phosphorus (P), in the form of nitrate, nitrite, ammonia/ammonium or phosphorus in wastewater leads to eutrophication [16]. which adversely affect aquatic eco system.

Water pollution in Periyar river

Mainstream land and water area in Kerala are polluted with heavy metals due to industrial effluents. Periyar River is the longest river and the river with the largest discharge potential in the Indian state of Kerala. Green peace India describes the lower Periyar as a cesspool of toxins, which have alarming levels of deadly poisons like DDT , Endosulfan, Hexa and trivalent chromium , Copper, lead, cyanide, BHC. Several studies have pointed out that the river bed has deposits of heavy metals like Lead, Cadmium, Mercury, Chromium, Nickel, Cobalt and Zinc. The chemical factories discharges their effluents to Periyar River and it eventually reach in to the Cochin estuary. The ecosystem of the river has many dead zones. Some of the major recommendations are ensuring zero effluent discharge from the industrial units in the Eloor stretch and zero emission from companies' .As per the study Eloor is the 35 th most toxic hotspot in the world and the third most toxic hotspot in India. Pollution of the river and surrounding wetlands has almost wiped out traditional occupations, including fishing and farming.

The common source of water pollution in Eloor is industrial waste. Therefore quality effluent should be improved before discharged through the outlets. Eloor industrial area situated around 13 KM north of the Ernakulum. It is an island of 14.21 Km 2 formed between two distributaries of river Periyar and largest industrial belt in Kerala. There are close to 200 industries of different kinds along the industrial belt including Fertilizers and chemicals Travancore, Indian rare earths limited, Hindustan Insecticides limited, Chemical-petrochemical products, Rare earth elements, rubber processing chemicals etc, discharge through the outlets with large quantity of effluents influence the Aquatic ecosystem of the Eloor. Local bodies do not posses proper eco friendly sewage treatment facilities resulting in the discharge of hazardous pollutants. Eco-friendly process need to be developed to clean up the environment without creating any harmful waste products [8]. If a biological agent is identified and developed to solve these problems it will be a great milestone to science. The enormous diversity and propensity to adapt to extreme and inhospitable habitats has led the scientific community to screen, identify promising strains / genera and develop promising microalgae-based technologies for wastewater treatment [7][28].

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Micro-algae based technology

Microalgae represent an integral part of the microbial diversity of wastewaters, which can also play a role in the self-purification of these wastewaters [24]. Phycoremediation refers to the technology of using algae for the remediation of wastes, predominantly in the treatment of wastewaters as a part of the secondary treatment [5][26]. It is the most beneficial method as it is a cost effective, easy to handle, less labour work is needed, Produce no hazardous secondary byproducts and residues can be used for bio fuel production.

Microalgae offer a low-cost and effective approach to remove excess nutrients and other contaminants in tertiary wastewater treatment, while producing potentially valuable biomass, because of a high capacity for inorganic nutrient uptake [2][18]. Using microalgae in continuous treatment processes would be of great advantage, because most industries are in dire exigency for implementing cost effective continuous treatment processes. Algal species are relatively easy to grow, adapt and manipulate within a laboratory setting and appear to be ideal organisms for use in remediation studies [6][26]. In addition, phycoremediation has advantages over other conventional physico-chemical methods, such as ion exchange, reverse osmosis, dialysis and electro-dialysis, membrane separation, activated carbon adsorption, and chemical reduction or oxidation, due to its better nutrient removal efficiency and the low cost of its implementation and maintenance [5][28].

Role of Blue Green Algae in Phyco-remediation

Blue-green algae (also known as Cyanobacteria) are the largest and most diverse group ofPhotosynthetic prokaryotes. Their habitats vary from fresh and marine water to terrestrial environments in different morphologies including unicellular and filamentous forms. They are oxygen-evolving organisms that respond to stress conditions such as light deprivation [4]. Cyanobacteria are nature's unique gift to mankind, as they possess several innate properties that make them ideal organisms with potential for multifaceted biotechnological applications. On account of their immense applied biotechnological potentials, they are being explored widely. Cyanobacteria are Gram-negative prokaryotes as they lack internal organelles, a discrete nucleus and the histone proteins associated with eukaryotic chromosomes, but form a connecting link with algae because of their pigment composition and photosynthetic mechanism.

These cells have developed natural methods of responding to metals such as copper, lead, and cadmium through passive accumulation in cells and through surface binding to various functional groups. They have also been found to remove harmful metals from the environment. For example, Spirulina platensis, a cyanobacterium, was shown to contain detectable levels of mercury and lead when grown under contaminated conditions [27], implying that this cyanobacterium was taking up the toxic metal ions from its environment. Further studies confirmed that this cyanobacterium both adsorbs and takes up metal ions [1]. Reports indicate that carboxyl groups on algal cell biomass are responsible for binding to various ions [10]. Live algae possess intracellular polyphosphates which participate in metal sequestration, as well as algal extracellular polysaccharides that serve to chelate or bind metal ions [13][29][30]. Strains of Synechocystis spp. have been shown to develop a thickened calyx when exposed to copper-stressed growth conditions [9]. Synechococcus sp. PCC 7942 was found to possess a copper-transporting P-type ATPase in the thylakoid membrane [3]. Synechococcus cedrorum 1191 was shown to be tolerant to heavy metals and pesticides [11]. Other investigators have studied the biosorption of heavy metals by algal biomass [25]. Spirogyra maxima have substantial ability to remove Lead and Manganese from waste water and hence, they could be recommended for phycoremediation [20].

Blue green algae have gained a lot of attention in recent years because of their potential applications in biotechnology they have been identified as a rich source of biologically active compounds with an antiviral, antibacterial, antifungal and anti cancer activities. In fact, some species can live in complex habitats submitted to extreme conditions, for example changes of salinity, temperature, nutrients, UV radiation etc therefore, they must adapt rapidly to the new environmental conditions to survive producing a great variety of secondary biologically active metabolite which cannot be found in other organisms [15]. Besides its natural character, other important aspects related to the microalgae are their easy cultivation, their rapid growing and the possibility of controlling the production of some bioactive compounds by manipulating the cultivation conditions in recent years, microalgae

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have gained much attention due to their high nutritional value, high value chemicals, high growth rate as higher to compared to higher plants and the ability to utilize light energy. They possess intracellular polyphosphate which participate in metal sequestration as well as algal extra cellular polysaccharides that serve to chelate or bind metal ions.

Many researches revealed the contribution of algal biomass for heavy metal removal from waste water. Low –cost cultivation and high heavy metal ion uptake capacity, with suitable environmental conditions (pH, temperature, and contact time) make algae biomass as a potential source for waste water bioremediation. Microalgae possess numerous considerable sequestering mechanisms and hence are demarcated as promising biosorbents. Heavy metals are non degradable and must be reduced to acceptable limits before discharging into the environment to avoid threats to living organisms. The studies from various sources indicated that the use of algae in phycoremediation is very effective and has potential for future applications. So there is a big need to explore this eco-friendly technique to reuse water resources and reduction of water pollution in India.

Microbial population in Periyar

Study on the qualitative and quantitative distribution of Blue Green Algal population and their ecobiological properties along the Cochin estuary shows [12], that the ecological conditions of Cochin estuary support their rich growth in this area and thereby adjoining Periyar river also. Chroococcus turgidus, C. tenax, Synechococcus elongatus, Synechocystis salina, Oscillatoria foreauii, O. fremyii, O.pseudogeminata, O. subtillissima, O. willei, Phormidium purpurescens and P. tenue were observed as versatile species in this area (Fig.1). Eloor industrial area situated around 13 KM north of the Ernakulum. It is an island of 14.21 KM 2 formed between two distributaries of river Periyar and largest industrial belt in Kerala. There are close to 200 industries of different kinds along the industrial belt including Fertilizers and chemicals Travancore, Indian rare earths limited, Hindustan Insecticides limited, Chemical-petrochemical products, Rare earth elements, rubber processing chemicals etc, discharge through the outlets with large quantity of effluents influence the Aquatic ecosystem of the Eloor. Total Coliform (TC) count in Periyar River, a major source of drinking water for the region, has gone up by several hundred folds in the past eight years, raising questions on drinking water safety, as per the data released by Kerala State Pollution Control Board (KSPCB) in the year 2020 [14].

Heavy metals present in Periyar

The major sources of pollution in the Periyar includes industrial pollution, Sewage, agricultural runoff etc. The river directly receives industrial effluents from the city. Metals play great role in the function of living organisms; they constitute nutritional requirements and fulfill a physiological role. But in the case of Heavy metal quantities in the environment is one of the persistent global environmental problems. This contamination caused by the increase of industries such as mining, fertilizers, tannery, paper, batteries, electroplating, chemicals etc. Heavy metals such as Zinc, Copper, Nickel, Mercury, Cadmium, Lead, Chromium and Arsenic released from the industries tend to accumulate in Organisms which may lead to a reduction in species diversity[8].

Blue green algae reported in Periyar river

Algal taxa belonging to the Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae dominated in the Periyar River. The Cyanophyceae includes Aanabena sp, Aphanocapsa sp, Cylindrosperma sp, Gleotrichia sp, Lyngbya sp, Nostoc sp, Oscillatoria sp, Phormidium sp, Spirullina sp, Synechococcus sp etc. [21].

A total number of 75 species of Cyanobacteria from 24 genera belonging to 7 families and 4 orders of the class cyanophyceae were recorded of which,31 were unicellular colonial forms, Cyanobacteria from Cochin estuary belonged to the following genera:

Aphanocapsa,Aphanothece,Chroococcus,Coelosphaerium,Dactylococcopsis,Eucapsis,Gloeocapsa,Gloeothece,Microcystis,Synechococcus,Synechocystis,Johannesbaptistia,Chlorogloeoa,Dermocarpa,Myxosarcinia,Spirulina,Arthospira,Oscillatoria,Phormidium,Lyngbya,Anabaena,

Pseudanabaena, Plectonema and Tolypothrix among these ,Oscillatoria was represented by maximum number of species;19 species were observed in this genera followed by Phormidium 13species,Chroococus5species,Aphanocapsa,Aphanothece,Gloeothece,Microcystis,Synechococcus and Synechocystis 2 species each and others by single species.(Figure I, II).[21].

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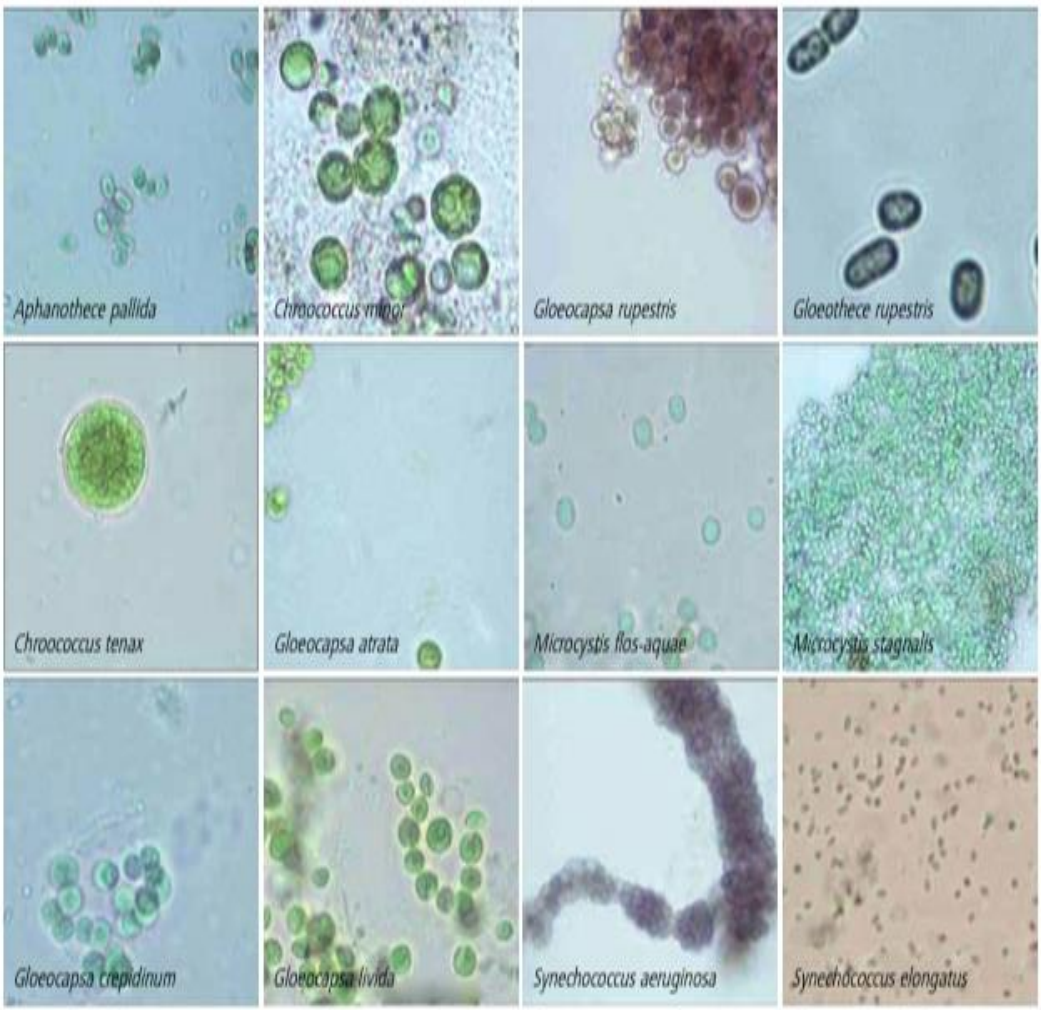

Figure I- Species diversity of cyanobacteria isolated from Cochin estuary

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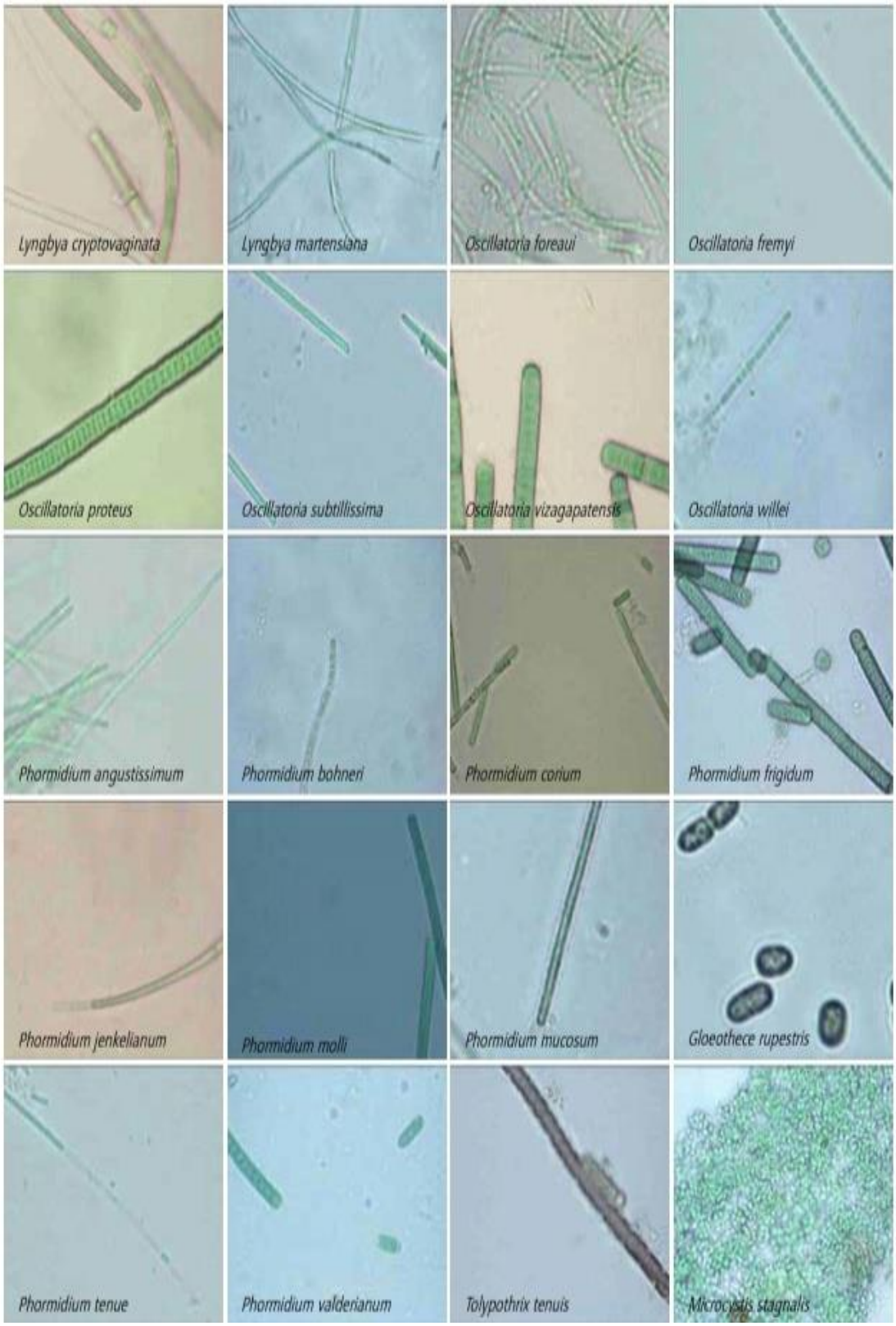

Figure II- Species diversity of Cyanobacteria isolated from Cochin estuary

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Heavy metal removal using Blue green algae

Heavy metals removal from biological agents in natural ecosystem. Also, biosorption charecteristics of Microcystis. Blue green algae investigation revealed that microcystis has the potential to remove heavy metal removal fruitful technology. Heavy metal through this nuisance bloom forming algae could prove an innovation technology. [22].

RESEARCH METHODOLOGY

The present Review article mainly used three types of methodology by Search Strategy in which Relevant scientific literatures from major databases were collected for Original research Articles on the Phycoremediation of Blue green algae In Periyar river. Second type Inclusion criteria in which Original scientific research studies that reported on the Phycoremediation of Blue green algae and the use of microalgae to clean up heavy metal in the Periyar was included. In the Third type Exclusion Criteria Articles that reported on Bioremediation of organic compounds and other biological techniques were excluded.

FUTURE OUTCOMES

Phycoremediation offers advantages over conventional methods like Land filling. Phycoremediation is often less expensive and site disruption is minimal, it eliminates waste permanently keeping focus on Bioremediation technology. The future out looks as genetic technology and Biofilm mediated bioremediation.

CONFLICTS OF INTEREST

The authors declared that there are no Conflicts of Interest regarding the publication of this paper.

CONCLUSION

Phyco-remediation is an eco-friendly tool to eradicate the excess toxics heavy metals from the industrial waste water. The blue green algae have been documented as a suitable and inexpensive factor for detoxification of industrial waste. Removal of heavy metal is very important in Eloor because it is complexed with almost 200 industries and the effluents are discharged in to the water leading to many health problems among the people near and around this polluted hotspot area. The mechanism for the removal of heavy metal through blue green algae works on the principle of adsorption onto the cell surface, the present review article mainly focused on the Phycoremediation potential of blue green algae based heavy metal removal with the effect of physicochemical parameters. Use of transgenic approaches to further enhance the heavy metal specificity and abatement property of blue green algae with the objective of using these blue green algae for the treatment of heavy metal contaminated waste water is required. Heavy metal safe level monitoring system should be established in the polluted area of the Periyar river. Concentration of all heavy metals in water should be measured at regular interval of time, Whenever he Heavy metal reaches above the safe level ,give immediate warning has to be issued and suitable action to be taken for Ecosystem protection.

DATA AVAILABILITY STATEMENT

The authors confirm that the data supporting the findings of this study are available within the article and its Supplementary materials.

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REFERENCE

1. Bender J, Rodriguez-Eaton S, Ekanemesang UM, Phillips P. Characterization of metal-binding bioflocculants produced by the cyanobacterial component of mixed microbial mats. Applied and Environmental Microbiology. 1994 Jul;60(7):2311-5.
2. Bolan N, Adriano D, Mahimairaja S. Distribution and bioavailability of trace elements in livestock and poultry manure by-products. Critical Reviews in Environmental Science and Technology. 2004 May 1;34(3):291-338.
3. Bonilla I, Bolaños L, Mateo P. Interaction of boron and calcium in the cyanobacteria Anabaena and Synechococcus. Physiologia Plantarum. 1995 May;94(1):31-6.
4. Borbély G, Surányi G, Kós P. Stress responses of cyanobacteria and the pleiotropic effects of light deprivation. FEMS Microbiology Ecology. 1990 Dec 1;7(2-3):141-52.
5. Dresback K, Ghoshal D, Goyal A. Phycoremediation of trichloroethylene (TCE). PHYSIOLOGY AND MOLECULAR BIOLOGY OF PLANTS. 2001;7:117-23.
6. Dubey SK, Dubey J, Viswas AJ, Tiwari P. Studies on Cyanobacterial biodiversity in paper mill and pharmaceutical industrial effluents. Biotechnology Journal International. 2011 Jul 5:61-7.
7. Fouilland E. Biodiversity as a tool for waste phycoremediation and biomass production. Reviews in Environmental Science and Bio/Technology. 2012 Mar 1;11(1):1-4.
8. Gardea-Torresdey JL, Arenas JL, Francisco NM, Tiemann KJ, et al. Ability of immobilized cyanobacteria to remove metal ions from solution and demonstration of the presence of metallothioneingenes in various strains. Journal of Hazardous substance research. 1998;1(1):2.
9. Gardea-Torresdey JL, Arenas JL, Webb R, Tiemann K, et al. Uptake of metal ions from solution by inactivated cells of cyanobacteria. InProceedings for 1996 Dec 31:48-58.
10. Gardea-Torresdey JL, Becker-Hapak MK, Hosea JM, Darnall DW. Effect of chemical modification of algal carboxyl groups on metal ion binding. Environmental Science & Technology. 1990 Sep;24(9):1372-8.
11. Gothalwal R, Bisen PS. Isolation and physiological characterization of Synechococcus cedrorum 1191 strain tolerant to heavy metals and pesticides. Biomedical and environmental sciences: BES. 1993 Jun 1;6(2):187-94.
12. Joseph S, Saramma AV. Species diversity of Cyanobacteria in Cochin estuary. Journal of the Marine Biological Association of India. 2016Jan;58(1):56.
13. Kaplan D, Christiaen D, Arad S. Chelating properties of extracellular polysaccharides from Chlorella spp. Applied and environmental microbiology. 1987 Dec;53(12):2953-6.
14. Kerala State Pollution Control Board (2020) Status of water supply and waste water generation and treatment in class I cities and class II towns of India report by KSPCB. http://www.indiawaterportal.org
15.Kumar V, Chopra AK. Reduction of pollution load of paper mill effluent by phytoremediation technique using water caltrop (Trapa natans L.). Cogent Environmental Science. 2016 Dec 31;2(1):1153216.
16.Liu W, Zhang Q, Liu G. Lake eutrophication associated with geographic location, lake morphology and climate in China. Hydrobiologia. 2010 May;644(1):289-99.
17. Lone MI, He ZL, Stoffella PJ, Yang XE. Phytoremediation of heavy metal polluted soils and water: progresses and perspectives. Journal of Zhejiang University Science B. 2008 Mar;9(3):210-20.
18. Munoz R, Guieysse B. Algal–bacterial processes for the treatment of hazardous contaminants: a review. Water research. 2006 Aug 1;40(15):2799-815.
19. Narasimha MN, Rangaswamy V. IMPACT OF EFFLUENTS OF SUGARCANE INDUSTRY ON SOIL PHYSICO CHEMICAL AND BIOLOGICAL PROPERTIES. I Control Pollution. 2007;23(1):73-6.
20. Nimisha P, Joseph S. Assessment of Phycoremediation Efficiency of Spirogyra Maxima by using Heavy Metals Manganese and Lead. International Journal of Environment, Agriculture and Biotechnology. 2020 Jun 5;5(3).
21. Panangattu, Sankarji ,Jayalakshmi., Jose John. Impact of massive flood in Kerala on the algal biodiversity of Periyar River.Indian Hydrobiologia, (2019).18(1&2):11-18.
22. Prasanthkumar, Santhakumaran,.Santhoshkumar,Kookal., JosephGeorgeRay. Diversity of fast growing algae of bloomed temple ponds in Kerala. Research gate, (2017);1-11.
23. Rai PK, Tripathi BD. Removal of heavy metals by the nuisance cyanobacteria Microcystis in continuous cultures: an eco-sustainable technology. Environmental Sciences. 2007 Mar 1;4(1):53-9.

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p-ISSN: 2319-9857

24. Sánchez-Bayo F. Insecticides mode of action in relation to their toxicity to non-target organisms. J. Environ. Anal. Toxicol. S. 2012;4:S4-002.
25. Schiewer S, Volesky B. Ionic strength and electrostatic effects in biosorption of divalent metal ions and protons. Environmental science & technology. 1997 Aug 28;31(9):2478-85.
26. Sen B, Alp MT, Sonmez F, Kocer MA, et al. Relationship of algae to water pollution and waste water treatment. Water treatment. 2013 Jan 16:335-54.
27. Slotton DG, Goldman CR, Franke A. Commercially grown Spirulina found to contain low levels of mercury and lead. Nutrition reports international (USA). 1989.
28. Thomas BF, Caineta J, Nanteza J. Global assessment of groundwater sustainability based on storage anomalies. Geophysical Research Letters. 2017 Nov 28;44(22):11-445.
29. Van Eykelenburg C, Fuchs A, Schmidt GH. Some theoretical considerations on the in vitro shape of the cross-walls in Spirulina spp. Journal of theoretical biology. 1980 Jan 21;82(2):271-82.
30. Zhang W, Majidi V. Monitoring the cellular response of Stichococcus bacillaris to exposure of several different metals using in vivo 31P NMR and other spectroscopic techniques. Environmental science & technology. 1994 Sep 1;28(9):1577-81.