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Role of algae-bacterial consortium in heavy metal contaminated water treatment

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Abstract
Heavy metal pollution of the environment is a global issue that has an impact on all types of natural life. Arsenic (As) and Cadmium (Cd), along with other heavy metals, permeate our environment and have a number of negative impacts. As and Cd are harmful compounds that are currently prevalent everywhere as a result of water pollution, temperature rise, and climate change in aquatic ecosystems. Using bacteria and algae to remove, decompose, or render harmless contaminants and harmful chemicals (As and Cd) in aquatic systems is currently gaining more attention. the use of bioremediation to remove heavy metals from aquatic environments. Heavy metal pollution of the environment is a global issue that has an impact on all types of natural life. Arsenic (As) and Cadmium (Cd), along with other heavy metals, permeate our environment and have a number of negative impacts. As and Cd are harmful compounds that are currently prevalent everywhere as a result of water pollution, temperature rise, and climate change in aquatic ecosystems. Using bacteria and algae to remove, decompose, or render harmless contaminants and harmful chemicals (As and Cd) in aquatic systems is currently gaining more attention. the use of bioremediation to remove heavy metals from aquatic environments.

Keywords: *Pseudomonas aeruginosa*, cyanobacteria, arsenic, cadmium, bioremediation

Introduction

Because of human industrial activity, heavy metals, a concern that affects nature's oxygen atmosphere, contaminate water and soil. Wastewater can contaminate aquatic habitats with heavy metals like arsenic and cadmium, which can lead to pathogenic algae, fish, and aquatic plants. Cyanobacteria "the blue-green algae" from a group of gram-negative, photoautotrophic prokaryotes. It consists of individual cells, such as small group cells, blue pigment phycocyanin, and inside small granules cyanosomes or phycobilisomes. Nowadays cyanobacteria are not only explored in agriculture, pharmacology, biofertilizer, antiviral activity, anticancer activity, and antioxidant, but also in bioremediation. Chemical precipitation, which removes heavy metals from effluents by hydroxide precipitation, coagulation, and flocculation, is frequently chosen because it is both economical and straightforward to use. 2011 (Fu and Wang). These expensive processes, which are unsuccessful at removing contaminants that contain heavy metals and organic compounds, include electrochemical treatment, ion exchange, filtering, and reverse osmosis. (Hakizimana *et al*., 2017; Montazer-Rahmati *et al*., 2011) [9, 21]. Because they are readily available and occur naturally, bioremediation methods to remove heavy metal contaminants from effluents are seen as being both inexpensive and ecologically beneficial when used to treat considerable quantities of heavy metal-rich industrial wastewater. A new innovation in the removal of heavy metals from industrial wastewater is microorganism-based bioremediation. It offers solutions that are economical, efficient, and acceptable to the environment. By becoming resistant to heavy metal ions, these organisms can tolerate environmental stress. Some organisms can change heavy metals from their active state to their dormant state. (Yin *et al*., 2019) [12].

Recent review discusses the use of microalgae and bacteria consortium together to treat wastewater in order to reduce CO_2 emissions, and also used as an effective biological absorbent due to their rapid growth and high absorption capacity and affinity.

Sources of Arsenic and Cadmium in the environment: The environment is a natural source of heavy metals. Other elements that affect the ecosystem include the degradation of both plant and animal contaminants, precipitation or environmental release of aerosols from lava flow, wind erosion, dust from burning forests, botanical exudates, and sea spray. However, because of the world's growing industrialization in recent years, anthropogenic activities have increased the concentration of toxic metals in the ecology. In a recent examination, anthropogenic sources made for 18% of the arsenic and Cadmium (7.6%), and natural sources made for 12% of the arsenic and cadmium 1.3%. India is the world's second-most contaminated nation. Soil pollution is a common problem in many major, crowded towns where there is significant industrial waste generation. In West Bengal, India, the Ganga Plain initially developed arsenic contamination in 1984 (Garai *et al*., 1984) [22]. Since then, groundwater with regard to arsenic and cadmium has been investigated in the Dhemaji district of Assam, India, and other states including Assam, Bihar, Jharkhand, Manipur, Chhattisgarh, and Uttar Pradesh, are afflicted by arsenic poisoning (Mridul *et al*., 2009) [23].

Arsenic and Cadmium exposure and toxicological effects in humans: As exposure in humans causes a number of illnesses, including skin lesions and keratosis. (Rahaman *et al*. 2021) [17]. Chronic exposure can have negative physiological consequences on the heart, kidneys, nervous system, lungs, reproductive system, hematopoietic system, and blood (Faita *et al*. 2013) [7].

Arsenicosis is a waterborne illness brought on by increasing levels of as in drinking water.

A number of factors contribute to its development, including the extent and length of exposure, genetic predisposition, nutritional status, and others (Santra, 2013) [24]. Chronic exposure can have negative physiological consequences on the heart, kidneys, nervous system, lungs, reproductive system, hematopoietic system, and blood (Rahaman *et al*. 2021) [17]. Additionally, As has genotoxic effects that include sister chromatid exchange, aneuploidy, deletion mutations, micronuclei production, chromosomal abnormalities, and DNA-protein cross-linking. (Faita *et al*. 2013) [7].

Heavy Metal Removable Methods

As and cd have been removed from the environment using a variety of physical, chemical, and biological techniques in both lab and field settings. Reverse osmosis, ion transfer, adsorption with activated c and alumina, complexation with metal ions, coagulation, immobilization, and modified coagulation, as well as filtering and precipitation, are some of the chemical processes used. Drinking water can also be filtered by nanofiltration, purification, vacuum-UV irradiation, and ultrafiltration to lessen the toxicity of arsenic.

The first creatures in biological systems are micro-organisms, which have a better capacity for adaptation and can survive under challenging circumstances. They are the key environmental adapters, changing their genetic make-up, transferring genetic material, and using a variety of other methods to keep the ecosystem's structure and functionality.

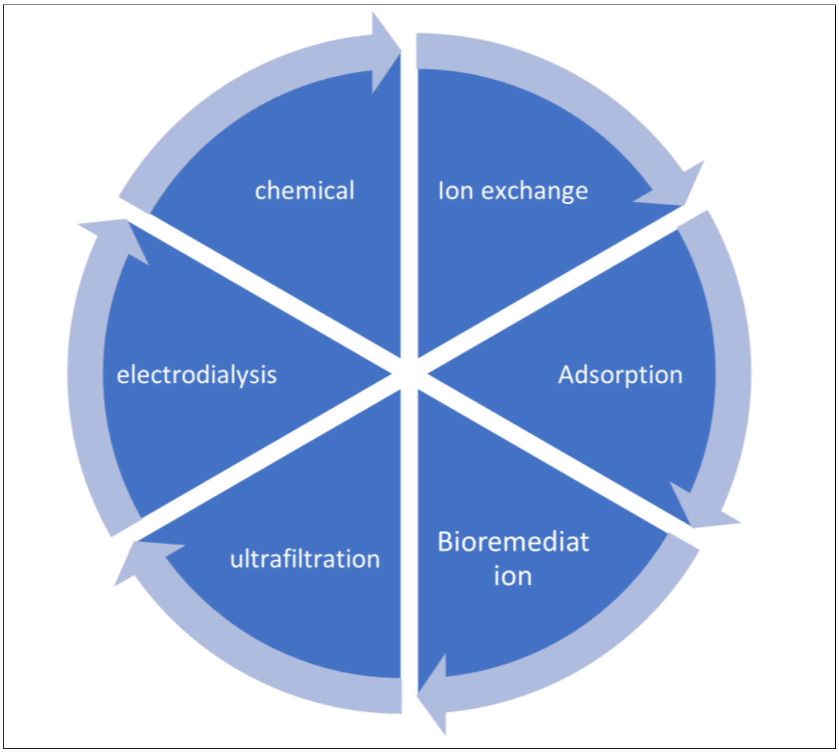

Fig 1: Heavy metals removable methods

Bioremediation

All procedures and actions used to restore the natural environment to its pre-pollution state are collectively referred to as bioremediation. It mostly makes use of bacteria, algae, and microorganisms, or their enzymes, to break down and change environmental pollutants into safe or less hazardous forms. It employs low-tech, low-cost methods that are typically well-liked by the common populace. While certain microbial processes immobilize metals and lessen their environmental mobility, others cause metals to become solubilized.

By using siderophores, methylation, autotrophic and heterotrophic leaching, chelation by microbial substances and volatilization, microorganisms may mobilise metals 2. Metal resistance is typically a plasmid-mediated trait in most of the bacteria studied. Bacterial plasmids containing resistance genes to several harmful metals and metalloids, such as and Cd, have been found.

Mechanisms involved in Arsenic Microbial Bioremediation

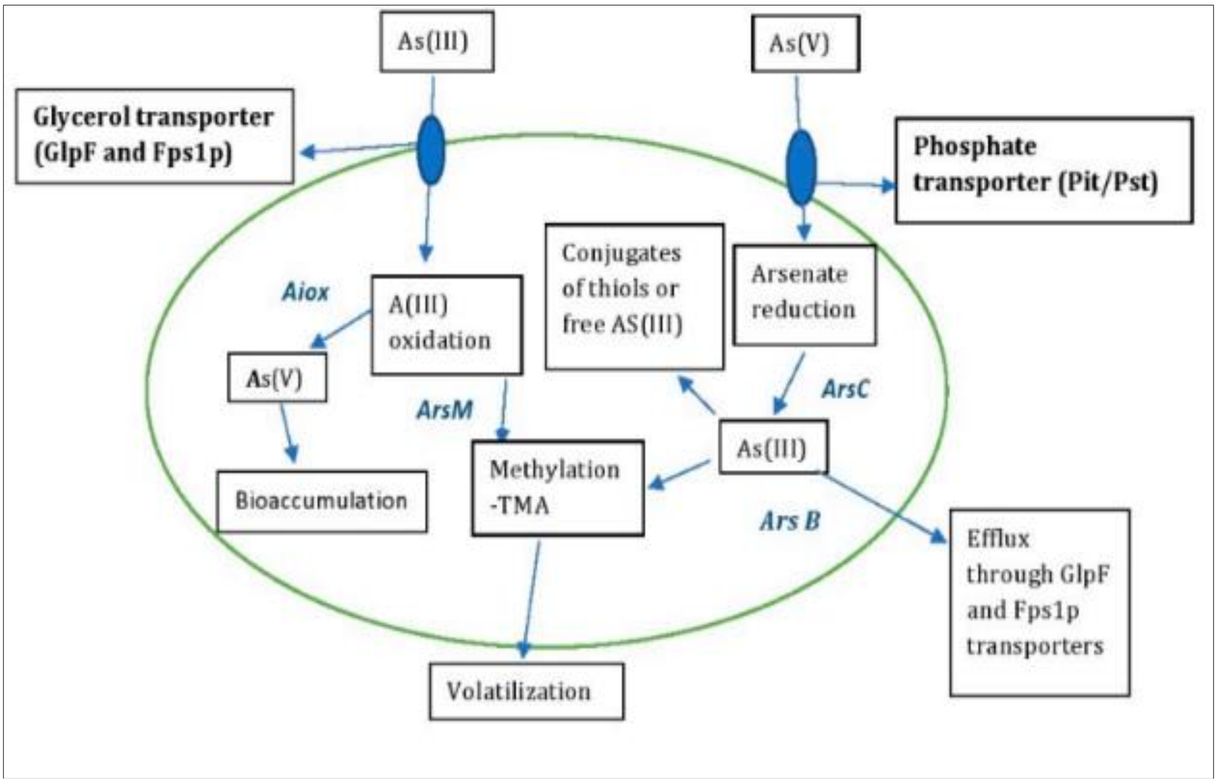

Fig 3: Bioremediation is a method used by bacteria to detoxify arsenic. (J.S.Y. Preetha, *et al.* 2023) [25]

Through enzymatic reduction reactions to oxidoreductases, Microbes can stabilize and detoxify heavy metals, making them less toxic to the environment (W. J. Baviskar., 2016) [4]. Resistant microorganisms recovered from various environmental samples mostly act on As (III) and As (V), transforming inorganic to organic forms through redox processes. (S. Paul., 2015). Numerous metabolic procedures, including oxidation, reduction, biosorption, methylation, and volatilization, are involved in the detoxification of arsenic. (S. Irshad., 2021) [10].

Mechanisms involved in Cadmium Microbial Bioremediation

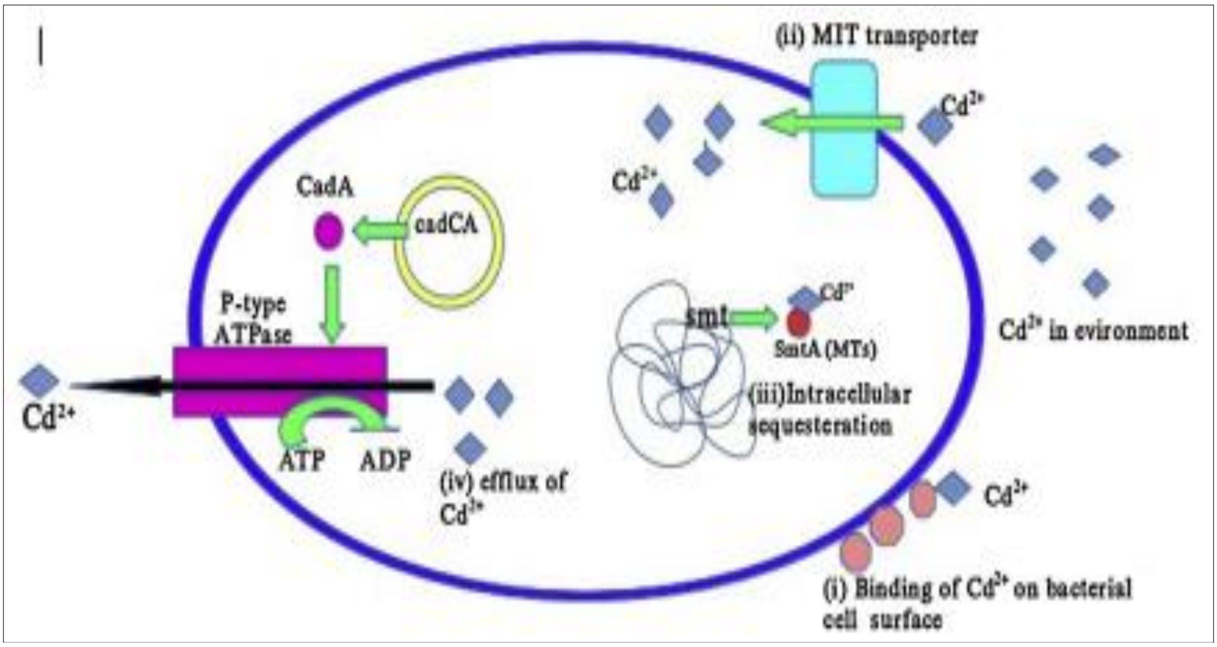

Fig 4: Bioremediation is a method used by bacteria to detoxify cadmium

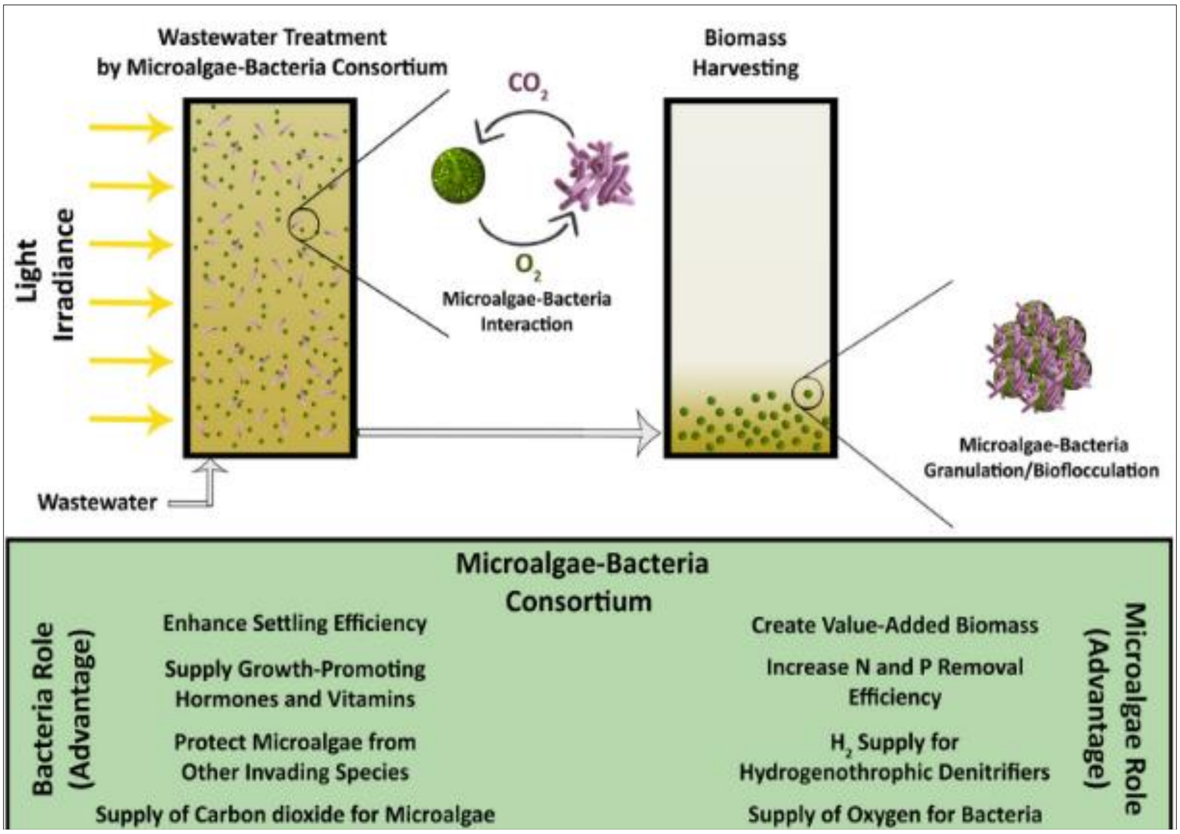

Fig 5: Wastewater treatment techniques (A. Fallahi., *et al.* 2021) [8]

Table 1: Heavy metal removal from wastewater by algae and bacteria

Algae	Bacteria	Origin of polluted water	Accuracy of Reduction of Heavy Metals	Reference
C. sorokiniana DBWC2, *Chlorella sp.* DBWC7	*Klebsiella pneumoniae* ORWB1, *Acinetobacter calcoaceticus* ORWB3	Synthetic wastewater	Copper 78.1% Chromium 76.3% Cadmium 55.2% Nickel 70%, Lead 65.1%	(Makut *et al.*, 2019) [14]
Chlorella sp., *Phormidium sp.*	Bacteria from sewage	Waste from tanneries	Nickel 74.54% Chromium 80%	(Sahoo *et al.*, 2019) [18]
C. vulgaris-BH1	Exiguo bacterium profundum-BH2	Wastewater with artificial metals	Copper78.67%, Chromium 56.4%, Nickel 80%	(Batool *et al.*, 2019) [26]
C. vulgaris, Scenedesmus quadricuda, Spirulina platensis	Bacteria from sewage	Urban wastewater	Cadmium 86%, Nickel 95%, Lead 87%	Abdel-Razek *et al.*, 2019) [27]
Scenedesmus sp.	Activated sludge micro-organism	Sewage wastewater	Chromium 100% Copper 59%, Nickel 65% Lead 83% Zinc 95%	(Lei *et al.*, 2018) [28]
Spirulina sp	Sulphate reducing bacteria		Cu 79.2%, Zn 88%, Fe 100%	Rose *et al.* (1998) [29]
Chlorella sp., *Scenedesmus obliquus*, *Stichococcus* strains, *Phormidium* sp.	*Rhodococus, Kibdelosporangium aridum*		Cu 62%, Mn 70%, Ni 62%, Fe 64%, Zn 90%	Safonova *et al.* (2004) [30]

Conclusion

Water pollution, increasing temperatures, and changing weather in aquatic habitats are all contributing factors to heavy metal contamination, which includes arsenic and cadmium. It is becoming more popular to use bacteria and algae in a process called bioremediation to remove these toxins from wastewater since it is both affordable and ecologically beneficial. Due to their tolerance to heavy metal ions, the photosynthetic prokaryote group known as cyanobacteria is particularly useful in bioremediation. These organisms can decrease CO_2 emissions, generate affordable biomass for bioenergy, and enhance biomass in a number of other ways. The damaging effects of heavy metals on aquatic environments can be considerably lessened by the employment of cyanobacteria and algae in bioremediation.

In India, poisoning from heavy metals like arsenic and cadmium is a serious problem because of soil degradation and the production of industrial waste. Using bacteria, algae, and other microorganisms, bioremediation is a low-tech method for removing contaminants from the environment and reverting it to its pre-pollution form. These procedures use oxidoreductases, which stabilize and detoxify heavy metals so they are less hazardous to the environment through enzymatic reduction processes. Arsenic toxicity is decreased throughout the detoxification process via oxidation, reduction, biosorption, methylation, and volatilization.

Future Aspects

- Algal-bacterial is the subject of intensive scientific study and development.
- Currently, algal-bacterial consortia provide enticing strategies and opportunities for environmental governance.

- This study focuses on the advantages of algal-bacterial mutually beneficial relationships for the environment, including bioremediation, waste water treatment.

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