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Microbial Strategies for Heavy Metal Removal from Industrial Wastewater

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Abstract: *The contamination of industrial wastewater with heavy metals poses a severe environmental and public health concern. Traditional methods of heavy metal removal often prove costly and environmentally unsustainable. In this context, microbial strategies have emerged as a promising and eco-friendly approach for effective heavy metal remediation from industrial wastewater. Microorganisms, including bacteria, fungi, and algae, have developed various mechanisms to withstand and sequester heavy metals from their surroundings. This review explores the diverse microbial strategies employed in heavy metal removal, encompassing biosorption, bioaccumulation, bioprecipitation, and bioleaching. These strategies exploit microbial cell surfaces, extracellular polymeric substances, and intracellular compartments to immobilize, transform, or release heavy metals. Moreover, recent advancements in genetic engineering and biotechnology have enabled the development of tailored microbial strains with enhanced metal-removal capabilities. The application of these engineered microbes, as well as naturally occurring strains, in bioremediation processes is discussed. This review also delves into the factors influencing microbial metal removal efficiency, such as pH, temperature, metal concentration, and co-existing contaminants. Additionally, the potential drawbacks and limitations of microbial strategies, including biomass disposal and long-term performance, are addressed. As heavy metal pollution continues to be a pressing global issue, understanding and harnessing microbial strategies for heavy metal removal from industrial wastewater holds significant promise for sustainable and cost-effective remediation practices. Integrating microbial processes into existing treatment methods can offer innovative solutions to mitigate the environmental impact of heavy metal contamination, thereby safeguarding ecosystems and public health.*

Keywords: biosorption, bioaccumulation, bioprecipitation, and bioleaching, heavy metal

I. INTRODUCTION

Pollution due to heavy metal is a serious issue. Rapid industrialization the heavy metal pollution is increased now a days. Cleaning up the polluted environment which is polluted by heavy metals by microbes or its enzymes is known as bioremediation. There are different methods for the removal of heavy metals they are membrane filtration, adsorption, ion exchange, electro dialysis and ultrafiltration.The presence of heavy metals in industrial wastewater represents a significant and persistent environmental challenge that has far-reaching implications for ecosystems and human health. Heavy metals, including cadmium, lead, mercury, chromium, and others, are ubiquitous in various industrial processes, and their discharge into wastewater streams poses a substantial threat to the environment and public well-being.

In recent years, microbial strategies have emerged as a promising and eco-friendly solution for heavy metal removal from industrial wastewater. Microorganisms, including bacteria, fungi, and algae, have demonstrated remarkable abilities to interact with and sequester heavy metals through a range of physiological and biochemical mechanisms. This interaction between microorganisms and heavy metals has opened new avenues for the development of bioremediation technologies that not only address the challenge of heavy metal pollution but also align with the principles of green and sustainable engineering.

The objective of the research is to study the amount of removal of heavy metals in the wastewater using the Yeast Saccharomyces cerevisiae. A removal of 95% is achieved under optimized conditions. In this study, procedure for immobilization of microorganisms in a polymer matrix was developed. Immobilization is achieved by cross-linking a

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high molecular weight chitosan polymer with lignosulphonate under mild condition from beads encapsulating bacterial cells. This method allows reuse of the cells , high cell loading and continuous processing. Also highlight the ease of conversion of batch process into a continuous mode and maintenance of high cell density. This is a major advantage among others for using immobilized cell systems.

1.1 PROBLEM STATEMENT

Heavy metals like arsenic, copper, cadmium, chromium, nickel, zinc, lead, and mercury are major pollutants of fresh water reservoirs because of their toxic, non-biodegradable and persistent nature. Factors responsible for the toxicity of heavy metals towards microorganisms: pH, oxidation reduction potential, inorganic anions, inorganic cations, water hardness, clay minerals, organic matter, and temperature.

II. LITERATURE REVIEW

The methods used for the removal of heavy metals by microorganisms are bioaccumulation, intracellular accumulation and extracellular accumulation. Gram positive bacteria is suited for metal ion removal. Fungi which is responsible for removal of uranium especially by Aspergillus fumigatus. Algae which is responsible for the removal are chlorella, Chlamydomonas, Ulothrix. (Ahmad et al., 2011). Fourier transform infrared analysis are especially used for analytical work and also used for analytical work and also used for determination of function group present in sample. Cyclic voltammetry have the mobility of microorganism to change the oxidation state of a metal via oxido-reduction process (Ahmad et al., 2011).

The potential of yeast Saccharomyces cerevisiae immobilized in chitosan by forming beads of chitosan/lignosulphonate matrix encapsulating the microorganism for biosorbing chromium metal ions in aqueous solution (Saifuddin.N et al., 2017) Bacterial cells have the ability to remove heavy metals by biosorption and bioaccumulation. Bacillus Subtilis strain exhibited high efficiency in biosorption of heavy metal (Abel et al., 2015)

Table: 2.1 Bacteria used for removal of heavy metal

BACTERIA	HEAVY METAL	REMOVAL CAPACITY(MG/G)	REFERENCE
Acinetobactor sp.	Zn(II)	36	Tabarakiet al.(2013)
Bacillus cereus	Cd(II)	31.9	Huang et al. (2013)
Bacillus sp.	Pb(II)	15.4	Ren et al. (2015)
Brevibacterium sp.	Zn(II)	41.9	Taniguchi et al(2000)
Desulfovibriodesulfuricans	Cd(II), Ni(II),Cr(IV)	99.9%, 98.3%, 74%	Ockjoo et al(2015)
Enterobacter cloacae	Pb(II),Cd(II), Ni(II)	171.8, 114.2, 32.2	Banerjee et al (2015)
Ochrobactrum sp.	Cd(II)	83.3	Khadivinia et al (2014)
Pseudomonas aeruginosa	Hg(II)	180	Yin et al (2016)
Pseudomonasfluorescence	Cr(vi)	40.8	Ozdemir et al (2009)
Enterobacter sp. J1	Cd(II)	46.2	Quintelas et al (2009)
Rhodobactercapsulatus	Zn(II)	160	Magnin et al (2014)
Staphylococcus epidermidis	Cr(IV)	56	Quiton et al (2018)

Table 2.2 Algae used for removal heavy metal

ALGAE	HEAVY METALS	REMOVAL %	REFERENCES
Chlorella sp.	Ca(II)	56	Raikova et al (2016)
Chlorella minutissima	Zn(II), Mn(II)	62,84	Yang et al (2015)
Chlorella vulgaris	Hg(II)	94.7	Peng et al (2017)
Eucheuma denticulatum	Pb,Fe,Cu,Zn	N/A	Rahman and sathasivam et al (2016)
Scenedesmus quadricauda	Cd(II),Pb(II)	65,69	Mirghaffari et al (2015)

III. MATERIALS AND METHOD

- The saccharomyces cerevisiae biomass used were routinely maintained in solid medium. YPD (Standard yeast complete medium) agar and preserved at 4℃.
- 10g of Bacro yeast extract, 20g of Bacto peptone and 20g of Bacto agar were added to approximately 700ml distilled water with constant stirring.
- 240g of glucose/dextrose was dissolved in 100ml od distilled water.
- Both were autoclaved separately.
- After allowing it to cool to about 50℃, media and glucose solution were combined and the volume adjusted to 1 liter with distilled water.
- The media was poured into sterile Petri dish.
- Cultures were grown by inoculating the liquid medium comprising the same substances expect the agar with the bacterial cells obtained from the YPD medium.
- Cultures were grown at 37℃ on an orbital shaker (200rpm).

IV. CONCLUSION

Using microorganisms to remove heavy metals from the environment is a viable and environmentally responsible method of reducing metal pollution in many contexts. Heavy metals can be absorbed, changed or even detoxified by microbes like bacteria and fungi through biosorption, bioprecipitation, and bioaccumulation. Compared to conventional chemical procedures, this approach has benefits like cost effectiveness, sustainability, and less environmental impacts. However, the type of microorganisms used, the environmental circumstances, and the particular metal pollutants present all have an impact on how effective microbial remediation is. To fully realize the potential of microbial based approaches for heavy metal removal and environmental cleanup, more study and optimization are required.

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