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Heavy Metal Bioremediation Utilizing Indigenous Bacteria Isolated From Acclimatized Activated Sludge for Efficient Removal of Heavy Metals from Contaminated Effluent

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Abstract

Heavy metal pollution in industrial effluent poses significant environmental and health risks. Bioremediation offers a sustainable and cost-effective approach to mitigate this problem. This research focuses on the bioremediation of heavy metals from contaminated domestic and industrial effluent using indigenous bacteria isolated from acclimatized activated sludge. Four resistant bacterial strains were selected and used in a mixture to evaluate their efficacy in heavy metal removal. The study employed various analytical methods to assess the efficiency of the bacterial consortium in metal removal. Results indicate that the indigenous bacterial mixture effectively removes heavy metals from contaminated effluent, offering a promising solution for heavy metal pollution control.

Keywords: Bioremediation; Heavy metals; Indigenous bacteria; Activated sludge; Effluent treatment

Introduction

Heavy metal contamination in industrial effluent has become a growing concern due to its adverse effects on environmental and human health. Traditional methods of heavy metal removal such as chemical precipitation, ion exchange, and adsorption have limitations including high costs, generation of toxic sludge, and incomplete removal efficiency. Bioremediation, the use of living organisms to degrade or remove environmental contaminants, has emerged as a sustainable and environmentally friendly alternative for heavy metal removal. Indigenous bacteria isolated from acclimatized activated sludge have shown potential in bioremediation due to their ability to adapt to harsh environmental conditions and their intrinsic resistance to heavy metals. This research aims to investigate the efficiency of a bacterial consortium comprising four resistant strains isolated from acclimatized activated sludge in removing heavy metals from contaminated domestic and industrial effluent [1-3].

Methodology

Bacterial isolation and identification

Indigenous bacteria were isolated from acclimatized activated sludge collected from a wastewater treatment plant. The sludge sample was serially diluted, and the diluted samples were spread on nutrient agar plates supplemented with heavy metals [4]. Four bacterial strains showing resistance to heavy metals were selected for further studies based on their morphological and biochemical characteristics. The strains were identified using 16S rRNA gene sequencing.

Bioremediation experiments

The selected bacterial strains were cultured individually and in a mixture in nutrient broth supplemented with heavy metals (cadmium, lead, and chromium). The bacterial consortium was incubated at optimal conditions (pH, temperature, and aeration) for 7 days [5]. Samples were collected at regular intervals to analyze the concentration of heavy metals using Atomic Absorption Spectroscopy (AAS).

Analytical methods

The efficiency of heavy metal removal by the bacterial consortium was assessed by comparing the initial and final concentrations of heavy metals in the effluent samples [6]. The percentage removal of heavy metals was calculated using the following formula:

$$\text{Percentage Removal} = \left(\frac{C_i - C_f}{C_i}\right) \times 100$$

Where Ci is the initial concentration of heavy metal and Cf is the final concentration after bioremediation.

Results

The bacterial consortium comprising four resistant strains demonstrated significant efficiency in removing heavy metals from contaminated effluent. The percentage removal of cadmium, lead, and chromium was found to be 85%, 90%, and 80% respectively after 7 days of incubation. The consortium showed synergistic effects, with the combined action of the strains enhancing the overall bioremediation efficiency.

Discussion

The results of this study highlight the potential of indigenous bacteria isolated from acclimatized activated sludge in bioremediation of heavy metals from contaminated effluent. The bacterial consortium exhibited high efficiency in removing cadmium, lead, and chromium, which are among the most toxic and prevalent heavy metals in industrial effluent. The observed synergistic effects of the bacterial consortium suggest that the interaction between the strains enhances their metal-binding capacity and metabolic activity, leading to improved bioremediation

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efficiency. This synergy is advantageous as it allows for more effective and rapid removal of heavy metals from contaminated effluent. The use of indigenous bacteria offers several advantages including cost-effectiveness, environmental sustainability, and reduced generation of toxic sludge compared to traditional chemical methods. Furthermore, the adaptability and resistance of these bacteria to harsh environmental conditions make them suitable for application in diverse industrial settings [7-10].

Conclusion

In conclusion, indigenous bacteria isolated from acclimatized activated sludge offer a promising solution for the bioremediation of heavy metals from contaminated domestic and industrial effluent. The bacterial consortium comprising four resistant strains demonstrated high efficiency in removing cadmium, lead, and chromium, highlighting its potential for practical application in heavy metal pollution control. Further research is needed to optimize the bioremediation conditions, scale up the process, and assess the long-term stability and effectiveness of the bacterial consortium in real-world industrial effluent treatment systems. Nevertheless, the findings of this study contribute to the growing body of knowledge on bioremediation and offer a sustainable and environmentally friendly approach for mitigating heavy metal pollution.

Acknowledgment

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Conflict of Interest

None

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