Potential of Microbial Biomass for Heavy Metal Removal: A Review

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ABSTRACT
Present review paper deals with extensive literature survey in exploring the potential of microbial biomass for the sequestering of toxic heavy metals from aquatic streams. Presently more than half billion people are underprivileged and deprived of fresh water, clean air, soil and pure food. Contamination of aquatic streams due to release of toxic metal ions is a stern issue demanding global concern. Toxic metals such as Cr (VI), Cd (II), Pb (II), Zn (II), Ni (II) and many more are being released in natural aquatic systems by various small and large scale industries such as tanneries, electroplating, galvanizing, pigment and dyes, metallurgical, paint, refining and metal processing etc. The utilization of various microorganisms such as yeast, algae and fungi helps in binding and extracting heavy metal ions such as Nickel, Cadmium, Lead and Chromium from natural as well as simulated wastewaters.

Keywords
Biosorption, Heavy metals, Microorganisms, Kinetic Studies

1. INTRODUCTION
Metals have played a critical role in industrial development and technological advances of modern society. Most metals are not destroyed; indeed, they are accumulating at an accelerated pace, due to the ever-growing industrialization. The major toxic metal ions hazardous to humans as well as other forms of life are Cr, Fe, Se, V, Cu, Co, Ni, Cd, Hg, As, Pb, Zn, etc. These heavy metals are of specific concern due to their toxicity, bio- accumulation tendency and persistency in nature [1,2,3]. In the past several disasters became natural evidences of metal toxicity in aquatic streams such as Minimata tragedy due to Methyl Mercury contamination and "Itai-Itai" by the contamination of Cadmium in Jintsu river of Japan [1,4]

Mounting health problems and its concern have motivated the researchers and environmentalists to find the solutions that would be helpful in the sequestering of these toxic metals from aquatic streams. The real impetus for improvements came in the 1950s and 1960s as a result of modification of the legislation and setting up of independent pollution prevention authorities at global level. Conventional methodologies like chemical precipitation, ion exchangers, chemical oxidation/reduction, reverse osmosis, electro dialysis, ultra filtration, etc. [5,6,7] were applied for the sequestering of heavy metals from aquatic streams. However, these conventional techniques have their own inherent limitations such as less efficiency, sensitive operating conditions, and production of secondary sludge and further the disposal are a costly affair [8]. Due to the problems mentioned above, research was intensified to look for alternative options to replace the costly and conventional methods. In last few decades attention has been diverted towards the utilization of microbial materials which can be suitable candidates for metal binding. The literature survey reveals the various options that have been explored by researchers in the removal process of heavy metals.

2. MICROBIAL BIOMASS FOR HEAVY METAL REMOVAL
High metal sorbing substrates such as bacterial, fungal and algal biomasses were explored in dead / inactive or in live form to remove heavy metals. Considerable potential was proved by various researchers for these naturally occurring and abundantly available small creatures. [9,10,11] Many bacterial species (e.g. *Bacillus, Pseudomonas, Streptomyces, Escherichia, Micrococcus* etc.), were tested for metal uptake. Algae was considered very promising sorbing agents [12,13,14] because of their prominent sorption capability and were readily available copiously in seas and oceans [15,16].

[17] Investigated the removal of Ni from solutions by *Pseudomonas alcaliphila*. It was inferred that the addition of an excess amount of citrate encouraged the complex degradation as well as Ni removal. [18] Evaluated the biosorption studies of Cr (VI) on dried vegetative cell and spore–crystal mixture of *Bacillus thuringiensis* var. *Thuringiensis* using the batch method as a function of pH, initial metal ion concentration and temperature. The optimum pH observed for Chromium (VI) ions was 2.0. Chromium (VI) ions uptake of *B. Thuringiensis* spore–crystal mixture was 24.1%, whereas its vegetative cell metal uptake was found 18.0%. [19] Studied that blue green algae *Spiruline* sp. was found capable of adsorbing one or more heavy metals including K, Mg, Ca, Fe, Sr, Co, Cu, Mn, Ni, V, Zn, As, Cd, Mo, Pb, Se, Al in addition to the biosorption of Cr^{3+}, Cd^{2+} and Cu^{2+} ions. [20] Reported that the biomass of *Enterobacter* sp. J1 isolated from a local industrial wastewater treatment plant was found very effective for the sequestering of Pb, Cu and Cd ions. The sp. was able to uptake over 50 mg of Pb per gram of dry cell, while having equilibrium adsorption capacities of 32.5 and 46.2 mg/g dry cell for Cu and Cd, respectively.

[21] Isolated heavy metal resistant bacteria from the soil samples of an electroplating industry, and the bioaccumulations of Cr (VI) and Ni (II) by isolates were also investigated. The optimum pH 7 indicated the applicability of the isolated *Micrococcus* sp. for the removal of Cr (VI) and Ni (II). [22] explored the use of powdered biomass of *R. nigricans* at optimum pH 2, stirring speed of 120 rpm, temperature of 45^0C and contact time of 30 minutes and results indicated the high adsorption at low initial concentrations. [23] Synthesized diethylenetriamine-bacterial cellulose (EABC) by amination with diethylenetriamine on bacterial cellulose (BC) for the adsorption properties of Cu (II) and Pb (II) and optimization studies were also carried out. Pseudo-second-order rate model was well fitted and adsorption isotherm was described by the Langmuir model.

The ability of biofilm of *Escherichia coli* supported on kaolin to remove Cr (VI), Cd (II), Fe (III) and Ni (II) from aqueous solutions was investigated in batch assays for the treatment of diluted aqueous solutions by [24]. The biosorption performance, in terms of uptake, followed the sequence of Fe (III) > Cd (II) > Ni (II) > Cr (VI). Recent reports [23] studied heavy metal bioremediation by a multi-metal resistant endophytic bacteria L14 (EB L14) isolated from the Cadmium hyper accumulator *Solanum nigrum* L. and was characterized for its potential application in metal treatment. Within 24 h incubation, EB L14 could specifically uptake 75.78%, 80.48%, 21.25% of Cd (II), Pb (II) and Cu (II) under the initial concentration of 10 mg/L. Similarly biosorption studies of heavy metals by whole mycelia of *A. niger*, *R. orysae* and *Mucar rouxi* for the removal of Cd, Ni and Zn. The efficiency was found to be enhanced by treating the cell wall fractions with 4 M NaOH at 120^{o}C.

3. CONCLUSION

In the light of above discussion it can be concluded that microbial biomass has a great potential for sequestering heavy metal ions from aquatic streams under optimized experimental conditions. Literature studies further explores the platform for the studies which may substitute chemical intensive conventional methods and directs towards greener technologies for environmental remediation.

4. REFERENCES

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