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Myco-remediation of chromium heavy metal from industrial wastewater: A review

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ABSTRACT

Chromium a heavy metal present in the effluent of the industries causes accumulation of toxicity in water. Chromium commonly has Cr (III) and Cr (VI), two oxidation states, in which hexavalent form causes more health issues to human, other species and environment. The increased anthropogenic effects, especially tannery industrial effluent contributes the higher percentage of chromium accumulation. Removal of heavy metal can be attributed to many aspects, conventionally the physio-chemical methods which superseded by biological means of remediation. Chromium resistant microbes can be used to remove metal ions of chromium from the effluent, as this can be considered an eco-friendly approach. The microbial accession of nanoparticles synthesis is being focused, due to its accuracy and specificity in results. Mycoremediation grabbed attention as fungal absorbance efficiency and the surface-mechanism of heavy metal ions correlates each other. Current study in-depth indulges the base to core mechanism of mycoremediation of chromium ions from different effluents. Fungal-assisted mechanism of chromium ions have insists to be fewer, which may gain attention by enhancing the methodology of removal of chromium ions. This study focuses on improvement of fungal strain and pave-way, to improvise the study with immobilization technique which renders usage of the adsorbents redundant usage and applications, substantially with the low-cost polymeric material alginate is given more importance for immobilization technique. Alginate apart from low-cost adsorbent, is an excellent support for fungal producing nanoparticles which would provide wide-cast and an extraordinary adsorbent material.

1. Introduction

Toxic heavy metals are inorganic chemical compounds that affects the environment causing pollution due to its non-biodegradability, accumulates the food chain, and bio-magnifications [47]. Strong heavy metal chromium (Cr) is found in waste products of industries including leather, ceramic materials, rubber, textile printing and dyeing, and chrome-plated metal components [91]. Basically, there are several oxidation states of chromium, the most dominant ones being Cr (0), Cr (III) or trivalent form, and Cr (VI) or hexavalent form [59]. A common heavy metal contaminant discharged from industries contaminating both agricultural soil and water bodies is Cr (VI) [29,56,57,86]. Hexavalent form of Chromium exists in different form based on their pH, pH range 1–6 dominant species the Hydrochromic acid, $HCrO_4^-$ and when the pH is more than 7, Chromate, CrO_4^{2-} [12,15,91].Comparing Cr (III), Cr (VI) is highly toxic and mobile in nature [27,88]. Cr (III) and Cr (VI) both have harmful consequences, such as altering cell shape and interact with chemicals, proteins, and DNA through the digestive, respiratory, and epidermal systems leading to the destruction of gene expression, respectively [29,96]. The USEPA (United States Environmental Protection Agency) recommends that drinking water should only contain 0.05 mg/L of chromium [42,59,89]. Therein, removal of chromium alongside with effective method with cost-effective proposition renders to be important.

Numerous methodologies have been built-in to remove the harsh chromium (Cr) metal. Currently, physical and chemical methods are available which enumerates its own disadvantages. Especially, the common methods ion exchange, photo-catalysis, chemical reduction and electro-kinetic remedies to treat the effluent containing Cr (VI) [83,88]. Although, disadvantages of these methods include building up of hazardous substances as by products, expensive operation and maintenance costs [90]. Bringing up an alternate method becomes mandate, Bioremediation becomes a best choice. Bioremediation occurs through varied mechanisms like bio-accumulation, biosorption and biotransformation which needs small investment, low-toxic accumulation, and very fewer secondary pollutants [41,79]. Despite all this, this method renders

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loss of microorganism which causes irregular developmental cycle and toxic effects which might have a greater impact in removal of Cr (VI) [32]. Certainly, a support material has been required in order to overcome the disadvantages rendering in making in more efficient adsorbent in different mechanisms. These support systems can be any type of natural or chemically modified materials. Certainly, Microbial Immobilization Technology (MIT), which becomes an exceptional methodology that paves way for researches upcoming in the field of sequestration of heavy metals from industrial effluents. This article reviews more on immobilization technology its uniqueness and advantages over other methods being currently studied, rendering greater understanding on views of MIT, especially, on fungal species. This article particulates on varied fungal immobilization, as they can be easily cultivable and has greater adsorptivity. The aim of the study is to create an outline on MIT with fungal species using a low-cost and supportive material for improved anchorage towards the heavy metal ions and render an impulsive way of sequestration of heavy metal Chromium from industrial effluent.

2. Sources and effects of heavy metal chromium

Heavy metals are substances that has high densities and higher level of toxicity. Most hazardous and cancer-causing heavy metals include lead (Pb), arsenic (As), cadmium (Cd), chromium (Cr), thallium (Th), mercury (Hg), and mercury (Cr) [84]. Chromium is found to be the twentieth most abundant element in earth’s crust, naturally found in ultramafic, basaltic and serpentinites rocks. Anthropogenic sources of chromium are from the effluents of industries including electroplating, paint, pigments chemical production, dyeing, electroplating, tell production, tanneries and paper pulp contributes in high chromium concentration wastes [26]. Especially, oxidations states of chromium has a greater impact on environmental and living beings dwelling. In agriculture, chromate fertilizers, tannery effluent, sewage sludge, and mine tailing drainage all release chromium in its oxidative forms, both trivalent and hexavalent [100,33,64,92]. According to the Central Water Commission (2019), the mining and ore processing, cement and asbestos manufacturing, and chemical industries all contribute to pollution of water bodies with chromium. The airborne particulates of Cr (VI) are released by mining, the chemical industry, and the energy sector. Individuals employed in sectors such as paint manufacture, metallurgical operations, mechanical alloying, animal skin dyeing, and electronic component manufacturing get affected mostly with many health hazards especially, cancer. Chromium is particularly known for its toxicity, one harsh carcinogen known since and causes many health issues [19]. The trivalent chromium in the cytosol interacts with various macromolecules, the genetic material as well and changes, as exposure increases causing mutagenicity. The valence state is directly proportional to the ill-effects caused to plants, especially affecting the growth and phytoharmones production. In addition, chromium causes cancer and allergic hypersensitivities in both humans and animals. To add-on, hexavalent chromium species acts as cancer-causing agents, mutagens and teratogens [38,105,51]. Common mode of exposure to chromium is through food, inhalation and skin contact.

In Human, chromium causes health issues including cancer especially in lungs, eczemic allergies, septal perforation, asthma in respiratory tracts, lung diseases, increased ulcer conditions in nasal layers, growth and reproductive abnormalities [80]. Likewise, in plants intake of Cr through carrier ions including sulphate/iron causes developmental defects of root, stem and leaves, and germination rate alterations. The up-take, transport and aggregation of Cr influences the poisonous effects on plants such as reduced photosynthesis, nutritional and oxidation imbalances, mutagenesis, lower seed germination rate, reduction in rate of growth, decrease in yield production, and suppressed activity of enzyme [71]. Industries release Cr into the soil and water, which enumerates in higher percent of pollution than in air. The discharged effluent penetrates into surface and ground water during the processing [72]. Increased concentration of the Cr level, decreases the level of soil fertility, its native microorganism and agriculture-functional ability [54]. Photosynthesis, water relation, oxidative balance, mineral nutrition and enzyme activity suppress are key impacts of Cr on plant physiology. Oxidative stress created through Cr can influence the lipid peroxidation, i.e., damage of cell membrane of plants [35]. Fig. 1. depicts a glimpse of Cr sources and its impacts on environment and human health.

3. Bioremediation process

The process "bioremediation”, eliminates hazardous pollutants such as heavy metals converting it to less hazardous chemicals, or elimination of entities causing the noxious action. Usage of biomass either dead/alive, degrades non-degradable substances and the final organic conversion into $CO_{2,}$ Water, nitrogen gas, etc. Bioremediation, especially targets specific contaminants and toxins causing zero ill effects on environment and living organisms. For any successful bioremediation process microorganism, nutrients and energetics are three important elements required. In any environmental conditions, contaminants can itself serve as carbon source thereby serving as energetics through redox reactions. At aerobic conditions, contaminants lose their electrons, while microbes use these as electron acceptor and reaching out anaerobic condition degrades the specific target pollutant [31].

Based on implementation process, bioremediation is classified into in-situ bioremediation and ex-situ bioremediation. Firstly, in-situ bioremediation involves introducing oxygen and nutrients into a contaminated environment through an aqueous solution, this allows natural bacteria to break down toxins. The methods used in this process include bioventing, bio-sparging, bio-slurping, and phytoremediation. Two subtypes of in-situ bioremediation exist: intrinsic bioremediation and artificial bioremediation. The former seeks to stimulate the microbes to boost metabolism by supplying them with nutrients and oxygen, while the latter directs microorganisms to the site of contamination. Ex-situ method involves application of methods after removing the contents in polluted environment and the methodologies involved are bio pile, windrows, bioreactor, and land farming. Kulshreshtha et al. [34]. Heavy metals are eradicated by bioremediation through bioaccumulation, and biosorption mechanisms. Bioaccumulation is a metabolism driven method where metal ions are accumulated through bio-sorbent intercellularly [94]. Through the physio-chemical process of biosorption, biomass gradually collect heavy metals by adhering to cell structure (Fomina M & Gadd, 2014). Bioaccumulation and biosorption techniques are the recently emerging approaches in wastewater treatment which is cost-efficient and intact to environment [21].

4. Immobilization and its methods

Microbial Immobilization Technology (MIT) is a cost-effective and environmentally friendly wastewater treatment technology that offers a significant alternative to traditional methods in industries. This method involves confining or retaining the free-living microbial cells and enzymes on a free surface area and keeping the complex active for various uses. Furthermore, various carriers and immobilization techniques can control chromium pollution by immobilizing microorganisms such as bacteria, fungus, and algae. This is regarded as an efficient way to reduce chromium pollution in microbial cells and enzymes [30,44,82].There are many researchers who reviewed the chromium removal with the MIT methodology, and a few of the prominent studies are tabulated in Table 1.

4.1. *Carrier selection*

The carrier is an important module in immobilization of substances onto it. The selection of the carrier material is one crucial factor that affects microbial immobilization [104]. The characteristics of the carrier

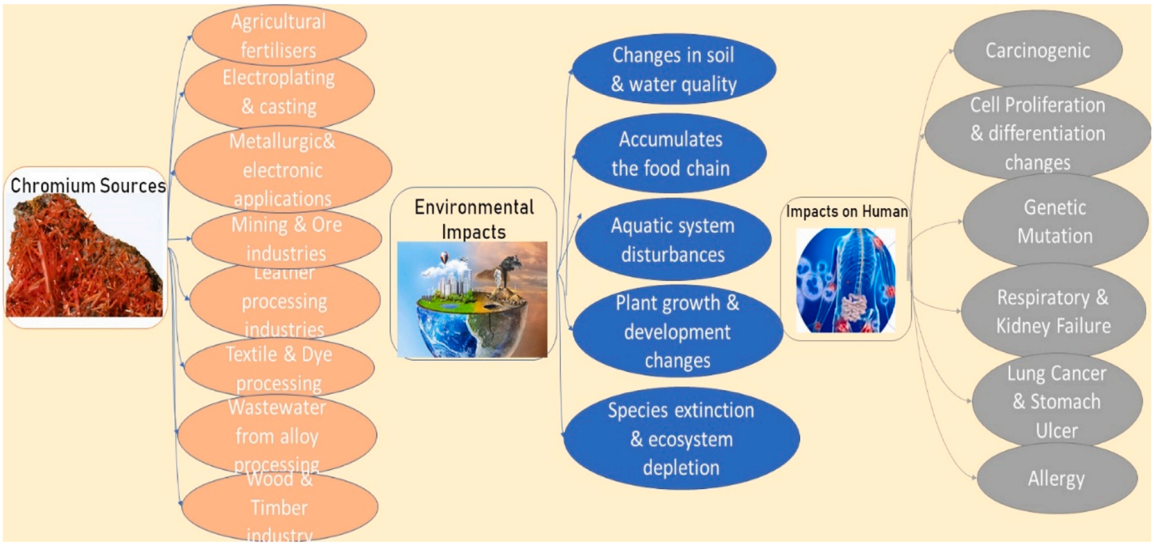

Fig. 1. Chromium sources and its toxicity.

Table 1
Chromium removal through MIT.

S. no	Microorganism	Carrier material	Method of immobilization	Reference
1.	*Fusarium oxysporum* OSF18	Sodium alginate	Biosorption	[14]
2.	Recombinant *Escherichia coli*	Magnetic pellets	Biosorption	[98]
3.	*Chlorella* sp.	Calcium alginate	Biosorption	[16]
4.	Cyanobacteria *Limnococcus limneticus*	Calcium alginate	Biosorption	[75]
5.	*5.1 Saccharomyces cerevisiae* *5.2 Rhizobium*	Multi-walled carbon nanotubes (MWCNT)	Biosorption	[70]

materials, like their mechanical strength, pore size, specific surface area, and structure, are significant for the microbial load [95,61]. At present, widely used carrier materials for this method are inorganic carriers, organic carriers, new-type carriers, and composite carriers.

4.1.1. *Organic carriers*

Organic materials are formed as gels using high-density polymers to embed microorganisms onto them [7]. Naturally occurring carriers (like agar and alginate) and manufactured polymers (like polypropylene, ammonia, polyvinyl alcohol, etc.) are the two subclasses of organic carriers [8]. Alginate is a translucent, permeable, and non-toxic matrix that protects immobilized cells from harsh environments and provides the microbe with an appropriate habitat [28,65]. Sodium and calcium alginate beads are the most widely used carriers, and recently, many researchers have studied on this basis. Though natural carriers are widely used, poor mechanical strength and chemical instability are their main disadvantages. Alternatively, synthetic polymers are used as they've got good mechanical strength, but their diffuse-ability is poor [101,87].

4.1.2. *Inorganic carriers*

Inorganic carriers, such as activated charcoal, biochar, diatomite, and others, are utilized because of the holes in their structure that allow bacteria to be adsorbed to the surface [77]. The most popular of them is biochar, its rich functional groups, large specific surface area, and greater pore structure [37]. Biochar is a high-quality inorganic carrier that efficiently adsorbs microorganisms, providing a stable environment due to its biodegradability efficiency [39,40]. Cr (VI) is adsorbed onto the phenolic, hydroxyl, and carboxylic functional groups of the biochar, which then converts it to Cr (III) reducing toxicity [103].

4.1.3. *Composite carriers*

Separately, organic and inorganic carrier materials tend to have a lot of drawbacks in complex environmental situations. Therein, researchers have tried composite materials, that is, complexes that can complement each other [104]. Samani & Toghraie, 2019 is a recent study that used a polyaniline/sawdust/polyethylene glycol (PANi/SD/PEG) composite that is used in the removal of Cr (VI) adsorbing and reducing the chromium from the wastewater. Though it is advantageous to combine two carrier materials, the high requirement for preparing the material and its expensiveness limit its usage and application.

4.2. *Techniques for Microbial Immobilization*

Due to usage and different composition of surface molecules on the microorganisms, immobilization methods are carried out in different ways. The most commonly used are categorized as adsorption, covalent bonding, embedding, medium interception, and composite method [11].

4.2.1. *Adsorption*

The physical characteristics of the carrier material or the force that exists between them and the microorganism to be adsorbed are highlighted by adsorption [25]. Certainly, the positives of the method are easy handling and preparation, good microbial activity and good mass transfer ability. Although, this tend to have weak contact between microorganism and carrier material, cause loosening. El Sayed and El-Sayed 2020 is one recent study that was to estimate the biosorption capacity of *Fusarium solani* to absorb Zn (II) and was observed to be at 600 mg/l Zn (II) concentration, pH 4.0 and 5.0 with incubation time of 30°C, time 40 min.

4.2.2. *Embedding*

Embedding, the encapsulation of the microbial cells to carrier, which will be effortless and has minimal effect on microbe cells. Commonly used embedding methods are fiber embedding, gel embedding and microcapsule [25]. Entrapping may cause larger mass transfer resistance, were the substrate and product should be compact molecules. Thereby, aerobic microorganism cannot be handled due to bad permeability [76]. Materials used in this method can be alginate, polyvinyl alcohol, etc. as these materials will have pores in their structure which will entrap the pollutants [9]. Cuong et al., 2018 is one research that looked at how much Cr (VI) heavy metal was removed from industrial wastewater using two melanin-embedded beads from two separate melanin powder (IMB/CMB) sources. The highest values for IMB and CMB, respectively, were 19.60 and 6.24 under optimal circumstances.

4.2.3. Covalent bonding

Covalent bonding uses the surface functional groups in order to bind with the carrier molecules. This method uses amino, carbon, imidazole, hydro and sulfhydryl functional group on the microbial cell surfaced to bind with the carrier molecule surface, so that it cannot be easily broken-off, having greater stability and strong binding force [20]. However, this method is difficult in handling, thus, presently this method isn't recomended for chromium-contamination [27].

4.2.4. Medium retention

The membrane biological approach is the source of the medium retention procedure. This particularly depends upon the carrier structure in order to trap the microorganism into its range, which rejects the movement of microorganism without affecting the material. Clogging and fouling of the membrane are the certain drawbacks of this method [81].

4.2.5. Composite immobilization

Combining one or two of the previously mentioned techniques results in composite immobilization. This can be beneficial if it operates simply, performs well, and is economical. A key component of this composite immobilization approach is the adsorption/embedding. Microorganisms and carrier molecules are mostly combined to create a compound that is fixed in the gel, much as calcium/sodium alginate. This highlights not only the high concentration of immobilization strength but also the inactivation of the microorganisms as a result of the carrier material's microenvironment and nutritional supplement [60]. Luo et al., 2019 study was about the immobilized *Shewanella xiamenensis* polyvinyl alcohol/graphene oxide biofilm, this estimate that film had great recyclability and biocompatibility, and graphene which acted as good electron shuttling to remove Cr (VI) by the microbe.

5. Fungal mechanism of heavy metal adsorption

Key factors involved in MIT are the selection of microbial strain and the carrier materials chosen. The cellular structure of the microorganisms traps the heavy metal ions and eventually adsorb these onto its sites of binding at microbial cell wall [48]. The amount of the adsorption depends upon the composition of the metal at cellular surface and kinetic equilibrium. MIT is faster as it follows equilibrium in minutes of the process initiation [17]. Taking in account bioaccumulation, microorganisms that collect heavy metals must be able to tolerate one or more metals at high concentrations and have improved transformational ability, which converts toxic chemicals into safer forms so that the organism can reduce the metal's toxicity level and retain metal [52].

A rigid cell wall composed of chitin, inorganic ions, lipids, nitrogenous polysaccharides, polyphosphate molecules, and protein molecules that can withstand toxicity is possessed by fungal species. With the help of its mycelium, spores, and internal and extracellular precipitation, the fungal cell wall's composition both tolerates and detoxifies the metal particles. Heavy metal elimination is achieved outside of the cells serving as ligand molecule binding sites for metal ions [18]. The first barrier works by ejecting chemicals that has the power to immobilize heavy metals. Heavy metals binding non-specifically through cell walls and melanin inside them, which is eliminated by the second barrier. The toxicity of heavy metals those cannot be removed by the exterior of the cell can be removed by interior structure of the cells [49]. The study focuses mainly on mycoremediation to remove chromium, different fungal strains involved in chromium is summarized in Table 2.

Table 2
Different fungal *spp*. used in Chromium removal.

S.no	Fungal Species used	Reference
1.	*Aspergillus niger*	[58]
2.	*Fusarium sp.*	[74]
3.	*Aspergillus niger, Rhizopus oryzae, Saccharomyces cerevisiae, Penicillium chrysogenum*	[58]
4.	*Fusarium solani*	[73]
5.	*Trichoderma viride*	[10]
6.	*Antrodia vaillantii*	[5]
7.	*Coriolus versicolour*	[69]
8.	*Termitomyces clypeatus*	[62]
9.	*Rhizopus sp. LG04*	[40,39]
10.	*Cladosporeum perangustum, Penicillium sp., Fusarium equiseti, Paecilomyces lilacinus*	[78]
11.	*Trichoderma sp.*	[85]
12.	*Saccharomyces cerevisiae, Rhizobium*	[70]
13.	*Penicillium oxalicum SL2*	[43]
14.	*Aspergillus terricola*	[50]
15.	*Fusarium oxysporum OSF18*	[14]
16.	*Aspergillus niveus, Aspergillus flavus, Aspergillus niger*	[13]
17.	*Aspergillus oryzae/ Penicillium roqueforti*	[45]
18.	*Byssochlamys sp., Candida maltose*	[3]

6. Applications of the immobilization with alginate beads

Alginate is most abundant polysaccharide present in nature. The use of alginate in removing heavy metal is the most interest-gaining study as, its structure and availability of the functional groups like bulk carbonyl and hydroxyl groups, which serve as the heavy metals' anchor sites throughout its polymer chain [2]. The utilization of alginate gel beads, which have been employed as adsorbents in the majority of current research. The mechanical strength of alginate gel is low, despite the fact that the ionic cross-linking method makes the preparation procedure simple and the conditions are benign. Parameters like alginate concentration, solution pH, salt concentration and type of salt are considered during the gelation, this is due to its large contribution to stabile nature, mechanical property and morphological structure of alginate gel [97]. Surface functionalization of material is to improve the mechanical strength of alginate and stability, this is also beneficial to alginate as it has established functional groups which enhances the binding capacity and absorptivity of the heavy metal to it. The selection of the material that incorporates with alginate has key role to enhance the adsorptivity. The choice of integrated material containing alginate is a crucial factor in determining the target pollutants' capacity to be adsorbed.

Functionalized alginate with organic compounds has always shown better results than the unmodified form in terms of characters and functional-ability. Omer et al., [55] studied to remove the Cr (VI) using tetraethylenepentamine on alginate via covalent interaction, which significantly improved the selectivity and adsorptivity of Cr (VI) as there was increased number of functional groups. This polymer was also incorporated with copolymer/ polymers in order to form a composite, this polymer can either be natural or synthetic containing the amine, aldehyde, methyl and sulfate groups for additional active sites for adsorption. Recent studies showed much use of chitosan [53,4], cellulose [24], xanthan gum [102], gelatin [68], poly-itaconic acid [46] and polyacrylonitrile [66] which showed multiple adsorption ability. Another interest gaining sections is alginate in immobilizing the micro-organisms like algae, bacteria, fungi and yeasts as they are easily-avail and holds greater potential applications majorly in wastewater treatment [36,1]. Carbonaceous materials (like biochar, activated charcoal, carbon nanotubes and graphene) are also one type of functionalizing as they have specific surface area, regulating chemistry, large mechanical & thermal stable characters and well-defined pore structure. Although, recent studies have shown the usage of magnetic based materials functionalized with alginate to exhibit good morphology and chemical stability, and easy separation of target from the sample solution from centrifugation or filtration [93]. Therefore, careful selection and handling of the alginate would enhance the adsorptivity of the heavy metals.

7. Sustainability of the immobilized microbe

Microbial immobilization technology is one of the most prominent method to evacuate heavy metals from industrial wastewater. While technological appropriateness and economic sustainability are important considerations, the chromium recovery volume and the immobilized microorganism's capacity for regeneration and reusability are also crucial. Henceforth, the immobilized microorganism must be regained with the eluent and used for the repetitive treatment cycles. As per many studies considered, NaOH has been considered as an effective absorbent material for elution and adsorbing the Cr from the biosorbent material being used [67,23,6]. Shailendra, *et al.,*2012 research used three adsorbents, observed that sodium hydroxide was observed to be good adsorbent, this might be due to adsorption of biosorbent material caused due to formation of the proton bridge effect on biosorbent, also alkaline washing will consume protons, recovery rate was found of Cr (VI) to be low. Additionally, it was difficult to separate the microorganisms, leads to secondary pollution. Recently, the alternative study has said that magnetically altered materials as carriers, which proved to be very stable and reusable as well as easily recyclable. This however had drawbacks as the adsorption ability was found out to be decreased 24 % after 5 runs of adsorption and desorption [99,22].

8. Insights and discussions

Although there are different mechanisms in removal of Chromium ions stated so far, adsorption stays to be quiet prominent. Mycoremediation based researches kept emerging since, but analyzing quiet few studies shows loss of fungal strains itself. Henceforth, this encounters to elaborate a mechanistic alternate method for more effective removal of Chromium ions. A composite adsorbent material prepared using the fungal strain synthesized nanoparticles immobilized with a low-cost support material may endure the removal pathway proficient. Since then, there is no study emerged with composite-based adsorbent for the removal of Chromium heavy metal, the reason for the adsorbent suggested is because of the sustainability of the support material rendering and the vacant spaces in its surface, the strength of the nanoparticles in order to adsorb and also, the selected fungal strain would have an extraordinary mechanism of captivating the negatively charged Chromium ions.

Improved mechanism of adsorption can be rendered using a composite material for any heavy metal ions can be noted from varied previous studies, one such example is the [63] which used a low cost composite adsorbent constructed in order to remove Cd and Pb ions from wastewater. Sustainability of beads made from alginate is literally the highest comparing to any other support material constructed, that is, the composite can be re-used for the removal mechanism until its ability to remove evades, each beads after optimized can be re-used for at least 2–3 cycles making cost effective process of removal. Despite of these advantages, the nanoparticles synthesis and beads formation using alginate would be challenging, but optimizing parameters could overcome the same.

9. Conclusion

Sequestration of heavy metals are one of the crucial and much required process, that must behanded to industrial sector, as the effluents from these sectors play key role in causing environmental pollution and troublesome to organisms. Various methodologies have been studied and kept studying since, as these heavy metals are enmesh. Bioremediation is a greater method for removal of heavy metals, especially mycoremediation is wondrous as this method uses fungus as adsorbent which anchors heavy metals stronger. Although, studies with varied fungal species have been conducted there are many commonly dwelling microbes like *Bacillus sp., Fusarium sp., sulfate reducing bacteria, Pseudomonas* which can be further studied through immobilization method as they are easy to isolate and has high detoxifying effects. Further, studied adsorbents were studied only in laboratory scale which can be upgraded to industrial scale tests for efficient validation. Adsorption isotherm and kinetics study for the so-studied adsorbent were found to be validated upto 96 %, there can be studies further enhanced removal upto 99 %. Eventually, carrier materials like biochar, nanoparticles, nanotubes, nanomaterials are kept unused functionalizing the material to immobilize which can be synthesized easier in laboratory scale easily and is also cost-effective. Reduction in coagulation and time consumption can be concentrated in further studies being conducted. Regeneration and reusage of the immobilized microbial adsorbents has to be further focused on. Recovery of the immobilized materials should be focused and studied. This study provides MIT as an irreplaceable method for recovery of heavy metal from industrial wastewater. MIT with fungal species can be eco-friendly, cost-effective if at all, further improvements can be a versatile methodology. Further, future prospects in view, studies with composite based on the immobilized fungal-synthesized nanoparticles. This study theoretically supports this mechanistic reasons, real-time research could be done for a prominent result analysis.

CRediT authorship contribution statement

R.V. Hemavathy:Writing – review & editing, Formal analysis, Data curation. **S. Shruthi**:Writing – original draft, Methodology, Data curation, Conceptualization

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: There is no such activities carried-out. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

No data was used for the research described in the article.

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