DISCUSSION

DISCUSSION

There are continuous researches going all over the globe regarding the biosorption of heavy metals and different ionic salts in water and different samples. Effective role of adsorbents now in existence as for different pH, temperature and nature of samples, thus lead to multiple absorbents and classes. Besides the absorption via carriers/adsorbents, a class of oxidizing bacteria is prevalent which oxidizes or degrades the specific element in the samples causing significant reduction.

Biosorption is now widely accepted as an effective method for chelating metals in water. Its performance, however, raises serious concerns when applied to actual industrial settings. Few studies have looked into whether or not fungal biosorbents are compatible with actual industrial effluents, so it's important to put the biosorption process through its paces before putting it into widespread use [129]. It is important to learn about the potential of a biosorbent for cleaning up metals and dyes in wastewater treatment plants/industrial effluents. The following are crucial considerations when using an adsorbent in an industrial setting:

a) Source and availability of the adsorbent
b) Effectiveness of removing the element
c) Cost/Reasonability
d) Ease of regeneration and availability of adsorbents.
e) Ease of usage of adsorbents as per processes

When considering a biosorbent for use in industrial settings, one of the most important considerations to take into account is how cost-effective it is. The true production costs of a new biosorbent are primarily comprised of the following:

a) Biosorbent prices,
b) transportation fees and
c) the cost of processing biomass into biosorbents are all factors to consider.

The biosorption process is more feasible than the industrial process because the raw material (biomass) is readily available as waste from another industry, and its source is close to the point of application. Although some biosorbents, like waste sludges, may be obtained for free, the high volume of material that would need to be transported could make the entire process unfeasible. As with any manufacturing procedure, the proximity of the raw material (biomass) source to the point of application improves the economic viability of the process. Considering these factors, it is clear that fungal biosorbents are a cost-effective choice.[162]

Both the design of the process and the type of process that will be used (batch or continuous) are entirely dictated by the selection of the biomass and the method that will be used to immobilize it. It is possible to operate biomass in a batch contactor configuration. In that case, the initial capital expenditure for the process development and set-up may be equivalent to chemical precipitation methods. Both methods necessitate using a contact vessel, a means of agitation, piping, and various ancillary devices like pH sensors and level controllers.

The costs of the immobilizing agent cannot be disregarded even though cell entrapment makes the biomass more robust mechanically and resistant to chemical and microbial degradation. Biosorbents can function in a packed or fluidized column configuration, depending on the availability of suitable and cost-effective immobilization techniques. Down-flow packed columns are more cost-effective to run than up-flow ones, but users sacrifice some control over effluent retention times, which could reduce biosorbent capacity. The efficacy of the waste stream can be improved by routing it through the columns/reactors in series. Ensuring that the added expense of a more advanced and automated treatment facility keeps the bank intact is essential. Due to the similarities between ion exchange and biosorption regarding technology and process principles, heavy metal biosorption is best carried out in fixed-bed continuous flow columns.

Because of the natural geochemical significance of fungal biosorption in the concentration of metals in soils rich in fungi and the fact that the potential of fungal biosorbents has been investigated, it is reasonable to anticipate that additional efforts will be made to commercialize biosorption in the field of heavy metal storage from wastewater [102]. Despite this, there have been only a handful of instances in which fungal biosorption processes have reached commercialization. There are many different types of commercially available biosorbents, such as AMT-BioclaimTM, which is made up of *Bacillus subtilis*, AlgaSORB, which is made up of *Chlorella vulgaris* [163]; and BIO-FIX,which is made up of a variety of different biomasses, including bacteria, algae [164], sphagnum peat moss, and fungi. The raw fungal biomass was immobilized on high- density polysulphone during the process that led to the development of the fungal biosorbent known as BIO-FIX. It has been discovered that this biosorbent is more selective for potentially harmful heavy metals than it is for alkaline earth metals. On the other hand, additional attempts to achieve a practical commercial application of fungal biosorbents have yet to be successful.

It is a bit of a contradiction that biosorption, which has been examined and perfected over decades, has a restricted number of applications. The limitations of the biosorption technology and the fact that the biosorption mechanism is not entirely understood may be the two primary reasons for this phenomenon. Over the last few decades, the fungus has garnered much attention as a promising biomaterial for eliminating metals due to its distinctive qualities. Fungus biosorbents are naturally susceptible to the same issues plaguing metal biosorption technology and benefit from its recent advancements.

Even though there has been only a limited amount of commercialization of biosorption, it is necessary to continue investigating the many different aspects that are significant to the application of biosorbents:

- The physicochemical settings, such as multi-ionic composition and pH, which should be selected to simulate the actual wastewater based on reaction kinetics studies and thermodynamics.
- The optimization of the parameters of the biosorption process, involving reuse and recycling, by researching the fluid dynamics and diffusion resistance on a sorption column or other chemical engineering reactors, for instance a fluidized bed reactor;

- The immobilization of the biomaterial; cutting costs associated with immobilization and, as a result, regeneration, distribution, and reuse of the biosorbent is essential. The selection of a good and inexpensive support material for biosorbent immobilization is one of the most critical factors. Other essential factors include improving reuse methods and enhancing the properties of immobilized biosorbents, such as pore ratio, chemical stability and mechanical intensity.

The immediate resolution to the issue above could involve implementing hybrid technologies. These technologies encompass integrated processes aimed at achieving efficient metal sequestration on an industrial scale. Hybrid technologies encompass two distinct categories: *Intra-biotechnological* and *Inter-biotechnological*. *Intra-biotechnological* approaches involve biotechnology-based techniques, such as biosorption, bio reduction, and bioprecipitation. On the other hand, *inter-biotechnological* methods integrate biotechnology-based processes with non-biotechnological processes, such as chemical precipitation and electrochemical processes. Both forms of hybrid technology can potentially utilize biosorption as an implemented process effectively. Additional ideas are required. However, it is imperative to sustain the pursuit of fundamental research concurrently. Several potential areas for future research in biosorption have been identified.

Hence, with ongoing research, particularly on pilot- and full-scale biosorption processes, it is anticipated that the landscape will evolve in the immediate future, rendering biosorption technology increasingly advantageous and appealing compared to existing technologies. The utilization of microbial biosorption presents a viable and cost-effective approach to address the removal and recovery of metals from aqueous solutions while also demonstrating environmental sustainability and efficacy. Using biosorbents' metal sorption capacity can be optimized by implementing pretreatment and immobilization techniques on the biomaterial while ensuring that physicochemical conditions are carefully controlled. Additionally, incorporating state-of-the-art technologies is recommended to enhance the effectiveness of this process further. The drawbacks associated with specific methods, such as inadequate metal removal, effective reagentand energy demands, and producing hazardous sludge or other waste materials necessitating careful disposal, have frequently been cited as reasons to advocate for amore cost-effective biological approach. This perspective has sparked considerable research interest in this area, leading to the development of several viable solutions to address the challenges mentioned above. Biosorption has frequently been suggested asa potential alternative or supplementary biotechnology in this particular context. However, paradoxically, it has yet to encounter much success in terms of practical implementation.

The utilization of a novel technology that combines carriers with oxidizing bacteria has shown promise in effectively, economically, and commercially viable reducing and removing iron and other elements from water samples while also demonstrating long-term stability.

Hence, it is imperative to acquire a deeper understanding of the fundamental principles and sophisticated methodologies to optimize the utilization of technology within practical industrial contexts. To enhance the adoption of biosorbent technology, it is imperative to develop strategies that concentrate on the facilities responsible for receiving used biosorbents. These centralized facilities would facilitate the subsequent processing of biosorbents, enabling either biomass regeneration or the conversion of recovered metals into a usable form. The development of biosorption technology for addressing heavy metal pollution in aqueous solutions necessitates an interdisciplinary approach that incorporates metallurgical expertise, the integration of biotechnological and non-biotechnological processes, and the fundamental sorption process. Therefore, the justification for conducting fungal biosorption studies is insufficient, particularly considering their potential for commercial development and application. The significance of employing multiple carriers for biosorption in environmental and conventional biotreatment processes indicates the need for additional investigation in these domains. The results of the present study corelates with the researches of the previous findings [165-181].

To corroborate the elimination/reduction of iron to larger volumes, properties of iron and principles of chemistry need to be considered. Principle of proportionality can be used to evaluate the elimination of iron in larger volumes. The key element to consider is the ratio of volume of the water to the Fe concentration.

Let us assume that the concentration of iron in 250ml of water is 10mg/L, we can determine the total amount of iron in the water by multiplying the concentration by volume –

Fe in 250ml of water = 10mg/l * 250ml = 2500mg

To measure elimination/reduction of iron in larger volume suppose 500ml, we can set up the following equation:

250ml (initial volume)/2500mg (initial Fe) = 500ml (desired volume)/ Z (desired iron)

Solving for Z by cross multiplying, we can easily calculate the amount of Fe that would reduce. However, methodology of elimination of iron, chemical properties and reaction kinetics etc. are some of the factors on which removal of iron actually depends. Hence, it is suggested to confer experts and scientific literature in the field for precise knowledge related to elimination Fe in different volumes.

Considering the elimination of every single heavy metal from water is necessary, the importance of Fe elimination sticks out due to its widespread presence. Fe is amongst the most frequently found contaminants in water resources, making its elimination a priority in processes of water treatment. Furthermore, the presence of Fe in water bodies can have prompt and striking effects on water quality, for instance staining and discoloration, which can be idyllically displeasing and bothersome for users.

Moreover, human health can be directly affected by the iron. Excessive levels of iron in drinking water opens the door for iron overload disorders, for instance hemochromatosis, which may instigate organ damage and different health complications. Even though, occurrence of other heavy metals like arsenic, mercury, lead and cadmium are also dangerous, their occurrence requires specific set of conditions for contamination.

On top of everything, elimination of iron from water resources is pivotal for facilitating the durability of plumbing systems and appliances. Accumulation of iron deposits in distribution systems lead to clogging of pipes, corrosion, staining and as a result flow of water is reduced. This gives rise to repairs which are costly, reduced efficiency of industrial and household equipment's that depends on water, as an example – dishwashers, irrigation systems, water heater etc.

In conclusion, while the elimination of each and every heavy metal from water is crucial, the extensiveness of iron contamination, its operational and aesthetical impact, potential health hazards and effect on distribution systems makes the elimination/reduction of iron an absolutely essential concern in water treatment processes.