An Overview of the Biosorption Method for Removing Heavy Metals from Contaminated Water

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Abstract

It has long been problematic to consume heavy metals from the environment. The disadvantages of conventional methods for the removal of hazardous metals include, among other things, a high reagent demand and the creation of toxic sludge. Toxic substances produced by metal plating, mining, sludge disposal, ore refinement, insecticides, and batteries. Therefore, efficient and environmentally friendly methods are needed for water treatment. Water pollution may be removed from the water supply using the practical and cost-effective technique of biosorption. This method is effective, economical, and environmentally friendly. Investigating sorption technology for the sequestration of pollutants is the focus of this review.

Keywords: Conventional, Heavy metals, Biosorption, Absorption, and Contaminants.

Introduction

Cr, Cd, Ni, Cu, and Pb are the principal toxic metal pollutants in wastewaters. Due to their non-biodegradability, poisonous compounds that have been released into the environment have caused environmental issues and may build up in the ecosystem.

Environmental problems are caused by heavy metal pollution.

Their concentration in fresh water is growing quickly due to industrial revolutions. The ecology is contaminated by industrial pollutants that include heavy metals.

Heavy metals are described as elements having metallic qualities and an atomic number larger than twenty, or metals that are often employed in industry and may be hazardous to humans and other living things. Heavy metals are a class of contaminants that cannot be broken down by living things.

Toxicology of heavy metals

An important environmental issue is caused by the toxicity of heavy metal pollution and its buildup in living organisms via food chains. Heavy metals have been the primary inorganic contaminants in nature because of their toxicity, persistence in nature, and biomagnification features. Even if they are present in undetectable amounts, concentrations may biomagnify to the point where they become dangerous.

Agricultural practises, coal-burning power plants, smelters, and mining sectors have all had major incidences of metal poisoning.

The majority of heavy metals released into wastewater are proven to be poisonous, cancer-causing, and seriously detrimental to human health8. Heavy metals are non-biodegradable, and their high levels of exposure to the environment have led to environmental issues.

Heavy metals contaminants are prevalent in the wastes of some industries, polymer industries, coal combustion plants, nuclear power plants, refineries mining operations, including metal plating and tanneries, and they seriously contaminate water systems when these wastes are released into water bodies.

Sources of heavy metals: Copper, lead, cadmium, arsenic, chromium, and nickel are the most typical heavy metal pollutants. Significant amounts of harmful compounds are found in the effluents from the leather, textile, tannery, galvanising, electroplating, paint, and other metal refining and processing processes. Both hexavalent and trivalent forms of chromium are present. The primary causes of toxicity include pulp processing, leather tanning, chromium plating, leather tanning, petroleum refining, and textile production. Brass manufacture and electric items require copper primarily.

The hazardous substances that are harmful to the environment, such as cadmium, arsenic, lead, chromium, zinc, and copper, also pose risks to human health. Problems arise when certain metals are concentrated in specific locations. The risk of cancer rises when heavy metals are released. The discharge of heavy metals raises the risk of cancer and has been linked to various degenerative disorders. The bones, endocrine glands, lungs, kidneys, liver, and central nervous system and the cardiovascular and gastrointestinal systems are all susceptible to injury from heavy metal poisoning in humans.

Contaminant removal is required:

Since they are environmentally harmful, heavy metals cannot be broken down biologically. In the food chain, heavy metal contamination of the water often becomes biomagnified. So it's crucial to get toxic materials out of the environment. Treatment of these pollutants in effluents before releasing them into water bodies is required due to toxicological effects on the environment.

Treatment using traditional procedures and their drawbacks:

Traditional water treatment methods use a mix of physical, chemical, and biological techniques to remove impurities and make water safe for consumption. Here are some of the most common traditional procedures, as well as their disadvantages:

Filtration: The process of passing water through a filter to remove contaminants is known as filtration. Filtration's primary disadvantage is that it cannot remove dissolved pollutants or pathogens.

Coagulation and flocculation: Coagulation is the process of adding a chemical coagulant to water, such as alum, to destabilise and clump together contaminants. Flocculation is the process of churning water to assist contaminants cluster together and settle. The primary disadvantage of coagulation and flocculation is that it is costly and time-consuming.

Sedimentation is the process of allowing water to settle so that pollutants sink to the bottom. The primary disadvantage of sedimentation is that it is time-consuming and does not remove all contaminants.

Disinfection is the destruction or inactivation of microorganisms in water by the use of chemicals or physical processes such as chlorination, UV radiation, or ozonation. The major disadvantage of disinfection is that it may not be effective against all diseases, and certain disinfectants may emit toxic byproducts.

Reverse osmosis: To eliminate contaminants, water is passed across a semi-permeable membrane. The primary disadvantage of reverse osmosis is that it is costly and energy intensive.

Traditional water treatment processes may be efficient at eliminating pollutants and making water safe to drink, but they have limitations such as cost, time, and efficacy against certain kinds of contaminants. When selecting a water treatment procedure, it is critical to carefully consider the advantages and disadvantages of each method.

Technology for Biosorption

The capacity of biological materials to remove hazardous chemicals from water is known as biosorption technology. Technology for biosorption provides benefits over traditional methods. The biosorbent has a modest price. Varying biomass may have varying metal-binding capacities for specific hazardous metals. Biosorbents are recyclable. With biosorption, sludge issues are nonexistent. Afterwards, metal can be recovered. Toxic metals in water may be removed using biomass. Waste products from large-scale industrial processes have come under the spotlight in recent adsorption investigations. In addition to toxicological standards, the behaviour of certain metals may also be based on typical data from research on their biosorption absorption. It is intriguing to explore and analyse elements like cadmium, chromium, arsenic, and copper because of their toxicity and chemistry. For the removal of the heavy metal ions, a variety of naturally occurring and waste materials, including coconut tree sawdust, cactus, olive stone cake, wool, and pine needles, have been employed as biosorbents. The biosorption experiments have used a range of microbial biomasses, including bacteria, cyano bacteria, algae, and fungus.

Batch studies: In a conical flask with a steady shaking motion, an adsorbent was added to a solution containing the appropriate concentration of metal ions. The biosorbent was subsequently removed by filtering the solution. Metal ion concentrations are measured both before and after adsorption. For batch studies, various parameters have been used, including contact time, adsorbent dose, pH, initial metal ion concentrations, and temperature. The time dependence studies provide information on the changes in metal ion adsorption that are time-related. For the sorption process and metal ions present in the solutions, such investigations need for a minimum contact time. Adsorbent surface area affects sorption. The quantity of metal ions adsorbed increases with adsorbent surface area. This seems to be caused by the biomass's increased availability of binding sites. Numerous working solutions with various pH levels have been used to determine the ideal pH for maximum removal.

Isotherms and Kinetics: To determine the maximum adsorption capacity of biosorbents and the appropriateness of biosorption, equilibrium data of metal ion biosorption are associated with adsorption isotherms. The adsorption isotherm demonstrates how the adsorbed molecules are distributed between two phases, such as the liquid and solid phases, when the adsorption process achieves an equilibrium condition. The kind of biosorption, such as monolayer or multilayer sorption, and the capacity of biosorption to rebuild heavy metal from the surface of biosorbent, are indicated by the greater applicability of adsorption data in a given isotherm. Adsorption isotherms are crucial for explaining how solutes interact with adsorbents and for effectively using adsorbents.

The adsorption investigations included a variety of isotherm models, including Langmuir, Freundlich, Redlich Patterson, Javanovic36, Dubbinnin astakhov, and Kobel corrigon. The primary kinetic models used to more accurately forecast how metal ions may biosorb onto biosorbents from waste fluids are the pseudo-first order model, pseudo-second order model, elovich model, and intra particle diffusion.

Instrumentation for analytical biosorption method

Both atomic absorption spectrophotometers and UV spectrophotometers are important analytical equipment for analysing pollutants because they can measure the colour intensity of heavy metals to calculate their quantities. Fourier converted infrared spectroscopy makes it easier to locate active areas on the biosorbents and confirm the sorption process. The different analytical methods, such as Atomic absorption spectroscopy, UV spectrophotometer, Fourier transformed infrared spectroscopy, and X-ray diffraction analysis, have been used for the biosorption process. These methods are useful for determining the metal concentration in water or waste water solutions, as well as for determining the chemical composition of interacted metal on the biosorbents. The existence of active sites on the sorbents is discovered using nuclear magnetic resonance spectroscopy.

Conclusion

The biosorption method for removing hazardous chemicals from water is an economical, environmentally beneficial procedure.

While biosorbents do not need to be disposed of safely, conventional methods for the removal of toxic metals have drawbacks like a high reagent requirement and the production of toxic sludge. Adsorption of toxicity from water using the biosorption approach is effective, affordable, and environmentally friendly.

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