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Review Paper

Heavy metals uptake from polluted water by biosorption-an overall review

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Abstract

Heavy metals uptake from environment has been a matter for a long time. Conventional methods for the elimination of toxic metals has disadvantages such as high reagent requirement and generation of toxic sludge etc. Toxic substances may be resulting from metal plating, mining operations, sludge disposal, refining ores, pesticides, batteries. Hence, economic and eco-friendly techniques are requisite for water treatment. Biosorption is an affordable and effective technical process applied to eliminate pollutants from water. This technology is efficient cost effectual and sustainable technology. In this review paper investigate sorption technology for the sequestration of pollutants.

Keywords: Heavy metals, conventional, biosorption, pollutants, uptake.

Introduction

Toxic metals i.e. Cr, Cd, Ni, Cu and Pb are main contaminants in wastewaters. The release of toxic materials into the environment has resulted environmental problems and due to their non-biodegradability, can accumulate in the environment. Heavy metal contamination results an environmental problem[1]. Due to industrial revolutions, their concentration in the fresh water is increasing very rapidly[2]. The industrial wastes containing heavy metals are contaminants in the ecosystem[3,4]. Heavy metals are defined as elements with metallic properties and an atomic number greater than twenty or metals have potential toxicity to human and other living organisms, commonly used in industry. Heavy metals are group of pollutants, which are not bio-degradable in living creatures[5]. Heavy metals contaminants are high in the wastes of some industries, such as metal plating, nuclear power plants, refineries, polymer industries, coal combustion plants, mining operations and tanneries[6] and cause serious heavy metal pollution in the water systems after exposed such wastes in water bodies.

Heavy metals toxicity

Heavy metal pollution results an important environmental problem due to the toxicity and their deposition in living creatures through food chains[6]. Due to their toxicity, persistence in nature, biomagnifications characteristics, heavy metals have been main inorganic pollutants in the nature. Even if they are present in undetectable quantities, concentrations may become biomagnified to such an level that they exhibiting toxic nature. The serious cases of metal toxicity are experience in mining industries, smelters, coal-burning power plants and agriculture[7]. Most of the heavy metals discharged into the wastewater are found toxic, carcinogenic and cause a serious health problems to the humans[8]. The heavy metals are non-biodegradable and exposure of large amounts of the metals into the natural environment has resulted in environmental problems[7,8].

Heavy metals sources: The most common heavy metal contaminants are copper, lead, cadmium, arsenic, chromium, and nickel. Effluents from leather, textile, tannery, galvanizing, electroplating, paint industries and other metal refining and processing operations contains significant quantities of toxic materials. Chromium exists in both hexavalent and trivalent forms. Chromium plating, leather, tanning, petroleum refining, textile manufacturing and pulp processing operations are main sources of toxicity. Copper is mostly in use of electric goods and brass production.

Hazards on human health: The toxic materials dangerous to environment such as, cadmium, arsenic, lead, chromium, zinc and copper. When Such metals concentrated in particular areas, pose some problems. Release of heavy metals increases the threat of cancers[9]. The release of heavy metals has been concerned in some degenerative diseases and increases the risk of cancers[9]. Heavy metal toxicity in human may damage the cardiovascular and gastrointestinal systems, central nervous system, lungs, kidneys, liver, endocrine glands and bones.

Necessity of contaminants removal: Heavy metals are toxic to environment and cannot be decomposed through biological degradation. Heavy metal contamination in water have a tendency to biomagnified during food chain. Hence removal of toxic materials from the environment is essential. In point of toxicological things on ecosystem, it becomes necessary to treat these contaminants in effluents before discharged into water bodies.

Conventional methods treatment and disadvantages: The technology for removal pollutants from water bodies include

chemical precipitation, ultra filtration, electrodialysis, reverse osmosis ion exchange and phytoremediation[10-12].The main disadvantages of the conventional methods are sludge generation, formation of toxic compounds during the process, high cost, and incomplete removal of certain ions and takes long time for heavy metal removal[13-14]. The disadvantages includes, high reagent and energy requirements, incomplete metal removal generation of toxic sludge that require careful disposal has made it necessary for a cost-effective treatment method that is capable of removing toxic materials from wastewater.

Biosorption Technology

Biosorption technology is the ability of biological materials for the removal of toxic substances
from water. Biosorption technology has advantages over conventional techniques. The cost of the biosorbent is low. Metal binding ability of various biomass can be different for various toxic metals. Biosorbents can be reused. No problems with sludge occur with biosorption. Metal can be recovered after sorption. Biomass can be applied to remove toxic metals from water. Recent adsorption experiments have focused attention on waste materials from large scale industrial operations[15-17]. Apart from toxicological criteria, in specific metals may also be based on representative their behavior may be in terms of results of studying their biosorption uptake. The toxicity and chemistry of elements such as cadmium, chromium, arsenic and copper make them exciting to research study. A number of naturally occurrence and waste materials such as coconut tree sawdust[18], cactus, olive stone cake and wool and pine needles[19] have been used as biosorbent for the removal of the heavy metal ions. A variety of microbial biomasses including bacteria, cyano bacteria, algae and fungi have been used in the biosorption studies[20].

Batch studies: A solution containing desired concentration of metal ions was treated with a certain amount of adsorbent in a conical flask at a constant shake[21-22]. The solution was then filtered and biosorbent filtered out. The concentration of metal ions before and after adsorption is determined. The different conditions have been applied for batch studies such as contact time, dose of adsorbent, pH, initial concentrations of metal ion and temperature. The time dependency studies offer data about the changes in metal ion adsorption related to time. In such studies the minimum contact time is required for sorption process and metal ions found in the solutions[23]. Sorption depends on surface area of adsorbent. Larger the surface of adsorbent then larger the amount of metal ion adsorbed. This appears to be due to the increase in the available binding sites in the biomass[24-26]. To find out optimum pH for maximum removal, a number of working solutions have been used with various pH[27, 28-32].

Isotherms and Kinetics: The equilibrium data of biosorption of metal ions are correlated with adsorption isotherms to find out the maximum adsorption capacity of biosorbents and suitability of biosorption. The adsorption isotherm indicates how the adsorbed molecules distribute between two phases like liquid and solid phases and when the adsorption process reaches on equilibrium state. The better applicability of adsorption data in a particular isotherm indicates the type of biosorption i.e. monolayer and multilayer sorption and the capability of biosorption to redevelop heavy metal from the surface of biosorbent. Adsorption isotherm is basically important to describe how solutes interact with adsorbents and is significant optimizing the use of adsorbents[33,34].

Various isotherm models such as Langmuir[33,34], Freundlich[34], Redlich Patterson[35], Javanovic[36], Dubbinnin astakhov[37] and Kobel corrigon[38]were used for the adsorption studies. The common kinetic models used for the more suitability of biosorption of metal ions on to the biosorbents from waste waters are pseudo – first order model, pseudo-second order model, elovich model and intra particle diffusion[39].

Biosorption analytical technique instrumentation

Atomic absorption spectrophotometer and UV-spectro-photometer concern analytical tools for determine heavy metal concentrations by measuring its color intensity are useful instrument for analysis of contaminants. Fourier transformed infrared spectroscopy is useful for verify sorption mechanism and for the determination of active sites present on the biosorbents. The various analytical techniques such as Atomic absorption spectroscopy is useful for the determination of metal concentration in water or waste water solutions, UV-spectrophotometer applied for determination of metal concentration in solution by color intensity, Fourier transformed infrared spectroscopy and X-ray diffraction analysis for crystallographic structure and chemical composition of interacted metal on the biosorbents have been used for the biosorption processes. The nuclear magnetic resonance spectroscopy is used to determine the presence of active sites on the sorbent[40-41].

Conclusion

The biosorption technique is low cost, environment friendly process for removal of toxic substances from water. Conventional methods for the elimination of toxic metals has disadvantages such as high reagent requirement and generation of toxic sludge and require a safe dumping whereas the biosorbents are not required to a safe disposal. Biosorption technique is efficient cost effectual and sustainable technology for adsorption of toxicity from water.

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