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Mini-Review Article

A Brief Discussion on Biosorption and Biosorption Technology

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ABSTRACT
Exposure of heavy metals in the environment especially in aquatic bodies is one of the major environmental issues. Heavy metals are non bio-degradable and accumulated in human body through food chains. Some heavy metals are essential for the growth and development of living organisms but most of them are very harmful even at very low concentrations. Addition of such metals into the waters may due to natural or anthropogenic activities. Various methods cited in the literature used for the removal of heavy metals are chemical precipitation, evaporation, electroplating, ion exchange, membrane filtration, carbon adsorption, phytoremediation etc. Among these biosorption is relatively new, cheap and efficient technique. This brief review discuss the effect of heavy metals and their sources, biosorption techniques, different parameters of biosorption and introduction of isotherm models and kinetic parameters for the suitability of biosorption of heavy metals on biosorbents.

Keyword: Heavy metals; conventional methods; biosorption; biosorption parameters

INTRODUCTION
Water pollution due to heavy metals is one of the challenging environmental issues. Heavy metals present in water or waste waters are in the soluble forms and become major aquatic contaminants. Due to industrial revolutions, their concentration in the fresh water is increasing very rapidly [1]. They are released in the environment due to natural and anthropogenic activities and almost all human activities have a significance contribution to release heavy metals in fresh and saline water, soil and air (Fig.1). Migration of these contaminants from contaminated to non contaminated areas as dust or leachates through the soil. The spreading of sewage and industrial wastes containing heavy metals are some tools for the heavy metal contaminants in the ecosystem [2,3]. Heavy metals are conventionally defined as elements with metallic properties and an atomic number greater than twenty or metals have potential toxicity to human and other living organisms or metals having density more than 4 gm/cm3 or metals commonly used in industry and toxic to man and other organisms in the environment. Heavy metals are group of pollutants, which are not bio-degradable in living organisms [4]. The most common heavy metal contaminants are copper, iron, zinc, lead, cadmium, arsenic, manganese, cobalt, chromium, mercury and nickel. Aqueous heavy metal pollution results an important environmental problem due to the toxicity of heavy metals and their deposition in living organisms through food chains [5].

HEAVY METALS IN NATURAL ENVIRONMENT

Heavy Metals in Natural Environment

Natural Processes

1. Volcanic eruptions
2. Metal corrosion
3. Leaching
4. Soil erosion

Human Activities

1. Mining
2. Fossil fuel combustion
3. Coal combustion
4. Nuclear power plants
5. Agricultural activities
6. Refineries and polymer Industries
7. Textile and paper industries

Fig.1: Sources of heavy metals in the environment

Heavy metals contaminants are usually high in the wastes of many industries, such as metal plating facilities, nuclear power plants, refineries, polymer industries, coal combustion plants, mining operations and tanneries [6] and cause serious heavy metal pollution in the fresh water systems after exposed such wastes in fresh water bodies. Metal contamination issues are becoming more serious in India and other developing countries. The serious cases of metal toxicity are observed in the areas of mining industries, foundries, 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 even at very low concentrations [8]. The heavy metals are non-biodegradable, persistant and exposure of large amounts of the metals into the natural environment has resulted in a number of environmental problems [7,8]. In human, heavy metal toxicity may damage central nervous system, the cardiovascular and gastrointestinal systems, lungs, kidneys, liver, endocrine glands and bones. The release of chronic heavy metals has been implicated in some degenerative diseases of physiological systems and increases the risk of cancers [9].

CONVENTIONAL METHODS OF HEAVY METAL REMOVAL AND BIOSORPTION

The commonly used procedures for removal of metal and heavy metal ions from aqueous streams include chemical precipitation, electrodialysis, ultra filtration, ion exchange, reverse osmosis 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 biosorption can be defined as the ability of biological material to take up heavy metals from waste waters through metabolically mediated or physicochemical pathways of uptake [15]. Biosorption is growth independent, not affected by the physiological activities of living microbial cells and more amounts of metals accumulated on the biosorbents. The major advantages of biosorption over conventional treatment methods are low cost, high efficiency, minimization of chemicals, no additional nutrient requirement, and reuse of biosorbent for further metal uptake and possibility of metal recovery [16-18]. Some disadvanges of biosorption like early saturation and lack of potential for multiple oxidation numbers for metal ions are very negligible. Recent adsorption experiments have focused attention on waste materials from large scale industrial operations [19-21]. A number of naturally occurrence and waste materials such as leaf mould [22], rice husk [23], groundnut husk [24], coconut husk and palm pressed fibers [25], coconut shell [26], coconut jute [27], coconut tree sawdust [28], cactus, olive stone cake and wool and pine needles [29] have been used as biosorbent for the removal of the heavy metal ions. A wide variety of microbial biomasses including bacteria, cyano bacteria, algae and fungi i.e. filamentous and unicellular yeast and lichens have been used in the biosorption studies [30].

BIOSORPTION TECHNOLOGY

The biosorption study is usually carried out in batch system although most envisaged industrial applications would employ some kind of flow through or continuous process. A wide variety of biosorption processes have been used and comparisons between them are difficult [30]. An industrial effluent mainly adds heavy metal ions to the water bodies. This effluent is used as an experimental solution to study the removal efficiencies of the adsorbents. In the recent past instead of using industrial effluent synthetic waste water is in practice as an experimental solution. It is the solution of some dissolved sulphate, chlorides, nitrate and other salts and used in the laboratory scale experiments and more homogenous and suitable than industrial waste water samples [31-35].

Batch operation: A solution containing desired concentration of metal ions was treated with a certain amount of adsorbent in a conical flask at a constant shake [36-37]. The solution was then filtered and biosorbent filtered out. The concentration of metal ions before and after adsorption is determined. The different process conditions have been applied for batch operation such as contact time, amount of adsorbent, pH, initial metal ion concentrations and temperature (Fig.2).

BATCH OPERATION

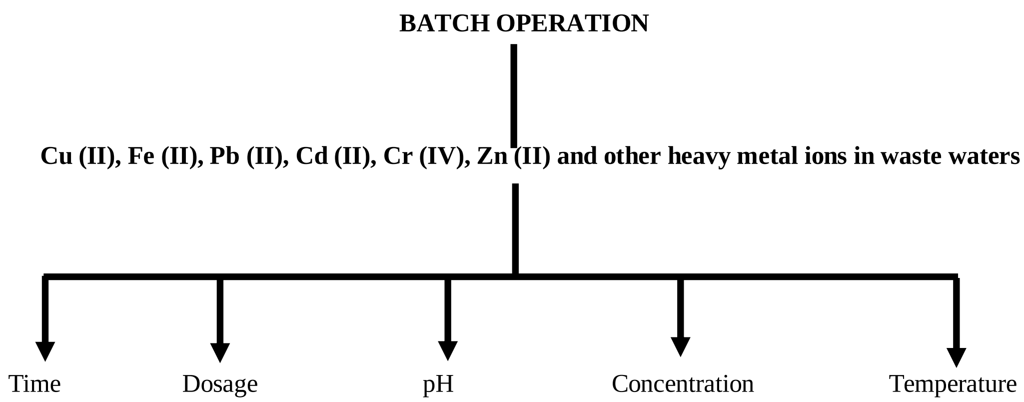

Fig.2 Batch operation including different parameters

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 the contact of biomass and metal ions found in the metallic solutions [38]. Larger the surface of adsorbent, are larger the amount of metal ion adsorbed. This appears to be due to the increase in the available binding sites in the biomass for the complexation of heavy metals [39-41]. In order to find out optimum pH for maximum removal, a number of working solutions have been used with different pH [42, 43-47]. The removal of metal ions increases with increase in pH; this may be due to the availability of non protonated active sites for metal ions and very less repulsion occurs between metal ions and non protonated active sites [40, 48-53]. The metal uptake by adsorbent increases till certain ranges of temperatures. But after a certain temperature the concentration of particular metal ion increases in waste water. In other words the adsorption rate decrease, it may be attributed to solubility of metal ions from biosorbents in solution [44,45,54,55].

Literature survey [56-58] reveals that the removal efficiencies of metal ions onto adsorbent are decreasing with concentration of these metal ions in synthetic waste water. But the metal ion adsorbate per unit mass of adsorbent (mg/g) increases with concentration of metal ions in synthetic waste water. This is due to an increase in the driving force of concentration gradient, as in the initial metal ion concentration [59-61].

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 viz. 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 adsorption and the capability of biosorption to regenerate heavy metal from the surface of biosorbent. Adsorption isotherm is basically important to describe how solutes interact with adsorbents and is critical optimizing the use of adsorbents [62,63].

Various isotherm models such as Langmuir [62,63], Freundlich [63,65], Temkin [66], Redlich Patterson [67], Javanovic [68], Dubbin radush kevich [69], Dubbinnin astakhov [70] and Kobel corrigon [71] 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 as proposed in the literature [72-75].

Analytical techniques: The various analytical techniques such as Atomic absorption spectroscopy for the determination of metal concentration in water or waste water solutions, UV-Vis spectrophotometer for determination of metal concentration in solution by color intensity, Fourier transformed infrared spectroscopy for the determination of active sites present on the biosorbents 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 of the biosorbent [76-77].

CONCLUSION

The biosorption process is efficient, cheap, and environmentally harmless, no excess chemicals are required and take no more time to metal uptake from the waste waters. Actually, this process is depend on the choice of good biosorbents and can be more successful. Recently, attention has been focused on various natural other solid wastage, which are able to remove heavy metal pollutants from the contaminated waste waters. Many waste materials from industrial and agricultural activities, naturally occurring waste materials, microorganisms i.e. algae, fungi, bacteria and some conventional cheap and artificial adsorbent represents potentially economical alternative. The conventional methods generate a large amount of sludge and other toxic compounds and need a safe disposal whereas the biosorbents are not needed to a safe disposal after the metal recovery.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this paper.

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