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BIOSORPTION: A solution for removal of toxic metals

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Abstract

Heavy metals contamination in ground water resources and in air has become a major issue of concern due to their higher toxicities, high capabilities in human body accumulaion and food chain, and carcinogenicities to humans and thus requires appropriate treatment of heavy metals before discharge in environment.

Some heavy metals in minute concentration are beneficial in some way but mostly there concentration exceeds the recommended level. Several research are carried out in order to eradicate the problems faced due to heavy metal contamination and biosorption is an ideal technology for this purpose.

Keywords: Heavy metals: Decontamination: Biosorption: Biosorbents

INTRODUCTION

A series of researches demonstrate that biosorption is a promising technology for removal of heavy metals from aqueous solutions. Heavy metal contamination in environment is major global concern due to its lethal effects. Most common contaminants found in contaminated water are Lead, mercury, chromium, arsenic, cadmium, zinc and nickel and their occurrence is great threat to living beings. Water is a source of life and energy, although millions of people are suffering with the shortage of fresh and clean drinking water. Rapid pace of industrialization, increased population, and unplanned urbanization have largely contributed to the severe water pollution . The main of freshwater pollution sources are discharge of untreated sanitary wastes, dumping of industrial effluent, and runoff from agricultural fields. Heavy metal ions have severe impact on all life forms as heavy metals are non-biodegradable, cleaning of contaminated water and soil is challenging. It is well known that 70–80% of all illnesses in developing countries are related to water contamination.

Sources and toxicity of certain metal ions are listed in Table 1[1].

- In view of the importance of water pollution control, a number of technologies have been developed. Several measures are taken to remove contamination and in order to minimize metal contents industries are instructed to treat waste before disposal. A number of methods that are operational already are chemical coagulation, ion exchange, reverse osmosis, solvent extraction, chemical precipitation, electochemical methods, adsorption using activated carbon. But all these conventional methods are although effective but are proving expensive due to non regenerable, non recyclable materials used and high cost production. So the objective is to search a technology which is cost effective and simple to design. Biosorption is emerging as an alternative technique that uses biological material to remove heavy metal from waste water. It can be performed using dead biomass and fragments of cells and tissues which may have some advantages as materials can be found easily as wastes or by-products and at almost no cost. This method is highly efficient it has low cost, no additional nutrient requirement, process is very rapid, as non-living material behaves as an ion exchange resin, the conditions of the process are not limited by the living biomass, no aseptic conditions required, process is reversible and metal can be desorbed easily thus recycling of the materials is quite possible.

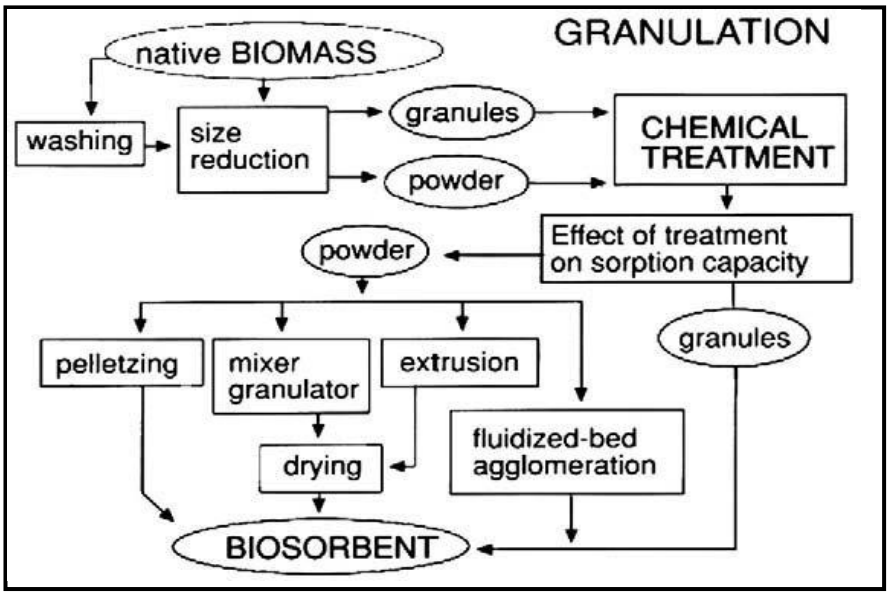
BIOSORPTION FUNDAMENTAL

Biosorption process involves, a solid phase (biosorbent, biological material) and a liquid phase(solvent, normally water) containing a dissolved species to be sorbed (sorbate, metal ion).

Table 1: Sources and toxic effects of heavy metals on human beings :

Metal	**Source**	**Toxic effects**
Lead	Elactroplating, manufacturing of batteries, pigments.	Anaemia, brain damage, loss of appetite, anorexia, diminishing IQ.
Cadmium	Electroplating, smelting, alloy manufacturing, pigments, mining, refining.	Carcinogenic, renal disturbance, lung insufficiency, bone lesions, hypertension, Itai-Itai disease, weight loss.
Mercury	Weathering of mercuriferous areas, volcanic eruptions, naturally- caused forest fires, biogenic emissions, battery productions, fossil fuel burning, Mining and metallurgical processes, paint, chloralkali industries.	Neurological and renal disturbances, corrosive to skin, eyes,muscles, kidney damage, impairement of pulmonary function.
Chromium(IV)	Electroplating, leather tanning, textile, dying, metal processing, wood preservtives, paints and pigments, steel fabrication and canning industries. Smelting, mining, energy production from fossil fuels, rock sediments.	Carcinogenic, mutagenic, teratogenic, Nausea, vomiting, severe diarrhoea, producing lung tumors.
Arsenic	Printed circuit board manufacturing, electronics plating, plating, wire drawing, copper polishing, paint manufacturing, wood preservatives and printing operations. Mining and manufacturing processes.	Gastrointestinal symptoms, disturbances of cardiovascular and nervous system functions, bone marrow depression, haemolysis, hepatomegaly, melanosis, polyneuropathy and encephalopathy, liver tumor.
Copper	Non-ferrous metal, mineral processing, paint formulation, electroplating, porcelain enameling, copper sulphate manufacture and steam-electric power plants	Reproductive and developmental toxicity, neurotoxicity, and acute toxicity, dizziness, diarrhoea.
Zinc		Causes short term ‘‘metal-fume fever”. Gastrointestinal distress.
Nickel		

Schematic diagram of processing different types of microbial biomass into usable biosorbents [2]:-



BIOSORBENTS

Biosorbent behaviour of various micro-organisms towards heavy metal ions is a function of the chemical make up of the microbial cells.Various biological material has an affinity for inorganic and organic pollutants meaning there is immense biosorption potential within countless types of biomaterial. Certain biosorbents are specific for particular type of metal ions. Several laboratories uses biomass which are easily available whereas other processed existing raw biomass to a certain level in order to enhance their properties. A large number of functional groups play important role in the metal ion uptake by the biosorbents.

Biosrbents such as Saragassum (algae absorbent specifically used for Cu (II) and Cr (III), Green algae "Spirogyra" is used as biosorbent material for Cr(VI). Use of algae as an absorbent is identified as a promising biosrbent as it have low requirement of nutrient, high uptake capacities, low cost, renewability, they produce large biomass since they are autotropic and unlike other biomass such as bacteria and fungi, they usually do not produce toxic substances**.** Metal ion binding on algal surface depends on different condition such as ionic charge of metal ion, algal species and chemical composition of the metal ion solution. *Holan and Volesky* had also reported the biosorption of Pb and Ni ion by biomass of marine algae.

Fungal biomass have been used efficiently for removal of toxic metal ion as it offers excellent metal binding properties and also biosorption provides an eco-friendly environment. Penicillium chrysogenum, extract gold from a cyanide ion solution [2] but the biosorption capacity was not substantial. Uranium and thorium can be removed by mucoralean fungi [5] whereby different metal deposition patterns could be clearly distinguished.

Numerous studies have shown, number of potential bacterial species capable of accumulating metals from aqueous environment. Bacteria make excellent biosorbents because of their high surface-to-volume ratios and a high content of potentially active chemosorption sites[7]. However evaluation of bacterial metal-sorbing properties has aroused several controversy as the basic principle of biosorption is the use of dead biomass but most of the experiments done with metals and bacteria have really concerned metabolically mediated bioaccumulation. Volesky and Holan [6], presented an extensive review of biosorption results, the strong biosorbent behavior of certain types of microbial biomass toward metallic ions is a function of the chemical makeup of microbial cells. In fact, the biomass is dead and all cells are metabolically inactive. For eg *Bacillus subtilis* known to bind with Cd, Cu, Pb and Al [8], *E. coli* cells efficiently bind copper, chromium and nickel and *M. luteus* sorbed cobalt ion most efficiently[9].

Biosorbent materials derived from low cost agricultural waste such as Peat, wood, pine bark, banana pith, soybean and cotton hulls, rice bran, saw dust, wool, orange peel can be used for the effective removal of heavy metal ion from waste water streams. The main advantage of agricultural waste biosorbent AWBs over other conventional adsorbents is their strong affinity and high selectivity toward heavy metals due to the abundant availability of binding groups on the AWBs surface, secondly are usually of low cost because generated from easy acquiring, abundant, agricultural origin materials (Marin-Rangel et al., 2012), Furthermore, AWBs can be easily processed, and recovered without effecting the environment (Wan Ngah and Hanafiah, 2008). Every year, large amounts of straw and bran from Triticum aestivum (wheat), a major food crop of the world, are produced as by-products/waste materials. The purpose of this article is to review rather scattered information on the utilization of straw and bran for the removal/minimization of metal ions from waters. High efficiency, high biosorption capacity, cost-effectiveness and renewability are the important parameters making these materials as economical alternatives for metal removal and waste remediation

CONCLUSION

Conventional technologies for decontamination of waste water by removal of toxic metal ions are proving expensive due to non-recyclable materials used and high costs and thus biosorption has attained importance as it is a technique that offers use of economical alternate biological materials for the purpose . Various functional groups such as carboxyl, sulphydryl and amido present make it possible for them to attach metal ions from waters. This article demonstrate use of several inexpensive and efficient biosorbent materials, for metal biosorption andtheir performance and drawbacks. The biosorption mechanism has been found to be quite complex. It comprises a number of phenomena including adsorption, surface precipitation, ion-exchange and complexation.

REFERENCES

[1] Biosorption of heavy metal ions using wheat based biosorbent. Umar Farooq , Janusz A. Kozinski a, Misbahul Ain Khan , Makshoof Athar. Bioresource Technology 101 (2010) 5043–5053

[2] Biosorption: a solution to pollution Regine H. S. F. Vieira, Boya Volesky INTERNATL MICROBIOL (2000) 3:17–24

[3] Biosorption: current perspectives on concept, definition and application Marina Fomina , Geoffrey Michael Gadd Bioresource Technology 160 (2014) 3–14

[4] Niu H, Volesky B (1999) Characteristics of gold biosorption from cyanide solution. J Chem Tech Biotechnol 74:778–784

[5] Volesky B (1987) Biosorbents for metal recovery. Trends Biotechnol 5:96–101 6.Volesky B, Holan ZR (1995) Biosorption of heavy metals. Biotechnol Prog 11:235–250

[6] Beveridge TJ (1989) The role of cellular design in bacterial metal accumulation and mineralization. Annu Rev Microbiol 43:147–171

[7] Fein JB, Daughney CJ, Yee N, Davis TA (1997) A chemical equilibrium model for metal adsorption onto bacterial surfaces. Geochim Cosmochim Acta 61:3319–3328

[8] Churchill SA, Walters JV, Churchill PF (1995) Sorption of heavy metals by prepared bacterial cell surfaces. J Environ Eng 121:706–711 10.

[9] Biosorption of La, Eu and Ybusing Sargassum biomass Vivian Diniz, Bohumil Volesky Water Research 39 (2005) 239–247

[10] A comprehensive review on biosorption of heavy metals by algal biomass: Materials, performances, chemistry, and modeling simulation tools Jinsong He, J. Paul Chen Bioresource Technology 160 (2014) 67–78

[11] Fungal Biosrption of Heavy Metals from Industrial Waste M. Ramesh1 , K. Subramanian2*, P. Kishore kumar 2014, AJMPS, Vol.2(2): 117-121

[12] Biosorbents for heavy metals removal and their future. Jianlong Wang , Can Chen Biotechnology Advances 27 (2009) 195–226

[13] 14.Heavy metal adsorption onto agro-based waste materials Ayhan Demirbas Sila Science, Trabzon, Turkey Journal of Hazardous Materials 157 (2008) 220–229

[14] Biosorption of heavy metals Nilanjan Das, R . vimala, P. Karthika Indian Journal of biotechnology Vol 7, April 2008, pp 159- 169

[15] Agricultural waste material as potential adsorbent for sequestering heavy metal ions from aqueous solutions Dhiraj Sud , Garima Mahajan, M.P. Kaur Bioresource Technology 99 (2008) 6017–6027

[16] Applicability of agricultural waste and by-products for adsorptive removal of heavy metals from wastewater T.A.H. Nguyen , H.H. Ngo , W.S. Guo , J. Zhang , S. Liang , Q.Y. Yue , Q. Li , T.V. Nguyen Bioresource Technology 148 (2013) 574–585

[17] Research Journal of chemistry & environment N. Ahalya, T. V. Ramchandran 1 & R.D. Kanamadi 2