International Standard Serial Number (ISSN): 2249-6807

International Journal of Institutional Pharmacy and Life Sciences 3(6): November-December 2013

INTERNATIONAL JOURNAL OF INSTITUTIONAL PHARMACY AND LIFE SCIENCES

Civil Engineering **Review Article……!!!**

Received: 26-10-2013; Revised; Accepted: 03-11-2013

BIOSORPTION OF HEAVY METAL REMOVAL FROM AQUEOUS SOLUTION USING BIOMASS- REVIEW

B.Shoba*, R.Thenmozhi

Department of Civil Engineering, Sri Ramakrishna Institute of Technology, Coimbatore -641010

Keywords:

Biosorption, biosorbent, biomass, heavy metals, algae, etc

For Correspondence:

B. Shoba

Department of Civil Engineering, Sri Ramakrishna Institute of Technology, Coimbatore -641010

E-mail:

shobadiwakar@gmail.com

ABSTRACT

Heavy metals released into aquatic environment due to various industrial operations, fly ash from incinerator, metal plating, leather tanning, petrochemical and fertilizers, etc. The discharge of industrial waste water in aquatic environment, if it contains heavy metals it leads to pollution. The conventional treatment methods are commonly used for removal of metal ions from aqueous streams. This treatment includes chemical precipitation, ion exchange, reverse osmosis, membrane filtration, and activated carbon adsorption. The conventional technologies are often ineffective and expensive, particularly for the removal of heavy metal ions at low concentrations as below 50 mg/l. These treatment methods are based on physical displacement or chemical replacement, it is generating large volume of toxic sludge, and the disposal of sludge waste is another problem. For more than a decade, researchers have been looking for alternative treatment for conventional methods. Biosorption can be promising alternative to treat industrial waste water in removing heavy metals. This review article provides a selective overview of the past achievements and present scenario in the biosorption studies.

INTRODUCTION

Due to industrialization, it leads the increased emission of pollutants in to aquatic ecosystem. The presence of toxic metals in waste water has accumulated in human being has several health hazards such as growth and developmental abnormalities, carcinogenesis, mental retardation, etc. Some important heavy metal pollutants are lead, cadmium, chromium, mercury, zinc and arsenic.

In industrial effluents, the presence of heavy meals leads to chronic poisoning in aquatic animals (Ellis, 1989). Small quantities of some metals are essential for life at low concentration but it is very toxic at high concentrations (Badar*et* al. 2000).The high concentration of heavy metals can damage the cell membranes, alter enzymes specificity, disrupt cellular functions and damage the structure of the DNA. The presences of heavy metals in waste water are not biodegradable and they tend to be accumulated in organisms and cause numerous diseases and disorders (Ozer and Pirincci, 2006). Using conventional methods, for heavy metal removal it generating large volume of toxic sludge and difficult to treat. In recent years using biotechnical concept in removing heavy metals is one of the effective techniques.

Algal biomass has been found to possess the potential removal of heavy metal from waste water. The advantage of using biosorption are low cost, high efficiency, minimization of chemical or biological sludge, possibility of metal recovery, regeneration of biosorbent and no additional nutrient requirement(Kratochvil and volesky, 1998). It is proven that the uses of marine macro green algae as excellent biosorbents; it is very effective in removal of metal ions from contaminated solution. The cost of biosorption is low and it is eco friendly (NirmalKumar*et al*, 2009). The aim of the paper is to study the biosorption process.

Biosorption:

Biosorption is the term that usually describes as the removal of heavy metals by the passive binding to non-living biomass from an aqueous solution (Davis *et al*., 2003). In the past research shown that using biosorbents have both living and dead microbial cells are able to uptake the metal ions. The living cells used as a sorbent in the heavy metal removal is toxic to the particular heavy metal, resulting in the death of cells. Living cells required additional nutrient for their growth, for these reasons dead cells are used as sorbent for heavy metal removal. Dead cells are not affected by heavy metals and also it does not required any nutrients, it may cheaper for this reasons dead cells are used as biosorption in heavy metal removal (Mofa A.S,1995). The dead biomass can be easily regenerated. The process involves a solid phase (sorbent or biosorbent:

biological material) and a liquid phase (solvent: normally water) containing a dissolved species to be sorbed (sorbate, metal ions). Metals are taken up by algae through adsorption. At first, the metal ions are adsorbed over the cell surface very quickly just in a few seconds or minutes; this process is called physical adsorption. Then, these ions are transported slowly into the cytoplasm in a process called chemisorptions. Biosorption include some agricultural waste(such as bagasse, cassava waste, coconut shell and fiber, coir pith, oil palm waste, olive waste, orange waste, peanut waste, rice husk, saw dust, sugar beet pulp, Tea factory waste, waste from tree nuts, Bengal gram husk and miscellaneous materials) fungi, bacteria, algae and yeast.

MATERIALS AND METHODS

Biosorption Preparation:

It is the process in which it utilizes inexpensive dead biomass to isolate the toxic heavy metals. Biosorbents are particularly feasible to use for removal of these contaminants from industrial effluents. Biosorbents are prepared from the naturally abundant and waste biomass of algae, fungi, or bacteria which is inactivated and usually pretreated by washing with acids or bases before final drying and granulation (Brierley, 1990; Brierley*et al.*, 1988; Fourest and Roux, 1994; Kratochvil*et al.*, 1997). Simple cutting and grinding of the dry biomass may yield stable biosorbent particles (Brierley, 1990; Fourest and Roux, 1994; Kratochvil and Volesky, 1997; Kratochvil*et al.*, 1997; Votapek*et al.*, 1978), Algae possesses the ability to take up toxic heavy metals from the environment, resulting in higher concentrations than those in the surrounding water (Megharaja*et al.*, 2003; Shamsuddoha*et al*., 2006).The preparation of biosorption procedure is given in fig1. This paper reviews the use of algae as biosorbents.

Biosorbent material: Algae as biosorbent

Achievements over the past study:

Apiratikul,R., *et al*, (2004) studied the biosorption of a mixture of two heavy metals solution such as Cu-Cd, Cu-Pb, Cu-Zn, Cd-Cu, Cd-Pb, Cd-Zn, Pb-Cu, Pb-Cd, Pb-Zn ,Zn-Cu, Zn-Cd, and Zn-Pb. The combination of two heavy metal solutions is mixed with dried Caulerpalentillifera. The mixture solution was then prepared with a primary heavy metal concentration varied from 10, 25, and 50 mg/l and the secondary heavy metal concentration fixed at 50 mg/l. To convert to molar concentration, the mass concentration was divided by the atomic weight of each metal species and the atomic weights of Cu, Cd, Pb, and Zn were 63.54, 112.4, 207.19, and 65.37 g/mol, respectively. The concentration of metal species was converted from mass concentration into molar units. In the above mentioned four heavy metals the biomass removal was low in Cd. The other three metals such as Cu, Pb and Zn the concentration lower than 1 mmol/l the removal efficiency were in the range of 90-95%. The concentrations higher than 1 mmol/l the removal efficiency were in the range of 75-90%. The adsorption of binary mixture of heavy metals solution onto the surface of the algae was found to be the adsorption capacity for any single metal decreased by 10-40%. The total adsorption capacity of the algae was found to decrease by 30-50% when there was more than one heavy metal in the solution. The total adsorption capacity for the heavy metals seemed to be lower in the binary mixture cases than the single component system.

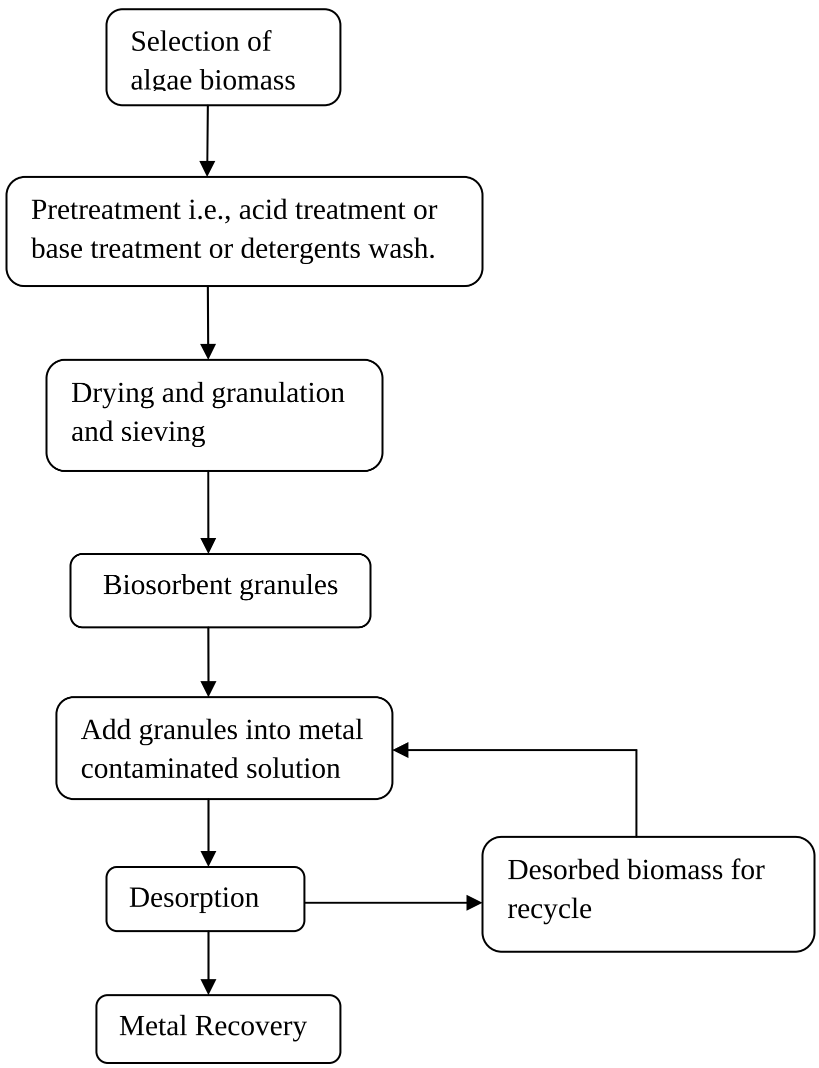

Fig 1.Schematic diagram of biosorption procedure

NarsiR..Bishnoi, *et, al.,* (2004) conductbiosorption experiment using spirogyra species for copper removals were carried out. The studies influence the optimization of the biosorption of Cu (II). In this study they examined the various factors such as pH (1 to 10), initial metal ion concentration (1 ppm to 10ppm), different contact period (30 to 180 mins), and differenttemperatures (25 ^{o}C to 50 ^{o}C) and varying quantities (such as 0.5, 1, 1.5, 2g) etc., with the above specified parameters with their influence to the metal ion concentration. They observed that the spirogyra species possessed better specific capacities for Cu (II) removal of 34.94mg/g of biomass. Spirogyra species has shown much better metal uptake capacity with pH (6 to 7) and contact time 30 minutes. From the above results it is clear that the metal uptake capacity is based on the pH and contact time.

Nirmal Kumar J.I, *et al*,(2009) used five green marine macro algae namely; 1. Cladophora fasicularis, 2.Ulvalactuca, 3.Chaetomorphasp, 4.Caulerpasertularioides and 5.Valoniopsis pachynema. The metal uptake capacities for Cd, Hg and Pb at various initial concentrations, 20, 40, 60 and 80 mg/ L and variable contact period of 60 and 120 minutes. The algae showed the highest metal removal efficiency of contact period at 120minutes. Cd reduction was found to be the highest at 20 mg/ L for all the marine algae except Caulerpasertularioides. The amount of Hg reduction was found to be at 20 mg/ L for Cladophorafascicularis, Ulvalactuca and Valoniopsispachynema. In Chaetomorphasp Hg reduction was found to be 40 mg/ L and CaulerpasertularioidesHg reduction was exhibited the maximum reduction of 60 mg/ L. The highest Pb reduction was observed at 20 mg/ L for all the algae green marine macro algae except ValoniopsispachynemaPb reduction was achieved at 40 mg /L. out of five marine green algae the highest metal adsorption ability of Cd, and Pb inChaetomorphasp.Hg reduction was high in Caulerpasertularioides. The biosorbent prepared from Chlorella species a fresh water alga used in batch study, from that results they concluded that the optimum contact time was 100 minutes at which 90% lead removal was obtained. The removal efficiency of leadis decreases as the initial lead ion concentration of the solution increases. Kanchana S, *et al*, (2011).

Nirmal Kumar J.I, *et al*, (2012) Using freshwater algae Spirogyra hyalina. The dried biomass of Spirogyra hyaline was used as biosorbent. The result showed that the highest amount of cadmium (Cd), mercury (Hg), and Arsenic (As) was adsorbed when the initial heavy metal concentration was 40 mg/l. whereas Lead (Pb), and cobalt (Co) has greatest removal of 80 mg/l.

CONCLUSION

The past research work results shown that the various algae's are used for the removal of heavy metal pollutants such as lead, cadmium, chromium, mercury, zinc and arsenic. The use of algae asan efficient biosorbent material can be considered an eco friendly and cost-effective approach for heavy metal removal. These algal species may be used for treatment of industrial waste water. From the past results the single metal adsorbent solutions seems to be more effective than combination of metals.

REFERENCES

1. Apiratikul, R., Marhaba, T.F., Wattanachira, S., and Pavasant, P (2004), Biosorption of binary mixtures of heavy metals by green macro algae.Songklanakarin J. Sci. Technol., 26(Suppl. 1): 199-207.
2. Badar, U., Ahmed, N., Beswick, A. J., Pattanapipitpaisal, P., and Macaskie, L.E. (2000), reduction of Chromate by microorganisms isolated from metal contaminated sites of Karachi, Pakistan. Biotechnology Letters, 22, pp 829-836
3. Brierley, J.A., Brierley, C.L., Decker, R.F. and Goyak, G.M. (1988). U.S. Patent 4 789 481.
4. Brierley, J.A. (1990), Production and application of a *Bacillus*-based product for use in metals biosorption. In: *Biosorption of Heavy Metals*, B. Volesky, ed. pp. 305-312, Boca Raton, FL: CRC Press.
5. Davis, Thomas A., BohumilVolesky and Alfonso Mucci (2003),A review of the biochemistry of heavy metal biosorption by brown algae. Water Res., 37, 4311-4330
6. Ellis, K.V. (1989), surface water pollution and its control" Macmillan press Ltd, Hound mill,Basingstoke, Hampshire RG 21 2xs and London, pp 3-18,97,100,101 and 208
7. Fourest, E. and Roux, J.-C. (1994). FEMS Microbiol. Rev. 14, 325-332
8. Garcia Sanchez. A, Alvarez Ayuso E and Jimenez de blas O, (1999),Sorption of heavy metals from industrial waste water by low cost mineral silicates, The mineralogical Society, 34,469-477
9. Kanchana, S and Dr.J.Jeyanthi, (2011),Biosorption of lead from Aqueous solution using Chlorella Species, International Journal of Institutional Pharmacy and Life Sciences,1(3),46-49.
10. Kratochvil, D. and Volesky, B. (1997),Trans. Inst. Min. Metall. Section C,

11. Kratochvil, D. and Volesky, B. (1997). Removal of heavy metals by a new biosorbent. In: Biotechnology and the Mining Environment, Proceedings of the 13thBiominet Meeting, L. Lortie, P. Bedard and W.D. Gould, eds. vol. SP 97-1, pp. 41-59, Ottawa, Ontario, Canada K1A 0G1: CANMET, Nat. Res. Canada.
12. Kratochvil, D., Volesky, B. and Demopoulos, G. (1997). Wat. Res. (in press). Langmuir, I. (1918). J. Am. Chem. Soc. 40, 1361-1403.
13. Kratochvil, D. and B. Volesky, (1998). Advances in the biosorption of heavy metals. Trends in Biotechnol, 16: 291-300.
14. Manisha Nanda,Dinesh Sharma, Arun Kumar., (2011), Removal of Heavy Metals from Industrial Effluent Using Bacteria, International journal of Environmental science, 781-787.
15. Megharaja, M; Ragusa, S.R; Naidu, R. (2003), Metal–algae interactions: implication of bioavailability. In: Bioavailability, Toxicity and Risk Relationships in Ecosystems. Naidu, R; Gupta, V.V.S.R; Rogers, S; Kookana, R.S; Bolan, N.S; Adriano, D.C. (eds.), p.109-144. Science Publishers, Enfield, New Hampshire, UK
16. Mofa A.S, (1995),Plants proving their worth in toxic metal cleanup,science 269,302-305
17. NarsiR.Bishnoi, Anju pant and Garima (2004).Biosorption of copper from aqueous solution using algal biomass, Journal of scientific & Industrial research, Vol. 63, pp 813-816.
18. Nirmal Kumar, CiniOommen and Rita N Kumar, (2009),Biosorption of Heavy Metals from Aqueous Solution by GreenMarine Macroalgae from Okha Port, Gulf of Kutch, India, American-Eurasian journal of Agriculture and Environmental Science.6 (3): 317-323.
19. Nirmal Kumar J.I and CiniOommen, (2012),Removal of heavy metals by biosorption using freshwater algae spirogyra hyaline, Journal of Environmental Biology,27-31.
20. Ozer A., Pirincci H. B. (2006), the Adsorption of Cd (II) ions on Sulphuricacid Treated Wheat Bran. Journal of Hazardous Materials, 13(2), pp 849-855.
21. SeemaDwivedi., (2012), Bioremediation of heavy metal by algae, current and future perspective, journal of advanced laboratory research in biology,195-199
22. Shamsuddoha, A.S.M; Bulbul, A; Huq, S.M.I. (2006), Accumulation of arsenic in green algae and its subsequent transfer to the soil–plant system. Bangladesh Journal of Microbiology; 22(2), 148–151.
23. Votapek, V., Marval, E. and Stamberg, K. (1978). U.S. Patent 4 067 821.