Journal of Global Biosciences
ISSN 2320-1355
Volume 5, Number 3, 2016, pp. 3785-3793
Website: www.mutagens.co.in
E-mail: submit@mutagens.co.in
researchsubmission@hotmail.com

Research Paper

REMOVAL OF POLLUTANTS IN WATER USING LOW-COST MATERIALS

V.Saritha[1], Ch.Bhavannarayana[2] and D. Bhavya Kavitha[1]

[1]Department of Environmental Studies,
GITAM Institute of Science,
GITAM University, Visakhapatnam, Andhra Pradesh, India.
[2]Department of Civil Engineering,
GIET Engineering College, Rajahmundry,
Andhra Pradesh, India.

Abstract

Heavy metal adsorption using low cost materials is gaining importance in the present scenario. Adsorption technologies are having two major benefits i.e., reducing the concentration of heavy metal ions to very low levels and the use of low-cost adsorbent materials. Removal of heavy metal ions in water and waste water from various waste materials of varied sources and their technical feasibilities were reviewed in this paper. Metal binding capacities, metal removal performances, sorbent dose, optimum pH, temperature, initial concentration and contact time were some of the parameters considered. Since the past decade, the use of these adsorbent materials have become more popular as they were low cost, biodegradable in nature, eco-rich and efficient.
Key words: Adsorbents, Heavy Metals, dose, pH and temperature.

INTRODUCTION

One of the major issues facing by the man is Environmental pollution. In the last few years it increased aggressively and reaching its peak point which can be seen by the condition of living creatures. Man and animals are directly affected by the toxic heavy metals, one of the major pollutants. Ground water resources are being contaminated by industrial waste water containing lead, copper, cadmium etc., which leads to the ground water pollution.

Segregation with respect to the quality of water is the major thing. Water with high quality is requisite for human life and water with acceptable quality can be used for agriculture, industrial, domestic and commercial uses. Water from these activities may directly or indirectly pollute the water. Every day some million tons of waste has been thrown into these fresh water bodies. Improper waste disposal is one of the major culprit which leads to the cause of abatement in fresh water. As we are having numerous polluting sources, it is difficult to provide proper treatment facility and also expensive. Herewith we are opting and moreover there is a pressing demand for innovative technologies as they are low cost, require low maintenance and energy efficient. As the requirement of control is minimum, this adsorption technique is suited because it is technically easy to separate and economically friendly also.

Heavy metals are the major contaminants present in the industrial waste water. Industries like metal plating, mining operations, tanneries, chloralkali, radiator manufacturing, smelting, alloy industries, storage battery industries etc., are the major sources of the heavy metal contamination in aqueous solution. Toxicology problems aroused in the nature due to the contaminated water, hence lot of studies are going on for the removal of most common pollutants like lead, copper(Cu), cadmium(Cd), zinc(Zn) and nickel(Ni) which are present in industrial waste water.

Numerous investigations have been taken place in order to protect the environment and living creatures through new methods due to the damage caused by the water pollution (Kadirvelu et al. 2001; Frisbieet al.2002; Antonio and Corredor 2004).

Several treatment processes such as chemical precipitation, adsorption, ion exchange and membrane filtration have been developed over the years to remove the heavy metals dissolved in industrial wastewaters. However, most of these techniques have some disadvantages, such as complicated treatment process, high cost and energy consumption.
Adsorption technique is the new process in removal of contaminants from aqueous effluents. Activated carbon is one of the popular adsorbent in the adsorption process because it is having high surface area, high adsorption capacity and high degree of surface reactivity. As there is a need for its regeneration after each adsorption experiment and as it is expensive, so to decrease the cost of treatment process, scientists attempted to investigate the inexpensive & efficient adsorbent materials.

For the removal and recovery of heavy metal ions from waste water, low-cost agricultural wastes are used as adsorbent materials.(Holan and Volesky 1994; Volesky and Holan 1995; Ake et al.2001; Ahalya et al. 2003; O¨ zcan et al. 2004; Tunali et al.2006). Hemicelluloses, lignin, extractives, lipids, proteins, simple sugars, water hydrocarbons and starch containing variety of functional groups are the basic components of the agricultural waste. (Bailey et al. 1999).Chemical functional groups, such as carboxyl, amino or phenolics(lignocellulosicbiosorbents) are modified with physical or chemical treatments to increase their sorption capacities through metal ion binding. (Demirbas¸ 2008).

Quest for new technologies has directed attention to bisorption for the removal of toxic metals from waste water which is based on the metal binding capacities of various biological materials. The ability of biological materials to accumulate heavy metals from waste water through metabolically mediated or physic-chemical pathways of uptake is called bisorpion. Nature of adsorbent surface and species distribution of metal cation are the major depending factors of adsorption of metal cation. pH plays main role in the surface distribution. (Namasivayam and Ranganthan1995).
Adsorbents used for removal of heavy metals (Manish Singh Rajput et al., 2015) are presented in the below table.

S.No	Author	Coagulant or Absorbent used	Material	Year
1.	Jeyakumar R. P. S. and Chandrasekaran V	activated carbons	marine green Ulvafasciata sp.	2014
2.	El-Maaty W.M.	activated carbon	dried water hyacinth stems and leaves	2014
3.	Ghorbani A.	red mud	red mud (bauxite ore processing waste	2014
4.	Murthy R. C.	*Cucumissativus*	*Cucumissativus*peel (CSP)	2014
5.	Seniunait J.	coffee grounds	coffee fruit	2014
6.	Sujata K.	red mud	red mud	2014
7.	Singh D. K.	PSC	Carbonized raw biomass	2013
8.	TahirUddin N. S. M. and Rahman S. Z. A.	charcoal and peanut shell	Peanut and charcoal	2013
9.	Pandhare G. G.	Neem leaves powder	Neem leaves	2013
10.	Sadaoui Z.	orange barks	from commercial oranges	2013
11.	Wolfová	nuts of European walnut	(*Juglansregia*)	2013
12.	Oluyemi E. A.	PKSC	Palm Kernel Shell Charcoal	2012
13.	Okafor P.C.	Coconut Shell (CNS)	*Cocosnucifera L*	2012
14.	Nwabanne J. T. and Igbokwe P. K.	nipa palm nut (NPN), palmyra palm nut (PPN), oil palm empty fruit bunch (EFB), oil palm fibre(OPF) and oil palm shell (OPS)	indigenous cellulose based waste biomass	2012
15.	T. O.	Blighia	Blighiasapida pod	2012
16.	Raju D. S. S. R.	Carica papaya leaf powder	Carica papaya leaf	2012
17.	Liu J.	Sesame	Sesame leaf	2012
18.	Adelaja O. A	Moringaoleifera powder	Moringaoleifera pods	2012
19.	Mondal N. K. and Das B	calcareous soil	calcareous soil	2011
20.	Kuchekar S.R.	Phenol formaldehyde resin	Tamarindousindica seeds.	2011
21.	Kumar U. and Acharya J,	chemically pretreated rice husk	Rice Husk	2011
22.	Eba1 F.	three acid activated carbons	prepared from plant biomass of colas edulis	2011

			shell (CAH), pentaclethramacrophylla husk (GAH) and aucoumeaklaineana sawdust (QAH)	
23.	Mousavi H. Z	WTRA	waste tire rubber ash	2010
24.	Asandel D	Chitosan	chitosan	2009
25.	Sha L	orange peel xanthate	Orange	2009
26.	Qaiser S	groundnut hul	Groundnut	2009
27.	Wahi R.	activated carbon	prepared from palm oil empty fruit bunches (EFB) to remove mercury (Hg(II)), lead (Pb(II)) and copper (Cu(II))	2009
28.	Mengistie A.A	activated carbon Birbira	developed from an indigenous Ethiopian medicinal plant leaves namely Birbira (*Militia ferruginea*)	2008
29.	Omar W. and Itawi H. A.,	kaolinite clay	kaolinite clay	2007
30.	Hashem M. A	Okra wastes	Okra from food canning processes	2007
31.	Yavuz O	Calcite	Calcite	2006
32.	Aziz H.	activated carbon and limestone	cheap available materials in such as charcoal, coconut shell carbon and a mixture of these carbons with limestone	2005

Some other sources of adsorbents beyond the above table are discussed below:
Anusha and Murugadoss, 2014 prepared activated carbon from sugar mill sludge. This was tested for the removal of heavy metals such as Nickel, Lead and Cadmium from the aqueous solution and the removal efficiency was noted at various time intervals and at bed depths of 2.5 cm, 5 cm and 10 cm.

Renge and Khedkar, 2012 used chitosan and egg shells for preparation of adsorbent. Natural and boiled hen and duck egg shells were washed with tap water several times then air-dried and incubated in hot air oven at 40^0C for 30 minutes (because protein component in egg shell can denature at high temperature; > 40^0C). Egg shells were ground to powder and made fine with the help of 60-100 mesh (0.25-0.104 mm) size particles (Arunlertareeet.al., 2007). Like most other natural coagulants, egg shell and chitosan can be used in treating the heavy metals with efficiency of 100% by choosing the adsorbent material precisely. Chitosan, egg shell wastes are cost effective and can be conveniently used in industrial waste water treatment plants.

Mechanical grinder has been used to ground the dried shells of Watermelon seeds into fine powder. To get the adsorbent in particular size ranging from 150 to 300µm, it should be sieved. After sieving process, powder should be dried and processed in air tight glass for further use. It is efficient in removal of Cu (II) from aqueous solution. Operating parameters of adsorption efficiency of Cu (II) are pH of solution, dosage, contact time, temperature, particle size, agitation speed were effective on the (Koel Banerjee et al., 2012).

Bengal gram husk (bgh) was used for biosorption studies in the original piece size (Ahalya et al., 2005). Biosorption observations on the ability of bgh to remove Cr (VI) indicate that the biomass is having potential application to sequester heavy metals from low concentration waste waters. Containing approximately 52% crude fibre composed of cellulose, hemicellulose and lignin, the bghbiomatrix indicates the presence of many –OH and – COOH groups in the lignocellulosic materials. Hydrogen of these groups is capable of ion exchange with metal cations.

Proteinious materials are the one which should putrefy under moist condition, because it is rich in algal and fungal biomass projected as metal bisorbents. The protein content in bgh is less than 5%. Additional cost factor is being introduced because metal sorption is based on the algal and fungal biomass and these are collected from the natural habitats which are pre-processed, cultured and transported under special conditions. For the removal of Cr (VI) ions, bghhas been used because it is an agro-industrial waste, which is cost-effective and efficient, and has been proved (Ahalya et al., 2005).

Rice husk were obtained from the local rice mill. The husks were dried in sunlight for one week, and then crushed and sieved to get particle size less than 1.5 mm. With the exception of crushing and sieving, the rice husks were not pretreated prior to the adsorption experiments. The dried biomass was designated as the Natural Rice Husk (NRH) (Manish Vishnu Rahate, 2013). The results obtained in their study showed that natural rice husks can be considered as a potential biosorbent for the removal of cadmium, lead and zinc metal ions. The adsorption of metal ions is strongly dependent on the adsorption time, initial pH of the solution, biosorbent dosage and initial concentration of metal ions.Ranking the adsorption ability of the measured metal ions, the following series is obtained: Cd(II)>Pb(II)>Zn(II). It is an effective biosorbent for the removal of cadmium, lead and zinc metal ions from water.

New approaches based on the use of natural inexpensive adsorbents for treatment have been reported (Badmus, et al., 2007). Chalf and tea waste were washed at the first step and then rinsed with distilled water. After drying at 100^0C, it was ground and screened (using screen with mesh size 40) and kept in plastic containers before the time of use (Amir, et al., 2005).The rapid uptake and high capacity of chalf, rice husk, sesame, sunflower and tea waste indicated that it could be a better alternative for the removal of Pb (II) from wastewater by sorption process. Kinetic experimental data revealed that intraparticular diffusion is not only the rate limiting step of the adsorption process. Kinetic, equilibrium and thermodynamic results revealed that Pb ion removal by the studied adsorbents proceeded through chemisorption and physisorption mechanisms. The results of equilibrium experiments indicated that removal efficiencies of the tested adsorbents were in the following order; sesame > tea waste > rice husk >chalf> sun flower.

Waste bamboo stems from the construction sites at the Petroleum Training Institute (PTI), Delta State of Nigeria; waste water samples from Warri Refining and Petrochemical Company(WRPC), Ekpan, Delta State were the major materials used in this study. Chemicals required for this study are concentrated hydrochloric acid and distilled water. The apparatus used for this study are muffle furnace (electronic furnace), thermocouple with temperature sensors, sieves of 1.0mm – 1.7mm, measuring cylinders, beakers, pipette, 100ml dropping funnel, glass wool, conical flasks, moisture cans, magnetic stirrers, cutting machine, air oven, sample bottles, desiccators, crucibles, filter papers with several.

Awoyaleet.al., 2013 study has shown that it is possible to produce efficient and effective adsorbents from bamboo. The removal of heavy metal ions was pH dependent as the concentration of both metals after adsorption at the maximum pH of 8 was recorded to be <0.001 ppm implying that adsorption capacity increases with increasing the pH value of the solution, and at a particular pH. The order of increase of removal percentage was Pb> Cufor both absorbents. Experimental results showed that the best pH for adsorption was 8 with contact time of 120 minutes. When the addition of the adsorbent dose increased, the percentage removal of metal ions also increased. A maximum removal of approximately 100% was due to the assumption of approximately 0ppm concentration of the metals at pH 8 and dosage of 44.

Low cost adsorbent (okra wastes) has shown a better adsorbent for Cd^{2+}, Fe^{2+} and Zn^{2+}. The most explanation of the highly sorption capacity of okra waste is that the negative charge of okra waste that make it capable to absorb the positively charged metals of for Cd^{2+}, Fe^{2+} and Zn^{2+}. From the kinetic model analysis using coefficient of determination, the pseudo-second order model was the most fitting for the description of Cd^{2+}, Fe^{2+} and Zn^{2+} transport from the bulk solution onto the surface of okra wastes adsorbents (Al-Barak and El-Said, 2010).

CONCLUSION

This paper presents a review on various waste materials obtained from natural sources to act as adsorbents. The review shows a great potential for the removal of heavy metals from wastewater. The sorption capacity depends on the type of the adsorbent and the nature of the wastewater treated as well. There is an urgent need of more detailed studies to be carried out so as to better understand the process of more effective and economic adsorption hence therefore to develop such a technology that matters truly and effectively.

Heavy metal removal has been studied by several authors and several treatment processes have been developed over the years. However, most of these techniques have some disadvantages, such as complicated treatment process, high cost and energy consumption. Adsorption of heavy metals from aqueous solutions is a relatively new process that has proven very promising in the removal of contaminants from wastewaters. The most popular adsorbent for the adsorption process is activated carbon, but it is very expensive and there is a need for its regeneration after each adsorption experiment. Adsorbent materials derived from wastes can be used for the effective removal and recovery of heavy metals ions from wastewater. Cost is an important parameter for comparing the sorbent materials.

The expense of individual sorbents varies depending on the degree of processing required and local availability. The effectiveness of the adsorption depends not only on the properties of the adsorbent, but also on various parameters (pH, temperature, initial concentration, contact time, particle size of adsorbent, etc.) used for the adsorption process. These parameters should also be taken into account while examining the potential of low-cost adsorbents.

REFERENCES:

1. C. Arunlertaree, W. Kaewsomboon, A. Kumsopa, P. Pokethitiyook and P. Panyawathanakit, Removal of Lead from Battery Manufacturing Wastewater by Egg Shell, Sci. Technol., 29(3), 857-868 (2007).
2. Nagham A. Ageena, The use of Local Sawdust as an Adsorbent for the Removal of Copper Ion from Wastewater using Fixed Bed Adsorption, J., 28(2), 859-860 (2010).
3. V. C. Renge, S. V. Khedkar and Shraddha V. Pande. Removal of Heavy Metals from Wastewater Using Low Cost Adsorbents: A Review. Sci. Revs. Chem. Commun.: 2(4), 2012, 580-584
4. G. Anusha, J. Raja Murugadoss. Modeling for Removal of Nickel and Lead from Industrial Wastewater by Adsorption. Journal of Water Pollution & Purification Research, Volume 1, Issue 3, (2014) 13-17
5. Manish Singh Rajput, Ashok K Sharma, Sarita Sharma, Sanjay Verma. Removal of lead (II) from aqueous solution using low cost abundantly available adsorbents: A review. International Journal of Chemical Studies 2015; 3(1): 09-14
6. Koel Banerjee, S.T. Ramesh, R. Gandhimathi, P.V. Nidheesh and K.S. Bharathi. A Novel Agricultural Waste Adsorbent, Watermelon Shell for the Removal of Copper from Aqueous Solutions.Iranica Journal of Energy & Environment 3 (2): 143-156, 2012
7. N. Ahalya, R.D. Kanamadi and T.V. Ramachandra.Biosorption of chromium (VI) from aqueous solutions by the husk of Bengal gram (Cicerarientinum). Electronic Journal of Biotechnology ISSN: 0717-3458 Vol.8 No.3, Issue of December 15, 2005.
8. Manish Rahate, PrashantDeshmukh, PawanLabhasetwar, ShyamShukla, VasantMhaisalkar. Low Cost Efficient Treatment for Contaminated Water. Daniel Thevenot. 13th edition of the World Wide Workshop for Young Environmental Scientists (WWW-YES-2013) – Urban waters: resource or risks?, Jun 2013, Arcueil, France
9. KRATOCHVIL D. and Volesky B. (1998). Advances in the biosorption of heavy metals. Journal of Trends in Biotechnology 16, 291–300.
10. BASSO M.C., Cerrella E.G. and Cukierman, A.L. (2002). Lignocellulosic materials as potential biosorbents of trace toxic metals from wastewater. Industrial and Engineering Chemistry Research 41, 3580–3585
11. AHALYA N., Ramachandra T.V. and Kanamadi R.D. (2003). Biosorption of heavy metals. Research. Journal of Chemistry and Environment 7, 71–79.
12. GARDEA-TORRESDEY J.L., de la Rosa G. and Peralta-Videa J.R. (2004). Use of phytofiltration technologies in the removal of heavy metals: a review. Pure and Applied Chemistry 76, 801–813.

13. VOLESKY B. (2001). Detoxification of metal-bearing effluents: biosorption for the next century. Hydrometallurgy 59, 203–216.
14. JAMES J. and M. S. Rao. (1986) Characterization of silica in rice husk ash. Am. Ceram. Soc.Bull. 65, 1177-1180
15. OLIVEIRA Waleska E., Franca Adriana S., Oliveira Leandro S. and Rocha, Sonia D. (2008). Untreated coffee husks as biosorbents for the removal of heavy metals from aqueous solutions. Journal of Hazardous Materials 152, 1073-1081
16. SARKANEN K.V. and Ludwig C.H. (1971). Lignins: Occurrence, Formation, Structure and Reactions. New York: Wiley-Interscience
17. Kafia M. ShareefSurchi. Agricultural Wastes as Low Cost Adsorbents for Pb Removal: Kinetics, Equilibrium and Thermodynamics. International Journal of Chemistry Vol. 3, No. 3; August 2011
18. O. Badmus, K. Audu, & U. Anyata. (2007). Removal of Lead Ion from Industrial Wastewaters by Activated Carbon Prepared from Periwinkle Shells (Typanotonusfuscatus), Turkish J. Eng. Env. Sci., 31. 251–263.
19. Nasim A. K., Shaliza I., &Piarapakaran S. (2004). Review paper; Elimination of Heavy Metals from Wastewater Using Agricultural, Wastes as Adsorbents, Malaysian Journal of Science, 23: 43 – 51.
20. Najua, D. T., Luqman, C. A., Zawani, Z., &Suraya, A. R. (2008). Adsorption of copper from aqueous solution by ElaisGuineensis kernel activated carbon., J. Eng. Sci. Tech., 3 (2), 180–189.
21. Malakootian M., Nouri J., &Hossaini H. (2009). Removal of heavy metals from paint industry's wastewater using Leca as an available adsorbent. Int. J. Environ. Sci. Tech., 6 (2), 183–190
22. Huda Yousif, Kafia M. Shareef. (2010). Rice Husk as a Low-cost Adsorbent for Cu, Ni and Zn removal from Polluted Water, International Conference on Biology, Environment and Chemistry – ICBEC, 28-30 December, Hong Kong, China
23. Amir H. M. Darush N., Forugh V., &Sharokh N. (2005). Tea waste as an adsorbent for heavy metal removal from industrial wastewaters, American Journal of Applied Sciences, Vol, 2 (1) 372–375
24. Awoyale, A.A., Eloka-Eboka, A.C. and Odubiyi, O.A. Production and Experimental Efficiency of Activated Carbon from Local Waste Bamboo for Waste Water Treatment. International Journal of Engineering and Applied Sciences. April 2013. Vol. 3, No. 2 ISSN 2305-8269
25. A.B.S. Al-Barak and S.M. El-Said, 2010. The Use of Some Food Industrial by Products for Waste Water Purification. Research Journal of Environmental Sciences, 4: 566-572
26. Kadirvelu K, Thamaraiselvi K, Namasivayam C (2001) Removal of heavy metals from industrial wastewaters by adsorption onto activated carbon prepared from an agricultural solid waste. BioresourTechnol 76:63–65
27. Frisbie SH, Ortega R, Maynard DM, Sarkar B (2002) The concentrations of arsenic and other toxic elements in Bangladesh's drinking water. Environ Health Prospect 110(11):1147–1153
28. Antonio GT, Corredor L (2004) Biochemical changes in the kidneys after perinatal intoxication with lead and/or cadmium and their antagonistic effects when coadministered. Ecotoxicol Environ Saf 57(2):184–189
29. Holan ZR, Volesky B (1994) Biosorption of Pb(II) and nickel by biomass of marine algae. BiotechnolBioeng 43:1001–1009

30. Volesky B, Holan ZR (1995) Biosorption of heavy metals. BiotechnolProg 11:235–250
31. Ake CL, Mayura K, Huebner H, Bratton GR, Phillips TD (2001) Development of porous clay-based composites for the sorption of Pb(II) from water. J Toxicol Environ Health Part A 63:459–475
32. Ahalya N, Ramachandra TV, Kanamadi RD (2003) Biosorption of heavy metals. Res J Chem Environ 7:71–79
33. O¨zcan AS, Erdem B, O¨zcan A (2004) Adsorption of Acid Blue 193 from aqueous solutions onto Na–bentonite and DTMA–bentonite. J Colloid Interface Sci 280:44–54
34. Tunali S, Akar T, O ¨ zcan AS, Kiran I, O¨zcan A (2006) Equilibrium and kinetics of biosorption of Pb(II) from aqueous solutions by Cephalosporiumaphidicola. Sep PurifTechnol 47:105–112
35. Bailey SE, Olin TJ, Bricka RM, Adrian DD (1999) A review of potentially low-cost sorbents for heavy metals. Water Res 33:2469–2479
36. Demirbas¸ A (2008) Heavy metal adsorption onto agro-based waste materials: a review. J Hazard Mater 157:220–229
37. Namasivayam C, Ranganthan K (1995) Removal of Cd (II) from wastewater by adsorption on waste Fe(III)/Cr(III) hydroxide. Water Res 29:1737–1744