DETOXIFICATION OF CD(II) BY USING ECO-FRIENDLY ADSORBENT MATERIAL PREPARED FROM SARACA ASOCA BARK

A. B. Sahare[a], B. D. Gharde[b]*amd S. G. Badne[c]
[a & b]Department of Chemistry, S.S.E.S. Amravati's Science College, Pauni Dist. Bhandara, M.S., India.
[c]Department of Chemistry, Shri Shivaji College of Arts, Commerce and Science, Akola, M.S., India.

A B S T R A C T
Wastewater containing high concentration Cd(II) is very toxic to living beings and responsible for various diseases. An eco-friendly adsorbent material has been prepared from Saraca asoca bark for its removal. The adsorbent have good adsorption capacity. The batch study was performed to fix the effect of various parameters on the adsorption of Cd(II). The studies indicate that adsorption of Cd(II) increases with pH and found maximum at slightly acidic for an optimum contact time of 50 minutes. The adsorption of Cd(II) was maximum at lower concentration and it increased with increasing doses of adsorbent. The light metal ions in solution interfere with adsorption of Cd(II) ions. Freundlich adsorption isotherm was tested to confirm the amount of adsorption.
Keywords: Cadmium removal, Asoca bark, Saraca asoca, Cadmium detoxification
Wastewater Treatment

1. Introduction

The heavy metals are considered to be non biodegradable pollutants. When accumulate in the body of humans, animals and plants through food chain they cause toxicity [1]. Now a days water pollution becomes a global problem because discharge of heavy metals, acids, waste materials, chemicals etc. directly into fresh water resources [2]. The demand of purified water increasing day by day and hence attention is given towards treatment of wastewater for removal of toxic substances and its reuse [3]. The wastewater contaminated with toxic metal ions can be lead to a serious life threat. The exposure to toxic metal ions in day to day life due to agricultural work, mining, transportation, etc. results into toxicity [4]. But, the consumption of heavy metal contaminated water causes major damage to life. Hence, treatment of toxic metal contaminated wastewater becomes very important environmental issue. The main sources of metal water pollution are discharge of industrial and mining effluents, anthropogenic activities etc. Toxic metals pollution leads to health hazards to living beings if exceed their concentrations above allowable limits [5]. The safety limits for some toxic metals are given in Table 1.

Different plant products, byproducts like plant skin, leaves, peanut skin, rice straw, bark etc. have been used to remove toxic metals efficiently from wastewater [6]. Not much work has been reported on *Saraca asoka* bark. Therefore the present investigation deals with the preparation of an adsorbent material from *Saraca asoka* bark known as substrate and treatment of Cd(II) contaminated wastewater by using this bark substrate.

Table 1 – Safety limits of some toxic metals

Sr. No.	Metals	Maximum allowable concentration (ppm)
1)	Arsenic	0.05
2)	Lead	0.05

3)	Cadmium	0.01
4)	Trivalent Chromium	1.00
5)	Hexavalent Chromium	0.05
6)	Mercury	0.005

2. Experimental

2.1. Preparation of Adsorbent

The *Saraca asoka* bark was dried, powdered and sieved to small size. The bark powder treated with 100 ml 0.1 N HNO_3 and 30 ml 40% HCHO overnight with occasionally stirred. The powder was then washed several times with distilled water to remove acid residue. Then filtered and finally sun dried and used for adsorption studies.

2.2. Batch Study

The batch study was carried out to fix the optimum conditions for adsorption of Cd(II) on bark substrate. The adsorption experiments were performed using synthetically prepared wastewater containing Cd(II) ions. In general, 1 gm bark substrate of *Saraca asoka* was agitated with 100 ml Cd(II) containing wastewater. The concentration of Cd(II) before and after adsorption was analyzed by standard methods [7]. The parameters studied are:

1) Effect of pH
2) Effect of contact time
3) Effect of initial metal ion concentration
4) Effect of doses
5) Effect of temperature
6) Effect of extra elements

The adsorption capacity of *Saraca asoka* bark substrate for Cd(II) ions was tested by Freundlich Adsorption Isotherm on the basis of batch study.

3. Results and Discussion

3.1. Effect of pH

The solubility of metal ions is affected by change in pH of the solution [8]. Hence, pH becomes very important parameter for the adsorption of metal ions [9]. In present investigation stalk solution of Cd(II) ion was prepared. The different pH of stalk solution ranging from 2 to 9 was fixed with the help of sulphuric acid and sodium hydroxide (buffer) and diluted to give a solution of 30 ppm of Cd(II) ions. The 100 ml solution of definite pH was agitated with 1 gm of bark substrate for 100 minutes. It has been observed that the adsorption of Cd(II) varies with the pH of solution at fixed concentration and the maximum adsorption of 91.2% was observed at pH 6. Further, it has been observed that the final pH of solution was less than initial pH. Hence, for the sack of convenience the optimum pH of 6 was fixed for further study. The results are shown in figure1.

3.2. Effect of Contact Time

Adsorption is an equilibrium process. Some time required to maintain equilibrium between adsorbent and adsorbate in the process of adsorption. After equilibrium the concentration of adsorbate in solution remains constant at constant temperature. It makes the contact time is an important parameter to maintain the equilibrium of adsorbed Cd(II) ions between solid substrate and solution [10]. In this case 100 ml Cd(II) ion solution of pH 6 was agitated with 1 gm of substrate for different intervals of time ranging from 10 minutes to 80 minutes. It has been observed that the Cd(II) adsorption was very rapid and about 40% removal takes place in 10 minutes. The Cd(II) ion concentration in solution remains constant after 50 minutes. Therefore, the contact time was fixed to be 50 minutes in subsequent studies. The results are shown in Figure 2.

3.3. Effect of initial metal ion concentration

The process of adsorption can be affected by the change concentration of adsorbing species in solution. Hence, effect of initial metal ion concentration plays an important role parameter in adsorption process [11]. In this case 100 ml solutions of pH 6 at different concentration of Cd(II) ion ranging from 30 to 65 ppm were agitated with 1 gm bark substrate for 50 minutes. It has been observed that the metal ion uptake was increased with increase in concentration. But, the % adsorption of metal ion decreases, it may be due to unavailability of adsorption sites. It could be concluded that the highest metal uptake would occur at the highest metal concentration [12]. The results mentioned in Figure 3.

3.4. Effect of adsorbent doses

The effect of adsorbent doses of bark substrate on the process of adsorption was examined by

using different doses ranging from 1 to 5 gm agitated with 100 ml Cd(II) ion solution for 50 minutes. It has been observed that the metal ion intake decreases with increasing adsorbent doses while the % removal metal ion from solution increases with increasing doses.

It may be because of on increasing adsorbent dosages, the available metal ions are insufficient to cover all the exchangeable sites on the adsorbent, resulting in a low metal ion uptake [13]. Thus, it may be concluded that the highest metal uptake occurs at the lowest adsorbent dose if the temperature and concentration of metal ion kept constant. The results are shown in Figure 4.

3.5. Effect of temperature

The temperature variation plays very important role in metal ion adsorption and temperature can highly affects the sorption process [14]. The effect of temperature on the adsorption of Cd(II) ion was examined by agitating 100 ml of Cd(II) ion solution with 1 gm of bark substrate at different temperatures ranging from 30ºC to 60ºC. A clear trend of decrease in adsorption with increasing temperature was observed. An opposite trend was reported by some workers [15]. The results of the experiment are mentioned in Figure 5.

3.6. Effect of extra element concentration

The process of adsorption can be affected by the presence of extra elements cations such as Na^{+}, Mg^{2+} and Ca^{2+} in the adsorption medium along with the metal ion under study [16]. The concentration of these elements in adsorption medium varied from 10 to 30 ppm in the present study. The 100 ml Cd(II) ion solution containing different concentrations of light metal ions was agitated with 1 gm of bark substrate for 50 minutes. It was found that the intake of Cd(II) ions decreases with increasing concentration of extra elements. The results obtained are given in Figure 6.

3.7. Effect of extra element concentration

There are many models have been proposed to explain adsorption equilibria. But, the most important factor is to have applicability over the entire range of process. The most widely used isotherms for adsorption of solute from solution on a solid adsorbent is the Freundlich isotherms (Bulut and Tez, 2007). The Freundlich Adsorption Isotherm can be written as:

$$\log \frac{X}{M} = \log k + n \log C_e$$

Where, X/M - Concentration of metal ion adsorbed per g of adsorbent.

Ce - Residual concentration of metal ion.

k - Adsorption capacity (in mg/l).

n- Intensity

The log X/M is plotted against log Ce gives straight line. The value of n obtained from slope and that of k is intercept of the graph. The plot was found to be a straight line indicating that the adsorption follows Freundlich model and the larger the k and n values, the higher is the adsorption capacity [17]. The magnitude of n gives an indication of favorability of the adsorption [18]. The value of n in the range of 2-10 represent good, 1-2 moderately difficult and less than 1 poor adsorption characteristics [19]. The Freundlich model implies that the adsorption of Cd(II) was based on sorption on heterogeneous surface. The higher adsorption of Cd(II) may be due to its greater tendency to undergo heterogeneous adsorption [20, 21]. The value of correlation regression R^2, for Cd(II) is found to be 0.867. The values in the adsorption isotherm are summarized in Figure 7.

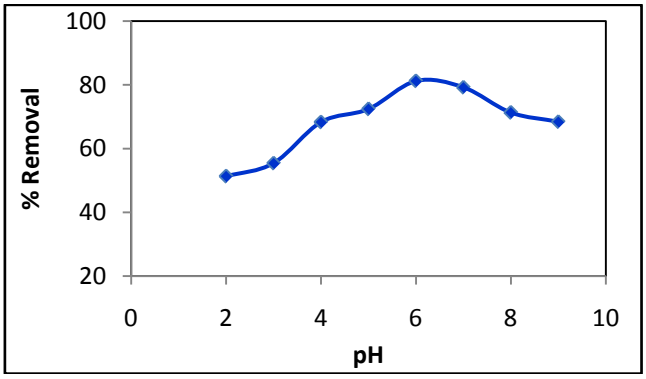

Fig. 1 – Effect of pH on adsorption of Cd(II)

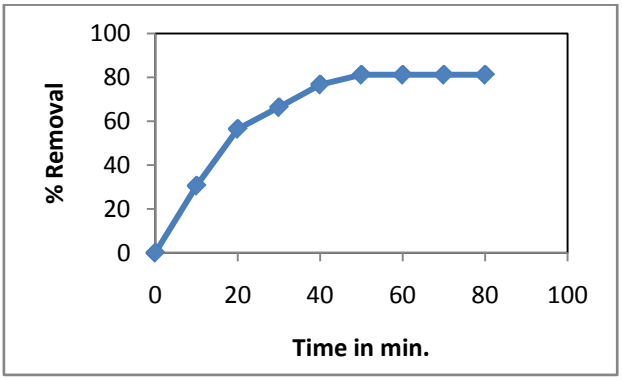

Fig. 2 – Effect of contact time on adsorption of Cd(II)

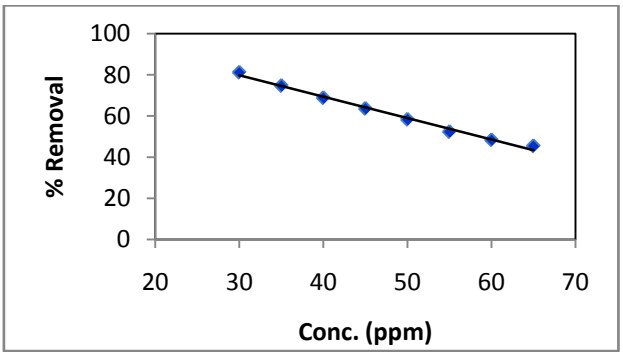

Fig. 3 – Effect of initial concentration on adsorption of Cd(II)

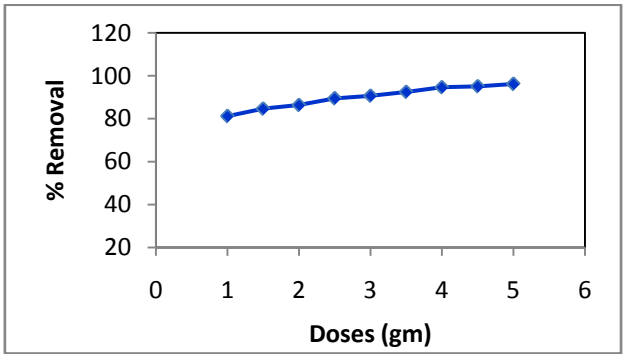

Fig. 4 – Effect of adsorbent doses on adsorption of Cd(II)

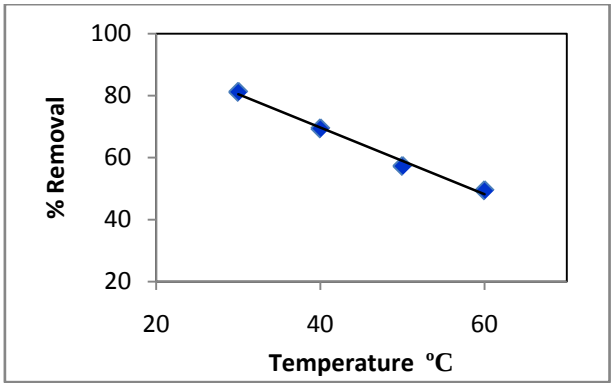

Fig. 5 – Effect of temperature on adsorption of Cd(II)

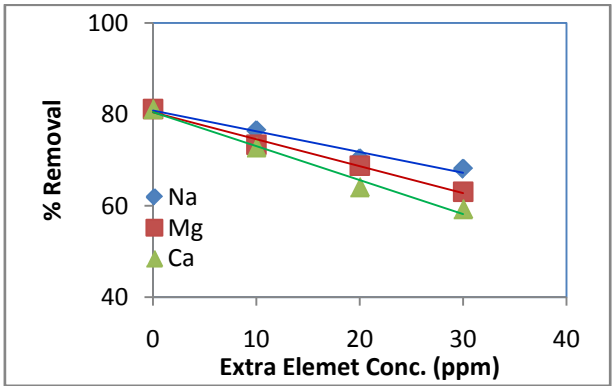

Fig. 6 – Effect of light metal ion concentration on adsorption of Cd(II)

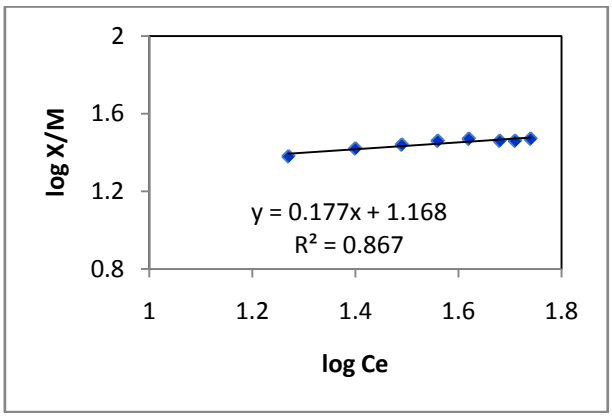

Fig. 7 – Freundlich adsorption isotherm for Cd(II) on bark substrate

4. Conclusion

The present study shows that the *Saraca asoka* bark substrate is found to be an effective adsorbent material for the treatment of Cd(II) in synthetically prepared wastewater. It is an easily available, eco-friendly and less expensive adsorbent material, so that it may be used in place of expensive activated charcoal. It has been observed that the adsorption not only depends upon nature of adsorbent material but also on some characteristics like contact time, initial metal ion concentration, doses of adsorbent etc. The effect of parameters like contact time, initial metal ion concentration, adsorbent doses, temperature and light metal ions concentration on adsorption efficiency reveals the typical trend shown by any adsorbent.

Acknowledgements

The authors are greatly thankful to the Principal, S.S.E.S. Amravati's Science College, Pauni Dist. Bhandara for providing necessary facilities.

REFERENCES

[1] R. A. Wuana et al. (2010). Removal of heavy metals from a contaminated soil using organic chelating acids, *International Journal of Environmental Science and Technology, 7(3)*, 485-496.

[2] Khitoliya R. K. (2004). *Environmental Pollution*, S. Chand Limited, 1-309.

[3] Gopi Krishna et. al. (2004), Preconcentrative separation of Chroium (IV) species from Chromium (III) by coprecipitation of its ethyl xanthate complex onto Napthalene, *Talenta, 63,* 41-46.

[4] Ona Gyliene et. al. (2008). Heavy metal removal from solution using natural and synthetic sorbents, *Environmental Research, Engineering and Management, 1(13)*, 28-34.

[5] Sohil Ayub et. al. (2001). Efficiency evaluation of Neem bark in treatment of industrial waste water, *Env. Poll. Con. J., 4(4),* 34-38.

[6] Rao, M.M. et al. (2009). Removal of mercury from aqueous solutions using activated carbon prepared from agricultural by-product/waste, *Journal of Environtal Management, 90(1),* 634-643.

[7] APHA (1995). *Standard Methods for Estimation of water and Wastewater*. American Public Health Association,

American Water Works Association, Water Pollution Control Federation, New York.

[8] Bhatti, H.N. et al. (2007). Removal of zinc ions from aqueous solution using Moringa oleifera Lam. (horseradish tree) biomass, *Process Biochem., 42,* 547-553.

[9] Qiu Y. et al. (2008). Surface characteristics of crop-residue-derived black carbon and lead(II) adsorption, *Water Res., 42,* 567-574.

[10] Pechyen, C. et al. (2007), Investigation of pyrolyzed chars from physic nut waste for the preparation of activated carbon, *J. Solid Mechanics Material Eng., 1(4),* 498-507

[11] V. S. Sethu et al. (2010). Adsorption characteristics of Cu (II) ions in aqueous solutions using Mangifera indica (Mango) leaf biosorbents, *Journal of Environmental Research And Development, 5(2),* 262-278.

[12] Pechyen, C. et al. (2007). Investigation of pyrolyzed chars from physic nut waste for the preparation of activated carbon, *Journal of Solid Mechanics and Material Engineering, 1(4),* 498-507.

[13] King P. et al. (2008). Biosorption of zinc from aqueous solution using Azadirachta indica bark: Equilibrium and kinetic studies, *J. Ha. Mate., 152(2),* 324-329.

[14] Tikomolora K. et al. (2002). Adsorption on quartz of Co(II) and Ni(II) in the form of hydroxide nanoparticles or metal ionic species from solution with pH close to that onset of hydroxide formation, *Russian J. Gen. Chem., 72(7),* 989-996.

[15] Tunali S. et al. (2006). Equilibrium and kinetics of biosorption of lead(II) from aqueous solutions by Cephalosporium aphidicola, *Sep. Purifi. Tech., 47(2),* 105–112.

[16] Chipin Huang and Huang C.P. (1996). Aspergilus oryzae and Rhizopus oryzae for Cu(II) removal, *Water Res. Oxford, 30(9),* 1985-1990.

[17] Desai A. J. and Desai H. H. (2014). Potential of Azadirachta indica Leaves for Removal of Hexavalent Chromium from Aqueous Solution with Reference to Adsorption Isotherm, *International Journal of Innovative Research and Development, 3(7),* 359-368.

[18] Patel N. S. and Desai H. H. (2011). Potential of Moringa oleifera seeds, leaves and barks for removal of Hexavalent Chromium from aqueous solution with reference to adsorption isotherm, *International Journal of Water Resources and Environmental Management, 3(2),* 12.

[19] Treybal R.E. (1981). *Mass transfer operations,* 3, Mc Graw Hill.

[20] Ramadevi A. and Srinivasan K. (2005). Agricultural Solid Waste for the Removal of Inorganics: Adsorption of Mercury (II) from Aqueous Solution by Tamarind Nut Carbon, *Res. J. of Chem. and Environ., 9(1),* 54-59.

[21] Upendra Kumar and Manas Bandyopadhyay (2005). Fixed Bed Column Study for the Removal of Ni(II) from Aqueous Waste by NCRH, *Res. J. of Chem. and Environ.,* 2005, 9(4): 81-86