Feasibility Study on Using Low Cost Adsorbents For The Removal of Cd(II) From Textile Wastewater

M. Karthikeyan[1], B. Asha[2]
[1, 2] Dept of Civil Engineering
[1, 2] Faculty of Engineering and Technology
Annamalai University, Annamalai Nagar-608002, TamilNadu, India.

Abstract- *Experimental investigation was carried out for the removal of Cd(II) using novel adsorbents such as azadirachta indica leave powder as a biosolvent from the textile wastewater. The parameters such as contact time, initial pH, and dosage content were varied in this research. The optimum biosorption of azadirachta indica leaf powder (AILP) was achieved at pH 6 for Cd(II). The adsorbent tested data was fitted with Langmuir and Freundlich isotherms and also computed by equilibrium thermodynamic and kinetic parameters, which showed the values of azadirachta indica leaf as a promising adsorbent for dyes in aqueous solution.*

Keywords- Cadmium, Azadirachta indica leave powder, Biosorbents, and Langmuir & Freundlich isotherms.

I. INTRODUCTION

The ground water is polluted through the industries discharge large amount of wastewater to the ground surface, after various chemical treatment processes are found to have more toxic effect due to the presence of chemicals. Removal of heavy metals from industrial wastewater is of primary importance because they are not only causing contamination of water bodies and also toxic to many life forms, such as contain non-biodegradable metals like Copper (Cu), Zinc (Zn),Nickel (Ni), Lead (Pb),Cadmium(Cd), and Chromium (Cr) into water stream. It causes various hazardous health problems due to consumption of polluted water. Among these heavy metals, pollution by Chromium is of major concern as the metal is used in electroplating, leather tanning, metal finishing, and Chromate preparation.

Adsorption techniques have become popular for wastewater treatment due to their efficiency in the removal of pollutants that are to be removed by biological methods. Chromium exists in environment both as Trivalent (Cr (III)) and Hexavalent (Cr (VI)) forms of which, Hexavalent form is 500 times more toxic than the trivalent one. Toxic chromic wastewater contaminates the environment by filtration Cd pollutants transportation in to ground waste and Cr (VI) includes skin irritation, lung cancer, as well as kidney, liver, and gastric damage to human beings. Human toxicity of Cr includes Skin Irritation, Lung cancer a smell as kidney liver gastric damage by U.S. Dept. of Health and Human services. The usual methods to remove Cr (VI) from aqueous effluents include chemical reduction, nanofiltration and bioaccumulation, adsorption on silica composites and on activated carbon. However, these approaches are not cost-effective and difficult to implement in developing countries.
The textile industry contributed about 2.2% of the total value of industrial in our country. Heavy metals are present in different hyper of industrial effluent being responsible for environmental pollution. Adsorption increased from 8.8% at pH 4.0 to 70.0% at pH 7.0 and 93.6% at pH 9.5, the higher values in alkaline medium being due to removal by precipitation, which was very fast initially and maximum adsorption was observed within 300 minutes of agitation by Krishna G. Bhattacharyya and Arunima Sharma. The Neem tree (Azadirachta indica) is the traditional plant of Indian Sub-Continent, which is Meliaceae family. Since ancient times, leaves have been in use to treat a number of human ailments and also as a household pesticide. It contains 59.4% moisture, 22.9% Carbohydrates, 7.1% Proteins, 6.2% Fiber, 3.4% minerals, 1% fats and a host of other chemicals. It makes as an air purifier and also leaves, bark, seeds and other parts of the plant are attributed a variety of meditative and bactericidal properties, such as an anti-inflammatory, anxiolytic, anti-androgenic, anti-stress, humoral and cell-mediated immune stimulant, anti-hyperglycemic, liver-stimulant, anti-viral and anti-malarial activities. Azadirachta indica leaf is used to develop a low cost adsorbent for the removal of Cd was taken primary batch process such as cleaning; drying, grinding, washing to remove pigments, and re-drying after were collected from the matured trees. Novie Febriana, et al, had removed copper ions. Tawde .S.P and S.A. Bhalerao comparative studied, Azadirachta indica (Neem) leaf powder and Activated charcoal for their adsorptive capacity to remove Chromium(VI).Vinodhini .V and Nilanjana Das was observed to removal of Cr(VI) by used Neem Sawdust Mamoona Arshad et al., had found out to remove the Zinc.

II. MATERIALS AND METHODS

The textile wastewater was collected and the parameters were analyzed as per Standard Procedures (APHA, 2000) and presented in the Fig. 1.

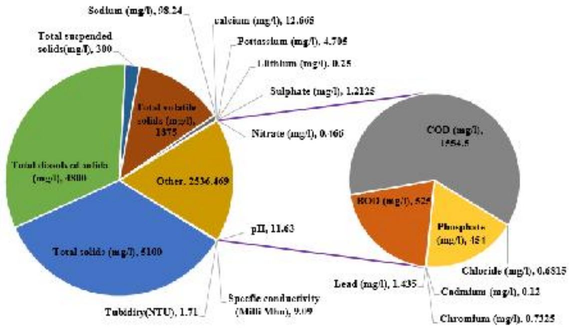

Fig.1. Characterization of average dye waste

A. Preparation of Biosorbent

The ripe azadirachta indica leaves were thoroughly washed with distilled water three to four times to remove dust and other impurities and were allowed to dry first at room temperature in a shade and then in an oven at 60ºC till the leaves became crisp that could be crushed into a fine powder in a mechanical grinder and then screened. Dried Azadirachta indica leaves powder were keeping in plastic containers stored in humidifier for further use. These fine powders were used as a biosorbent. In the present study the powdered materials in the range of 300 microns of average particle size were then directly used as biosorbent without any pretreatment.

B. Biosorption Study

A known quantity of biomass is taken and added with the industrial waste and the mixture is placed over the mechanical shaker. The sample were taken out at a specific duration of time and centrifuged at 1000rpm for 15 minutes the supernatant liquid was separated low residual Cd(II) metal ion was analyzed.

III. RESULTS AND DISCUSSION

A. Effect of contact time

Biosorption equilibrium was characterized, as the time required for substantial toxic metal ion to achieve a constant value during this process. The characteristic curves for time Vs % removal is shown in Fig.2. The biosorption was slightly and gradually increased from 68.57% to 90% with an increase in biosorbent dosage from 0.5 to 2.0g with respect to contact time in the range from 30 minutes to 150 minutes. The percentage removal efficiency was achieved from 68.57% to 88.50 % for 0.5 g of absorbent (AILP) added to the wastewater for Cd(II) removal. For 1.0g of AILP as an absorbent added to get 89.50% removal efficiency was obtained with contact time 90 minutes and sudden reduced at 120 and 150 minutes. For 1.5g of absorbent added to get 85.71%and 87.20% was absorbed in the 30 minutes and 60 minutes respectively. Further increased contact time from 60 minutes to 90 minutes the removal efficiency of Cd(II) was decreased to 71.42%. When contact time increased from 90 minutes to 120 minutes, the elimination of Cd(II) was attained 78.57% at 150 minutes. For 2g of AILP absorbent added to get removal efficiency was obtained 85.24% with contact time 30 minutes, beyond the contact time from 30 minutes to 90 minutes, the maximum removal efficiency was attained 90% with contact time 90 minutes and reached equilibrium condition after increased contact time. Among the four dosages of biosorbents 90% of Cd was removed in 90 minutes at the dosage of 2.0g. The biosorption process was rapid in the beginning level due to adequate surface area of the biosorbent was available for the removal of cadmium. As contact time increases, huge amount of heavy metal gets adsorbed onto the surface of the biosorbent due to Vander Waal's forces of attraction and results in decreased of available surface area by Varma et al.. The biosorbent, normally, forms a thin one molecule thick layer over the surface.

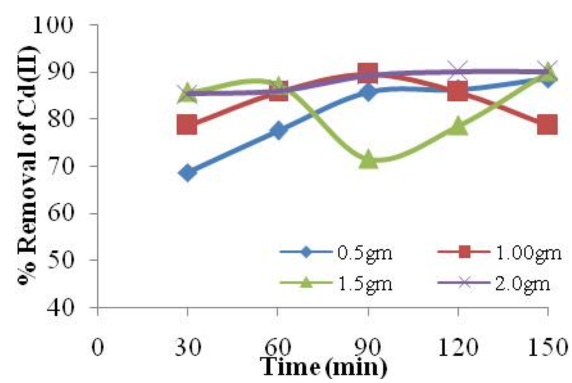

Fig.2. Effect of contact time Vs % removal of Cd(II)

B. Effect of dosage content

The percentage removal of Cd(II) was drawn against biosorbent dosage and percentage removal of AILP for the dosage from 0.25g to 2.0g.The AILP Biosorption was increased from 75.71% to 90% of Cd(II) at the dosage from 0.25 to 2.0g. The characteristic curves on the amount of substance added Vs % removal are shown in Fig.3. Among the eight dosages of biosorbents, AILP was higher removal efficiency (89.75%) with dosage content of AILP 1.5g. Beyond the dosage from 1.5g to 2.0g, the removal efficiency was equilibrium conditions. At low biosorbent, the metal of Cd(II) ions present in effluent could interact with the binding sites, and thus the percentage adsorption was increase to high than those at higher initial Cd(II) ion concentrations. At high biosorbent, lower adsorption yield is due to the saturation of adsorption sites. Based on this process, the results of purification yield can be increased by diluting the wastewaters containing high metal ion concentrations.

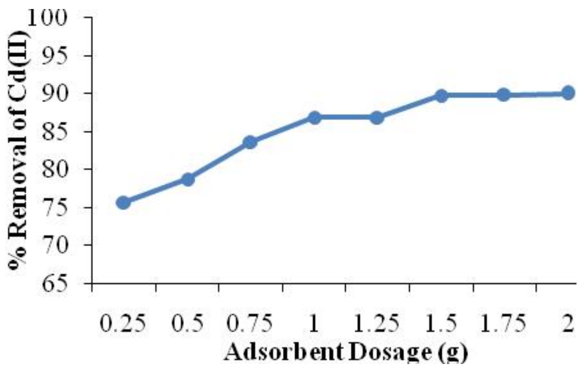

Fig. 3 Effect of dosage content Vs %removal of Cd(II)

C. Effect of pH

The solution pH is one of the parameter having considerable influence on the biosorption of metal ions, because the surfaces changes density of the adsorbent and the charge of the metallic specimen present on the pH. The adsorption isotherms and the influence of the pH on the adsorption of each metallic ion by a series of ozonized activated carbons, the adsorption capacity and the affinity of the adsorbent augmented with the increase in acid-oxygenated groups on the activated carbon surface by M. Sanchez-Polo and J. Rivera-Utrilla, Saumya S.Pillai et al., had reported to removed heavy metal by potato starch. The maximum Biosorption of AILP was attained at maximum pH 6.0 for Cd(II). The percentage removal of Cd was drawn against pH of the solution. The pH of the solution was taken from 1 to 10.The percentage removal of Cd was attained the high removal efficiency of Cd(II) and it was 88.85% at pH level of 6. The curves on pH Vs % removal is shown in Fig.4.

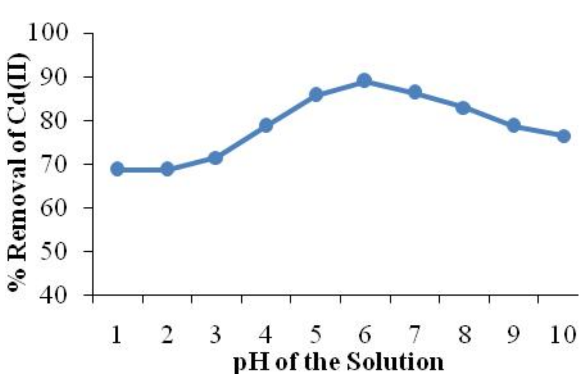

Fig. 4. pH Vs % removal of Cd(II)

IV. KINETICS OF ADSORPTION

The kinetics of Cd adsorption on AILP was studied with respect to different amounts of the adsorbent. The interactions appeared to attain equilibrium rapidly after about one hour agitation. Adsorption is a chemical process used in water and wastewater treatment. The most widely used models to describe the equilibrium behaviors of adsorbate uptake are the well-known Langmuir and Freundlich sorption isotherms. The Freundlich model was derived empirically, while the Langmuir adsorption isotherm was derived from the rational considerations. To date the Langmuir and Freundlich equations have been considered as independent models.

The linearised isotherms are the most informative of presenting the results. The experimental data is shown in the Fig.5 and Fig.6. The essential characteristics, sorption intensity "a" (l/mg) and sorption capacity "b" (l/mg) and linearised Langmuir equation according to Neem leaf are given below.

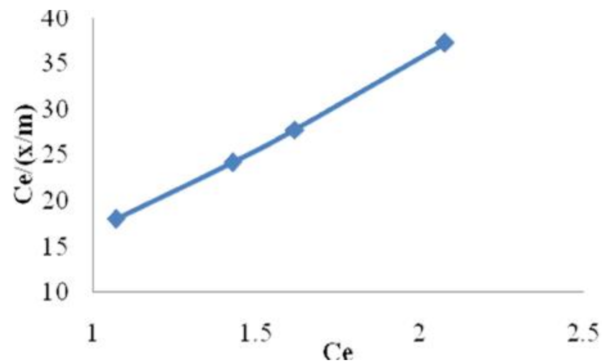

Fig. 5. Linearised Langmuir isotherm for the adsorption of Cd(II)

The intercept 1/n is the estimation of the sorption capacity and K is an estimate of sorption intensity

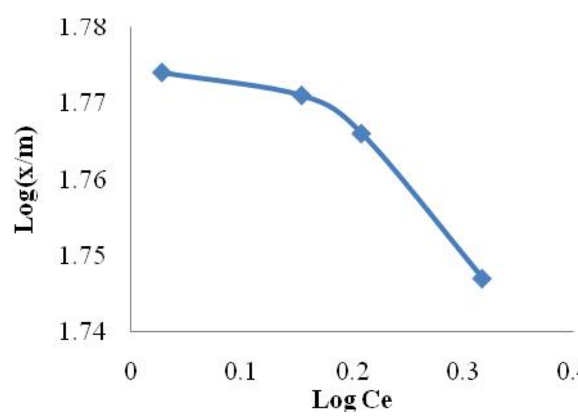

Fig. 6. Linearised Freundlich isotherm for the adsorption of Cd(II)

From Langmuir isotherm, the adsorption affinity constant (b) and maximum capacity (qmax) of the ion Cd(II) to form a complete monolayer on to the surface of the AILP. Biomass was estimated at 0.105 and 19.115 mg/g, respectively. For Freundlich isotherm the constants related to the adsorption coefficients (Kf) and intensity (1/n) were 1.780 and 0.091 respectively. The correlation coefficients obtained from the Langmuir model and Freundlich model were 0.997 and 0.842, respectively. However as the solutions handled are very dilute in the present work, Langmuir equation was observed to be more suitable for the experimental data.

V. CONCLUSION

In the present study, Biosorption experiments for the removal of Cd metal ion from aqueous solutions have been carried out using dried azadirachta indica leaf powder as low cost and natural available adsorbents. It was found that the biosorption was rapid and increased by the decrease in biosorbent average particle size. The optimum biosorption was achieved at pH 6.0 (AILP) for Cd(II). The percentage removal was The maximum removal efficiency of Cd(II) was obtained and it was 90% at the level of pH 6 with the dosage content of AILP 1.5g and contact time 90 minutes. The adsorption isotherm data was satisfactory explained by Langmuir and Freundlich isotherm models. The Freundlich isotherm had been well fitted the biosorption of Cd with chemically modified azadirachta indica leaf. Finally the dried AILP can be used as an alternative effective natural biosorbents, the removal of heavy metals from wastewater.

REFERENCES

[1] APHA(2000),"Standards methods for water and wastewater

[2] Dhinakaran.G, (2011), "Dye removal from aqueous solution using low cost adsorbent", International journal of environmental sciences.1 (7), pp.1492-1503.

[3] Ghaedi.M. et al., (2011), "A novel acorn based adsorbent for the removal of brilliant green", Journal of Desalination, (281), pp. 226–233.

[4] Gopalakrishnan S., et al (2013), "Biosorption of Chromium (VI) from Industrial Effluent using Neem Leaf Adsorbent", Res. J. Chem. Sci. pp. 48-53.

[5] Krishna G. Bhattacharyya and Arunima Sharma (2005), "Azadirachta indica (Neem) Leaf powder as a biosorbent for removal of Cd(II) from aqueous medium", Journal of Hazardous Materials. (125) , pp. 102-112.

[6] Krishna G. Bhattacharyya and Arunima Sharma (2005), "Kinetics and thermodynamics of Methylene Blue adsorption on Neem (Azadirachta indica) leaf powder", Journal of Dyes and Pigments.(65), pp. 51-59.

[7] Krishna G. Bhattacharyya and ArunimaSarma. (2003), "Adsorption characteristics of the dye, Brilliant Green, on Neem leaf powder", Journal of Dyes and Pigments.(57), pp. 211–222.

[8] Krishna G. Bhattacharyyaa, et al., (2009), "Neem leaf powder as a biosorbent for Ni(II) in aqueous medium", Journal of Hazardous Materials. (165), pp. 271–278.

[9] M. Sanches-Polo and J. Rivera-Utrilla (2002), "Adsorbent-adsorbate interactions in the adsorption of Cd(II) and Hg(II) on ozonized activated carbons", Environ. Sci.Technol. (36), pp. 3850–3854.

[10] Mamoona Arshad, et al., (2008), "The use of Neem biomass for the biosorption of Zinc from aqueous solution", Journal of Hazardous Materials. (157), pp. 534–540.

[11] NoureddineBarka et al (2013), "Biosorption characteristics of Cadmium and Lead onto eco-friendly dried cactus (Opuntiaficus indica) cladodes." Journal of Environmental Chemical Engineering. (1), pp. 144–149.

[12] NovieFebriana, et al., (2010), "Neem leaf utilization for Copper ions removal from aqueous solution", Journal of the Taiwan Institute of Chemical Engineers. (41), pp. 111–114.

[13] Pandharipande S. L., and Rohit P. Kalnake, (2013), "Tamarind fruit shell adsorbent synthesis, characterization and adsorption studies for removal of Cr(vi) & Ni(ii) ions from aqueous solution", International Journal of Engineering Sciences & Emerging Technologies, 4 (2), pp. 83-89.

[14] Reena Malik et al (2012), "Neem Leaf Utilization for Copper and Zinc Ions Removal from Aqueous Solution",International Journal of Science and Research. 3(5), pp. 695-705.

[15] Renmin Gong, et al.,(2007), "Removal of basic dyes from aqueous solution by sorption on phosphoric acid modified rice straw", Journal of Dyes and Pigments.(73), pp. 332-337.

[16] SaumyaS.Pillai et al., (2013), "Biosorption of Cr(VI) from aqueous solution by chemically modified potato starch: Equilibrium and kinetic studies", Jr of Ecotoxicology and Environmental Safety.(92), pp. 199–205.

[17] Tawde. S.P and S.A. Bhalerao. (2010), "Biosorption of Chromium (VI) from an aqueous solution using Azadirachta indica. A. Juss. (Neem) and activated charcoal: A comparative study", An International Journal. 2(2), pp. 4-10.

[18] U.S. Dept of Health and Human services (1991), "Toxicological profile for chromium", Public Health Services Agency for Toxic substances and Disease Registry, Washington D.C.

[19] Vadivelan. V and Vasanth Kumar.K. (2005), "Equilibrium, kinetics, mechanism, and process design

for the sorption of methylene blue onto rice husk",Journal of Colloid and Interface Science. (286), pp. 90–100.

[20] Varma, Srinivas, Nagamani, PremSagar and Rajsekhar (2010), "Studies on biosorption of Cadmium on Psisdium guajava leaves powder using statistical experimental design", Journal of Chemical and Pharmaceutical Research, 2(5), pp. 29-44.

[21] Vinodhini. V and Nilanjana Das, (2009), "Mechanism of Cr (VI) Biosorption by Neem Sawdust", American-Eurasian Journal of Scientific Research. 4 (4), pp 324-329.

[22] Vinodhini. V, and Nilanjana Das., (2010), "Packed bed column studies on Cr (VI) removal from tannery wastewater by neem sawdust", Journal of Desalination.(264), pp. 9–14.