Research Article **ISSN: 2349 – 7106**

Asian Journal of Research in Chemistry and Pharmaceutical Sciences

Journal home page: www.ajrcps.com

EXPULSION OF CADMIUM (II) ION FROM INDUSTRIAL EFFLUENTS BY ADSORPTION USING SWEET LIME (*CITRUS LIMETTA)* TREE LEAF POWDER

Prerna Mundel*[1], Nikita Choudhary[1], Shobha Sharma[1], Arun Kumar Suthar[2], Anju Sharma[3]

[1*]Department of Chemistry, Jai Narain Vyas University, Jodhpur, Rajasthan, India.
[2]Department of Chemistry, Leela Devi Parasmal Sancheti Kanya Mahavidyalaya, Vidyawadi, Rani, Pali, Rajasthan, India.
[3]Department of Chemistry, Sri Baldev Ram Mirdha Government College, Nagaur, Rajasthan, India.

ABSTRACT

Adsorbent for removal of Cd (II) was prepared by grinding sweet lime tree leaves. The removal of toxic heavy metal like Cd (II) was studied using adsorption technique. In the present study the adsorption of toxic heavy metal from industrial wastewaters on to sweet lime (*Citrus limetta*) tree leaf powder (CLTLP) was studied. The percent adsorption varies with adsorbent dose, pH and contact time. Adsorption model of CLTLP well fitted in Langmuir as well as in Freundlich model. The present investigation shows that CLTLP is an effective adsorbent for the removal of Cd (II) from aqueous solutions.

KEYWORDS

Adsorption, Heavy Metals, Wastewater, Sweet lime and Adsorbent.

Author for Correspondence:

Prerna Mundel,
Department of Chemistry,
Jai Narain Vyas University,
Jodhpur, Rajasthan, India.

Email: prernamundel@gmail.com

INTRODUCTON

Rapid industrialization has led to increased disposal of heavy metals into the environment[1]. The tremendous increase in the use of the heavy metals over the past few decades has inevitably resulted in an increased flux of metallic substances in the aquatic environment[2]. The metals are special because of their persistency in the environment[3]. At least 20 metals are classified as toxic, and half of these are emitted into the environment in quantities that pose risks to human health[4]. The ability of a water body to support aquatic life as well as its suitability for other uses, however, depends on many trace elements[5].

A number of technologies have been developed over the years to remove heavy metals from industrial wastewater[6]. The most important technology includes coagulation/flocculation, precipitation, ion-exchange, electrochemical processes and membrane technology. All the chemical methods have proved to be much costlier and less efficient than the biosorption process. In addition, chemical methods increase the pollution load on the environment.

Biomaterials that are available in large quantities or certain waste from agricultural operations may have potential to be used as low cost adsorbents, because they represent unused resources that are widely available and environmentally friendly[7]. Low cost and non-conventional adsorbents include agricultural by-products such as nut shells, wood, bone, peat, coconut shells, processed into activated carbons and biomass. The objectives of this work were to investigating the adsorptive capacity of the bioadsorbents by varying pH of solution, contact time, adsorbent dose, during the treatment of metal ion in aqueous solution[8].

MATERIAL AND METHODS

Preparation of Adsorbent

The *Citrus limetta* (Sweet Lime) tree leaves were collected. It was gathered from tree into clean plastic bags. Leaves were washed by triple distilled water and laid flat on clean surface to dry. Dry leaves were grounded with grinder. After grounded, the leaf particles were sieved and *Citrus limetta* tree leaf powder (CLTLP) stored into plastic bag, and ready to use.

Preparation of Adsorbate

Stock solution of Cadmium (1000 mg/L) was prepared using standard method. The concentration range of Cadmium prepared from stock solution varied between 10 to 50 mg/L. All chemicals of analytical reagent were used in the research work.

Batch Adsorption Experiment

Batch adsorption studies were carried out using CLTLP. Batch experiments were conducted at ambient temperature using the optimum conditions of all factors that influence adsorption such as adsorbent dose, pH, and contact time. 100 ml sample of Wastewater containing Cd (II) was placed in a 250mL conical flask and 1.0 gm adsorbent was added. The mixture was mechanically stirred at 200 rpm on a reciprocate shaker. 0.1 N HCl or 0.1 N NaOH aqueous solutions were used to adjust the pH of the test solution. The Cd (II) concentration of the treated wastewater was analyzed at time interval between 0 and 120 min using standard methods recommended for examination of water and wastewater[9].

The percentage removal of the Cd (II) and the amount of Cd (II) adsorbed were calculated by the following equations-

$$\% \text{ removal} = \frac{(C_i - C_e)}{C_i} \times 100$$

$$\text{Amount adsorbed (qe)} = \frac{(C_i - C_e)}{M} \times V$$

Where C_i = initial concentration of Cd (II) solution in mg/L

C_e = equilibrium concentration of Cd (II) solution in mg/L

M = mass of the adsorbent in grams (gm)

V = Test solution volume in liter (L)

RESULTS AND DISCUSSION

Effect of Adsorbent Dose

The effect of the adsorbent dose was studied at room temperature by varying the sorbent amounts from 5 to 20 g/L. For all these runs, initial concentration of Cadmium was fixed as 10 mg/L. Figure No.1 shows the adsorption of Cadmium increases rapidly with increase in the amount of leaf powder due to greater availability of the surface area at higher concentration of the adsorbent. The notable increase in adsorption was observed when the amount of dose was increased from 5 to 20 g/L. Any further increment in the adsorbent dose beyond this did not cause any notable change in the adsorption. This may be due to saturation of adsorption sites as a result of overloading of adsorbent particles. From the results, it is revealed that within a certain range of initial metal concentration, the percentage of metal adsorption on leaves is determined by the sorption capacity of the leaves[10]. The maximum removal of Cadmium was obtained in the adsorbent dose of 10 g/L.

Effect of Contact Time

Adsorption of Cadmium was measured at given contact time for five different initial Cadmium concentrations from 10 to 20 mg/L. From Figure No.2, the plot reveals that the rate of percent Cadmium removal increases with time[11]. This is probably due to larger surface area of the leaves being available at beginning for the adsorption of Cadmium ions. Most of the maximum percent Cadmium removal was attained after about 80 min of shaking time for different initial concentrations. The increasing contact time increased the Cadmium adsorption and it remains constant after equilibrium reached in 60 min for different initial concentrations[12].

Effect of pH

The pH of the solution is one of the parameters having considerable effect on the biosorption of metal ions, because the surfaces charge density of the adsorbent and the charge of the metallic species depend on the pH. In the present work, the extent of Cd (II) biosorption was investigated in the pH range 1.0–7.0 with a constant amount of CLTLP 10.0 g/L solution of concentration. At higher pH value, above optimum pH, the negative charge on the biomass cells promotes the uptake of metal ions.

With lower pH, the overall charge of surface become positive, this will prevent the approach of positively charge metal ions. It is likely that protons will then compete with metal ions for ligands and thereby decreases the interaction of metal ions with the cells. Whereas at higher pH (>5), the ligands attract positively charged metal ions and binding occurs, indicating that the major process is an ion exchange. Mechanism that involve an electrostatic interaction between the positively charged groups in cell walls and metallic cations, was found similar for biosorption of Cd (II) by CLTLP when the extent of biosorption increased continuously pH range of 1.0–6.0.Biosorption is maximum at pH-5.0 than it becomes slower down[13].

Adsorption Models

The isotherm study concentrated on the interaction between adsorbate and adsorbent. The data observed in this research work related in Langmuir and Freundlich adsorption isotherms. The Langmuir isotherm is assumption which depends on the removal due to monolayer sorption takes place on a homogeneous surface of adsorbent without any association between adsorbed particles were as Freundlich is based on equilibrium sorption occurred on the heterogeneous surfaces[14]. Linear equations of Langmuir and Freundlich isotherms are shown below in equation (a) and (b) respectively.

$$\frac{1}{q_e} = \frac{1}{(q_{max}K_L)}\frac{1}{C_e} + \frac{1}{q_{max}}$$

Equation (a)

In the above equation, the Cd (II) adsorbed capacity is denoted by q_e in mg/g and q_{max} is the maximum amount adsorbed in mg/g. The equilibrium Cd (II) concentration is represented by C_e in mg/L and Langmuir isotherm constant is represented by K_L in L/mg.

$$\log q_e = \log k_F + \frac{1}{n}\log C_e$$

Equation (b)

In equation b, the equilibrium Cd (II) concentration is denoted by C_e and q_e is the amount adsorbed in mg/g; k_F is the empirical constant of Freundlich in mg/g and 1/n is the Freundlich exponent. The linear plot shows the Freundlich and Langmuir isotherm application in Figure 4 and 5.

$$\frac{1}{q_e} \text{vs.} \frac{1}{C_e}$$

The data representation in both the adsorption isotherms shows that the Freundlich isotherm correlates well with coefficients as compare to Langmuir. The R^2 value obtained in Freundlich is 0.9738 whereas in Langmuir is 0.9276. Figure No.6.4 shows the Freundlich isotherm.

The study forecasted that the adsorbent surface has heterogeneous nature and worthy for adsorption. Figure No.5 shows the Langmuir isotherm.

The dose of CLTLP optimizes 10 gm/L for the concentration of Cd (II) ions 5 mg/L at pH 4-5. Maximum removal recorded at minimum initial concentrations. The optimum time of contact was found 80 Min. The lower size particle sieved CLTLP has more resulted uptake capacity of Cd (II) ions. Adsorption model of CLTLP well fitted in Langmuir as well as in Freundlich model.

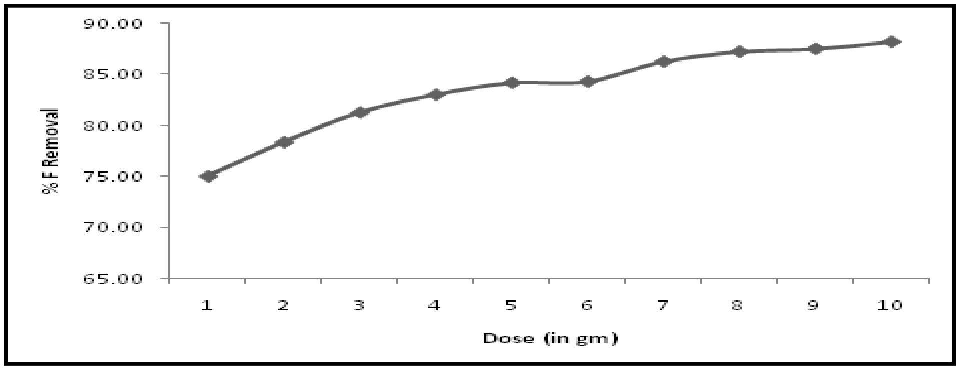

Figure No.1: Effect of adsorbent dose on Cd (II) adsorption

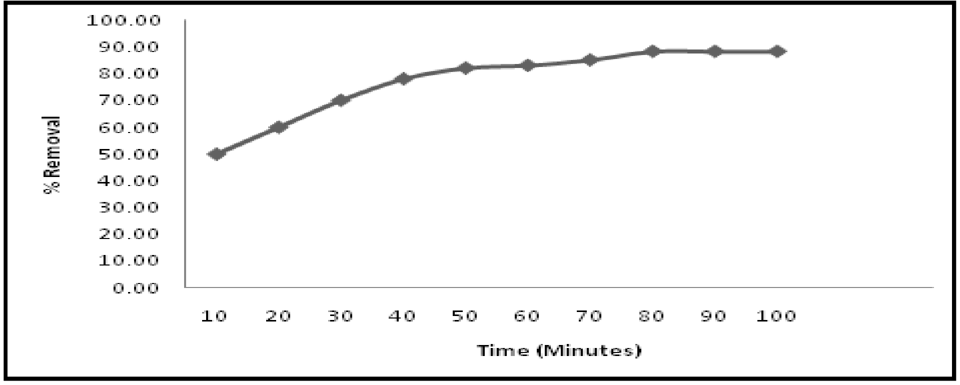

Figure No.2: Effect of contact time on Cd (II) adsorption

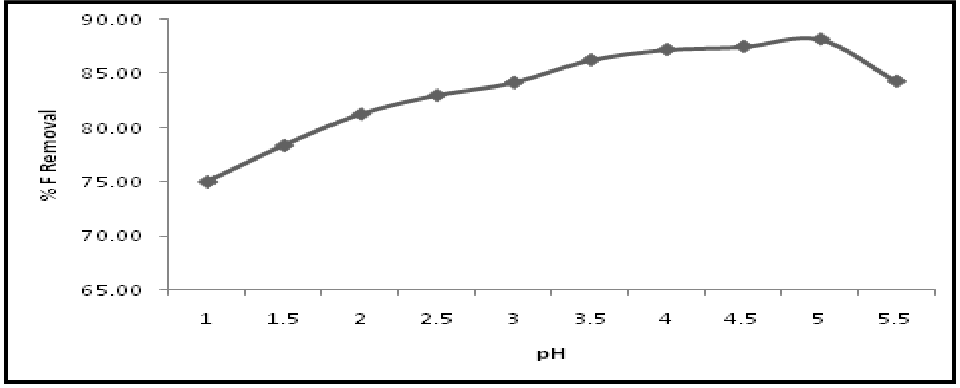

Figure No.3: Effect of pH on Cd (II) adsorption

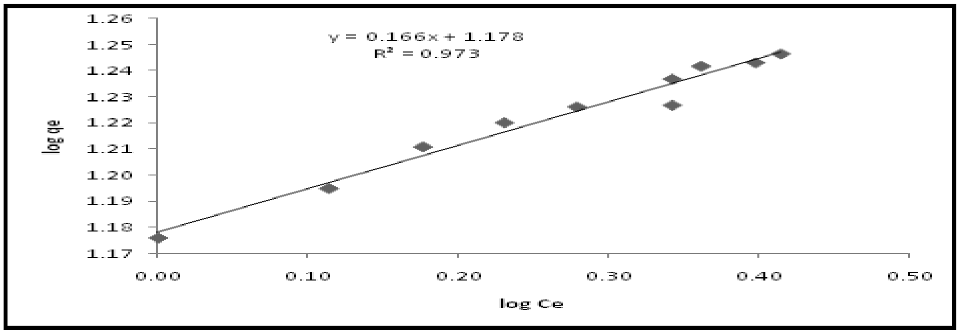

Figure No.4: Plot for Freundlich isotherm for the adsorption of Cd (II)

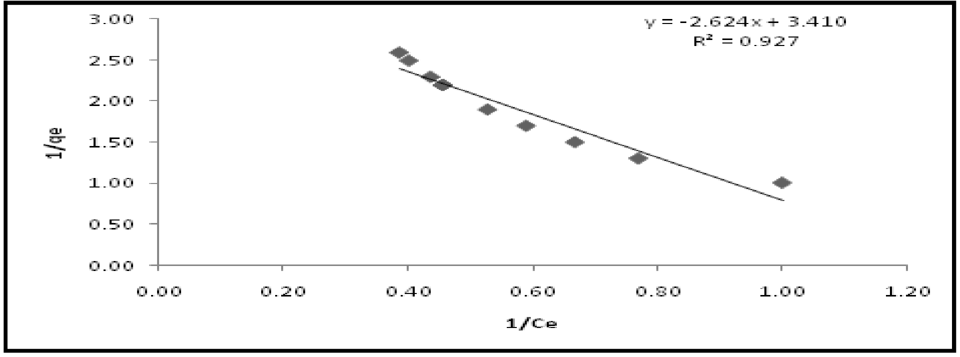

Figure No.5: Plot for Langmuir isotherm for the adsorption of Cd (II)

CONCLUSION

The present investigation shows that CLTLP is an effective adsorbent for the removal of Cd (II) from aqueous solutions.

ACKNOWLEDGEMENT

The authors wish to express their sincere gratitude to Department of Chemistry, Jai Narain Vyas University, Jodhpur, Rajasthan, India for providing necessary facilities to carry out this research work.

CONFLICT OF INTEREST

We declare that we have no conflict of interest.

BIBILIOGRAPHY

1. Rahmani A, Zavvar Mousavi H and Fazli M. Effect of nanostructure alumina on adsorption of heavy metals, *Desalination,* 253(1-3), 2010, 94-100.
2. Erwa, Ibrahim Y and Amna A. Ibrahim. Removal of Chromium (VI) ions from Aqueous Solution Using Wood Sawdust as Adsorbent, *Journal of Science and Technology,* 17(2), 2016, 112-121.
3. Ghazy S E and Gad A H M. Separation of Zn (II) by sorption onto powdered marble wastes, *Indian Journal of Chemical Technology,* 15(5), 2008, 433-442.
4. Khorasgani, Changani F. Removal of Cd (II) and Cr (VI) from electroplating wastewater by coconut shell, *International Journal of Environmental Engineering and Management,* 4(4), 2013, 273-280.
5. Amuda O S, AAm Giwa and Bello I A. Removal of heavy metal from industrial wastewater using modified activated coconut shell carbon, *Biochemical Engineering Journal,* 36(2), 2007, 174-181.
6. Sewvandi G A and Adikary S U. Removal of heavy metals from wastewater using chitosan, *Society for Social Management Systems Internet Journal,* 7(1), 2011, 1-7.
7. Goyal P, *et al.* Saraca indica leaf powder for decontamination of Pb: removal, recovery, adsorbent characterization and equilibrium modeling, *International Journal of Environmental Science and Technology,* 5(1), 2008, 27-34.

8. Kumar, Senthil P and Kirthika K. Equilibrium and kinetic study of adsorption of nickel from aqueous solution onto bael tree leaf powder, *Journal of Engineering Science and Technology,* 4(4), 2009, 351-363.
9. Arshad, Mamoona, *et al*. The use of Neem biomass for the biosorption of zinc from aqueous solutions, *Journal of Hazardous Materials,* 157(2), 2008, 534-540.
10. Kaushal, Achla, and Singh S K. Critical analysis of adsorption data statistically, *Applied Water Science,* 7(6), 2017, 3191-3196.
11. Terdputtakun, Apiradee, *et al*. Adsorption isotherm models and error analysis for single and binary adsorption of Cd (II) and Zn (II) using leonardite as adsorbent, *Environmental Earth Sciences,* 76(22), 2017, 777.
12. Jimoh, A A, *et al*. Sorption Study of Cd (II) from Aqueous Solution Using Activated Carbon Prepared from Vitellaria paradoxa Shell, *Journal of Bioremediation and Biodegredation,* 6(3), 2015, 1.
13. Vashantha R, Jeyavathana Samuel and Asma Banu N. Adsorption of Cadmium (II) Ions from Simulated Wastewater Using Raw Luffa Husk: Kinetics, Isotherm and Thermodynamic, Studies, *International Journal of Innovative Research in Science, Engineering and Technology,* 5(5), 2016, 7846-7857.
14. Mobasherpour, Salahi I E and Pazouki M. Removal of nickel (II) from aqueous solutions by using nano-crystalline calcium hydroxyapatite, *Journal of Saudi Chemical Society,* 15(2), 2011, 105-112.

Please cite this article in press as: Prerna Mundel. Expulsion of cadmium (II) ion from industrial effluents by adsorption using sweet lime (*citrus limetta)* tree leaf powder, *Asian Journal of Research in Chemistry and Pharmaceutical Sciences,* 7(2), 2019, 341-346.