Comparative Adsorption Studies of the Removal of Cadmium (II) Ions by PVAC-SP and ACSP

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Abstract— The purpose of this study is to compare the adsorption capacity of Poly vinyl alcohol coated activated carbon derived from stem of Saivadora persica (PVAC-SP) and without coated charcoal of the same. The study reveals that the surface modification of activared carbon increase the adsorption. furthermore adsorption of Cd (II) increased with the increased pH value. In the present study pH 5 and contact time of 150 min. was found to be optimum for ACSP and pH 5 and contact time 150min. for PVAC-SP. The effect of doses shows that activated charcoal derived from Saivadora persica of 2.5 gram dose could remove the 81.7 Cd (II) and poly vinyl alcohol coated carbon of Saivadora persica of 2.5 gram remove the 91.2% Cd(II) from water and the adsorption conformed to the Freundlich and Langmuir adsorption isotherm. The values of constant for the isotherms were found. Comprehensive characterization of parameters indicates PVAC-SP to be a good adsorption material for treatment of Cd(II) from wastewater.

Keywords— Adsorption isotherm, waste water, heavy metal, cadmium, activated charcoal, pH, Saivadora persica Abbreviation: ACSP-Activated Carbon of Saivadora persica PVAC-SP Poly vinyl alcohol coated carbon of Salvadora persica.

I. INTRODUCTION

Activated carbon1 widely known as activated charcoal is a form of carbon which is porous and have large surface area available for adsorption. In adsorption process activated carbon is the most widely used adsorbent in waste water treatment throughout the world, but high cost and regeneration limits its use and encouraged researchers to look for new integrated methods2 and low cost adsorbent3,4 such as dry plants biomass5, fly ash6,metal hydrides an dvarious other bioadsorbents. cadmium is an extremely toxic metal commonly found in industrial workplaces. Due to its low permissible exposure limit, overexposures may occur even in situations where trace quantities of cadmium are found. In this study an attempt was made to determine the effectiveness of the surface modified7 activated carbon prepared from stem of plant Salvadora persica . It was used to remove cadmium from synthetic wastewater and to investigate the mechanisms of adsorption onto activated carbon by performing a batch experimental process8.

II. MATERIAL AND METHODS

A. *Preparation of synthetic wastewater:*

Synthetic wastewater sample was prepared by using analytical grade cadmium nitrate. For pH adjustment throughout the experiment, hydrochloric acid and/or sodium hydroxide solutions were used as necessary. The stock solution contained 2 g/l of Cd(II)..

B. *Carbon preparation:*

Stem of plant Salvadora persica was collected and air dried for 48 h. . Activated carbon of the S. persica was prepared by treating the pieces of stem with the concentrated sulphuric acid (5 times its volume) and kept in oven at 150'C for 24 hours.It was filtered and washed with distilled water repeatedly to remove sulphuric acid (washing tested with two drops of barium chloride solution) and finally dried (in oven at 300'C) and powered using mortar and pestle. The resulting black product was kept in an air-free oven maintained at 300 °C for 5 h. The particle size of activated carbon between 40 to 60 mesh size was used. Batch experiments(6) were performed at 27 2 °C. Then samples were mechanically agitated at 100 rpm. The concentrations of cadmium was estimated.

C. *Preparation of polyvinyl alcohol coated carbon of Salvadora persica (PVAC-SP):*

Polyvinyl alcohol is good hydrophilic polymer and has water-adsorbing capacity. The powdered ACSP was treated with an emulsion of readily available synthetic polymer-PVA. Nine parts by weight of activated carbon obtained from the stem of Salvadora persica were mixed with one part by weight of PVA to form a semisolid mass. The agglomerated product was dried and ground into fine powder. The adsorbent was sieved to 40-60 mesh size and dried at 110^{o}C for 2 hours.

D. *Adsorbate:*

A stock solution of cadmium (2mg/ml) was prepared by dissolving Cd (NO3)2.4H2O in 0.1M HNO3. The solution was standardized complex metrically with EDTA (disodium salt) using Xylenol orange indicator.

E. *Batch adsorption studies:*

The experiments were carried out in the batch mode for the measurements of adsorption capacities .The effect of pH (3, 4, 5, 6, 7and 8), contact time (30-150 min), adsorbent dose (.5-3.5 g/l) and initial metal ion concentration (60 – 180 mg/l) at room temperature using stopper bottles. The initial pH of solution was adjusted by using 0.05 N HCl or 0.1N NaOH without changing the volume of the sample. After agitating the sample for the required contact time, the contents were centrifuged and filtered through Whatman No.41 filter paper and unreacted cadmium in the filtrate was analyzed by atomic absorption spectrophotometer.

III. RESULT AND DISCUSSION

A. *Effect of contact time:*

In adsorption system, the contact time play a vital role irrespective of the other experimental parameters, affecting the adsorption kinetics. Figure 1 depicts the effect of contact time on percent removal of Cd(II). In the case of adsorbent used, there was an appreciable increase in percent removal of metal up to 150 minutes. for ACMO and 120 minutes for PVAC-MO and thereafter further increase in contact time, the increase in percent removal was very small. Thus the effective contact time is taken as 150 min. for ACSP and 120 min. for PVAC-SP adsorbents and it is independent of initial concentration (shows in figure 1).

B. *Effect of pH:*

The adsorptive capacity of Salvadora persica was dependent on pH of cadmium solution. At lower pH values, the large number of H+ ions neutralizes the negatively charged adsorbent surfaces, thereby reducing hindrance of the Cd(II) ions, At the high pH values, the reduction in adsorption may be due to the abundance of OH- ions causing increased hindrance to diffusion of Cd(II) ions.

For both ACSP and PVAC-SP at the pH 5, the percent removal of Cd(II) ion increase sharply, attaining values that stay almost constant. There after the percent removal decreases with increase in pH (shows in figure 2)

C. *Effect of adsorbent dose:*

The effect of adsorbent dose on percent removal of Cd(II) is shown in figure 3. Adsorbent dose was varied between 1 – 3.5 g/l for adsorbents used. The percent removal of Cd (II) increases at a faster rate initially with increases in adsorbent dose. For ACSP, percent removal was found to be increasing with increase in adsorbent dose upto 2.5 g/l. Thus, the effective dose of ACPC was considered as 2.5 g/l. In case of PVAC-SP removal rate was found to be moderate after 2 g/l.

D. *Effect of initial metal ion concentration:*

Effect of initial Cd (II) ion concentration over the percent removal of Cd(II) is shown in figure 4 and shows that, as the concentration of Cd(II) in solution increases, the percent removal of Cd(II) decreases for both the adsorbents used. These results may be explained on the basis that the increase in the number of ions competing for the available binding sites and also because of the lack of active sites on the adsorbent at higher concentration.

There were more metal ions were left unadsorbed in solution at higher concentration levels.

IV. CONCLUSION

1. The present study demonstrates the utility of adsorbents such ACSP and PVAC-SP. These raw adsorbent are easily, locally and cheaply available and require a small degree of pre-treatment before their utilization.
2. The efficiency of PVAC-SP as an adsorbent is superior to that of ACSP.
3. The maximum percent removal of Cd(II) was found to be 91.2% and 81.7% with PVAC-SP and ACSP at pH 5 for both adsorbent.
4. Extent of removal depends on the Cd ion concentration and pH
5. Adsorption capacity of PVAC-SP was grater then ACSP.
6. We can use PVAC-SP for removal of other metal ions or dyes from wastewater.

REFERENCES

[1] Bansode et al., 2003,P.R. Bansode, J.N. Losso, W.E. Marshall, R.M. Rao, R.J. Portier,Adsorption of metal ions by peanut shell-based granular activated carbons Bioresour. Technol., 89 (2003), pp. 115–119

[2] Mavrov et al., 2003,V. Mavrov, T. Erwe, C. Blocher, H. Chmiel Study of new integrated processes combining adsorption, membrane separation and flotation for heavy metal removal from wastewater Desalination, 157 (2003), pp. 97–104

[3] Babel and Kurniawan, 2003 S. Babel, T.A. KurniawanLow-cost adsorbents for heavy metals uptake from contaminated water: a reviewJ. Hazard. Mater., B97 (2003), pp. 219–243

[4] Kurniawan et al., 2005,T.A. Kurniawan, G.Y.S. Chan, W.H. Lo, S. Babel Comparisons of low-cost adsorbents for treating wastewaters laden with heavy metalsSci. Total Environ., 366 (2–3) (2005), pp. 409–426

[5] Singanan M, Abebaw A, Vinodhini S (2007) Studies on the removal of hexavalent chromium from industrial wastewater by using biomaterials. Electron J Environ Agr Food Chem 6, 2557–64.

[6] I. M. Sharma, S.K. Saini Removal of cadmium and nickel from wastewater using bagasse fly ash – a sugar industry waste Water Res., 37 (2003), pp. 4038–4044

[7] Tien CJ (2002) Biosorption of metal ions by freshwater algae with different surface characteristics. Process Biochem 38, 605–13.Aksu. Z (2001) Equilibrium and kinetic modelling of cadmium (II) biosorption by C. vulgarisin a batch system: effect of temperature. Separ Purif Tech 21, 285– 94.

Figures and Tables:

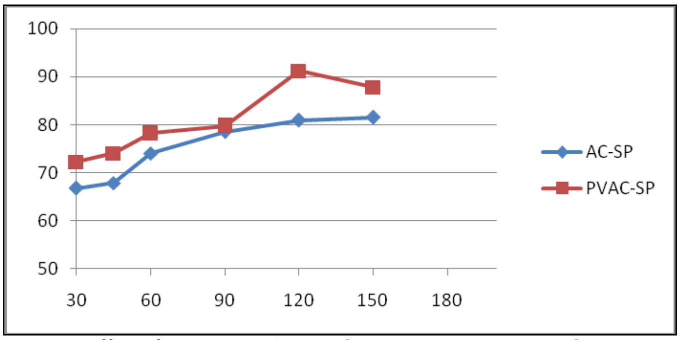

Fig. 1. Effect of contact time(X axis shows contact time,Y axis shows % removal)

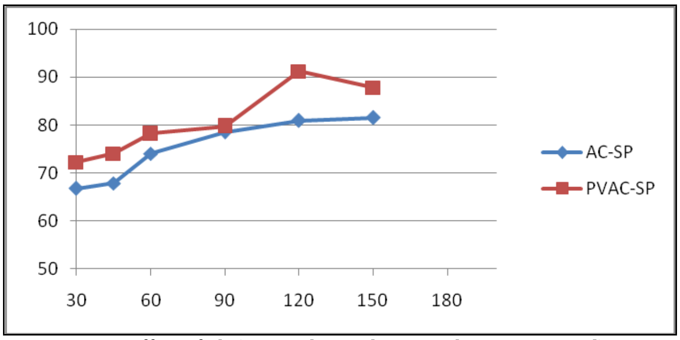

Fig. 2. Effect of ph (X axis shows ph,Y axis shows % removal)

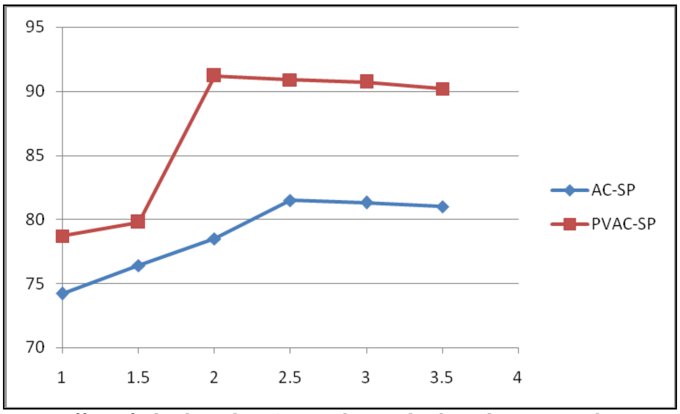

Fig. 3.Effect of adsorbent dose (x axis shows adsorbent dose, y axis shows % removal)

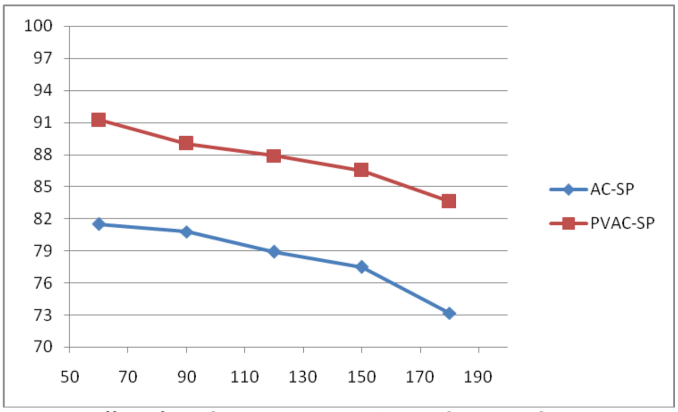

Fig. 4. Effect of metal ion concentration (x axis shows metal ion conc., y axis shows % removal)

TABLE I. EFFECT OF CONTACT TIME (AT PH 5 AND ADSORBENT DOSE OF 2.5 g AND INITIAL METAL ION CONCENTRATION = 60 PPM.)

CONTACT TIME (MIN.)	% REMOVAL BY AC-SP	% REMOVAL BY PVAC-SP
30	66.8	72.3
45	67.9	74.1
60	74.1	78.2
90	78.5	79.7
120	80.9	91.2
150	81.5	87.8

TABLE II. EFFECT OF PH (AT CONTACT TIME = 150 MIN., INITIAL METAL ION CONC. = 60 PPM, ADSORBENT DOSE = 2.5 G)

PH	%REMOVAL BY AC-SP	% REMOVAL BY PVAC-SP
3	62.2	79.5
4	65.7	80.8
5	81.5	91.2
6	71.1	78.9
7	74	79.6
8	53.5	61.9

TABLE III. EFFECT OF ADSORBENT DOSE (AT PH =5, CONTACT TIME = 150 MIN. AND INITIAL METAL ION CONCENTRATION = 60 PPM.)

ADSORBENT DOSE(g)	%REMOVAL BY AC-SP	% REMOVAL BY PVAC-SP
1	74.2	78.7
1.5	76.4	79.8
2	78.5	91.2
2.5	81.5	90.9
3	81.3	90.7
3.5	81	90.2

TABLE IV. EFFECT OF INITIAL METAL ION CONCENTRATION (AT PH = 5, ADSORBENT DOSE =2.5 g, AND CONTACT TIME = 150 MIN.)

METAL ION CONC. (PPM.)	%REMOVAL BY AC-SP	% REMOVAL BY PVAC-SP
60	81.5	91.2
90	80.8	89
120	78.9	87.9
150	77.5	86.5
180	73.2	83.6