Mini Review

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Heavy metals removal from industrial wastewater by nano adsorbent prepared from cucumis melopeel activated carbon

Abstract

Activated carbon produced from Cucumis Melopeel (CM) was used as adsorbent to remove Cr6+, Cd2+, Ni2+ and Pb2+ ions from Battery industry and electroplating industrial wastewater. Batch adsorption experiment was conducted to examine the effects of adsorbent dosage, contact time, pH and metal ion concentration on adsorption of Cr6+, Cd2+, Ni2+ and Pb2+ ions from the wastewater. The obtained results showed that, the adsorption of the metal ions was adsorbent dosage, contact time, pH and metal ion concentration dependent. The optimum adsorbent dosage, metal ion concentration and pH, were found to be at 250 mg, 100 mg/L and pH 3 to 6 respectively. The study also showed that activated carbon prepared from Cucumis Melopeel can be efficiently used as low cost alternative for removal of metal ions.

Keywords: Cucumis melopeel, Activated carbon, Heavy metals, Adsorption, Kinetic, Wastewater

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Introduction

Wastewater from numerous industries such as paints and pigments, glass production, mining operations, metal plating, and battery manufacturing processes are known to contain contaminate such as heavy metal. Heavy metals such as Pb, Cd, Cr, Ni, Zn, Cu and Fe are present in industrial wastewater, these heavy metals in wastewater are not biodegradable and their existence in receiving lakes and streams causes bioaccumulation in living organisms, which leads to several health problems in animals, plants and human beings such as cancer, kidney failure, metabolic acidosis, oral ulcer, renal failure and damage in for stomach of the rodent.[1] As a result of the degree of the problems caused by heavy metals pollution, removal of heavy metals from wastewater is important.[2] Investigation into new and cheap methods of metal ions removal has been on the increase lately. Recently efforts have been made to use cheap and available agricultural wastes such as coconut shell, orange peel, rice husk, peanut husk and sawdust as adsorbents.[3-5] to remove heavy metals from wastewater.[6] For this research, activated carbon made from Cucumis Melopeel was used as adsorbent to remove Cr, Cd, Ni and Pb present in battery industry and electroplating wastewater. Parameters such as pH, metal ion concentration, adsorbent dosage and contact time, were investigated at room temperature. While the pseudo first-order models were used to analyze the kinetic data. The pore structure in activated carbon produced from Cucumis Melopeel was investigated using Scanning Electron Microscope (SEM).

Material and methods

Cucumis Melo Peel was collected from in and around pazhamudir nilayam of Coimbatore. The collected peels were cut into small pieces, washed with tap water several times to remove dust and dirt rinsed with deionised distilled water and then dried. The dried musk melon peels were placed in the muffle furnace and carbonization was carried out at 200oC for 2 hrs. The carbonized material was ground to a fine powder. The resulting material was sieved in the size range of 75µm particle size. It was placed in an air tight container for further use.

Ball milling process

Cucumis Melo peel Activated Carbon from pyrolysis process was further processed using high energy ball mill (Vibration micro-Pulveriser "Pulverisette 0" Fritsch) is composed of an agate mortar containing an agate ball (5 cm in diameter) where about 6.5g of carbon powder was introduced. Ball milling amplitude (vertical vibration intensity) was constant and 3000 vibrations/min were carried out at room temperature. The milling times were 2 hours, 3hours, and 6hours experimented in air atmosphere.

Metal plating and battery industry wastewater

Industrial waste water was containing Cr (VI), Pb (II), Cd (II) and Ni (II) collected from electroplating industries and battery industries around Coimbatore area, Tamil Nadu was characterized and subjected for adsorption studies. The waste water collected from electroplating industries was found to contain large quantities of chromium and nickel ions and effluent collected from battery industries was found to contain large quantities of lead and cadmium ions. The pH of the industrial effluent collected varied from 3.5 to 4.5. Therefore, the pH is adjusted to pH 3.0 for Cr (VI) using 0.1N H2SO4 and pH 6.0 for Pb (II), Cd(II) and Ni(II) using 0.1N NaOH. The initial concentration of the industrial effluent collected varied from 135mg/L to 190 mg/L. In order to bring the samples to lower concentrations (100mg/L), the industrial waste water is diluted and measured its absorbance in the detectable range. 250mg of adsorbent added to 50 mL of respective waste water and agitated to equilibrium by batch studies. After agitation the supernatant was centrifuged and analyzed spectrophotometically for the residual metal ion concentration.[6] The characteristics of electroplating and battery industry wastewater are given in the Table 1 & 2.

Characterization of adsorbent: Scanning electron microscope (SEM) (5910LV SEM model) machine was used to check the surface morphology of activated carbon produced from Cucumis Melopeel (Figures 1-4).

Adsorption study: In the present work, removal of Cadmium (II), Chromium (VI), Nickel (II) and Lead (II) metal ions are carried out using adsorbent prepared from Cucumis Melo peel (Figure 5). The adsorption studies are performed by conducting batch mode experiments by varying the parameters such as pH, initial concentration of the metal solution, adsorbent dosage and agitation time. The experimental data obtained and the findings of the present study are interpreted and discussed in the light of the objectives set forth. The results are used to evaluate the optimum conditions for the removal of these metals from aqueous solution and to examine their efficiencies for the treatment of Plating and Battery industrial effluent containing these metals using the low cost adsorbent CMAC.

Table 1 Characteristics of the electroplating wastewater

S. No.	Parameter	Concentration (mg/L)
1	pH	3.6
2	Conductivity(mS/cm)	5
3	Total dissolved solids(mg/ L)	48.0
4	Ni (mg/L)	165.0
5	Cr (mg/L)	139.0
6	Zn (mg/L)	72.0
7	Cu (mg/L)	21.0
8	Chlorides(mg/L)	55.75
9	Oil & Grease(mg/L)	12

Table 2 Characteristics of the battery industry effluent

S. No.	Parameter	Concentration (mg/L)
1	pH	4.1
2	Conductivity(mS/cm)	2.3
3	Total dissolved solids(mg/ L)	30.0
4	Pb(mg/L)	190.0
5	Cd(mg/L)	135.0
6	Zn (mg/L)	19.0
7	Cu (mg/L)	8.5
8	Sulphates(mg/L)	260.0

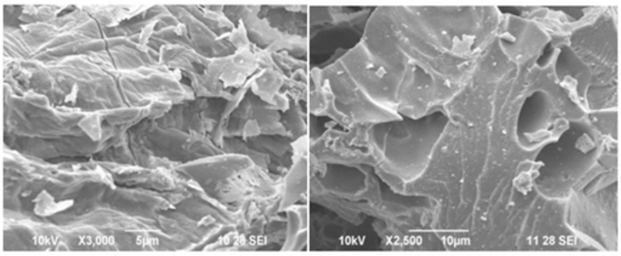

Figure 1 SEM images of Chromium (VI) loaded CMAC at 5 µm 10 µm.

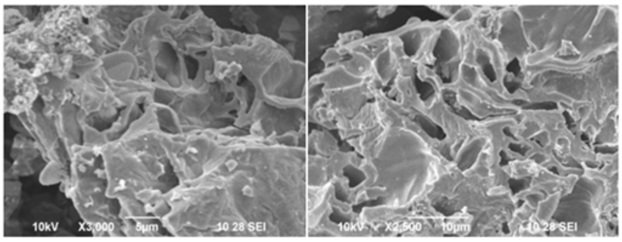

Figure 2 SEM images of Cadmium (II) loaded CMAC 4.3 (d) at 5 µm (a), 10 µm (b).

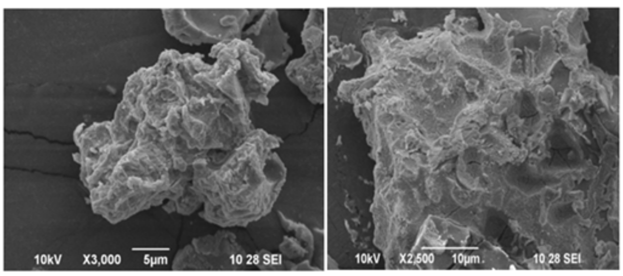

Figure 3 SEM images of Lead (II) loaded CMAC4.3. (c) at 5 µm(a),10 µm(b).

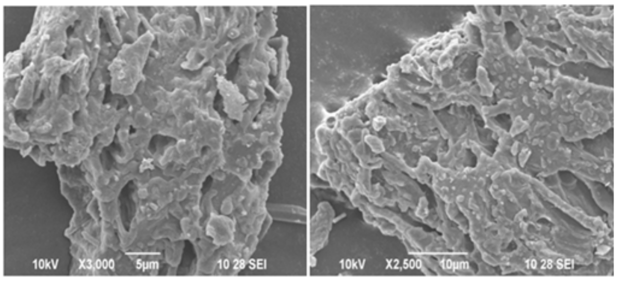

Figure 4 SEM images of Nickel (II) loaded CMAC 4.3(e) at 5 µm (a), 10 µm (b).

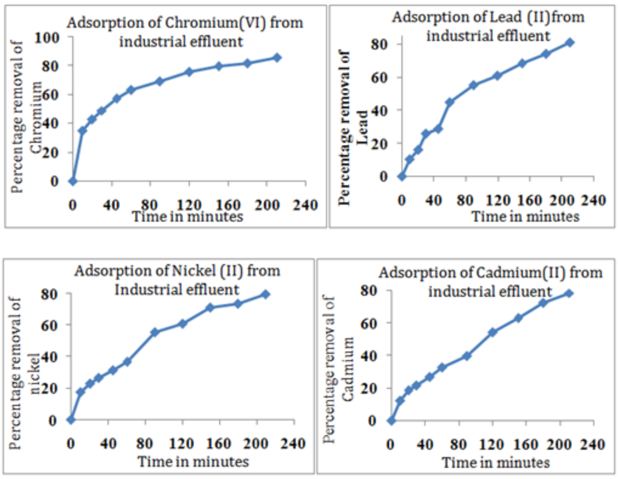

Figure 5 Adsorption of Cr (VI), Pb (II), Ni (II) and Cd (II) from Industrial Effluent Conditions.

Effect of contact time: The effect of contact time on removal of metal ions was studied for a period of 210 min. 250mgs of the adsorbent (activated carbon from Cucumis Melopeel) was added to different conical flask containing 50 mL of wastewater, the flask was closed and placed in a rotary shaker, and agitated at 150 rotation per minute (rpm), for each of the different contact times chosen (10, 20, 30, 45, 60, 90,120,150,180 and210 minute). The content of each flask was filtered and analyzed after each agitation time.[7]

Effect of adsorbent dosage: Different dosages of the adsorbents (50-250mg) were added in different conical flasks containing 50 mL of wastewater solution, corked and agitated in a shaker for 3 h at a speed of 150 rotations per minute (rpm) at a room temperature. The content of each flask was then filtered and analyzed after the agitation time.[8]

Effect of pH: Over a pH range of 3-6, the effect of pH on adsorption on metal ions was studied. For this particular study, 50 mL of wastewater was measured into different 250 mL conical flask and 250mg of the activated carbon being the optimum adsorbent from the previous experiment, was added and agitated at 150 rpm for one hour. The pH was adjusted from 3-6 using HCI and NaOH. The Whatman filter paper was used to filter the mixture and the filtrate analyzed to determine the concentrations of metal ions.

Effect of initial concentration of metal ion: The study of the distribution of the metal between the adsorbent and the metal ion solution at equilibrium is important to assess the adsorption capacity of the adsorbent for the Metal ions. The effect of initial concentration of metal solutions on the removal of metal from Plating and Battery industrial effluent with 250mg of the adsorbent CMAC by varying the agitation time from 10 to 210 minutes. The results obtained show

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that the percentage removal of metal ions from plating and battery industrial effluent used in this study are 81.62 for Cr(VI) ,73.90 for Pb(II), 73.42 for Ni(II) and 72.40 for Cd(II) (Table 3), when the initial concentration of metal ion solution (Cd(II),Cr (VI), Ni (II) and Pb(II) is 100 mg/L in 210 minutes of agitation time. In addition, perusal of the results indicated that with increase in metal ion concentration the percentage removal decreased, but the amount of metal adsorbed/unit weight of the adsorbent (mg/g) increased for all the four metals used in this study suggest that, the metal removal using adsorption technique is concentration dependent. Further, it was observed that the rate of adsorption was higher in the initial stages, because of the metal uptake onto exterior surface. After that the metal ions are entered into pores (interior surface),[9] This is due to an increase in the driving force of the concentration gradient, as an increase in the initial metal ion concentration, mass transfer driving force became larger and the interaction between the metal and adsorbent was enhanced, hence resulting in higher adsorption capacity.[10]

Table 3 Adsorption of Cr (VI), Pb (II), Ni (II) and Cd (II) from Industrial Effluent Conditions

Time in Minutes	Removal of Metal Ions in Percentage			
	100mg/L Cr(VI)	100mg/L Pb(II)	100mg/L Ni(II)	100mg/L Cd(II)
10	34.70	10.14	17.72	12.24
20	42.86	15.94	22.78	18.37
30	48.98	26.09	26.55	21.43
45	57.14	28.99	31.65	26.53
60	63.27	44.93	36.71	32.65
90	69.39	55.07	55.7	39.8
120	75.51	60.87	60.76	54.08
150	79.59	68.12	70.89	63.27
180	81.63	73.90	73.42	72.45
210	81.62	73.90	73.40	72.39

Adsorbent Dosage: 250 mg; pH: 3.0 ± 0.2 to 6.0± 0.2; Temperature: Room T

Conclusion

From the obtained results, it is evident that activated carbon produced from cucumis melopeel is a good adsorbent for removal of lead, nickel, cadmium and chromium ions. Batch experiments were conducted and showed that the adsorption of lead, nickel, cadmium and chromium ions are time dependent, adsorbent dosage dependent, pH dependent and concentration of metal ions dependent. Cucumis melopeel (a waste) is inexpensive and readily available, thus this study provide a cost effective means for removing metal ions from contaminated water or effluents.

Acknowledgments

None.

Conflicts of interest

None.

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