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Batch Experiment Studies on Bio-Sorption of Pb(II) and Cu(II) Metal Ions using Activated Carbon from Prosopis Juliflora Bark and Leaves

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Abstract:
Different heavy metals such as Lead (Pb), Cadmium (Cd), Copper (Cu), Chromium (Cr), Mercury (Hg), Zinc (Zn) and Arsenic (As) are the core elements used as color pigments in textile industries. This is widely effecting the aquatic environment causing high increase of metallic substances in water resources, which is a threat for the environment and human health. Among different processes adsorption by activated carbon is an efficient process to remove heavy metals from waste water. Activated carbon at the same time has become exorbitant. Research is being done on pioneering different low cost adsorbents from different agricultural wastes that can be used compellingly to remove different heavy metals from textile waste water. My work discuss about the efficiency of removing heavy metals such as copper and lead by using activated carbon from Prosopis Juliflora bark and leaves. Prosopis Juliflora is widely known for the extensive property of absorbing water and certain heavy metals. Activated carbon was formed from Prosopis juliflora bark and Prosopis Juliflora leaves through Physical and chemical treatment separately. Stock solution for lead and copper was formulated with proper care in the lab. Batchwise experiments were conducted to study Effect of adsorption by varying adsorbent dosage, pH and contact time of the adsorbent with the solution. It was concluded that capacity of adsorption of the modified activated carbon from Prosopis Juliflora bark and leaves for heavy metals such as copper and lead was more efficient. This activated carbon can be used as a promising bio-adsorbent for removing Heavy metals from Textile effluent.

Keywords*: Activated carbon, Adsorption, Prosopis Juliflora leaves and Bark, Heavy metals*

Introduction:

Textile waste water has contributed the maximum to the pollution of the water and the environment in recent times. Textile industries use gallons of water for different processes imposed in textile production. The dying and washing process in textile production is condemned as a leading offender in polluting the water bodies in the environment [2]. The input of textile waste water to the surface water bodies not only have negative impact on aquatic, plants and animals and human [1], but also decreases the self purification of water bodies ,which again is an environment constrain. Textile effluent have high load of pollutants in terms of heavy metals, dyes, organic & inorganic materials [2]. This further increases the COD, BOD, pH, turbidity, salinity, suspended solids, etc. which is beyond the acceptable limit of the environment. Textile effluent contains more amounts of dyes and heavy metals. Textile industries use a large quantity of water for the production process. The waste water from the washing and drying units of textile industries are main source of heavy metals disposed to environment.

Heavy metals in large amount increase the toxicity of the water and which has tremendous risk effect to the ecosystem. As the effluent treatment plants are energy consuming, expensive, includes different complicated process, so many industries discharge the effluent water without any proper

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treatment. This increases the concentration of heavy metals in the surface and as well under ground water in specific areas which is of great concern for the researches. Different treatment methods are being used for the reduction of heavy metals from the water bodies [3-4]. Among the techniques the most efficient process are ion exchange [8], reverse osmosis [8], adsorption on activated carbon [10]. But these techniques are very expensive and required skilled person. This is why many industries are reluctant to use these techniques for the heavy metal removal.

Recently adsorption has become one of the most effective technique and use of low cost adsorbent[4] to remove heavy metals have reduce the cost of the effluent treatment to a greater extent. Low cost adsorbents are derived mainly from cheap agro waste like coir pith, pine tree bark, neem bark powder, tea waste, Wheat husk [8] Rice paddy [9] etc which is available locally [5].These adsorbents are mainly used as adsorbent for dye removal and heavy metal removal[11].Different heavy metals found in textile effluent are lead, arsenic, nickel, mercury, chromium, copper, zinc, etc. These heavy metals are found to be toxic and hazardous for the environment and human health. When heavy metals surpass its permissible limit causes serious impact and develop different disorders in human health [7]. Low cost adsorbents are found to be more efficient in removing different dyes like reactive yellow [10], direct dyes [11], acid blue 40 [12], reactive dyes [13] etc. Even different natural adsorbents are used for removal of heavy metals like fluoride [14], Nickel [1-14], chromium etc.

The aim of this experiment is to study the adsorption of heavy metals like copper and lead on activated prosopis juliflora bark and prosopis juliflora leaves. Despite the usefulness of copper in many essential processes in our day to day life but prolonged and over exposure to the metal can result in intense complexities in plants, animals as well as human beings. Further study has been done on the affect of adsorption variables like adsorbent dosage, pH, contact time on adsorption of copper and lead.

2. Method and Materials

2.1 Textile Effluent:

Textile effluent was collected from the water line of Erode stretch, Tamilnadu and initial concentration of heavy metals was evaluated by using PERKIN ELMER OPTIMA 5300 DV ICP-OES.

2.2 Stock solution preparation:

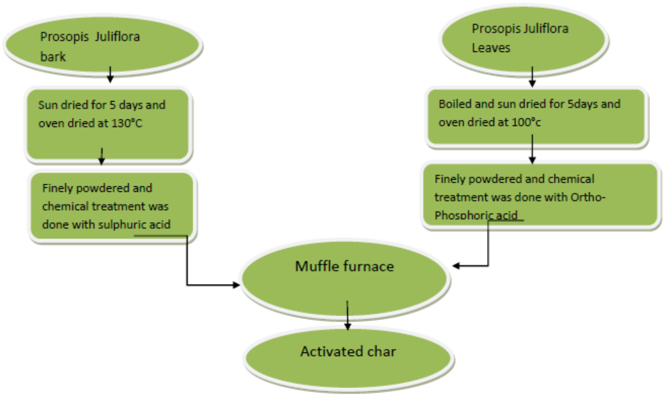
Stock solution of 0.1 mole of Cu ions are prepared by dissolving Copper sulphate penta hydrate (CuSO4.5H2O) to distilled water and similarly 0.1 mole of Pb ions was prepared by dissolving Lead Nitrate heptahydrate ($PbNO_3$.7H2O) in distilled water. This solution was used as sample solution for adsorption studies. Adsorption experiment was carried out on these samples using activated Prosopis juliflora bark and leaves in proportion of 2:1.

2.3 Prosopis juliflora bark and Prosopis juliflora leaves

Prosopis juliflora bark was collected from local area in Chennai**.** The collected PJB materials were sun dried for 5 days and then finely powdered with grinding machine in local mill. Purified water was used for intensive washing of the powered materials to remove all the grime and mud particles. The powdered PJC (Prosopis Juliflora carbon) was oven dried at 130°C for 20 hrs to remove excess moisture and was sieved to get uniform particle size of 150 mesh size. Then the powder was treated with concentrated sulphuric acid for 10 hours then washed with water to get rid of excess acid. The product was dried in a muffle furnace for about 3 hours at the temperature of 800°C. The resulting powder was used for adsorption experiment.

The Prosopis juliflora leaves were collected from various places in Chennai, Tamil Nadu,India. The leaves were boiled in water for 5 mins to take out the green color and dirt present in leaves. Then they were sun dried for 5 days and oven dried at 100°C for 20hrs to extract the moisture content present in the leaves. The dried leaves were grinded in a mixer.

The powdered leaves were sieved to get uniform particle size of 150 meshes. The chemical treatment of the leaves were done by soaking 30gm of prosopis juliflora in 50ml of ortho-phosphoric acid(30%) for 24hrs. Then it was washed in distilled water to extract the acid content from the leaves and was activated in Muffle furnace. The process of converting Prosopis Juliflora bark and leaves into activated carbon had been shown in the flow diagram 1.



3. Experimental

The initial concentration of metal ions like Arsenic, Copper, Lead, Cadmium, Mercury, Zinc where analyzed using PERKIN ELMER OPTIMA 5300 DV ICP-OES .The initial effluent concentration is shown in fig 1:

Fig 1: metal concentration in textile effluent

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PERKIN ELMER OPTIMA 5300 DV ICP-OES

Sample code	Element symbol and Wavelength (nm)	Weight of sample in gms / Volume in ml	Dilution factor	Concn.in ppm µg/ml (or) mg/litre	RSD %	Weight percentage
Effluent sample 1	As 188.979	-	1	0.020 mg/L	-	-
	Cd 228.802	-	,,	-0.002 mg/L	-	-
	Cr 267.716	-	,,	0.090 mg/L	-	-
	Cu 327.393	-	,,	0.078 mg/L	-	-
	Fe 238.204	-	,,	1.122 mg/L	-	-
	Hg 253.652	-	,,	3.382 mg/L	-	-
	Mg 285.213	-	,,	25.96 mg/L	-	-
	Pb 220.353	-	,,	0.018 mg/L	-	-
	S 181.975	-	100	97.13 mg/L	-	-
	Zn 206.200	-	1	1.868 mg/L	-	-

The tannery effluent was treated with the activated carbon mixture of prosopis juliflora bark and leaves by mixing 1gm of activated carbon to 10 ml of effluent for 180 mins. The treated effluent metal ion concentration was evaluated using PERKIN ELMER OPTIMA 5300 DV ICP-OES.

Distinguishing the keen affinity of the activated char mixture towards adsorption of Pb(II) and Cu(II) ions a separate stock solution was prepared and the adsorption efficiency of activated char towards these metal ions were observed separately.

Adsorption experiment was conducted by taking the sample solution in conical flask and required amount of adsorbents were added to it. It was stirred using mechanical stirrer and the effect was observed by changing the adsorption parameters like pH, adsorbent dosage and contact time.

4. Result and Discussion:

The treated textile effluent showed a great affinity towards the adsorption of lead and copper this was make out from the following result obtained from PERKIN ELMER OPTIMA 5300 DV ICP-OES.

Fig 2: metal concentration in treated effluent

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PERKIN ELMER OPTIMA 5300 DV ICP-OES

Sample code	Element symbol and Wavelength (nm)	Weight of sample in gms / Volume in ml	Dilution factor	Concn.in ppm µg/ml (or) mg/litre	RSD %	Weight percentage
Sample 3	As 188.979	-	,,	-0.413 mg/L	-	-
	Cd 228.802	-	,,	-0.002 mg/L	-	-
	Cr 267.716	-	,,	-0.001 mg/L	-	-
	Cu 327.393	-	,,	0.004 mg/L	-	-
	Fe 238.204	-	,,	0.032 mg/L	-	-
	Hg 253.652	-	,,	0.415 mg/L	-	-
	Mg 285.213	-	,,	13.46 mg/L	-	-
	Pb 220.353	-	,,	0.005 mg/L	-	-
	S 181.975	-	100	64.92 mg/L	-	-
	Zn 206.200	-	1	0.107 mg/L	-	-

Fig 3: graphical representation of removal of metal ions

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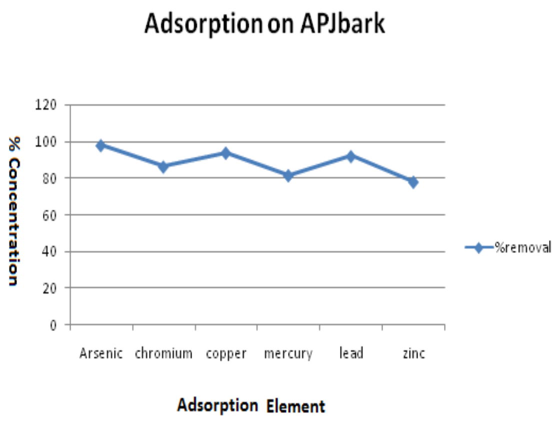
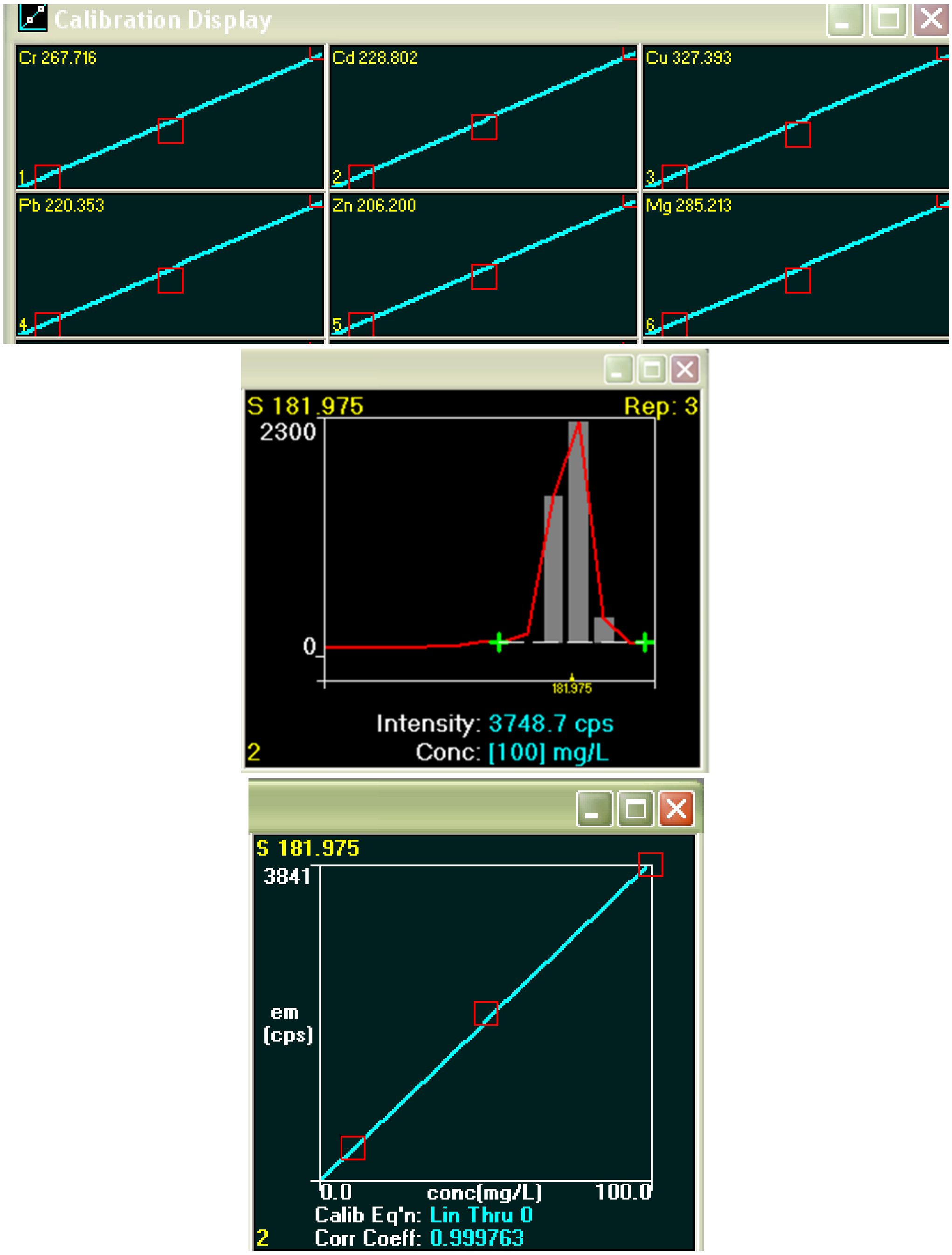


This shows the adsorption capacity of Activated char of Prosopis Juliflora bark and leaves in removing the heavy metals like arsenic , Chromium ,copper, Mercury, Lead and Zinc. The adsorption capacity of the material decreases in order As>Cu>Pb>Cr>Hg>Zn. The detail analysis can be done by the calligraphy result.

Fig 4: calligraphy of analyzed result



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4.1 Effect of pH

The pH of the solution influences the properties of PJB, affects the adsorption mechanisms to a great extent. As shown in Fig.3 the variation of Pb(II) and Cu(II) adsorption on Prosopis juliflora bark. For Cu (II), adsorption increases with pH and is maximum at 5. The results indicated that Cu (II) removal was increased to maximum and then decreased with pH variation from 4 to 9 . 89% of Cu(II) was found to be maximum at pH 5 and 91% for Pb(II).

Table 1: Effect of pH on adsorption

pH	4	5	6	7	8	9
%removal of Cu	64	91	79	60	58	55
%removal of Pb	76	89	67	66	59	53

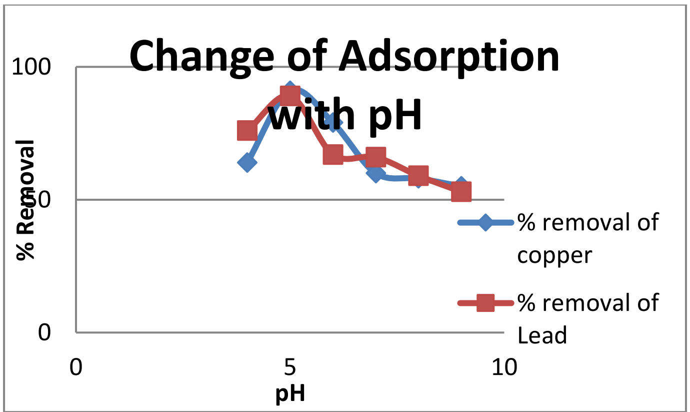

Fig. 5 Effect of pH on adsorption of Cu and Pb

3.2 Effect of adsorbent dosage

Adsorbent dosage is a main factor for persuading the adsorption efficiency of a specific substance. In this trial and error method of examination the quantity of mixture of Prosopis Juliflora bark and leaves were varied in range of 50mg to 200mg.In this assessment all other criteria's like contact time and pH was kept constant. Adsorption of Cu (II) and Pb(II) was examined in this prevailing conditions. It was observed in fig.3 that removal efficiency of the metal ions was directly proportional with increase in adsorbent quantity. There is no further increase in adsorption after 200 mg of adsorbent. The optimum measure of the adsorbent was found to be 200mg where removal of of Cu (II) was about 94.27%. Similar properties was shown by Pb(II) adsorptions. Within the dosage of 150mg to 250 mg the variation of Pb adsorption was almost constant. The maximum Average adsorption for Lead was 93.67% at adsorbent dosage of 200mg.

Table 2: Effect of adsorbent dosage on adsorption

Adsorbent dose	50	100	150	200	250
%removal of Cu	75	77	87	93	94.5
%removal 0f Pb	81	83	93	94	95

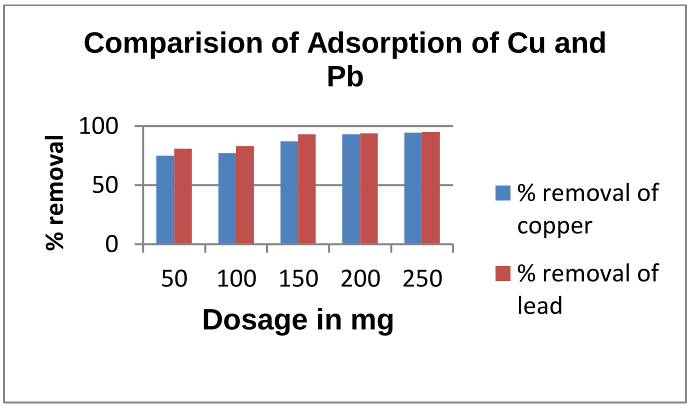

Fig. 6 Comparison of Adsorption of Cu and lead with Adsorbent dose

3.5 Comparison of effect of contact time on Cu(II) And Pb(II)

Contact time of the adsorbent with the sample also contribute in determining the removal efficiency of metal ions. The observation in Fig 4 was made up that the affinity of the ions in the samples towards the adsorbents was increased with increase in contact time. It was observed that after a period of contact time the adsorption remained persistent. The outcome of the observation was stipulated that the efficiency of removing Cu (II) was enhanced from 15 to 94% with the variation of contact time from 10 to 240 minutes. After 210 minutes it was observed that there was a negligible change in the removal efficiency and the percentage removal of Cu (II) remains unchanged and found to be 91%. From this it can be estimated that equilibrium was attained at 210 minutes. The optimal contact time of Cu (II) was 210 minutes with removal efficiency of 91%. The optimum contact time for lead adsorption was 180 min with 89% removal.

Table 3: Effect of contact time on adsorption

Time	10	30	60	90	120	150	180	210	240
%removal 0f Cu	25	39	52	63	75	82	90.8	91	91.3
%removal of Pb	19	34	48	64	73	81	88.3	89	88.8

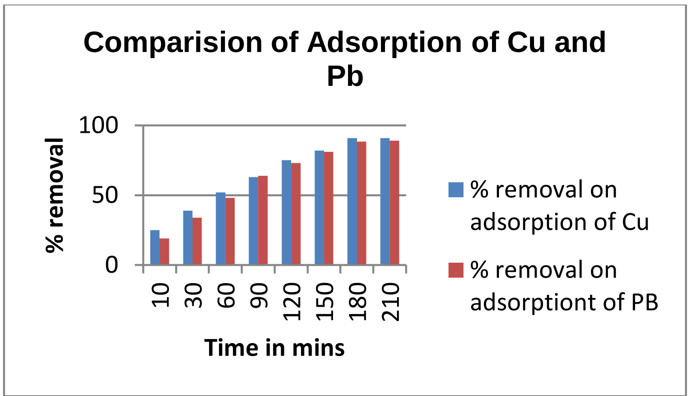

Fig. 7 Comparison of Adsorption of Cu and lead with Time

CONCLUSION

Based on the results of this study following conclusions could be drawn that prosopis juliflora bark and leaves can be effectively used for adsorption of Heavy metals like Copper and Lead. This method is economical compared to other conventional methods for removal of Heavy metals. By removing the heavy metals the textile effluent can be reused for industrial and agricultural purposes. This experiment shows that invasive plant like prosopis juliflora can become a green solution for over shading the metal ion concentration from textile effluent.

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