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Adsorption Of Pb(II),Cu(II),Cr(III),Fe(II) And Zn(II) Ions From Industrial Wastewater By Papaya Stem Activated Carbon

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Abstract :- The ability of activated carbon prepared from Papaya stem to adsorb Pb(II), Cu(II), Cr(III), Fe(II) and Zn(II) ions from synthetic wastewater has been studied through batch experiment. Batch adsorption study was performed to observe the effect of contact time, pH and initial metal ion concentration on adsorption of Pb(II),Cu(II), Cr(III) , Fe(II) and Zn(II) ions from synthetic wastewater. The results obtained from the studies reveal that, the adsorption of metal ions depends upon initial metal ion concentration, pH and contact time. The optimum contact time, initial metal ion concentration and pH for Pb(II) is 5 hrs., 9 mg at pH 8, for Cu(II) 5 hrs, 8 mg at pH 8, for Cr(III) 5 hrs.9 mg at pH 8, for Fe(II) 5 hrs. 9 mg at pH 10 and for Zn (II) 5 hrs, 9 mg at pH 8 respectively. Langmuir and Freundlich isotherms were studied and the values obtained are in agreement with Langmuir isotherm and better fitted to Freundlich isotherm. The aim of this work is to develop inexpensive, easily available, effective adsorbents from papaya stem as alternative to existing commercial adsorbents.

Keywords: - Adsorption, Heavy metal ions, Papaya stem Activated carbon, Synthetic wastewater

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I. INTRODUCTION

Waste water from various industries contains large amount of heavy metal ions, like zinc, iron, nickel, lead, chromium, cadmium and copper (Konstantinos et al., 2011).The heavy metal ions are toxic, carcinogenic and non-biodegradable. The continuous deposition of heavy metals in rivers, lakes streams and other water sources causes bioaccumulation in the living organisms. The bioaccumulation may lead to several health problems like kidney failure, cancer renal failure, oral cancer etc. (Booker., 2000).The effluents from various industries like electroplating, metal processing, textile and dyeing industries, soap industries etc. contains large amount of heavy metal ions which when enters in water bodies causes severe health problems. The presence of heavy metal ions must be controlled to an acceptable level, in accordance to environmental regulations worldwide, before being discharged to the environment (Konstantinos et al., 2011). Each heavy metal ion can be hazardous to human health if it is present beyond its threshold limit. Hence before disposal the industrial effluents must be treated to overcome the toxic effects of heavy metal ions to human health, aquatics lives or causing avoidable damage to the natural environment (Li et al., 2006).

There are several treatment methods have been suggested and used to remove heavy metals from wastewaters.These methods include ion exchange, chemical precipitation, cementation (Dean et al., 1972), membrane processes (Aydiner et al., 2006), coagulation and flocculation (Amuda et al., 2006), Flotation and electrochemical treatment. However these techniques are expensive and time consuming. Hence there is a need of process which is simple inexpensive and less time consuming. Several Investigations had been performed by researchers to search new and cheap methods for removal of metal ions from industrial wastewater; however, adsorption process suggested has most economically viable method. Thus, in this study Papaya Stem Activated Carbon (PSAC) is used for heavy metals removal from industrial effluents because it has been reported to be inexpensive, widely applicable, efficient and less time consuming. (Kannan and Rengasamy, 2005).

Adsorption is found to be one of the most effective techniques for removal of heavy metal ions from wastewater. This technique provides availability of different types of adsorbents having high adsorption efficiency(Harland, 1994; Cooney, 1999).There are several adsorbent materials containing different chemical functional groups used for adsorption but their high cost restrict their use on large scale(Babel and Kurniawan, 2003; Bailey et al., 1999).

In this present work, papaya stem was chemically treated with H_2SO_4 solution to prepare chemically activated carbon which was used in the process of removal of heavy metals from synthetically prepared wastewater. The adsorption capacity of produced adsorbent was studied for heavy metal ions like Pb(II),Cu(II), Cr(III) , Fe(II) and Zn(II) for three different parameters i.e. contact time, initial metal ion concentration and pH.

II. MATERIALS AND METHODS

2.1 Adsorbent preparation:

Agricultural waste used in this study is papaya stem. The agro waste was collected from local fields and washed many times with distilled water to remove dust. It was then sundried for two weeks. The dried agro waste was carbonized in Muffle furnace at 450ºc for 1 hr.The carbonized agro waste was finely ground to powder and then soaked in 2N H_2SO_4 for 24 hrs.at room temp. The sample was placed in an oven and heated to 100ºc for 2 hrs. After cooling it was washed with distilled water and then soaked in 10 % KOH solution for 30 min. and then washed several times with distilled water to remove any remaining acid until a neutral pH was achieved. The sample was then dried in an oven at 100ºc for 1 hr.This activated carbon was used for further studies in removal of heavy metal ions from synthetic wastewater.

2.2 Preparation of synthetic wastewater:

To perform the adsorption experiments, 1000mg/L of copper, zinc, lead, iron and chromium standard solutions were prepared from $CuCl_2.2H_2O$, $ZnSO_4.7H_2O$, $Pb(NO_3)_2.6H_2O$, $FeCl_3.6H_2O$ and $K_2Cr_2O_7$ using distilled water. All chemicals used were of analytical grade purity. To stock solution 3-6 drops of concentrated HNO_3 were added to prevent hydroxide formation. The required concentrations of solutions for experiments were made from the synthetic stock solution with required amount of distilled water. 0.1N Hydrochloric acid and 0.1N Sodium hydroxide were used to adjust the solution pH.

2.3 Adsorption experiment

Adsorption capacity of Papaya Stem Activated Carbon (PSAC) for adsorption of Pb(II),Cu(II), Cr(III) , Fe(II) and Zn(II) ions was determined by Batch studies in a series of five 100 ml conical flasks containing 50 ml of wastewater. 1g of the previously prepared Papaya Stem Activated Carbon (PSAC) was added to the solution, the flasks were shaken at 25ºc and agitation speed 200 rpm. The solutions were then filtered off. The initial and final concentration of metal ions was measured by AAS (Elico SL 168) at the maximum absorption wavelength and the adsorption capacities of the adsorbent were calculated. When equilibrium was attained the maximum adsorption capacity of PSAC was calculated by mass balance equation (1)

$$Q_e = \frac{(C_0 - C_e)V}{m} \qquad \text{……(1)}$$

Where m is the mass of adsorbent (g), V is the volume of the solution (L), C_0 is the initial concentration of metal (mg/L), C_e is the equilibrium metal concentration (mg/L) and Q_e is the metal quantity adsorbed at equilibrium (mg/g).

The percent removal of metals from the solution was calculated by the following equation (2):

$$\% \text{ Removal} = \frac{(C_0 - C_e)}{C_0} \times 100 \qquad \text{……(2)}$$

III. RESULTS AND DISCUSSION

3.1 Effect of contact time

To determine the effect of contact time on the adsorption of the studied cations from synthetic wastewater solutions, the experiments were performed with a constant concentration of salt solution i.e. 5 mg/L.The adsorption equilibrium of all the investigated cations was reached at 5 hrs of contact time. In the first 3 hrs. All the studied cations were fast adsorbed and then the adsorption speed was decreased as the pores of the PSAC were blocked by the ions. Hence 5 hrs. were designated for the subsequent studies to ensure complete equilibrium.

3.2 Effect of pH

The pH Value of the medium highly affects the adsorption capacity of the adsorbent material due to the dependence of process of cation exchange between solid surface and the wastewater solution containing heavy metal ions. The effect of pH of solution on adsorption of heavy metals was studied by using 1g of PSAC in 50 ml wastewater solution having initial metal ion concentration 5 mg/L at pH values ranging from 2-10 for 5 hrs. at 25ºC and 200 rpm agitation speed. At lower pH the adsorption of metal ions onto activated carbon was found to be low. At higher pH from 6-10 the metal uptake gradually increased.

3.3 Effect of initial metal ion concentration

The effect of initial metal ion concentration was determined at a pH 8 for Pb(II), Cu(II), Cr(III) and Zn(II), at pH 10 for Fe(II) ions at shaking time of 5 hrs.The removal efficiency values of PSAC for metal ions

increases with increase in initial metal ion concentration. The maximum percentage removal observed at 9 mg/L metal ion concentration for Pb(II), Cr(III), Fe(II) and Zn(II) ions and at 8 mg/L for Cu(II) ions by keeping all other parameters constant.

3.4 Determination of Langmuir constants

Calculated Langmuir constants are tabulated as follows,

Table 1 Langmuir Isotherm

Metal ion	Constants	PSAC
Zn(II)	Q_0(mg/g)	17.82
	R^2	0.9165
	R_L	0.1381
	b(L/mg)	1.247
Cu(II)	Q_0(mg/g)	24.41
	R^2	0.8013
	R_L	0.1328
	b(L/mg)	1.305
Pb(II)	Q_0(mg/g)	38.69
	R^2	0.9393
	R_L	0.2006
	b(L/mg)	2.073
Fe(II)	Q_0(mg/g)	29.18
	R^2	0.7069
	R_L	0.1023
	b(L/mg)	1.753
Cr(III)	Q_o(mg/g)	46.88
	R^2	0.9349
	R_L	0.2110
	b(L/mg)	0.7478

3.5 Determination of Freundlich Constants

The calculated Freundlich constants are:

Table 2 Freundlich Isotherms

Metal ion	Constants	PSAC
Zn(II)	K_f	1.4809
	n	5.2576
	R^2	0.9765
Cu(II)	K_f	1.1420
	n	5.2659
	R^2	0.9765
Pb(II)	K_f	1.2221
	n	4.0016
	R^2	0.9706
Fe(II)	K_f	1.1077
	n	4.1684
	R^2	0.989
Cr(III)	K_f	1.2336
	n	4.7619
	R^2	0.9764

IV. CONCLUSION

In the present study,the removal of heavy metal ions Pb(II), Cu(II), Cr(III) , Fe(II) and Zn(II) from synthetic wastewater solutions by adsorption through batch adsorption technique was studied. The results obtained showed that the adsorption of studied metal ions is contact time dependent, pH dependent and initial metal ion concentration dependent. Rate of adsorption increases with increase in pH of solution. In first 3 hrs there is fast removal of metal ions and the equilibrium reaches at 5 hrs. At high initial metal ion concentration rate of adsorption increases. The equilibrium adsorption data was described by both Langmuir and Freundlich models and the adsorption capacity of PSAC decreased in the following sequence: 46.88 mg/g [Cr(III)] >38.69 mg/g [Pb(II)] >29.18 mg/g [Fe(II)] 24.41 mg/g [Cu(II)] >17.82 mg/g [Zn(II)]. The obtained results indicated that a good adsorbent can be obtained from activated carbon prepared from papaya stem for adsorption of Pb(II), Cu(II), Cr(III) , Fe(II) and Zn(II) ions from wastewater. Papaya stem is readily available and inexpensive, thus this present work provides natural adsorbent which is cost effective and capable of removing heavy metal ions from wastewater.

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