STUDIES ON THE REMOVAL OF HEAVY METAL IONS FROM AQUEOUS SOLUTIONS BY WASTE OF VEGETABLE AMBADI

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Abstract

In the Present work the waste of vegetable Palakwas used as adsorbent for removal of heavy metals like Fe(III), Cu(II), Cr(II) from aqueoussolution.The adsorption characteristics of all three metals on waste of Palakwas evaluated as a function of varying adsorbent dose, temperature and time. The percentage removal of Fe(III), Cu(II), Cr(II) by waste of Palakcarried under different conditions during this findings was significant. The order of adsorption on waste of Palak of metals ions were Cu >Fe>Crduring the findings. The adsorption data fitted well into Freundlich and Langmuir adsorption models. The results shows that waste of Palak vegetable holds a great potential in removal of metal ions from aqueous solution. The thermodynamic study has showed that the Fe(III), Cu(II), Cr(II) ions adsorption on the surface of waste of vegetable Palak was physical adsorption and the process was spontaneous and exothermic.

Keywords:- Waste of vegetable Palak, Heavy metal ions,Freundlichisotherm, Langmuir isotherm.

Introduction

Heavy metals such as Iron, Copper, Lead, Zinc, Nickel, Chromium have harmful effects on human physiology and other biological systems when they exceed the tolerance level.[1,2].They pose serioushealthy hazards through entry into the food chain, therefore they must be removed from industrial waste effluents. In recent past development of efficient and eco-friendly methods for removal of heavy metals are receiving attention by agro waste as adsorbent by various researchers[3-9].Literature survey reveals that no work has been reported on thermodynamic study by using waste of vegetablePalak(WVP) as an adsorbent for removal of Iron, Copper and Chromium from Aqueous solution.

In the present investigation an attempt has been made to study the feasibility of waste of vegetablePalak as a cheap, locally and easily available for the adsorption of Iron, Copper and Chromium. The adsorption of heavy metals ions from aqueous solution was carried to study varying adsorbent dose, temperature & time.

Experimental

Adsorbent

The adsorbent selected for the present work was waste of locally available vegetable Palak.The dried waste material of Palakwere grinded into powder and was boiled in distilled water to remove the suspended matter and dust for one hour and filtered. The residues left was treated with formaldehyde and finally with very dilute solution of sulphuric acid. It was then stirred for half an hour vigorously using mechanical stirrer at room temperature. Then it was filtered and washed with distilled water repeatedly to remove free acid. After chemical treatment the residue was dried first in air and finally in oven at 90-100°c for 8-10 hours and powdered using electric grinder. The homogeneous powder was pass through mesh for desired particle size (9.8-41.8 micron).The adsorbent once prepared was used throughout the experimental work. The particle size of the adsorbent

wasof the same mesh(9-8-41-8 micron)The particle sizeof adsorbent selected for these experiments were on the basis of their settlement at the bottom of the system, so that the portion of the solution could be taken out conveniently from the supernatant liquid.

Preparation of Adsorbate Solution

Iron, Copper and Chromium were the metal ions selected for the present investigation. The chemicals were all of Analytical grade and used without further purification. The solutions were prepared in doubly distilled water. Prepared by using first metal distillation unit and then all quick fit glass assembly in permanganticconditions, wherever necessary the prepared solutions were standardized as per literature[10].

Batch Adsorption Experiments

Each batch adsorption study was carried out by contacting WVPwith the ions Fe(III), Cu(II), Cr(II) under different conditions for 60 minutes in glass tube. The uptake of metal study on WVPwas carried systematically and at temperature 30°C to evaluate effect of adsorbent dose, contact time on adsorption of metal ions. The effect of temperature on the adsorption was carried out in order to study the thermodynamics of the process. Each study was conducted in thermo stated water bath and the residual metal ions were analyzed. The amount of metal ions adsorbed from solution was determined by difference[10]The concentration of metal ion solution were determined from calibration curve spectrophotometrically(shimatzu-1211) at their respective wavelength i.e. Iron (λmax = 515 nm)

Result and discussion

Effect of Temperature

The magnitude of the temperature effects for the adsorption process is one of the most important criteria for the efficient removal of heavy metals from the waste water[12] . The data of heavy metal ions adsorption onto WVP at different temperature indicates decrease in adsorption with rise in temperature (13)from 308K to 318. This effects may attributes to a negative temperature co-efficient of solubility of the solute or to a steep simultaneous decrease of real adsorption of solvent. The effect of temperature on adsorption of metal ion on WVP is given in figure 1

Table No. 1.1 Adsorbate : Iron

Effect of Temperature on Adsorption of Adsorbate

Sr. No.	Temperature (0 K)	Amount Adsorbed	Fractional Removal
[illegible]	[illegible]	[illegible]	0.506
[illegible]	[illegible]	[illegible]	0.494
[illegible]	[illegible]	[illegible]	0.463
[illegible]	[illegible]	[illegible]	0.444
[illegible]	[illegible]	[illegible]	0.438
[illegible]	[illegible]	[illegible]	0.431

Table No. 2.1 Adsorbate : Copper

Effect of Temperature on Adsorption of Adsorbate

Sr. No.	Temperature (0 K)	Amount Adsorbed	Fractional Removal
1	283	60.00	0.600
2	293	58.75	0.588
3	298	57.50	0.575
4	303	55.00	0.550
5	308	55.00	0.550

6	313	52.50	0.525

Table No. 3.1 Adsorbate : Chromium

Effect of Temperature on Adsorption of Adsorbate

Sr. No.	Temperature (0 K)	Amount Adsorbed	Fractional Removal
1	283	31.54	0.631
2	293	30.38	0.608
3	298	28.08	0.562
4	303	26.92	0.538
5	308	26.54	0.531
6	313	25.72	0.514

Figure 1: Effect of temperature on removal of metal ion

Effect of Contact Time

In adsorption studies,effect of contact time plays vital role irrespective of the other experimental parameters affecting adsorption kinetics and dynamics . The adsorption studies were carried vout at different contact time at constant initial concentration of Iron ,Copper and Chromium with fixed dose of adsorbent .In the present investigation it is observed that at initial stage adsorption is rapid and become slow and get stagnated with increase in time. This may be due to immediate solute adsorption on the surface of adsorbent with subsequent slow removal of the remaining amount of metal ions. Similar findings are also reported by other researchers[14] The effect of temperature on adsorption of metal ion on WVA is given in figure 2

Table No. 1.2   Adsorbate :**Iron**

Effect of Time on Adsorption of Adsorbate

Sr. No.	Time	Amount Adsorbed	K cal
1	0	45.62	--
2	5	46.87	1.116
3	10	53.75	0.516
4	15	58.12	0.337
5	20	60.00	0.266
6	25	61.25	0.224
7	30	63.12	0.186
8	35	63.75	0.168

Table No. 2.2   Adsorbate : Copper

Effect of Time on Adsorption of Adsorbate

Sr. No.	Time	Amount Adsorbed	K cal
1	0	53.75	--
2	5	57.50	1.010
3	10	63.75	0.455
4	15	68.75	0.276
5	20	72.50	0.193
6	25	73.75	0.160
7	30	75.00	0.136
8	35	75.00	0.126

Table No. 3.2 Adsorbate chromium

Effect of Time on Adsorption of Adsorbate

Sr. No.	Time	Amount Adsorbed	K cal
1	0	26.92	--
2	5	29.23	0.544
3	10	30.00	0.358
4	15	31.15	0.262
5	20	31.92	0.212
6	25	32.69	0.175
7	30	33.08	0.155
8	35	33.08	0.144

Figure 2 :Effect of contact time on removal of metal ion

Effect of Adsorption dose

Effect of adsorption dose plays an important role in standerdisingthe adsorption process with quantification of adsorbate solution and the adsorbent. The present study reveals that as the adsorbent dose increase from 1 gm to 5 gm, the removal efficency of all free metal ions increase on the surface of WVA as shown in figure 3. The incease in adsorption with increase in WVA dose may be attributed to the increase in the availability of active sites or surface area at higher concentration of the adsorbent .

Table No. 1.3 **Adsorbate :**Iron

Effect of Variation in the Amount of Adsorbent

Sr. No.	Adsorbentgms. (m)	Amount Adsorbed (x)	log x/m	logC
1	1	49.38	1.6935	1.7044
2	2	56.88	1.4539	1.6347
3	3	60.63	1.3055	1.5952
4	4	63.75	1.2024	1.5593
5	5	66.88	1.1263	1.5202

Adsorbate : Chromium **Table No. 3.3**

Effect of Variation in the Amount of Adsorbent

Sr.No.	**Adsorbentgms. (m)**	**Amount Adsorbed(x)**	**log x/m**	**log C**
1	1	27.62	1.4412	1.3499
2	2	29.52	1.1691	1.3112
3	3	30.95	1.0136	1.2798
4	4	31.90	0.9018	1.2576
5	5	32.86	0.8177	1.2341

Figure 3: Effect of adsorbent dose on removal of metal ion

Adsorption Isotherms

The adsorption isotherm is a graphical representation of amount of substance adsorbed against the residual concentration of the adsorbate in the solution[15].The adsorption data for a wide

range of adsorbate concentration and adsorbent doses were analyzed using Langmuir and Freundlich isotherm in order to find the adsorption capacity of WVA adsorbate Freundlich theory suggested that the ratios of the amount of solute adsorbed onto a given mass of adsorbent to the concentration of the solute in the solutions are not constant at different concentration of solution[16].The Freundlich isotherm was verified by using least square fit and regression analysis and computer programming in EXCELL.The value of regression coefficient r^2 found to be very close to one which indicates the good correlation exists between log X/m and log c .The Langmuir mode(17) represents monolayer adsorption on a set of distinct localized adsorption sites having the same adsorption energies. The essential characteristics of Langmuir isotherm is expressed in terms of dimensionless constant separation factor or equilibrium factor R_L which is indicative of the isotherm and is indicative of the nature of the isotherm and is enlisted below as:

R_L value	Types of Isotherm
$R_L > 1$	Unfavorable
$R_L = 1$	Linear
$0 < R_L < 1$	Favorable
$R = 0$	Irreversible

The adsorption of all three metal ions are favorable on to the surface WVA as R_L value in the present study falls in the O $< R_L <$ 1 and is agreement with findings of Lodha et al(18)

Thermodynamic parameter

Thermodynamic parameters evaluates the nature of adsorption of adsorbate and its magnitude during adsorption process . The change in Gibbs free energy(△ G) , enthalpy changes (△ H) and entropy change (△ S) were calculated and are summarized in the tabular form in Table 1 .

According to Laura[19] △ G upto -15 KJ/ mole are connected with physical interaction between adsorption site and metal ions is physical adsoption. In the present investigation △ G values of Fe(III), Cu(II) , and Cr(II) are below -15 KJ/mole indicates physical adsorption. The negative value of △ H indicates exothermic process. Our observation supported by Soon-Yong.et.al[20]. The positive value of △S suggest increased randomness at the solid-liquid interface solvent molecule which are displayed by the adsorbed species gain more translational entropy than was lost by the adsorbate ions Furthermore before adsorption process takes place the adsorbate ions are heavily solvated (the system is more ordered) and this order may be lost when the ions are adsorbed on the surface due to release of solvated water molecules.

Table 1 :- Thermodynamic parameters at different temperature.

Adsorbate	Temprature/K	- △ G	- △ H	S△
Iron	303	-84	-3875	12.37
	308	-55		
	313	-26		
Copper	303	-386	-4263	12.68
	308	-392		
	313	-259		
Chromium	303	-619	-7206	21.52
	308	-587		
	313	-506		

Conclusions

It has been proved that activated WVA is an excellent adsorbent for removal of heavy metal ions from aqueous solution under certain physiochemicals conditions. The result indicates the potentially practical value of WVA as adsorbent. The dimensionless equilibrium parameter R_L found to be in the range between 0 to 1 is indicative of favorable adsorption onto the surface of thermodynamic parameters △ G, △ H and △ S shows spontaneous process.

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