Research Article

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Efficient adsorption of Pb^{+2} and Cd^{+2} from effluents on Eco-Friendly and low cost adsorbent developed from *Achyranthes aspera* Linn. stem

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ABSTRACT

Heavy metals are major toxicants found in industrial wastewater, they adversely affect to the aquatic flora, animals and human beings . In this study, the removal of heavy metals like Pb^{+2} and Cd^{+2} from aqueous solution using eco- friendly and low cost activated carbon has been investigated . The carbon is prepared from *Achyranthes aspera* Linn. stem by treatment with conc. H_2SO_4. The powdered raw material and chemically treated material of specific micron size is used by employing various temperature. The results revealed that the removal of dye by chemically treated material is more effective than raw material at higher temperature. The experimental data is analyzed using Freundlich and Langmuir isotherm models and it is fit with these isotherm models. The adsorption capacity (Q_m) for Pb^{+2} and Cd^{+2} is calculated at 25,35 and45^{0}C . It is found to be a potential adsorbent for removal of Pb^{+2} and Cd^{+2} from effluents.

Key words: *Achyranthes aspera* Linn., heavy metals, adsorption, adsorption isotherms.

INTRODUCTION:

The increase in industrial activity during recent years is greatly contributing to the increase of heavy metals in the environment, mainly in the aquatic systems [1]. Water pollution due to heavy metals is an issue of great environmental concern[2]. Heavy metals like lead and cadmium are toxic e.g. they damage nerves, liver, kidney, bones, reproductive systems and block functional groups of vital enzymes. These metal ions are non bio-degradable. They adversely affect to the aquatic flora, animals and human beings[3]. Heavy metals like lead, cadmium etc. are present in waste water from several industries such as metal cleaning, plating baths, refineries, paper and pulp, dyes and pigments, glass, ceramic, paints, catalysis chemical manufacturing, etc[4-6]. Lead is known to be one of the heavy metals and widely used in many industrial applications such as electro plating, metal finishing, textile, storage batteries, pigments, fuels, photographic materials, explosive manufacturing, etc. Major lead pollution is through automobiles and battery manufacturers [7]. Cadmium is introduced into water from smelting, metal plating, cadmium nickel batteries, phosphate fertilizers, mining, paints, pigments, plastics, stabilizers, alloy industries, ceramics, etc. [8 - 10].

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In recent years considerable attention has been devoted to the study of removal of heavy metal ions from solution by adsorption using natural materials. Natural materials that are available in large quantities or certain waste from agricultural operations have potential to be used as low cost adsorbent, as they represent unused resources, widely available and environmental friendly[11]. Some previous investigations on the removal of heavy metal ions with many agricultural byproducts have been reported[12-18]. The goal for this research is to develop inexpensive, highly available, effective metal ion adsorbent from nature as alternative to existing conventional adsorbents.

MATERIALS AND METHODS:

I] Preparation of adsorbent :

The plant material was collected from the Purander district of Pune, Maharashtra, India. It was authenticated form Botanical survey of India, Pune, Maharashtra, India. The air shade dried and pulverized stem material of *A. aspera* was used. The raw material (100g) was charged with A. R. grade concentrated H_2SO_4 (35 ml), which was charred and kept in an oven at 100-110^{0}C for six hours for complete carbonization. The carbonized material was washed with distilled water to get free from acid and dried at 110^{0}C for six hours. The dried material was grounded and sieved to get uniform particle size (63 mesh).

II] Adsorption study:

Batch adsorption studies:

The adsorption experiments were carried out in a batch process with pH-4.6 and pH- 4.4 for Pb^{+2} and Cd^{+2} respectively at 25, 35 and 45°C. In each adsorption experiment, 1 gm of adsorbent was added into 50 ml standard solution (700 mg/lit.) and 50 ml distilled water. The mixture was stirred at 500 rpm on a mechanical stirrer for different intervals of times. After predetermined time intervals, adsorbent was separated from solution by filtration method. The amount of lead, cadmium in the filtrate was determined by titrating against standardized EDTA solution.

The proportion of heavy metal removed from solution were calculated from $(C_o - C_e)$

Where, C_o and C_e are the initial and equilibrium concentration of heavy metal respectively. The amount of adsorbed metal ion per unit mass of adsorbent q_e (mg/g) was calculated by the equation :

$$q_e = (C_0 - C_e) V / W$$

Where, C_o and C_e (mg/L) : The initial and equilibrium concentration of heavy metal

V (L) : The volume of the solution

W (g) : The weight of adsorbent used

The removal percentage of heavy metal was calculated as follows

% Removal of metal = $C_0 - C_e / C_0 \times 100$

RESULTS AND DISCUSSION:

The percent removal of heavy metals (Pb^{+2} and Cd^{+2})from aqueous solution of activated carbon is maximum as compared to powdered raw material. The results of raw material and activated carbon reveals that percent removal of heavy metals is directly proportional to the temperature. This indicates chemisorptions process.

The results are summarized of heavy metals (Pb^{+2} and Cd^{+2}) for raw material (RM) and activated carbon (AC) at 25^{0}C, 35^{0}C, 45^{0}C (**Tables 1,2,3 & 4,5,6)** respectively. The data is shown by graphs **(Figures 1,2 & 3,4)** respectively.

A: Effect of Temperature on % Adsorption of Pb^{+2} with respect to Time

Table 1 :

Time in minutes	% Removal using RM	% Removal Using AC
1	16.51	51.14
2	18.05	56.22
3	23.84	58.06
4	29.67	63.67
5	31.14	67.82
10	37.23	70.46
20	42.54	75.04
30	46.53	79.39
60	52.12	83.27
120	52.12	83.27
180	52.12	83.27

Adsorbent dose=1gm/50ml at 35mg/50ml conc., pH-4.6

Table 2 :

Time in minutes	% Removal using RM	% Removal Using AC
1	18.36	55.28
2	22.13	58.05
3	27.56	62.36
4	32.62	66.49
5	37.58	69.27
10	41.74	73.41
20	45.82	78.08
30	49.64	84.28
60	55.51	91.76
120	55.51	91.76
180	55.51	91.76

(Adsorbent dose=1gm/50ml at 35mg/50ml conc., pH-4.6)

Table 3 :

Time in minutes	% Removal using RM	% Removal Using AC
1	19.91	57.21
2	24.53	59.02
3	28.36	64.41
4	34.27	67.34
5	38.17	71.36
10	43.45	75.24
20	46.52	80.04
30	50.68	87.28
60	59.82	96.23
120	59.82	96.23
180	59.82	96.23

(Adsorbent dose=1gm/50ml at 35mg/50ml conc., pH-4.6)

B: Effect of Temperature on % Adsorption of Cd^{+2} with respect to Time

Table 4 :

Time in minutes	% Removal using RM	% Removal Using AC
1	11.24	45.45
2	15.67	48.23
3	21.84	51.36
4	27.26	55.53
5	30.74	58.27
10	36.13	60.14
20	40.28	66.27
30	45.19	70.45
60	50.54	76.54
120	50.54	76.54
180	50.54	76.54

(Adsorbent dose=1gm/50ml at 35mg/50ml conc., pH- 4.4)

Table 5 :

Time in minutes	% Removal using RM	% Removal Using AC
1	14.82	50.62
2	19.67	53.34
3	25.04	58.23
4	30.22	60.34
5	35.14	61.53
10	39.39	63.67
20	43.09	65.80
30	47.27	72.05
60	52.67	80.50
120	52.67	80.50
180	52.67	80.50

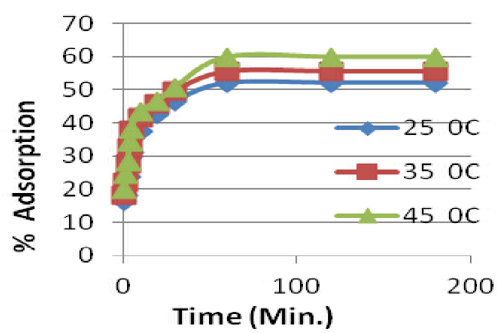
(Adsorbent dose=1gm/50ml at 35mg/50ml conc., pH- 4.4)

Table 6 :

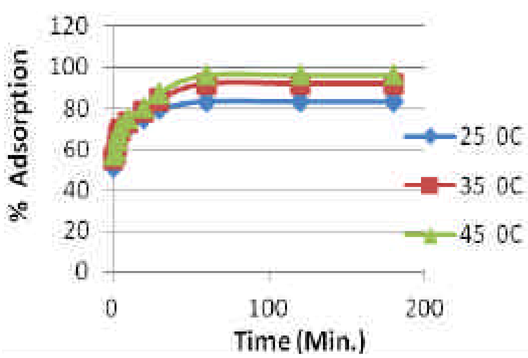
Time in minutes	% Removal using RM	% Removal Using AC
1	16.82	53.14
2	21.23	55.23
3	26.64	61.54
4	31.34	64.67
5	36.21	69.33
10	40.41	72.18
20	44.41	77.27
30	48.14	80.56
60	53.64	84.23
120	53.64	84.23
180	53.64	84.23

(Adsorbent dose=1gm/50ml at 35mg/50ml conc., pH- 4.4)

Figure. 1,2 Effect of Temperature on % Adsorption of Pb^{+2} with respect to Time by the graphs

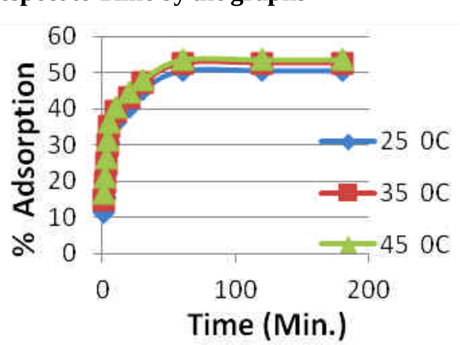


a) RM

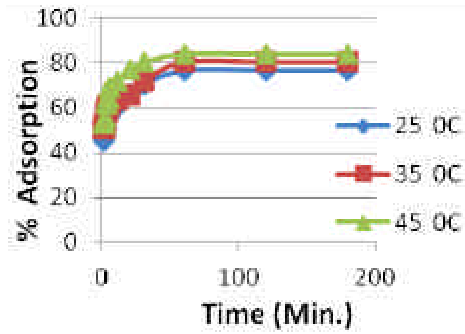


(b) AC

Figure. 3,4 : Effect of Temperature on % Adsorption of Cd^{+2} with respect to Time by the graphs



a) RM



(b) AC

Result reveals that heavy metals (Pb^{+2} and Cd^{+2})are highly adsorbed by the activated carbon while the removal percentage of Pb^{+2} is higher than Cd^{+2} .

III] Adsorption Isotherm

The experimental data are analyzed by the linear form of the Freundlich and Langmuir isotherms [19,20].

A] Freundlich isotherm :

The linear form of Freundlich isotherm is represented by the equation :$\log q_e = \log K_f + 1/n \log C_e$

where,

q_e : The amount of heavy metal adsorbed per unit mass of adsorbent at equilibrium (mg/g)

C_e : The equilibrium concentration of heavy metal ion in solution (mg/L)

K_f and n : Freundlich constants incorporating the factors affecting the adsorption capacity and intensity of adsorption respectively.

Linear plots of $\log q_e$ versus $\log C_e$ indicates that the adsorption of heavy metals obeys the Freundlich adsorption isotherm (**Figure 5,6**). The values of Constants (n and K_f) were calculated from the slope and intercept of the plot and are presented (**Tables 7,9).**

B] Langmuir isotherm :

The linear form of the Langmuir isotherm equation is represented by :$C_e/q_e = 1/Q_m b + C_e/Q_m$

Where,

C_e (mg/L) : The equilibrium concentration of the adsorbate

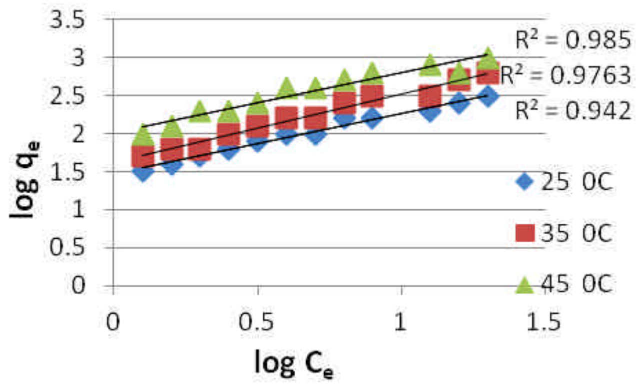
q_e (mg/g) : The amount of adsorbate adsorbed per unit mass of adsorbent at equilibrium

Q_m and b : Langmuir constants related to maximum adsorption capacity and intensity of adsorption respectively.

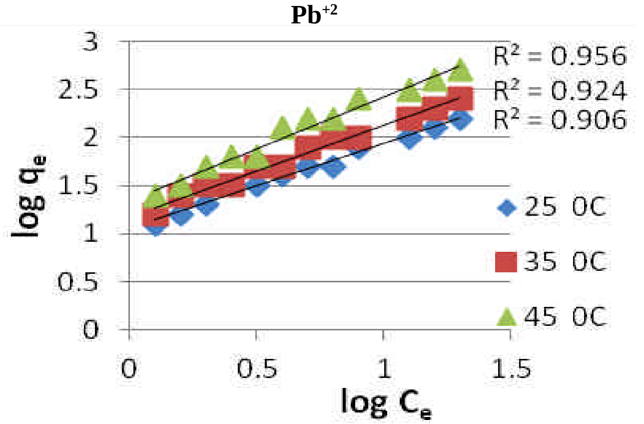
The linear plot of specific adsorption capacity C_e/ q_e against the equilibrium concentration (C_e) indicate that the adsorption of heavy metals obeys the Langmuir adsorption isotherm (**Figure. 7,8**).

The Langmuir constant Q_m and b were calculated from the slope and intercept of the plot and are presented (**Tables 8,10).**

Figure. 5,6 : Freundlich Isotherm for the adsorption of Pb^{+2} and Cd^{+2}

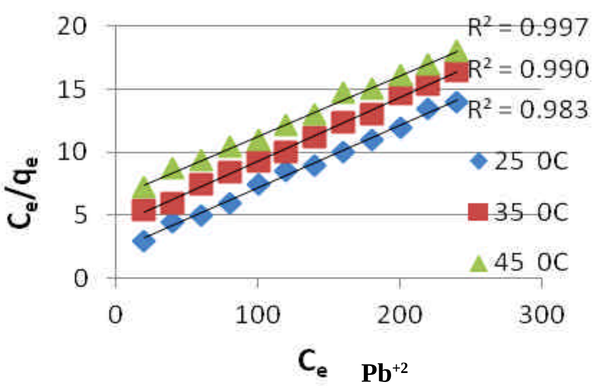


Pb^{+2}

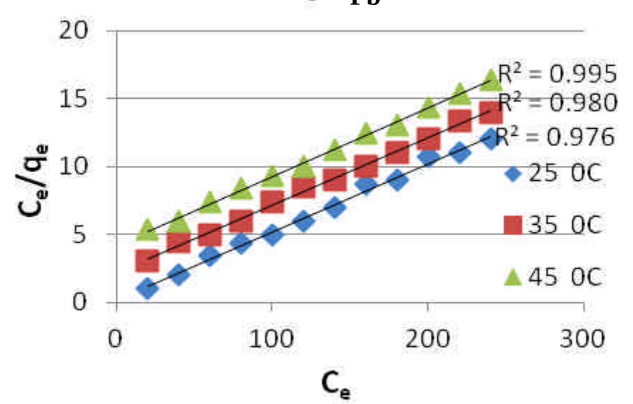


Cd^{+2}

Figure. 7,8 : Langmuir Isotherm for the adsorption of Pb^{+2} and Cd^{+2}



Pb^{+2}



Cd^{+2}

Table 7,8] Freundlich and Langmuir isotherm constants and correlation coefficients for the adsorption of Pb^{+2} by AC at different temperatures

Freundlich isotherm

Temp. (⁰C)	Kf (mg/g)	n	R^2
25⁰C	18.6	2.3	0.942
35⁰C	19.5	2.5	0.976
45⁰C	21.4	2.8	0.985

Langmuir isotherm

Temp. (⁰C)	Q_m (mg/g)	b (L/mg)	R^2
25⁰C	50.4	0.20	0.983
35⁰C	53.6	0.23	0.990
45⁰C	54.2	0.25	0.997

Tables 9,10 : Freundlich and Langmuir isotherm constants and correlation coefficients for the adsorption of Cd^{+2} by AC at different temperatures

Freundlich isotherm

Temp. (⁰C)	Kf (mg/g)	n	R^2
25⁰C	16.3	2.7	0.906
35⁰C	17.2	2.9	0.924
45⁰C	19.6	3.0	0.956

Langmuir isotherm

Temp. (⁰C)	Q_m (mg/g)	b (L/mg)	R^2
25⁰C	32.7	0.26	0.976
35⁰C	35.3	0.28	0.980
45⁰C	37.8	0.29	0.995

Freundlich isotherm constant (K_f, n) and Langmuir isotherm constant (Q_m, b) linearly increases with increase in temperature. The correlation coefficients (R^2) are very close to unity. This indicates that heavy metals are favorably adsorbed by activated carbon.

CONCLUSION:

The present investigation is an attempt to explore the possibility of using *Achyranthes aspera* Linn. stem as a activated carbon for the removal of heavy metals (lead and cadmium) from wastewater.

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