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Use of Leaves of Cauliflower for the Removal of Iron from Waste Water

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The paper describes the use of modified powder of leaves of cauliflower for the removal of iron from industrial waste water. The presence of heavy metals are toxic even in trace quantities. In the present study we used leaves of cauliflower for the binding of Fe^{2+} ions. The removal of Fe^{2+} is efficient at pH 1 and temperature 25°C.

Key words: Leaves. cauliflower, removal, iron, waste water.

INTRODUCTION

The presence of heavy metal ions in sewage, industrial and mining waste has received greater attention in recent years. These are toxic even in trace quantities. Several methods such as precipitation, adsorption, ion exchange, electrochemical reduction[1] etc. are available to remove heavy metal cations from the effluent. Some of these metals have certain limitations and interferences by the presence of other ions. The use of cheap agricultural waste in this field is receiving attention on account of economic consideration coupled with reasonably good efficiency. Some of the researchers used tree barks, cotton capsule shells, saw dust[2–7], rice straw, groundnut husk, carbon[8], tea leaves[9], waste wool[10], peanut skin[11, 12] etc. for the removal of heavy metal ions. However, little work has been performed on the binding of heavy metals using agricultural wastes such as vegetable leaves, cane sugar, husk etc.

Heavy metals are found in the effluents of industries such as paper and pulp, organic and inorganic chemicals, petrochemicals, fertilizers, metal processing etc. Due to the toxicity of metal ions some limits have been imposed by the public health authorities regarding their effluent concentration.

In the present study we have used an agricultural waste product, *i.e.*, leaves of cauliflower, which binds to Fe^{2+} and minimizes pollution.

EXPERIMENTAL

Preparation of solutions

Chemicals of AR grade of S.D. Fine were used without further purification. Solutions were prepared in double distilled water. The solution of ferrous

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ammonium sulphate, hydroxylammonium chloride, H_2SO_4 and sodium acetate are prepared as described in the literature[13].

Preparation of Substrate

The waste leaves of cauliflower were collected locally, dried in air and powdered. 32 mL of 2N H_2SO_4 solution was taken in a 250 mL capacity beaker and 40 mL formaldehyde solution was added to it. The contents were stirred thoroughly. About 50 g of cauliflower leaf powder was added to this mixture while stirring. The beaker containing the syrupy mass thus obtained was kept in an oven at 50°C and ground to fine powder. The substrate thus prepared was used for the present study.

Batch experiment

Batch adsorption studies were carried out using glass stoppered conical flask, containing sample solutions at the desired pH and adsorbent material. The pH of the solution was adjusted with HCl or NH_4OH solution. The flask was shaken for the required time period at the desired temperature by a mechanical strirrer. All the experiments was carried out at 30°C except while studying the temperature effect. After the required time period the contents of the flask were filtered through sintered glass crucible and analysed spectrophotometrically using 1,10-phenanthroline as a reagent.

RESULTS AND DISCUSSION

The concentration of Fe(II) in the test solution was determined by spectrophotometer method using 1,10-phenanthroline. The basic parameters which affect the adsoption have been studied. The parameters depend on contact time, temperature, pH etc.

Vegetable leaves, tree bark etc. contain polyphenols; when these are treated with formaldehyde and H_2SO_4, they form phenol formaldehyde resin which may act as an ion-exchanger and henece will act as the best adsorbent.

TABLE-1

Effect of contact time		Effect of pH		Effect of temperature	
pH	2.5	Contact time	1 h	Contact time	1 h
Temperature	25°C	Temperature	25°C	pH	2.5
Initial conc. of Fe^{2+}	100 ppm	Initial conc. of Fe^{2+}	100 ppm	Initial conc. of Fe^{2+}.	100 ppm
Time in min	Removal of Fe(II) (%)	pH	Removel of Fe(II) (%)	Temperature (°C)	Removal of Fe(II) (%)
15	82	1.0	88	25	85
30	83	2.0	84	40	79
45	87	3.0	81	50	79
60	89	4.0	81	60	77

At room temperature 100 ppm solution of Fe(II) was stirred with the powder of leaves of cauliflower in a glass stoppered flask. It is observed that cauliflower leaves adsorb 82% within 15 min. After 30 min adsorption slightly increases up to 83% for cauliflower. At about 1 h it reaches to 89%. This indicates the formation of monolayer coverage of the adsorbate on the water surface of the adsorbent. The equilibrium time remains constant after 1 h.

At 1 pH binding of Fe(II) ion by leaves of Cauliflower was 88% while at 2 pH it decreases up to 84%. At pH 3 it indicates 81% binding property and then it becomes constant at 4 pH. In basic media Fe^{2+} may get precipitated out; hence only acidic pH range was studied.

As temperature increases the adsorption properties decrease. At 25°C leaves of cauliflower indicate 82% adsorption whereas at 60°C the adsorption decreases to 77% by leaves of cauliflower. This shows the exothermic nature of the process. The decreases in adsorption with rise of temperature may be due to the enhanced escaping tendency of the Fe(II) ion from the surface of adsorbent.

The thermodynamic parameters such as free energy (ΔG), enthalphy change (ΔH) and entropy change (ΔS) were determined using the following equations and presented in Table-2.

$$K_c = \frac{C_{ad}}{C_e} \tag{1}$$

$$\Delta G = -RT \ln K_c \tag{2}$$

$$\log K_c = \frac{\Delta S}{2.303R} - \frac{\Delta H}{2.303RT} \tag{3}$$

where K_c = equilibrium constant, C_{ad} = amount of Fe(II) adsorbed (mg) on the adsorbent per litre of the solution at equilibrium and C_e = equilibrium concentration (mg) of Fe(II) in the soluton.

TABLE-2
FREE ENERGY CHANGE

S. No.	Temperature (°C)	−ΔG J/mol
1.	25	144.35
2.	40	76.71
3.	50	53.18
4.	60	27.41

The graph plotted between log K_c *vs.* $1/T \times 10^{-4}$ gives a straight line. It is observed that $\Delta H(1.01 \times 10^{-5})$ of adsorption is positive which indicates endothermic process whereas positive $\Delta S(1.4167 \times 10^{-2})$ indicates increase in randomness of the solid-solution interface during adsoption. Similarly negative (− ΔG) shows feasibility of the adsorption process.

Conclusion

Leaf of cauliflower is an excellent adsorbent. The removal may take place *via* ion-exchanger process. At room temperature, *i.e.*, 25°C and contact time 1 h, the leaves of cauliflower show maximum adsorption. As pH increases, the leaves of cauliflower indicate decreasing adsorption property.

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