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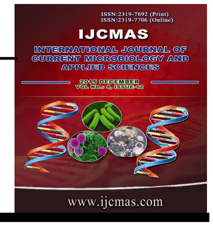

Original Research Article

Adsorption Study of Acetic Acid using Low Cost Biosorbent

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Keywords

Adsorption, Acetic Acid, *Polyalthia longifolia* Seeds

A B S T R A C T

The present work investigates the potential use of biosorbent prepared from seeds of *Polyalthia longifolia* commonly called as 'Ashok' for the removal of acetic acid from aqueous solution. The effect of temperature on the removal of acid at different initial concentrations at its original pH was studied by batch method. At a constant temperature, adsorption from a solution – solid system depends upon concentration of solution, provided the nature and amount of adsorbent is kept constant. The batch adsorption studies of acetic acid have been carried out at (30, 40 and 50^{0}C) different temperatures. The experimental data have been evaluated using Freundlich and Langmuir isotherm model. The linear plots obtained shows applicability of Freundlich and Langmuir isotherms. Maximum adsorption has been found to be 29.4 % at 30 ^{0}C for lower concentration at 0.100 gm adsorbent dose. The maximum adsorption capacity (Q^0) was found to be 48.07 mg/gm at 40^{0}C.

Introduction

Many environmental issues are growing day by day and are threatening the survival of mankind on earth. Water pollution is one of them. With rapid increase in population and growth of industrialization, quality of both surface and ground water is changing day by day. Discharge of industrial wastewater has increased. There is the need to find cheap and efficient method for the treatment of industrial wastewater prior to disposal into natural water. Effluent is usually treated by either physical or chemical processes includes, ion exchange, membrane filtration, electrochemical destruction, irradiation and ozonation [1, 2]. However, these processes are very expensive and could not be effectively used to treat the wide range of pollutants.

The adsorption process is potential alternative to conventional treatment techniques for the removal of pollutants from the contaminated effluent. Adsorption is most adaptable and widely used method due to its high removal capacity and easy to operate at large scale [3-6]. Adsorption is operative in most natural, physical, biological, chemical system and has industrial applications. Activated carbon is the most widely used adsorbent because of its excellent adsorption efficiency.

Commercially available activated carbons are very expensive and restrict its use in developing countries including India. In this scenario, natural raw materials are a possible source of low-cost adsorbents that could provide a successful solution. This has promoted a growing research interest into the production of low cost alternatives to the activated carbon. Researchers have used different biosorbents for the removal of pollutants from waste water [7, 8].

The objectives of this work are to explore and investigate the potential use of biomaterial for the removal of acid from aqueous solution. The effect of temperature on the removal of acid at different initial concentrations at its original pH was studied by batch method. At a constant temperature, adsorption from a solution – solid system depends upon concentration of solution, provided the nature and amount of adsorbent is kept constant.

The review of literature highlights the necessity of cost effective biosorbents. Though a number of studies have been made in this line, no investigation was made to explore the possibility of usage of *Polyalthia longifolia* seeds, a garden waste, as the precursor for activated carbon preparation. Therefore, conversion of *P. longifolia* seeds to low-cost adsorbent will serve dual purpose. Firstly, unwanted waste will be converted to a value added product and secondly, this product may be efficiently used for abatement of environmental pollution.

Experimental

Preparation of Biosorbent

The seeds of *Polyalthia longifolia* were collected in Pune, Maharastra, India. Plant material is authenticated at Botanical Survey of India, Pune, India. Its Voucher Specimen No. is BSI/WRC/Tech/2009/ POLMK1.
The seeds were washed, dried in an oven, crushed and powdered. The powder was sieved to get uniform particle size (0.063 mesh). It is stored in air tight bottle. Used as it is for adsorption study.

Preparations of Solution

Stock solution of 0.5 N acetic acid and 0.1N Na0H were prepared. Acetic acid of various strength was prepared from 0.5 N acetic acid. All chemicals used are of Analytical grade.

Adsorption Experiment

The initial concentration of acetic acid was determined by titrating it with 0.1N Na0H. 50 ml. solutions of different concentrations were taken in a dry conical (100 ml) containing accurately weighed (0.100 gm.) biosorbents. The flasks were stoppered and kept in a water bath to attain the required temperature. The solutions were continuously stirred at 500 rpm for 30 min. to attain equilibrium. After filtration through Watman filter paper, the residual concentrations in the solution at equilibrium were determined by titrating it with 0.1N Na0H solution volumetrically.

Adsorption Study

Analytical Method

The amount of acid adsorbed on the biosorbent, q_e (mg/g) was calculated using mass – balance relationship given in equation 1.

$$q_e = (C_0 - C_e)\ V / 1000 \ x \ w \qquad (1)$$

Where, q_e is the quantity of acetic acid uptake by biosorbent (mg/g) at equilibrium

C_0 is the initial concentration (mgL^{-1}) of acetic acid.
C_e is the concentration of acetic acid after sorption at equilibrium (mgL^{-1}).

V is the volume of acetic acid solution (ml);

W is the mass of adsorbent (g.).

Adsorption Isotherms

The equilibrium sorption isotherms are fundamentally important in designing biosorption system. The capacity of sorbent, equilibrium relations between sorbent and sorbet are described by adsorption isotherms, at a fix temperature. Freundlich and Langmuir isotherms were obtained as in equation 2 and 3.

The linearized Freundlich isotherm is represented as,

$$\log q_e = \log K_F + (1/n) \log C_e \qquad (2)$$

Where, K_F (mg/g) and 1/n are Freundlich constants including all factors affecting the adsorption capacity and favorability of adsorption onto biosorbents.

The plots of log q_e vs. log C_e are used to determine the values of K_F and 1/n from the intercept and slope.

Freundlich parameter 1/n relates to the surface heterogeneity. .

When 0 ‹ 1/n › 1, adsorption is favorable; 1/n = 1, adsorption is homogeneous and there is no interaction between the adsorbed species and 1/n › 1, adsorption is unfavorable.

The Langmuir equation is used in the linearized form in order to evaluate adsorption capacity and Langmuir constant as,

$$C_e/ q_e = 1/ (Q^0 b) + C_e/Q^0 \qquad (3)$$

Where, Q^0 = Langmuir constant related to maximum adsorption capacity (mg/g).

b = Langmuir constant related to binding energy of the adsorption system (Lmg^{-1}) .

The plot, of Ce/ q_e vs. C_e is used to determine the values of Q^0 and b from the slope and intercept respectively.

Results and Discussion

The adsorption of acetic acid on the untreated seed material is studied by batch mode adsorption. The effect of initial concentration and temperature are investigated. The sorption isotherm is the relationship between the sorbate in the liquid phase with the solid phase at equilibrium at constant temperature. The applicability of adsorption isotherms Freundlich and Langmuir have been determined. The Freundlich (Fig. 1, 2 and 3) and Langmuir isotherms (Fig. 4, 5 and 6) are shown at 30, 40 and 50 ^oC respectively. Parameters obtained from the plots are given in Table no. 1 and 2. The adsorption capacity (mg/g) (Table No. 3) and percent adsorption (Table No. 4) at above mentioned temperatures are calculated.

Adsorption Isotherms

The Freundlich plot of log q_e vs. log C_e are used to determine the constants K_F (Freundlich constant) and 1/n (indicates favorability of adsorption) from the intercept and slope. The K_F values obtained at three different temperatures indicate that the adsorption capacity increases with increase in temperature. This trend has been reported by some researchers for biosorption of dyes and other compounds (9, 10). It may be due to possibility of an increased porosity and total pore volume and enlargement of the biosorbents with rise in temperature. 1/n values between 0 and 1 indicate favorability of adsorption. The adsorption of acetic acid on untreated material is favorable as the 1/n values are 0.3773, 0.2331 and 0.6369 for above mentioned temperatures.

It indicates interaction of molecules of acetic acid with the functional groups present on the biosorbent. Freundlich model has values of correlation coefficient lower than 0.96 (11), at 30 and 40 ^{0}C, but higher than 0.96 at 50 ^{0}C, which restricts utility of the model to describe acetic acid adsorption on untreated material at lower temperature . The

Langmuir plot, of Ce/ q_e vs. C_e is used to determine the Q^0 and b from the slope and intercept respectively at different temperatures. Maximum adsorption capacity (Q^o) was found to be obtained, 48.07 mg/g at 40 ^{0}C with linear coefficient of expansion greater than 0.96 (R^2 = 0.9889) indicate applicability of Langmuir isotherm model. Binding energy (b) of the system increases with increase in temperature (Table No.2). The large values of b indicate strong bonding at given temperature.

Effect of Temperature and concentration

It was observed that as temperature increases adsorption capacity and % adsorption decreases indicating the process is favorable at lower temperature. It indicates the process of biosorption is exothermic and physisorption takes place may be due to desorption process which is favorable at higher temperature.

The biosorption capacity increases with increase of initial acetic acid concentration and then remains constant. This is because increase in concentration increases the ratio of the initial number of molecules to the available surface area. The molecules try to bind with the functional groups present on the biosorbents (12, 13). Higher initial concentration provides an important driving force to overcome mass transfer resistance of the molecules between liquid and solid phase's thus increasing uptake. At the same time percentage removal was higher at lower concentration may be due to large number of sites are available for adsorption. As concentration increases saturation of molecules on surface leads to decrease in percent adsorption and the constant adsorption capacity.

In conclusion, the untreated powdered material obtained from seeds of *Polyalthia longifolia* can be used for the removal of acetic acid from waste water. Sorption technology can be a feasible alternative for removing acetic acid from industrial effluents.

Table.1

Temperature(K)	Freundlich constant		
- -	K_F	1/n	R^2
303	2.48	0.3773	0.9417
313	2.22	0.2331	0.9458
323	1.24	0.6369	0.9988

Table.2

Temperature(K)	Langmuir constant		
	Q^o	b	R^2
303	35.71	0.1245	0.9566
313	48.07	0.2311	0.9886
323	9.46	0.6854	0.8938

Table.3

Concentration (gm/l)	Adsorption capacity(mg/g)		
	30^{o}C	40 ^{o}C	50 ^{o}C
0.0051	15	9	7
0.0102	18	10	7
0.0153	21	12	9
0.0204	27	13	11
0.0255	27	13	8

Table.4

Concentration (gm/l)	Percent adsorption		
	30^{o}C	40 ^{o}C	50 ^{o}C
0.0051	29.41	17.64	13.72
0.0102	17.64	9.80	6.86
0.0153	13.72	7.84	5.88
0.0204	13.23	6.37	5.39
0.0255	10.58	6.37	3.13

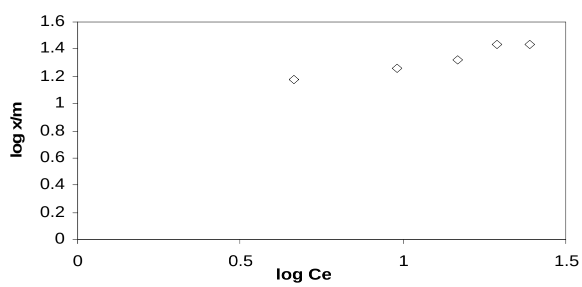

Fig.1. Freundlichl Isotherm at 30 0C for PM

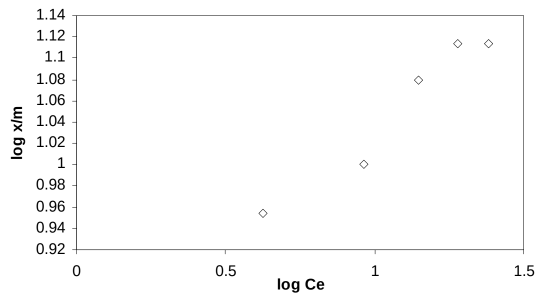

Fig.2. Freundlich Isotherm for AceticAcid at 40 0C PM

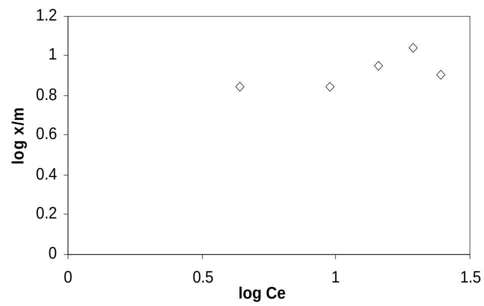

Fig.3. Freundlich Isotherm 50 0C- PM

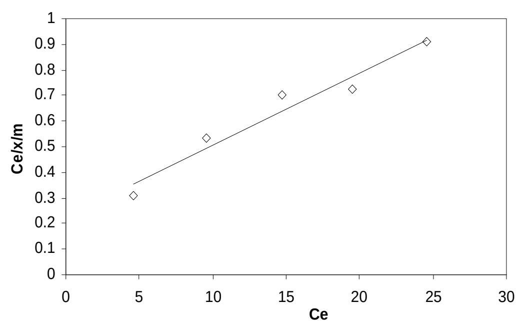

Fig.4. Langmuir Isotherm for Acetic Acid at 30 0C for- PM

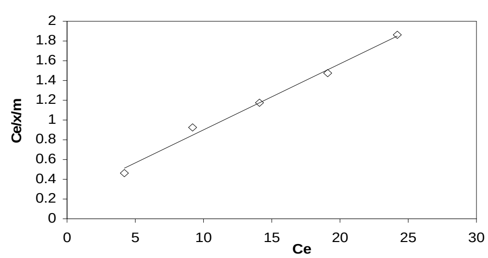

Fig.5. Langmuir Isotherm for Acetic Acid at 40 0C- PM

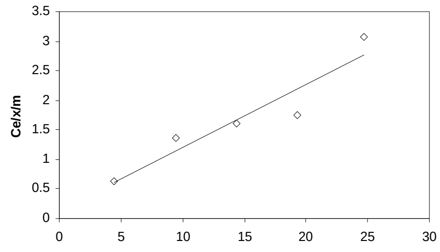

Fig.6. Langmuir Isotherm for Acetic Acid at 50 0C - PM

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