

ADSORPTION STUDIES OF PHENOL ON GODA SAND : A CASE STUDY

M. B. Ubale*, J. V. Bharad* and M. N. Farooqui**

'Department of Chemistry, Vasantao Naik Mahavidyalaya Aurangabad (India) **Department of Chemistry, Aurangabad College for Women, Aurangabad (India)

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ABSTRACT

Adsorption of phenol on Goda Sand was investigated to assess the possibility of treating waste water streams from resin and Pharmaceutical works for removal of toxic materials. The effect of several factors governing the adsorption such as initial concentration, temperature, pH, have been studied. The adsorption equilibrium is well co-related by Langmuir and Freundlich adsorption isotherms.

Key words :- Goda Sand, Adsorption, Phenol, Langmuir adsorption isotherm, Freundlich adsorption isotherm.

INTRODUCTION

Phenol in a large quantity is discharged into waste water stream by the resin and Pharmaceutical industries. Phenol is non-bio-logically Oxidizable Organic Compound and it can be separated by adsorption method.

The discharge of Phenol into natural streams has created significant concern as it imparts toxicity which upsets the biological activity.

Many workers investigated adsorption of Phenol on different adsorbent by physico-chemical treatment processes as it is highly effective, cheap and easy method.

The different adsorbent such as acetyl trimethyl ammonium bromide, treated silica¹⁻², activated carbon obtained from dust of leather industry³ and also adsorption of chemically and biologically important compound on the solid surfaces⁴⁻⁶.

Research survey reveals that various adsorbents are used to remove phenol from waste water such as wood, fire clay etc. Khattri and Singh⁷ reported removal of basic dyes from aq. solution using sand collected

from the sone river (U. P).

In the present investigation, we have selected Goda Sand collected from Godavari river, Paithan (Maharashtra) as adsorbent.

EXPERIMENTAL

All the solutions were prepared by using doubly distilled water. Phenol was used for the present study. Goda Sand samples were collected from Godavari river at Paithan, Dist. Aurangabad (M.S.). The samples were sieved for particles of 16 - mesh size, then boiled with concentrated HCl to remove surface impurities and washed with boiling water repeatedly till the complete removal of chloride ipns. The sample were dried, activated at 400°C for four hours and then allowed to cool.

Batch adsorption experiments were carried out by shaking fixed quantity of phenol solution with known concentration containing 1 gm of treated Goda Sand for about two hours.

The remaining amount of Phenol was estimated in the supernatant solutions spectrophotometrically by treating with Fehling's

solution.

For kinetic measurements, different aliquots were withdrawn at regular time intervals. The effects of different parameters on the adsorption of Phenol using the sand were investigated.

RESULT AND DISCUSSIONS

The fraction removal of Phenol (F_R) was calculated using equation.

$$F_R = \frac{C_0 - C}{C_0} \quad (1)$$

Langmuir adsorption isotherm model was applied for adsorption equilibrium.

$$\frac{C_e}{Q_e} = \frac{1}{Q_0 b} + \frac{C_e}{Q_0} \quad (2)$$

Where C_e is concentration of Phenol in ppm after equilibrium.

Q_e is the amount of phenol in ppm adsorbed per gm of adsorbent after equilibrium.

Q_0 and b are Langmuir constant related to adsorption Capacity and Energy of adsorption respectively.

The linear plot of C_e/Q_e v/s C_e shows That

adsorption obeys Langmuir model.

Value of Q_0 and b are presented in

Table-1 .

The essential characteristics of Langmuir isotherm can be expressed in terms of a dimensionless constant, separation factor or equilibrium parameter R_L which is defined as

$$R_L = \frac{1}{1 + BC_0} \quad (3)$$

Where C_0 is initial concentration in ppm and

B is Langmuir constant

The R_L values between zero and one indicate favorable and is given in Table-2

Table-2 values and Type of Isotherm

R_L Values	Type of Isotherm
$R_L > 1$	Unfavourable
$R_L = 1$	Linear
$0 < R_L < 1$	Favourable
$R_L = 0$	Irreversible

Khatri⁷ reported adsorption of Phenol on some sand and the value of R_L from 0.07 to 0.12 for Resorcinol where as for phenol from 0.08 to 0.13. However for the adsorption of Cr ion on activated carbon, Bandhop-adhya⁹ reported $R_L = 0.59$ D.S. De and J.K. Basu¹⁰ studied adsorption of Resorcinol on modified dust and reported value of $R_L = 0.025$.

The Freundlich adsorption isotherm.

$$\log \left(\frac{x}{m} \right) = \log k + \frac{1}{n} \log C \quad (4)$$

Where C is the equilibrium concentration of phenol

x/m is the amount adsorbed

The plot of $\log (x/m)$ Vs $\log C$ was obtained to be linear. It shows that the adsorption follows Freundlich isotherm. The values of n obtained were between 2 and 10 which indicates favourable adsorption.

In the present work the adsorption kinetics were studied by using Lagergren equation.

$$\log (q_e - q) = \log q_e - \frac{K^2_{ad} t}{2.303} \quad (5)$$

Where q is the amount adsorbed at time " t "

q_e is the amount adsorbed at equilibrium time

Linear plots of $\log (q_e - q) V/s t$ indicate the applicability of Lagergren. Further, it confirms adsorption process as first order kinetics. The value of $K'_a d$ are shown in table-1.

The rate constant of intra-particle diffusion K_p were determined using Weber and Moris relationship by plotting amount of dye adsorbed versus square root of time.

$$q = K_p t^{1/2} \quad (6)$$

The results reveal that the initial part of these plots is straight line not passing through the origin shows that intra-particle diffusion is not the only rate controlling step.

Sand samples are generally rich in metal oxides. Khattri and Singh⁷ suggested that when oxides are mixed with the phenol solution, there is surface hydroxylation which gives negatively charged surface.

The surface complex so formed at adsorbate-adsorbent interface may be attributed to phenolate anion.

The Normalized root mean square error

(NRMS) for both the isotherm was calculated using equation 7.

$$NRMS = \sqrt{\frac{1}{n} \sum \left[\frac{Y_{e'}'_{exp} - Y_{e'}'_{cal}}{Y_{e'}'_{exp}} \right]^2} \times 100 \% \quad (7)$$

$Y_{e'}'$ can be calculated for Langmuir isotherm using equation 8

$$Y_{e'}' = \frac{(K_1 Q C_e)}{1 + K_1 C_e} \quad (8)$$

$Y_{e'}'$ can be calculated for Freundlich isotherm using equation 9.

$$Y_{e'}' = K_2 C_e^b \quad (9)$$

NRMS error obtained for the present investigation is given in table-1.

Variation of Contact Time

Temp : 27 ± 0.5 °C		Table-3. Variation of Contact Time			Initial Cone : 50 ppm
Sr. No.	Contact Time	% adsorption of Resorcinol	% Adsorption of Phenol	Fraction removal of Resorcinol	Fraction removal of Phenol
				F_R	F_R
1	5 Min.	23	28	0.23	0.28
2	10 Min.	30	32	0.30	0.32
3	15 Min.	44	36	0.44	0.36
4	20 Min.	47	44	0.47	0.44
5	25 Min.	48	46	0.48	0.46
6	30 Min.	52	49	0.52	0.49
7	35 Min.	54	50	0.54	0.50
8	60 Min.	55	52	0.55	0.52
9	120 Min.	56	55	0.56	0.55

Table-4. Variation of Initial Concentration

Conc ⁿ of Sol ⁿ C ₀ in ppm	Resorcinol		Phenol	
	Amount Adsorbed Q _e in ppm	Equilibrium Concentration C _e = C ₀ -Q _e in ppm	Amount Adsorbed Q _e in ppm	Equilibrium Concentration C _e = C ₀ -Q _e in ppm
50	35	15	29	21
100	70	30	64	36
150	101	49	44	56
200	135	65	113	87
250	180	90	142	108
300	173	145	127	155

Table-5. Variation of Adsorbent

Initial Cone 300 ppm		
Weight of adsorbent in gms	Amount Resorcinol Adsorbed Q _e in ppm	Phenol Adsorbed Q _e in ppm
1	70	58
2	133	103
3	187	144
4	219	179
5	237	203

Table-6. Variation of pH

Initial Cone 100 ppm		
PH	Amount Resorcinol Adsorbed	Amount Phenol Adsorbed
3.10	32	31
4.04	34	34
5.13	37	36
5.97	40	37
6.93	44	38

Effect of contact time :

In adsorption studies, effect of contact time plays vital role irrespective of the other experimental parameters effecting adsorption kinetics. The adsorption studies were carried out at different contact time as constant initial concentration of phenol with a fixed dose of adsorbent.

In the present investigation, it is observed that at initial stage, adsorption is rapid and becomes slow and gets stagnated with increase in time. Thus, the first order kinetic nature of adsorbate - adsorbent system is attributed to exponential adsorption.

Effect of initial concentration :

In present investigation, the effect in initial concentration of phenol solution and amount of phenol adsorbed on Goda Sand was undertaken with a fixed dose of adsorbent and constant contact time by varying the initial concentration of phenol.

The present study reveals that amount of phenol adsorbed exponentially increases while the percentage removal decreases with increase in initial concentration of phenol. This may be attributed to lack of available active sites on the adsorbent surface compared to relatively large number of active

sites required for the high initial concentration of phenol.

Variation of adsorbent :

In present study, the variation of adsorbent and at fixed dose of adsorbate *i.e.* with a constant concentration of phenol with optimum contact time. As the amount of adsorbent increased.

Adsorption also increased may be attributed to increase in availability of the active sites due to this increase in the surface area.

Effect of pH :

The present study was carried in the phenol solution of 100 ppm, pH range of 3.0 to 7.0. With increase in the pH of solution from 3.0 to 7.0 adsorption of phenol increases.

The increased adsorption of Phenol may be attributed to binding of phenol molecules to the adsorbent (Goda Sand), whereas lower adsorption at lower pH may be attributed to the presence of excess Hydrogen ion which lowers binding of phenol molecules on Goda Sand.

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