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Adsorption of Phenolic Compounds from Industrial Effluent by Activated Carbon

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Abstract:
Phenol is a major pollutant in the wastewater because of its presence in the effluent of major processing and refining plants. The adsorption of phenol is found to be the most important problem being faced by many industries like petrochemical, petroleum refineries, coal gasification operations, liquefaction processes, resin manufacturing industries, dye synthesis units, pulp and paper mills, pharmaceutical and textile industries. Various methods are used for removing the phenol from industrial effluent such as adsorption, photodecomposition, volatilization and other various biological and non-biological methods. In the present study an attempt is made to remove the phenol by adsorption technique using activated carbon. The adsorption of phenol by activated carbon will be investigated to know it's assessing towards possible way of usage as an adsorbent. The optimum conditions for maximum adsorption from the batch phenol adsorption onto activated carbon will be found out by using the results obtained as the parameter and can be analyzed to predict the efficient factors.

Keywords: Factors influencing rate of adsorption, Industrial waste, Activated carbon, phenol compounds.

INTRODUCTION

Phenol is considered as the pollutant because of its toxic nature and harmful effect to organisms even at very low concentrations. Apart from the toxic effects, phenolic compounds create an oxygen demand in available waters, and gives odor and taste to water even in minute concentrations with their compounds. Water bodies including Surface water and ground waters are contaminated by phenolic compounds as a result of the continuous release of these compounds from various industries like petrochemical, phenol producing industries and coal conversion industries. Hence, the not useful water containing phenolic compounds should be treated prior to their release into the water streams. General methods for the removal of phenolic compounds in aqueous solutions are divided by three main categories, they are: physical, biological and chemical treatment. Among these methods, physical method of adsorption is generally considered as the effective, best, low-cost and most frequently used technique for the removal of phenolic pollutant compounds. Therefore, search for economical and easily available adsorbents has led so many researchers to investigate for more economic and efficient as well as quick techniques of using the natural and artificial materials as adsorbents. Presently, using the inorganic materials in the form of adsorbents has become one of the hot research fields[1-5]. Adsorption, as it is a simple and relatively cost efficient method, it is widely used technique in the removal of toxic pollutants from industrial effluents. Even though the adsorbents used may differ in their adsorption rates and depending on the type of pollutant present in the solution, etc[6-8]. Properties affecting the adsorbent rate are; surface area of adsorbent available, homogeneous pore size on adsorbent, structural properties of adsorbent, selective adsorption ability, regenerating easily, and finally it can be used in multiple ways. Since the artificial adsorbents satisfy most of the above conditions they are relatively expensive, so use of natural adsorbents is an important area of research. The objective of the present work is to predict the capability of activated carbon used as an adsorbent for removal of phenol from industrial waste. This study presents the optimum values for the following parameters Agitation time, Adsorbent size, Adsorbent dosage, concentration of adsorb ate in the industrial waste, Volume of industrial waste and pH of industrial waste.

MATERIALS AND METHODS

Effect Of Various Parameters On % Removal Of Phenol From Industrial Effluent

Effect of Agitation Time:

- 6 conical flasks are taken in which 50ml of 1ml /lit industrial effluent solution is taken. Its P^H is maintained at 3 and into that flask and we add 0.5 grams of 150-mesh sized adsorbent.
- After that the flasks are arranged on the orbital shaker to facilitate the adsorption to take place. Each flask is drawn for 10, 20, 30, 40, 50, 60 minutes respectively
- After completion of adsorption process adsorbent is filtered using a filter paper.
- Filtered samples are collected and the readings of the optical densities of each solution are noted after calibrating the spectrometer with the blank solution using pure distilled water.
- By using the calibration curve, we will find out the concentrations of the phenolic compounds adsorbed by the adsorbent and we can also find out the % removal of phenol.

Effect of Initial Concentration of industrial effluent solution:

- 7 conical flasks are taken in which different concentrations of industrial effluent solutions. The concentrations used are 1.2, 1, 0.8, 0.6, 0.4, 0.2, 0.1 (grams/lit) respectively.

- 50ml solution of each concentration is taken into each flask and its P^H is maintained at 3.For this flasks 0.5 grams of the adsorbent of (150-mesh size) is added.
- Conical flasks are arranged for shaking for time scale of 110 minutes and then the samples are send for filtration by filter paper.
- The filtrate is then taken into the spectrometer quiet and then optical density for each concentration solution is taken. This should be done only after calibrating the colorimeter by the blank solution prepared with distilled water.
- By using the calibration curve, we will find out the concentration of phenol adsorbed by the adsorbent from which we can find out the % removal of phenol.

Effect of Size of Adsorbent:

- Take 5 stopper flasks into which we add 50ml of 1 gm/lit concentration of industrial effluent solution and its P^H is maintained at 3.For that we add 0.5 gms of adsorbent of different sizes.
- Different sizes which we considered are 6, 10, 36, 85, 150 mesh size respectively and then all the conical flasks are kept for shaking for an optimal time period of 110 minutes on an shaker.
- After completion of shaking filtration is done from which the filtrate is collected in to the sample cell and the optical densities are noted.
  By using the calibration curve, we will find out the concentration of phenol adsorbed by the adsorbent from which we can find out the % removal of phenol.

Effect of Dosage of Adsorbent:

- 5 conical flasks are taken in which 50ml of 1 ml/lit industrial effluent solution is taken and its P^H is maintained at 3. For these conical flasks we add adsorbent of 150-mesh size of varying amounts of 0.1, 0.2, 0.3, 0.4, 0.5 grams respectively.
- All these flasks are kept for orbital shaking for time period of 110 minutes and then they are taken out. Filtered solution is collected and is taken into a quiet whose optical density is noted from the colorimeter.
- By using the calibration curve, we will find out the concentration of phenol adsorbed by the adsorbent from which we can find out the % removal of phenol.

Effect of Volume of Solution:

- Firstly take 5conical flasks into which we add 0.5 grams of adsorbent(150-mesh size) next we add different volumes of stock solution prepared earlier of 1(ml/lit) industrial effluent .The test solution is maintained at a P^H of 3.The different volumes we used here are 10, 20, 30, 40, 50 ml of industrial effluent solution.
- The flasks are kept for orbital shaking on a shaker for 110 minutes. After the completion of agitation filtration is done so that the filtrate is taken to measure the optical density
- By using the calibration curve, we will find out the concentration of phenol adsorbed by the adsorbent from which we can find out the % removal of phenol.

Effect of P^H of Solution:

- 5 conical flasks in which each of 50ml of 1gm/lit concentration of industrial effluent solution is taken .The P^H of each flask are varied. The solutions of different P^H we used are 3, 5, 9, 11, 12 respectively. For these flasks we add 0.5gms of 150-mesh size of adsorbent and keep for shaking for time period of 110 minutes on a shaker.
- The flasks are filtered from which the filtrate is taken as sample to the spectrometer and the optical density is noted.
- By using the calibration curve, we will find out the concentration of phenol adsorbed by the adsorbent from which we can find out the % removal of phenol.

Calculation of % removal of phenol

The amount of phenol removed from the initial industrial effluent can be given by

$$\frac{(\text{Initial conc.} - \text{final conc.})}{(\text{initial conc.})} \times 100$$

RESULTS AND DISCUSSIONS

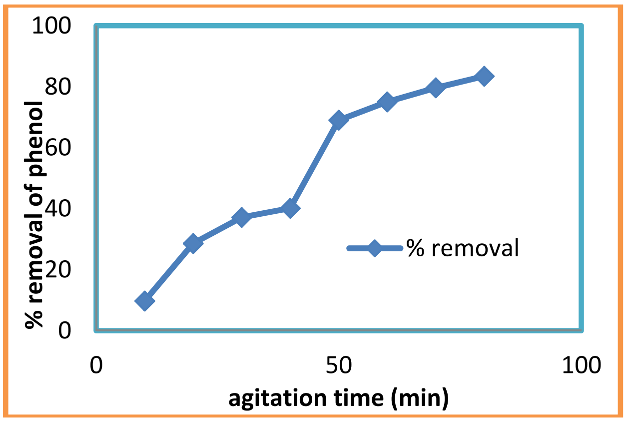

Fig 1: Variation in % Removal of phenol from industrial effluent with Time

From the 1st factor that is effect of agitation time on % removal of phenol from industrial effluent we can clearly observe that as the agitation time increases the %removal also increases as the Activated Carbon will be in contact with the solution for more time and adsorbs more [9-15] .At some point the adsorption will be maximum and further adsorption is not possible as shown in figure 1 and Table 1.

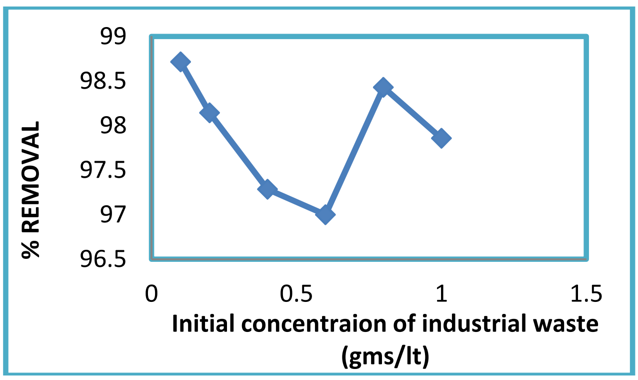

Fig 2: Variation in % Removal of phenol from industrial effluent Solution

From the 2nd factor that is effect of initial concentration of industrial effluent in the solution taken on % removal of phenol can be observed as if the initial concentration of the solution is less the % removal is high and when the concentration is kept increasing the adsorption rate is decreased in the experiment as shown in figure 2 and Table 2.

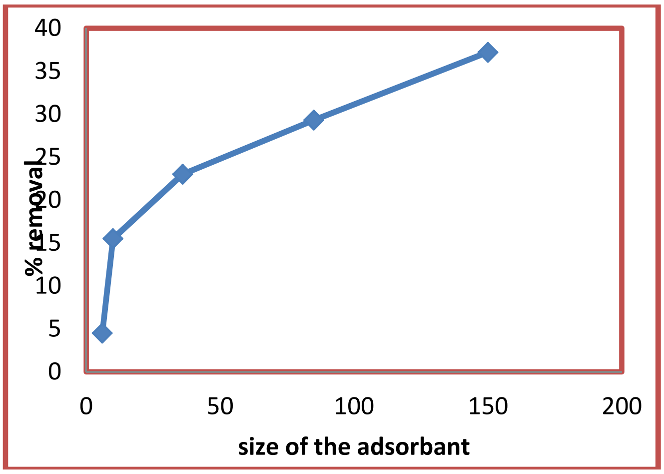

Fig 3: Variation in % Removal of phenol from industrial effluent with Size of Adsorbent

From the 3rd factor that is effect of size of adsorbent on the % removal of phenol gives the clear result that as the size of the activated carbon increases the %removal also increasing because of availability of more micro pore spaces in the carbon. And we observed at 150 mesh size of activated carbon the adsorption is high as shown in figure 3 and Table 3.

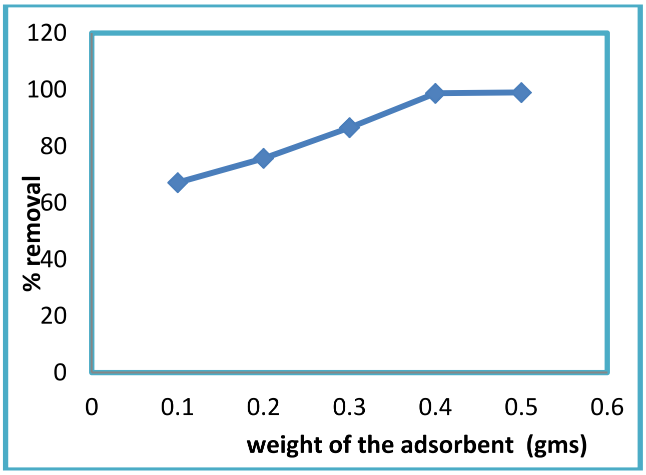

Fig 4: Variation in % Removal of phenol from industrial effluent with Dosage of Adsorbent

From the 4th factor that is effect of dosage of adsorbent on % removal of phenol can be observed that as the amount of adsorbent that is activated carbon increases the adsorption rate also increases. At the 0.5 grams of adsorbent used the adsorption of phenol from industrial waste is more as shown in figure 4 and Table 4.

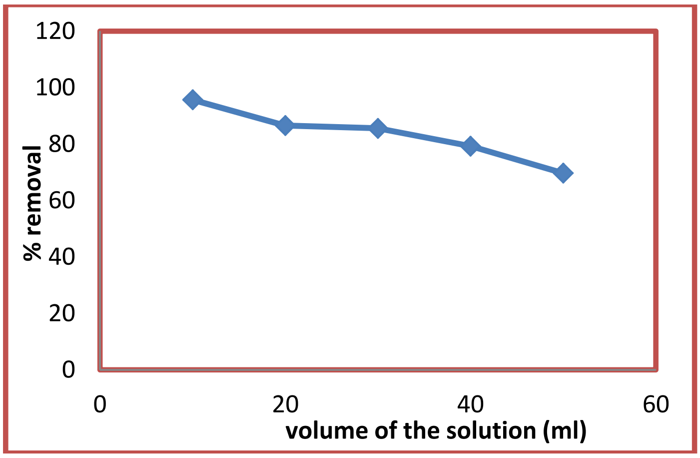

Fig 5: Variation in % Removal of phenol from industrial effluent with Volume of Solution

From the 5th factor that is effect of volume of solution on the % removal of phenol is observed that at lesser volumes of solution the adsorption of phenol is high. As the volume of the solution increased the adsorption rate keep on decreases as shown in figure 5 and Table 5.

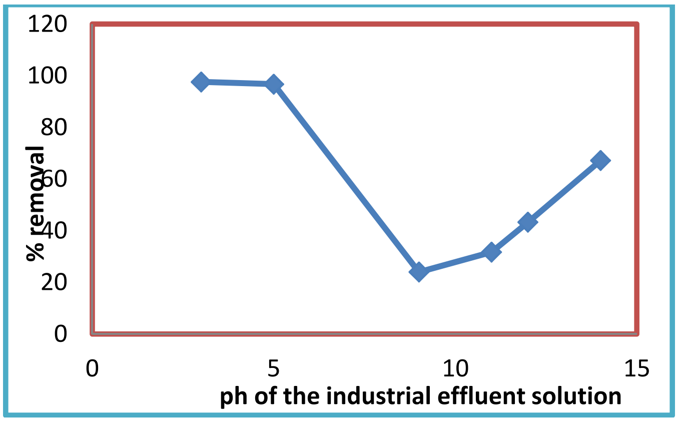

Fig 6: Variation in % Removal of phenol from industrial effluent with P^H of Solution

From the 6th factor that is effect of P^H on %removal of phenol .we can observe that at acidic conditions i.e.; at P^H 3 the adsorption rate is high. And as the alkaline nature increases again the adsorption is observed increasing as shown in figure 6 and Table 6.

Table 1: Variation in % Removal of industrial effluent with Time

Agitation Time(min.)	Optical Density	% Removal
10	1.14	6.8
20	1.14	6.8
30	1.11	13.4
40	1.08	20
50	1.06	26.3
60	1.06	26.3

Table 2: Variation in % Removal with Initial Concentration of industrial effluent Solution

Initial Concentration of industrial effluent Solution(ml/lit)	Optical Density	% removal
1	0.015	97.857
0.8	0.011	98.428
0.6	0.021	97
0.4	0.019	97.285
0.2	0.013	98.142
0.1	0.009	98.714

Table 3: Variation in % Removal with Size of Adsorbent

Mesh Number	Optical Density	% Removal
6	1.15	4.5
10	1.10	15.5
36	1.07	23
85	1.05	29.3
150	1.02	37.2

Table 4: Variation in % Removal with Dosage of Adsorbent

Weight of Adsorbent(gms)	Optical Density	% Removal
0.1	0.23	67.142
0.2	0.17	75.714
0.3	0.094	86.571
0.4	0.009	98.71
0.5	0.007	99

Table 5: Variation in % Removal with volume of Solution

Volume of Solution(ml)	Optical Density	% Removal
10	0.03	95.714
20	0.094	86.571
30	0.101	85.571
40	0.145	79.285
50	0.212	69.714

Table 6: Variation in % Removal with Initial P^H of Solution

Initial P^H of Solution	Optical Density	% Removal
5	0.023	96.714
9	0.532	24
3	0.017	97.571
11	0.478	31.714
12	0.397	43.285
14	0.23	67.142

CONCLUSION

From this project we have tried to find out the optimum conditions at which the phenolic compounds from industrial wastes to be adsorbed using the biological material. We used activated carbon as the biological adsorbent and effluent taken from the coal mining industry as the test solution and we have performed various factors by changing parameters so that we can find out the maximum % removal of phenol from the effluent. And from this project we have observed that the maximum adsorption of the phenol i.e.; (grater % removal) is seen at in the 1^{st} factor at maximum agitation time 60min maximum adsorbance is 26.3% as we increase the agitation time the adsorption even may be more. From the 2^{nd} factor the effect of Initial concentration at lesser concentration 0.1 ml/lit the adsorbance % is very high such as 98.8%. From the 3^{rd} factor affect of adsorbent size higher the adsorbent size higher the % removal of phenol at 150 mesh size activated carbon the % removal is 35%. From 4^{th} factor effect of adsorbent dosage on the % removal is like as the adsorbent dosage increases the % removal of phenol increases. from factors 5 and 6 we can observe that effects of volume of the solution and P^H of the solution is like as the volume and P^H increases the % removal decreases and at lesser volumes and at acidic conditions the absorbance is maximum. From these results we conclude that by following these optimum parameters we can efficiently remove the phenolic compounds from the industrial effluent and make sure that the toxic nature of that effluent is reduced.

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