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# Adsorption Studies of Fluoride on Physically Activated Carbon Prepared from *Peltophorum Pterocarpum*

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**ABSTRACT:** Paper deals with the study of fluoride removal by using fruit of *Peltophorum Pterocarpum*. The removal efficiency of fluoride by using physically activated carbon is 73.48% with an optimum contact time of 30-minute, Concentration of fluoride remaining in solution 1.326 mg/L and fluoride adsorbed 3.674 mg/L. The removal efficiency of fluoride is 78.77% with an optimum dosage of 225 mg, Concentration of fluoride remaining in solution 1.061 mg/L and fluoride adsorbed 3.938 mg/L. The amount of fluoride not only depends on the surface area, optimum time and optimum dosage but also depends on pH. Similarly, the experiment was conducted by varying the pH and adsorption of fluoride by using physically activated carbon is 90.36% at a pH of 9, Concentration of fluoride remaining in solution 0.782 mg/L and Fluoride adsorbed 4.518 mg/L.

**KEYWORDS:** pH, Dosage, Temperature, Contact Time, Fluoride, Sorption Kinetics, Sorption Equilibrium, Temkin Isotherm, Freundlich Isotherm, Column Tracer Experiments, *peltophorum pterocarpum* etc.

## I. INTRODUCTION

Earth is the most beautiful planet of our solar system, abundance of clean air, water and soil help in sustaining life on this planet. Earth is the only planet known so far, where one can find so much of life. Beautiful nature and clean environment are gift of God not only to the mankind, but for all living creatures of this planet. All the living creatures except man use the resources of earth for the sole purpose of their survival for one day. But man utilises and exploits resources of the earth not only for survival for one day but for his future plans, relating to an individual, society and country.

Man's quest for securing his future, along with his today, coupled with population explosion and industrialization is leading to over exploitation of resources of earth. Over utilization of natural resources is leading to pollution of air, soil and water. Water is one of the most important elements on the earth. Every living being needs water for its survival. Without water everything, plants, animals, human beings, other living beings, microbes etc will perish. According to the UN estimates, the total amount of water on earth is about 14,000 Billion Cubic Meters (13CM) which is enough to cover the earth with a layer of 3,000 meters depth. About 2.7 percent of the total water available on earth is fresh water of which about 75.2 percent lies in frozen in Polar Regions and another 22.6 percent is present as ground water. The requirements of the fresh water in the various sectors such as domestic, irrigation, Industry, energy and others increases significantly all over the world.

Over the last thirty years, the use of pure water for drinking and other purposes have been dominant concern along with the concern of better environment. In years to come, water purification process will be a major challenge throughout the globe. Ground water is major sources of water for domestic purpose in India. It was believed that the ground water is pure and safer than the surface water due to earth covering which works as a natural filter. But it's not true. Few decades back, water was considered to be pure and unpolluted if it was odourless, free from turbidity and good from aesthetic point of view. But now, the whole concept of water pollution has changed.

There is need to DE fluoridation of water in contaminated areas [1]. Fluorides are present in all Environmental components: water, soil, air and living organisms. It finds its way into water as a result of rocks weathering and leaching, as well as precipitation along with gas and dust pollution of anthropogenic origin [2]. Based on the survey, it is observed that the maximum removal of fluoride is dependent on pH [3]. Observed that 60 percentage of water is contaminated with fluoride [4].

### 1.1 SCOPE OF THE STUDY

The scope of present study is to use fruit of *PeltophorumPtrocarpum*(Copper pod) as an alternate low-cost adsorbent. The fruit is available locally and abundantly and is thrown away as waste, causing litter. The interest to choose this fruit is that it has not being used as adsorbent in any other research domain.

### 1.2 OBJECTIVES

- To study the properties of the physical activated prepared carbon.
- To determine the fluoride removal by adsorbent as a function of contact time, adsorbent dosage and pH.

### 2. SOURCES OF FLUORIDE

The source of fluoride in surface or ground water is:

The sea, the atmosphere, the earth's crust, Rock forming minerals, Rocks, Commercial ores, Soils.

### 3. MATERIALS AND METHODS

#### 3.1 SELECTION OF SUITABLE ADSORBENT AND ITS RAW MATERIAL

##### 3.1.1 PELTOPHORUMPTEROCARPUM (COPPER POD)

#### General classification

Scientific	:	<i>PeltophorumPterocarpum</i>
Pronunciation	:	Pell-TOFF-oh-rum teer-KAR-pum
Common name (s)	:	Yellow Poinciana, copper pod, golden flame, yellow Gulmohur, yellow flame, yellow flamboyant.
Family	:	Leguminosae
Origin	:	Not native to North American



**Fig 3.1: Fruit of *Peltophorum Pterocarpum***

Fruit	:	<i>PeltophorumPterocarpum</i>
Fruit shape	:	Elongated; Pod
Fruit length	:	3 to 6 Inches
Fruit covering	:	dry or hard
Fruit Color	:	Purple; Red

#### 3.2 PREPARATION OF ACTIVATED CARBON

Adsorption technique was employed by using physically activated carbon prepared from fruit of *peltophorumpterocarpum*. There are two methods to prepare activated carbon, namely.

- Physical activation
- Chemical activation

In the present study physical activation is employed to prepare activated carbon from powder of fruit of *peltophorumpterocarpum*.

**Table 4.1: Effect of Contact Time on Fluoride Removal by Physically Activated Carbon**

- Initial fluoride concentration  $C_0 = 5$  mg/L, Dosage of Adsorbent = 100 mg
- pH =  $7.8 \pm 0.02$ , Volume of sample = 100 ml, Temperature =  $32 \pm 1$  °C



Time in minutes	Concentration of fluoride remaining in solution (mg/L)	Fluoride adsorbed (mg/L)	% removal of fluoride
5	4.570	0.430	8.6
10	4.126	0.874	17.48
15	3.861	1.139	22.78
20	2.240	2.760	55.2
25	1.869	3.131	62.62
<b>30</b>	<b>1.326</b>	<b>3.674</b>	<b>73.48</b>
35	1.326	3.674	73.48
40	1.326	3.674	73.48
45	1.326	3.674	73.48
50	1.326	3.674	73.48
55	1.326	3.674	73.48
60	1.326	3.674	73.48

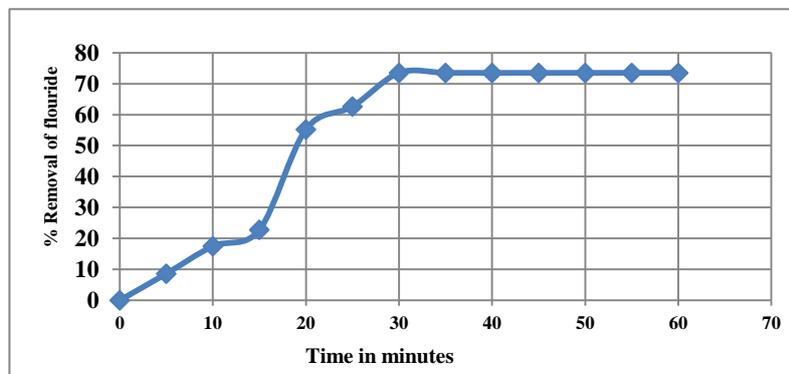


Figure 4.1: Effect of contact time on fluoride removal by physically activated carbon

**4.2 EFFECT OF ADSORBENT DOSAGE**

Effect of adsorbent dosage in removal of fluoride is studied and graph of percentage of fluoride removal versus dosage is plotted as shown in below figure 4.4.

**Table 4.4: Effect of Adsorbent Dosage on Physically Activated Carbon**

Initial fluoride concentration CO = 5 mg/L  
 Dosage of Adsorbent = 100 mg  
 pH = 7.8 ± 0.02  
 Volume of sample = 100 ml  
 Temperature = 32 ± 1 °C

Adsorbent dosage in mg	Concentration of fluoride remaining in solution (mg/L)	Fluoride adsorbed (mg/L)	% removal of fluoride
25	3.909	1.091	21.82
50	3.483	1.516	30.33
75	2.837	2.162	43.25
100	2.578	2.421	48.43
125	2.316	2.684	53.69
150	1.925	3.075	61.50
175	1.600	3.400	68.00
200	1.336	3.664	73.28



<b>225</b>	<b>1.061</b>	<b>3.938</b>	<b>78.77</b>
250	1.061	3.938	78.77
275	1.061	3.938	78.77
300	1.061	3.938	78.77

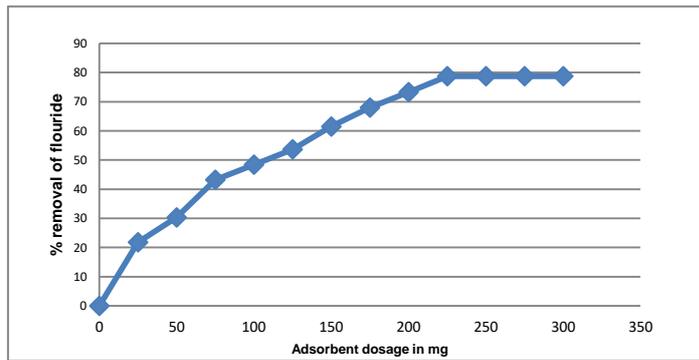


Figure 4.4: Effect of adsorbent dosage on fluoride removal by physically activated carbon

**4.3 EFFECT OF pH ON FLOURIDE REMOVAL**

The pH of solution has influence on the extent of removal efficiencies of fluoride by prepared activated carbon at different pH values are shown in below figure 4. The amount of fluoride not only depends on the surface area, optimum time and optimum dosage but also depends on pH.

From the below mentioned figures, it is observed that the removal efficiency of fluoride by using physically activated is 90.36%, at a pH of 9.

**Table 4.7: Effect of pH On Fluoride Removal by Physically Activated Carbon**

- Initial fluoride concentration  $C_0 = 5 \text{ mg/L}$
- Contact time = 30 min
- Dosage of Adsorbent = 225 mg
- $\text{pH} = 7.8 \pm 0.02$ , Volume of sample = 100 ml, Temperature =  $32 \pm 1 \text{ }^\circ\text{C}$

pH	Concentration of fluoride remaining in solution (mg/L)	Fluoride adsorbed (mg/L)	% removal of fluoride
6.75	3.983	1.016	20.33
7.00	3.960	1.039	20.79
7.25	3.919	1.081	21.62
7.50	3.832	1.168	23.36
7.75	2.252	2.748	54.96
8.00	2.088	2.911	58.23
8.25	1.704	3.295	65.91
8.50	1.057	3.142	78.85
8.75	0.885	4.114	82.29
<b>9.00</b>	<b>0.782</b>	<b>4.518</b>	<b>90.36</b>
9.25	1.990	3.010	60.19
9.50	2.134	2.866	57.32

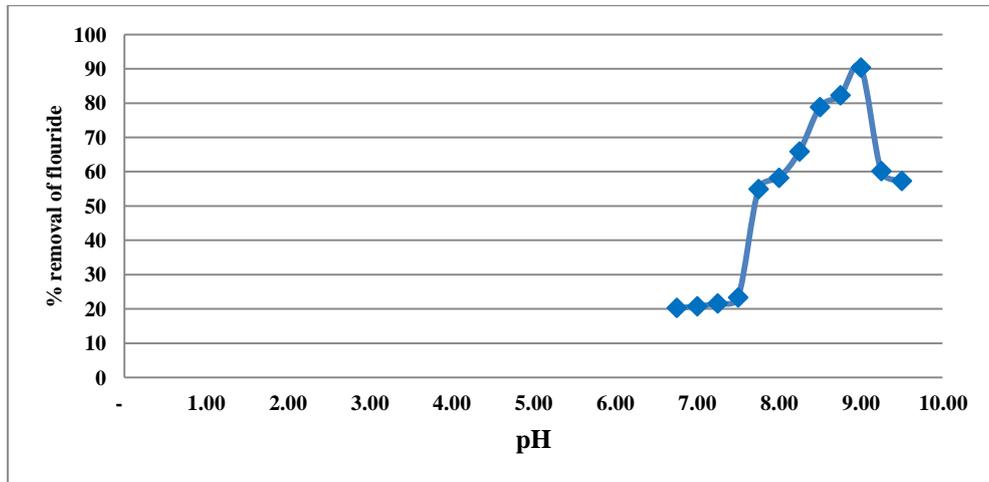


Figure 4.7: Effect of pH on fluoride removal by physically activated carbon

Table 4.10: Optimum Contact Time, Optimum Dosage and Optimum pH for Prepared Carbons

Sl.NO.	Type Of Carbon	I.R	Optimum Time (In Minutes)	Optimum Dosage (mg)	Optimum pH
1.	Physically activated carbon	-	30	225	9

4.4 EFFECT OF SORPTION KINETICS

The kinetics of fluoride removal was performed at room temperature at different time interval of adsorption. The model values of reaction rate constant for different carbons are studied and resulting plots are shown in below figure 4.11. The batch kinetic data for the adsorption of the fluoride was tested for the first order reaction.

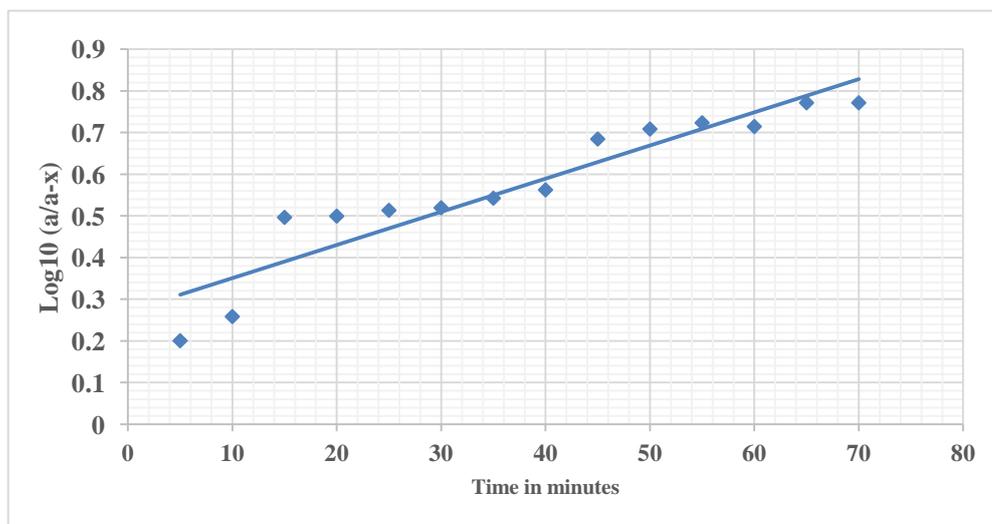


Figure 4.11: Effect of reaction rate constants on fluoride removal by physically activated carbon



Figure 4.14: Reaction Rate Constants for Prepared Carbon

Type of carbon	I.R.	'K' values from calculation	'K' values from graph
Physically activated	-	0.365	0.016

4.5 SORPTION EQUILIBRIUM

Sorption equilibrium isotherms are useful for the estimation of the amount of sorbent needed for sorbing a required amount of sorbate from solution. The most widely used equations to present the adsorption data are Freundlich and Langmuir isotherms. The sorption equilibrium data are filled for all the isotherms.

a) LANGMUIR'S ISOTHERM

The Langmuir isotherm is used to describe the single layer adsorption and the linear form of the Langmuir's isotherm. Calculated model data and the plot of linearised Langmuir isotherm [C / (X/M) versus C] for different adsorbents are shown in below figure 4.15.

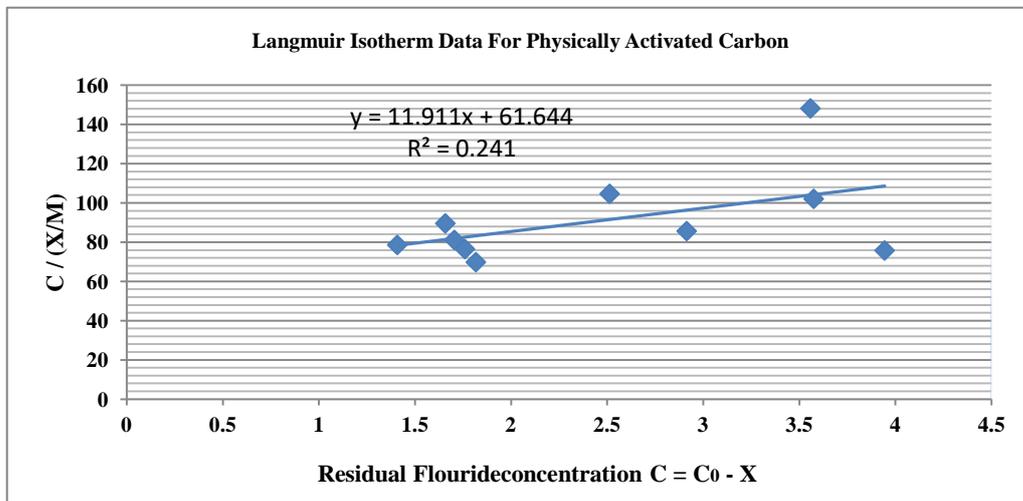


Fig.4.15: Plot of Langmuir Isotherm for physically activated carbon

b) TEMKIN ISOTHERM

The simple form of adsorption isotherm model, has been developed considering the chemisorption of an adsorbate onto the adsorbent, is represented as

$$X = a + b \ln C$$

Where,

C = Concentration of adsorbate in solution at equilibrium (mg/L).

X = Amount of metal adsorbed per unit weight of adsorbent (mg/gm).

a = An empirical constant related to adsorption capacity.

b = An empirical constant related to intensity of adsorption.

For the Temkin isotherm equation, the energy of adsorption is a linear function of the surface coverage. The Temkin isotherm is valid only for an intermediate range of ion concentrations.

The plot of ln C versus X gives a straight line with slope and intercept, knowing intercept and slope the constants 'a' and 'b' are calculated respectively. The model calculations of adsorption isotherm data for Temkin isotherm are shown in below figures 4.19.

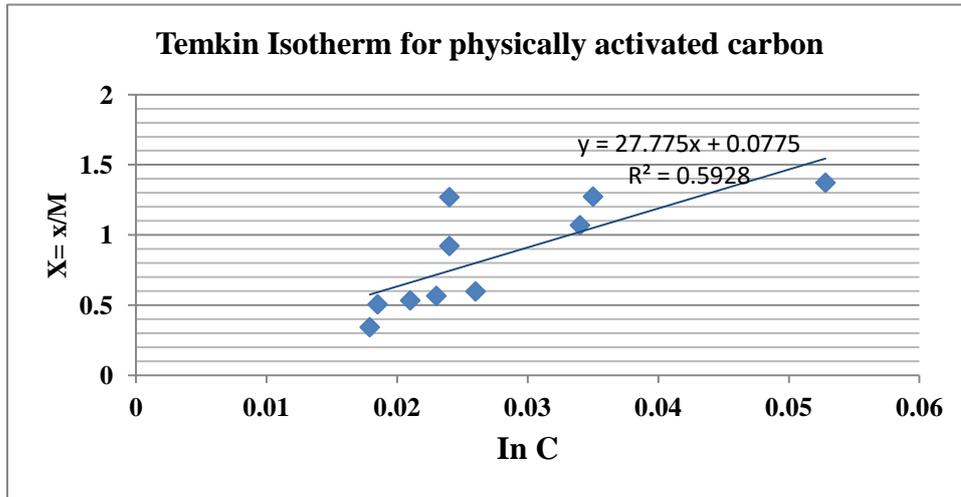


Fig.4.19 Plot of Temkin Isotherm for physically activated carbon

c) **FREUNDLICH ISOTHERM**

Experimental data are often plotted in this manner as a convenient way of determining whether removal of materials from solution is accomplished by adsorption, and as a means of evaluating the constants “K” and “1/n”. The plots of linearised Freundlich isotherms for different carbons are shown in figure 4.23.

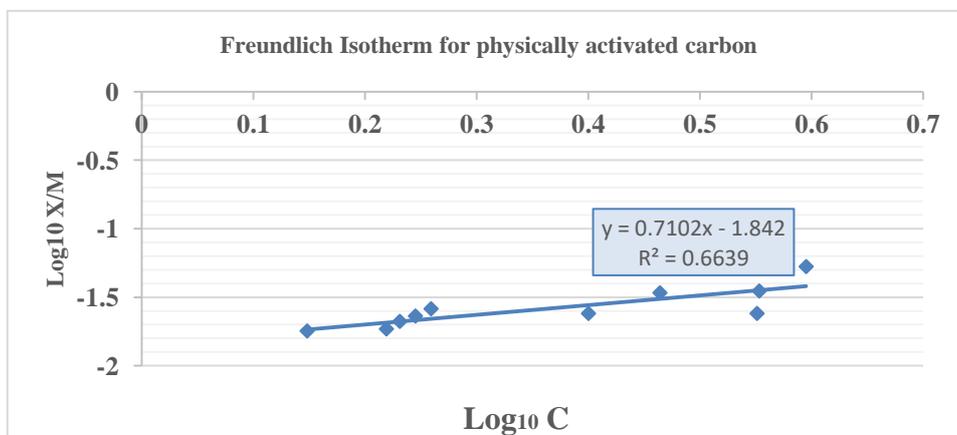


Table-4.26 Constants for freundlich isotherm for prepared carbons

Type of Carbon	I.R	Constant ‘1/n’	Constant ‘K’
Physically activated	-	0.7102	0.610

4.7.1 **SINGLE ADSORPTION OF FLUORIDE ON PHYSICALLY ACTIVATED CARBON**

A series of column tracer experiments have been performed on physically activated carbon and the Fig.4.26 shows tracer breakthrough curve for 5mg/L of initial concentration. The results obtained with different concentrations are fit to Adsorption isotherms.

Similar experiments were performed for concentrations of 10mg/L, the result of the tracer experiment are fit to Freundlich isotherm as shown in below fig 4.26 and the results are analysed.

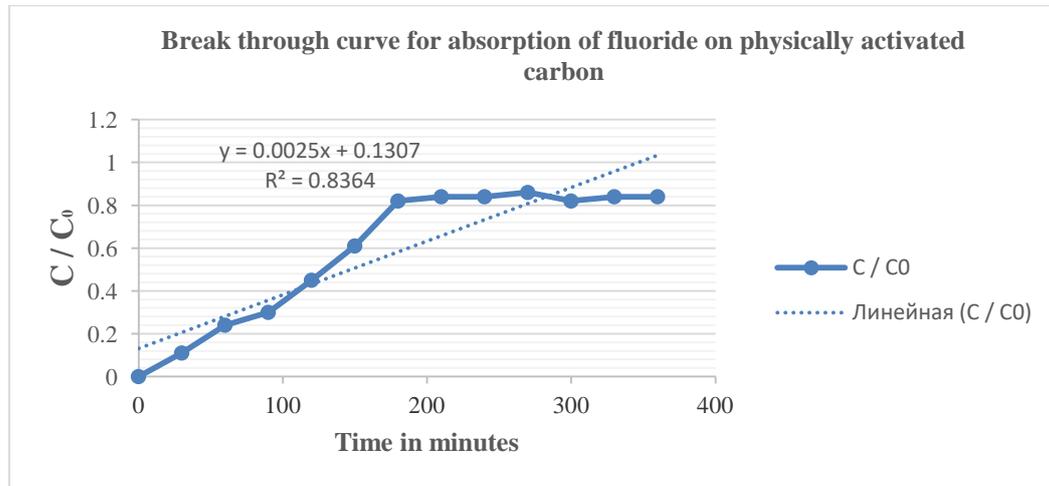


Fig. 4.26: Break Through Curve for Single Adsorption of fluoride on Physically Activated Carbon

Type of carbon	Initial concentration, Caq (µg/l)	Concentration of fluoride in ground, Cads (µg/l)	Log <sub>10</sub> Caq	Log <sub>10</sub> Cads
Physically activated carbon	5	4.800	0.698	0.681
	10	8.25	1.000	0.916

#### IV. CONCLUSION

Based on the experimental study following conclusions are drawn:

1. The Experimental results shows good removal efficiency of fluoride from ground water by using physical activated carbon derived from fruit of PeltophorumPterocarpum (Copper pod).
2. The kinetics of adsorption of fluoride with physically activated carbon were studied by estimating the effect of contact time on the percentage removal of fluoride. The data and results from the experiment reveal that removal of fluoride increases with increase in contact time and attains equilibrium at particular time. Hence optimum contact time for physically activated carbon is 30 min with removal efficiency of 73.48%.
3. The result of experiment on optimization of dosage of adsorbent reveals that, increase in amount of dosage added, increases the removal of fluoride from the solution. Hence Optimum dosage for physically activated carbon is 225mg with removal efficiency of 78.77%.
4. The adsorption of fluoride is mainly pH dependent. The removal efficiency of adsorbent increases with decrease in pH value. It has been observed that maximum adsorption takes place in slight alkaline medium around pH-9.0 for physically activated carbon with removal efficiency of 90.36%.

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