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ADSORPTIVE REMOVAL OF PHENOL FROM AQUEOUS SOLUTION USING BIOMASS-DERIVED ACTIVATED CARBON: EQUILIBRIUM, ISOTHERM AND THERMODYNAMIC STUDIES

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Abstract: *Phenolic compounds are important contaminants in industrial wastewater, creating a need for effective and economical treatment approaches. The present study investigates the adsorption of phenol from aqueous solution using eight carbon adsorbents (C1–C8) prepared from biomass materials, including bamboo dust, sawdust, rice husks, and used tea leaves through pyrolysis and/or sulfuric-acid treatment. Batch adsorption experiments were conducted to evaluate the influence of initial phenol concentration, adsorbent dosage, pH, contact time, and temperature on removal efficiency. Considerable differences were observed among the adsorbents, with C3 demonstrating comparatively high phenol removal; at a dosage of 4.8 g dm^{-3}, it removed approximately 80% of phenol under the specified experimental conditions. Increasing contact time generally enhanced adsorption, with C3 adsorbing up to 92% of phenol from a 50 mg dm^{-3} solution after five hours. The equilibrium data were evaluated using Freundlich and Langmuir isotherm models, both of which adequately represented phenol adsorption across the investigated temperatures of 303, 308, and 313 K. The reported Langmuir separation-factor values ($0 < R_l < 1$) indicated favourable adsorption, while adsorption generally decreased with increasing temperature, suggesting an exothermic process. Overall, the findings demonstrate the potential of biomass-derived carbon adsorbents as relatively inexpensive materials for phenol removal from contaminated aqueous systems and highlight the potential value of agricultural residues in wastewater-treatment applications.*

Keywords: *Phenol adsorption; biomass-derived carbon; activated carbon; wastewater treatment; Langmuir isotherm; Freundlich isotherm; adsorption thermodynamics.*

1. INTRODUCTION

Phenolic compounds are important organic pollutants frequently encountered in industrial wastewater and can adversely affect water quality even at relatively low concentrations. Their effective removal from contaminated water is therefore an important aspect of wastewater treatment. Among the available treatment approaches, adsorption using activated carbon is widely investigated because of its relatively simple operation, high adsorption potential, and ability to remove dissolved organic contaminants. The production of activated carbon from agricultural and biomass wastes can further improve the sustainability and economic feasibility of adsorption-based treatment by converting inexpensive waste materials into useful adsorbents.

The present study investigates the adsorption of phenol from aqueous solution using eight carbon adsorbents prepared from biomass materials, including bamboo dust, sawdust, rice husks, and used tea leaves. The adsorption performance is examined under different phenol concentrations, adsorbent dosages, pH conditions, contact times, and temperatures. Experimental results show considerable variation in adsorption performance among the prepared carbons; for example, under the reported dosage experiment, C3 exhibited substantially greater phenol removal than C5. Activation The equilibrium behaviour is further evaluated using Freundlich and Langmuir adsorption isotherms, both of which were applied successfully to the eight carbon adsorbents at different temperatures. Thus, the study provides a comparative

assessment of biomass-derived carbon materials as potentially economical adsorbents for the removal of phenolic pollutants from contaminated water.

2. ADSORPTION OF PHENOL

In order to discover the equilibrium mechanisms involved in the adsorption of phenol on eight different carbons and to analyze the adsorptive interaction of phenol from aqueous solution:

- Carbon 1 from Bamboo Dust, made by pyrolyzing bamboo dust
- Carbon from C2 Bamboo Dust, made by exposing it to a very concentrated sulfuric acid solution.
- C3 Saw Dust Carbon, made from saw dust by pyrolysis
- Carbon 4 from Rice Husks, made by pyrolyzing rice husks
- Carbon 5 from tea leaves, made by pyrolyzing old tea leaves
- Carbon from C6 tea leaves, produced by exposing them to a very concentrated sulfuric acid solution.
- Sulfuric acid was used to create C7 saw dust carbon.
- The C8 Rice Husk Carbon was made by subjecting it to a very concentrated sulfuric acid solution.

Chemicals used

Further purification was not performed on the phenol, which was obtained from Qualigens Fine Chemicals India. Starting with a stock solution of 500 mg dm^{-3}, the solutions were prepared using double distilled water. The stock solution was used to make a variety of standard solutions with absorbance readings ranging from 50 to 100 mg dm^{-3} [λ_{max} - The 269 nm wavelength was used to build the calibration curve.

The impact of adsorbent density

Using a constant adsorbent dosage of 0.8 g dm^{-3}, six different phenol concentrations (50, 60, 70, 80, 90, and 100 mg dm^{-3}), a contact period of 2 hours, pH 6.0, and temperature 303 K, batch adsorption studies were conducted. Table 1 displays the statistics from the findings that pertain to the percentage of adsorption. Figure 1 also shows the eight distinct carbon adsorbents' % adsorption as a function of adsorptive concentration. Increasing adsorption capacity is best shown by the following sequence of the adsorbents: C3, C7, C2, Cl, C4, C6, C8, and finally C5. The carbons Cl, C2, C3, C4, C5, C6, C7, and C8 absorbed 53%, 71%, 82%, 31%, 15%, 29%, and 21% of the phenol in a solution at a concentration of 50 mg dm^{-3}. It is not surprising that the adsorption was greatest for the lowest concentration phenol solution; this might be because there were fewer phenol molecules initially reaching the accessible surface sites, leading to a high adsorption rate. After that point, the fractional adsorption stops being dependent on the starting concentration. The starting concentration determines the proportion of phenol removed because, as the concentration increases, the number of phenol molecules reaching the surface decreases relative to the number of accessible adsorption sites.

Table 1 The results for percentage adsorption of phenol on various carbons at 303 K, with a contact period of 2 hours, a carbon dosage of 0.8 g dm^{-3}, and a pH of about 6

Adsorbent	Percentage phenol adsorbed at concentration (mg dm^{-3}) of					
	50	60	70	80	90	100
C1	53.0	57.5	43.6	38.1	35.0	34.0
C2	71.0	65.0	62.9	60.6	59.4	58.0
C3	82.0	81.7	68.6	70.0	65.0	62.5
C4	31.0	33.3	25.0	23.1	24.4	25.5
C5	15.0	14.2	12.9	12.5	11.7	11.0
C6	29.0	26.7	23.6	22.5	20.6	19.5
C7	80.0	70.0	60.7	62.5	54.4	52.0
C8	21.0	19.2	20.0	18.1	17.2	16.5

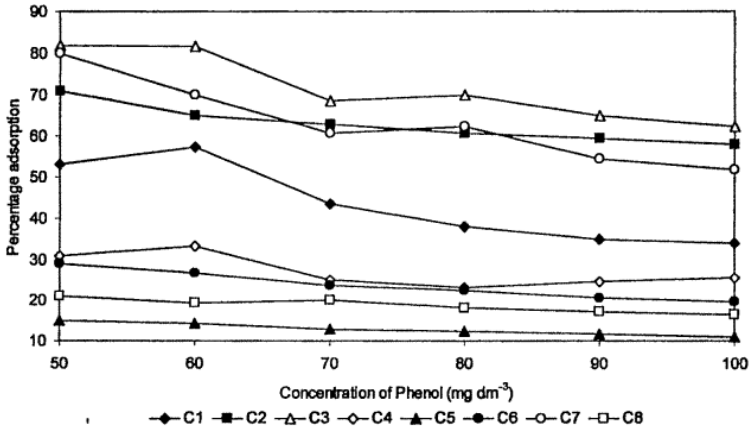


Figure. 1 Variation of percentage adsorption for phenol on the carbon adsorbents [Carbon dose 0.8 g dm^{-3}, temperature 303 K, pH ~ 6, contact time 2 h].

The findings of this study show that even a tiny amount of the carbons utilized in this work may totally remove phenol from water, even if the quantity of phenol in polluted water is considerably lower than 50 mg dm^{-3}.

3. HOW MUCH ADSORBENT MATTERS

In the adsorptive-adsorbent equilibrium system, it stands to reason that additional carbon would lead to more adsorption. The growth may not be linear, however, since there are a number of constraints that make it such that adding more carbon doesn't always lead to more adsorption sites. In this study, the carbon dosage was adjusted for each of the eight adsorbents independently, ranging from 0.8 to 4.8 g dm^{-3}. The findings are shown in Table 2 and Figure 2 in terms of % adsorption at a constant phenol content of 100 mg dm^{-3}, temperature 303 K, contact period 2 hours, and pH ~ 6. As in the situation of increasing adsorptive concentration, the order of the eight adsorbents remained consistent with the increasing carbon dose: C3 > C2 > C7 > Cl > C4 > C6 > C8 > C5.

Under identical circumstances, a dosage of 4.8 g dm^{-3} of C3 carbon was able to remove almost 80% of the phenol from a solution, but a dose of C5 carbon was only able to remove about 21.5%. Nonetheless, when the carbon dosage increased, the quantity absorbed per unit mass dropped, according to all of the data. As an example, when the amount of phenol was raised from 0.8 to 4.8 g dm^{-3}, the adsorption on C3 carbon fell from 78.1 mg g-1 to 16.7 mg g^{-1}. It is believed that when the carbon content in the adsorptive-adsorbent equilibrium increases, some of the adsorption sites become inaccessible. The predicted quick rise in % adsorption with increasing carbon dosage did not occur, hence.

Table 2 Data on the percentage of phenol adsorbed on various carbon dosages at 303 K, with a contact period of 2 hours, a phenol concentration of 100 mg dm^{-3}, and a pH of about 6.0

Adsorbents	Percentage of phenol adsorbed at the carbon dose (g dm^{-3}) of					
	0.8	1.6	2.4	3.2	4.0	4.8
C1	34.0	34.5	34.0	50.0	50.0	53.0
C2	58.0	59.0	61.0	63.5	68.0	74.5
C3	62.5	63.5	68.0	72.0	75.5	80.0
C4	25.5	25.5	37.5	44.0	50.0	52.5
C5	11.0	11.0	18.0	21.5	20.0	21.5
C6	19.5	25.0	30.0	43.5	48.5	51.5
C7	52.0	58.0	60.0	61.0	62.0	74.0
C8	16.5	20.5	24.5	25.5	27.5	28.5

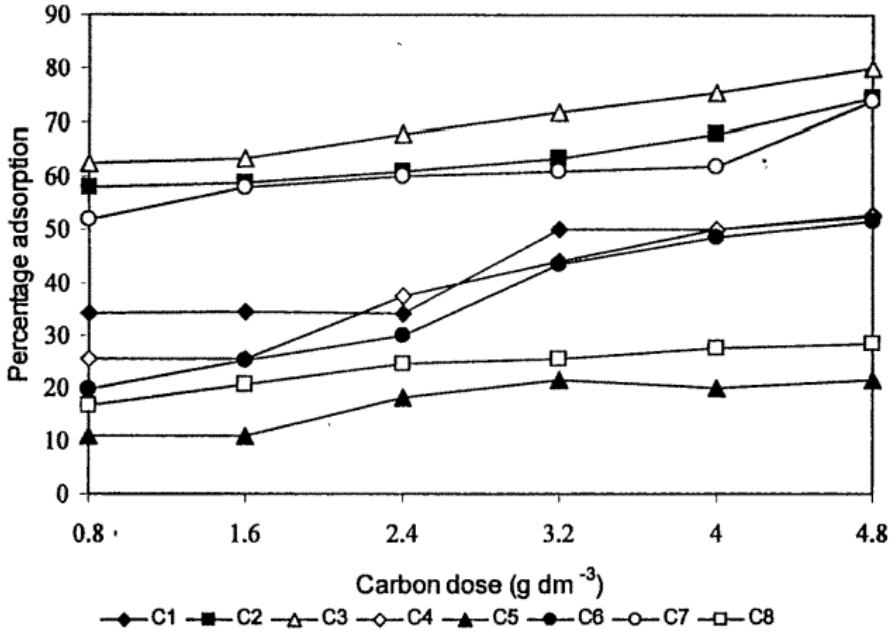


Figure 2 The proportion of phenol adsorbed on carbons as a function of carbon dosage. [Phenol concentration 100 mg dm^{-3}, temperature 303 K, pH ~ 6.0, contact time 2 h]

Influence of pH

In a further set of studies, the pH was varied from 2.0 to 9.0 while the other parameters, including temperature (303 K), carbon dosage (0.8 g dm^{-3}), phenol concentration (100 mg dm^{-3}), and contact duration (two hours), were held constant. Figure 2 displays the results from Table 3, which shows the % adsorption as a function of pH. Phenol adsorption on Cl, C2, and C4 peaked at around pH 5.0 and dropped sharply as the pH rose to 6.0 across all eight adsorbents. As the pH continued to rise, the adsorption once again rose, reaching pH 8.0, after which almost all of the carbon adsorbents exhibited a declining trend.

Table 3 shows the impact of pH on the phenol adsorption on carbons at 303 K during a 2-hour contact period with a phenol concentration of 100 mg dm^{-3}, a pH range of 4.0 to 6.0, and a carbon dosage 0.8 g dm^{-3}]

pH	Percentage of phenol adsorbed on the carbon adsorbents							
	C1	C2	C3	C4	C5	C6	C7	C8
2	55.0	58.0	60.0	25.0	21.5	33.5	50.0	31.0
3	62.0	64.0	63.5	26.5	22.0	35.5	58.5	32.5
4	63.5	65.0	65.0	29.0	28.5	39.5	63.5	34.0
5	65.0	67.5	68.0	31.5	30.5	40.5	67.5	36.5
6	55.0	58.0	62.5	25.5	28.5	39.0	65.0	34.5
7	54.0	62.0	58.0	24.0	27.5	41.5	57.0	34.0
8	65.5	61.5	69.5	35.0	34.5	37.5	62.0	32.5
9	61.0	60.0	64.5	33.0	32.5	30.5	60.0	28.5

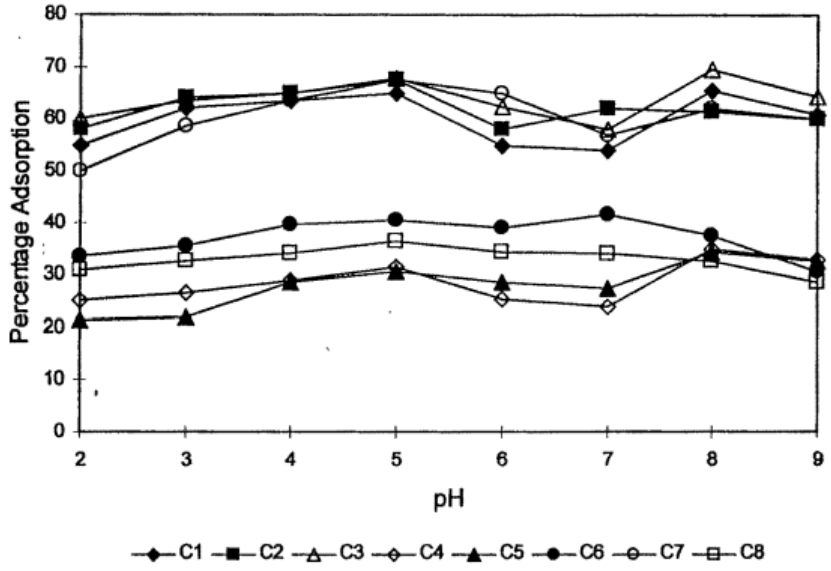


Figure 3 The impact of pH on the phenol adsorption on carbons. At 303 K with a phenol concentration of 100 mg dm^{-3} and a carbon dosage of 0.8 g dm^{-3}, the reaction time was 2 hours.

Since phenol is transformed into the anionic phenolate ion at acidic pH, the adsorptive-adsorbent interaction at pH > 7 can only be explained as the interaction between the carbon surface and the phenolate anions. Uncharged phenol interacts with the carbon surface in the acidic pH range. It is unclear why, in the acidic range, these interactions occur least at pH 2.0.

Results from contacting tune

Time has an effect on the quantity of Phenol absorbed by the activated carbon. For each of the eight carbons, we measured the percentage adsorption as a function of time (1–5 h) at 303 K for six distinct phenol concentrations (50–100 mg dm^{-3}) and a fixed carbon dosage (0.8 g dm^{-3}). To achieve adsorption equilibrium, the solutions were shaken in a mechanical shaker. The filtrates were then examined using spectrophotometry. Afterwards, the initial adsorptive concentrations for each of the eight carbons were plotted against the percentage phenol adsorptions at various contact periods. Figures 4a–4h show the corresponding graphs. The adsorptive solution included 50 mg dm-3 of phenol, and the C3 carbon dosage of 0.8 g dm^{-3} was able to adsorb up to 92% of the phenol during 5 hours of shaking time, but only 71% at 1 hour. As the shaking lime was modified from 1 to 5 hours, the adsorption for C5 carbon rose from 14% to 19%. Almost all of the carbons followed a similar pattern. The rate curve demonstrated that the dye was taken up quite quickly at the beginning, but at a slower rate as equilibrium was approached. These kinds of findings are typical after an initial absorption and subsequent slow diffusion-controlled process involving pore diffusion between and among particles.

Adsorption kinetics

Adsorption parameters were computed using the linear forms of the basic two-parameter isotherms resulting from Freundlich and Langmuir:

i) The Freundlich isotherm in its linear form: graph (x/m) = n log Ce + log K

ii) The Langmuir isotherm in its linear form: Ce/(x/m) = 1/ab + (l/b) Ce—

The phenol adsorption on all eight carbons (C1–C8) at three distinct temperatures (303 K, 308 K, and 313 K) was well-fit by both isotherms.

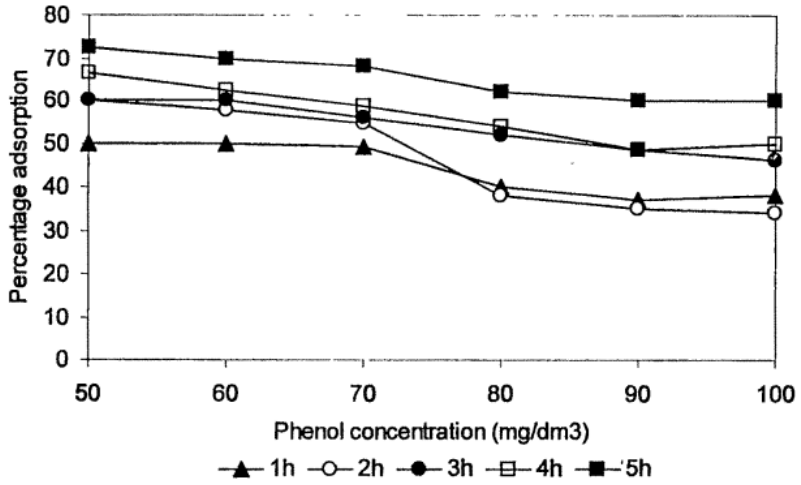


Figure 4a: Percentage phenol adsorption on Cl as a function of contact time [Carbon dose 0.8 g dm^{-3}, pH ~ 6.0, 303 K).

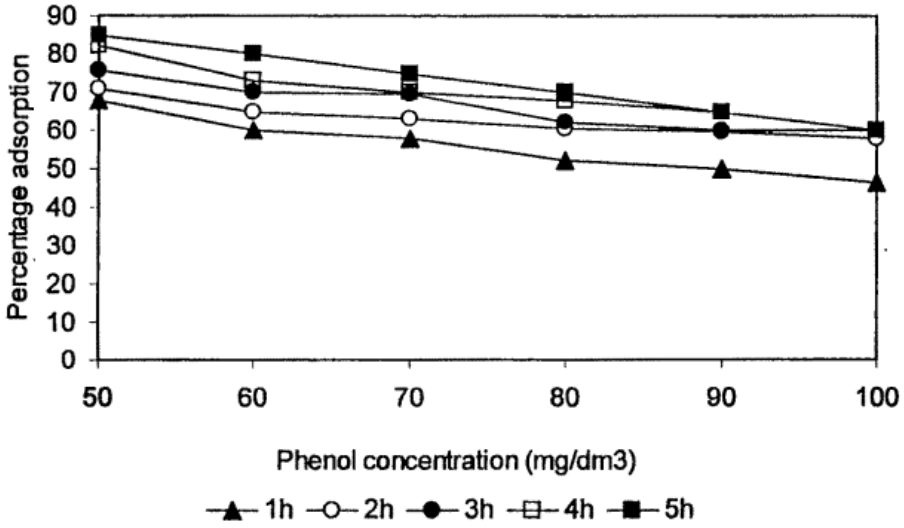


Figure 4b: The effect of contact duration on the proportion of phenol adsorbed on C2 [Carbon dose 0.8 g dm^{-3}, pi I ~ 6.0, 303 K].

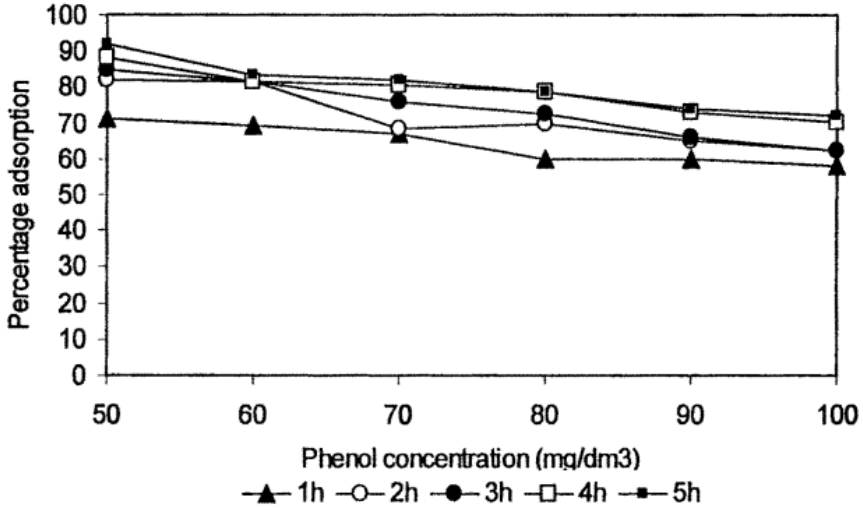


Figure 4c: The effect of contact duration on the proportion of phenol adsorbed on C3 [Carbon dose 0.8 g dm^{-3}, pH ~ 6.0, 303 K].

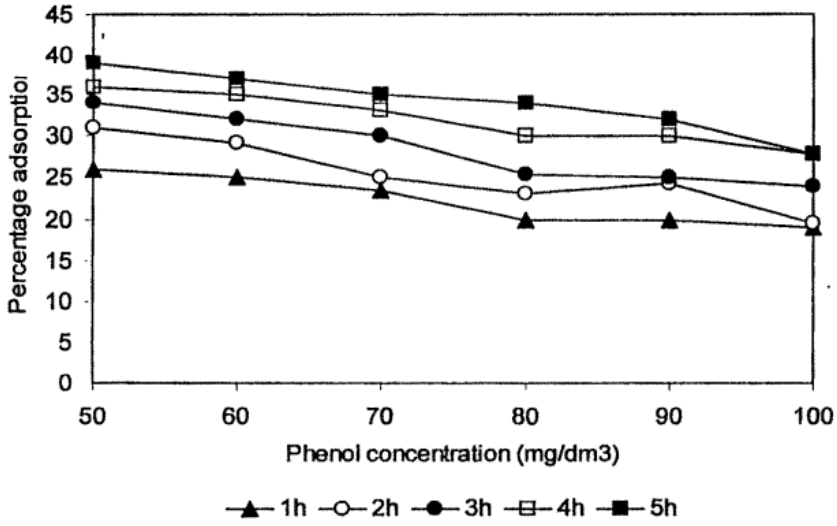


Figure 4d: Effect of contact duration on phenol % adsorption on C4 [Carbon dose 0.8 g dm^{-3}, pH ~ 6.0,303 K].

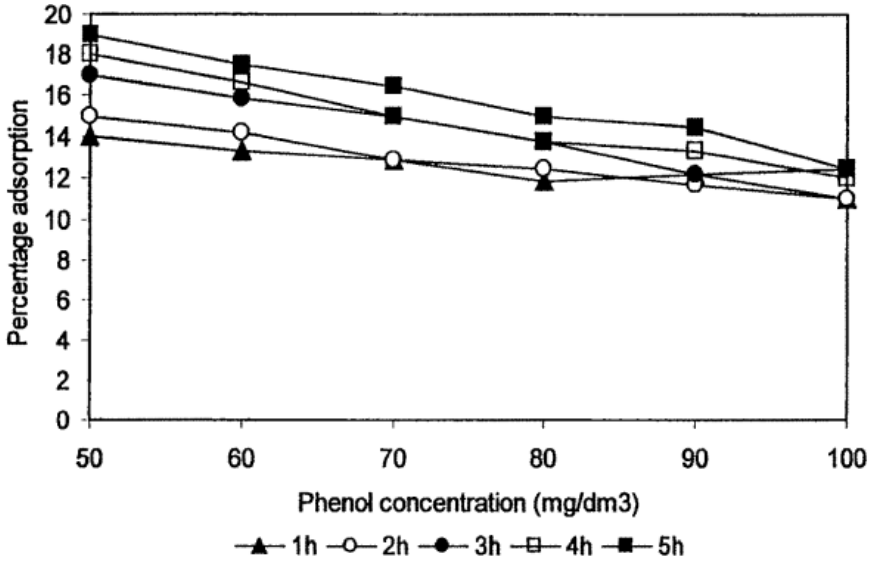


Figure 4e: Effect of contact duration on phenol % adsorption on C5 [Carbon dose 0.8 g dm^{-3}, pH ~ 6.0, 303 K]

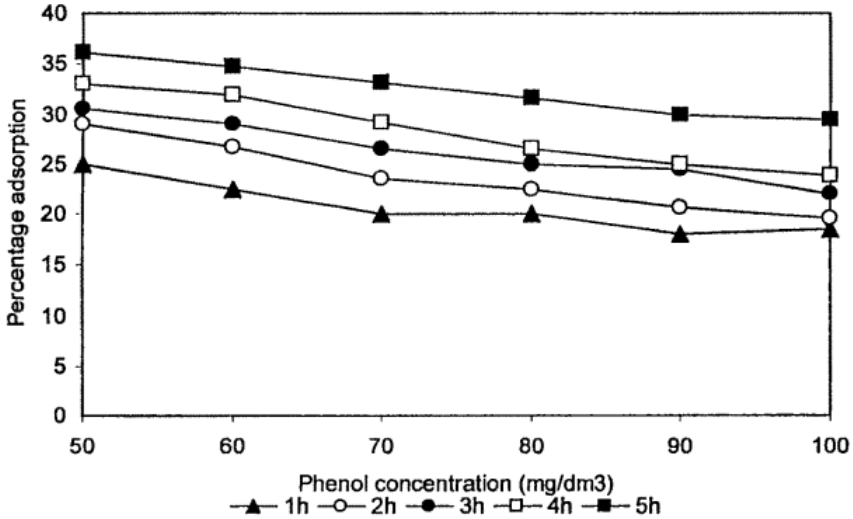


Figure 4f: Effect of contact duration on phenol % adsorption on C6 [Carbon dose 0.8 g dm^{-3}, pH ~ 6,0, 303 K],

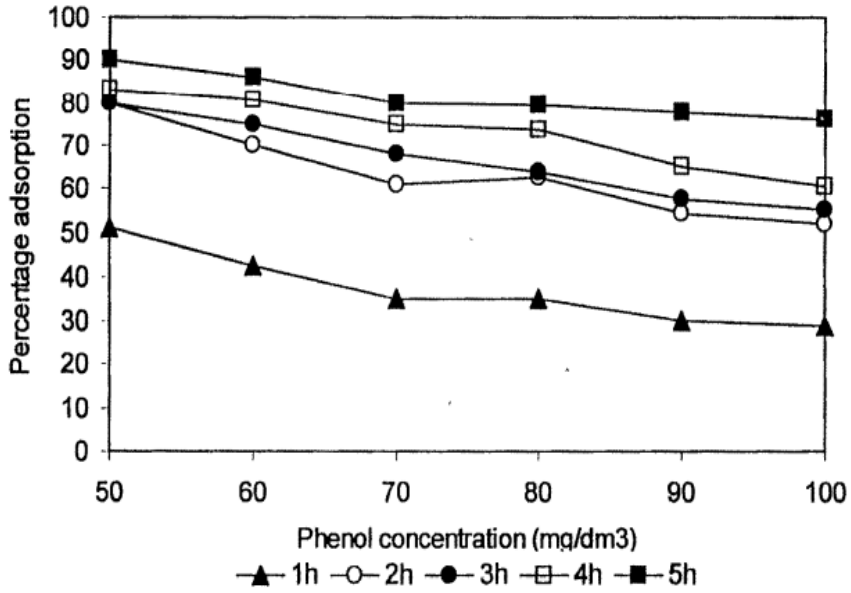


Figure 4g: The effect of contact duration on the proportion of phenol adsorbed on C7 [Carbon dose 0.8 g dm^{-3}, pH ~ 6,0, 303 K],

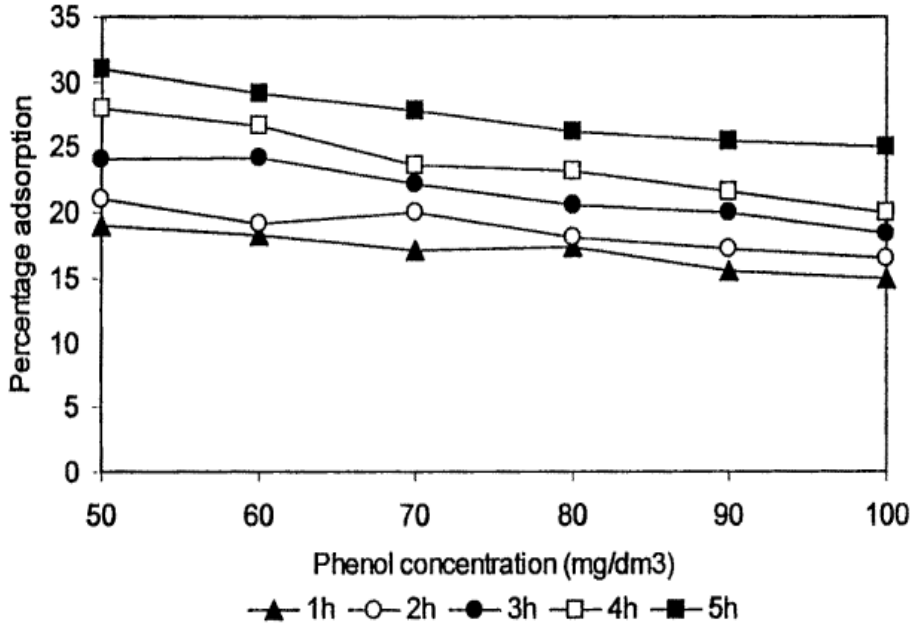


Figure 4h: The effect of contact duration on the proportion of phenol adsorbed on C8 [Carbon dose 0.8 g dm^{-3}, pH ~ 6,0, 303 K],

According to the Freundlich and Langmuir equations, the phenol adsorption process is shown by the straight-line graphs. Table 5 shows the Freundlich and Langmuir parameters calculated from the die plots. The adsorption isotherms show that adsorption is a good thing. In every instance, the values ranging from 0.11 to 0.95 for the adsorption intensity, which is determined by the Freundlich constant, n, are less than 1. At the lowest adsorption temperature (303 K), the carbons may be ranked according to their Freundlich adsorption capacities (K), which vary from 0.75 to 33.13. As a result, the carbons can be organized as follows: C7 > C3 > C2 > C 1 > C4 > C6 > C8 > C5. When looking at the percentage of adsorption as a function of adsorptive concentration and adsorbent dosage, this sequence does not match up perfectly. The values of a and b (monolayer coverage) do not always match the sequence given above when it comes to the Langmuir parameters. The greatest value for the Cl carbon is in 'a,' while the highest value for the B carbon is in 'b'. Even though phenol adsorption is mostly a chemisorptive process, the differences must be attributable to the fact that it is occurring on a surface that is energetically nonuniform.

Table 4 At three different temperatures—303 K, 308 K, and 313 K—shows the Freundlich and Langmuir adsorption coefficients for phenol adsorption on the carbon adsorbents. (Contact time 2 h, carbon dose 0.8 g dm^{-3}, pH ~ 6.0)

Carbon	Temperature K	Freundlich Constants		Langmuir Constants		
		n	K (dm^3g^{-1})	a (dm^3g^{-1})	b (mg g^{-1})	R_L
C1	303	0.21	14.72	7.77	17.64	0.001
	308	0.11	15.84	8.16	17.50	0.001
	313	0.40	11.73	1.62	19.80	0.006
C2	303	0.44	27.22	1.52	46.08	0.007
	308	0.21	26.76	10.06	28.41	0.001
	313	0.24	23.08	3.75	29.33	0.003
C3	303	0.17	30.14	5.83	35.71	0.002
	308	0.14	29.91	16.95	31.06	0.001
	313	0.25	25.17	6.75	25.97	0.001
C4	303	0.95	6.84	0.81	18.90	0.012
	308	0.52	5.96	1.57	10.98	0.006
	313	0.65	4.67	0.36	17.39	0.027
C5	303	0.52	1.35	0.02	24.10	0.400
	308	0.62	1.37	0.01	25.58	0.515
	313	0.68	2.12	0.01	24.94	0.578
C6	303	0.35	5.19	0.03	33.00	0.229
	308	0.63	1.14	0.01	39.06	0.494
	313	0.59	1.04	0.01	31.65	0.497
C7	303	0.17	33.13	0.17	70.92	0.054
	308	0.36	14.33	0.06	78.13	0.145
	313	0.29	18.25	0.08	68.49	0.106
C8	303	0.62	1.37	0.01	43.5	0.478
	308	0.66	0.97	0.01	43.48	0.543
	313	0.71	0.75	0.01	48.54	0.595

For a more accurate description of the Langmuir type of adsorption, see Table 4 for the average values of R_L. A value between 0.0005 and 0.5952 was typical for this dimensionless equilibrium parameter, R_L. The favorable phenol adsorption on the prepared carbons is shown by all die values of R_L being less than 1 and greater than 0. Adsorption coefficients for phenol on activated carbon cloth (ACC), ocresol on bagasse fly ash, and two activated carbons were found to be in the same range, showing similar values K = 0.28 - 0.40 dm^{-3} g^{-1}; 'n' = 0.88 - 0.99; 'a' = 0.006 - 0.036 $dm^{-3}g^{-1}$, 'b' = 69.08 - 313.68 mg g^{-1} and R_L = 0.22 - 0.62. The adsorbent is able to successfully remove phenol from the wastewater stream due to the high binding interactions between phenol molecules and the carbon surface. However, the interaction forces are not strong enough to render the process irreversible.

The phenol adsorption on carbon in this study is not irreversible since R_L is not equal to zero. Therefore, the adsorbed phenol should be easily retrievable from the carbon surface by agitation with water or an alkali.

Temperature and other thermodynamic variables' effects

By doing the batch adsorption tests at three distinct temperatures—303 K, 308 K, and 313 K—the impact of temperature

on the phenol adsorption on carbons was investigated. For a constant adsorbent dosage of 0.8 g dm^{-3}, Table 5 shows the % adsorption as a function of temperature for each of the eight carbon samples (Cl to C8). For all carbon samples (Cl to C8), the findings reveal that the adsorption constantly decreased with temperature. As an example, at 303 K, 0.8 g dm^{-3} of C7 carbon absorbed 80% of the phenol from a 50 mg dm^{-3} solution; however, at 313 K, or a temperature rise of 10 K, the absorption decreased to 65%. Each of the eight carbon adsorbents showed a comparable decline. Based on these findings, it may be concluded that the adsorption process generates heat.

As the temperature increases, the adsorptive's solubility and chemical potential change, with the latter serving as the determinant of the adsorption process. It has been previously documented that when the temperature rises, the solubility of an adsorptive substance increases, the chemical potential lowers, and the adsorption is reduced. However, if temperature has the opposite impact on solubility, then the two effects will operate counter to each other, leading to an increase or reduction in adsorption, correspondingly.

We computed values of the distribution coefficient, K_d, in order to determine thermodynamic parameters and for every one of the eight carbons, a plot was generated showing K_d against 1/T. The usual diagrams for adsorbents with a C4 and C6 surface area. Each adsorbent's ΔH°, ΔS°, and ΔG° thermodynamic parameters were determined by analyzing the linear plots' slopes and intercepts.

Table 5: Phenol adsorption percentage values at 303 K, 308 K, and 313 K for the various carbons. (Contact time 2 h, carbon dose 0.8 g dm^{-3}, pH ~ 6.0)

Adsorbent	Temperature (K)	Percentage adsorbed of phenol at concentration (mg dm^{-3}) of					
		50	60	70	80	90	100
C1	303	53.0	57.5	43.6	38.1	35.0	34.0
	308	60.0	50.8	40.7	40.6	34.4	33.5
	313	42.0	40.8	36.4	32.5	31.1	30.0
C2	303	71.0	65.0	62.9	60.7	59.4	58.0
	308	80.0	74.2	67.9	63.8	58.3	51.5
	313	71.0	62.5	60.0	56.9	52.2	48.5
C3	303	82.0	81.7	68.6	70.0	65.0	62.5
	308	86.0	83.3	78.6	71.3	63.9	58.0
	313	74.0	66.7	67.1	61.9	56.1	50.5
C4	303	31.0	33.3	25.0	23.1	24.4	25.5
	308	23.0	21.7	19.3	18.1	17.8	19.0
	313	19.0	17.5	17.1	16.3	16.1	15.0
C5	303	15.0	14.2	12.9	12.5	11.7	11.0
	308	12.0	11.7	10.7	10.0	10.0	9.5
	313	10.0	9.2	9.3	8.8	8.3	8.0
C6	303	29.0	26.7	23.6	22.5	20.6	19.5
	308	18.0	18.3	16.4	15.6	15.6	14.5
	313	16.0	14.1	12.9	13.1	12.8	12.0
C7	303	80.0	70.0	60.7	62.5	54.4	52.0
	308	64.0	60.0	57.1	54.4	50.0	47.0
	313	65.0	60.0	56.4	52.5	48.9	44.5
C8	303	21.0	19.2	20.0	18.1	17.2	16.5
	308	18.0	17.5	15.7	15.6	15.6	14.5
	313	17.0	16.7	15.7	15.0	15.6	14.0

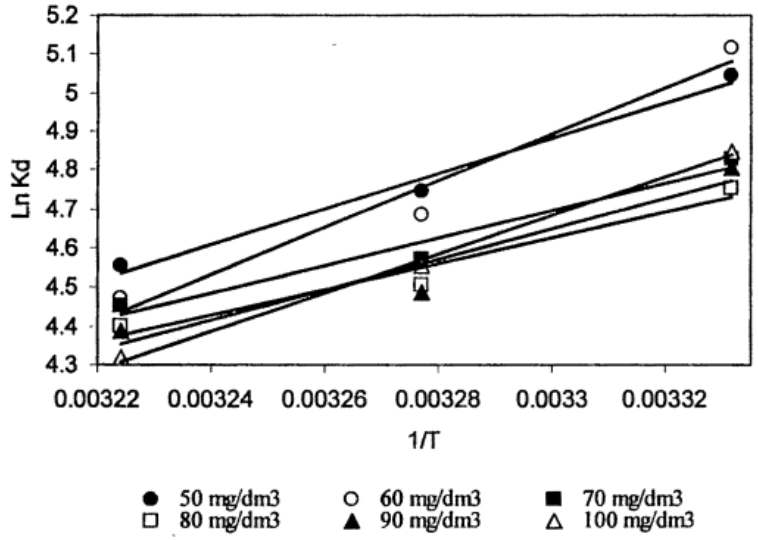


Figure 5a: Plot of In K_d vs I/T in order to adsorb phenols onto carbon (C4)

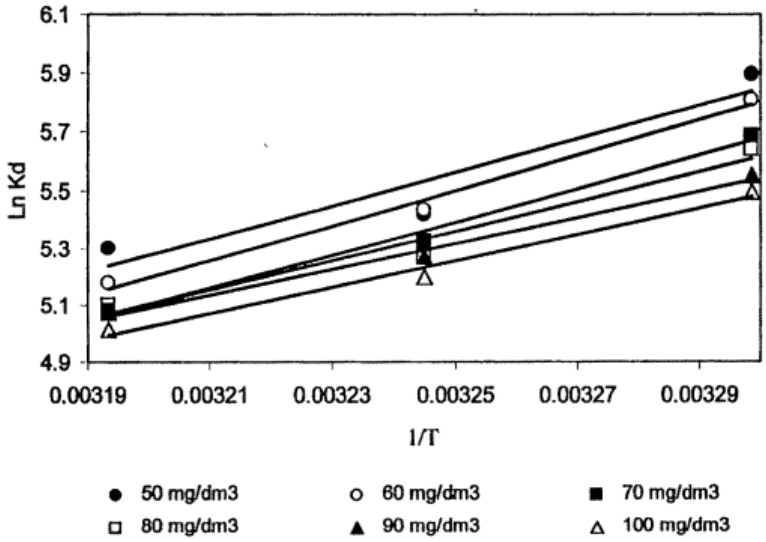


Figure 5b: Plot of in K_d vs I/T to the carbon C6 for the purpose of phenol adsorption

Table 6: Data on the thermodynamics of phenol adsorption on various carbons (Contact time 2 h, carbon dose 0.8 g dm^{-3}, pH ~ 6.0)

Carbon	Phenol ($mg\ dm^{-3}$)	$(-)\Delta H^0$ $kJmol^{-1}$	Mean (-)	ΔS^0 $JK^{-1}mol^{-1}$	Mean	(-) ΔG^0 kJ mol^{-1}			
						303K	308K	313K	Mean
C1	50	17.81	14.9	12.27	13.6	21.52	21.58	21.64	19.0
	60	26.44		40.88		38.82	39.03	39.23	
	70	13.90		1.48		14.34	14.35	14.36	
	80	12.24		3.27		13.23	13.25	13.26	
	90	9.07		12.83		12.96	13.02	13.09	
	100	9.65		10.69		12.89	12.94	12.99	
C2	50	9.57	7.6	18.18	23.0	15.06	15.15	15.24	14.7
	60	3.03		38.55		14.71	14.90	15.09	
	70	3.60		36.25		14.58	14.75	14.94	
	80	5.03		31.19		14.48	14.64	14.79	
	90	10.30		13.60		14.42	14.49	14.56	
	100	14.32		0.00		14.32	14.32	14.32	

C3	50	8.09	8.2	23.69	24.9	15.24	15.36	15.48	15.8
	60	0.85		47.25		15.09	15.33	15.56	
	70	1.53		43.90		14.83	15.05	15.27	
	80	9.78		16.77		14.84	14.93	15.01	
	90	11.64		9.99		14.66	14.71	14.76	
	100	17.01		8.06		19.45	19.49	19.53	
C4	50	37.91	36.3	-84.52	-80.5	12.31	11.89	11.46	11.5
	60	50.01		-124.37		12.35	11.73	11.11	
	70	29.24		-57.47		11.85	11.56	11.28	
	80	27.34		-51.78		11.66	11.40	11.14	
	90	32.30		-67.96		11.71	11.37	11.03	
	100	41.10		-96.68		11.80	11.32	10.84	
C5	50	32.05	28.7	-62.20	-52.4	13.19	12.88	12.57	12.5
	60	34.37		-70.20		13.09	12.73	12.38	
	70	25.71		-42.60		12.79	12.58	12.37	
	80	28.20		-51.14		12.70	12.44	12.19	
	90	26.55		-46.10		12.58	12.35	12.12	
	100	25.14		-41.95		12.42	12.21	12.00	
C6	50	47.14	43.9	-106.98	-97.9	14.71	14.18	13.64	13.8
	60	49.98		-116.71		14.60	14.02	13.45	
	70	47.90		-110.89		14.29	13.73	13.18	
	80	42.64		-94.02		14.14	13.67	13.20	
	90	37.60		-78.00		13.96	13.57	13.18	
	100	38.37		-81.01		13.81	13.41	13.00	
C7	50	16.51	11.5	2.64	17.2	17.31	17.32	17.34	16.8
	60	12.23		15.76		17.01	17.09	17.17	
	70	5.65		35.96		16.55	16.73	16.91	
	80	13.81		9.68		16.74	16.79	16.84	
	90	8.53		26.00		16.41	16.54	16.67	
	100	12.31		13.17		16.31	16.37	16.44	
C8	50	16.73	13.8	8.99	9.9	19.45	19.50	19.54	16.9
	60	11.06		9.02		13.79	13.84	13.88	
	70	19.17		17.60		24.52	24.59	24.68	
	80	15.00		4.50		16.36	16.38	16.40	
	90	8.09		17.83		13.49	13.58	13.67	
	100	13.02		1.24		13.39	13.40	13.40	

4. CONCLUSION

Activated carbon was effectively made from agricultural byproducts, including green coconut shells. Elements and their linkages, including carbon, hydrogen, oxygen, and nitrogen, were detected by FTIR. The crystalline structure of activated carbon is shown by the strong peaks seen in XRD. Activation methods have a substantial impact on activated carbon, and using H_2SO_4 to activate it improves both the pore size distribution and adsorption potential. Dye removal from textile industry waste is a useful application for the generated activated carbon.

An inexpensive and efficient way to remediate polluted water, the carbonized waste materials may be used to prepare carbon-beds, according to the current investigation's findings. The precise process by which micropollutants interact with carbon surfaces is not well understood as no carbon family member is defined by a specific structural formula. The

surface functional groups are thought to have a significant effect in retaining the micropollutants via rather strong connections. Water treatment; air and gas purification; food processing; sweetener decolorizing; solvent vapor recovery; and chemical, pharmaceutical, and mineral processing are the top five most important global markets for activated carbon, in that order. Environmental concerns, especially those pertaining to the cleaning of water and air, are a major motivator for the activated carbon industry. In addition to being the case in the world's more industrialized regions, this trend is expected to gain significant traction in the marketplaces of fast-developing nations during the next five years. With this in mind, we can assess the significance of the current effort.

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