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MODELING AND UNDERSTANDING THE ADSORPTION PROCESS OF CHLOROPHENOL ON ACTIVATED CARBON OF WASTE LEATHERS

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Abstract– In this study, activated carbon synthesized from Waste Leathers was used as a sorbent to put off 4- chlorophenol (4-CP) from aqueous solutions. They have an effect of contact time (30-180 minutes), pH (1-6), adsorbent dosage (50-200 mg/l), and preliminary 4-CP concentration (10-60 mgl^{-1}) in batch experiment used to be investigated on the sorption. The sorbent used to be distinct for the use of scanning electron microscopy (SEM), Fourier Transform Infrared (FTIR) spectrometer and X-ray diffraction, and XRD. Equilibrium for 4-CP sorption used to be reached at contact time of a 180 minutes. The pH of 1 used to be additionally determined to be the top of the line pH in the sorption process. Fitting the experimental statistics to special kinetic and isotherm models illustrated that the experimental facts was properly geared up via pseudo-second order kinetic (R2 > 0.97) and Freundlich isotherm (R2 > 0.98) models. According to the results, activated carbon prepared from Waste Leathers is a lower priced nice choice for the sorption of 4-CP from aqueous solutions.

INTRODUCTION

Water, air and soil pollutions due to industrial activity has been regarded as one of the most necessary issues in the modern-day century, mainly in developing countries (Jourvand *et al.*, 2015). Phenol and phenolic compounds have been listed as precedence pollution in water and wastewater due to the fact of their excessive toxicity and low biodegradability (Nguyen *et al.*, 2015). The important sources of environmental air pollution with 4-chlorophenols are effluent from petrochemical units, coal gasification sites, oil refineries, and pharmaceutical industries. A phenolic compound identified as a precedence pollutant through the United States Environmental Protection Agency (USEPA) due to its toxicity, carcinogenicity, and mutagenicity to residing organisms is 4-chlorophenol (4-CP)(Ahmed *et al.*, 2013; Sze *et al.*, 2012). The most permissible restriction of 4-CP in potable water is 0.5 mgL^{-1} Normally, 4-CP is no longer degraded thru organic cure in aqueous media. Therefore, many methods such as electrochemical oxidation, photocatalytic degradation, ultra-filtration, wet oxidation, solvent extraction, membrane separation and adsorption have been used to cast off 4-CP from aqueous solutions. (Dominguez-Vargas *et al.*, 2009; Sarkar *et al.*, 2006). Among the physicochemical methods, adsorption technique has been broadly utilized as a cure method for natural pollutants. (Nourmoradi *et al.*, 2012; Babaei *et al.*, 2014). This technique is one of the fine therapy choices for the elimination of pollution like 4-CP from water and wastewater, due to the fact it is viable to get better the sorbent and adsorbate. Adsorption onto activated carbon due to its easy utility and excessive sorption potential is the most in many instances used method for the elimination of poisonous natural pollutants. However, sorption through business activated carbon is expensive. Therefore, researches on the manufacturing of activated carbon from cheap, local, agricultural wastes, and industrial wastes specially due to its affordable have received interest

worldwide (de Luna *et al.*, 2013; Dehestaniathar *et al* 2014). In addition to activated carbon, use of some adsorbents such as carbon black8, XAD-4 resin (Bilgili *et al.*, 2006), surfactant- modified herbal zeolite (Kuleyin *et al.*, 2007), immobilized soybean peroxidase (Gomez *et al.*, 2009), chitosan (Li *et al.*, 2009), pumice handled with cationic surfactant (Akbal *et al.*, 2005), Amberlite XAD-16 resin (Abburi *et al.*, 2003) perlite (Koumanova *et al.*, 2002), bentonite and *Azolla filiculoides* biomass has been said for 4- CP elimination from aqueous solutions. Waste Leathers is the spinoff of the industrial enterprise and its authentic material is used in the manufacturing of food wears, containers. In this study, Waste Leathers used as ainexpensive sorbent in the manufacturing of activated carbon for the elimination of 4-CP from artificial wastewater. The impact of parameters such as contact time, pH, adsorbent dosage, and initial concentration used to be investigated on the sorption.

MATERIALS AND METHODS

Preparation of endocrine disruptors

The endocrine disruptors chosen for the adsorption research in the existing work had been 4-Chlorophenol. Stock solution with a concentration of 1000 mg L^{-1} were prepared through dissolving the required quantity of substances, as shown in Table 1. The test solutions prepared by suitable dilution of this solution. The pH of the solutions had been adjusted by using addition of 0.1 M solution of HCl or NaOH

Preparation of adsorbent

Activated carbon of waste leather (ACWL) accumulated from the leather-based industries, pallaavaram area, have been overwhelmed with laboratory-scale crushers, powdered with a disk pulverizer, and sieved to 0-63 mesh (ASTM). The powdered adsorbent used to be washed, dried at 105°C for 10 hr in an oven, and saved in high-density polythene (HDPE) bags. Powdered adsorbent used to be soaked in HCl 0.1 M solution for 24 h, accompanied by means of filtering and washings with distilled water. Afterwards, it was dried in an oven at 105°C for 10 h and saved in HDPE bags.

Determination of Carbon Characteristics

The activated carbon samples have been characterized by the use of FT-IR SHIMADZU spectrophotometer. The surface morphology of the adsorbents has been found with XRD and SEM.

Proximate Analysis of Carbon

Activated carbon samples have been prepared from the waste leathers collected from the leather industries. About 500 g of samples have been amassed in an air tight aluminum container. Samples for proximate analysis, have been pulverized to a mesh dimension <100 μ and dried for 12 hours in a desiccator.For proximate analysis for the dedication of moisture content, volatile matter, ash content material and constant carbon laid down. (Indian Standard IS: 1350 (Part- I)-1984 (Nnaji *et al.*, (2017) was followed.

Ultimate Analysis

The Ultimate evaluation of activated carbon is used for determination of carbon, hydrogen, Sulphur, nitrogen and ash content as observed in gaseous products for entire combustion. The trendy technique is defined in (IS:1350, phase II-2000). (Nnaji *et al.*, 2017). The quantity of warmth generated at some point of the combustion of a unit of weight of a activated carbon pattern is described as calorific value. Activated carbon calorific values and their traits have been decided in accordance to IS: 1350–1974, 1975 in a bomb calorimeter.

Adsorption Experiments

The adsorption studies were carried out at 30 ±1°C and pH of the solutions were adjusted with 0.1M HCl and 0.1M NaOH. A known amount of adsorbent was added to system and allowed sufficient time for adsorption equilibrium. The batch experiments had been carried out in Erlenmeyer glass flasks of 100 mL capacity. To assist mixing of the options with the adsorbents, the combination used to be shaken in a mechanical shaker (Remi make) at appropriate (100-300) rpm for three hours. Then the mixture was filtered and the remaining

Table 1. Preparation of stock solution of endocrine disruptors

Endocrine disruptors	Molecular Formula of endocrine disruptors	Weight (g) of salts per liter
4-Chlorophenol	C_6H_5ClO	1.000

endocrine disruptors concentration was determined in the filtrate using Spectro UV-Vis Double Beam UVD- 3500, Labomed Inco photo meter at suitable ë max. The effect of various parameters on the rate of adsorption process were observed by varying mesh dimension of adsorbent, contact time (t), initial concentration of endocrine disruptors(Co), adsorbent dose, initial pH of solution and temperature. The solution volume (V) was kept constant 50 ml. The endocrine disruptors adsorption (%) at any instant of time was determined by the following equation:

endocrine disruptors adsorption (%) = (Co –Ce) × 100/ Co

Where

Co is the initial concentration and

Ce is the concentration of the endocrine disruptors at equilibrium.

To increase the accuracy of the data, each experiment was repeated three times and average values were used to draw the graphs.

Adsorption isotherms

Adsorption research has been made at distinct initial concentrations, ranging from 10 mg L^{-1} to 60 mg L^{-1}, at most efficient pH, for a contact time of 180 min. at room temperature. From the information obtained, the mechanism of adsorption used to be studied, by the utility of four isotherm equations, particularly these of Langmuir (eq: 1), Freundlich (eq: 2), Redlich-peterson (eq: 3) and Dubinin-Kaganer-Radushkevich (DKR) (eq: 4) have been plotted by way of the use of fashionable straight-line equations and corresponding parameters had been calculated from their respective graphs.

$$Ce/X = 1/K^*KL + Ce/K \quad .. (1)$$

$$KL = b^* q0$$

$$\log qe = \log KF + 1/n \log Ce \quad .. (2)$$

$$qe = KR\ Ce / (1+bRC e\beta) \quad .. (3)$$

$$\log qe = \log Xm - \beta\varepsilon 2/2.303 \quad .. (4)$$

Kinetics of adsorption

The % of adsorption of endocrine disruptors used to be decided at more than a few time intervals, particularly 10, 20, 30, 40, 50 and 60 mins. The

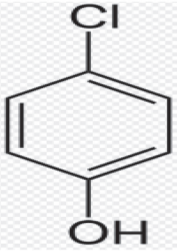


Fig. 1. 4-Chlorophenol

information had been fed into 4 specific kinetic models and the equilibrium adsorption capacities and different beneficial parameters had been calculated,they are Lagergren's pseudo-first order kinetics(eq:5), Pseudo-second order kinetics(eq:6), Elovich kinetics(eq:7), and intra-particle diffusion model(eq:8).

$$\log (qe-qt) = loqe - k1t/2.303 \quad ... (5)$$

$$t/qt = 1/k2.qe2 + t/qe \quad ... (6)$$

$$qt = 1/\beta \ln \alpha\beta + 1/\beta \ln t \quad .. (7)$$

$$qt = kp\ .\ t1/2 \quad .. (8)$$

Thermodynamics of the adsorption

Four vital thermodynamic parameters had been deduced for the adsorption process, specifically the alternate in Gibbs free energy (ΔG^o,eq:9), Enthalpy changes (ΔHo,eq:9), change in Entropy (ΔS^o,eq:10). and the activation energy (Ea,eq:11)

$$\Delta G^o = -RT \ln Kc = \Delta H^o - T\Delta S^o \quad ——————— (9)$$

$$\ln Kc = -\Delta H^o/RT + \Delta S^o/R \quad ——————— (10)$$

$$\log K = \log A - (Ea / 2.303RT) \quad ——————— (11)$$

RESULTS AND DISCUSSION

Proximate Analysis

The effects of proximate evaluation for moisture, volatile matter, fixed carbon, and ash are given in Table 2 and Figures 2(a,b,c).

Fixed Carbon

The fixed carbon content material of activated carbon, aside from moisture and ash, is 91.2%. The constant carbon values rely generally on the C and

Table 2. Proximate analysis of activated carbon

	Moisture%	Ash%	Fixed Carbon%	Volatile matter%
ACWL	1.3	3.2	91.2	4.3

2.(a)

2.(b)

2(c)

Fig. 2. (a,b,c) (Raw waste leather &Activated carbon)

O values in the activated carbon. It is nicely recognised that the FC content material will increase with the improve of the activated carbon rank. (Maharani *et al.*, 2010).

Ultimate Analysis

The consequences of analyzed parameters Carbon, Hydrogen, Nitrogen, Sulphur and Oxygen are tabulated in Table 3. The consequences of every factor are mentioned under in detail.

Table 3. Ultimate analysis of activated carbon samples

	%C	%H	%N	%S	%O
ACWL	86.54	2.98	1.09	0.89	8.5

Carbon

The Carbon content material in the amassed activated carbon samples from the learn about vicinity is 86.54wt.%. The excessive concentrations of C are usually attribute of vitrinite macerals. It is additionally nicely recognised that the C content material in activated carbon will increase step by step with growing activated carbon rank in Table 3. (Mohammadi *et al.*, 2010).

Oxygen

The oxygen content in the samples is 8.5% by way of weight. The decrease O content material is attribute of high-range activated carbon. (Liu *et al.*, 2008).

Methods

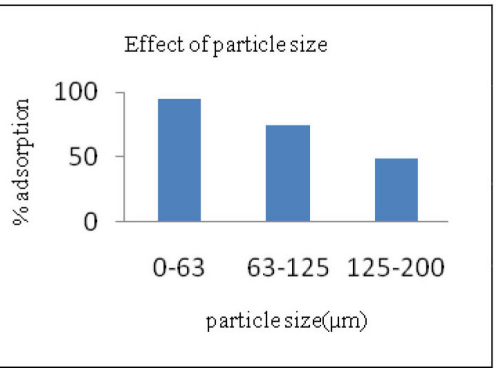
Adsorption of 4- Chlorophenol on ACWL was studied via batch mode, making use of specific variables like adsorbent dosage, pH of the medium, contact time, initial attention of 4- Chlorophenol and temperature. The measurement of adsorbent particles was maintained consistent at under 63µm. Experiments have been carried out so that the impact of any one variable used to be studied, retaining all others constant. This was repeated with all the different variables.

Effect of particle Size

Three extraordinary particles sizes have been used in this lookup work 0-63, 63-125, 125-200 microns. Adsorbent particles with greatest surface areas 0-63 micron have been determined to have adsorbed most 4 - Chlorophenol than these with smaller surface areas 63-125 and 125-200 microns. This capability that the greater the surface area, the greater the adsorption capacity, the decrease the

Table 4 & Figure -4
Effect of particle size on removal of 4-Chlorophenol using *ACWL*
pH : 1.0,Temperature : 30° C

Particle Size, µm	% Adsorption
0-63	94.68
63-125	73.77
125-200	48.78



surface location the decrease the adsorption capacity. Again, the small sized particle used to be discovered to have higher adsorption capacities than the corresponding giant sized activated carbon particle of the equal weight as end result of distinction in porosity of the adsorbents as particles with smallest dimension affords a large surface area (Rehman *et al*., 2013) and the effects are proven in Fig. 4 and Table 4.

Effect of adsorbent dosage

As adsorbent dosage increases 4-Chlorophenol uptake increases as proven in the Table 5 and Figure 5. It used to be evident that the quantity of 4-Chlorophenoluptake is increased from 48.45% with 50mg adsorbent up to 89.03% with 200mg adsorbent. Prior to that, it is obvious that the percentage elimination of 4-Chlorophenolis increased as the adsorbent dosage is increased from 50mg up to 200 mg due to the constrained availability of the wide variety of adsorbing species for a incredibly large range of surface sites on the adsorbent at greater dosage of adsorbent. It is possible that with greater dosage of adsorbent there would be larger availability of exchangeable sites for 4-Chlorophenol. The impact of the mass of the adsorbent in the adsorption of 4- Chlorophenol used to be studied at the best pH:1 and at room temperature 30°C. 50 ml of solution of 4-Chlorophenol with an initial concentration of 10mgL^{-1} was blended with 50.0 mg of the adsorbent and the combination was shaken for a hundred and eighty minutes. After centrifugation, the quantity of 4-Chlorophenol in the supernatant used to be estimated quantitatively (Onundi *et al.*, 2010).

Table 5 and Figure 5
Effect of adsorbent dosage on removal of 4-Chlorophenol using *ACWL*
pH : 1.0, Temperature : 30° C
Time: 3 hours, Initial concentration: 10 mgL^{-1}

Mass(mg)	% Adsorption
50	48.45
100	57.63
150	73.64
200	89.03

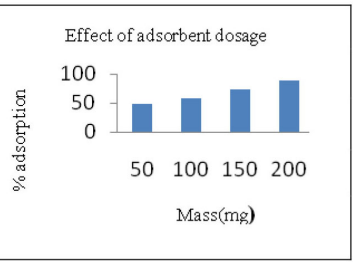
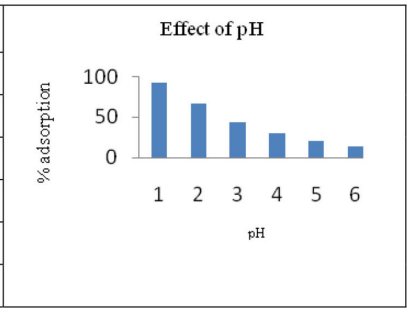


Figure 6 and Table 6
Effect of pH on removal of 4-Chlorophenol using *ACWL*
Adsorbent Dosage: 150 mg, Time : 3 hours
Temperature: 30°C, Initial concentration: 10 mgL^{-1}

pH	% Adsorption
1	91.6
2	66.10
3	43.89
4	30.21
5	20.78
6	14.03



Effect of pH

One of the most vital elements affecting the adsorption of 4-Chlorophenol is the acidity of the solution. Version of pH can promote modifications on the adsorbent and impact the protonation of active sites that are on the surface of the adsorbent. As considered in Table 6 and Fig 6, the easiest values of the adsorption potential for the activated carbon used to be determined at pH:1 which is due to the formation of hydrogen bonds between the adsorbate and the adsorbent, ideally given when the surface of the adsorbent is positively charged (Auta *et al.*, 2011).

Table 7 & Figure 7
Effect of contact time on removal of 4-Chlorophenol using *ACWL*
pH: 1.0, Adsorbent Dosage: 150 mg
Initial concentration: 10 mgL^{-1}

Time (min)	% Adsorption
30	69.03
60	74.31
90	76.52
120	83.87
150	94.95
180	99.01

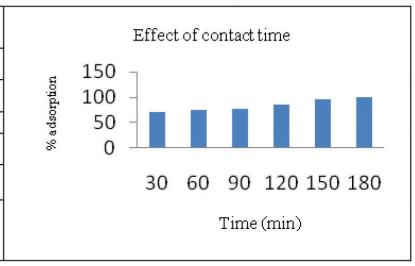
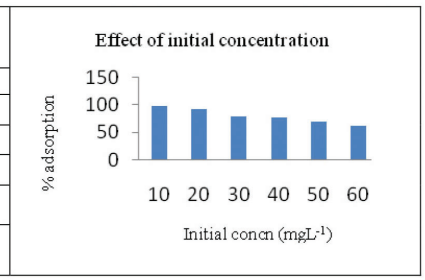


Figure 8 and Table 8
Effect of initial concentration on removal of 4-Chlorophenol using *ACWL*
pH : 1.0, Time : 180 min.
Adsorbent dosage: 150mg, Temp: 30° C ±1

Initial Concn. (mgL^{-1})	% Adsorption
10	97.31
20	90.67
30	77.81
40	75.41
50	68.31
60	60.64



The adsorptions of 4-Chlorophenol on these activated carbons dependence at neutral or alkaline pH. The above-mentioned consequences led to infer that the 4-Chlorophenol is retained on the activated carbon surface to the interactions π- π*, which can show up between the heterocyclic rings of the 4-Chlorophenol and the aromatic rings of the activated carbon; likewise, hydrogen bridges can be created between the 4-Chlorophenol and the sites corporations of the activated carbon. The adsorption of natural pollution on activated carbon, hydrogen bonds, Van der Waals forces and π – π* donor-acceptor interactions play a key position in the adsorption process. Based on the consequences beforehand exposed, it was determined to consider the activated carbon derived from ACWL at pH:1, which implies that the work was once accomplished on the 4-Chlorophenol in its neutral form. (Beltrame *et al.,* 2018). The uptake and proportion elimination of 4- Chlorophenol from the aqueous solution are strongly affected by using the pH of the solution as illustrated in Fig.6. The uptake of 4-Chlorophenol is decreased from 91.6% to 14.03% when the pH is increased from pH 1 to pH 6, Table (6) 4-Chlorophenol sorption is cited to enlarge considerably 91.6 percent adsorption ability at pH:1.

Effect of contact time

Time of adsorption is modified from 30 to 180 minutes, effectivity first expanded from 69.03% to 99.01% afterwards no remarkable change is observed. As time increases the surface coverage of the adsorbent is excessive and in addition no adsorption take place. The impact of contact time on the adsorption of 4-Chlorophenolon ACWL is proven in Table 7 and Figure 7. Adsorption is increased as contact time is increased and is most 99.01 % at 3h. Figure 7 displays that the curve is easy and continuous, 4-Chlorophenol to saturation, suggesting viable monolayer coverage of the 4-Chlorophenol on ACWL. Nearly 69.03% adsorption has taken vicinity inside 30 minutes of contact time with the adsorbent which shows the effectivity of ACWL as adsorbent. More time is required for attainment of equilibrium. (Alvarez-Torrellas *et al.,* 2016).

Effect of initial concentration

At low initial concentrations, the ratio of initialconcentration of 4-Chlorophenol ions to the on hand energetic sites of adsorbent is high; therefore, the elimination effectivity of 4-Chlorophenol is greater and at lower concentrations, in addition residual 4-Chlorophenol ions stay in the aqueous solution. Figure 8 indicates that adsorption capability decreases from 97.31% to 60.64% as the initial concentration is increased from 10 to 60 mgL^{-1}. The vogue is that of the end result of the revolutionary limit in the electrostatic interplay between the 4- Chlorophenol and the absorbent energetic sites. Moreover, this can be defined by means of the truth that much less adsorption sites had been being included as the 4-Chlorophenol concentration increases. Besides, lower initial concentrations 4-Chlorophenol to an amplify in the affinity of the 4-Chlorophenol in the direction of the lively sites. The decline in the adsorption potential is due to the availability of smaller quantity of surface sites on the adsorbent for an extraordinarily large quantity of adsorbate species at higher concentrations. The experimental effects of adsorption of 4-Chlorophenol on ACWL at a range of initial concentrations are proven in Table 8 and Figure 8 (Kavak, 2009).

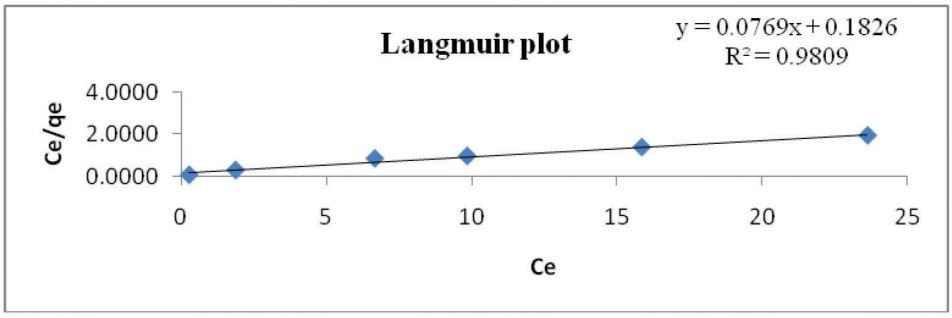
Adsorption isotherm

Isotherm parameters, evaluated from the linear plots of equations illustrated in Table.9 and Figures 9(a,b,c,d). The sorption equilibrium consistent K_L rate for the Langmuir isotherm, ie. $5.47645 mgL^{-1}$ indicated the excessive adsorption potential of adsorbent towards 4-Chlorophenoladsorption. This is in flip supported through the values of the dimensionless separation element (R_L), which are much less than one. The R^2 (correlation coefficient) value 0.981 indicated that the Langmuir isotherm is properly for explaining the Chlorophenol adsorption. The R^2 value calculated for the Freundlich isotherm was discovered to be 0.989, indicating that the experimental information can be defined by means of the Freundlich isotherm. The adsorption potential (K_F) value as calculated from the Freundlich isotherm was 4.83727.

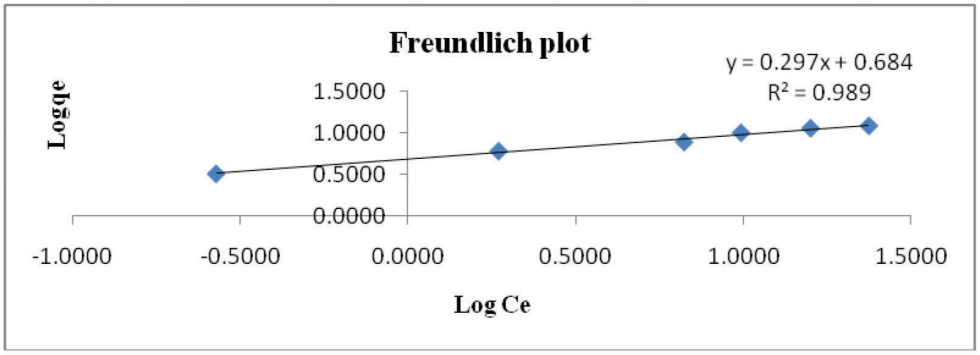
The values of Freundlich steady (n), are a lot increased than one, implying that the adsorption technique is ruled through physisorption only. The R^2 value calculated for the Redlich-peterson isotherm was determined to be 0.913, indicating that the experimental facts can be defined with the aid of the Redlich-peterson isotherm. The β value as calculated from this isotherm used to be 0.1925. The Dubininl–Kaganer–Radushkevich (DKR) mannequin was adopted to describe the single-solute adsorption isotherms. The R^2 value calculated

Table 9. Figures (a,b,c,d)
Isotherm parameters for the adsorption of Chlorophenol on *ACWL* at 30° C
pH: 1.0, Adsorbent dosage: 150mg, Initial concentration: 10 mgL^{-1}

Langmuir parameters	K_L = 5.47645	q_{l0} =12.98701	b_L = 0.421687	R^2 =0.981
Freundlich parameter	K_F = 4.83727	n =1.460707	-	R^2 = 0.989
Dubinin-kaganer-Radushkevich parameters	β = 1.37259	b = 0.656	q_{l0} =4.528976	R^2 = 0.999
Redlich peterson parameters	β= 0.1925	K_R = 5.194805	b_R= 3.896104	R^2 = 0.913



9(a)



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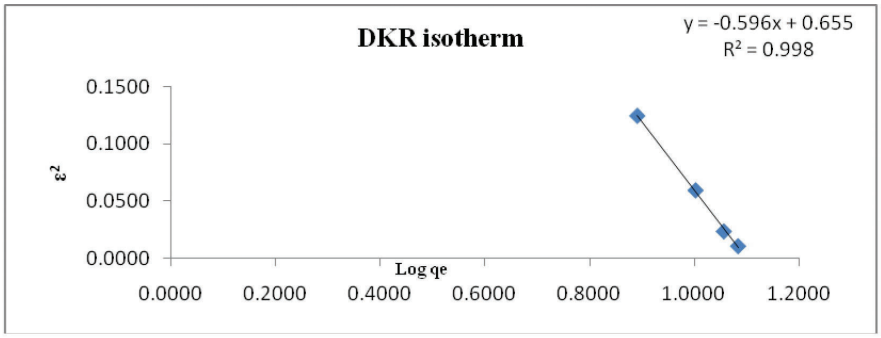

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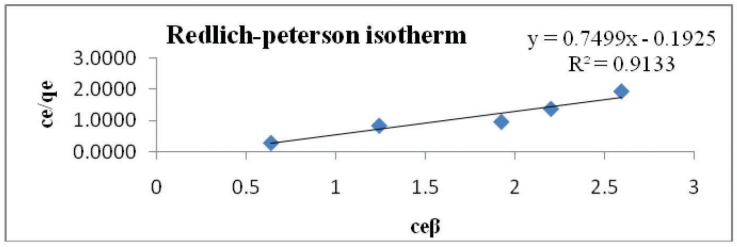


9(d)

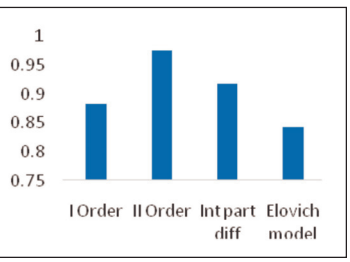
for the DKR isotherm was observed to be 0.999, indicating that the experimental information can be defined by way of the DKR isotherm poorly. The β value as calculated from this isotherm used to be 1.37259. The values of desorption constant, (β) in the Redlich-Peterson and the Dubinin-Kaganer-Radushkevich isotherms is a measure of the desorption constant. Its values are much less than 1, indicating beneficial adsorption. The sorption electricity å in the DKR isotherm is a precious parameter to distinguish between physisorption and chemisorption. Lower values advocate physisorption is more.(Chong, M. F., 2009 et al).

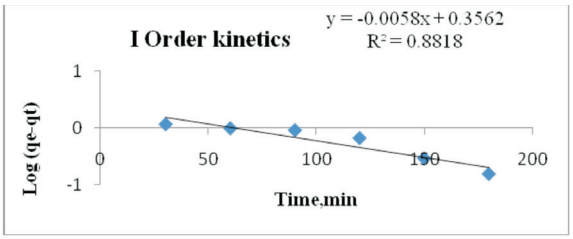
Kinetics

Adsorption kinetics research supply a grasp of adsorption value and controlling mechanism of the process. In order to elucidate the adsorption kinetics of 4-Chlorophenol ion by means of prepared adsorbent, the pseudo-first-order and the pseudo-second-order kinetics models had been employed to take a look at the experimental data. Nonlinear varieties of the pseudo-first-order and the pseudo second-order kinetic mannequin are represented by way of equations 5 and 6. Nonlinear mannequin of pseudo-first-order and pseudo-second-order kinetics mannequin for 4-Chlorophenol adsorption onto prepared adsorbent have been proven in table.10 and Figures.10.(a.b.c.d.e) respectively. By evaluating the R^2 and adsorption ability values anticipated in table.10 andFigures.(a.b.c.d.e) the pseudo first-order kinetic mannequin is now not terrific for modelling the 4-Chlorophenol adsorption onto prepared adsorbent. It is apparent from the outcomes that the pseudo-second-order kinetic mannequin (R2 >0.9) has been supplied a higher correlation of experimental data. This kinetic mannequin suggests that adsorption manner is

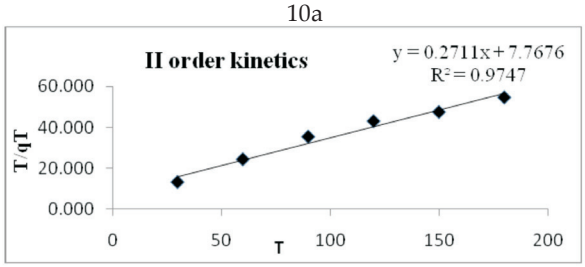
Table 10, Figures 10(a,b,c,d,e)
Kinetic parameters for the adsorption of 4-Chlorophenol on *ACWL* at 30°C
pH: 1.0, Adsorbent dosage: 150mg
Initial concentration: 10 mgL^{-1}

I Order	0.882
II Order	0.975
Int Part diff	0.918
Elovich model	0.843

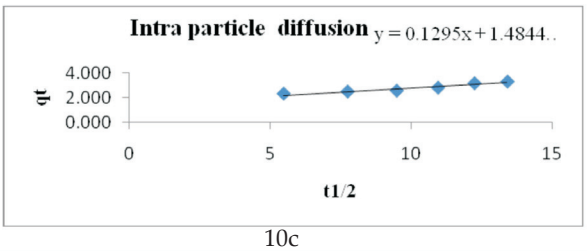




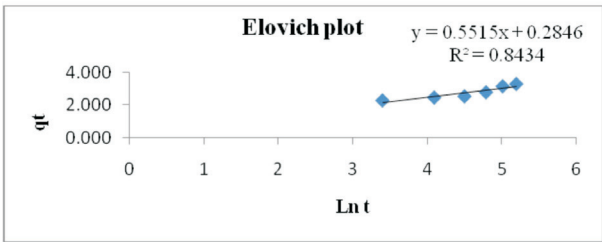
10a



10b



10c



10d

managed by means of the physisorption mechanism (Shikuku *et al.*, 2015).

Thermodynamic Parameters

Tables 11 (a,b) suggests the thermodynamics parameters for the adsorption of 4-Chlorophenol onto ACWL adsorbent when the temperature was 30,40,50 and 60°C, %G° was negative, so the adsorption procedure was spontaneous and feasible. Moreover, all % G° values had been much less than 20 kJ/mol, which may also point out that the adsorption of 4-Chlorophenol onto activated carbon happened thru physical adsorption. Additionally, the enthalpy value (%H°) was positive, suggesting that the adsorption manner used to be endothermic, and the effects are in accordance with the vogue in which the adsorption potential improved with improved temperature. In this study, the absolute rate of enthalpy is in the vary

of the adsorption enthalpy associated to hydrogen-bonding interactions (2-40kJ/mol). This typically due to the fact the chlorine atoms of 4-Chlorophenol act as hydrogen-bond acceptors and shape hydrogen bonds with the hydrogen atoms of activated carbon.

Activation energies for adsorption of 4-Chlorophenol on adsorbent is calculated by use of the Arrhenius equation (eq 11), plotted in Figs. 11 (a,b) and tabulated in Tables 11(a,b). The activation energy received in this case, point out that physical forces are concerned in the sorption mechanism and sorption feasibility (Zhou and Gupta).

Effect of temperature

The % of 4-Chlorophenol adsorption is studied as a

Table 11(a,b). Figure 11
Thermodynamic parameters for the adsorption of 4-Chlorophenol on *ACWL*
pH: 1.0, Adsorbent dosage: 150mg
Initial concentration: 10 mgL^{-1}

ΔG0	ΔH0	ΔS0	Log 10 Ka	1/T
-3494.82	19.14714	57.44143	0.602201	0.003299
-4568.94			0.762144	0.003193
-5092.14			0.823134	0.003095
-6482.3			1.016397	0.003002

Table 11(b). Figure (b)
Arrhenius plot for the adsorption of Chlorophenol using *ACWL*

Arrhenius parameters	Value
Ea	25.15552
Log A	4.9355
R^2	0.963

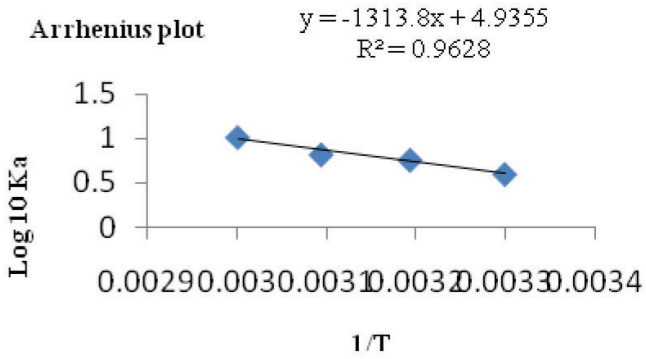
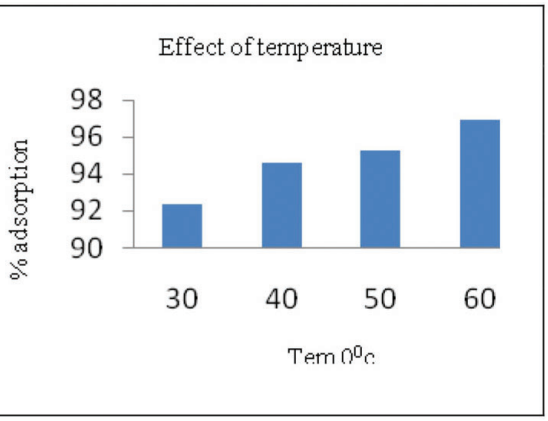


Table 12, Figure-12
Effect of temperatureon the adsorption of 4-Chlorophenol on *ACWL*
pH: 1.0, Adsorbent dosage: 150mg
Initial concentration: 10 mgL^{-1}

Tem (0^0c)	% Adsorption
30	92.31
40	94.55
50	95.23
60	96.89



characteristic of temperature in the vary of 30-60°C. It was located that adsorption yield extend with enlarge in temperature. The minimal adsorption was 92.31% at 30°C and most adsorption was 96.89 percent at 60°C for 10mgL^{-1}initial concentraion of 4-Chlorophenol solution. The impact of temperature on the adsorption of 4-Chlorophenol on ACWL is proven in figure.12 and table.12. This is natural due to the fact make bigger in temperature offers the imperative power for the endothermic procedure of adsorption, 4-Chlorophenol to an extend in the charge of the process. The factor to be preferred is that even at room temperature ample (more than 92.31%) adsorption has taken place. This in flip confirms the effectivity of the adsorbent in the removal of 4-Chlorophenol.(Dotto, G.L.,2012).

FT-IR Study

FT-IR (JASCO FTIR-3500) spectra of the activated carbon samples earlier than and after adsorptions are proven in the figures.13a&b respectively.The spectra supply the evidences for the presence of surface businesses on the adsorbent's surface. Notable variations amongst them are the top intensities. The carbons have marked variations in the intensities of almost all the absorption bands, reflecting that the density of corresponding practical agencies vary a lot. After adsorption some peaks is vanished due to desorption in to adsorbate and few peaks are barely shifted to greater or decrease wave numbers due to electrostatic forces. There are no new peaks after adsorption established absence of formation of new compounds shown. As can be inferred from the figures, the adsorption frequencies are nearly the identical and it is presumed that the practical businesses have been no longer affected due to adsorption, which solely endorses that solely physisorption has taken place. After adsorption some peaks is vanished due to desorption in to adsorbate and few peaks are barely shifted to greater or decrease wave numbers due to electrostatic forces. As can be inferred from the figures, the adsorption frequencies are nearly the equal and it is presumed that the useful preparations have been now not affected due to adsorption, which solely endorses that solely physisorption has taken place.(Chen, B., 2011 et al., Vardon, D. R., 2013.,et al).

Figure 13(a). 13(b) FT-IR spectrum of ACWL of4-Chlorophenol

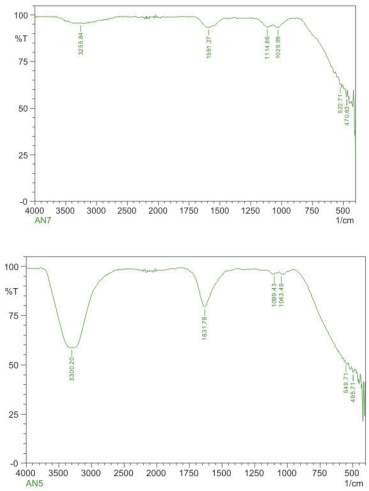
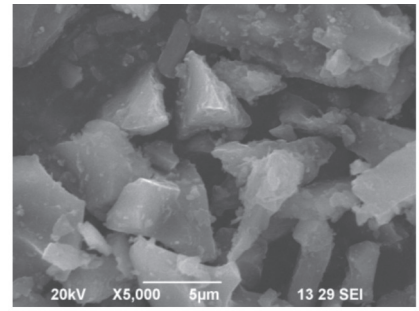


Fig. 13(a). Before adsorption of 4-Chlorophenol

SEM analysis

The SEM micrograph of ACWL derived activated carbon introduced in figures.14 a and b suggests the heterogeneous surface and excessive porosity. The located pores in these carbonaceous substances are commonly giant macropores, which are used for adsorbates to omit into microporous system. The surface morphology of ACWL was once examined the usage of Scanning Electron Microscopy (SEM), before and after adsorption and the corresponding SEM micrographs had been got at an accelerating

Figure 14(a). 14(b) SEM micrograph of *ACWL 4*-Chlorophenol



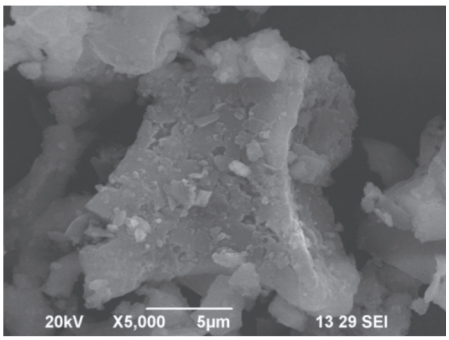


Fig. 14(a). Before adsorption of 4-Chlorophenol

voltage of 15 kV (Hitachi SE 900) at 5000 magnification and are introduced in Figures. 14a and 14b. At such magnification, the ACWL particles confirmed hard areas of surface inside which micropores had been definitely identifiable. This adsorbate factor are not uniformly disbursed onto the surface of activated carbon and they are existing due to the fact most of the minerals in adsorbent are not misplaced in the course of the pyrolysis method and continue to be on activated carbon structure (Suliman *et al.*, 2016).

XRD Study

The X-ray Diffraction Studies have been carried out the use of Rigaku Corporation, Japan X-ray Diffractometer 40KV / 30mA, Model D/Max ULTIMA III. The diffraction patterns of the adsorbent ACWL, before and after adsorption of 4-Chlorophenol, are suggests in determine 15(a) and 15(b). It is evident from the figures that there is no considerable exchange in the spectra of adsorbent before and after adsorption. This may additionally be due to the truth that adsorption does not alter the chemical nature of the surface of the adsorbent. The adsorption is ruled through vulnerable Van der Waals forces and is physically in nature (Liu *et al.*, 2010).

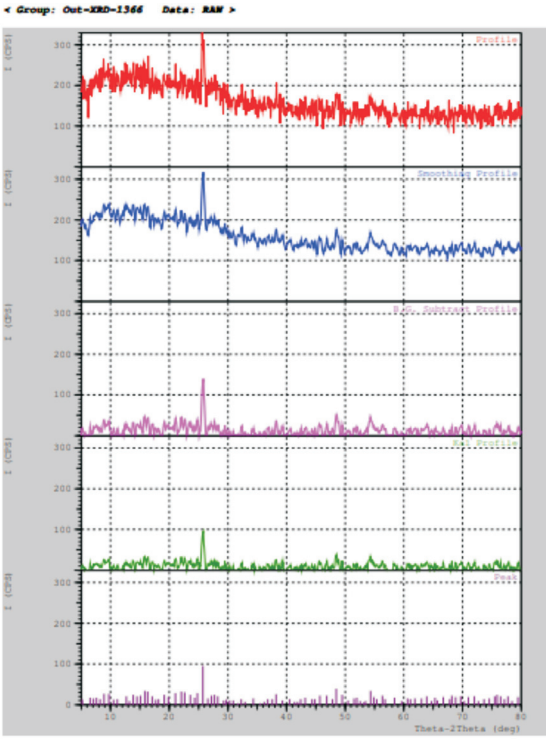


Fig. 15(a). 15(b). XRD pattern of *ACWL 4*-Chlorophenol

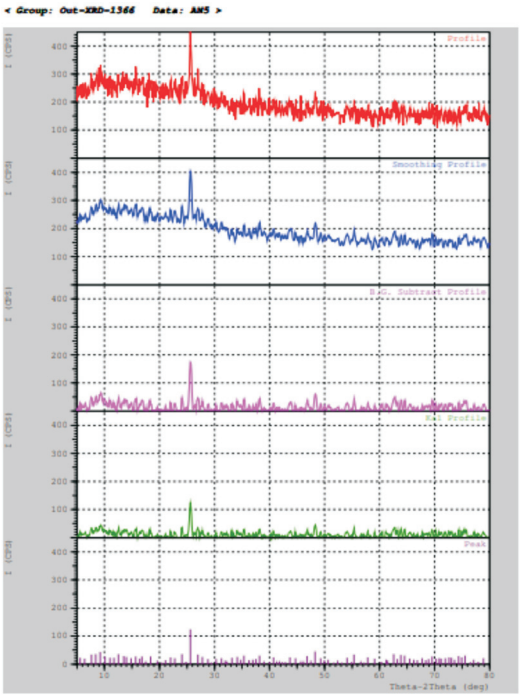


Fig. 15(a). Before adsorption of 4-Chlorophenol

CONCLUSION

In this batch study, Waste Leather's activated carbon was used as an adsorbent for the uptake of 4-CP from aqueous solutions. The most desirable contact time for the elimination of 4- CP through carbon was thirty minutes. Moreover, the most desirable pH received used to be 1. The Freundlich isotherm mannequin and pseudo-second order kinetic mannequin described the records higher than different isotherm and kinetic modelsrespectively. It can be concluded from this learn about that non bio degradable Waste Leather's activated carbon (ACWL) can be employed as a inexpensive adsorbent for the elimination of 4-CP from aqueous solution.

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