

Adsorption of phenol from aqueous solutions onto an adsorbent prepared from dry palms of *Phoenix dactylifera*.L (Ghars variety) cultivate in the south east of Algeria

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ABSTRACT

The removal of phenol from aqueous solutions by adsorption has received considerable attention in recent years due to its toxicity which may cause damage to various systems of the human body. In order to preserve the environment and the valorization of agricultural waste, the palms of *Phoenix dactylifera*.L have been used to remove several contaminants including phenolic compounds. The main object of this study is the use of an adsorbent prepared from dry palms of Ghar variety of Algerian origin to remove phenol from aqueous solutions. Contact time and initial phenol concentration are parameters that influence the adsorption process developed. The Langmuir model and the Freundlich model were chosen for the representation of the experimental results.

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Introduction

Phenol and its derivatives are used in a number of applications such as chemical, pharmaceutical, petroleum, paper, wood, rubber, dye and pesticide industries [1-2]. Phenols are classified as priority pollutants due to their toxicity to organisms even at low concentrations. Their adverse environmental and public health impacts have been proved by increasing evidences, such as death of aquatic life, inhibition of the normal activities of microbial community and carcinogenicity to animals [3-4]. In view of the high toxicity, wide prevalence and poor biodegradability of phenols, it is necessary to remove them from wastewaters before discharge into water bodies.

Various processes have been employed for the removal of phenols from aqueous solution including advanced oxidation, membrane filtration, biological degradation, electrochemical oxidation, photocatalytic degradation and adsorption [5-7]. Among these methods, adsorption is still the most versatile and widely used, since it can effectively remove many types of pollutants and the design and operation are convenient [8-10].

The aim of present research was to evaluate the feasibility of using an adsorbent prepared from dry palms stones of *Phoenix dactylifera*.L (Ghars variety) cultivated in Ouargla region situated in the south east of Algeria for the removal of phenol from aqueous solution. The influence of experimental

conditions such contact time and initial phenol concentration were studied.

Materials and methods

Materials

The pH measurements were made using a pH meter (Hanna 4221). The phenol concentrations in the sample were determined using UV spectrophotometer (Spectro Scan 80).

Preparation and characterization of adsorbent

In this study, we chose as adsorbent, the dry palms of the Ghars variety, widely grown in the region of Ouargla. These products are degradable materials, of porous structure and require only low costs for the preparation of adsorbent. The dry palms were thoroughly washed with hot distilled water and then dried at 105 °C for 24 hours. The dry palms are crushed and sieved to retain only the fraction between 0.5 and 2 mm. Final products are kept away from the air. The Table 1 displays the characteristics of adsorbent [11].

Table 1. Characteristics of adsorbent

Physical properties	Dry palms adsorbent
Porosity (%)	28.30
Apparent density (g/cm ³)	0.15

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Adsorption experiments

The stock phenol solution was prepared by dissolving phenol in bi-distilled water at 100 mg/l. Working solutions were prepared by diluting different volumes of stock solution to achieve the desired concentration.

In the batch studies, 0.1 g of the adsorbent was placed in a flask containing 20 ml of a phenol solution with the desired concentration. The flask was continuously shaken (50 rpm) at 30°C and pH (5.33). At the end of each step, the supernatant liquids were filtered and the phenol concentrations were determined using a UV spectrophotometer. The contact time was determined as the time required for the concentration of the phenol in the solution to reach equilibrium (2 h) [11]. The amount of phenol adsorbed by the solid (q) and the percent of phenol removal were calculated using the following equations:

$$q = (C_0 - C_e) \frac{V}{m}$$

$$\text{phenol removal (\%)} = \frac{(C_0 - C_e)}{C_0} 100$$

Where C_0 is the initial concentration of phenol (mg/l), C_e is the concentration of phenol at equilibrium adsorption (mg/l), V is the volum of solution (l) and m is the mass of adsorbent (g).

The effect of the initial concentration of metal (40–100 mg/l) was also examined in order to determine its influence on the adsorption rate and also to obtain the adsorption isotherm. The shaking speed (50 rpm), the amount of adsorbent (0.1g), the contact time (2 h), the pH (5.33) and the temperature (30°C) were kept constant [11].

Results and discussions

Effect of contact time

The effect of the contact time on the adsorption phenol by dry palms adsorbent is shown in Fig. 1. These data have been obtained from starting adsorbent and working solution without any pH adjustment (pH = 5.33). The results showed that increasing the contact time increased the phenol adsorption and then leveled up after 2h.

The adsorption of phenol reaches 10.384 mg/g after 24 hours, which corresponds to a percentage of 51.92 %. Most of this pollutant is adsorbed during the first 2 hours of the process. It is therefore conceivable that it is a physisorption.

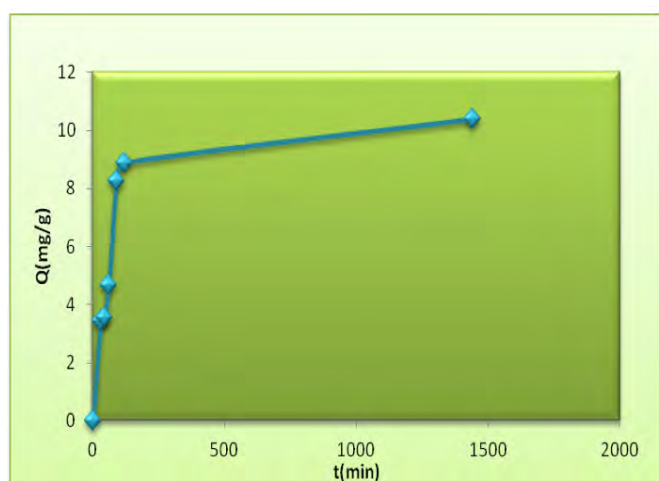


Fig. 1. Effect of the contact time on the removal of phenol.

Effect of initial concentration of phenol

Dependency of the process of phenol removal from different initial concentrations (40–100 mg/l) by the prepared adsorbent is illustrated in Fig.2.

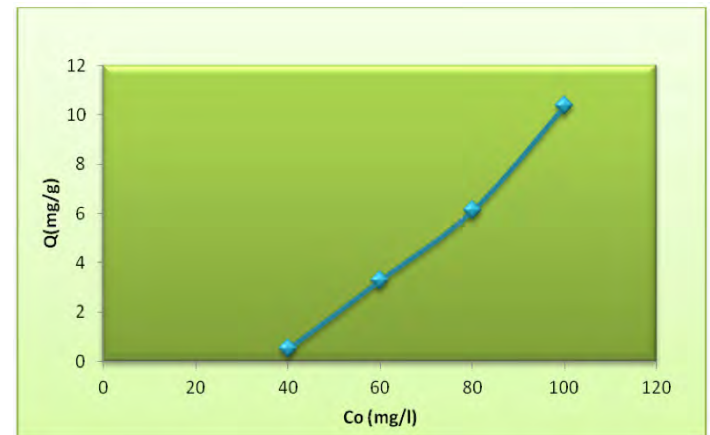


Fig. 2. Effect of the initial concentration on the adsorption of phenol.

The concentration has a considerable influence on the adsorption rate, which varies from 0.508 mg/g to 10.384 mg/g. The percentage of adsorption increases also from 6.35% to 51.92%. This result is encouraging because it proves both the affinity and the marked capacity of dry palms adsorbed this pollutant.

Adsorption isotherm

The equilibrium adsorption isotherms are of fundamental importance in the study and design of adsorption systems. According to the slope of the initial portion of the curves, they are classified into various groups. In this work, the isotherm curve (Fig. 3) corresponds to S-type in Gile's classification.

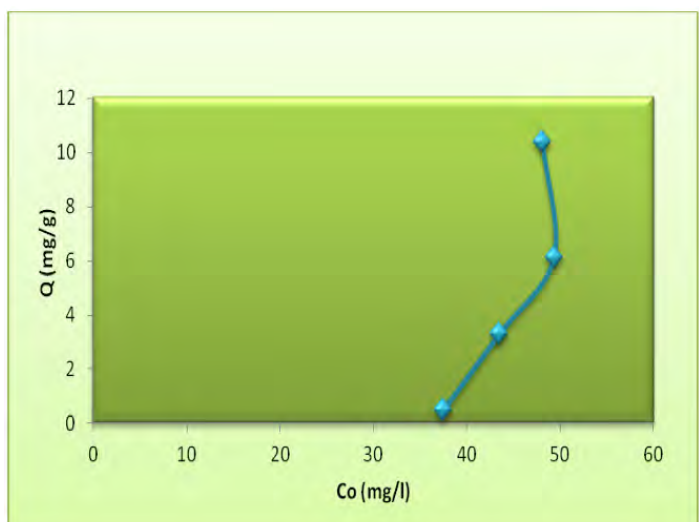


Fig. 3. Adsorption isotherm of phenol onto dry palms adsorbent.

Several methods have been published in the literature to describe experimental data of adsorption isotherms. The Langmuir and Freundlich models are the most frequently employed models. In this work, both models were used to describe the relationship between the amount of phenol adsorbed and its equilibrium concentration in solution at 30 °C, pH = 5.33, for initial concentrations (40–100 mg/l) during 2h.

Table 2. Constants of Freundlich and Langmuir in the adsorption of phenol onto dry palms adsorbent.

Langmuir model			Freundlich model		
q_0 (mg/g)	b (l/mg)	R^2	K (mg ¹⁻ⁿ l ⁿ g ⁻¹)	n	R^2
-0.1787	-0.02	0.8432	$7.43 \cdot 10^{-17}$	10.104	0.9271

The linear form of the Langmuir isotherm model can be represented by the using equation below:

$$\frac{C_e}{q} = \frac{1}{q_0} C_e + \frac{1}{q_0 b}$$

Where q is the amount of solute adsorbed per unit weight of adsorbent (mg/g), C_e is the equilibrium of concentration of solute in the bulk solution (mg/l), q_0 is the monolayer adsorption capacity (mg/g) and b is the constant related to the free energy of adsorption. The constants of Langmuir isotherm given in the Table 2 are obtained by plotting C_e/q_e versus C_e .

The linear form of the Freundlich isotherm model is given by the following equation:

$$\log q = \frac{1}{n} \log C_e + \log K$$

Where K is the constant indicative of the relative adsorption capacity of the adsorbent (mg/g) and n is the constant indicative of the intensity of the adsorption. The constants of Freundlich isotherm given also in the Table 2 are obtained by plotting $\log q$ versus $\log C_e$.

The correlation coefficients show that the Freundlich model is adapted for the representation of the experimental results of the adsorption of phenol onto dry palms adsorbent.

Conclusion

At the end of this research, it can be concluded that it is possible to produce an effective adsorbent from the dry palms of the date palm of the Ghars variety cultivated in the region of Ouargla.

This adsorbent can be used to remove phenol from aqueous solutions. Measurement of adsorption has shown a real potential for removing these contaminants. The results also showed that the contact time and the initial concentration of this pollutant could also affect the adsorption capacity of the adsorbent. Experimental data on phenol adsorption followed the Freundlich model.

The results of this study can be useful for environmental engineers in the design and implementation of a continuous wastewater treatment plant.

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Conflicts of interest

Authors declare no conflict of interests.

Notes

The authors declare no competing financial interest.

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