Removal of phenol from Industrial Effluents using Activated Carbon and Iraqi Porcelanite Rocks – A Comparative Study

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ABSTRACT

The current study aims to remove organic pollutants (phenol) from industrial effluent using batch adsorption on activated carbon and Iraqi porcelanite rocks, and also to compare the removal efficiency of phenol for both adsorbents. Batch mode adsorption experiments were performed by varying different fractional size of adsorbent. The obtained results indicated that the adsorption of phenol increases with decreasing particle size of adsorbent. It seems that activated carbon with 45 µm particle size is more effective in removal of phenol than Iraqi porcelanite rocks powder of the same particle size. The results also proved that the activated carbon has the ability to remove organic pollutant (phenol) more efficient than Iraqi porcalenite rocks. In addition, the adsorption data fit vary well with freundlich model of adsorption isotherm.

Key words: Activated carbons,Iraqi porcelanite rocks, Phenol, Adsorption ,Adsorption Isotherm.

INTRODUCTION

Phenol and substituted phenols are one of the important categories of aquatic pollutants, which are considered as toxic, hazardous and priority pollutants [1]. The wastewaters discharged from pesticide, paint, solvent, pharmaceuticals, and paper and pulp industries and also from water disinfecting process will contribute to main source of phenol(2). Phenol, as a class of organic compounds, has been known as a common and hazardous contaminant in water environment [3]. Also these compounds form complexes with metal ions discharged from other industries, which are carcinogenic in nature. It is water soluble and highly mobile [4]. Even small amount of phenol may cause severe diseases like cancer, nausea, vomiting, paralysis, smoky colored urine, etc… [5].

The maximum permitted concentration level of phenol being 0.5-1 mg/l for industrial wastewater and 1µg/liter for drinking water. So it highly essential to save the water resources and aquatic life by removing these compounds from wastewater before disposal (4). Several methods, such as microbial degradation, adsorption, chemical oxidation, solvent extraction and reverse osmosis are being used for removing phenols from wastewater [6]. Among the methods used to phenols removal, adsorption is one of the simplest and widely applied methods [7].

Adsorption, as a simple and relatively economical method, is a widely used technique in the removal of pollutants. Although the adsorbents used may vary due to the change in adsorption conditions depending on the type of pollutants, the properties affecting the efficiency of an adsorbent are; a large surface area, the homogeneous pore size, well defined structural properties, selective adsorption ability, easy regeneration, and multiple use [8, 9].

In this study activated carbon and Iraqi porcalanite rocks powder as adsorbents have been used for removal of phenol from industrial effluent. Activated carbons, the most important commercial adsorbents, are materials with large specific surface areas, high porosity, adequate pore size distributions and high mechanical strength. On the other hand the Iraqi porcelanite rocks represent one of the most and great adsorbents, because it is containing high percentage of silicon reached to 50% [6, 10].

In this research, comparison between activated carbon and Iraqi porcalanite rocks for removal of phenol will be done.

MATERIALS AND METHODS

Preparation of Activated Carbon

The type of activated carbon was used in research is Granular activated carbon (GAC). Grinding (GAC) by FRITSCH planetary mono mill and then sieved sample to different size fractions (45, 75, and 212 µm), for laboratory tests.

Preparation of Iraqi Porcelanite Rocks

The sample rocks were crushing by a mechanical crusher (Retsch type BB1/A) into small pieces ,and then washed with excessive amounts of deionized water to remove of suspended materials .Then were dried in an oven for 12 hours at 150 ^{o}C. Then grinding sample by FRITSCH planetary mono mill, and then sieved to different size fractions (45, 75, and 212 µm), for laboratory tests.

Characterization of Activated Carbon and Iraqi porcelanite rocks

- Characterization by SEM type Tescan Vega 3 (Czech).
- Characterization by X-ray diffraction type Shimadzu 6000.
- Characterization by FT-IR type Shimadzu by using KBr to analysis the sample.
- Measurement of surface area and porosity.

The BET surface area of activated carbon and Iraqi porcelainte rocks powder were determined by nitrogen adsorption. In this work, adsorption of nitrogen at 77.3 K was used to determine parameters like surface area and pore volume.

Preparation of Solutions

A standard stock solutions of phenol (100 ppm) prepared by dissolving (0.1gm) of phenol crystal (ROMIL Ltd. /England) in (1liter) from deionized water (DDW). Several concentrations (0.07, 0.1, 1, 5, 10, 15, and 20 ppm) were prepared from standard stock solution.

Adsorption Experiments

In the batch adsorption experiment, a predetermined amount (0.15gm) of each adsorbent (Activated Carbon and porcalanite rocks) is mixed with100 ml of known concentration of phenol solution (adsorbate) in dark stoppard bottles (100 ml) in capacity, and stirred for constant contact time (120 minute) by oscillating shaker the speed of the shaker was selected to be (150 rpm.) in a constant room temperature and subsequently is separated by filter paper. Batch adsorption experiments were performed by varying different size fractions of adsorbents, to evaluate the equilibrium characteristics for the adsorption of phenol compounds on adsorbent. The stander and residual phenol concentrations were analyzed using HPLC (High Performance Liquid Chromatography type Shimadzu LC-2010AHT Japan).

Adsorption isotherms were obtained by plotting the amount of organic adsorbed per mg/gm versus the corresponding equilibrium concentration. The amount of phenol adsorbed by the adsorbent was calculated from the equation [11].

$$Qe = V (Co– Ce) / m……… 1$$

Where V: is the volume of solution (ml), m is the mass of the adsorbent (gm), C_O is the initial concentration (mg/L) and C_e is the concentration at equilibrium (mg/L).

Analysis of phenol

The phenol concentrations were determined by high-performance liquid chromatography (HPLC) type (Shimadzu LC-2010A HT, Japan).

The column packing ODS-C_{18} (octadecylsaline) 5µm and made out of stainless. The dimension of column was (25cm x 4.6 mm). Mobile phase was prepared from acetonitrile and deionized water (30:70). The column was washed with acetonitrile and deionized water before every analysis.

RESULTS AND DISCUSSIONS

Characterizations of the surface morphology of the adsorbents were studied using different tools:

The XRD spectrum of Iraqi porcelanite rocks (Fig. 1) indicates existence of certain amount of Quarts and Opal -CT ; which are known as irregular interferents between two phases, krestoplyte and traidamayte-alpha; and also some other (kaolin and samktite) which can be found together with fine size silica .

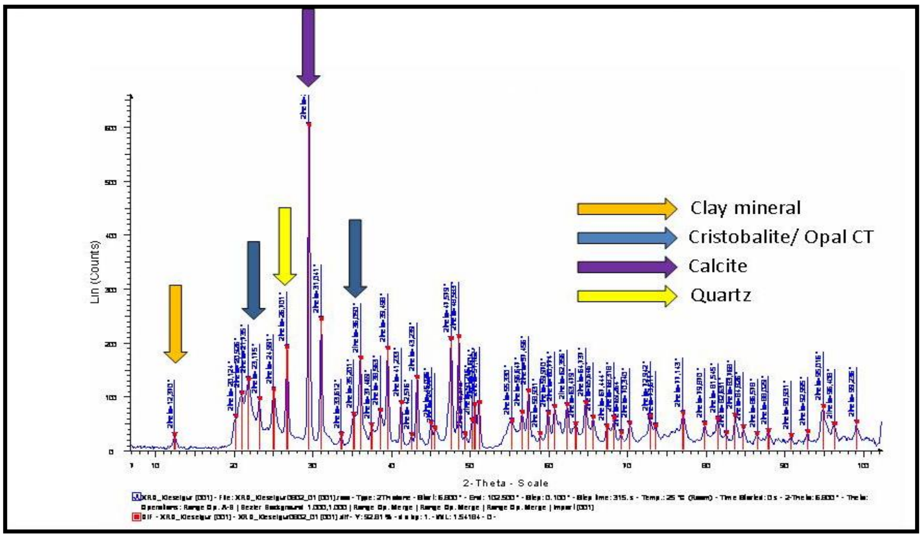
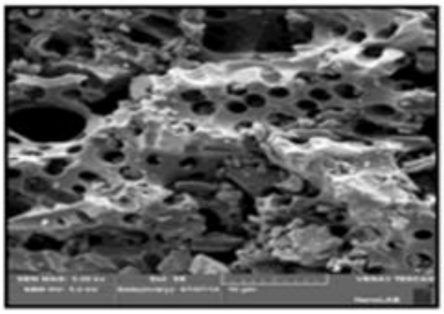
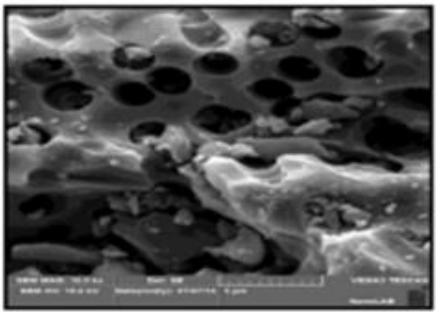


Fig. (1) XRD Spectrum of Iraqi Natural Porcelanite

The SEM of (Fig. 2) indicates the external surface of the activated carbon is well-developed porous structure. The external surface shows a rough area having different pore diameters distributed over the surface of activated carbon, and (Fig3) indicates the mineral composition of the iraqi porcelanite rocks composed from krestoplyte, kaolinite and carbonates.



a) SEM image of surface Activated Carbon in 5.00 KX magnifications.



b) SEM image of surface Activated Carbon in 10.0KX magnifications.

Fig. (2) SEM image of Surface Activated Carbon

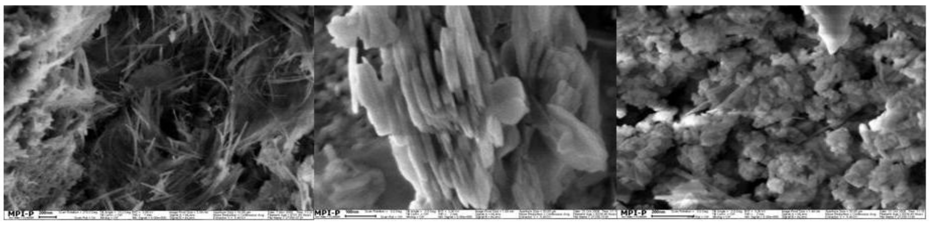


Fig. (3) SEM images of iraqi porcelanite rocks

The surface area and porosity table (1) shows the BET surface area, pore volume and pore diameter values of activated carbon and iraqi porcelanite rocks, and this also indicate the surface area of activated carbon higher than the surface area of Iraqi porcelanite rocks.

Table (1) BET Surface Area, Pore Volume and Pore Diameter Values of the Samples.

Sl. No	Sample	BET Surface area (m^2/g)	Pore Volume (cm^3/g)	Pore Diameter (nm)
1	Iraqi porcelanite Rocks	22.275	0.071	5.572
2	Activated carbon	734.534	0.025	3.116

The FT-IR was used to indicate the active groups or site of the adsorbents material.

A- The results of FT-IR spectra of activated carbon (Fig.4) showed the existence of C-H groups at 2980.00 cm^{-1},2884.56 cm^{-1}, C=C at 1571.01

cm^{-1}, C-O at 1139.28 cm^{-1} ,C-C at 670.39 and 654.49 cm^{-1}. This might have influence on the adsorption process.

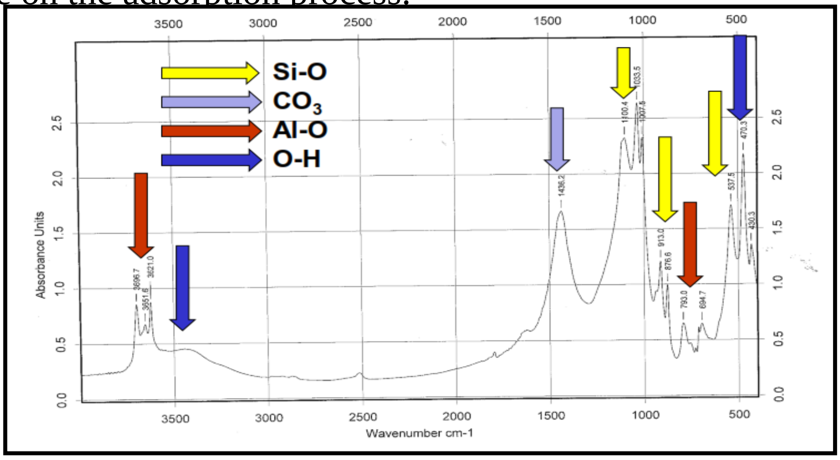


Fig. (4) FTIR Spectrum of Activated Carbon

B- The results spectra of Iraqi porcelanite rocks (Fig.5) shows existence of Si-O groups at 1100.4cm^{-1},913.0cm^{-1},537.5 cm^{-1} and CO_3 at 1436.2cm^{-1} C and O-H at 3420.8 cm^{-1} and 470.3 cm^{-1}, this might have influence on the adsorption process.

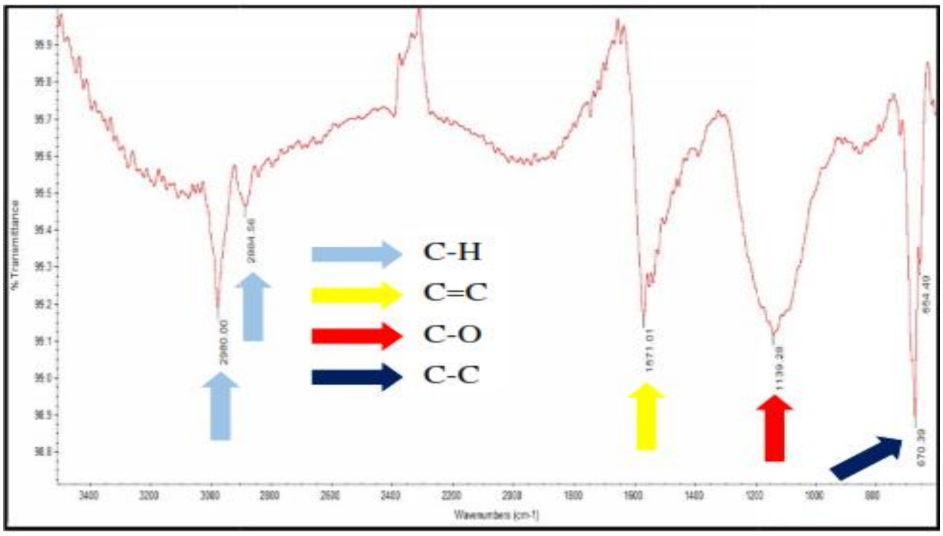


Fig. (5) FT.IR of of Iraqi natural Porcelanite Rocks

Effect of Particle Size on adsorption process

The effect of particle size on adsorption process of two adsorbent materiel (activated carbon and iraqi porcelanite rocks as a powders) have been studied by using different particle sizes (45µm, 75 µm and 212 µm) at the same weight of the adsorbent**s.** Fig. (6) Shows the effect of particle size of the adsorbents on phenol adsorption, at room temperature. The results showed that the removal percentage of phenol increased with decre … te that fine … an the coars … orbent caus … active sites … moval perce…

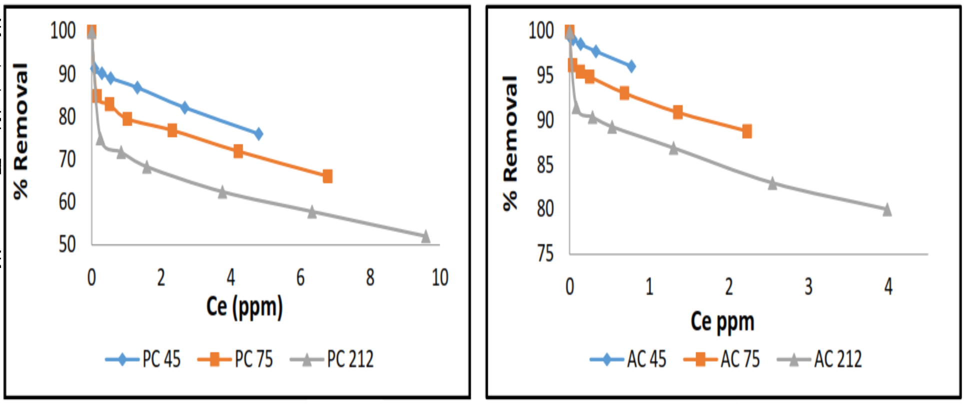


Fig. (6) Effect of particle Size for the adsorption of phenol on the surface (A) Iraqi porcelanite rocks, (B) activated carbon.

Fig. (7) Shows the comparison between two adsorbent depending on particle size 45 µm. It seems that activated carbon with 45 µm particle size is more effective in removal of phenol than iraqi porcelanite rocks of the same particle size. This result may be related to large surface area of AC than Iraqi porcelanite rocks as shown in table (1). High surface area of adsorbent lead to create more active site on the surface of activated carbon. This will increase the capacity of phenol adsorption.

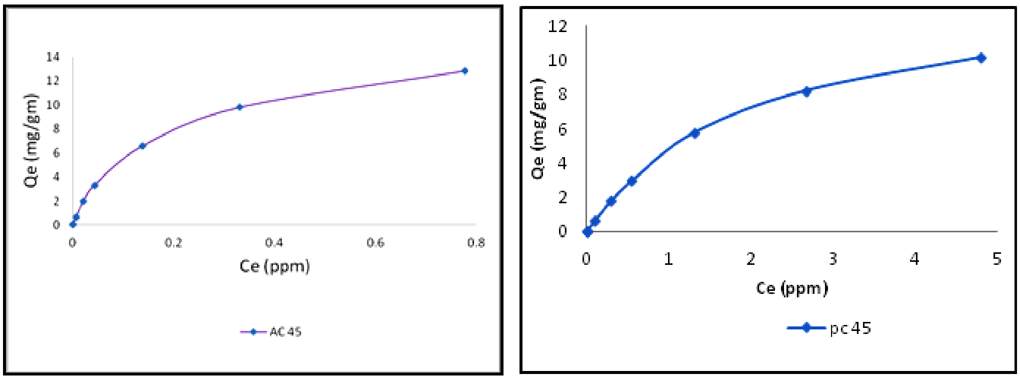
(A) (B)

Fig. (7) Comparison between two adsorbent depending on particle size 45 µm. Adsorption Isotherm

The general shape of the adsorption isotherms, for phenol on activated carbon and Iraqi porcelanite rocks which are fitted with freundlich model from plotting the amount of the adsorbate Qe versus concentration equilibrium (C_e), as shown in (Fig. 8). The amount of phenol adsorbed by the adsorbent was calculated from the equation.

$$Q_e = V\,(C_o - C_e) / m$$

Where Q_e = quantity of adsorbent (mg), V = volume of solution (ml), C_e= initial concentration (mg/l), C_o = concentration at equilibrium (mg/l) and m is the mass of the adsorbent (gm).



(A) **(B)**

Fig. (8) The adsorption isotherm of phenol onto the surface (A) activated carbon, (B) iraqi Porcelanite rocks.

Fig.9 shows a plot of log Q_e against log Ce in order to obtain freundlich constant. The plot gives a straight line. The slope of isotherms model as constants were found to be = 0.5851 for the adsorption of phenol

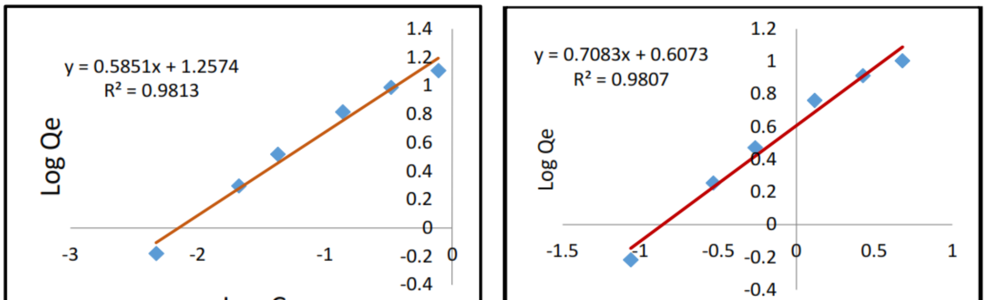


Fig. (9) The constant of the freundlich equation onto surface (A) activated carbon, (B) iraqi porecalenite rocks.

CONCLUSIONS

In this study**,** the adsorption of phenol onto activated carbon and iraqi porcelanie rocks as a powder were investigated. The result indicated that the percentage removal of phenol was considerably affected by particale size of adsorbents. The results showed that the percentage of removal increased with decreasing particle size of the adsorbent and seems to be according to the order:

$$45\ \mu m > 75\ \mu m > 212\ \mu m$$

It seems that activated carbon with 45 µm particle size is more effective in removal of phenol than iraqi porcelanite rocks of the same particle size. The experimental data showed that the applicability of the freundlich model onto adsorption process by using activated carbon and Iraqi poreclanite rocks. It can be concluded that the activated carbon has the ability to remove organic pollutant (phenol) more efficient than iraqi porcalenite with different concentrations, also using the batch method in the adsorption process (removal) proved high efficiency in the removal of phenol from aqueous solutions.

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أزالة الفينول من مياة الصرف الصناعي باستخدام الكربون المنشط وصخور البورسلينات العراقية – دراسة مقارنة

الخلاصة

تهدف الدراسة الحالية لإزالة الملوثات العضوية (الفينول) من مياه الصرف الصناعي باستخدام(Batch Adsorption) على الكربون المنشط وصخور البورسلينات العراقية وكذلك مقارنة كفاءة ازالة الفينول لكلا المادتين . أجريت تجارب (Batch Adsorption) من خلال تغيير حجم الجسيمات للمادة المازة. وأشارت النتائج التي تم الحصول عليها بأن امتزاز الفينول يزداد مع نقصان حجم الجسيمات من المادة المازة. كما تبين بأن الكربون المنشط مع حجم جسيمات 45 ميكرون هو أكثر فعالية في إزالة الفينول من مسحوق صخور البورسلينات العراقية من نفس حجم الجسيمات.كما وأثبتت النتائج أيضا بأن الكربون المنشط لديه القدرة على إزالة الملوثات العضوية (الفينول) بأكثر كفاءة من صخور البورسلينات العراقية. اضافة الى أن بيانات الامتزاز تتطابق تماما مع نموذج فروندليتش ايزوثيرم .