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An Investigation of a Petrochemical Wastewater Treatment utilizing GAC: A Study of Adsorption Kinetics

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Abstract

The goal of the present research was to reduce the COD of the typical petrochemical wastewater via adsorption technique using a commercial granular activated carbon (GAC) as adsorbent. The parameters of kinetic models as well as; adsorption isotherms were determined through utilizing the Langmuir and Freundlich isotherms. The key parameters of k_L = 0.0009 L/mg and q_m = 33.33 mg/g for the former and n_f=0.5 L/mg and k_f = 4e-6 mg/g for the latter isotherms were resulted. Moreover, pseudo-first and -second order kinetics equations were implemented. These resulted in coefficients of k_1=0.006min^{-1} and q_e=2025mg/g as well as; k_2=0.011mg/mg.min and q_e=286mg/g; respectively for 5cm bed length. In addition, obtaining the correlation coefficients of 0.94 and 0.61 for these 1st and 2nd order kinetics; respectively indicated advantageous use of the former kinetic model. Ultimately; the current investigation paved down the road for predicting the system's behaviour on industrial scale.

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Keywords: Petrochemical wastewater, Adsorption, Granular Activated Carbon, Equilibrium Isotherm, Kinetic Model

1. Introduction

Adsorption as a high performance technique for removal of contaminants from wastewaters has been proposed by researchers [1-6]. Adsorption is a mass transfer operation in which material is transferred from

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liquid to solid phase and some physical as well as; chemical interactions occurring on their interface. Adsorption process depends upon physical properties, large superficial area, micro-porous structure, high adsorption capacity and adsorbent surface reactivity. In recent years adsorbents like GAC and Powdered Activated Carbon (PAC) have been more widely utilized for investigating organic and inorganic contaminants removal from the wastewaters [7-10]. Generally, a comparison of previous researches indicated using activated carbon, whether powdered or granular, as an effective mean for removal of non-biodegradable waste materials from wastewater [3]-[5].

2. Experiments

To investigate adsorption trends and factors affecting it, tests were performed in two stages on the petrochemical wastewater effluents with the Phenol initial concentration of 28000 ppm using commercial granular activated carbon adsorbent. The apparatus used was a 3cm diameter adsorption column with a reciprocating pump entering the wastewater effluent samples into the column from the top under desired flow rates. Experiments were done for the bed's adsorbent packing lengths of 5 and 8cm. Characteristics of the GAC adsorbent in these experiments were shown in Table 1.

Table 1. Physical characteristics of the GAC adsorbent used in this research

Parameters	Amount
Density (kg/m^3)	350-550
Mean Particle Diameter (mm)	1.5-7.5
Specific Surface Area (m^2/g)	>900
Porosity (cm^3/g)	0.88

3. Kinetic Equations

Through previous researches, various kinetic models proposed for adsorption [1-6] amongst which the pseudo-first order Lagergren as well as*;* pseudo-second order kinetic models chosen to be utilized due to their applicability in the present research (see equations 1 and 2, below):

Pseudo-first order Lagergren relationship presented as follows:

$$\ln (q_e\text{-}q) = \ln q_e - k_1 t \qquad (1)$$

In which, the q_e (mg/g) was the amount of adsorbed COD at equilibrium, q (mg/g) the amount of adsorbed pollutant at time t and k_1 the adsorption rate constant (min^{-1}). It is reminded that, the k_1 and q_e were obtained from a linear plot of $ln\ (q_e\text{-}q)$ vs. time.

On the other hand, the pseudo-second order equation provided below:

$$t/q = (k_2\ q_e^2)^{-1} + t/q_e \qquad (2)$$

In which, k_2 (mg/mg.min) was the pseudo-second order adsorption rate constant while the q_e (mg/g) the amount of adsorbed COD at equilibrium. It is reiterated that, these values were obtained from the linear plot of t/q vs. time.

The outcomes of these models were presented in figures 1-4. Moreover; the obtained kinetic parameters from these models at a 28000ppm phenol initial concentration were provided in Table-2.