



Sorption of phenol from synthetic aqueous solution by activated saw dust: Optimizing parameters with response surface methodology



Omprakash Sahu^{a,*}, Dubasi Govardhana Rao^a, Nigus Gabbiye^a, Addis Engidayehu^a,
Firomsa Teshale^b

^a School of Chemical and Food Technology, Bahir Dar Institute of Technology, BDU, Ethiopia

^b School of Chemical and Bio-Engineering, Addis Ababa Institute of Technology, Addis Ababa, Ethiopia

ARTICLE INFO

Keywords:

Adsorption
Bio-waste material
Phenol
Saw dust
Wastewater treatment

ABSTRACT

Organic pollutants have an adverse effect on the neighboring environment. Industrial activities are the major sources of different organic pollutants. These primary pollutants react with surrounding and forms secondary pollutant, which persists for a long time. The present investigation has been carried out on the surface of activated sawdust for phenol eliminations. The process parameters initial concentration, contact time, adsorbent dose and pH were optimized by the response surface methodology (RSM). The numerical optimization of sawdust (SD), initial concentration 10 mg/l, contact time 1.5 h, adsorbent dose 4 g and pH 2, the optimum response result was 78.3% adsorption. Analysis of variance (ANOVA) was used to judge the adequacy of the central composite design and quadratic model found to be suitable. The coefficient of determination values was found to be maximum Adj R² 0.7223, and Pre R² 0.5739 and significant regression at 95% confidence level values.

1. Introduction

Phenol is an essential industrial solvent for different production concern. In cooperation with its position under 595 hazardous wastes among 1678 listed on Environmental Protection Agency National Priorities List [1]. Phenol is available in air, water, and soil by industrial activities and natural deterioration of organic wastes. Phenol degraded rapidly in air and soil by hydroxyl radical reaction (estimated half-life 14.6 h), and persist in water for a somewhat longer period [2]. If degradation is sufficiently slow, phenol in sunlight water will undergo photooxidation with photochemically produced peroxy radicals, and leach to groundwater [3]. The most common anthropogenic sources of phenol in water include coal tar [4], waste water from processing industries such as resins [5], plastics [6], fibers [7], adhesives [8], iron and steel [9], leather [10], paper pulp mills [11] and wood treatment facilities [12]. The addition of this there is two natural sources of phenol in aquatic media are animal wastes and decomposition of organic wastes [13].

In literature, aqueous phenolic wastes have been treated for many years by different methods including chemical oxidation [14], chemical coagulation [15], extraction with solvents [16,17], membrane technology [18], ion exchange [19] and adsorption [20,21]. Among them, physical adsorption method is generally considered to be the best,

effective, economical and most frequently used method for the removal of phenolic pollutions [22]. Different types of synthetic and natural adsorbents have been used to treat the phenolic wastewater by researchers [23]. Attention has been focused on natural adsorbents (bacteria, fungi, yeast, algae, agricultural by-products, and wood by-products), which have good absorption capacities due to large surface area, homogeneous pore size, well defined structural properties, selective adsorption ability, easy regeneration, and multiple uses [24]. Adsorbent methods has been also applied for removal of DDT [25], cyanide [26], copper [27], mercury [28], color dye [29] etc. Among them waste biomass consider to be easily available in almost all region with reasonable price. The major component of biomass like lignin, cellulose and hemicellulose provides large surface area and better attachment with aromatic organic compound [26,29].

The main aim of this research work is to subtract the phenol from synthesized wastewater by adsorbent technique. The experiment was performed in the batch reactor. The effect of different experimental parameters such as the solution pH, temperature, sorbate concentration on the adsorption has been optimized by using response surface methodology. The interaction between phenol molecules and activated surface has been studied with Langmuir isotherm. The characterisations of adsorbent and adsorbed were also studied with Fourier transfer infrared (FTIR), energy diffractive x-ray (EDX-ray) and scanning electron

* Corresponding author.

E-mail address: ops0121@gmail.com (O. Sahu).

<http://dx.doi.org/10.1016/j.bbrep.2017.08.007>

Received 19 December 2016; Received in revised form 11 July 2017; Accepted 16 August 2017

Available online 24 August 2017

2405-5808/ © 2017 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

micrographic (SEM).

2. Material and methods

2.1. Materials

2.1.1. Chemical and water sample

All the analytical grade chemicals were used in this experiment supplied by Himedia Laboratories Pvt. Ltd. Mumbai India. A stock solution containing 1000 mg/L of phenol was prepared by dissolving 1 g of pure phenol crystal in 1 L of Millipore water (Q-H₂O, Millipore Corp. with a resistivity of 18.2 MX-cm).

2.1.2. Adsorbent

The sawdust was arranged from the local timber industry and washed with distilled water to remove the dust particles. To prevent the color leaching and other impurities sawdust were washed until clear solution obtained. Finally, washed biosorbent was dried at 75 °C in the oven for 8 h. To prepared activated carbon, dried sawdust mixed with 2 N H₂SO₄ in 1:3 solid to liquid ratio and kept in a muffle furnace at temperature 200 °C for 14 h. The sawdust activated carbon was washed with millipore water to eliminate residual chemicals and dried at 60 °C temperature for 24 h. Additional soaking has been done with 1% NaHCO₃ solution and kept overnight for the complete elimination of acid. The product was washed with double distilled deionized water until superficial liquid were acquired and dried at 60 °C for 12 h. Finally, the adsorbent was stored in an airtight poly bag for the experiment. The physicochemical characteristics of activated sawdust are mention in Table 1.

2.2. Methods

2.2.1. Experimental design

The parameters initial concentration (IC), contact time (CT), adsorbent dosage (AD) and pH on adsorption efficiency with sawdust was studied with a standard response surface methodology (RSM) design called central composite design (CCD). This method helps to optimize the effective parameters with a minimum number of experiments, and also to analyze the interaction between the parameters [30]. In this study percentage adsorption has been taken as a response (Y) of the system, while process parameters, initial concentration 5–40 mg mL⁻¹; pH: 2–10; Contact time 1–3 h and adsorbent dose 0.5–5 g has been taken as input parameters. For statistical calculations, the levels for the four main variables X₁(IC), X₂(t), X₃(g) X₄(pH) were coded as according to the following relationship.

$$x_i = \frac{(X_i - X_0)}{\delta X} \quad (1)$$

where X₀ is the value of X_i at the center point and δX presents the step change. The variables and levels of the design model are given in Table 2. The results of the Y (response) of adsorption were measured according to design matrix listed in Table 3. From experimental observations, it was assumed that the higher order interactions were small

Table 1
Characteristics of activated sawdust.

S.No	Characteristics	Values
1	Specific gravity	0.61
2	Bulk density (Kg/m ³)	415
3	Porosity (%)	72
4	Mean pore radius (Å)	4.5
5	Surface area (m ² /g)	19
6	Moisture content (%)	50.1
7	Loss on ignition (w/w %)	96.12
8	BET surface area (m ² /g)	910

Table 2
Factors and levels of the experimental design for adsorption.

Factors	Level 1 (-α)	Level 2 (-1)	Level 3 (0)	Level 4 (+1)	Level 5 (+α)
Inlet concentration (mg/l)	5	10	20	30	40
pH	2	4	7	8	10
Contact Time (h)	1	1.5	2	2.5	3
Adsorbent Dose (g)	0.5	1	3	4	5

Table 3
The different combination of the factors for the experimental design.

Runs	X ₁ (Initial Concentration)	X ₂ (Contact Time)	X ₃ (adsorbent dose)	X ₄ pH	Y (% adsorption)
1	0	0	0	0	73
2	0	0	0	-2	82
3	1	-1	1	1	91
4	-1	-1	1	-1	96
5	0	0	0	0	67
6	-1	1	-1	-1	74
7	-1	1	1	1	97
8	0	0	0	0	67
9	-2	0	0	0	81
10	0	0	0	0	67
11	0	0	0	0	67
12	1	1	1	-1	85
13	-1	-1	1	1	51
14	2	0	0	0	55
15	0	0	0	2	9
16	-1	-1	-1	1	92
17	1	1	-1	1	47
18	0	0	0	0	67
19	1	-1	-1	1	71
20	1	-1	1	-1	53
21	0	0	-2	0	30
22	-1	1	-1	1	92
23	1	1	-1	-1	75
24	-1	-1	-1	-1	93
25	0	-2	0	0	30
26	1	1	1	1	32
27	-1	1	1	-1	92
28	1	-1	-1	-1	55
29	0	2	0	0	67
30	0	0	2	0	91

relative to the low order.

2.2.2. Experiment

The sorption of phenol on sawdust was studied in a batch mode at room temperature. The kinetic adsorption experiments were carried out in 100 mL flasks sealed with Parafilm, to prevent the loss of phenol by volatilization. The general method has been used for this study. A known weight of sawdust was equilibrated with 60 mL of the phenol solution (known concentration) at room temperature of 21 °C for a known period of time (Table 3). All adsorption studies were conducted in a rotary incubator shaker at agitation speed (Sa) of 150 rpm. The flasks were then removed from the shaker and the final concentration of phenol in the solution was analyzed using a spectrophotometer UV. The pH of the suspension in the experiments was adjusted with NaOH 0.1 M (1 M) and H₂SO₄ 0.1 M (1 M). In addition, for the reliability of adsorption data, blank tests were also carried out in the same way.

The adsorption efficiency of phenol in solution was calculated by equation:

$$\text{Removal}(\%) = \frac{(C_0 - C_e) \times 100}{C_0} \quad (2)$$

The phenol concentration retained on the adsorbent phase (q mg mg⁻¹) was calculated by equation:

Download English Version:

<https://daneshyari.com/en/article/5506964>

Download Persian Version:

<https://daneshyari.com/article/5506964>

[Daneshyari.com](https://daneshyari.com)