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Performance and Isotherm Studies in Phenol Adsorption From Wastewater Using Low Cost Biomass Derived From Coconut Shells

Mohan Rao T., Debre Berhan University, Ethiopia
K. Rajesh Kumar, SR Engineering College, India
G. Shyamala, SR Engineering College, India
R. Gobinath, SR Engineering College, India

ABSTRACT

With the growth of urbanization and industrialization, water bodies are getting polluted. Among various pollutants, phenol-based pollutants are common water pollutions which originate from wastewater discharged from processing manufacturing industries like petrochemical refineries, ceramic plants, textile processing, leather processing, synthetic rubbers, etc. These pollutants are toxic and have long-term ill effects on both humans and aquatic animals. Adsorption is well proven technique which is widely used for removal of pollutions from aqueous environments. But this process, is hindered due to the cost of adsorbents especially for large scale continuous processes. In this regard, adsorbents derived from waste biomass can be a great asset to reduce the cost of wastewater treatment. To meet this objective, coconut shells are chosen as biomass which is abundantly available from south east Asia. This biomass is converted into activated carbon and hence used to remove phenol from wastewater. Batch adsorption experiments were performed with different initial concentration, carbon dosage, pH and contact time. At a lower concentration of 50 mg/L of initial feed (phenol) concentration resulted in around 90% phenol removal and henceforth optimum results in phenol removal obtained in only 64%. Experimental results are in good agreement with Langmuir adsorption isotherm model and have shown a better fitting to the experimental data. These studies confirm that the coconut shell-based activated carbon could be used to effectively adsorb phenol from aqueous solutions.

KEYWORDS

Activated Carbon, Adsorption, Coconut Shell, Isotherm, Phenol Removal, Wastewater Treatment

1. INTRODUCTION

Phenol is a colourless, hygroscopic and crystalline substance, which turns pink in air owing to its oxidation. It is a derivative of benzene, is an important raw material and/or product of chemical and allied industries (e.g. petrochemicals, oil refineries, plastics, leather, paint, pharmaceutical, steel industries, pesticides, antiseptics, dyes, antirust products, synthetic resins, biocides, photographic

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chemicals, ink, varnishes, etc.) (Kujawski et al., 2004; Adak et al., 2006). Phenol includes a variety of hydroxybenzenes and substituted hydroxybenzenes. These are common water pollutants. The major sources containing phenols are the wastewaters from processing manufacturing industries engaged in oil refining, coal tar processing, petrochemical production, coke oven byproducts, plastic industry, ceramic plants, textile processing, leather processing, synthetic rubber processing, pesticides & insecticides production, manufacture of dyes and dyeing, pharmaceutical, steel industries, glass production, phenolic resin industries etc. (Singh et al., 2008; Goud et al., 2005; Mohanty et al., 2008).

Phenolic compounds are water soluble and highly mobile and hence are likely to reach drinking water sources downstream from discharges, where, even at low concentrations, they can cause severe odour and taste problems and pose risks to populations. Phenols may also come to the environment through the agricultural runoff and domestic waste (Burleigh et al., 2002; Hairuddin et al., 2019; Karri et al., 2017; Karri et al., 2017). Chronic toxic effects due to phenols reported in humans include vomiting, difficulty in swallowing, anorexia, liver and kidney damage, headache, fainting and other mental disturbances. That phenol is highly toxic and difficult to degrade biologically have led to setting up of rigid limits on the acceptable level of phenol in the environment. According to the recommendation of World Health Organization (WHO), the permissible concentration of phenolic contents in potable waters is 1 $\mu g\ L^{-1}$ (Schulze, 1986) and the regulations by the Environmental Protection Agency (EPA), call for lowering phenol content in wastewaters less than 1 $mg\ L^{-1}$ (Dutta et al., 1998).

The presence of phenols and phenolic compounds in wastewater is a major problem for adverse effects on aquatic life and stringent environmental regulations attracts the attention of chemists and environmental engineers for its control (Shyamala, 2016; Shayamala, 2017; Ayawei et al., 2015; Theivarasu & Mylsamy 2011). Therefore, removal of phenols from waters and wastewaters is an important issue in order to protect public health and environment.

There are many methods about how to deal with the removal of phenol from the wastewater, such as adsorption, chemical oxidation, precipitation, distillation, solvent extraction, ion exchange, membrane processes, and reverse osmosis, etc. (Busca et al., 2008; Rengaraj et al., 2002; Han et al., 2004; Ozbelge et al., 2002; Lingamdinne et al., 2018; Karri et al., 2018). Biological process is particularly suited to wastewater containing small amount of phenol. Pretreatment of wastewater is made through oxidation process when phenol concentration is very high. In coagulation and flocculation process, large amount of sludge is generated which may cause disposal problems. Among various physicochemical processes, adsorption is widely used for the removal of phenol from wastewater (Karri et al., 2017; Karri & Sahu, 2018; Karri & Sahu, 2018).

The biggest barrier in the application of this process by the industries is the high cost of adsorbents presently available for commercial use (Acharya et al., 2009; Rastogi et al., 2008; Nizamuddin et al., 2019; Lingamdinne et al., 2019; Karri et al., 2018). The cost of adsorption technology application can be reduced, if the adsorbent is inexpensive. So, there is a need to develop low cost and easily available adsorbents for the removal of phenols from the aqueous environment. The materials developed for this purpose range from agricultural waste products, biomass and various solid substances (Sahu et al., 2010; Singh et al., 2008; Namane and Hellal 2006; Al-Asheh et al., 2003).

2. MATERIALS AND METHODS

2.1. Adsorption Experiments

Batch adsorption experiments were performed by contacting 1 g of the selected activated samples with 100 mL of the aqueous solution of different initial concentration at natural solution pH. The experiments were performed in a thermal shaker at controlled temperature (25 ± 2 °C) for a period of 2 hour at 120 rpm using 250 mL Erlenmeyer flasks containing 100 mL of different phenol concentrations at room temperature. Continuous mixing was provided during the experimental period with a constant

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