Chapter 8
Betung Bamboo-Based Magnetic Biochar for Dye Removal

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ABSTRACT

Water is one of the vital resources of human life. The rapid development of the industrial sector in developing countries is one of the main factors that contribute to water pollution, due to a lack of environmental awareness. Therefore, it is very important to remove the pollutants from industrial wastewater before being discharged into water bodies. Adsorption using inexpensive and high availability materials such as magnetic biochar is a promising alternative. Embedding magnetite (Fe3O4) into biochar not only aims to solve the separating problem, but also to strengthen the adsorption performance of the biochar. This book chapter introduces the preparation and characterization of magnetic biochar derived from betung bamboo. Furthermore, a discussion was conducted to provide a perspective on the use of magnetic biochar in adsorption technology, particularly in the removal of dyes in an aqueous solution. Finally, the isotherm models for the magnetic biochar-dye system are discussed at the end of this chapter.

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INTRODUCTION

Water is one of the vital resources of human life. The availability of water on earth is very large, covering 70% of the earth of which 3% is available as freshwater. However, among these, only 0.06% are accessible. Unfortunately, most of the world's population lives in developing countries with the provision of clean water is still a serious problem. The rapid development of the industrial sector in developing countries is one of the main factors that contribute to water pollution due to a lack of environmental awareness. The discharge of wastewater into the stream without prior treatment has reduced the self-cleaning capacity of the water and increased the pollution of water bodies. It is further exacerbated by the fact that some synthetic dyes, heavy metals, and organic compounds contained in the wastewater are toxic, teratogenic, mutagenic, carcinogenic, and nonbiodegradable (Wang et al., 2022; Astuti et al., 2011). Therefore, it is very important to remove the pollutants from industrial wastewater before being discharged into the water bodies. Several researchers have developed biological and physicochemical methods to remove pollutants from wastewater, including electrocoagulation (Prasetyaningrum et al., 2018), coagulation-flocculation (Badrus, 2018), ultrafiltration membrane (Aryanti et al., 2015), UF membrane (Istirokhatun et al., 2015), micellar-enhanced ultrafiltration (MEUF) membrane (Aryanti et al., 2017), anaerobic sequencing batch reactor (Rahayu et al., 2015), biosorption (Hadiyanto et al., 2014), phytoremediation using microalgae (Soeprobowati and Hariyati, 2017), anaerobic baffled reactor (Sumantri et al., 2015), advanced oxidation processes (Azizah and Widiasa, 2018), and adsorption (Astuti et al., 2016). The adsorption process with the advantages of simple process, easy operation, high efficiency, and low cost is a great alternative (Chafidz et al., 2018). Coal fly ash (Astuti et al., 2017), coal bottom ash (Kusmiyati et al., 2017), zeolite (Imandiani et al., 2018), clay (Darmawan et al., 2019), composite (Chen and Tseng, 2022), chitosan (Wang et al., 2022), activated carbon (Al-Latief et al., 2015; Arnelli et al., 2018; Arnelli et al., 2019), and biochar (Meng et al., 2022) have been used as adsorbents. Among these materials, biochar is an environmentally friendly adsorbent and has high economic value for removing organic and inorganic pollutants in aqueous solutions, including dye (Astuti et al., 2022).

Biochar, a black carbonaceous material, can be produced through the pyrolysis process under limited or no oxygen conditions (Medeiros et al., 2022) at a temperature of 300-1000 ^{o}C from various types of biomass such as sludge (Liu et al., 2022), organic waste (Zhang et al., 2022), agricultural waste (Ajeng et al., 2022; Murad et al., 2022), algae (Sun et al., 2021), forest residue (Aghababaei et al., 2017), and animal manure (Hossain et al., 2021). Besides biochar, pyrolysis of biomass also produces bio-oil and syngas. Therefore, the operation condition needs to be considered to obtain high-yield biochar. As a carbon-rich material and highly aromatic solid