



Improved heterocyclic aromatic hydrocarbon compound adsorption using functionalised rice husk biochar

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ABSTRACT

Carbazole (CBZ) is a hazardous heterocyclic aromatic hydrocarbon (HAH) that pollutes water bodies, and the treatment remains a challenge due to its high persistence in the environment. This study chemically modified rice husk biochar (RHB) with starch derivative (DS) to develop an effective adsorbent. Thus, functionalised RHB with starch derivative (RHBDS) was synthesised to remove CBZ from synthetic wastewater. Based on a Box-Behnken design, the DS functionalisation optimisation was successfully performed. The parameters, including RHB mass of (5–10) g, DS concentration of (1–5)% w/v, and sonication period of (1–5) min, were analysed using Design Expert. These parameters were then utilised to investigate the optimal conditions (removal rate response and adsorption capacity) for the adsorbent. The removal rate and the adsorption capacity ranged from 83.85 to 98.94 % and 335.41 to 395.76 mg/g, respectively. Consequently, the RHB mass of 6.50 g, DS concentration of 1 % w/v, and sonication period of 5 min within the experimental domain exhibited the best conditions with desirability of 1.0. The 92.67 % removal rate and adsorption capacity of 370.59 mg/g were also obtained under optimal conditions. Compared to RHB, RHBDS demonstrated four times the adsorption capacity for the CBZ removal from synthetic water, which were 23.03 mg/g and 98.01 mg/g, respectively. Therefore, the RHBDS compound could be a promising adsorbent in removing CBZ from wastewater.

1. Introduction

The wastewater treatment sector gains increasing interest as greater demands are necessary for low-cost, sustainable, and environmentally friendly innovations. Environmentalists are also concerned about the heterocyclic aromatic hydrocarbons (HAH) waste of petroleum industries. The HAH compound is toxic and mutagenic, which can cause health issues for the inhabitants of the water bodies (Jha and Bharti, 2002). Carbazole (CBZ) is one of the heteroaromatic nitrogen-containing compounds known for its resistant nature and cancer-causing effects (Manas et al., 2019). Currently, the CBZ compound is identified as the second-highest low molecular-weight aromatic hydrocarbon in the water of Sungai Perak (Abd Manan et al., 2021). In

addition to CBZ application in the fuel industry, carbazole is an organic dye used in pharmaceuticals and solar cells (Celma et al., 2023).

The CBZ compound can be eliminated from wastewater using several approaches, including biological and denitrogenating processes. According to (Abdul Lateef Khan, 2021), CBZ biodegradation demonstrated effective removal from lake water. Nonetheless, the biodegradation process was relatively time-consuming and involved microorganisms or enzymes. Moreover, the performance was significantly affected by the frequent change in environmental conditions.

Moreover, the prime by-products of rice production typically include rice husk, straw, and bran. Generally, rice husk biochar (RHB) consists of 50 % cellulose, 25 to 30 % lignin, 15 to 20 % silica, and 10 to 15 % moisture, contributing 20 % of the rice weight (Singh, 2018). Rice husk,

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