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Removal of Pharmaceuticals from Single and Multicomponent Wastewater by Activated Carbon

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Abstract **–** The growing needs for pharmaceuticals and personal care products have resulted in the production of large quantities of wastewater from pharmaceutical manufacturing plants. The manufacturing process of pharmaceuticals leads to the discharge of substantial volumes of highly polluted wastewater containing organic contaminants such as sulfa drugs, compounds derived from aniline, and solvents, which can pose significant risks to the environment and human health. These pharmaceutical pollutants, often categorized as emerging contaminants, are not effectively removed by conventional wastewater treatment methods, emphasizing the need for advanced treatment technologies to mitigate their impact.

In order to address these challenges, this study aims to evaluate the effectiveness of utilizing activated carbon adsorption for the removal of pharmaceuticals from moderately to highly concentrated multicomponent wastewater, which resembles the effluent produced by pharmaceutical manufacturing plants. The primary objectives of this study include understanding the adsorption behaviour of selected pharmaceuticals, assessing the effects of competition on the adsorption capacity of activated carbon, and optimizing the adsorption process for practical applications. To achieve these objectives, six pharmaceutical compounds were selected to create a synthetic wastewater that were treated by activated carbon at varying dosages in both single and multicomponent wastewater until equilibrium was reached. The adsorption capacity of the activated carbon was also studied at various pH levels in a series of batch experiments. The total organic carbon (TOC) was employed as a key indicator to characterize the wastewater and to evaluate the process efficiency. By varying these parameters, their effects on the removal efficiency of pharmaceutical compounds were studied. Additionally, Langmuir and Freundlich isotherm models are used to analyze the experimental equilibrium data, providing insights into the equilibrium state between the activated carbon and the pharmaceuticals in wastewater.

The study's findings indicated that activated carbon was more effective at removing pollutants in acidic pH conditions. Furthermore, the distribution of pharmaceuticals on the activated carbon surface could be better explained using the Freundlich isotherm, suggesting a multilayer adsorption mechanism. Additionally, activated carbon demonstrated improved performance in treating highly concentrated wastewater. Moreover, in multicomponent wastewater, the equilibrium capacity of activated carbon remained largely unaffected, with the exception of aniline and benzene, which exhibited some competitive adsorption. Finally, by addressing the challenges of pharmaceutical wastewater treatment and exploring the potential of activated carbon adsorption, the results showed activated carbon as an effective treatment technique for mitigating the release of pharmaceutical contaminants into water resources, ultimately promoting a sustainable and cleaner future.

Keywords**:** Pharmaceutical removal; wastewater treatment; multicomponent wastewater; high-strength wastewater; activated carbon adsorption.

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