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Effective Application of *Jatropha Curcas* Husk Activated $ZnCl_2$ for Adsorption of Methylene Blue: Isotherm, Kinetics and Development of Empirical Model

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ABSTRACT

Water conservation is critical for both the natural environment and human development however, there is wastewater generation, particularly in the production of pulp, printing, leather, plastic, dye, and textile mills. Large-scale industrial wastewater purification necessitates the employment of low-cost adsorbents to lower the cost of large-scale industrial wastewater treatment procedures. In this study, the husk of *Jatropha curcas* (JHC) was carbonized, activated, and impregnate with $ZnCl_2$ for use in batch tests to adsorb methylene blue (MB) from an aqueous solution. The effects of concentration, stirring speed, contact time, pH, and adsorbent dosage on adsorption isotherms and kinetics were examined. The Freundlich isotherm model accurately described the adsorption isotherm, while pseudo-second-order adequately fitted the kinetic data. The dye-loaded adsorbent could be regenerated by chemical regeneration after five desorption cycles. These findings suggested that JHC could be a good adsorbent for removing MB from wastewater and could help with industrial wastewater treatment.

1. Introduction

The discharge of colored wastewater/dye effluent into the aquatic environment because of the activities of various industries such as paper and pulp, printing, leather, plastic, textile, and dye, poses threats to humans, animals, and the environment [1]. Significant amounts of organic pollutants discharged by industry may be hazardous to flora and wildlife, lowering autotrophic organism photosynthesis substantially [2]. The textile dyeing industry produces and releases 280,000 tons of dyes into water streams each year across the world [3,4]. Dyes are organic molecules that are less biodegradable due to their complex aromatic molecular structure. Methylene blue (MB) is cationic [5], and it's widely used in cotton, textiles, wools, and colorants, with reports of material durability and ease of use [6,7]. MB can have various harmful effects on both humans and animals [8,9] due to its chemical properties which may lead to mutagenic and carcinogenic properties in a wide range of living beings [10]. Among the several dye removal procedures available, including catalytic oxidation, electrochemical oxidation, biological therapy, coagulation/flocculation, ozonation, photocatalytic degradation, and sonocatalytic degradation, adsorption stands out as the most effective [1]. The adhesion of atoms, ions, gas, liquid, or dissolved solids to a surface is known as adsorption [11]. Other procedures have the disadvantages of creating toxic sludge, carcinogenic byproducts, costly equipment, and energy costs. Also, water treatment by adsorption may cost 5.0–200 USD m^{-3}, whereas other technologies may cost twice as much [2]. It is a well-known technology to use Activated Carbon (AC) as an adsorbent in wastewater treatment [12-14]. When nonrenewable commercial AC-based for removing dyes is used, materials such as coal and petroleum coke are expensive consequently, agricultural biomass can be employed because of the advantages of eco-friendly and low-cost alternative resources [3,4]. JHC is a good source for the development of ACs in the adsorption process because it is cheap and is an agro-industrial solid waste [1,4,15]. Adsorption ability is a function of surface area,

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