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High-efficiency river water treatment via pilot-scale low-pressure hybrid membrane photocatalytic reactor (MPR) utilizing ZnO-Kaolin photocatalyst

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A R T I C L E I N F O

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A B S T R A C T

River pollution poses a significant threat to ecosystems and human health, underscoring the need for effective and scalable treatment methods. A recent pilot-scale study has refined a hybrid membrane photocatalytic reactor (MPR) incorporating ZnO-Kaolin photocatalyst to treat Sembrong river water. The ZnO-Kaolin was characterized using multiple analytical techniques. X-ray diffraction (XRD) confirmed the wurtzite phase of ZnO and the anorthic structure of kaolinite, with a crystallite size of 40 nm. Fourier transform infrared spectroscopy (FTIR) revealed Zn—O stretching vibrations alongside the characteristic Si-O-Al and Si-O-Si bonds of kaolin. Field emission scanning electron microscopy (FESEM) demonstrated a uniform distribution of 50 nm ZnO nanoparticles on the kaolin surface, while optical band gap analysis showed a value of 3.25 eV, indicating favorable photocatalytic activity for ZnO-Kaolin. Optimal conditions for pollutant removal were established, with a photocatalyst loading of 0.05 g/L of ZnO-Kaolin, a membrane pressure of 0.5 bars, and 225 watts of UV light leading to significant pollutants removal, 86 % for ammoniacal nitrogen, 92 % for chemical oxygen demand (COD), 85 % for biochemical oxygen demand (BOD), and 99 % for suspended solids. The hybrid system also reduced flux decline by 18 %, improving ultrafiltration membrane efficiency. Additionally, the pH and dissolved oxygen of the treated water increased to 6.0 and 6.3 mg/L, respectively, elevating the Water Quality Index (WQI) to 87.17, corresponding with Class II standards. These results suggest that the hybrid MPR could be an effective option for sustainable large-scale river water treatment.

1. Introduction

The quality of river water has been progressively deteriorating due to various contaminants from industrial discharges, agricultural runoff, and urban waste [1]. These contaminants include intricate organic compounds, heavy metals, and harmful microorganisms, posing considerable threats to both human health and aquatic ecosystems [2]. Rivers are vital water sources for drinking, agriculture, and industry, making their pollution a significant environmental concern worldwide [3]. Nevertheless, current approaches, including coagulation, flocculation, sedimentation, and filtration, have drawbacks when it comes to effectively dealing with pollutants such as ammoniacal nitrogen (AN), chemical oxygen demand (COD), biochemical oxygen demand (BOD), and suspended solids (SS), which are major contributors to river pollution.

The coagulation and flocculation struggle to effectively remove

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