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Integrating ammonium-based polymer with phytoremediation for phosphate and chemical oxygen demand reduction in palm oil mill effluent

Lukman Hakim[1], Aster Rahayu[1*], Siti Jamilatun[1], Vivi Sisca[2], Joni Aldilla Fajri[3]

[1] Department of Chemical Engineering, Faculty of Industrial Technology, Universitas Ahmad Dahlan, Tamanan, Bantul, D.I. Yogyakarta, 55191, Indonesia
[2] Research Center for Chemistry, National Research and Innovation Agency B.J. Habibie Science and Techno Park, Serpong, South Tangerang, Banten, 15314, Indonesia
[3] Department of Environmental Engineering, Faculty of Civil Engineering and Planning, Universitas Islam Indonesia. Jl. Kaliurang Km 14.5, Yogyakarta, 55584, Indonesia
* Corresponding author's e-mail: aster.rahayu@che.uad.ac.id

ABSTRACT

Environmental pollution caused by the palm oil industry is a severe problem. In palm oil production, liquid waste is obtained as palm oil mill effluent containing COD and phosphate, which can pollute aquatic ecosystems and soil. Phytoremediation technology with modification using ammonium-based polymer adsorbents effectively reduces palm oil mill effluent contaminants. This study aimed to test the effectiveness of phytoremediation and adsorption modification technology using ammonium-based polymer adsorbents to consider environmentally friendly and economical reducing pollutants in palm oil mill effluent. *Vetiveria zizanioides* plants were cultivated in floating treatment wetlands, and the planting media was varied using ammonium-based polymer to treat palm oil mill effluent with a volume of 3 L. The performance of the modified reactor in degrading COD and phosphate was examined by monitoring the floating treatment wetlands for 9 days and measuring the physiochemical parameters. Variations in ammonium-based polymer showed optimal performance using a lower ratio of 0.3. This combination of technologies removed COD by around 77.3% with an adsorption capacity of 558.4 mg/g and phosphate by around 59.5% with an adsorption capacity of 2.77 mg/g within nine days. These results could be elaborated on with tertiary treatment for future treatment to enhance removal according to the quality standards of the Ministry of Environment and Forestry in Indonesia.

Keywords: adsorption, ammonium polymer, chemical oxygen demand, palm oil mill effluent, phosphate, phytoremediation.

INTRODUCTION

Palm oil is Indonesia's largest plantation commodity, and the plantation area is growing very rapidly (Listiningrum et al., 2022). In 2015, the estimated CPO (crude palm oil) production was around 31 million tons, increasing to 46 million tons in 2020 and 47 million tons in 2023, with a productivity of 2.79 million tons/million hectares. In 2023, substantial production was supported by a rise in oil palm plantations, which cover 16.8 million hectares and comprise areas from smallholder plantations, government plantations, and private plantations (Ministry of Agriculture Indonesia, 2024). The development of the palm oil industry has had a positive impact on society because it provides job opportunities, but on the other hand, it has also had a severe negative impact caused by CPO production activities (Shahputra and Zen, 2018).

In the operational activities of industry, palm oil is only produced in 20% of fresh fruit bunches (FFB), and the remaining 80% is disposed of as waste (Kramanandita et al., 2014; Suksong et al., 2020). In general, 1 ton of fresh FFB produces around 0.5–0.75 tons of palm oil mill effluent (POME) and 0.2–0.3 tons of empty fruit bunches (EFB) (Abnisa et al., 2013; Irvan, 2018). POME