PENYERAPAN ZAT WARNA *METHYL ORANGE* MENGGUNAKAN BIJI ALPUKAT (*Persea americana* Mill.)

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ABSTRACT

ADSORPTION OF METHYL ORANGE USING AVOCADO SEED (*Persea americana* Mill.)

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Water pollution caused by synthetic dyes has become a major environmental concern due to its adverse impacts on aquatic ecosystems and human health. Synthetic dyes are extensively used in various industries because of their strong affinity toward substrates. Methyl Orange (MO), an anionic azo dye widely employed in textile industries and laboratory applications, is recognized for its toxicity, potential carcinogenicity, and resistance to biodegradation. Various treatment technologies have been developed for dye-contaminated wastewater, including membrane separation, coagulation, and adsorption. Among these methods, adsorption has received considerable attention owing to its simplicity, cost-effectiveness, operational convenience, and high removal efficiency. This study aimed to evaluate the potential of avocado seed (*Persea americana* Mill.) as an environmentally friendly biosorbent for the removal of MO from aqueous solutions. Adsorption performance was evaluated by optimizing the solution pH, initial dye concentration, contact time, and biosorbent heating temperature. Adsorption equilibrium, kinetics, thermodynamics, and biosorbent characteristics were further investigated using *Fourier Transform Infrared Spectroscopy* (FTIR), *Scanning Electron Microscopy-Energy Dispersive X-ray Spectroscopy* (SEM-EDX), *Thermogravimetric Analysis* (TGA), and *X-Ray Fluorescence* (XRF). The point of zero charge (pH_{pzc}) of the biosorbent was determined to be 6.1. Optimum adsorption conditions were achieved at pH 3, an initial MO concentration of 1200 mg/L, a contact time of 60 min, and a biosorbent heating temperature of 50°C, resulting in the highest experimental adsorption capacity of 65.2183 mg/g and a removal efficiency of 54.35%. Equilibrium data were best described by the Freundlich isotherm model (R^2 = 0.9879), indicating multilayer adsorption on a heterogeneous surface. The adsorption kinetics followed the Pseudo Second Order (PSO) model (R^2 = 0.9821). Thermodynamic analysis revealed negative Gibbs free energy change (ΔG°) values, a positive enthalpy change (ΔH° = 4.5468 kJ/mol), and a positive entropy change (ΔS°), suggesting that the adsorption process was spontaneous, endothermic, and associated with an increase in entropy at the solid liquid interface. The characterization results revealed changes in functional groups, surface morphology, and elemental composition after adsorption, indicating the involvement of electrostatic interactions, hydrogen bonding, π-π interactions, pore filling, and ion exchange. The application of the biosorbent to real laboratory wastewater achieved an adsorption capacity of 0.7987 mg/g under the initial conditions, which increased to 0.9965 mg/g under the optimized conditions. These findings indicate that avocado seed has the potential to be developed as an alternative biosorbent for reducing *Methyl Orange* content in wastewater.

Keywords**:** *Adsorption, Methyl Orange, avocado seed, biomass*