A Quantitative Study of The Energy Use of Low-Pressure Cold Plasma for Biochar Modification and its Application on Boron-Contaminated Soil

Prof. Dr. Ir. Bayu Rudiyanto, S.T., M.Si. as *The Supervisor*

Muhammad Baqir Mohammadi
Renewable Energy Engineering Study Program
Department of Engineering

ABSTRACT

Boron contamination in agricultural soil poses a significant threat to crop productivity due to its narrow concentration range between essentiality and toxicity. While biochar is a promising remediation agent, conventional activation methods are often energy-intensive and environmentally taxing. This study provides a quantitative analysis of Low-Pressure Cold Plasma (LPCP) as a rapid, energy-efficient, and green technology for modifying Cocoa Pod Husk (CPH) biochar to enhance boron remediation. CPH biochar was treated with LPCP at a constant power of 15 watts for varying durations, resulting in distinct energy inputs (9 kJ, 18 kJ, and 27 kJ). These modified biochars were applied at a 4% (w/w) dosage to soil artificially contaminated with 20 mg/L of boron and incubated for 30 days. Results demonstrated a strong, direct quantitative relationship between LPCP energy input and the biochar's remediation efficacy. The highest energy treatment (27 kJ) achieved the most significant reduction in soluble boron, decreasing the concentration to 8.03 mg/kg, which corresponds to a 59.84% removal efficiency. A strong negative linear correlation was established between plasma energy input and the final boron concentration (R^2 =0.9143). Concurrently, the soil's Cation Exchange Capacity (CEC) showed a significant linear increase with higher energy input (R^2=0.834), rising by 67.5% to 34.4 meq/100g in the 27 kJ treatment group. Notably, Electrical Conductivity (EC) exhibited a quadratic response, peaking at the 18 kJ treatment (768.01 µS/cm) before decreasing at 27 kJ (571.3 µS/cm), suggesting an optimal energy level to maximize nutrient retention while mitigating salinity risks. This research concludes that LPCP modification is highly effective for enhancing biochar properties for soil remediation, establishing a clear quantitative link between energy dosage and improvements in boron adsorption and soil fertility indicators.

***Keywords**: Biochar, Boron, Energy Input, Low-Pressure Cold Plasma (LPCP), Soil Remediation*