ABSTRAK

PENGEMBANGAN PROSES KOAGULASI/FLOKULASI-ADSORPSI *HYBRID* UNTUK PENYISIHAN BORON DALAM PENGOLAHAN AIR LIMBAH

Boron merupakan salah satu polutan yang sering ditemukan dalam PLTU batubara dan aktivitas industri lainnya, yang keberadaannya di perairan dapat mengganggu ekosistem dan menurunkan kualitas air. Metode penanganan yang efektif diperlukan untuk mengatasi masalah ini, salah satunya adalah pengembangan proses *hybrid* yang mengombinasikan metode koagulasi-flokulasi dan adsorpsi guna meningkatkan efisiensi penghilangan boron. Penelitian ini bertujuan untuk mengidentifikasi kinerja *hybrid* dalam penyisihan boron dari air limbah. Proses *hybrid* melibatkan agen pengendap $Ca(OH)_2$ dan adsorben (HCl-NZC serta CUR-CPTMS-HCl-NZC) dengan parameter pH (4, 6, 8, 10, dan 12), konsentrasi awal boron (10, 20, 30, 40, dan 50 ppm), serta dosis (0,1; 0,2; 0,3; 0,4; dan 0,5 gram). Karakterisasi yang dilakukan dalam penelitian ini meliputi penentuan konsentrasi unsur boron dalam sampel menggunakan instrumentasi *Inductively Coupled Plasma-Optical Emission Spectrometry* (ICP-OES), *Fourier Transform Infrared* (FTIR) digunakan untuk mengkarakterisasi gugus fungsi dalam agen pengendap dan adsorben. Sedangkan, *Brunauer-Emmett-Teller* (BET) digunakan untuk menentukan ukuran pori, volume pori, dan luas permukaan dari adsorben. Hasil proses *hybrid* terbaik ditemukan pada agen pengendap $Ca(OH)_2$ dan adsorben HCl-NZC dengan pH 8, konsentrasi awal boron 10 ppm, dan dosis 0,4 gram, dengan % penyisihan boron sebesar 88%.

Kata kunci: boron; *hybrid*; Koagulasi-flokulasi; adsorpsi; penyisihan.

ABSTRACT

"THE DEVELOPMENT OF HYBRID COAGULATION/FLOCCULATION-ADSORPTION PROCESS FOR BORON REMOVAL IN WASTEWATER TREATMENT"

Boron is one of the pollutants commonly found in coal-fired power plants and other industrial activities. Its presence in water bodies can disrupt ecosystems and degrade water quality. Effective treatment methods are required to address this issue, one of which is the development of a hybrid process combining coagulation-flocculation and adsorption methods to enhance boron removal efficiency. This study aims to evaluate the performance of the hybrid in removing boron from wastewater. The hybrid process involves the use of $Ca(OH)_2$ as a precipitating agent and adsorbents (HCl-NZC and CUR-CPTMS-HCl-NZC) under varying parameters, including pH (4, 6, 8, 10, and 12), initial boron concentrations (10, 20, 30, 40, and 50 ppm), and adsorbent dosages (0.1, 0.2, 0.3, 0.4, and 0.5 grams). Characterization methods in this study include determining boron concentrations in the samples using Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES). Fourier Transform Infrared (FTIR) spectroscopy was employed to characterize functional groups in the precipitating agent and adsorbents, while the Brunauer-Emmett-Teller (BET) method was used to determine pore size, pore volume, and surface area of the adsorbents. The best performance of the hybrid process was achieved using $Ca(OH)_2$ as the precipitating agent and HCl-NZC as the adsorbent at pH 8, an initial boron concentration of 10 ppm, and an adsorbent dosage of 0.4 grams, resulting in a boron removal efficiency of 88%.

Keywords: boron; hybrid; coagulation-flocculation; adsorption; removal.