

Potential of Biogas Recovery from Industrial Wastewater and CO₂-Equivalent Emission Mitigation

Witchuda Uea-aree

Maejo University – Chumphon Campus, Lamae Subdistrict, Lamae District, Chumphon Province 86170, Thailand.

**Corresponding Author Email: kruwitchuda10@gmail.com*

Abstract

This study evaluates the potential for biogas recovery from industrial wastewater in Thailand and quantifies associated carbon dioxide-equivalent (CO₂e) emissions under selected anaerobic wastewater treatment options. The assessment focuses on palm oil mill effluent and compares upflow anaerobic sludge blanket (UASB), continuous stirred tank reactor (CSTR), and covered lagoon (CL) systems using wastewater flow, chemical oxygen demand (COD), COD removal efficiency, methane-emission estimates, electricity-related emissions, and analytic hierarchy process (AHP) decision criteria. Hydraulic loading ranged from 327 to 579 m³/day, equivalent to 99,582 to 170,647 m³/year for the principal treatment systems. Influent COD was approximately 5,556 mg/L for the CSTR/UASB dataset and 60,819-69,887 mg/L for the CL sites. COD removal efficiencies were approximately 90% for UASB, 80% for CSTR, and 60% for CL. Baseline methane emissions were estimated at 54,698 tCO₂e/year for UASB, 26,249 tCO₂e/year for CSTR, and 19,075-23,844 tCO₂e/year for CL. With biogas capture and utilization, methane emissions decreased to 5,383 tCO₂e/year for UASB and 6,512 tCO₂e/year for CSTR, corresponding to reductions of approximately 90% and 75%, respectively. CL systems showed lower reductions of approximately 26-33%. AHP results identified UASB, with performance close to anaerobic covered lagoon treatment, as the most favorable option for treatment consistency, methane recovery, and greenhouse-gas mitigation. The results indicate that high-rate anaerobic systems with effective biogas utilization can convert agro-industrial wastewater into a renewable energy resource while substantially reducing greenhouse gas emissions in Thailand.

Keywords: Anaerobic wastewater treatment; Analytic hierarchy process; Biogas; COD removal; Greenhouse-gas mitigation; palm oil mill effluent