MODIFIED ADSORBENT AND LONG CHAIN FATTY ACID INHIBITION MODELING FOR ANAEROBIC TREATMENT OF PALM OIL MILL EFFLUENT WITH AEROBIC POST-TREATMENT

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ABSTRACT

ZIDAND ANAND HIDAYAT. Modified Adsorbent and Long Chain Fatty Acid Inhibition Modeling for Anaerobic Treatment of Palm Oil Mill Effluent with Aerobic Post-Treatment. Supervised by ALLEN KURNIAWAN and SITI NIKMATIN.

Palm oil mill effluent (POME) contains high concentrations of oil and grease (O&G) that can impair anaerobic treatment through long-chain fatty acid (LCFA) formation. This study evaluated a modified oil palm empty fruit bunch (OPEFB) adsorbent, an integrated adsorption–Anaerobic Rotating Biological Contactor (AnRBC)–Moving Bed Biofilm Reactor (MBBR) system, and a modified Anaerobic Digestion Model No. 1 (ADM1) incorporating LCFA inhibition. The optimum adsorbent, produced at 400 °C, achieved O&G and SCOD removal efficiencies of 48.59% and 13.50%, respectively. The integrated system performed best at an HRT of 3 days, while the modified ADM1 accurately predicted acetate dynamics (R^2 = 0.926, MAPE = 7.23%). These findings demonstrate an effective strategy for improving the treatment and modeling of lipid-rich POME.

Keywords: Anaerobic Digestion Model No. 1; Anaerobic Rotating Biological Contactor; Long-chain fatty acids Inhibition; Oil and Grease; Palm oil mill effluent

ABSTRAK

ZIDAND ANAND HIDAYAT. Modified Adsorbent and Long Chain Fatty Acid Inhibition Modeling for Anaerobic Treatment of Palm Oil Mill Effluent with Aerobic Post-Treatment. Dibimbing oleh ALLEN KURNIAWAN dan SITI NIKMATIN.

Limbah cair pabrik kelapa sawit (LCPKS) mengandung minyak dan lemak (O&G) yang tinggi sehingga dapat mengganggu proses pengolahan biologis anaerob melalui pembentukan asam lemak rantai panjang (LCFA). Penelitian ini mengevaluasi adsorben tandan kosong kelapa sawit (TKKS) termodifikasi, sistem terintegrasi adsorpsi–*Anaerobic Rotating Biological Contactor* (AnRBC)–*Moving Bed Biofilm Reactor* (MBBR), serta model *Anaerobic Digestion Model No. 1* (ADM1) termodifikasi. Adsorben optimum pada suhu pirolisis 400 °C menyisihkan O&G dan SCOD masing-masing sebesar 48,59% dan 13,50%. Sistem menunjukkan kinerja terbaik pada HRT 3 hari, sedangkan model ADM1 memberikan prediksi asetat yang baik (R^2 = 0,926; MAPE = 7,23%). Hasil penelitian menunjukkan bahwa integrasi adsorben TKKS termodifikasi dan ADM1 termodifikasi efektif untuk meningkatkan pengolahan LCPKS berkadar lipid tinggi.

Kata kunci: *Anaerobic Digestion Model No. 1*; *Anaerobic Rotating Biological Contactor*; inhibisi asam lemak rantai panjang; limbah cair pabrik kelapa sawit; minyak dan lemak.

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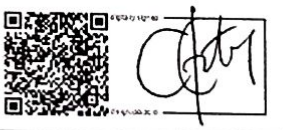

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PREFACE

The author offers profound praise and gratitude to Almighty God for endless grace, blessings, and guidance, which have granted the author good health and the ability to complete this undergraduate thesis on schedule. This undergraduate thesis, entitled *"Modified Adsorbent and Long Chain Fatty Acid Inhibition Modeling for Anaerobic Treatment of Palm Oil Mill Effluent with Aerobic Post-Treatment"* has been prepared and submitted to fulfill the requirements for a bachelor's degree in the Department of Civil and Environmental Engineering at IPB University.

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Hopefully, this scientific work will be helpful for those who need it and for the advancement of science.

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Zidand Anand Hidayat

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V	=	Reactor volume (L)
Q	=	Influent flow rate (L d^{-1})
HRT	=	Hydraulic retention time (d)
S_{ac}	=	Acetate concentration (gCOD L^{-1})
$S_{ac,in}$	=	Influent acetate concentration (gCOD L^{-1})
S_{pro}	=	Propionate concentration (gCOD L^{-1})
S_{bu}	=	Butyrate concentration (gCOD L^{-1})
S_{va}	=	Valerate concentration (gCOD L^{-1})
S_{fa}	=	Liquid-phase LCFA concentration (gCOD L^{-1})
$S_{fa,bio}$	=	Biofilm-bound LCFA concentration (gCOD L^{-1})
H_{xac}	=	Healthy methanogenic fraction (–)
X_{ac}	=	Acetoclastic methanogen biomass concentration (kgCOD m^{-3})
X_{pro}	=	Propionate-degrading biomass concentration (kgCOD m^{-3})
X_{c4}	=	Butyrate/valerate-degrading biomass concentration (kgCOD m^{-3})
$K_{s,ac}$	=	Half-saturation constant for acetate uptake (gCOD L^{-1})
$K_{s,pr}$	=	Half-saturation constant for propionate uptake (gCOD L^{-1})
$K_{s,c4}$	=	Half-saturation constant for C4 uptake (gCOD L^{-1})
$k_{m,ac}$	=	Maximum specific acetate uptake rate (d^{-1})
$k_{m,pr}$	=	Maximum specific propionate uptake rate (d^{-1})
$k_{m,c4}$	=	Maximum specific C4 uptake rate (d^{-1})
Y_{pro}	=	Biomass yield coefficient for propionate degradation (–)
Y_{c4}	=	Biomass yield coefficient for butyrate/valerate degradation (–)
q_{sat}	=	Maximum LCFA adsorption capacity (gCOD L^{-1})

k_{ads} = LCFA adsorption coefficient (d^{-1})
k_{damage} = Methanogenic cell damage coefficient (d^{-1})
K_{Xfa} = LCFA inhibition constant (–)
q_{max} = Langmuir maximum adsorption capacity (mg g^{-1})
K_L = Langmuir adsorption constant (L mg^{-1})
R_L = Langmuir separation factor (–)
K_f = Freundlich adsorption constant (mg g^{-1})
$1/n$ = Freundlich adsorption intensity factor (–)

GLOSSARY

Seeding	:	The initial introduction of microbial cultures into a treatment system to establish an active biological community for wastewater degradation.
Acclimatization	:	The process by which microorganisms gradually adapt to the characteristics of POME, enabling them to maintain metabolic activity and treatment efficiency under reactor operating conditions.
Biomass	:	The total population of living microorganisms responsible for the biological conversion and degradation of organic pollutants in wastewater treatment systems.
Palm Oil Mill Effluent (POME)	:	A liquid by-product generated during palm oil processing, containing high levels of organic matter, suspended solids, oil and grease, nutrients, and acidic compounds.
Anaerobic Rotating Biological Contactor (AnRBC)	:	An anaerobic treatment process that utilizes rotating support media to promote biofilm growth and facilitate the degradation of organic contaminants in the absence of oxygen.
Moving Bed Biofilm Reactor (MBBR)	:	An aerobic biological treatment system that employs freely moving carrier media as attachment surfaces for biofilm development.
Hydraulic Retention Time (HRT)	:	The average duration that wastewater remains within a treatment unit or reactor, influencing the extent of biological and physicochemical treatment processes.
Anaerobic Digestion Model No. 1 (ADM1)	:	A mathematical model developed by the IWA to simulate anaerobic digestion processes, including substrate conversion, intermediate metabolite formation, and microbial growth