# ABSTRAK

**Adryansyah Anugrah Pratama, NIM 4223210016 (2026) Sifat Kinetika dan Termodinamika Adsorpsi Zn(II) oleh Komposit Polimer Berpori Cu(TAC)2 Berbasis Limbah Plastik dengan Karbon Aktif Tandan Kosong Kelapa Sawit.**

Pencemaran logam berat, khususnya seng (Zn), dalam limbah industri kelapa sawit merupakan permasalahan lingkungan yang memerlukan penanganan efektif. Penelitian ini mengembangkan material adsorben komposit KA–$Cu(TAC)_2$ berbasis karbon aktif dari tandan kosong kelapa sawit (TKKS) yang dimodifikasi dengan *Metal Organic Frameworks* $Cu(TAC)_2$ menggunakan asam tereftalat hasil depolimerisasi limbah plastik PET. Kajian isoterm, kinetika, dan termodinamika digunakan sebagai kerangka analitik untuk mengevaluasi mekanisme dan kinerja adsorpsi. Karbon aktif disintesis melalui karbonisasi pada 500°C dan aktivasi kimia $H_3PO_4$ 10%, kemudian dikompositkan dengan $Cu(TAC)_2$ melalui metode refluks. Karakterisasi material dilakukan menggunakan XRD dan SEM, sedangkan konsentrasi Zn(II) diukur dengan AAS. Hasil karakterisasi XRD menunjukkan komposit memiliki sistem kristal triklinik dan monoklinik, dengan morfologi SEM memperlihatkan distribusi partikel MOFs yang merata pada matriks karbon aktif. Kondisi optimum adsorpsi dicapai pada massa adsorben 1 gram, konsentrasi 180 ppm, dan waktu kontak 30 menit dengan kapasitas adsorpsi 9,66 mg/g. Kesetimbangan adsorpsi paling sesuai dengan model Freundlich ($R^2$=0,988), kinetika mengikuti model pseudo-orde kedua ($R^2$=0,9458), dan analisis termodinamika menghasilkan $\Delta H°$= −48,18 kJ/mol, $\Delta S°$= −191,14 J/mol.K, serta $\Delta G°$ bernilai positif yang mengindikasikan proses eksotermik dan non-spontan pada kondisi standar. Komposit KA–$Cu(TAC)_2$ terbukti superior dibandingkan karbon aktif tanpa modifikasi.

**Kata kunci** : adsorpsi, karbon aktif TKKS, *Metal Organic Frameworks*, kinetika dan termodinamika, limbah plastik PET

# ABSTRACT

**Adryansyah Anugrah Pratama, NIM 4223210016 (2026) Kinetic and Thermodynamic Properties of Zn(II) Adsorption by Plastic Waste-Based Porous Polymer Composite $Cu(TAC)_2$ with Activated Carbon From Oil Palm Empty Fruit Bunches**

Heavy metal pollution, particularly zinc (Zn), in palm oil industrial wastewater represents an environmental problem requiring effective remediation. This study developed a composite adsorbent material KA–$Cu(TAC)_2$ based on activated carbon derived from empty fruit bunches (EFB) of oil palm, modified with $Cu(TAC)_2$ Metal Organic Frameworks using terephthalic acid obtained from the depolymerization of PET plastic waste. Isotherm, kinetic, and thermodynamic analyses were employed as analytical frameworks to evaluate the adsorption mechanism and performance. Activated carbon was synthesized through carbonization at 500°C followed by chemical activation using 10% $H_3PO_4$, then composited with $Cu(TAC)_2$ via reflux method. Material characterization was conducted using XRD and SEM, while Zn(II) concentration was measured by AAS. XRD characterization revealed that the composite possesses triclinic and monoclinic crystal systems, with SEM morphology showing uniform distribution of MOF particles throughout the activated carbon matrix. Optimal adsorption conditions were achieved at an adsorbent mass of 1 gram, concentration of 180 ppm, and contact time of 30 minutes, yielding an adsorption capacity of 9.66 mg/g. Adsorption equilibrium best fitted the Freundlich model ($R^2$=0.988), kinetics followed the pseudo-second-order model ($R^2$=0.9458), and thermodynamic analysis yielded $\Delta H°$= −48.18 kJ/mol, $\Delta S°$= −191.14 J/mol·K, and positive $\Delta G°$ values, indicating an exothermic and non-spontaneous process under standard conditions. The KA–$Cu(TAC)_2$ composite demonstrated superior performance compared to unmodified activated carbon.

**Keywords** : adsorption, EFB activated carbon, Metal Organic Frameworks, kinetics and thermodynamics, PET plastic waste