

INTISARI

Penelitian ini mengembangkan hidrogel berbahan dasar selulosa (CMC-Na dan HEC) sebagai polimer alami dan polimer sintesis (akrilamida, asam akrilat), dengan tambahan silika dari *fly ash* PLTU Paiton, K-humat, dan pupuk NPK untuk aplikasi pertanian berkelanjutan. Sintesis dilakukan melalui reaksi grafting dan *crosslinking* (MBA, APS) pada suhu 70°C, diikuti pengeringan. Karakterisasi meliputi FTIR, pengukuran *swelling ratio* (SR), uji mekanik (UTM), uji germinasi kecambah, dan analisis pelepasan NPK (Kjehdal, UV-Vis, AAS). Hasil FTIR mengonfirmasi terbentuknya ikatan Si-O-Si, gugus karbonil dan interaksi polimer-NPK. *Swelling* terbaik dicapai pada 2% wt/v Na₂SiO₃ (SR=147 g/g) dan 10% v/v K-humat (SR=109 g/g). Komposisi dengan silika+NPK menghasilkan SR=123 g/g, sedangkan kombinasi silika+K-humat+NPK SR=99 g/g. Penambahan silika dan K-humat meningkatkan kekuatan tarik dan ekstensi, serta mempercepat pertumbuhan kecambah (hipokotil dan radikula terpanjang pada perlakuan silika+K-humat). Hidrogel menunjukkan perilaku *slow-release* dengan kumulatif pelepasan konsentrasi N < 5%, P < 10%, K < 0,1% dalam 100 jam. Model kinetika Korsmeyer-Peppas dan Peppas-Sahlin menggambarkan dominasi mekanisme difusi untuk N dan K, serta P.

Kata kunci : Hidrogel; *Fly Ash*; K-humat; Pelepasan NPK

ABSTRACT

This study presents the design and characterization of a composite hydrogel based on natural cellulose derivatives (CMC-Na, HEC) and synthetic polymers (acrylamide, acrylic acid), reinforced with Silika extracted from Paiton PLTU fly ash, potassium humate, and NPK fertilizer for controlled-release agricultural applications. The hydrogel was synthesized via grafting and crosslinking (MBA, APS) at 70°C and subsequently dried. Characterization techniques included FTIR spectroscopy, swelling ratio (SR) measurements, tensile testing, seed germination assays, and NPK release analysis (Kjeldahl, UV-Vis, AAS). FTIR confirmed the formation of Si-O-Si bonds, polymer carbonyl groups, and polymer-NPK interactions. Optimal swelling was observed at 2% wt/v Na₂SiO₃ (SR = 147 g/g) and 10 % wt/v potassium humate (SR = 109 g/g). The formulation with Silika+NPK achieved SR = 123 g/g, while Silika+humate+NPK reached SR ≈ 99 g/g. The addition of Silika and humate enhanced tensile strength and elongation, and significantly promoted seedling growth (longest hypocotyl and radicle under Silika+humate treatment). Release studies demonstrated a slow-release profile of concentration cumulative release of N < 5%, P < 10%, K < 0,1% over 100 hours. Kinetic modeling using Korsmeyer-Peppas and Peppas-Sahlin models indicated diffusion-controlled release for N and K, and P.

Keywords : Hydrogel; Fly Ash; K-Humate; NPK Release