

Sustainable Fertilizer Strategies Using Nanocellulose-Based Nutrient Capture Materials

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Approximately 140 Gt of agricultural biomass is wasted annually, contributing to environmental pollution. However, this also presents a substantial opportunity to create functional biomaterials by extracting lignocellulosic polymers or using biotechnological methods to produce bacterial cellulose. This research investigates two hydrogel materials designed to capture nutrients from wastewater and serve as reservoirs for reuse in agriculture as fertilizers. These materials—based on TEMPO-oxidized cellulose nanofibers (TOCNB) and peracetic acid-oxidized bacterial nanocellulose modified with magnetite and reinforced with gelatin and glutaraldehyde (POBN-Fe₃O₄-Gel-GA)—were developed to adsorb ammonium from municipal wastewater. Structural analyses via XRD, FTIR, and SEM confirmed the successful synthesis of the biocomposites. UV-Vis spectroscopy showed an ammonium adsorption capacity of around 30 mg/g, affected by pH, ionic strength, and contact time, with optimal results at pH 7–8 and 25°C. Bean germination tests revealed that ammonium-loaded materials supported plant growth similar to commercial urea, highlighting their potential as controlled-release biofertilizers and their role in promoting a circular economy.