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INVESTIGATION ON HYDROGEL-BASED SLOW-RELEASE FERTILIZER  
INCORPORATED WITH SiO<sub>2</sub> NANOPARTICLE AT DIFFERENT  
CONCENTRATIONS

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**INVESTIGATION ON HYDROGEL-BASED SLOW-RELEASE  
FERTILIZER INCORPORATED WITH SiO<sub>2</sub> NANOPARTICLE  
AT DIFFERENT CONCENTRATIONS**

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## ABSTRACT

### INVESTIGATION ON HYDROGEL-BASED SLOW-RELEASE FERTILIZER INCORPORATED WITH SiO<sub>2</sub> NANOPARTICLE AT DIFFERENT CONCENTRATIONS

Conventional fertilizers released nutrients too rapidly, which could exceed plant uptake and contribute to waste. The reliance on these fertilizers also degraded soil structure, impacting root growth. Hydrogels emerged as a solution by improving water and nutrient retention, ensuring more stable agricultural productivity and promoting sustainable farming practices. This study aimed to develop and evaluate cellulose-based hydrogels incorporated with varying concentrations of silica dioxide (SiO<sub>2</sub>) nanoparticles for potential application as controlled-release phosphate fertilizers. FTIR analysis confirmed the successful incorporation of SiO<sub>2</sub> within the cellulose matrix, while water uptake tests demonstrated a decline in water uptake capacity with increasing nanoparticle content. Nutrient release analysis revealed that increasing SiO<sub>2</sub> loading from 1 to 5 wt.% has resulted in lower phosphate release. A higher SiO<sub>2</sub> loadings particularly at 5 wt.%, effectively minimized phosphate released by restricting water diffusion and nutrient mobility within the hydrogel network. Moreover, the phosphate release profile was pH-dependent, with faster phosphate release observed under acidic conditions (pH 4) compared to neutral conditions (pH 7). The cumulative phosphate release at pH 4 was considerably higher than at pH 7, demonstrating the pH-responsive behavior of the hydrogel system. These findings suggest that SiO<sub>2</sub>/cellulose-based hydrogels are promising and sustainable alternative for agricultural applications, capable of enhancing nutrient efficiency and tailoring nutrient release according to pH conditions.