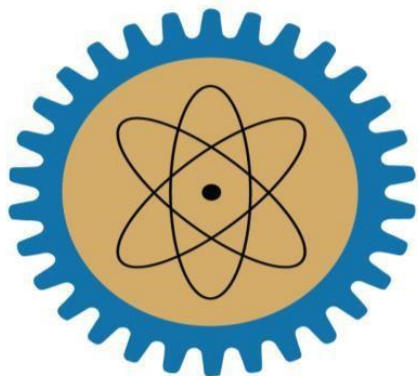




**BUSITEMA
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Pursuing Excellence

**FACULTY OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF POLYMER, TEXTILE AND INDUSTRIAL
ENGINEERING**

**Magnetite Nano-Catalyst Enhanced Microbial Pretreatment of Banana
Pseudostem for Improved Biogas Production.**

By

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ABSTRACT

The recalcitrant lignocellulosic structure of banana pseudostem limits its biogas yield, necessitating effective pretreatment. This study optimized nanocatalytic microbial pretreatment using magnetite (Fe_3O_4) nanoparticles and *Pleurotus ostreatus* to enhance delignification and subsequent biogas production from Ugandan banana pseudostem biomass. Physicochemical characterization revealed moisture content of 89.75%, volatile solids of 75.1% of total solids, a C/N ratio of 41.0, and lignocellulosic composition of 35.5% cellulose, 20.1% hemicellulose, and 13.2% lignin. Magnetite nanoparticles crystallite size 100 nm, showing spherical to octahedral morphology were synthesized via co-precipitation, and *P. ostreatus* inoculum 3.2 g/L dry mycelium was cultured. Central Composite Design optimization established optimal pretreatment conditions of 3.09% w/w magnetite and 13.14% v/w microbial inoculum, achieving 79.7% delignification with a statistically significant synergistic interaction ($p < 0.05$). Fourier Transform Infrared spectroscopy confirmed lignin peak reduction at 1510 cm^{-1} and 1240 cm^{-1} , while X-ray diffraction and scanning electron microscopy validated structural disruption and increased surface porosity. The combined pretreatment produced 0.01997 m^3 biogas per 100 g dry biomass which is 47% increase over untreated controls, with methane content of 68.3% and methane yield of $0.00018\text{ m}^3\text{ CH}_4/\text{g VS}$. Kinetic analysis using the modified Gompertz model revealed shorter lag phase of 2 days and higher maximum production rate $0.00416\text{ m}^3/\text{day}$, confirming accelerated hydrolysis. The combined pretreatment achieved 59% of the theoretical maximum biogas yield. This green pretreatment technology, integrating nanocatalysis with fungal delignification, offers a sustainable pathway for valorizing banana agricultural residues into renewable energy, with direct applicability to existing fiber decortication operations.

Keywords: Anaerobic digestion, banana pseudostem, biogas, delignification, magnetite nanoparticles, *Pleurotus ostreatus*, response surface methodology