***The use of engineered biochar to manufacture alternative phosphorus fertilizer derived from recycled sources***

## Introduction

Phosphorus (P) is a critical nutrient for agricultural productivity, but its overuse in chemical fertilizers leads to environmental issues such as eutrophication. This project aims to develop modified biochar as a sustainable solution for phosphorus recovery from wastewater and its application as a slow-release fertilizer. By leveraging biochar's adsorptive properties and modifying its structure, this research seeks to address nutrient recycling challenges while reducing environmental impacts.

## Objectives

1. Investigate the structural and chemical properties of biochar and its modifications.
2. Assess the efficiency of modified biochar in phosphorus adsorption from wastewater.
3. Evaluate the potential of phosphorus-loaded biochar (BC-Fe-P) as a slow-release fertilizer in agricultural applications.
4. Compare the performance of BC-Fe-P with conventional fertilizers in terms of nutrient release and environmental sustainability.

## Methodology

### 1. Biochar Modification

- Activation techniques such as steam, acid, and alkaline treatments will be used to enhance porosity, surface area, and functional groups.
- Composite formation will involve impregnation with metal oxides (e.g., goethite), clays, or organic compounds to improve adsorption capacity.

### 2. Phosphorus Adsorption Studies

- Wastewater derived from municipal sludge dehydration will serve as the phosphorus source.
- Adsorption experiments will optimize conditions (e.g., pH, concentration) to maximize phosphorus loading.
- Freundlich and Langmuir models will be applied to analyze adsorption behavior and determine maximum loading capacity.

### 3. Characterization Techniques

- Scanning Electron Microscopy (SEM) and Energy Dispersive Spectroscopy (EDS) will assess surface morphology and elemental composition.

- Fourier Transform Infrared Spectroscopy (FTIR) will confirm functional group changes and successful phosphorus adsorption.

**4. Soil Incubation Tests**

- Simulated field conditions will evaluate phosphorus release from BC-Fe-P compared to conventional fertilizers like superphosphate.
- The P-Olsen method and Molybdenum Blue test will measure phosphorus availability over time.

**5. Sequential Extraction Tests**

- Desorption kinetics will be studied to understand phosphorus release rates and compare them with reference materials.

**Expected Outcomes**

1. Development of modified biochar with enhanced phosphorus adsorption capacity.
2. Demonstration of BC-Fe-P as a slow-release fertilizer that reduces phosphorus leaching risks.
3. Validation of nutrient recycling from wastewater as an environmentally sustainable practice.
4. Identification of optimal modification techniques for biochar production.

**Future Directions**

- Conduct pot trials with plants to evaluate the agronomic performance of modified biochars.
- Explore alternative materials for biochar modification and pre-treatment methods before pyrolysis.
- Scale up production processes for practical agricultural applications.

**Significance**

This project addresses critical challenges in nutrient management by integrating wastewater treatment with sustainable agriculture. By developing a cost-effective, eco-friendly alternative to chemical fertilizers, it contributes to circular economy principles while mitigating environmental risks associated with phosphorus overuse.