Abstract:

Converting Biomass Waste into Sustainable Fertilizer through Struvite Recovery

Sustainable fertilizers play a crucial role in addressing global food security challenges while minimizing environmental impact. While traditional fertilizers, though effective in promoting crop growth, contribute to soil degradation, water pollution and greenhouse gas emission, sustainable alternatives offer benefits like improved soil health, reduced environmental impact and enhanced nutrient cycling. Among these alternatives, struvite recovery from waste materials is a promising approach. Struvite is a natural mineral with composition $NH_4PO_4Mg \cdot 6H_2O$, which can be precipitated from wastewater or liquid biomass waste and used as slow-release fertilizer.

Herein, the precipitation of struvite was tested in combination with the well-established process of anaerobic digestion, able to convert organic wastes into biogas, a green energy source, and digestate, rich in nitrogen (N) and phosphorous (P). Struvite was efficiently precipitated from the digestate liquid fraction of two different biomass types: livestock waste and the organic fraction of municipal solid waste.

When the digestate is separated into solid and liquid fraction, P tends to accumulate in the solid, while to be recovered as struvite it must be solubilized and transferred to the liquid part. Various physical and enzymatic pre-treatments were hence applied on the starting substrate before anaerobic digestion, aiming to solubilize the organic phosphorous and promote biogas production. Hydrodynamic cavitation strongly promoted P solubilization, and the performance of this process was even improved when followed by the addition of the enzymes for organic matter degradation (cellulase, hemicellulase and protease) and organic phosphate hydrolysis (phosphatase and phytase). The pre-treatments also increased biomethane production during anaerobic digestion.

High quality struvite was achieved from the digestate liquid fraction of the two biomass wastes, presenting high purity and relatively low carbon content. The slow-release capacity of the two products was evaluated and compared in different conditions. Overall, these are promising results for the application of this process in circular systems for the recovery of N and P and the reduction of nutrient losses in the environment.

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