EFFECT OF STEPWISE FEEDING OF PIG SLURRY DURING ANAEROBIC DIGESTION ON STRUVITE CRYSTALLIZATION: A PILOT-SCALE WASTE BIOREFINERY.

N.I. Kallikazarou[1], I.A. Fotidis[2], L. Koutsokeras[3], D.A. Kokkinidou[3], C. Michael[4], E. Constantinide[5], G. Constantinides[3], A.S. Anayiotos[3], G. Botsaris[4], and M.G. Antoniou[1,*]

[1]Department of Chemical Engineering, Cyprus University of Technology, P.C 3036, Limassol, Cyprus

[2]Department of Environment, Ionian University, P.C. 29100 Zakynthos, Greece

[3]Department of Mechanical Engineering and Materials Science and Engineering, Cyprus University of Technology, P.C. 3036, Limassol, Cyprus

[4]Department of Agricultural Sciences, Biotechnology and Food Science, Cyprus University of Technology, P.C 3036, Limassol, Cyprus

[5]Department of Environment, Ministry of Agriculture, Rural Development and Environment, P.C 2025, Strovolos, Nicosia, Cyprus

* *maria.antoniou@cut.ac.cy*

ABSTRACT

High ammonia concentrations (>3 g NH_4^+-N L^{-1}) released from the degradation of organic wastes rich in nutrients (nitrogen (N) and phosphorus (P)) could lead to suboptimal biogas production during anaerobic digestion (AD)[1]. In addition, globally, nutrient-rich digestate effluents are still discarded in agricultural land[2], releasing nutrients into the environment with adverse effects including the pollution of surface (eutrophication) and groundwater, emissions of greenhouse gases, and soil erosion, that in return impact human health. This study aimed to assess and advance the integrated scheme of nutrient recovery in the form of struvite, and of energy formation as biogas from livestock waste. Struvite is a crystalline mineral, which constitutes a slow-release high-value fertilizer, containing equal molar concentrations (1:1:1) of magnesium, ammonium, and phosphate ($MgNH_4PO_4 \cdot 6H_2O$), that can be recovered from nutrient-rich wastewater[3]. Biogas is a renewable fuel, that can be produced by the biodegradation of organic matter. The effect of a specific feeding strategy during AD on the crystallization of struvite from pig slurry at pilot scale was first investigated, while a microbial tracking study was also conducted on this experiment. The results showed that the stepwise feeding of the substrate to the digester alleviated ammonia inhibition. Experimentally measured methane production efficiency reached approximately 90% of the theoretical production, thus indicating a stable anaerobic digestion process. The produced struvite was of very high purity (> 95 w/w) (XRD using RIR method). SEM analysis revealed the production of typical struvite crystals such as orthorhombic. The obtained XRF spectra indicated that heavy metals were within the acceptable regulatory limits. No carcinogens were detected (PAHs, and Cr^{6+}). Finally, pathogens such as *Salmonella* spp. *and Escherichia coli*, were absent (Regulation (EU) 2019/1009). All of the above, indicate the production of a high purity product, safe to use in agriculture and horticulture. To conclude, this integrated innovative process for recovering energy and nutrients from pig slurry can lead to high biogas yield and the production of high-purity struvite organo-mineral fertilizer, thus minimizing nutrient losses, safeguarding the declining phosphate rock, and making this process energy independent.

KEYWORDS: nutrients, anaerobic digestion, struvite, biogas, pilot scale

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