Nitrogen recovery from agro-industrial and urban sludges by struvite precipitation in a strategy to overcome methane production inhibition by ammonium nitrogen

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1. Introduction –The most recent trend in wastewater treatment processes is to foster bottom-up synergies in order to move forward resources recovery towards a circular economy. In this regard, manure and slurries produced by animal breeding farms are accessible sources for bioenergy recovery. However, their high ammonium nitrogen content may inhibit biomethanation processes and energy output. Another environmental burden concerns the excess sludge from decentralised urban wastewater treatment plants (WWTP) because sustainable land disposal is difficult to achieve, even in some rural regions. The precipitation of magnesium ammonium phosphate (struvite, $MgNH_4PO_3.6H_2O$) is mostly applied as an anaerobic digestion post-treatment process. However, the present research follows an alternative perspective: the study aimed at advancing the knowledge on controlled struvite precipitation prior to the biomethanation process. The goal is to reduce biological inhibition constraints related to C/N unbalance and to facilitate further energy recovery from co-digestion of human excreta and animal wastes. Therefore, in a nitrogen rich system and using two sources of magnesium (marine salt and $MgCl_2$), bioassays were carried out in order to test the effect of different molar ratios (NH_4^+: Mg – 1:3 and 1:1.5). Furthermore, the chemical composition of precipitates was assessed.

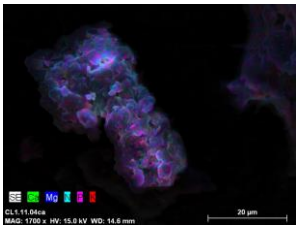

Figure 1. Agglomerated amorphous crystal

2. Experimental – The struvite precipitation experiments were carried out using a mixture of cattle manure from a dairy farm and waste sludge from a small domestic wastewater treatment plant. The experiments were performed using batch reactors with a working volume of 296 mL of cattle manure and sewage sludge (1:1; v/v). The pH was adjusted to 8.5 by dropwise addition of NaOH (1M) and then, the sources of magnesium were added. The batch reactors were placed in a orbital incubator at temperature of 35°C and under stirring of 150 rpm. The experiments were carried with a reaction period of 1 hour and, thereafter, the solution was allowed to settle for 30 minutes. The elemental composition of the precipitates was performed with a SEM-EDS and the crystals characterization by X-ray diffraction.

3. Results and Discussion - The initial volatile solids content for all assays was 10.74 ± 0.04 g L^{-1}. At the tested conditions, P- PO_4^{3-} and N-NH_4^+ were precipitated with a maximum observed efficiency of 27% and 70%, respectively. The SEM-EDS and XRD analysis confirmed the presence of pure struvite ($NH_4MgPO_4.6H_2O$) and potassium struvite ($KMgPO_4 \cdot 6H_2O$) and suggests the presence of amorphous crystals of magnesium and calcium containing species in the precipitates (Figure 1).

4. Conclusions - Nitrogen and phosphorus recovery from domestic and agro-livestock sludges by chemical precipitation is a sustainable approach in a circular economy framework. Besides, when ammonium drives anaerobic processes inhibition, struvite removal may be positive. The results point that struvite pre-treatment of a mixture of animal organic wastes and domestic sludge is a feasible option in rural areas for in-situ fertilizer production and to enhance further bioenergy recovery processes.