DRY TOILET CONFERENCE 2018

Nutrients 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

- How can we optimize the oversized anaerobic municipal wastewater treatment systems?
- Can the struvite precipitation in the circular economy to valorize the anaerobic digestate?
- Is the struvite precipitation a feasible option in rural areas for in-situ fertilizer production?
- Can it enhance further bioenergy recovery processes?

1. INTRODUCTION

Struvite precipitation pre-treatment

chemical precipitation resulting from the stoichiometric addition, or in excess, of magnesium.

- Improving the energy recovery;
- Increasing the mineral resources recovery;
- Enriching the recycled fertilizer;
- Boosting the nutrients economy

2. OBJECTIVES

Objectives :

- to optimize the biological treatment of domestic excreta and animal wastes overcoming C/N imbalancing;
- to increase estruvite (*N,K,Ca–struvite*) production and to reduce the mineral fertilizer requirements in agriculture;
- to contribute to an integrated solution of energy valorization and nutrients recovery at local level.

3.MATERIALS AND METHODS

Struvite precipitation pre-treatment: Operation conditions

Assay 1 : Control

- Temperature: 35 º C
- mixing: 120 rpm
- HRT: 2hours

Assay 2: $MgCl_2$ / NH_4^+: Mg 1:3

- Temperature : 35 º C
- mixing: 120 rpm
- HRT: 2hours

Assay 3:$MgCl_2$ / NH_4^+: Mg 1:1,5

- Temperature : 35 º C
- mixing: 120 rpm
- HRT: 2hours

Assay 4:Sea Salt / NH_4^+: Mg 1:1,5

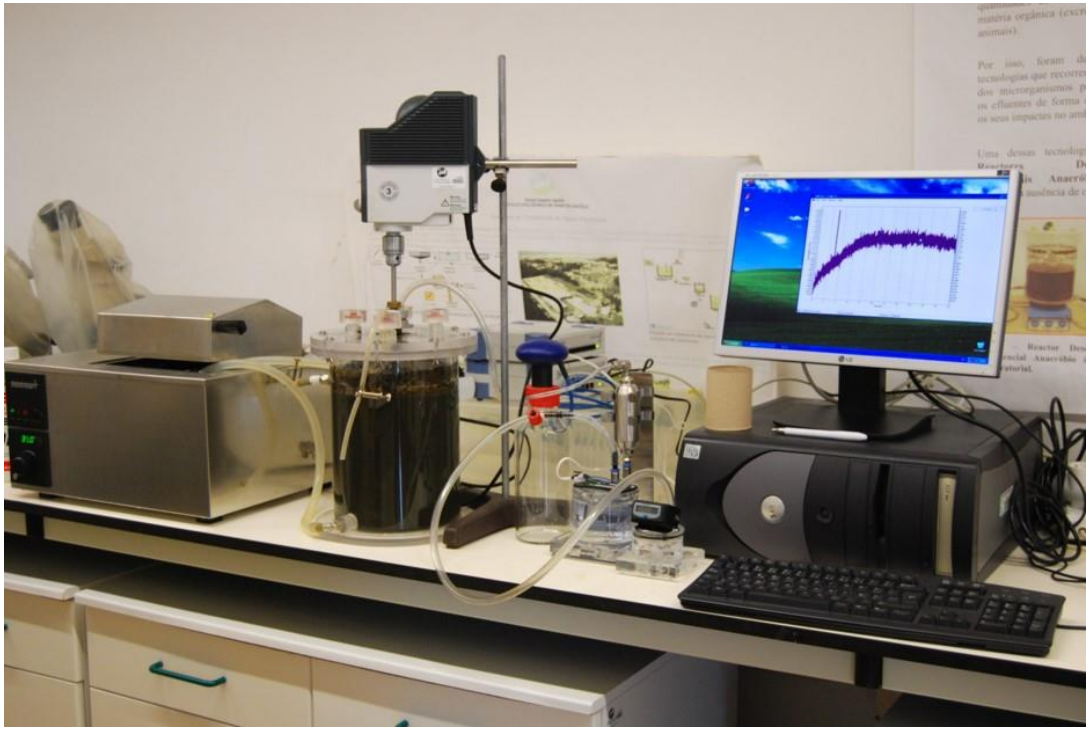
- Temperature : 35 º C
- mixing: 120 rpm
- HRT: 2hours

Monitoring parameters

pH, electric conductivity, solids, ammonium nitrogen, phosphorus.

3.MATERIALS AND METHODS

Anaerobic Sequencing Batch Reactor (ASBR): Experimental set-up

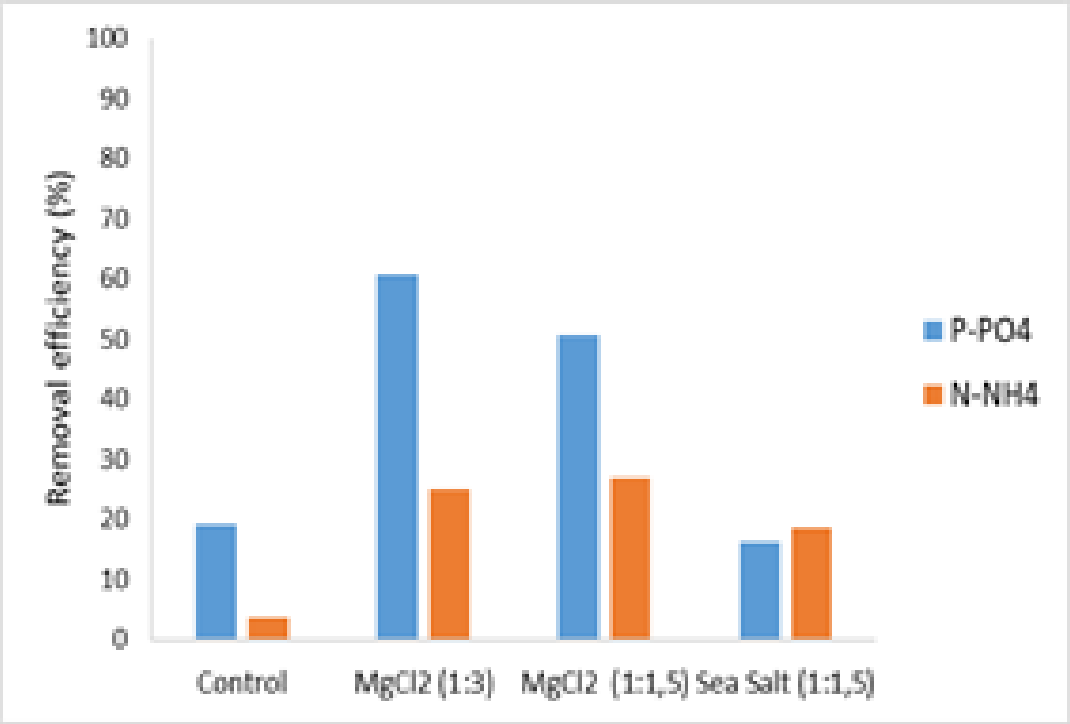


4 RESULTS

Chemical characterization

Parameters	Sewage Sludge	Cattle manure
$N\text{-}NH_4$ (mg L^{-1})	924.0 ± 14.00	1288.0 ± 28.00
PO_4^{3-} (mg L^{-1})	731.9 ± 6.74	293.1 ± 5.66
TKN (mg L^{-1})	3193.6 ± 0.00	3483.1 ± 42.79
pH	7.1	7.7
TVS (g L^{-1})	4.3 ± 0.02	8.0 ± 0.25
TS (g L^{-1})	14.1 ± 0.20	19.5 ± 0.55
VSS (g L^{-1})	3.1 ± 0.30	1.2 ± 0.00
COT (g L^{-1})	2.4 ± 0.01	4.4 ± 0.14
C:N	0.8	1.3

4 RESULTS



Effect of magnesium source and the proportion NH_4^+ : Mg^{2+} on the P-PO_4 and N-NH_4 removal efficiency.

- $MgCl_2$ 1:3 and 1:1,5: N-NH_4 removal of 25% and 27%;
- $MgCl_2$ 1:3 and 1:1,5: P-PO_4 removal of 61% and 51%;
- $MgCl_2$ 1:1,5: N-NH_4 and P-PO_4 removal of 27% and 51%;
- Sea Salt 1:1,5: N-NH_4 and P-PO_4 removal of 18% and 16%;

4 RESULTS

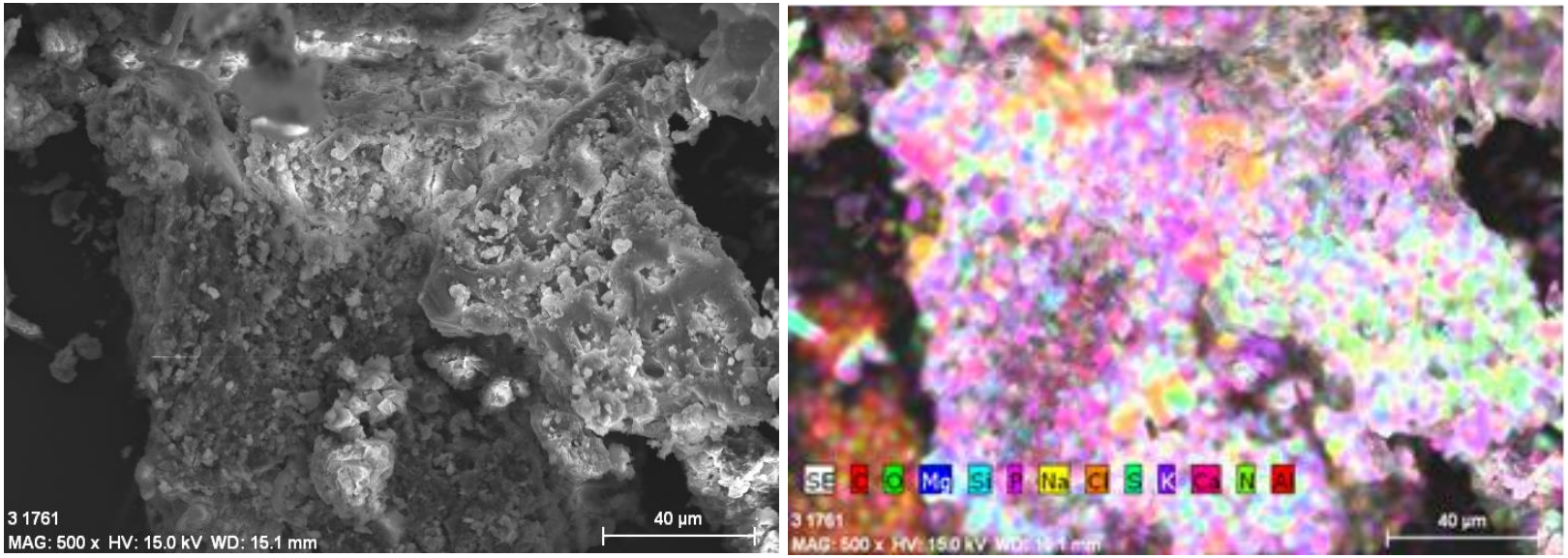
Characterization of the supernatants and precipitates in terms of P-PO4 and N-NH4

	$P\text{-}PO_4$ (mg L^{-1})		$N\text{-}NH_4$ (mg L^{-1})	
	Precipitate	**Supernatant**	**Precipitate**	**Supernatant**
Control	1007 ± 1	647 ± 154	1232 ± 192	1183 ±109
$MgCl_2$ (1:3)	668 ±113	79 ± 17	756 ± 53	630 ± 99
$MgCl_2$ (1:1,5)	668 ± 32	403 ± 47	1061 ± 134	945 ± 148
Sea Salt (1:1,5)	793 ± 66	450 ± 1	1033 ± 25	1001 ± 30

- The lowest content of $P\text{-}PO_4$ and $N\text{-}NH_4$, was found in the precipitates and supernatants of the assay where $MgCl_2$ was used in a proportion of NH_4^+:Mg^2 1:3.
- It may suggest that both dissolved phosphorus and nitrogen may have been recovered and converted to magnesium containing species

4 RESULTS

SEM- EDS analysis

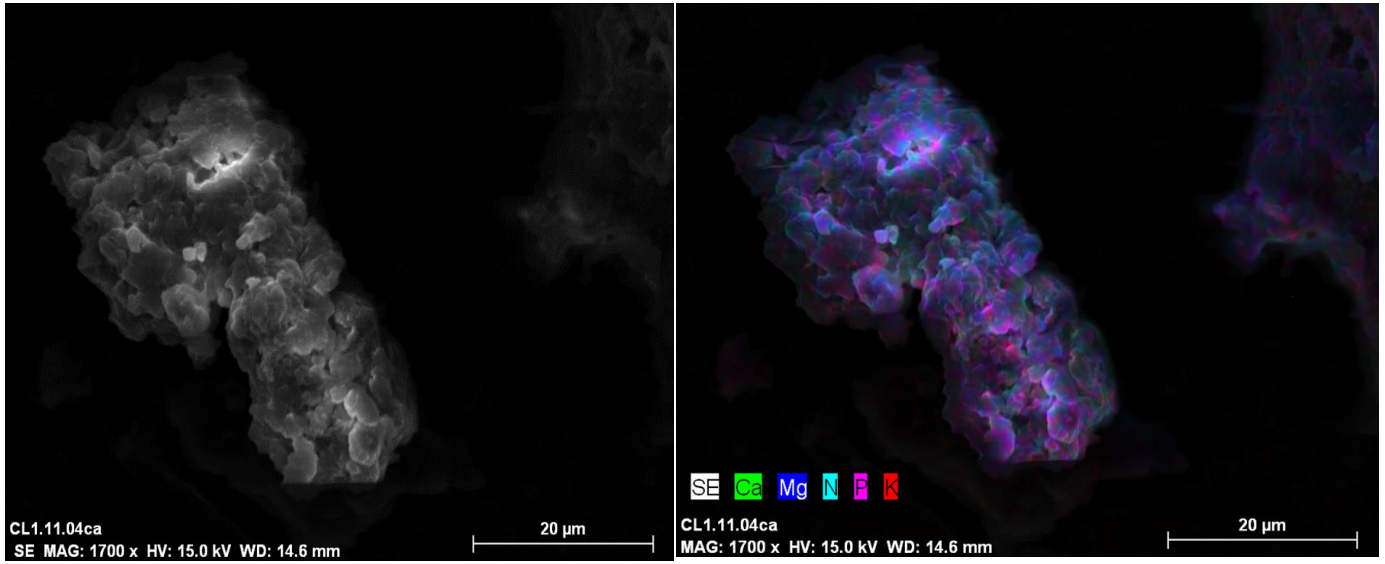


Control assay sample.

- heterogeneity is a challenge;
- high quantity and diversity of solids content

4 RESULTS

SEM- EDS analysis

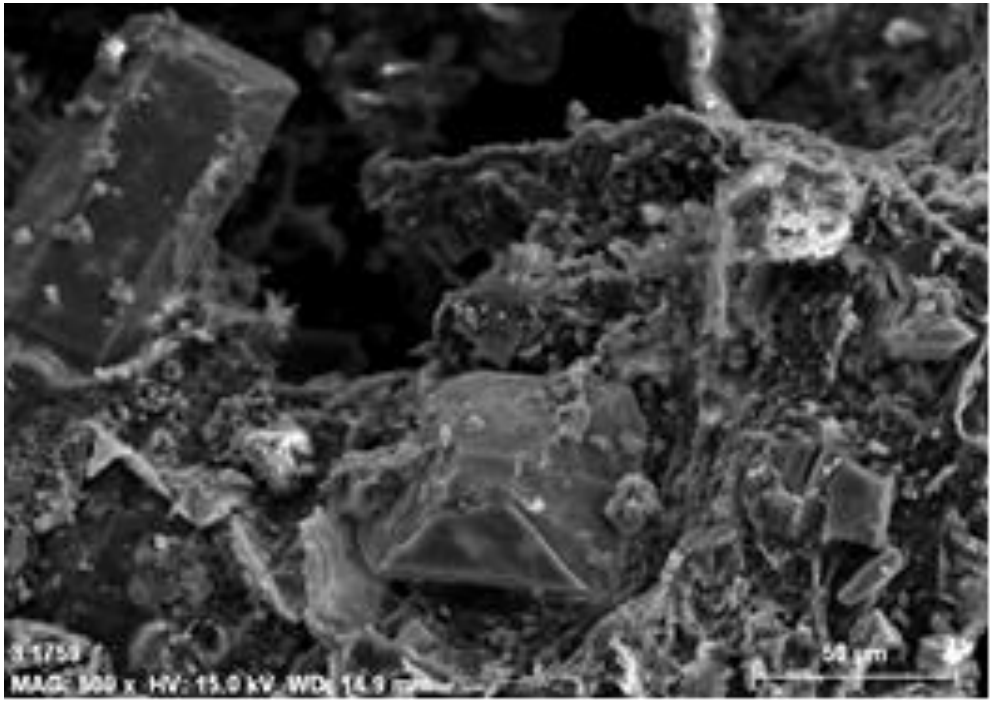


Agglomerated amorphous crystals in the MgCl2 (1:3) assay

The elemental composition shows oxygen (46%), carbon (27%), magnesium (11%), nitrogen (4%), phosphorus (9%) and potassium (2%).
It could be potassium struvite or calcium struvite.

4 OPERATIONAL RESULTS

SEM- EDS analysis

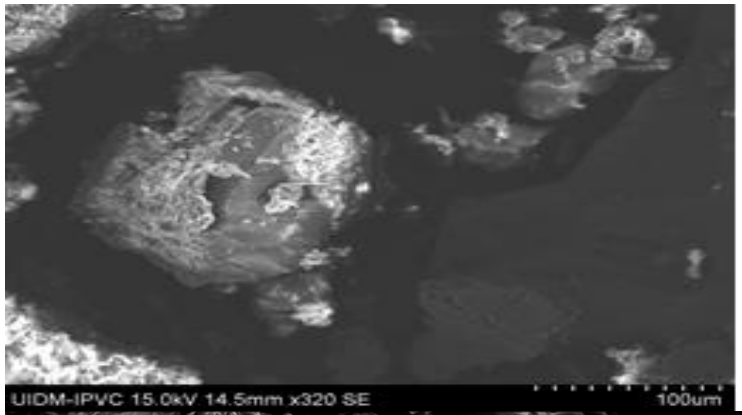


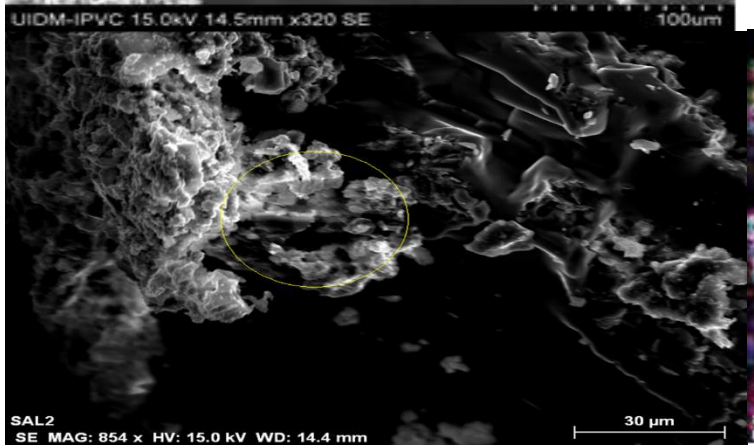
Crystal in the MgCl2 (1:1.5) assay

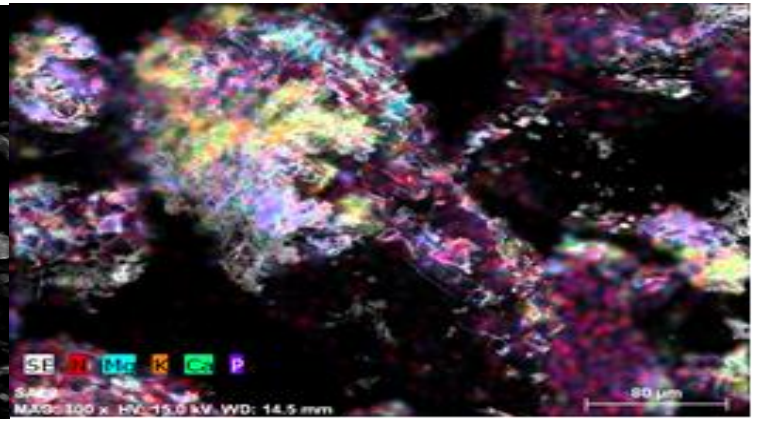
The elemental composition reveals the presence of oxygen (43%), nitrogen (3%), magnesium (12%), phosphorus (13%) and potassium (0.3%).

4 OPERATIONAL RESULTS

SEM- EDS analysis



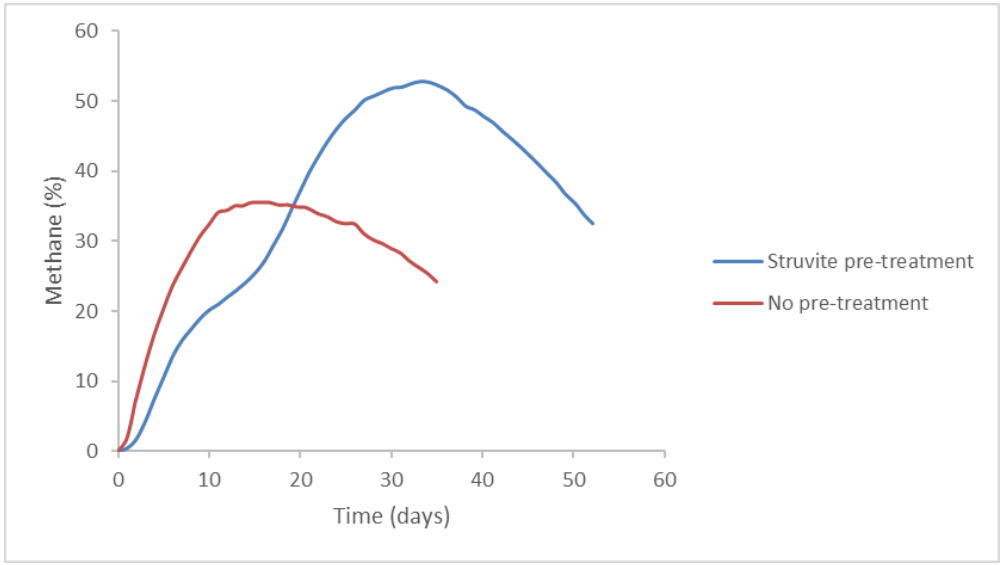




The elemental composition shows the presence of oxygen (22%), nitrogen (4%), magnesium (2%), phosphorus (2%), potassium (2%), sodium (5%) and sulfur (2%).

Crystal land amorphous compounds in the marine salt (1:1.5) assay

4 OPERATIONAL RESULTS



Profile of methane production

- methane content increase in 34%, approximately, when the struvite precipitation pre-treatment is applied.
- the quality of the fertilizer in terms of nutrients enrichment is enhanced (K, Ca, N, P and Mg)

5. CONCLUSIONS

- The application of struvite precipitation (*K, Ca, N-struvite*) pre-treatment to the domestic excreta and animal wastes may optimize the anaerobic codigestion process in terms of:

i) Nutrients recovery (K, Ca, N, P, Mg);

ii) Fertilizer enrichment (*K, Ca, N- struvite*);

iii) Increase of methane content improving the self sufficiency of the biological processes.

- Struvite precipitation is a feasible option in rural areas for in-situ fertilizer production and to enhance further bioenergy recovery processes.

Thank you!!

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