CUT Pilot Plant

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RE-LIVE WASTE

Struvite

- Crystalline mineral salt with equal molar concentrations of magnesium (Mg), ammonium (NH_4^+), and phosphates (PO_4^{3-}).
  - **$MgNH_4PO_4 \cdot 6H_2O$**
- Slow nutrient releaser.
- Not easily washed-out with rain.
- Insect repellant.
- Struvite crystals are in the orthorhombic.
- Color depends on the constituents used during production:
  - water, wastewater type, magnesium source.
  - White, yellowish, brownish-white, or grey.

SEM image of orthorhombic struvite crystals

Bottom of the bottle with synthetic struvite

Struvite from CUT pilot

Flotats X. et al., *Monografías de actualidad*,65, (2001), 51

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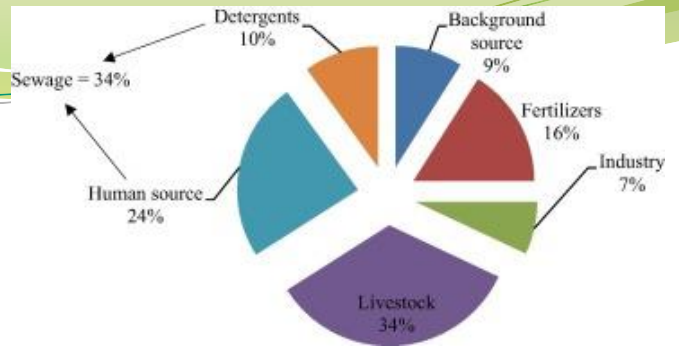
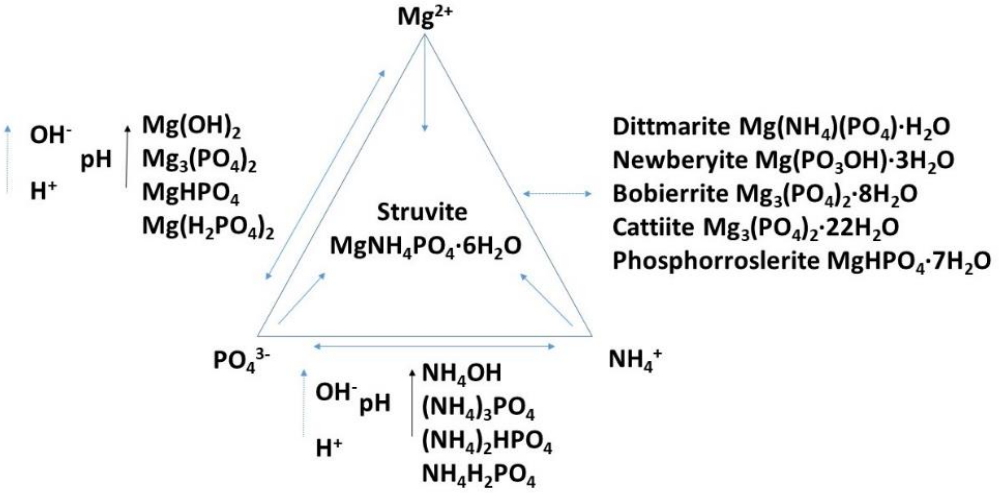
Struvite Precipitation

- Matrix:
  - Municipal wastewater (sewage)
  - Livestock waste (treated or untreated)
    - Swine
    - Poultry
    - calf
  - Industrial wastewater
  - Dairy wastewater
  - Agro-industrial wastes



Sources of P in the wastewaters



Tansel B. et al., *Chemosphere*,194,(2018), 504

- $Mg^{2+} + NH_4^+ + PO_4^{3-} + 6H_2O \rightarrow MgNH_4PO_4 \cdot 6H_2O\downarrow$ (alkaline conditions)

- Addition of a Magnesium source is needed to optimize the struvite crystallization process.

Rahman, M.Md et al., Arabian Journal of Chemistry, 7 (2014) 139-155

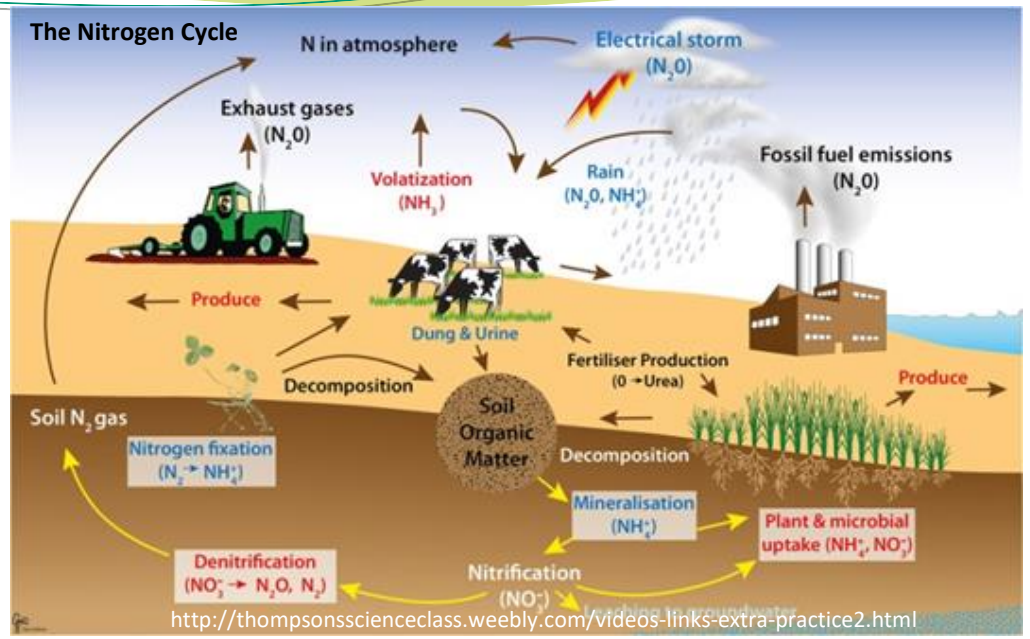
Advantages and disadvantages of struvite

ADVANTAGES:

- Struvite production from livestock waste is a sustainable solution for nutrient recovery.
  - Synthetic mineral fertilizers are produced from phosphates rocks, which are depleting.
- Compliance with Nitrates Directive 91/676/EEC.
- Struvite, in the granular from, is a slow-release fertilizer
  - Slow release of nitrogen (N) and phosphorus (P) are enhance the plants' growth at different stages.
- Struvite produced from wastewater streams contributes to the reduction of greenhouse gases emissions, pollution of surface (eutrophication), and groundwater, and soil fertility problems.

DISADVANTAGES:

- Struvite produced from wastewater streams may contain heavy metals, PCBs, PAHs, hormones, pesticides.
  - Pretreatment of the wastewater stream used for its production is of great significance.



Phosphate rock

Soil acidification

Eutrophication

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Location of CUT Pilot

- Location: Armenis Nicos & Sons Ltd, Monagroulli, Lemesos
- Livestock farming activities: 35,000 pigs/yr
- Biogas plant

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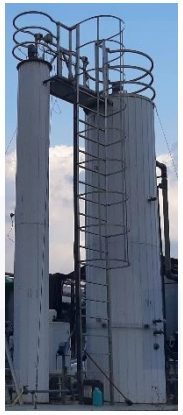
The CUT Pilot

Mixing and Homogenization Tank

Compost Unit

Bio-trickling filter

Biofilter



Dark Fermentation (DF) and Anaerobic Digestion (AD)

Struvite Crystallization Reactor (SCR)

Filter Bags

UF Ceramic Membrane

short cut Sequencing Batch Reactor (scSBR)

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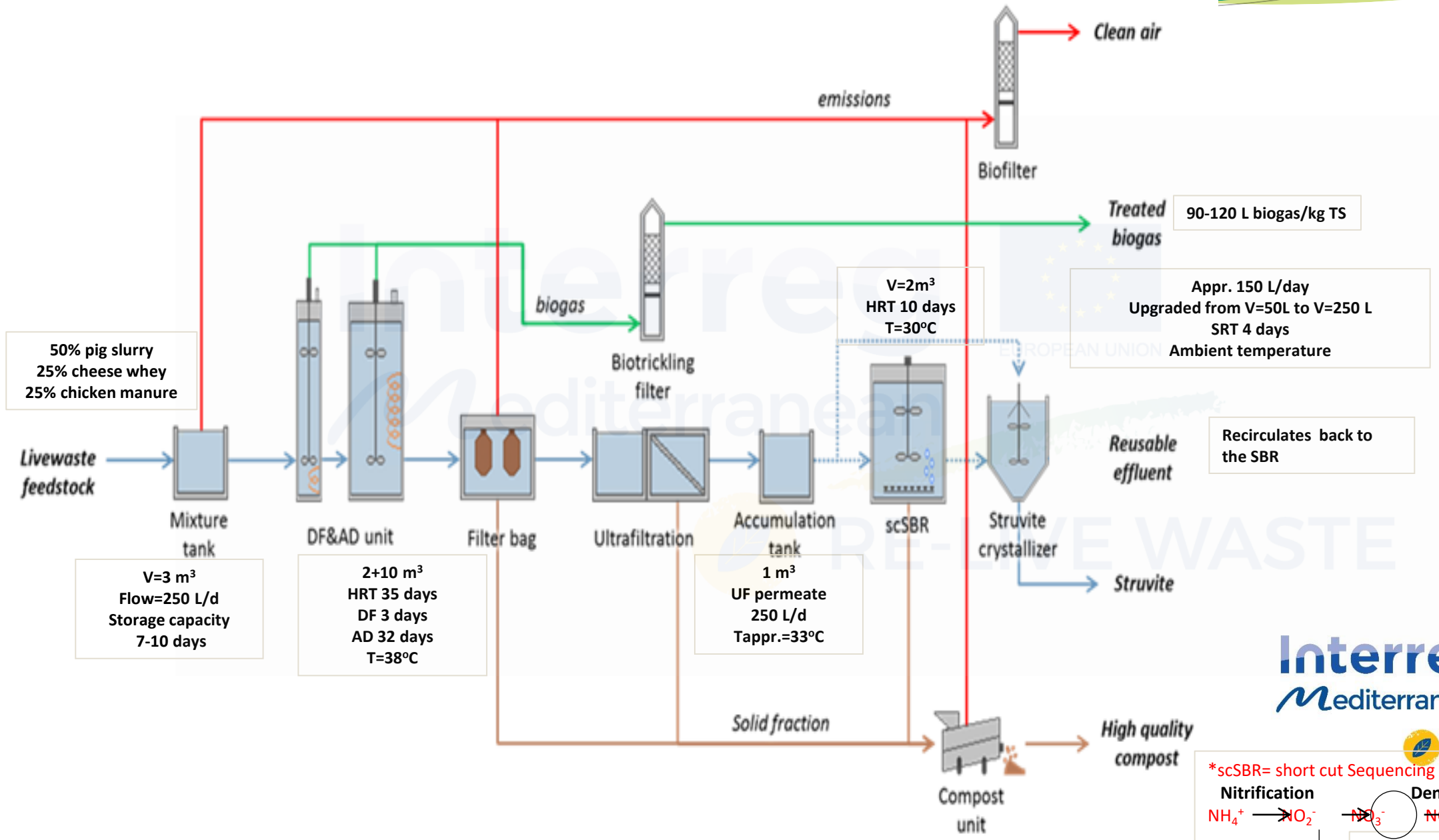
PILOT PLANT PROCESSES



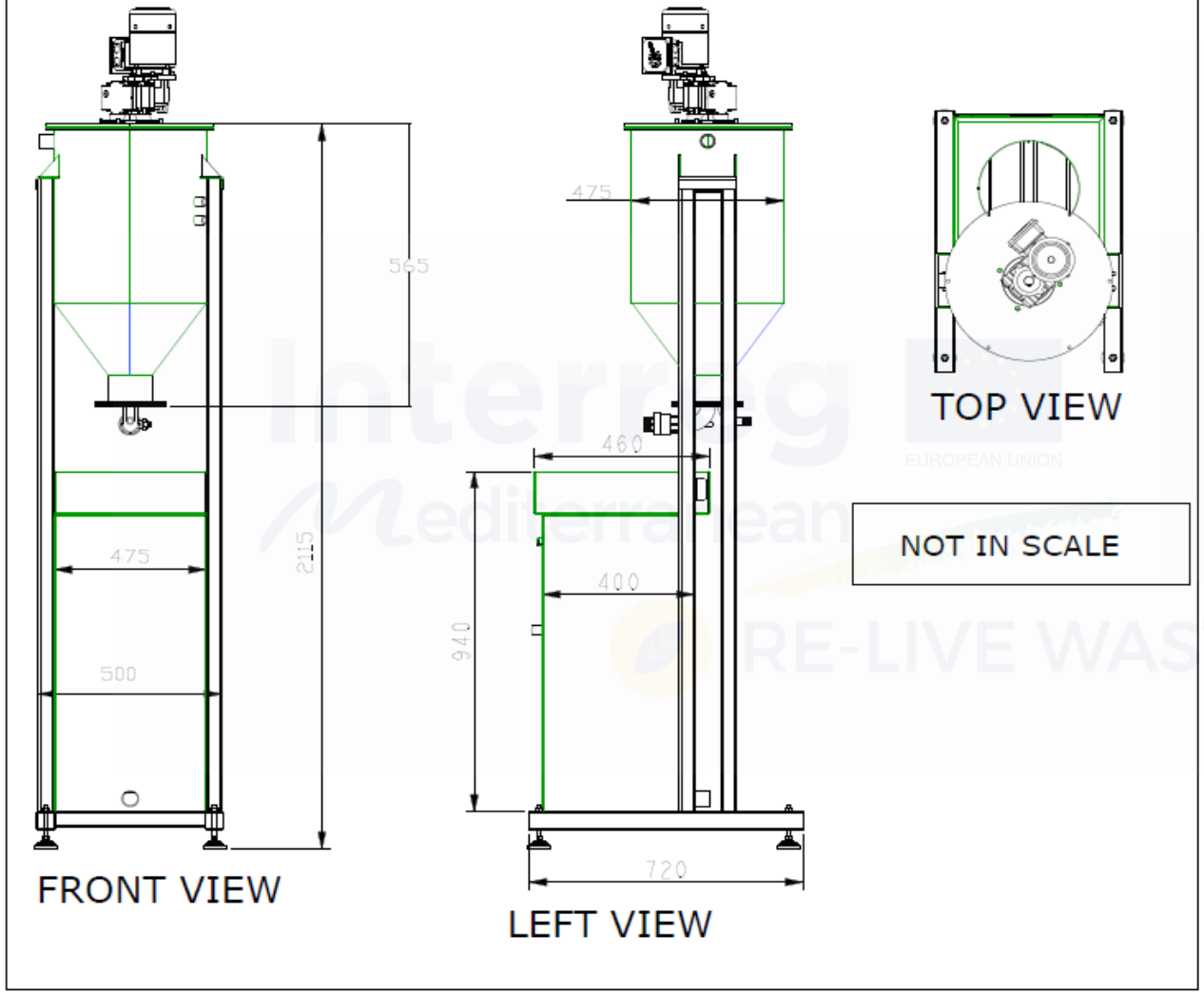
*scSBR= short cut Sequencing Batch Reactor

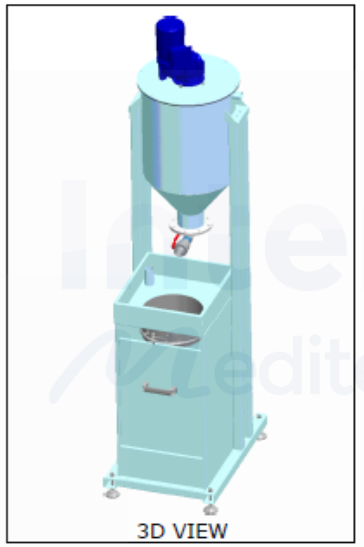
Nitrification **Denitrification**

$NH_4^+ \rightarrow NO_2^- \rightarrow NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2 \rightarrow$

Pathway

CUT Pilot Upgrade





Interreg Mediterranean - RE-LIVE WASTE

RE-LIVE WASTE- Improving innovation capacities of private and public actors for sustainable and profitable REcycling of LIVEstock WASTE

Responsible Partner
SERECO BIOTEST S.a.s.

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Rev.	01	041218

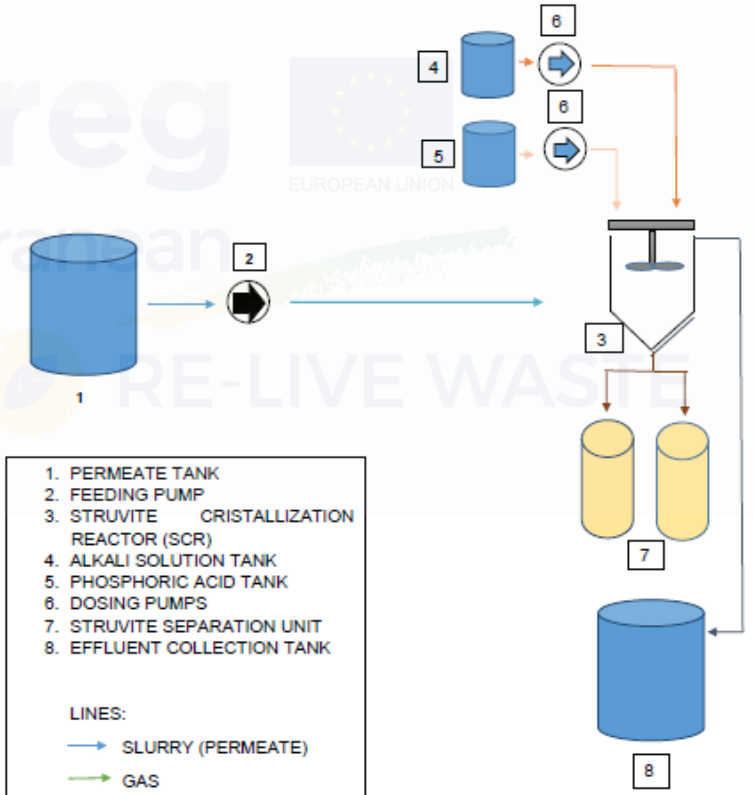
File: CY_RD_041218_rev 01.dgw

TITOLO
DESIGN AND FABRICATION OF INTEGRATED SYSTEM FOR THE TREATMENT OF LIVESTOCK WASTE
Reactor drawing - Optimization

Elaborato: CY_RD_041218_rev 01

RIF	1° emissione	Disegnato	Verificato	Approvato	Riferimento	Scala
CY	041218	RP	AT	LP	CYPRO	FS

DIAGRAM FLOW SCP
(STRUVITE CRYSTALLIZATION PLANT)



1. PERMEATE TANK
2. FEEDING PUMP
3. STRUVITE CRISTALLIZATION REACTOR (SCR)
4. ALKALI SOLUTION TANK
5. PHOSPHORIC ACID TANK
6. DOSING PUMPS
7. STRUVITE SEPARATION UNIT
8. EFFLUENT COLLECTION TANK

LINES:
- SLURRY (PERMEATE)
- GAS
- $Mg(OH)_2$
- H_3PO_4
- ORGANIC STRUVITE/SEP
- TREATED EFFLUENT

Struvite Unit Upgrade

LIFE LIVE WASTE

- SCR 50 L
- Chemicals added:
  - $Mg(OH)_2$
  - NaOH
- NH_4^+:PO_4^{3-}:Mg^{2+}: 1:0.3:1
- Quantity: 150 g/day

RE-LIVE WASTE

- SCR 250L
- Chemicals added:
  - $Mg(OH)_2$
  - H_3PO_4
  - NaOH
- NH_4^+:PO_4^{3-}:Mg^{2+}
- Quantity: 4,500 g/batch

Goals of upgrade:

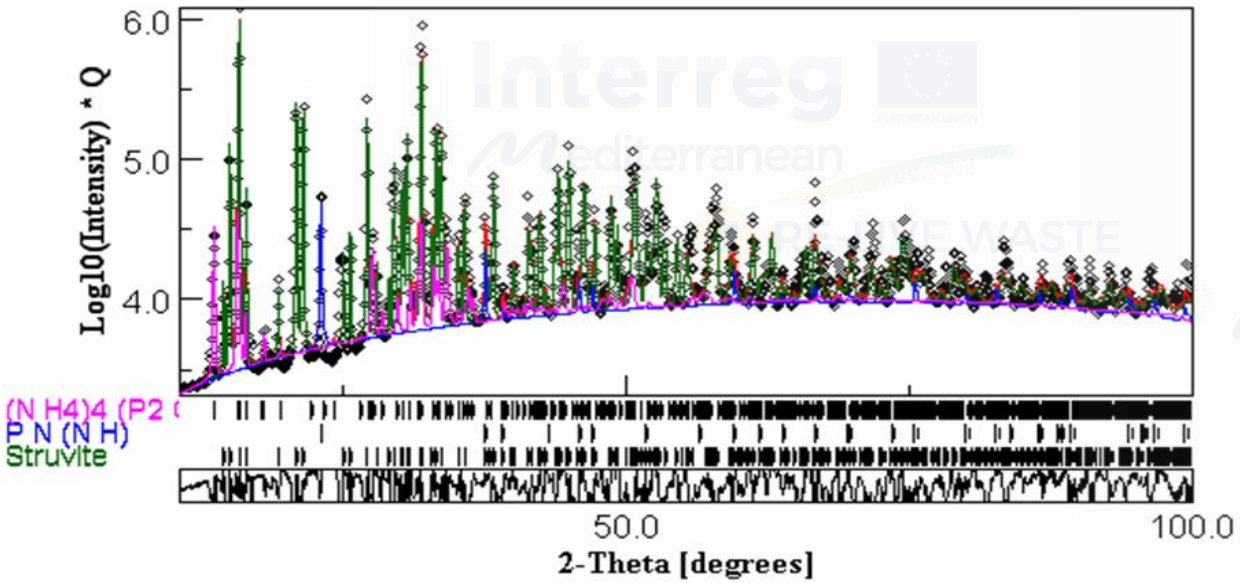
- Recovery of Nitrogen and Phosphorus as Struvite
- N-abatement in the swine wastewater
  - High ammonium concentrations in swine wastewater)
- Increase struvite production and quality

Darwish M., et al., *Separation & Purification Reviews* , 45,(2016),261.; Latifian M., et. al., *Environmental Technology*, 33, (2012), 2691.; Perera P.W. A. et al., *Biomedical and Environmental Sciences*, 20, (2007), 343.

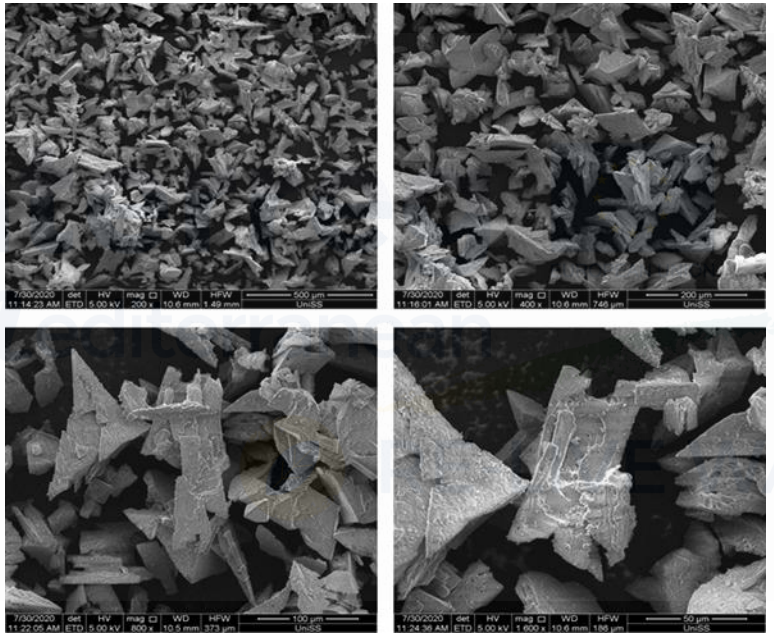
Struvite precipitation at the pilot

Precipitation experiment at the pilot (struvite combined from the runs of 24 & 28/02/20)

XRD analysis from UNISS



SEM characterization from UNISS



Quantitative analysis: Struvite 92.5 %

phosphorus nitride imide 1.5 %

ammonium phosphate 6.0 %

Not regular shape, 80-200 µm

Struvite obtained from the pilot has:
-No pathogens
-No carcinogens
-No heavy metals

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EU Regulation 2009/2019/EC

Agronomic Evaluation

- For the evaluation of struvite as a potential fertilizer additive, two experiments, one for baby leaf lettuce (*Lactuca sativa*) and one for radish (*Raphanus sativus*) were conducted.
- The obtained results support that the physical chemical characteristics of the crops were substantially enhances (i.e., water retention).
- The post-harvesting behavior of the crops was similar to those produced with the commercial fertilizers.
- Struvite could substitute conventionally produced fertilizers.

T1 T2 T3 T4 T5

- T1: Peat without fertilizers
- T2: Peat + Fertilizer (1)
- T3: Peat + Fertilizer (2)
- T4: Peat + Struvite (1)
- T5: Peat + Struvite (2)

Conclusions:

- Struvite of **high purity (89-99%)** was produced in the CUT pilot from anaerobically treated livestock waste.
- Struvite was **free** of pathogens, transition metals, and carcinogens.
- Proven to be as **efficient** as commercially available fertilizers.
- An environmentally friendly approach for **nutrient recovery.**
- A **sustainable solution** for mitigating of soil acidification, greenhouse gases emissions, and pollution of surface and groundwater.
- Opening **new market** opportunities in Cyprus and EU on biofertilizers.
- Supports **circular economy**

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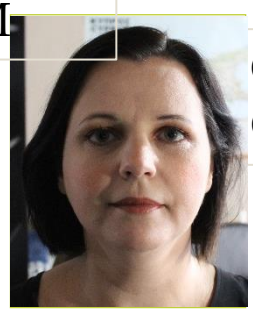

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Thank you for your attention!