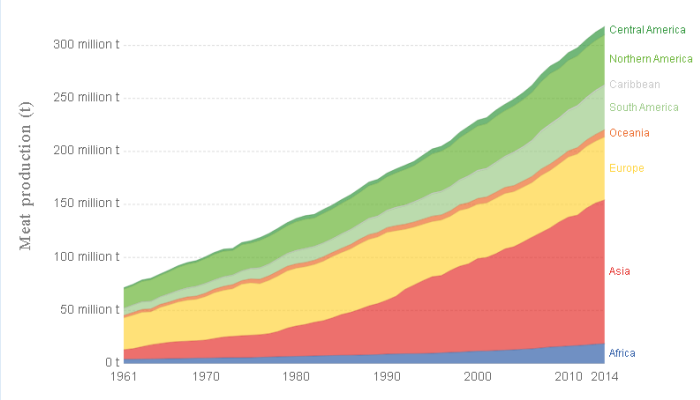
Phosphorus recovery from the liquid fraction of digestates by crystallization of struvite

S. Zangarini, T. Pepè Sciarria, F. Tambone, F. Adani

PHOSPHORUS: NUTRIENT AND POLLUTANT

Steady growth of population and food demand, especially meat *(FAO, 2018)*



Farming intensification and increasing of waste production *(Eurostats, 2017)*

LIVESTOCK EFFLUENTS

Treatments required

N and P high content

Logistical and economic problem

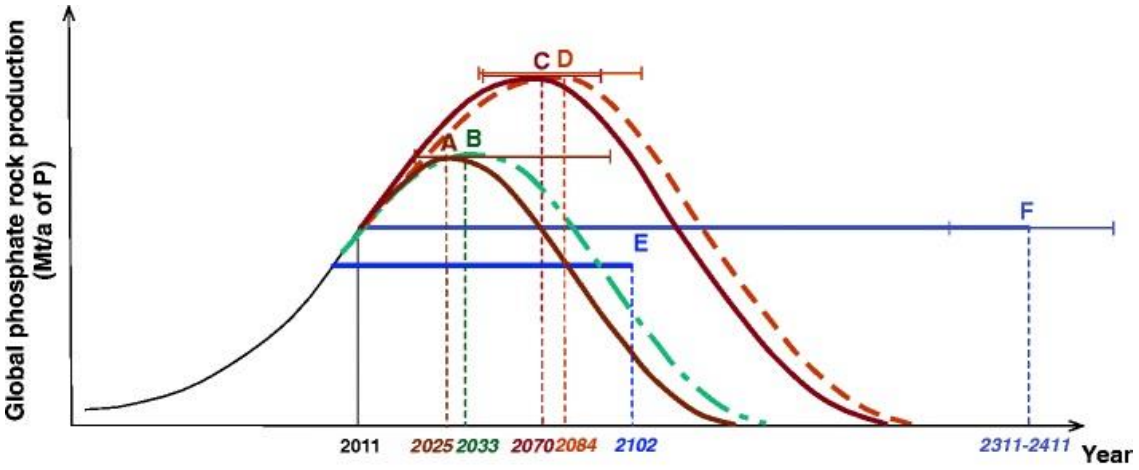
Water bodies EUTROPHICATION

PHOSPHORUS: NUTRIENT AND POLLUTANT

PHOSPHATIC MINERAL FERTILIZERS

- HIGH PRICES
  (globally limited: Morocco, China, South Africa)

- NON-RENEWABLE RESOURCE

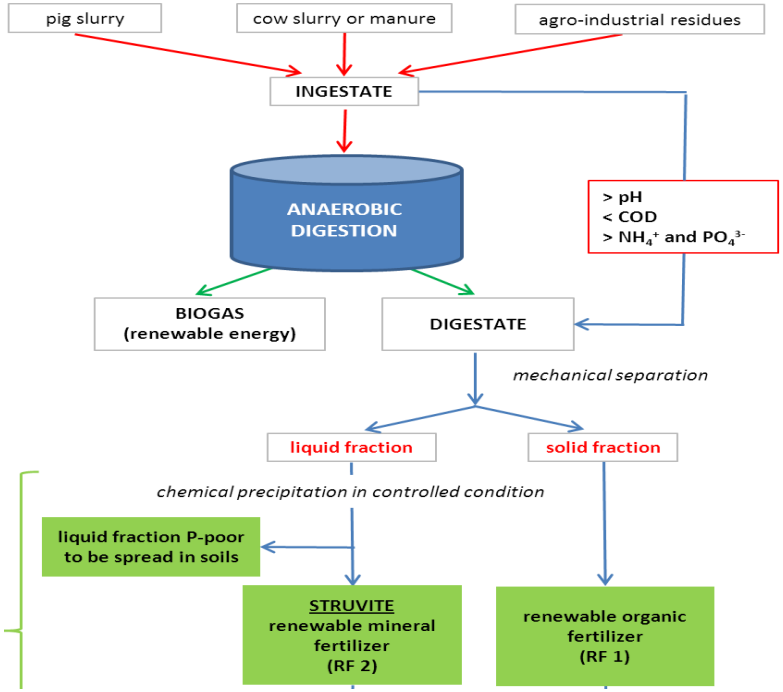


LEGEND:

A = Mohr & Evans (2013); B = Cordell et al (2009a); C = GPRI, 2010; Cordell et al, 2011b; D = Walan (2013); E = Fixen (2009); F = IFDC (2010)

Project Overview

- Preliminary Tests:
  - Mg sources comparation(MgO, $MgCl_2$, Seawater bittern)
  - determine starting conditions/parameters
  - prototype efficiency tests
- Crystallization tests:
  - struvite synthesis ($NH_4MgPO4*6H_2O$) from digestate
  - evaluation of parameters change effects
- Future purposes:
  - tests on different types of digestate
  - agronomic tests



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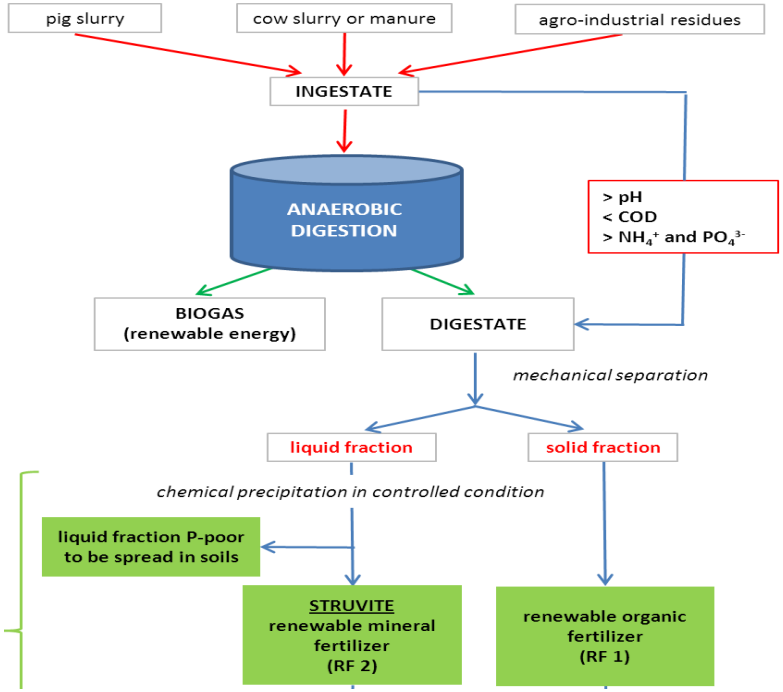
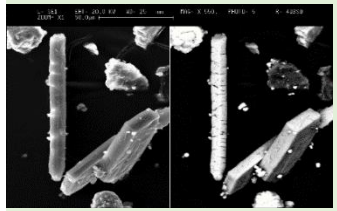
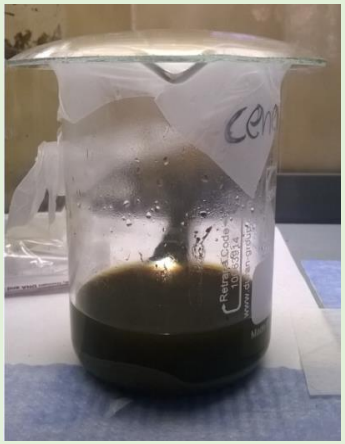


Preliminary tests

BATCH TESTS

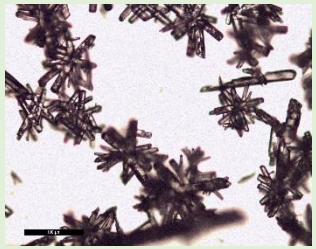
Seawater bittern: optimal Mg source
Mg^{2+}:PO_4^{3-}: **1.8:1** initial ratio





SYNTHETIC SUBSTRATE TESTS

P removal tests in ideal condition:
99% effciency



Crystallizer prototype setup

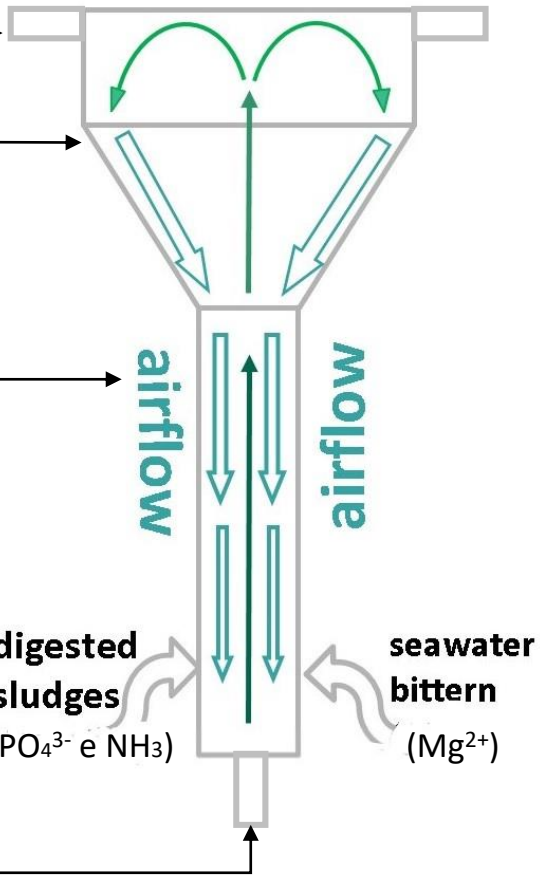
OUTPUT:
Effluent reduced in P content

CLARIFIER: top section, rising and falling of the centers of crystals nucleation

UPFLOW: middle section, ascending particles in the column.
Upflow velocity = Total flow/ section

COLLECTING: bottom section, particles and crystals deposition and collection

INPUT:
Filtered liquid fraction
SWB solution



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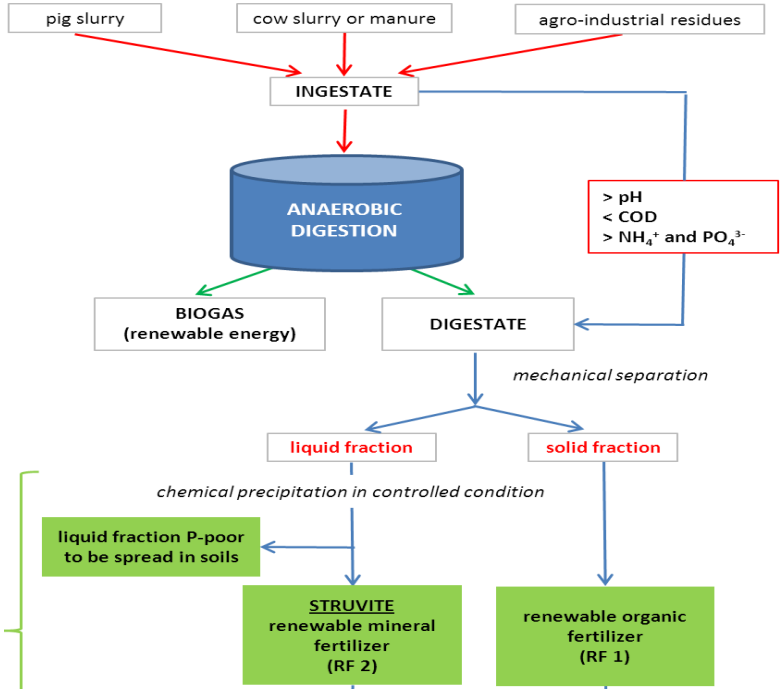
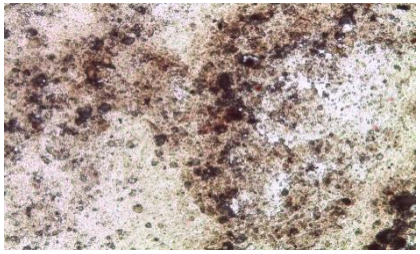


Crystallization tests

Test 1

pH = 9.5
Mg^{2+}:PO_4^{3-} = **1.8:1**
Air flow= 0.5 L min^{-}
TS = **3.3%**

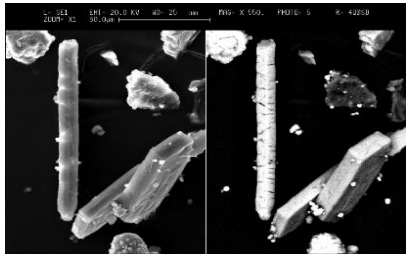


Test 2
Test 2.1

pH = 9.5
Mg^{2+}:PO_4^{3-} = **2:1**
Air flow= 0.5 L min^{-}
TS = 3.3 – **4.5%**

Test 3
Test 3.1

pH = 9.5
Mg^{2+}:PO_4^{3-} = **3:1**
Air flow = 0.5 L min^{-}
TS = 3.3 – **4.5%**



Results

Test 1

PARAMETERS

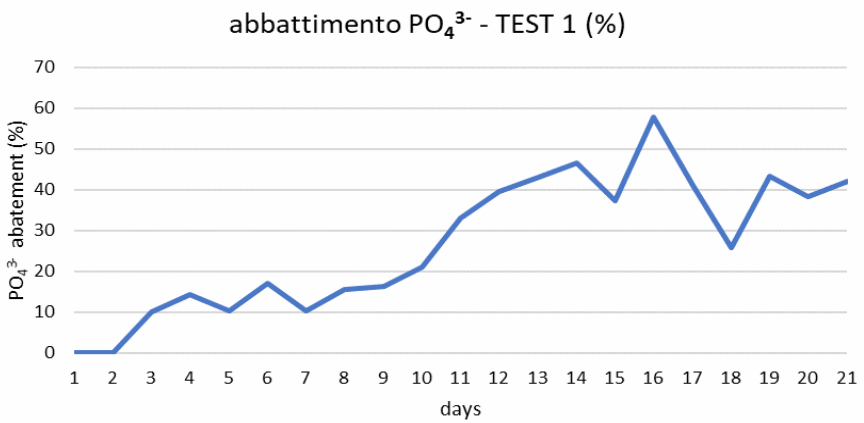
pH = 9.5

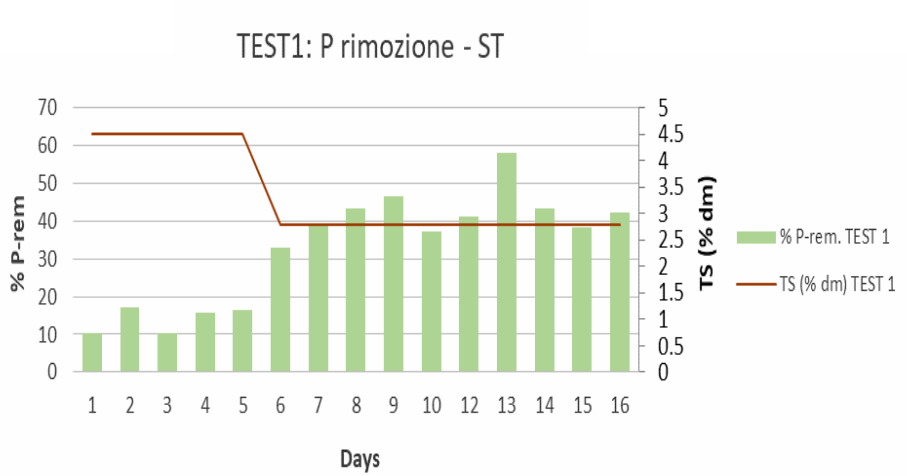
Air flow = 0.5 L/min

Mg^{2+}:PO_4^{3-} = 1.8:1

ST = 3.3%

P removal: 60%





Results

Test 2

PARAMETERS

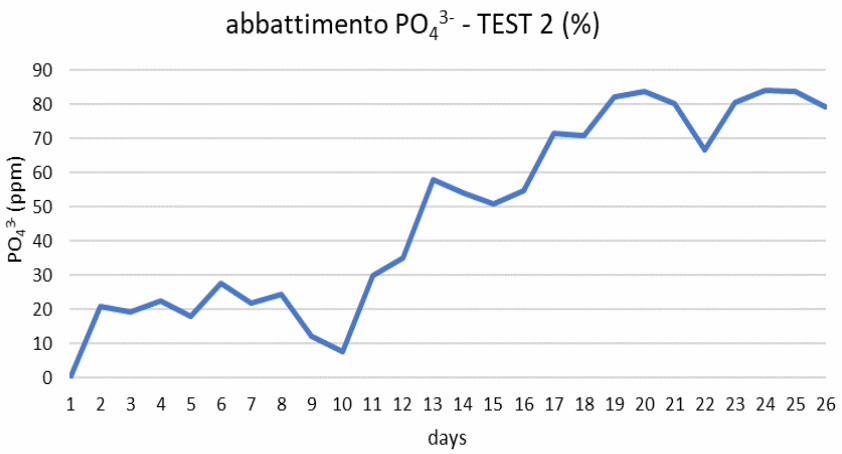
pH = 9.5

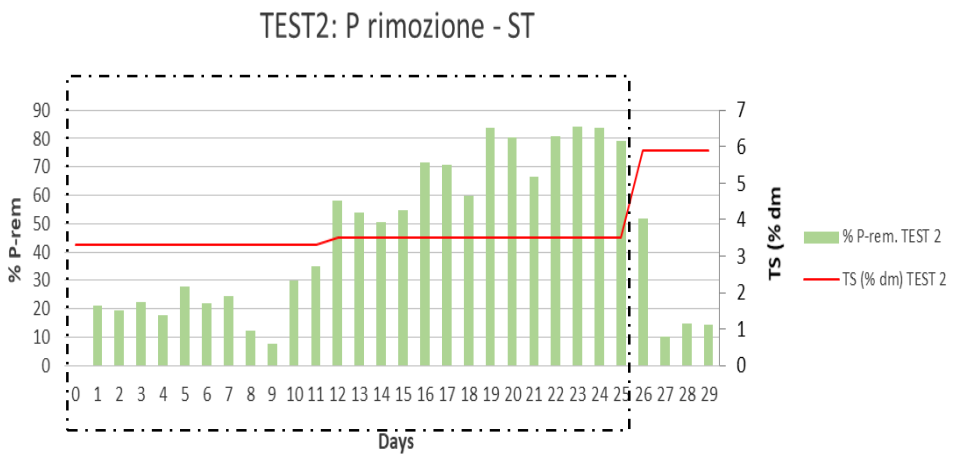
Air flow = 0.5 L/min

Mg^{2+}:PO_4^{3-} = 2:1

ST = 3.3%

P removal: 85%





Results

Test 2.1

PARAMETERS

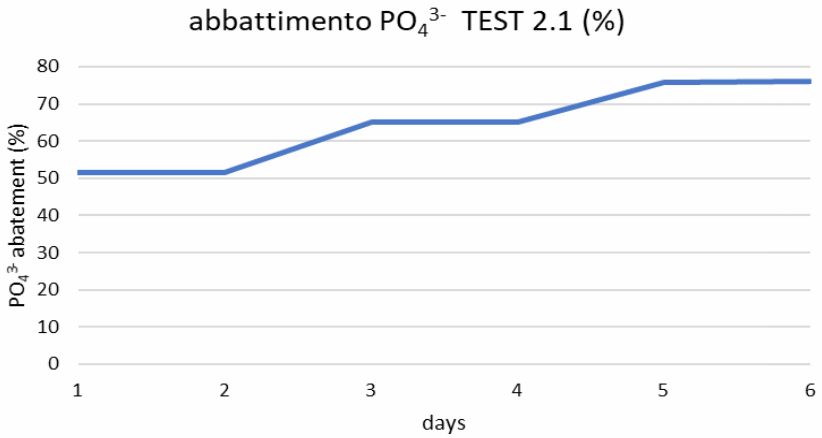
pH = 9.5

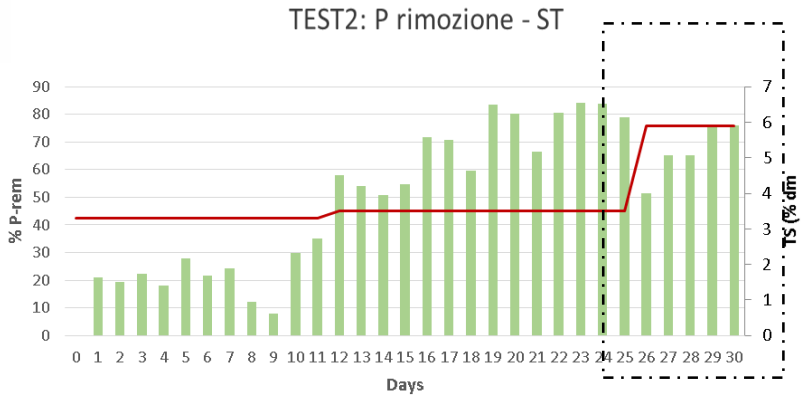
Air flow = 0.5 L/min

Mg^{2+}:PO_4^{3-} = 2:1

ST = 4.5 %

P removal: 76 %





Results

Test 3

PARAMETERS

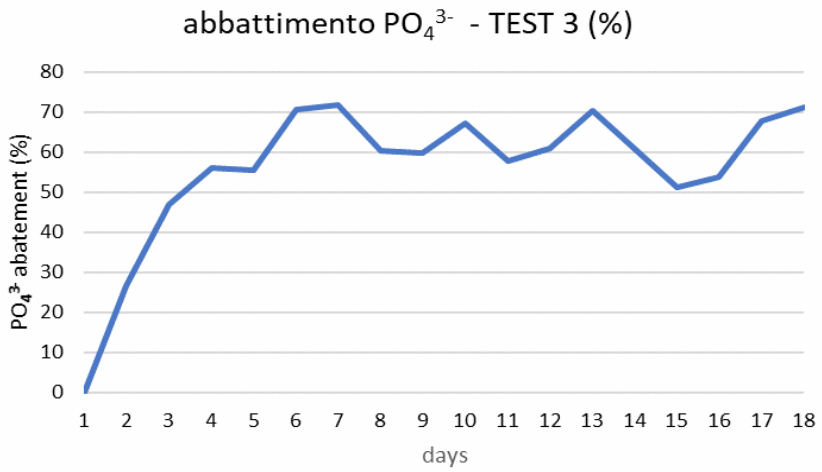
pH = 9.5

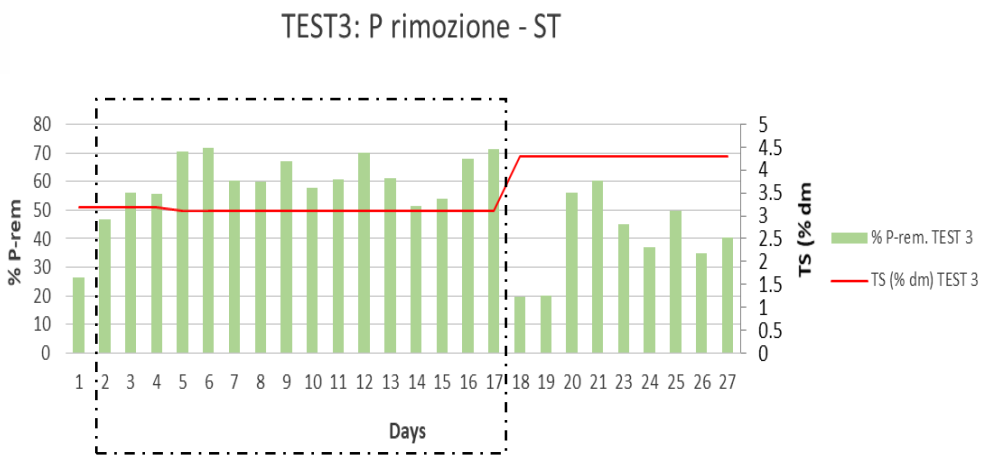
Air flow = 0.5 L/min

Mg^{2+}:PO_4^{3-} = 3:1

ST = 3.3 %

P removal: 72 %





Results

Test 3.1

PARAMETERS

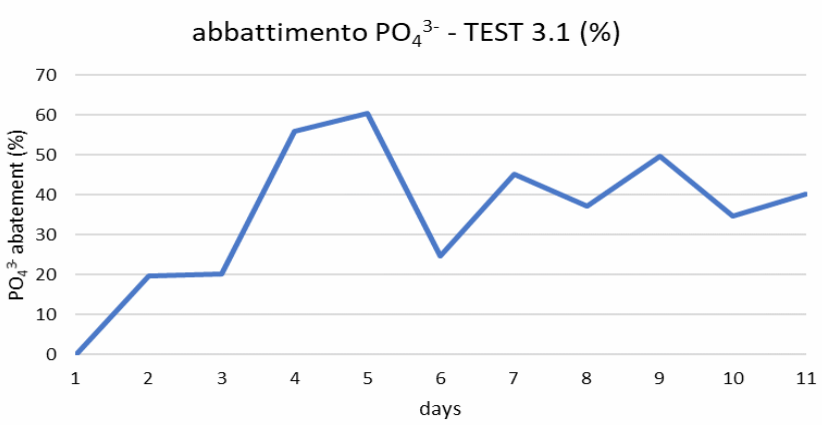
pH = 9.5

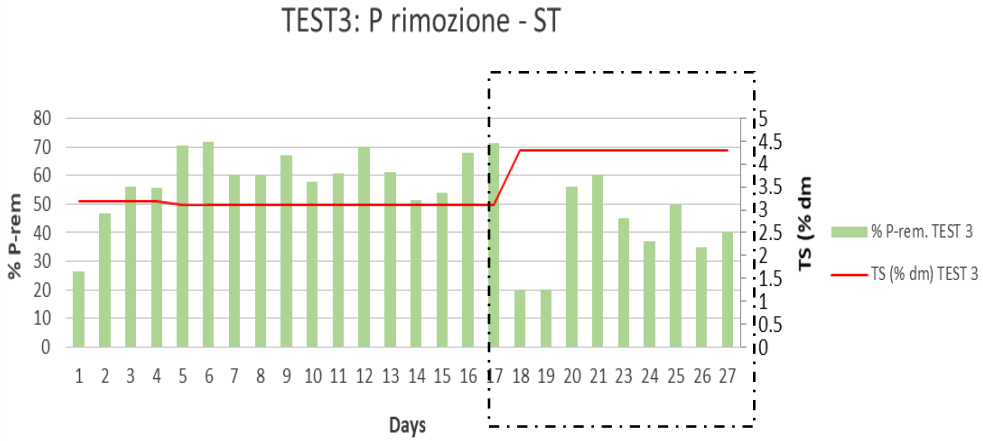
Air flow = 0.5 L/min

Mg^{2+}:PO_4^{3-} = 3:1

ST = 4.5 %

P removal: 62 %



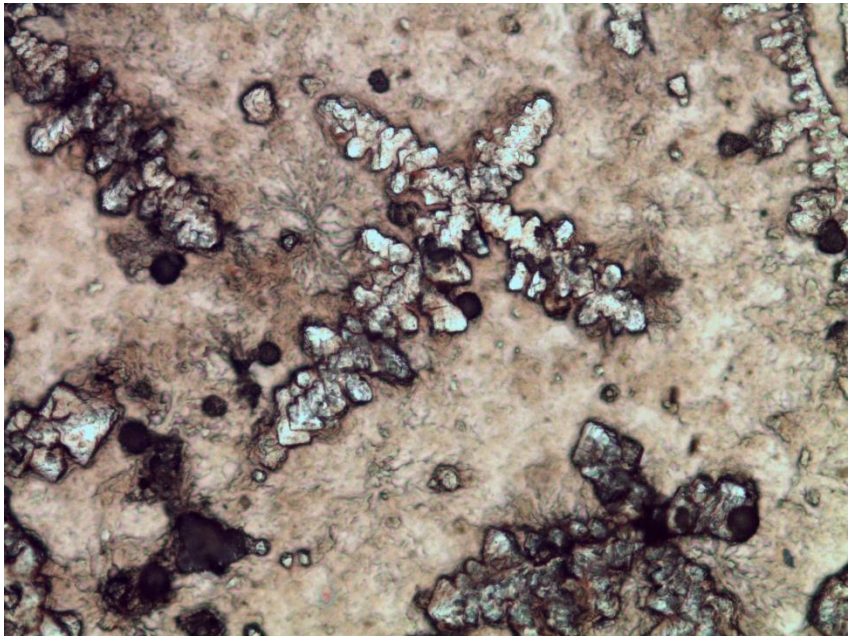


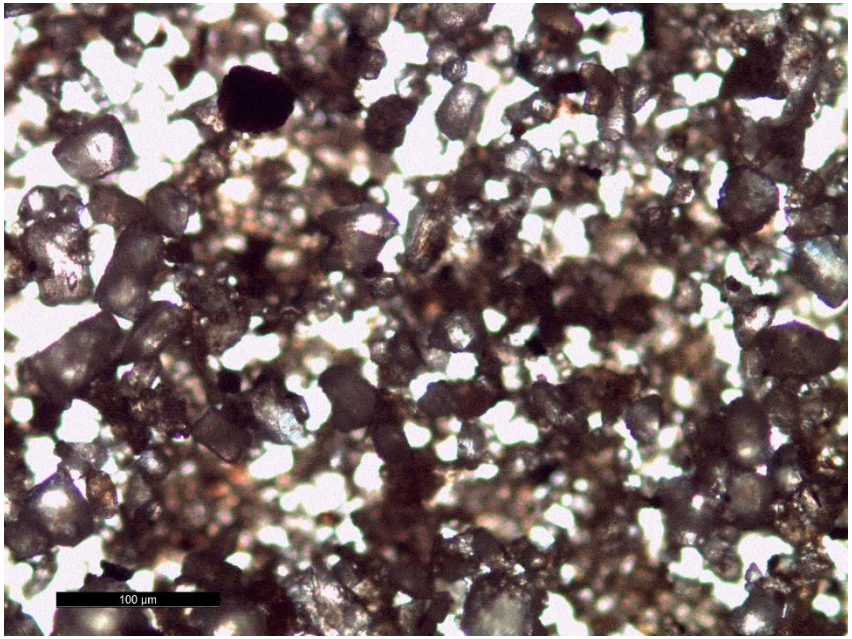
Results

MICROSCOPIC ANALYSIS

Test 2 (85% removal):

- High concentration of **crystals**
- Identification of **dendritic** structures



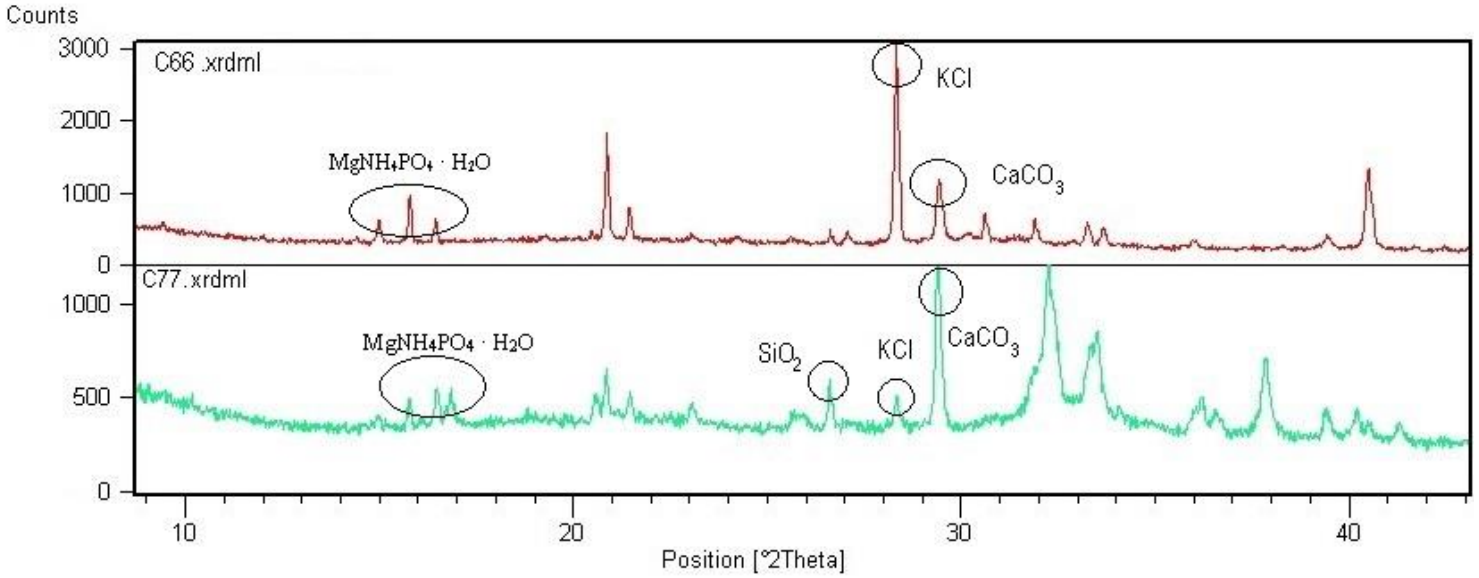


Results

X-RAY DIFFRACTION ANALYSIS

Test 2 (85% removal):

- Mineral component confirmed as **struvite**



Summary and Future purposes

- Phosphorus removal in standard conditions: **85** %
- Phosphorus removal using **high TS** content (~4,5%) : **60-70%**
- **Seawater bittern** is an effective Mg source in P removal

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- Tests on **different types of digestate**
- **Agronomic** tests

Thank you for your attention

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