European Sustainable Phosphorus Platform

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22ª Fiera internazionale del recupero di materia ed energia e dello sviluppo sostenibile

Green & Circular Economy
6-9 Novembre 2018
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IN CONTEMPORANEA CON
KEY ENERGY

Nutrient and water recycling through the management of manure: the case history of Lombardy Region

Gabriele Boccasile – Regione Lombardia

3rd EUROPEAN NUTRIENT EVENT @ ECOMONDO 2018

8 - 9 November 2018, Rimini, Italy

www.smart-plant.eu/ENE3

BIOGAS PLANTS 2018

- >400 operating

Anaerobic Digestionion as a tool

(circular economy + sustainability)

. . ANAEROBIC DIGESTION:

Digestate (!!!)

+

Biogas (!)

Science of the Total Environment 526 (2015) 116–126

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

The role of biological processes in reducing both odor impact and pathogen content during mesophilic anaerobic digestion

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HIGHLIGHTS

- Anaerobic digestion (AD) could produce annoyance for humans, i.e. odors and pathogens
- Because of bio-stabilization process, AD reduces potential odours production
- Biological process is responsible of pathogen reduction because of NH_3 production.
- Substrate competition, as well, is responsible for pathogen reduction.
- Plant characteristics and feedstock influence the results for pathogen reduction.

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Pathogens
Toxic ammonia

ABSTRACT

Mesophilic anaerobic digestion (MAD) produces renewable energy, but it also plays a role in reducing the impact of digestates, both by reducing odor and pathogen content. Ten full-scale biogas plants characterized by different plant designs (e.g. single digesters, parallel or serial digesters), plant powers (ranging from 180 to 999 kWe), hydraulic retention time (HRT) (ranging between 20 to 70 days) and feed mixes were monitored and odors and pathogens were observed in both ingestates and digestates. Results obtained indicated that MAD reduced odors (OU) from, on average, $OU_{ingestate} = 99{,}106 \pm 149{,}173$ OU m^{-2} h^{-1} ($n = 15$) to $OU_{digestate} = 1106 \pm 771$ OU m^{-2} h^{-1} ($n = 15$).

Pathogens were also reduced during MAD both because of ammonia production during the process and competition for substrate between pathogens and indigenous microflora, i.e. Enterobacteriaceae from $6.85 * 10^3 \pm 1.8 * 10^1$ to $1.82 * 10^1 \pm 3.82 * 10^1$; fecal Coliform from $1.82 * 10^4 + 9.09$ to $2.45 * 10^1 \pm 3.8 * 10^1$; *Escherichia coli* from $8.72 * 10^3 \pm 2.4 * 10^1$ to $1.8 * 10^1 \pm 2.94 * 10^1$; *Clostridium perfringens* from $6.4 * 10^4 \pm 7.7$ to $5.2 * 10^3 \pm 8.1$ (all data are expressed as CFU g^{-1} ww).

Plants showed different abilities to reduce pathogen indicators, depending on the pH value and toxic ammonia content.

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the results for pathogen reduction.

ABSTRACT

Mesophilic anaerobic digestion (MAD) produces renewable energy, but it also plays a role in reducing the impact of digestates, both by reducing odor and pathogen content. Ten full-scale biogas plants characterized by different plant designs (e.g. single digesters, parallel or serial digesters), plant powers (ranging from 180 to 999 kWe), hydraulic retention time (HRT) (ranging between 20 to 70 days) and feed mixes were monitored and odors and pathogens were observed in both ingestates and digestates. Results obtained indicated that MAD reduced odors (OU) from, on average, $OU_{ingestate}$ = 99,106 ± 149,173 OU m^{-2} h^{-1} (n = 15) to $OU_{digestate}$ = 1106 ± 771 OU m^{-2} h^{-1} (n = 15).
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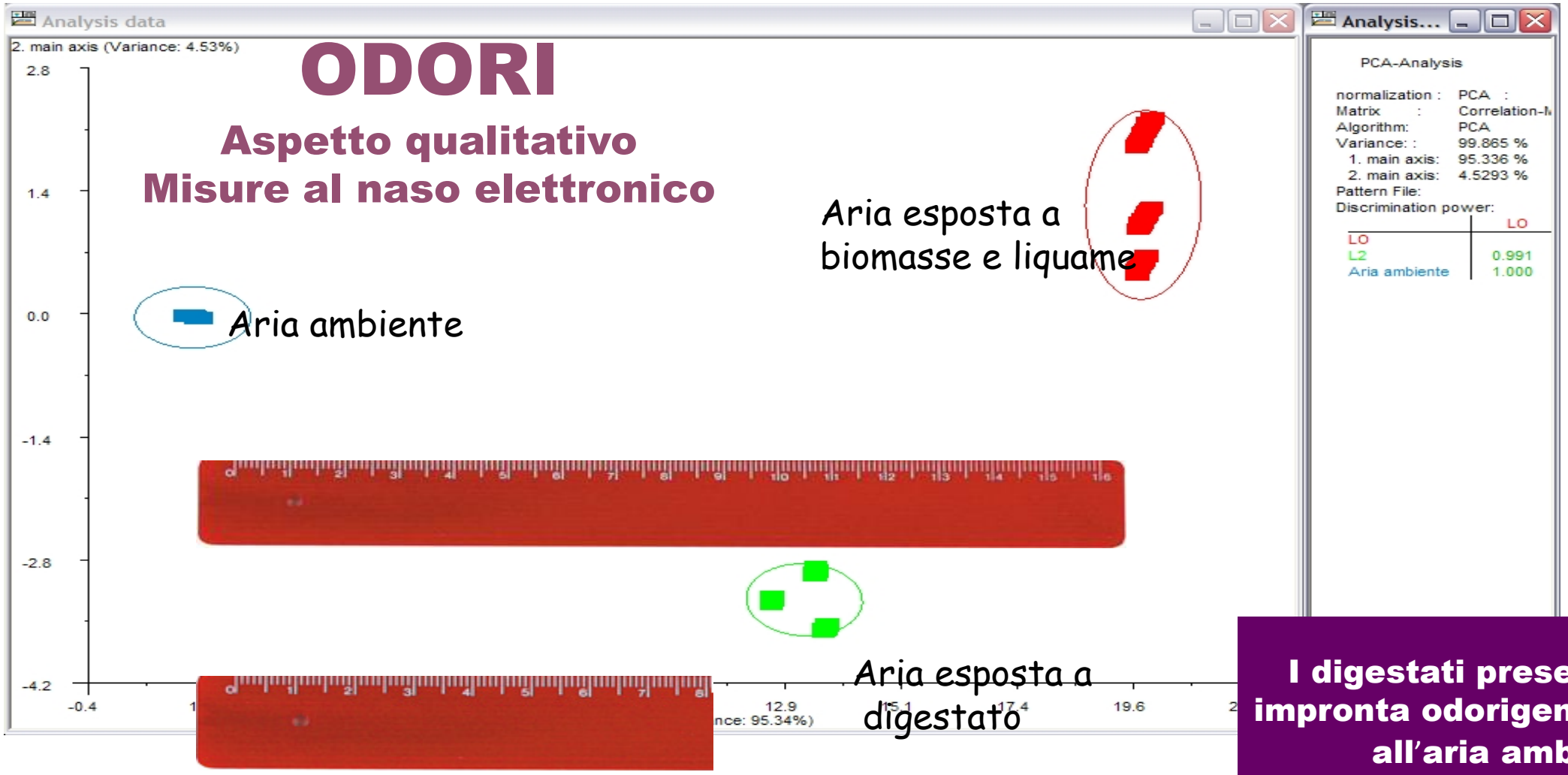
Plants showed different abilities to reduce pathogen indicators, depending on the pH value and toxic ammonia content.

s with renewable bioenergy
pean Union (EU) as part of a

crops. Biogas production has been developed a lot in the EU in recent decades and in particular in Germany and Italy. In Italy, biogas has been developed considerably in the Lombardy Region in an agricultural context (Adani et al., 2013) because of the presence of intensive animal breeding

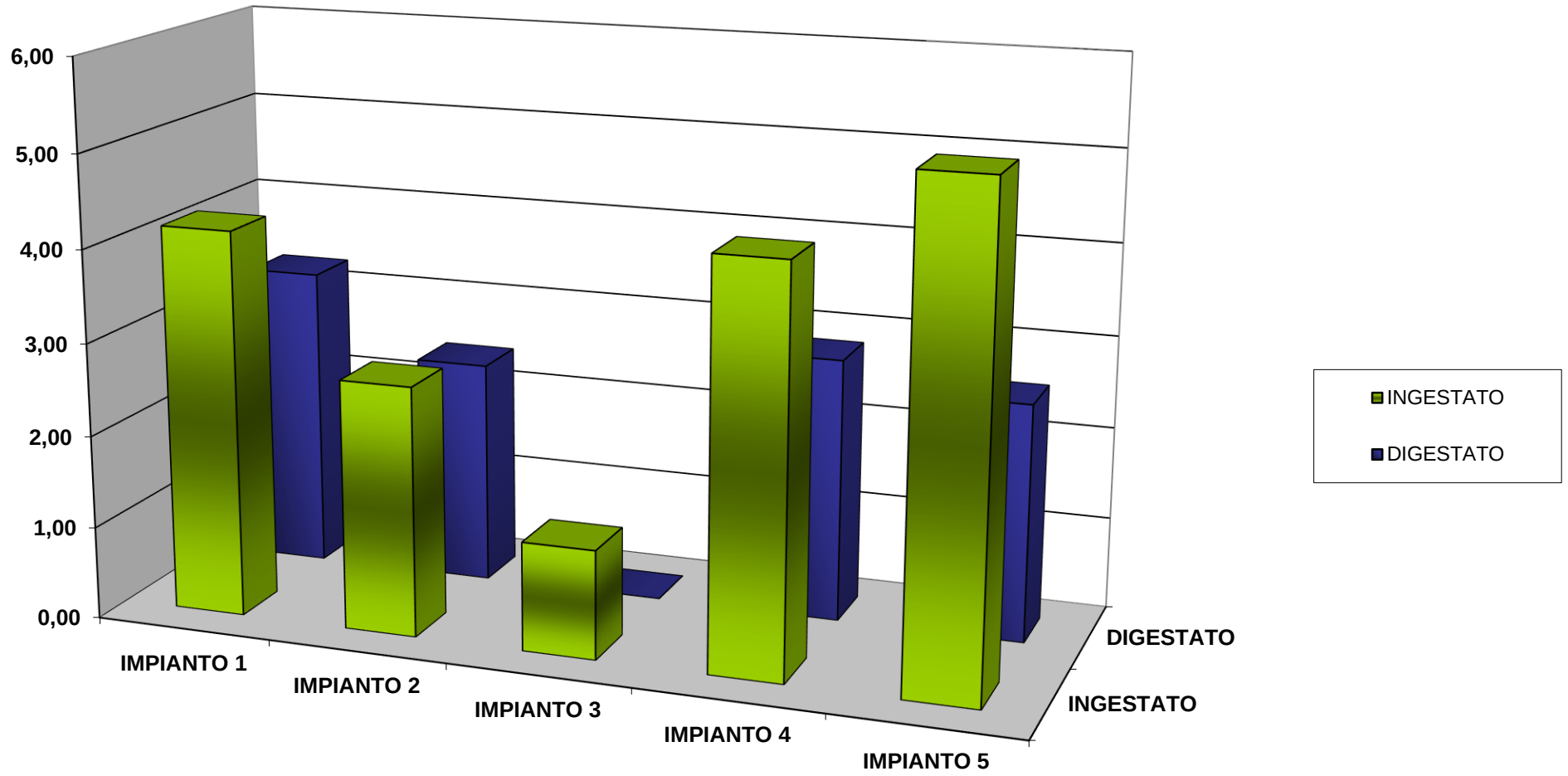
ODORI

Aspetto qualitativo
Misure al naso elettronico



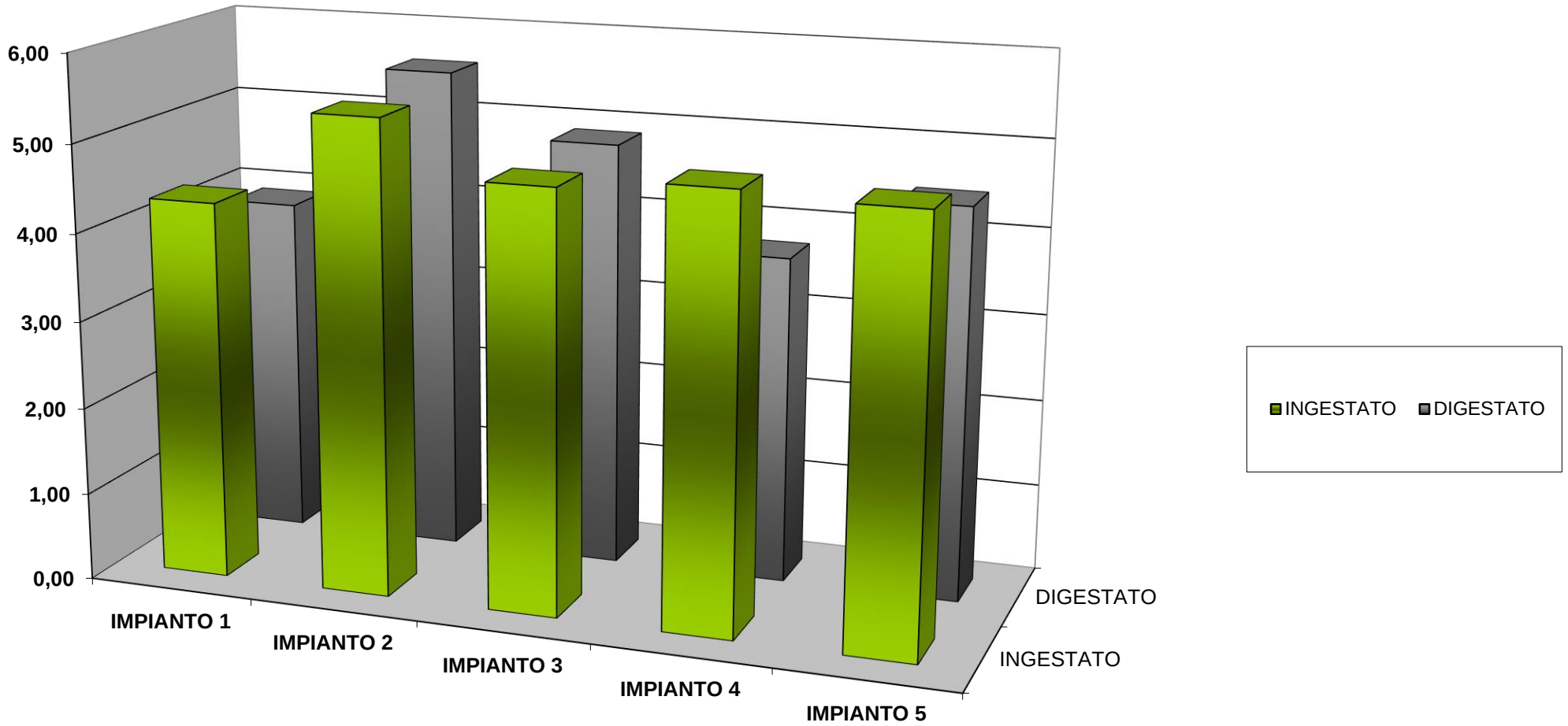
I digestati presentano una impronta odorigena piu' vicina all'aria ambiente

Escherichia coli : Log10 CFU ml



Gruppo Ricicla- Ist. Zooprofilattico di BS- Regione Lombardia, 2012

Clostridium perfrigens: Log10 CFU ml



Gruppo Ricicla- Ist. Zooprofilattico di BS- Regione Lombardia, 2012

- Anaerobic digestion: useful biotechnology able to transform the nutrients contained into plant-available forms so that digestate can replace mineral fertilizers.
- The treatment of livestock effluents by anaerobic digestion processes can play a key role in producing fertilizers.
- AD leads to several changes in the composition of the resulting digestates for what that concern ammonia content, pH, COD, pathogens and odor emission.
- Digestates are characterized by biologically stable organic matter and ready available nutrients content (i.e. NH_4^+ and PO_4^{3-})

Nitrogen mineralization from digestate in comparison to sewage sludge, compost and urea in a laboratory incubated soil experiment

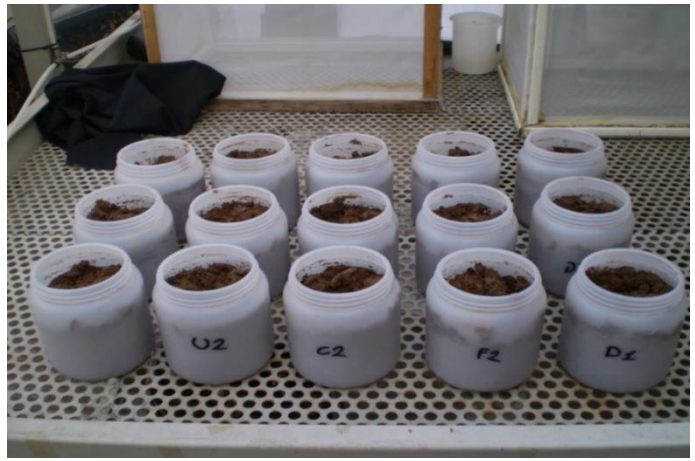
Fulvia Tambone[1]* and **Fabrizio Adani**[1]

[1] Ricicla Group, Dipartimento di Scienze Agrarie e Ambientali, Produzione, Territorio, Agroenergia, Università degli Studi di Milano, Via Celoria 2, 20133 Milano, Italy

INCUBATION TEST AT LABORATORY SCALE

- No fertilizer **T**
- Soil + Compost **C**
-Soil + sewage sludge **SS**
- Soil + Digestate **D**
- Soil + Urea **U**

90 days, T 25°C, U 60% WHC



300 kg N ha^{-1}

Nitrogen balance

	t ha^{-1}	N_{tot}	$N\text{-}NO_3^-$	Efficiency
			kg ha^{-1}	%
C	22.6	300	136	45
SS	24.8	300	150	53
D	83.3	300	262	88
U	0.65	300	300*	100

High organic matter mineralization rate.
High content of $N\text{-}NH_4^+$

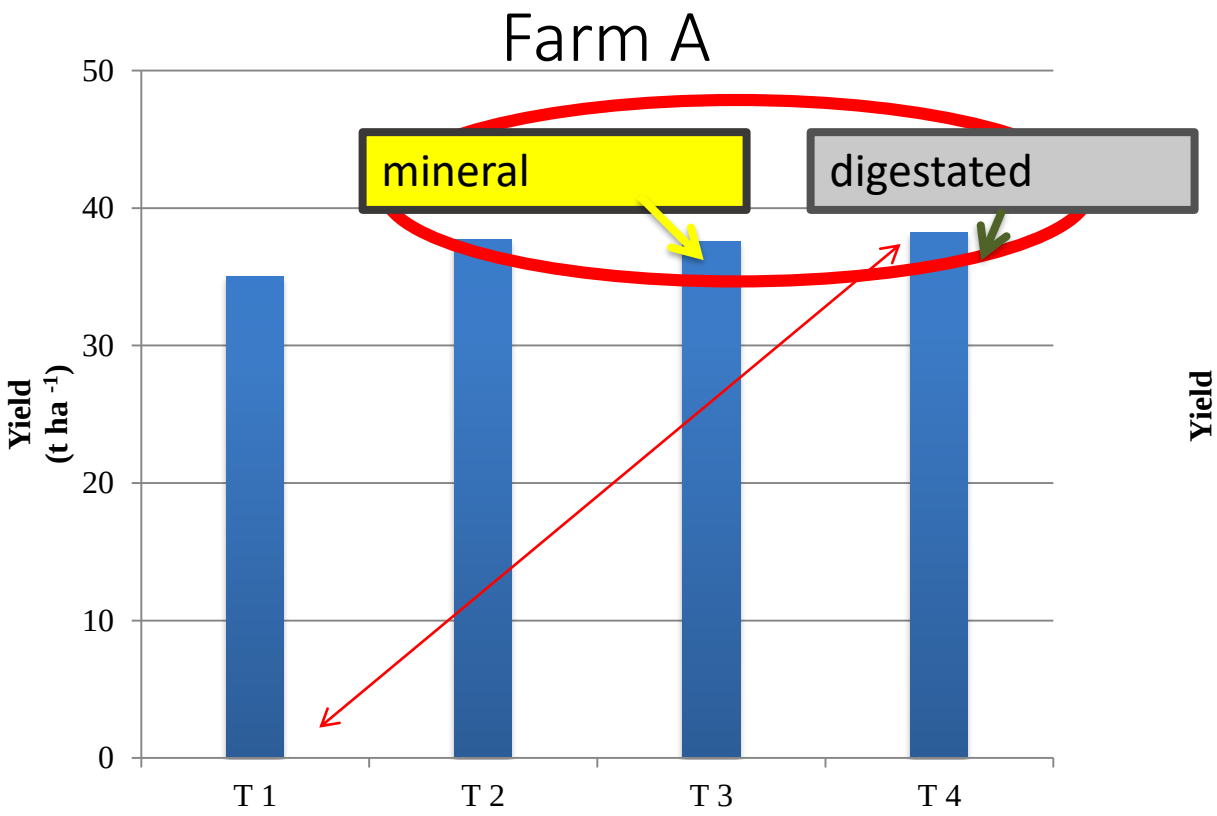
* Assuming that all the nitrogen added by urea is mineralized

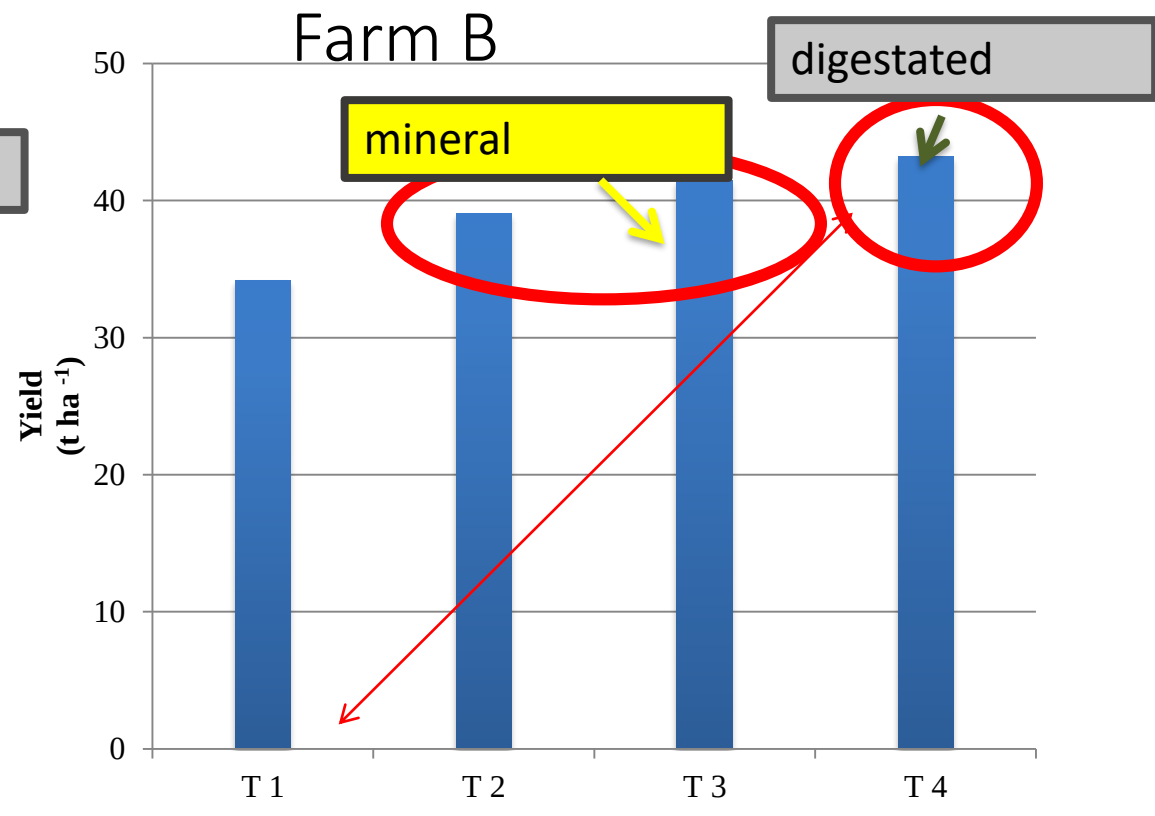
Conclusions

- Efficiency digestate ≅ urea
- Digestate ≅ mineral fertilizers

- Necessity to consider soil and environment differents characteristics and conditions
- Distribution Systems (injection or surface)

Maize silage trials





Farm A: maize silage in the different theses
T1 = no fertilization – cover: no fertilization
T2 = superficial raw digestate - injected raw digestate
T3 = urea - urea
T4 = injected raw digestate – injected digestate liquid fraction

Farm B: maize silage in the different theses
T1 = no fertilization - localized fertilization
T2 = Superfilcial raw digestate- localized fertilization
T3 = urea - localized fertilization
T4 = Injected raw digestate - localized fertilization

Carozzi, Riva, Acutis , Tambone, Adani Progetto NERØ, 2012

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Italian Phosphorus Platform

15 ANNI

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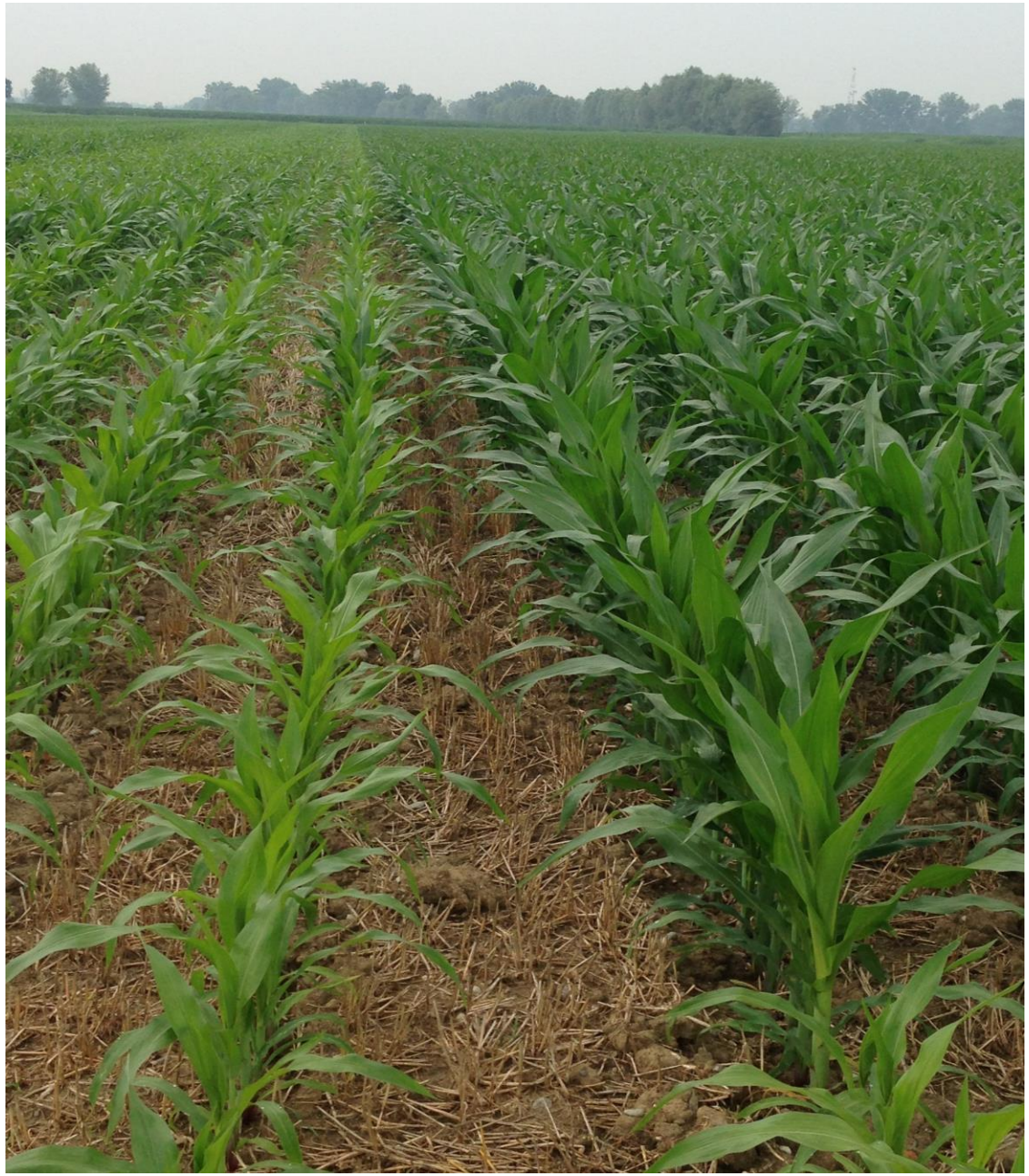
2015
Caravaggio BG
Progetto Post NERØ
Gruppo Ricicla UniMi DISAA

in line with the provisions of the Nitrate Directive



NOT in line with the provisions of the Nitrate Directive

2015

Progetto Post NERØ

Gruppo Ricicla UniMi DISAA

Caravaggio BG

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Short-term experiments in using digestate products as substitutes for mineral (N) fertilizer: Agronomic performance, odours, and ammonia emission impacts

C. Riva [a], V. Orzi [a], M. Carozzi [b], M. Acutis [b], G. Boccasile [c], S. Lonati [a], F. Tambone [a], G. D'Imporzano [a], F. Adani [a,*]

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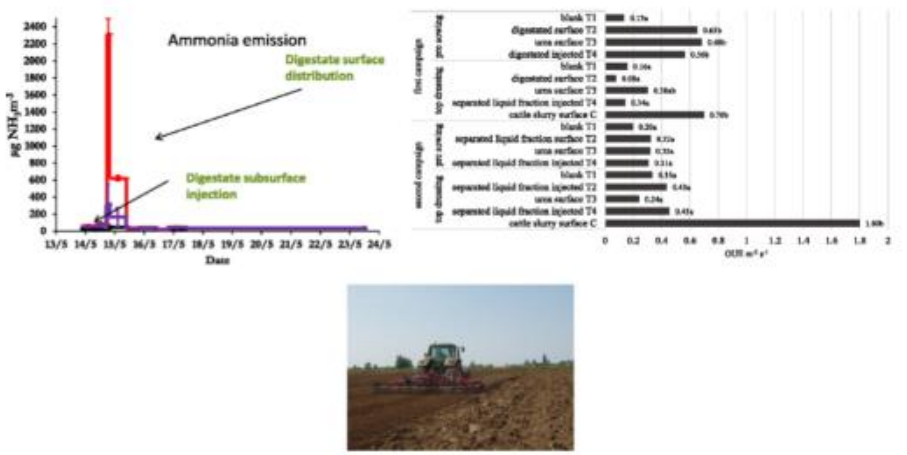
[c] DG Agricoltura, Regione Lombardia, Piazza Lombardia, Milano, Italy

HIGHLIGHTS

- Anaerobic digestion produced useful fertilizers, i.e. the digestate.
- Digestate misuses led to odours and ammonia impacts.
- Pre-sowing and topdressing use of digestate substituted completely N-fertilizers.
- Subsurface injection of digestate reduced greatly odour and NH_3 emissions.
- Digestate use allowed producing maize silage as well as using urea.

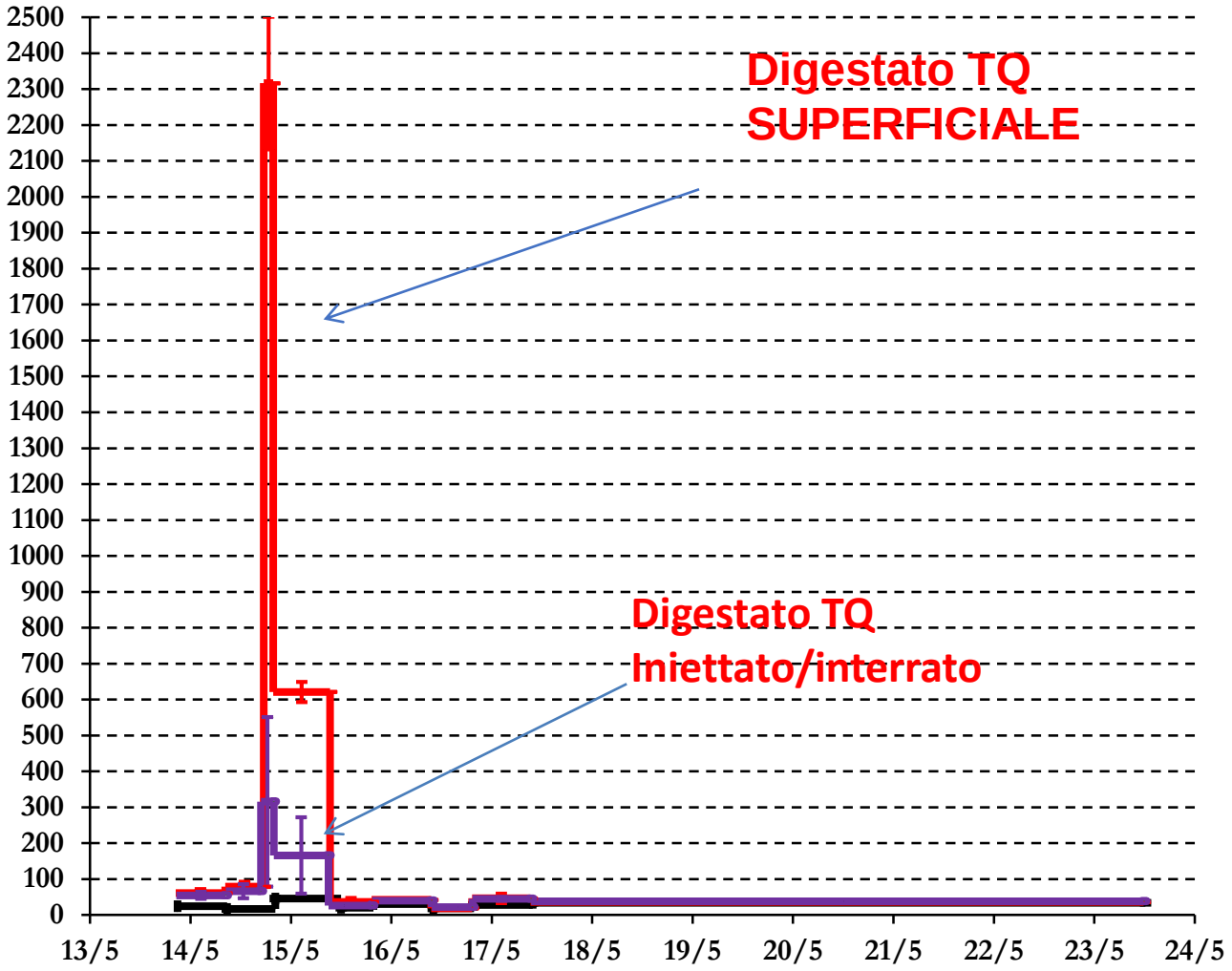
GRAPHICAL ABSTRACT



ABSTRACT

Anaerobic digestion produces a biologically stable and high-value fertilizer product, the digestate, which can be used as an alternative to mineral fertilizers on crops. However, misuse of digestate can lead to annoyance for the public (odours) and to environmental problems such as nitrate leaching and ammonia emissions into the air. Full field experimental data are needed to support the use of digestate in agriculture, promoting its correct management. In this work, short-term experiments were performed to substitute mineral N fertilizers (urea) with digestate and products derived from it to the crop silage maize. Digestate and the liquid fraction of digestate were applied to soil at pre-sowing and as topdressing fertilizers in comparison with urea, both by surface application and subsurface injection during the cropping seasons 2012 and 2013. After each fertilizer application, both odours and ammonia emissions were measured, giving data about digestate and derived products' impacts.
The AD products could substitute for urea without reducing crop yields, apart from the surface application of AD-derived fertilizers. Digestate and derived products, because of high biological stability acquired during the AD, had greatly reduced olfactometry impact, above all when they were injected into soils (82–88% less odours than the untreated biomass, i.e. cattle slurry). Ammonia emission data indicated, as expected, that the correct use of digestate and derived products required their injection into the soil avoiding, ammonia volatilization

NH_3 digestato PRE-SEMINA



BKG - media µg NH3/m3

Tesi 2 - media µg NH3/m3

Tesi 4 - media µg NH3/m3

Carozzi, Riva, Acutis , Tambnoe, Adani Progetto NERØ, 2012

MORE EFFICIENCY

LESS NITROGEN

Proposal by **GRUPPO RICICLA** and Regione Lombardia:

Liquid fraction = fertilizer if:

Efficient management + efficient separation	**$N\text{-}NH_4$ > 70-80%**
Efficient use by plants	**90%**

Efficient digestion:

- Biological stability
- Sanitary aspects
- N_{tot} content
- N- NH_4content

Utilization efficiency:

- N dosed following crop budget
- Covered storage tanks
- Application by injection, immediate incorporation or localized fertigation

Proposal by GRUPPO RICICLA and Regione Lombardia:

Liquid fraction = fertilizer if:

Efficient management + efficient [illegible]	[illegible] NH [illegible]-8[illegible]%
Efficie[illegible]	[illegible]

COMPARABLE DIGESTATE

Efficient digestion:

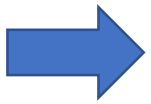
- Biological stability
- Sanitary aspects
- N_{tot} content
- N- NH_4content

Utilization efficiency:

- N dosed following crop budget
- Covered storage tanks
- Application by injection, immediate incorporation or localized fertigation

Organic Manure for Urban Farmers

- The recovery of biomasses' nutrients becomes a process to produce fertilizers.



FERTILIZERS®
RENEWABLE

Un aiuto può derivare dalla revisione di norme nazionali ed europee, rimuovendo le barriere amministrative oggi presenti e valorizzando percorsi di economia circolare che coinvolgano a pieno titolo anche il settore zootecnico, riconoscendo il valore degli effluenti di allevamento

JRC

EUROPEAN COMMISSION

. . SAFE-MANURE Programme

…..not only re-use in the farm……..but

……farmer became fertilizers producer

... production of mineral fertilizers from digested manure


MANERBIO BS


MANERBIO BS


MANERBIO BS


MANERBIO BS


LODA
MANERBIO BS


MANERBIO BS


➢2009-2011set up
➢2012 operating
➢60 mc/day digestate
➢30 /40 t/month ammonium sulphate

MANERBIO BS

2018

MANERBIO BS

2018


MANERBIO BS
2018

Untreated

After ultrafiltration

After reverse osmosi


...volumes
reduction
+ chemical fertilizers

- 2009-2010 set up
- 2011 operating
- 50 mc/day digestato
- 7 t/month ammonium sulphate

- 2009-2011set up
- 2012 operating
- 100 mc/day digestate
- 30 /40 t/month ammonium sulphate


PLEIADE®
PLEIADE®
ORELIS


1/4"
FGF4
PVC
DANGER
HIGH PRESSURE
MAX. PRESSURE
1000 PSI.


.. UP TO 70%
delivered to surface water


VIPITENO BZ
2017


OB IMPIANTI
SN M-6161
OB IMPIANTI
SN M-6162
OB SNC IMPIANTI
SN M-6131
SERBATOIO T-110/1 - OB-SLURLESS Alimento Primo Stadio RO1
TANK T-110/1 - OB-SLURLESS First Stage RO1 Feed
VIPITENO BZ
2017

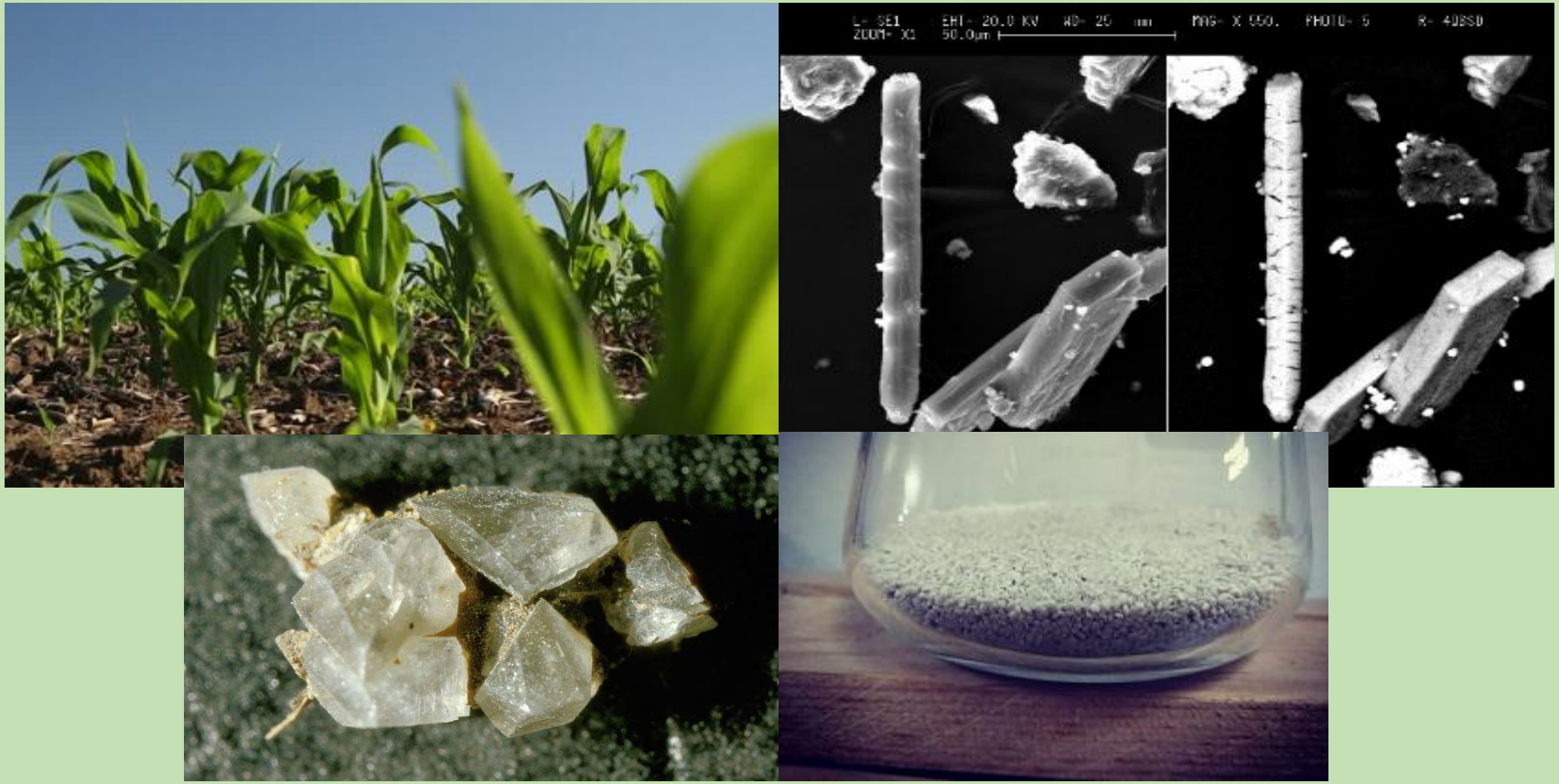

VIPITENO BZ
2017

VIPITENO BZ

2017


VIPITENO BZ
2017

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



S. Zangarini, T. Pepè Sciarria, F. Tambone, F. Adani Gruppo Ricicla UniMi DISAA

Crystallization operating scheme

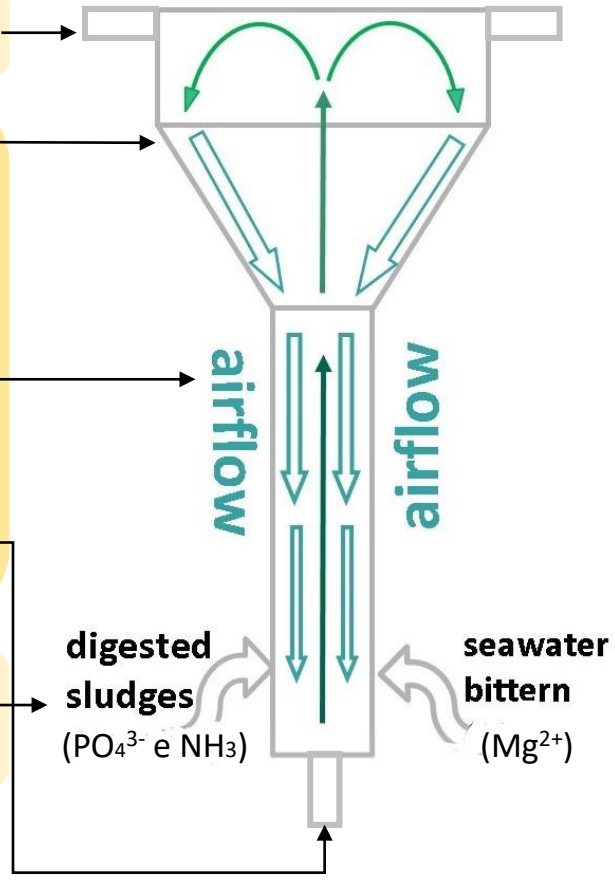
OUTPUT:
Effluente impoverito di fosforo

CLARIFIER: parte superiore, zona di ascesa e ricaduta dei centri di nucleazione.

UPFLOW: dove avviene la fase dinamica di spostamento dei solidi.
Upflow velocity = Total flow/ section

COLLECTING: zona di ricaduta dei cristalli, asportazione del precipitato

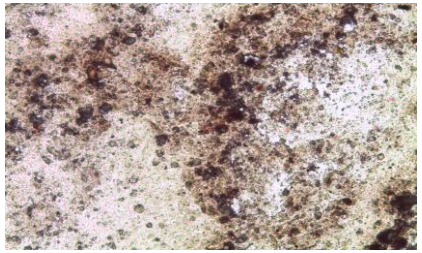
INPUT:
separato liquido filtrato
soluzione diluita di SWB



crystallizer test scheme

Test 1

pH = 9.5
Mg^{2+}:PO_4^{3-} = **1.8:1**
flusso aria= 0.5 L min^{-1}
ST = **3.3%**

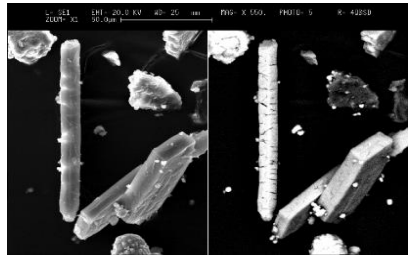


Test 2
Test 2.1

pH = 9.5
Mg^{2+}:PO_4^{3-} = **2:1**
flusso aria= 0.5 L min^{-1}
ST = 3.3 – **4.5%**

Test 3
Test 3.1

pH = 9.5
Mg^{2+}:PO_4^{3-} = **3:1**
flusso aria= 0.5 L min^{-1}
ST = 3.3 – **4.5%**



Results

Test 1

PARAMETRI

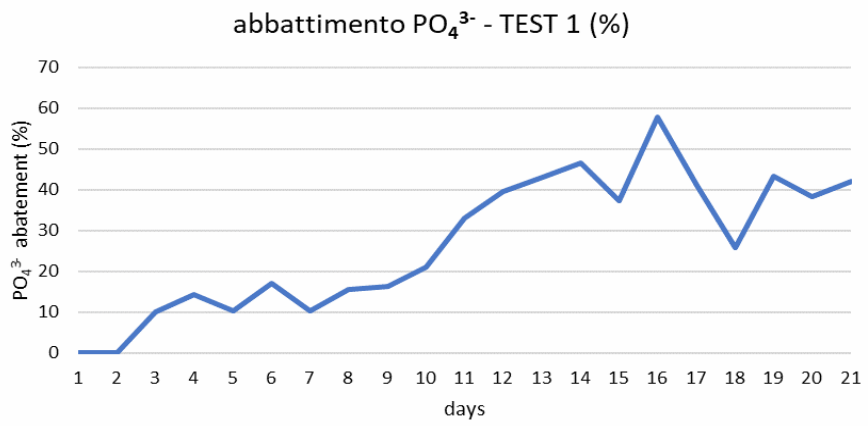
pH = 9.5

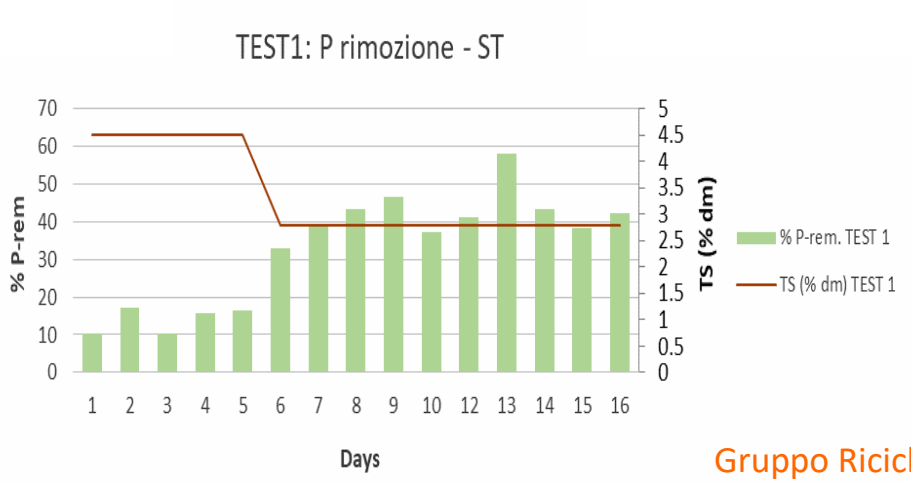
Flusso d'aria = 0.5 L/min

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

ST = 3.3%

P reduction : 60%





Gruppo Ricicla UniMi DISAA

Results

Test 2

PARAMETRI

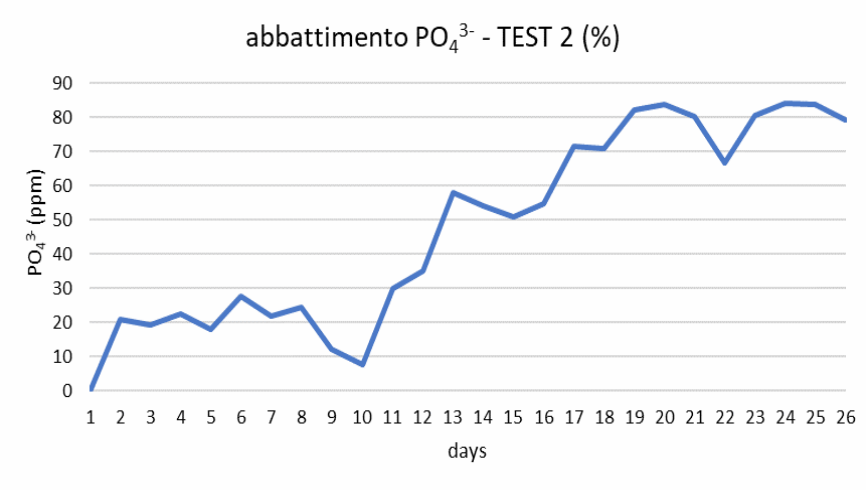
pH = 9.5

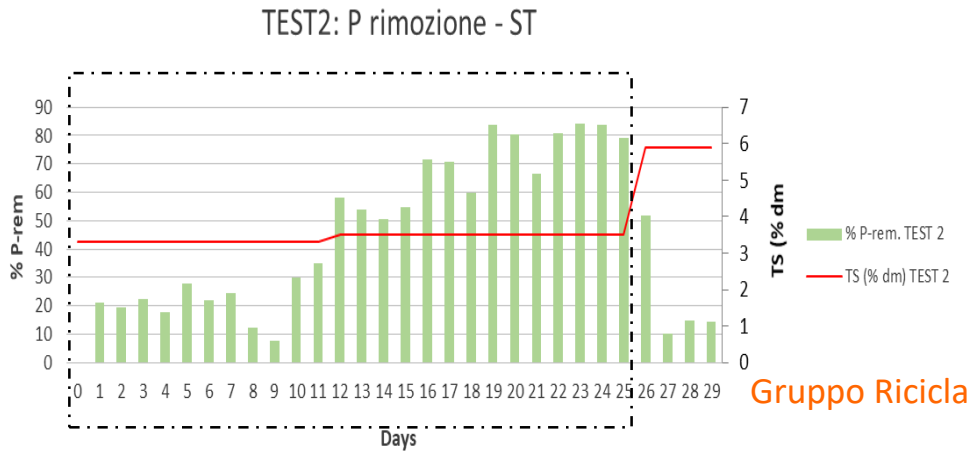
Flusso d'aria = 0.5 L/min

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

ST = 3.3%

P reduction: 85%





Gruppo Ricicla UniMi DISAA

Results

Test 2.1

PARAMETRI

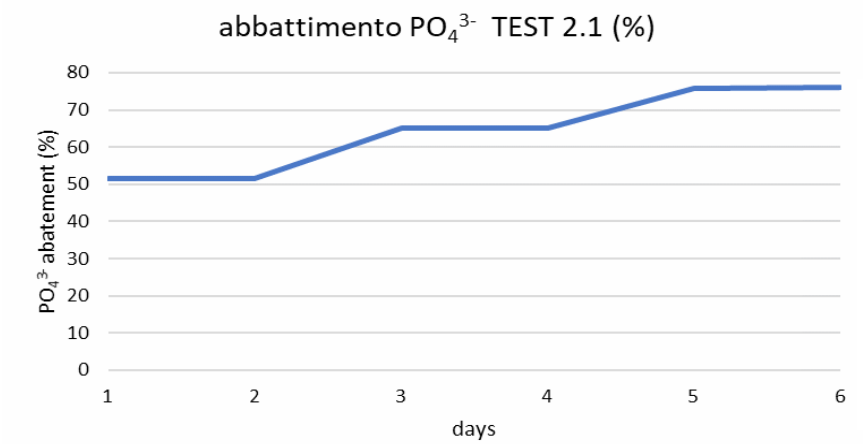
pH = 9.5

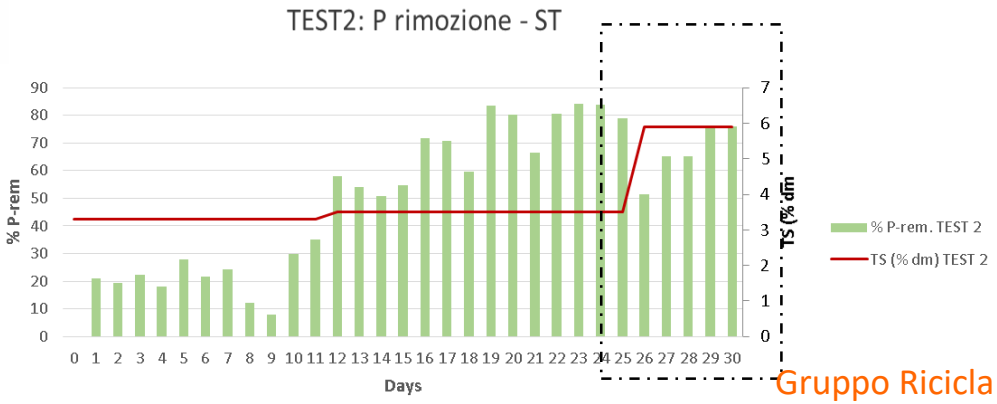
Flusso d'aria = 0.5 L/min

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

ST = 4.5 %

P reduction: 76 %





Results

Test 3

PARAMETRI

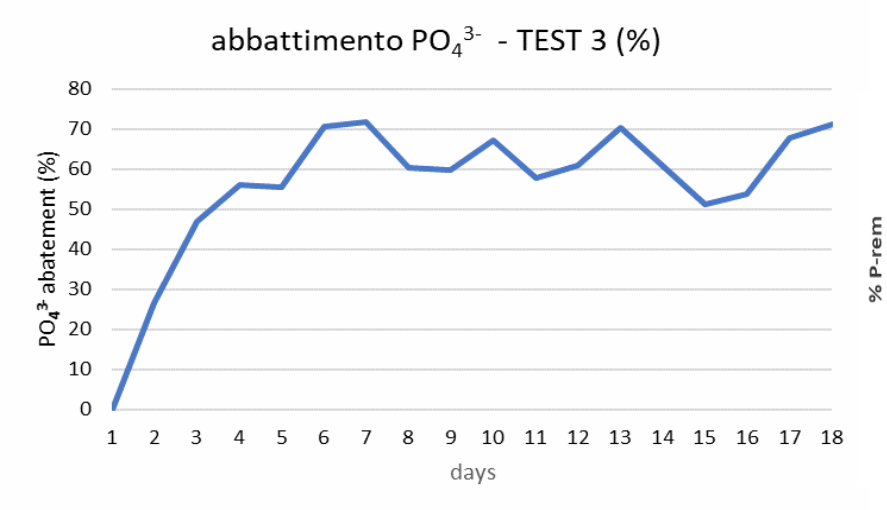
pH = 9.5

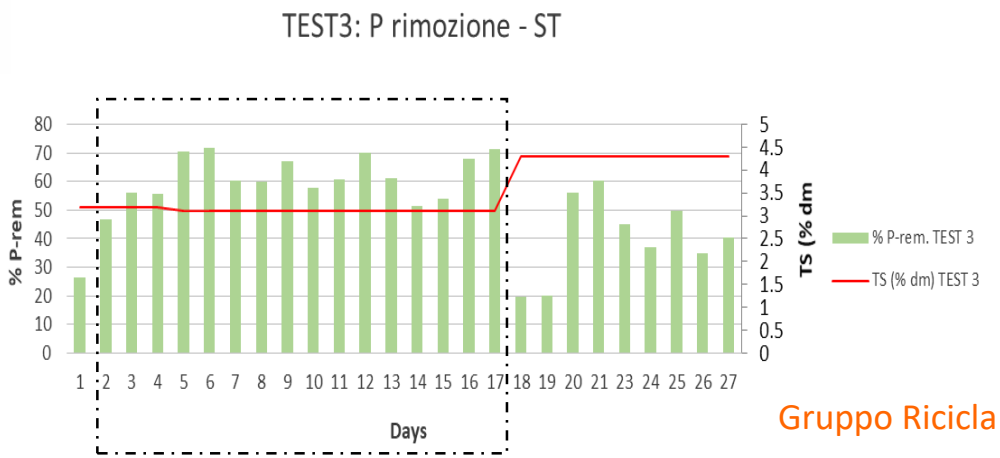
Flusso d'aria = 0.5 L/min

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

ST = 3.3 %

P abbattuto: 72 %





Gruppo Ricicla UniMi DISAA

Results

Test 3.1

PARAMETRI

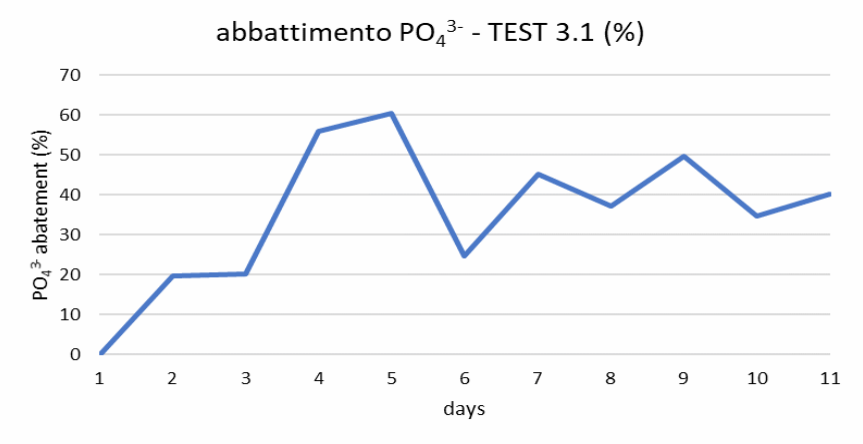
pH = 9.5

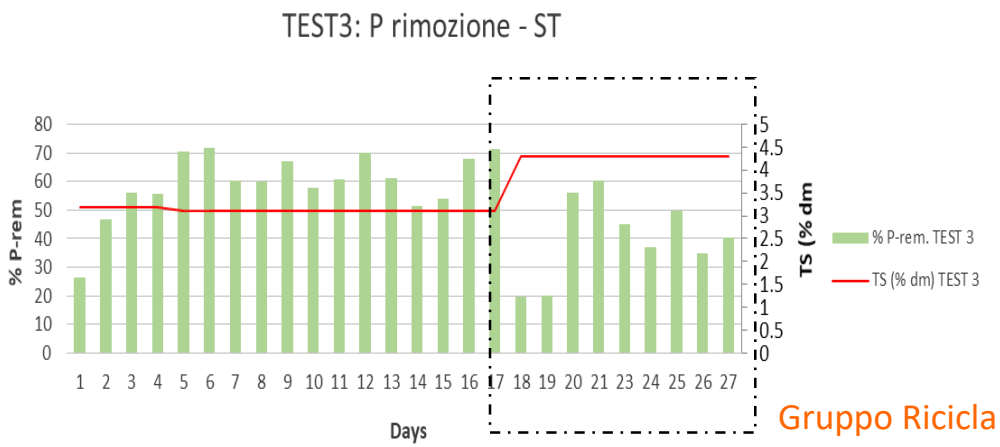
Flusso d'aria = 0.5 L/min

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

ST = 4.5 %

P abbattuto: 62 %





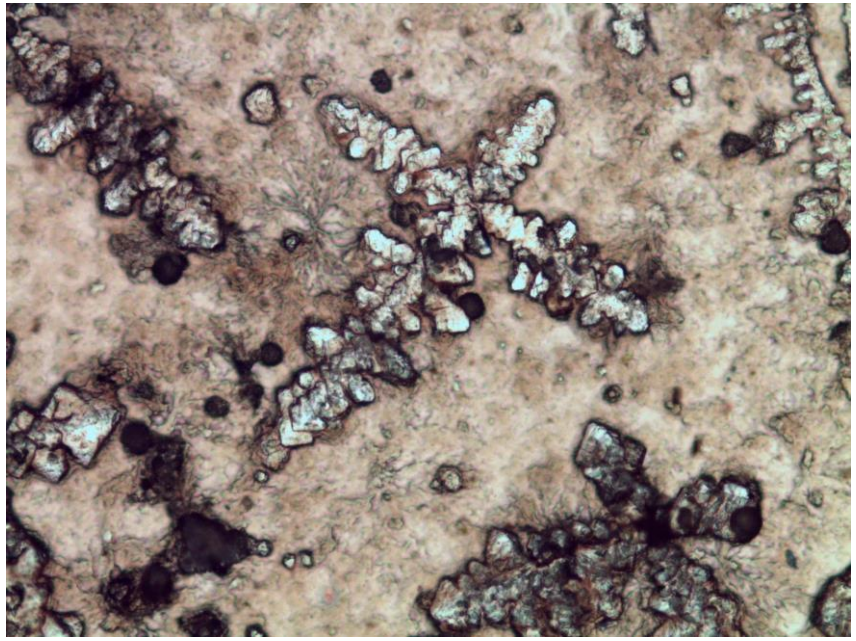
Gruppo Ricicla UniMi DISAA

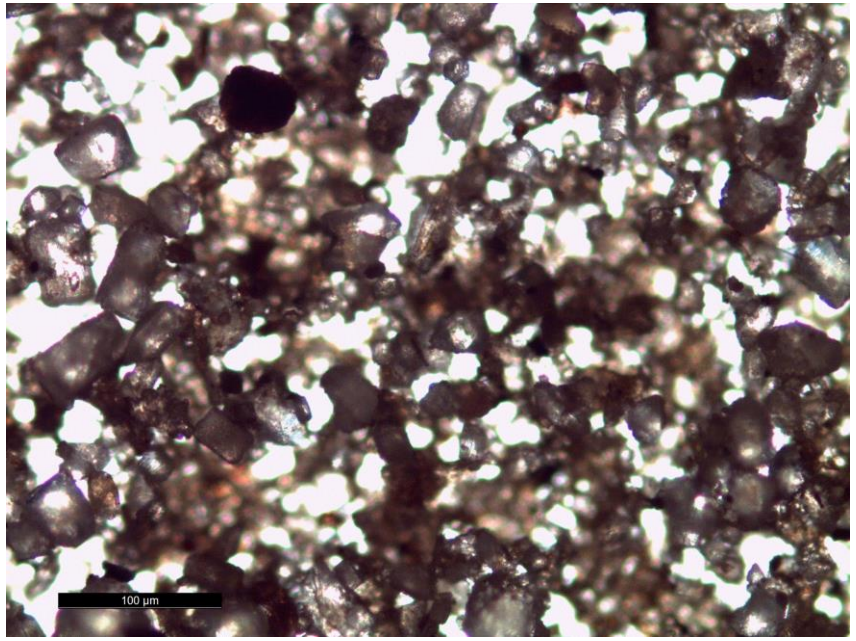
Results

OPTICAL MICROSCOPY ANALYSIS

Test 2 (85% reduction):

- abundance of **mineral crystals**
- Identificate **strutture** dendritiche, pennate, ramificate





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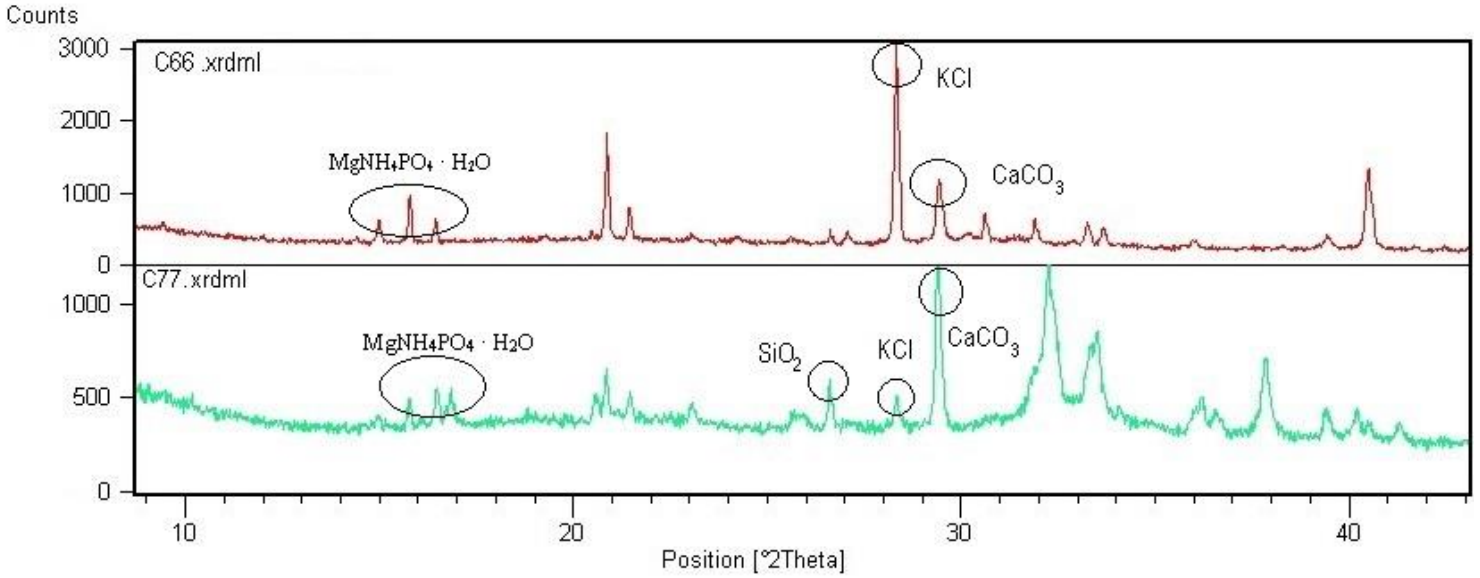
Results

DIFFRACTION ANALYSIS

Test 2 (85% reduction):

- mineral component identified as **struvite**



Conclusioni e sviluppi futuri

- **Phosphorus abatement achieved** under standard conditions : **85** %
- Phosphorus abatement achieved with **high ST content**(~4,5%) : **60-70%**
- **Seawater bittern** valid alternative to $MgCl_2$.
- Precipitate rich in organic carbon, phosphates, magnesium and ammonium: **renewable fertilizer to be tested**
- **Possible transition from prototype to plant scale**