NuReSys®

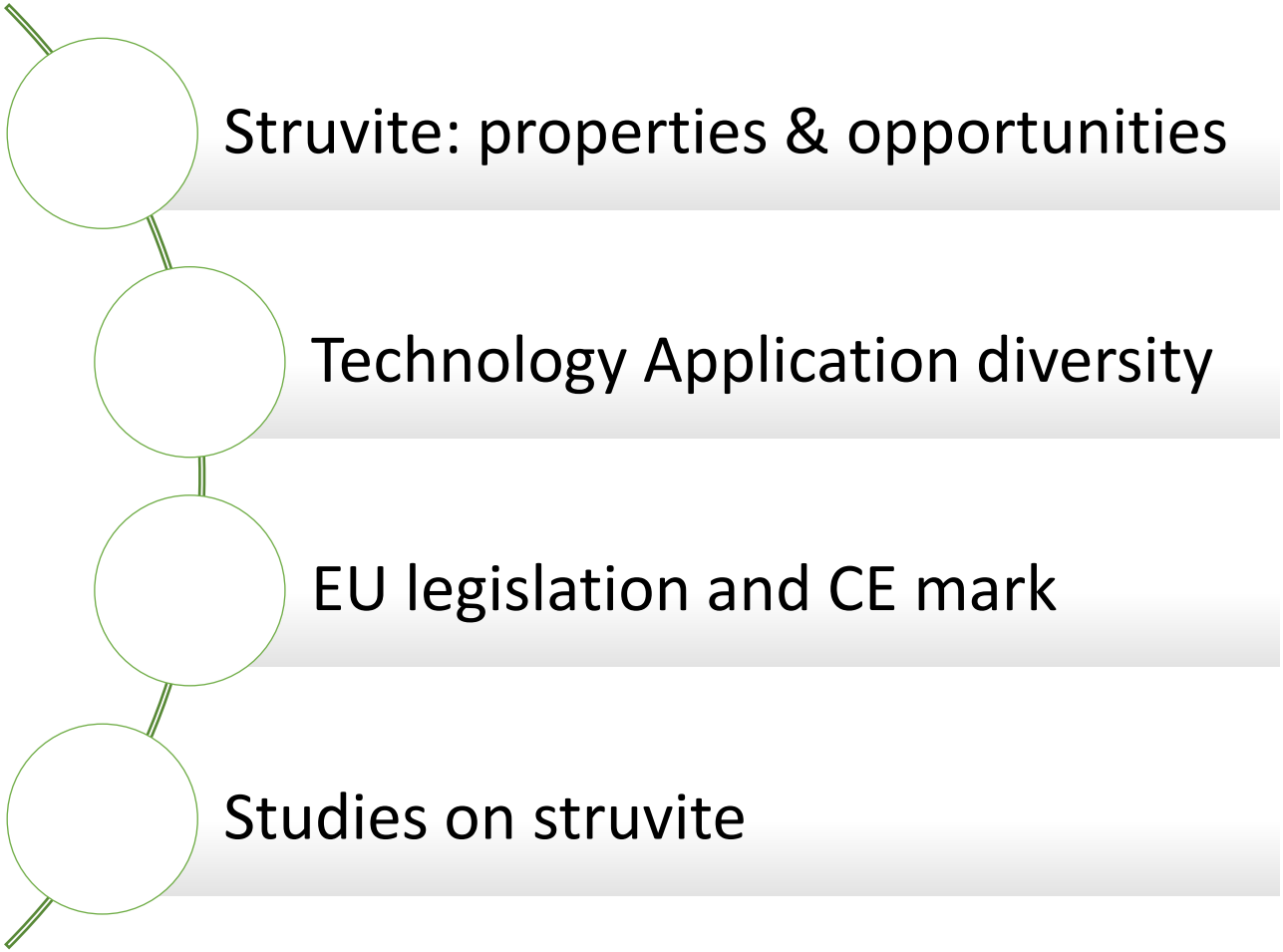
recovers nature's essentials

Struvite – a new option for improving phosphorus balances in organic agriculture

Naturland

ferplay

Table of contents



Struvite as an Alternative Fertilizer

- Mineral fertilizer = Limited resource & high environmental impact
  No P mines in EU (Norway ?)
  Phosphorus listed as critical substance EU

- Quality concerns depending on Mg reagent used (soluble versus low soluble Mg salts)
  Lower quality but consistent product.

- Struvite = excellent fertilizer properties but bad fertilizer
  LOW SALINITY = Droughts

  $MgNH_4PO_4.6H_2O$ 5,7% N 12,6% P 10% Mg 0% K

- No K = but opportunity at hand in producing K-struvite = still bad NPK ratio

  $MgKPO_4.6H_2O$ 0% N 11,4% P 8,7% Mg 17,7% K

- Recent research = struvite versus mineral = at least as good or even better
  = clear advantage 

emission = due to slow-release properties

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Slow-release fertiliser

- Can be used as a precision fertilizer and in organic farming:

SOEPENBERG since 1954

Struvite is a Controlled Release Fertilizer

- Roots „seek“ for nutrients in soils (this is true for N, P).
- Roots concentrate around the struvite pellet.
- By acidification, the roots solubilize the struvite and take nutrients up efficiently.

Struvite pellet after 4 months

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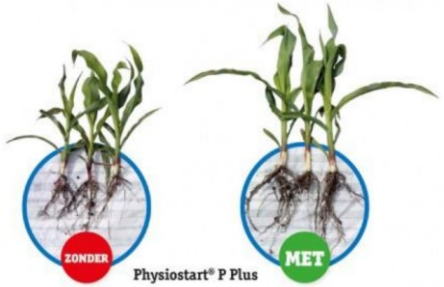
Struvite as an Alternative Fertilizer

- Root induced organic acid release
  Nitrification by soil microbiota

https://crystalgreen.com/

- Phyto-start (Timac)



- Need for Market-pull product

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Struvite as a ‘feed material’

- Further processing of struvite can add value.

SOEPENBERG since 1954

How to turn Struvite into a Fertilizer Product

Pelletizer

Granulator

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Application diversity

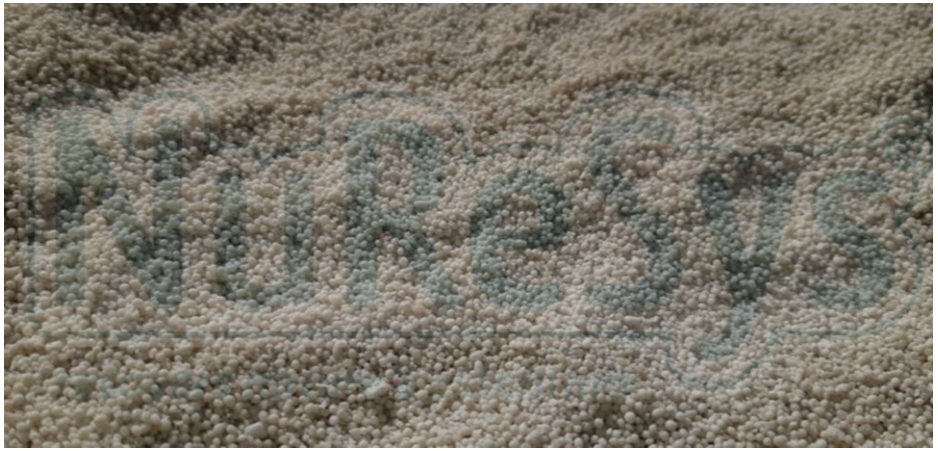
MWWTP on Centrate

MWWTP on Digestate

IWWTP on Centrate

Bio-Stru®

Sustainable Circular Fertilizer



https://bio-stru.com/

Technology – General

Motivation P recovery ≠ P recovery as fertilizer

- Scaling Prevention & Gritt clogging reactors



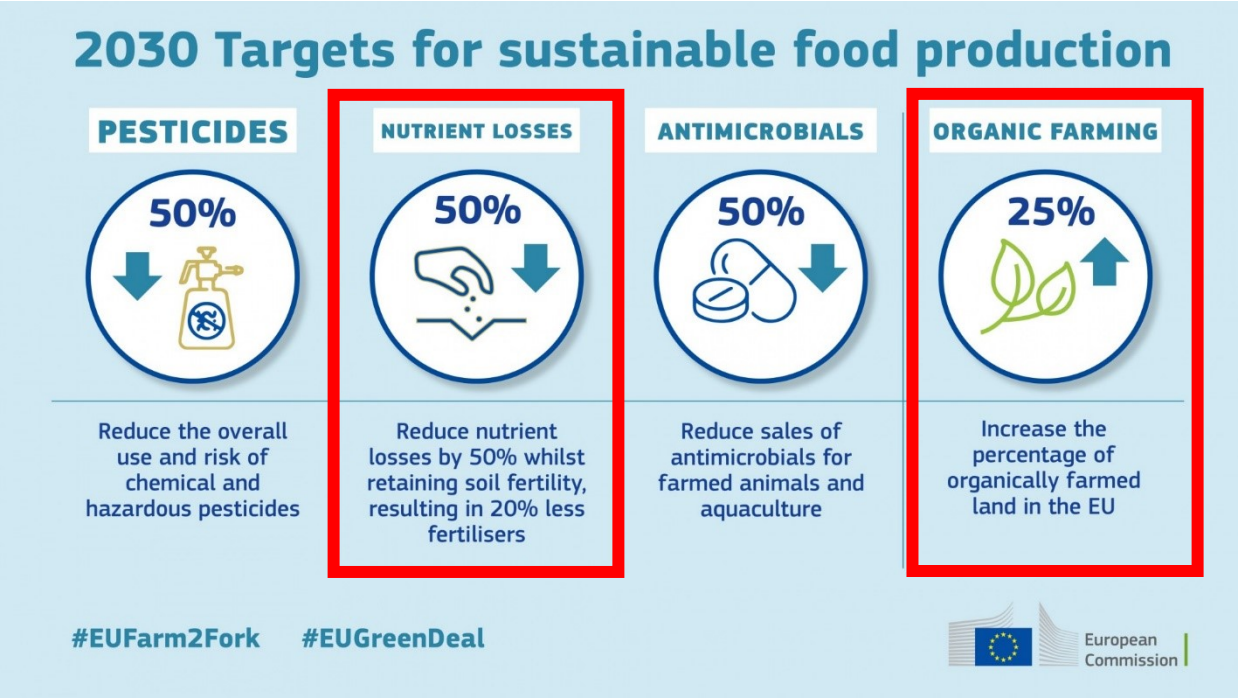
- Reducing back-flow PO4-P (up to 25% of P load)
- Stabilizing Bio-P removal in main WWTP

IPM

Depending on the specific situation at your plant and your immediate and/or future expectations, NuReSys combines its different technologies in order to Integrate Phosphate Management solutions.

Benefit resulting from using Struvite

EU Greendeal



GENERAL:

Reduced GHG emmission @ high level NOx
Decreased dependency of imported phosphates
Transition to circular economy

https://newsroom.eosta.com/en/what-does-the-eu-green-deal-mean-for-the-fruit-and-vegetable-sector/

Regulation 2019/1009 - EU fertilizers

An EU fertiliser product

Struvite

Requirements of product function category (Annex I)

PFC 1(C)(I)(a)(ii): COMPOUND SOLID INORGANIC MACRONUTRIENT
FERTILISER

Minimum concentrations*

- 3 % of total nitrogen (N),
- 3 % of total phosphorus pentoxide (P_2O_5),
- 3 % of total potassium oxide (K_2O),
- 1,5% of total magnesium oxide (MgO),
- 1,5 % by mass of total calcium oxide (CaO),
- 1,5 % by mass of total sulphur trioxide (SO_3), or
- 1% of total sodium oxide (Na 2 O).

Total sodium oxide (Na 2 O) < 40 %.
The sum of all declared macronutrient contents shall be at least 18 % by mass.

Requirements of relevant component material category (Annex II)

CMC 12: PRECIPITATED PHOSPHATE SALTS AND DERIVATES

Struvite recovered from wastewater is allowed (both municipal and industrial)

The precipitated phosphate salts shall contain:

- phosphorus pentoxide (P_2O_5) > 16 % of the dry matter content;
- Organic carbon (Corg)< 3 % of the dry matter content;
- <3 g/kg dry matter of macroscopic impurities above 2 mm (organic matter, glass, stones, metal and plastics;
- <5 g/kg dry matter of the sum of the macroscopic impurities referred.

*by mass

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R2086

EU Regulation - CMC12 conti.

- The precipitation process shall take place under controlled conditions in a reactor.
- Pathogens:

Micro-organisms to be tested	Sampling plans			Limit
	n	c	m	M
Salmonella spp.	5	0	0	Absence in 25 g or 25 ml
Escherichia coli or *Enterococcaceae*	5	5	0	1 000 in 1 g or 1 ml
Clostridium perfringens	5	5	0	100 CFU in 1 g or 1 ml
Ascaris sp. viable eggs	5	0	0	Absence in 25 g or 25 ml

- The dry matter of precipitated phosphate salts and derivates shall be measured using vacuum drying at 40 °C until constant weight to avoid the loss of crystal-bound water.
- Heavy metal contamination:

Regulated metals (mg/kg)*	EU Fertilizer limit
Zn	1500
Cu	600
Ni	100
Cr VI	2
Cd	60
Pb	120
Hg	1
As (inorg.)	40

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R2086

EU FPR-CE Mark

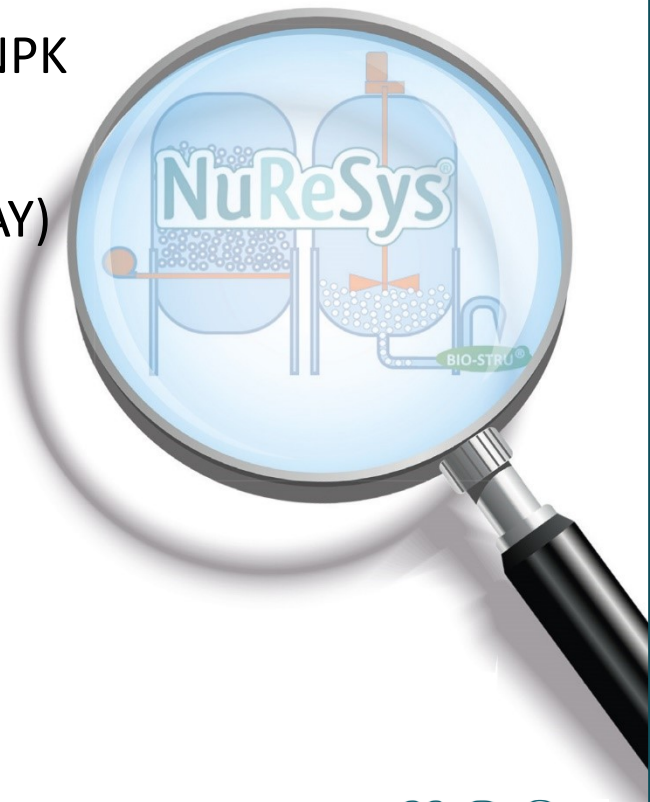
- The regulatory framework is in place EU 2019/1009 and EU 2019/1009
- Notified body can examine each production site to see if struvite meets the laid-out criteria
- EU Fertiliser product regulation CE mark can be obtained

✓Allows use in organic farming

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R2086

Application of struvite as a fertilizer

- Used as a booster in the sowing stage
- Used in organic farming
- Mixed with conventional fertilisers to optimise NPK
- Mixed with organic/recovered fertilisers (FERPLAY)



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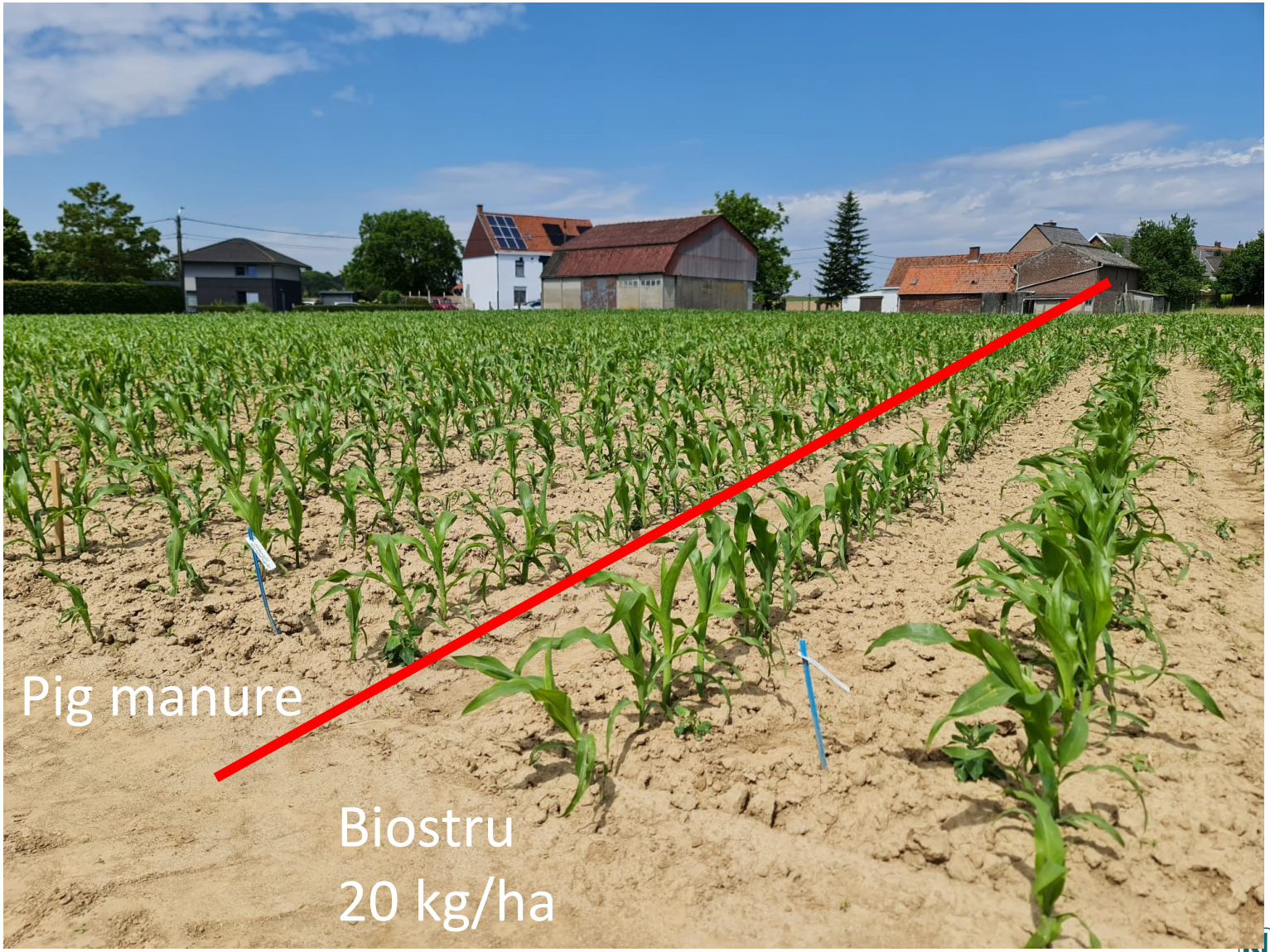
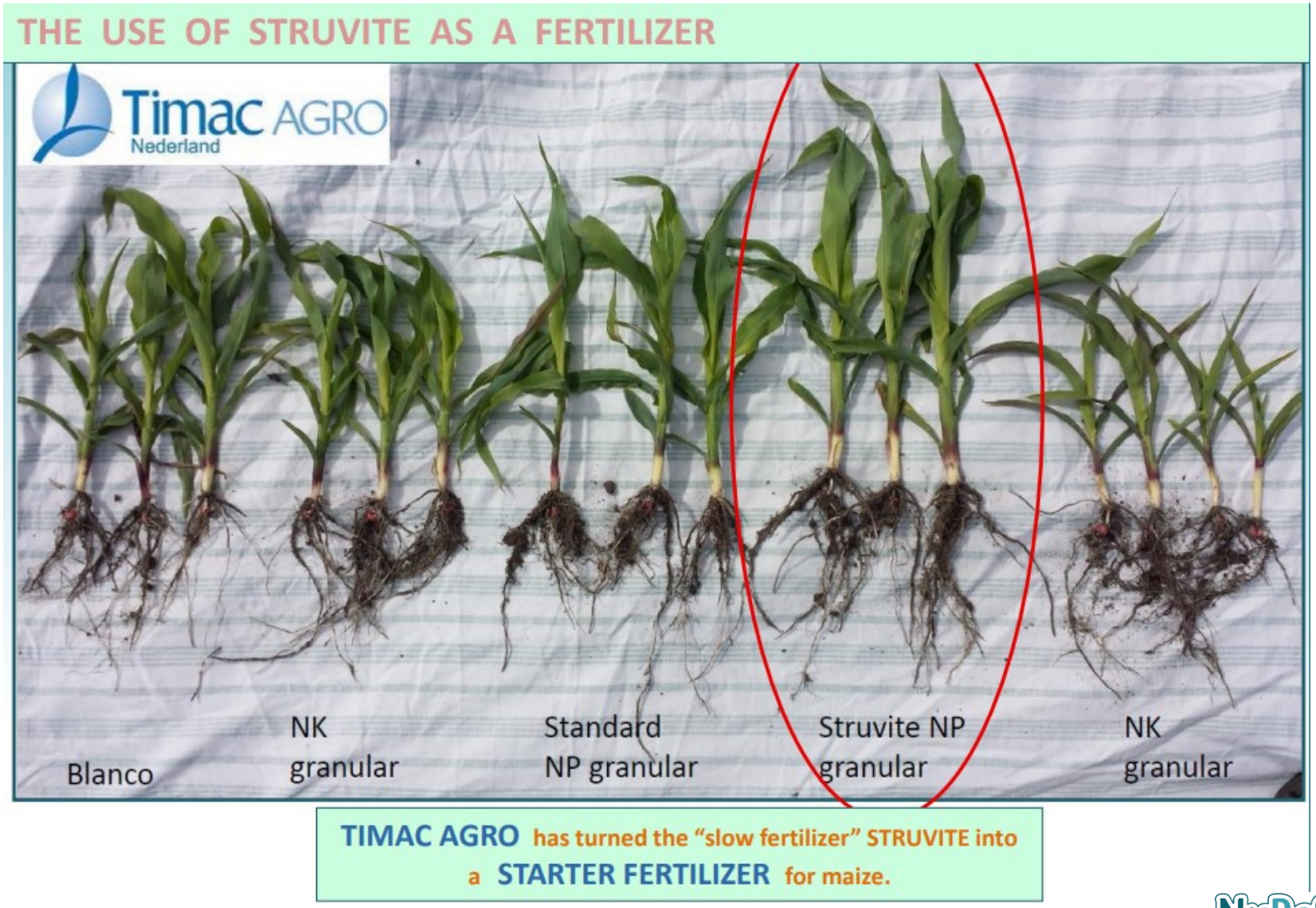
Bio-Stru field trails - Maize



Bio-Stru field trails -Maize



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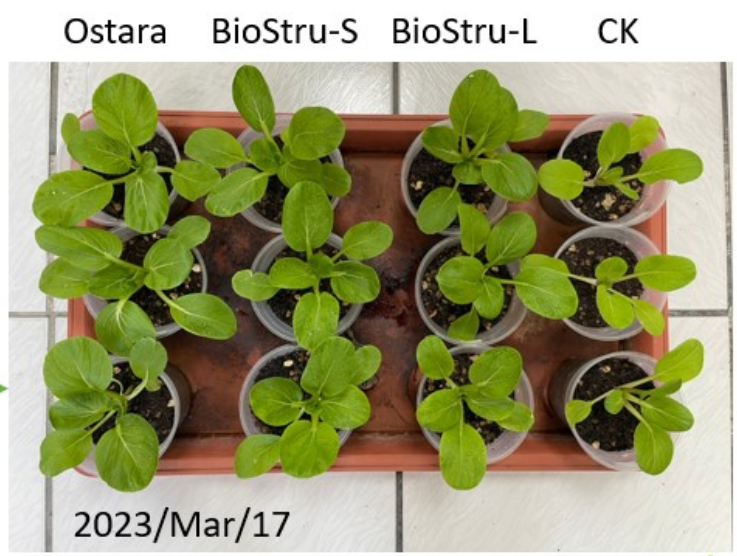
Struvite field trails – far Asia



- Ostara was purchase from the dealer shop in Taiwan
- Use same gram of Ostara, BioStru-S and –L (2 different particle size) and directly mix with pak choy roots.
- CK, water + foliar fertilizer 14-15-10 1 time on 10 Mar.
- We test 2 weeks, there is no harmful to roots.

A systematic comparison of commercially produced struvite: Quantities, qualities and soil-maize phosphorus availability

Table 3
Heavy metal content of the analyzed struvite samples (Empty cells: measured content < limit of detection (LOD). N.A.: Not Applicable). Color fill of the cells indicates to which extend the regulatory limit is approached or if no regulation applies.

			Type I: digestate									**Type II**: dewatering liquor of digestate										**Type III**: UASB effluent						
Regulated metals (mg/kg)*	EU Fertilizer limit	LOD	Aiirprex 1	Aiirprex 2	Airprex 3	Aiirprex 4	Aiirprex 5	HHNK 1	NuReSys 1	Vecht		Phosgreen 1	Phosgreen 2	Phosgreen 3	NuReSys 2	NuReSys 3	Anphos 1	Anphos 2	Pearl 1	Pearl 2	Pearl 3	Naskeo	Nuresys 4	Nuresys 5	Phospaq	Anphos 3	Anphos 4	Anphos 5
Zn	1500	1	50	24	40	26	33	2	13	33		4.2	1.6	1.8	55		5.6	1.4			13	8.1	14	548	241	501	4.8
Cu	600	1	28	17	16	7.4	7.5	2	3.3	20					64		1.5				6.3	1.2	1.4	70	73	92	
Ni	100	1	2.3	3.4	1.5	1.4	1.1			1.3					4						12			5.5	6	5.2	
Cr VI	2	1.5																									
Cd	60	1																							1.9	2	
Pb	120	2	19	2.4	3.4	3.4				3.5					9.9									3.7	3.1	2.2	
Hg	1	0			0		0.1			0					0						0						
As (inorg.)	40	0.5	0.6												0.6						5.7			1.3	1	1.2	
Metals not regulated for in the fertilizer regulation (mg/kg)																											
Mn	N.A.	1	179	129				30	193		43	64	94	28	441	28	688	211				121		201			154
Cr	N.A.	1	2.9	1.6	3.3	4.8	2	6.2	7	2.5				6.8	13						2.7	7.5		9	5.4	5.7	

Muys, M., Phukan, R., Brader, G., Samad, A., Moretti, M., Haiden, B., ... & Spiller, M. (2021). A systematic comparison of commercially produced struvite: Quantities, qualities and soil-maize phosphorus availability. *Science of the Total Environment*, *756*, 143726.

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A systematic comparison of commercially produced struvite: Quantities, qualities and soil-maize phosphorus availability

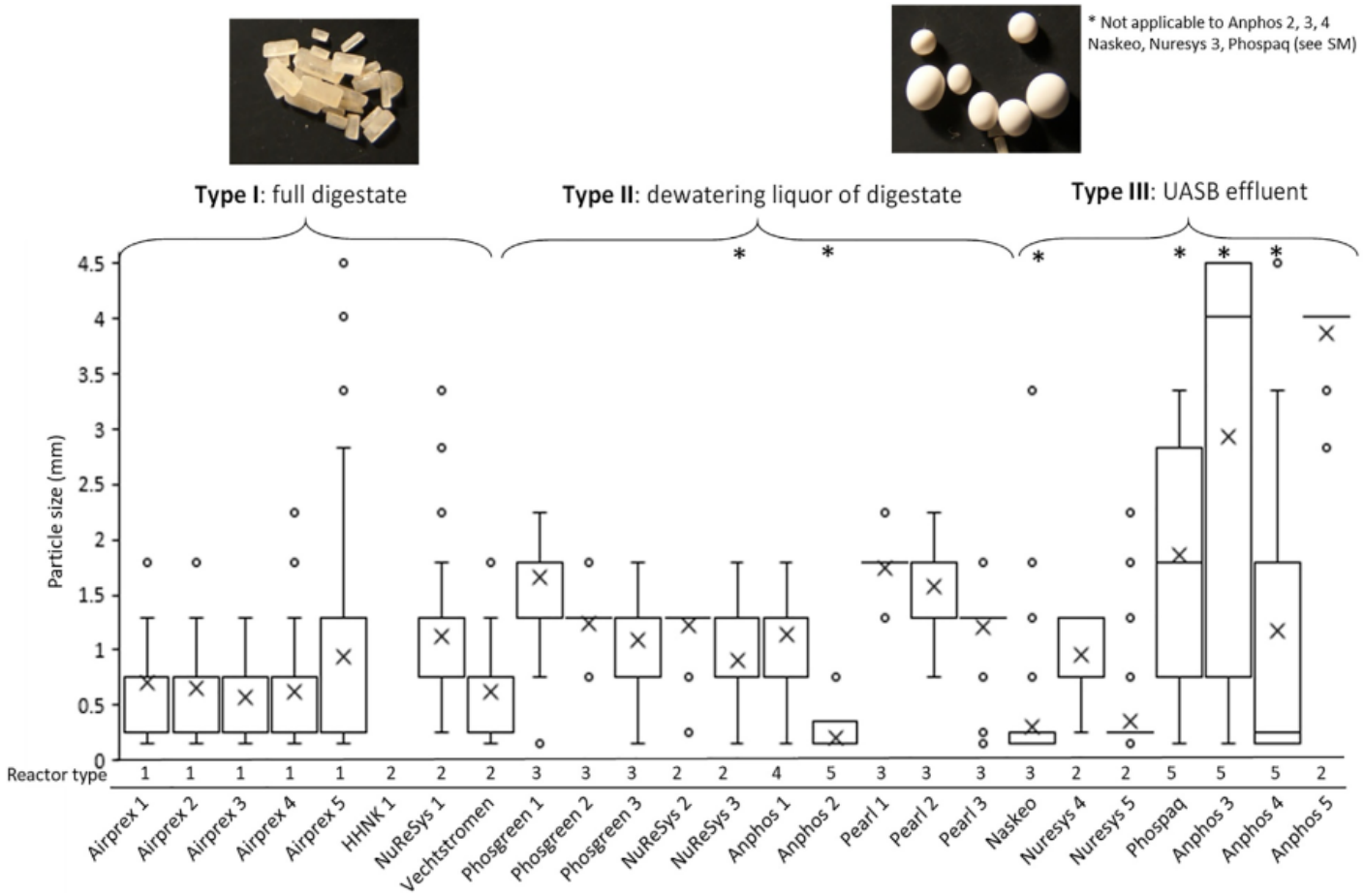

Fig. 5. Mass fraction distribution per particle size for all analyzed struvite samples. Crosses indicate the mean particle size (mm). Numbers indicate the reactor type as follows: 1 Airlift reactor, 2 Continues stirred tank reactor, 3 Fluidized bed reactor, 4 Tank aerated, 5 Tank mixed. Histograms, descriptive statistics and pictures per sample are presented in the SM Section 6, raw data shown in SM Table 4.

Muys, M., Phukan, R., Brader, G., Samad, A., Moretti, M., Haiden, B., ... & Spiller, M. (2021). A systematic comparison of commercially produced struvite: Quantities, qualities and soil-maize phosphorus availability. *Science of the Total Environment*, *756*, 143726.

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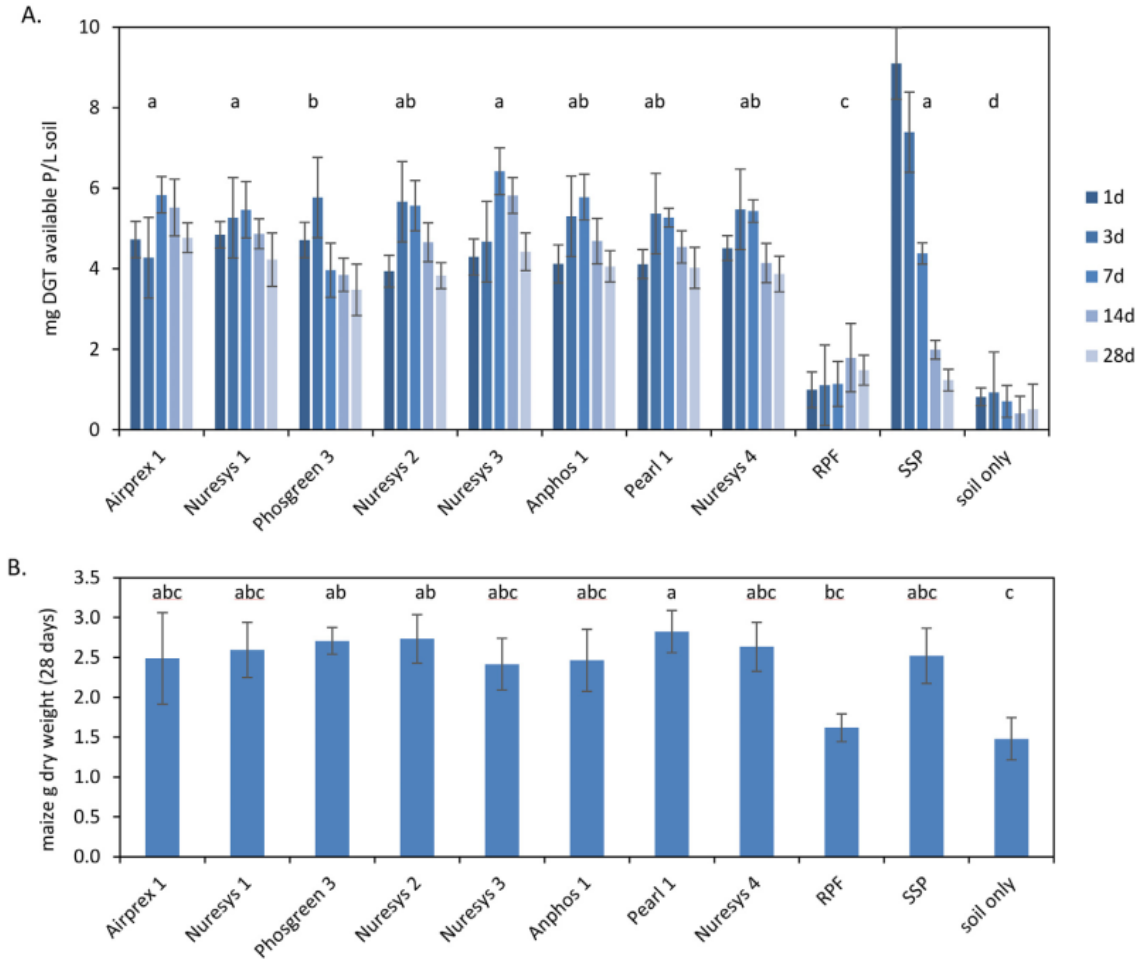

Fig. 6. A) Available P in days after germination in maize seedlings pots fertilized with struvite, rock phosphate (RP), single super phosphate (SSP) or without additional P fertilization (soil only). P collected in 24 h hours with DGT after the indicated time points are shown. P application was normalized to the P content of each sample so that in each pot the same amount of P was applied. B) Maize seedling dry weight after 28 days. Letter codes indicate significant differences between overall release patterns (i.e. different letters represent significant differences $p < 0.01$), for example letter combinations containing the latter 'a' are not significantly different from each other, while a combination not containing the letter 'a' is significantly different.

Muys, M., Phukan, R., Brader, G., Samad, A., Moretti, M., Haiden, B., ... & Spiller, M. (2021). A systematic comparison of commercially produced struvite: Quantities, qualities and soil-maize phosphorus availability. *Science of the Total Environment*, *756*, 143726.

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Publications for net Struvite Nox emissions

- Yang, Z., Ferron, L. M., Koopmans, G. F., Sievernich, A., & van Groenigen, J. W. (2023). Nitrous oxide emissions after struvite application in relation to soil P status. *Plant and Soil*, 1-15.
- Wang, L., Ye, C., Gao, B., Wang, X., Li, Y., Ding, K., Li, H., Ren, K., Chen, S., Wang, W. and Ye, X., 2023. Applying struvite as a N-fertilizer to mitigate N2O emissions in agriculture: Feasibility and mechanism. Journal of Environmental Management, 330, p.117143.
- Fukumoto, Y., Suzuki, K., Kuroda, K., Waki, M. and Yasuda, T., 2011. Effects of struvite formation and nitratation promotion on nitrogenous emissions such as NH3, N2O and NO during swine manure composting. Bioresource technology, 102(2), pp.1468-1474.
- Britton, A.T., Sacluti, F., Oldham, W.K., Mohammed, A., Mavinic, D.S. and Koch, F.A., 2007, June. Value from waste–struvite recovery at the city of Edmonton's gold bar WWTP. In Proc. IWA Specialist Conference: Moving Forward–Wastewater biosolids sustainability.

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