This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 818470

NUTRIMAN

Nutrient Management and Nutrient Recovery Thematic Network

Presentazione di casi di tecnologie e prodotti fertilizzanti ottenuti da processi di Bioeconomia: STRUVITE

Sofía Grau – DAM

27 May 2021

- Sofía Grau.
- Project manager Innovation department.

Depuración de Aguas del Mediterráneo

WWTP Management.

PHORWater

LIFE12 ENV/ES/ 000441

Integral Management Model for Phosphorus recovery and reuse from Urban Wastewater

With the contribution of the LIFE finantial instrument of the European Union

NUTRIMAN

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- Tecnología ID: 207
- Producto ID: 208

NUTRIMAN

CONTENT

Struvite recovery.

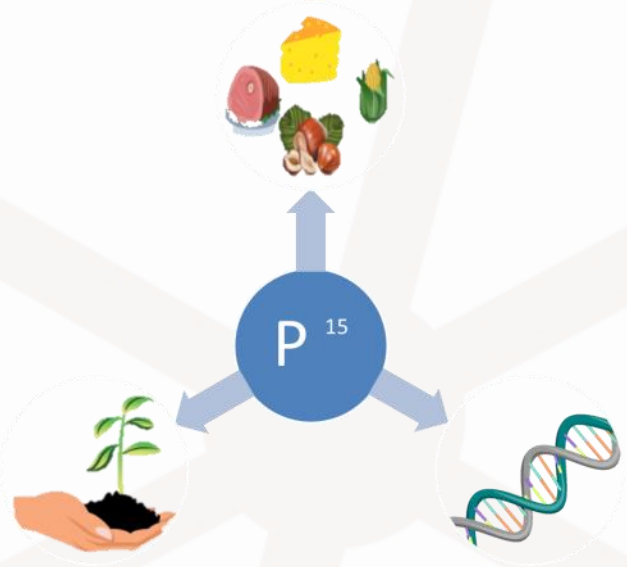
Struvite product.

Field test results.

Future.

STRUVITE RECOVERY

Why Phosphorous?



1. It is essential for living organisms.

2. It is a limited natural resource.

4. There are no major P deposits in Europe.

5. There is no known substitute.

STRUVITE RECOVERY

Phosphorous and environment.

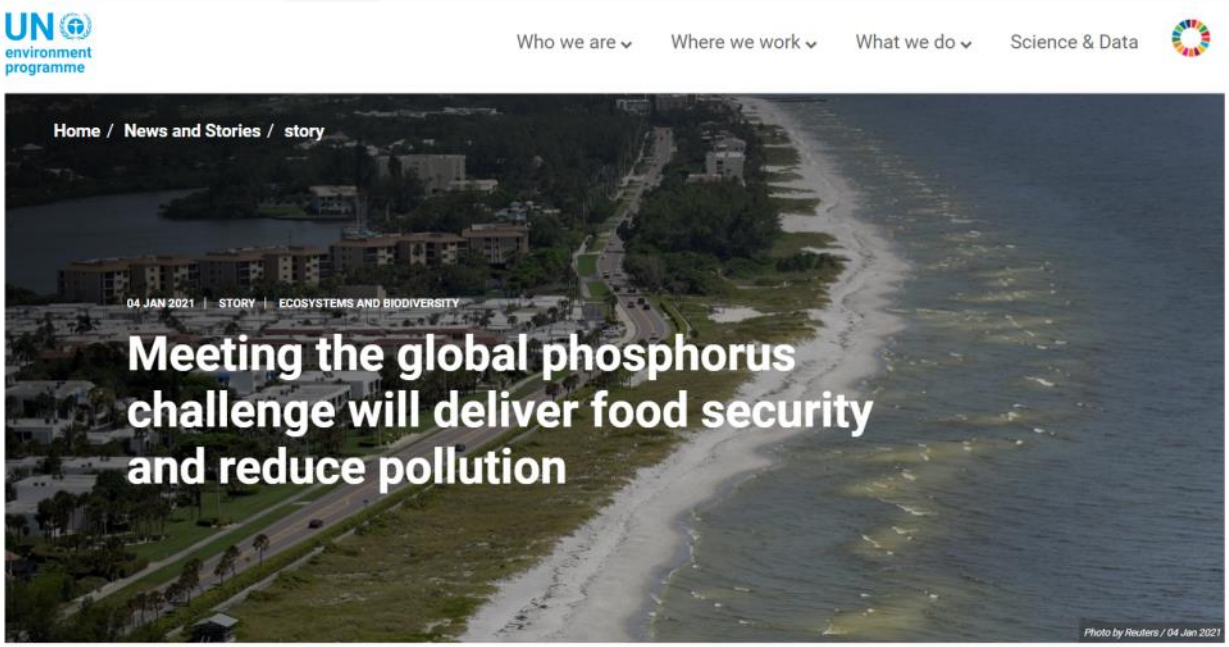
Bayovar P deposit.

(Source: http://infraestructuraperuana.blogspot.com/2014/04/yacimiento-de-fosfatos-de-bayovar.html)

Effects of P discharges.

STRUVITE RECOVERY

On 2017 European Commission included phosphorus and phosphates in the Critical Raw Material List.



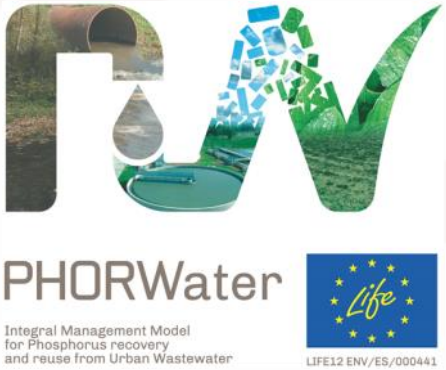
Fuente: https://www.unep.org/

STRUVITE RECOVERY

What to do?

1. Reducing external dependency on P supply.
2. Boosting more efficient agriculture.
3. Encouraging P recovery solutions.

STRUVITE RECOVERY



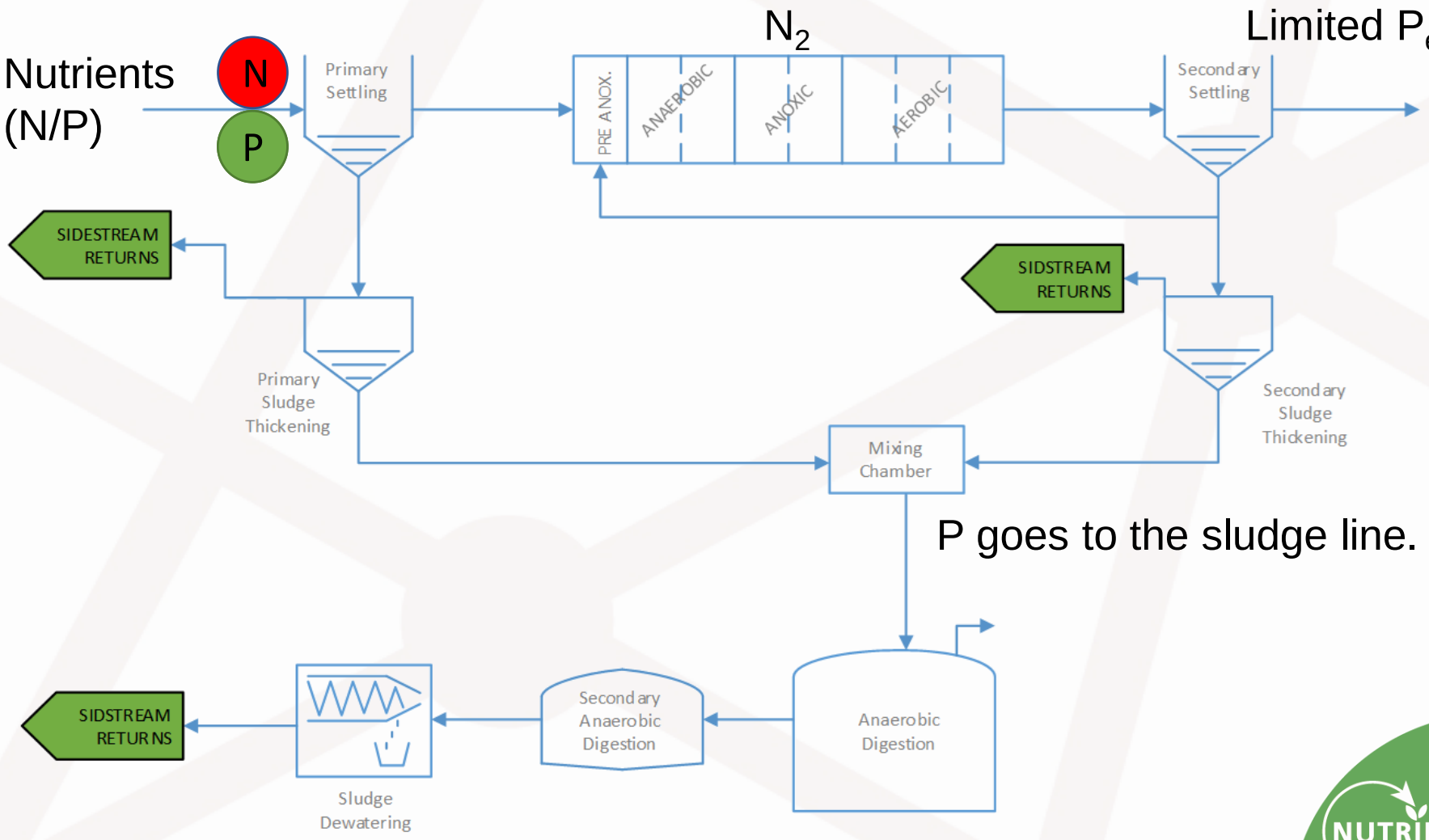
"Integral Management Model for Phosphorus Recovery and reuse from Urban Wastewater"

Sustainable Management of P in WWTPs

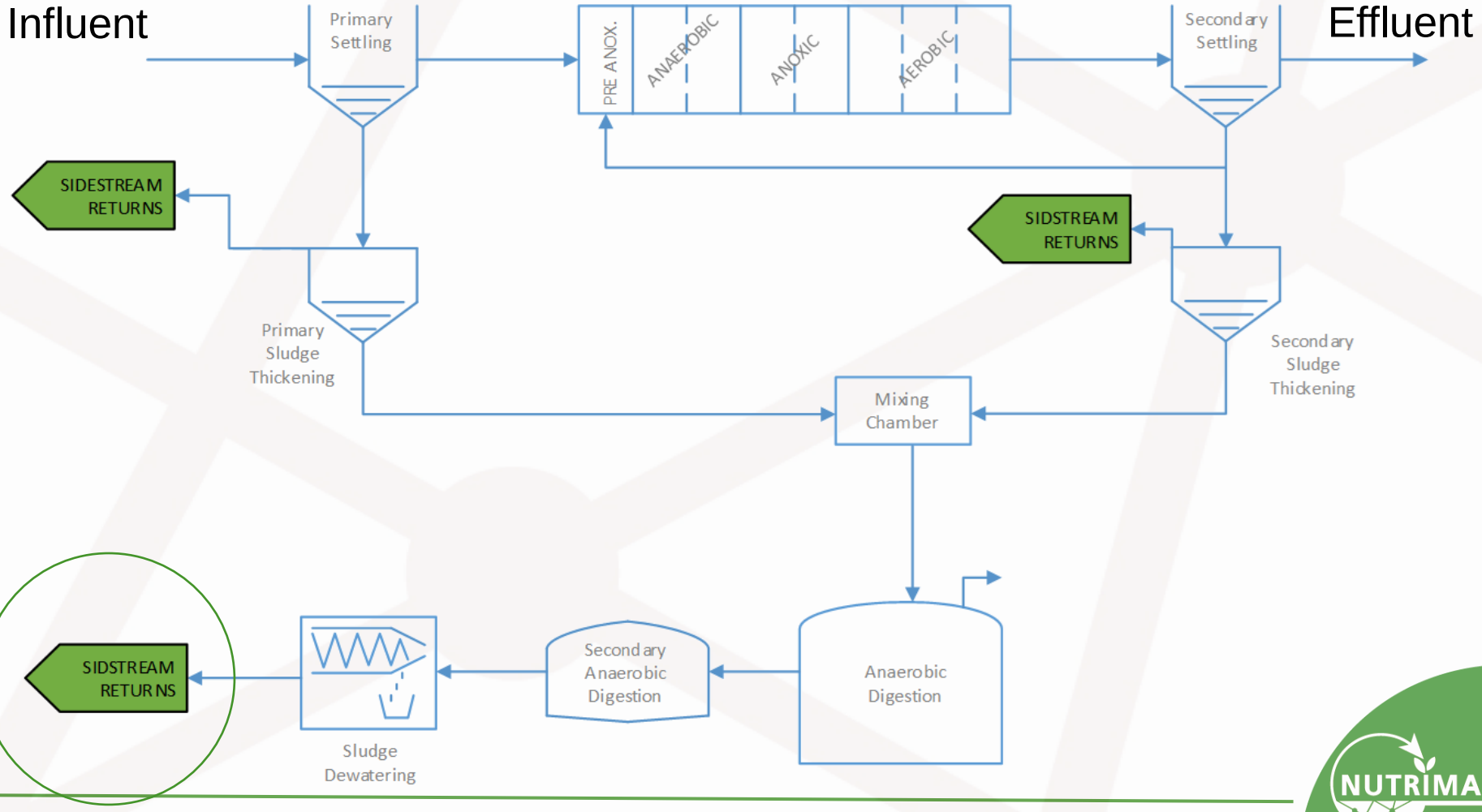
Uncontrolled P precipitation

P recovery from sludge line supernatants

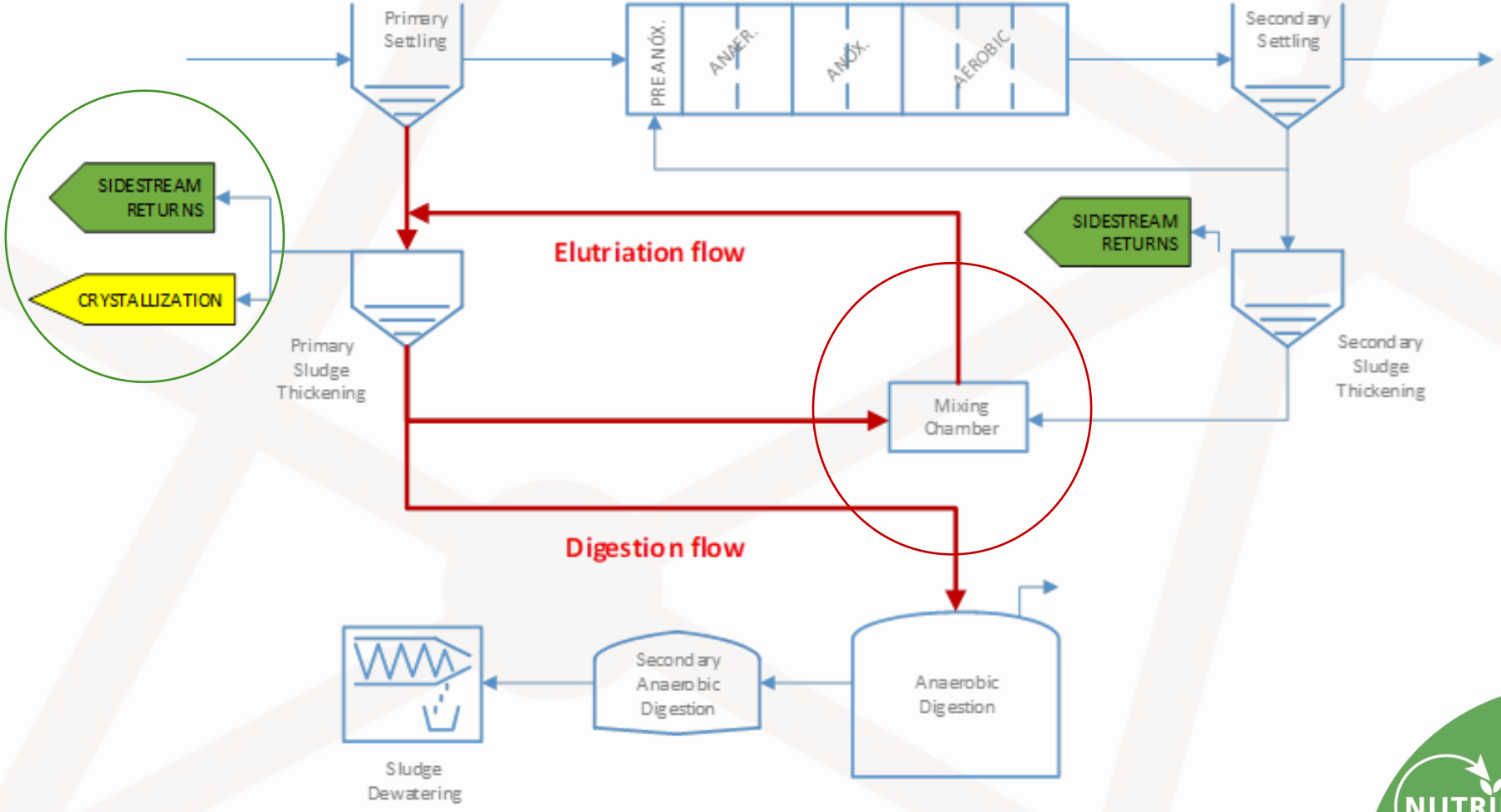
STRUVITE RECOVERY



STRUVITE RECOVERY

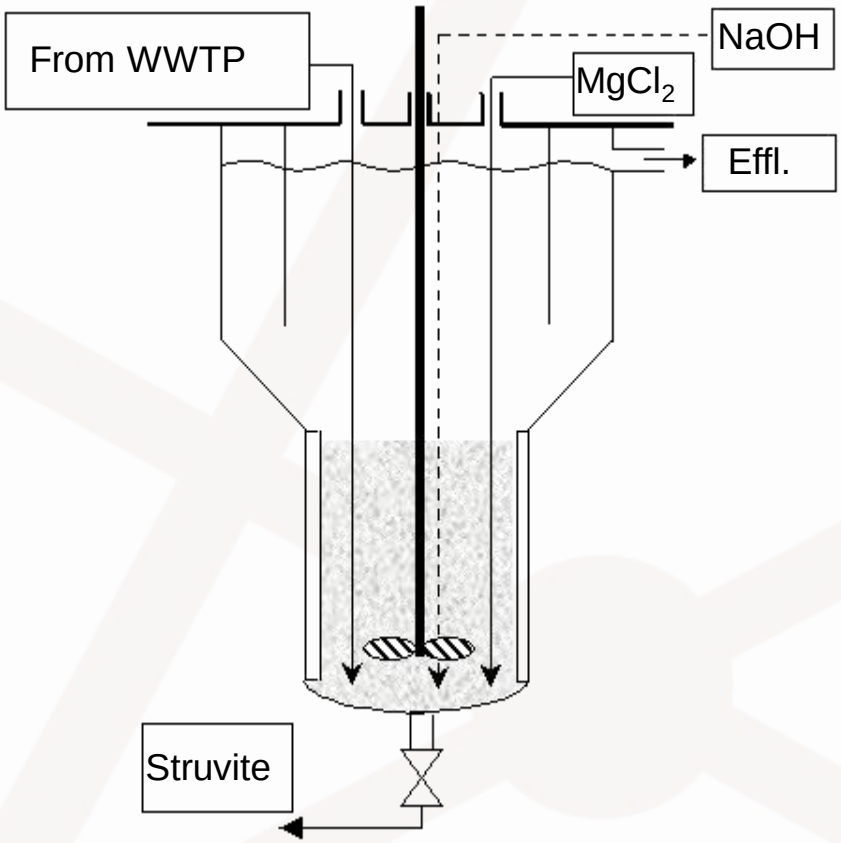


STRUVITE RECOVERY



THE REACTOR

- CSTR(reaction)+Settling

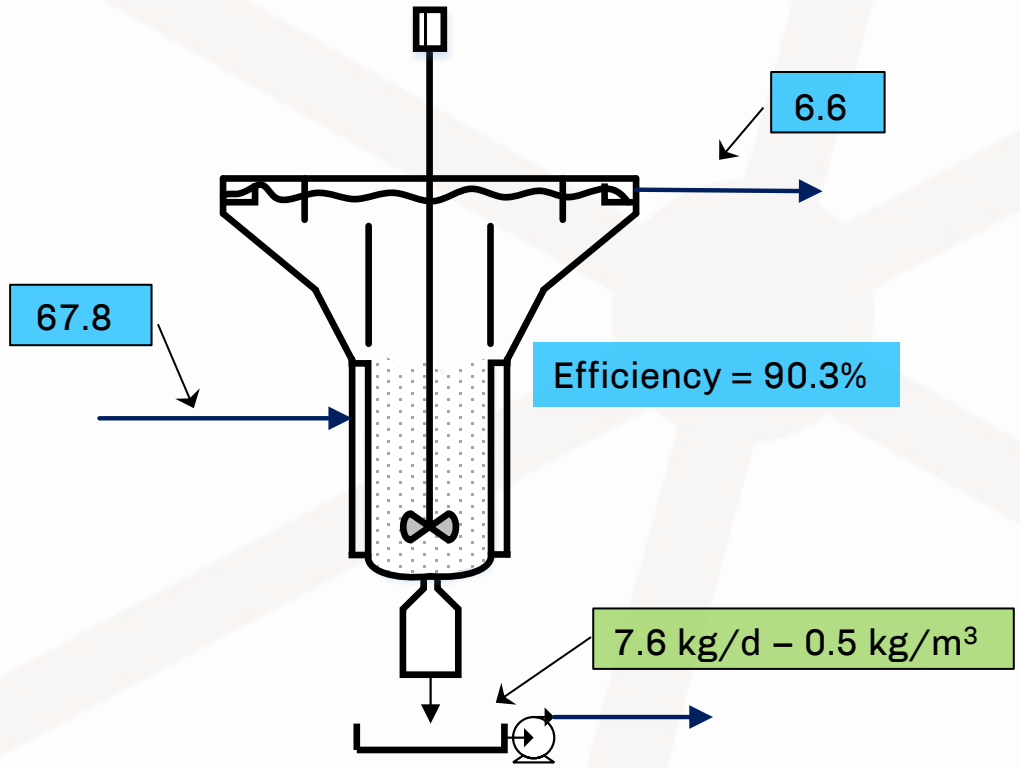


- Prototype: 20L ⟶ 5m^3.
- Flow: 20 m^3/d.
- Two areas:
  - Mixed, where the reaction takes place.
  - Settling, to separate struvite from liquid fraction.
- The P-rich flow from the WWTP is **continuously fed** to the reactor while struvite is **recovered in batches**.

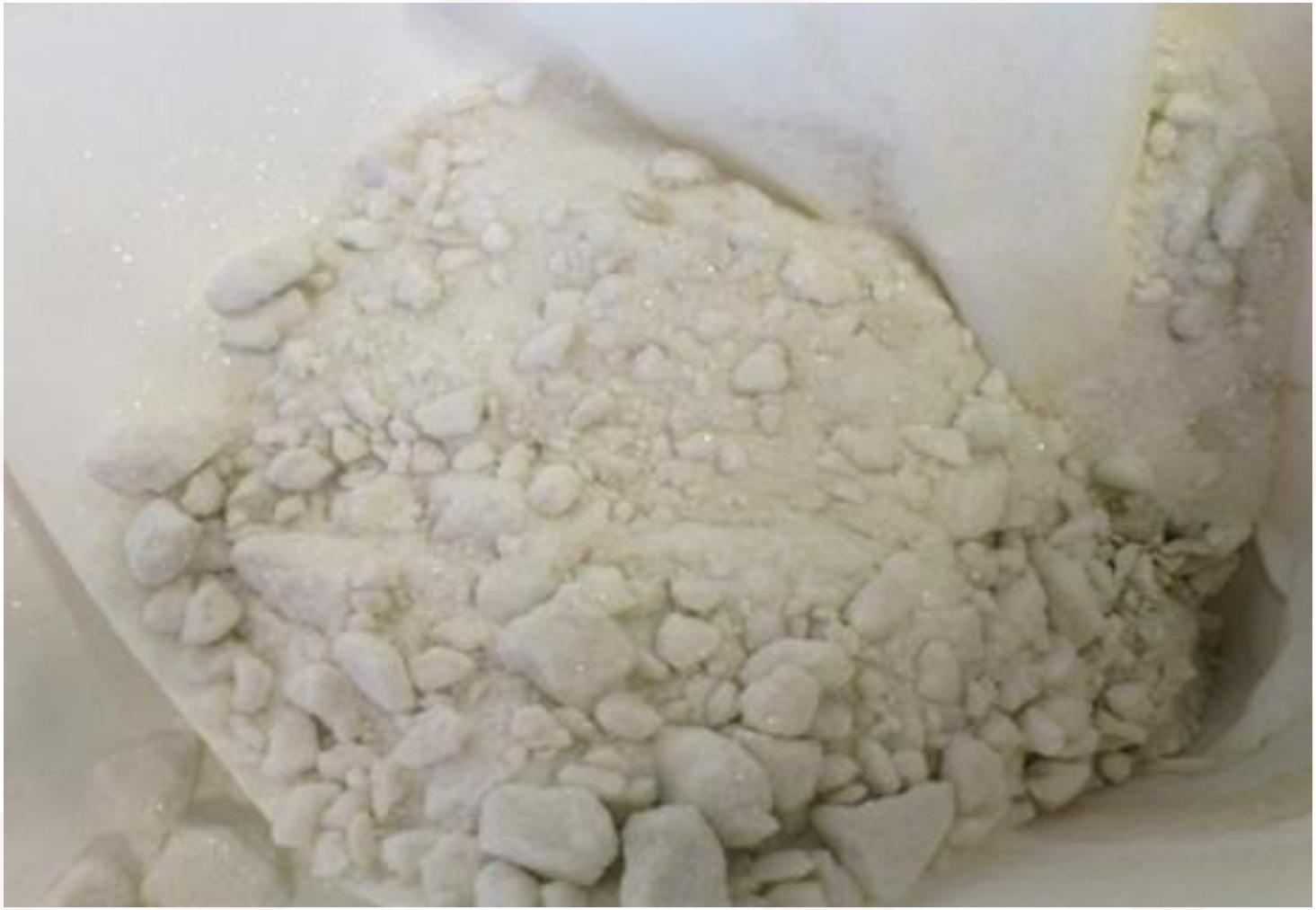
THE REACTOR

- Demonstration plant.

Operational parameter	Set Value
pH	8.7
Molar ratio (Mg/P)	1.3
Inlet flow (m^3/d)	20,0
Reaction zone HRT (h)	2.5
Total HRT (h)	6.1
Agitator speed (rpm)	69
[Mg^{2+}] (mg Mg/L)	4800



THE PRODUCT

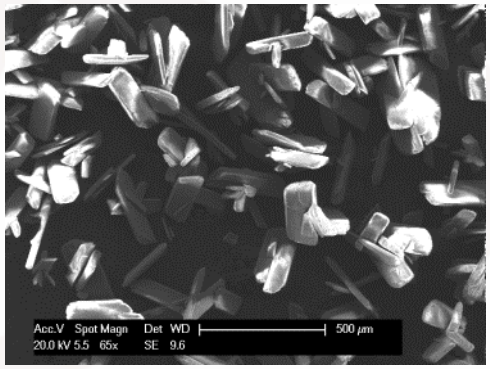


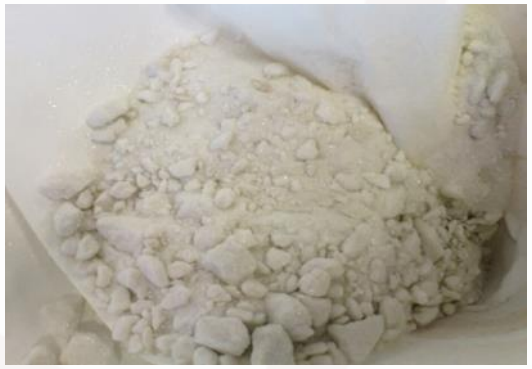
STRUVITE PRODUCT

$$MgNH_4PO_4{\cdot}6H_2O$$

Struvite recovery reaction:

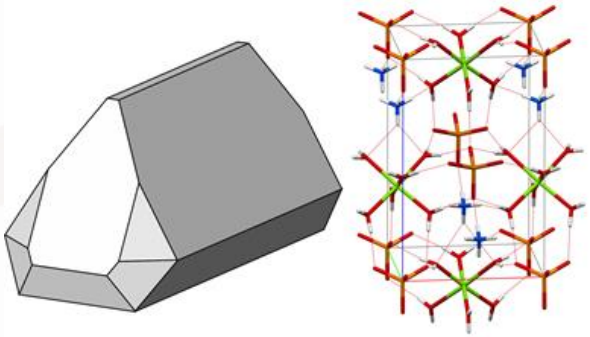
$$Mg^{2+} + NH_4^+ + PO_4^{3-} + 6H_2O \rightarrow MgNH_4PO_4 \cdot 6H_2O$$





STRUVITE PRODUCT

Parameter	*Characteristics*	*Reference*
Nature	Mineral salt	
Chemical name	Magnesium ammonium phosphate hexahydrate	
Formula	$MgNH_4PO_4 \cdot 6H_2O$	
Appearance	White glowing crystal	Bassett & Bedwell, 1933
Structure	Orthorhombic: regular PO_4^{3-} octahedral, distorted $Mg(H_2O)_6^{2+}$ octahedral, and NH_4^+ groups all held together by hydrogen bonding	Abbona & Boistelle, 1979
Molecular weight	245,43 g/mol	
Density	1,711 g/cm^3	Borgerding, 1972
Solubility	Low in water: 0,018 g/100 mL at 25 °C in water High in acids: 0,033 g/100 mL at 25 °C in 0,001 N HCl 0,178 g/100 mL at 25 °C in 0,01 N HCl	Bridger *et al.*, 1961
Solubility constant	10E-13,26	Ohlinger *et al.*, 1998



The low water solubility and the high solubility in acidic solution bring ideal properties as a slow-release fertilizer

STRUVITE PRODUCT

- Nutrients:

5 N%, 29 P_2O_5%, <1,0 K_2O%

- Characteristics:
- Size: >200 µm
- TOC: <0,5 %
- Purity: 81%
- No presence of heavy metals.

STRUVITE PRODUCT

- Nutrients:

5 N%, 29 P_2O_5%, <1,0 K_2O%

Micropollutant	Unit (µg/kg)	Micropollutant	Unit (µg/kg)
Octylphenol	<0.1	Hexachlorobenzene	1.1
t-Nonylphenol	<0.5	Hexachlorobutadiene	2.6
4-Nonylphenol	<0.05	Pentachlorobenzene	3.4
Alachlor	<3	Trifluralin	<0.3
Chlorfenvinphos	<5	123-Trichlorobenzene	<0.5
Aldrin	<0.1	124-Trichlorobenzene	3.4
Dieldrin	<0.1	135-Trichlorobenzene	<0.5
Isodrine	<0.1	Quinoxyfen	<0.1
Endrin	<0.1	Aclonifen	<1
Endosulfan 1	<0.5	Irgarol	<1
Brominated diphenylethers	<10	Terbutryn	<0.6
Chloroalkanes	<60	Di(2-ethylhexyl)-phthalate	<1.5
Anthracene	<1	Naphthalene	32.7
Benzo(a)pyrene	2.5	Fluoranthene	3.8
Benzo(b)fluor-anthene	3.2	Benzo(g,h,i)-perylene	0.8
Benzo(k)fluor-anthene	1.8	Indeno(1,2,3-cd)-pyrene	1.3
Diclofenac	<0.5	Paracetamol	<50
Acetylsalicylic acid	<10	Ibuprofen	<1

STRUVITE RECOVERY

- Struvite was first described on 1845, found at the Hamburg sewage system.
- The WWTP problems due to uncontrolled struvite precipitation are known since 1970s.
- Its uncontrolled precipitation damages severely pipes and equipment.
- It is considered a promising fertilizer due to its slow release properties.



STRUVITE RECOVERY

- Struvite can be recovered either from urban WWTP, industrial WWTP or livestock waste.

- Struvite can be used as fertilizer and reduce the European external dependency on P-supply.

- Nowadays, there are several industrial struvite recovery plants in Europe and the recovered struvite is used as fertilizer.

Tecnología / *Parámetro*	*Phospaq™*	*Anphos*	*NuReSys©*	*Unitika Phosnix©*	*Ostara Pearl®*	*Crystalactor©*
Tipo de reactor	CSTR con difusión de aire	BSTR	CSTR	FBR	FBR	FBR
Nombre del producto	Estruvita	Estruvita	BioStru®	Estruvita	Crystal Green®	Estruvita, CaP, MgP
Rendimiento de recuperación (%)	10-40 %N 80 %P	80-90 %P	5-20 %N >85 %P	80-85 %P	10-40 %N 80-90 %P	10-40 %N 70-80 % P
Instalaciones industriales (Nº)	11	3	7	2	8	4

FIELD TEST RESULTS

- Field test.

Potato

FIELD TEST RESULTS

- Field test.

Corn

FIELD TEST RESULTS

Potato

Corn

- Results with conventional fertilization and struvite fertilization were similar.
- **Number of plants**: no significant difference.
- P-availability from **soil**: bigger on struvite fertilized crops.
- **Leaf** analysis: No significant difference.
- No **phytotoxicity** neither **any handling problem** with the struvite.

FUTURE – What's missing?

- STRUVITE

5 N%, 29 P_2O_5%, <1,0 K_2O%

- CONVENTIONAL FERTILIZERS

NPK

- Combination of struvite with other fertilizers.

THE NEW COMBINATION

- Scarole

- Persimmon

CONCLUSIONES

- Struvite obtained is a high-quality product.
- The lack of N and K is not a problem.
- It can be combined with other mineral fertilizers.
- It can be applied with organic fertilizers (compost).

Struvite obtained by DAM meets all the requirements to be consider as a safe slow release fertilizer.

- The new Regulation1009/2019 opens the way for using struvite as fertilizer in the whole European Union.

CONTACTO

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Thank you

For Your Attention

Special thanks to CEBAS-CSIC for sharing pictures from the field test.

Nutrient Management and Nutrient Recovery Thematic Network

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