Nutrient Management and Nutrient Recovery Thematic Network

From innovation to practice: the Farmer Platform as an inventory for recovered organic and low input fertiliser solutions

Struvite from livestock waste: ID 250 & ID 256

Francisco Corona – Cartif

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STRUVITE RECOVERED FROM LIVESTOCK WASTE

- Francisco Corona, Ph.D.
- Researcher of Circular Economy Area from Fundación Cartif.

[CENTRO TECNOLÓGICO] CARTIF

Research & Technology Organisation

STRUVITE HISTORY

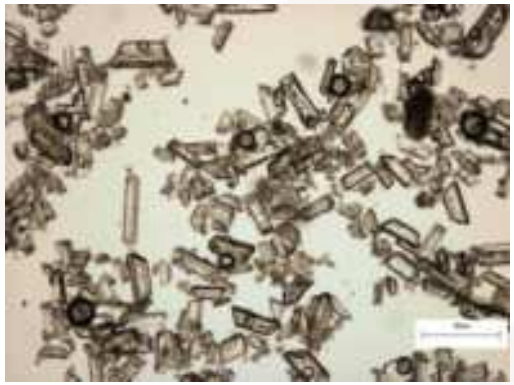
- Struvite was first identified as a crystalline material by Rawn in 1937.
- Since the 1970s, struvite has been a frequent problem in WWTPs.
- Struvite deposits spontaneously in the pipes and produce clogging.
- On the other hand, struvite formation is also considered a very promising strategy for P recovery because of its potential as a slow-release fertiliser.

STRUVITE

- Ammonium (N) and phosphate (P) can be removed from the wastewater or livestock waste by precipitating a salt of phosphate and ammonium called struvite.

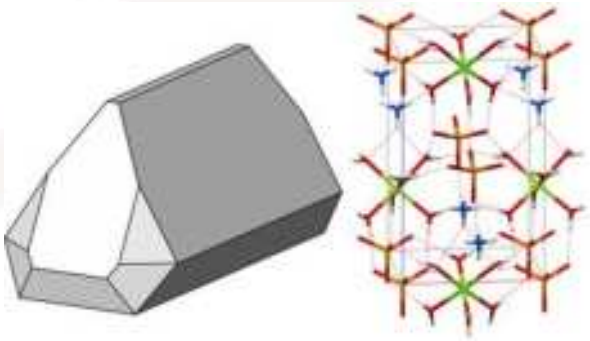
The reaction that takes place is:

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



STRUVITE PROPERTIES

Parameter	*Características*	*Reference*
Nature	Mineral salt	
Chemical name	Magnesium ammonium phosphate hexahydrate	
Formula	$MgNH_4PO_4 \cdot 6H_2O$	
Aspect	White glowing crystal	Bassett & Bedwell, 1933
Structure	Orthorhombic: regular PO_4^{3-} octahedra, 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 en 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 media gives it ideal properties as a slow-release fertiliser

STRUVITE INDUSTRIAL SCALE

- Nowadays there are large scale struvite crystallisation facilities with the potential to obtain a commercial product.

- This struvite could be used as a biofertiliser and replace phosphate fertilisers, in which the P comes from the extraction from the phosphate rock.

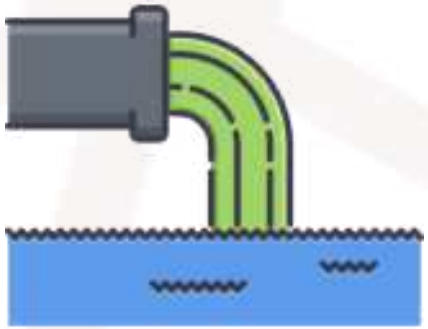
Technology / *Parameter*	***Phospaq™***	***Anphos***	***NuReSys©***	***Unitika Phosnix©***	***Ostara Pearl®***	***Crystalactor©***
Kind of reactor	CSTR with air diffusion	BSTR	CSTR	FBR	FBR	FBR
Product name	Struvite	Struvite	BioStru®	Struvite	Crystal Green®	Struvite, CaP, MgP
Recovery yield (%)	10-40 %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 (e struvite) >90 %P (CaP)
Large scale facilities (Nº)	11	3	7	2	8	4

STRUVITE PRODUCTION

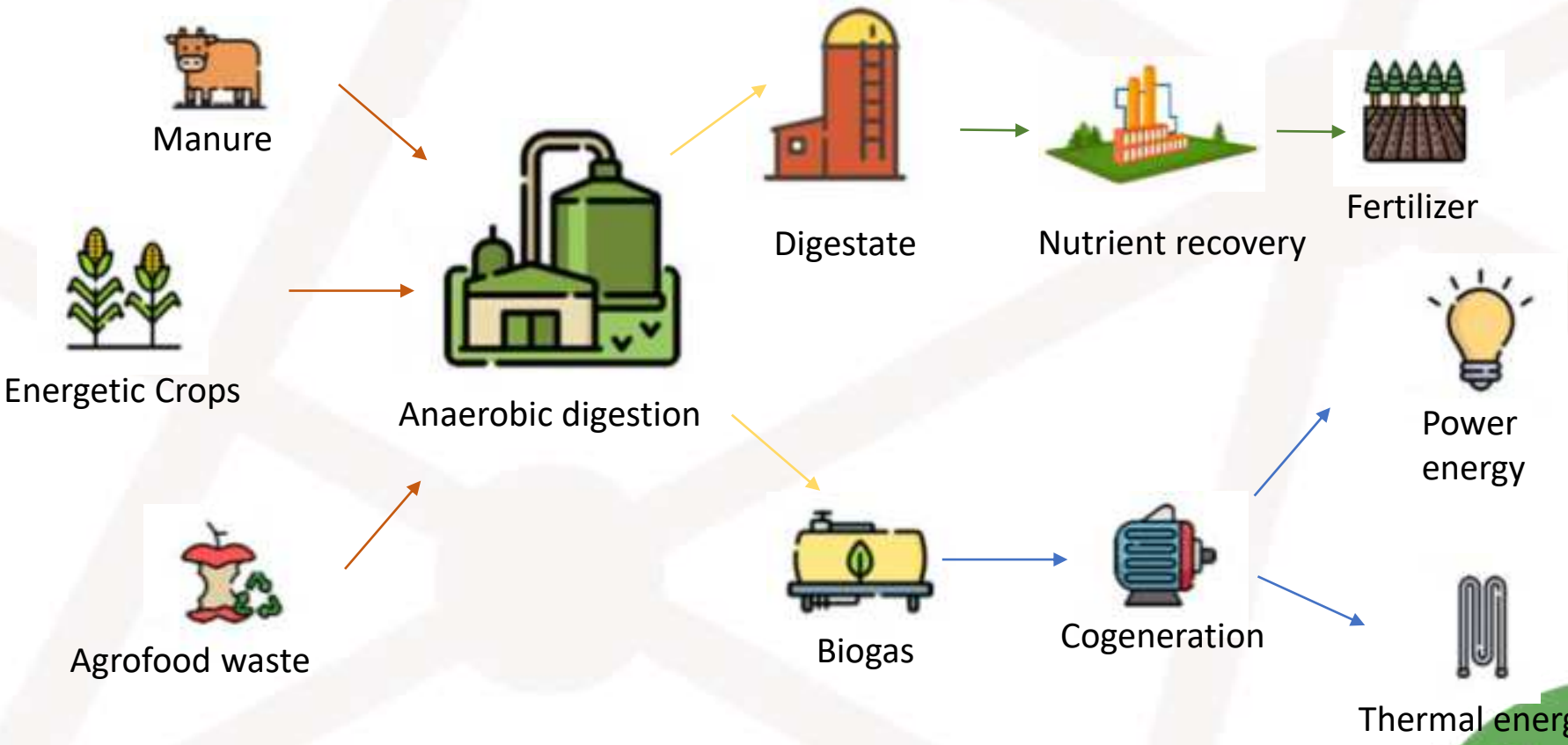
- Nowadays there are large scale struvite crystallisation facilities with the potential to obtain a commercial product. Struvite can mainly be obtained by recovering N and P from two types of effluent:

1) Wastewater from treatment plants.

2) Livestock waste.



VALORIZATION OF AGRO AND LIVESTOCK WASTE BY ANAEROBIC DIGESTION

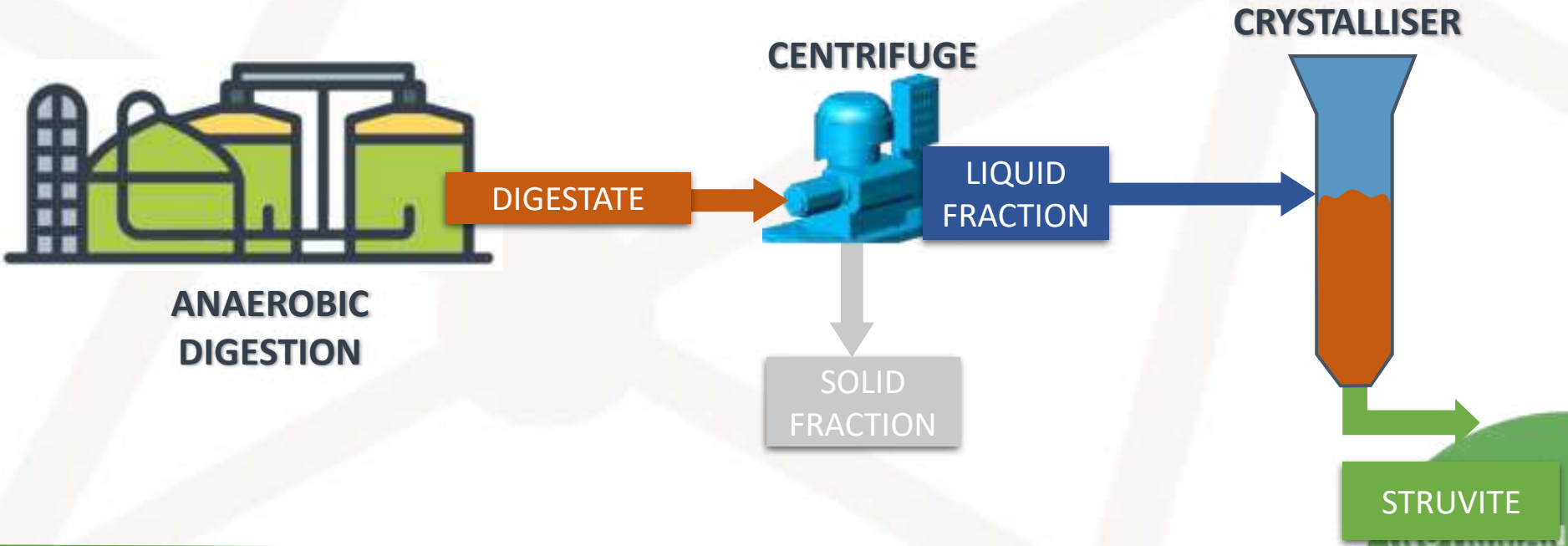


Adapted from: www.cleancoastresources.com

STRUVITE PRODUCTION FROM CARTIF

- Cartif produces the struvite from the digestate coming from the anaerobic digestion of the pig slurry.

- Digestate is the liquid by-product obtained from the anaerobic digestion process.



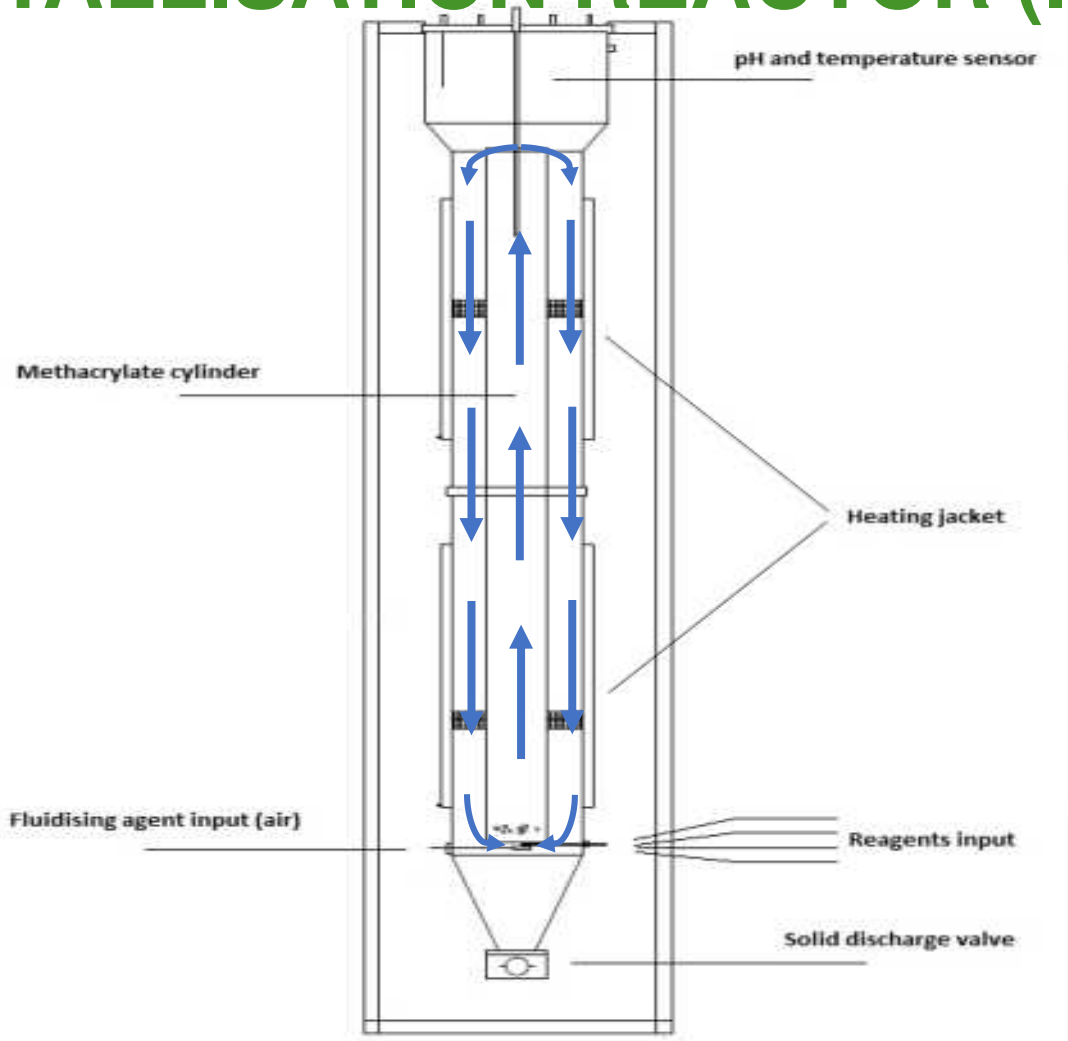
CRYSTALLISATION REACTOR (ID 256)

- The pilot plant for struvite production is composed by a 50 L reactor made of borosilicate glass with a cylindrical shape.

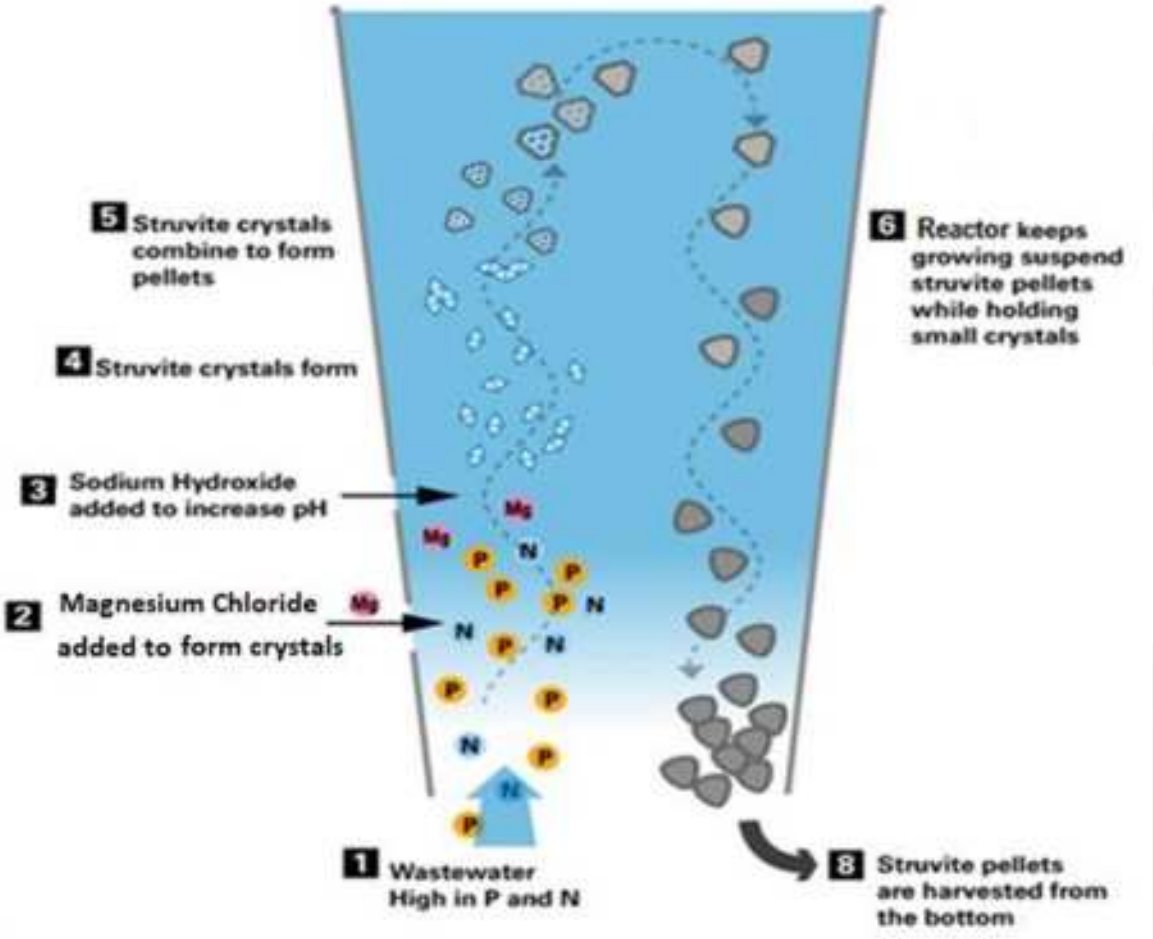
- Magnesium chloride ($MgCl_2 \cdot 6H_2O$) was used as Mg source.

- The pH of the samples was 8.5, so it was necessary to add a concentrated alkali (50% NaOH solution) to raise the pH value to 9.0.

CRYSTALLISATION REACTOR (ID 256)

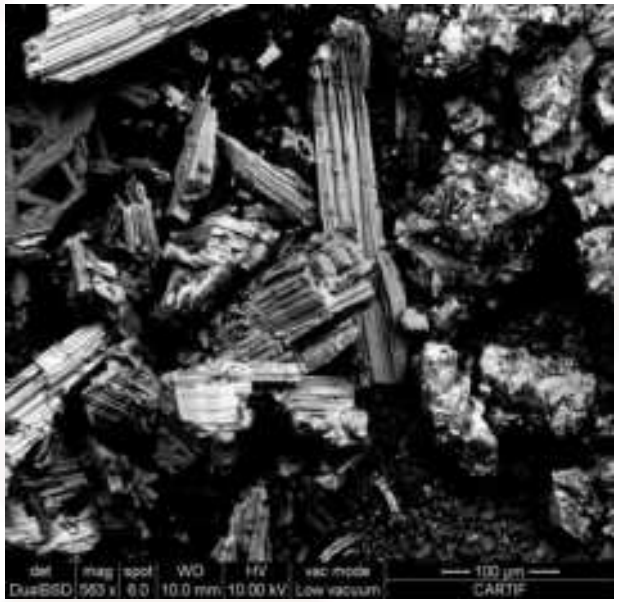


CRYSTALLISATION REACTOR (ID 256)



CRYSTALLISATION REACTION

- Scanning Electron Microscope (SEM) image of the struvite crystals obtained in this study.



- As can be seen, the crystals obtained have the characteristic shape of struvite crystals (needle-shaped crystals).

STRUVITE COMPOSITION (ID 250)

Parameter	Struvite from CARTIF
C (%w)	3,0
H (%w)	6,9
N (%w)	4,74
Al (%w)	n.d.
Ca (%w)	0,165
Fe (%w)	0,001
Mg (%w)	8,918
P (%w)	11,211
K (%w)	0,561
Si (%w)	n.d.
Na (%w)	0,817
Ti (%w)	n.d.

Parámetros	Struvite from CARTIF
Ba (mg/kg)	n.d.
Cd (mg/kg)	n.d.
Co (mg/kg)	n.d.
Cr (mg/kg)	n.d.
Cu (mg/kg)	n.d.
Mn (mg/kg)	n.d.
Mo (mg/kg)	n.d.
Ni (mg/kg)	n.d.
Pb (mg/kg)	n.d.
Sb (mg/kg)	n.d.
Sr (mg/kg)	n.d.
V (mg/kg)	n.d.
Zn (mg/kg)	0,001

n.d.: not detected

CONCLUSIONS

- Nutrient composition and characteristics of struvite from are very similar than commercial struvite.
- Struvite has no significant content of PTEs or other contaminants that would prevent its use as a biofertiliser.
- Organic matter (carbon content) of struvite can give it undesirable organoleptic properties (bad odour or dark colour), causing it to be rejected by the final user.
- Organic matter could be removed from the struvite by a scrubber.

Struvite obtained by Cartif meets all the requirements to be used as a slow release biofertiliser

CONTACT

DOLORES HIDALGO BARRIO (project manager)

dolhid@cartif.es

FRANCISCO CORONA ENCINAS

fraenc@cartif.es

www.cartif.es

Parque Tecnológico de Boecillo
Parcela 205. 47151. Boecillo, Valladolid
SPAIN
+34 983 546504
+34 983 548911

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www.nutriman.net

@NUTRIMANnetwork

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