## **Crystal Green®** as an Organic Fertiliser



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- Crystal Green<sup>®</sup> is the registered trade mark for Ostara's Pearl<sup>®</sup> process produced struvite.
  - The Pearl process treats the liquor at sewage treatment works (STW)
- The product is magnesium ammonium phosphate hexahydrate, an insoluble slow release phosphate fertiliser MgNH<sub>4</sub>PO<sub>4</sub>.6H<sub>2</sub>O
- Thames Water opened the first European Pearl plant at Slough STW in 2012
- End of Waste status was necessary prior to production so that Crystal Green could achieve product status and be sold as a high quality slow release fertiliser.
  - This was achieved in March 2010



## Pearl<sup>®</sup> Nutrient Recovery has a Rapidly Growing Installation Base





- Due to waste water origin, stringent requirements were put in place by the Environment Agency to ensure very low risk to health and the environment
- Consistent analysis of nutrients N,  $P_2O_5$  and MgO in every batch
- Low in PTE's (Potentially Toxic Elements i.e. heavy metals)
- Absence of pathogens E. coli, faecal coliforms and Salmonella
- Data was supplied from independent analyses of commercial production samples to satisfy all these requirement



## Heavy Metal (PTE) Comparison

	EU Fertiliser Regulations		Rock	MAP
	Current	Proposed <sup>2</sup>	phosphate 28%	52%
Arsenic	60	40	11	7-30
Cadmium	60*	40*	<mark>89</mark>	<mark>0-330</mark>
Chromium – hexavalent	2	2		
Chromium – total	N/A	100	<mark>188</mark>	17
Copper	N/A	600		
Lead	150	120	10	0-10
Mercury	2	1	0.05	
Nickel	120	100	29	7-350
Zinc	N/A	1,500	239	10-3,010

Rock phosphate data ref. Mortvedt, J.J. 2005

Crystal Green mean all sites 2016 QC data \*Cd is in mg/kg  $P_2O_5$ 

<sup>1</sup>All values are in mg/kg product except cadmium

DAP 46%	TSP 46%	Crystal Green 28%	
10-23	13-16	0.45	
<mark>7-76</mark>	<mark>11-96</mark>	0.087	
		<0.1	
<mark>55-196</mark>	89	1.03	
		1.60	
1-10	4-13	0.16	
		0.005	
14-48	15-118	0.39	
50-386	61-1,296	2.26	

<sup>2</sup> Current proposal under the new EU Fertiliser Regulations; subject to change



- Limited organic phosphate fertilizer options when need is shown
- Rock phosphate is one of very few products currently allowed
- Rock phosphate is non-renewable
  - Mined in North Africa, Middle East, Russia, USA
  - Estimates vary as to when this source will run out
- Agronomically rock phosphate is not very efficient –poor availability in soils of pH5.5 or above, only a small fraction of the P is actually available to plants
  - Estimates between 1/20 and 1/3 as effective as superphosphate fertiliser
  - Soils cannot absorb the P released
  - Bolland and Gilkes, 1990 Fertilizer Research 22 79-95



## Phosphorus Reserves Are Limited and Highly Concentrated





- Currently Struvite is not listed or allowed in organic farming Annex 1 of EC 889/2008
- Submission via DEFRA to EGTOP (EU Expert Group for Technical Advice on Organic Production) for consideration of struvite to be allowed in organic farming (March 2015)
- EGTOP reported that Struvite can be included in Annex 1
  - It must first be included in the EUFertiliser Regulations
  - New Fertiliser Regulations (2018) will include struvite
  - Product MUST be "hygienic & safe"
  - STRUBIAS Report includes struvite, which would form part of the new regulations
- When EU Fertiliser Regulations are in place with the STRUBIAS bolt-on, Crystal Green<sup>®</sup> struvite can be used in organic farming



- Acid exudates from plant roots (citrate, malate, oxalate) dissolve Crystal Green
  - e.g. Talboys *et al* 2016 Plant and Soil <u>401</u>109-123:
- soil pH
  - Crystal Green is 100% NAC soluble
  - Rock Phosphate is only 75% NAC soluble & has low levels of available P
- Studies comparing Rock Phosphate and Crystal Green to water soluble fertilisers shows benefits of water soluble (TSP) or citrate soluble (Crystal Green) fertilizer over rock phosphate

• Dissolution of Crystal Green is independent of



## University of Southampton: Interaction of Growing Roots and Crystal Green Fertilizer



Source: "Imaging the interaction of roots and phosphate fertiliser granules using 4D X-Ray tomography". Ahmed et al., Plant Soil (Springer International Publishing, Switzerland, 2014) 401:125-134



## University of Southampton

## Localised measurements



 $TSP - 3.7 mm^3$ 



\* Root volume for 5050\_01 @ week 12



## CG – 22.14mm<sup>3</sup>



50

## Crystal Green Results: Conventional Farming Potato Trial

Crystal Green vs. TSP: marketable potato yield (>45mm) in the UK 2012 & 2014 (average across broadcast/banded applications and two P rates)



Source: Sustainable Arable LINK Project – AHDB 2017



## Ongoing work on P sources for **Organic Farming**

- Nurec4org Trial

  - •Fertilizers

    - •3 sources of rock phosphate

    - •Nil P control
  - •Crops
    - •Beans grown in pots using a P-depleted soil (2017)

    - •Maize in the field (2018)
- - •5 year study

  - •Yield and soil health

- •Berge Research Station

  - •3 sources of struvite including Crystal Green
  - •Dung from an organic farm
  - •Conventional fertilisers TSP and DAP

## •University of Manitoba

•Rock Phosphate vs. Crystal Green



# THANK YOU

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