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Phosphorus recovery from livestock manure for green fertilizers production: The ManureEcoMine project MANUREECOMINE

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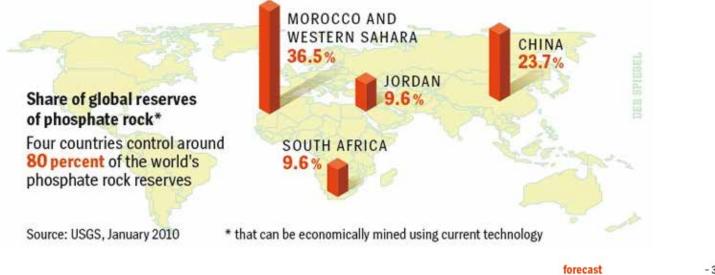
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2nd ESPC, Berlin, March 4th 2015

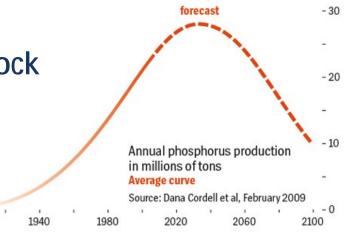
Phosphate becoming a strategic resource

Unequal distribution of phosphate rock reserves: Europe is dependent on external supply



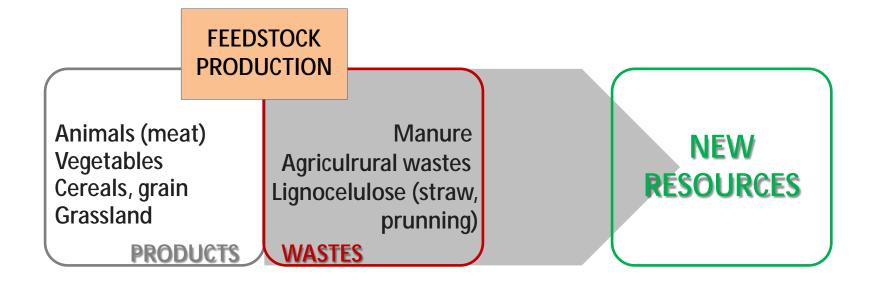
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Increasing demand of phosphate rock while production will stall and decrease in near future



Phosphate becoming a strategic resource

Europe needs more self-sufficiency of P-resources



Recovering nutrients from wastes could reduce the dependence on mineral (external) sources

Challenges



- European cows and pigs jointly produce about 1.27 billion ton/year, corresponding to 500,000 Olympic swimming pools of manure
- Direct re-use on soil of manure represents an **eutrophication threat** in nitrate vulnerable zones (NVZ)
- Nutrients present in manure have a potential value of €10.7 billion/year, farmers now pay €15.5 billion/year for synthetic fertilizers
- EU is **import dependent** for synthetic fertilizer: ore for P, and fossil fuel for N
- Current **dissipative manure treatment** technologies are costly and generate no nutrient resources recovery nor value in return

ManureEcoMine

Resource mining from manure





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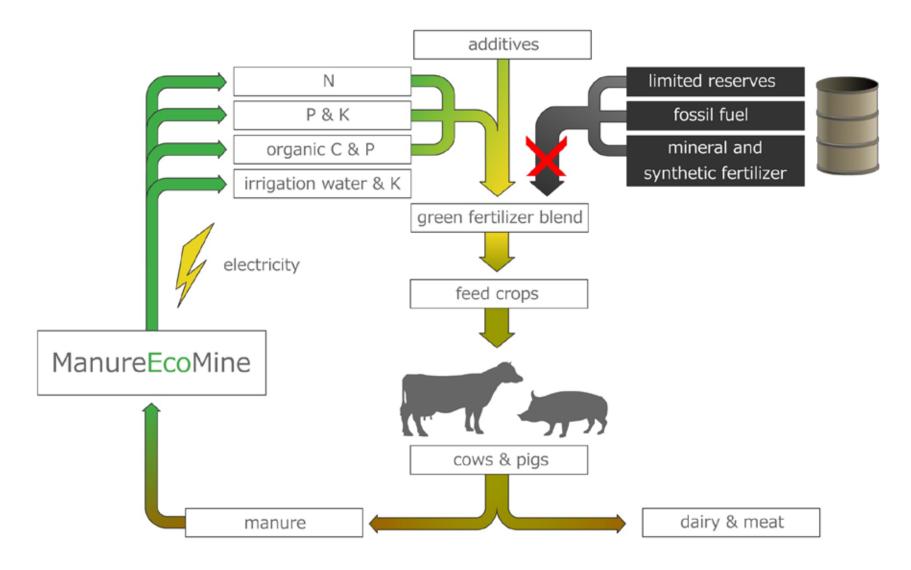
Green fertilizer up-cycling from manure : Technological, economic and environmental sustainability demonstration



ManureEcoMine project is funded by the European Community's Seventh Framework Programme (FP7/2007-2013) under Grant Agreement n° 603744 Slide 4

Project concept





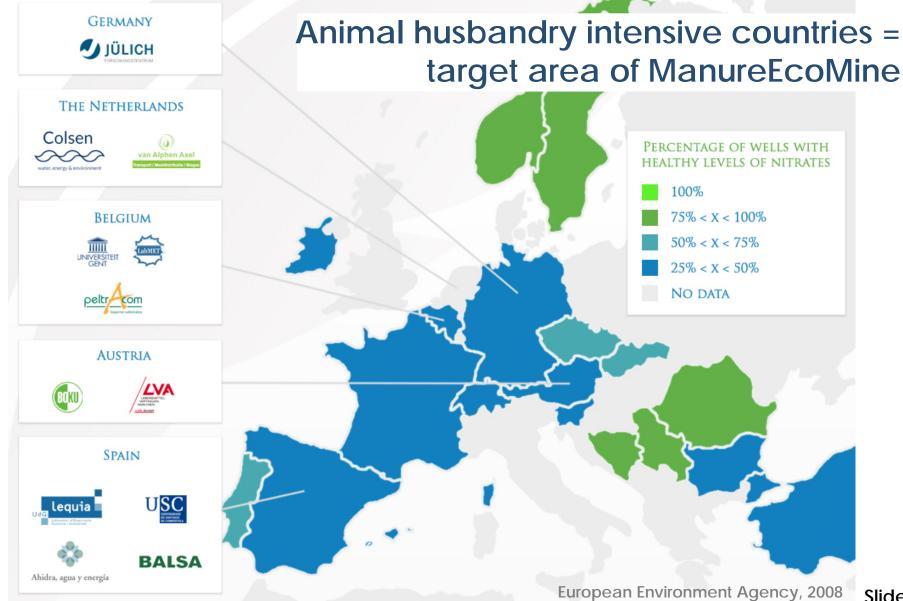
Final objectives



- **ü** Farmers: **technical means** to extract nutrient streams from manure
- **ü** Full energy self-sufficiency: process built on the biogas technology platform
- industry: methods to blend streams into high performance
 fertilizer and soil enhancement products
- **ü** New green fertilizers: better and more specific plant growth effects than raw manure
- **ü** Economic and technological feasibility: integrate technologies that have not yet reached the market
- **ü Preserve the environment:** recovering and reusing nutrients from livestock manure

Project participants

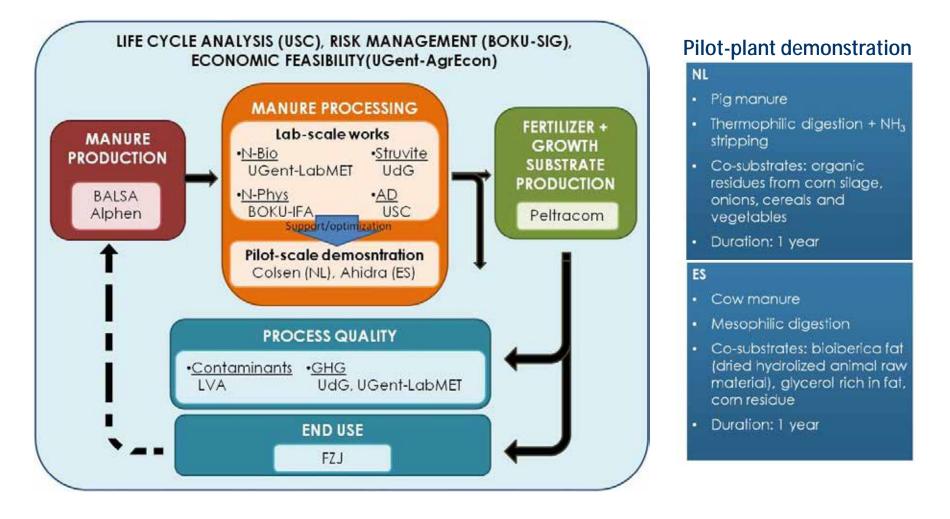




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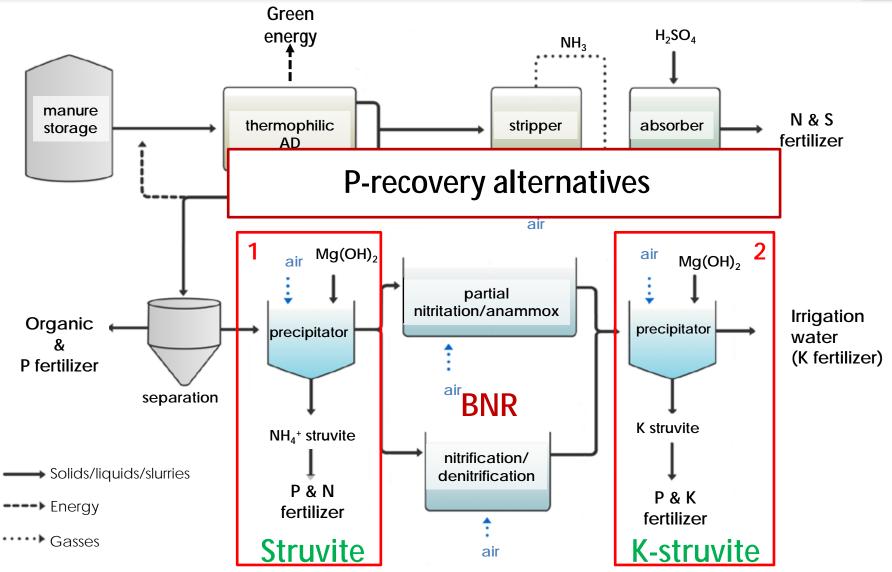
Scope of the project





Core technologies









Why struvite?

- **ü** Slow releasing fertilizer:
 - o Long presence in soil, enhancing nutrient up-take by plants
 - Reduction of the dosing frequency and risk of nutrients leaching to water bodies
- **ü** Soil enhancement effect: complete fertilizer with N/K, Mg and P plus the possibility of including organics and other nutrients (such as Ca). Improvement of soil equilibrium.
- **ü** High performance fertilizer : better and more specific plant growth effects than raw manure



Struvite recovery process in ManureEcoMine

• Expected concentrations after S/L separation:

\$ 500 mg PO₄³⁻ L⁻¹.
\$ 2000 mg NH₄⁺ L⁻¹, 5000 mg K⁺ L⁻¹
\$ 1-2 g SS L⁻¹.

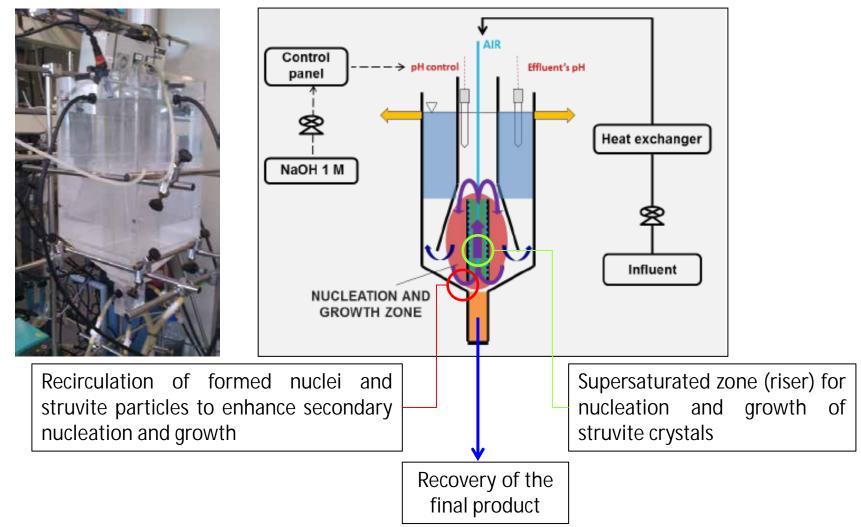
- Operational conditions:
 - § 100 L manure day⁻¹
 - § Continuous feeding
 - § 3.5h HRT, ambient temperature to 35°C, pH 8.5.



Struvite precipitation



Crystallyzer for struvite precipitation





Specific challenges for struvite precipitation (P-recovery)

- Precipitate NH₄⁺-struvite or K-struvite (depending on the configuration)
- Optimal P-recovery (as it is the limiting compound)
- Testing the **presence of possible interferences** due to manure characteristics (formation of other precipitates)
- Assessing the effect of SS presence in the influent on struvite formation/precipitation
- Obtain a high added value fertilizer. Assess the control of the quality and characteristics of the final product



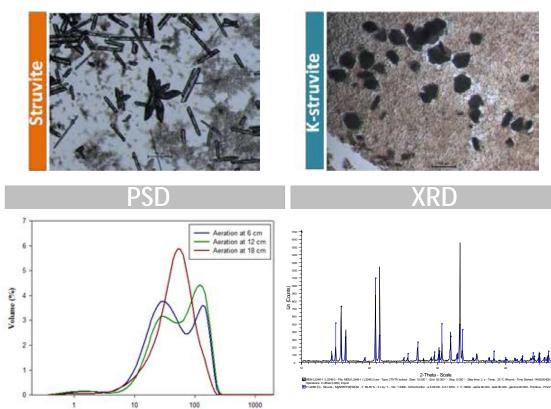


Some preliminary results

ü The crystallizer's design has been tested

Particle Diameter (µm)

 $\ddot{\mathbf{u}}$ NH₄⁺-struvite and k-struvite have been recovered treating simulated manure, with P-removal efficiencies up to 95.4%.



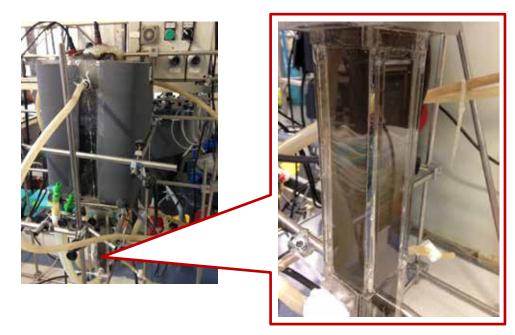


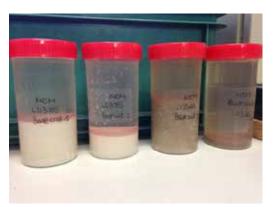
Struvite precipitation



Some preliminary results

• Struvite precipitation obtained from real manure after S/L separation (still with 1000 mg SS)





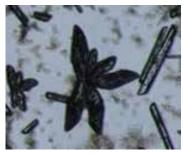
• Assessment of up-flow velocity as a control parameter for final particle size

Assessment of struvite as fertilizer



üPhosphorus is recovered from manure





Struvite

• Then, how do we recycle P into the soil?

- Assessment of struvite's performance as fertilizer compared to conventional products
- Use of struvite as nutrient source in optimal fertilizers blendings with other by-products obtained from manure
- Analysis of the behavior and fate of nutrients coming from green fertilizer in soil compared to chemical fertilizers
- Evaluation of possible presence of micropolutants in green fertilizers obtained from manure

Green fertilizer blending

- Safety of the blended products: nutritional quality
- Fertilizer and growing media blending: cash crop and ornamental plant
- Fertilizer and soil enhancer blending: outdoor and field crops



Investigate the optimal "recipe" for optimal plant growth and soil equilibrium





Some preliminary results

PGMIX 14-16-18 vs NH₄⁺-struvite (1 g/l)

- Similar results in pant grow
- •Struvite pH > PGMIX pH (probably not optimal for basic soils)
- Conductivity struvite < conductivity PGMIX.
- Release of struvite more in accordance to plant demand





Effect of green fertilizer blend on plant and soil

- Plant performance and biomass yield: effects of recovered nutrients
- Plant nutrient availability: different soil pH
- Soil health and rhizosphere (micro)biology: effects of nutrient leaching







(Forschungszentrum Jülich GmbH)

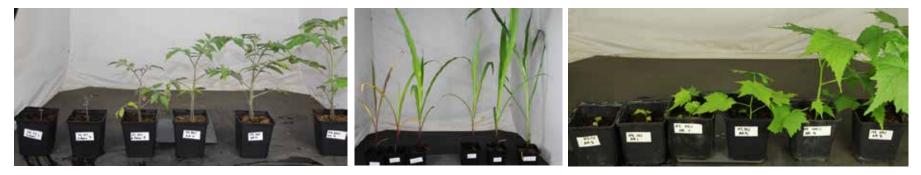




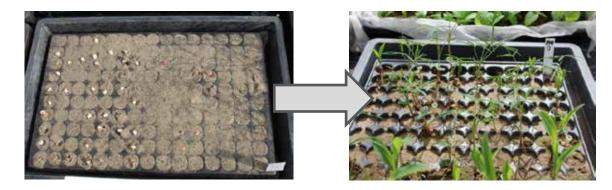
Some preliminary results



• Dose response curve: analysis of the correct amount of nutrients for each target plant



- Dose Analysis of release of phosphorus from the struvite
- •Effect of struvite on germination and first days growth of lupin (Lupinus angustifolius) and maize (Zea mays)





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Economic sustainability

- Economic best practices guide for processes involved
- Online quick scan tool
- Environmental sustainability
 - Mitigation of greenhouse and acidifying gas emissions of the pilot plant
 - Energy balance and maximum recovery performance of the pilot plant
 - Greenhouse gas emissions from plant growth and soil tests
 - Life Cycle Impact Assessment to demonstrate low environmental impact of ManureEcoMine
 - Risk analyses and safety management for trace contaminants
 - Analysis and minimization of potential contaminants into the recovered product
 - Risk assessment and risk management plan for safe and sustainable fertilizer recovery

Thank you for your kind attention MANUREECOMINE BALSA UNIVERSITEIT

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MEM PARTNERS GATHERED AT COLSEN IN HULST (NL) ON 28-30 APRIL FOR THE 6th month project meeting

www.manureecomine.ugent.be

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