Production routes for alternative fertilisers from agricultural residues

TRAINING – Improved Nutrient Recycling in the Bioeconomy

SESSION #2

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Research & Technology Organisation

Centro Tecnológico CARTIF

What is CARTIF?

What is CARTIF?

TECHNOLOGICAL CENTER– technic knowledge
FOUNDATION – private non-profit

*"Our mission is **generate technological knowledge** and to propose innovative ideas so that companies can **improve their competitiveness** and help them adapt to an **ever-changing market**."*

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SCALEUP
community-driven bioeconomy development

What we work in?

Agrifood and Processes

- Natural resources and climate
- Circular economy
- Biotechnology and sustainable chemistry
- Agrifood
- Testing laboratory

Energy

- Energy and climate policy
- Energetic efficiency
- Energy systems
- Smart Cities
- Smart Grids

Digital and Industrial Systems

- Industrial solutions
- Industry 4.0
- Natural and cultural heritage
- Construction and infrastructures
- Health and Wellness

Business models

- CARTIF develop R+D projects for companies, offering personalized technological services and technological consulting of the highest level.
- CARTIF develop R+D projects financed by public funds reached in national and international competitive calls.
- CARTIF advise public administrations (city councils and regional governments) in the planification and development of innovative projects with high economic return.

CARTIF in figures

129
Ongoing projects

International Projects
60%

Projects with Companies
33%

National and Regional Projects
7%

248
Total projects in
main international programmes

Framework Programmes
162 Projects (32 coordinated)
68.8M€

INTERREG
20 Projects (5 coordinated)
3.3M€

LIFE
34 Projects (16 coordinated)
7.4M€

Iberoamericanos
32 Projects (8 coordinated)
1.6M€

298
Custom

211
Staff (37 PHD)

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community-driven
bioeconomy development

Circular Economy

Boost the eco-innovation

Development of processes and products and we encourage the use of efficient and sustainable technologies, applying knowledge and strategies based on ecological innovation.

Evaluation of environmental technologies

We evaluate the environmental technologies, calculating the carbon footprint in terms of GHG emissions and making the Life Cycle Analysis of products, processes and/or services.

Design of plants for the energetic revalorization of residues

We offer integral solutions in the design of pilot plants and industrial for the energetic revalorization of residues, based on the circular economy concept.

Transformation of farmers and agrifood residues in biogas

We analyze and transform in biogas the agrifood and farming residues, we valorized the digestate and we evaluate the viability of biomethanization and product purification processes.

Revalorization of residues and obtainment of new products.

We apply biotechnology to the development of new productive processes and the support of existing processes in the agrifood sector, by the development of biotechnological processes: biocatalysis and enzimatic technologies.

Recovery of plastics by chemical and thermal recycling

We offer innovative solutions in the utilization of plastics, based on chemistry decomposition and/or thermica for the production of new products.

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Circular Economy

Promoting the zero waste concept, through the sustainable management of residual streams and by-products, as well as the Research in new product alternatives.

MAIN RESEARCH LINES

1. Design and development of **biological processes** for organic waste treatment: anaerobic (co)digestion with/without pre-treatment, microalgae, dark fermentation and bio-electrochemical processes.
2. Development of **separation/upgrading technologies for gaseous mixtures**.
3. Design and development **of thermochemical processes for the treatment of organic waste** (biomass and plastics).
4. Design of residues pretreatment srategies (lignocellulose and others).
5. Development of **depolimerazation of plastics processes**: obtaining monomers and gases.
6. Development of **composite valorization** technologies: fibre recovery.
7. **Recovery of nutrients** of residual currents and second life cycle as fertilizers (struvite, digestate, biologically stabilised manure)
8. **Reuse of water: advanced treatments for the removal of emerging and recalcitrant pollutants.**
9. Research on **metal recovery processes** from batteries, brine, electronic and other waste streams and equipment.

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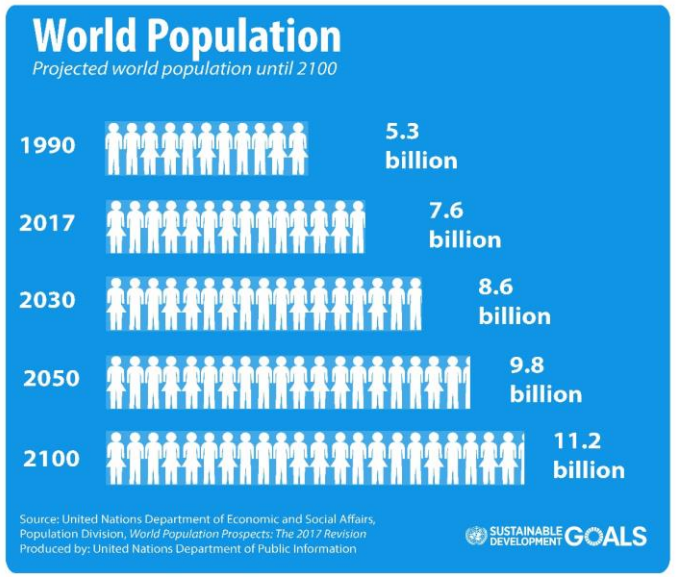
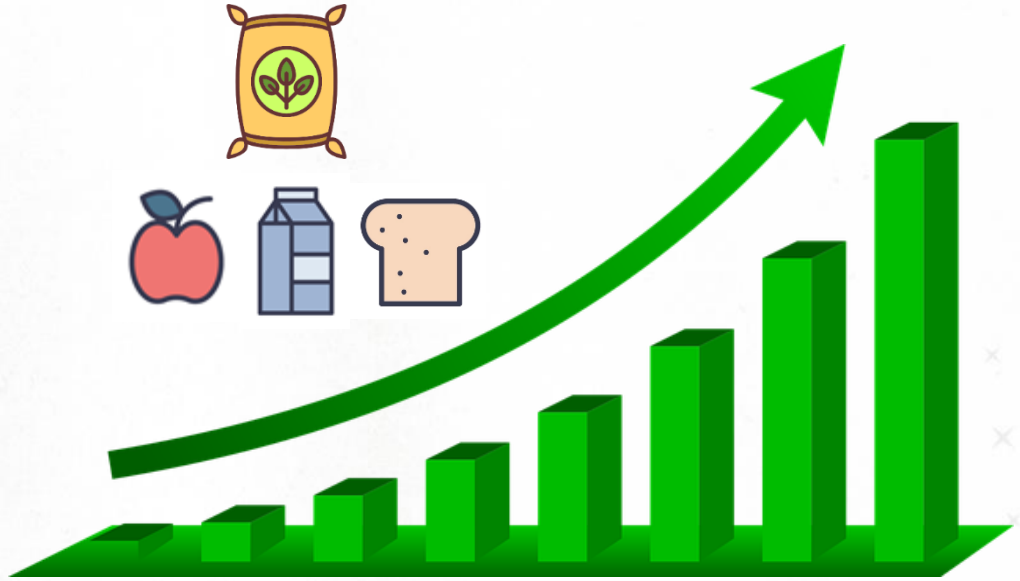
Introduction

Fertilizer demand



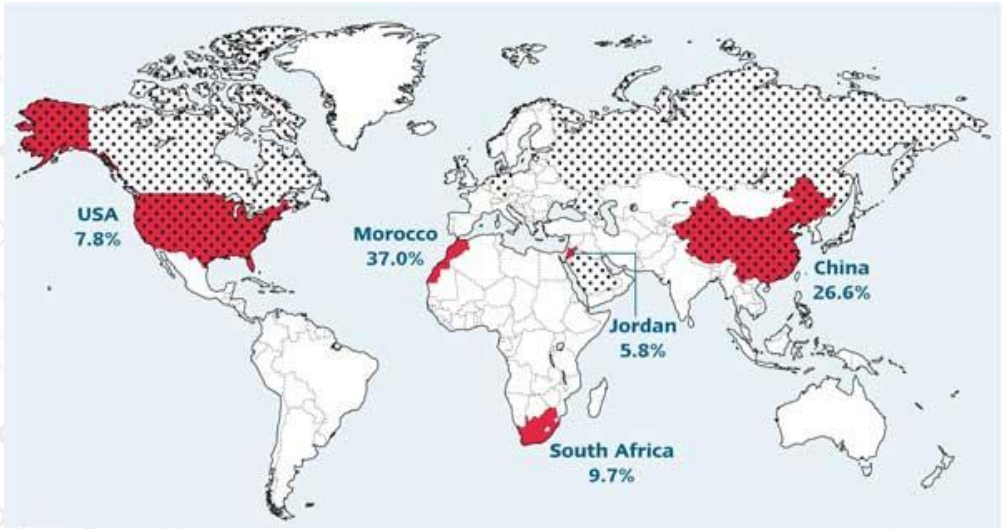


Source: United Nations

NPK demand is estimated to grow by 0.9 % per year reaching 263 Mt in 2024

Mineral fertilizer production follows a linear and not very sustainable model

Importance of phosphorus recovery

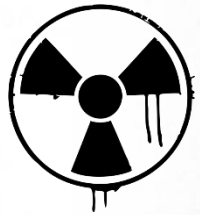


Adapted from: The Broker

- 5 countries control more than 90% of the production of P

Huge EU dependence on mineral P

- Essential, non-renewable and irreplaceable resource. Only 2% of applications have a viable substitute
- P is categorized as Critical Raw Material
- P mineral contaminated with U and Cd



tural and livestock wastes. Generation and problems

Production of agricultural and livestock wastes due to intensive agriculture and livestock production

400 million head of cattle in the EU → 1,200 Mt/y manure (Nutrients: NPK) → Direct application to land

↓

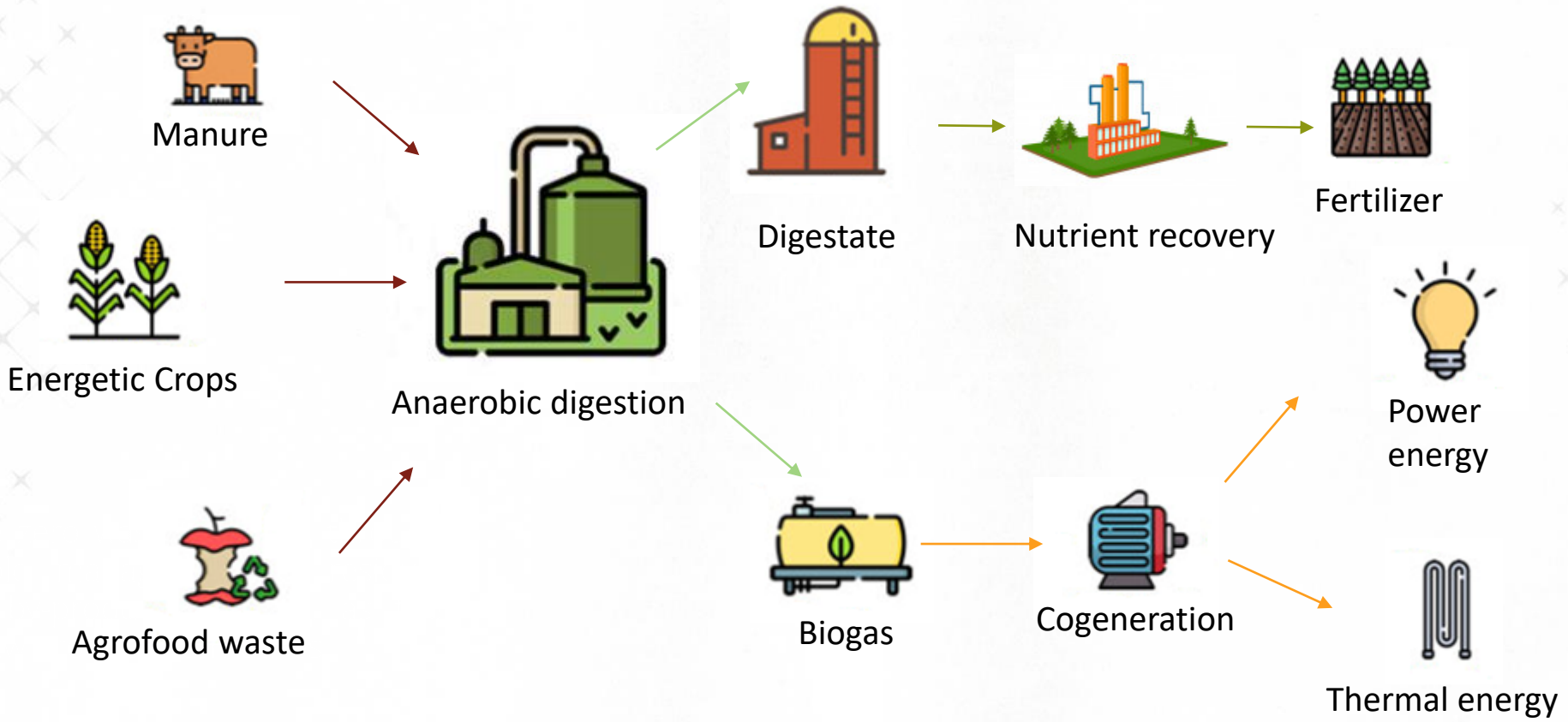
Non-effective fertilization (loss of N, P, K)

↓

Environmental problems:

- Odors
- CH_4 and NH_3 emissions
- Pathogen release
- Leaching

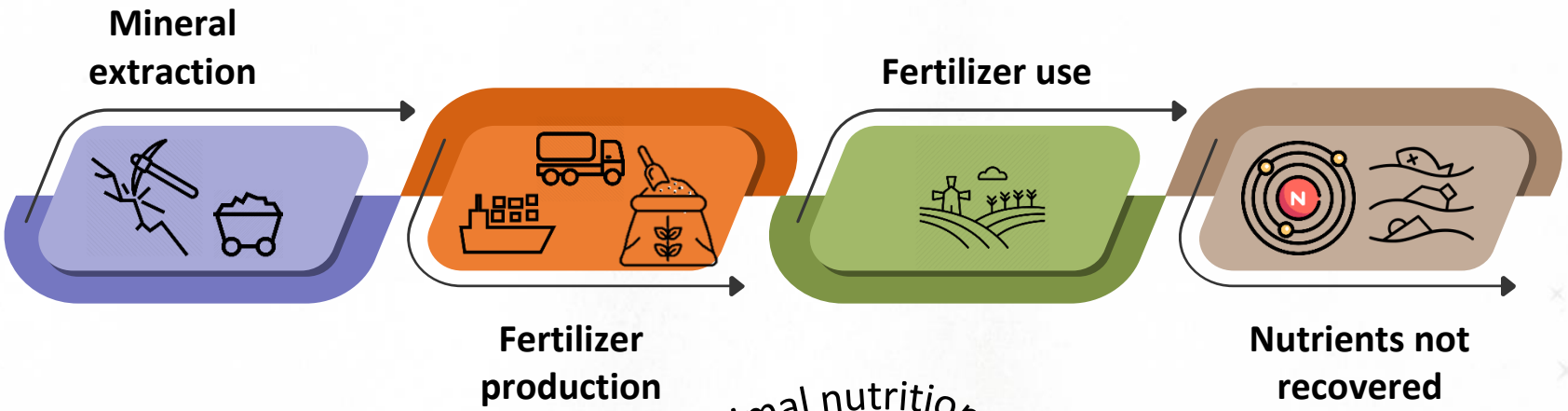
[TECHNOLOGY CENTRE] 30 CARTIF ANNIVERSARY ı of agro and livestock waste by anaerobic digestion



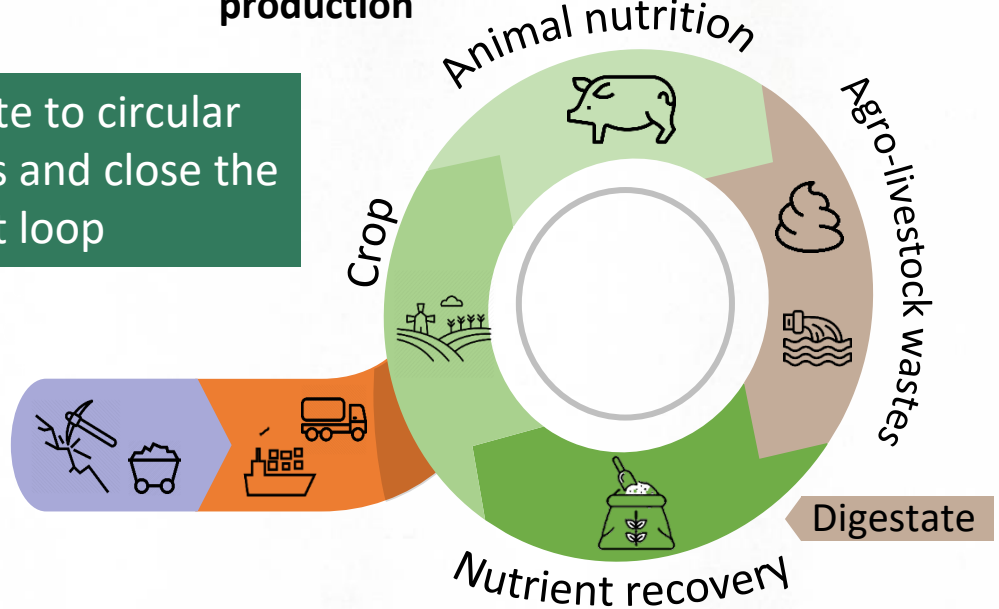
Adapted from: www.cleancoastresources.com

SCALE UP community-driven bioeconomy development

Nutrient recovery

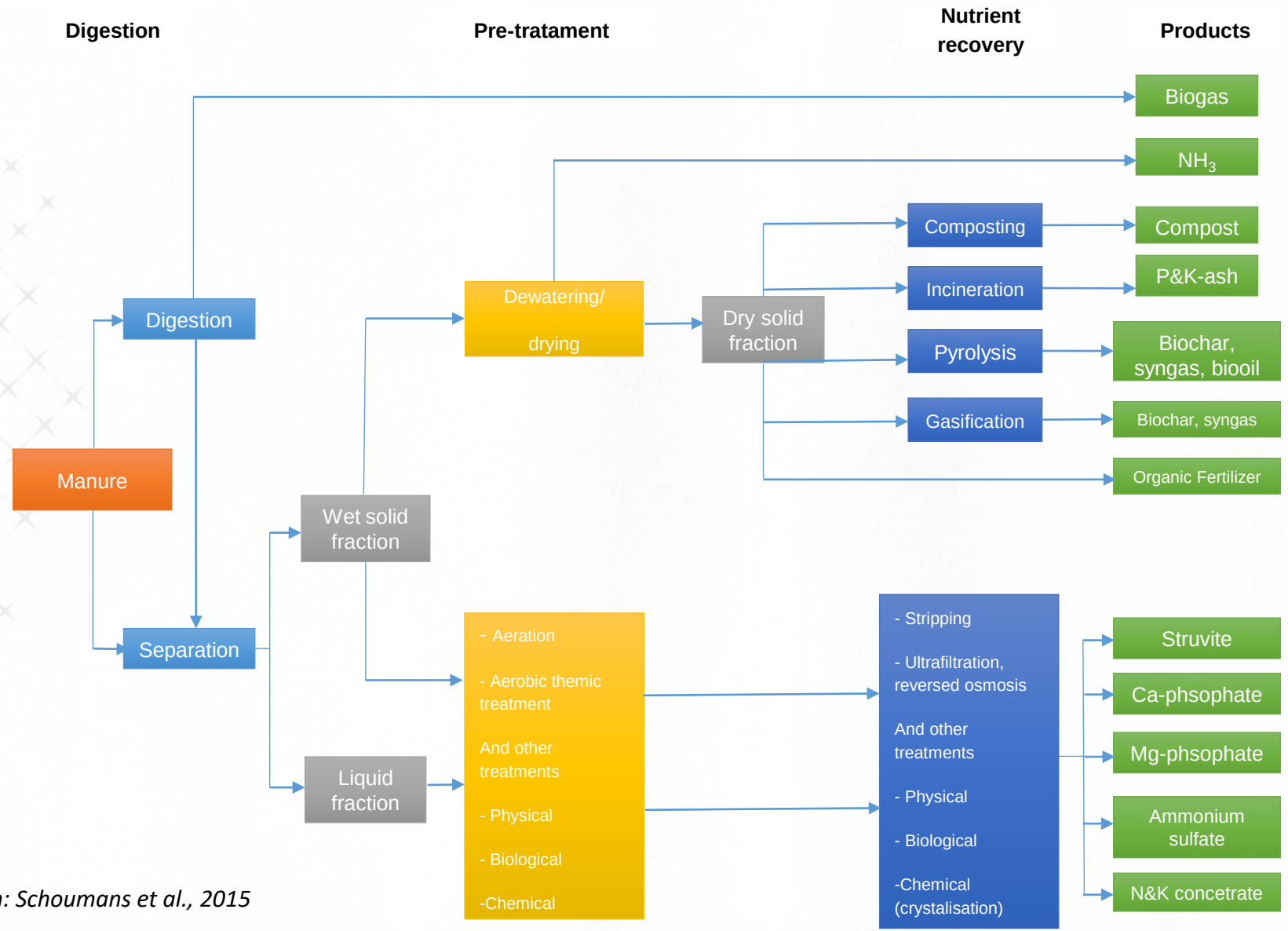


Need to migrate to circular economy models and close the nutrient loop



Digestate valorization technologies

.eading technologies for digestate processing



Adapted from: Schoumans et al., 2015

Solid phase - Composting

- Compost is a humus-like material derived from organic waste composting as a result of the action of aerobic bacteria, fungi, and other organisms.

- Depending on composting method, size, intensity of the operation and the input material, a large range of qualities can be produced.

- Composting of the solid fraction increases the concentration of nutrients in the solid fraction, but can also result in the loss of N in the form of ammonia.

Source: www.nutriman.net

Solid phase – Pyrolysis & Gasification

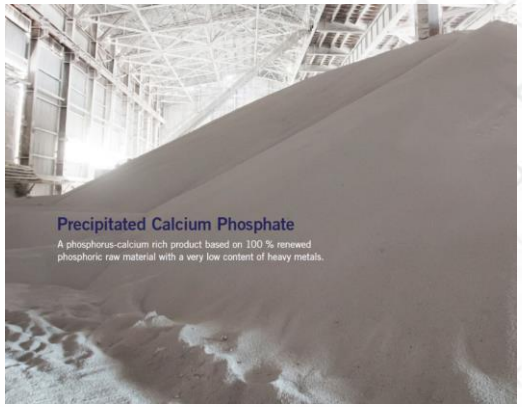
- Pyrolysis is the thermochemical process (450 ºC) that converts under non-oxidizing conditions a material to a carbonaceous solid (biochar).
- Biochar is a material with high carbon content, produced from cellulose based plant or bio-based by-products, which is expressively made for soil functional applications.
- Biochar does not have economical important level of nutrient content itself but acting as soil improver.

Source: www.cartif.es

Source: www.nutriman.net

Liquid phase – Crystallization

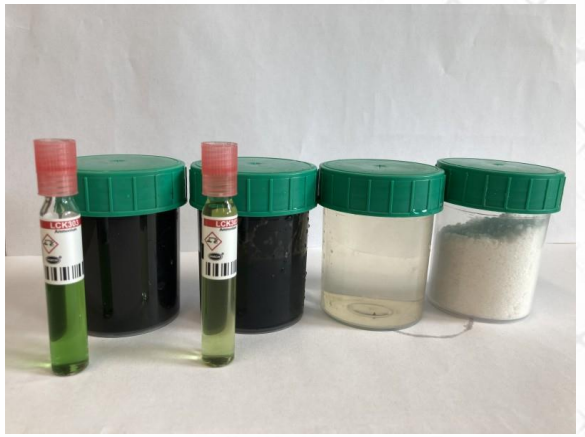
- Crystallization is an important separation process by which fluids are purified through the formation of solids.
- Crystallization/chemical precipitation processes can be used to recover the nutrients present in the digestate (mainly N and P) to obtain solid biofertilizers.
- Struvite (magnesium ammonium phosphate) or Calcium Phosphate are typical products obtained by that way.
- The main disadvantage of chemical precipitation is that it requires a large amount of chemicals, which results in higher operating costs.



Source: www.nutriman.net

Liquid phase – Stripping/Scrubbing

- The stripping is performed by blowing air through N-rich waste streams while increasing temperature or pH which will gasify the mineral nitrogen (NH_3).
- This is considered a pre-treatment needed before the scrubbing N recovery process where the NH_3-filled air will be washed with acidified (HNO_3 or H_2SO_4) water (scrubbing) to capture the ammonium in liquid form (ammonia sulphate from H_2SO_4 or ammonia nitrate from HNO_3).
- A major problem with digestate stripping is the use of packed columns, as residual solids present in the liquid can clog these columns. In addition, it is a process that is often associated with high maintenance and cleaning costs.



Source: www.nutriman.net

Liquid phase – Algae production

- Microalgae cultivation is recognized as one of the promising solutions for the nutrient recovery in the digestate.
- The process is to biologically accumulate and recover nutrients from complex liquid wastewater streams via photosynthesis.
- Using digestate to grow microalgae possesses several barriers including the inappropriate concentrations of nutrients, high turbidity, presence of competing biological contaminants.

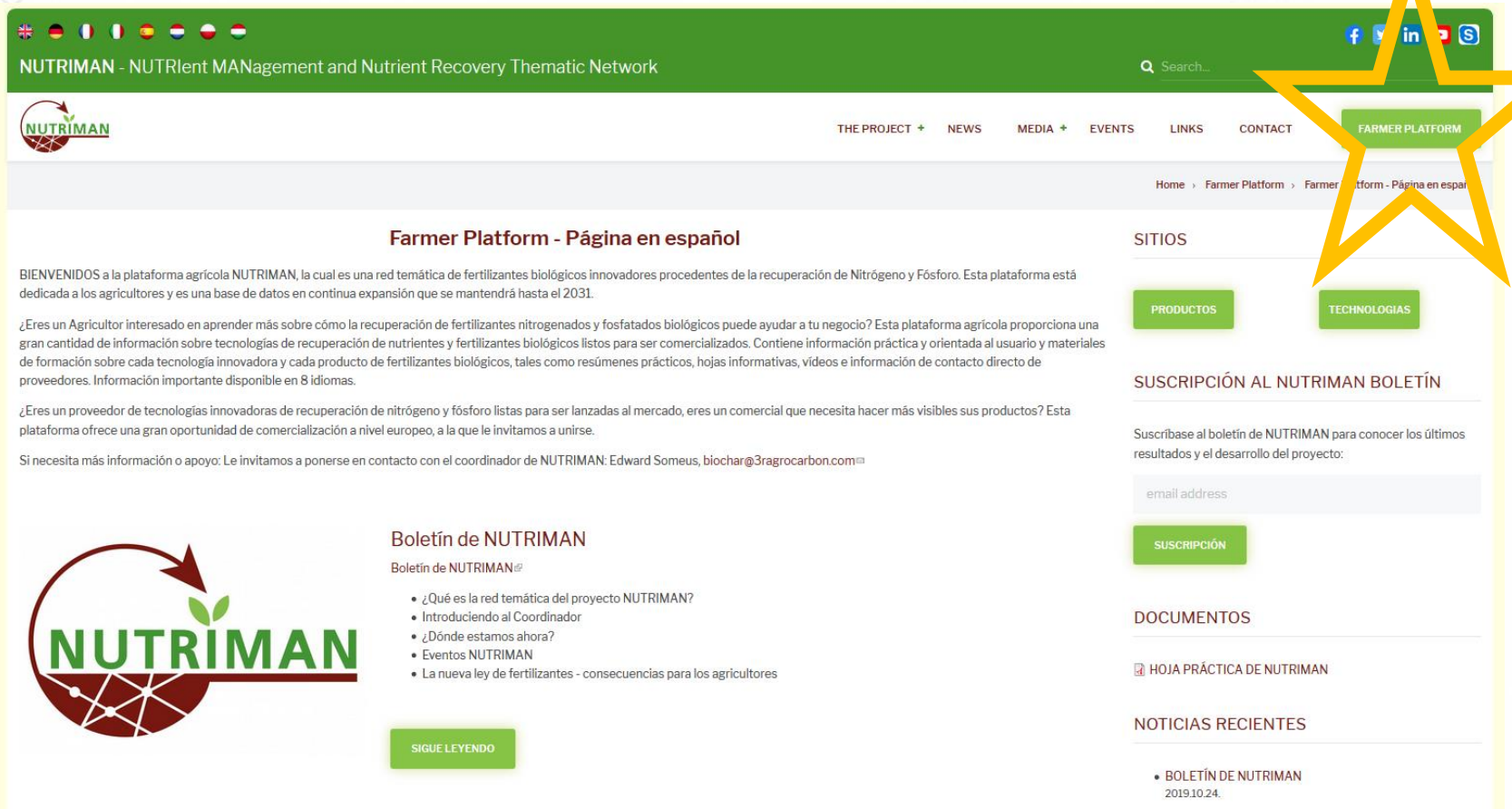
Liquid phase – Membranes

- Membrane purification is a physical separation process in which the liquid to be purified (feed) passes through a porous membrane. Depending on the pore size of the membrane and the Trans Membrane Pressure (TMP), some particles are retained by the membrane and remain in the concentrate or retained. Other particles and partially purified water (the permeate) pass through the membrane.

- The major drawback is that the membranes foul very quickly due to the high content of suspended solids in the digestate.

Source: www.nutriman.net

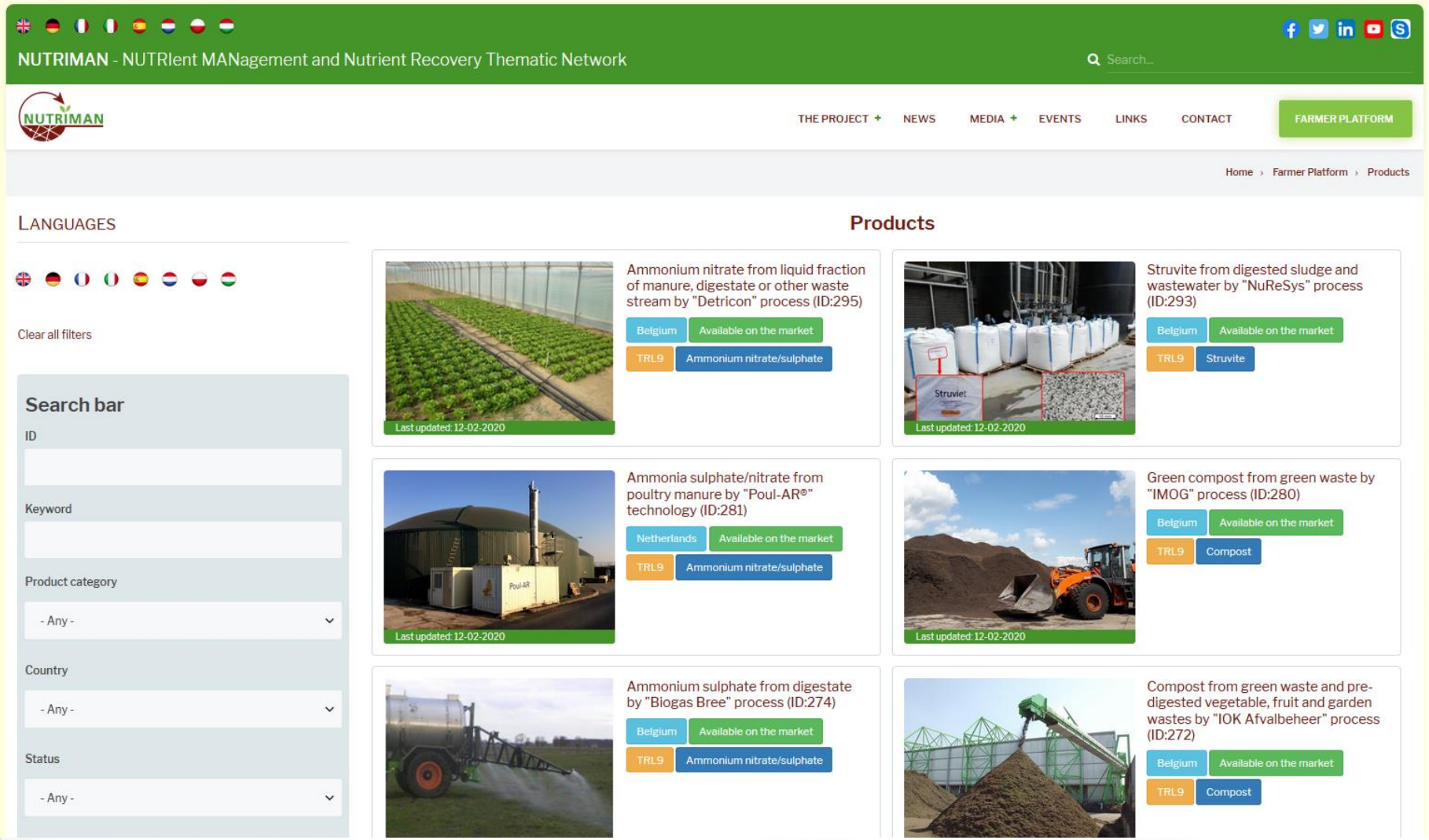
NUTRIMAN Project Platform



H2020-RUR-2018-1
CSA – Coordination and support action

https://nutriman.net/farmer-platform

NUTRIMAN Project Platform



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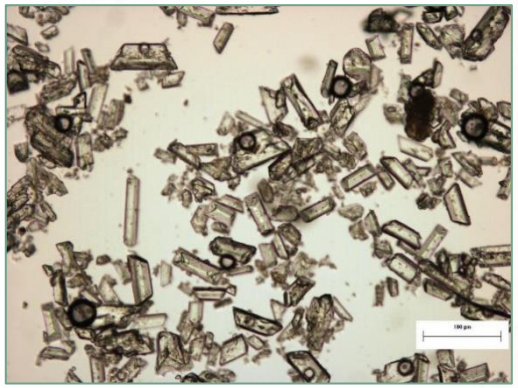
Digestate/WW valorization recent trends

Struvite crystallization

- 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:

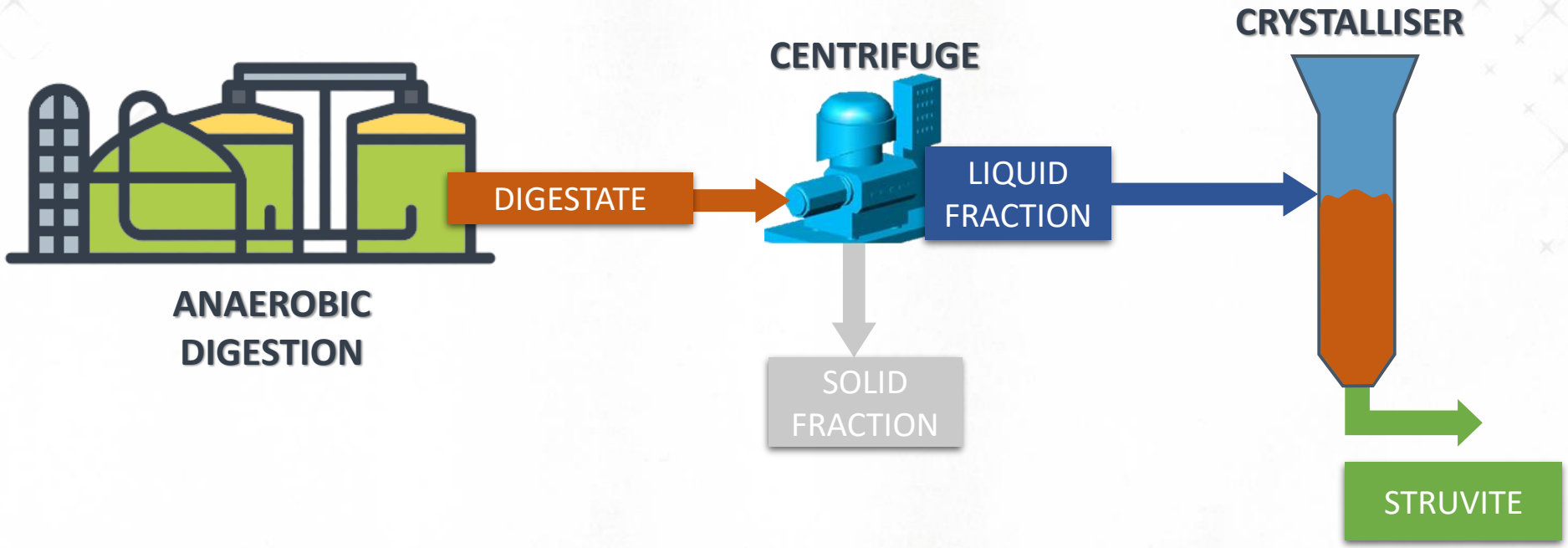
$$Mg^{2+} + NH_4^+ + PO_4^{3-} + 6H_2O \rightarrow MgNH_4PO_4 \cdot 6H_2O$$



Struvite crystallization

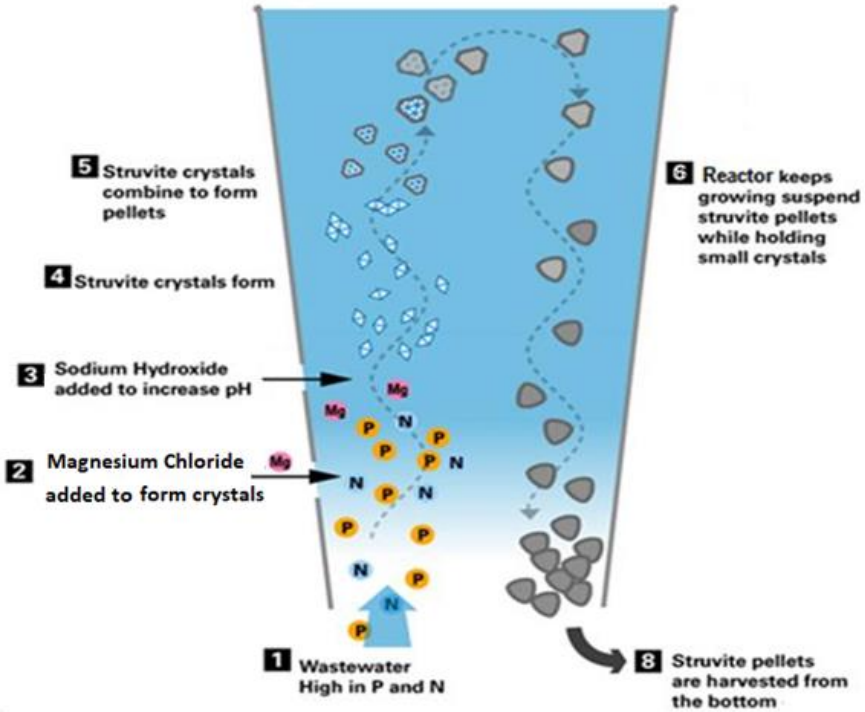
- Cartif produces the struvite from the digestate coming from the anaerobic digestion of the pig slurry.

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



Struvite crystallization

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



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