Leading nutrient recycling R&D projects

Speed-Date presentations of current EU and nationally funded projects (H2020, LIFE, INTERREG, industry, etc.)

Kimo van Dijk - ESPP - kimovandijk@phosphorusplatform.eu

The following research projects on nutrient recycling and management will present. More information can be found in the ESPP R&D project list at www.phosphorusplatform.eu/R&D

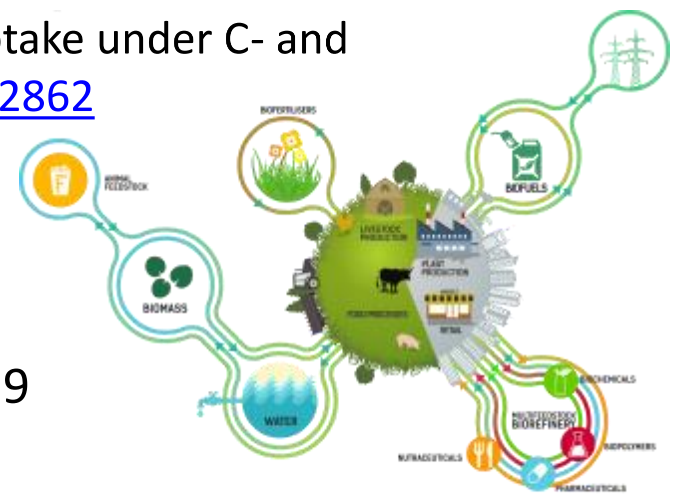
Add your projects!

AgroCycle	ALGAECAN	ASHES	Biorefine
Bonus Promise	DECISIVE	DOP	ENRICH
IMPROVE-P	INCOVER	Newfert	Nurec4org
Phos4You	Phorwärts	QUB Phosphorus from Wastewater	RAVITA
The Resource Container	RichWater	Run4Life	SMART-Plant
SABANA	SYSTEMIC	Water2Return	3R2020+

AGROCYCLE

for a circular economy

- Project Objectives:
  - Achieve a 10% increase in the recycling and valorisation of agricultural waste by 2020
  - Further develop, demonstrate and validate novel processes, practices and products for the sustainable use of agricultural waste, co-products and by-products
  - Recovery and re-use of nutrients from waste in the food chain
- Results: Nematodes enhance plant growth & nutrient uptake under C- and N-rich conditions http://www.nature.com/articles/srep32862
- AgroCycle
- Sustainable techno-economic solutions for the agricultural value chain
- Start Date: 1st June 2016 End Date: 31st May 2019



This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No. 690142 in collaboration with the People's Republic of China and the Hong Kong Government

Adding sustainability to the fruit and vegetable processing industry through solar-powered algal wastewater treatment
LIFE ALGAECAN

DURATION: Start: 02/10/2017 - End: 31/12/2020

Objectives contributing to nutrient recycling and management

- ***To demonstrate the technical and economic feasibility of an innovative concept for FVPI wastewater treatment based on a solar-powered heterotrophic microalgae culture to substitute, in the long term, the traditional aerobic digestion as preferred method for the treatment of these streams since instead of waste sludge and nutrients losses, added-value microalgae are produced(biofertilisers, animal feed, etc).***
- ***Design, construction and operation of 1 prototype operating at 2 demo sites, Spain and Slovenia.***

Results

- ***Reduction of greenhouse gas emissions due to the fuel savings by renewable energy used: 0.581 kg CO2 eq/kWh used***
- ***100% Reduction of the environmental impact associated with waste sludge generation in traditional aerobic treatment systems and its (usual) landfilling***
- ***100% Reduction of nutrient losses associated with waste sludge generation in traditional aerobic treatment systems.***

Mr. Jesús Mª Martin, Project Manager

ASHES – Nutrient recycling from the thermo-chemical processing of waste bagasse and straw

A German-Brazilian collaborative research project

Residues from the production of sugar and ethanol

Bagasse | **Other** | **Straw**

Thermal treatment

Ash

Fertilizer | **Additive for Biopolymers**

Duration: 04/2015 –03/2018

Funded by: BMBF, Germany

Federal Ministry of Education and Research

- P and K cycle in the sugar cane industry
- Evaluation of (co-)combustion/gasification (with chicken manure, sewage sludge)
- P and K extraction by leaching/precipitation
- Increasing P-availability by AshDec process
- Fertilizing effects in plant growth tests in comparison to extraction methods + DGT

➡ Recommendations for the thermal conversion to secondary fertilizers (Next Generation Fertilizer Strategy)

Fraunhofer UMSICHT · KIT Karlsruhe Institute of Technology · Fraunhofer IGB · CUTEC · JÜLICH FORSCHUNGSZENTRUM · Outotec · BAM · UFG UNIVERSIDADE FEDERAL DE GOIÁS · CNPEM · Ministério da Agricultura Pecuária e Abastecimento LANAGRO-GO · GOVERNO FEDERAL BRASIL PAÍS RICO É PAÍS SEM POBREZA · INSTITUTO FEDERAL DE EDUCAÇÃO, CIÊNCIA E TECNOLOGIA GOIÁS Câmpus Goiânia · TECNARO The Biopolymer Company inside

Hannes Herzel (BAM)

The Biorefine Cluster

MISSION

The Biorefine Cluster Europe interconnects projects & people within the domain of nutrient and energy cycling (Refining chemicals, materials, energy and products from bio-based waste streams).

JOINT STRENGHTS: MAXIMIZED PROJECT IMPACT & ADDITIONAL 'CONVINCING POWER'

- Inter-project exchange
- Optimise outreach and efficiency by:
  - Synchronizing communication strategies & events;
  - Producing complementary communication tools to avoid double work;
  - Cross-promoting activities;
  - Co-organizing powerful stakeholder events, meetings, workshops, …
- Enhanced exposure through BCE channels
  - Website
  - Social Media
  - Newsletter
  - Joint events
- Exchange of data and results
- Centralization of literature search, deliverables or other outputs
- Expert mobility between entities involved
- Stronger network with community of experts
- Stay updated on proposals/projects that fit your expertise
- Improve exchanges with industry
- Accelerated market implementation

CONTACT & INFO: biorefine.eu (update in Jan. 2018)
Evi.Michels@UGent.be

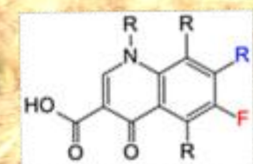
BONUS PROMISE – Phosphorus Recycling of Mixed Substances (1.4.2014 – 31.3.2017)

BONUS
SCIENCE FOR A BETTER FUTURE OF THE BALTIC SEA REGION

- **Results:**
  - **Thermophilic anaerobic digestion and pasteurization:**
    - **Less pathogens**
    - **Still heavy metals and antibiotics**
  - **Gasification + ASH DEC-treatment (sewage sludge)**
    - **Eliminated most of the risks**
    - **ASH DEC increased P bioavailability**

Manure, sewage sludge, industrial by-products

Antibiotics?



Heavy metals?

mmm.fi
MINISTRY OF AGRICULTURE AND FORESTRY

ptj
Projektträger Jülich
Forschungszentrum Jülich

VINNOVA

Luke
NATURAL RESOURCES INSTITUTE FINLAND

DECISIVE

Organisational innovation:

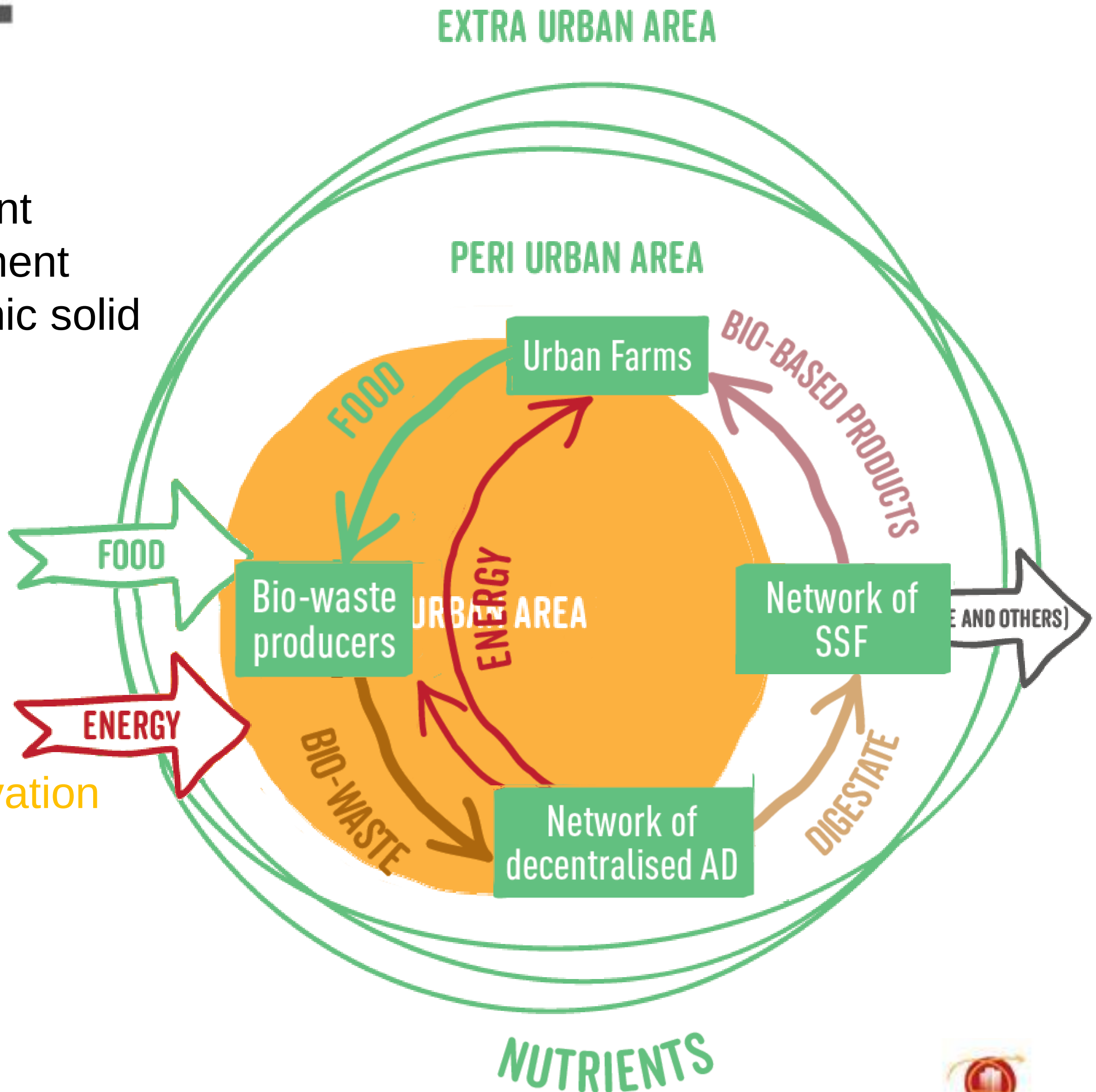
- A method to plan efficient decentralised management scheme for urban organic solid waste based on urban metabolism study

Technological innovations:

- Micro-AD and biogas valorisation
- SSF

Policy and economic innovation

- Guidelines/advices for environmental Policy
- Urban farm concept
- New waste business



LIFE DOP - Demonstrative mOdel of circular economy Process in high quality dairy industry

Implement a demonstration model using innovative and **sustainable practices** from **feed** production in the field to stable and **manure management.**

Objectives and results contributing to nutrient recycling and management in the proposed model:

Implement AD of slurry to increase nutrient management efficiency

Implement proper distribution of liquid digestate in the cheese district (high efficiency)

No use of synthetic fertilizers

Export of solid digestate to non-breeding areas

Manage slurry by an on line stock exchange platform to re-balance nitrogen load and create value

Implement LCA to asses the save of impacts of the proposed model with respect to the reference.

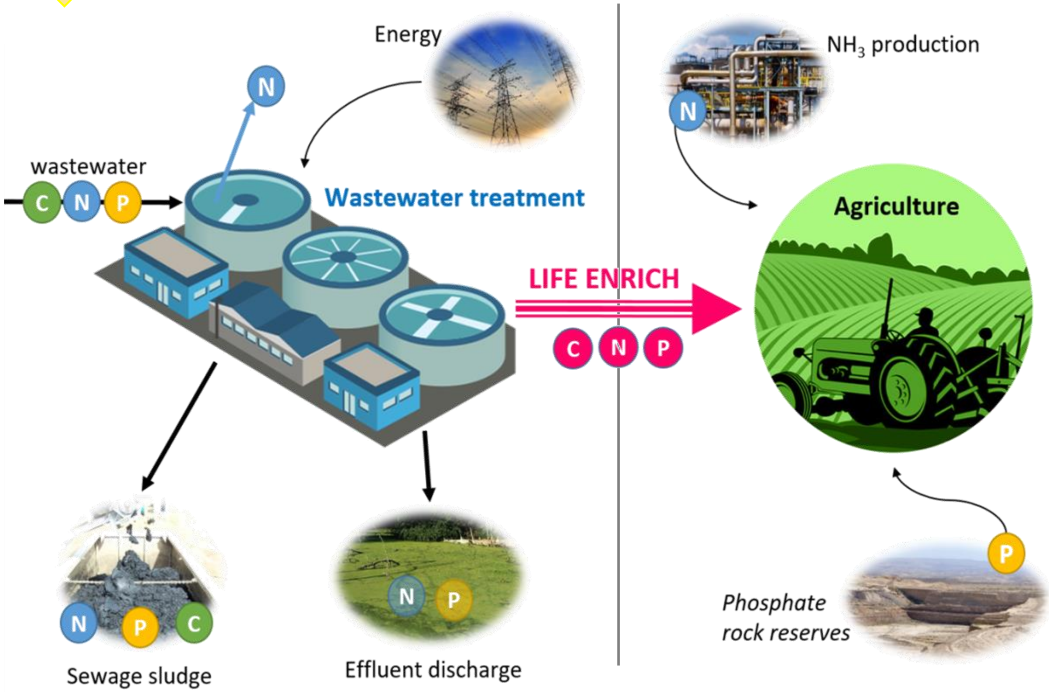
LIFE ENRICH

Enhanced Nitrogen and phosphorus Recovery from wastewater and Integration in the value Chain

1st September 2017
to
28th February 2021

OBJECTIVE

Demonstrate the technical, economic and environmental feasibility of a new value chain based on the recovery of nutrients from WWTPs and its valorisation in agriculture.



EXPECTED RESULTS:

- Development of a **new business model**, that ensures a market and an economic feasibility for the fertilizers produced.
- Development and validation of different **technologies** for N and P recovery from wastewater.
- Conversion of the recovered nutrients to **high agronomic value products** for agriculture.
- Push for the **update of the legal framework** about the use of fertilizers produced from wastewater.

Improved Phosphorus Recycling: Navigating between Constraints

	P recovery	P fertilizer value	Organic matter	PTEs	Organic Pollutants	Env. impact	Overall Score
Bio-waste compost					?		
Bio-waste digestates							
Meat and bone meal							
- ashes							
Sewage sludge					?		
- Struvite (AirPrex)							
- Struvite (Stuttgart)							
- AshDec Rhenanite							

Further information: Möller et al. 2017 Advances in Agronomy Volume 147 in press

www.improve-p.uni-hohenheim.de www.youtube.com/watch?v=LBKmgw5LjLA

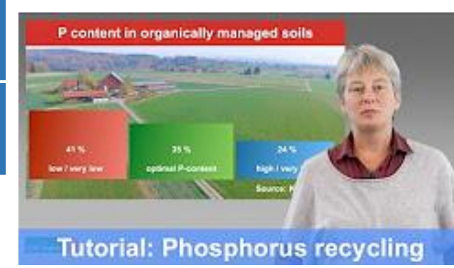
IMPROVE

2013-2016

CORE organic II

P availability
Risk assessment
LCA
Acceptance

Scale: 4 3 2 1



Else K. Bünemann
FiBL Switzerland
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INCOVER Project (GA: 689242): Innovative Eco-Technologies for Resource Recovery from Wastewater

Target: Waste stream into a source of new added-value bio-products through 3 case-studies at demo scale.

Nutrient recovery activities:

- To validate P and N adsorption technologies using innovative adsorbent materials to recover 70-80% of N and P from WW.
- Smart solar disinfection systems and irrigation technology based on wireless sensor networks and communication devices.
- To demonstrate nature-based processes and a hydrothermal carbonization technology to produce bio-fertilizer.

Duration: June 2016 – May 2019

http://incover-project.eu

ict4water.eu

INCOVER Consortium

Newfert Nutrient Recovery from Biobased Waste for Fertilisers Production (July 2015-June 2018)

OBJECTIVES

Development of a new value chain based on nutrient recovery bioprocesses from waste streams for manufacturing biobased NPK fertilisers

- Suitability of 8 different biobased waste streams and residues to the fertiliser industry
- Dedicated nutrient recovery chemical processes from liquid and solid (recovery ratios up to 80%)
- Biobased NPK fertilisers: with at least 10% of recycled compounds,
  free of hazardous compounds,
  reducing the cost production in 5%

RESULTS

- 45 biobased materials analised (10 selected for being tested within fertilisers processes)
- 3 biobased materials clusters: a) Ashes
  b) Struvites
  c) Developed phosphate
- Pilot plant scale: 1. Phosphate production
  2. Struvite from pig slurry
  3. Biobased materials integration in NPK process
- Up to 25 % substitution rate from biobased materials

www.newfert.org

Horizon 2020 European Union Funding for Research & Innovation
Bio-based Industries Consortium
BIO-BASED INDUSTRIES Public-Private Partnership
PRO MAN · D&M Drage & Mate International · irstea · Fertiberia · Kompetenzzentrum Wasser Berlin · universidad de león

Nutrient recyclates for organic farming

- Duration: 01/2017-12/2018
- Contacts: Fabian.Kraus@kompetenz-wasser.de / CKabbe@p-rex.eu

nurec4org

KOMPETENZZENTRUM Wasser Berlin

Bioland Beratung

IASP

sponsored by DBU Deutsche Bundesstiftung Umwelt www.dbu.de

Interreg
EUROPEAN UNION
North-West Europe
Phos4You
European Regional Development Fund

We deliver Phosphorus "made in Europe"

RESSOURCEN- UND MATERIALEFFIZIENZ

Phosphorus is a nutrient essential for all living organisms, but a finite resource on earth.
Phos4You proofs that Phosphorus recovery & recycling from waste water is possible.

from Sept. 2016 to Sept. 2020

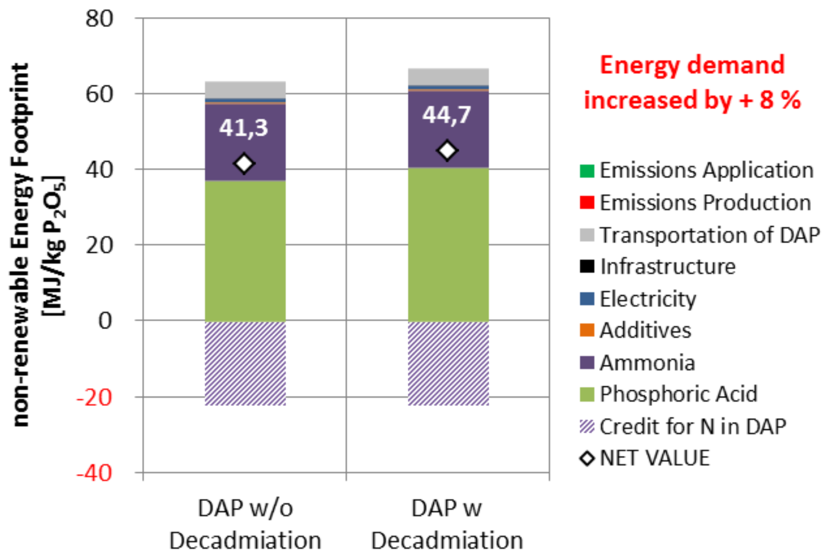
PHORWÄRTS - LCA study to compare fertilizer production from rock phosphate with P-recovery from the wastewater stream

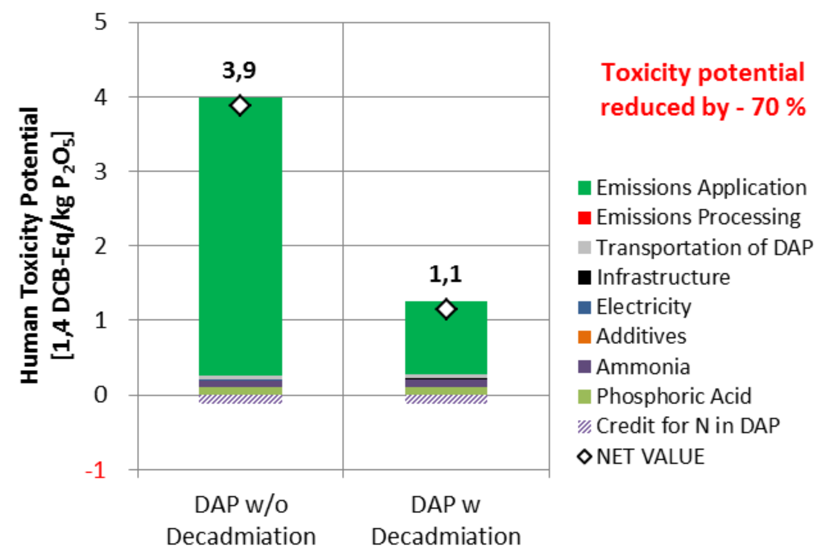
Project Activities:

- Comparative Life-Cycle-Assessment of conventional phosphorus fertilizer production and different processes for phosphorus recovery from wastewater stream
- Comparative risk assessment of fertilizers application regarding their contamination with heavy metals and organic pollutants
- Cost estimation of the various production methods

Duration: 9/2016 – 2/2018
Project Volume: 140 k€
Contact: Fabian Kraus,
fabian.kraus@kompetenz-wasser.de

Umwelt Bundesamt





Use of a natural polymer for the removal and recovery of phosphorus from wastewater

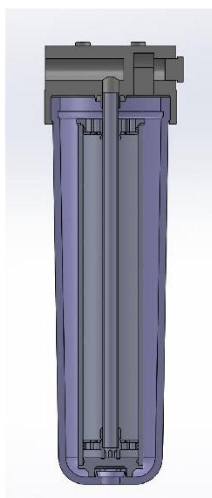
P. McAleenan, J. W. McGrath, **K. Macintosh** and P. Manesiotis
Queen's University Belfast, Stranmillis Road, Belfast, BT9 5AG, UK
pmcaleenan02@qub.ac.uk

1) Synthesis natural polymer beads

Bead design allows efficient and easy packing into filters and was optimised to maximise flow rate and surface area

2) Filter Design

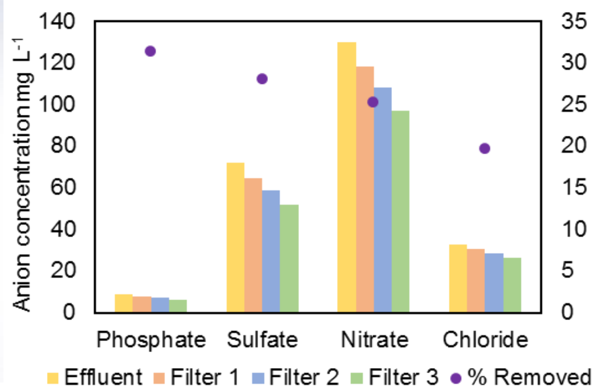
The filter uses a suspension flow mechanism to pass wastewater through at a rate of 1 L min-1 for 10 L

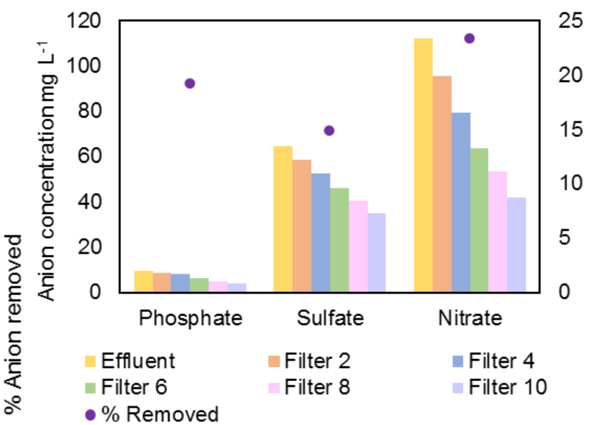


3) Phosphorus removal from wastewater

An effluent standard and wastewater were both passed through multiple filters of polymer beads

After 3 filters, a 31 % removal was seen in the effluent standard and a 19 % removal seen in the wastewater

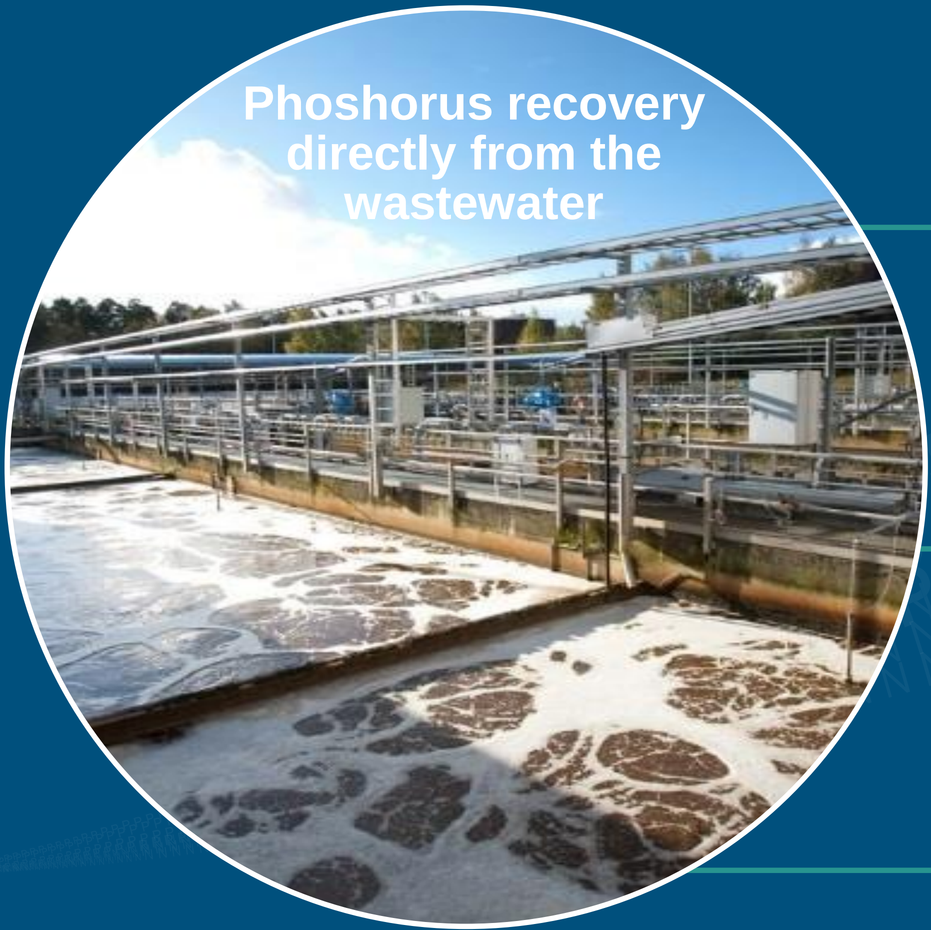




Anion	Removal from effluent standard	Removal from effluent after 3 filters	Removal from effluent after 10 filters
Phosphate	31 %	19 %	58 %
Sulphate	29 %	15 %	46 %
Nitrate	25 %	23 %	63 %
Chloride	19 %	-	-

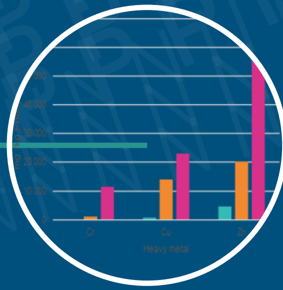
RAVITA

New Perspective – Out of the Box Solution Innovation for Nutrient Harvesting in WWTPs



Phoshorus recovery directly from the wastewater

End product: Phoshoric acid

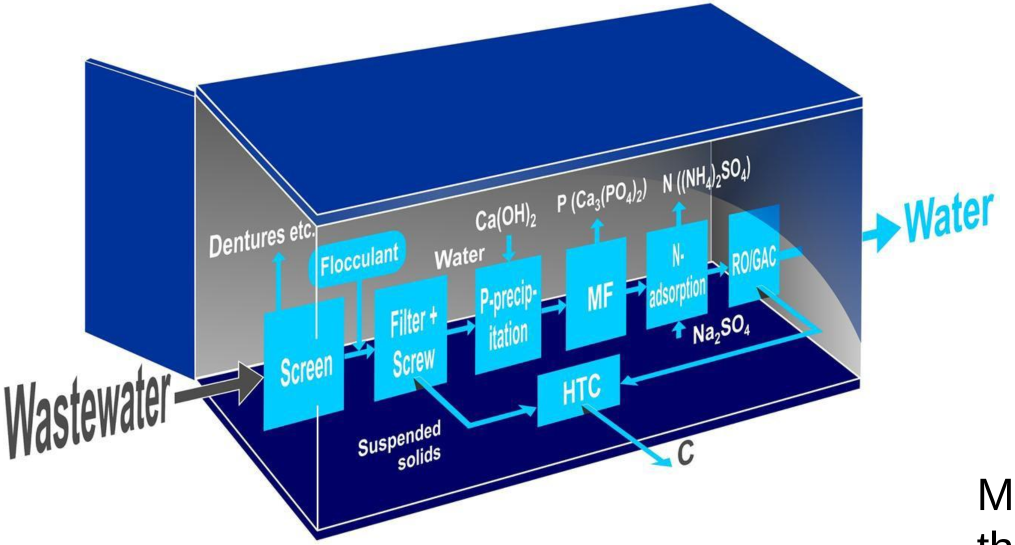


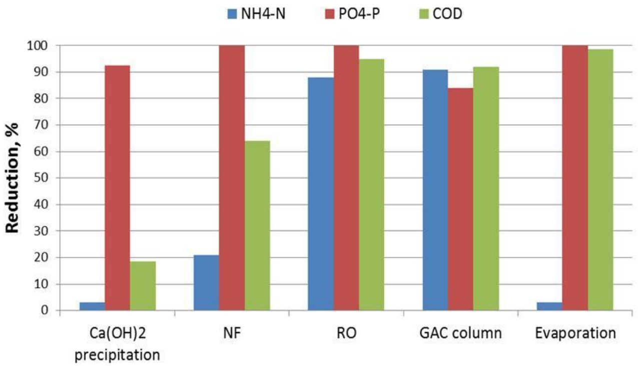
Low level of micro pollutants

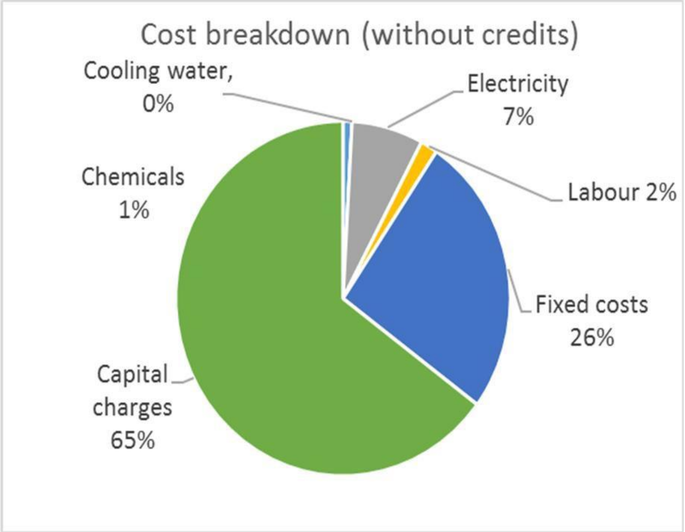
Combi process with the nitrogen recovery

Project Schedule: 1/2015-12/2019

Resource container: P - N - C recovery from wastewater







Municipal sewage and waste waters from the bioindustries could be used as sources of carbon and nutrients much more effectively than they are today.

Here we consider waste water as a feed-stock, from which valorizable substances can be extracted for various applications and the water is produced for reuse.

The operating model does not include any biological treatment, and can therefore be flexibly implemented in various scales locally or as seasonal solutions.

Project title: First application and market introduction of combined wastewater treatment and reuse technology for agricultural purposes

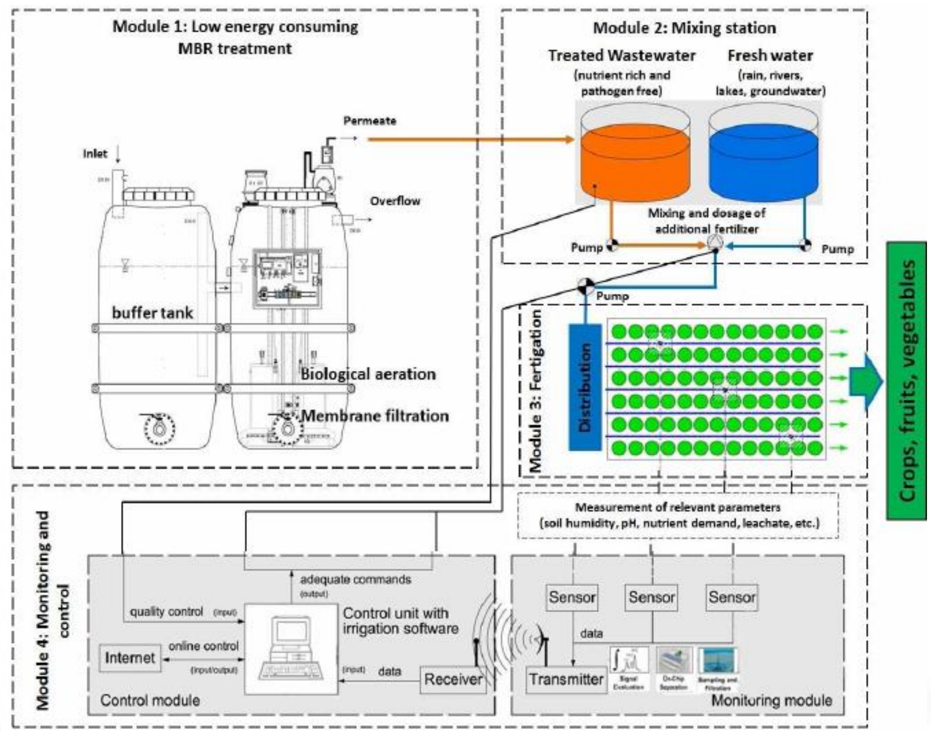
Objectives and expected results:

- Demonstration and market uptake of technology for the reuse of treated wastewater in agriculture.

- Integration of treatment and irrigation in a single system tailor-made to wastewater reuse

- Prototype functioning in operational environment in South Spain

- Agronomic study, LCA and CBA



Starting date: February 1st, 2016

End date: July 31st , 2018

European Nutrient Event

Basel, 19th October, 2017

RUN4LIFE

Recovery and Utilization of Nutrients 4 Low Impact FErtilizer

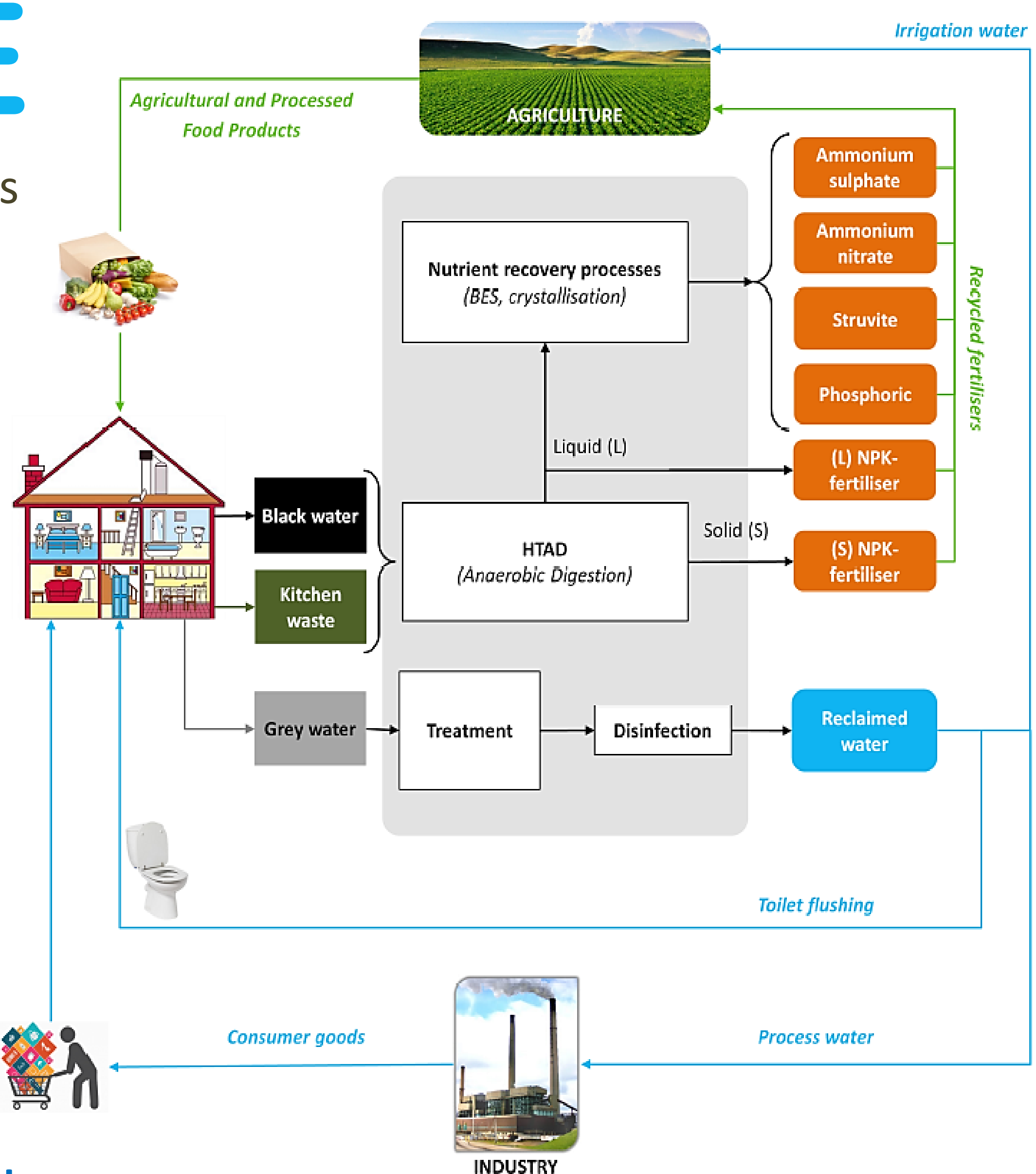
June 2017 → June 2021

Circular economy to safeguard food production and water resources

- **Decentralized nutrient recovery** from wastewater at the **source**
- **Domestic wastewater:** important **nutrient carrier** not exploited currently

Objectives

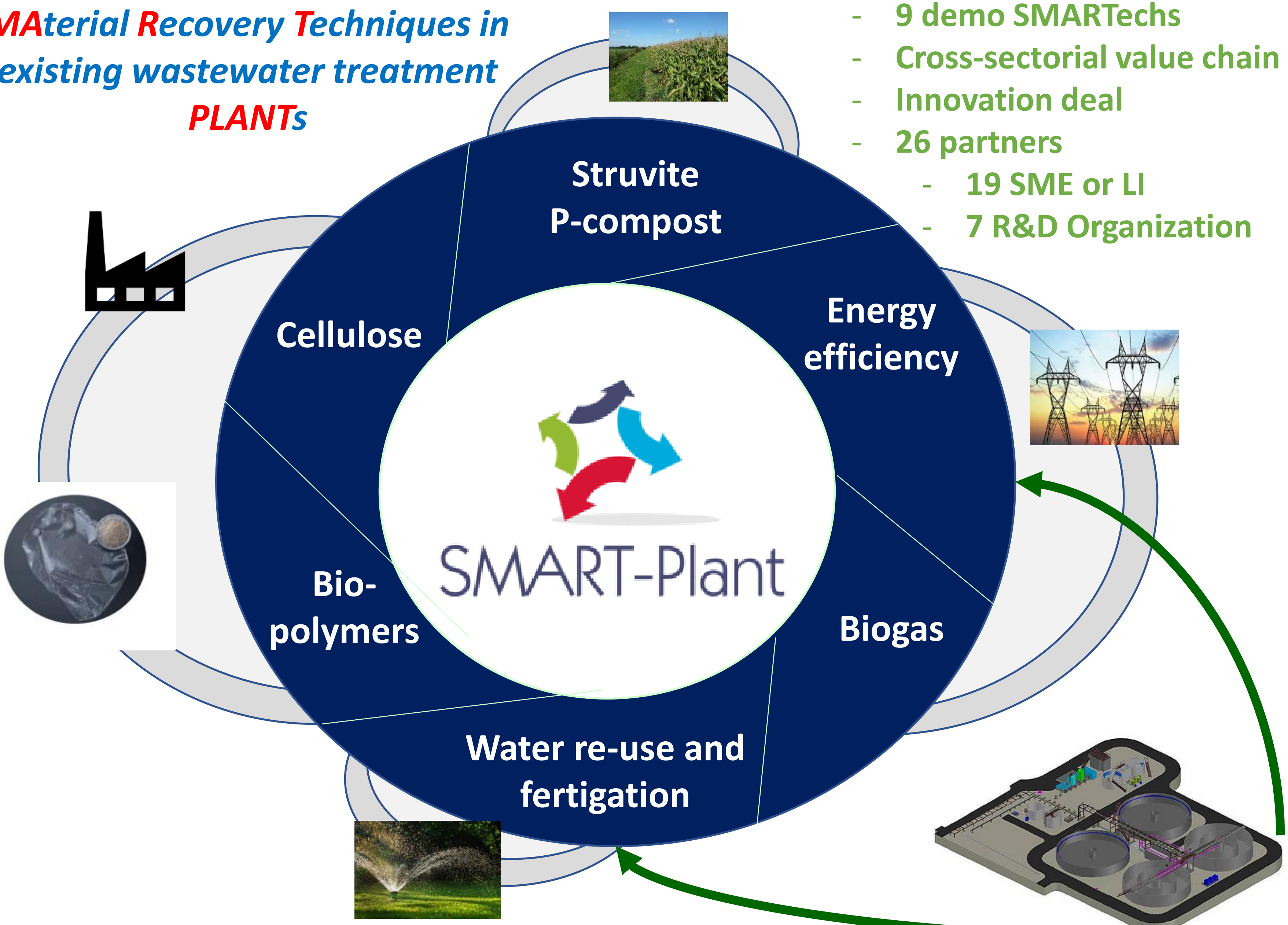
- **Improve innovative technologies**
- **Large scale demonstration of nutrients recycling**
- **Evaluate impacts on environment, society and economy**
- **Promote acceptance of recycled products**
- **Value chain for the recovered products**



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730285

Scale-up of low-carbon footprint MAterial Recovery Techniques in existing wastewater treatment PLANTs

- **Horizon2020 IA**
- **9 demo SMARTechs**
- **Cross-sectorial value chain**
- **Innovation deal**
- **26 partners**
  - **19 SME or LI**
  - **7 R&D Organization**

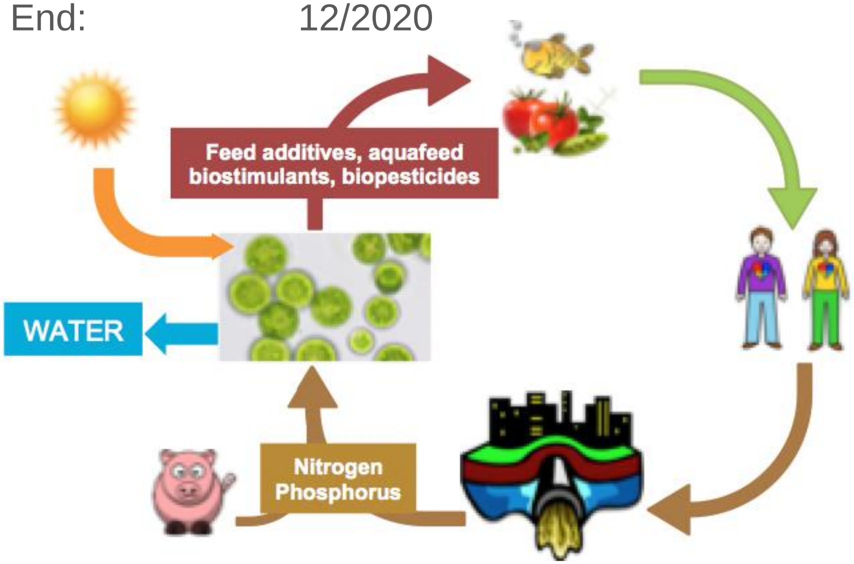


www.smart-plant.eu **Start: 01/Jun/2016 – End: 31/may/2020**

SABANA : Sustainable Algae Biorefinery for Agriculture aNd Aquaculture

This project is funded by the European Union

Start: 12/2016
End: 12/2020



Demonstrate an integrated microalgae-biorefinery to produce high-value and low-value products for agriculture and aquaculture

accomplishing market and social requirements

Objectives contributing to nutrient recycling and management :

Implement large scale microalgae production recovering nutrient from wastewater and slurry

No use of synthetic fertilizers

Recovery of nutrients contained in wastewater

Recovery of waste CO2 and minimization of greenhouse gas emissions from wastes (wastewater and flue gases)

Implementing LCA of the whole model

SYSTEMIC

www.systemicproject.eu

Coordination: Oscar Schoumans, Wageningen Environmental Research

Horizon 2020

Systemic large scale eco-innovation to advance circular economy and mineral recovery from organic waste in Europe (2017 -2021)

Using existing large scale digesters plants as a technology hub for new business in recovery & recycling of energy, nutrients and soil improvers

- Advancing TRL (5 → > 7) at 5 demonstration plants (Nl, B, D, UK, It) including development of viable business cases (leading pioneers)
- Business opportunities for 10 outreach locations (first followers)
- Policy advise to overcome innovation barriers and advancing CE in the EU

REcovery and REcycling of nutrients TURNing wasteWATER into added-value products for a circular economy in agriculture

Start: July 1st, 2017 // End: December 31st, 2020

Aim: fostering **industrial symbiosis** by **treating slaughterhouses' wastewater** and **recovering nutrients** based on a **Circular Economy approach**. *Project outcomes:*

- **1 Integrated system to treat wastewater** → novel combination of technologies and processes in cascade maximising the extraction of valuable products.
- **2 Slaughterhouse Raw Materials (SRMs)** → the basis for the agronomic products.
- **3 Agronomic Products (APs): one fertiliser and two biostimulants** → free of pathogens and pollutants ready to commercialise.

ESPP R&D nutrient recycling event, October 19th – 11th, 2017, Basel (Switzerland)

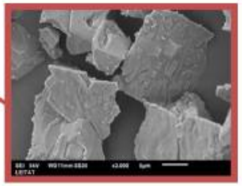
3R2020+ project - From waste to resource by recycling

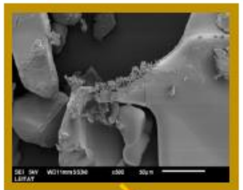
Acronym	Full name	Project description	Start-time	End-time	Funding	Website
3R2020+	From waste to resource by recycling	**The aim is to investigate innovative technologies to recycle** sewage sludges into **struvite and ammonic sulphate as fertilizers.**	01/06/2015	31/05/2019	CIEN CALL (CDTI)	www.3r2020.com

LAB TESTS

	PO_4^{3-} (mg/L)	NH_4^+ (mg/L)
Wet digestion effluent	75	1100

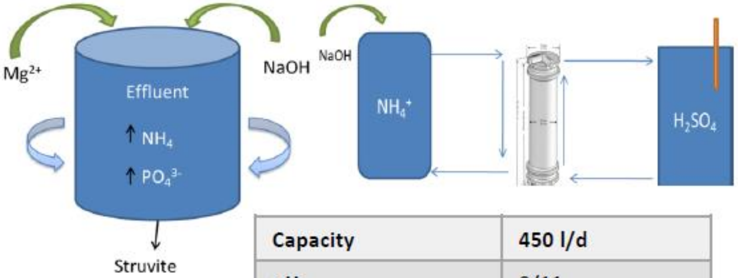
Experimental		pH (después de dopar y ajustar)	$[P]_0$ (después de dopar y ajustar) (mg/L)	$[P]_f$ (mg/L)	Reducción P (%)	Pureza máxima Estruvita
Af0	Agua Af; P orig; adición de Mg en gran exceso; pH9,5	9,50	28	16	43%	11%
Af1	Agua Af; P orig; Mg orig: relación Mg:P original	8,67	23	18	19%	17%
Af1.1	Agua Af; P orig; Mg orig; directa en decantadores; relación Mg:P orig	8,64	30	16	47%	-
Fo1	Agua F; P orig; Mg orig; directa en decantadores; relación Mg:P orig	8,54	28	25	11%	-
Af2	Agua Af; Mg orig; P añadido a relación Mg:P =0,8	8,57	49	37	23%	20%
Bf1	Agua Af; Mg orig; P añadido a relación Mg:P=0,5	8,60	75	55	27%	22%
Bf2	Agua Bf; $[P]_0$=300 ppm dopando con H^3PO_4; Mg orig	8,50	306	254	17%	-
Bf3	Agua Bf; $[P]_0$=300 ppm dopando con H_3PO_4 hasta relación Mg:P=0,8	8,50	294	70	76%	34%
Bf4	Agua Bf; $[P]_0$=300 ppm dopando con H_3PO_4 hasta relación Mg:P=1,5	8,50	288	4	99%	63%
Bf5	Agua Bf; $[P]_0$=300 ppm dopando con Na2HPO4 hasta relación Mg:P =1,5	8,50	300	13	96%	54%
Cf1	Agua Cf; Mg original; Mg:P=1,5 dopando con Na2HPO4	8,50	24	16	33%	35%
Cf2	Agua Cf; Mg original; Mg:P=1,5 dopando con H_3PO_4	8,52	18	17	9%	38%





Experimental conditions		Neutralization time (h)	$[NH_4^+]_f/[NH_4^+]_0$	NH_4^+ reduction (g)	Efficiency in NH_4^+ reduction ($g/h.m^2$)*	AS (g)
AS3	Q_{NH4}=0,8 L/min	4,0	0,61	9,1	2,7	31
AS5	Q_{NH4+}=1,6 L/min	1,0	0,74	4,6	8,6	25
AS6	Q_{NH4+}=2,4 L/min	0,9	0,63	9,6	23,5	32
AS7	Q_{H+}=0,28 L/min	1,0	0,64	7,0	13,0	31

TESTS IN PILOT PLANT



Capacity	450 l/d
pH	8/11
Tª	4/50 ºC

Ministerio de Economía y Competitividad
CDTI Centro para el Desarrollo Tecnológico Industrial
HidroQuimia
Biopolis
MAiER
CLH
Biomasa Peninsular
TECNICAS REUNIDAS
urbaser

Leading nutrient recycling R&D projects

Speed-Date presentations of current EU and nationally funded projects (H2020, LIFE, INTERREG, industry, etc.)

Kimo van Dijk - ESPP - kimovandijk@phosphorusplatform.eu

Kanton Zürich Baudirektion Amt für Abfall, Wasser, Energie und Luft
Phos4You
CETAQUA WATER TECHNOLOGY CENTER
EasyMining
OSTARA Creating Val from Waste
SYSTEMIC Circular solutions for biowaste
BSAG Baltic Sea Action Group
ecophos
incopa
SCIENCE CAMPUS PHOSPHORUS RESEARCH ROSTOCK
Outotec
SEDE VEOLIA
EGLV.DE LIPPE VERBAND
SMART-Plant
Hitz Hitachi Zosen
Biomasa Peninsular
Budenheim
NUTRIENT PLATFORM NL
PRAYON
Queen's University Belfast
DEUTSCHE PHOSPHOR PLATTFORM
Thames Water
CLARIANT
SEVERN TRENT WATER
DIE 48ER DEIN WIEN
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