Innovative 2-stage treatment of urban wastewater in Flanders for sustainable nitrogen recovery and reuse

Sarah Moreno Sayavedra (sarah.morenosayavedra@ugent.be)

Lennert Dockx, Maria Natalia Ruiz Gordo, Lydia Yeboah, Ivona Sigurnjak, Erik Meers

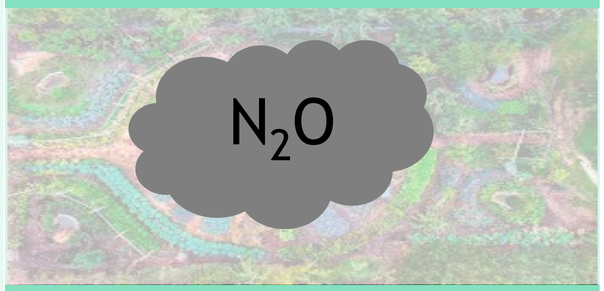
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101000752.

N recovery from municipal wastewater

[1] IPCC (2019) Refinement to the 2006 Guidelines

N recovery from municipal wastewater

WWTP N_2O emissions



~ 1.6% of influent TN load[1]

WWTP energy consumption (EU)

20-45 kWh net energy input/PE [2]

[1] IPCC (2019) Refinement to the 2006 Guidelines

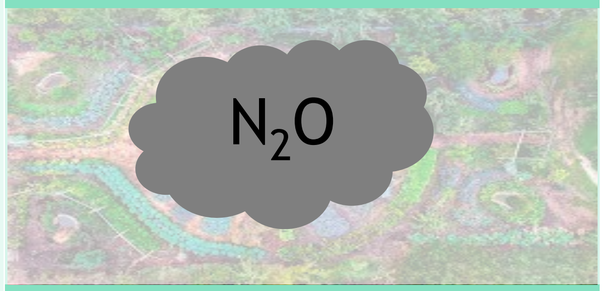
[2] International Water Association (2021)

GHENT UNIVERSITY

WALNUT

N recovery from municipal wastewater

WWTP N_2O emissions

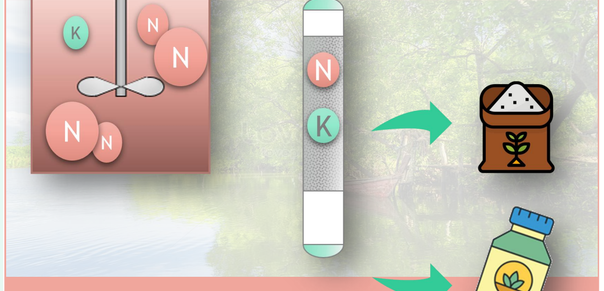


~ 1.6% of influent TN load[1]

WWTP energy consumption (EU)

20-45 kWh net energy input/PE [2]

N recovery and reuse



2.82% of EU inorganic N demand in conventional WWTP effluent[3]

GHENT UNIVERSITY WALNUT

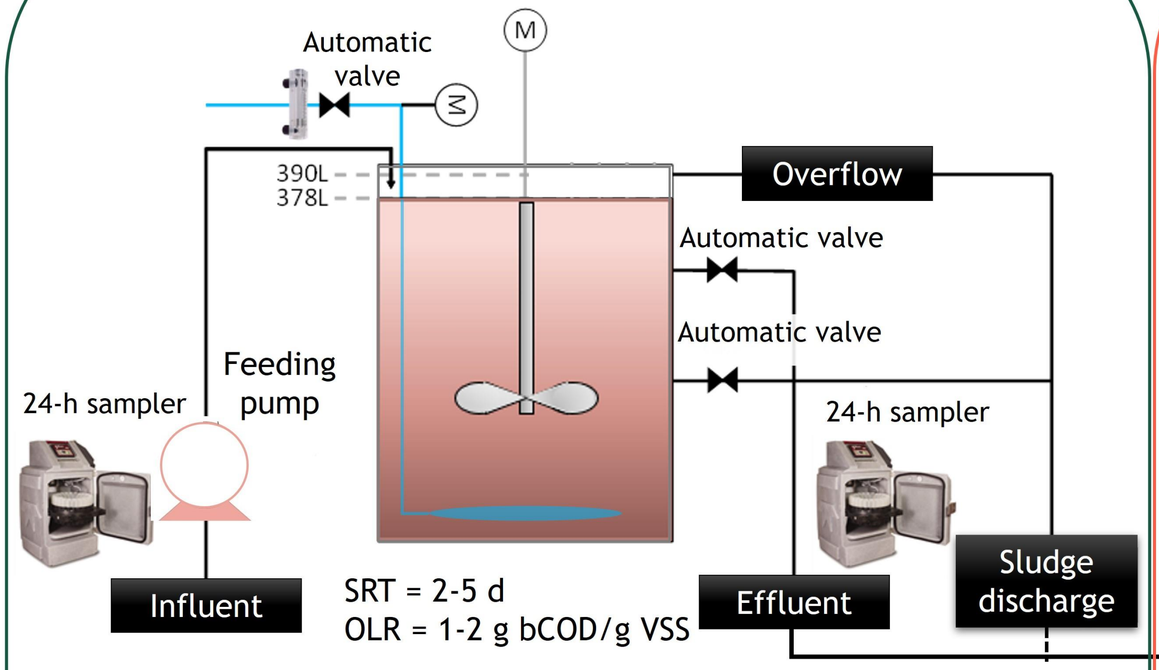
[1] IPCC (2019) Refinement to the 2006 Guidelines [2] International Water Association (2021)
[3] European Pollutant Release and Transfer Register, Eurostat (2023)

Pilot N recovery and wastewater treatment system: HRAS/CS + adsorption

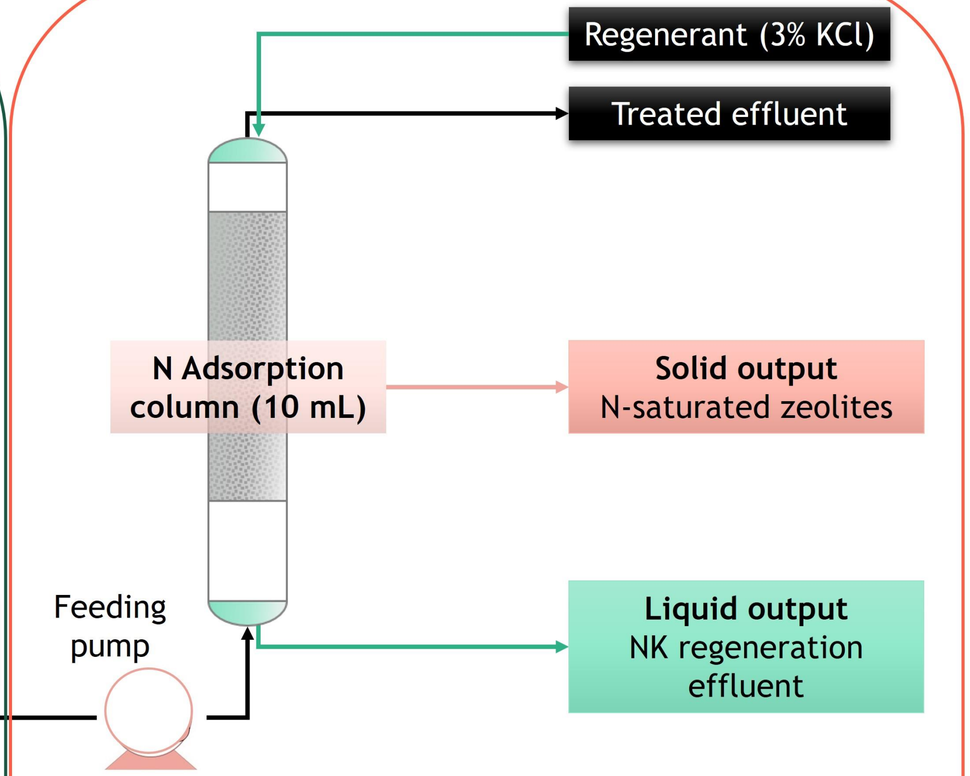
Aquafin

Two-stage system

Stage 1: HRAS/CS (Pilot Sequencing Batch reactor)



TRL 6



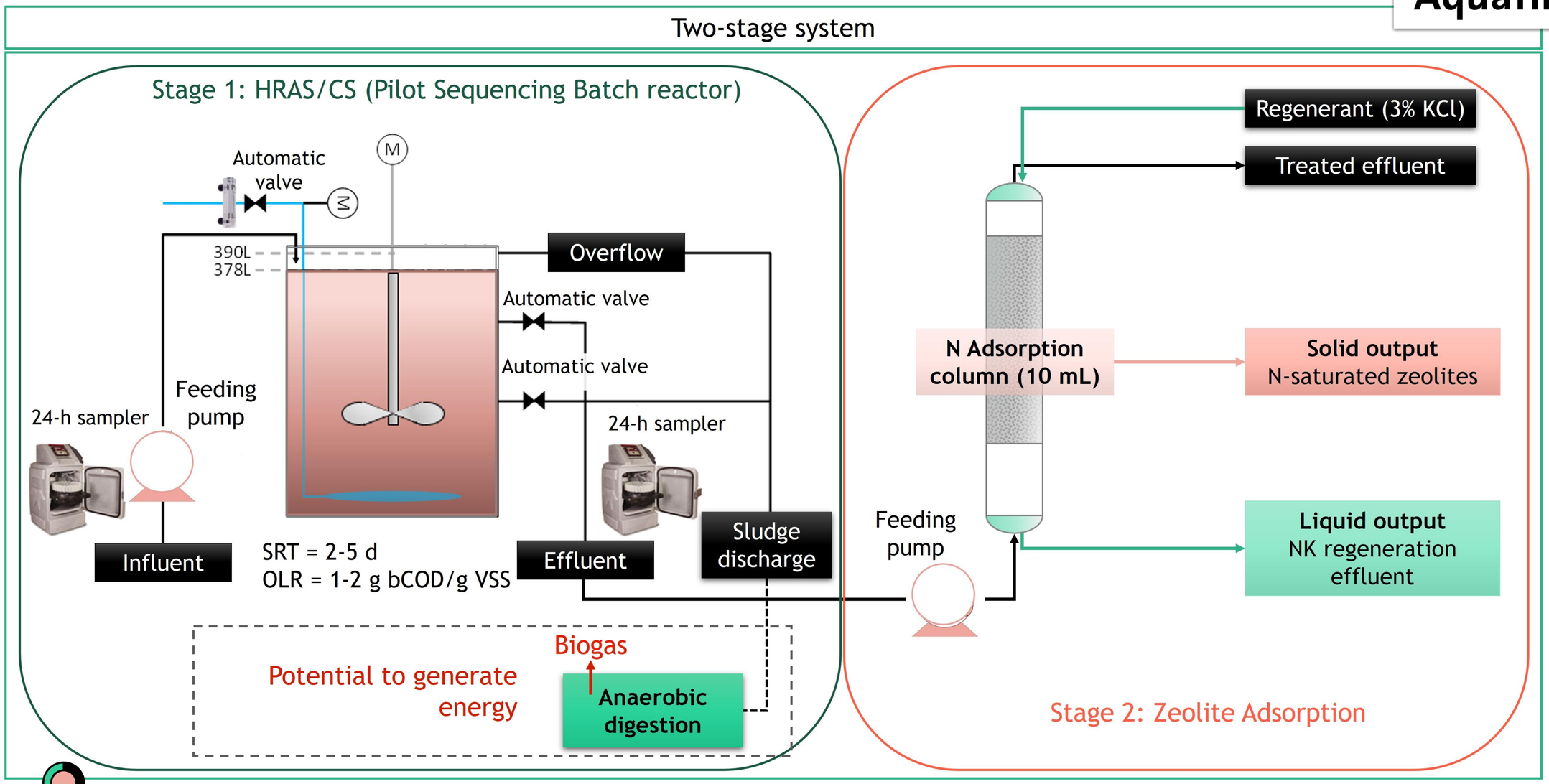
Stage 2: Zeolite Adsorption

TRL 5

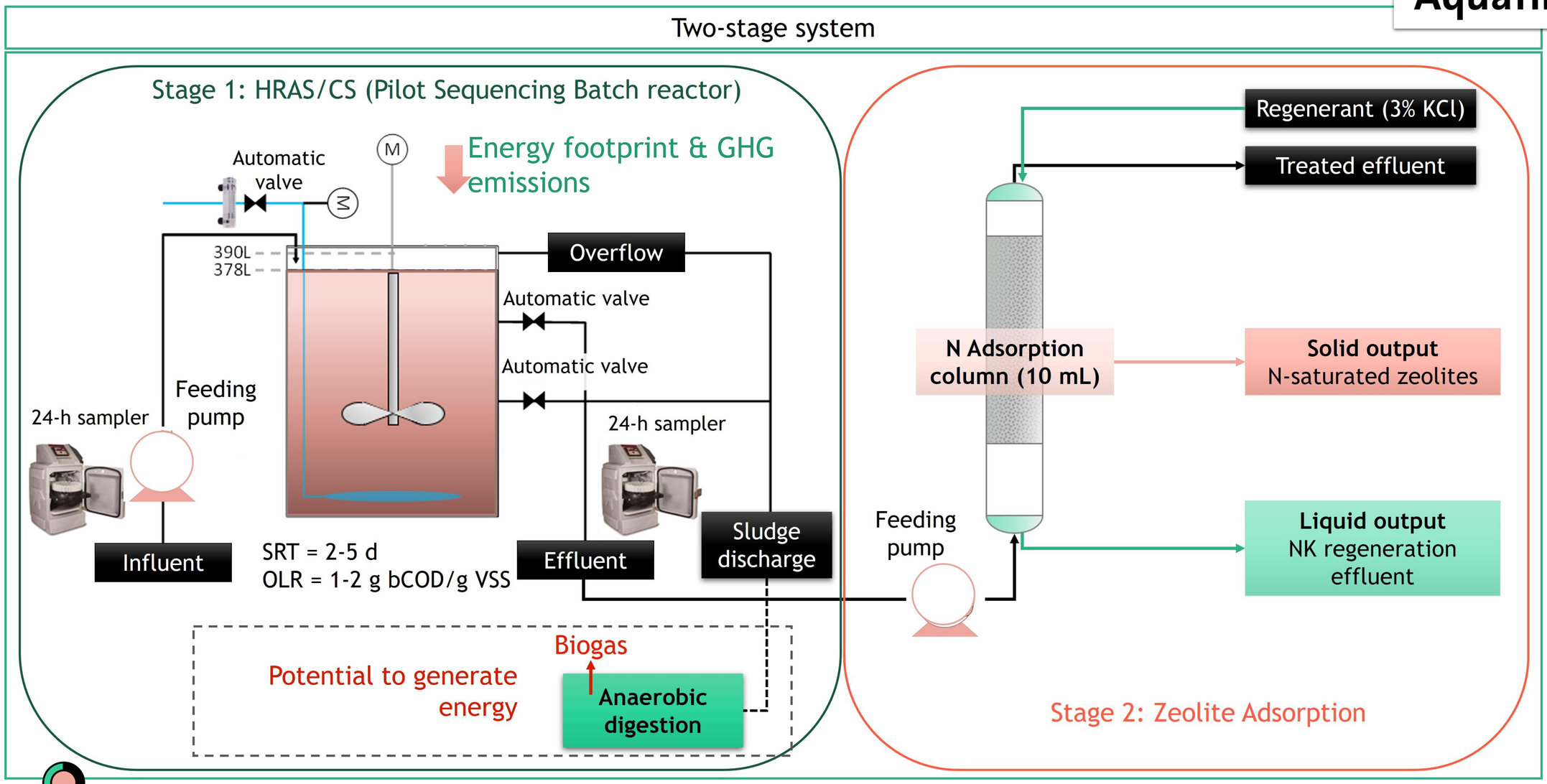
GHENT UNIVERSITY

WALNUT

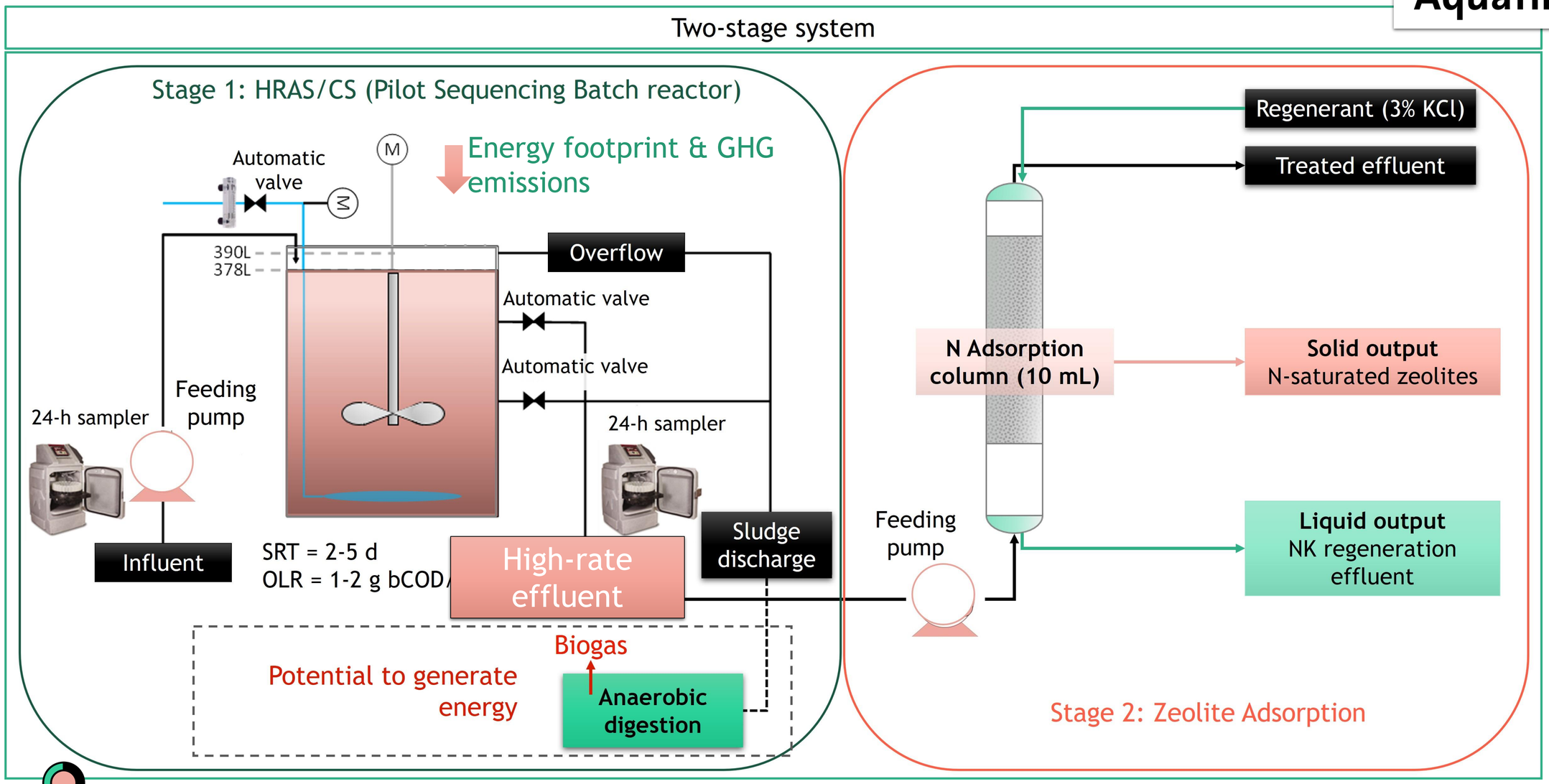
Pilot N recovery and wastewater treatment system: HRAS/CS + adsorption



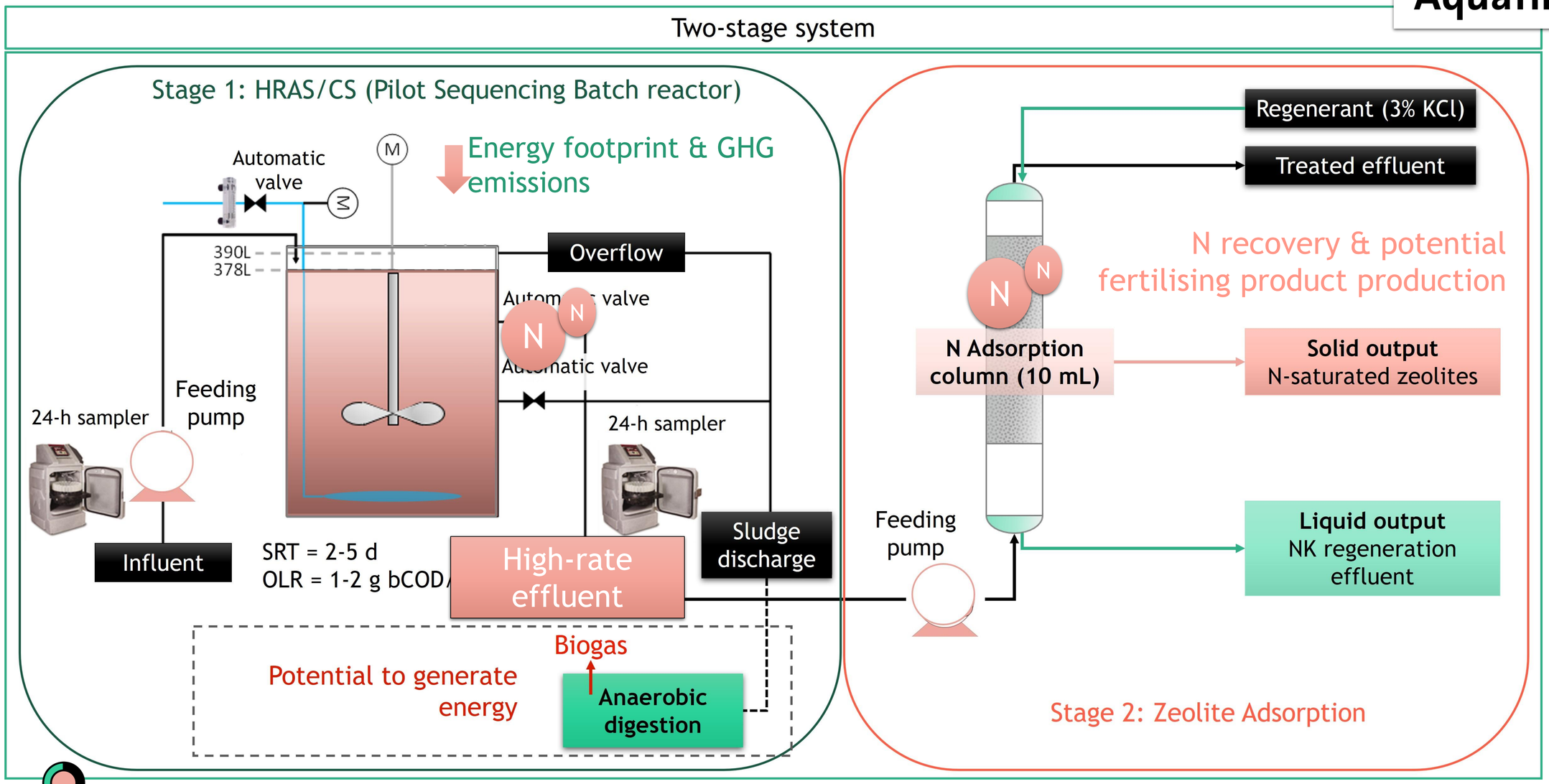
Pilot N recovery and wastewater treatment system: HRAS/CS + adsorption



Pilot N recovery and wastewater treatment system: HRAS/CS + adsorption



Pilot N recovery and wastewater treatment system: HRAS/CS + adsorption



Zeolite adsorption performance

Operational Parameters

- 9-10 BV/h (70 L/h)
- 0.5-1mm zeolite
- pH 5-6.5
- 7 L column
- 14-34 mg/L NH_4^+-N in influent

Pilot Performance	
N content on product (g/kg)	3.6-4.3
NH_4 removal between WW	80-99%
	50-130

Zeolite adsorption performance

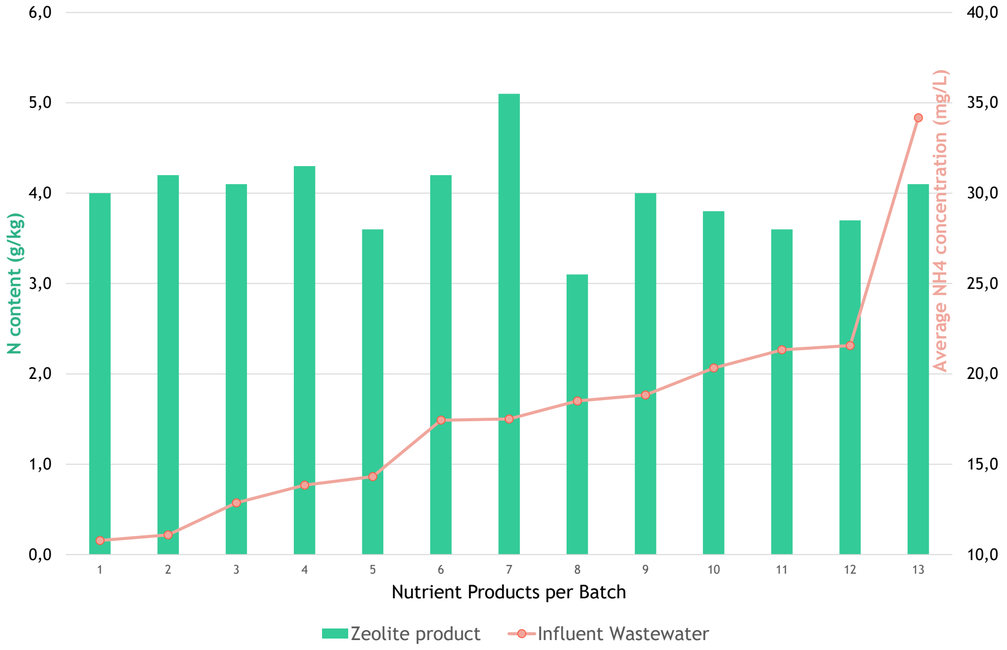
Operational Parameters

- 9-10 BV/h (70 L/h)
- 0.5-1mm zeolite
- pH 5-6.5
- 7 L column
- 14-34 mg/L NH_4^+-N in influent

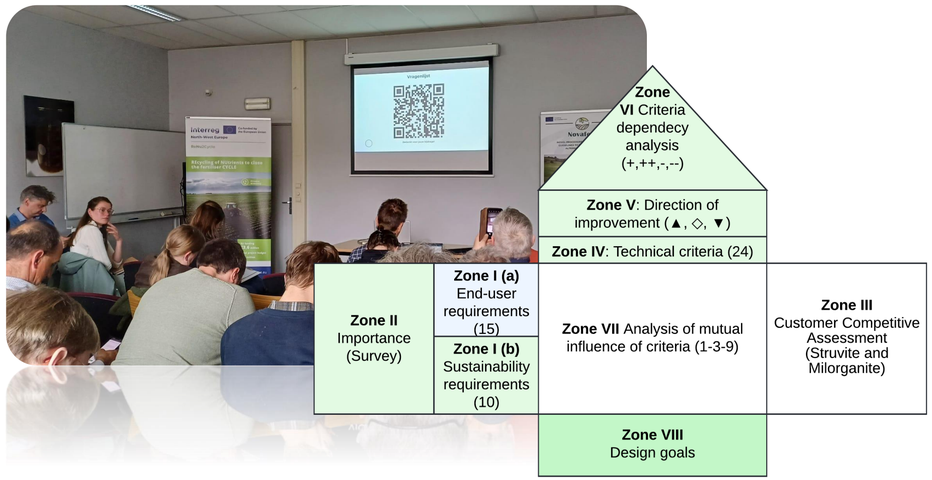
Pilot Performance

N content on product (g/kg)	3.6-4.3
NH_4 removal between WW	80-99%
	50-130

- Effect of N influent ammonium concentration on N content in product?



Challenges in N recovery with Zeolite



Marketability Assessment

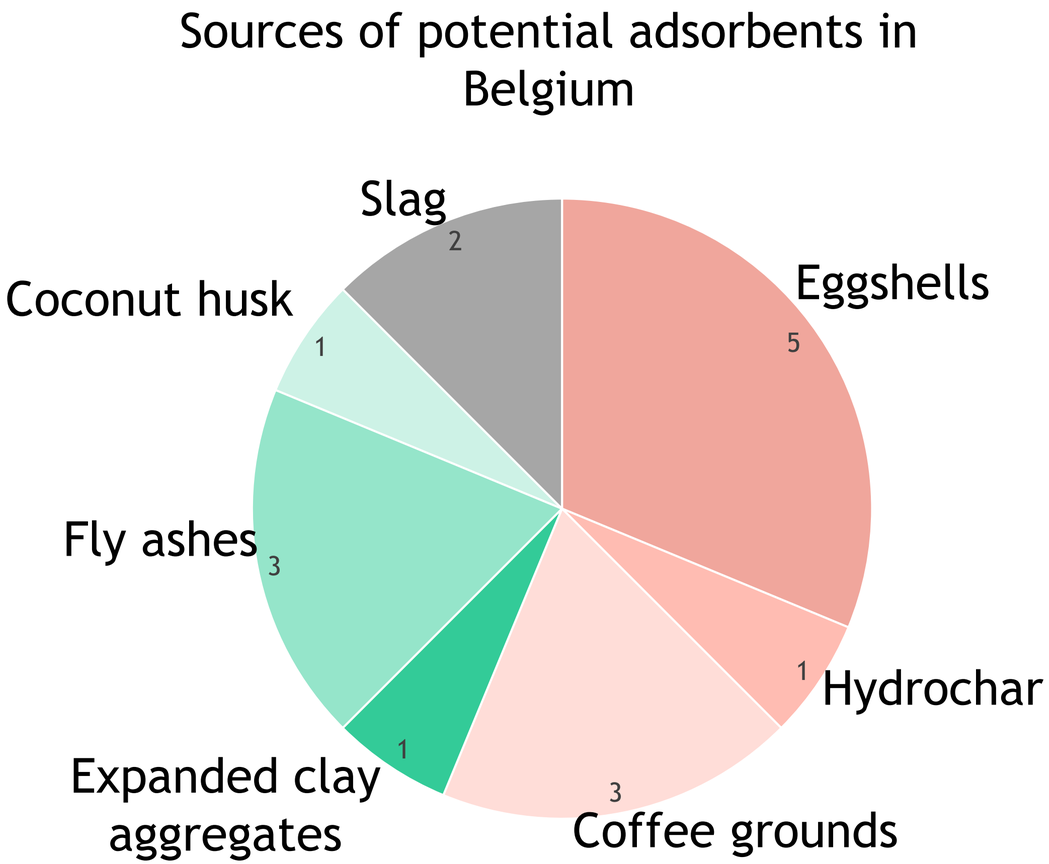
- Inorganic material
- Low nutrient content

Sustainability

- Local availability
- Zeolite extraction

Overcoming challenges in N recovery

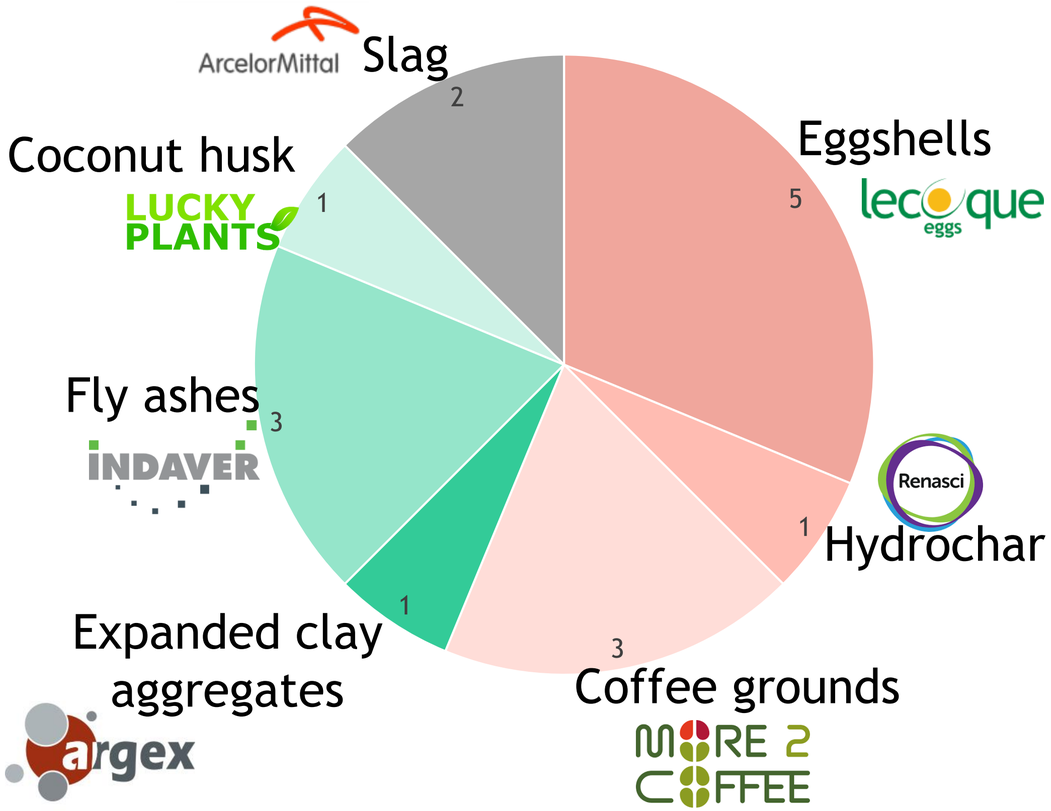
Local materials



Overcoming challenges in N recovery

Local materials

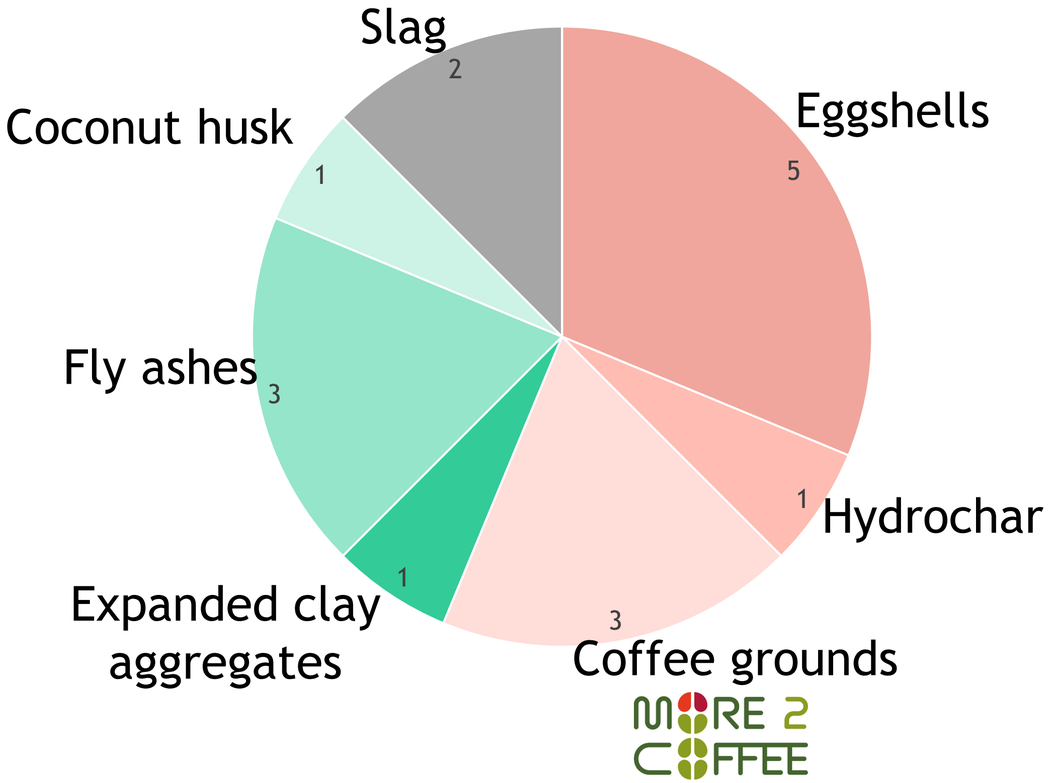
Sources of potential adsorbents in Belgium



Overcoming challenges in N recovery

Local materials

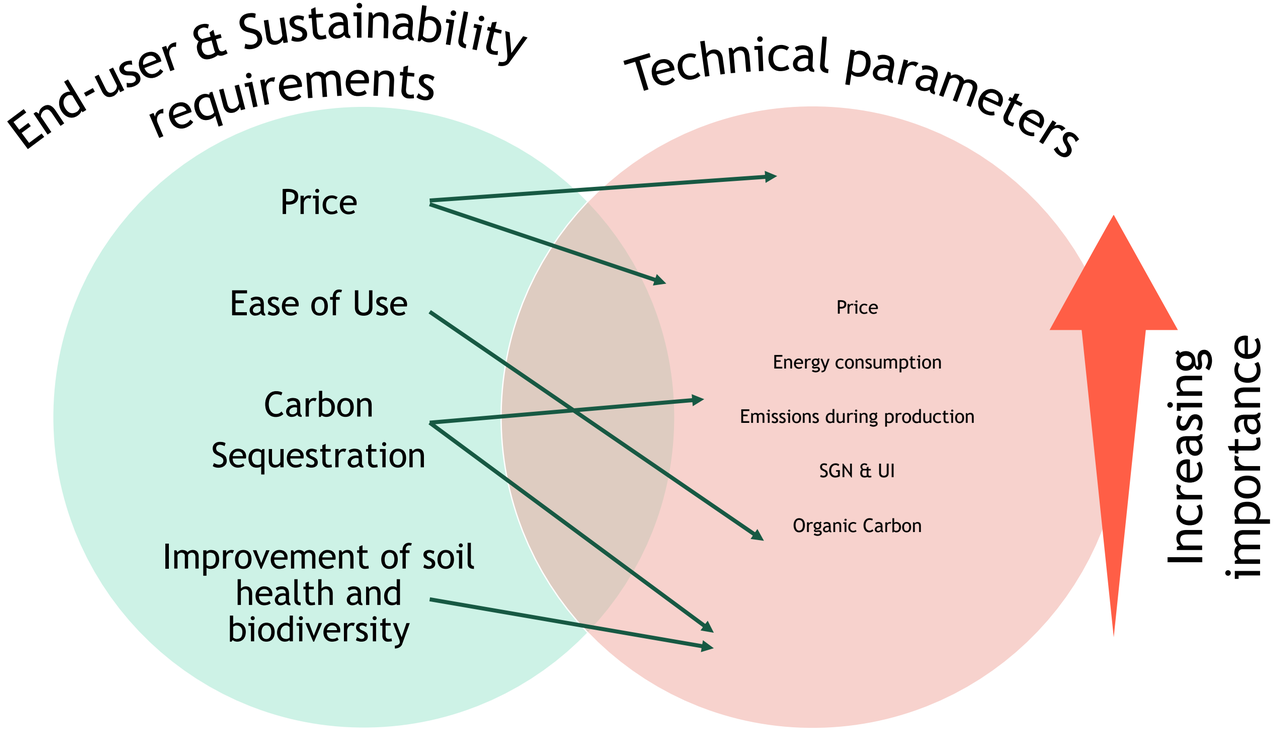
Sources of potential adsorbents in Belgium



MORE 2 COFFEE

House of quality and sustainability

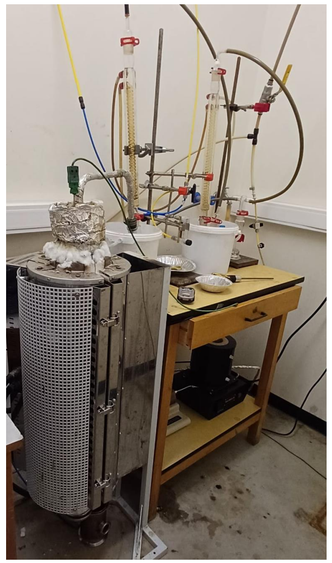
Key Parameters



WALNUT

Overcoming challenges in N recovery

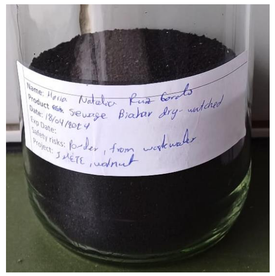
MORE 2 COFFEE



ACGB: KOH-Coffee ground biochar

AquaGreen

Aquafin



SSB: Sewage sludge biochar

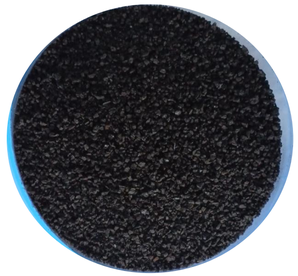
MgSSB: Mg-loaded sewage sludge biochar

ASSB: Steam-activated sewage sludge biochar

WALNUT

Overcoming challenges in N recovery

ACGB: KOH-Coffee ground biochar



ASSB: Steam-activated sewage sludge biochar

Overcoming challenges in N recovery

VZ:
Virgin Zeolite

ACGB:
KOH-Coffee ground biochar

ASSB:
Steam-activated sewage sludge biochar

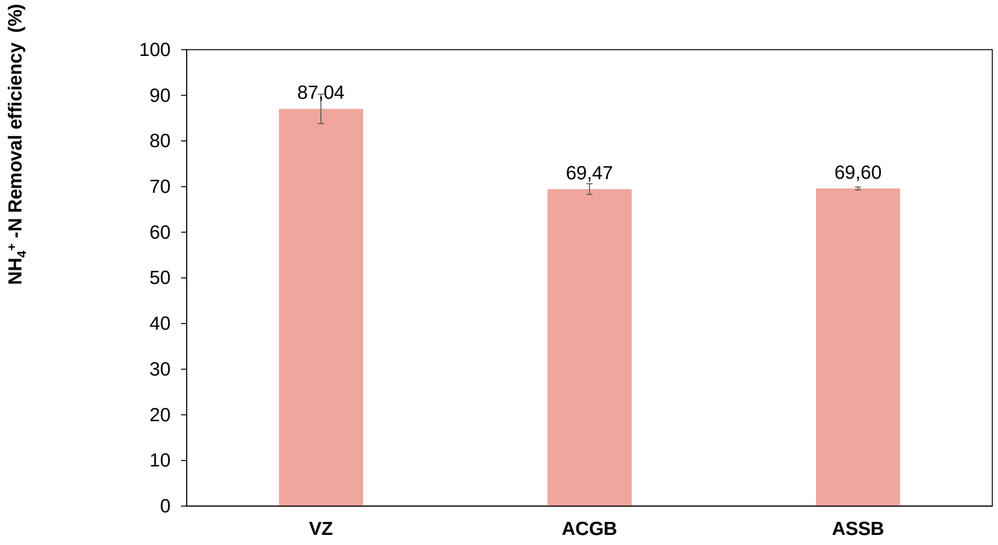
Overcoming challenges in N recovery

VZ:
Virgin Zeolite

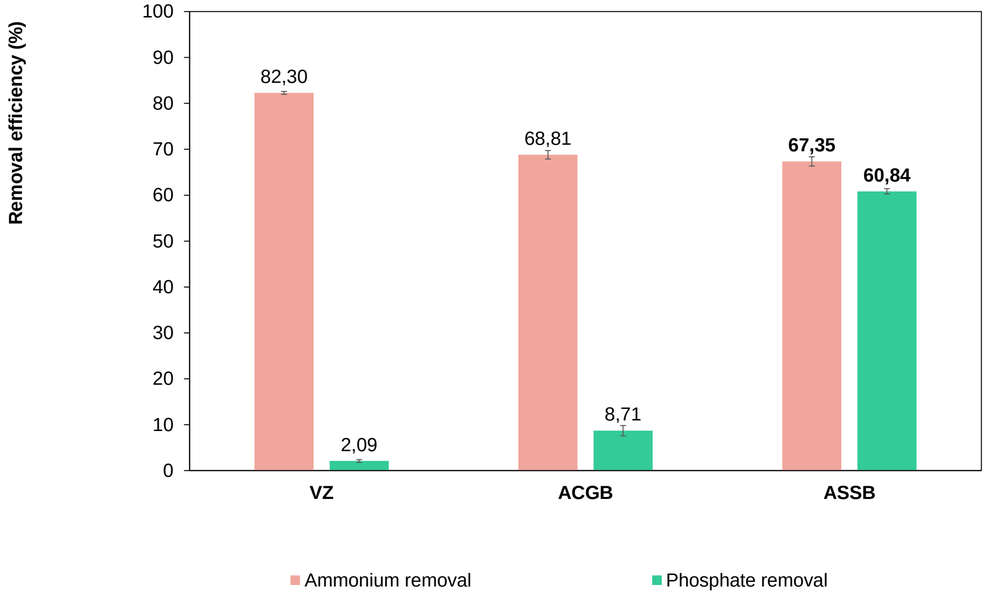
ACGB:
KOH-Coffee ground biochar

ASSB:
Steam-activated sewage sludge biochar

NH_4^+ removal efficiencies



NH_4^+ and PO_4^{3-} removal efficiencies



Overcoming challenges in N recovery

VZ:
Virgin Zeolite

12.5 g/L

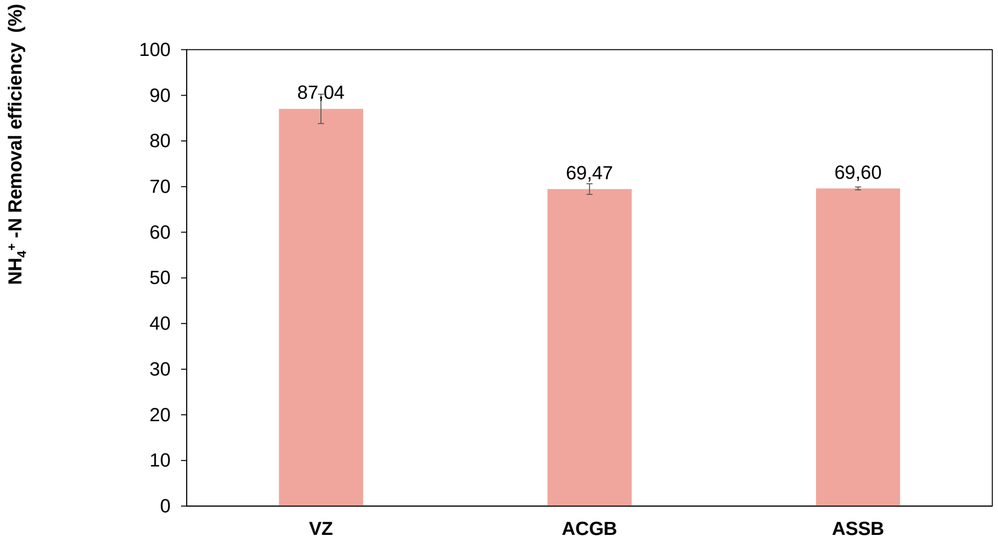
ACGB:
KOH-Coffee ground biochar

20 g/L

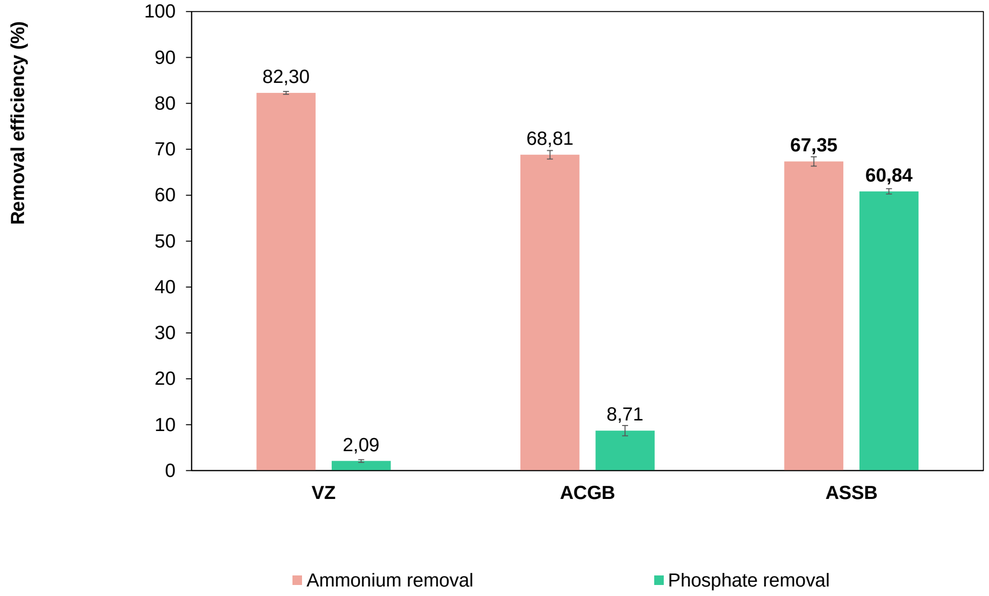
ASSB:
Steam-activated sewage sludge biochar

120 g/L

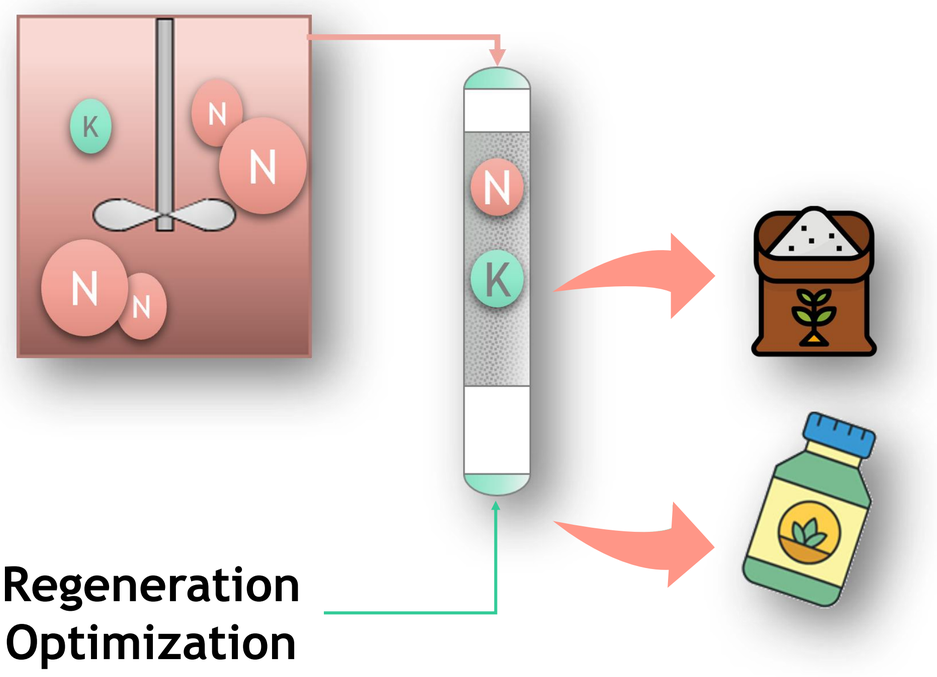
NH_4^+ removal efficiencies



NH_4^+ and PO_4^{3-} removal efficiencies



Future perspectives

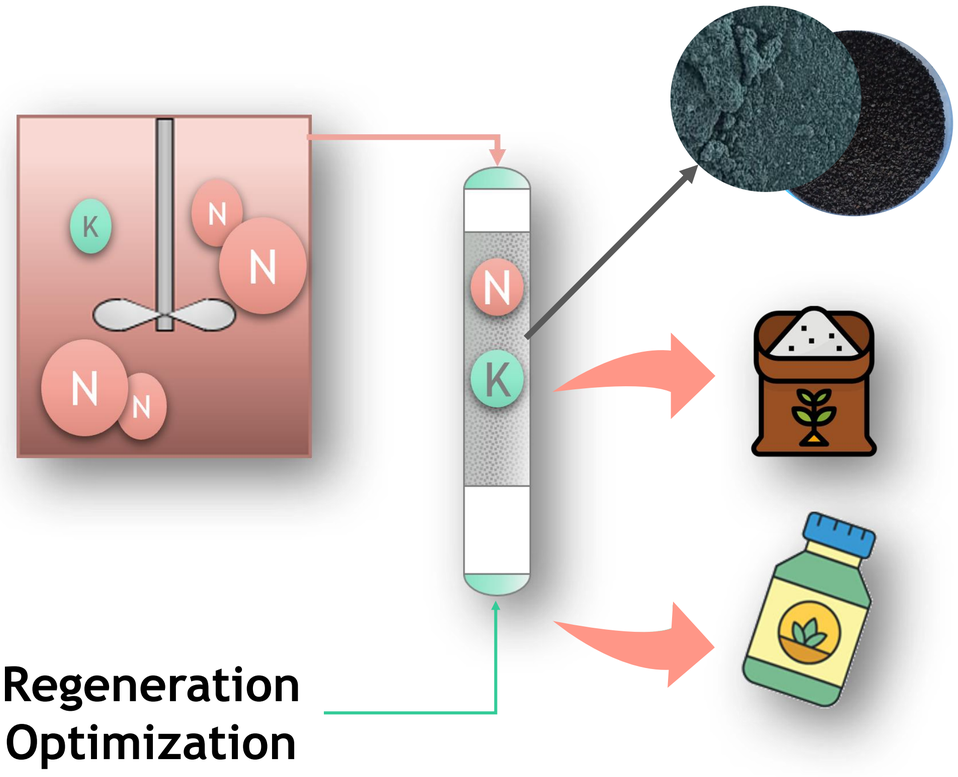


1 **Regeneration**
Optimization

High-rate activated sludge + adsorption

WALNUT

Future perspectives



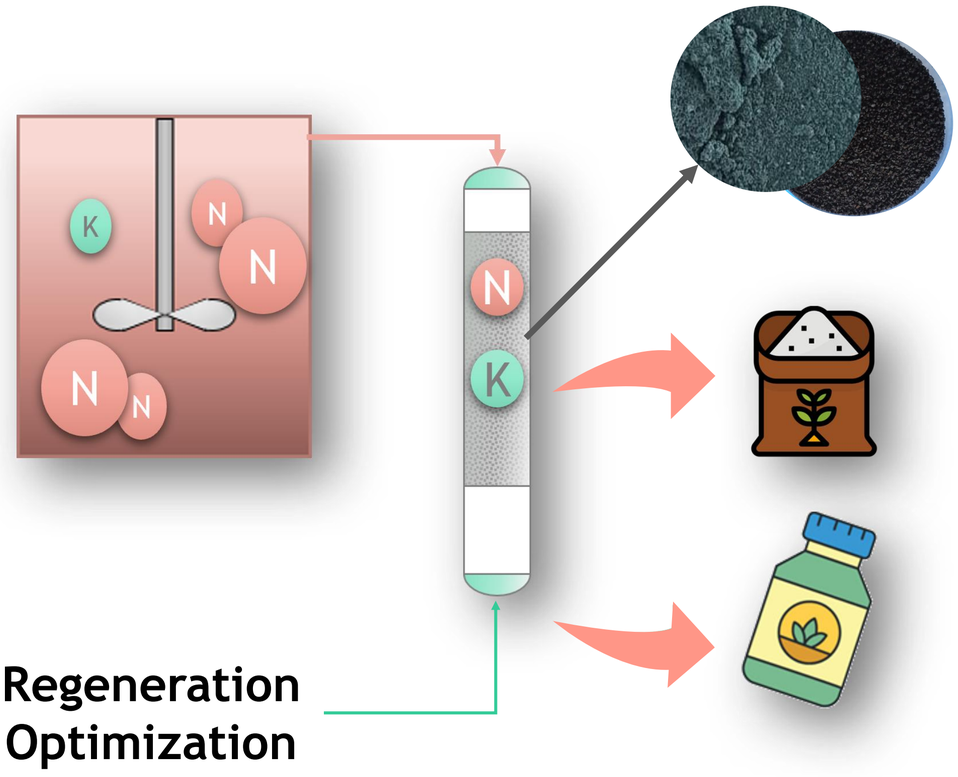
1 **Regeneration Optimization**

2 **Testing local adsorbents**

Vs.

High-rate activated sludge + adsorption

Future perspectives



1 **Regeneration Optimization**

2 **Testing local adsorbents**

Vs.

3

High-rate activated sludge + adsorption

Conventional activated sludge

WALNUT

Thank you • Gracias • Grazie • Merci
Obrigado • Ευχαριστώ • Tak • Kösz • Bedankt

Sarah Moreno Sayavedra

sarah.morenosayavedra@ugent.be

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101000752.

CETAQUA
WATER TECHNOLOGY CENTRE

Alicia González Míguez (CETAQUA)
Teresa Alvariño Pereira (CETAQUA)
Celia María Castro Barros (CETAQUA)
Leticia Rodríguez Hernández (VIAQUA)

RESEARCH
COLLABORATION
THINKING FORWARD

CETAQUA
WATER TECHNOLOGY CENTRE

Alicia González-Míguez (CETAQUA)
Teresa Alvariño Pereira (CETAQUA)
Celia María Castro-Barros (CETAQUA)
Leticia Rodríguez-Hernández (VIAQUA)

From N removal to N recovery, a sustainable alternative for N-based fertilizers

Summary

1. CETAQUA & nutrient
2. WalNUT & N-recovery
    - Cetaqua's technology
    - Pilot plant- Ourense's WWTP
    - Pilot plant layout
    - Pilot plant results
    - Full scale implementation

CETAQUA
WATER TECHNOLOGY CENTRE

1. Cetaqua & nutrient

Who are we and what are we doing here?

We are a water technology centre involved in many research project related to wastewater treatment and resource recovery.

Currently working in 5 national and international projects related to nutrient sustainability.

5 underway projects related to nutrient recovery

Aim.

Develop large-scale urban circular bioeconomy initiatives by providing technical, economic, financial and legal expertise, emphasizing in develop concrete investments.

Aim.

Map and assess alternative fertilisers made from secondary raw materials, and highlight their benefits in order to promote their wide-scale production and use on field.

Aim.

Redesign the value and supply chain of nutrients from WW, creating innovative solutions for its recovery while contributing sustainability in the EU agricultural sector.

Aim.

Integrate circular economy principles into the wastewater cycle through nutrient and celulose recovery, waste-to-energy technologies and waste-to-resource process.

Aim.

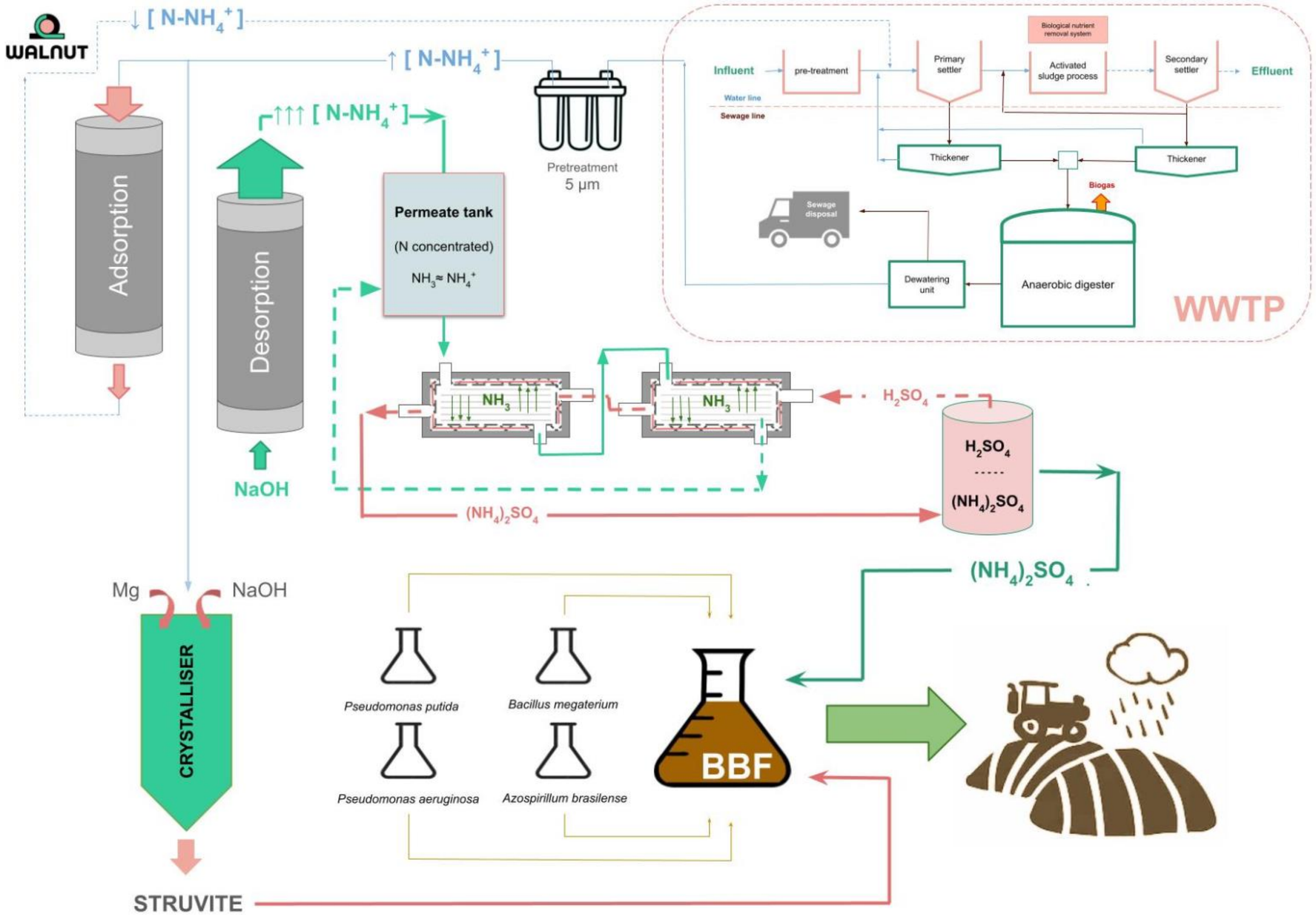
Demostrate (TRL8) technology solutions that limit N/P emissions of N/P emitting sectors by modeling, developing & designing 6 alternative solutions.

CETAQUA
WATER TECHNOLOGY CENTRE

2. WalNUT & N-recovery

Cetaqua's technology

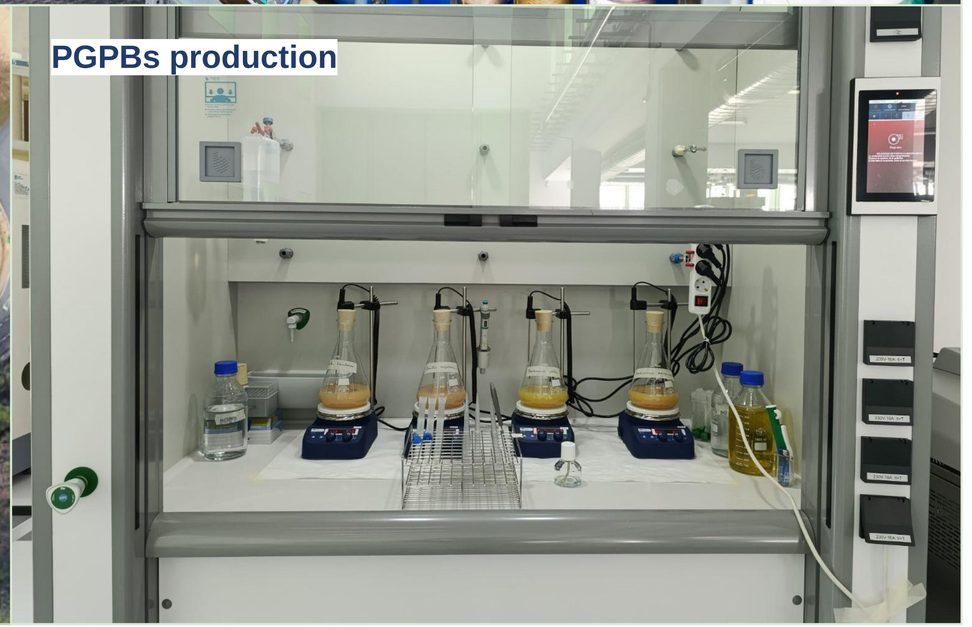
- Zeolite-based cation exchange system.
- Hollow fibre membrane contactor unit.
- N recovery in form of $(NH_4)_2SO_4$.
- Mixed with struvite (P) and PGPBs to produce a smart Bio-based biofertilizer.
- Pot trials finished and field trials planned for 2025.



Pilot plant - Ourense's WWTP

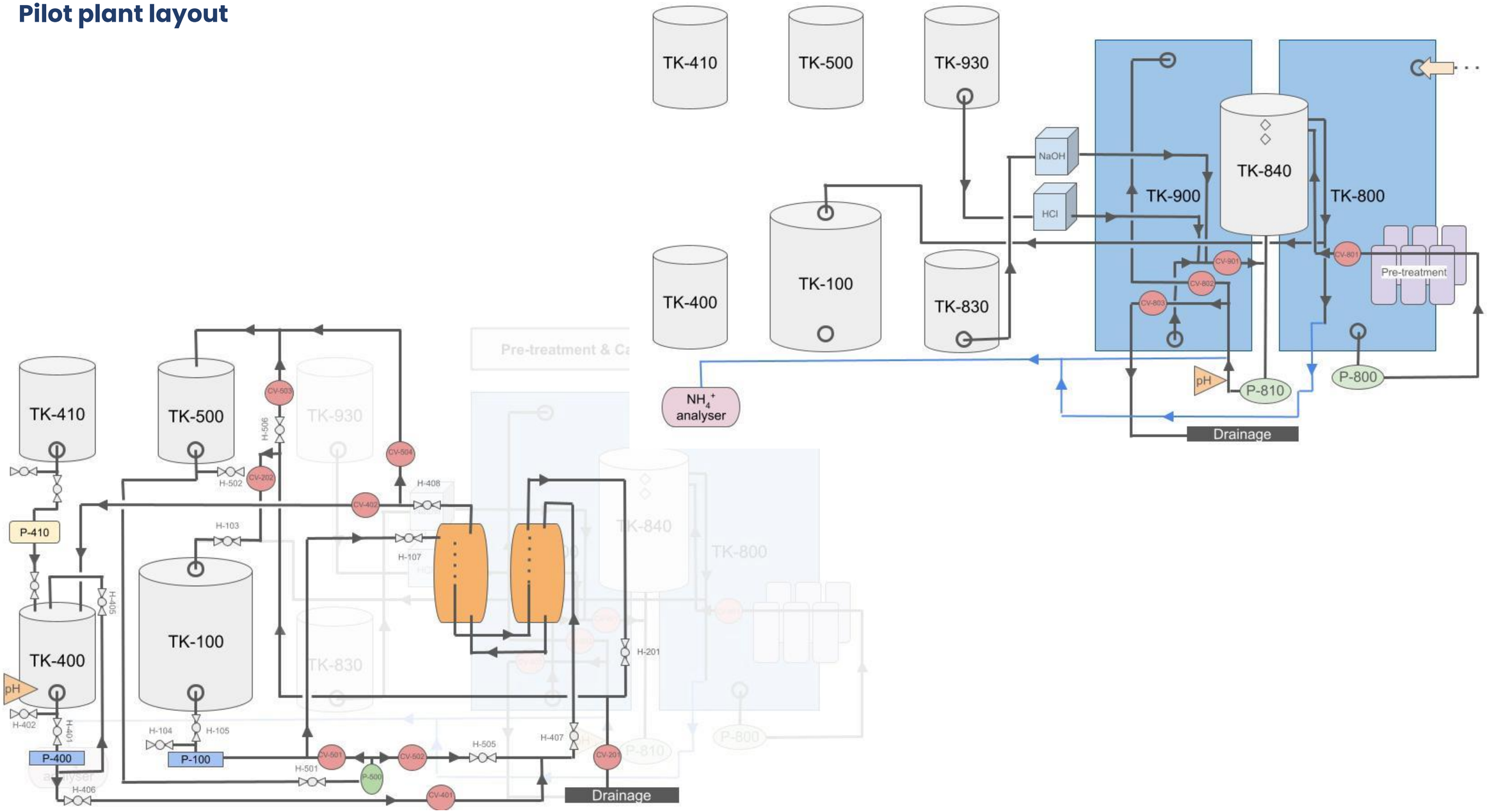
- Pilot plant for N recovery installed and operating.
- Operational conditions optimized in lab scale.
- 91% N removed & 65% N recovered.
- Main unforeseen:
  - Low N on feedstock.
  - N concentrations variation.
  - Irregular flow rates.
- However, this affects the duration of the process but not it's efficiency.

Location



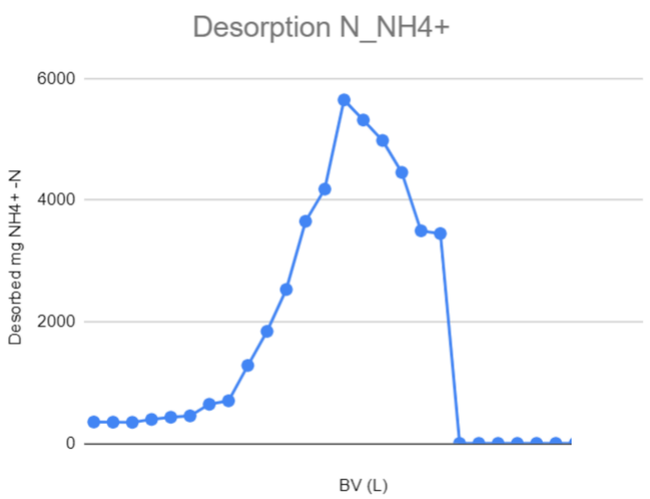
CETAQUA
CENTRO TECNOLÓGICO DEL AGUA

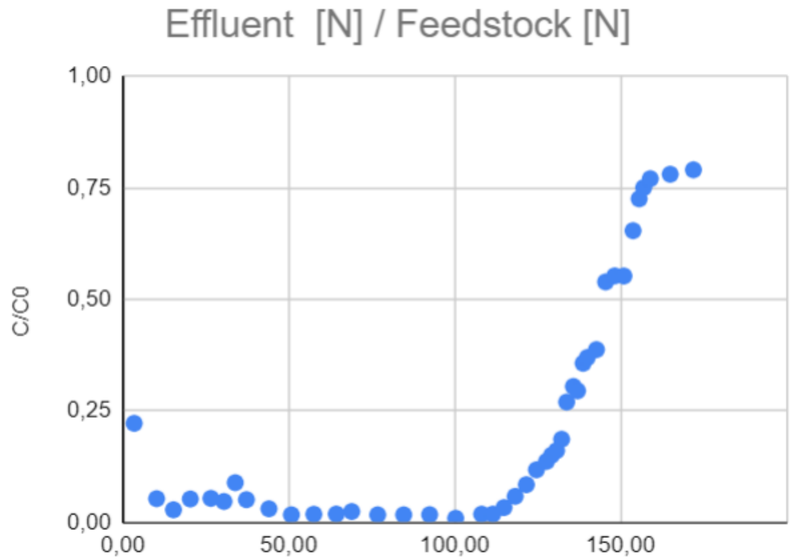
Pilot plant layout

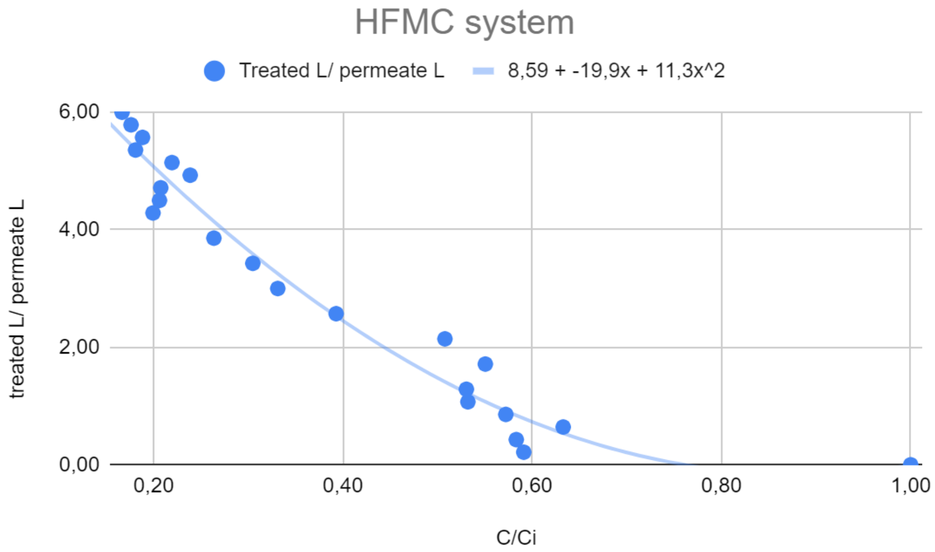


Pilot plant results

- Adsorption process works as expected, according to lab-scale results despite HRT alterations and [N] variations on fedstock.
- 91% N removal.
- Desoptons process also perform according to lab-scale results maintaining operational conditions.
- HFMC operating at highest flow-rates than previously tests (lab-scale limitations). Already optimization conditions.
- 65% N recovery in form of $(NH_4)_2SO_4$.







Pilot plant design

- WW treated/ day: **1.3m³/d** when working in continuous mode.
- 90% N removal & 65% N recovery.
- **305Kg** recovered **N/ year**.
- OPEX: 6.5K €/year
- 75% OPEX related to zeolite concentration process.
- Zeolite impact: economic and environmental Test out.

Full scale implementation (Ourense's WWTP)

- Rejected water treated: **100 m3/ day**.
- **23.5 t** recovered **N / year**.
- 9k € sells / year.
- Savings:
  - Up to **343.500 MWh / year**
  - Up to **89 t CO_2 eq / year**

CETAQUA
WATER TECHNOLOGY CENTRE

Greetings

CETAQUA
WATER TECHNOLOGY CENTRE

WWW.CETAQUA.COM

Contact me!

Alicia González Míguez
(alicia.gonzalez@cetaqua.com)

Barcelona

Crta. d'Esplugues, 75, 08940 Cornellà de Llobregat,
Barcelona Tel. 93 312 48 00

Galicia

Aquahub - A Vila da Auga | Rúa de José Villar Granjel, 33,
15898 Santiago de Compostela, A Coruña | Tel. 881 02 50 40

Andalusia

Calle Severo Ochoa, 7 29590 Málaga | Tel. 952 02 85 92

Chile

Los Pozos 7340, Piso 2, Comuna de Las Condes, Santiago de Chile |
Tel. +56 22569 2407

Walnut Platform: A new platform for Agro-Industrial symbiosis

Maria Kyriazi
National Technical University of Athens
School of Chemical Engineering
Unit of Environmental Science & Technology
kyriazimaria@mail.ntua.gr

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101000752.

Industrial Symbiosis

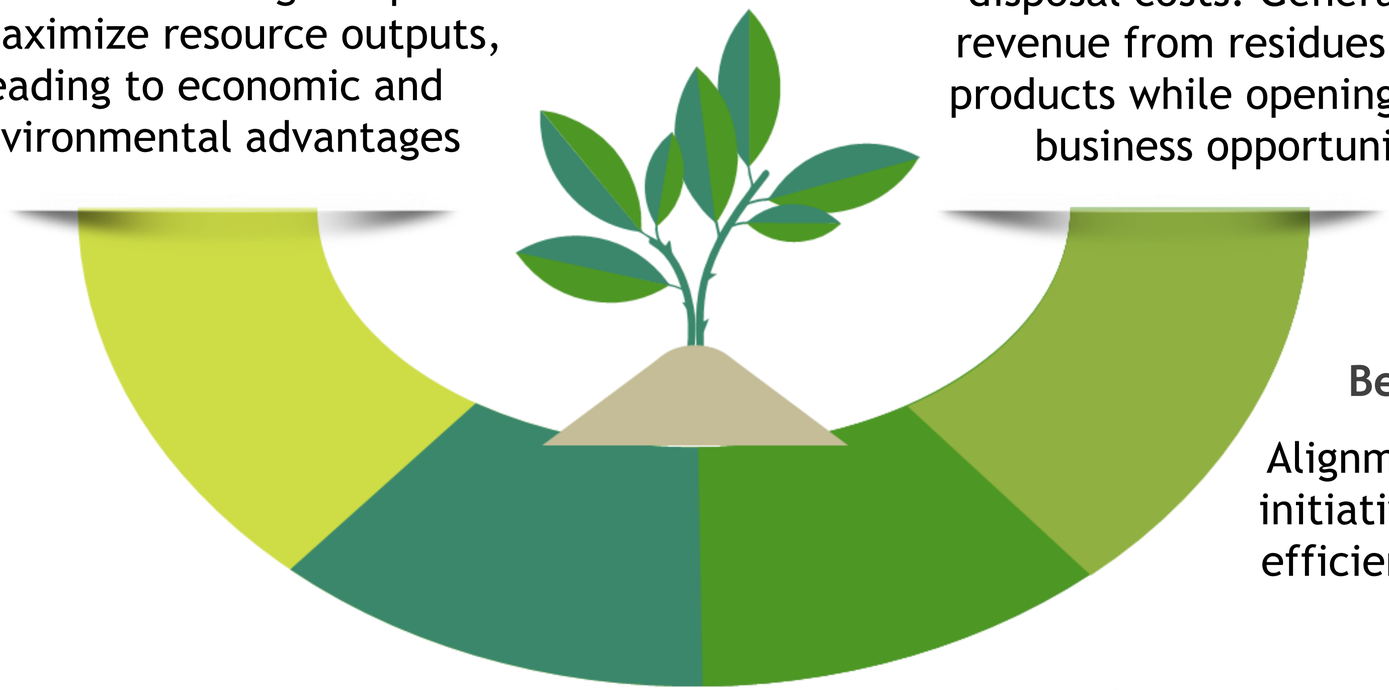
Industrial symbiosis is a collaborative approach where companies mutually share resources, by-products, and expertise to achieve economic benefits, reduce environmental impact, and promote sustainability.

Benefit (1)

Industrial symbiosis fosters collaboration among companies to maximize resource outputs, leading to economic and environmental advantages

Benefit (5)

Reduction of raw material and waste disposal costs. Generate new revenue from residues and by-products while opening up new business opportunities



Benefit (4)

Alignment with global initiatives for resource efficiency and circular economy

Benefit (2)

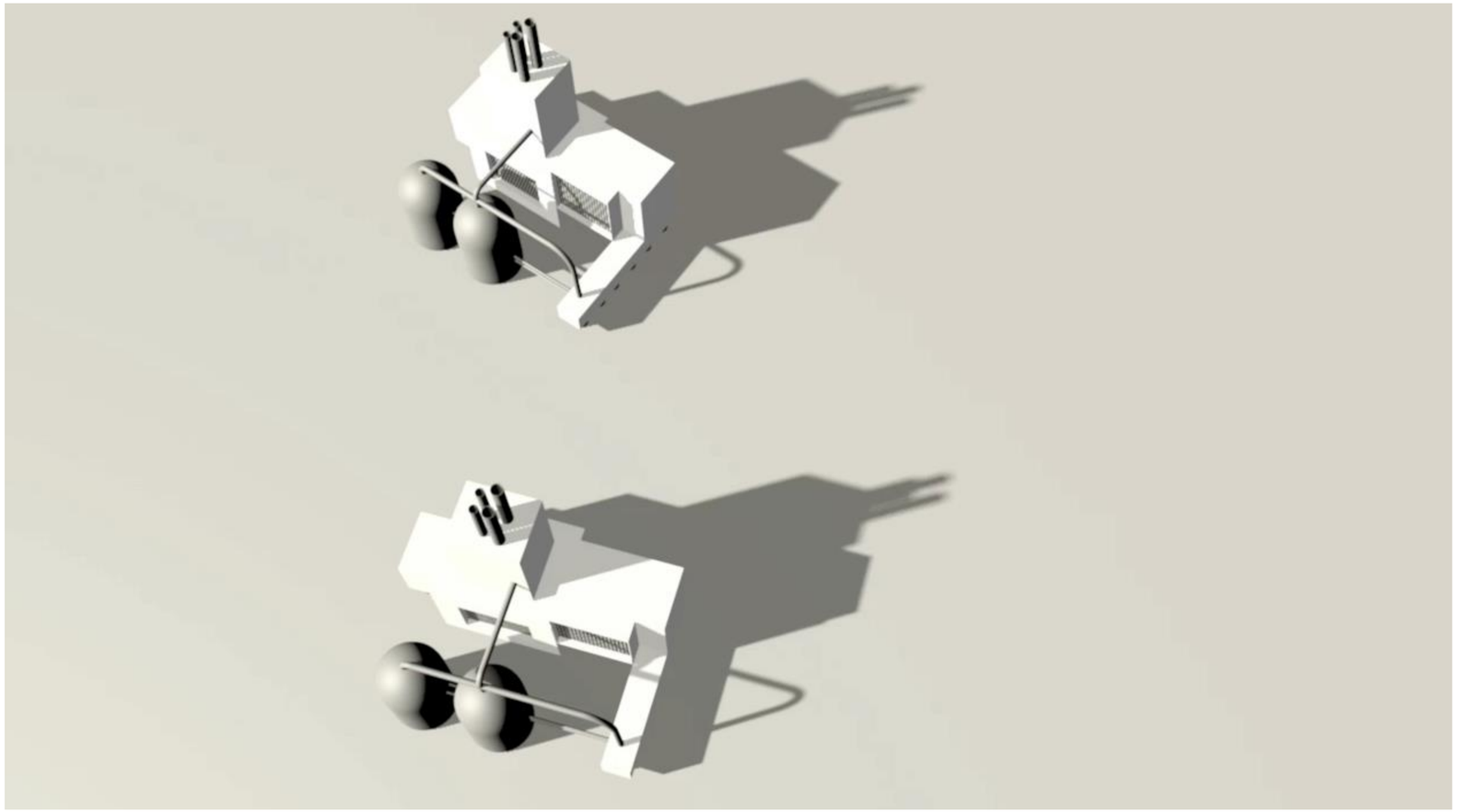
Create opportunities for companies to enhance profitability and competitiveness by reducing resource costs

Benefit (3)

Has significant environmental benefits, including a decrease in material demand, waste generation, and CO_2 emissions

WALNUT

What is Industrial Symbiosis (IS)?



IS vs Recycling

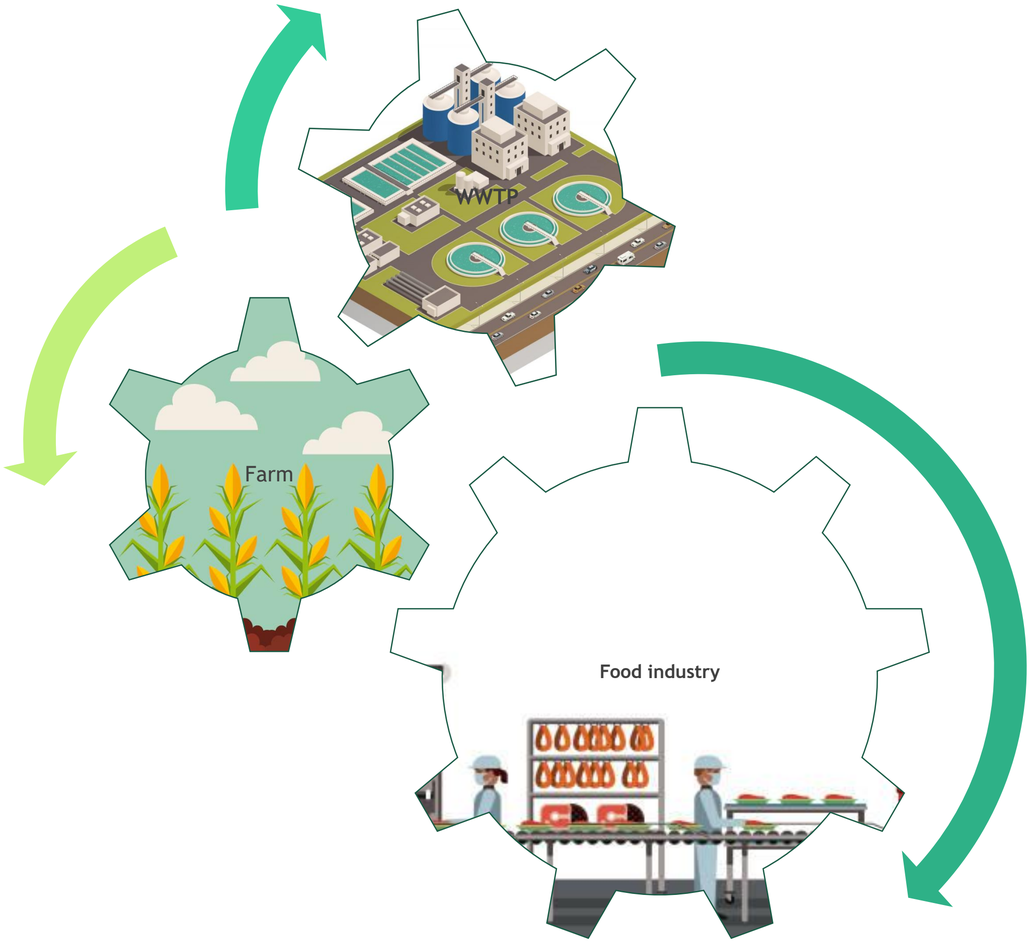
IS focuses on opportunities to
reduce, reuse
and to move waste
and residuals up the value chain
by providing resource- and energy-saving
alternatives to traditional
management or recycling options.

WALNUT

Agro-Industrial Symbiosis

When wastewater turns into secondary raw materials ….

- Agro-industrial symbiosis is derived from the concept of industrial symbiosis,
- applied to the food production and processing chain,
- farms, food processors, energy producers and other industries operate in an integrated manner (Helenius et al., 2020),
- strengthening local socio-economic ties.



The idea of Walnut platform

Walnut aims to the implementation of smart systems which can contribute to the recovery of nutrients from WW

Adoption of the new systems by the market

Low environmental footprint

+

Economic feasibility and social acceptance

?

Facilitate the communication between stakeholders

Aim of the Walnut Platform

The platform enables the creation of a network among different stakeholders, active in the domain of NR.

WP addresses to:

- Interested in wastewater management
- Technology providers
- Nutrients market suppliers
- Wastewater aggregators
- End users of BBFs
- Consultants

Walnut Platform helps …

Farmers → to find suppliers of BBFs

WWTPs → to find new market for recovered materials

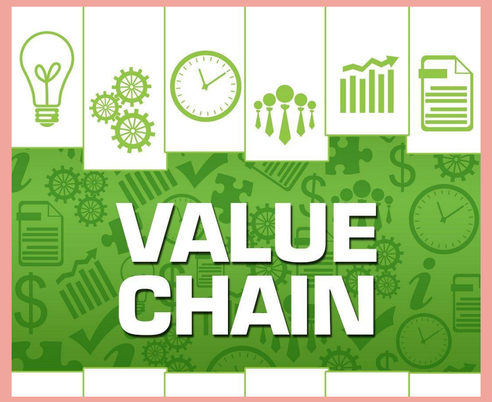
WW producers (owner and aggregator) → to find easily WWTP to collaborate or to start the treatment of their WW

Fertilizers companies → to find cheaper and more sustainable raw materials

All the users → to find a consultant

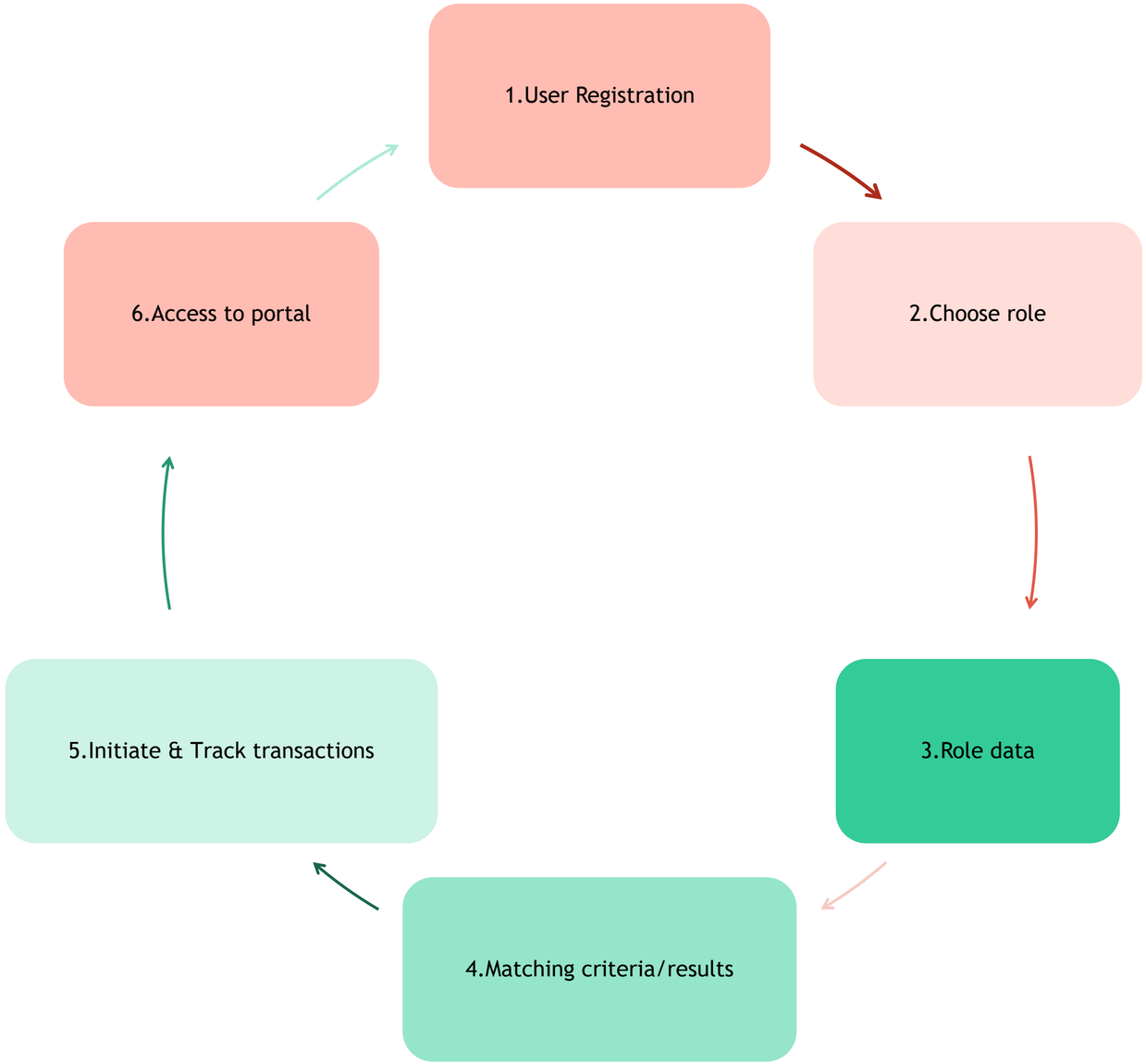
WW producers and WWTPs → to find technology providers

Technology providers → to find new customers



WALNUT

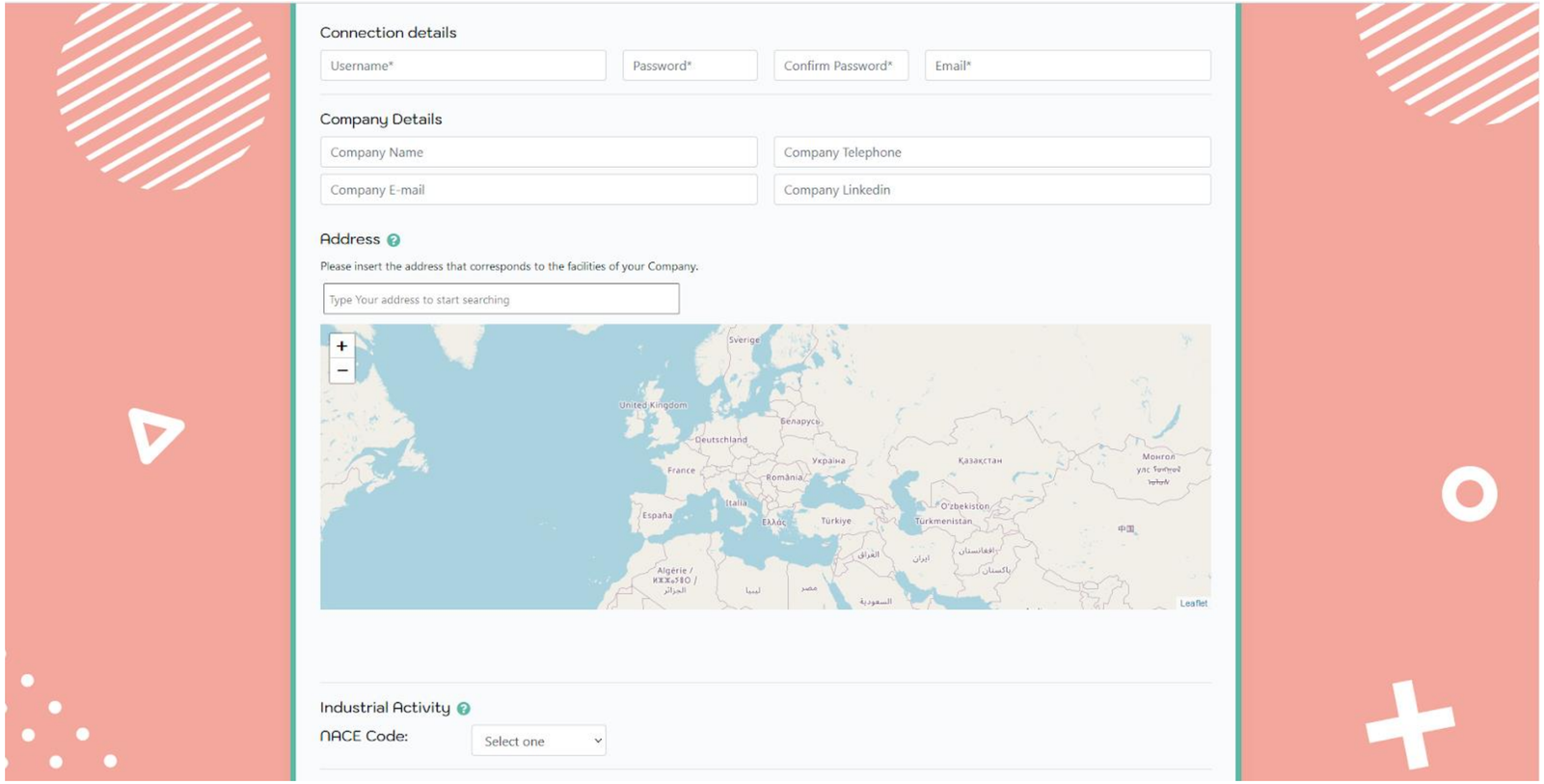
Steps to be followed



User Registration

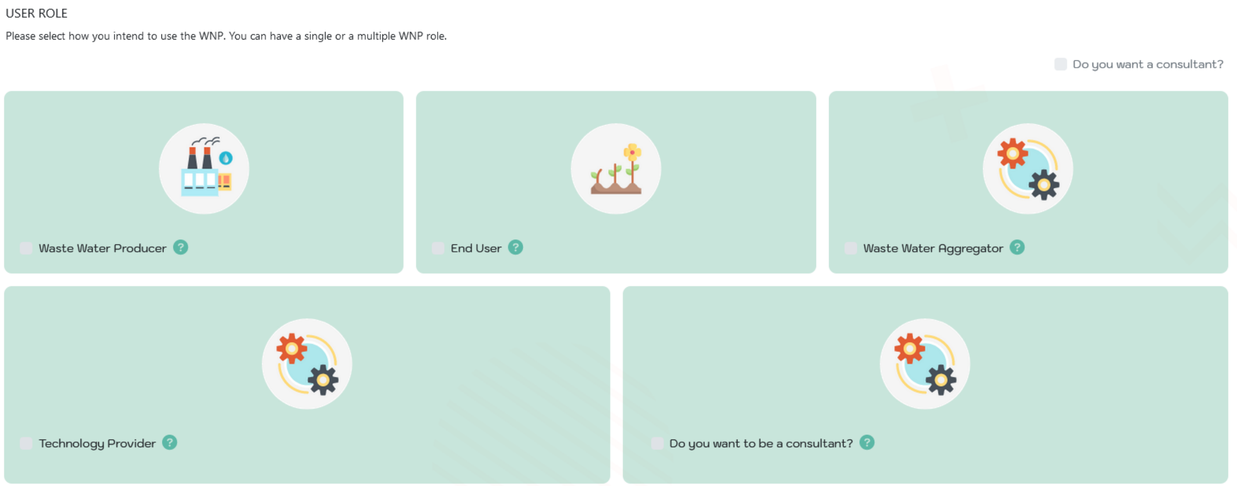
Information you will be asked to provide during registration:

1. Create Username & password
2. Company details
3. Address
4. NACE code



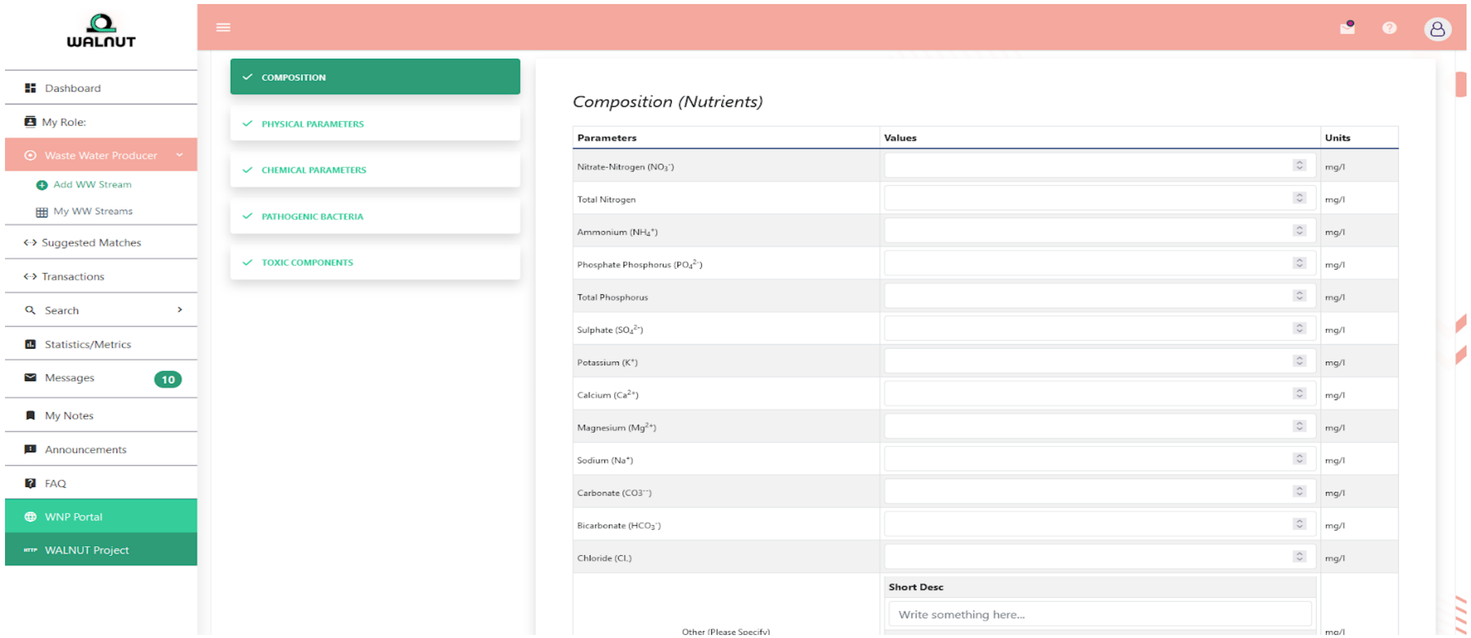
Choose role

- Waste Water Producer
  1. You don’t apply NR technologies
  2. You apply NR technologies
  3. Both
- End User
  1. Farmer
  2. Agricultural association
  3. Bio-based fertilizer producer
- Waste Water Aggregator
- Technology Provider
- Consultant



Input parameters

- Wastewater stream info
- Composition, nutrients, chemicals, impurities etc.
- Recovered products
- Technologies
- Sectors on which consultation can be given



Matching criteria/results

The matching algorithm is based on 3 variables

1) Distance between users

- The closer the distance between relevant users the higher the matching score on this variable

2) Nutrients and Water

- The more components you match with a supplier/provider the higher the matching score of this variable

3) Quantity

- The closer the quantity provided/requested from parties the higher the matching score for this variable

More information

→ Walnut platform tutorial (YouTube)

→ https://walnutplatform.eu

→ walnutproject.eu

uest.gr

Thank you • Gracias • Grazie • Merci
Obrigado • Ευχαριστώ • Tak • Kösz • Bedankt

Kyriazi Maria: kyriazimaria@mail.ntua.gr

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101000752.