NEWBIES

Layman's report

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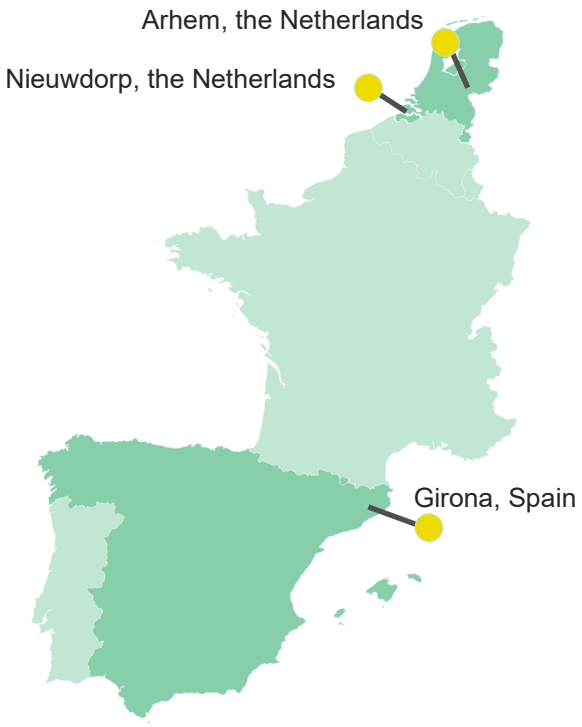
Life



project information

Reference: LIFE17 ENV/NL/000408

Acronym: LIFE-NEWBIES

Start date: 01/07/2018

End date: 31/12/2021

Total Budget: 1,249,375 €

EU Contribution: 747,602 €

consortium

Wetsus, European centre of excellence for sustainable water technology, is performing research aiming for pre-competitive development of entirely new concepts and breakthrough technologies in the field of water treatment. Wetsus research in electrochemical system technology led to many patents in this field.

wetsus
european centre of excellence
for sustainable water technology

Evides is a water cycle company. We produce drinking water, treat industrial and municipal wastewater and produce process water for industries. Evides develops sustainable solutions to treat wastewater and recover resources.

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ICRA is a research institute that seeks to provide a complete and efficient response to the problems and challenges related to integral water cycle and is, therefore, structured as a multidisciplinary water research centre around three main research areas: Resources and Ecosystems, Water Quality, Technologies and Evaluation

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W&F Technologies B.V. is an SME which is active in the field of electrochemical engineering and water treatment. W&F Technologies has its own technological development, and provides technical advice and technical management to various customers. The technology development within W&F Technologies focuses on the integration of water technology and electrochemical engineering

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background

Fertiliser run-offs are causing reactive nitrogen compounds to degrade sensitive water bodies in EU. When the fertilising nutrients make their way into rivers, they foster weeds that disrupt aquatic ecosystems. Also, removing reactive nitrogen in water treatment plants is not easy. For now, it requires an energy intensive process that converts the nitrogen compounds back into the unreactive gas it used to be: the N_2 that makes up about 70% of the atmosphere.

Recovering nitrogen directly would offer a valuable ingredient to create new products such as fertilisers. At present, these fertilisers are created mainly using yet another energy intensive process that turns the unreactive atmospheric N_2 into a reactive chemical. Shortcutting this inefficient cycle, would cut greenhouse gas emissions on both ends of their production chain. So, that is exactly what NEWBIES was designed for.

motivation

Fixed nitrogen is an essential element to plant growth

The Netherlands uses excess nutrients imported from overseas

12k tons of nitrogen can be recovered from Dutch wastewater treatment plants. This amount is sufficient for what Dutch greenhouses currently use.

Fossil gases are burned to produce nitrogen compounds, releasing enormous amounts of CO_2 in the atmosphere

objectives

The LIFE NEWBIES project aimed to demonstrate a new technique to extract ammonium from wastewater in an economic, effective and energy-efficient way. The objective was to design, construct, and test a pilot scale installation which can recover nitrogen from different kinds of wastewater, including reject water from wastewater treatment plant, urine and landfill leachate, and turn it into valuable fertilizer.

Project partners had analyzed the market for recovered nitrogen once transformed into fertilizer for use in agriculture. They have also searched for interested stakeholders needed for scaling up the technology.

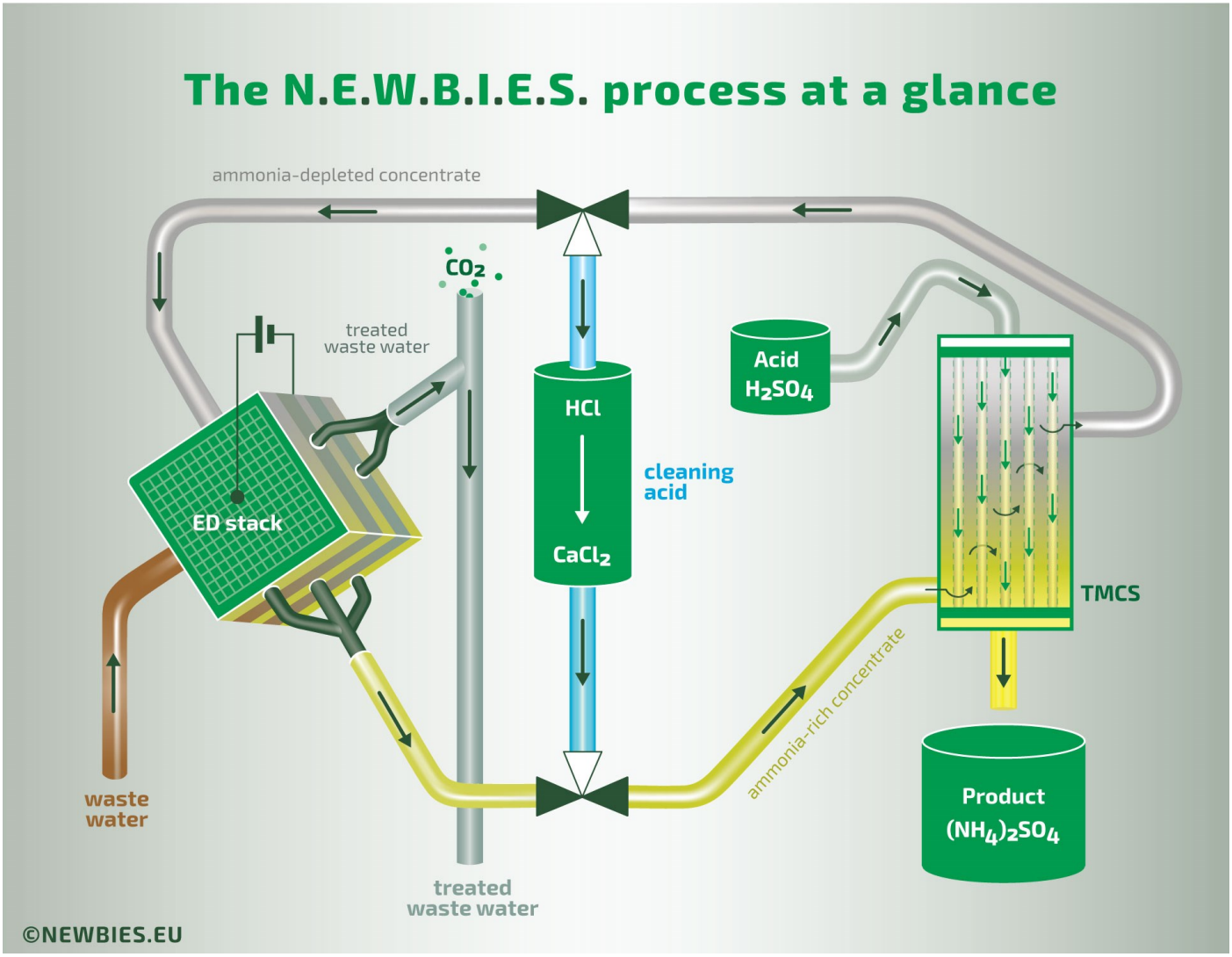
In doing so, the LIFE NEWBIES project tackled the objectives of the EU Water Framework Directive, the Urban Waste Water Directive and of the circular economy action plan.

to produce

- A pilot plant instalation to recover nitrogen from waste
- Recover 1 kg of nitrogen per day from 3 different waste streams
- Remove >90% of the nitrogen from water in these in these waste streams while consuming less chemicals than state-of-the-art technologies
- Produce a marketable nitrogen compound that is pure enough to be reused as fertiliser in agriculture

to reduce

- Reduce the energy consumed by the process to under 4.5 kWh per kg of nitrogen recovered and halve its greenhouse gases emissions
- Reduce the cost of the nitrogen recovery in the process to under €0.20 per kg



how to do it

The process treats wastewater containing high concentrations of nitrogen in the form of ammonia, like greenhouse run-off waters and reject water from wastewater treatment plants.

First, a waste stream is introduced into an *ElectroDialysis (ED)* stack in which the ammonium is transported through a charged ion exchange membrane to the concentrate side.

The concentrate is then introduced into a gas membrane stripper (a process formally known as TransMembraneChemiSorption, or TMCS in short), where the gaseous ammonia flows across the molecular filter, changing into a liquid phase.

By adding an acid, like sulfuric acid, the nitrogen compounds can be collected for reuse.

main achievements

1. potential of the constructed pilot plant

- removal and recovery of 1 kg nitrogen per day from selected wastewaters
- all at a low electrical energy expense
- automated cleaning-in-place procedures to minimize waste pretreatment requirements
- ready made for future upgradeability

2. energy efficiency

- The current method of N-fixation in the Haber-Bosch process plus the energy required to remove it in the the nitrification-denitrification process of wastewater adds up to 25 kWh per kilogram of nitrogen. Alternative choice is to use Haber-Bosch and Annamox processes which consume together ~15.0 kWh/kg of nitrogen. Electrical energy consumption reached in the Newbies project was:
  - 10-20 kWh to recover N from digestate
  - 8.8 kWh to recover N from urine,
  - 28 kWh to recover N from landfill leachate

  Project targets such as the energy consumption of 4.4 kWh/kg of nitrogen recovered and the removal of 1 kg of nitrogen/day have not been reached during the Newbies project, see Table 1. Further technology improvements are required to optimize energy consumption, improve nitrogen removal and reduce chemical consumption.

Table 1. Achieved results

	Digestate Girona	Urine	Leachate	Objectives as stated in the Grant Agree-
Removal (%)	40-60	83	≈ 30	90
Product concentration (g $(NH_4)_2SO_4$/ L)	≈ 150	≈ 200	≈ 200	A nitrogen enriched with optimal composition to be used as fertilizer
Energy consumption (Wh/g N Removed)	10-20	8.8	≈ 28	4.4
Mass recovered (kg N/d)	0.35	0.7	0.17	1

3. the resulting fertiliser

- Tests show that the recovered fertiliser performed well, as both raddish and spinach grew better using the recycled nitrogen than when no fertilizer was applied.
- After harvests the soil mantained proper acidity.

NEWBIES fertiliser works just like normal commercial fertilisers. For example:

- NEWBIES fertiliser contains enough nitrogen to be classified as a (usual commercial) liquid fertiliser
- concentration of heavy metals is well below the allowed threshold

But is not allowed to be used commercially, as it is produced from a waste source

highlights
communication & dissemination

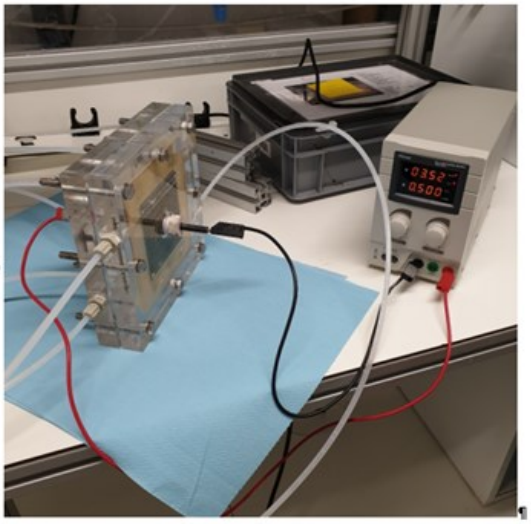
Visits, demonstrations, and 8 conferences

3 workshops

Local radio and television

Layman video and website:
newbies.eu

outreach



NEWBIES together with the European project RawMaterials@schools designed an education toolkit for highschool students to learn about nitrogen recovery

outlook

The knowledge obtained during this LIFE-NEWBIES project will be used in the follow up project “Circulaire-N”. Circulaire-N is a Dutch public-private research project with as consortium partners Waternet, Waterbedrijf Limburg, Technical University of Delft, Blue-tec, I3 Technologies and Pure Water Group. Special attention will go towards reducing energy consumption by optimized stack design and better pretreatment. The project will include the manufacturing and testing of a pilot installation, which will be commissioned winter 2022 to treat the digestates from municipal water water treatment sludge digesters in Amsterdam and Venlo. The pilot will be designed to treat 10 kg N per day, so 10x larger then the previous NEWBIES pilot. For the Venlo case, noteworthy is the presence of a Thermal Pressure Hydrolysis step included in the sludge line, which will substantially alter the composition of the sludge and therewith the digestate reject compared to the digestate tested within NEWBIES. The parties involved expect to have a market-ready technology by 2026.

publications

Rodrigues, M., Paradkar, A., Sleutels, T., Heijne, A. ter, Buisman, C. J. N., Hamelers, H. V. M., & Kuntke, P. (2021). Donnan Dialysis for scaling mitigation during electrochemical ammonium recovery from complex wastewater. In Water Research (Vol. 201, p. 117260). Elsevier BV. https://doi.org/10.1016/j.watres.2021.117260

Rodrigues, M., de Mattos, T. T., Sleutels, T., ter Heijne, A., Hamelers, H. V. M., Buisman, C. J. N., & Kuntke, P. (2020). Minimal Bipolar Membrane Cell Configuration for Scaling Up Ammonium Recovery. In ACS Sustainable Chemistry & Engineering (Vol. 8, Issue 47, pp. 17359–17367). American Chemical Society (ACS). https://doi.org/10.1021/acssuschemeng.0c05043

Rodrigues, M., Sleutels, T., Kuntke, P., Hoekstra, D., ter Heijne, A., Buisman, C. J. N., & Hamelers, H. V. M. (2020). Exploiting Donnan Dialysis to enhance ammonia recovery in an electrochemical system. In Chemical Engineering Journal (Vol. 395, p. 125143). Elsevier BV. https://doi.org/10.1016/j.cej.2020.125143

Rodrigues, M., Lund, R.J., ter Heijne, A., Sleutels, T., Buisman, C. J. N., & Kuntke, P. (2022). Application of ammonium fertilizers recovered by an Electrochemical System. In Resources, Conservation and Recycling (Vol. 181, p. 106225). Elsevier BV. https://doi.org/10.1016/j.resconrec.2022.106225

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