First version of TEB (D1.6)

Anne Kleyböcker, KWB,
Anna Serra Clusellas, Sandra Casas Garriga, Eurecat
Jungeun Kim & Jan Hofman, Ubath
George Karavokiros, NTUA

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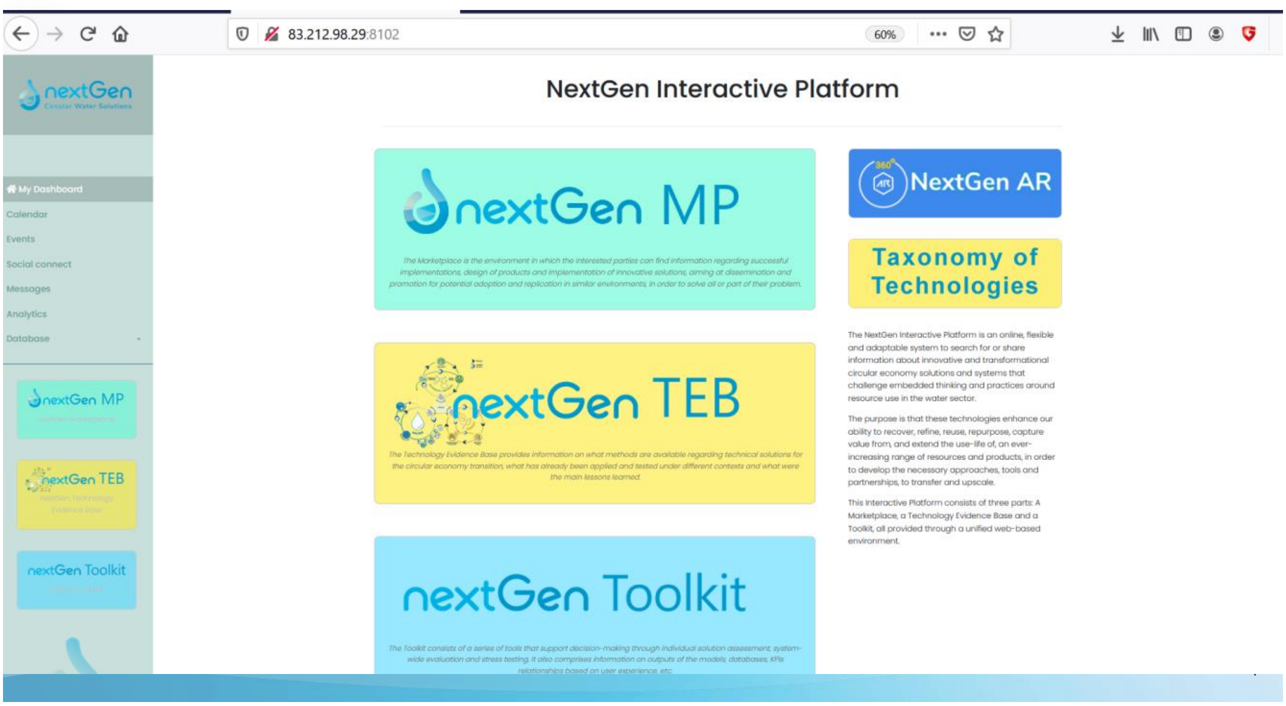
TEB address: http://83.212.98.29:8102/

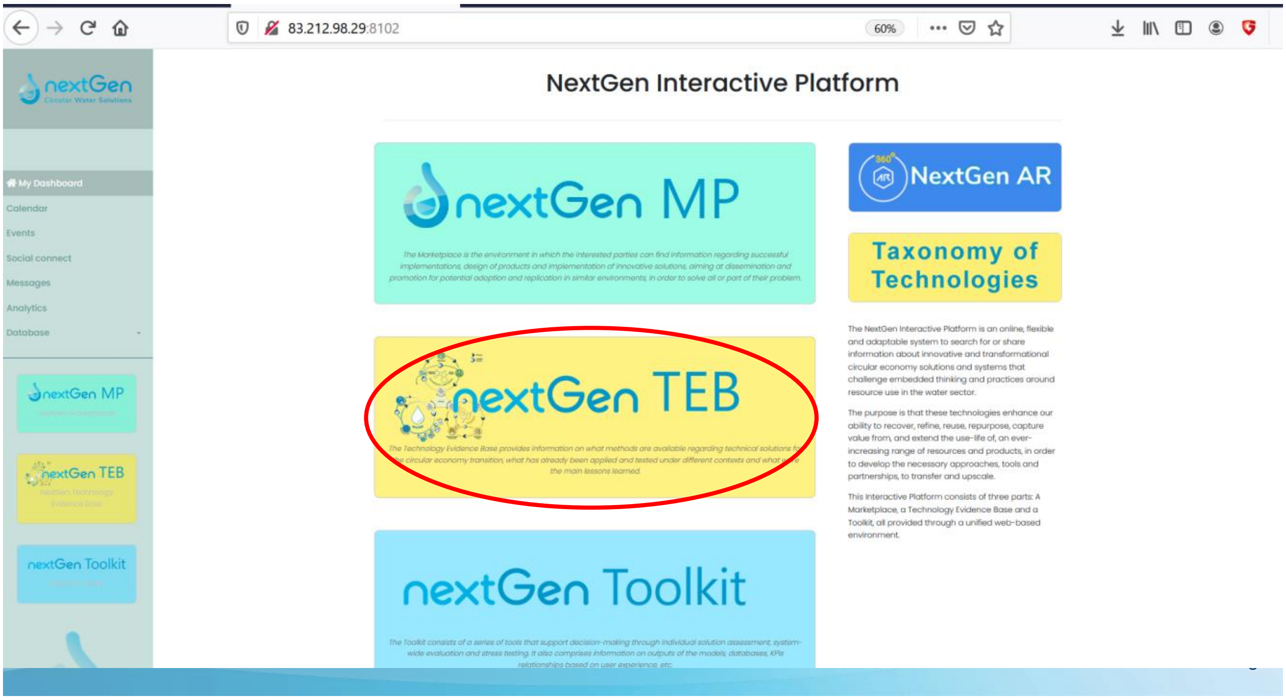
The first version is presented on a preliminary webpage. The intension is to show the first version to the project partners especially to Water Europe, who will host the TEB after NextGen will have finished. After their feedback, the updated version will move to the NextGen homepage until the TEB is finalized.

For the first version, only one factsheet was uploaded as an example. However, the other 23 factsheets are already prepared and in revision.

Elaboration of factsheets and reviews

- 24 factsheets were prepared by the CTG leaders
- Correspondingly to the case study applying the technology described in the factsheet, each factsheet was sent to the CS leader and/or the responsible CS partner for that technology and further elaborated.
- Finally, a review of the factsheets was conducted by
  - Jan Hofman (University of Bath),
  - Fabian Kraus and Christian Remy (KWB) and
  - Xavier Martínez and Irene Jubany (EURCAT)

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The Marketplace is the environment in which the interested parties can find information regarding successful implementations, design of products and implementation of innovative solutions, aiming at dissemination and promotion for potential adoption and replication in similar environments, in order to solve all or part of their problem.
NextGen AR
Taxonomy of Technologies
nextGen TEB
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This Interactive Platform consists of three parts: A Marketplace, a Technology Evidence Base and a Toolkit, all provided through a unified web-based environment.
nextGen Toolkit
The Toolkit consists of a series of tools that support decision-making through individual solution assessment, system-wide evaluation and stress testing. It also comprises information on outputs of the models, databases, KPIs relationships based on user experience, etc.


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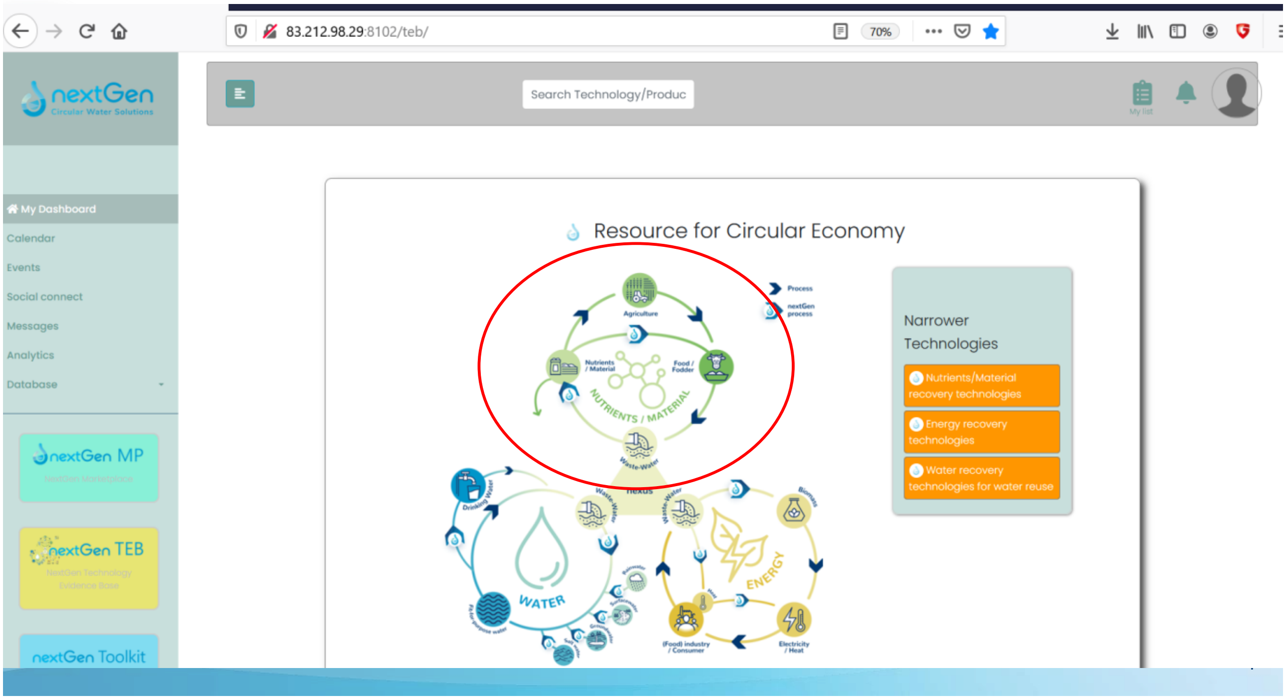

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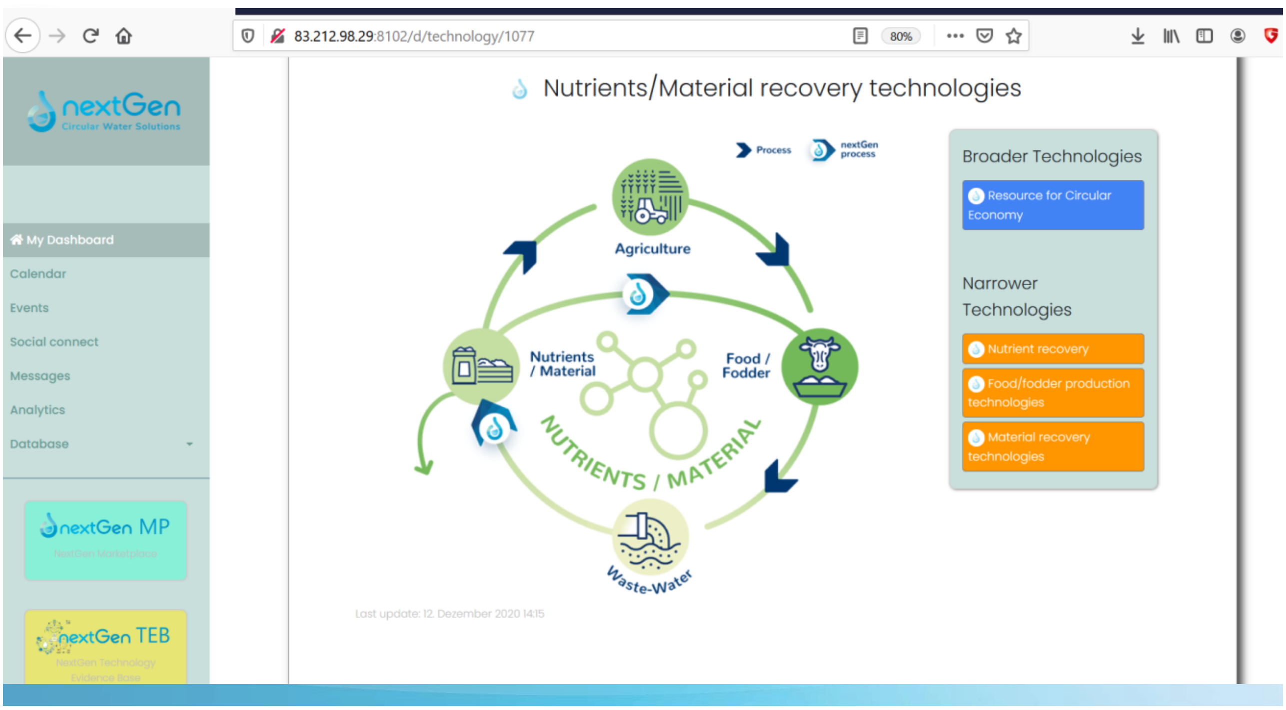

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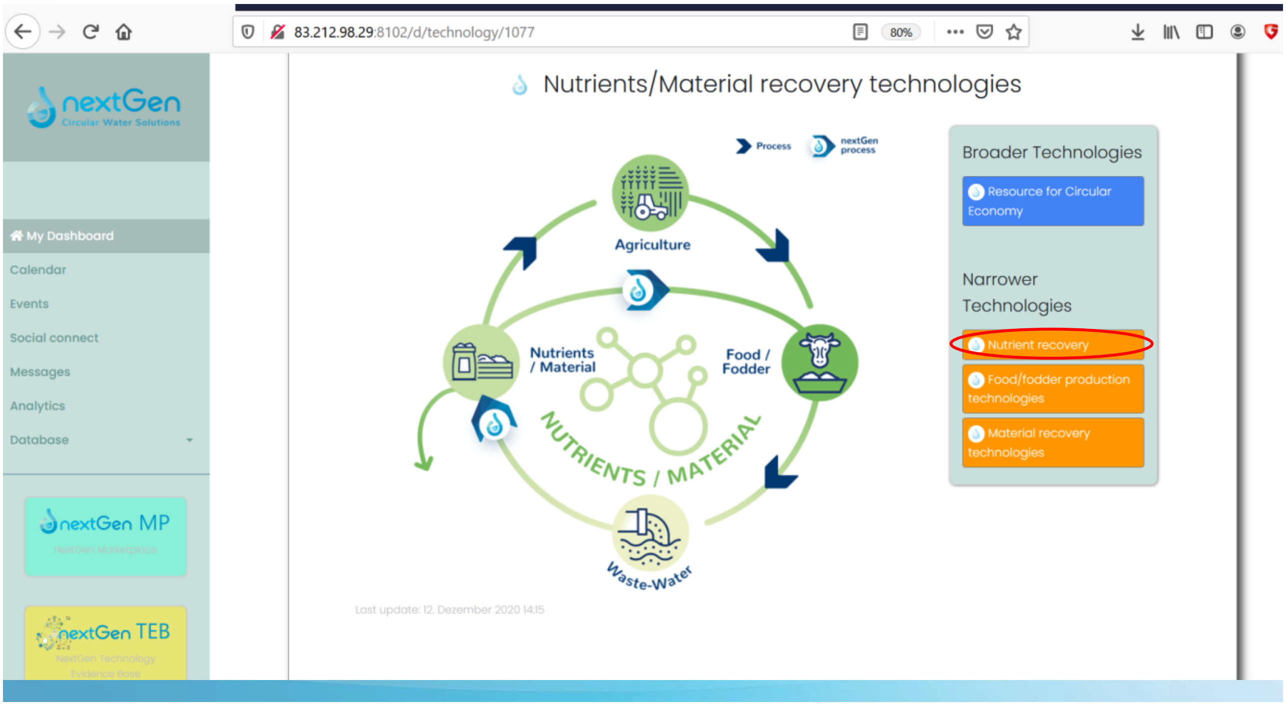
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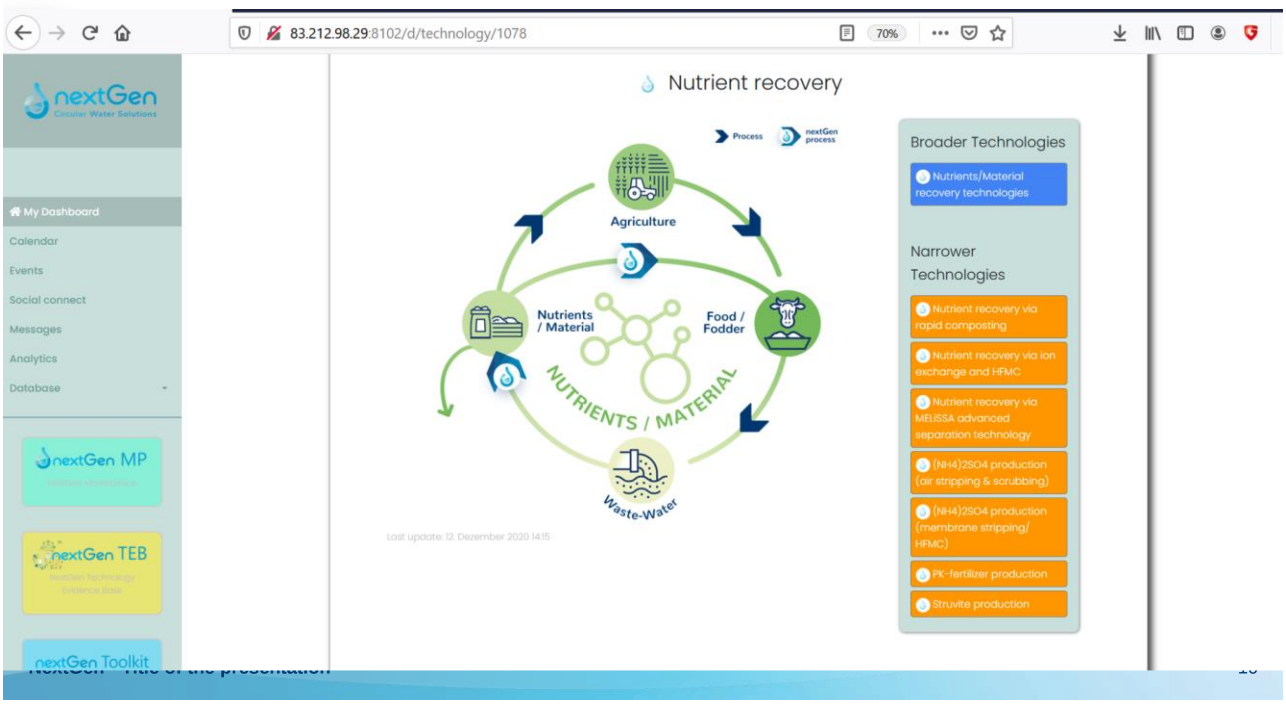
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Nutrient recovery via MELISSA advanced separation technology
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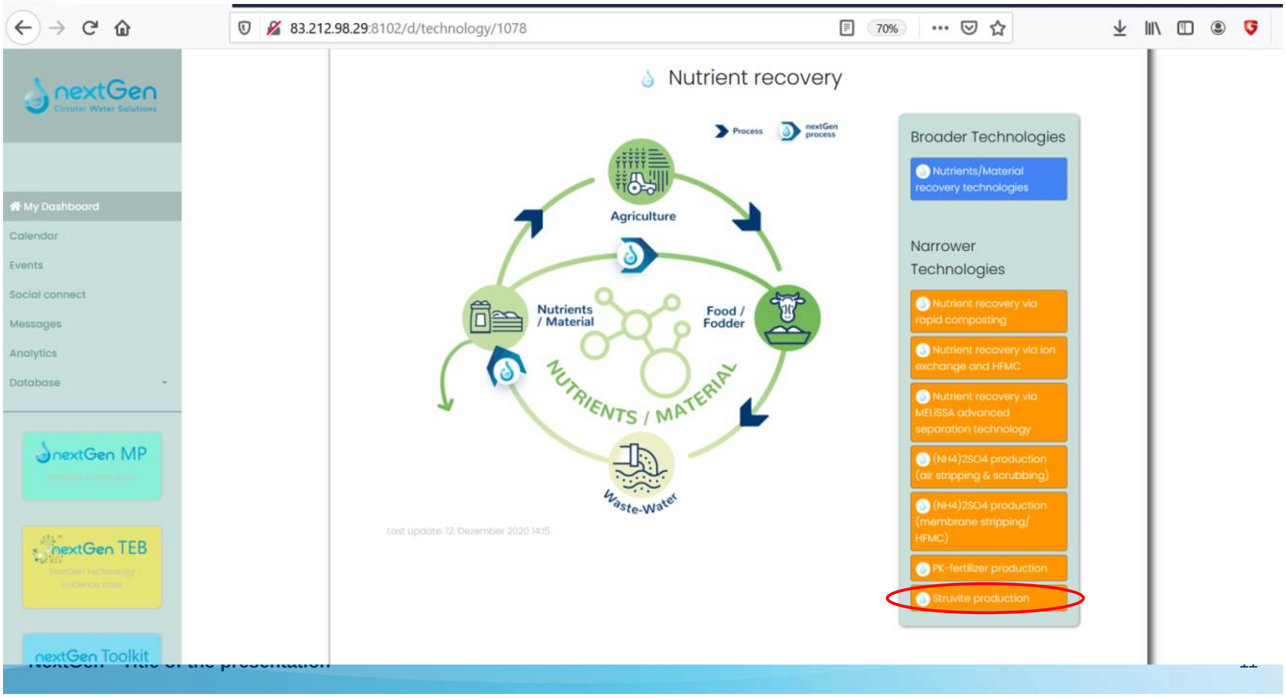
(NH4)2SO4 production (membrane stripping/ HFMC)
PK-fertilizer production
Struvite production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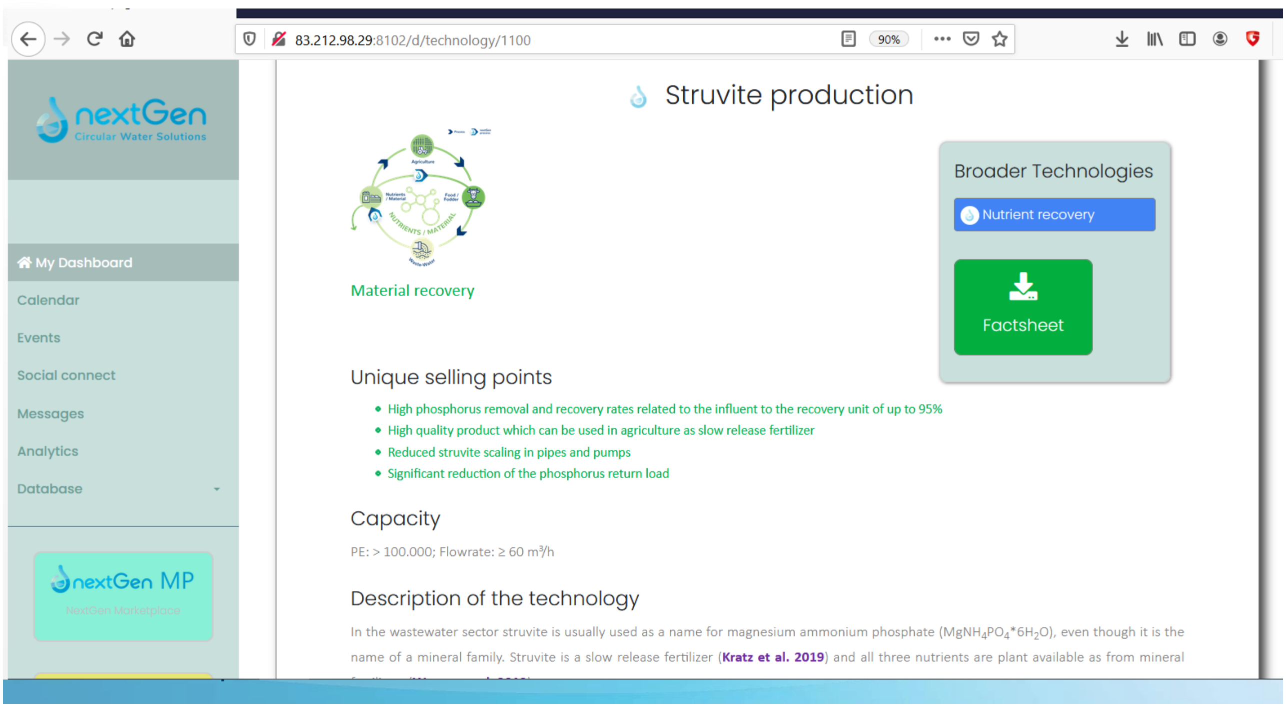
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Factsheet
Unique selling points
High phosphorus removal and recovery rates related to the influent to the recovery unit of up to 95%
High quality product which can be used in agriculture as slow release fertilizer
Reduced struvite scaling in pipes and pumps
Significant reduction of the phosphorus return load
Capacity
PE: > 100.000; Flowrate: ≥ 60 m³/h
Description of the technology
In the wastewater sector struvite is usually used as a name for magnesium ammonium phosphate (MgNH4PO4*6H2O), even though it is the
name of a mineral family. Struvite is a slow release fertilizer (Kratz et al. 2019) and all three nutrients are plant available as from mineral


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Nutrient recovery
Factsheet
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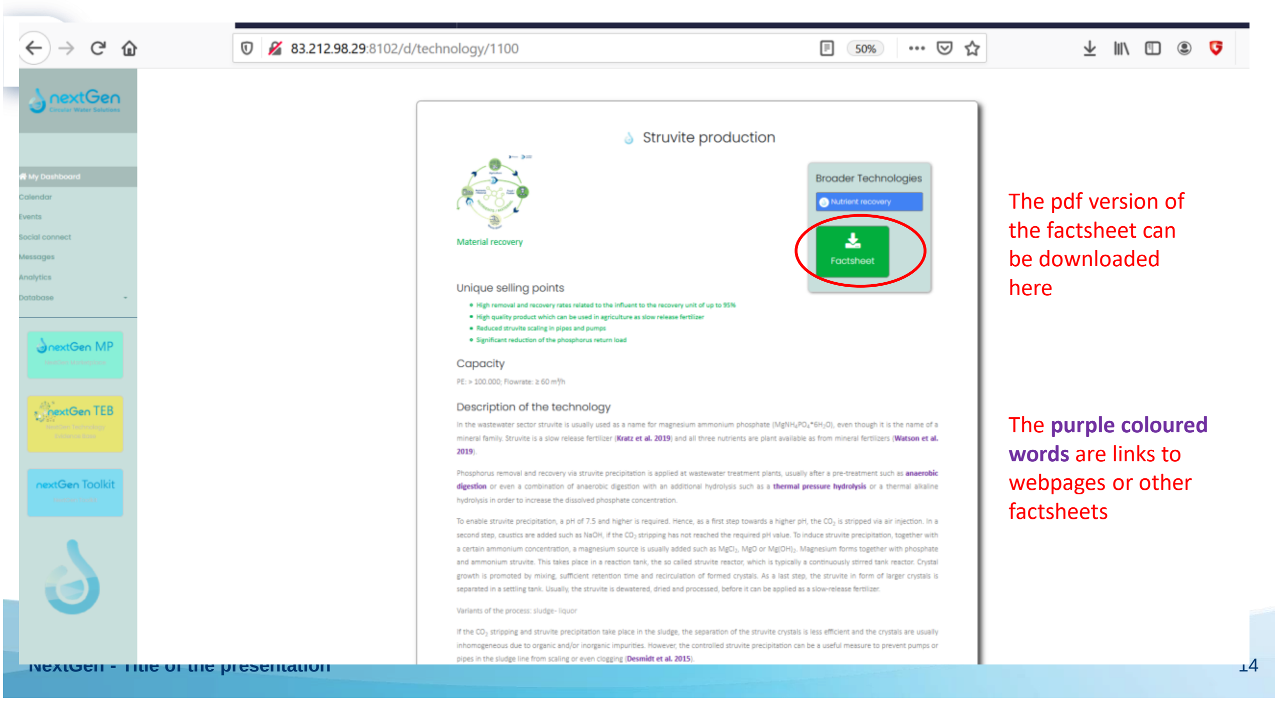
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Surfacewater
Groundwater
Salt water
Fit-for-purpose water
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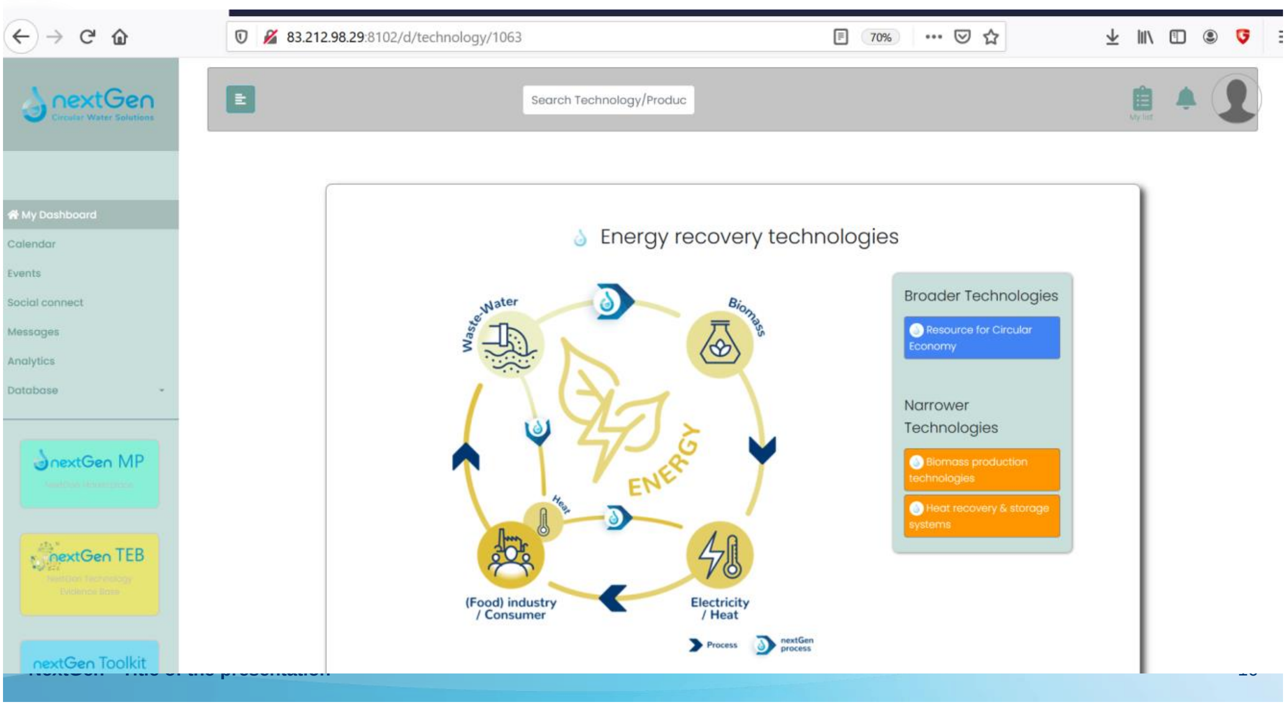
Wastewater treatment technologies for water reuse
Rainwater harvesting systems
Surface water and infiltration systems
Groundwater systems
Desalination technologies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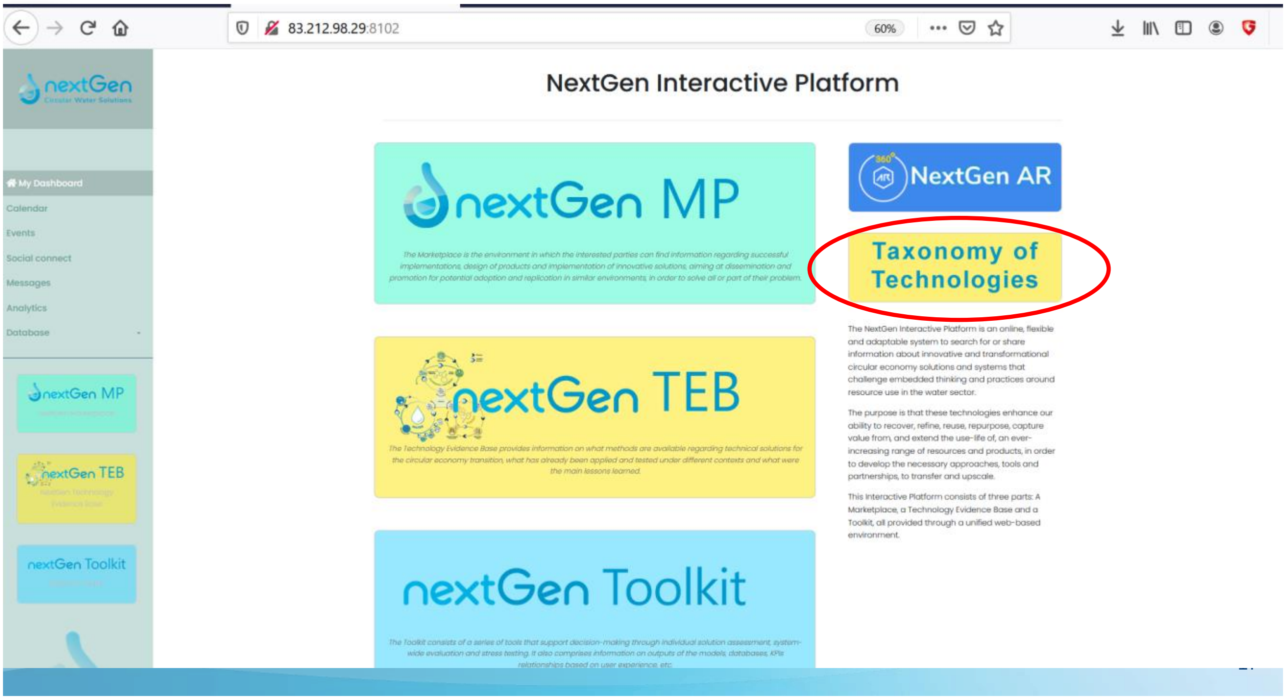
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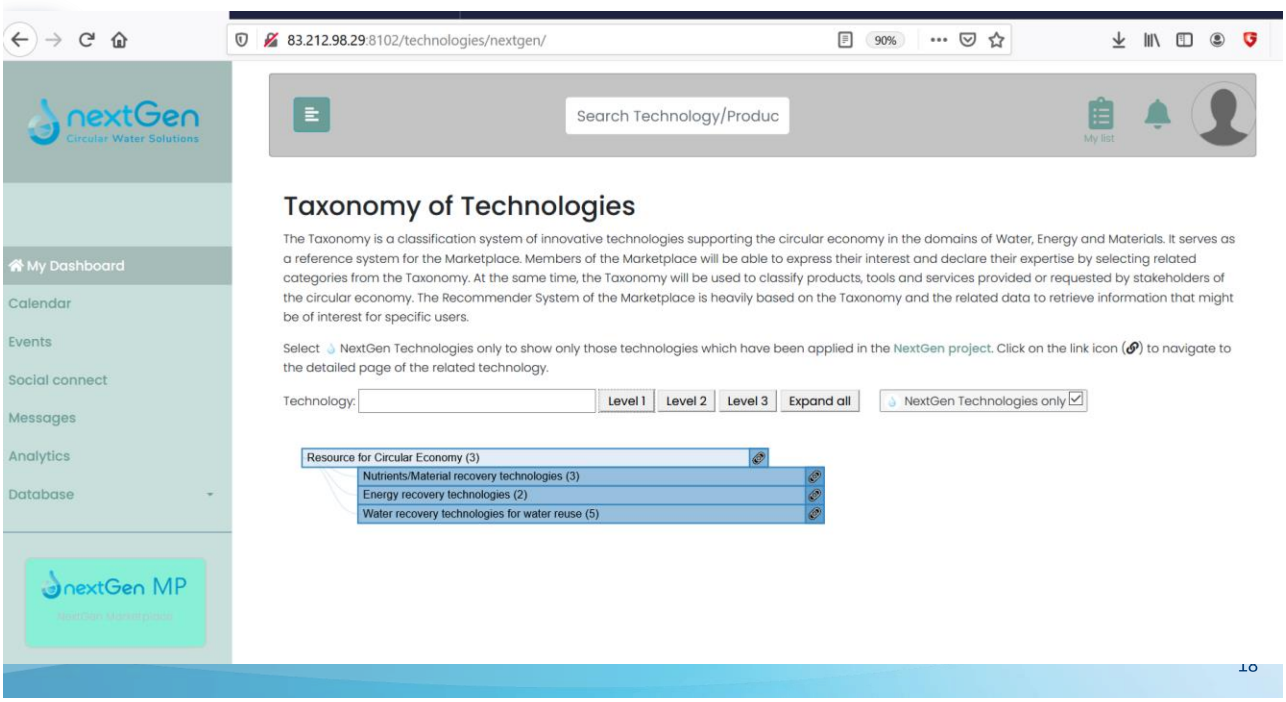
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Taxonomy of Technologies
The Taxonomy is a classification system of innovative technologies supporting the circular economy in the domains of Water, Energy and Materials. It serves as a reference system for the Marketplace. Members of the Marketplace will be able to express their interest and declare their expertise by selecting related categories from the Taxonomy. At the same time, the Taxonomy will be used to classify products, tools and services provided or requested by stakeholders of the circular economy. The Recommender System of the Marketplace is heavily based on the Taxonomy and the related data to retrieve information that might be of interest for specific users.
Select NextGen Technologies only to show only those technologies which have been applied in the NextGen project. Click on the link icon to navigate to the detailed page of the related technology.
Technology:
Level 1
Level 2
Level 3
Expand all
NextGen Technologies only
Resource for Circular Economy (3)
Nutrients/Material recovery technologies (3)
Energy recovery technologies (2)
Water recovery technologies for water reuse (5)

Overview on the factsheets (light red coloured) already prepared

- Resource for Circular Economy (3)
  - Nutrients/Material recovery technologies (3)
    - Nutrient recovery (7)
      - Nutrient recovery via rapid composting
      - Nutrient recovery via ion exchange and HFMC
      - Nutrient recovery via MELiSSA advanced separation technology
      - $(NH_4)_2SO_4$ production (air stripping & scrubbing)
      - $(NH_4)_2SO_4$ production (membrane stripping/ HFMC)
      - PK-fertilizer production
      - Struvite production
    - Food/fodder production technologies (1)
      - Microalgae and purple phototrophic bacteria production in a photobioreactor
    - Material recovery technologies (2)
      - Granulated activated carbon (GAC) production via pyrolysis of dried sludge & loc
      - Rapid composting
  - Energy recovery technologies (2)
  - Water recovery technologies for water reuse (5)

Overview on the factsheets (light red coloured) already prepared

- Resource for Circular Economy (3)
  - Nutrients/Material recovery technologies (3)
  - Energy recovery technologies (2)
    - Biomass production technologies (4)
      - Enhanced biogas production due to thermal pressure hydrolysis
      - Biochar production
      - Methane production via combined anaerobic membrane bioreactor (AnMBR) and membr
      - Biogas production via anaerobic digestion
    - Heat recovery & storage systems (3)
      - Heat recovery via heat exchangers
      - Low grade heat recovery (sewer)
      - Aquifer Thermal Energy Storage
  - Water recovery technologies for water reuse (5)

- Resource for Circular Economy (3)
  - Nutrients/Material recovery technologies (3)
  - Energy recovery technologies (2)
  - Water recovery technologies for water reuse (5)
    - Wastewater treatment technologies for water reuse (4)
      - Biological systems (3)
        - Anaerobic Membrane Bioreactor (AnMBR)
        - Membrane Bioreactor (MBR)
        - Metabolic Network Reactor (MNR)
      - Membrane systems (5)
        - Decentralised membrane treatment (sedimentation-grid-discfilter-UF-RO-UV)
        - Regenerated membranes for ultra- or nanofiltration
        - Metabolic Network Reactor (MNR) coupled to MELisSSA advanced separation systems
        - Anaerobic Membrane Bioreactor (AnMBR)
        - Membrane Bioreactor (MBR)
      - Adsorption systems (2)
        - Granulated activated carbon treatment
        - Nutrient removal and recovery via ion exchange and membrane contactor
      - Advanced oxidation processes (AOP) (3)
        - Hydrogen peroxide/UV
        - Ozone/UV
        - Hydrogen peroxide/UV & activated carbon
    - Rainwater harvesting systems (2)
    - Surface water and infiltration systems (3)
    - Groundwater systems (2)
    - Desalination technologies (3)

Overview on the factsheets (light red coloured) already prepared

- Resource for Circular Economy (3)
  - Nutrients/Material recovery technologies (3)
  - Energy recovery technologies (2)
  - Water recovery technologies for water reuse (5)
    - Wastewater treatment technologies for water reuse (4)
    - Rainwater harvesting systems (2)
      - Infiltration ponds for water storage
      - Automatic floodgates for water storage and to replenish aquifers
    - Surface water and infiltration systems (3)
      - Infiltration ponds for water storage
      - Automatic floodgates for water storage and to replenish aquifers
      - Large scale aquifer storage & recovery systems
    - Groundwater systems (2)
      - Artificial storage and recovery (ASR) system
      - Large scale aquifer storage & recovery systems
    - Desalination technologies (3)
      - Decentralised membrane treatment (sedimentation-grid-discfilter-UF-RO-UV)
      - Regenerated membranes for ultra- or nanofiltration
      - MELiSSA advanced separation systems

Timeline

Jan. 2021	Feedback of NextGen partners regarding layout, functionality, structure, etc.
Feb./Mar 2021	Revision of TEB according to the suggestions of the partners
Apr 2021	Uploading of the other factsheets & moving to the NextGen homepage
From May 2021 on:	Extension of the TEB regarding results of other NextGen WPs

Factsheet – Struvite production

AUTHORS: A. Kleyböcker, J. Schneider

DATE: 18/12/2020

VERSION: V4

This project has received funding from the
European Union's Horizon 2020 research and

Struvite production

Material recovery

Wastewater treatment technology

Unique selling points:

- ✓ High phosphorus removal and recovery rates related to the influent to the recovery unit of up to 95%
- ✓ High quality product which can be used in agriculture as slow release fertilizer
- ✓ Reduced struvite scaling in pipes and pumps
- ✓ Significant reduction of the phosphorus return load

Capacity:

PE: > 100.000; Flowrate: ≥ 60 m^3/h

Description of the technology

In the wastewater sector struvite is usually used as a name for magnesium ammonium phosphate ($MgNH_4PO_4*6H_2O$), even though it is the name of a mineral family. Struvite is a slow release fertilizer (**Kratz et al. 2019**) and all three nutrients are plant available as from mineral fertilizers (**Watson et al. 2019**).

Phosphorus removal and recovery via struvite precipitation is applied at wastewater treatment plants, usually after a pre-treatment such as **anaerobic digestion** or even a combination of anaerobic digestion with an additional hydrolysis such as a **thermal pressure hydrolysis** or a thermal alkaline hydrolysis in order to increase the dissolved phosphate concentration.

To enable struvite precipitation, a pH of 7.5 and higher is required. Hence, as a first step towards a higher pH, the CO_2 is stripped via air injection. In a second step, caustics are added such as NaOH, if the CO_2 stripping has not reached the required pH value. To induce struvite precipitation, together with a certain ammonium concentration, a magnesium source is usually added such as $MgCl_2$, MgO or $Mg(OH)_2$. Magnesium forms together with phosphate and ammonium struvite. This takes place in a reaction tank, the so called struvite reactor, which is typically a continuously stirred tank reactor. Crystal growth is promoted by mixing, sufficient retention time and recirculation of formed crystals. As a last step, the struvite in form of larger crystals is separated in a settling tank. Usually, the struvite is dewatered, dried and processed, before it can be applied as a slow-release fertilizer.

Variants of the process: sludge - liquor

If the CO_2 stripping and struvite precipitation take place in the sludge, the separation of the struvite crystals is less efficient and the crystals are usually inhomogeneous due to organic and/or inorganic impurities. However, the controlled struvite precipitation can be a useful measure to prevent pumps or pipes in the sludge line from scaling or even clogging (**Desmidt et al. 2015**).

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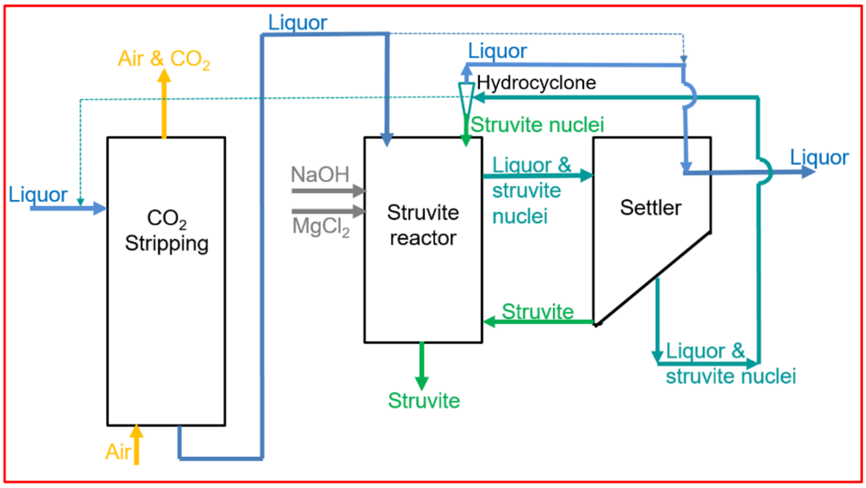
If the CO_2 stripping and struvite precipitation take place in the liquor (e.g. after dewatering), the subsequent separation of the struvite is very efficient. However, the higher phosphate concentrations are, the lower the dewatering efficiency of the upstream dewatering unit is (**Kuhn et al. 2013**). Thus, the dewatering step might require more energy and sometimes even additives such as polymers in order to reach the required liquor quality. In the liquor, the crystals grow usually homogeneous. In NextGen the focus is on struvite production in the liquor, hence, the following sections will focus on this technological solution only.

Flow scheme of the technology

The flow scheme shows an example for struvite production in the liquor. After CO_2 stripping, the struvite crystals precipitate in the struvite reactor as already described. Macro crystals settle down ready to leave the struvite reactor and micro crystals (struvite nuclei) are distributed in the liquor and enter the settling reactor. There, they can further grow and settle down. However, if they are still too small for settling, they are transported back to the struvite reactor. The hydrocyclone separates the small crystals from the liquor. They serve as struvite nuclei and lead to an improved crystal growth within the struvite reactor. The system of the reactors is very flexible, shown by the dotted lines that indicate an alternative way of operation.



Pictures of the technology

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Synergetic effects and motivation for the implementation of the technology

- ✓ **Reduction of the phosphate return load of a WWTP**

The WWTP profits from the reduced phosphate return load. Thus, a part of iron or aluminium salts often used for a conventional chemical removal might be saved due to the lower return load.

- ✓ **Prevention of clogging events in pipes**

Depending on the chemical composition of the wastewater and the pH conditions, struvite can precipitate in undesired parts in the wastewater treatment plant e.g. in pipes leading to scaling and clogging. Due to a controlled removal of the phosphate from the liquor, those processes will be diminished or even avoided in the subsequent plant parts.

Requirements of the technology and operating conditions

In order to reach high struvite yields, the dissolved phosphate concentration in relation to the total phosphorus content should be as high as possible in the reactor influent. At least the concentration should be at 50 mg PO_4-P/L, while the total suspended solids (TSS) and total solids (TS) should be below 600 mg/L and 2%, respectively. Furthermore, ammonium and magnesium need to be present. Therefore, a molar ratio of Mg:N:P between 1:2:1 and 1:12:1 should be maintained in the reactor.

Parameter	Units	Min	Max	Reference
PO_4-P (influent to reactor)	mg/L	50	-	Cornel and Schaum (2009)
TSS (influent to reactor)	mg/L	-	600	NextGen D1.5 (in prep.); Ohl 2020
TS (influent to reactor)	%	-	2	NextGen D1.5 (in prep.); NuReSys 2020
pH (in reactor)	-	7.5	9	NextGen D1.5 (in prep.), Cornel and Schaum (2009), Shaddel et al. (2019)
Mg:N:P molar ratio (in reactor)	-	1:2:1	1:12:1	Shaddel et al. (2019)

Key performance indicators

Besides the P-recovery rates, also the solubility of struvite in neutral ammonium citrate (NAC) is shown as a key performance indicator. This solubility P_{NAC} can give a hint to the plant availability and agronomic effectiveness of the fertilizer.

Parameter	Units	Min	Max	Reference
P-recovery rate (influent struvite production unit)	%	90	95	NextGen D1.5 (in prep.)
P-recovery rate (influent WWTP)	%	10	20	NextGen D1.5 (in prep.)
P_{NAC}	%	69	96	Kratz et al. 2019

Links to related topics and similar reference projects

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Phosphorus recovery processes	Reference
Struvite production	Case study "Braunschweig" (NextGen)
Hydroxyapatite production	Case study "Spernal" (NextGen)

References

Cornel, P., Schaum, C. (2009). Phosphorus recovery from wastewater: needs, techniques and costs. Water Science and Technology, 59, 1069–1076. https://doi.org/10.2166/wst.2009.045

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Outlook

Case study specific information will be provided, when the results of the other work packages are available:

- **Lessons learned from the case study**
- **Outcome of the assessments**
- **Legal and regulatory information concerning the whole value chain concerning the technology**
- **Business opportunities**

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