

Nutrient Upcycling from Wastewater Treatment

Technical & non-technical Roadmap: from science to practice

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Summary

1. **Context** - Global stakes & Ecosystemic link between water utilities - water management cycle - agriculture
2. **A look into Veolia's Phosphorus recovery roadmap**
3. **Challenges : Phosphorus recovery by water utilities** - Techno push or Market pull?
4. **Steps Forward:** business development opportunities, new solutions & strengthening partnerships

1. Context: Stakes



Water cycle management

- water resource protection (quality) - fertilization strategies
- water resource protection (quantity) - REUSE



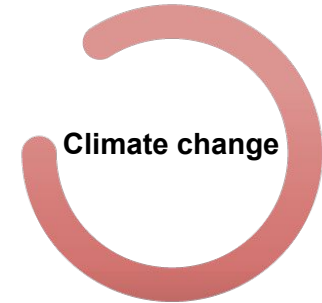
Soil Conservation practices

- Organic and sustainable fertilisation strategies
- Soil amendments



Nutrient Recycling

- namely from by-products of waste and wastewater ttt

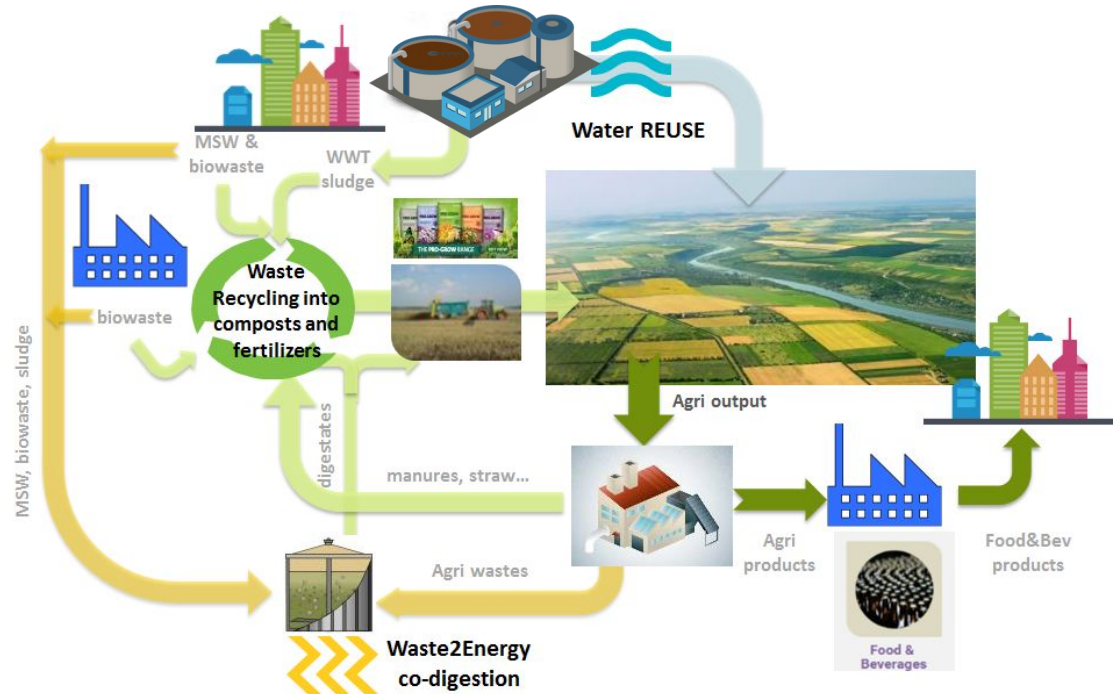


Emission reduction through optimal fertilisation

Soil Carbon sequestration

Ecosystemic Approach

- Ecosystemic links between
cities & territories
water cycle management
& agriculture



Ecosystemic Approach

- **Soils render a number of ecosystem services**
 - *Food security*
 - *Water resilience*
 - *Carbon Sink*
 - *Biodiversity reservoir*



Ecosystem Services are economic methods to assess economic value of both visible & invisible (w/o market value) costs and benefits costs in order to enable a full cost/benefit analysis

Ecosystemic link between water utilities & agriculture

- Paradigm shift from **dissipative treatment to resource recovery**
- #1 resource from WW is **water**
- then come a number of **mineral nutrients** essential for plant growth (food production)
- as well as **organic carbon**, essential for soil health, soil water resilience and role as Carbon Sink

70%

fresh **water** use in agriculture

80%

potential for recycled **N-P-K**, expressed as fraction of new demand (+24 Mtons 2015-2025)

1000 Gt

of **organic C** stored in Soil (30 cm layer)

Veolia's ecosystemic approach

- Veolia's approach to resource recovery, and in particular nutrient recovery is not limited to the perspective of a wastewater **utility operator**, nor to that of a **technology provider**
- Veolia looks at the **full water and nutrient cycles**, Veolia's business units provide a range of solutions and services including
 - design & build WWTPs,
 - operate WWTPs,
 - services in watershed management,
 - technologies aiming at nutrient and resource recovery;
 - valorisation of WWTP by-products, in particular into agricultural processes
- Veolia develops and operate numerous **circular economy solutions** for **agricultural applications**, stemming from our **water, waste** and **energy** business lines



2. A look into Veolia's P-recovery roadmap



2012-2015



Phos4You - We deliver Phosphorus "made in Europe"

2016-2020



PhosForce 2018-2021

- Field research on WW by-product agronomic valorisation for over 20 years
 - R&D on Phosphorus recovery from Water Utilities for over a decade
- Partnerships with Academia, Professional Associations, Industries and European Institutions
 - FP7, H2020, Interreg, EIT funded projects as well as internally funded R&D and B2B partnerships
 - *Currently: Phos4You, PhosForce, Yara-Veolia Alliance*



<https://eitrawmaterials.eu/project/phosforce/>

<https://www.nweurope.eu/projects/project-search/phos4you-phosphorus-recovery-from-waste-water-for-your-life/>



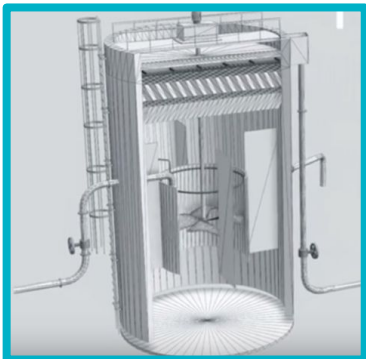
2. A look into Veolia's P-recovery roadmap

An internal working group to coordinate all group initiatives with link to P recovery

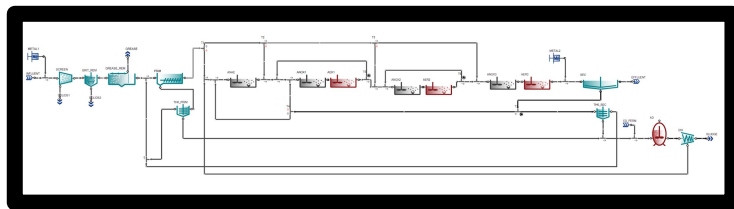
- **Research & Development ; Technology & Performance ; Business Units** (D&B, O&M, Sludge Management)
- Aim to define and continuously update a **Strategic Roadmap** on P recovery comprising **Technology Benchmark, Value Chain Assessment, Partnerships**
- Working group tackles different type of questions:
 - Science and Engineering Questions,
 - Industrial Questions: Scale up, Economic feasibility,
 - Operational troubleshooting: for demo and 1st commercial references, what are the roadblocks? implementation challenges?,
 - Societal questions such as Total Value of P
- Through this working group, the scope of P recovery R&D program within Veolia has broaden from technology development, to operational implementation to a full value chain approach

Main aim is to tackle the implementation gap

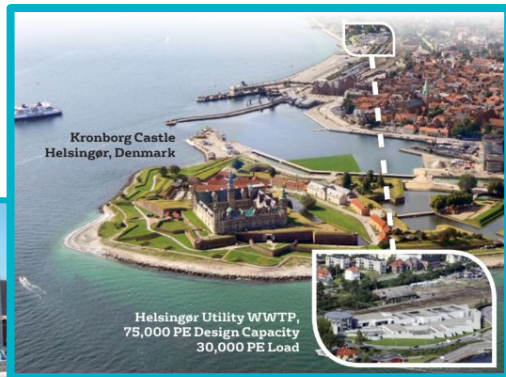
2. A look into Veolia's P-recovery roadmap



Struvia



Schönebeck WWTP



Kronborg Castle
Helsingør, Denmark

Helsingør Utility WWTP,
75,000 PE Design Capacity
30,000 PE Load

Helsingør WWTP



Spain's first phosphorus
recovery plant

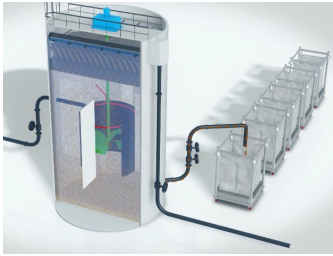
SUR WWTP

Integrated Value Chain Approach

- Technology development (eg Struvia)
- Technology benchmark (eg P from Ash)
- Design & Build - decision support for different retrofitting options (Eg. BioP/Sidestream BioP)
- Scale-up, Implementation and Operational challenges
- Product (Fertilizer) development
- Product valorisation (agronomic value)
- Life Cycle Analysis - Value Chain
- Industrial Symbiosis (Energy Efficiency)
- Local circular economy opportunities

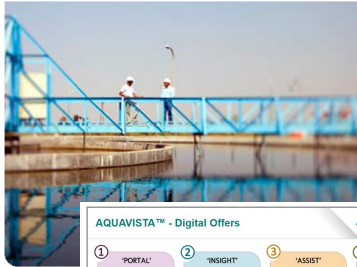
Veolia's value chain approach

WWTP Design & Build



Veolia Water Technologies
Krüger; Tech provider
Partnerships

WWTP Operation



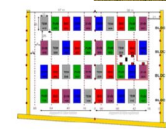
Veolia

Product Valorisation



SEDE BD Partnerships

Agronomic R&D



R&D partnerships

Technology developments

Plant Wide Modeling

Decision support systems

Organo-mineral and NPK Product development

Field tests

Smart App for sustainable farming (Soil C focus)

What is STRUVIA®?

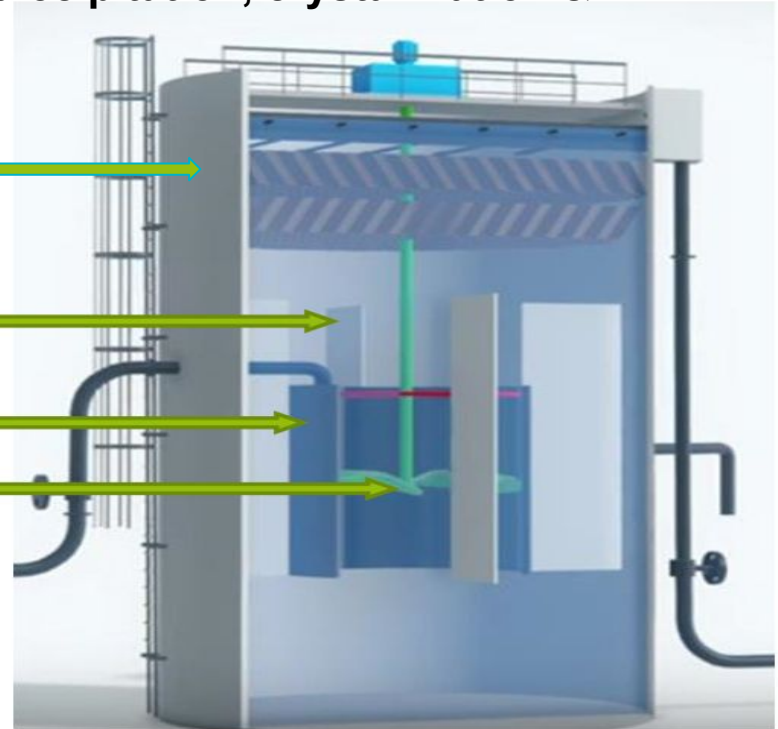
Compact reactor that enables simultaneous precipitation, crystallization & separation

Lamellar decanting
Patented Turbomix®

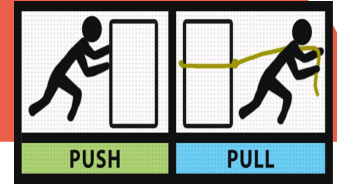
Anti-vortex plates

Draft tube

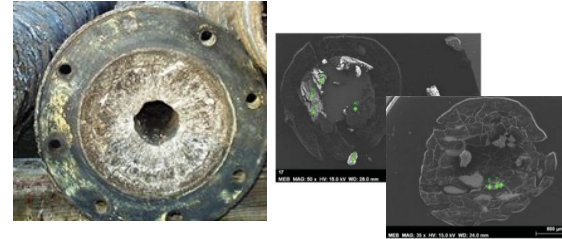
Axial flow agitator with
downward thrust



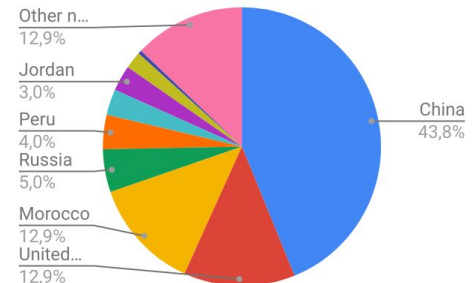
3. Challenges: Techno push or Market pull?



- *Development of P-rec technologies was (and is) based on solving operational issues at the WWTP*
- *Demand for P sourcing is not what's pulling the development of technologies for P recovery*
- *Prototypes P-rec technologies & products but no (yet) clear/mature market for WWTP derived phosphate-salts*
- *This is changing, though, and initiatives and partnerships between water utilities and fertilizer companies are rising*
- *Also agri-tech and food-tech have taken an interest in nutrient recovery*
- *Somewhere in “murky” waters between techno push and market pull, environmental regulations may help create market opportunities*



Global PR Mine Production: ~218 Mt (avg. 2010-2014)



Total value of P-recovery

- Environmental Benefits
 - *Protecting & Improving Water Quality*
 - *Increasing Performance of Waste Management*
 - *Substituting fossil P*
- Food Security & Geopolitical Stability
 - *Increasing P Independence*
 - *Decreasing Exposure to Geopolitical and Supply Risks*
- Business Opportunities
 - *Co-recovery of Nutrients, Metals & Energy*
 - *Eco-labelling as a Marketing Tool*



Need for an **integrated approach** to:

- *Internalize part of the co-benefits*
- *Share the burden of extra-costs*

Market and business development challenges

Demand side:

- **Type of product sought by market** (fertilizer, amendment, biostimulant,...)
- **Comply with specifications** regarding composition (safety requirements, technical specs) and **functional properties** (agronomic specs: plant availability, plant nutrition, soil conditioning, stimulation of soil microfauna and microbial activity...)
- **Compliance with Regulation** - EoW, REACH, EU Fertilizer



Supply side:

- **Compliance w/ Regulation** - End of Waste, REACH, EU Fertilizer regulations
- **Nutrient content / presence of metals, contaminants**, which impacts both safety regulations but also functional pptides ⇒ impact on bioavailability of nutrients
- **Technical Accessibility**
- **Cost-effectiveness of recovery process(es)**
- **Adaptation of WWTP / Co-benefits**



4. Opportunities in the German Market

New legislation on P recovery from WWTP has now entered into effect in Germany

**NEW
LEGISLATION!!**

P recovery by WWTPs > 50,000 PE

< 20 g P/kg DS in output sludge

Target 1

> 80% P-recovery on ashes following mono incineration

Target 2

Time frame:

by 2029, the **WWTPs with more than 100,000 p.e.** will need to recover phosphorus (by 2032 for WWTPs between 50,000 and 100,000 p.e.).

The **WWTP operators** need to show an **implementation plan by 2023**.



**Municipal
Market**

**New opportunity
estimated at 400 M€/year,**

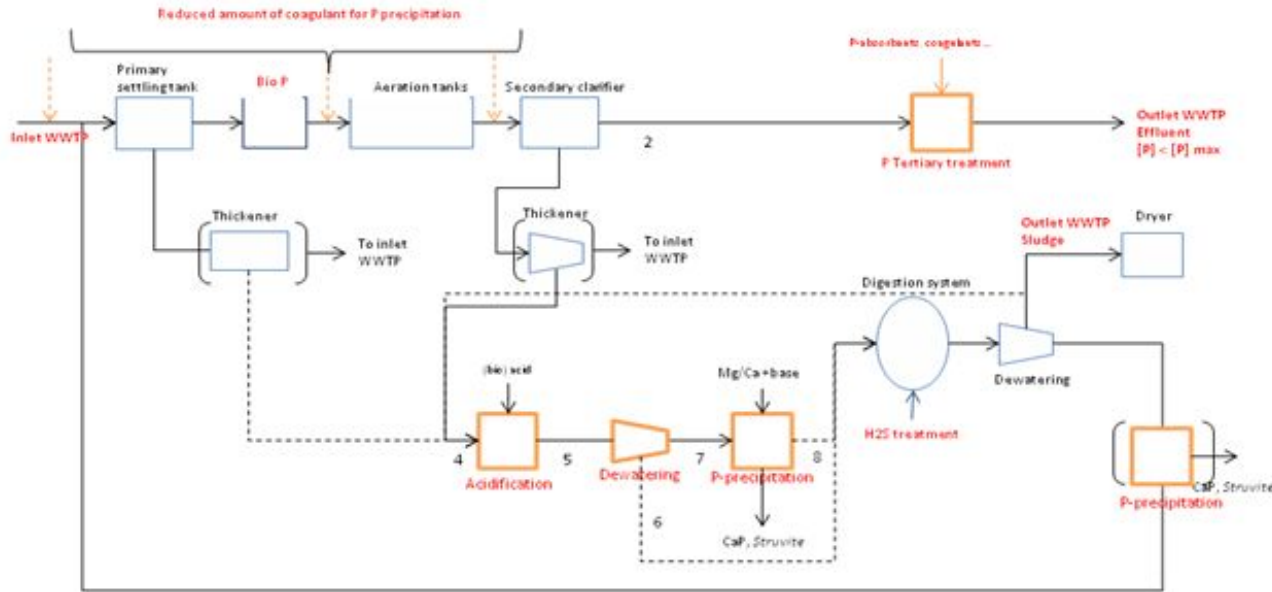
including

- **D&B & O&M** activities
- **Upstream & Downstream** activities

Time to Market:

Implementation plans by 2023

Target 1: < 20 g /Kg DS



A market-ready solution will be offered to the German market up to 2020, comprising:

- Mature technology with demonstration at full-scale on a German WWTP (Schönebeck)
- Technical guidelines / model to replicate other WWTP
- Secured IP
- Certified product
- Full marketing package

Veolia's offer comprises not only the "technological bricks/processes" that enable the recovery, but actually the decision making process enabling to find for a given type of WWTP and type of WW/sludge what is the optimal effort required to reach the new target

Decision Support System for Plant retrofits targeting P

NEW#we are RESOLVED
Developments!!

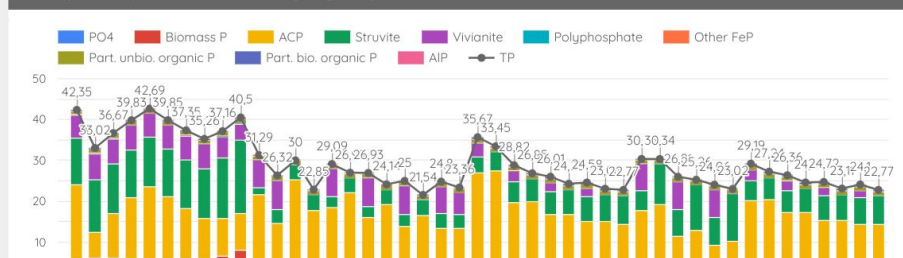
- Scenario
- Saisir un terme à rechercher
- Base 1
 - BASECa50 2
 - BASECa100 3
 - BASECa150 4
 - BASESRT20 5
 - AC02 6
 - AC04 7
 - AC06 8
 - AC08 9
 - AC10 10
 - BASTR 11
 - BASTRCa100 12
 - BASTR-Fe 13
 - BASTR-FeCa100 14
 - AC02BASTR 15
 - AC02BASTR-Fe 16

KPIs OVERVIEW | EFFLUENT | SCENARIO DETAILS | P FRACTIONS | BIO & TS\$ | P & N PROFILES | RANKING

Process KPIs, costs & profit sources

Id	Name	Total phosphorus in sludge (gP/kgTSS)	Weighted rejected pollutants	Sludge production (kg TSS/d)	Iron chloride consumption (kgFe/d)	Acid consumption (m3/d)	Total airflow rate (Nm3/h)	Methane production (kg/d)	Brushite or struvite production (kgP/d)
1	Base	42,4	30,9	2,7 k	55,4	0	69,9 k	514,1	0,0
2	BASECa50	33,0	62,9	2,5 k	55,4	0	69,9 k	517,4	0,0
3	BASECa100	36,7	51,0	2,6 k	55,4	0	69,9 k	516,1	0,0
4	BASECa150	39,8	40,0	2,7 k	55,4	0	69,9 k	515,0	0,0
5	BASESRT20	42,7	29,0	2,8 k	55,4	0	67,9 k	537,9	0,0
6	AC02	39,8	40,0	2,7 k	55,4	0,2	69,9 k	515,1	0,0
7	AC04	37,4	48,8	2,6 k	55,4	0,4	69,9 k	516,1	0,0
8	AC06	35,3	57,8	2,6 k	55,4	0,6	70 k	518,8	0,0

Phosphorus profile in final sludge (gP/kgTSS)



Currently under development for German Market

target <20 gP/kg DS in output sludge

DSS enables to compare #retrofit scenarios and select based on range of KPIs

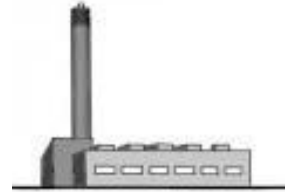
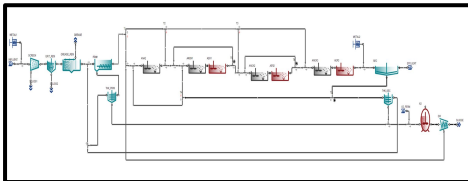
Based on SUMO plant wide model with specific Calibrations

Target 2: 80% P rec from ISSA



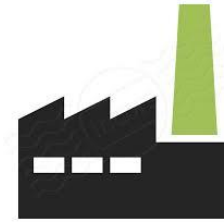
Adapt WWTPs

- Biobased coagulants >> lower Fe/Al content P by-product
- Increase BioP >> enable stronger P uptake / release & lower Fe/Al content P by-product
- Hydrolysis/Acidogenesis: Increase PO₄ release >> enable recovery
-



Incinerate Sludge & Prepare Ash

Impact of Incineration conditions on P extractability



Valorize Ash Leachate as Secondary raw material

Leaching (selectivity)
Impact on Process Lines
Impact on Fertilizer functional pties (P plant availability)

Conclusions

Veolia's P-roadmap aims to integrate following aspects into development of Nutrient Upcycling Strategies

- (i) assess potential from different processes and technologies to enable process line and plant optimization;
- (ii) use simulation and multi-objective optimization (with multiple criteria: environmental, economic, territorial specificities - bridge territorial needs and resources) to optimize process lines and plants;
- (iii) consider impacts of integrating resource recovery both upstream and downstream of wastewater treatment, and namely being able to anticipate product specifications or even integrate a product based approach to process line development;
- (iv) integrate business model and market design considerations.

Take Home Message

Main message of the presentation is to highlight the need for a transverse, multi-disciplinary approach to develop successful strategies for nutrient upcycling

- Diagnosis: Return on Experience from business units : what is the implementation gap?
- Foster shared experiences between research and practice
- Promote collaboration with other industrial sectors (cross-fertilization)
- Use models and decision support tools - water utilities scale but also to model value chain interactions
- Pursue Technology and Process Development
- Regulation as a development lever

THANK YOU!