Waste Water Treatment from the Netherlands, Recent developments in a circular economy

Merle de Kreuk
TU Delft

Circularity and recovery (?)

Economic activity → waste → Environmental problems

↓

Mixture of undefined resources

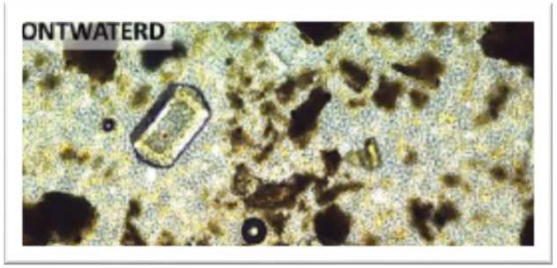
↓

Biological processes

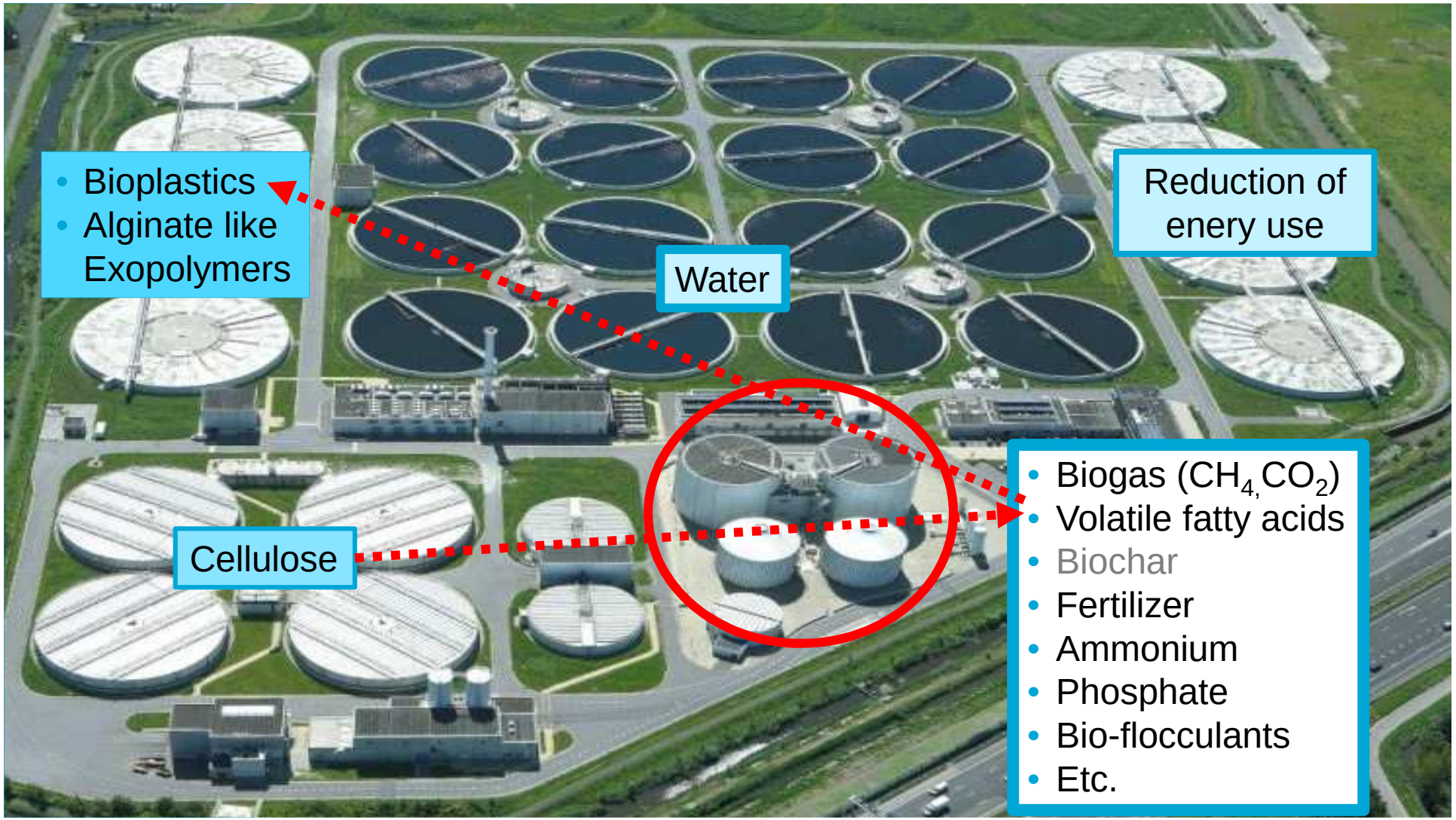
↓ ↓ ↓

Considerations for recovery - phosphate

Aim for cicularity:
Clean natural fertilizer



Or do we just solve a problem?


• Bioplastics
• Alginate like Exopolymers
Water
Reduction of enery use
Cellulose
• Biogas (CH_4, CO_2)
• Volatile fatty acids
• Biochar
• Fertilizer
• Ammonium
• Phosphate
• Bio-flocculants
• Etc.


Aerobic Granular Sludge Technology
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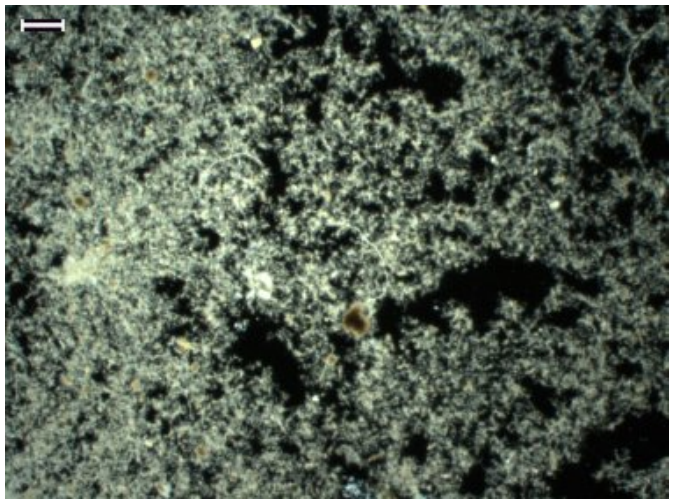
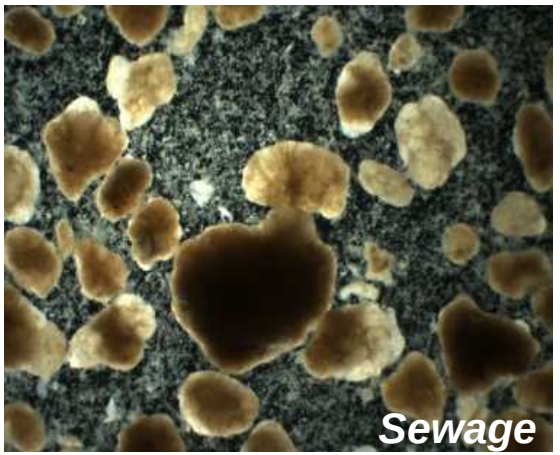
Compact systems: Enhance settling



Bacterial growth in activated sludge…



…use granules: Aerobic granular sludge!

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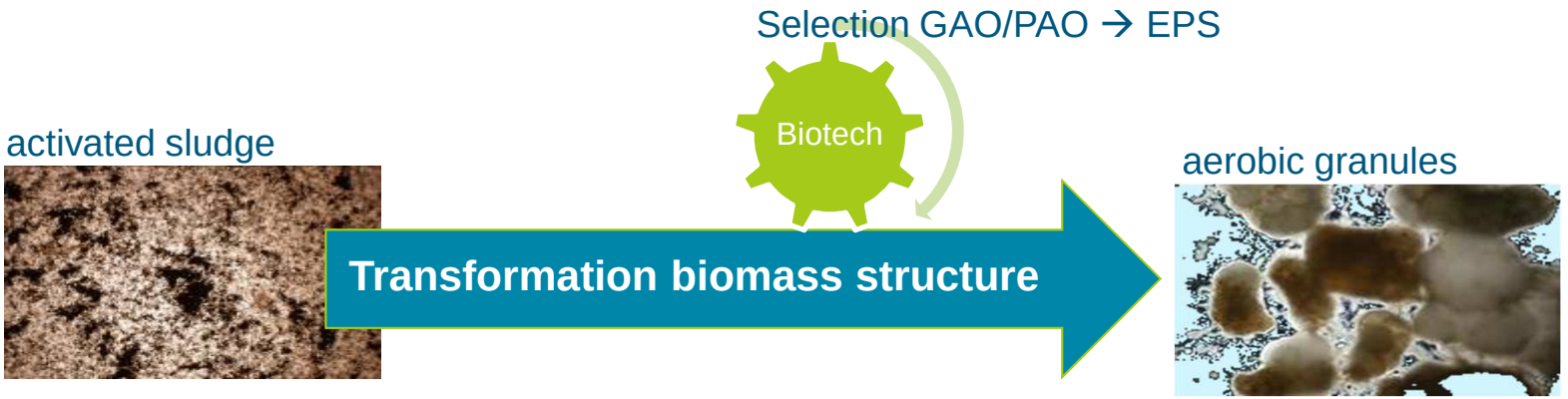
How to make Granular Activated Sludge?



Operation of Nereda results in stable granulation thanks to

- **Initial uptake of BOD by granules during feeding**
- **Growth on adsorbed / stored BOD during aeration**
- Sludge blanket surface wasting of excess sludge
- **Applying selection each cycle to all sludge**

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Royal HaskoningDHV
Enhancing Society Together

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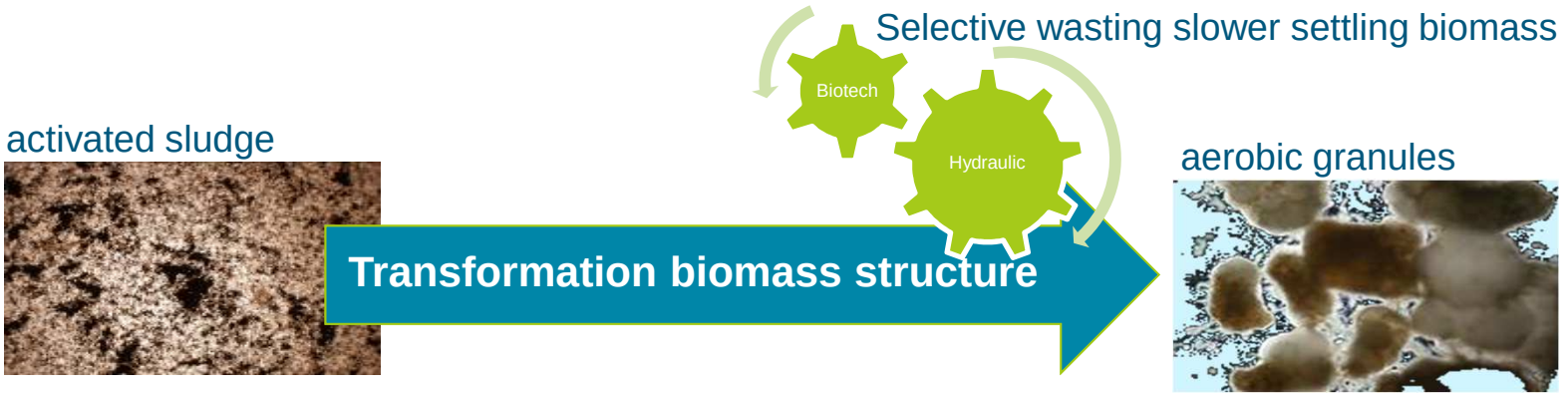

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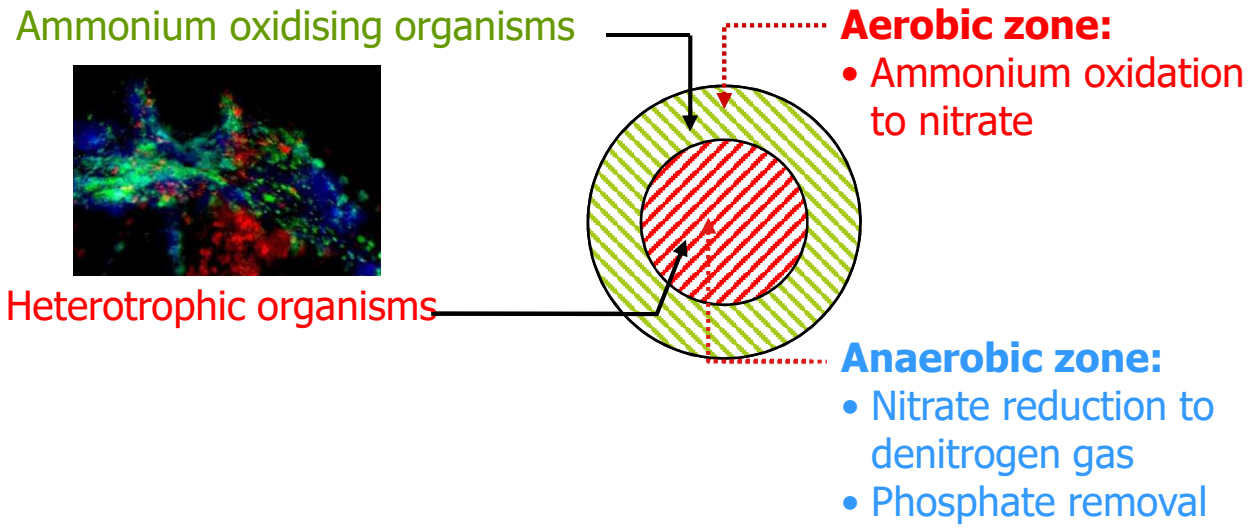
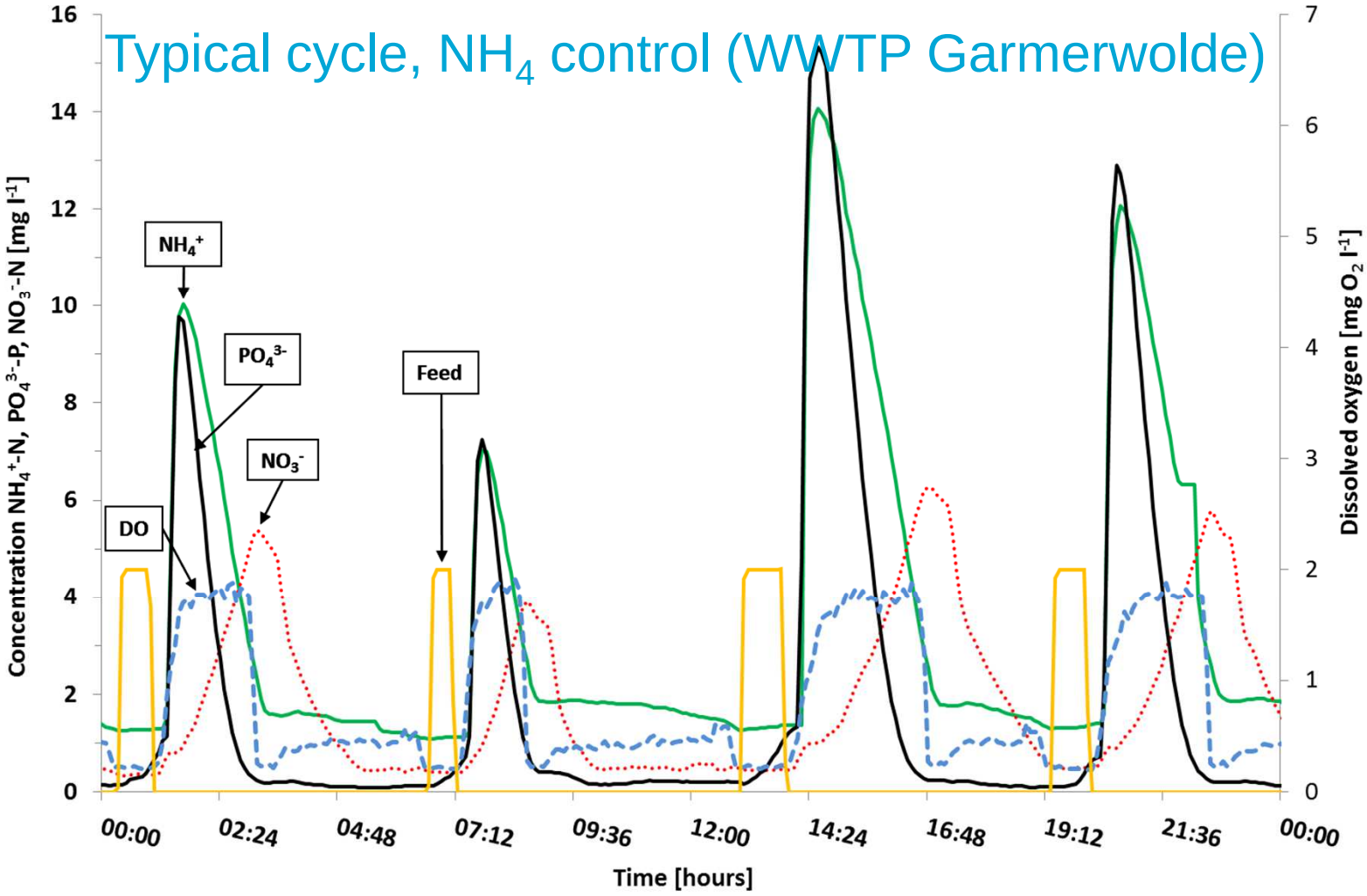
How to make Granular Activated Sludge?

- Oxygen gradient due to diffusion limitation during aeration (O_2 depleting towards core)
- BOD storage throughout the granule during anaerobic feeding;
- Slow growing organisms are favoured due to lack of BOD during aeration



Typical cycle, NH_4 control (WWTP Garmerwolde)



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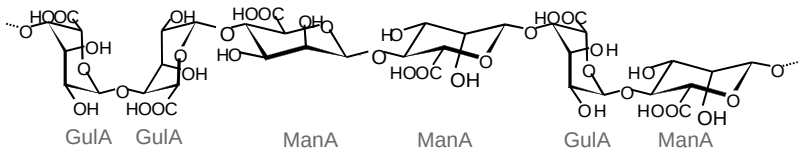
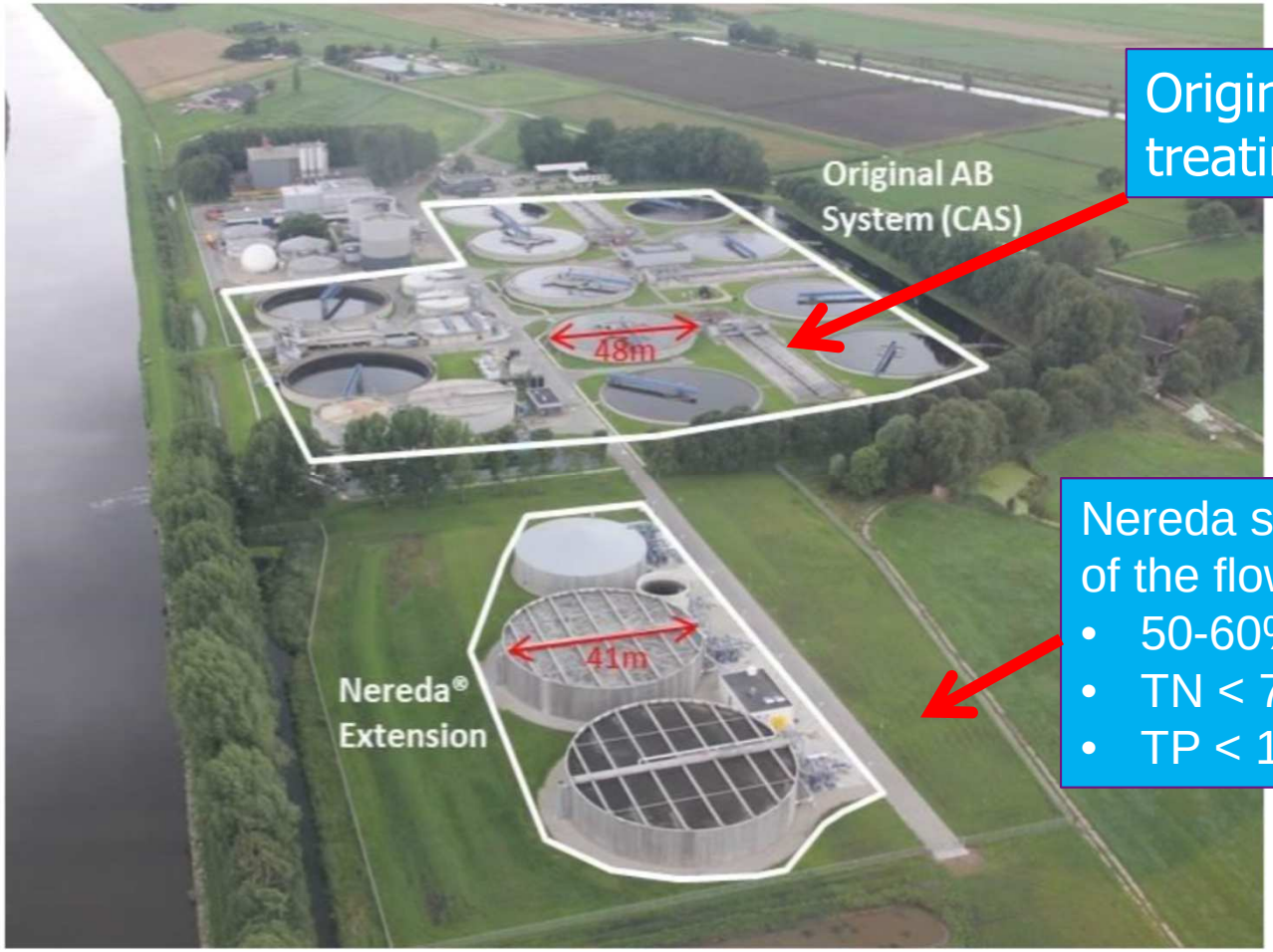
Nereda, full scale since 2012

- Saves space (small footprint);
- Saves building materials (one tank concept);
- Saves energy and produces energy rich waste sludge;
- Produces biopolymers (Kaumera)



...and > 60 build since



Original AB system (CAS) treating 50% of the flow

Nereda system treating 50% of the flow

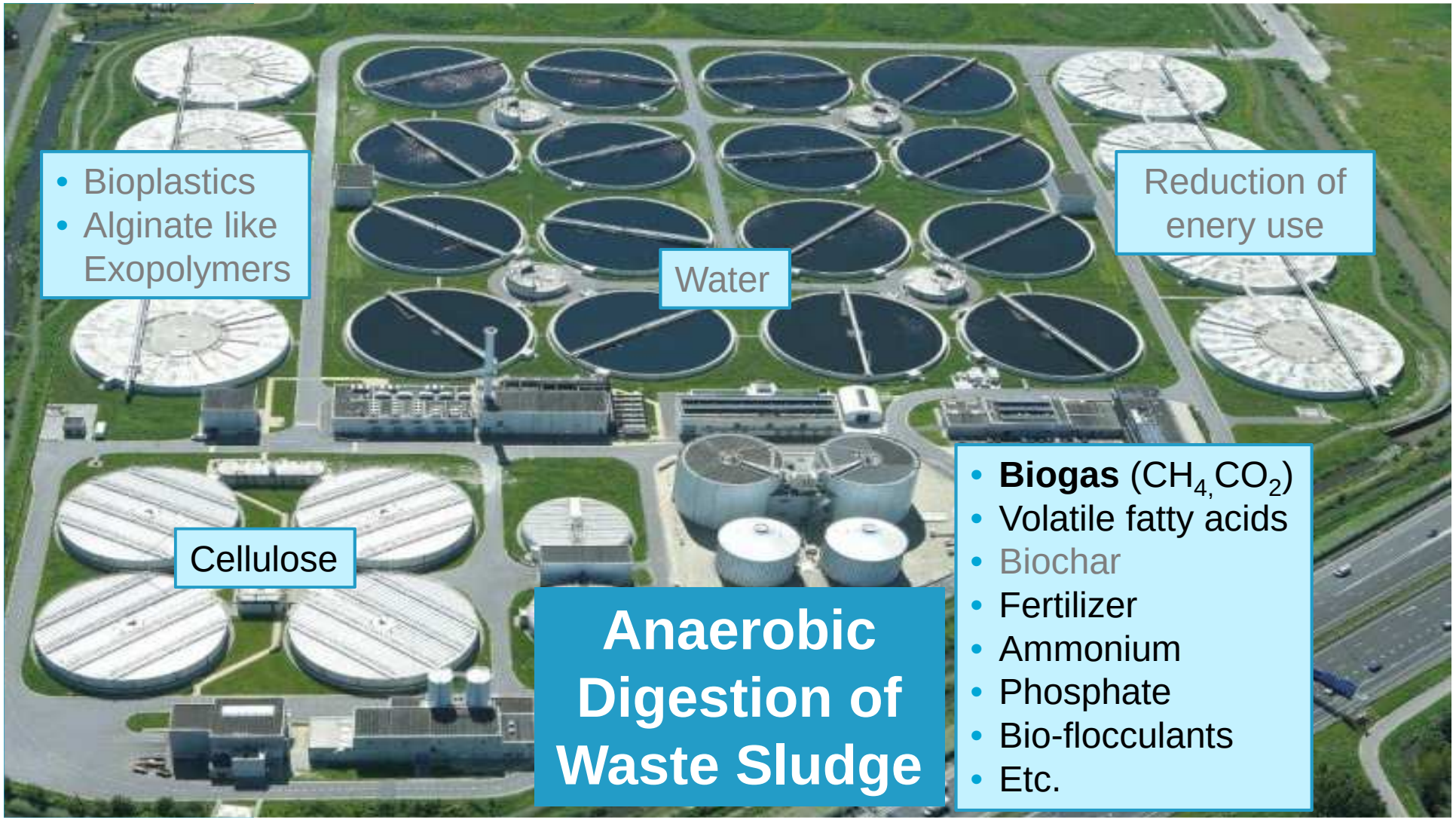
- 50-60% less energy requirement
- TN < 7 mg/L
- TP < 1 mg/L

Technology invented too late for WWTP Harnaschpolder…

…but maybe not for Hong Kongs Sha Tin WWTP

75% less area, 30% less energy* en less construcion materials needed for wastewater treatment= cheap and sustainable!

** 12-25 kWh/pe/year vs. Conventional 25-75 kWh/year*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Anaerobic Digestion of Waste Sludge
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Less sludge = more degradation

- 10-15 L sludge production at 6 g/L per person/day (Appels et al., 2008)
- Sludge consists of:

Living Bacteria (10-15%)
Higher organisms
Carbohydrates (7-17%)
Proteins (25-62%,
mostly around 35%)
Lipids
DNA/RNA (1-3,5%)
Humic matter (15-27%)

Fibres (cellulose, plants)
Cel fractions
Clay and precipitates
Heavy metals
Hair
OMP
Plastic

(percentages are weight percentage VSS, From Gonzalez et al, (2018))

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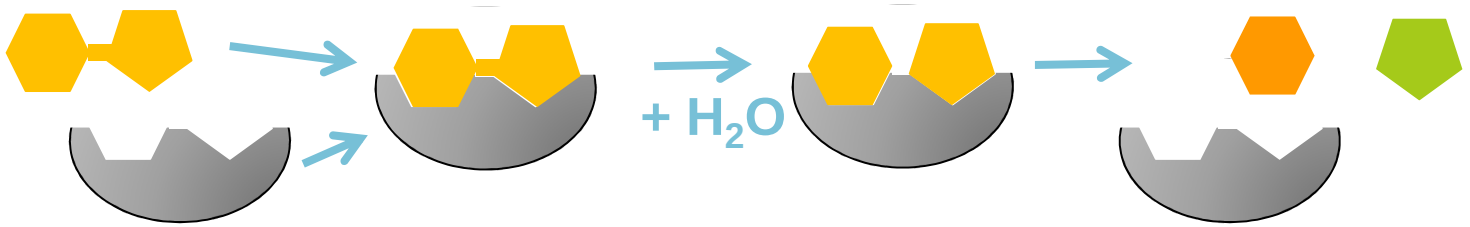
Considerations for recovery – biogas, VFA

Sludge ⇩ ⇔ Sludge conversion ⇧ ⇔ Biogas production per g ⇧

Conversion ⇧ ⇔ Dewaterability ⇧ ⇔ processing costs ⇩



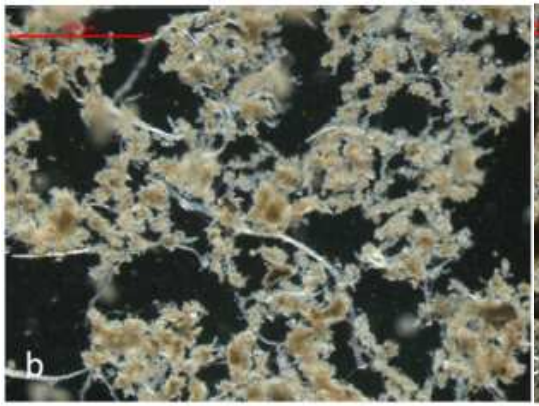
Enhanced by:

- Pre-treatment of sludge
- Increased mixing
- Different reactor design, e.g. plugflow

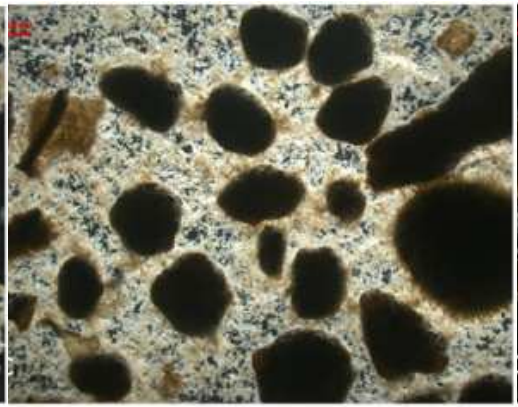
} Current research focus

Digestion of waste AGS

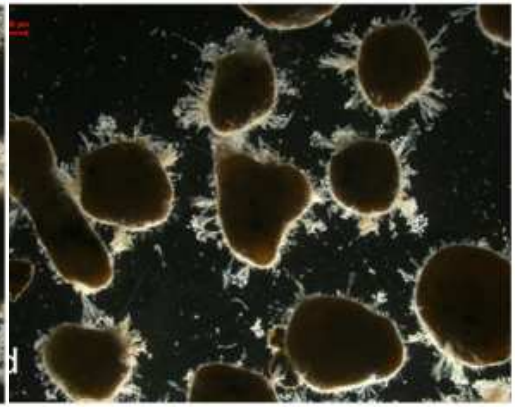
Waste granular sludge



AGS



Washed granules



Concluding remarks

- AGS technology reduces energy use, building material, and spaces, while very good effluent quality is reached
  → even for water reuse
- Primary sludge ends in the flocculated fraction or waste granular sludge, leading to high biogas recovery from WAGS
- SEPS is a biopolymer, that is not easy to degrade, gives structure to the granules….
- ….and can be recovered as a product

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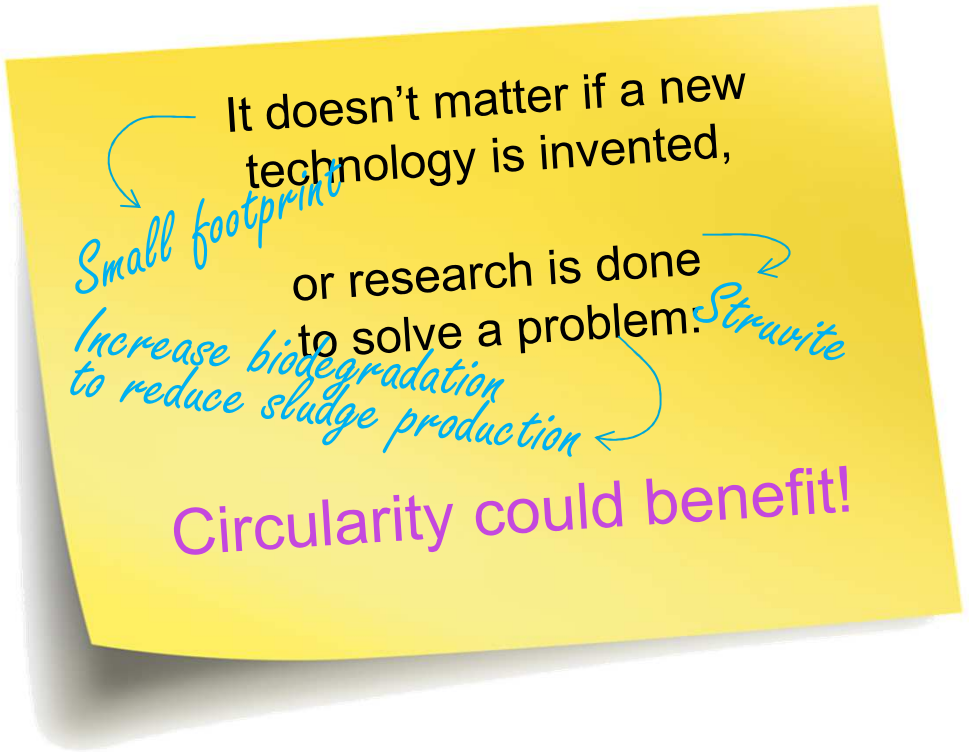

It doesn't matter if a new technology is invented,
Small footprint
or research is done to solve a problem:
Struvite
Increase biodegradation to reduce sludge production
Circularity could benefit!

Thanks to my AGS and AD team









Antonella Piaggio, Sara Toja Ortage, Peng Wei, Lenno van der Berg, Adrian Gonzalez
Steef de Valk, Alexander Hendriks, Hongxiao Guo, Javier Pavez

Online courses TU Delft

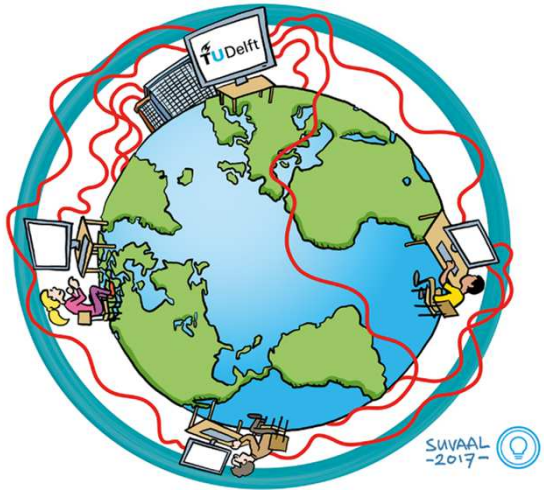
https://online-learning.tudelft.nl/courses/

Professional education courses:

- Nanofiltration and reverse osmosis in Water treatment
  10th April 2019
- High Rate Anearobic Wastewater Treatment
  15th May 2019
- **Aerobic Granular Sludge Technology**
  January 2020

Free courses:

- Urban sewage treatment
- Drinking water treatment



16TH IWA World Conference on Anaerobic Digestion

Accelerating natural cycles with anaerobic digestion

23-27 June 2019

Delft, The Netherlands

Early bird registration open till 15th of April

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