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

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Circularity and recovery (?

Economic activity → waste → Environmental problems

Mixture of undefined resources

Biological processes
Considerations for recovery - phosphate

Aim for circularity:
Clean natural fertilizer

Or do we just solve a problem?
• Bioplastics
• Alginate like Exopolymers

Water

• Biogas (CH$_4$, CO$_2$)
• Volatile fatty acids
• Biochar
• Fertilizer
• Ammonium
• Phosphate
• Bio-flocculants
• Etc.

Cellulose

Reduction of energy use
Aerobic Granular Sludge Technology

- Bioplastics
- Alginate like Exopolymers

Water

- Reduction of energy use

Cellulose

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Compact systems: Enhance settling

Bacterial growth in activated sludge...

...use granules: Aerobic granular sludge!
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**
How to make Granular Activated Sludge?

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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)
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
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

Technology invented too late for WWTP Harnaschpolder...

...but maybe not for Hong Kongs Sha Tin WWTP
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Anaerobic Digestion of Waste Sludge

Cellulose
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%)

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

Fibres (cellulose, plants)
Cel fractions
Clay and precipitates
Heavy metals
Hair
OMP
Plastic
Considerations for recovery – biogas, VFA

Sludge $\downarrow \Leftrightarrow$ Sludge conversion $\uparrow \Leftrightarrow$ Biogas production per g $\uparrow$

Conversion $\uparrow \Leftrightarrow$ Dewaterability $\uparrow \Leftrightarrow$ processing costs $\downarrow$

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
It doesn’t matter if a new technology is invented, or research is done to solve a problem. Circularity could benefit!
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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
23-27 June 2019

Delft, The Netherlands

Early bird registration open till 15th of April