# TORWASH® sewage sludge treatment

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# TORWASH® sewage sludge treatment

Increased biogas production, highly-efficient dewatering and phosphate recovery

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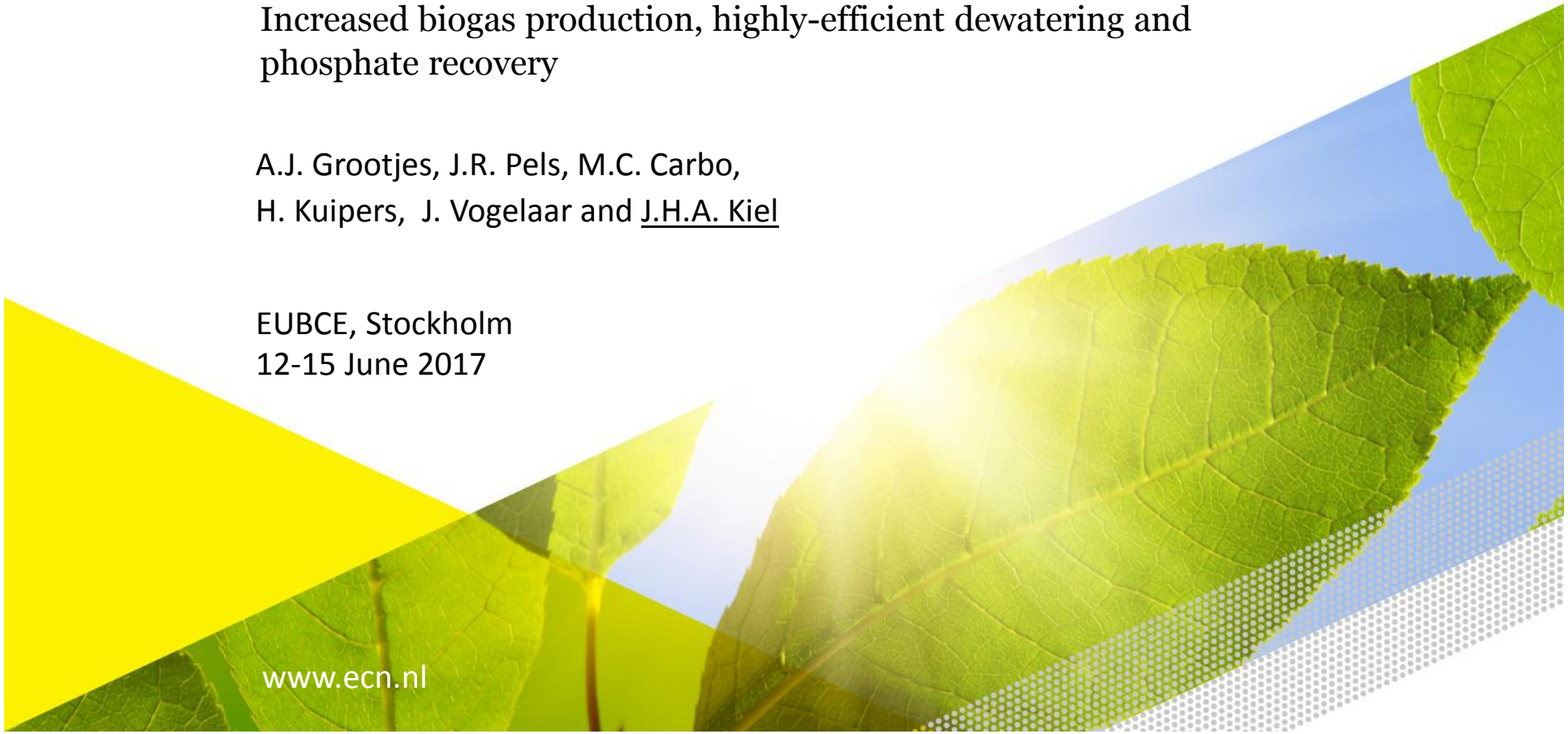

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# ECN acts as a bridge between science and corporate innovation

**Mission**

We develop knowledge and technologies that enable a transition to a sustainable energy system

Not-for-profit research institute
Founded in **1955**
**5** Commercial licensing deals / year
**500** Employees
**+/-20** patents a year
**€ 80 M** annual turnover

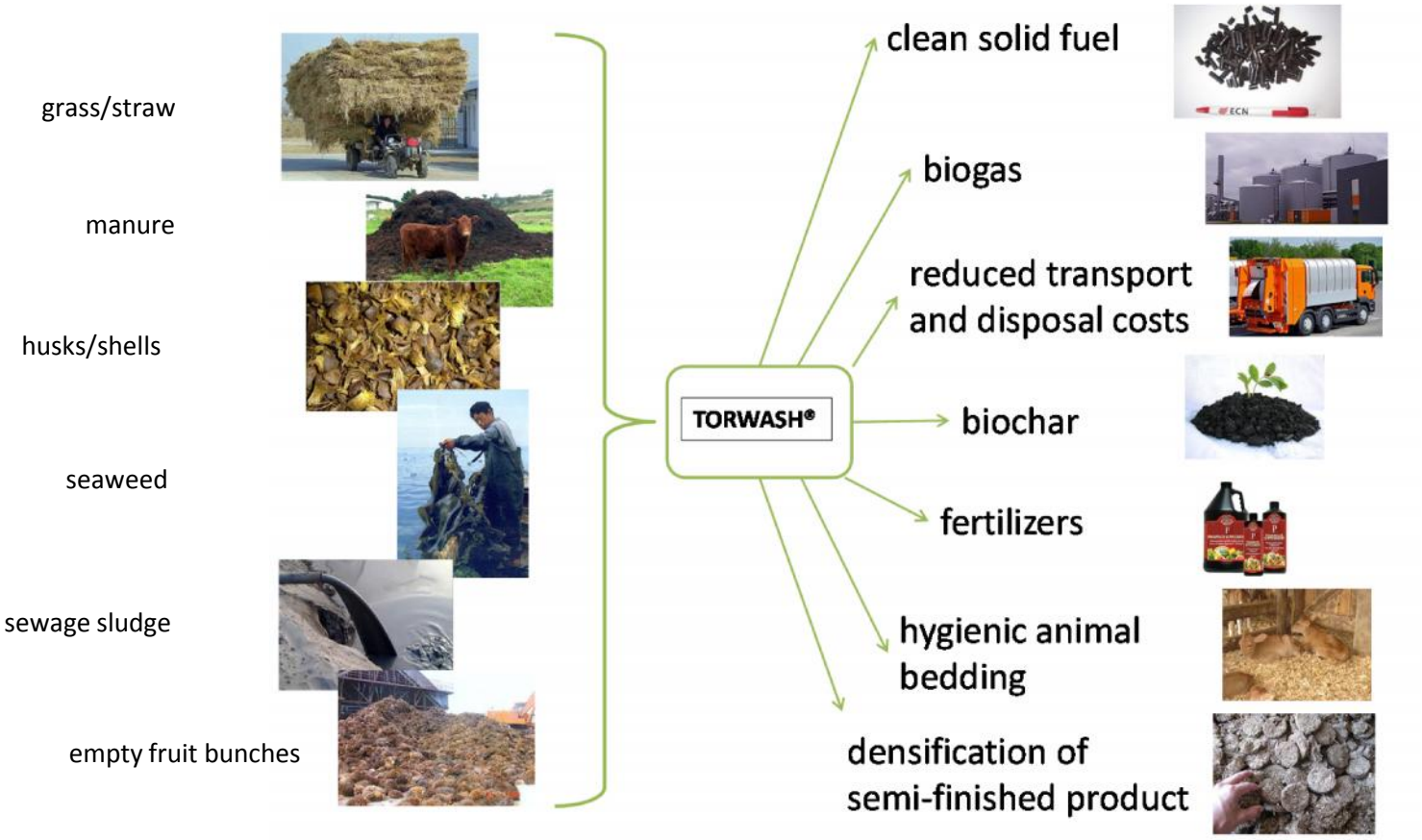
# Water Authority Zuiderzeeland

- Population: 400.000
- Largest city: Almere
- No. 1 priority: clean water, today and in the future
- Climate neutrality
- Self-sufficient in energy
- Low costs for citizens
- 5 sewage treatment plants
  - with digestion
  - without digestion

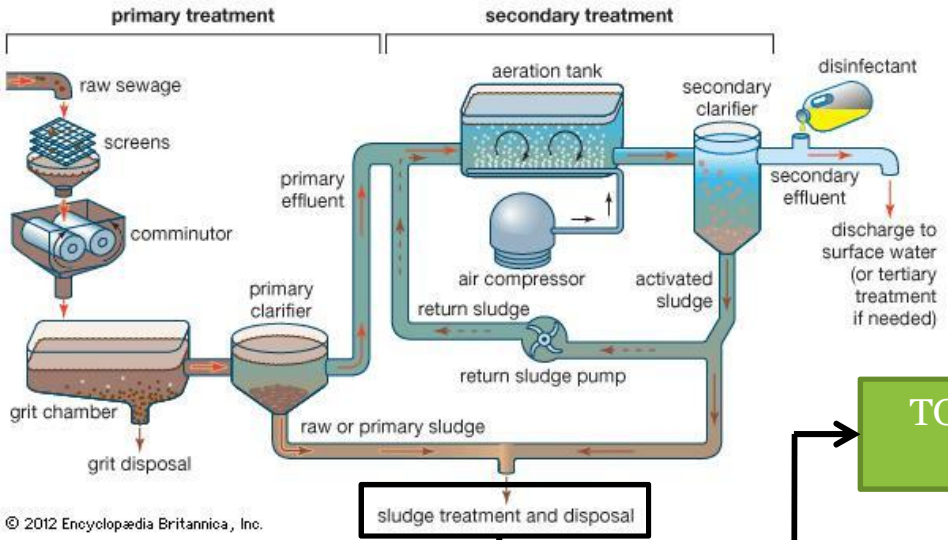
# TORWASH® = Wet torrefaction + Washing

- Upgrading of biomass feedstocks that have too much water or too much salt
- Under pressure in liquid water 150-250°C → changes in biomass structure that weaken fibres and releases water + ions
- Unique concept:
  - It enables efficient mechanical dewatering
  - It enables removal of salts to a high degree
  - Mild process conditions allow digestion of the effluent
  - ECN patent WO 2013/162355
- Goal: maximum energy in form of 2 fuels
  - Solid biomass pellets
  - Biogas from digestion of effluent
- Latest development: controlled release of phosphorus

# TORWASH® : A multi-purpose process for green solutions



# TORWASH® → Digestion




Sewage sludge

8-12 wt% dry matter

TORWASH® Reactor

Press

Liquids

Anaerobic Digester

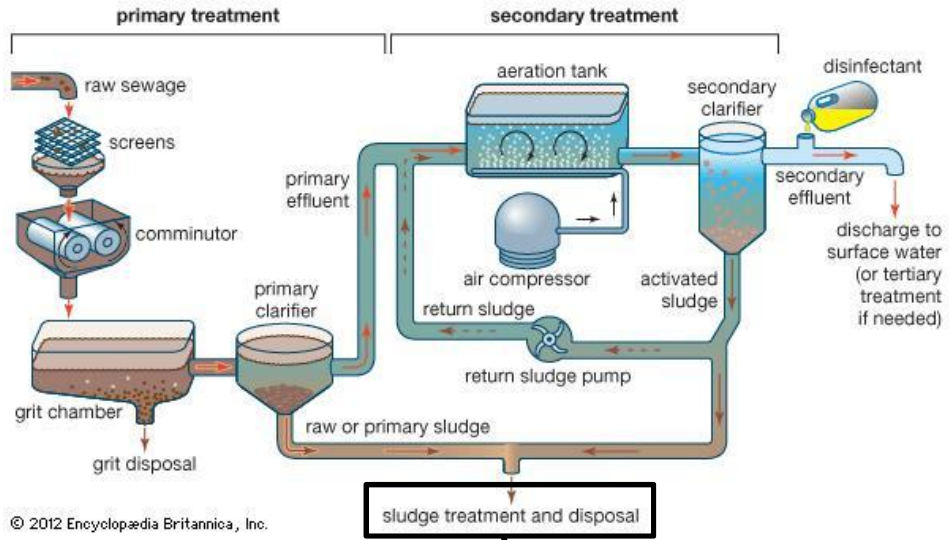
Liquid Effluent No Solids

>60 wt% dry matter

Dewatered cake

incinerator

# Digestion → TORWASH®




>60 wt% dry matter

Dewatered cake

Press

Liquids recycling

TORWASH® Reactor

10 wt% dry matter

Slurry digested sewage sludge

Filter

Liquid Effluent No Solids

Sewage sludge

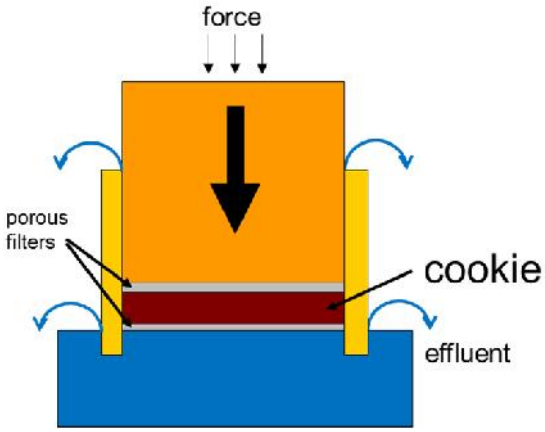
8-12 wt% dry matter

# Project TORWASH® of sewage sludge

- Experimental programme
  - Two kinds of sewage sludge: digested and undigested
  - (Three kinds of manure (cows, pigs, chicken))
  - Testing in 20L autoclave with sewage sludge “as received”
  - Slurry pressed in Carver Die (2¼ inch)
  - Digestion tests, batch 18-25 days

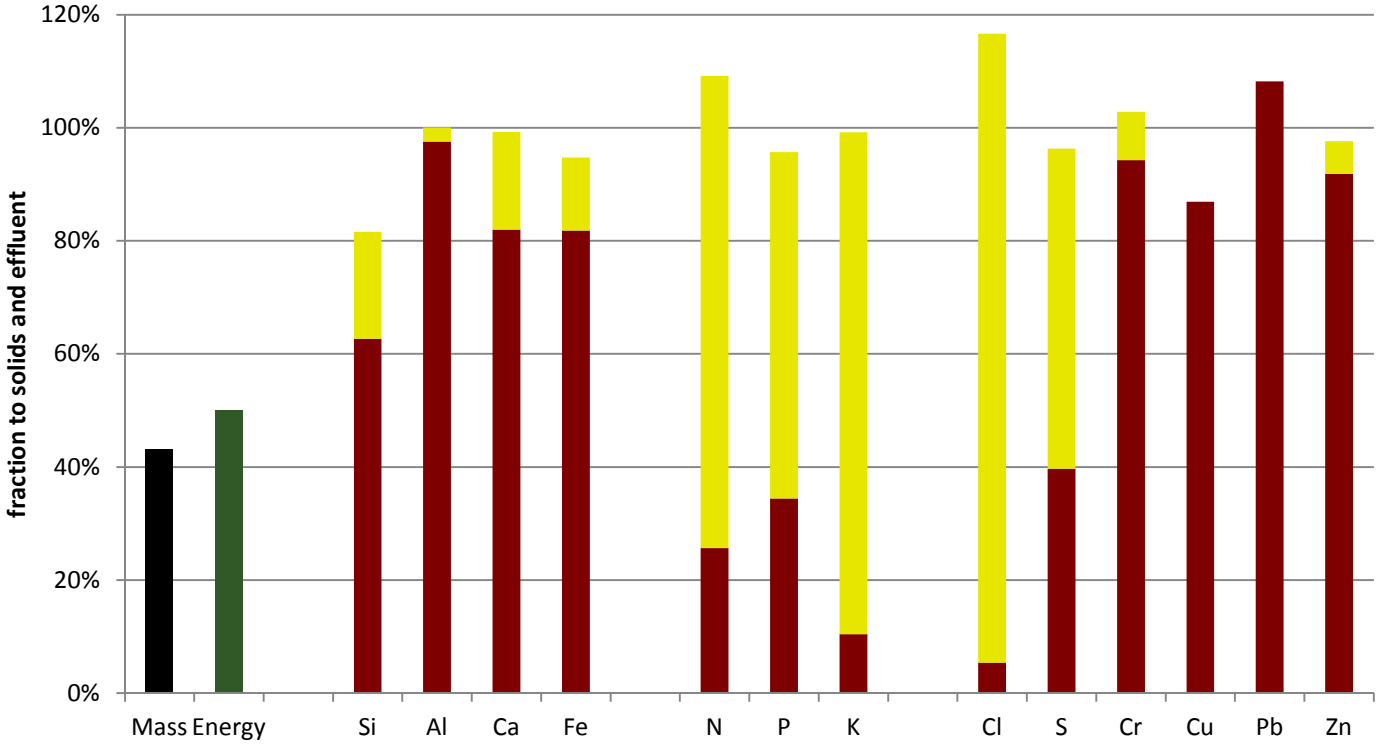
- Highly efficient mechanical dewatering
  - modern sludge presses reach 21-24% dry matter
  - manure separator: up to 20% dry matter

| | Sludge | Press cake |
|---|---|---|
| | before TORWASH® | after TORWASH® |
| Undigested sludge | 8-12% | 67% |
| Digested sludge | 8-12% | 61% |
| Manure | 5-20% | 67% |



# TORWASH® of undigested sludge

## Distribution of elements




K and Cl: >90% in effluent

nutrients mostly in effluent

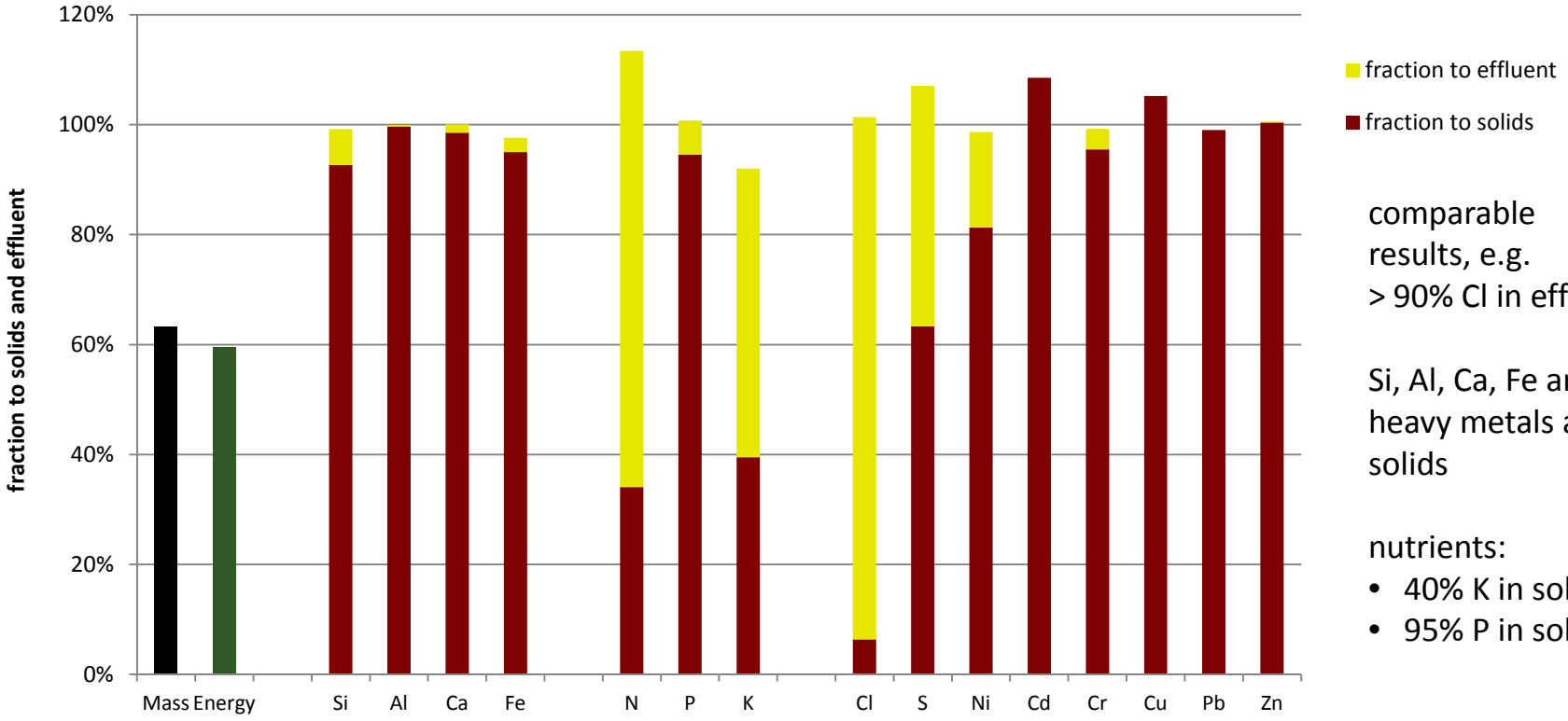
Si, Al, Ca, Fe to solids

heavy metals stay in solids → incinerator

* Mass and Energy in solid product

# TORWASH® of digested sludge

## Distribution of elements




comparable results, e.g.
> 90% Cl in effluent

Si, Al, Ca, Fe and heavy metals all in solids

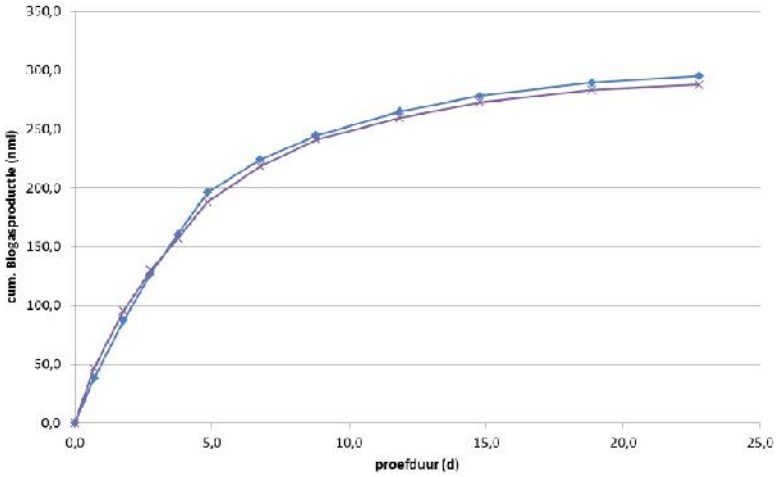
nutrients:

- 40% K in solids
- 95% P in solids

# Digestion tests


Foto 1. Glas reactor

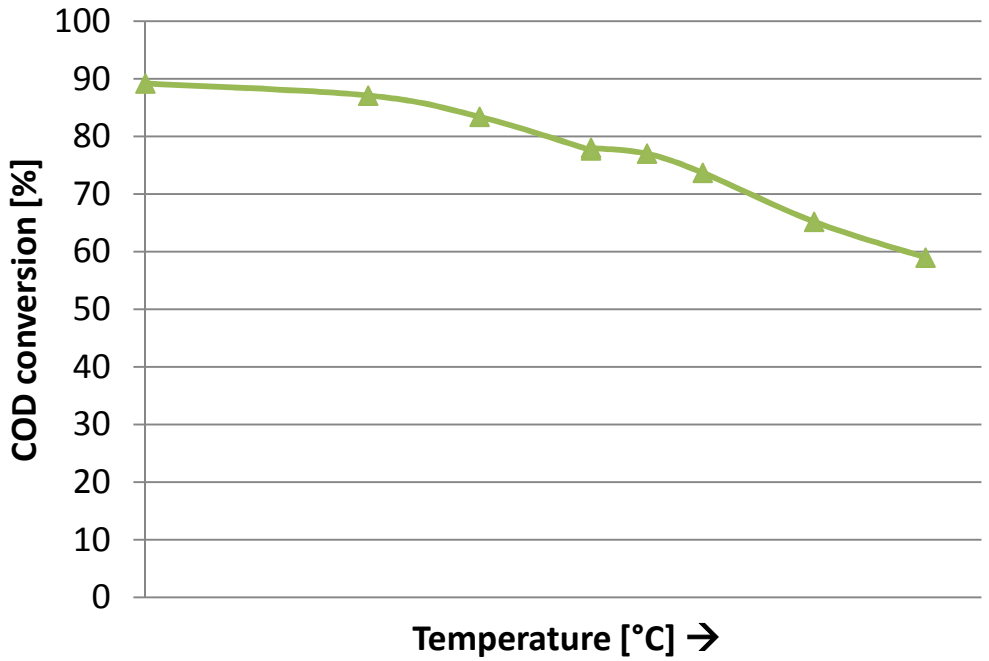

Foto 2. Broedstoven ruimte




- Batch tests at OPURE
  - 18-25 days
  - Filtered effluent after TORWASH®
- Measurements
  - COD measurements before and after
  - biogas production
  - methane content → methane production
- For TORWASH® assessment purposes, digestibility is defined as the COD conversion

# Digestion of TORWASH® effluent

## COD in effluent for undigested sewage sludge



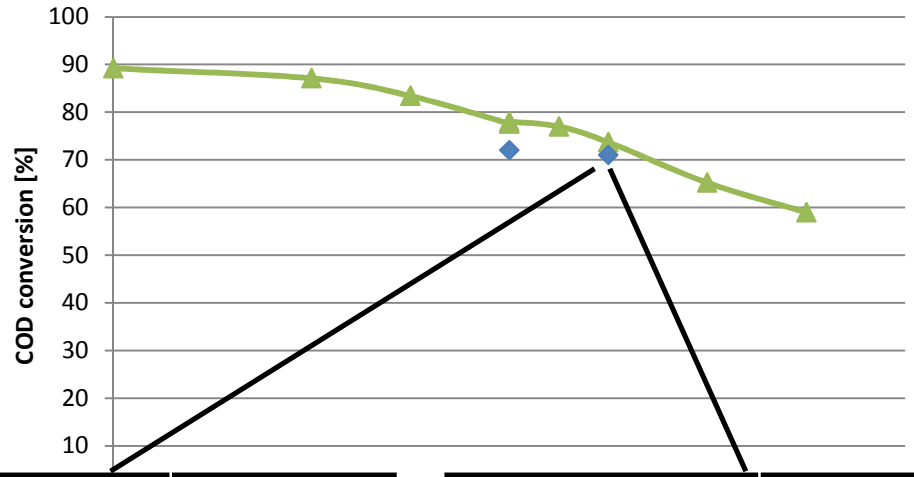

- Digestibility expressed as conversion of COD
- Gradual decrease with increasing temperature
- Digestibility is the same for effluent from TORWASH® of grass, EFB, etc.

# Biogas production

- Biogas from digestion of TORWASH® effluent
  - More than 50% of organic dry matter dissolved
  - Digestion of dissolved organic matter is fast
- High rate IC(X)-type reactor, e.g. *BIOPAQ®IC*
  - Efficient: short time: hours instead of weeks
  - Less volume, more biogas yield
  - Cost effective (low CAPEX, OPEX)

*BIOPAQ®IC*
source: Paques

# Digestion of TORWASH® effluent
## Undigested vs. digested sewage sludge




| Dry matter content | |
|---|---|
| After centrifuge, before TORWASH® | 8% w/w |
| After TORWASH® and dewatering | 61% w/w |

| COD conversion | 71% |
|---|---|
| Biogas yield | 11.1 $Nm^3/m^3$ |
| Methane content | 69% v/v |
| Methane yield | 7.6 $Nm^3/m^3$ |

- Digestion expressed as conversion of COD
- Green = undigested sludge
- Blue = digested sludge
- Effluents equally well digestible

# Methane and energy yield in different configurations

- TORWASH® + digestion of only effluent gives the same amounts of biogas as TPH + full classic digestion (= +10% compared to classic digestion)
- TORWASH® of digestate after classic digestion:
  - Digestion of effluent gives extra biogas, solid product easy to dewater
  - Effluent may be recycled back to main digester → open question

| Process configuration (starting with undigested sludge) | Current situation (only centrifuge) | Classic digestion | Classic Digestion with TPH | TORWASH® → IC(X) digestion | Classic Digestion → TORWASH® → IC(X) digestion |
|---|---|---|---|---|---|
| Methane Production [$Nm^3$/kg organic dm] | 0 | 0.13 | 0.14 | 0.14 | 0.19 |
| Dry matter content of press cake after dewatering [wt%] | 21 – 24 | 21 – 24 | max. 30 | > 65 | > 60 |
| Total energy production * [MJ/kg organic dm] | 2.8 | 6.3 | 7.0 | 11.7 | 12.2 |

* Energy production is sum of thermal values of two fuels, biogas and press cake, based on LHV

# P-recovery via TORWASH®

- Sewage sludge and manure contain large amounts of phosphorus
- Solubility of phosphorus changes with TORWASH® chemistry
  - Temperature is one parameter …
  - … but limited by TORWASH® optimization
  - Other conditions used to manipulate P
- Fate of P can be controlled in TORWASH®
  - 95% P in solids is possible
  - 95% P in effluent is also possible
- Effluent from TORWASH® may contain double the amount of P compared to effluent from TPH

# Summary

- Lab tests have been successful for both digested and undigested sludge
- Main result: Sewage sludge converted into solid fuel and biogas
  - Chemical changes enable efficient dewatering and salt removal
  - Digested and undigested sludge: press cake > 60% dry matter
  - Effluent from TORWASH® digestible, but it gradually loses digestion capability with increasing temperature
    - At preferred TORWASH® conditions about 70% digestibility
  - TORWASH® of digested sludge gives extra biogas
  - Two TORWASH® process configurations that boost energy production
- Fate of Phosphorus can be controlled for recovery
  - Temperature is just one parameter that determines fate of P and other elements
  - Other parameters used to control P → fertilizer, via effluent or via solids

# Consortium

This presentation was made in close cooperation with Water Authority Zuiderzeeland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