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TORWASH® sewage sludge treatment

Increased biogas production, highly-efficient dewatering and phosphate recovery

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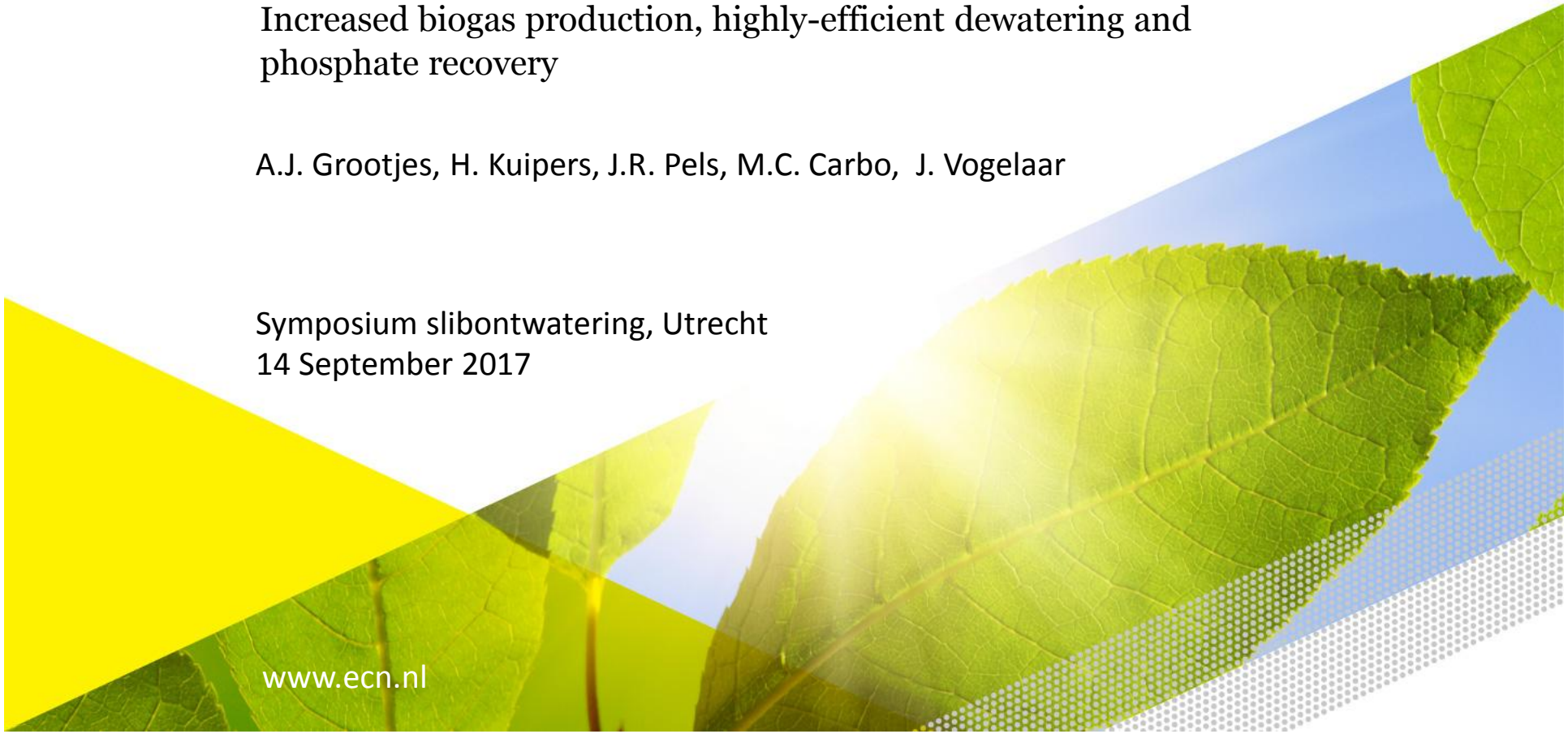

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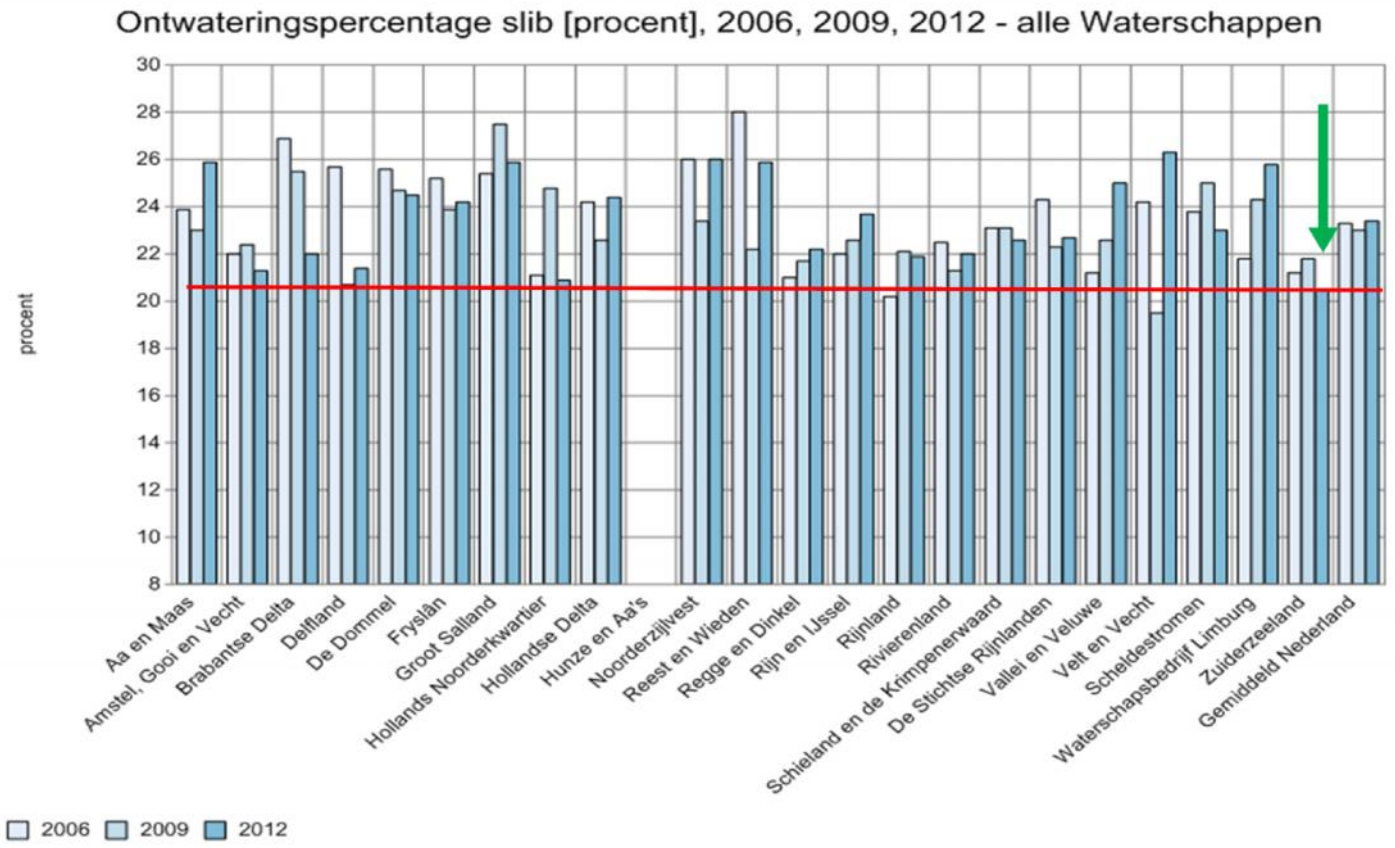


Waar het mee begon

- Bestuur ZZL wil minder en droger slib, meer duurzame energie en grondstoffen
- 2015 1- 1,5 % droger door procesvoering
- 2018 10% minder slib door Ephyra
- 2018 -2020 dosering kationen ???
- 2017-2030 groei in Flevoland

- ZZL na 2018 34.000 ton slibkoek, circa € 2,5 miljoen, (nu in NL circa 110 miljoen)
- Verbetering ontwaterbaarheid minimaal
- Er blijft altijd slib over!!

“haal eruit wat erin zit, doe datgene weg waar je niets meer mee kan en doe dit zo goedkoop mogelijk”

Hoe? “zo goedkoop mogelijk”

Kunnen we de hoeveelheid slib niet verder verkleinen? en is er nog een waarde aan toe te kennen?

In 2015 mogelijk het antwoord gevonden:

TORWASH® ???

ECN acts as a bridge between science and corporate innovation

Mission

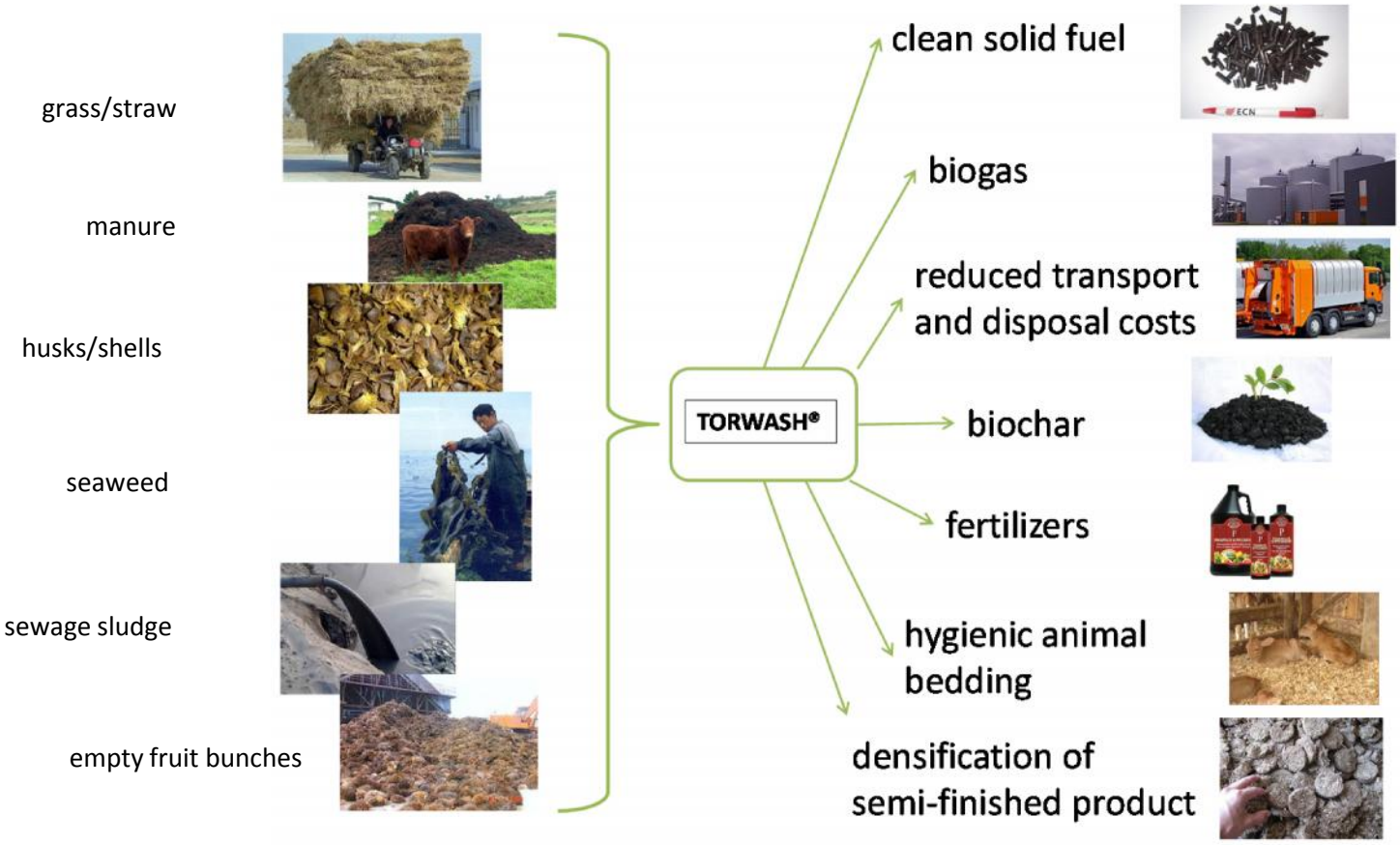
We develop knowledge and technologies that enable a transition to a sustainable energy system

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

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 recovery of phosphorus

TORWASH® : A multi-purpose process for green solutions



Why is TORWASH® unique?

Because:

- It enables efficient *mechanical* dewatering
- It opens up biomass and thus enables complete removal of salts
- Its mild process conditions allow digestion of the effluent to biogas
- It doesn't use additives:
  - no catalysts
  - no pH control
  - no flocculants
  - no enzymes

The TORWASH® promise
Almere as an example

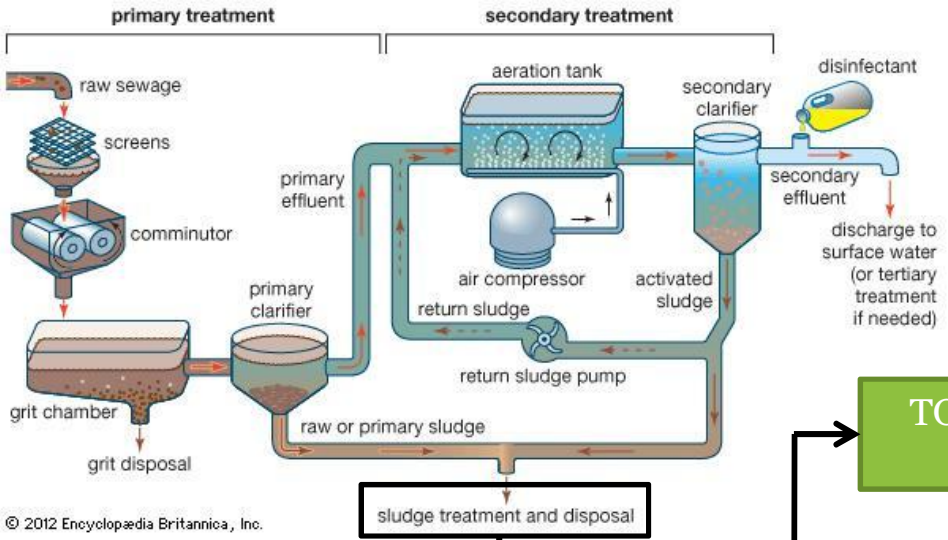
	Dry matter	Volume [ton]	Disposal costs*
Centrifuge	8%	56 000	
Existing Press	**21%**	**21 000**	**M€ 1.3**
Best Press	24%	19 000	M€ 1.1
THP	30%	15 000	M€ 0.9
TORWASH®	**65%**	**3 100**	**M€ 0.2**

* € 60 per ton "as received" in all cases

repeatedly obtained for various raw materials

- Amounts of sludge reduced from 21 to 3 kton/year
- Potential savings on disposal costs € 1.1 million/year
- Additional savings when polyelectrolyte (PE) is no longer needed: € 0.2 million/year

TORWASH® → Digestion



Sewage sludge

8-12 wt% dry matter

TORWASH® Reactor

Press

Liquids

Anaerobic Digester

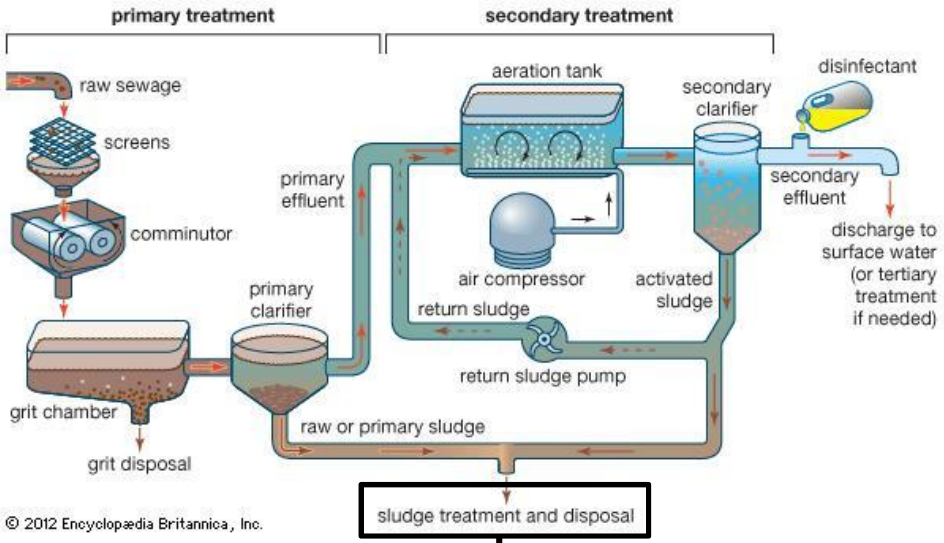
Liquid Effluent No Solids

>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

Visible effect of TORWASH®

Sludge from AWZI Almere before and after TORWASH®

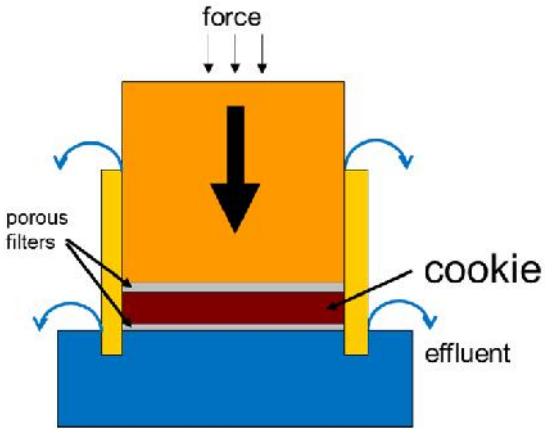
- Left: untreated sludge
- Right: TORWASHed sludge

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

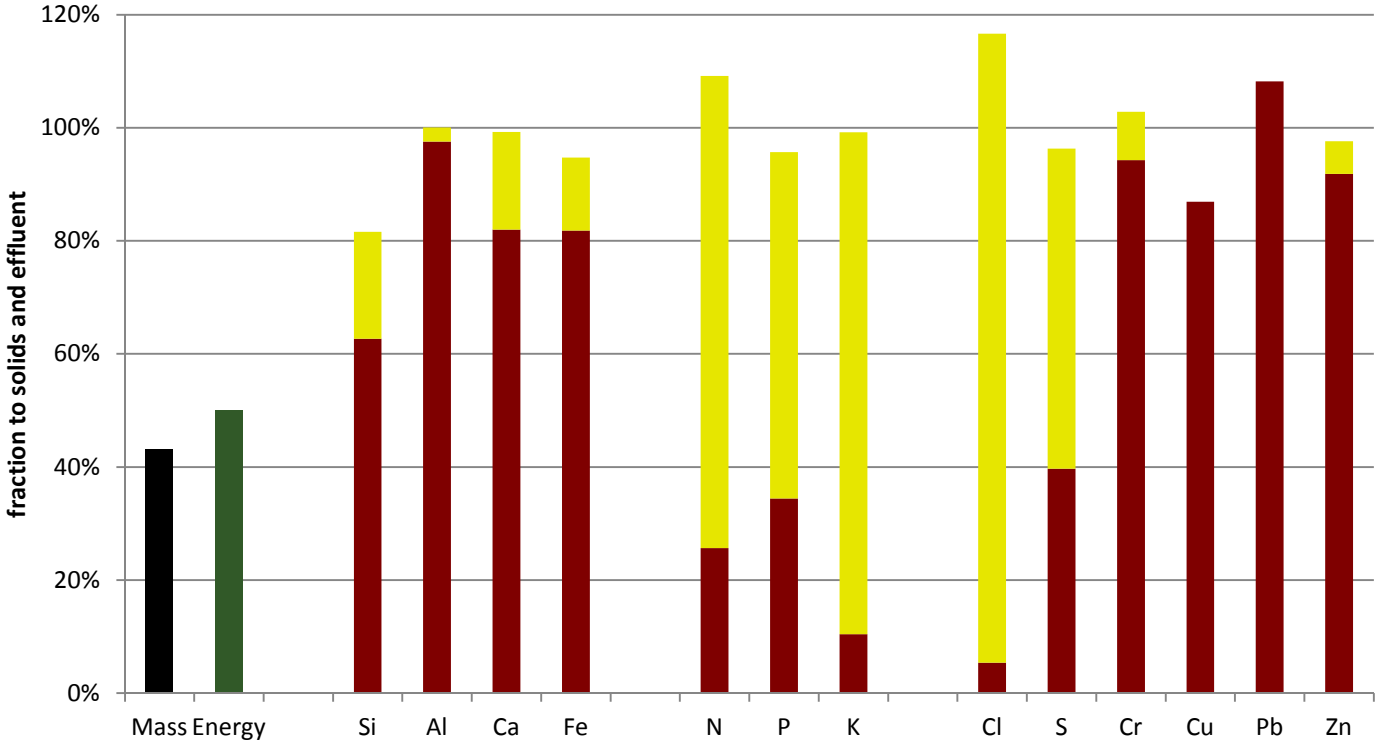
- Highly efficient mechanical dewatering
  - modern sludge presses reach 21-24% dry matter
  - manure separator: up to 20% dry matter

	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

Fuel Quality – undigested sludge

	Moisture	Ash 550°C	Ash 815°C	Volatile Matter	Calorific Value (HHV, dry)		Calorific Value (LHV, as received)
	%	%	%	%	MJ/kg		MJ/kg
Non-digested sludge – input	95	16	16	69	19		negative
Non-digested sludge – product	33	21	20	64	22		13
Wood chips	8	2.6	2.1	79	19		16
Coal mixture	3	-	12	32	24		22

	C	H	N	S
	%	%	%	%
Non-digested sludge – input	42	6.2	6.9	0.8
Non-digested sludge – product	49	6.3	4.1	0.7
Wood chips	48	6.5	0.5	0.04
Coal mixture	72	4.5	1.4	0.85

municipal waste
10 MJ/kg
(LHV, wet)

Values are on dry basis, except moisture

TKI-BBEG EnCORE

EnCORE (Efficiente Cascadering en Opwerking Rioolslib voor Energie-neutrale bedrijfsvoering)

Doel: Het doel is meer biogas en grondstoffen uit zuiveringsslib te produceren t.o.v. een klassieke slibvergister, door adaptatie en optimalisatie van de combinatie van een 'Upflow Anaerobic Sludge Blanket' (UASB) vergister van slib dat middels TORWASH® is voorbehandeld.

Activiteiten:

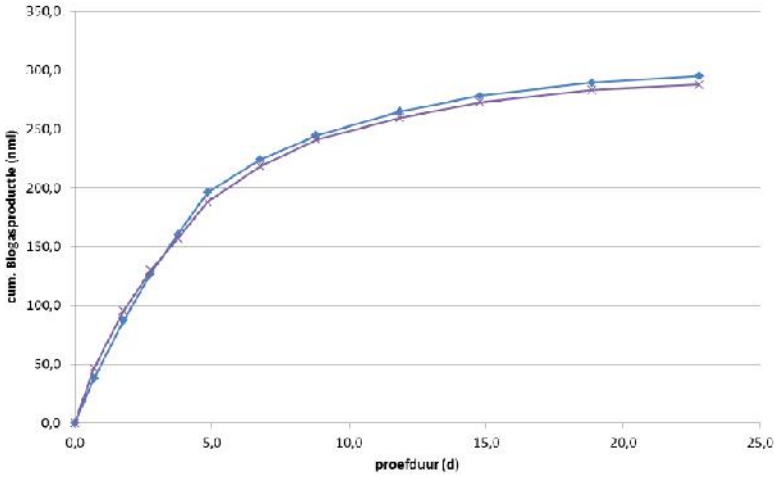
- Kleine schaal vergistingstesten
- Pilotschaal TORWASH® testen (Almere)
- Adaptatietesten effluentvergisting
- Kwantificeren fosfaat terugwinning

Na EnCORE: opschalen naar volleschaal demo

Digestion tests


Foto 1. Glas reactor

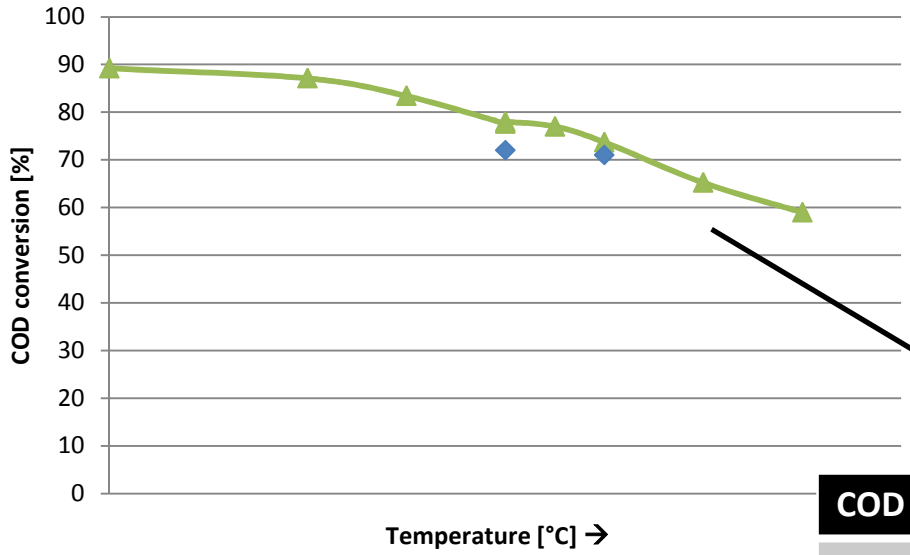
Foto 2. Broedstoven ruimte



- 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

Undigested vs. digested sewage sludge



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

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

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

Process configuration (starting with undigested sludge)	Current situation	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

P-recovery via TORWASH®

- Sewage sludge and manure contain large amounts of phosphorus
- Solubility of phosphorus changes with TORWASH® chemistry
  - Temperature is the most important parameter
- 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
- Pilot TORWASH® reactor will be tested (EnCORE project)
- 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
  - TORWASH® of digested sludge gives extra biogas
  - Two TORWASH® process configurations that boost energy production
- Fate of Phosphorus can be controlled for recovery
  - Temperature determines fate of P and other elements

Consortium

This presentation was made in close cooperation with Water Authority Zuiderzeeland

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