



KENNISEVENT NIEUWE SANITATIE

Een samenwerking over de grenzen heen...

28 November 2019 – Bovendonk, Hoeven (NL)

WELKOM

wifi

BovendonkGuests

welkom@bovendonk





Johan Ceulemans, VITO

DAGVOORZITTER

PROGRAMMA

12.00 - 12.50 u Ontvangst met lunch

13.00 - 13:55 u Plenaire sessie

- * Opening door dagvoorzitter – *Johan Ceulemans, VITO*
- * Duurzame sanitatie in een maatschappelijke context – *Hugo Gastkemper, RIONED*
- * Technologische ontwikkelingen decentrale sanitatie – *Jules van Lier (TUD)*

14:00 - 15:00 u Parallelle sessies

Transport | Natuurlijke systemen | High-Tec ontwikkelingen | Afvalwater tot drinkwater

15:00 - 15.25 u Pauze

15.30 - 16.30 u Parallelle sessies

Inzameling | Compacte systemen | Terugwinning grondstoffen | Toepassingen

16.40 - 17:35 u Plenaire sessie

- * Discussie met interactieve peiling – *Johan Ceulemans, VITO*

Surf met uw smartphone naar www.menti.com en gebruik de code 43 90 75

- * Panel reflectie, ontwikkelingen in NL en België “wat mogen we van toekomst verwachten”
Bert Palsma, STOWA / Wendy Francken, Vlario / Jules van Lier, TU Delft

17.35 - 18.30 u Netwerkborrel

DUURZAME SANITATIE IN EEN MAATSCHAPPELIJKE CONTEXT



Hugo Gastkemper, RIONED

Duurzame sanitatie in een maatschappelijke context

Hugo Gastkemper
Stichting RIONED

Kennisevent Nieuwe Sanitatie
Hoeven, 28 november 2019



Techniek en samenleving

- Techniek: onderschatting samenleving
- Samenleving: onderwaardering techniek
- Bruggen:
 - Vanzelfsprekendheid
 - Vervullen behoeften
 - Beschermen tegen onheil

Verschil tussen oude en nieuwe sanitatie?

- Hét verschil: schaal
- Ook: overtuiging
- Doelen gelijk:
 - Gezondheid / milieubescherming
 - Hergebruik stoffen
 - Beperking / benutting energie
 - Kostenbeheersing
 - Beperking ruimtebeslag

Wie beslist? Individu of samenleving?

- Samenleving verplicht tot omgaan met afvalwater:
 - vanwege gevaar: zuivering
 - vanwege doelmatigheid: riolering
- Individu: vrijheid beperkt.
Overheid beslist wie op riolering

Individu of collectief?

- IBA: noodzakelijke voorziening of verworven autarkie?
- Kleinschalige waterzuivering (kwzi): ook in Nederland? Van overheid of van collectiviteit?

Wat hebben we geleerd?

- Buitengebied weinig ontwikkeling: steeds hoge kosten. Hoe betalen we rioolvervanging? Hoe krijgen we betere zuivering ter plaatse?
- Communaal sterke verbetering: beheerste kosten, terugwinning stoffen, energie (en effluent), verwijdering nieuwe stoffen
- Verschilmaker: technologie

TECHNOLOGISCHE ONTWIKKELINGEN DECENTRALE SANITATIE



Jules van Lier, TU Delft

(R)Evoluties in de afvalwaterketen?

Opmaat naar circulariteit ?

Jules van Lier / j.b.vanlier@tudelft.nl
28 november 2019

Sewage:

- We “produce” about 125 L/p.day (25-500)
- Clean water becomes sewage (99,9% = water)
- Contains fecal matter, urine
- Contains pathogens
- Contains detergents, micro pollutants
- Stinks and smells
- Nuisance when not managed well
- Cause of waterborne diseases

→ So, not very ‘sexy’ topic



Sewage (Netherlands):

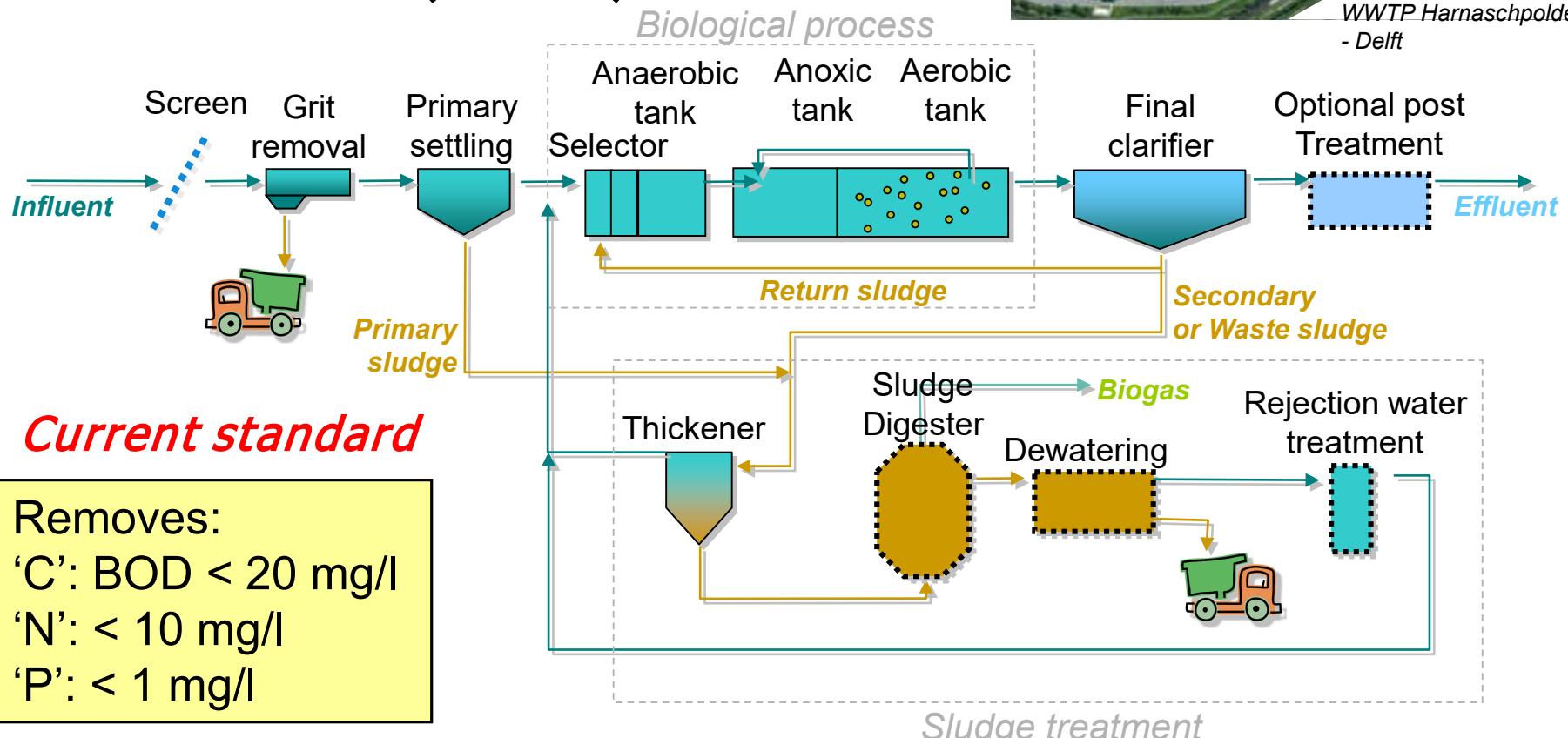


- Almost each house connected to sewerage
- All sewage is treated (C, N, P)
- Pollution & eutrophication is halted (restored ecosystems)
- Each households pays several 100 euros/year (sewerage tax, water authority tax)
- 110.000 km pipeline; 100 billion on assets (2/3 pipes, 1/3 treatment systems)
- Costs will increase in future? (higher treatment demands & assets renovation).

Job well done? This is it?



Basic WWTP process: activated sludge & biological nutrient removal (BNR)



Current challenges of Sewage Treatment Plants (STPs) in NL:

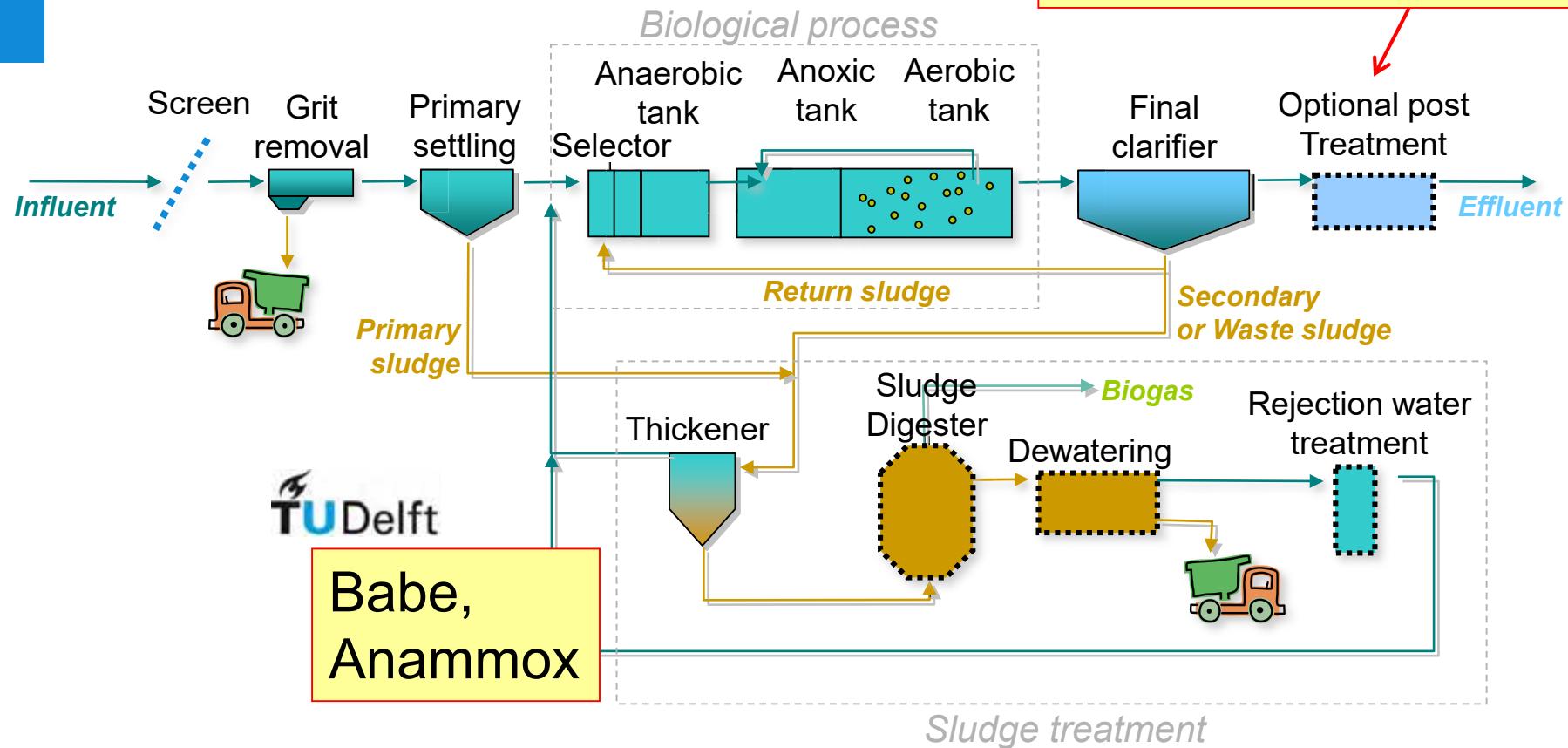
- More stringent discharge criteria (EWFD):
 - N: 10-15 → 5-7 → 2.2 mg/L
 - P: 1-2 → 0.35 → 0.1 mg/L
- Energy efficiency / less fossil fuel consumption
- Recovery of resources
- Reduction green house gas emissions (CH_4 , N_2O , etc.)
- Less/no (?) micro-pollutants in effluent
- No (antibiotic) resistant bacteria / pathogens in effluent
- Etc.

Current and upcoming effluent restrictions set the **boundary conditions** for new developments (like resource recovery)

Optimised N/P removal in BNR plant

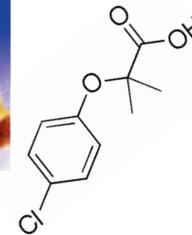


Denitrifying sand filters
Chemical P removal



Final effluent polishing?

Polishing effluents with membranes?



MF/PAC – aeration

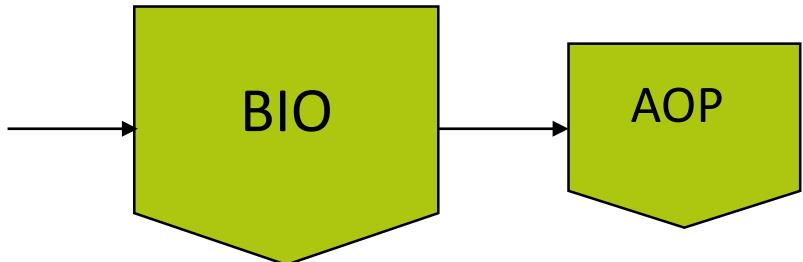


UF post treatment

Increased attention for
micro-pollutants,
pathogens, antibiotics
resistance



Advanced oxidation of effluents?

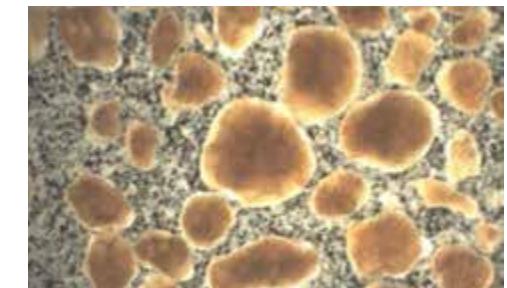


..€€€..

Techniques, eg.:

- O₃
- H₂O₂ (/UV: radicals)
- Fenton Fe³⁺/Fe²⁺ catalysis
- TiO₂ with UV light

Upgrade of activated sludge: NEREDA®



Advantages:

- 35-45% reduction energy consumption!
- 75% reduction space requirement!
- Decreased investment and operational costs
- Highly efficient for BOD (<10 mg/L), N (<10 mg/L), P (<1 mg/L)
- Produced sludge mass **source for “bio-plastics”?**



2019: More than 70 NEREDA applications



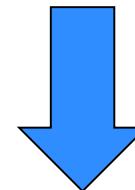
2005: Vika, The Netherlands,
5,000 p.e.

2019: Ringsend Dublin, Ireland
Ultimate capacity 2,400,000 p.e.

Agreements between **Ministry** and **Union of Water Authorities:**



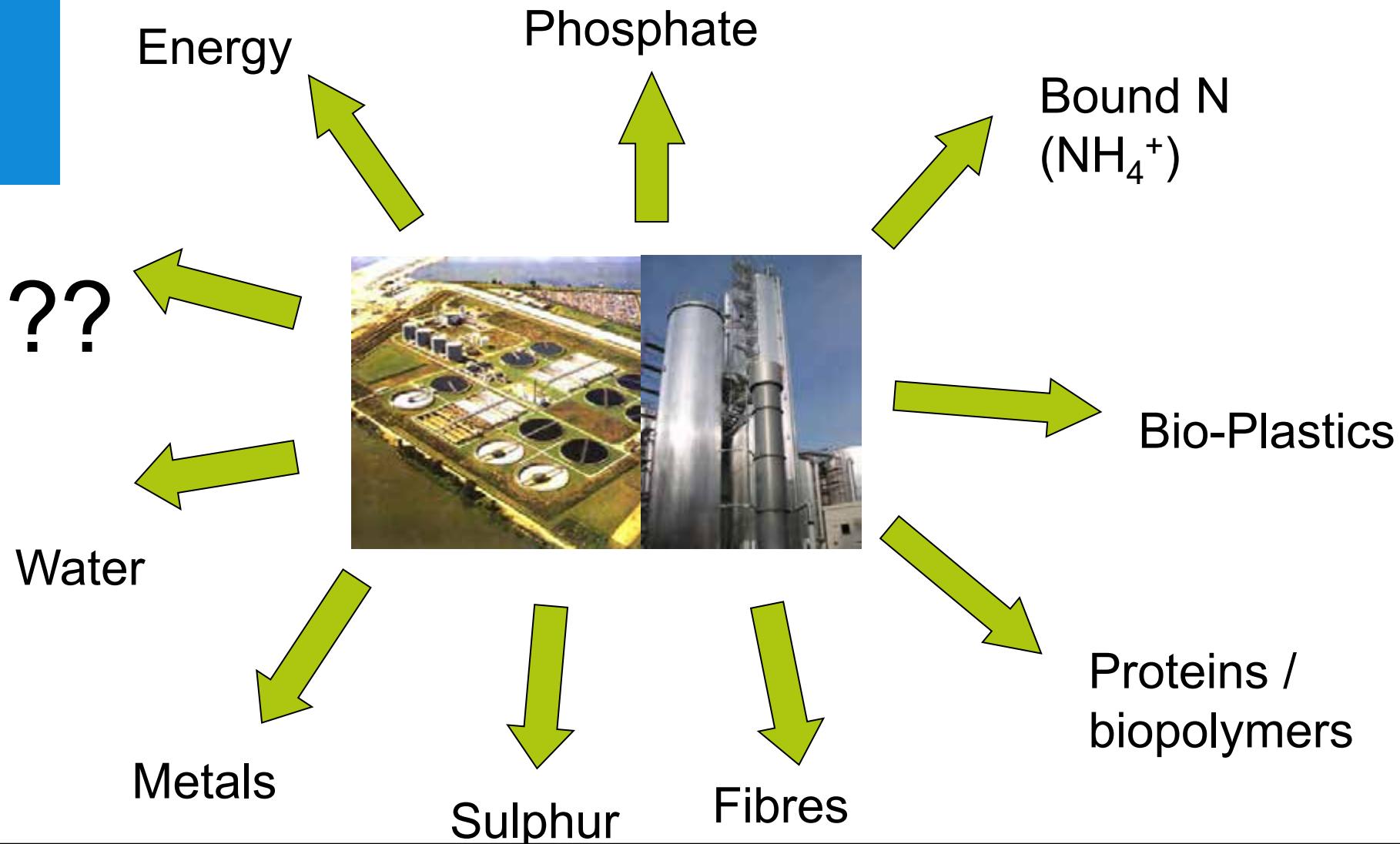
The Green Deal



The Resource Factory!

Sewage becomes sexy..!!

Resource Recovery from Waste Water?!

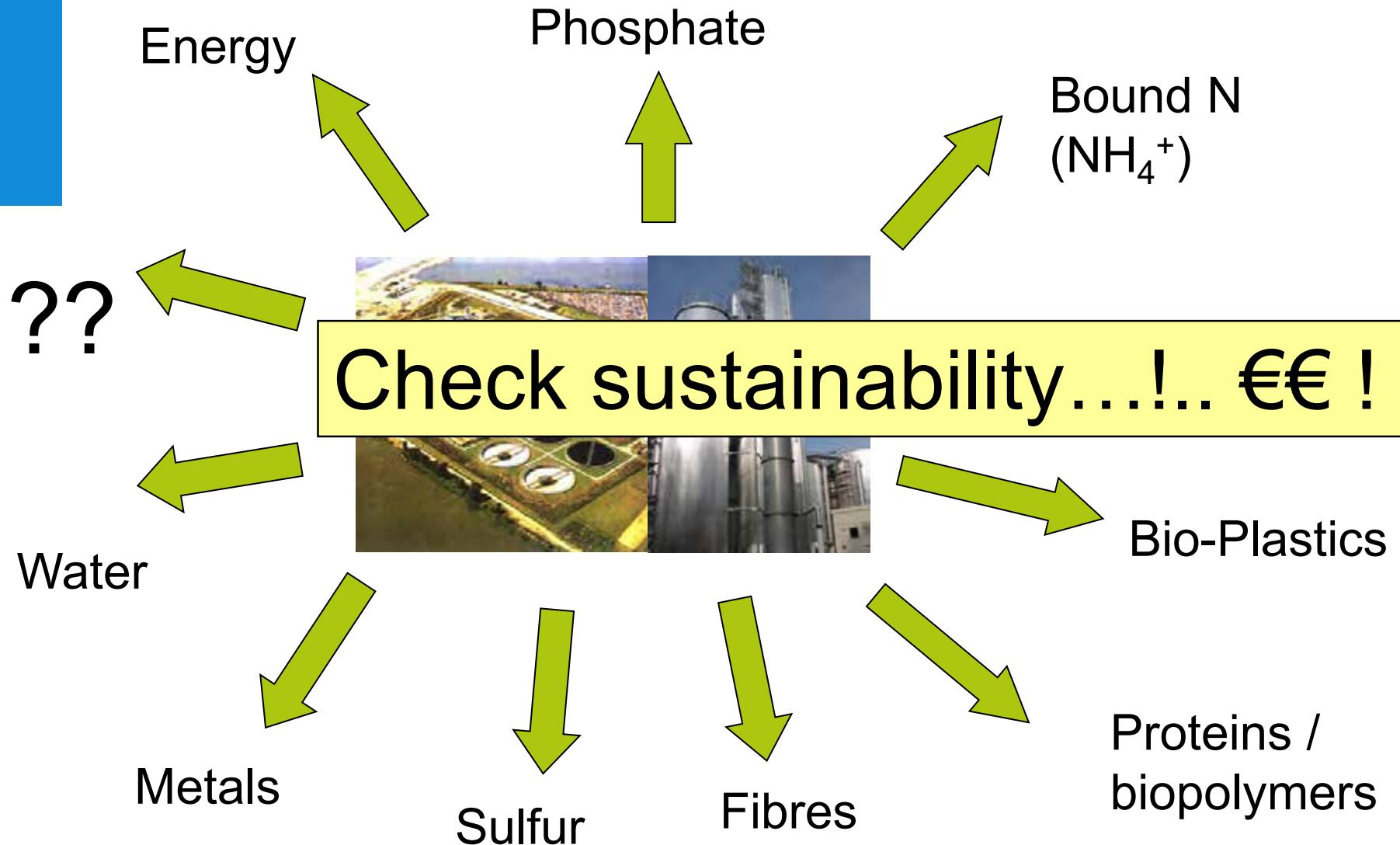


The Resource Factory as Export Product?



Earning money with sewage treatment??

Resources from Wastewater Treatment Plants



Energy (thnx to the Energy Factory!)

- Enhance digestion: CH₄! (Alkaline, THP, enzymes, plug-flow digestion)
- Improved conversion efficiency: CHP+, SOFC
- High value use: automotive, gas-grid injection
- Gasification residues (syngas)
- Thermal energy?



Eneco Delft: → effluent heat for district heating



WWTP Harnaschpolder - Delft

From centralized sewer systems:

Decentralised, in households: heat exchangers shower/bath, dish/cloth washing

Nutrients: phosphorus, nitrogen

P recovery (centralized):

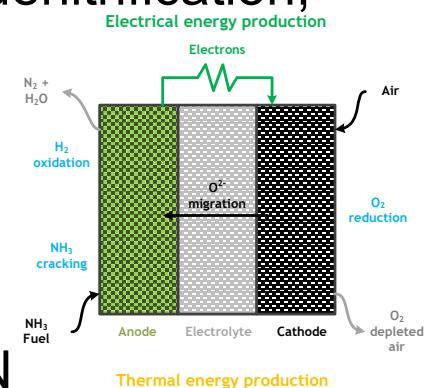
- Implemented: Airprex, Ostara, Phosphaq, other, ..
- So far: struvite $\text{NH}_4\text{Mg}(\text{PO}_4)_6\text{H}_2\text{O}$
- Low market value..! (businesscase?)
- Vivianite?, PO_4^{3-} ? From ashes?



Reduced nitrogen ($\text{NH}_4^+/\text{NH}_3$)

- Domestic wastewater: only destruction via: nitrification/ denitrification, anammox (at expense of fossil fuel)
- Direct reuse: manure / 'treated' sewage in agriculture
- Stripping and recovery: generally as $(\text{NH}_4)_2\text{SO}_4$
- $\text{NH}_4^+/\text{NH}_3$ recovery via gasphase: precursor of proteins?
- NH_3 as fuel in a solid oxide fuel cell (SOFC)?:

15 MJ/kg N or 4.2 kWh/kg N



Other resources from sewage?

Proteins?

- From waterline = No Go
- From N via gas phase?



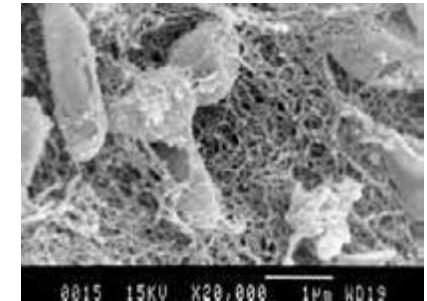
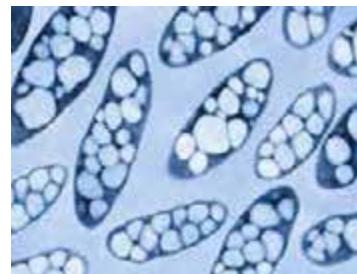
Fibres?

- Paper factory = No Go
- Fuel? VFAs?
- Road construction?!

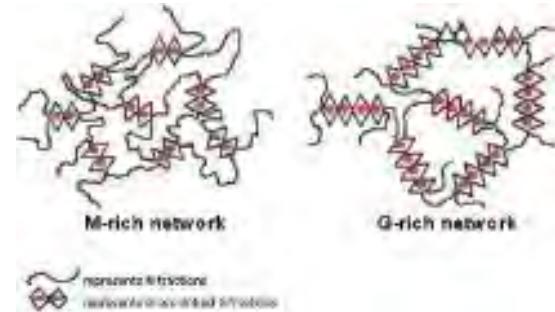
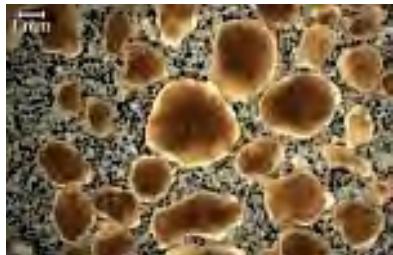


Bioplastics?

- PHA requires sugar-rich WW..
- Downstream processing..?
- Overrated benefits...?
- Kaumera (Nereda) offers potentials



Alginate-like biopolymer in NEREDA granules



15-25% of structural gel

Opening: 02-10-2019
Biopolymer recovery plant



Winner of the 2019 AquaTech Innovation Award (Nov. 2019)!

Decentralised – Centralised..

What problems do we solve / What objectives do we pursue?

Reducing costs at STP / Conveyance network?

- Reducing operating costs?
- Reducing construction costs?
- Driving new businesses?

Recovery of resources?:

- At what scale recovery economically feasible?
- Can recovered resources be used locally? Market price?
- Is (frequent) truck transport requested?

What about water?:

- Local need for (alternative) fresh water resources?
- Decentralised users: decentralised collection
- What is decentralised? 100? 1000? 10.000? 100.000? 1.000.000?

Use of Treated Sewage in NL

- Centralized recovery (treated sewage as reliable water source)
- Treated sewage upgraded in water factory for industrial reuse
- With adequate treatment of concentrate: concomitant accomplishment of current and future effluent (FWD) criteria



WWTP Emmen



Terneuzen



DOW



Global urban water scarcity: potentials for treatment & reuse / multiple use



Water scarcity:

- ✓ Threatens urban health
- ✓ Loss of labour hours (illness)
- ✓ Increases social inequity
- ✓ Scares off (large) industries
- ✓ Limits economic growth!
- ✓ Competitive claims!!





Decentralised
treatment and
water reuse

UASB + biotower trickling filter
Residential area Merida, Mexico



Embedding decentralised treatment & reuse in condominium: Fortaleza, Brasil

- Sewage from about 150 p.e
- UASB + SAF + Sandfilter + chlorination
- Effluent reuse in gardening



Decentralised sewage treatment for water reuse (in landscaping)

- Sewage from 12.000 p.e
- UASB + SAF + Sand filter + chlorination
- Effluent reuse in landscaping (Beach-Park) and combatting sea water intrusion



Clean effluent!



Engineer Paiva!



Combined anaerobic-aerobic treatment in single reactor: BIOPAQ®UBOX REACTOR

Balneário Camboriú – SC, Brasil

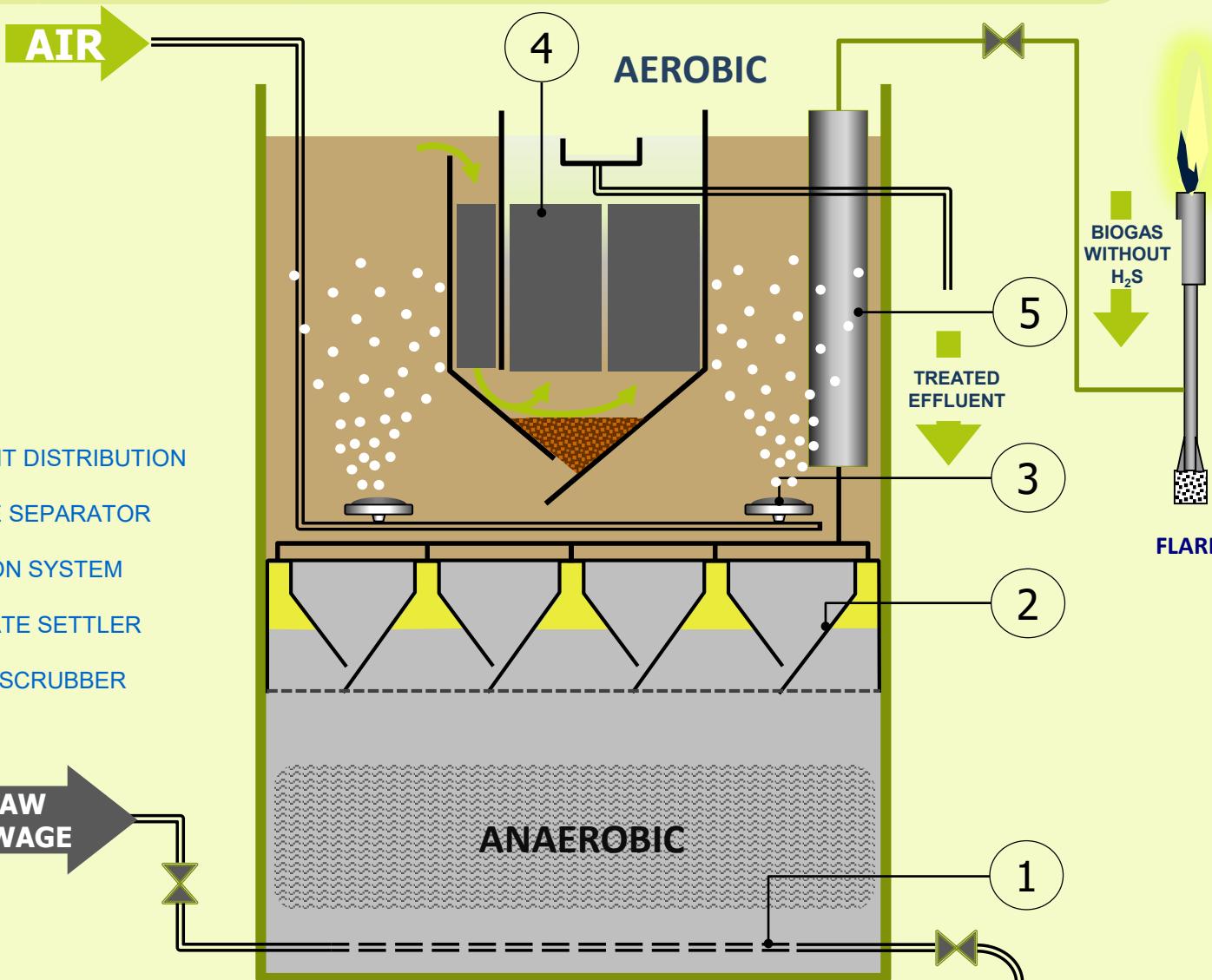
Capacity: 6.000 inhabitants

STP includes tertiary treatment (N + P + SS removal of nitrogen)

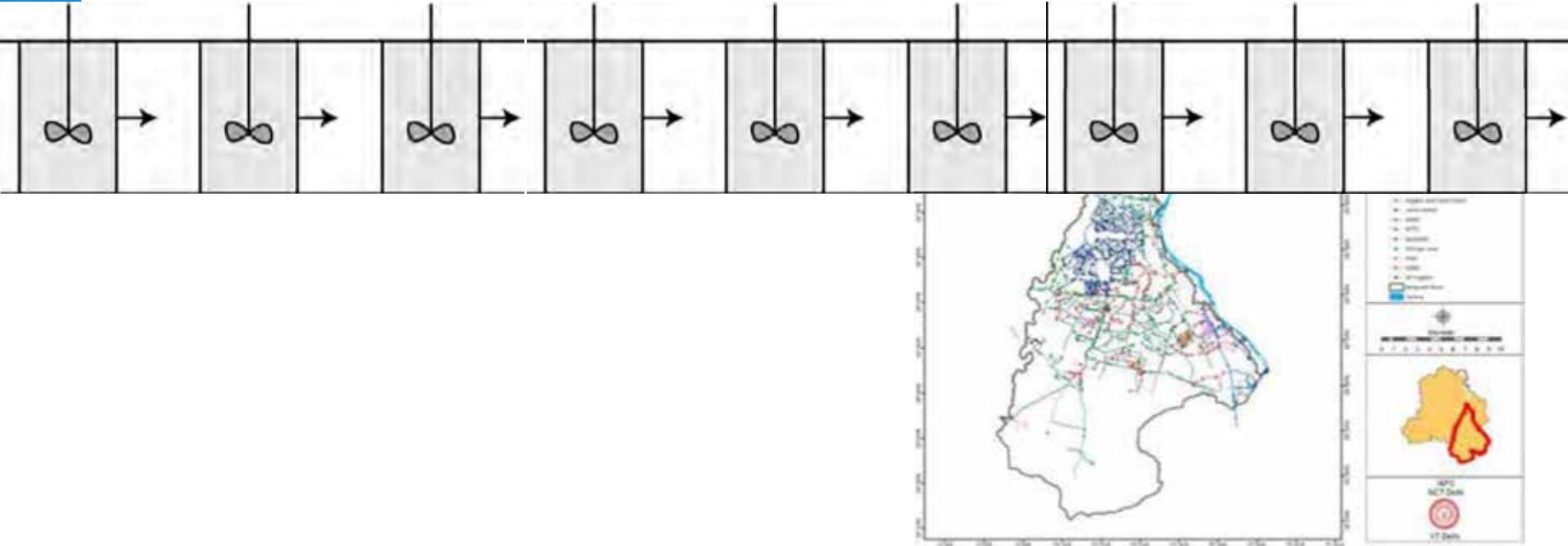


BIOPAQ®UBOX REACTOR

Working principle



Cleaning up Barappulah drain New Delhi: Decentralised treatment & reuse



- Catchment: 3.3 mln persons
 - Total length >20 km
 - $90.000 \text{ m}^3 \text{d}^{-1}$
- Type of wastewater:**
- Household
 - Hospital
 - Metal Workshops

Cleaning up Barappulah drain New Delhi: Decentralised treatment & reuse



Barapullah
drain



Research in NL + India

(TUD, WUR, KNAW-NIOO, VU, IHE, TERI, NEERi, IIT-D)



Meer info: Steef de Valk:



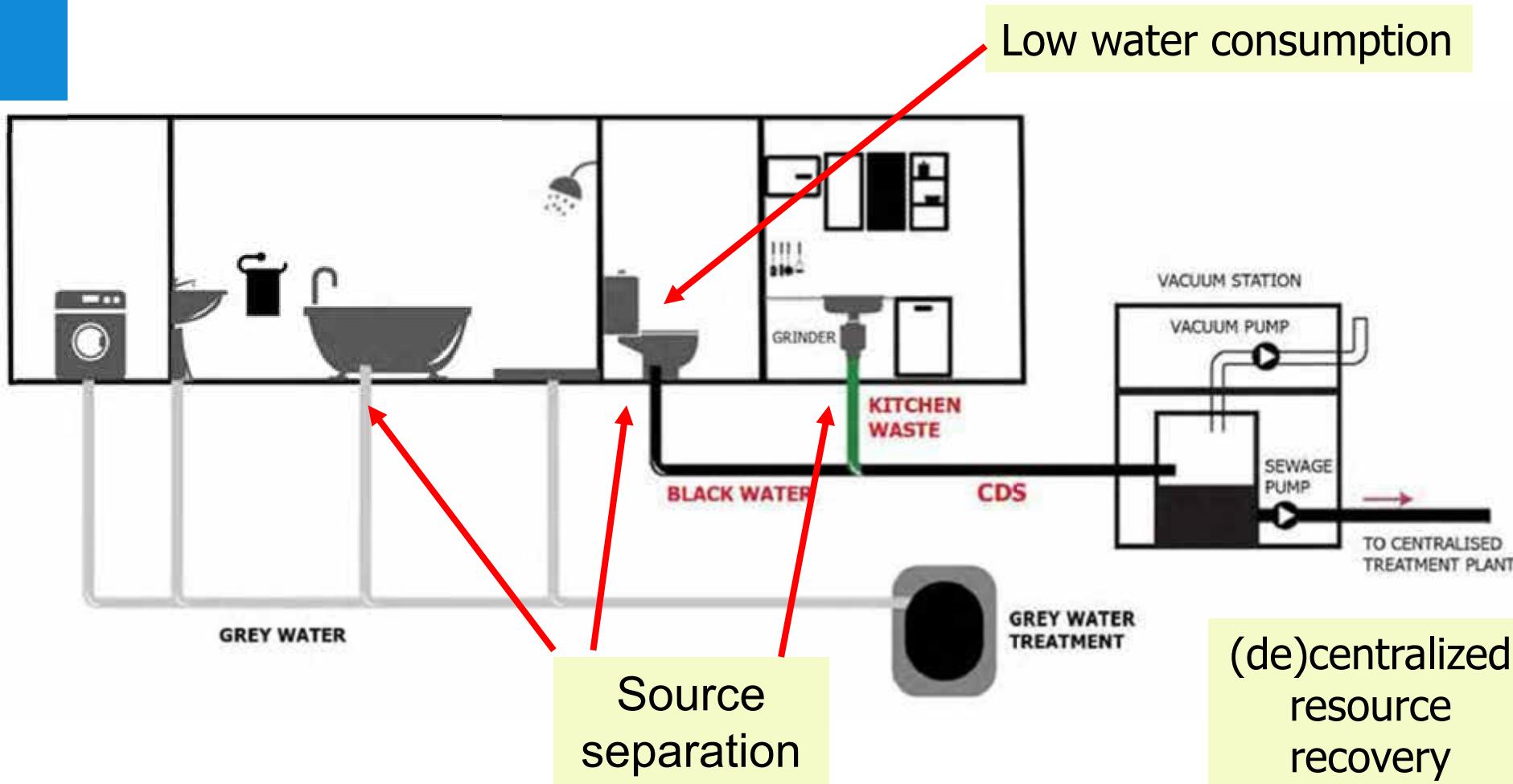
Indian and Dutch partners



Koningspaar opent afvalwaterzuiveringspilot in New Delhi



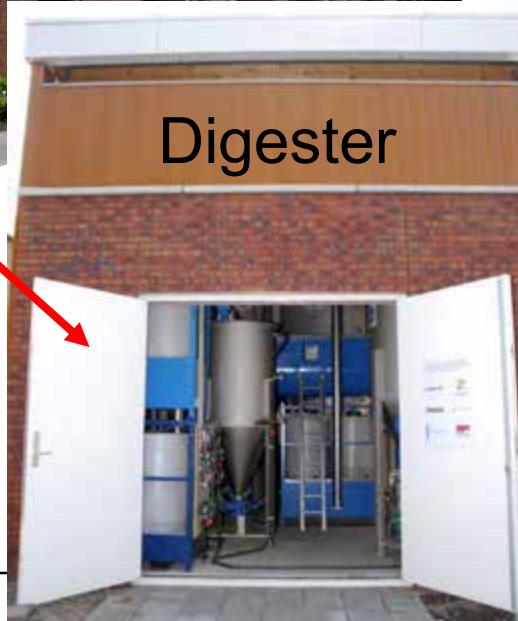
New Sanitation: Source separation at household level



The “Sneek Approach”: Separation at the source using vacuum sewers



Grietje Zeeman,
Wageningen UR



Black water:

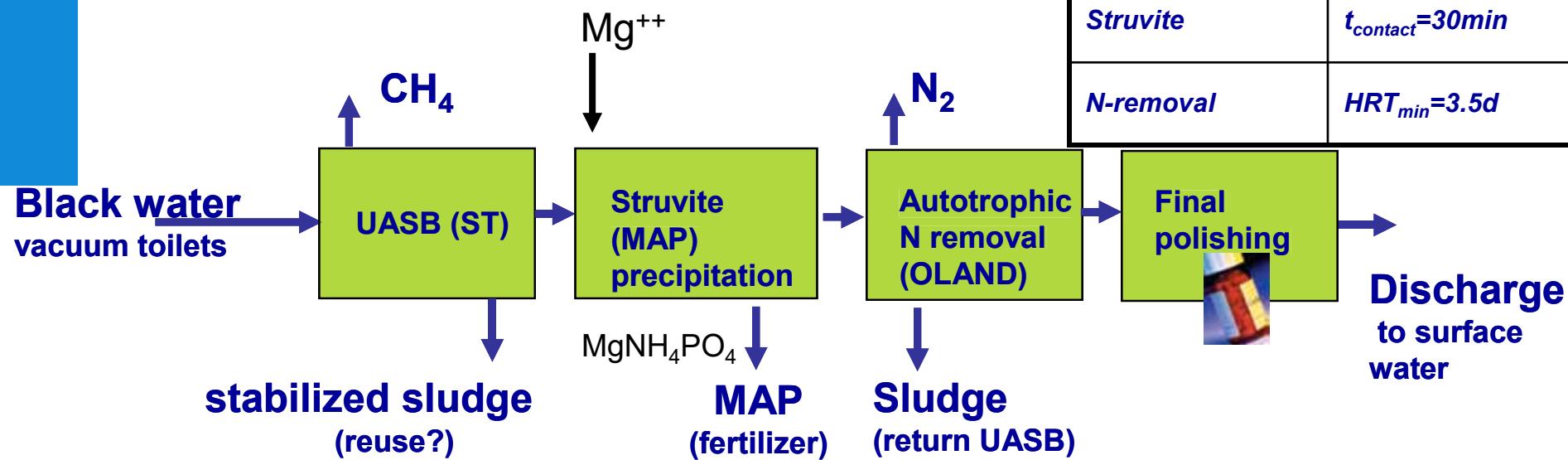
- Decentralised digestion
- Energy returns to household?
- Nutrients as fertilisers?
- Digested matter: soil conditioner?

Vacuum toilet

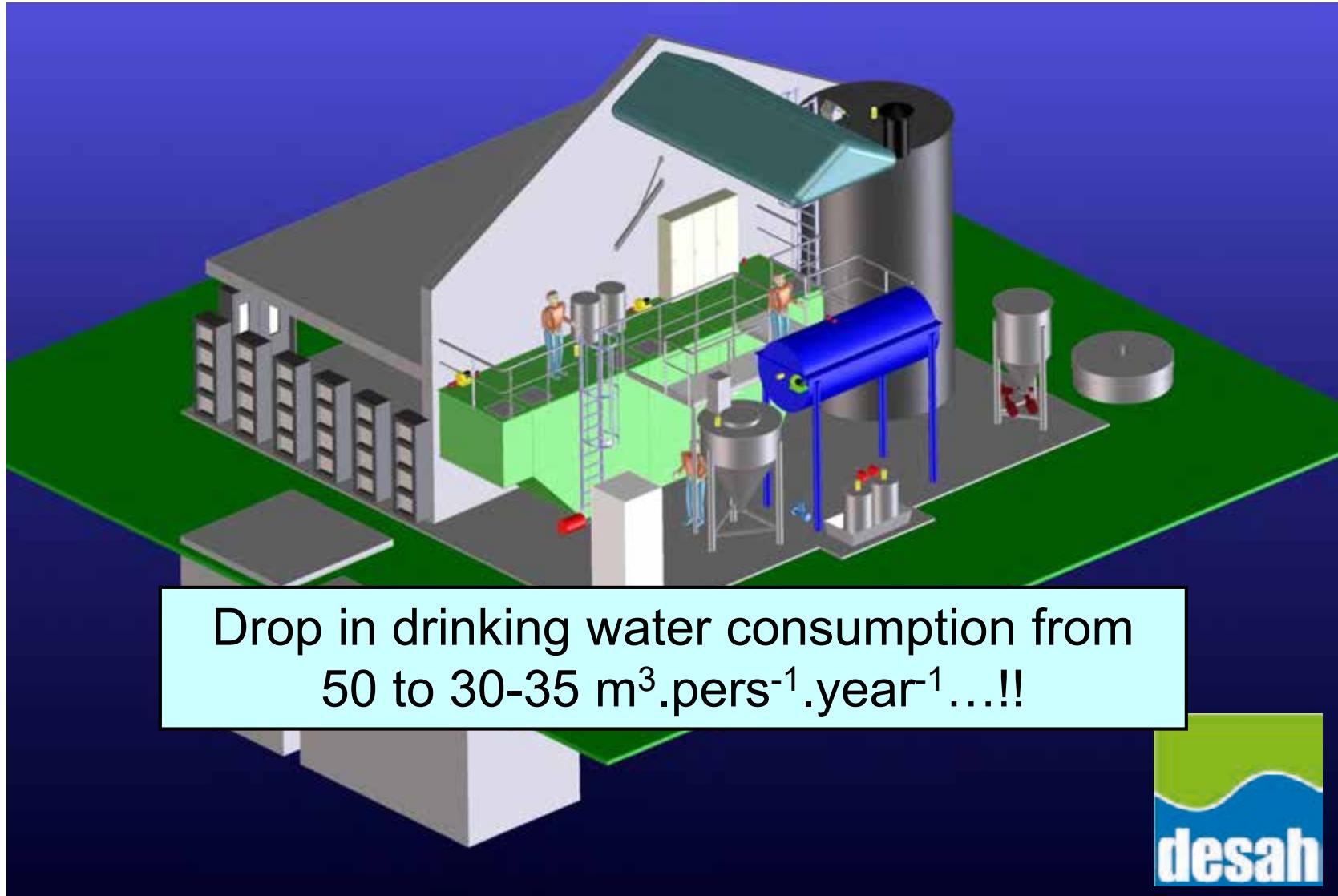


Black water treatment: Sneek

<i>UASB (ST)</i>	$HRT_{min}=7d; T_{max} = 30^{\circ}C$
<i>Struvite</i>	$t_{contact}=30min$
<i>N-removal</i>	$HRT_{min}=3.5d$



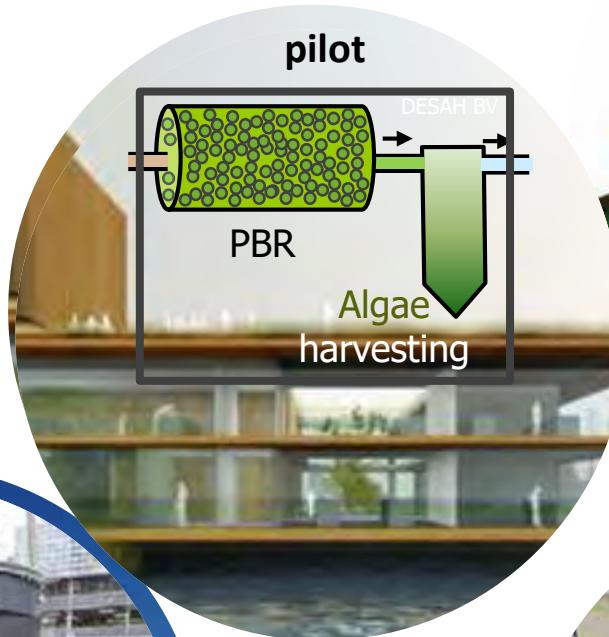
250 houses DeSaR project: started 2012



Drop in drinking water consumption from
50 to 30-35 m³.pers⁻¹.year⁻¹...!!



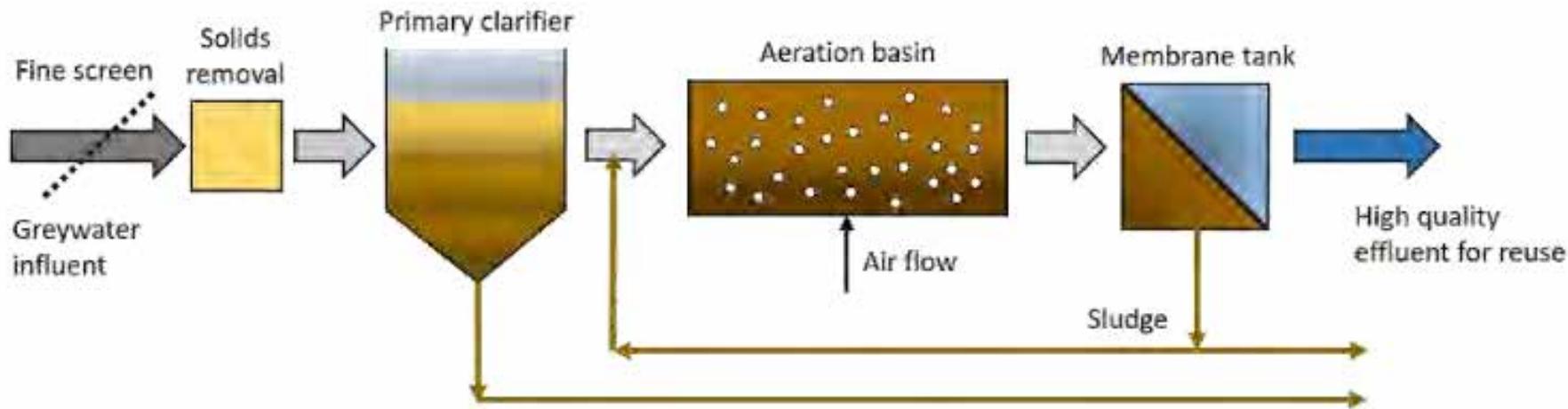
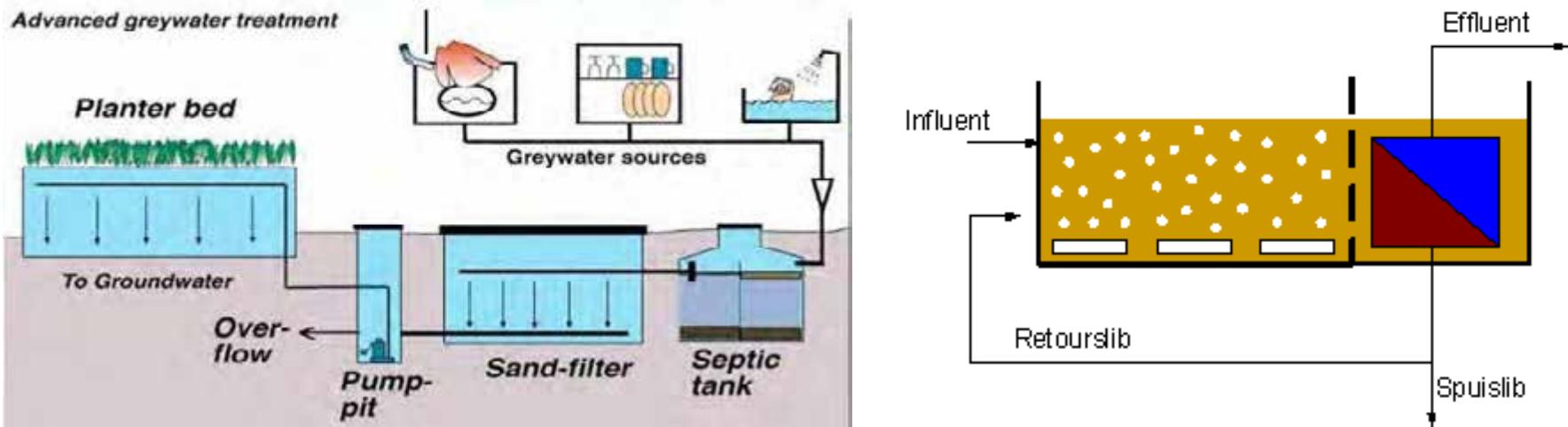
Full scale applications



Grey water: Constructed wetland?



Grey water: Compact systems?



Upscaling source-separated sanitation?

➤ **Rural areas:** more easy to implement:

- ✓ Low population density (less environmental impact)
- ✓ Logic boundaries for sanitary service
- ✓ Cost reduction: less need for pressure mains connections
- ✓ Land availability
- ✓ Reclaimed grey water for non-potable uses (e.g. gardening, infiltration/groundwater recharge)
- ✓ Constraints:
 - Resource recovery financially viable?
 - Required level of treatment (emission prevention)?
 - Greenhouse gas emissions (CH_4 / N_2O)?
 - Need for expert knowledge?
 - Remote control possible?
 - Operation and maintenance?

Upscaling source-separated sanitation?

➤ **Urban areas:** level of application: centralized ↔ decentralized

✓ **Decentralised approach:**

- Household / estates / flats / office buildings / district?
- Again: what problems are we solving?

✓ **Centralised approach:** alternative for conventional sewerage?

- Separate sewers for black water/ kitchen waste: pressurized / vacuum / gravity?
- Separate sewers for grey waters (no solids!), Use of gravity sewers. Could serve decentralized water reuse

Centralised treatment black water: simplification of STP!!

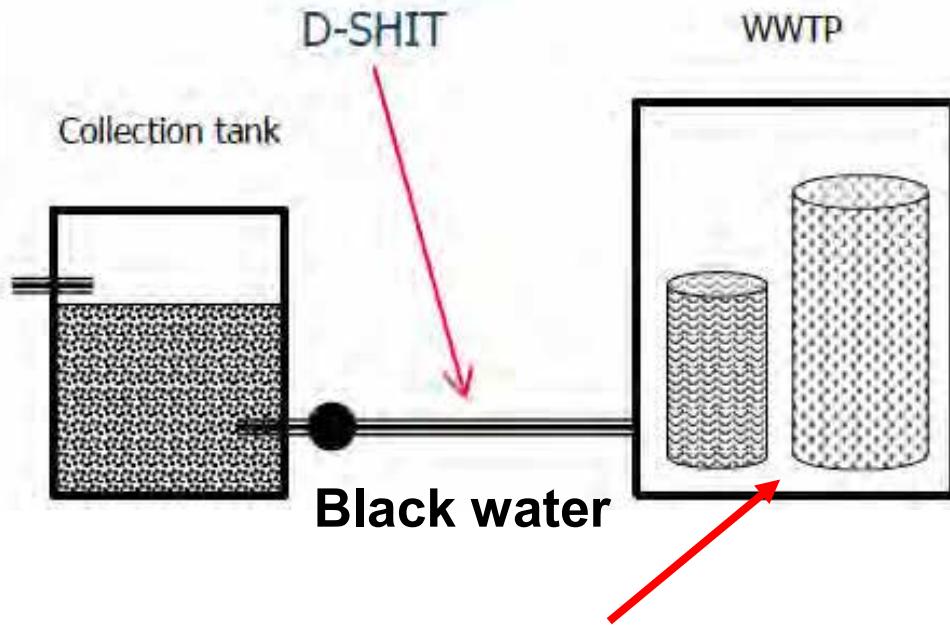
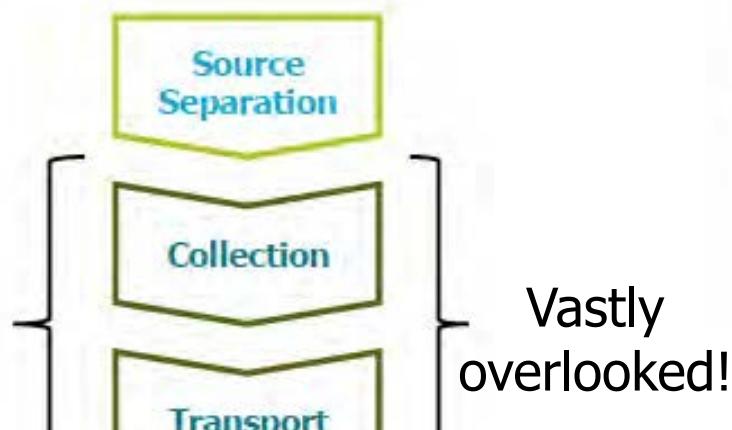
- Small diameter (< 200 mm?) transport to centralized digester
- No need for nitrification / denitrification at STP!
- Facilitates recovery of N/ P/ Energy!
- Keeps medicine rests concentrated: facilitates treatment!

Upscaling source-separated sanitation in urban areas?

Black water conveyance

PhD-thesis: Dr. Adithya Krishnan Thota Radhakrishnan (TUD, 2019)

Domestic Slurry Hydraulics
In Transport (D-SHIT)



“Primary digester” + recovery of
Energy, P, N, PHA?

Grey water: recovery for local
use / aquifer recharge?

Take home messages

- Make clear what problem(s) will be solved by implementing decentralized sanitation
- At small scale, the financial viability of resource recovery becomes questionable
- Water reclamation for multiple use seems to be a driver of interest for decentralized approach (at water-stressed locations)
- Centralized black water treatment in urban areas simplifies required sewage treatment plants.

Acknowledgement: colleagues, students, cooperating companies!

Thanks for your attention!

Questions??