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The challenge to treat concentrated black water

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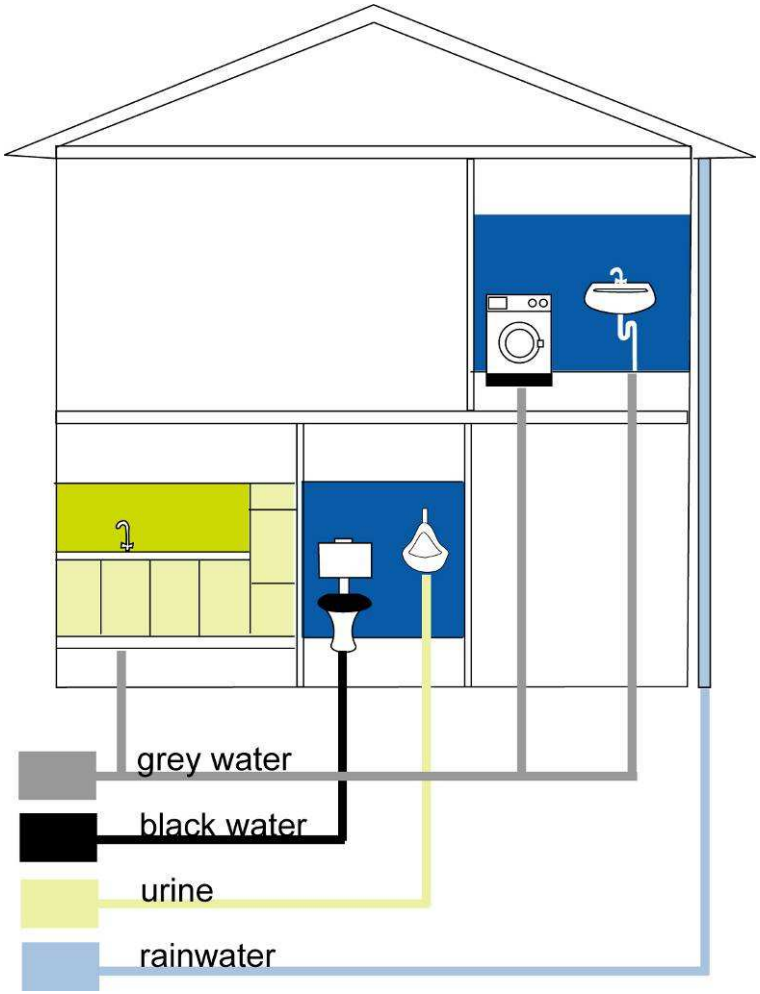
WAGENINGEN UNIVERSITY
Environmental Technology

combining scientific excellence with commercial relevance

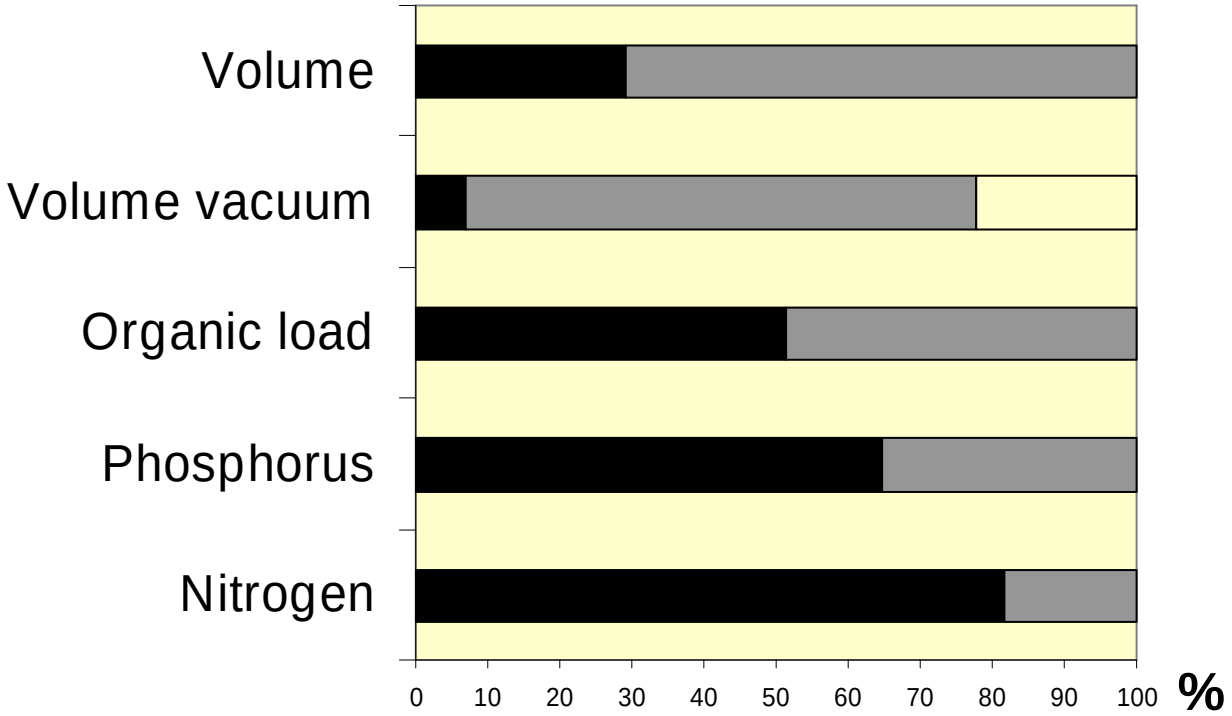
Separation at source

Treatment of source separated household wastewater:

- **Energy recovery**
- **Nutrient recovery**
- **Efficient removal of micro-pollutants**



Do not mix diluted streams with polluted streams!



Black water: vacuum toilet water, 7 L/p/d

Grey water: discharges from laundry, showers, hand basins and kitchen 95 L/p/d

Combined anaerobic treatment and partial nitritation

$CH_4(g)$

Methane production
Low sludge production
Nutrients conserved in liquid effluent

$N_2(g)$

Nitrogen is not a limiting resource
Low sludge production
Less aeration and no extra carbon source

Anaerobic treatment

Autotrophic nitrogen removal

P recovery

After Post treatment discharge to surface water

Optional: direct reuse of effluent and sludge in urban agriculture

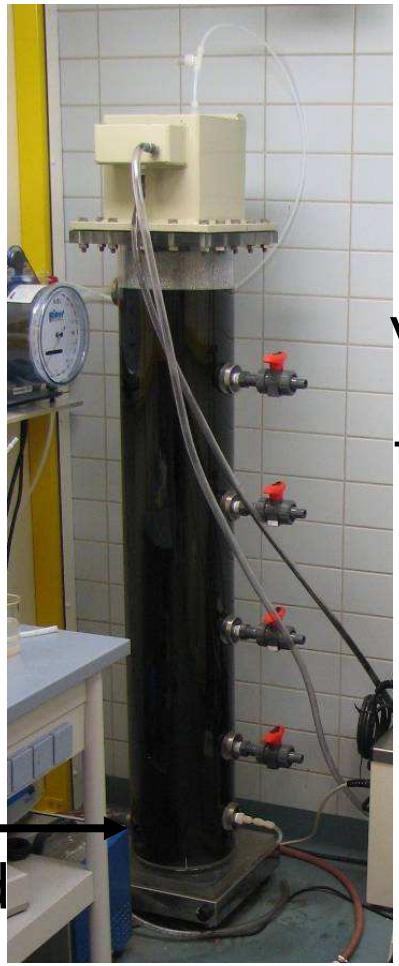
Black water from demonstration project Sneek, NL

	Unit	Value
pH	-	8.8
Organic compounds (COD total)	gCOD/L	10
Total nitrogen Ammonium	gN/L	1.9 1.4
Total phosporus Phosphate	gP/L	0.22 0.079

Special attention to: pathogens and hormones (estrogens) and medicine residues

Anaerobic treatment in a UASB reactor

- **UASB: Upflow Anaerobic Sludge Bed**
- **Separation of sludge, liquid and gas**
- **No space for sludge accumulation as in a UASB septic tank [Kujawa-Roeleveld et al., 2006]**
- **In operation for > 518 days**



V = 50 L

T = 25 ºC

1.1 kgCOD/m^3/d

Anaerobic treatment of black water: results

	Unit	UASB reactor This research
Influent	-	Black water, vacuum toilets, Sneek
Reactor volume	L	50
Up flow velocity	cm/h	0.77
Volumetric loading rate	kgCOD/m^3/d	1.1
HRT	days	9.1
SRT	days	273
COD total removal	%	74
Level of methanisation	%	59

Anaerobic treatment of black water: results

	Unit	UASB reactor This research	UASB-septic tank (Kujawa et al., 2005, 2006)
Influent	-	Black water, vacuum toilets, Sneek	Black water, vacuum toilets, Wageningen University
Reactor volume	L	50	200
Up flow velocity	cm/h	0.77	0.23
Volumetric loading rate	kgCOD/m^3/d	1.1	0.42
HRT	days	9.1	29
SRT	days	273	n.d.
COD total removal	%	74	78
Level of methanisation	%	59	58

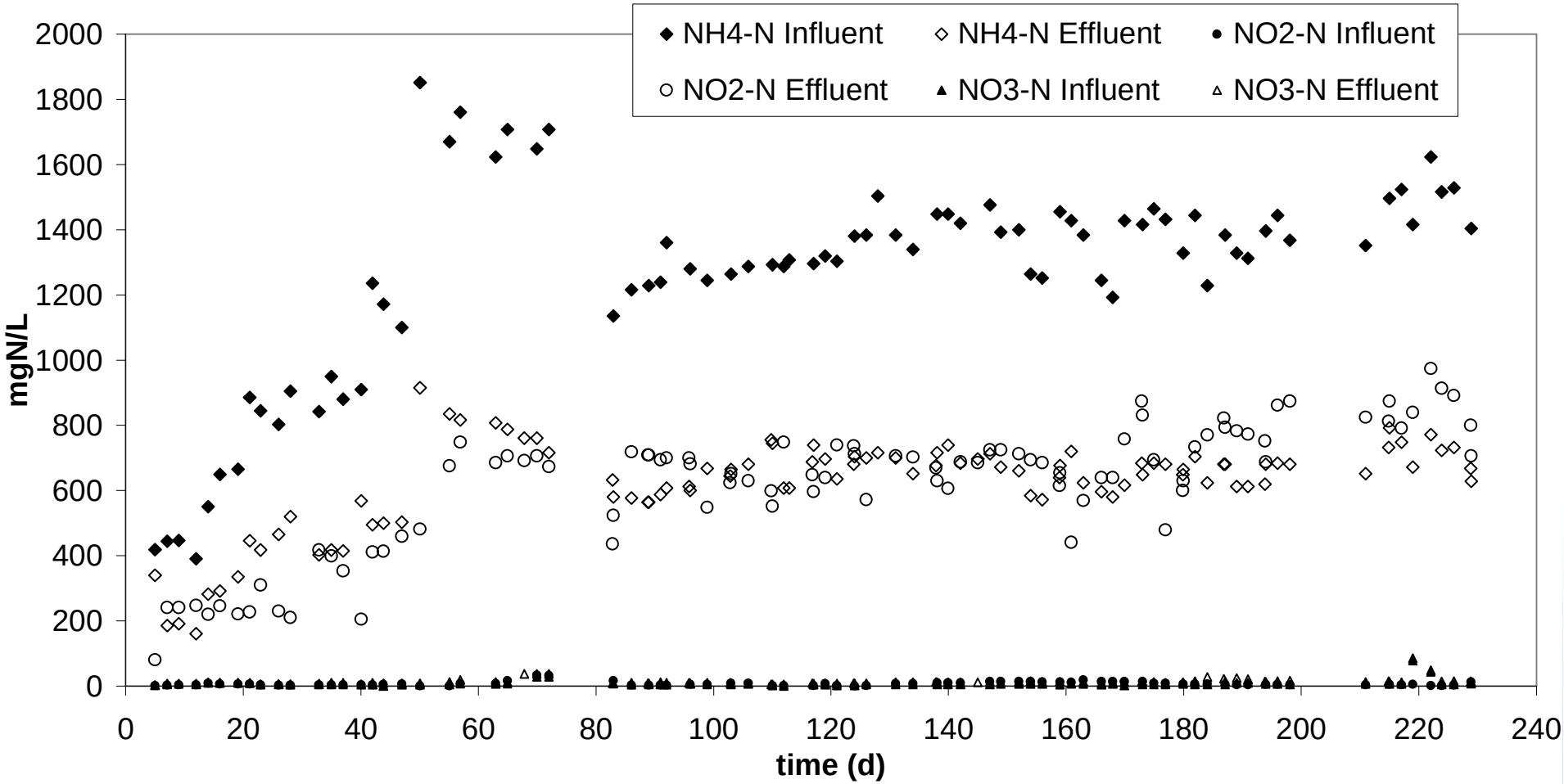
Partial nitritation in a continuous mixed reactor

- **To convert ammonium in UASB effluent for 50% to nitrite:**

  $NH_4^+ + HCO_3^- + 0.75\ O_2 \rightarrow$
  $0.5\ NH_4^+ + 0.5\ NO_2^- + 1.5\ H_2O + CO_2$

- **Volume of 3.2 L**
- **HRT of 1.3 days**
- **34 ℃**
- **DO > 2 mg/L**
- **Washout of nitrite oxidizers**

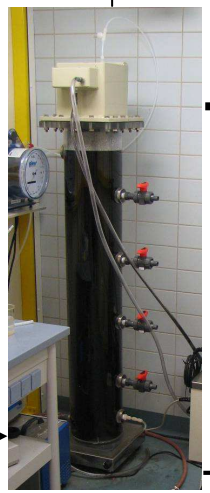
UASB effluent can easily be converted to 50:50 NH_4:NO_2



Black water treatment: the total treatment concept

Methane:
2.4 m^3/m^3 of black water

T = 25 ºC



Autotrophic nitrogen removal

T: 34 ºC and 25 ºC

P recovery:

struvite

Removal of micro-pollutants and pathogens

Discharge to surface water

Optional: direct reuse of effluent and sludge in urban agriculture

UASB or
UASB-septic tank

Anaerobic treatment and partial nitritation of black water is feasible

- **Anaerobic treatment in a UASB reactor**
- **Partial nitritation of the UASB effluent**
- **Next steps to be researched:**
  - Anammox
  - Phosphorus recovery
  - Removal of pathogens and micro-pollutants

Questions?