Anaerobe zuivering van huishoudelijk afvalwater; energie produktie & grondstoffen terugwinning

22-04-2014, Grietje Zeeman; WUR-ETE
Grietje.Zeeman@WUR.nl
Industrialized countries

large quantities of water for toilet flushing

Dilution of toilet waste water
Basic setup of aerobic treatment

Raw sewage → screens → grit chamber

primary sedimentation tank → activated sludge tank → secondary sedimentation tank

sludge digestion

Treated effluent

Sludge → sludge dewatering
Basic setup of anaerobic treatment

Raw sewage → screens → grit chamber → high-rate anaerobic treatment → effluent polishing pond → Treated effluent

Sludge drying beds → Sludge
AWWT plant
Bucaramanga, Colombia
UASB
UASB (Upflow Anaerobic Sludge Bed) reactor

- Developed by Lettinga (1970’s)
Low temperature & low concentration

Large UASB reactors
Low temperature & low concentration

UASB-sludge digester

Under development


Separation at source

‘New Sanitation’

food

organic fertilizer

Recovery system

energy

BW

K

GW

treatment
‘New Sanitation’; restore the cycle with agriculture
Barrel system

End of the 19th century:

Feces & urine collected in barrels
Hygienic?

Abraham: "what, not yet forbidden....?"

Barrel system

Van Zon, 1986
Raw materials; BW & KW

<table>
<thead>
<tr>
<th></th>
<th>Black water &amp; Kitchen waste (g p⁻¹d⁻¹)</th>
<th>% of total domestic Wastewater &amp; Kitchen waste</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>12.3 g</td>
<td>92</td>
</tr>
<tr>
<td>P</td>
<td>1.6 g</td>
<td>80</td>
</tr>
<tr>
<td>K</td>
<td>3.9 g</td>
<td>84</td>
</tr>
<tr>
<td>organics</td>
<td>111 g COD</td>
<td>69</td>
</tr>
</tbody>
</table>

adapted from Zeeman & Kujawa-Roeleveld, 2011
The potential for recovery

<table>
<thead>
<tr>
<th>BW + KW (tons per year)</th>
<th>Fertilizer production (tons per year)</th>
<th>% coverage</th>
<th>Energy equivalent</th>
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<tbody>
<tr>
<td>P</td>
<td>3.9*10^6</td>
<td>#14.9*10^6</td>
<td>27</td>
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Phosphorus is a finite resource

Recovery and reuse of nitrogen needed?
Haber-Bosch process

\[ \text{N}_2 + 3 \text{H}_2 \rightarrow 2\text{NH}_3 \]

Energy use: *37-45 kJ/g N;

The potential for recovery

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</tr>
<tr>
<td>N</td>
<td><em>30.9</em>10^6</td>
<td>##121*10^6</td>
<td>25</td>
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The potential for recovery

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<tr>
<td>COD</td>
<td>280*10^6</td>
<td>±cooking energy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>69*10^9 m^3 CH_4 per year</td>
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</table>
‘New Sanitation’

• Collection (WC) & transport with minimal water use
  • vacuum toilets
  • water free urinals
  • urine separation toilets
• Separation at source
  • BW separate from GW
Modern vacuum collection and transport

- comfort

- minimal water use (≤ 1Litre per flush)
2001 & 2006

EET & STOWA supported
‘New Sanitation’
Full scale application

Vila Flora; Venlo
‘New Sanitation’
Full scale application

Sneek; 250 houses
New sanitation in NIOO building
New sanitation ‘Brouwershuis’
New sanitation ‘Brouwershuis’
Black water UASB treatment, nitritation-anammox & struvite-precipitation

1.8 m³ CH₄/m³

N₂

UASB

P-recovery

Autotrophic N-removal

Black water treatment

- UASB
- Biogas
  - MP & Pathogens
  - Sludge
  - Phosphorus
  - Nitrogen
  - MP & Pathogens
  - Effluent

- Air
- Local use
Black water treatment

- Biogas
- MP & Pathogens
- Sludge
- Phosphorus
- Nitrogen
- MP & Pathogens
- Effluent

UASB

Agriculture
Simultaneous AD & Ca-phosphate precipitation

Granule formation in black water UASB reactor (a) dried granule (b) and inorganic core of granule (burned at 550°C) (c)

Taina H. Tervahauta, Renata D. van der Weijden, Roberta L. Flemming, Luc’ia Hern’andez Leal, Grietje Zeeman, Cees J. N. Buisman (submitted)
NH$_3$-recovery; microbial fuel cell

- migrational ion flux to the cathode
- driven by electron production
- anaerobic degradation of organic matter in urine.

N & P recovery; microalgae growth on urine

Schematic representation of current and future black water according to new sanitation concepts. Tania Fernandes, NIOO
Water scarcity

20th century:
• 6* increase water use
• > 2* population growth
2025

1.8 billion people live in countries with an absolute water shortage (UN, 2007)
Bio-flocculation of grey water (GW)

Treated grey; potential water source

Grey water management at community level (Hernandez, 2010)
Micro-pollutants
Micro-pollutants (MPs)

*almost 200 micro-pollutants from personal care products in GW

**190 different pharmaceutical substances recorded


Fate MPs in biological BW- or GW-treatment

*Personal care products in GW

**Pharmaceutical residues & estrogens in BW


Conclusies; anaerobe zuivering van huishoudelijk afvalwater;

3 ‘Nieuwe Sanitatie’ toepassingen in Nederland
Verbeteringen ‘Nieuwe Sanitatie’ in ontwikkeling
Ontwikkeling UASB-slibvergisting systeem
Conclusies; anaerobe zuivering van huishoudelijk afvalwater;

VRAGEN?