AECOMIX™ – combined treatment of waste and waste water towards clean water and biogas
Nijhuis Water Technology

- Total solution provider offering own innovative industrial solutions
- Long history: > 2500 reference plants, > 50 countries worldwide
- High level of process and application knowledge of many industries
- From products to total solutions, including re-use and recovery
- Market leader in DAF systems
- Headquarters in Doetinchem, the Netherlands
- Sales & Service Centers, Poland, Russia, Asia Pacific, China, USA, Egypt and Latin America
- Nijhuis Industries: 50 million Euro turnover / 250 employees
- Industrial and municipal clients
Global presence with over 2500 references
Technologies by Nijhuis Water Technology

Water | Primary treatment
- Removal of coarse solids, suspended solids and emulsified matters

Water | Secondary treatment
- Removal of dissolved matters
Technologies by Nijhuis Water Technology

Water | Tertiary treatment & Recycling
- Removal of recalcitrant fraction, disinfection, process water

Waste to Valuable | Energy from organics | Recovery of valuable resources
- Transform organics to energy
- Extract valuable substances, Fats/Oils, Starch, Ammonia, Phosphor, Fertilizer
## Waste water and waste characteristics

### food and beverage industry

### Waste water

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Icecream</th>
<th>Chocolate</th>
<th>Cheese</th>
<th>POME</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD</td>
<td>mg/l</td>
<td>10,000</td>
<td>9,000</td>
<td>4,000</td>
<td>65,000</td>
</tr>
<tr>
<td>BOD</td>
<td>mg/l</td>
<td>6,500</td>
<td>6,000</td>
<td>2,500</td>
<td>30,000</td>
</tr>
<tr>
<td>TSS</td>
<td>mg/l</td>
<td>1,200</td>
<td>1,650</td>
<td>750</td>
<td>25,000</td>
</tr>
<tr>
<td>FOG</td>
<td>mg/l</td>
<td>1,100</td>
<td>700</td>
<td>250</td>
<td>8,000</td>
</tr>
<tr>
<td>TKN</td>
<td>mg/l</td>
<td>80</td>
<td>60</td>
<td>20</td>
<td>1,200</td>
</tr>
</tbody>
</table>

### Organic waste

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Ice cream</th>
<th>Chocolate</th>
<th>Cheese</th>
</tr>
</thead>
<tbody>
<tr>
<td>waste</td>
<td>%</td>
<td>0,8</td>
<td>0,03</td>
<td>20</td>
</tr>
<tr>
<td>% of flow</td>
<td>%</td>
<td>400,000</td>
<td>1,350,000</td>
<td>55,000</td>
</tr>
<tr>
<td>COD</td>
<td>mg/l</td>
<td>248,000</td>
<td>920,000</td>
<td>2,000</td>
</tr>
<tr>
<td>TSS</td>
<td>mg/l</td>
<td>40,000</td>
<td>270,000</td>
<td>1,250</td>
</tr>
<tr>
<td>FOG</td>
<td>mg/l</td>
<td>400,000</td>
<td>1,350,000</td>
<td>55,000</td>
</tr>
</tbody>
</table>
Aerobic versus Anaerobic

COD Balance Aerobic

- Good effluent quality
- Biological nitrogen removal
- Requires typical 0.5 kWh/kg COD or 0.3 hp/lb COD for aeration.
- High sludge production

COD Balance Anaerobic

- Often post-treatment required,
- No biological nitrogen removal
- No phosphorus removal
- Produces typical 3.5 kWh/kg COD or 2.1 hp/lb COD as methane.
- Low sludge production
Pretreatment options like: depacking, shredding, pasteurization
Excess sludge Biotreater can be added directly or after pre-treatment
Mixing Aecomix: mechanical or gas-mix
Dissolved biogas flotation
Characteristics of food and beverage industry

- Intensive water use
- High pollution levels divided in 2 categories:
  1. breweries and soft drinks → Mainly soluble pollutants
  2. dairies, confectionaries, meat fruit and vegetable → Mixed, including high TSS, FOG

- Typical solutions:
  - For 1. : High rate anaerobic : UASB and EGSB/IC type
  - For 2. : Pretreatment required before UASB (FOG, TSS removal) or other solution

This presentation gives an innovative solution for group nr 2
They often also have factory wastes to deal with
DAF pre treatment combined with anaerobic treatment in two different installations
DAF pre treatment combined with anaerobic treatment in two different installations

- Proven and robust concept with pretreatment with coagulation-flocculation flotation process to remove TSS and FOG
- Disadvantages:
  - Use of chemicals – handling
  - Sludge's to be treated in digesters, additional steps
  - No solution for factory wastes
  - More CAPEX intensive solution
  - In case of no digester=> disposal costs sludge
• Solution for concentrated waste water or a mix of waste water and organic (factory) wastes
• Anaerobic digestion with solids liquid separation to reduce retention time
• A simple and robust process
• Pretreatment options like: depacking, shredding, pasteurisation
The waste water mixed with factory waste, provides following typical data:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Icecream</th>
<th>Chocolate</th>
<th>Cheese</th>
<th>POME</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD</td>
<td>mg/l</td>
<td>13,200</td>
<td>49,000</td>
<td>14,000</td>
<td>65,000</td>
</tr>
<tr>
<td>BOD</td>
<td>mg/l</td>
<td>8,100</td>
<td>30,000</td>
<td>8,000</td>
<td>30,000</td>
</tr>
<tr>
<td>TSS</td>
<td>mg/l</td>
<td>3,200</td>
<td>3,000</td>
<td>1,150</td>
<td>25,000</td>
</tr>
<tr>
<td>FOG</td>
<td>mg/l</td>
<td>1,400</td>
<td>8,800</td>
<td>500</td>
<td>8,000</td>
</tr>
<tr>
<td>TKN</td>
<td>mg/l</td>
<td>80</td>
<td>60</td>
<td>20</td>
<td>1,200</td>
</tr>
</tbody>
</table>
Aecomix digester – Some process details

- Organic loading: 3-8 kg COD/m$^3$/d
  : 0,2 – 0,5 lb COD/d.cu ft
- Hydraulic retention time: 2-12 days
- Solids retention time: 20 – 100 days
- Operating temperature: standard 37 °C (99 °F)
- MLSS range: 0.5 – 2%
- Heating: tubes along the wall
- Mixing: mechanical or gas mixing
- H2S removal: De-sulphurisation grid
- Excess sludge bioreactor can be added as substrate
Aecomix – Dissolved Biogas Flotation

- Biogas solubility is superior to air
- Dissolving is controlled to obtain microscopic gas bubbles
- Flotation requires gas to solids ratio of approx 15 l/kg (3600 gal/ton)
- Recycle pump is used to mix biogas into fluid (to avoid pressurizing the gas)
- Solids loading flotation: 15 kg/m²/h (3,1 lb/hr/sq ft)
- Flocculant required: 3-6 g/kg ds (6 -12 lb/ton)
- Power consumption Biogas flotation : 0.3-0.6 kW/m³ (1,5-3,0 hp/1000 gal)
Aecomix TM reference case: Candy Factory

Flow : 100 m$^3$/d (26,500 gpd)
COD : 10,000-65,000 mg/l, average : 35,000 mg/l
TSS : average : 6,500 mg/l

Process :
• Equalisation tank.
• 2 Aecomix reactors of 750 m$^3$ each in series with mechanical mixing.
• Biological treatment – aerobic with activated sludge flotation.
• Sand filter.
• Carbopure.
Influent COD and removal rates

Average organic loading: 1.8 kg COD/m³.d
0.11 lb COD/d.cu ft

Effluent COD
Plant results: operational stability

Fos-Tac measurements

FOS – (Fatty Acids) : TAC – (Total Alkalinity) ratio shows stability and plant loading.

- Stable anaerobic system with Fos-Tac <0.45
Plant results: effluent quality

<table>
<thead>
<tr>
<th>Parameters</th>
<th>influent</th>
<th>effluent</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD:</td>
<td>35.000 mg/l</td>
<td>45 mg/l*</td>
</tr>
<tr>
<td>BOD:</td>
<td>17.500 mg/l</td>
<td>&lt; 5 mg/l</td>
</tr>
<tr>
<td>TSS:</td>
<td>6.500 mg/l</td>
<td>9 mg/l</td>
</tr>
<tr>
<td>FOG:</td>
<td>50 mg/l</td>
<td>&lt;1 mg/l</td>
</tr>
<tr>
<td>Temperature:</td>
<td>35-45 °C (95-113 °F)</td>
<td></td>
</tr>
<tr>
<td>pH:</td>
<td>4.2 – 5.2</td>
<td></td>
</tr>
</tbody>
</table>

*Over the last 7 month the COD removal rate Aecomix was 98%*

Effluent is used as irrigation water and for cooling towers.
In the OPEX the following is considered for the Aecomix:
• Aecomix concept as described above incl. dewatering

Compared to a conventional pretreatment – UASB – sludge digester:
• A flocculation-flotation system with PAC, NaOH and flocculant
• An UASB reactor
• A digester for DAF sludge + chocolate waste, incl. dewatering

<table>
<thead>
<tr>
<th>Parameter</th>
<th>units</th>
<th>Aecomix</th>
<th>Coag/flocc/DAF/UASB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power consumption</td>
<td>hp/d</td>
<td>540</td>
<td>605</td>
</tr>
<tr>
<td>PACl (40%)</td>
<td>lb/d</td>
<td>-</td>
<td>32</td>
</tr>
<tr>
<td>NaOH (33%)</td>
<td>lb/d</td>
<td>11</td>
<td>34</td>
</tr>
<tr>
<td>Flocculant</td>
<td>lb/d</td>
<td>2,6</td>
<td>1,3</td>
</tr>
<tr>
<td>Operator attention</td>
<td>h/d</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>OPEX total (incl. man hour)</td>
<td>USD/m³</td>
<td>1.80</td>
<td>3.00</td>
</tr>
<tr>
<td>Energy potential biogas</td>
<td>hp/d</td>
<td>8450</td>
<td>8450</td>
</tr>
</tbody>
</table>
BAT selection model for Aecomix™

- **COD** \(_{\text{non-soluble load (O&G/TSS)}}\)
- **COD** \(_{\text{soluble load}}\)
- **Aerobic WWT**
- **UASB/EGSB or IR**
- **Fine screen Flotation**
- **Sludge digester**
  - Dairy
  - Read meat / Poultry
  - O&G
  - Distillery
  - Beverage
  - Palm mill

SOLID SOLUTIONS IN A FLUID WORLD
Take home message for Aecomix™

- **A robust chemical low and economic solution** for food and beverage industries with substantial amounts of TSS and FOG, such as:
  - Dairy (cheese), ice cream, confectionary.
  - Vegetables.
  - Distilleries.
  - POME effluent (Palm Oil Mill Effluent).
  - Others.
- A simple **one step solution** for factories to deal with their waste and waste water.
- From waste (water) destruction to energy production (heat, power).
- Combines digestion and gas storage in one system.
- Achieve COD reductions in effluent **over 95% (upto 99%)**.
- Dissolved Biogas Flotation is a robust and cost effective S/L separation.
- **Lower CAPEX an OPEX (>20%)** compared to traditional process and requires less operator attention.
NAR to remove Ammonia from manure / sludge and digestate
• High ammonia levels are toxic to both aerobic and anaerobic biological processes. (> 4 g/l of N-Kjeldahl at pH of 7,2)
• Biological removal of high ammonium loads is very difficult due to low COD/N ratio
• The Nijhuis Ammonia Stripper or NAR is a process to remove Ammonia and to convert it into Ammonium sulphate ((NH$_4$)$_2$SO$_4$) solution.
• Ammonium sulphate is a nutrient with market value.
Preliminary CO₂ stripping with air saves NaOH
NAR full scale plant
## Ammonium and Nitrogen removal NAR plant

<table>
<thead>
<tr>
<th>Date</th>
<th>NH4-N Influent [mg/l]</th>
<th>NH4-N Effluent [mg/l]</th>
<th>NH4-N Removal [%]</th>
<th>TN Influent [mg/l]</th>
<th>TN Effluent [mg/l]</th>
<th>TN Removal [%]</th>
<th>(NH4)2SO4 [mg/l]</th>
<th>(NH4)2SO4 [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>25-9-2014</td>
<td>2,100</td>
<td>240</td>
<td>88,6</td>
<td>2,500</td>
<td>420</td>
<td>83</td>
<td>67,500</td>
<td>32</td>
</tr>
<tr>
<td>9-10-2014</td>
<td>2,163</td>
<td>567</td>
<td>73,8</td>
<td>2,352</td>
<td>630</td>
<td>73</td>
<td>67,500</td>
<td>32</td>
</tr>
<tr>
<td>15-10-2014</td>
<td>2,096</td>
<td>640</td>
<td>69,5</td>
<td>2,200</td>
<td>700</td>
<td>68</td>
<td>67,500</td>
<td>32</td>
</tr>
<tr>
<td>18-10-2014</td>
<td>2,244</td>
<td>265</td>
<td>88,2</td>
<td>2,376</td>
<td>204</td>
<td>91</td>
<td>68,300</td>
<td>33</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>2,151</strong></td>
<td><strong>428</strong></td>
<td><strong>80</strong></td>
<td><strong>2,357</strong></td>
<td><strong>489</strong></td>
<td><strong>79</strong></td>
<td><strong>67,900</strong></td>
<td><strong>33</strong></td>
</tr>
</tbody>
</table>
## NAR digestate treatment

- Flow = 100 ton/day (26,500 gpd)
- Ammonium concentration = 2.8 g/l
- Removal ammonium = 80%

<table>
<thead>
<tr>
<th>System</th>
<th>Investment costs</th>
<th>Costs per N removed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>USD</td>
<td>USD/lb N</td>
</tr>
<tr>
<td>CAPEX</td>
<td>520.000</td>
<td>0.40</td>
</tr>
<tr>
<td>OPEX</td>
<td>-</td>
<td>0.62</td>
</tr>
<tr>
<td>Total</td>
<td>520.000</td>
<td>1.02</td>
</tr>
</tbody>
</table>

- Heating through steam
- Ammonium sulphate: 30 USD/ton

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Depreciation period M+E [yrs]</td>
<td>10</td>
</tr>
<tr>
<td>Depreciation period civils [yrs]</td>
<td>10</td>
</tr>
<tr>
<td>Interest</td>
<td>4%</td>
</tr>
</tbody>
</table>
Take home messages NAR

• Ammonium recovery is a new interesting technology for digestate treatment and can increase biogas production

• Ammonium sulphate is a nutrient with market value.

• Nitrogen removal is interesting at concentrations > 2 g/l of Ammonium.

• Removal efficiency is approx. 80 % on ammonium nitrogen removal

• Hardness of digestate is important

• NAR makes biological post treatment more stable and cheaper
Questions ?
Biogas chicken plant Ukraine
<table>
<thead>
<tr>
<th>Food &amp; Beverage</th>
<th>Oil &amp; Gas</th>
<th>Waste-to-value</th>
<th>Other industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>MARS</td>
<td>bp</td>
<td>Bernard Matthews</td>
<td>e-on</td>
</tr>
<tr>
<td>Moypark</td>
<td>ExxonMobil</td>
<td>Dew Valley</td>
<td>AMEROPA</td>
</tr>
<tr>
<td>Cargill</td>
<td>LUKOIL</td>
<td>PetroChina</td>
<td>Dow</td>
</tr>
<tr>
<td>Coca-Cola</td>
<td>Nestle</td>
<td>CEDROS</td>
<td>Solvay</td>
</tr>
<tr>
<td>Nestle</td>
<td>KRAFT</td>
<td>FasoGaz</td>
<td>GlaxoSmithKline</td>
</tr>
<tr>
<td>SaraLee</td>
<td>Unilever</td>
<td>ConocoPhillips</td>
<td>AkzoNobel</td>
</tr>
<tr>
<td>Kraft</td>
<td>Vopak</td>
<td>Premier Foods</td>
<td>ABN-AMRO</td>
</tr>
<tr>
<td>Del Monte Quality</td>
<td></td>
<td>Farmers Hendrix</td>
<td></td>
</tr>
</tbody>
</table>

**Strong customer base**
Key offerings – the Nijhuis solutions

- Screening (Drum Filter, Curved screen, Cloth filter, Aquarake, ..).
- Gravity separation (API, CPI, NTB, ILS, Hydro cyclone, ..).
- Flocculation, Flotation (PFR, NTR, DAF, DGF, IAF, ..).
- Biological (Aerobic & Anaerobic).
- Filtration (Sand, Carbon, MMF, Nutshell, ..).
- Oxidation and disinfection (Ozone, UV, AOP).
- Membrane filtration (UF/NF/RO).
- Nutrient recovery (ammonia recovery, phosphorus, fat).
- Anaerobic digestion.
- Dewatering systems.