Sonication of sludge by high-power ultrasound technology - Practical Experiences

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1. Ultrasonic Disintegration of Biomass on WWTP
Options for Biosolids Disintegration

- Intensification of anaerobic biosolids digestion
- Intensification of aerobic biosolids digestion
- Combating bulking and foaming sludge
Disintegration of Biosolids

- **sludge floc**
- **sludge water**
- **bacteria**
- **inert particles**
- **extracellular polymers**
Light-microscopical Analysis

untreated WAS

30s sonicated

energy

90s sonicated
Effect of sonication on particle size distribution

![Graph showing the effect of sonication on particle size distribution. The x-axis represents particle size in micrometers (µm) ranging from 1 to 1000, and the y-axis represents volume cumulative percentage ranging from 0% to 100%.

- Reference: 30 W/L, 20s (= 0.17 Wh/L)
- 30 W/L, 20s (= 0.17 Wh/L)
- 80 W/L, 20s (= 0.44 Wh/L)
- 220 W/L, 20s (= 1.28 Wh/L)
- 310 W/L, 20s (= 1.72 Wh/L)
2. Enhancing Aerobic Biomass Digestion
Bünde WWTP, Germany
Case Study
Initial Conditions:
- Design capacity: 40,000 PE
- Actual Load: 54,000 PE
- Alternating nitrification and denitrification @ 22 d sludge age
- Floating sludge due to excessive growth of filamentous micro-organisms

Desired Goal: Reduction of process fluctuations
- Minimization of waste activated sludge production
- Sustainable reduction of N-conc. in the effluent
- Combating filamentous organisms
Bünde WWTP, Germany

Ultrasound Installation in 2006:
Sonication of 30% of the TWAS (~ 30 m³/d) @ 4.0 kWh/m³
Bünde WWTP, Germany

Results of US Installation:

- No foaming or bulking sludge in the activated sludge tank
- 25% reduction of waste activated sludge mass
- Reduction of the nitrogen concentration in effluent (N < 5 mg/l)
3. Enhancing Anaerobic Biomass Digestion
Bamberg WWTP, Germany
Case Study
Bamberg WWTP, Germany

Initial Conditions:
- Design capacity: 220,000 PE
- Actual Load: 330,000 PE
- 150 m³/d primary sludge, 250 m³/d TWAS
- (3) Egg-shaped digesters with 18 d HRT
- 35% average VS degradation

Desired Goal:
- Achieve a minimum of 40% VS degradation
  - Solution 1: Build another 3,000 m³ egg-shaped digester
  - Solution 2: Use of ultrasound to increase VS destruction
Bamberg WWTP, Germany

Ultrasound installation in 2004:
Sonication of 30% (in 2004) - 80% (in 2008) of the WAS (~ 70 – 100 m³/d) @ 2 - 3 kWh/m³
Bamberg WWTP, Germany

Results of US Installation:

- Volatile solids destruction improved from 34 to 50%
- Significantly increased biogas production (+45%)
- Avoided construction of a new digester = savings of 1.5 million EUR
Energy-self-sufficient operation on Bamberg WWTP
US-Trial on Shek Wu Hui STW, Hong Kong
Shek Wu Hui STW, Hong Kong

Initial Conditions:
- Design capacity: 300,000 PE
- 191 m$^3$/d primary sludge, 179 m$^3$/d TSAS
- 4 Anaerobic digesters with 21 d HRT
- Ca. 42% average VS degradation

US-Trial:
- Sonication of 15% (ca. 1 m$^3$/h) of TSAS @ 5 kWh/m$^3$
Shek Wu Hui STW, Hong Kong

Biogas production

Biogas production [m$^3$/d]

US suspended since 18/8/14

Biological adaptation period
4. Combating Filamentous/Foaming Sludge
Combating Filamentous Sludge

Original → Short Sonication → Long Sonication
Seevetal WWTP, Germany (165,000 PE)

Sonication of Return Activated Sludge (1% RAS @ 2 kWh/m³)
5. Development of US-reactor
US-reactor for Biosolids Treatment

**Requirements**

- Treatment of large volumetric sludge streams
- High degree of biosolids cell disintegration
- Continuous operation in spite of varying sludge properties
- Resistant against reactor blockage (sludge impurities)
- Automatic system
- Low maintenance
**Full-scale Ultrasound Reactor 2006**

- Reactor volume: 30 L
- Power consumption: 5 kW
- Continuous operation
- No. of oscillators: 5
- Frequency: 20 kHz
- Intensity: 25 to 50 W/cm²
- Sonication time: 1 to 3 min
- Sonication dose: 3 to 9 kWh/m³
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Conclusions

• Biomass treatment with ultrasound is a mature technology

• Detailed and specific lab, pilot and full-scale studies have demonstrated the potential of and the practical uses of ultrasound biomass disintegration for biodegradation enhancement.
Thank you for your attention!