



VARESI

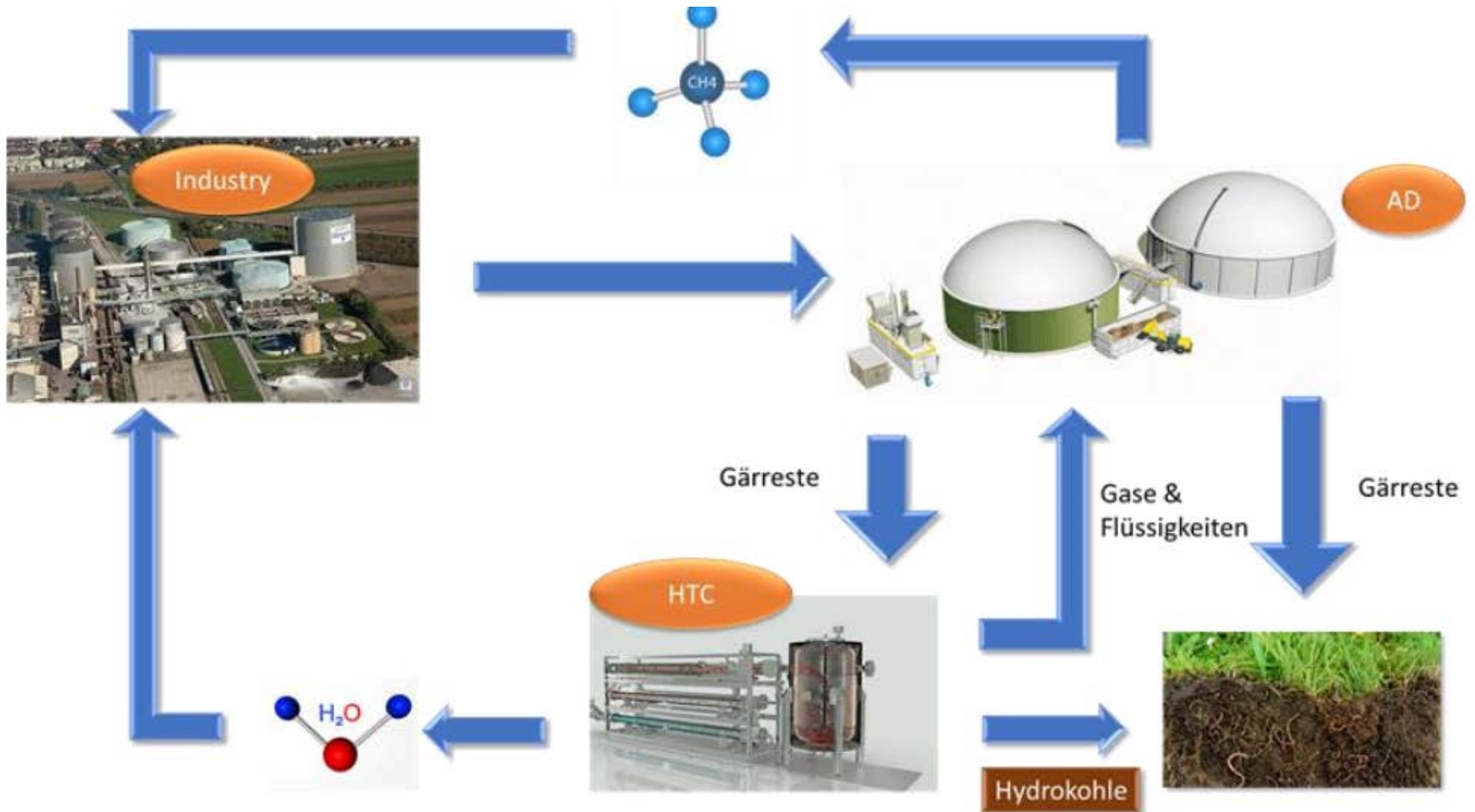
Valorisation of industrial residues for a sustainable industry

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VARESI – process scheme



Projekt „VARESI“



- Konsortium:
 - BOKU, Institute of Environmental Biotechnology (UT)
 - BOKU, Institute of Chemical and Energy Engineering (IVET)
 - ZHAW, Institut of Chemistry and Biotechnology (ICBT)
 - ZHAW, Institut of Sustainable Development (INE)
 - AAT, Abwasser- und Abfalltechnik GmbH
 - ATRES, Biogas Analyse und Anaerob Technik

- Ziele des Projektes:
 - Valorisation of organic residues from industry
 - Energyproduction from organic residues onsite the production plant
 - Zero waste concept
 - Optimal integration of energy in the industrial process
 - CO₂-neutral production processes
 - Process evaluation

Arbeitspakete, Tasks



- Work packages:
 - Anaerobic digestion of residues
 - Lab scale continuous digestion of residues
 - Hydrothermal carbonisation (HTC) of digestate
 - Digestates of following industries/biogas plants: slaughterhouses, paper industry, breweries, dairies, ethanol production
 - Parameters HTC digestate: temperature, hydraulic retention time, dry matter content
 - HTC process water treatment
 - Anaerobic digestion: batch-tests, fed-batch, continuous tests
 - Analytic HTC process water: pH, TS/OTS, COD, TKN, $\text{NH}_4\text{-N}$, short chain carbonic acids, aromatic carbonic acids, phenols
 - Energetic implementation
 - Mass- and energybalance of process modell (IPSEpro)
 - Implementation of bigas plant and HTC process in the case studies
 - Sozio-technical-evaluation
 - Identifying most important influences onf the innovation (energy, waste, political and regulatory)
 - Ermittlung vielversprechender Anwendungen Identifying most promising applications

Hydrothermal carbonisation (HTC), composition HTC Abwasser

- HTC:
 - Temperature: 180°C – 250°C
 - Pressure: bis 20 bar
 - Dry matter content: 15% - 20%
 - Products: Hydrochar, synthesis gas, water
- HTC process water:
 - Short chain carbonic acids (VFAs), aromatic carbonic acids, phenols, nitrogen
 - Inhibition is increasing with temperature and time in HTC reactor
 - Used raw material/substrate
 - pH value,..



Substrate analysis: HTC process water anaerobic wastewater sludge; 200°C; 1,00 h

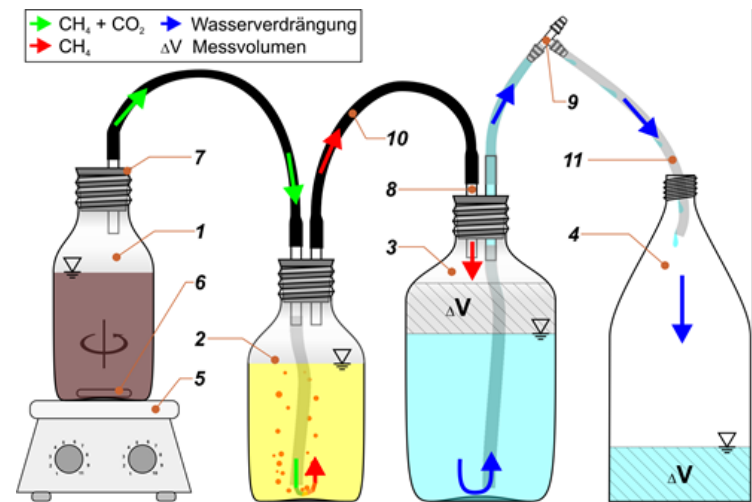
Parameter	Einheit	Ergebnis
pH Wert	-	5,77
Trockensubstanz	%	0,93
organische Trockensubstanz	%	0,73
Gesamtstickstoff (TKN)	g/kg	2,11
Ammoniumstickstoff (NH ₄ -N)	g/kg	1,57
chemischer Sauerstoffbedarf (CSB)	g/kg	13,32
Essigsäure	mg/l	4 292
Propionsäure	mg/l	1 627
Buttersäure	mg/l	1 472
Valeriansäure	mg/l	460
Iso-Buttersäure	mg/l	397
Hexansäure	mg/l	213
Ameisensäure	mg/l	118
Galakturonsäure	mg/l	114
el. Leitfähigkeit	mS/cm	10,88
Phenolgehalt	mg/l	90,80

Parameter	Einheit	Ergebnis	Einheit	Ergebnis
Aluminium	mg/kg FM	3,20	mg/kg TS	344
Bor	mg/kg FM	0,78	mg/kg TS	83,60
Calcium	mg/kg FM	281,00	mg/kg TS	30 300
Cobalt	mg/kg FM	0,02	mg/kg TS	2,29
Chrom	mg/kg FM	0,07	mg/kg TS	7,58
Kupfer	mg/kg FM	0,14	mg/kg TS	15,10
Eisen	mg/kg FM	441	mg/kg TS	47 400
Kalium	mg/kg FM	169	mg/kg TS	18 200
Magnesium	mg/kg FM	81,10	mg/kg TS	8 720
Mangan	mg/kg FM	2,09	mg/kg TS	224
Molybdän	mg/kg FM	0,02	mg/kg TS	2,35
Natrium	mg/kg FM	100	mg/kg TS	10 800
Nickel	mg/kg FM	0,06	mg/kg TS	6,38
Phosphor	mg/kg FM	43,10	mg/kg TS	4 640
Schwefel	mg/kg FM	200	mg/kg TS	21 500
Selen	mg/kg FM	0,01	mg/kg TS	0,73
Zink	mg/kg FM	1,26	mg/kg TS	136
Arsen	mg/kg FM		mg/kg TS	4,83
Blei	mg/kg FM		mg/kg TS	<6,00
Cadmium	mg/kg FM		mg/kg TS	<0,50
Quecksilber	mg/kg FM		mg/kg TS	0,07

Anaerobic digestion: batch-bests



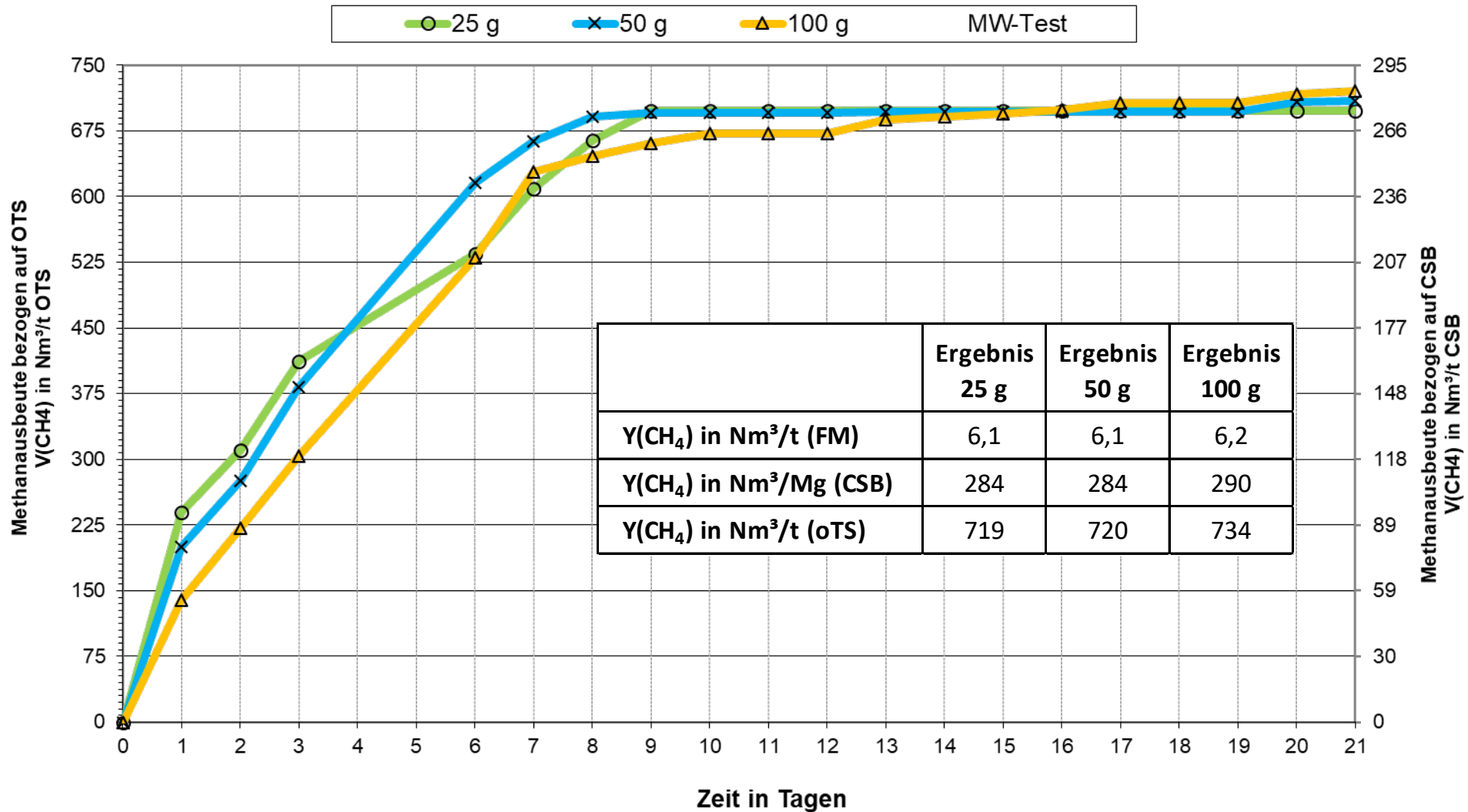
- Inoculum:
 - 50% anaerobic wastewater sludge, 50% digestate energy crop biogas plant
 - 300 ml inoculum in 500 ml bottle
- Biomethane measurement, NaOH for CO₂ capture
- Inhibition test:
 - 25 g HTC – PW
 - 50 g HTC – PW
 - 100 g HTC – PW
- triplicate



Batch-tests: results



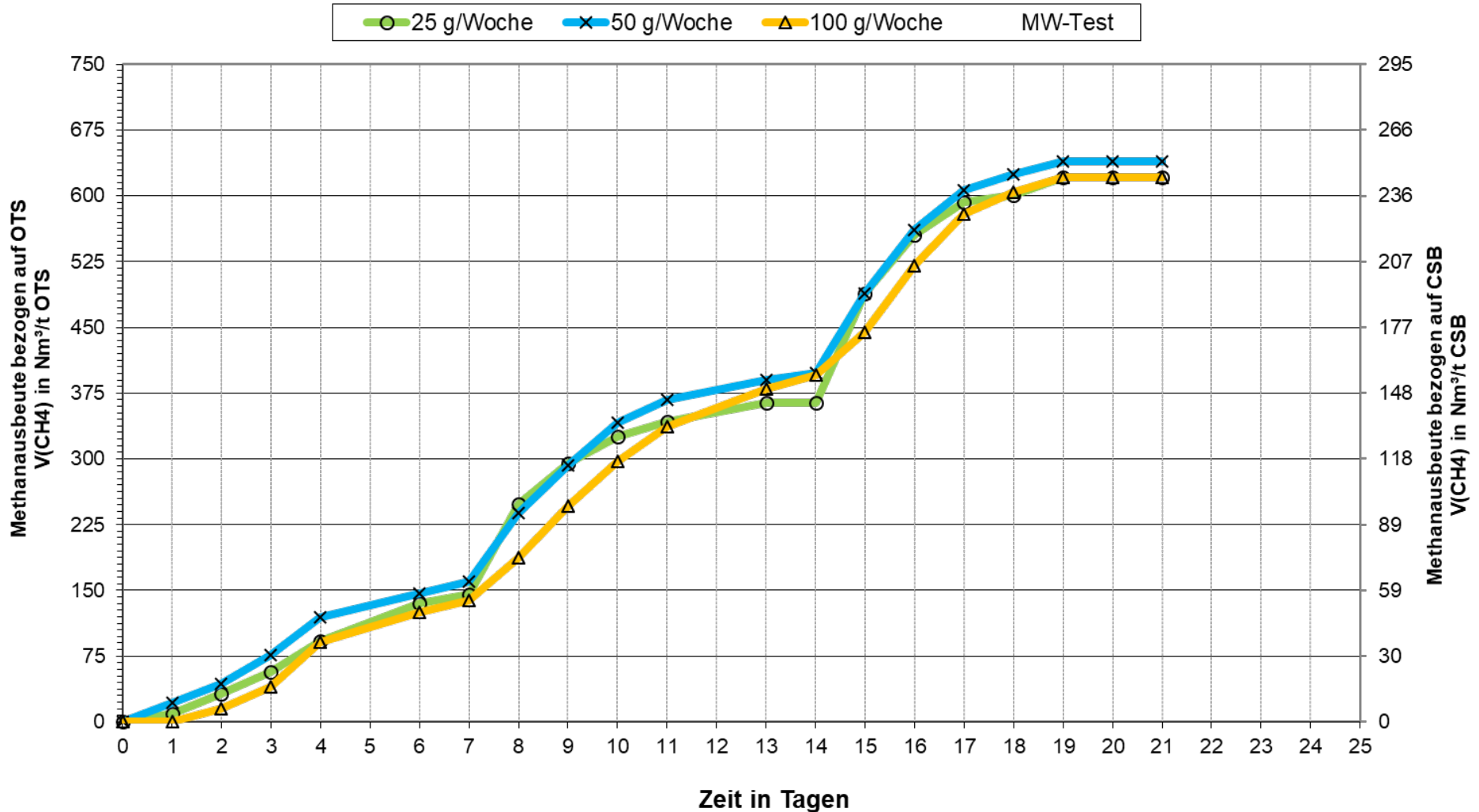
Methanproduktion von HTC Abwasser



Anaerobic digestion: Fed-batch



Methanproduktion von HTC Abwasser



Anaerobic digestion: Fed-batch volatile fatty acids concentration (week 3)



Woche 3	Einwaage HTC-PW	pH	Essig- säure [mg/l]	Propion- säure [mg/l]	i-Butter- säure [mg/l]	Butter- säure [mg/l]	i-Valerian- säure [mg/l]	Valerian- säure [mg/l]	Gesamt [mg/l]
1. Tag	25 g	8,06	255	120	0	130	25	35	565
nach 7 Tagen	25 g	8,12	30	0	0	0	0	0	30
1. Tag	50 g	7,98	490	215	0	200	50	80	1 035
nach 7 Tagen	50 g	8,14	65	5	0	0	0	0	70
1. Tag	100 g	7,99	950	355	0	295	90	150	1 840
nach 7 Tagen	100 g	8,18	210	0	0	0	0	0	210

Next steps



■ Continuous digesters

- 6,00 liter volume
- 1 x CSR
- 1 x fixed bed reactor with filling material
- Characterisation of change in microbiome (16S rRNA)



■ Inhibition tests (batch-tests)

- Different inoculum
- inhibition of bacteria oder archaea
- Inhibition by phenols
- Improving analytic HTC-PW, GC-MS





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