Project Microphilox

Biological Landfill Gas Cleaning

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PROFACTOR

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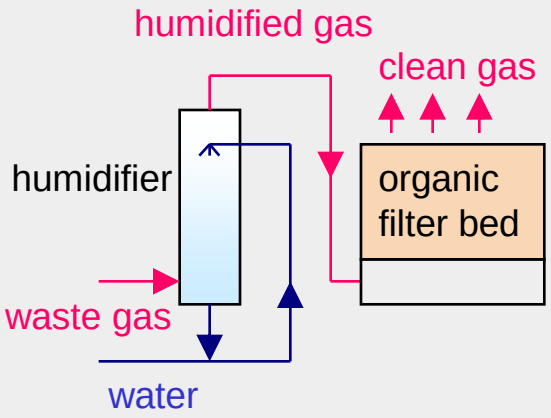
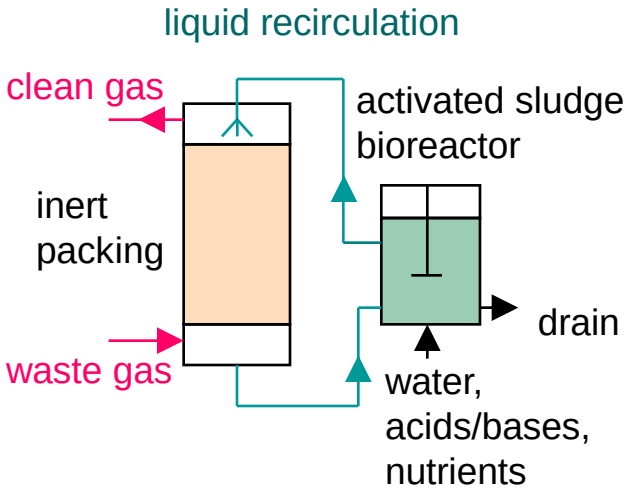
Biological Gas Cleaning

Biofilter



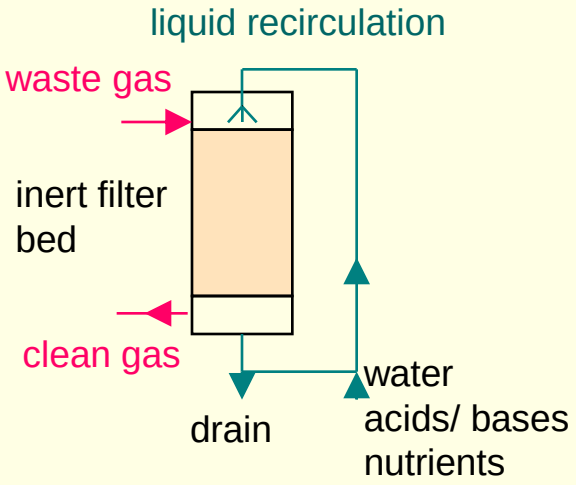
- High efficiency (~90-99%)
- Cheapest one
- Moisture and pH difficult to control → acidification

Bioscrubber



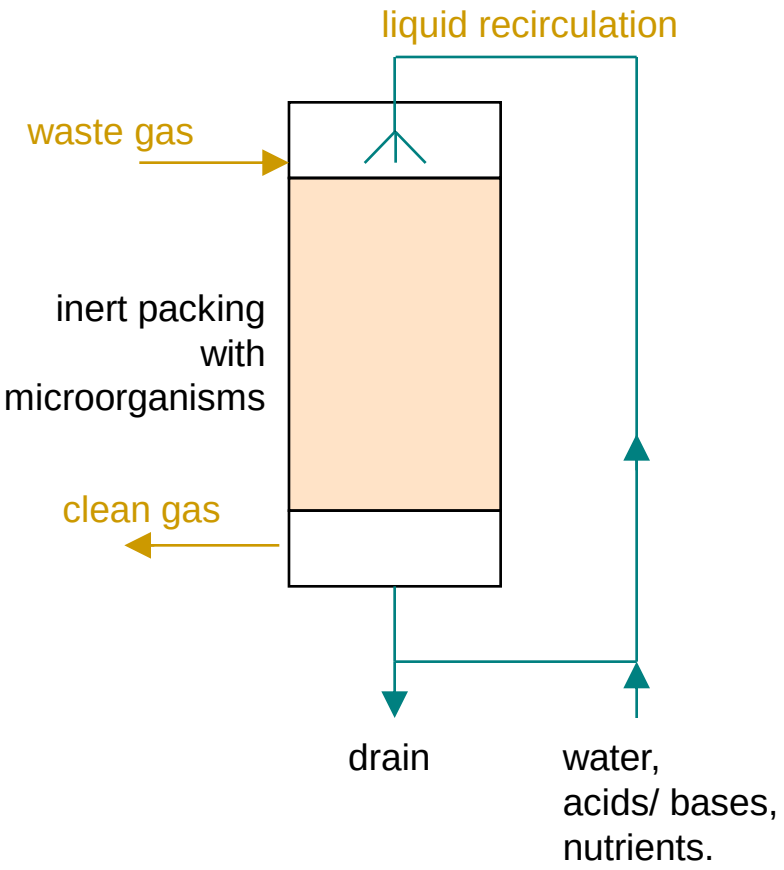
- High efficiency (>90%)
- Usually the most expensive
- Two units
- Easy control of pH and liquid medium → not acidification

Biotrickling filter



- High efficiency (>90%)
- Usually medium price
- Easy control of pH and liquid medium → not acidification

Biotrickling filter



- Microorganisms to degrade H_2S:

  bacteria genus Thiobacillus

- Thiobacillus
  - ✓ Common bacteria.
  - ✓ They do not oxidise CH_4
  - ✓ Their carbon source is CO_2
  - ✓ They are aerobic (fac. anaerobic)
  - ✓ They obtain energy for growth from oxidising inorganic sulphur substrates

$$H_2S + 0.5\ O_2 \rightarrow S + H_2O$$

$$H_2S + 2\ O_2 + 2\ OH^- \rightarrow SO_4^{2-} + 2\ H_2O$$

Siloxanes

Siloxane clean-up efficiencies reported by Hagmann *et al.* (2001)

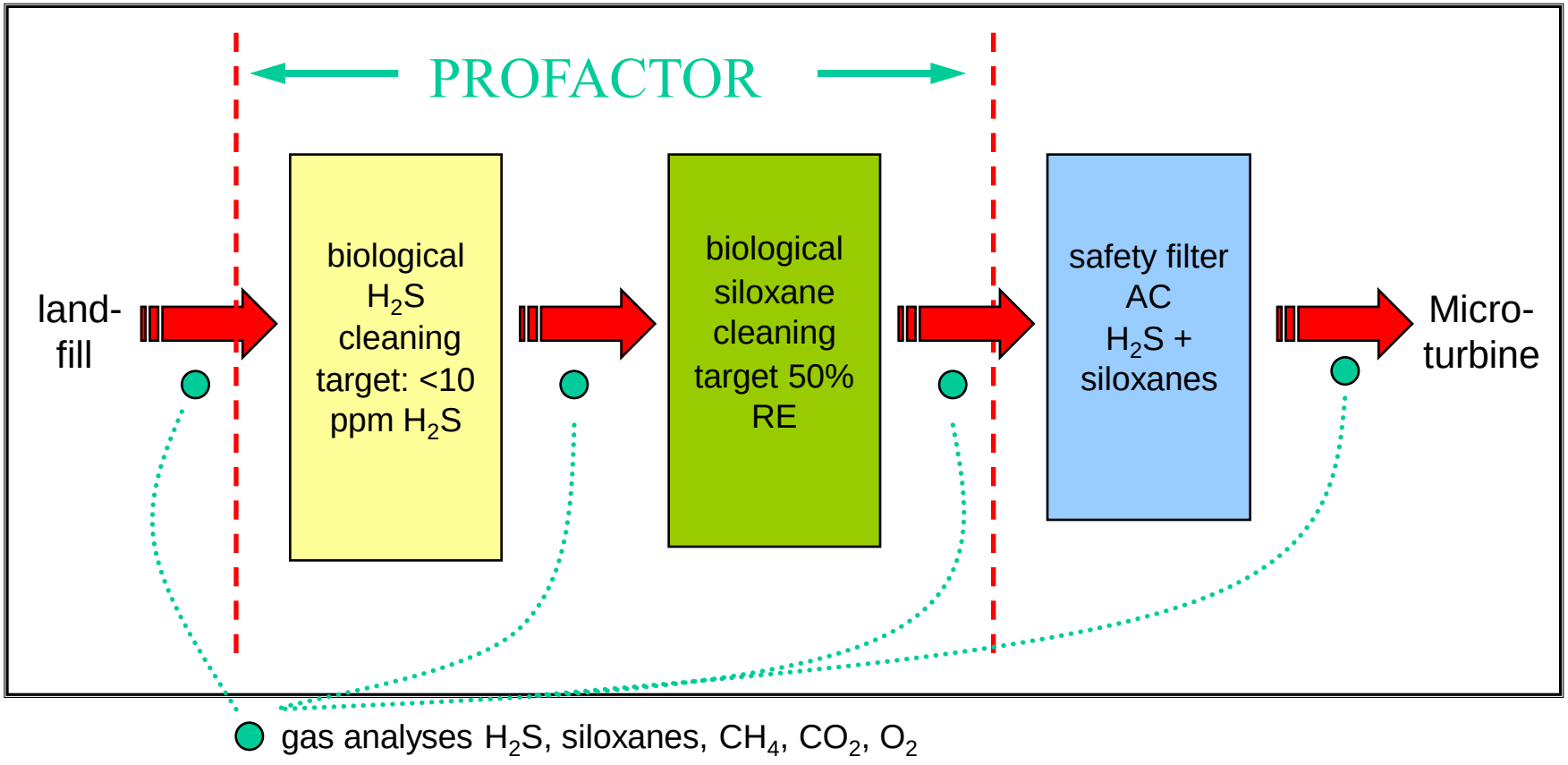
Procedure	Type of technique	Clean-up efficiency (%)
Cooling to –25°C	Continuous	25.9
Freezing to –70 °C	Continuous	99.3
Activated carbon	Non-continuous	>99.1
Solvent washing	Continuous	60.0

- High costs for regeneration
- Material disposal
- Energy demand

Better: Biological siloxane cleaning?

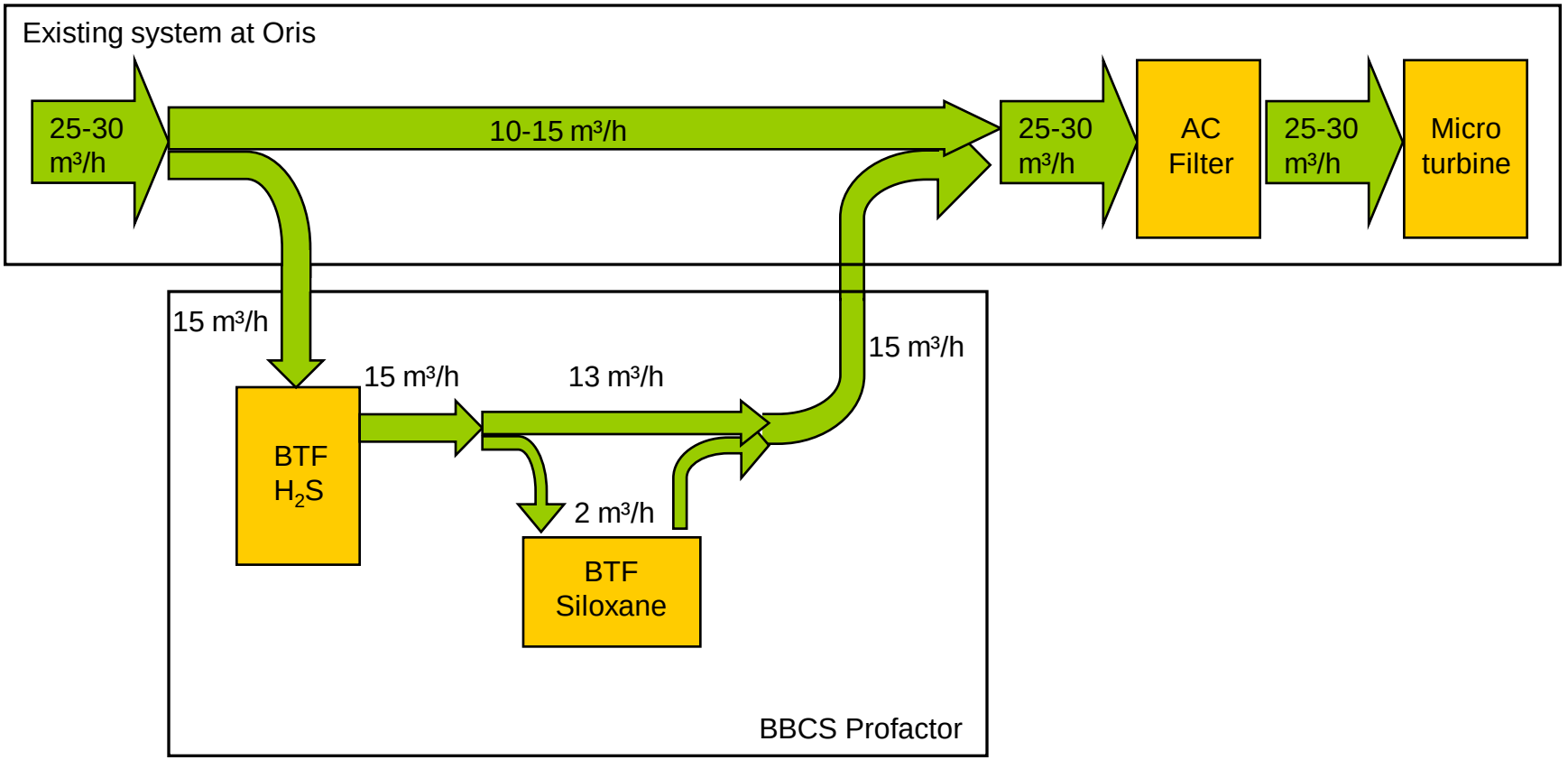
Overview Project

Prototype set-up



Overview BBCS

Prototype set-up: biological biogas cleaning system (BBCS)



Development of siloxane filter

- Taking advantage of previous experience
  - AMONCO
  - PROBAT

  → Screening for siloxane degrading organisms
    - Pseudomonas putida
    - Bacteria isolated from different waste water treatment plants
      - STEYR
      - WACKER

AFTER 6 MONTHS ADAPTATION

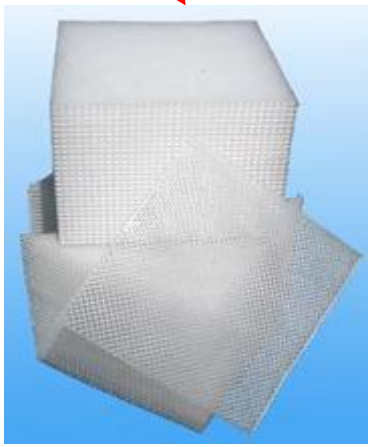
T = 20 C

Development of siloxane filter

Column 1 Column 2

Open pore foam packing material

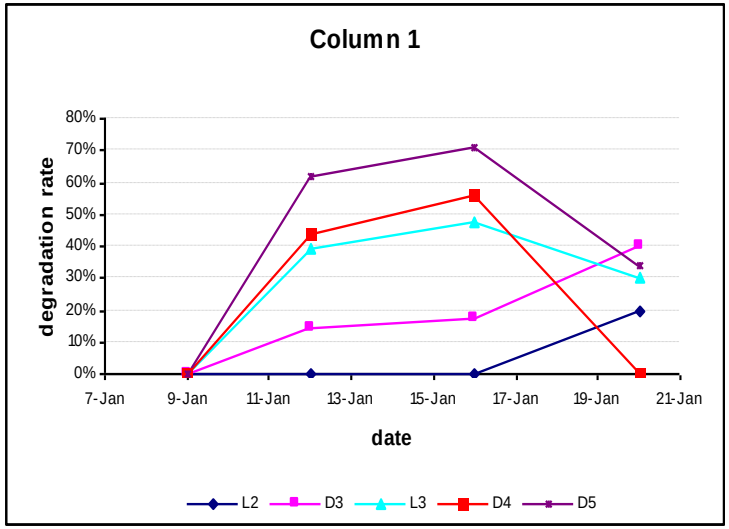
Structured packing material

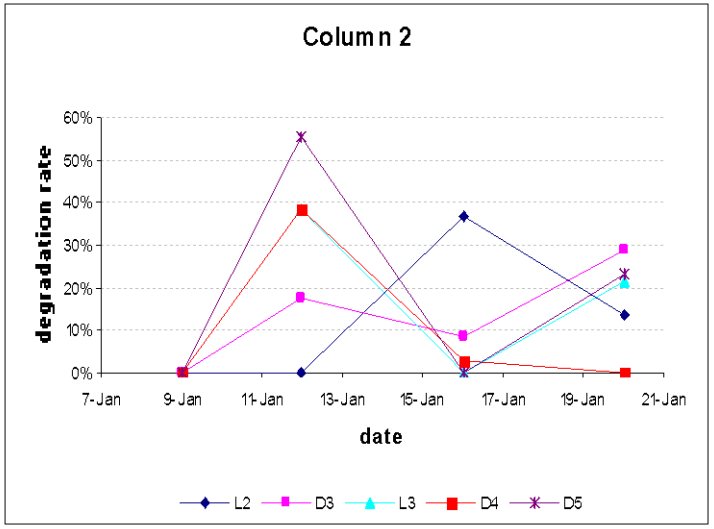


Packing material influences:

- liquid distribution
- mass transfer
- bacterial growth

Laboratory Results





degradation rate column 1					
	L2	D3	L3	D4	D5
9-Jan	0%	0%	0%	0%	0%
12-Jan	0%	14%	39%	44%	62%
16-Jan	0%	18%	48%	55%	71%
20-Jan	20%	40%	31%	0%	34%

Inoculation with mixed cultures

degradation rate column 2					
	L2	D3	L3	D4	D5
9-Jan	0%	0%	0%	0%	0%
12-Jan	0%	18%	38%	39%	56%
16-Jan	37%	8%	0%	3%	0%
20-Jan	14%	29%	22%	0%	23%

Laboratory Results

Results of H_2S cleaning experiments

Calculated cleaning efficiency	2000 ppm – 10 ppm H_2S
Experimental results	1000 ppm – <1 ppm H_2S
Removal efficiency	99%

Results of Siloxane cleaning experiments

Experimental results	Siloxanes (D4)
Removal efficiency	biotrickling filter: ~30%, bacteria growth detected

Upscaling

Development Steps

Lab.: from 20l/h to 200l/h

Prototype; Weibern (A):

1 m³/h

Biotrickling Filter System; Pucking (A)

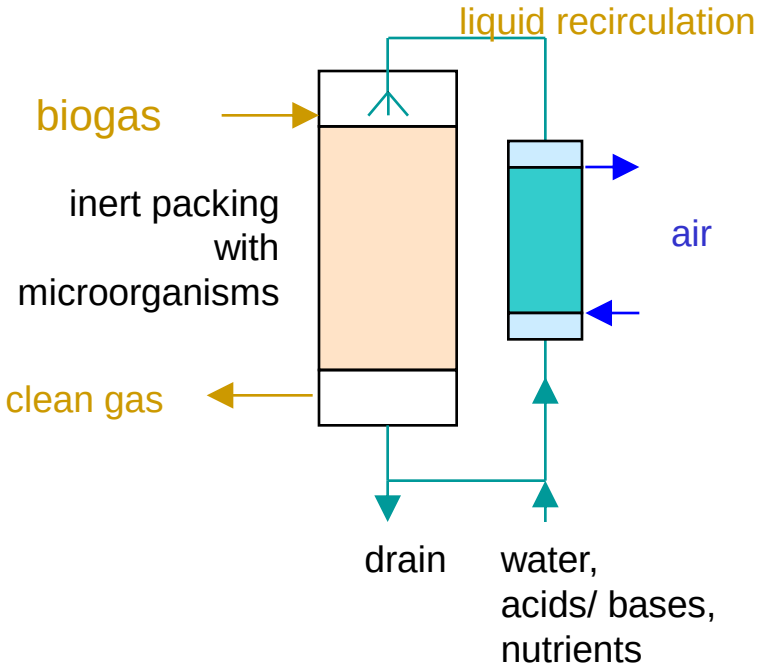
10 m³/h

Upscaling to

Biotrickling Filter System; Oris (E)

15 m³/h

Profactor System – Bubble Column



Upscaling

Development Steps

Lab.: batch cultures

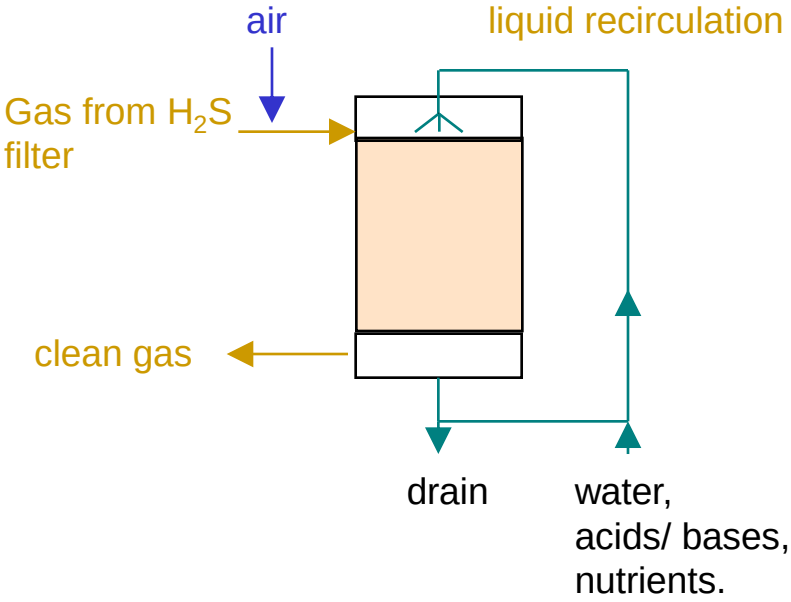
Lab.: 30l/h

Upscaling to

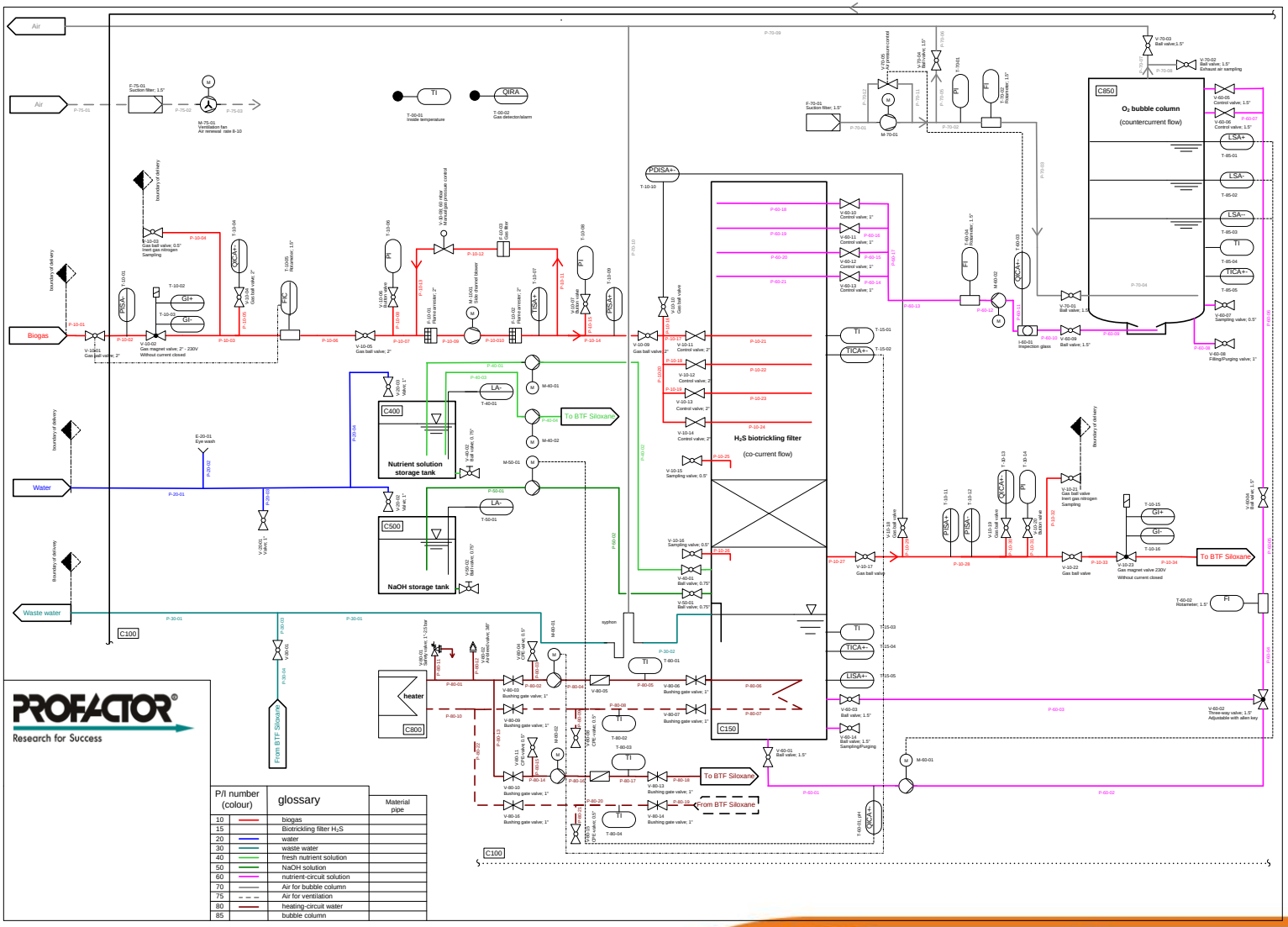
Prototype Biotrickling Filter System field test; Oris (E)

2 m³/h

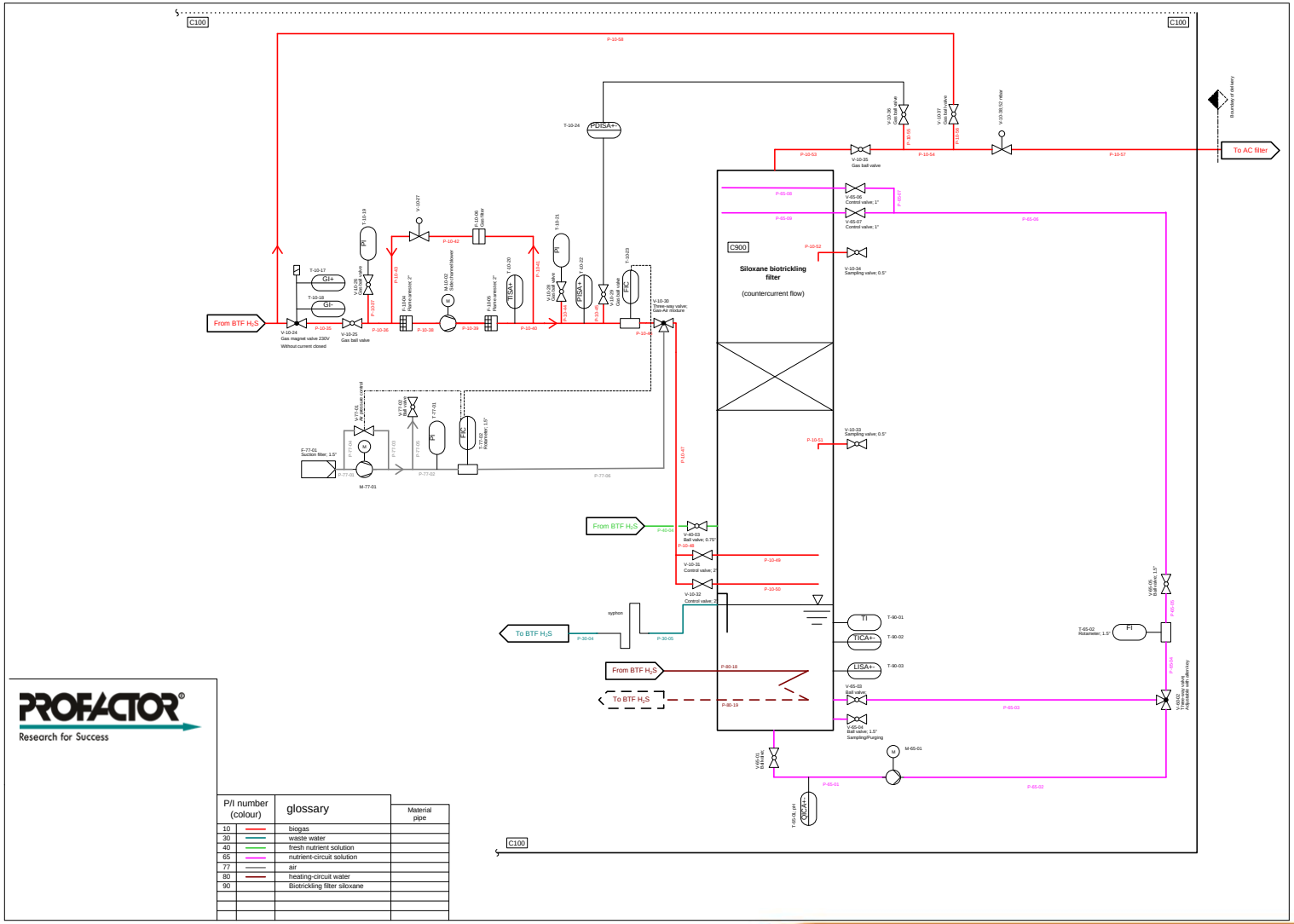
Profactor System – Biotrickling Filter



Drawing


Air
Biogas
Water
Waste water
C850
O2 bubble column
(countercurrent flow)
H2S biotrickling filter
(co-current flow)
Nutrient solution storage tank
NaOH storage tank
heater
To BTF Siloxane
From BTF Siloxane
PROFACTOR
Research for Success
P/I number (colour)
glossary
Material pipe
10 biogas
15 Biotrickling filter H2S
20 water
30 waste water
40 fresh nutrient solution
50 NaOH solution
60 nutrient-circuit solution
70 Air for bubble column
75 Air for ventilation
80 heating-circuit water
85 bubble column

Drawing


C100
C900
Siloxane biotrickling filter
(countercurrent flow)
From BTF H2S
To AC filter
To BTF H2S
From BTF H2S
To BTF H2S
From BTF H2S
To BTF H2S
PROFACTOR
Research for Success
P/I number (colour)
glossary
Material pipe
10 biogas
30 waste water
40 fresh nutrient solution
65 nutrient-circuit solution
77 air
80 heating-circuit water
90 Biotrickling filter siloxane

Dimension

Calculation values H2S biotrickling filter	Microphilox H2S-BTF
Total Filter Height	1,8 m
Filter Bed Height	0,93 m
Biotrickling Filter Diameter	0,65 m
Biotrickling Filter Volume (carrier material)	0,31 m³
Biogas Flow Rate	15 m³/h

Calculation values bubble column	Microphilox H2S-BTF
Total Column Height	1,7 m
Liquid Height	1,2 m
Column Diameter	0,4 m
Liquid Volume	0,15 m³
Air Flow Rate	1 m³/h

Calculation values Siloxane biotrickling filter	Microphilox Siloxane-BTF
Total Filter Height	2 m
Filter Bed Height	1,06 m
Biotrickling Filter Diameter	0,4 m
Biotrickling Filter Volume (carrier material)	0,13 m³
Biogas Flow Rate	2 m³/h

Manufacturing

Selection of manufacturer:

- 6 companies contacted
- 3 offers compared

IDM

DEYMAN

- Engineering company
- Equipment for laboratory and pilot plants
- Located in Avilés (Asturias)
- SME (10 employees)

IDM

- Manufacturing company
- Equipment for water treatment and cleaning
- Located in Llanera (Asturias)
- SME (20 employees)

ADEPRO

- Engineering company
- Prototypes and tailor-made products for R&D
- Located in Avilés (Asturias)
- SME (10 employees)

Manufacturing

Assembling process 2007:

	MAY				JUNE				JULY				AUGUST				SEPTEMBER				
Material ordering																					
Pieces assembly																					

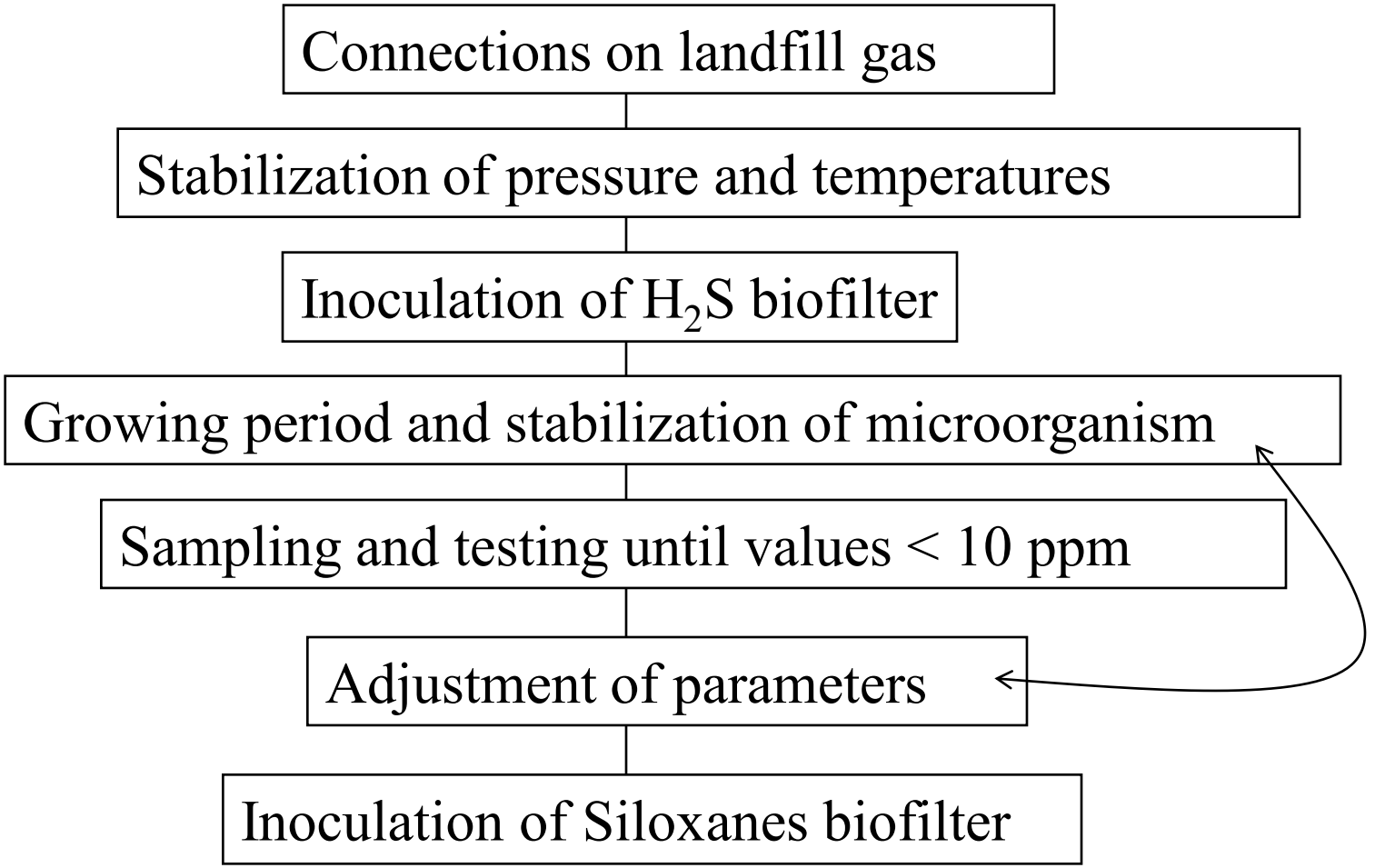
July-August holiday phase!

Manufacturing

Transport to Oris
October 2007:

Start up

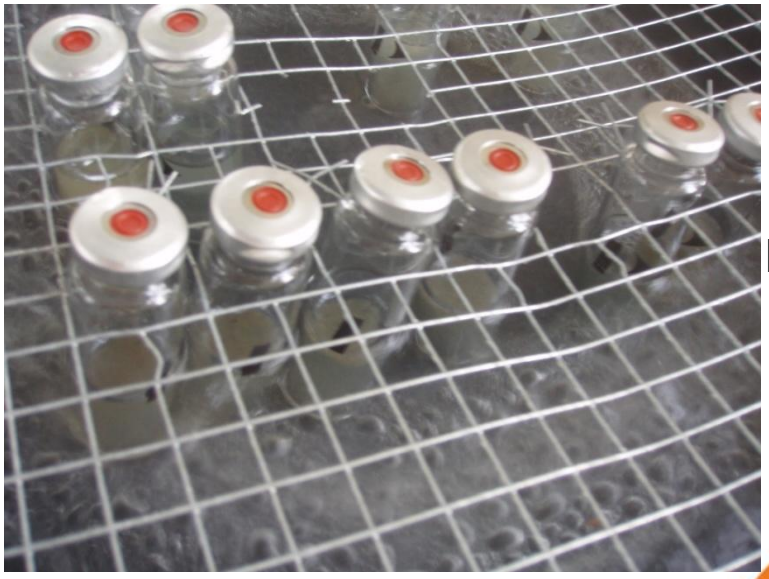
Start up


Connections on landfill gas
Stabilization of pressure and temperatures
Inoculation of H_2S biofilter
Growing period and stabilization of microorganism
Sampling and testing until values < 10 ppm
Adjustment of parameters
Inoculation of Siloxanes biofilter

Operation

Student from University of La Coruña -One year training contract

MAIN TASKS
❑ Adjusting parameters ❑ Control system ❑ Refilling of consumables ❑ Sampling and Reporting...

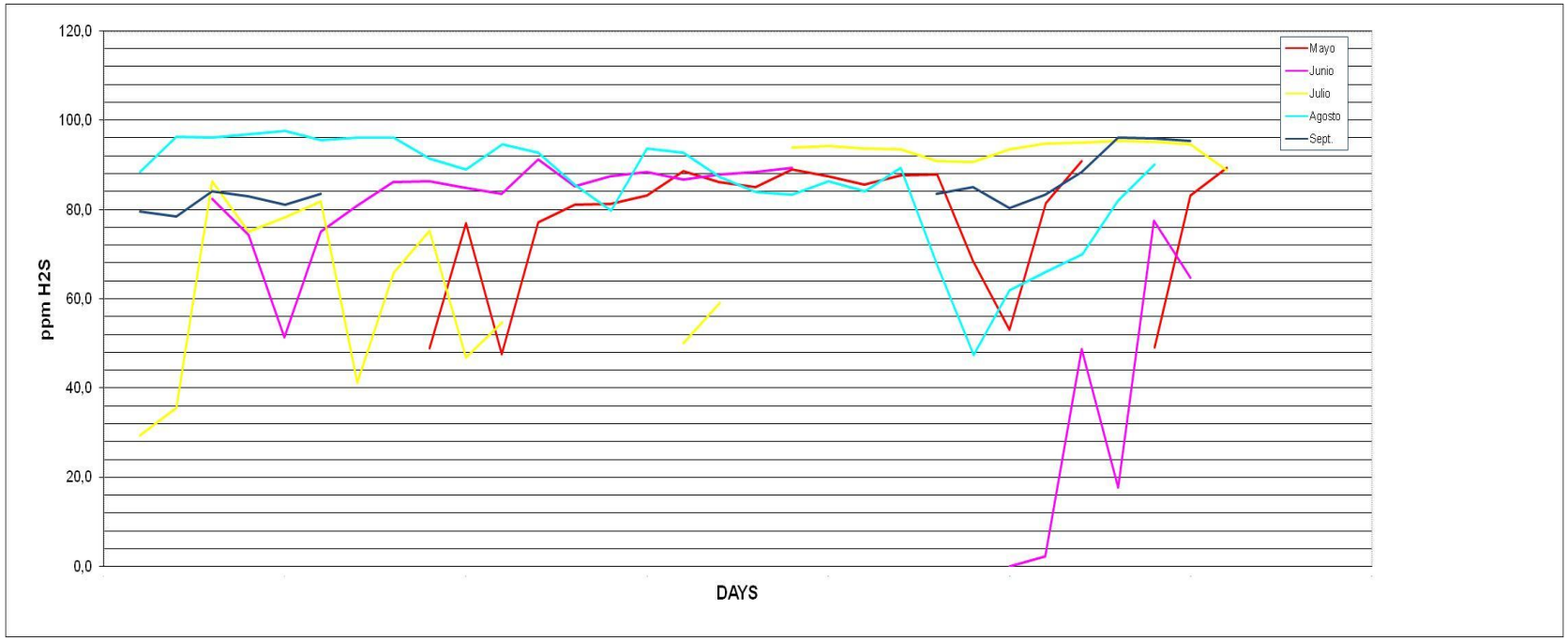


Sampling

Liquid Gas

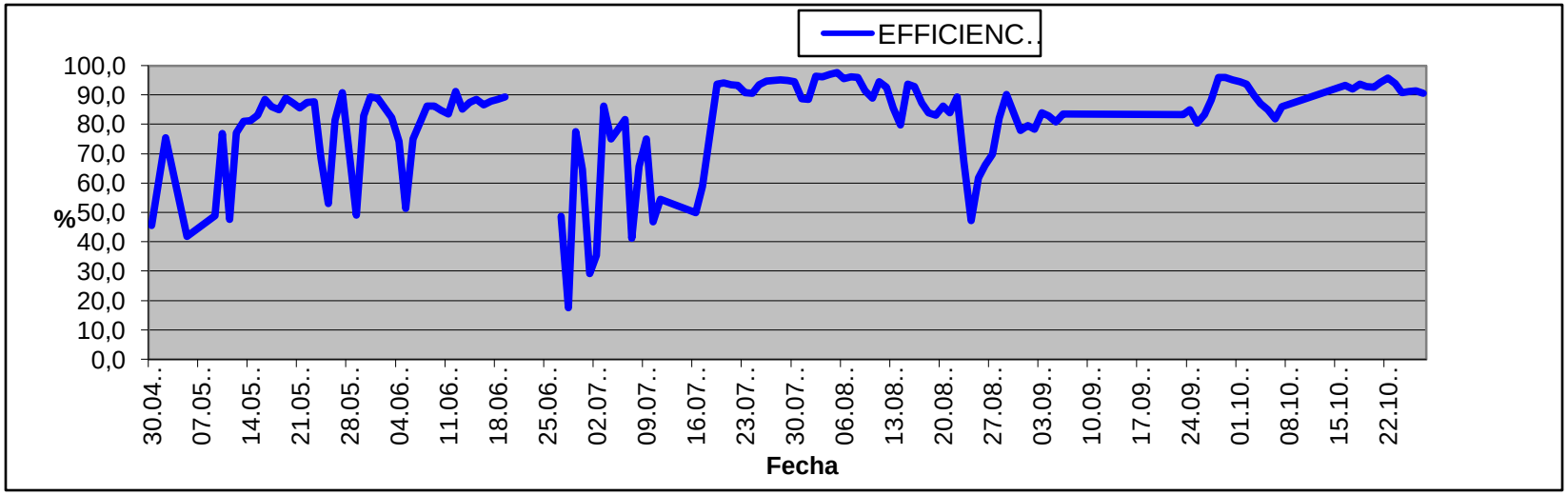
Results

H2S concentration in the inlet gas (May – September 2008)



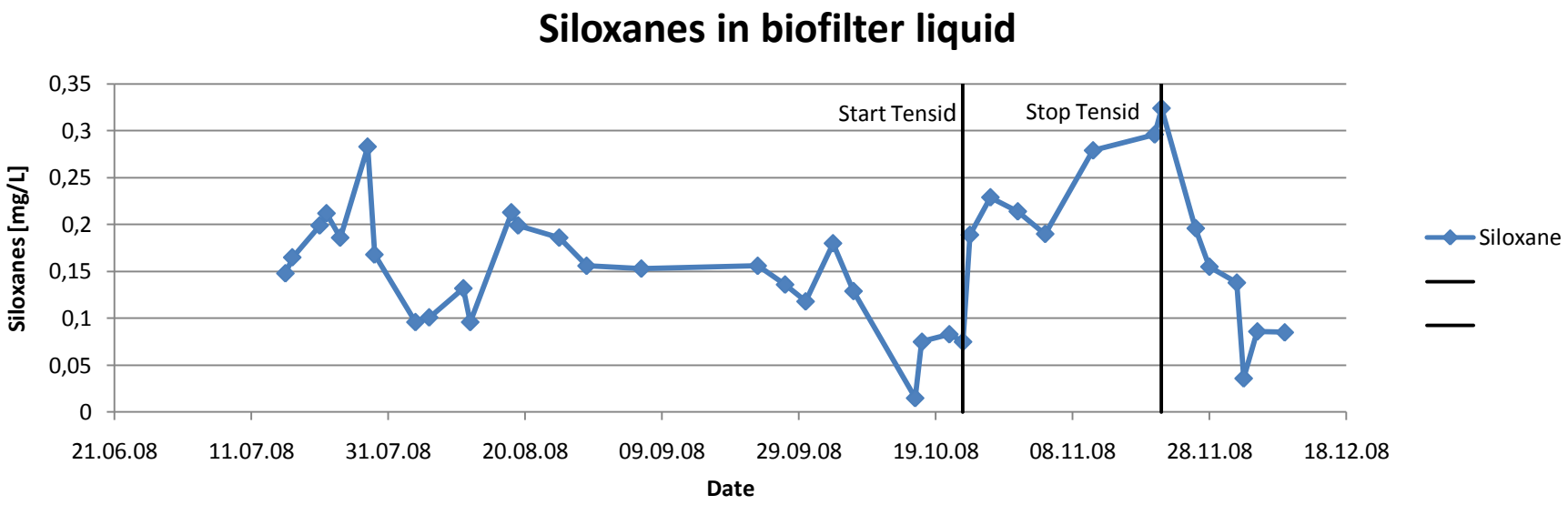
Results

H2S removal efficiency of the biotrickling filter



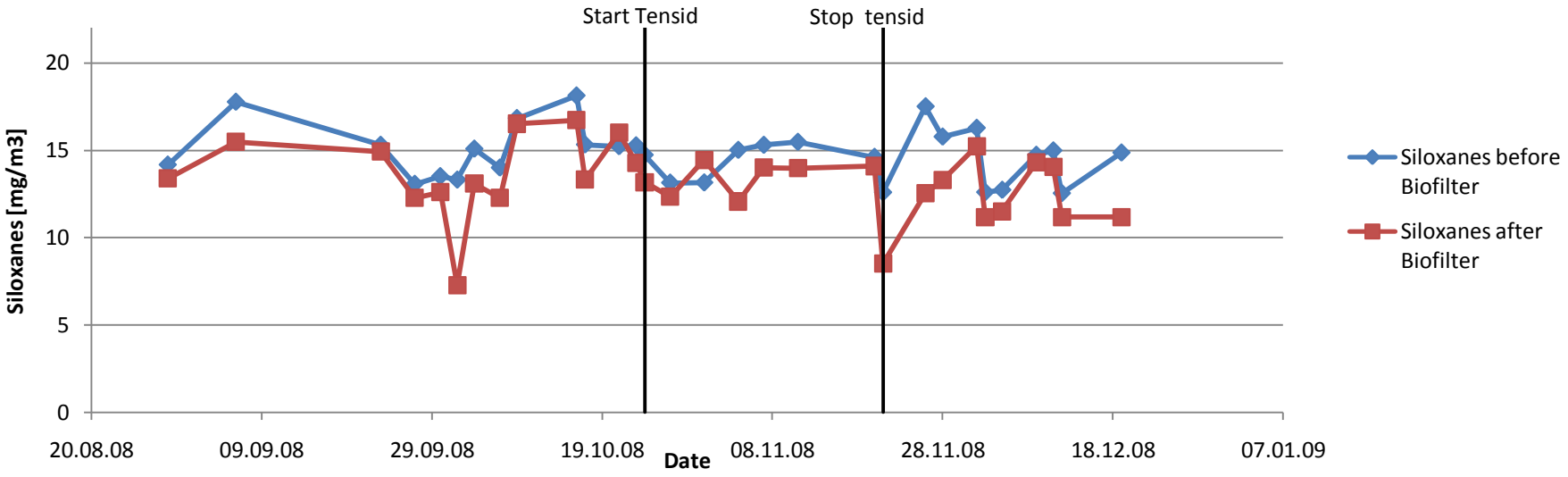
Results

Siloxane concentration in the liquid phase



Results

Siloxane concentration in the gas phase



Conclusion

Conclusion

- Biological Biogas Cleaning system was testing for nine months
- Some modifications were necessary for a good operation
- Problems with gas supply from the „old landfill part“ at the beginning and power supply
- Best removal efficiency of H2S only if the biotrickling filter is running with a continuous landfill gas flow
- Siloxane removal only in the laboratory tests, not with the filter at the landfill
- No significant effects of tensid addition regarding improvement of the solubility of siloxanes

Thank you!

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