



Biodiesel production from urban sewage sludge

Zuzana Dedova PhD
University of Luxembourg

Lipid pilot team:

Marie Louise Uwizeye (PhD student), Fernanda Muniz Sacco (MSc student), Silvia Venditti PhD, Prof Joachim Hansen – University of Luxembourg (L)

Arsou Arimi PhD – Remondis Aqua (DE)

Amelie Leger – SIVOM de l'Alzette (FR)

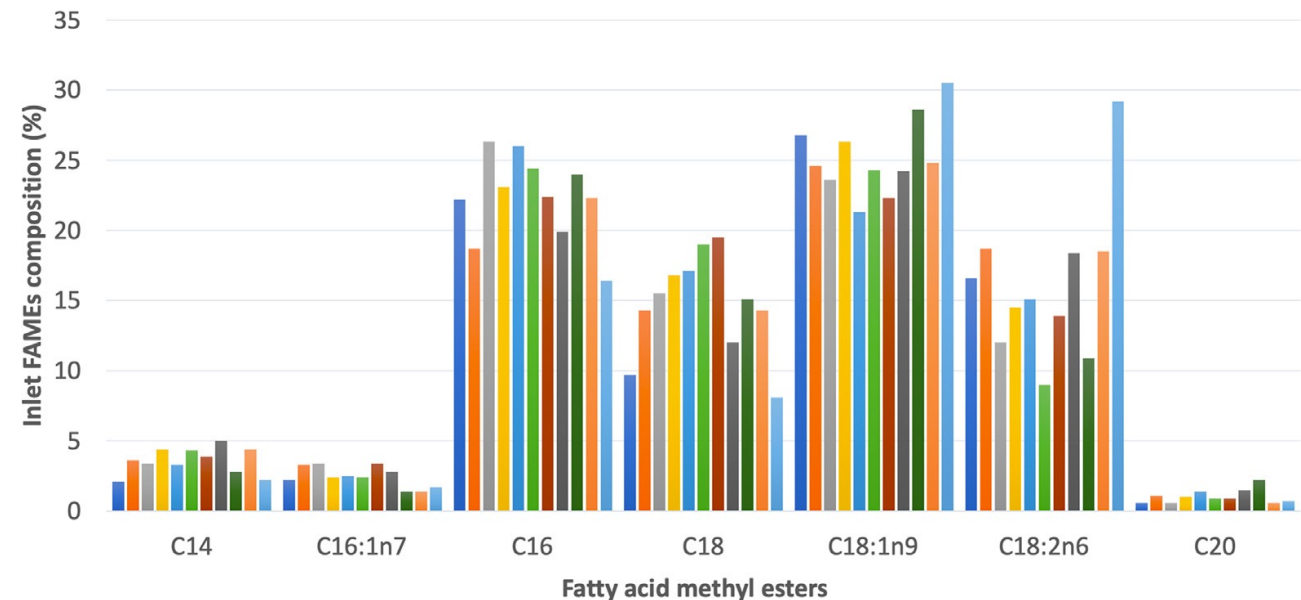
#EUGreenWeek
2021 PARTNER EVENT

Lipids in municipal sewage

FACULTY OF SCIENCE, TECHNOLOGY AND MEDICINE



- Daily load of lipids to municipal sewage:
 - 35 to 50 g/PE
 - 45 % of the lipids originates from faeces while 55 % from kitchen waste
- Lipids are present in both liquid and particulate forms



- Most common lipids in the STP influent are C18:1 (oleic acid), C16:0 (palmitic acid), C18:2 (linoleic acid) – all known to be suitable for the production of biodiesel
- The range of LCFAs (>C12) in sewage varies from 20 to 500 mg/l with an average value of 150 mg/l

- Particulate lipids: are removed in the sand and grease trap and then disposed at high costs for the operators
- Dissolved lipids: are used from activated sludge bacteria

Two possibilities:

- 1) In large WWTPs (> 20.000 PE) activated sludge is digested and biogas is produced → **energy production**
- 2) In other wastewater treatment plants, sludge with accumulated lipids is disposed → **valuable resources are being lost**

→ **Lipids are not used at their potential**

Overall potential:

- 50 g / inhabitant per day = 18 kg lipids / inhabitant per year
- In NW-Europe around 250 million people are connected to municipal sewage treatment plants
- Total load of lipids in the inflow of municipal wastewater treatment plants: 4.5 million tons per year in total
- In addition: industrial wastewater treatment plants

→ **Impressive potential for biodiesel production from wastewater**



First work on biodiesel production (Mondala et al. 2009):

- Production of FAMEs (fatty acid methyl esters = biodiesel) from conventional sludge (primary and activated sludge) by chemical transesterification: biodiesel yield 10% FAMEs of dry biomass
- Estimated costs for production: 0.20 €/L biodiesel

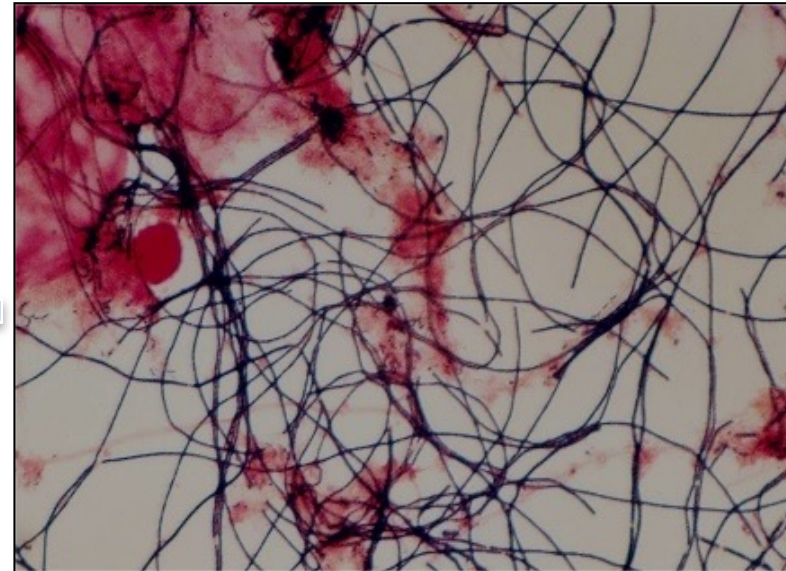
→ Using biomass known to accumulate LCFAs is possible to increase the yield and to reduce the costs for biodiesel production

Background

FACULTY OF SCIENCE, TECHNOLOGY AND MEDICINE

Interreg
North-West Europe
WOW!
Interregional Development Fund

UNIVERSITÉ DU
LUXEMBOURG



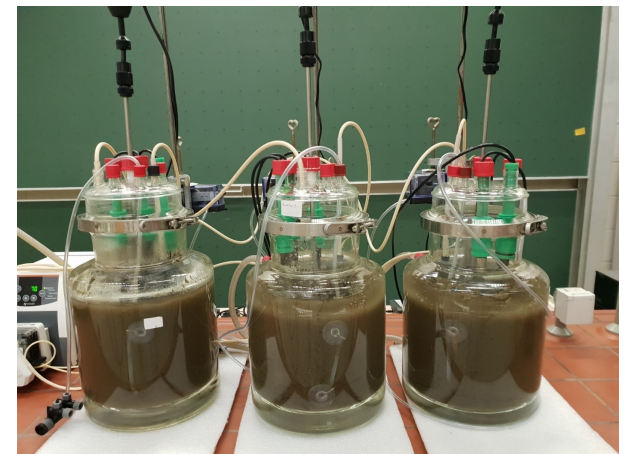
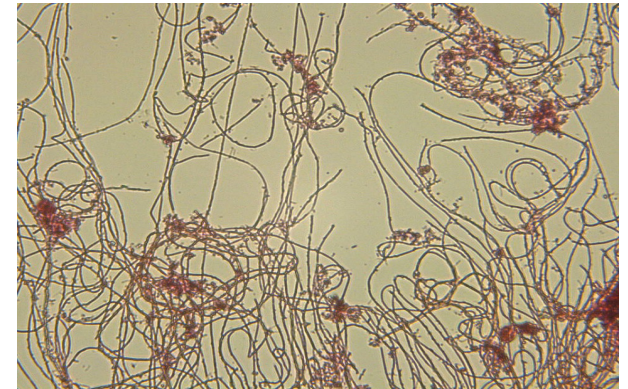
Bulking and foaming
is a common **PROBLEM**
in municipal WWTPs

Microthrix parvicella is
known to be responsible for
foaming and bulking

Microthrix parvicella can accumulate
long chain fatty acids (LCFAs) that can
be harvested for biodiesel production
OPPORTUNITY

Selection of *Microthrix parvicella* as a lipid accumulator in municipal WWTP for the production of biodiesel

- Based on literature review and experience with foaming and bulking at 7 STPs in Luxembourg, 5 experimental scenarios were developed and tested at lab-scale:
 - Aeration mode
 - DO concentration
 - Sludge loading
 - Feeding regime
 - Temperature
- Main factors affecting growth of *Microthrix parvicella* and the ability to accumulate lipids were determined
- Technology able to select *M. parvicella* was developed
- Lipids accumulated by *M. parvicella* were characterized



Lesson learned from the lab-scale experimental study

📄 FACULTY OF SCIENCE, TECHNOLOGY AND MEDICINE

Interreg
North-West Europe
WOW!
European Regional Development Fund

uni.lu
UNIVERSITÉ DU
LUXEMBOURG

- Preliminary results (from about >20 samples from the lab-scale experiment):
 - ✓ ~63 mg FAME/g of dry solid was produced (6.3% biodiesel yield)
 - ✓ Transesterification was 98% efficient
- Scenario
 - ✓ Continuous feeding with real wastewater
 - ✓ Intermittent aeration
 - ✓ Low temperature of 12°C
 - ✓ Long sludge age of >30 days
 - ✓ Sample taken after 4 weeks
 - ✓ Increase of Microthrix observed



Objectives of the lipid-pilot installation

📄 FACULTY OF SCIENCE, TECHNOLOGY AND MEDICINE

Interreg
North-West Europe
WOW!
Interreg Regional Development Fund

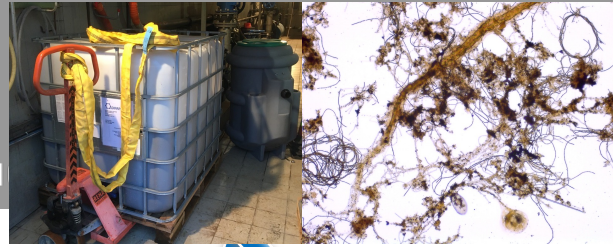
uni.lu
UNIVERSITÉ DU
LUXEMBOURG

- Operate at “real conditions” using favourable operational parameters for *Microthrix parvicella* growth and lipid accumulation (University of Luxembourg – SIVOM)
- Test settleability of the sludge and recirculation
- Characterize long-chain fatty acids (LCFAs) in the influent (GC-MS, LIST)
- Characterize specific LCFAs being accumulated in the set of bioreactors
- Calculate mass balance and evaluate performance of the pilot (Remondis Aqua)
 - Dispatch sludge samples to Animox (Germany) for development of the lipid extraction protocol
 - Dispatch samples of the extracted lipids to the IRSA (Italy) for the transesterification to biodiesel and assessment of biodiesel quality (by Animox)
- Evaluate development of microbial community within the experimental time and in changing seasons at the sewage treatment plant (genomics, LCSB)
- To test feasibility of the technology to eventually give design recommendation for upscaling



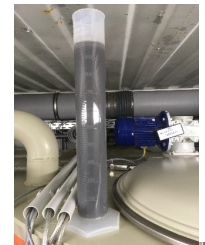
Lipid pilot

FACULTY OF SCIENCE, TECHN



4 m³ Mixing tank (homogenization)

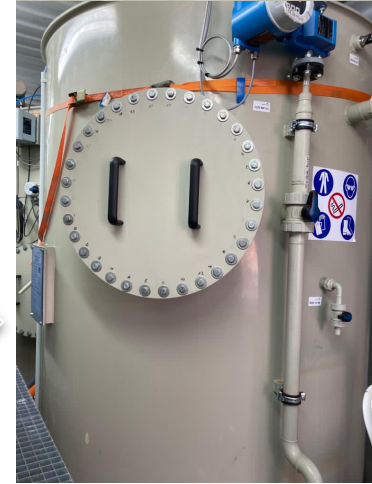
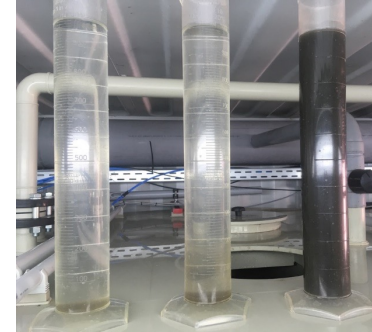
Inlet water (after screen)



4 m³ Reactor 1 (anoxic, lipid accumulation)



4 m³ Reactor 2 (micro-aerobic, biomass growth)



3.7 m³ Separation unit



Storage tank (effluent)

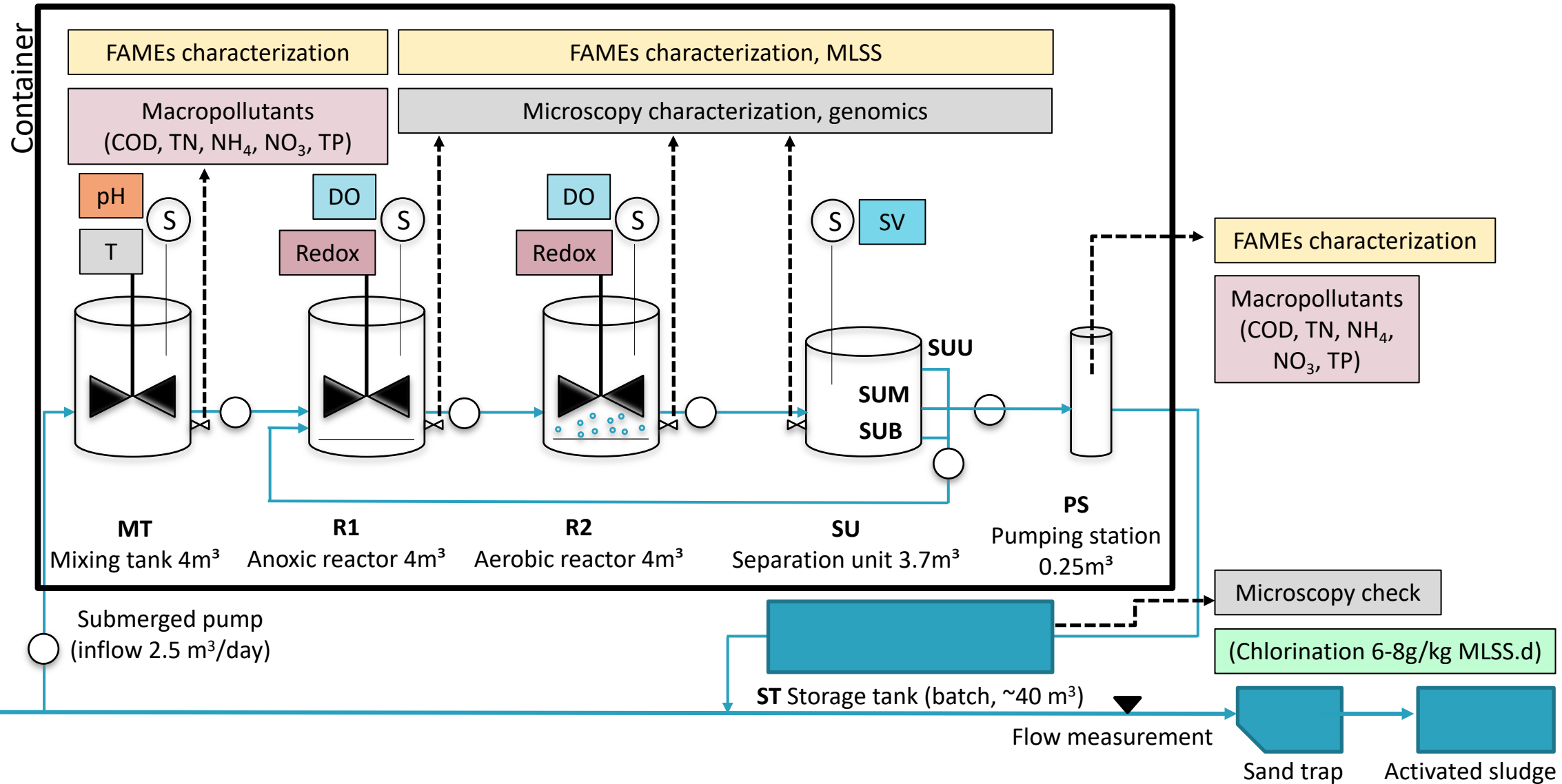
Inoculation with surplus sludge (SIVOM)

Sludge recirculation

Surplus sludge (lipid enriched biomass)

Lipid-pilot sampling design

FACULTY OF SCIENCE, TECHNOLOGY AND MEDICINE

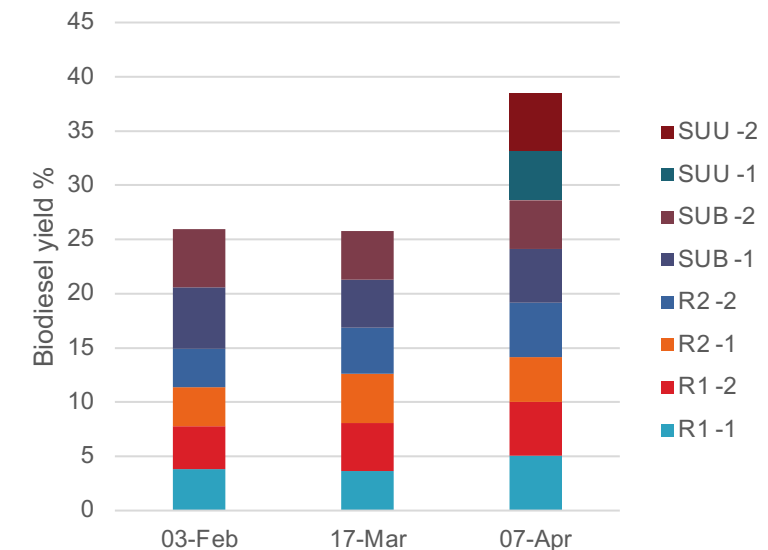
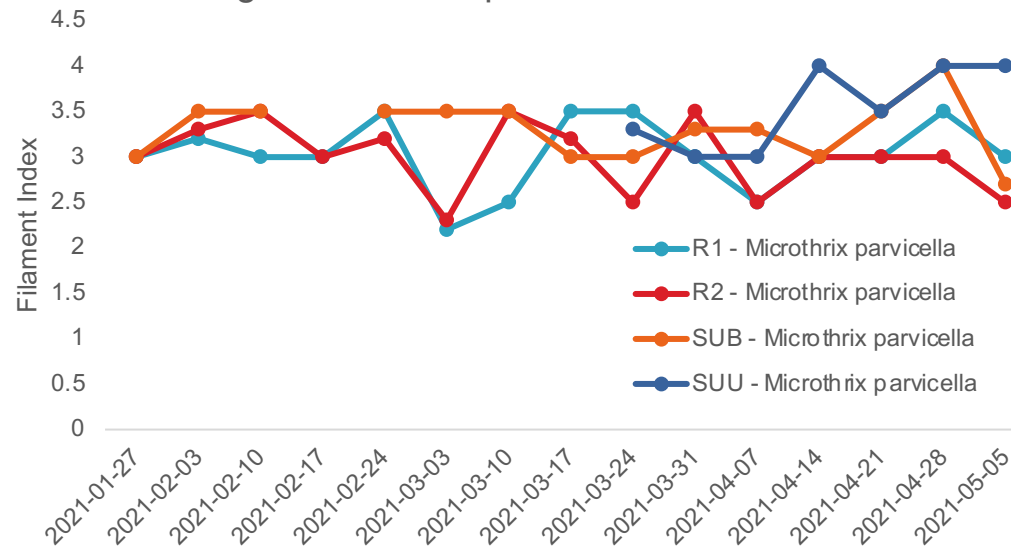
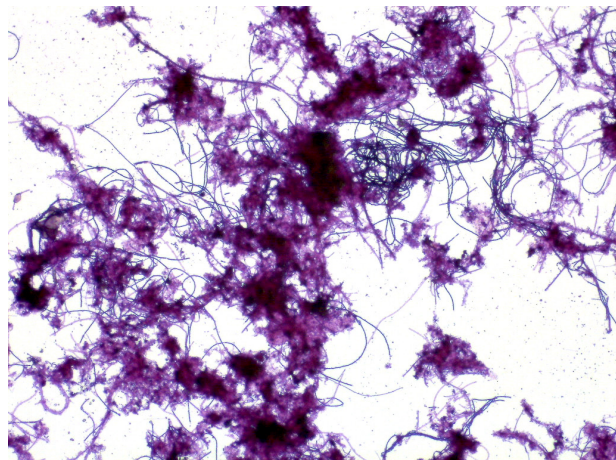
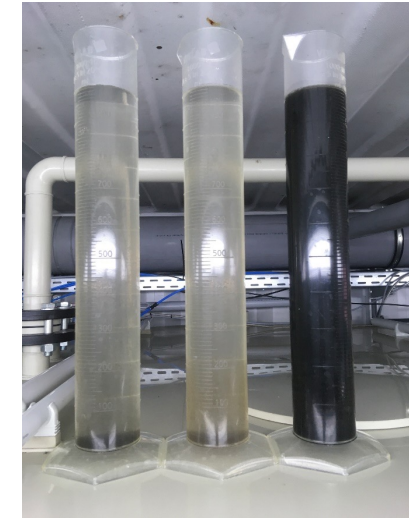


Lipid pilot – first results

FACULTY OF SCIENCE, TECHNOLOGY AND MEDICINE

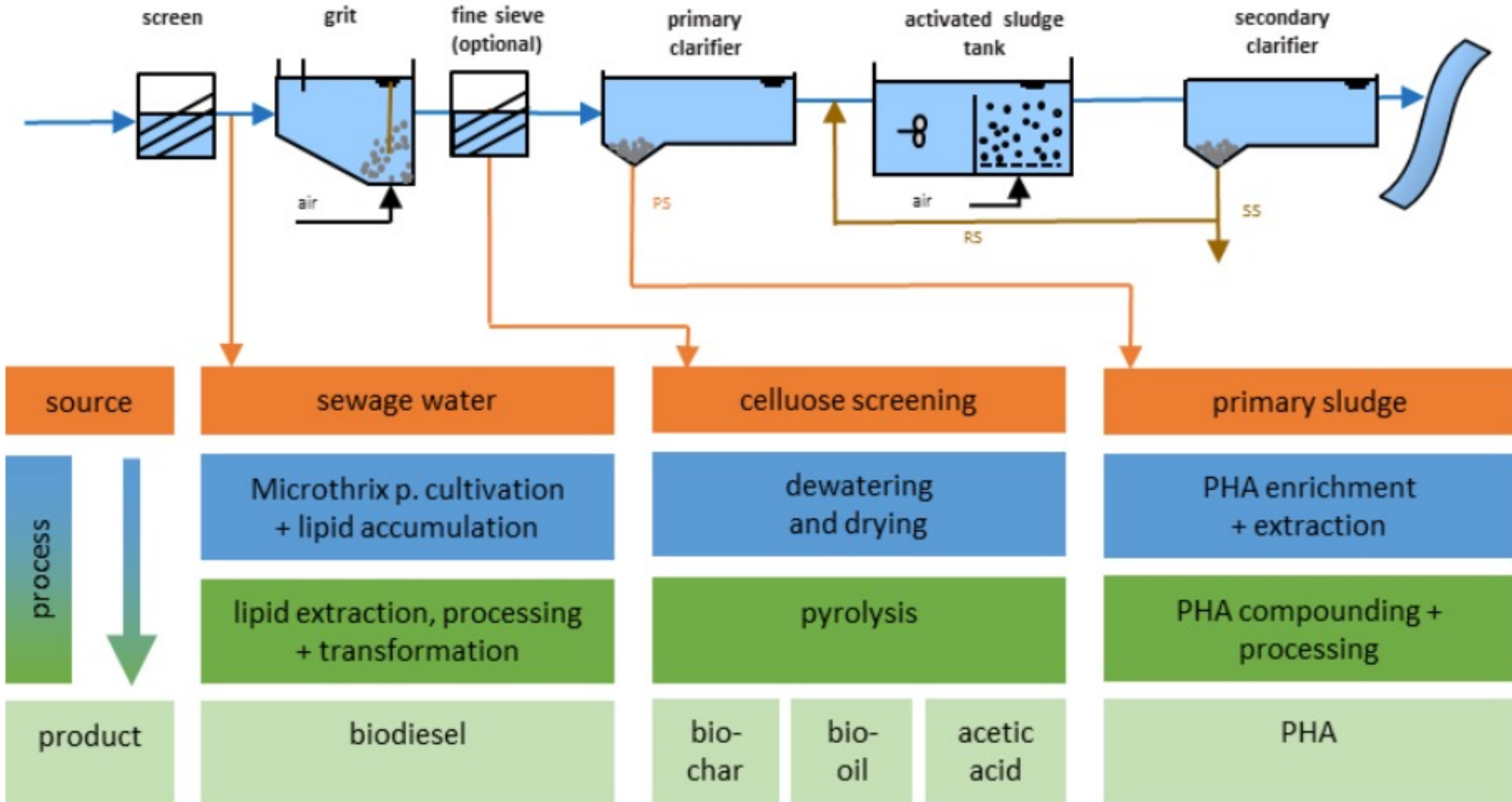


- Optimum conditions for *Microthrix* growth and lipid accumulation are maintained (FI 2.5-4)
- Biodiesel yield 4-5.3% with ~84% transesterification efficiency
- Challenges of the technology
 - Inlet sewage water poor in LCFAs (32-35 mg/l) – **specific challenge at WWTP SIVOM** (average BOD 93.5 mg/l)
 - Separation of sludge
 - Influence of all parameters in separate tanks
 - Slow growing bacterium
 - Not to carry *Microthrix parvicella* in the following treatment steps



Context

FACULTY OF SCIENCE, TECHNOLOGY AND MEDICINE



- Lipid-pilot is running at favourable conditions for the selection of *Microthrix parvicella* and lipid accumulation
- Settleability of sludge is still very good
- Biodiesel yield in the first few months 50 mg/g even in a "poor sewage"
- One step further to circular wastewater!

- **What are the next steps?**
 - Up-scaled extraction of lipids from the lipid-rich sludge, production of the demo-biodiesel and assessment of its quality (Remondis + Animox and later CNR)

- **Timeline**
 - The pilot run is estimated to 8 months (January-August 2021)
 - Collection and transportation of sludge to Animox (from June/July for the method development and then in August 2021)

A microscopic view of a biological sample, likely a tissue section, showing numerous thin, fibrous structures and small, dark, granular particles. The background is a light, yellowish-brown color. The text "Thanks for your attention" is overlaid in the center in a bold, black, sans-serif font.

Thanks for your attention