Interreg North-West Europe WOW!

EUROPEAN UNION

European Regional Development Fund

LIPIDS PILOT

FROM LIPIDS TO BIODIESEL

BIODIESEL FROM SEWAGE

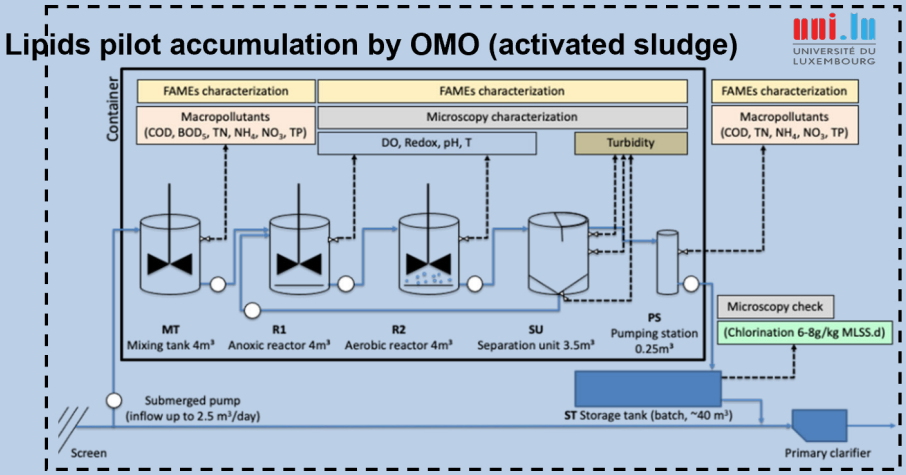
Municipal sewage sludge has an abundant organic content and amount of lipids, that can be converted into biodiesel. Moreover, oleaginous microorganisms (OMO), such as Microthrix parvicella, can be used in a productive way to increase lipids content, as they accumulate lipids in their cells and membranes. These OMO are known for causing serious operational problems (foam and bulking) in wastewater treatment plants (WWTP); however, by applying circular economy (CE), these problems can be converted into a solution (biodiesel production).

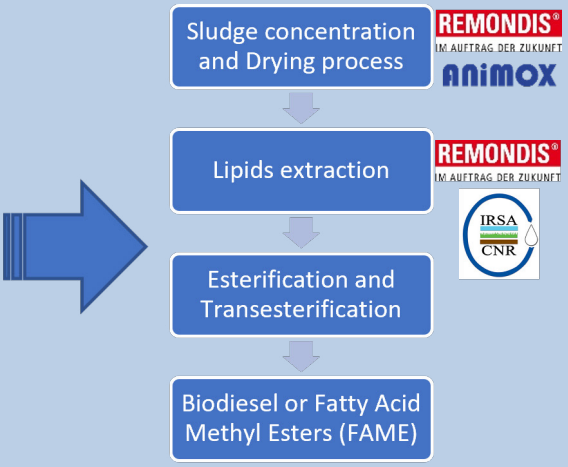
The biodiesel production is summarized by the following steps:
A pilot-plant designed as selector was connected to the inlet WWTP (after the grid chamber), with ideal parameters to offer optimum conditions for M. parvicella growth and lipids accumulation. Afterwards, the activated sludge, enriched with lipids, was sent to specialized companies for the demo-biodiesel production and quality assessment.

WHAT IS BIODIESEL?

Biodiesel is a biofuel produced from renewable sources, which can be originated from agricultural crops (first-generation), or from agricultural crops and industrial processes as by-products (second-generation), or from OMO, as a third-generation of biofuels. The product has to meet standard specifications for biodiesel, such as EN 14214 in Europe.

PRODUCTION PROCESS





LIPIDS ACCUMULATION (PILOT)

The preliminary results of biofuel and biodiesel, obtained through the transesterification of extracted lipids are summarized in the table on the right.

- **Lipids =>** the bioreactors content was 56-74% higher than the inflow
- **Biofuel =>** the sum of bioreactors content was 5 times higher than the inflow
- **Biodiesel =>** the sum of bioreactors content was 9 times higher than the inflow
- **Biodiesel =>** the biodiesel production from bio-reactors represented 36% of Biofuel:

	Inflow	Outflow	Bioreactors			
			R1	R2	SUB	SUU
Lipids content (mg/g SS)	39,68	36,42	68,99	62,86	63,82	62,05
Lipids yield (%)	4%	4%	7%	6%	6%	6%
Transesterification (%)	80%	72%	70%	71%	73%	71%
Biofuel content (mg/g SS)	32,25	24,38	45,36	42,14	45,65	43,71
Biofuel yield (%)	3,2%	2,4%	4,5%	4,2%	4,6%	4,4%
Biodiesel content (mg/g SS)	7,31	2,7	13,8	10,73	13,58	25,72
Biodiesel yield (%)	0,7%	0,3%	1,4%	1,1%	1,4%	2,6%
Biodiesel/ Biofuel (%)				36%		

R1: lipids accumulation
R2: biomass growth
SUB: separation unit- Bottom level
SUU: separation unit- Upper level

Individual FAMEs:
Inflow wastewater: mostly C16:0 and C18:0
Bioreactors: fatty acids accumulated in the bioreactors C16:1, C18:1 and C18:2

SLUDGE CONCENTRATION AND DRYING PROCESS

Concentration of the activated sludge:
The activated sludge samples from the pilot plant were harvested as a foam fraction and a liquid fraction which were concentrated through direct separation, freezing/thawing/centrifugation as well as vacuum evaporation.

Drying of the concentrated activated sludge:
Following the concentrating process, the collected concentrated activated sludge was dried through freeze-drying, air drying and combination of these approaches.

LIPIDS EXTRACTION AND TRANSESTERIFICATION INTO BIODIESEL

Lipid extraction:
After initial characterization of the dried sludge, the lipid component was extracted via three different approaches.

Biodiesel recovery and purification:
The reacted extract (namely biofuel), having a total FAMEs content of about 30%, was distilled under vacuum to obtain a first distillate with FAMEs content of 88-92 wt.%.
Two purification steps were performed to improve the FAMEs content, including a second distillation under vacuum as well as a dry wash with SiO2 as adsorbent, resulting in a final biodiesel product that complies with EN14214.

CONCLUSIONS

Lipids accumulation (pilot): The pilot plant parameters provided favorable conditions for M. parvicella growth and lipids accumulation. Therefore, the lipids-pilot demonstrated being a promising technology to accumulate lipids from sewage sludge.

Sludge concentration and drying process: The implemented concentrating and drying methods were found to be effective and the composition of the lipids and their overall content in samples dried by different methods remained stable.

Lipids extraction and transesterification into Biodiesel: The reactive extraction approach with methanol on a pre-treated sludge using H_2SO_4 was found to be the most effective extraction path. The extracted fraction could successfully be recovered and purified into a final biodiesel product which meets the standard specifications (EN14214) for biodiesel in Europe.

MORE INFORMATION

- Download the complete reports:
  1. Technical report on operation of demo scale selector for lipids
  2. Technical report on concentration of the sludge, lipids extraction, recovery and production of demo-biodiesel
- Contact Fernanda Muniz Sacco fernanda.muniz@uni.lu or Arsou Arimi arsou.arimi@remondis.de

Parameter (Units)	*Specification EN14214*	*Demo-biodiesel*
Methyl Ester content *(wt.%)*	>96.5	98.5
Sulphated ash content *(wt.%)*	<0.02	-
Water content *(mg/kg)*	<500	10
Acid value *(mg KOH/g)*	<0.5	<0.1
Iodine value *(g I_2/100 g)*	<120	38.5
Linolenic acid methyl ester *(%)*	<12	absent
Methanol content *(wt.%)*	<0.2	<0.01
Monoglyceride content *(wt.%)*	<0.7	absent
Diglyceride content *(wt.%)*	<0.2	absent
Triglyceride content *(wt.%)*	<0.2	absent
Free glycerine *(wt.%)*	<0.02	absent
Total glycerine *(wt.%)*	<0.25	-
Group I metals (Na + K) *(ppm)*	<5	4.1
Group II metals (Ca + Mg) *(ppm)*	<5	3.3