Sanitary Environmental Engineering Division

9th IWA Odour & VOC/Air Emission Conference
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University of Salerno

Advanced photo-biotechnology for the simultaneous control of VOCs and GHGs emissions

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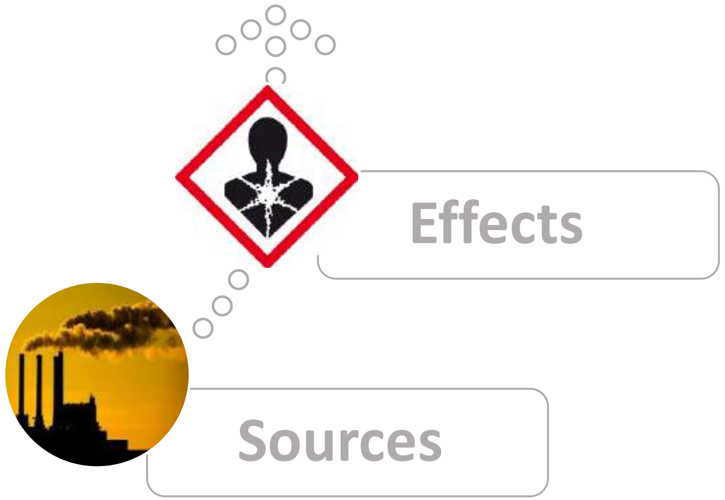
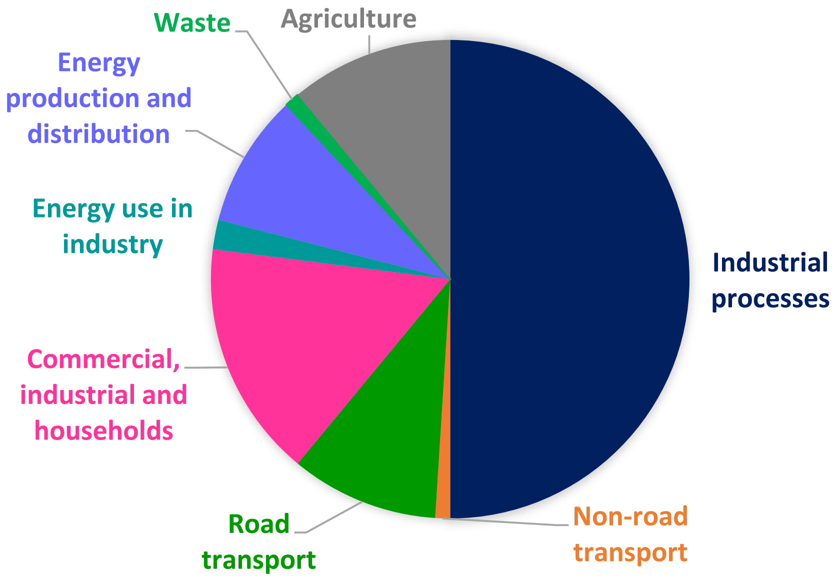
Introduction

VOCs and related effects/impacts



- ✓ Some VOCs are carcinogenic, teratogenic or mutagenic;
- ✓ Irritation, headaches, liver and kidney damage;
- ✓ Photochemical pollution;
- ✓ **Odour annoyance.**



- ✓ Road and non-road transport;
- ✓ Energy production, distribution and use;
- ✓ Paints, inks, glues, cosmetics and other different industrial sectors;
- ✓ Petrochemical sector;
- ✓ Environmental protection plants (biological reactions).

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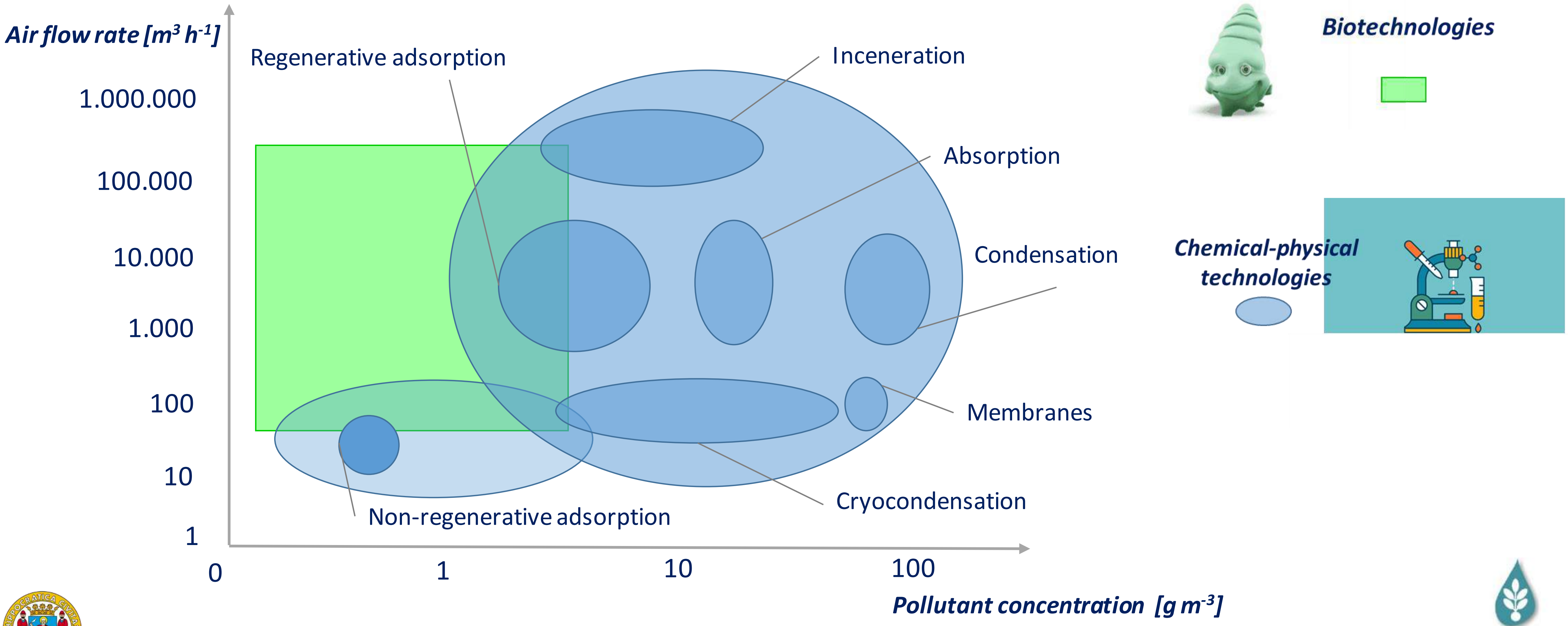
Akmirza et al., 2017; EPA 2017; Benami et al., 2016; Bindra et al., 2015

Introduction

Air treatment technologies



Oliva et al., 2018, *Alfonsin et al., 2015; Bindra et al., 2015, Munoz et al. 2013*

Introduction

Air treatment technologies

Sustainable treatment

Biological degradation
(Biomass to Energy)

Physical-chemical treatment
(costly)

Objectives

Main Goals

1. To develop and evaluate an integrated technology for the abatement of VOCs, with a simultaneous capture of the CO_2.

2. Evaluate and maximize the efficiency of the proposed technology in terms of toluene abatement and CO_2 capture by using UWW and DWW.

3. Asses the production of biomass and evaluate its potential in energy conversion, to make the process more sustainable and cost-effective.

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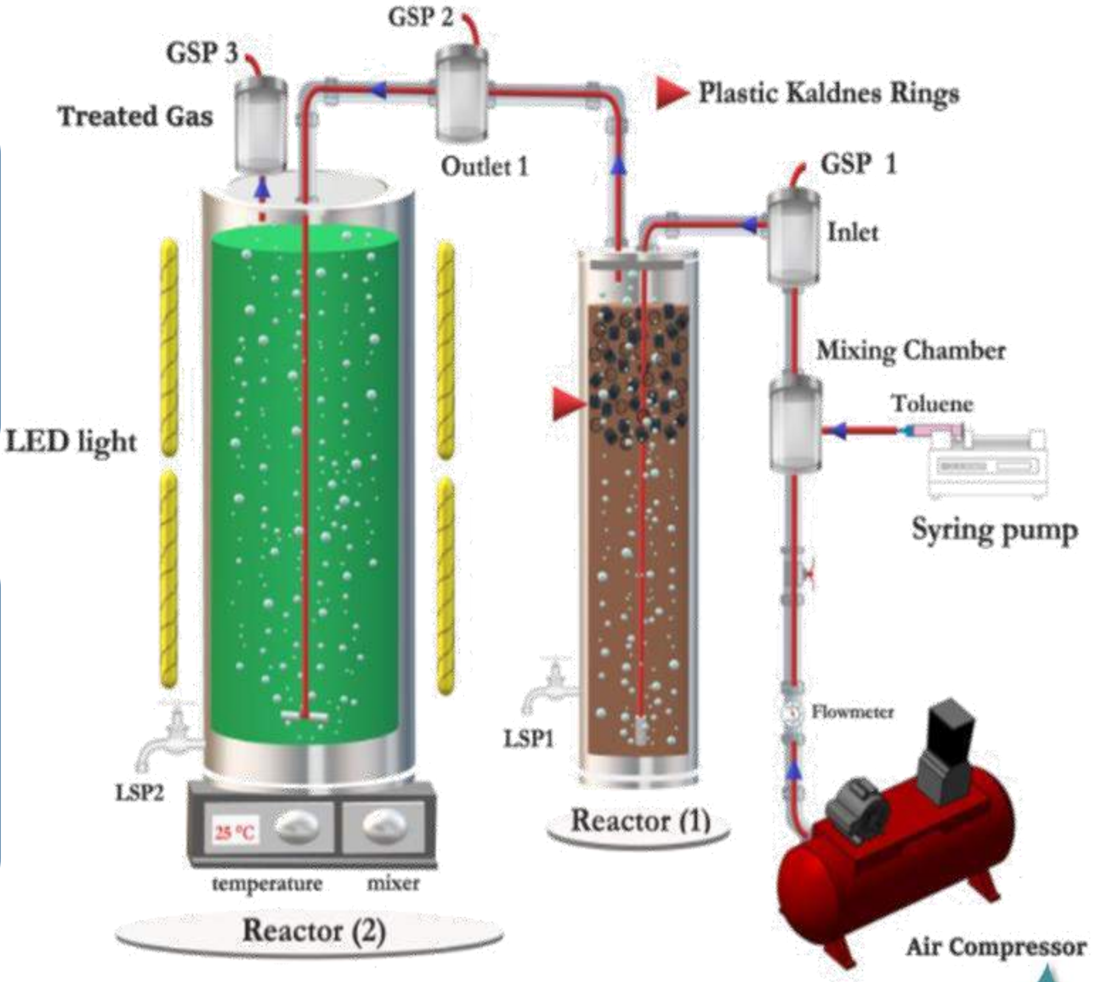
Materials and methods

Integrated MBBR and APBR

The system is composed of two reactors:

Moving Bed Bioreactor (MMMR) – R1
- Inoculated with active sludge
- Working volume: 6.50 L
- 30% filling factor with plastic carriers

Algal Photo-Bioreactor (PBR) – R2
- Inoculated with microalgae
- Working volume: 26 L
- Illumination rate: 12:12 hour using LEDs



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Materials and methods

Microorganism' preparation and inoculum

Bacterial sludge (0.5 L) from the wastewater treatment plant located in Battipaglia (Salerno, Italy) was centrifuged at 9000 rpm in 10 mins and resuspended in a synthetic wastewater medium for the inoculation in the reactor R1.

R1

The Chlorella vulgaris (C. Vulgaris CCAP 211/11B) acquired from the Culture Collection of Algae and Protozoa (CCAP), Dunberg, Scottland were pre-inoculated with bold basal medium (BBM) was centrifuged at 9000 rpm in 10 mins and resuspended in a synthetic wastewater medium for the inoculation in the reactor R2.

R2

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Materials and methods

Experimental program and operating conditions

Stages	Q_G [l/min]	feeding time [h/d]	Light Intensity [Lux]	Type of WW	Toluene inlet concentration [mg/m^3]	Dev. Standard
I	1	24	6457.9	UWW	256.2	63.0
II	1	8	6457.9	UWW	286.0	49.2
IIIa	0.5	8	6457.9	UWW	413.9	92.6
IIIb	0.5	24	6457.9	UWW		
IIIc						
IV	0.5	24	6457.9	DWW	447.3	155.1
Va	0.5	24	9534.7	DWW	563.5	115.3
Vb						
Vc						
VIa	1	24	9534.7	DWW	472.6	163.1
VIb						
VIc						

Synthetic urban wastewater used as alternative source of nutrients

Synthetic dairy wastewater used as alternative source of nutrients

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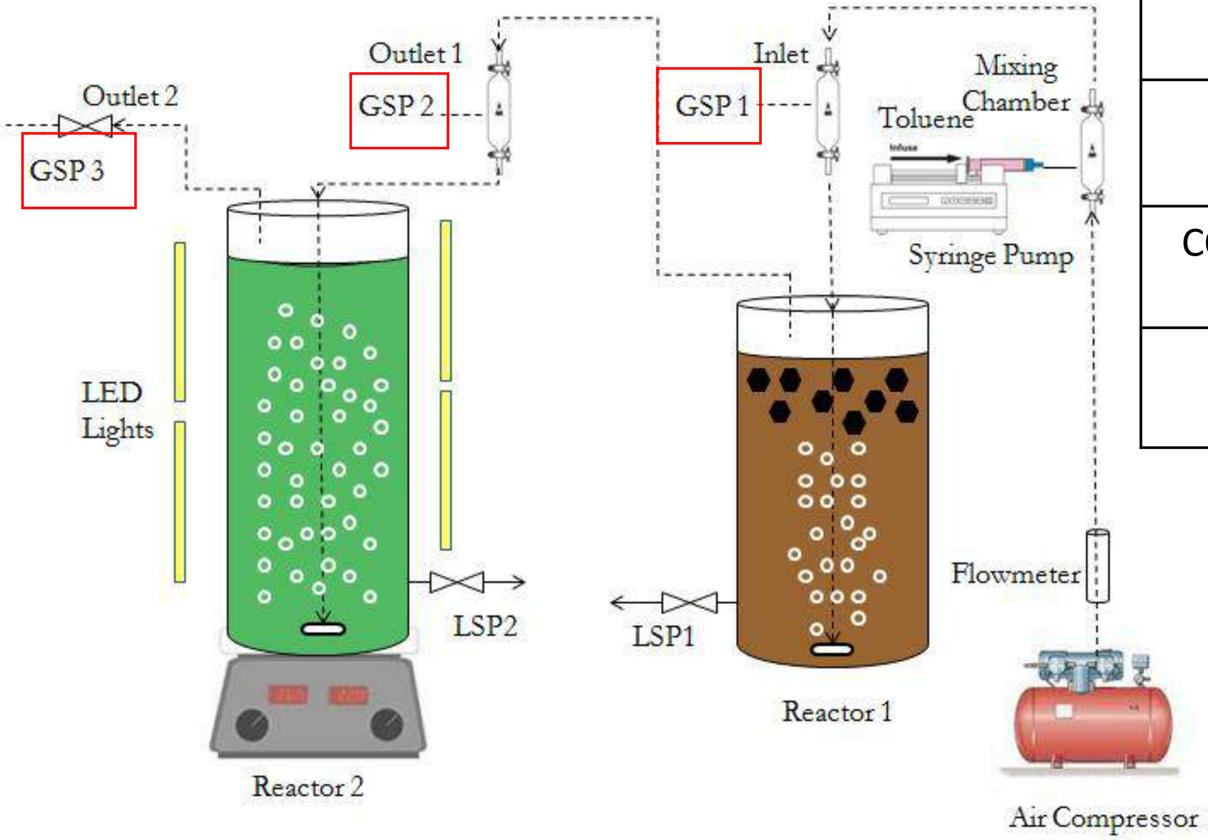
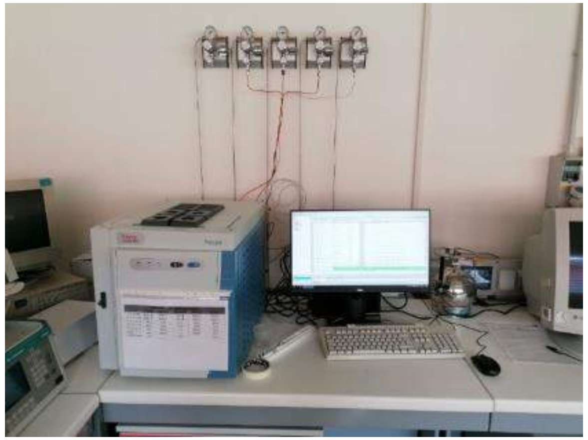
Materials and methods

Analytical instruments and methods



Parameter	Sampling points	Frequency	Method
Toluene concentration	GSP1, GSP2, GSP3	Daily	GC-PID
CO2 concentration	GSP1, GSP2, GSP3	Daily	GC-TCD
Pressure	GSP1, GSP2	Daily	Pressure meter



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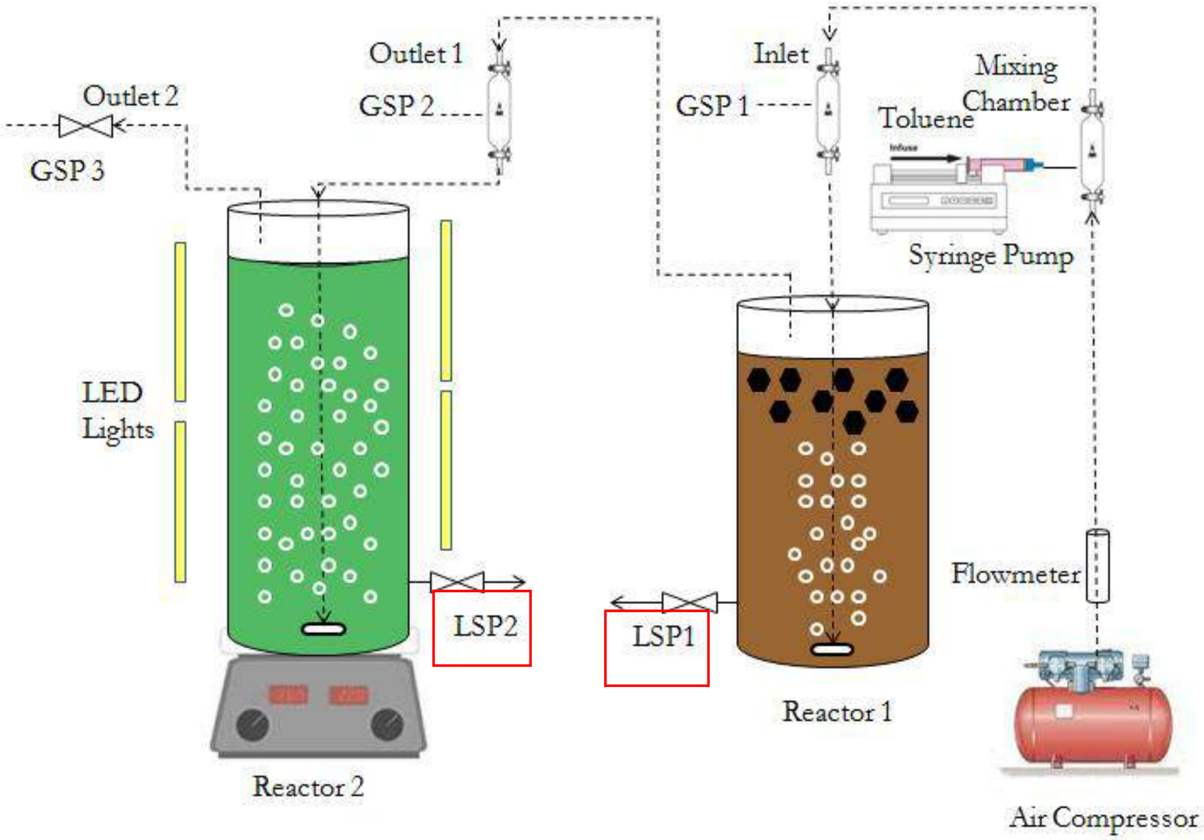
Materials and methods

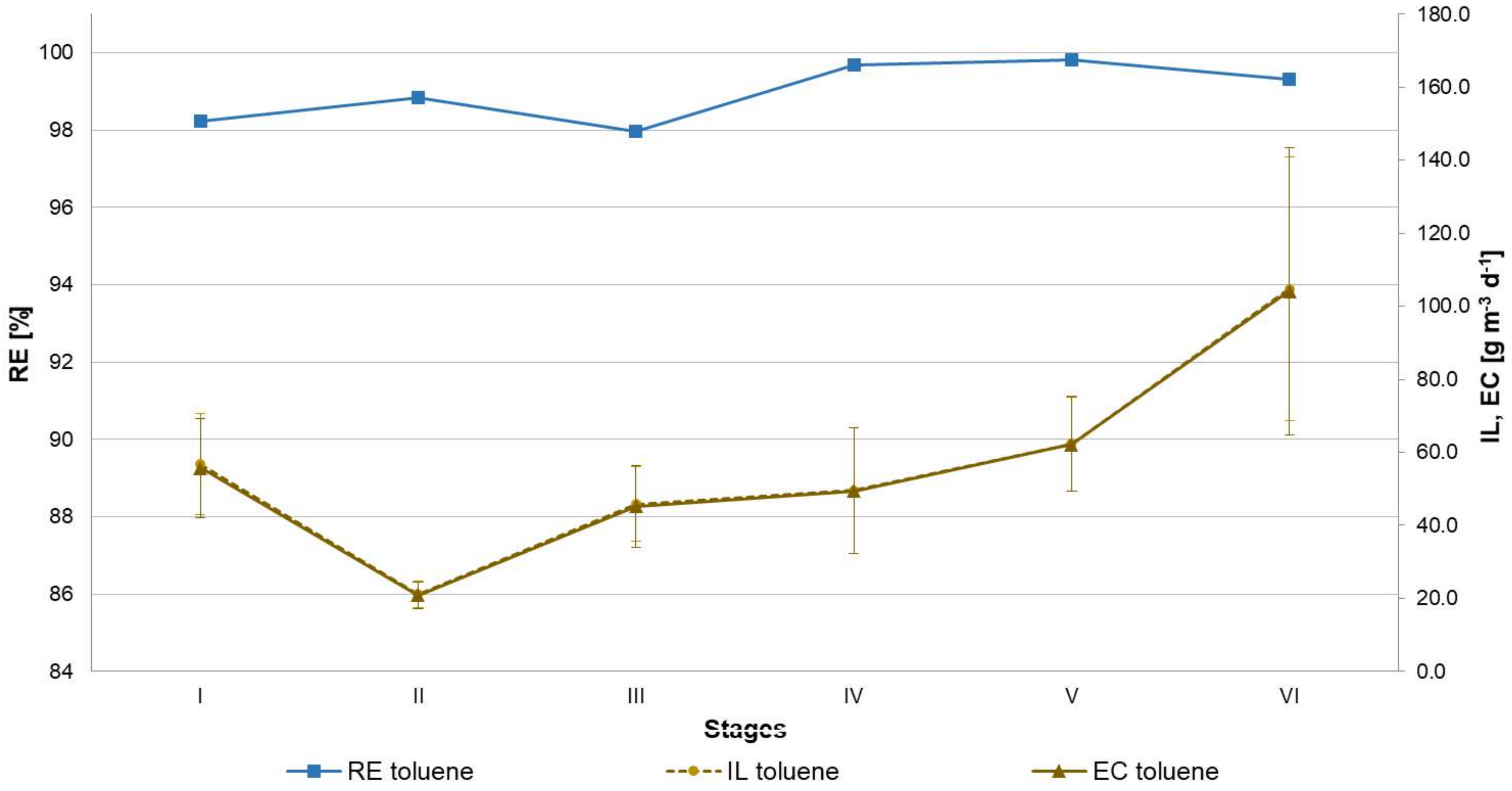
Liquid phase characterization



Parameter	Sampling points	Frequency
NH_4-N	LSP1, LSP2, mineral medium	Twice a week
Total suspended solid	LSP1, LSP2	Twice a week
Chorophill-a	LSP2	Twice a week
Dissolved Organic Carbon	LSP1, LSP2, mineral medium	Twice a week
Anions	LSP1, LSP2, mineral medium	Twice a week
pH, DO, Temperature	LSP1, LSP2	Daily

Results and Discussion

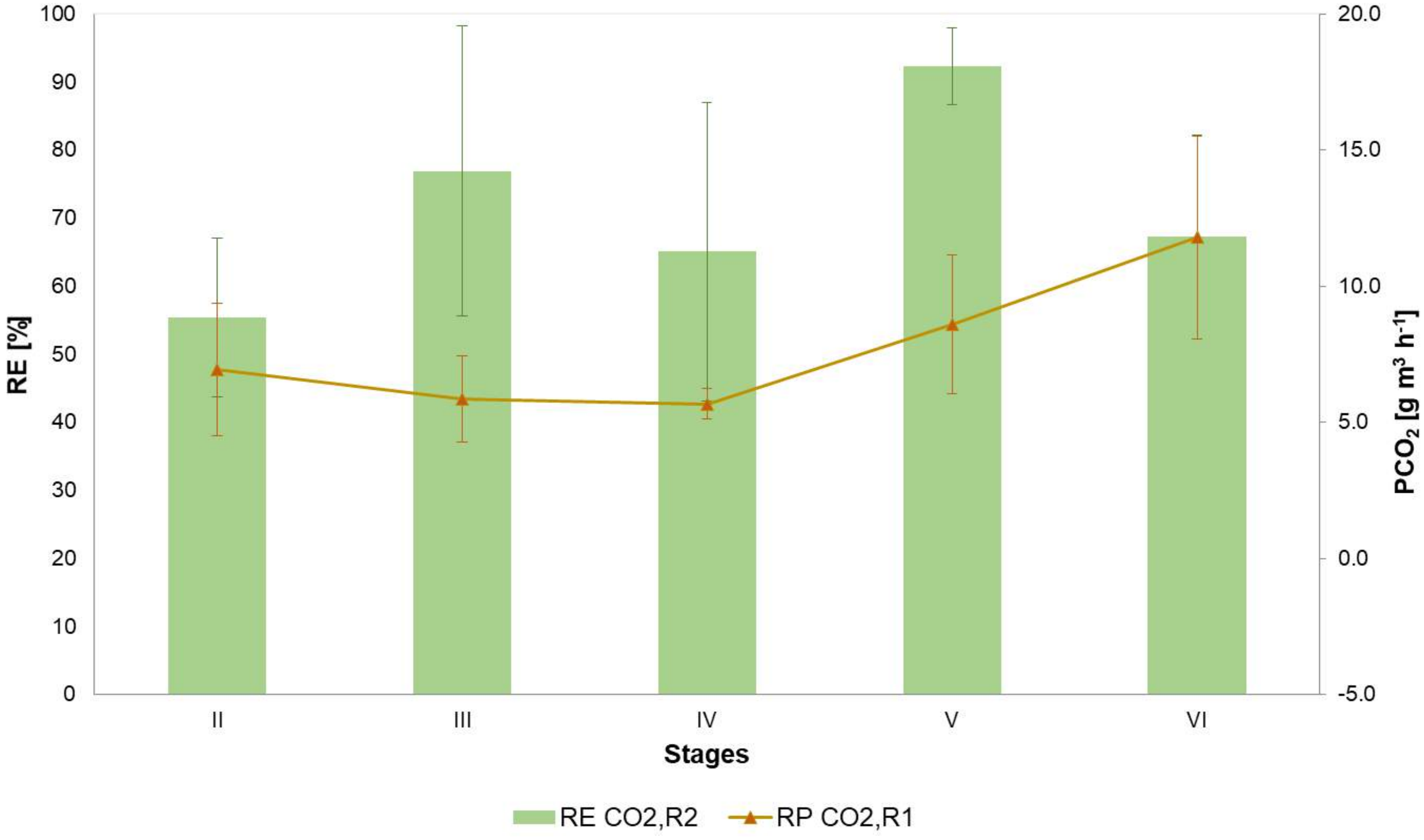
Average Removal efficiency and elimination capacity of toluene



- **Average Elimination Capacity [g m^{-3} d^{-1}]**
  range: 19.17 – 141.25
- **Average Removal Efficiency$_{overall\ system}$[%]**
  range: 97.90 – 99.93

Results and Discussion

CO_2 production and removal efficiency

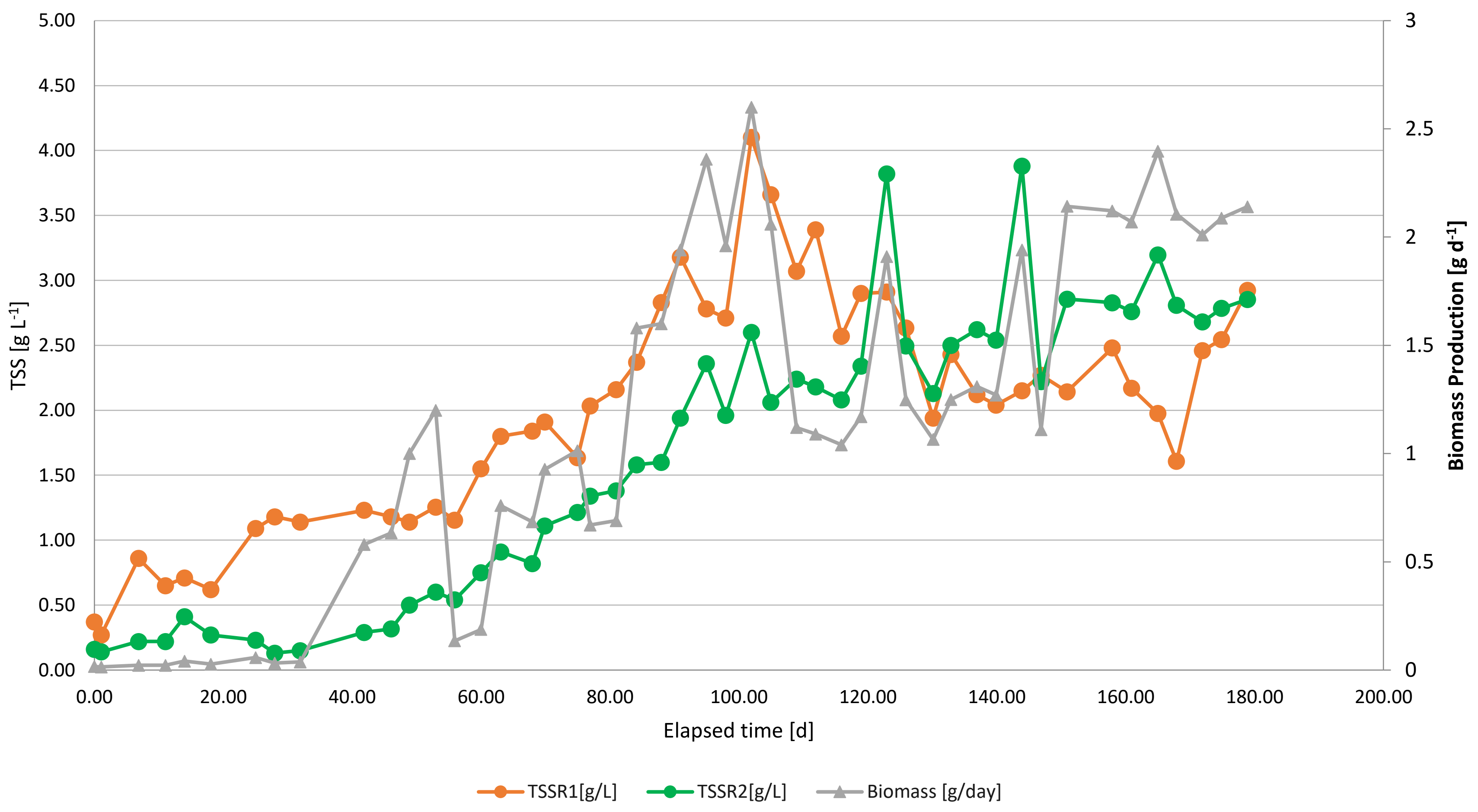


- **Average CO_2 Production [g m^{-3}h^{-1}]**
  range: 5.23 – 16.51

- **CO_2 Capture Efficiency [%]**
  range: 38.37 – 95.84

Results and discussions

Total suspended solid and biomass production



- **TSS [g L^{-1}]**
  MBBR: 0.142 – 4.10
  APBR: 0.13 – 3.88

- **Biomass Production [g d^{-1}]**
  range: 0.014 – 2.60

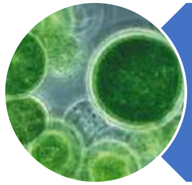
Results and discussions

Chlorophyl-a

Conclusion

Toluene removals up to 99% was obtaneid for the investigated conditions

APBR was able to reach a CO_2 capture efficiency up to 96%



The algal photo-bioreactor reached biomass concentration of 4 g/l, with a biomass production up to 2 g/d

The use of alternative sources of nutrients (UWW, DWW) allowed to reduce the use of chemicals, besides promoting the production of valuable products (lipids).

Working Progress

Testing the abatement efficiency of the algal photo-bioreactor with H2S and mixture of contaminants.

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Thank you for your attention!

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