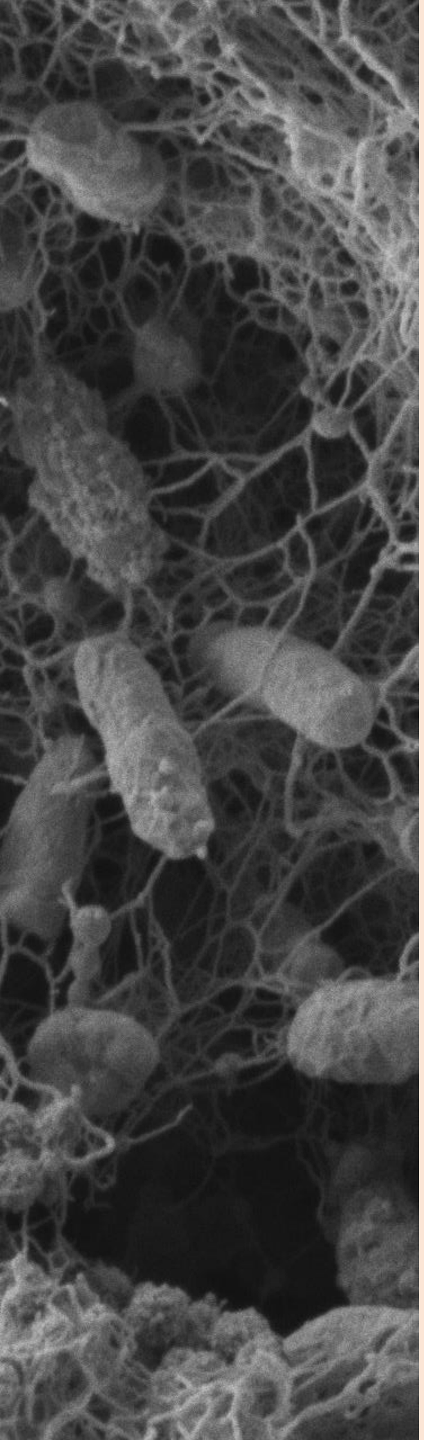


Biodegradable plastics, a sustainable solution for the environment?

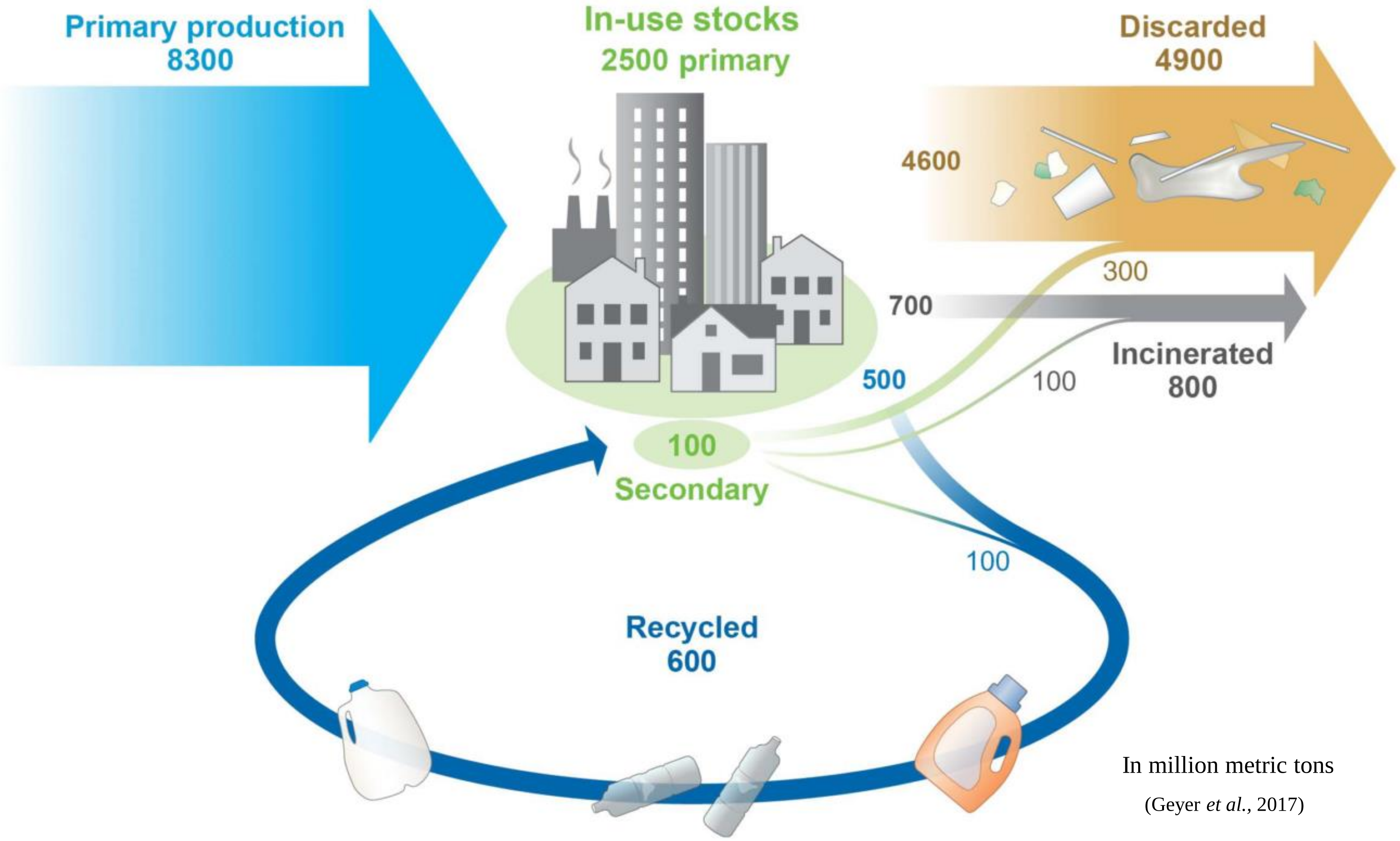
Alice Delacuvellerie
Proteomics and Microbiology Laboratory
University of Mons (Belgium)

UMONS Université de Mons

ProtMic

fnrs LA LIBERTÉ DE CHERCHER

Introduction



In million metric tons

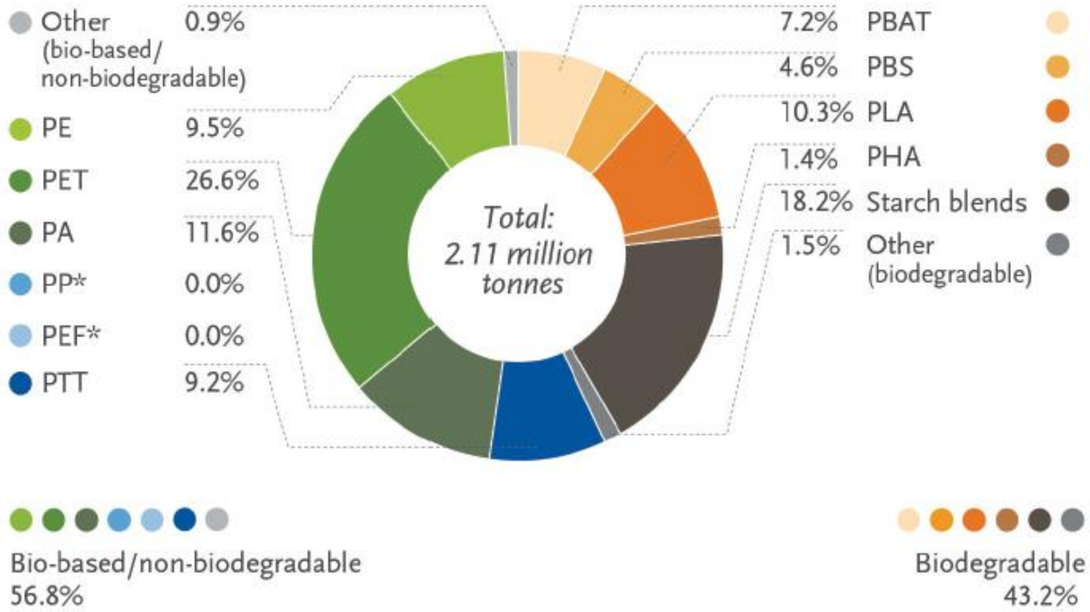
(Geyer *et al.*, 2017)

5 trillions of plastic pieces into oceans

Introduction

Biodegradable plastics

90% into CO_2 in compost at 70°C in 180 days



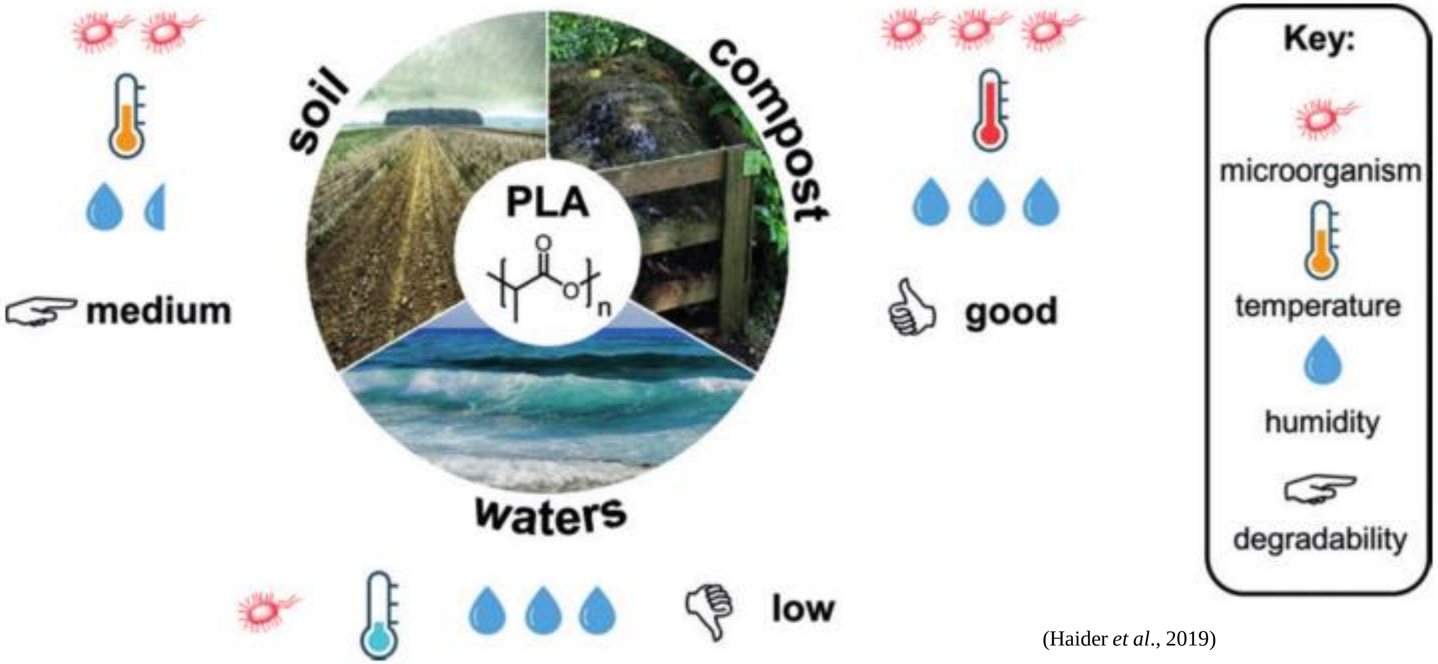
(Bioplastics market data, 2018)

PLA: excellent oxygen and water barrier properties, replacement for PS and PP

PBAT: similar properties than LDPE

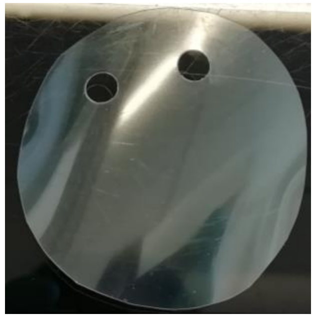
Introduction

What about degradation into environmental conditions?
What about bacterial community?



(Haider *et al*., 2019)

Strategy



Degradation analysis

Weight Loss
DSC (Differential Scanning Calorimetry)
GPC (Gel Permeation Chromatography)
ATR-FTIR

(Benali *et al.*, 2015)

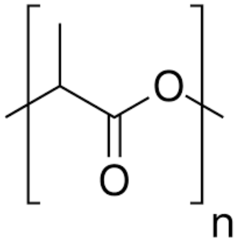
Bacterial community analysis

DNA extraction (DGGE, 16S rRNA amplicon sequencing)

Methods

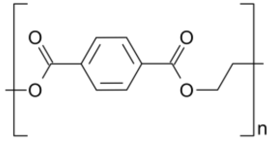
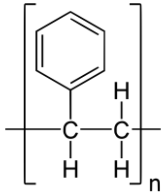
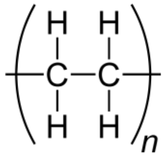
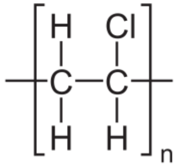
Biobased

- Semi-crystalline PLA (4032D)
- Amorphous PLA (4060D)

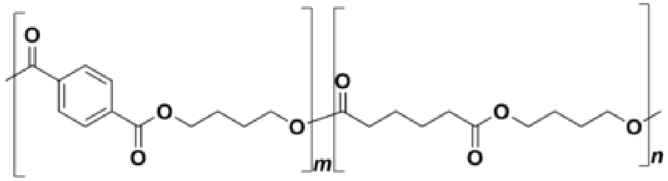


Non-biodegradable

Biodegradable

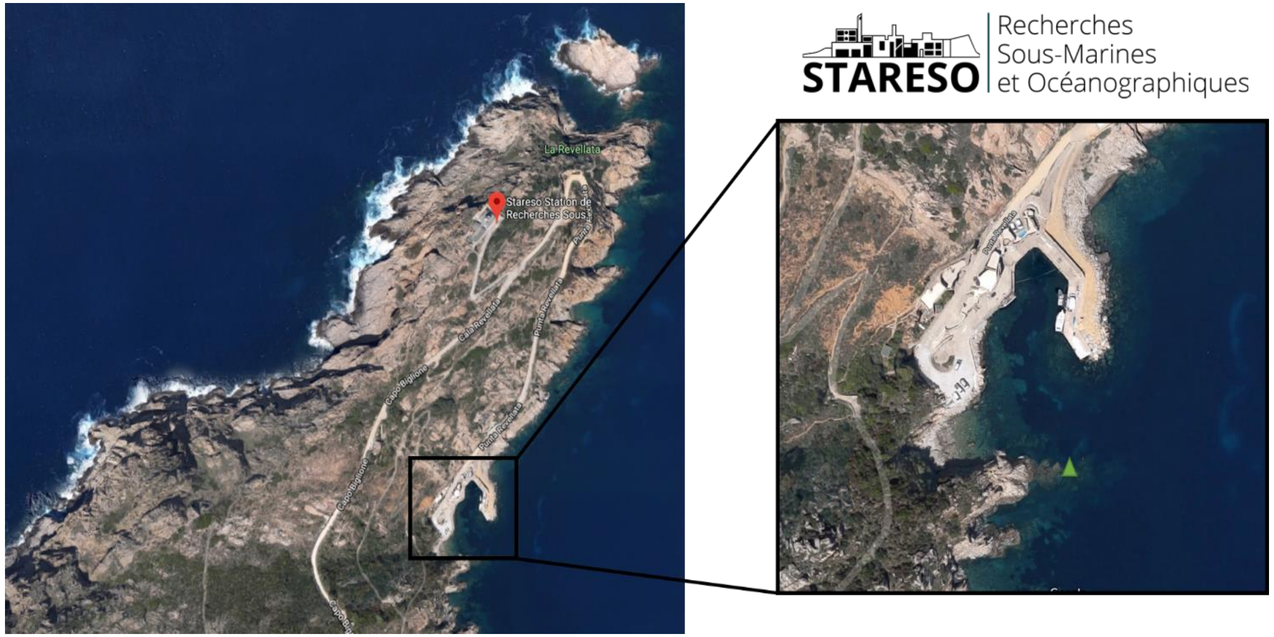
- PET 
- PS 
- LDPE 
- PVC 

- PBAT



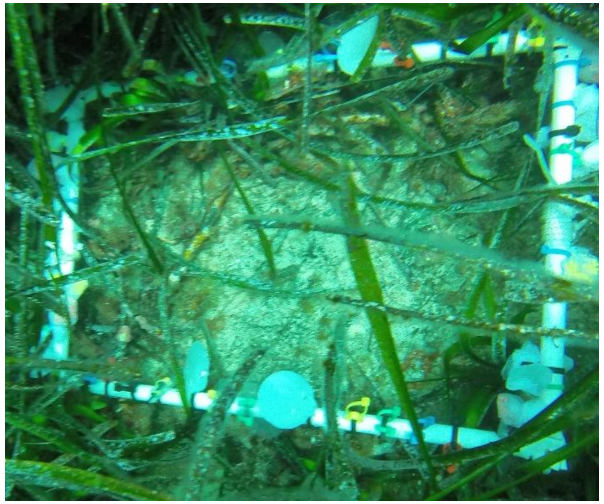
Petro-based

Methods



STARESO
Recherches
Sous-Marines
et Océanographiques

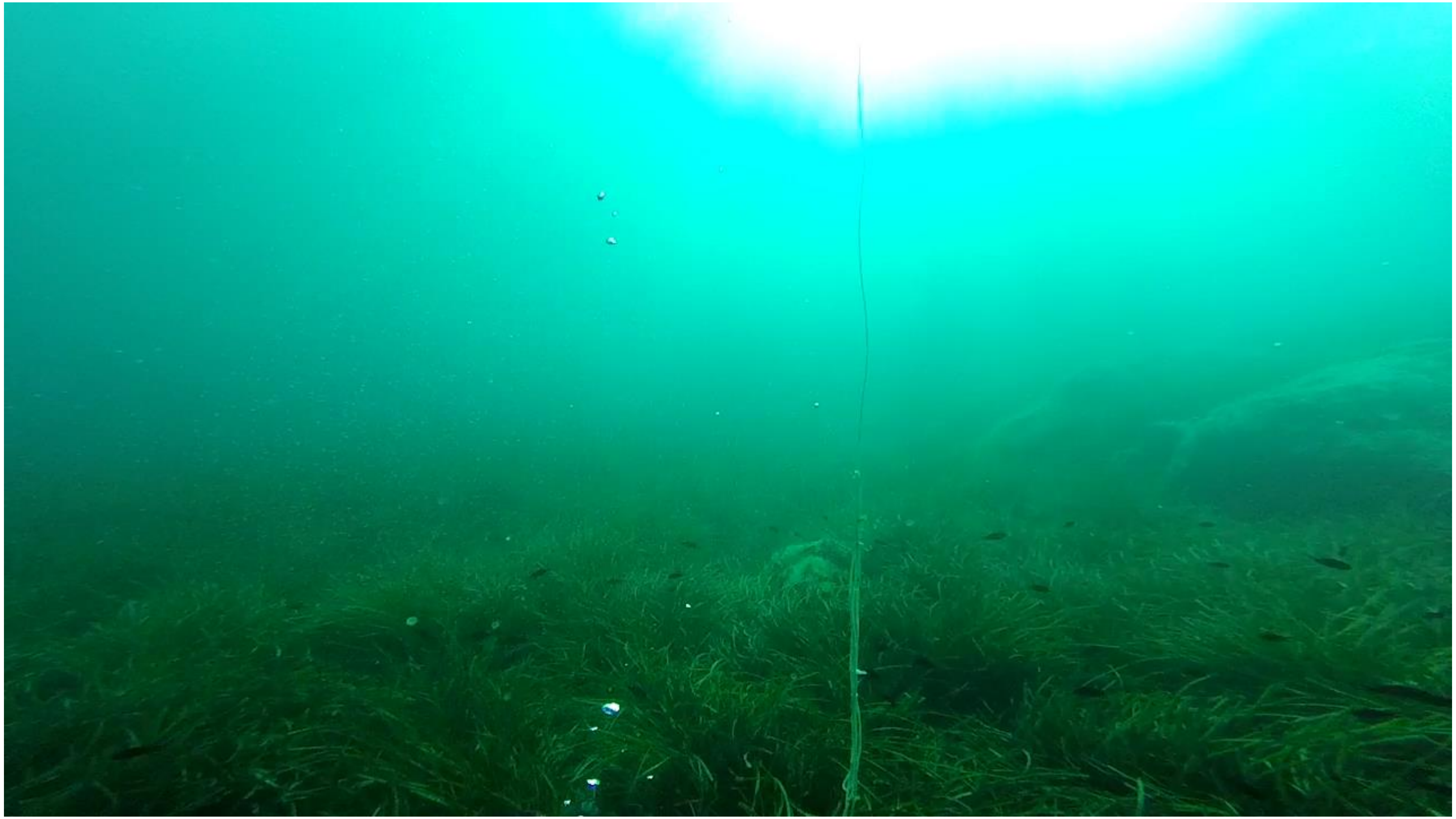
4.5 m



8 m

Methods

Water column (4.5 m)

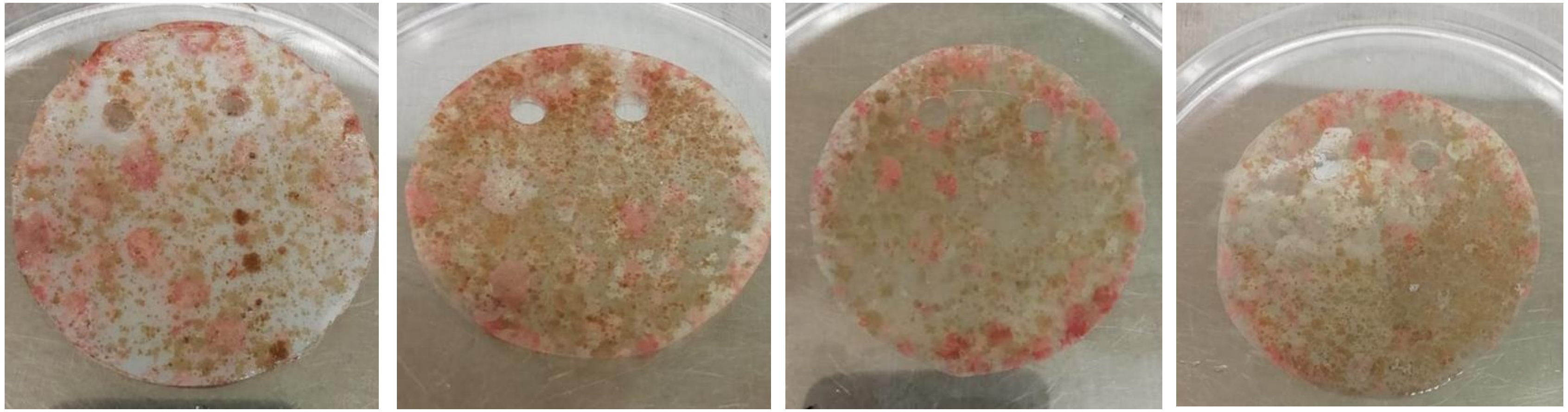


Methods

Plastics on sediment (8 m)

Methods

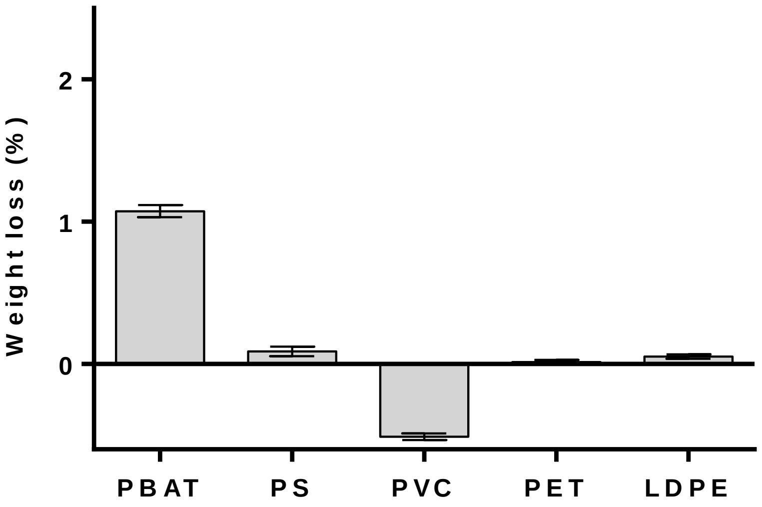
Plastics on sediment



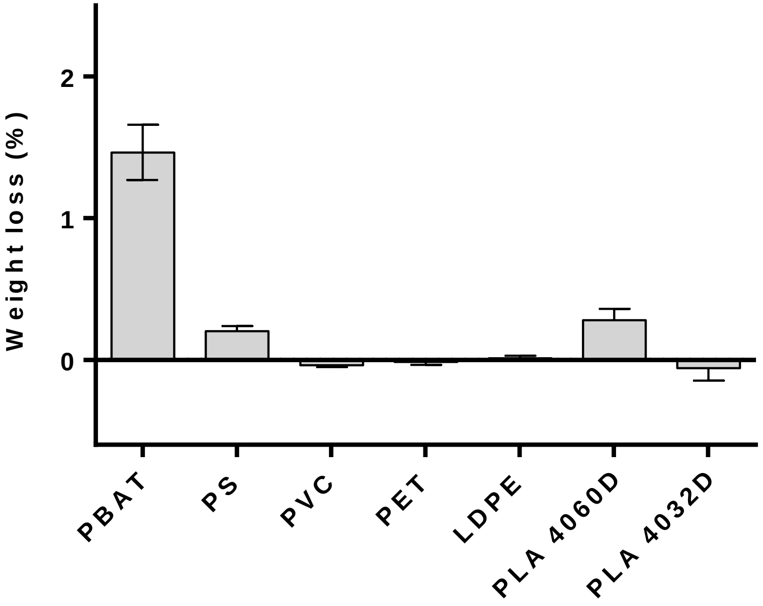
Plastics in the water column

Degradation analysis

Water column plastics



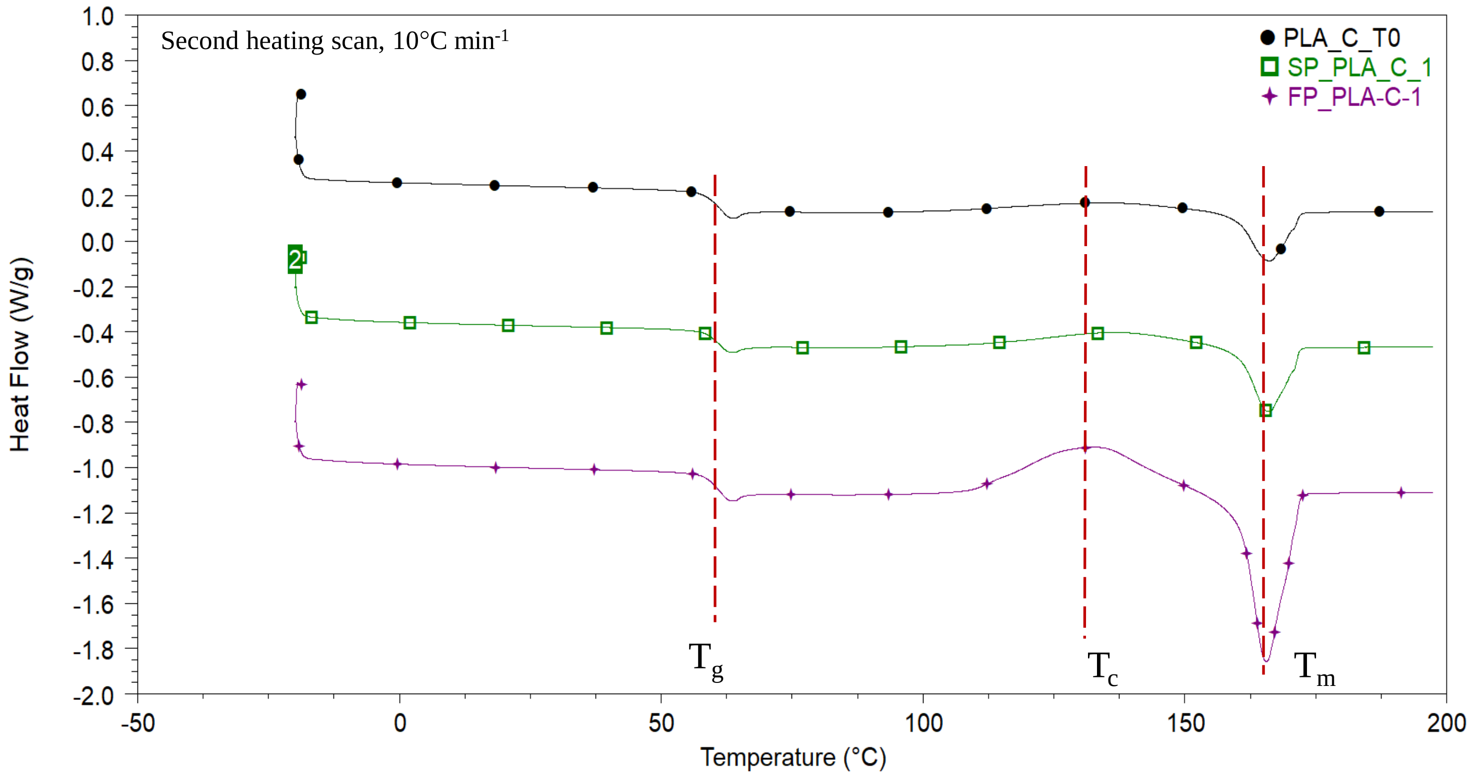
Sediment plastics



Around 1% of weight loss for PBAT

Degradation analysis: DSC

Semi-crystalline PLA (4032D)



T_g = Glass transition temperature

T_c = Cold crystallisation temperature

T_m = Melting temperature

$$\chi_c = \left[\frac{\Delta H_{m(t)} - \Delta H_{c(t)}}{\Delta H^0_m}\right] \times 100$$

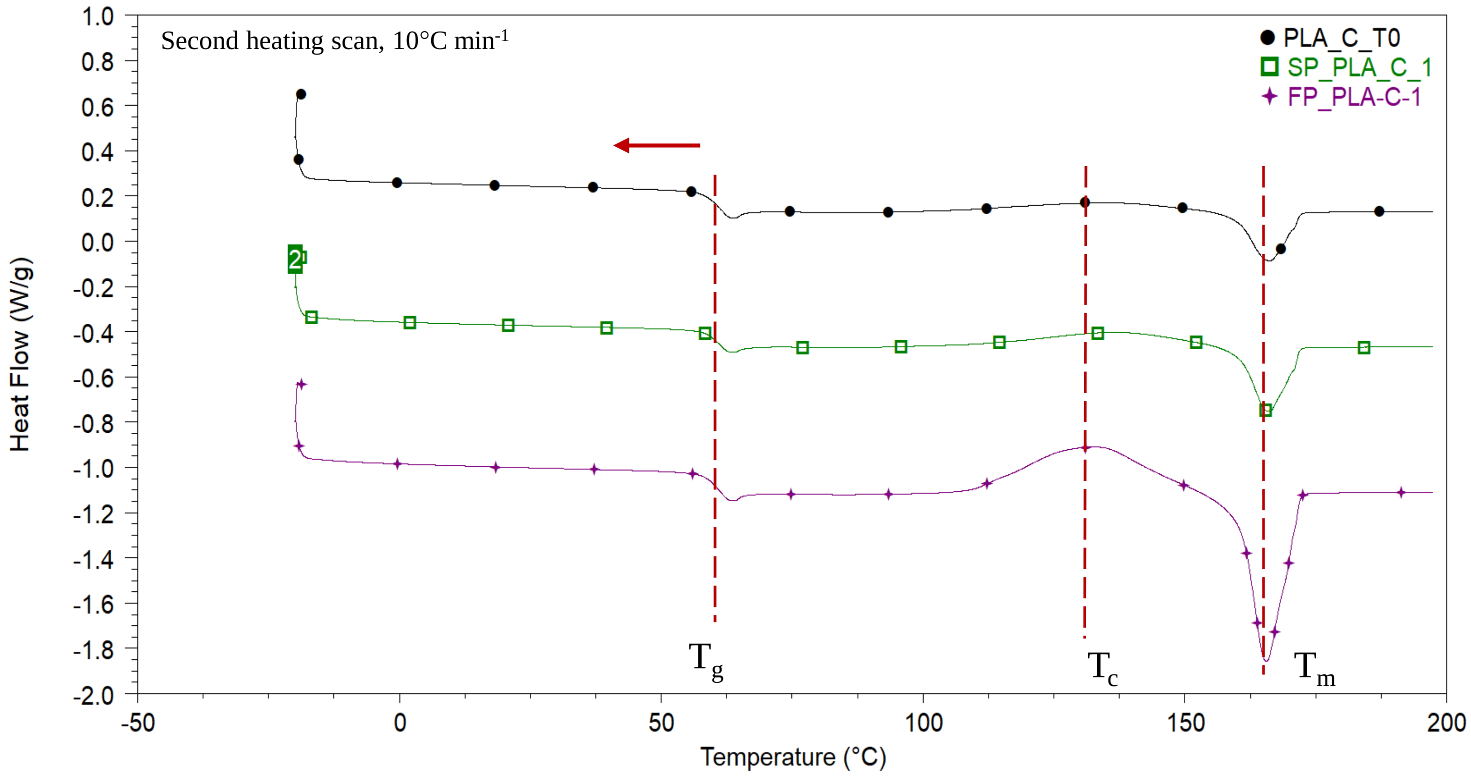
ΔH_m = Melting enthalpy

ΔH_c = Enthalpy of cold crystallisation

ΔH_0 = Melting enthalpy of the 100% crystalline polymer

Degradation analysis: DSC

Semi-crystalline PLA (4032D)



T_g = Glass transition temperature

T_c = Cold crystallisation temperature

T_m = Melting temperature

$$\chi_c = \left[\frac{\Delta H_{m(t)} - \Delta H_{c(t)}}{\Delta H^0_m} \right] \times 100$$

ΔH_m = Melting enthalpy

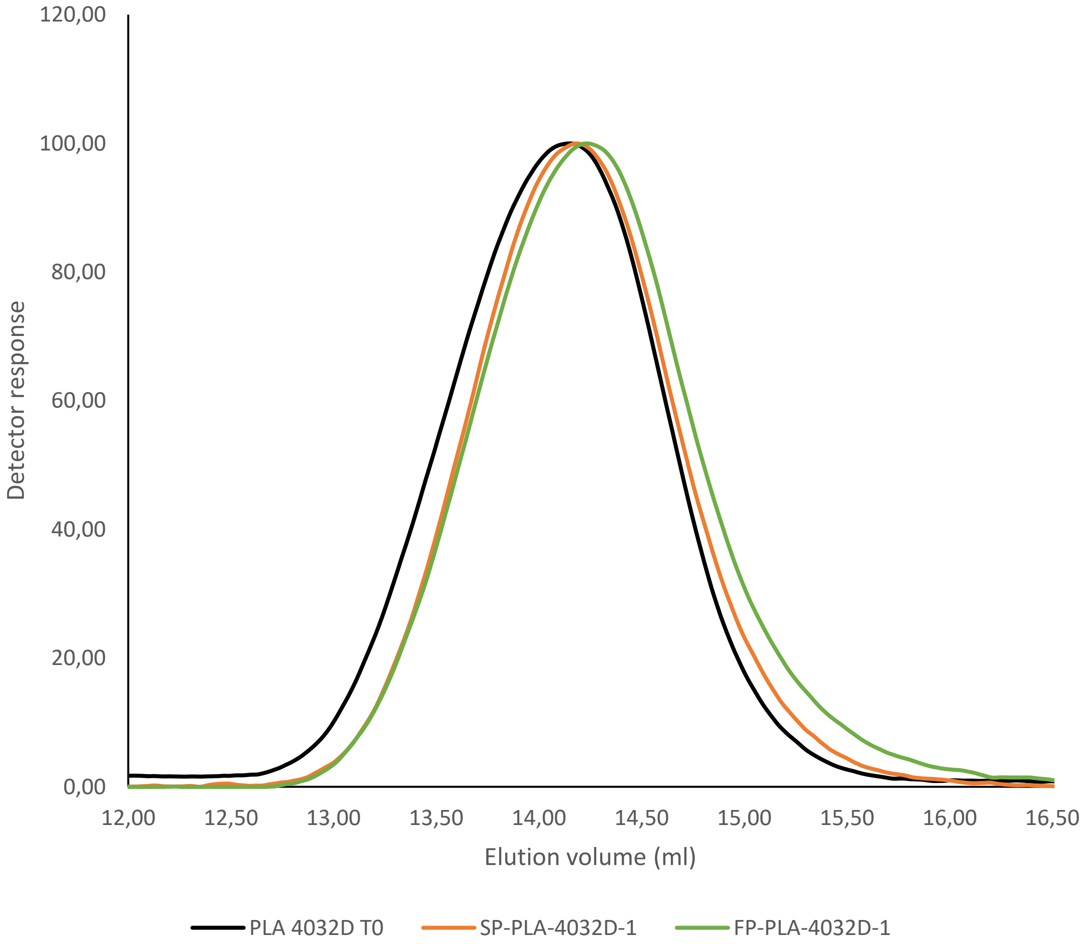
ΔH_c = Enthalpy of cold crystallisation

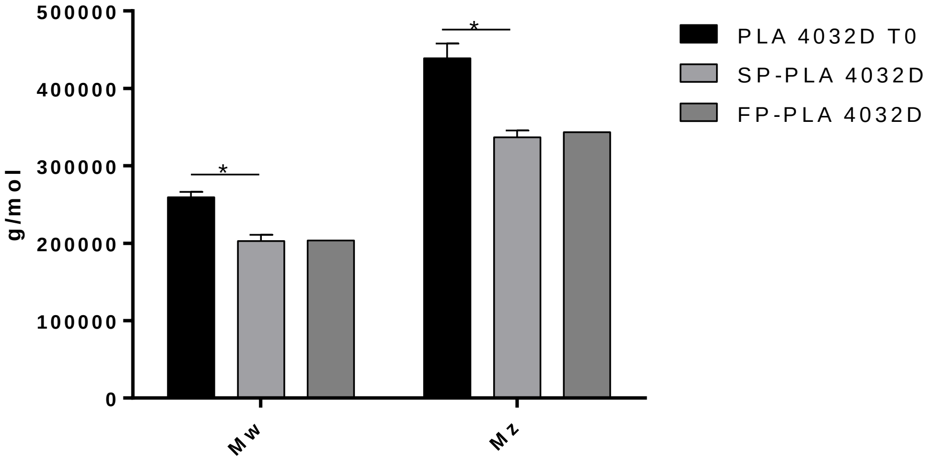
ΔH_0 = Melting enthalpy of the 100% crystalline polymer

Degradation analysis: GPC

Semi-crystalline PLA (4032D)

Mn	= Number average molar mass
Mw	= Mass average molar mass
Mz	= Z average molar mass
D	= Dispersity (Mw/Mn)
Mp	= peak molecular weight

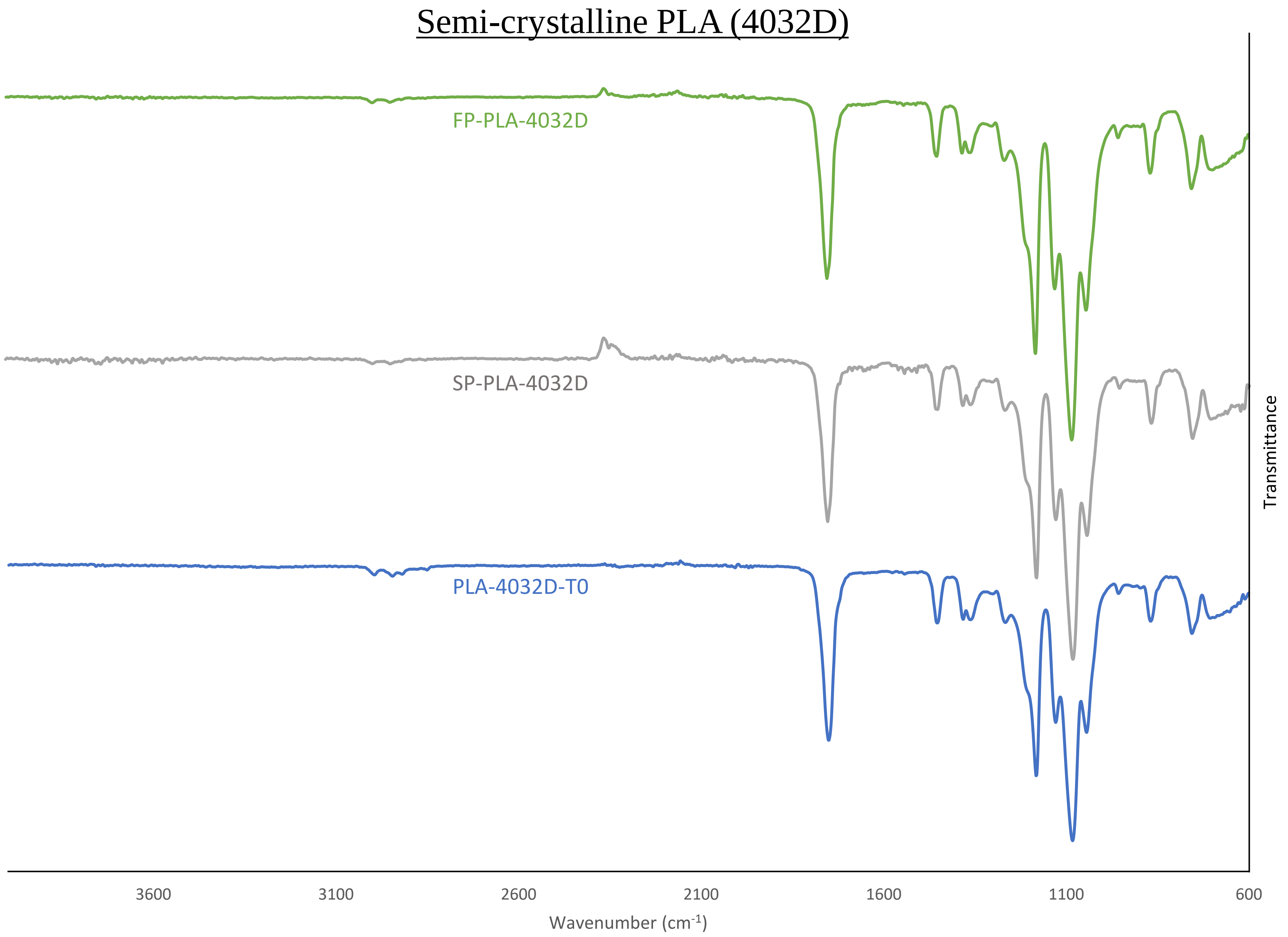




*, $p < 0.05$;**, $p < 0.01$;***, $p < 0.001$.

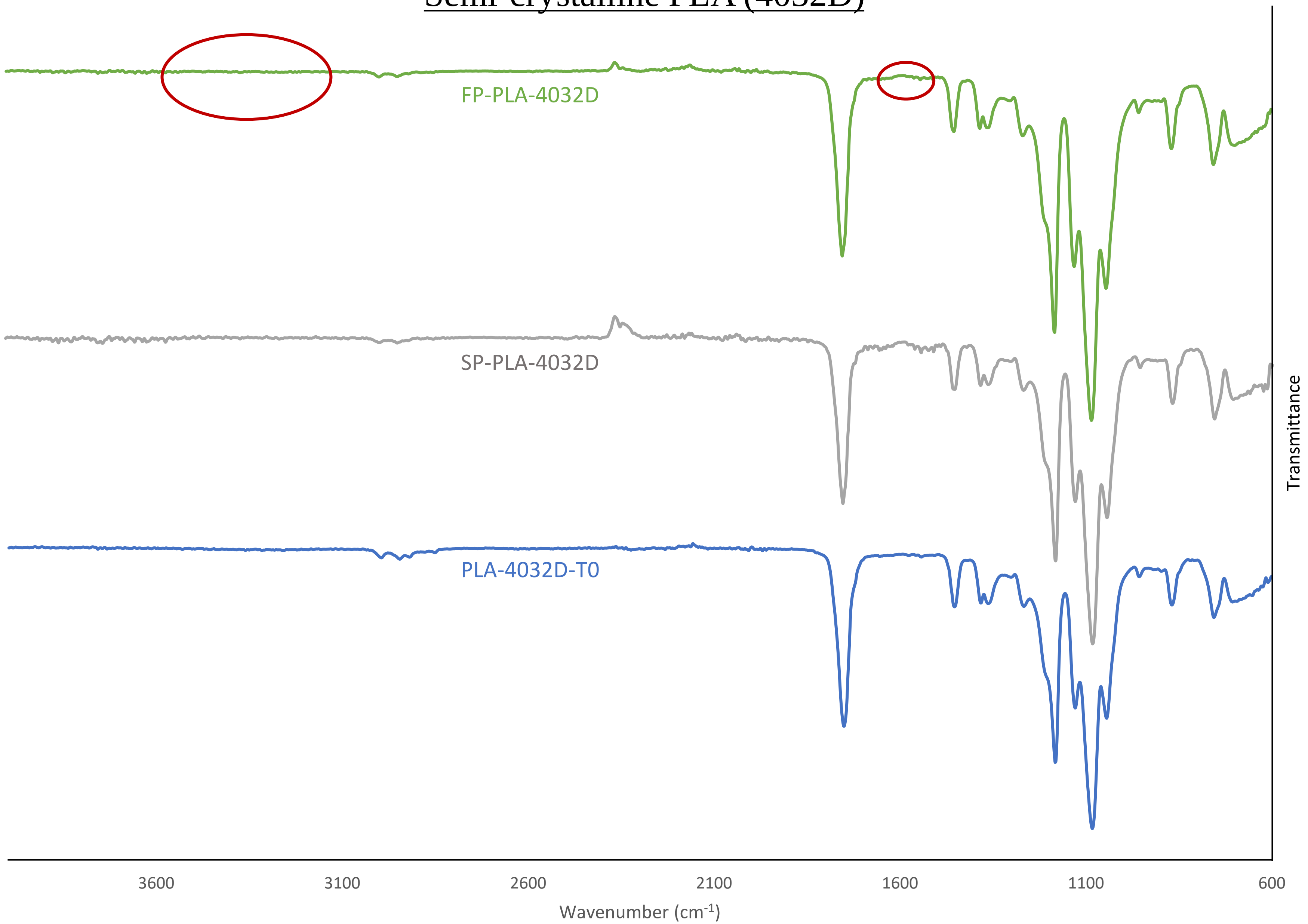
All polymers are not soluble into chloroform

Degradation analysis: ATR-FTIR



Degradation analysis: ATR-FTIR

Semi-crystalline PLA (4032D)



Degradation analysis

Samples	Visible aspect	Weight loss	GPC	DSC	ATR-FTIR
SP-PLA-4032D			Mw, Mz	ΔHcc	
FP-PLA-4032D		NA*	Mw, Mz	ΔHcc	
SP-PLA4060D		0.2%	Mw, Mz and Mp		
FP-PLA-4060D		NA*	NA*	NA*	NA*
SP-PBAT		1.5%			
FP-PBAT		1%			
SP-PS		0.2%	Mw, Mz		
FP-PS		0.1%	D, Mz		
SP-LDPE			ND**		
FP-LDPE			ND**	T_g, ΔH_m χ_c	
SP-PET			ND**		
FP-PET			ND**		
SP-PVC			ND**		
FP-PVC			ND**		

*NA: Not acquired (lost samples)
**ND: Not determined (polymer not soluble into chlorofom)

FP= « Floating plastic » (4.5 m under the water surface)
SP= « Sediment plastic » (8 m under the water surface, on the sediment)

No difference in comparison with the initial time (T_0)
One or more parameters are different in comparison with T_0
All parameters are different in comparison with T_0

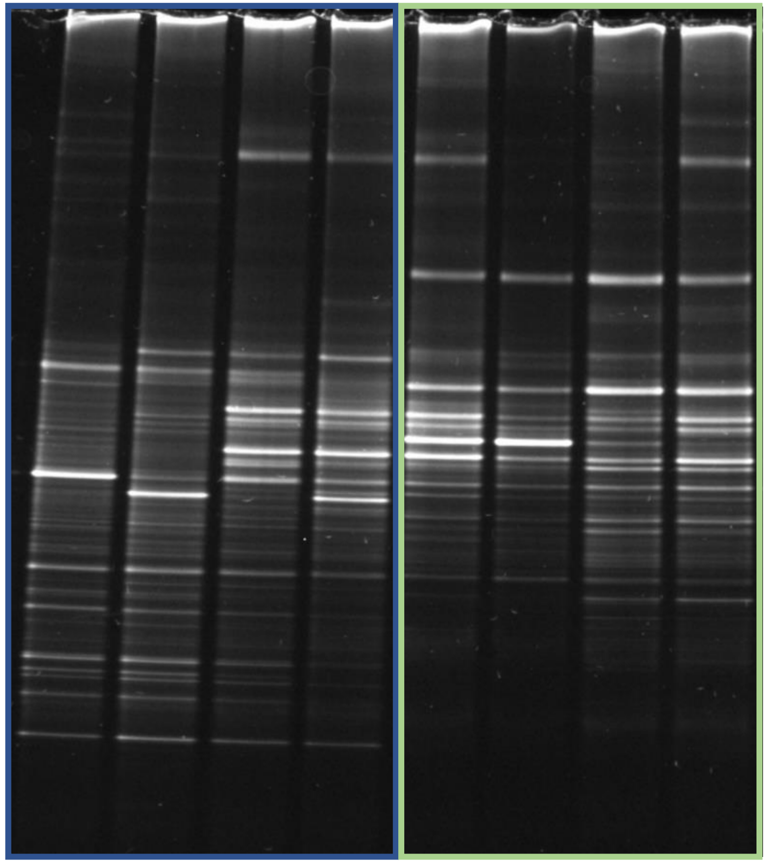
Degradation analysis

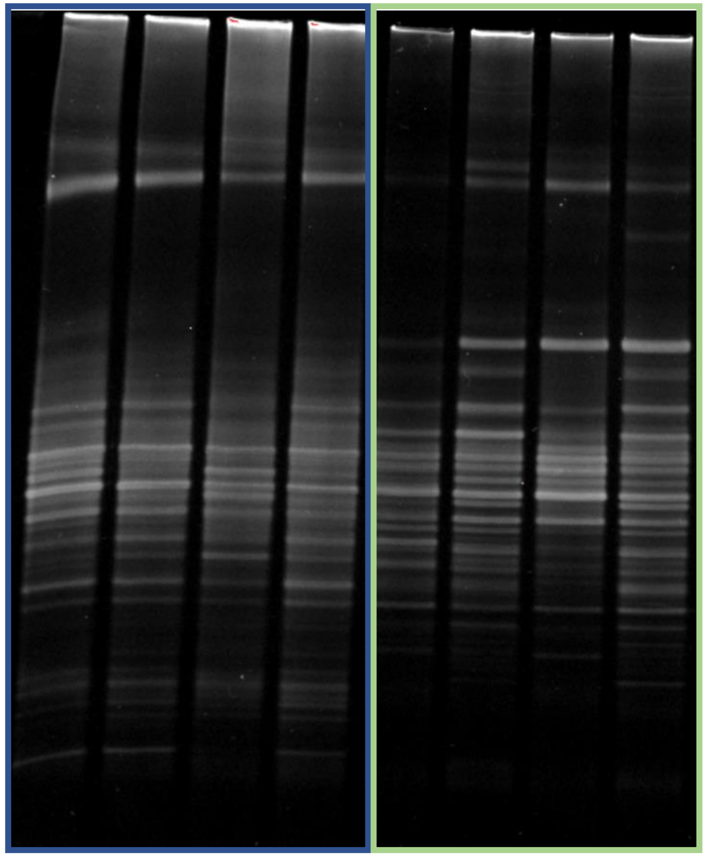
Samples	Visible aspect	Weight loss	GPC	DSC	ATR-FTIR
SP-PLA-4032D			Mw, Mz	ΔHcc	
FP-PLA-4032D		NA*	Mw, Mz	ΔHcc	
SP-PLA4060D		0.2%	Mw, Mz and Mp		
FP-PLA-4060D		NA*	NA*	NA*	NA*
SP-PBAT		1.5%			
FP-PBAT		1%			
SP-PS		0.2%	Mw, Mz		
FP-PS		0.1%	D, Mz		
SP-LDPE			ND**		
FP-LDPE			ND**	T_g, ΔH_m χ_c	
SP-PET			ND**		
FP-PET			ND**		
SP-PVC			ND**		
FP-PVC			ND**		

*NA: Not acquired (lost samples)
**ND: Not determined (Polymer not soluble into chlorofom)

No visible degradation of biodegradable plastics

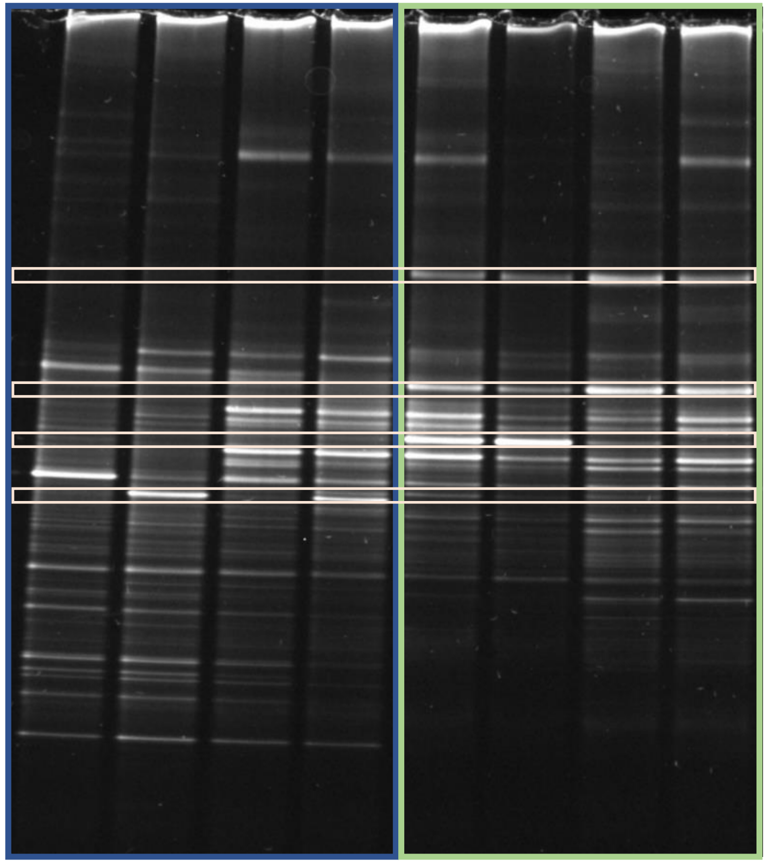
Bacterial community analysis



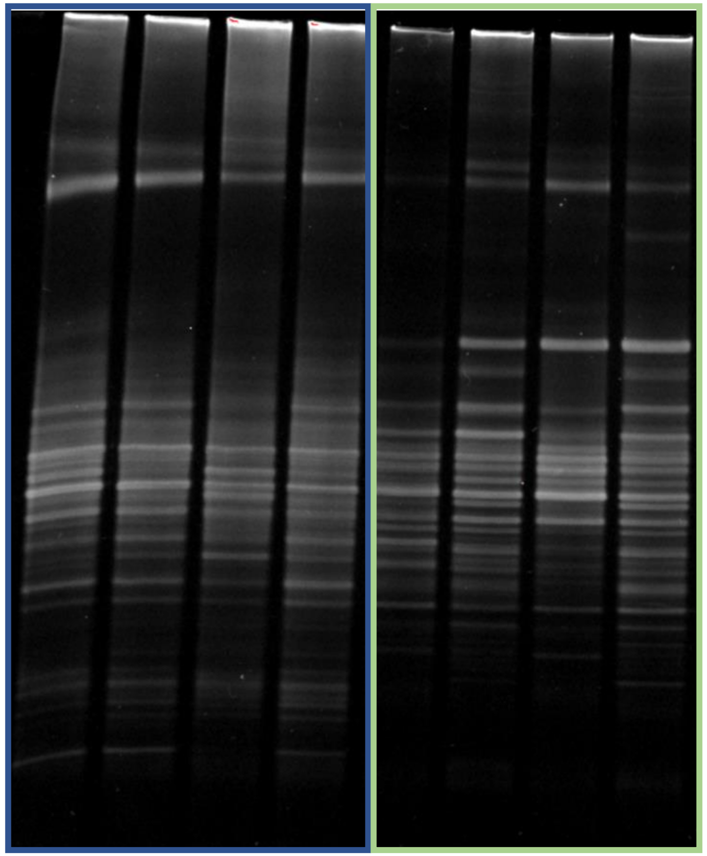


Bacterial community analysis

SP-PBAT FP-PBAT

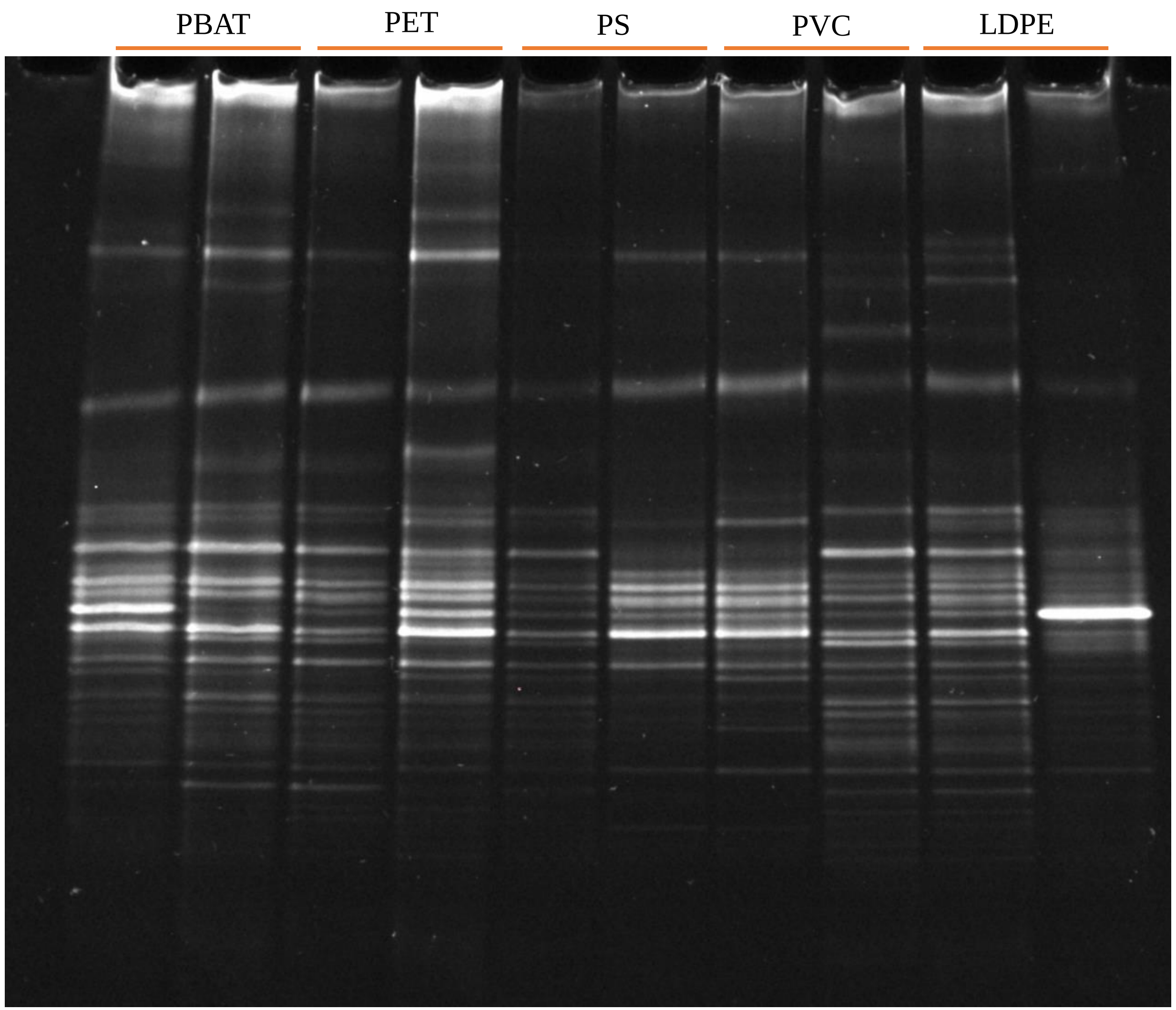


SP-PS FP-PS



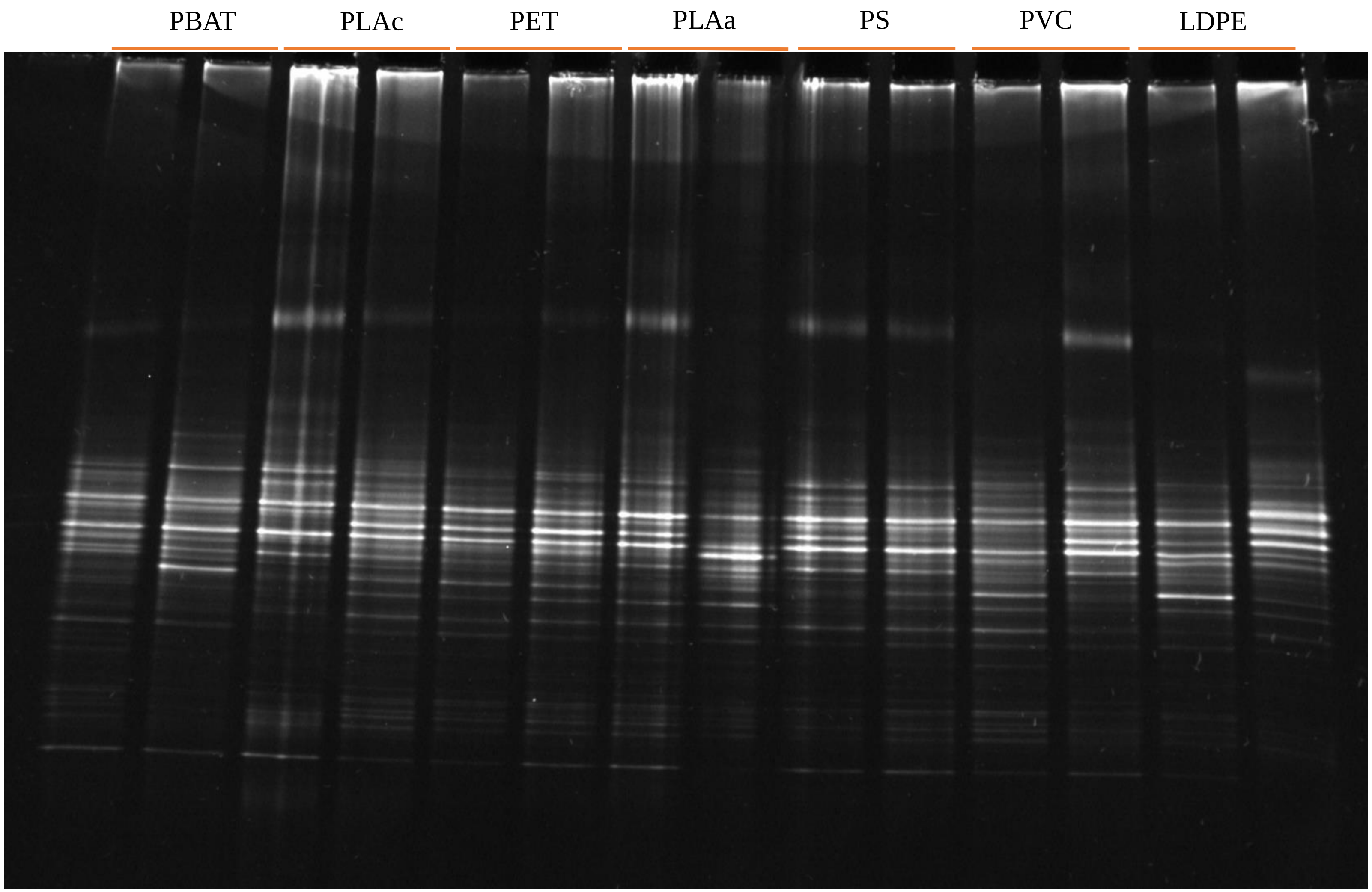
➜ Difference in the bacterial composition (water column *vs* sediment)

Bacterial community analysis in water column plastics



No difference according to the plastic nature

Bacterial community analysis on sediment plastics



No difference according to the plastic nature

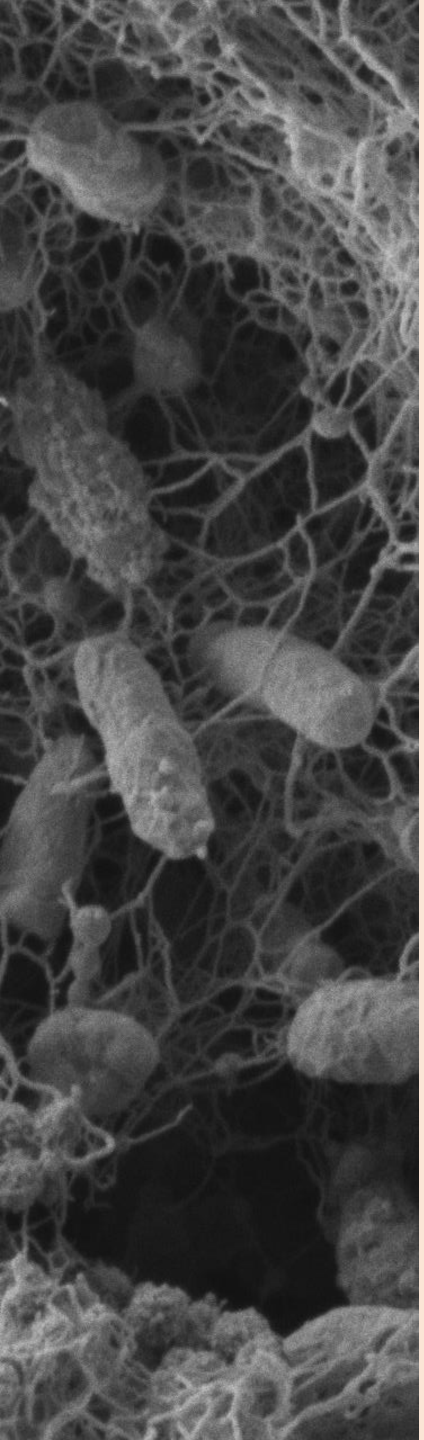
Conclusion & perspectives

- No visible degradation after 80 days
- Difference in microbial composition of biofilm: water column *vs* sediment
- No difference in microbial composition biofilm depending on the polymer nature

→ The concept of « biodegradable plastics » is relative

Perspectives

- 16S rRNA amplicon sequencing analysis
- Immersion for a long time (2, 4 and 6 months) into Mediterranean sea



Acknowledgments

Supervisor: Prof. Ruddy Wattiez
Proteomics and Microbiology Laboratory:

ProtMic
UMONS Université de Mons

Polymer and Composite Materials Laboratory: Samira Benali , Sébastien Moins et Jean-Marie Raquez

SMPC

Oceanology Department: Sylvie Gobert

Océanologie biologique
LIÈGE université
STARESO Recherches Sous-Marines et Océanographiques

National Scientific Research Fund (F.R.S-FNRS)

fnrs LA LIBERTÉ DE CHERCHER