Mediterranean Congress of Chemical Engineering

Preliminary optimization of the environmental performance of PHA downstream processing

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USABLE PACKAGING
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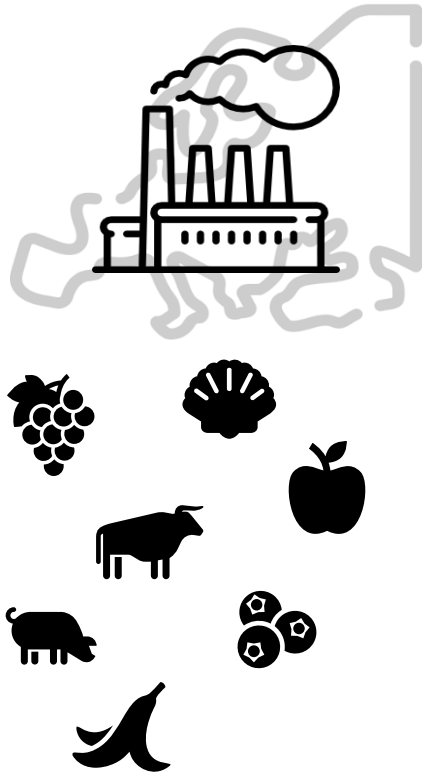
Building blocks for a sustainable bioplastic value chain

100 Mt of food waste/year

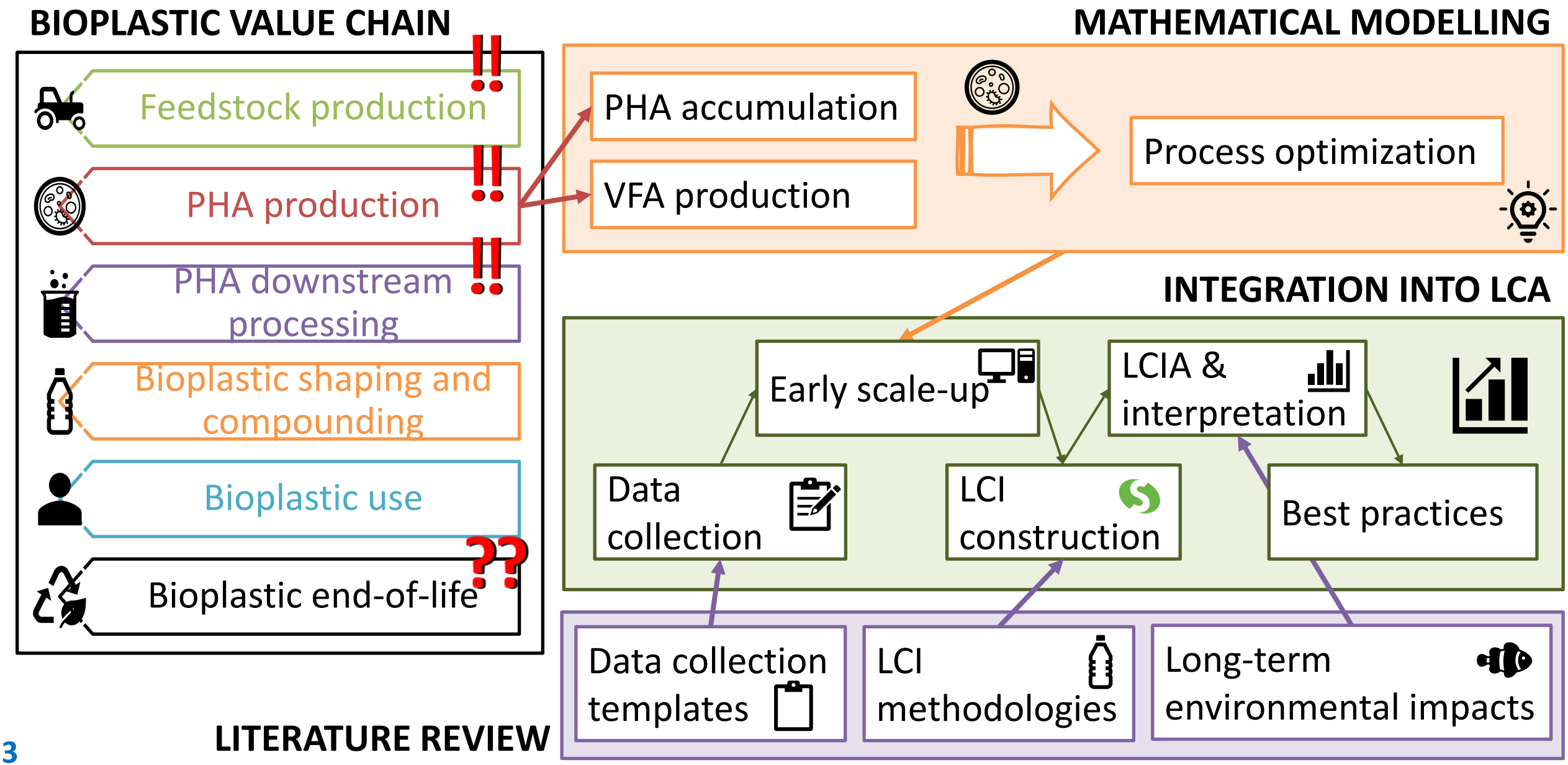


Building blocks

Biobased packaging products

… but how?

Framework: knowledge integration for efficient decision making



Bioplastic value chain hotspot: PHA downstream processing

Feedstock production

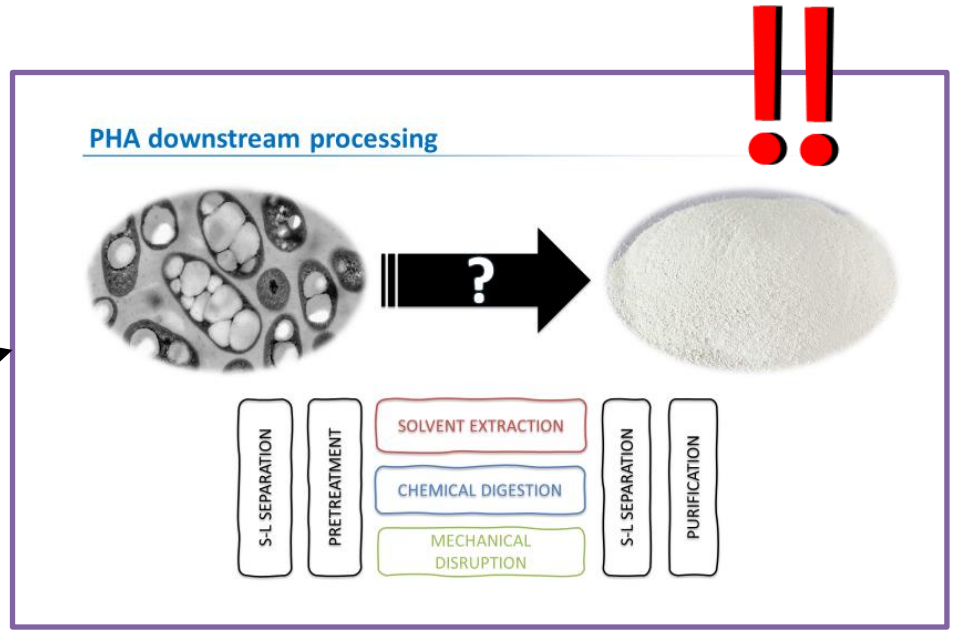
PHA production

PHA downstream processing

Bioplastic shaping and compounding

Bioplastic use

Bioplastic end-of-life



Optimization of the environmental performance

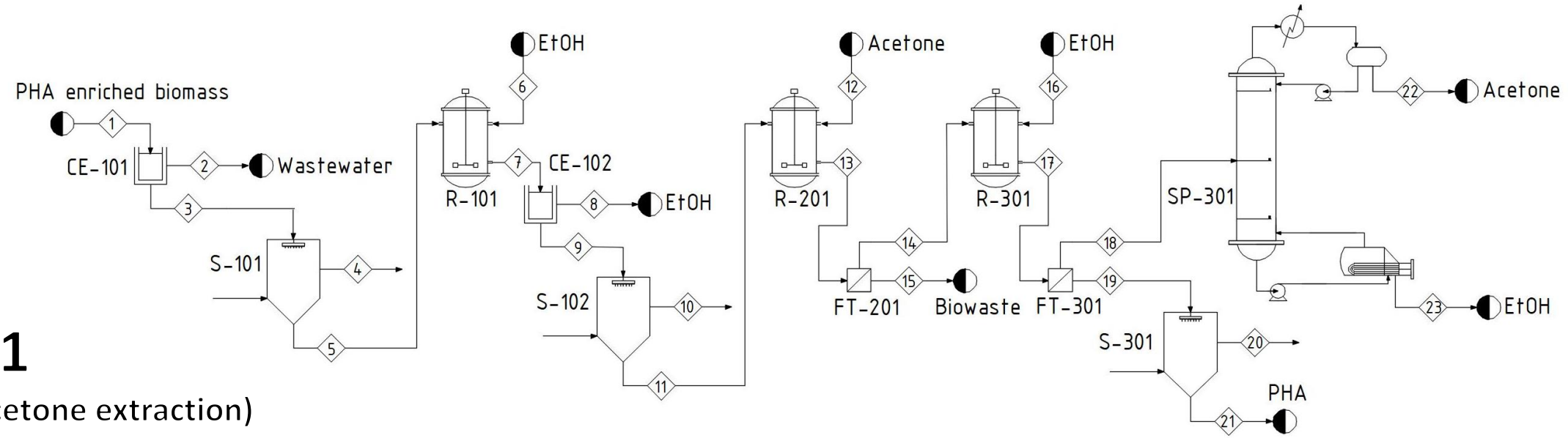
Product requirements and processes selection

Quality	Chemical impurities	High molecular weight	Comply EU No 10/2011?
High-grade (H)			
Low-grade (L)			

G	Feedstock	Culture	Method	TRL
H1	Glucose	Pure	Acetone extraction	9
H2	Food waste	Pure	HPH + SDS digestion	9
H3	Oleic acid	Pure	NaOH + Lysol digestion	4
H4	Glucose, soybean oil	Pure	Ethyl acetate extraction	6

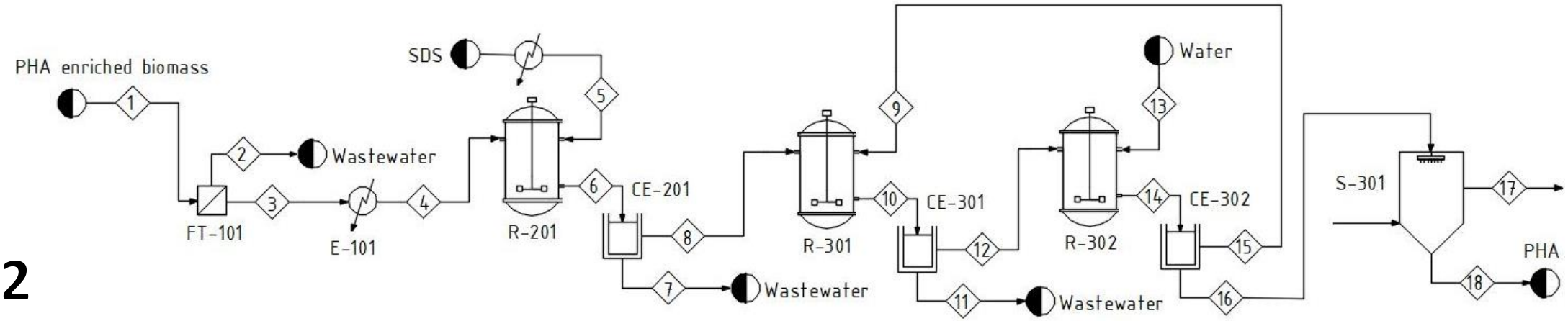
G	Feedstock	Culture	Method	TRL
L1	Methane	Pure	Acetone extraction	4
L2	Canning wastewater	Halophilic bacteria	Osmotic shock + SDS digestion	4
L3	Wastewater	Mixed culture	NaClO + SDS digestion	4
L4	Molasses byproducts	Pure	Fusel alcohols extraction	8

Scenarios definition



H1

(acetone extraction)



L2

(osmotic shock + SDS digestion)

Goal & Scope

SYSTEM FUNCTION: to obtain high-grade or low-grade PHA powder

FUNCTIONAL UNIT: 1 kg high-grade PHA powder or 1 kg low-grade PHA powder

GATE-TO-GATE: from PHA enriched biomass to PHA powder

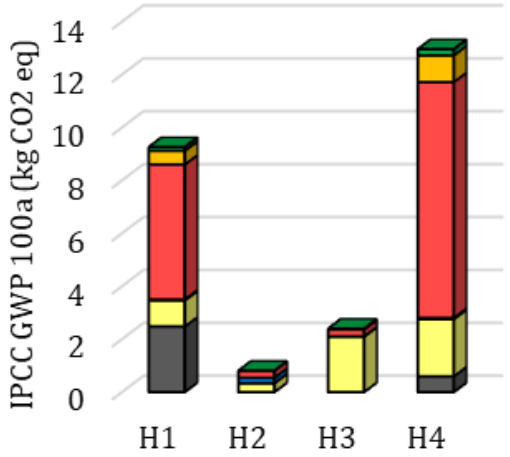
PRIMARY DATA: mass and energetic balances from defined processes (articles, patents & process simulation)

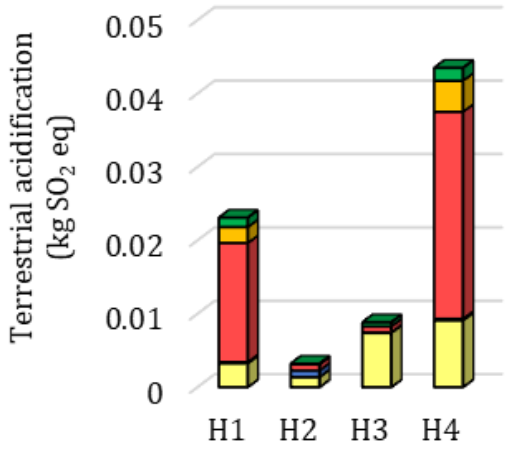
SECONDARY DATA: Ecoinvent v3.3

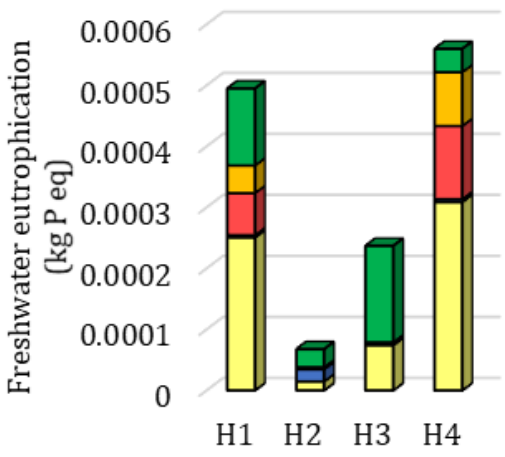
ecoinvent

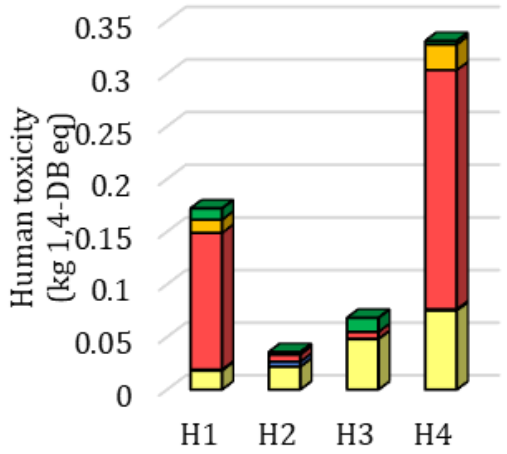
MIDPOINT APPROACH:
Global warming (IPCC method), terrestrial acidification, freshwater eutrophication, human toxicity, freshwater ecotoxicity and fossil depletion (ReCiPe (H) v1.13)

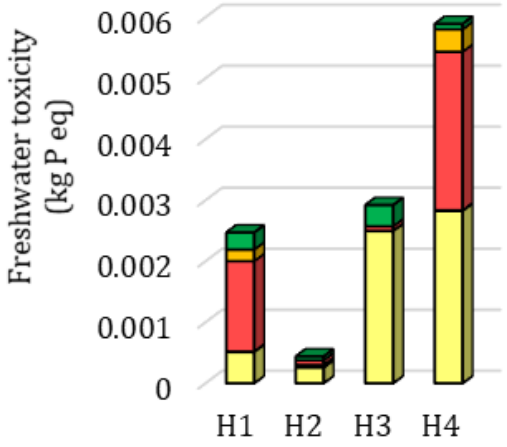
Life cycle impact assessment: 1 kg high-grade PHA

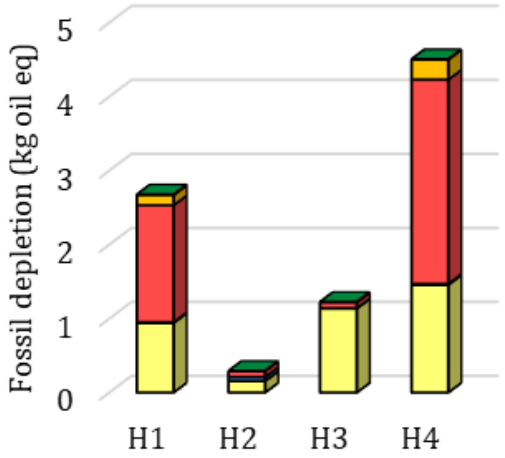












H1

(acetone extraction)

H4

(ethyl acetate extraction)

H3

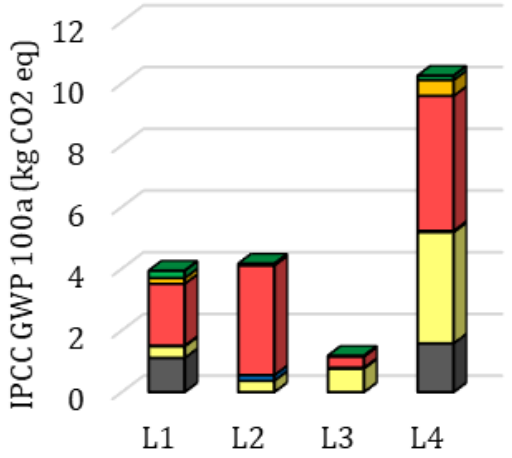
(NaOH + Lysol digestion)

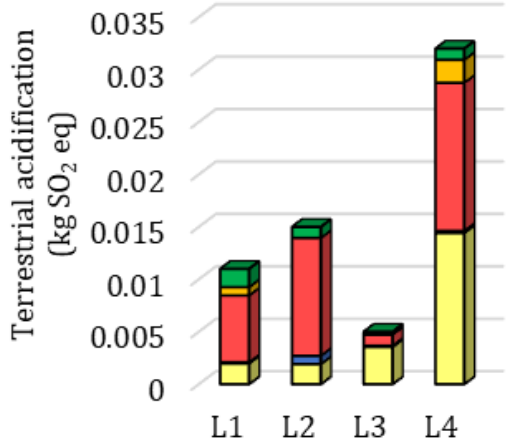
H2

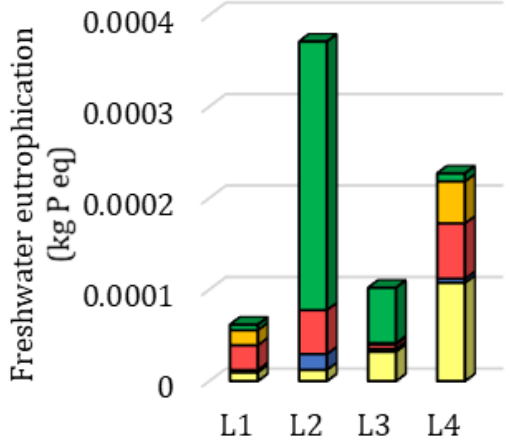
(HPH + SDS digestion)

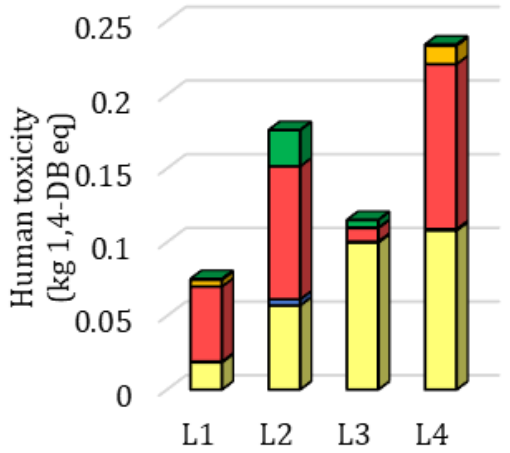
Direct emissions | Chemicals | Electricity | Heat duty | Cooling duty | Waste or wastewater treatment

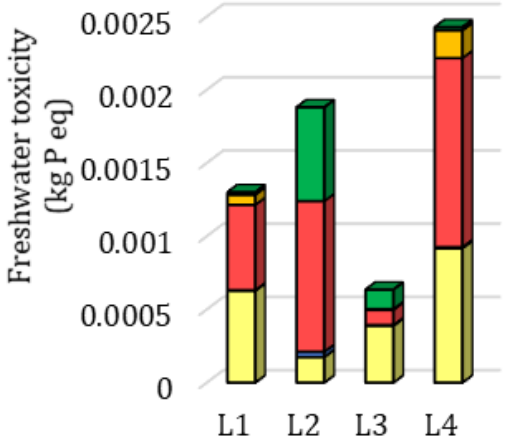
Life cycle impact assessment: 1 kg low-grade PHA

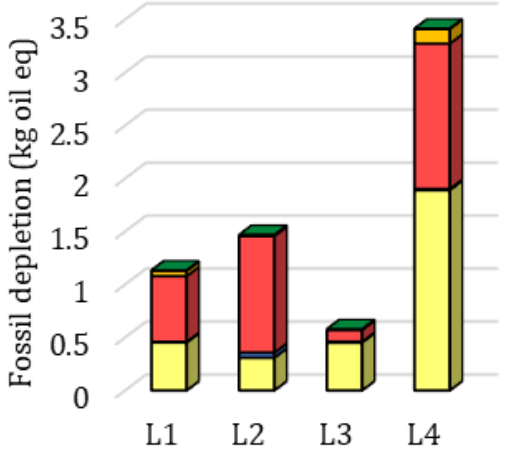












L4
(fusel alcohols extraction)

L1
(acetone extraction)

L2
(osmotic shock + SDS digestion)

L3
(NaClO + SDS digestion)

Direct emissions | Chemicals | Electricity | Heat duty | Cooling duty | Waste or wastewater treatment

Optimization of the environmental performance

Technology	Hotspot	Scenario assessed	Result
Solvent extraction	Heat consumption in solvent recovery	Oil as heat source	
		Natural gas as heat source	
Chemical digestion	Chemicals consumption	Chemicals are not recovered	
		Chemical are recovered	
Mechanical disruption	Electricity consumption in HPH	High-carbon electricity mix (Polish)	
		Low-carbon electricity mix (Swedish)	

Process	Framework	Improvement actions	Environmental impacts reduction		
			GWP	Human toxicity	Fossil depletion
L2	Larger facilities with available residual vapor	Heat integration	83%	50%	73%
L4			12%	13%	11%

Conclusions

- Most promising PHA downstream processes were identified and evaluated
- Preliminary insights for the optimization of their environmental performance were provided
- Solvent extraction require high amounts of energy. Heat integration and the utilization so-called green solvents can reduce the environmental impacts
- Chemical digestion shows a better environmental performance when is combined with mechanical disruption or chemicals are recovered
- High pressure homogenisation is the most promising method from a environmental perspective

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