The degradation and biodegradation of biodegradable plastics at end of life

ARC Training Centre for Bioplastics and Biocomposites

School of Chemical Engineering,
The University of Queensland

The University Of Queensland
AUSTRALIA

QUT

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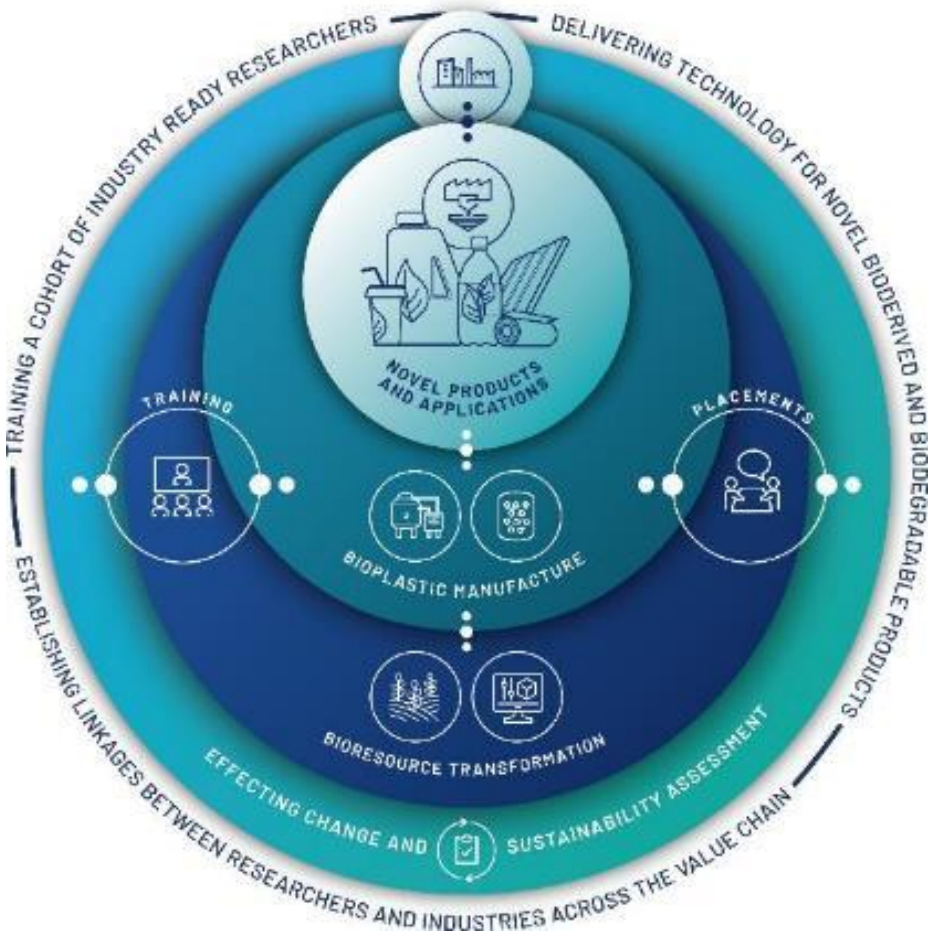


- **Deliver advances in technology** for the development of bioplastic and biocomposite products for the new bioeconomy
- **Train a cohort of industry ready researchers**, laying the foundations for accelerated growth in Australia's bioplastics and biocomposites industry
- **Establish linkages between leading research groups and partner organisations** to strengthen the capabilities of Australian industry to service rapidly growing local and international markets in bio-derived and biodegradable products

Bioplastics and Biocomposites – advancing our transition to a sustainable plastics future

Biomass flows

Biotech for manufacture

Films

Composites

Slow release

#1 Bioresource Transformation

#2 Bioplastic Manufacture

#3 Novel Bioplastic & Biocomposite Products and Applications

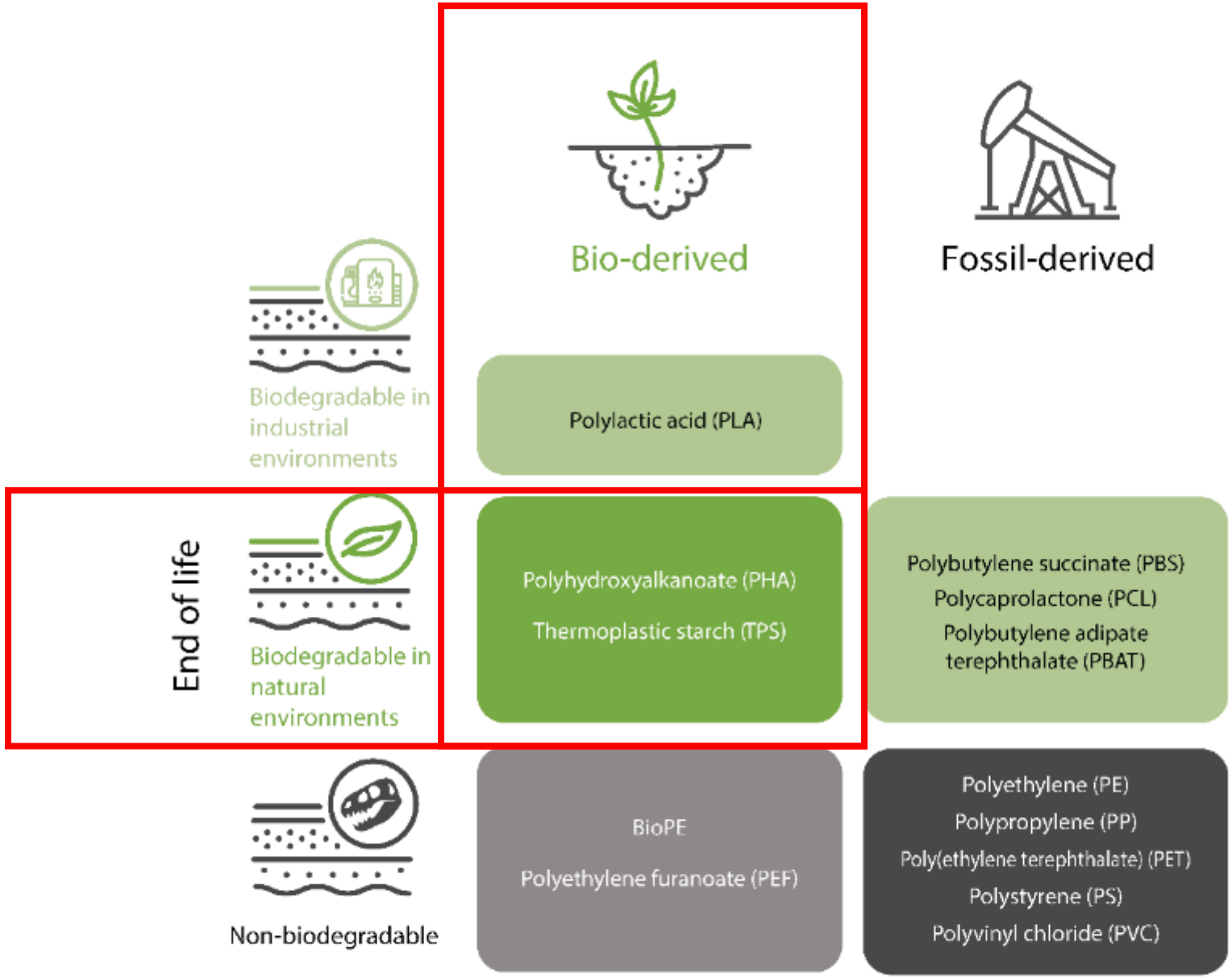
#4 Effecting Change and Sustainability Assessment

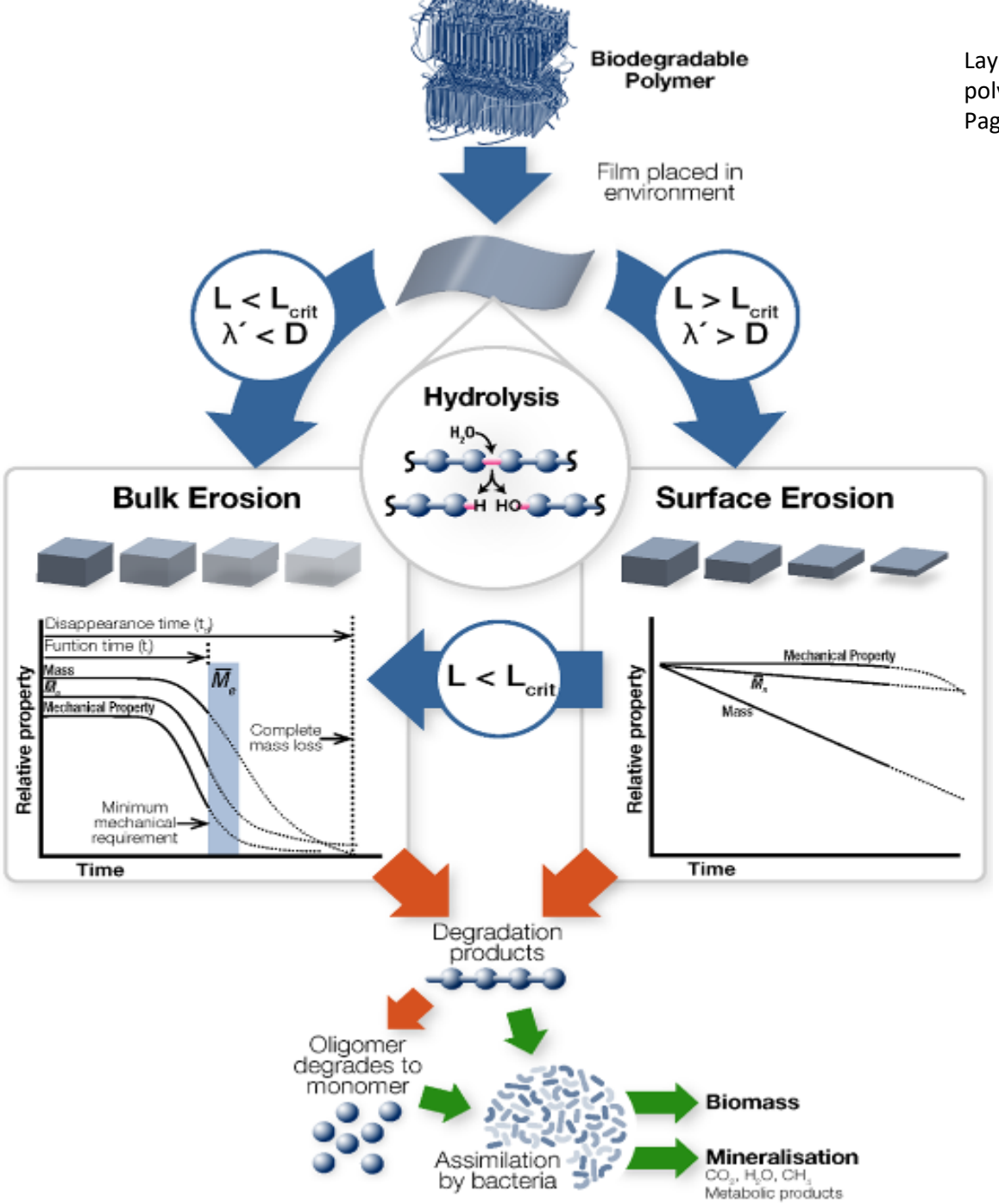
Consumer expectation

End-of-life management

Education

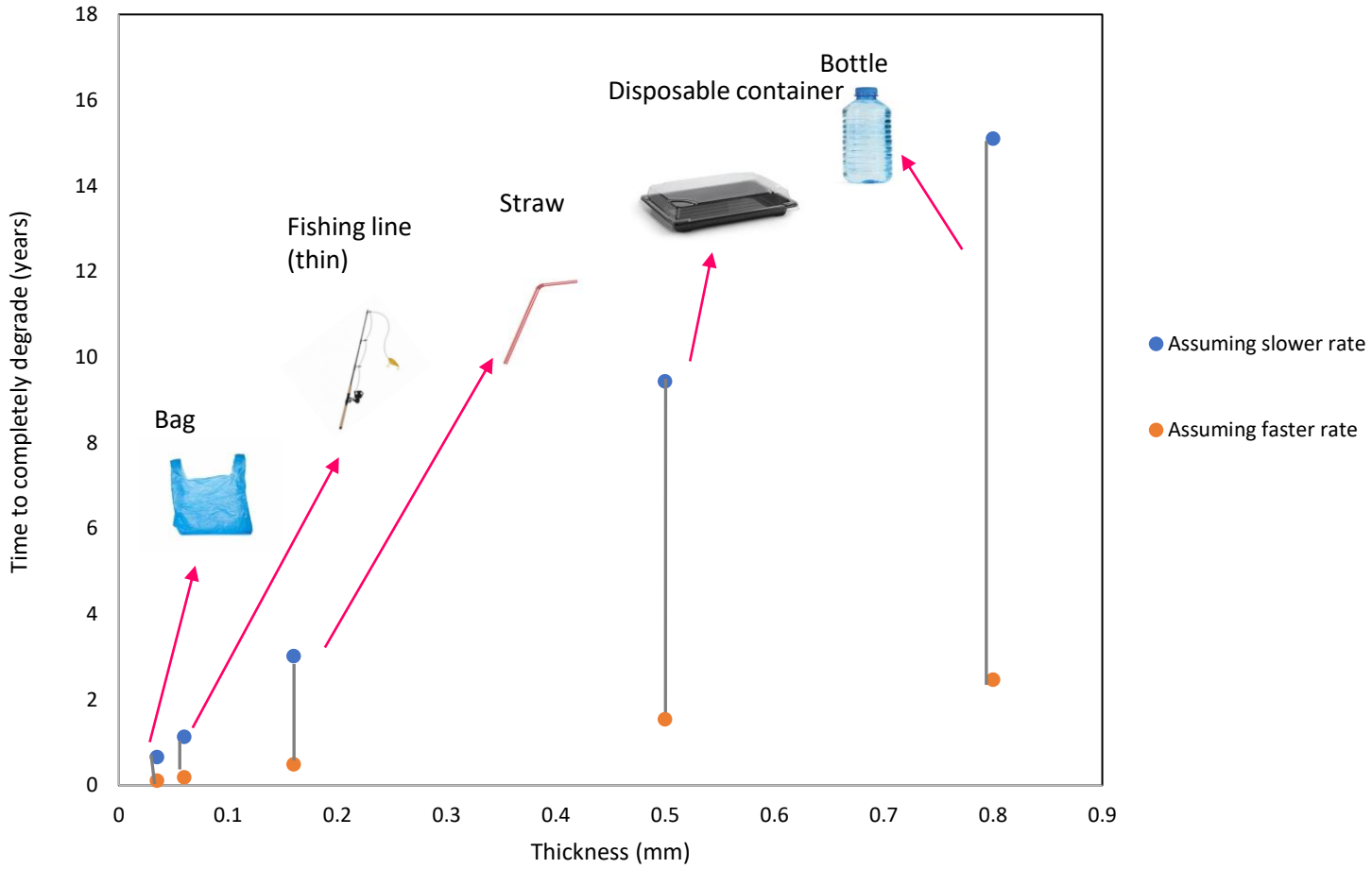
Bioplastics and biocomposites research at UQ


Bio-derived
Fossil-derived
Biodegradable in industrial environments
Polylactic acid (PLA)
End of life
Biodegradable in natural environments
Polyhydroxyalkanoate (PHA)
Thermoplastic starch (TPS)
Polybutylene succinate (PBS)
Polycaprolactone (PCL)
Polybutylene adipate terephthalate (PBAT)
Non-biodegradable
BioPE
Polyethylene furanoate (PEF)
Polyethylene (PE)
Polypropylene (PP)
Poly(ethylene terephthalate) (PET)
Polystyrene (PS)
Polyvinyl chloride (PVC)



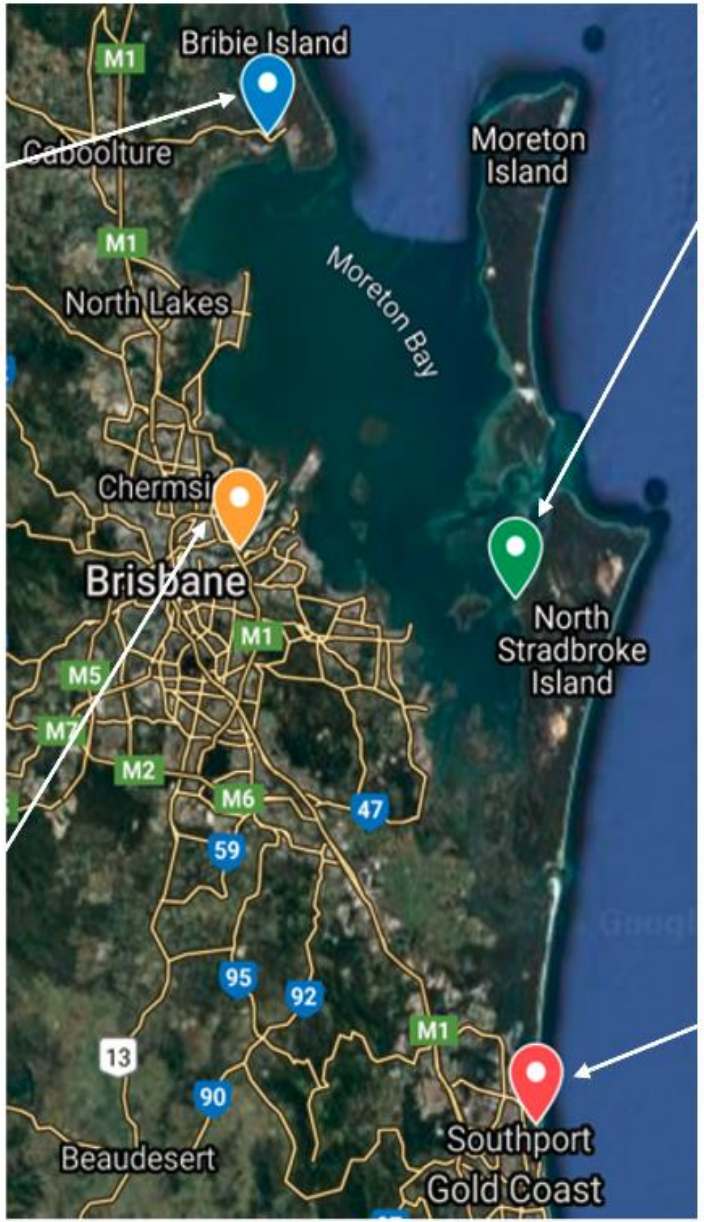
Laycock et al., Lifetime prediction of biodegradable polymers, Progress in Polymer Science, Volume 71, 2017, Pages 144-189,

Marine biodegradation of PHA – literature on lifetimes



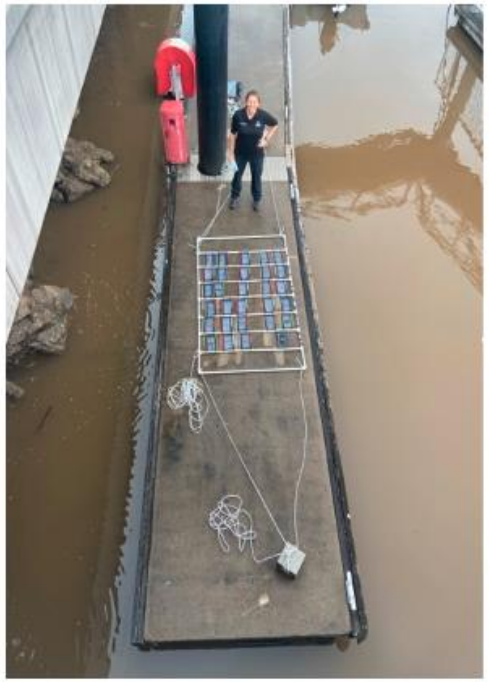
Dilkes-Hoffman et al Marine Pollution Bulletin 142 (2019) 15–24

Spinnaker Sound Marina



Moreton Bay – Dunwich

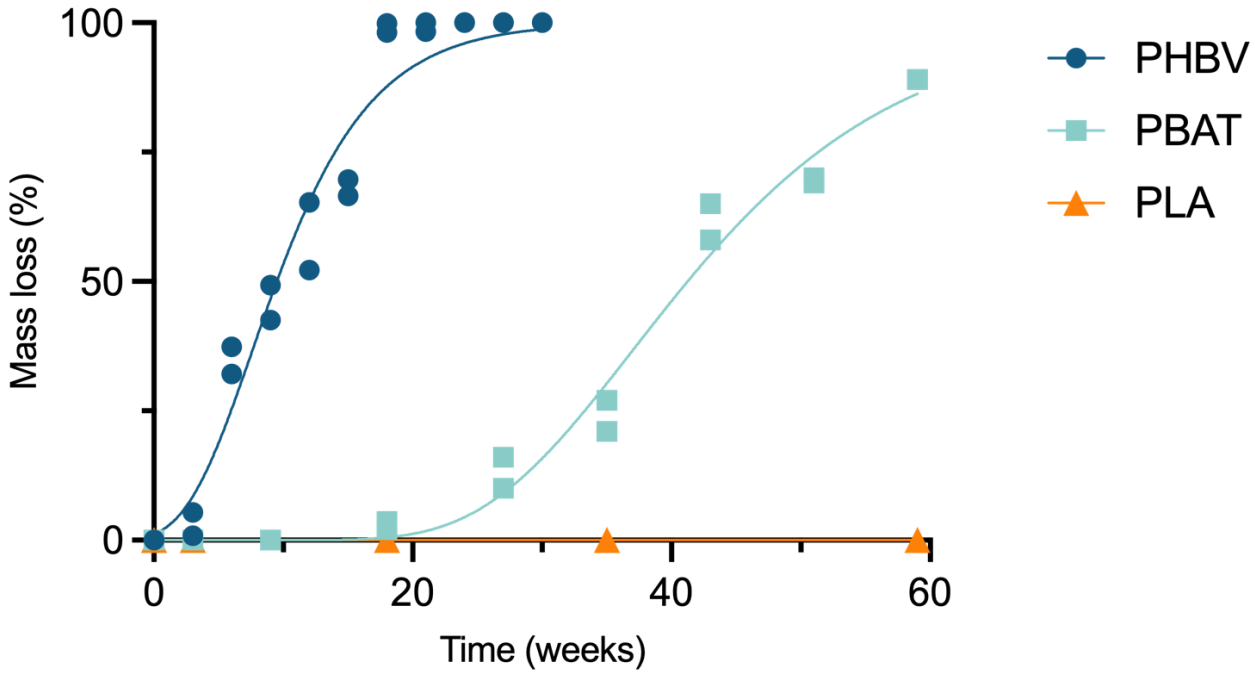
Rivergate Marina



‘Mesocosm’ Sea World

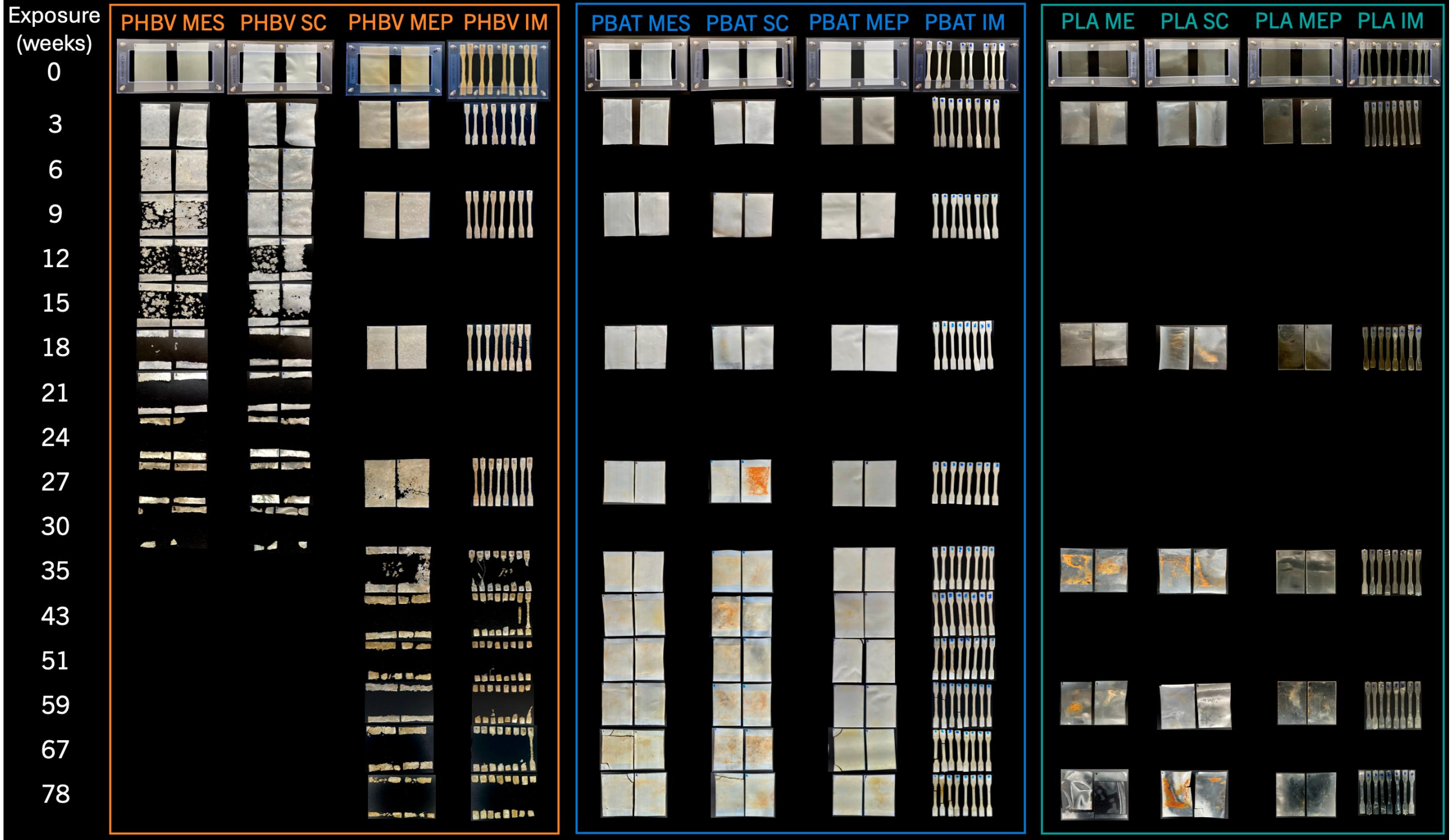
1. To characterise the relative biodegradability of a range of bioplastics in aquatic environments.

Material Comparison – PHBV, PBAT, PLA

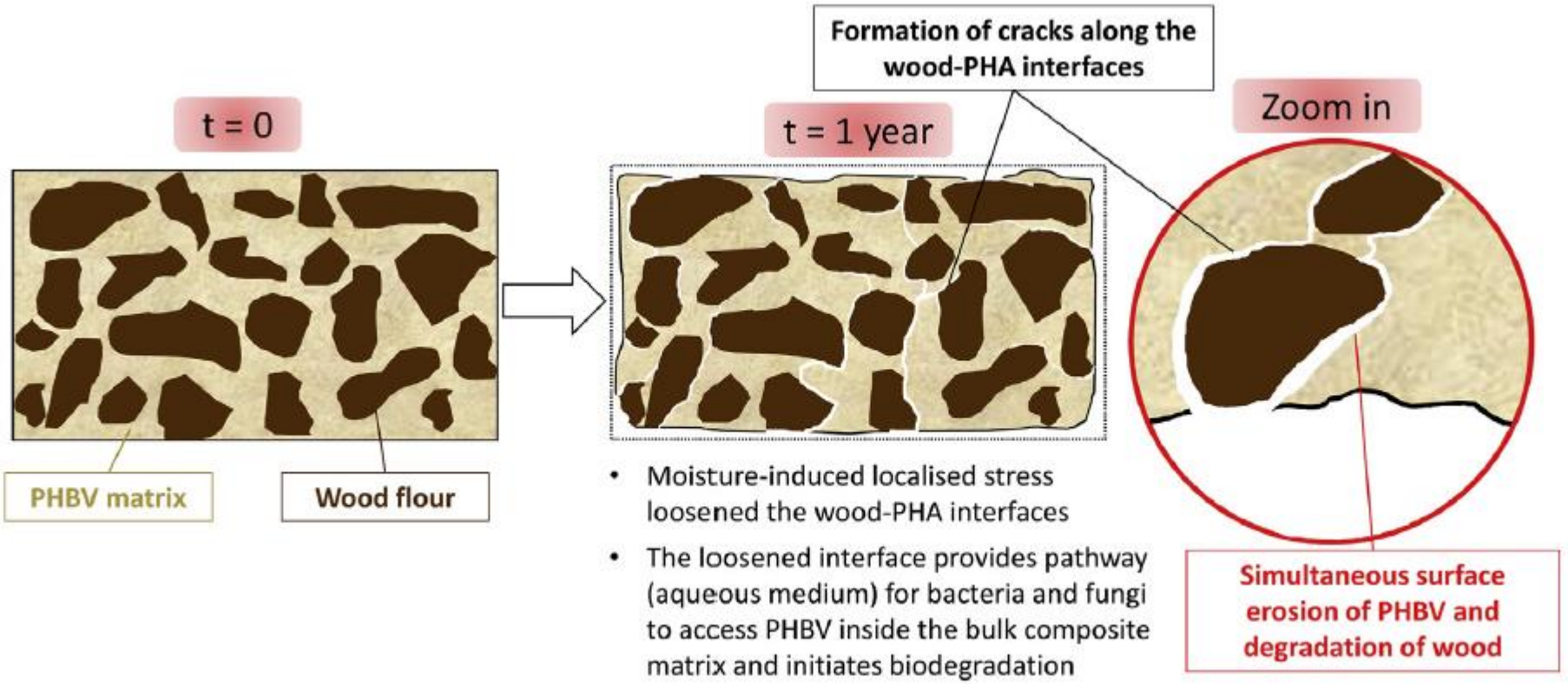


PHBV sample sets 10/10 retrieved
PBAT sample sets 8/10 retrieved
PLA sample sets 4/5 retrieved

Research Rig at RMB site with shockingly clear water in the Brisbane River!


Exposure (weeks)
0
3
6
9
12
15
18
21
24
27
30
35
43
51
59
67
78
PHBV MES
PHBV SC
PHBV MEP
PHBV IM
PBAT MES
PBAT SC
PBAT MEP
PBAT IM
PLA ME
PLA SC
PLA MEP
PLA IM

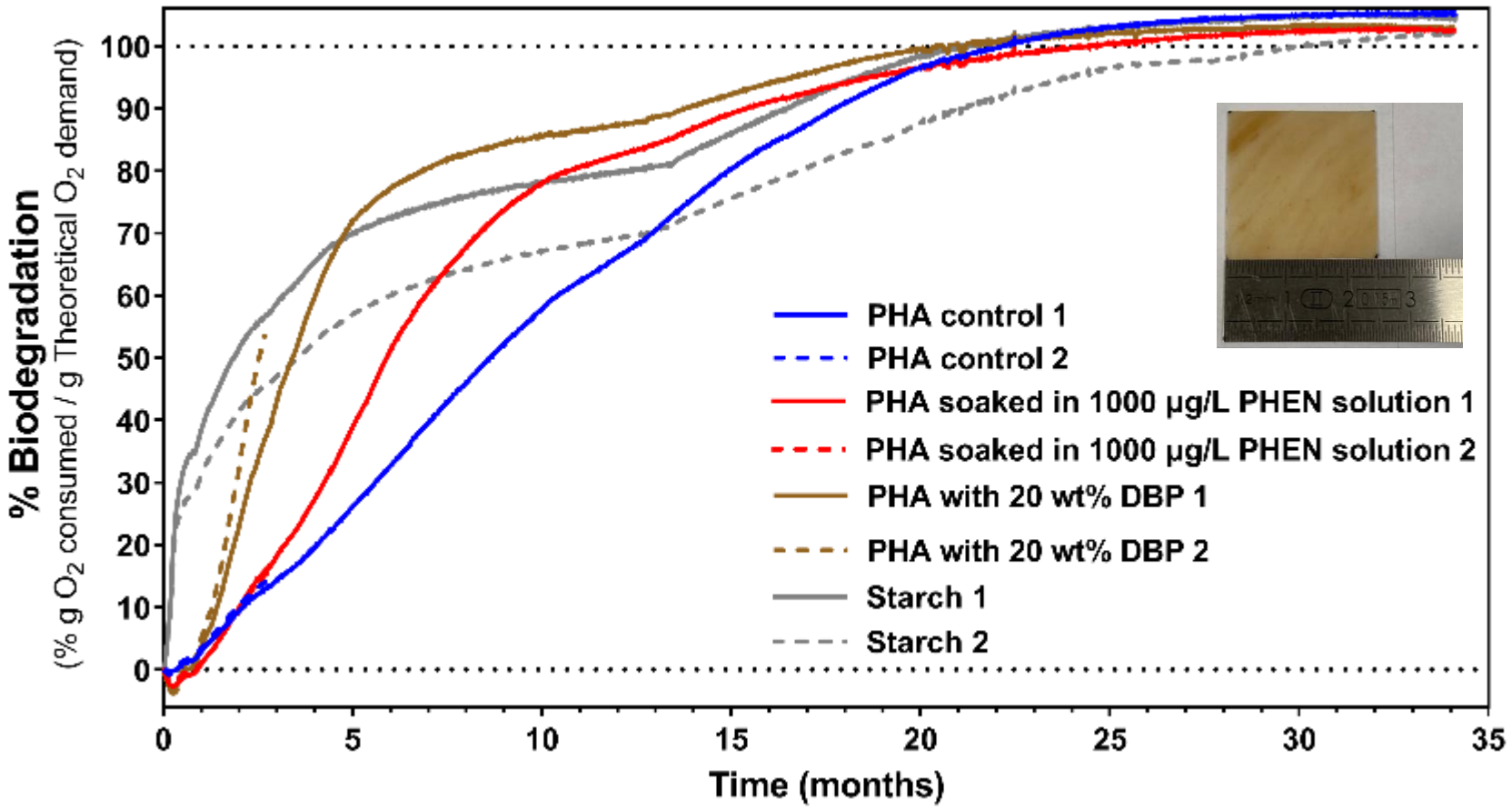
Effect of hydrophilic fillers on biodegradation



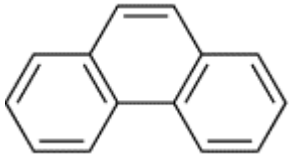
- Moisture-induced localised stress loosened the wood-PHA interfaces
- The loosened interface provides pathway (aqueous medium) for bacteria and fungi to access PHBV inside the bulk composite matrix and initiates biodegradation

C.M. Chan et al. / Sustainable Materials and Technologies 21 (2019) e00099

Impact of toxic additives on biodegradation

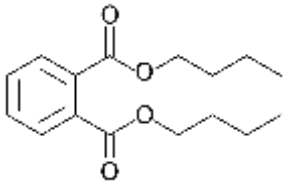


Phenanthrene (PHEN)



- Common toxic pollutant found in ocean and on microplastics
- Plastic sheet equilibrated in 100 mL of PHEN solution at 1000 $\mu g.L^{-1}$ for 14 days
- Quantified by GC/MS: **<u>58.8 ± 3 µg</u>** sorbed on surface

Dibutyl phthalate (DBP)



- Widely-used as plasticiser for plastics in processing
- Solvent-blended at 20 wt%, then precipitated and melt-pressed

In-vivo biopolymer degradation – controlled release for management of Simplexin poisoning

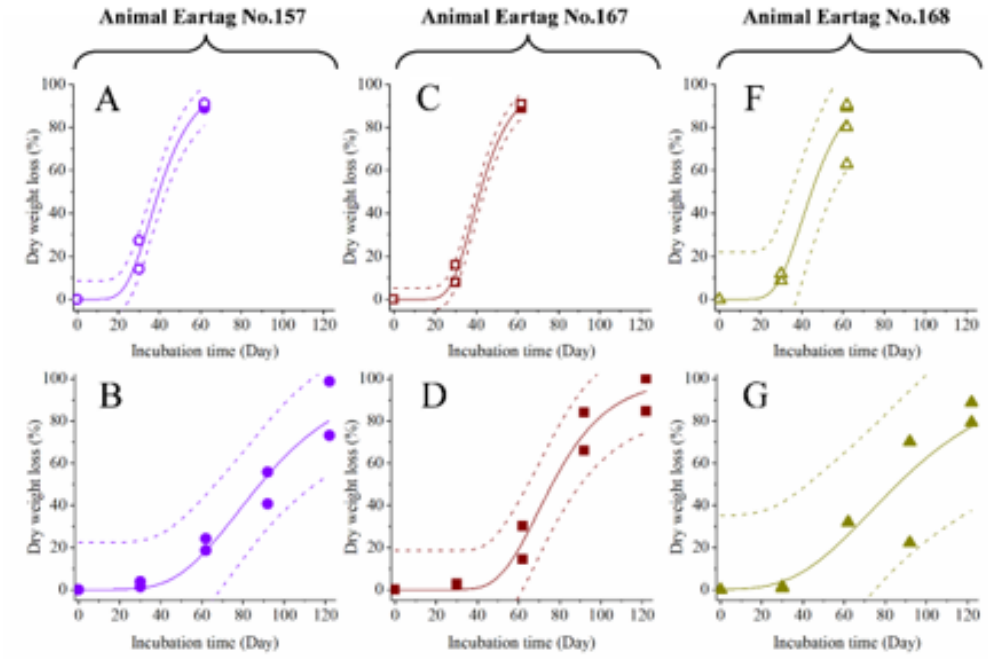
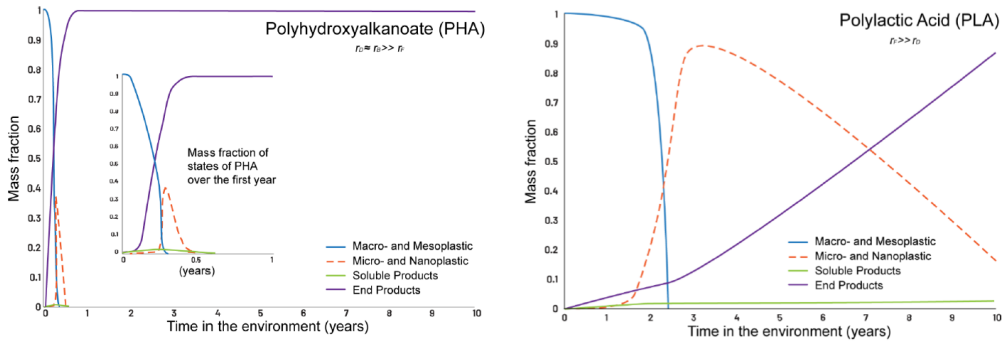


Figure 9-3. Dry weight losses (wt.%) of (A) the 3D printed scaffold PHBV samples and (B) the extruded solid cylinder samples incubated in the steer with Eartag No.157, (C) the scaffolds and (D) solid ones in the steer with Eartag No.167, and (E) the scaffolds and (F) solid ones in the steer with Eartag No.168, versus different lengths of time (data are shown as symbols, the fits with models as solid lines, and the 95% confidence prediction bands as dashed lines).

Biodegradable plastics Hazards of transition states



Transition States	Lifetime		
	Polyethylene (PE)	**Polylactic Acid (PLA)**	**Polyhydroxyalkanoate (PHA)**
Macro- and mesoplastic	Months to years	Months to years	Weeks to months * $r_D \approx r_B > r_F$
Micro- and nanoplastic	Hundreds of years * r_D very slow	Years * $r_F >> r_D$	Days to weeks
Soluble Products	Weeks to months	Weeks to months	Hours

Biodegradability of plastics: Discussion paper

A joint collaboration between Corrs Chambers Westgarth and the University of Queensland

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Biodegradable plastics present a potential solution to some of the issues relating to plastic wastes.

Challenges: scope and role in an increasingly circular economy are not straight forward.

There is unlikely to be a simple or singular solution. A multi-faceted approach is required.

Upcoming Event Notice

Biodegradable Plastics:
The Problems and the Solutions

The plastics problem

Background to biodegradable plastics

Current policy and legislative landscape

Potential solutions

Where: Brisbane

When: November 2024

Contact: centreforbioplastics@uq.edu.au

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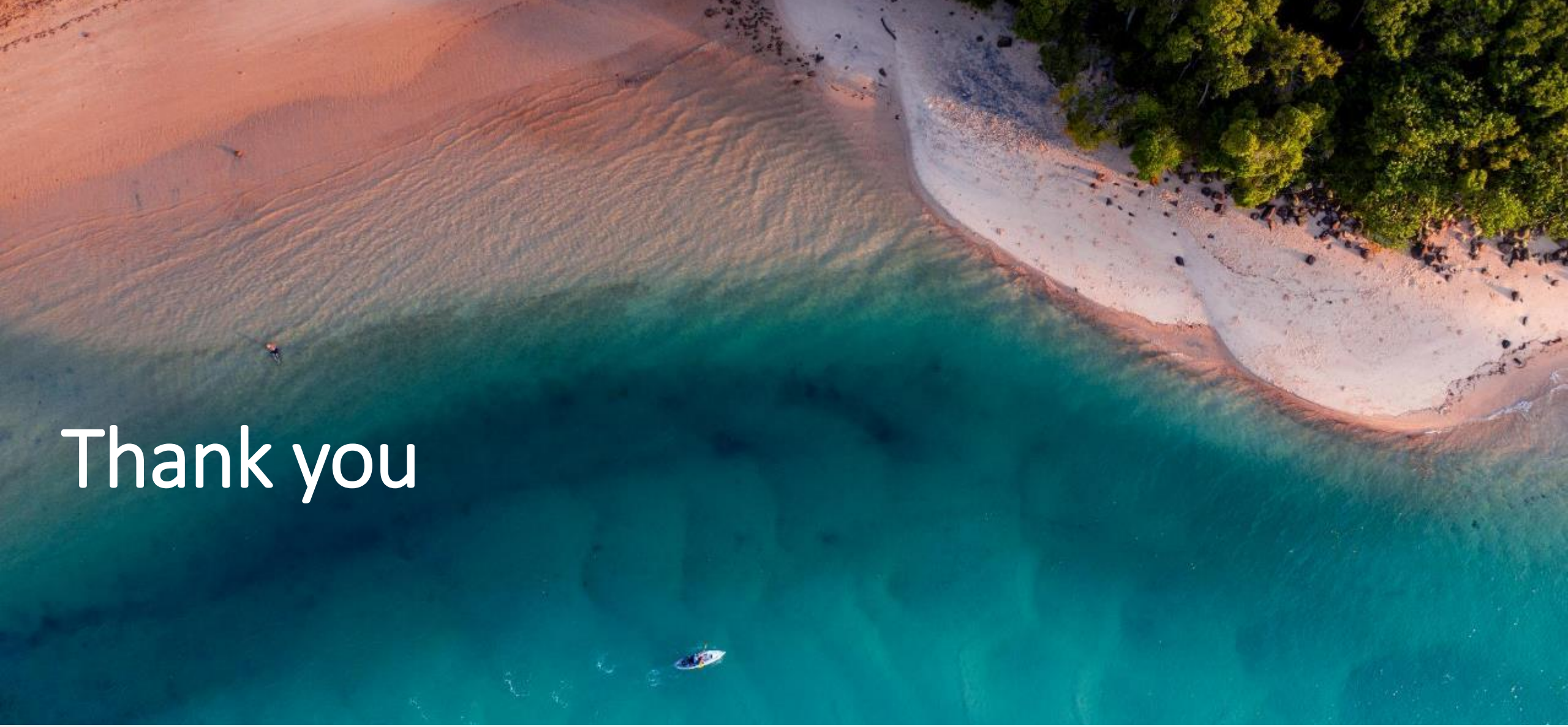

Thank you

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