



Are Biodegradable Plastics the Solution to Plastic Pollution?



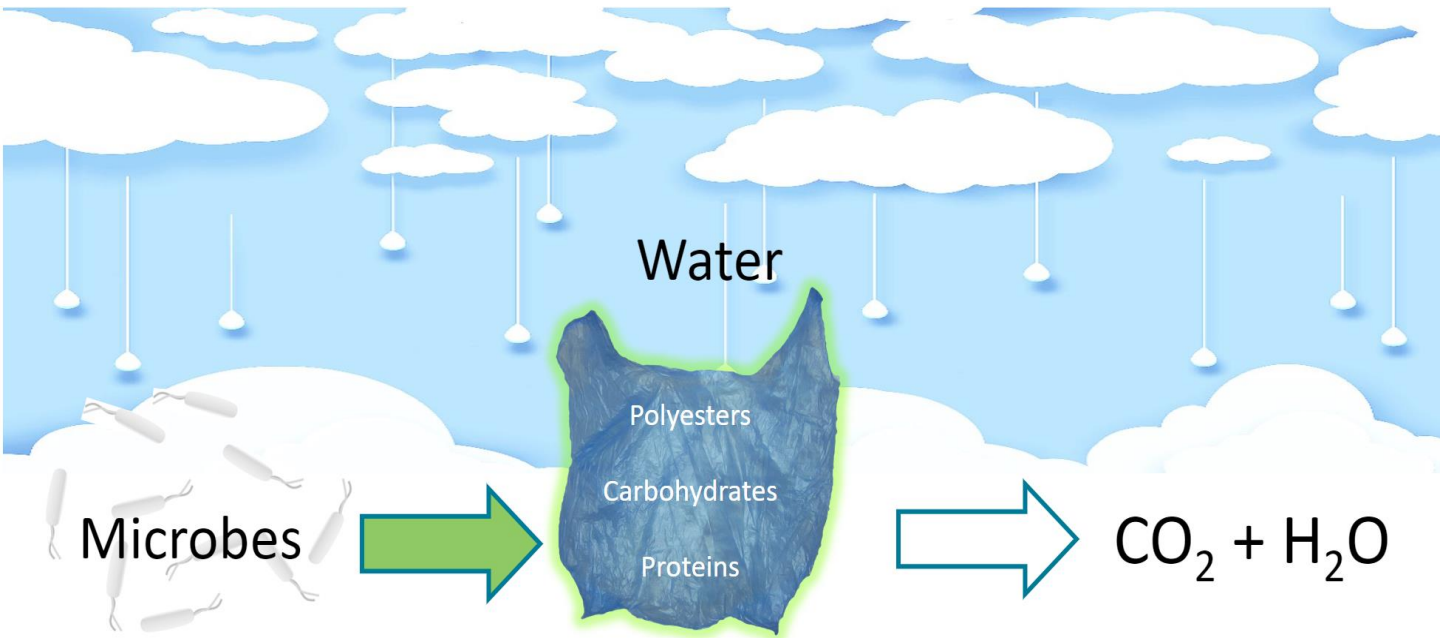
- Definition
- Waste hierarchy
- Limitations
- Why Biodegradables
- Green washing
- R&D at CSIRO

Ending Plastic Waste Symposium 2023

Pete Cass, PhD | CSIRO Manufacturing

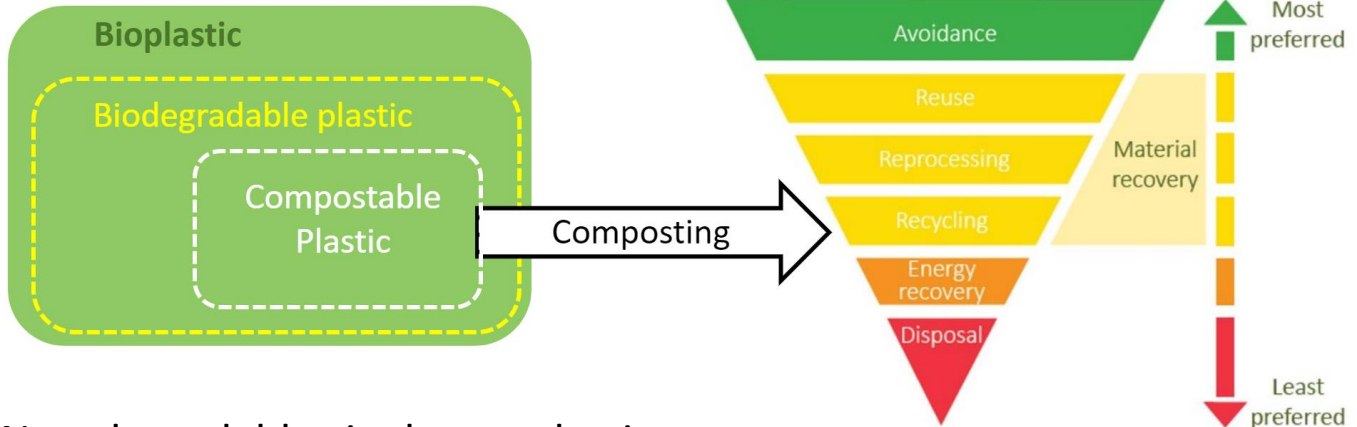


What are Biodegradable Plastics?





Biodegradable Plastics as a Waste Management Strategy



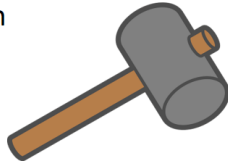
Non-degradable single use plastics may be substituted for compostable plastics for certain applications

Recycle or Compost Option?

Limitations of Biodegradable Plastic

Mechanical Properties

- Reduced strength
- Low flexibility
- Reduced impact resistance



Barrier Properties

- Affects food self-life

O₂ H₂O



Recycling

- Unsuitable for mechanical recycling

Thickness

- Mainly thin films
- Affects degradation rate



Cost

- 3-5X conventional plastics





Consideration for using Biodegradable Plastics

- Reduce environmental footprint
- Increased consumer demand
- Evolving legislation for single-use plastic bans



Best Argument for Biodegradable Packaging

- Even if waste collection, sorting, and recycling were significantly improved, waste management will always be problematic



- Littering
- Negligence
- Incidental exposure
- Illegal dumping



Further Challenges for Biodegradable Plastics

• **Poor Performance of Compostable Plastics using Citizen Science in the UK**

Purkiss et. al. The Big Compost Experiment...., Frontiers in Sustainability, 3, 2022, 1-18

- Home compost study using 9,701 citizens
- 60% of certified home compostable did not meet performance targets
- Concluded that compostable plastics are not effective

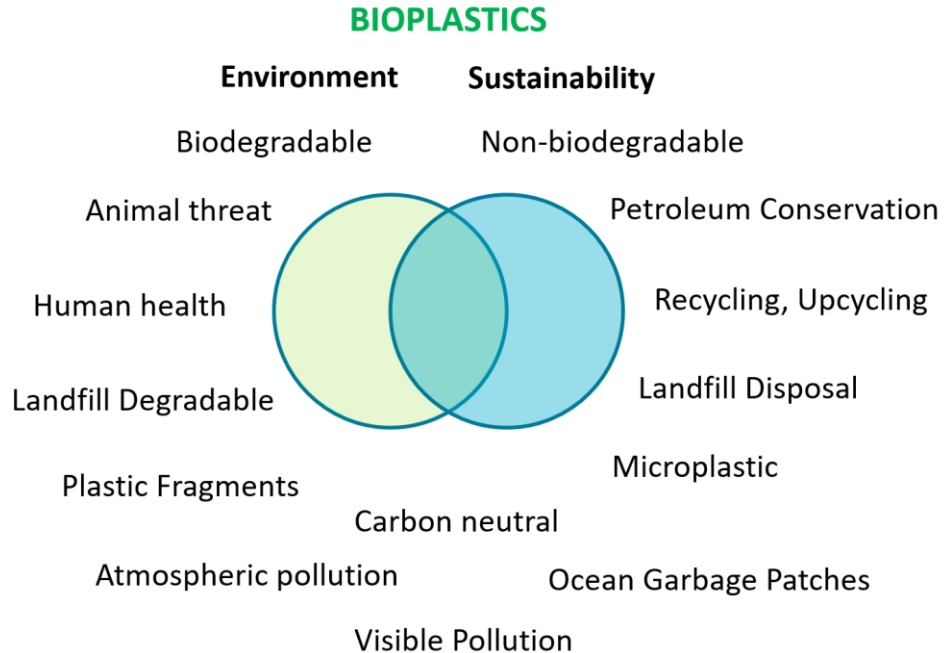
Why?

- Packaging is engineered to maximise mechanical performance limited to an ideal compost environment
 - Temperature, airflow, nutrients, moisture, microbe loading e.t.c.
 - Changes to certification targets may be necessary?



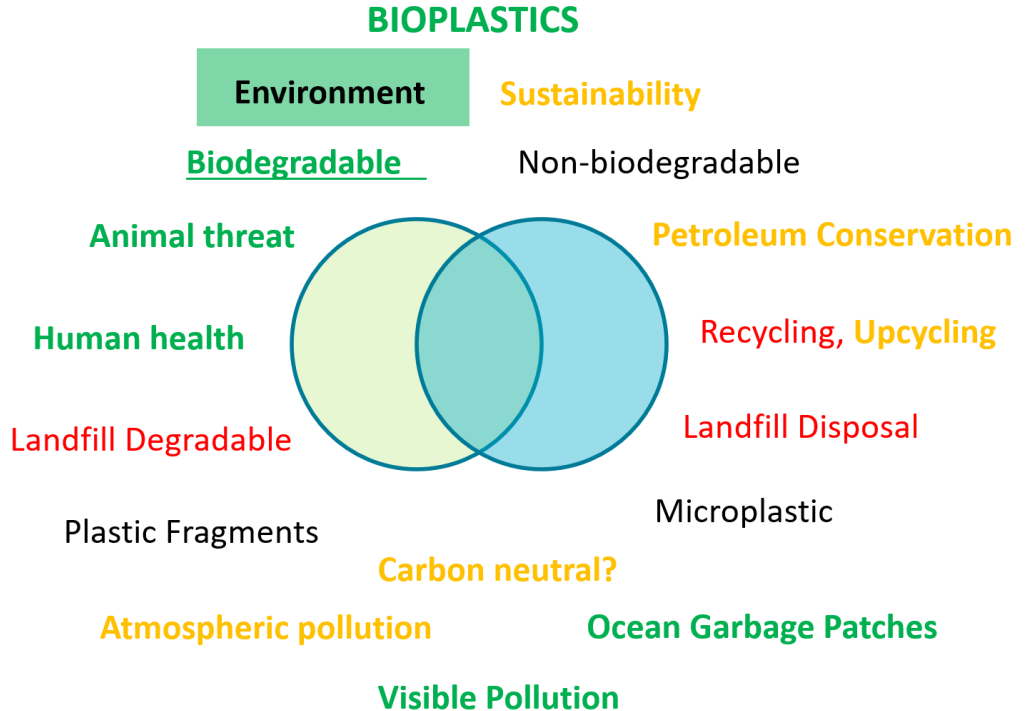
Value Proposition

*There is no
'one-strategy'
to suit all
needs*





Our Focus





Consumer choices...

• Green washing – value proposition, misconception, or deception?

1. Oxo-degradable

- Disintegrates
- Reduced Animal Threat
- Persistent microplastics
- Nonrecyclable



2. Non-degradable Bioplastic

- Uses less petrochemicals
- Recyclable
- Non-degradable, environmental pollution



3. Uncontrolled 'Green' Plastics

Petrochemical blends – polyethylene + PLA or starch

- Uses less petrochemicals
- Carbon capture (if non-degradable)
- Problematic recycling
- Non-degradable, environmental pollution

Unverified Compostable Plastic - Excessive degradation period?

- Environmental/animal hazard
- Accumulates in compost bin
- Produces methane in landfill





...are biodegradable plastics the solution to plastic pollution?



- Depends on value proposition and tolerance to limitations
- Only recommended for certain applications (see APCO)
- **Technology is evolving and essential to address limitations**

R&D Needs and Challenges

- Degradation rate and Mechanical Performance
- Recycling (Upcycling)
- Oxygen/moisture barrier performance
- Clear end-of-life Labelling for Consumers
- Banning green washed products

.....**Learn More**

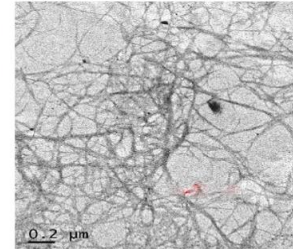
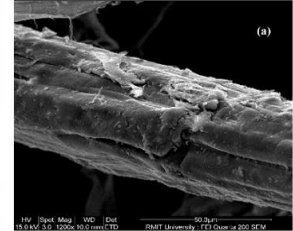




R&D Activities at CSIRO

- **Biodegradable composites to improve mechanical properties**
 - nanocellulose incorporation into biodegradable polyesters
 - Kingshuk Dahli, PhD student RMIT

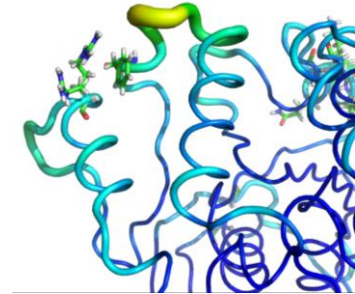
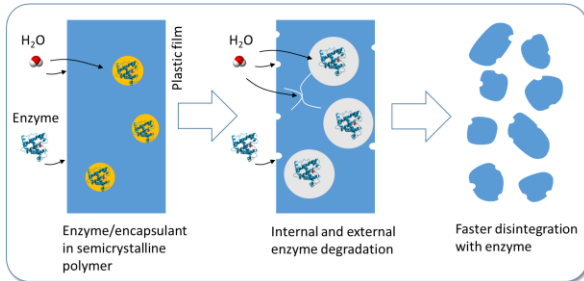
- **Assisting start-up Uluu with their PHA polymers**
 - materials evaluation
 - material processing





R&D Activities at CSIRO

- Enzyme incorporation into polyesters for enhanced degradation rates -> **thicker, stronger home compostable plastics**



- Contract R&D for Enzide Technologies™ (form. Earthpak)
- Enzyme engineering for targeted activity and thermal stability (Biocatalysis and Synthetic Biology Team)
- MOFs enzyme encapsulation technology (Licence from CSIRO)





Thank you

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extra slides



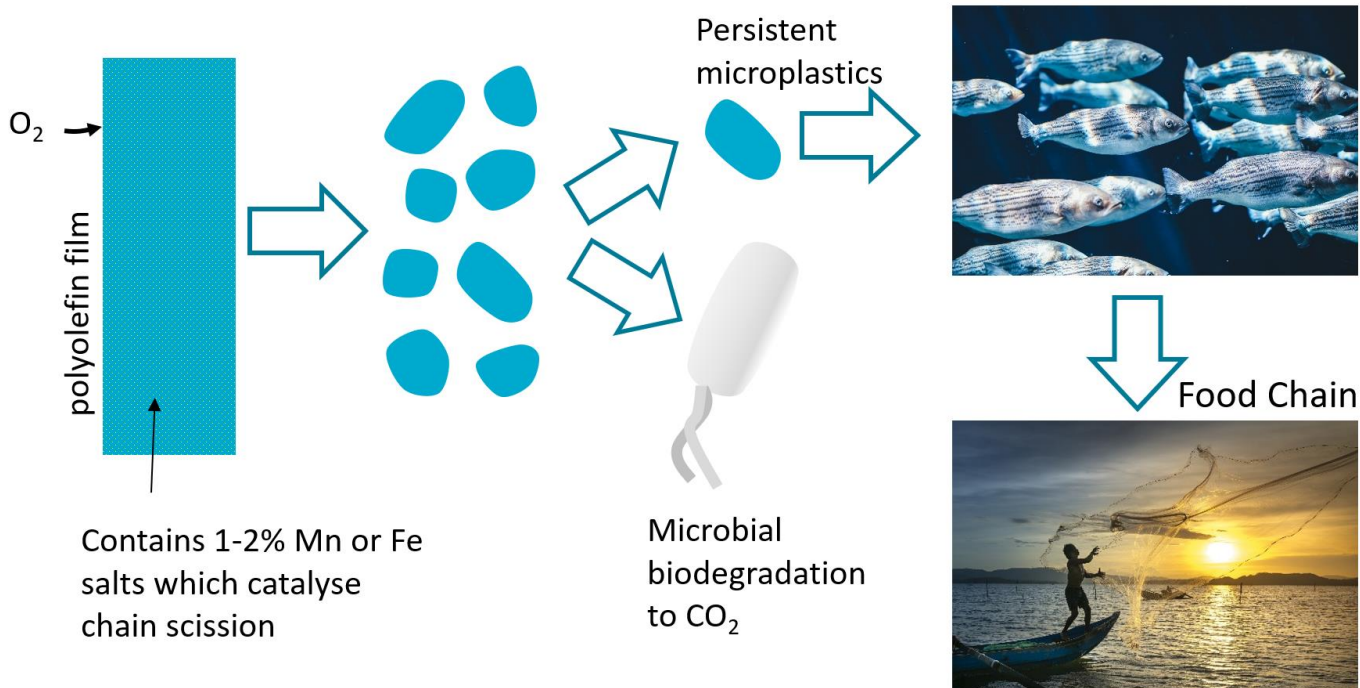
Biodegradable Plastics Classification Based on Degradation Environment



<u>Application</u>	<u>Temperature</u>	<u>Relative Degradation Rate</u>	<u>Microbial Mineralisation</u>	<u>Hydrolysis</u>	<u>Product</u>
Oxo-degradable	ambient	Variable	some	via catalysis	micro plastic + CO ₂ + H ₂ O
Industrial Compostable	60°C	Fast	Yes	Yes	CO ₂ + H ₂ O
Home Compostable	ambient	Moderate	Yes	Yes	CO ₂ + H ₂ O
Biodegradable - soil	ambient	Slow	yes–moderate	Yes	CO ₂ + H ₂ O
Biodegradable - marine	ambient	V. Slow	yes–slowly	Yes	CO ₂ + H ₂ O
Biodegradable - water	ambient	V. Slow	yes–slowly	Yes	CO ₂ + H ₂ O

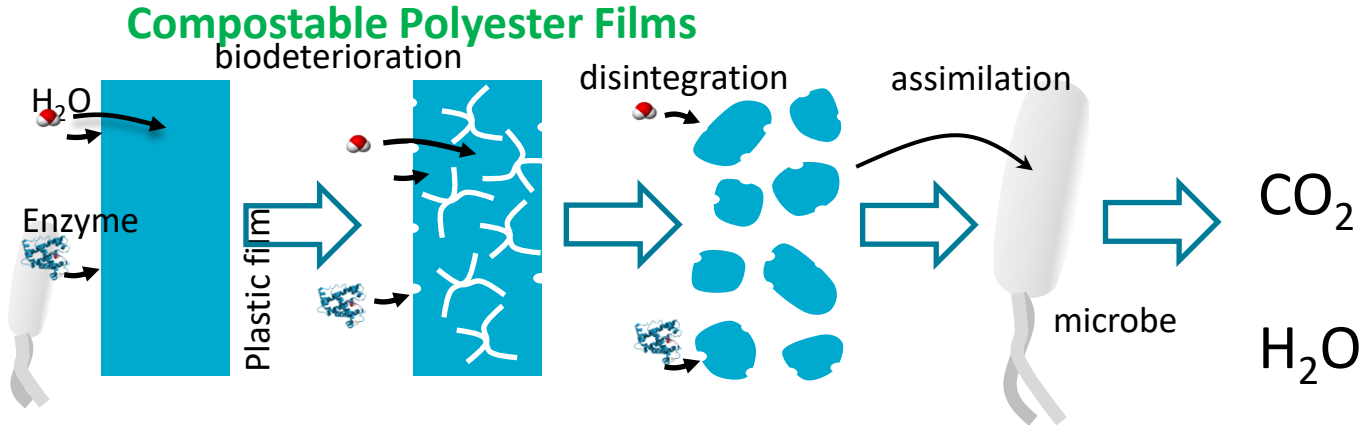
Mechanical performance

Oxo-biodegradable films e.g., oxo-polyethylene



Compostable Polyester Films

Compostable Polyester Films

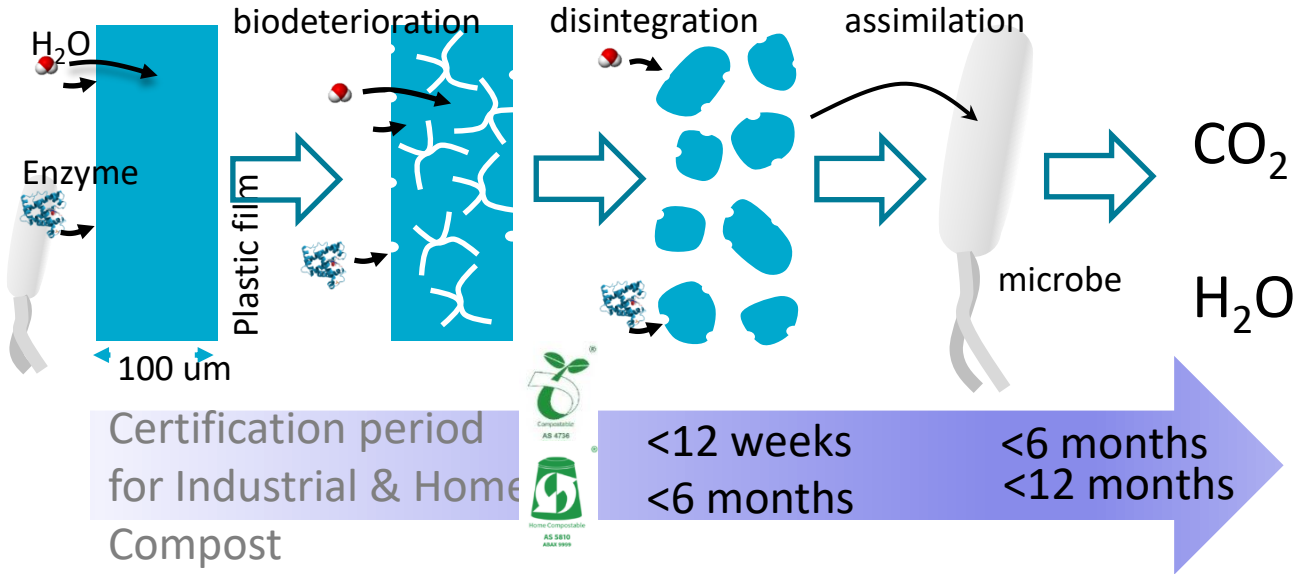


Industrial @ $>60^{\circ}C$, e.g. PLA

Home @ $<30^{\circ}C$, e.g. all other biodegradable plastics (excluding PLA)



Compostable Polyester Films





Compostable Polyester Films

