Useful applications of biodegradable plastics

Technical aspects

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- Soil degradable products
- Marine degradable products
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Introduction

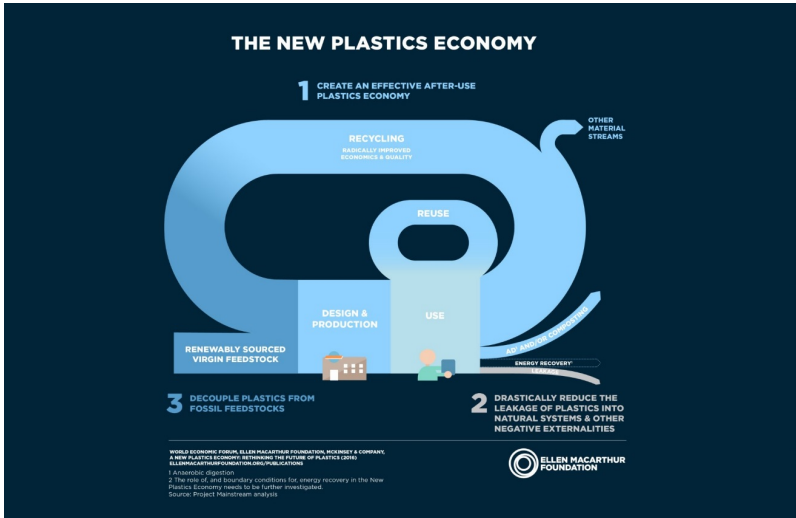
- Current focus of the plastic industry and policies
    - Plastic recycling (recycling targets & recyclability requirements)
    - Reduction of plastic use (carrier bag legislation)
    - Prevention of pollution (SUP and microplastic regulations)

- How do biodegradable plastics fit in current plans?

Introduction

- New Plastics Economy model by the Ellen MacArthur Foundation

1) Create an after-use plastic economy
2) Reduce leakage into natural environments
3) Decouple from fossil feedstocks



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hen biodegradable products?

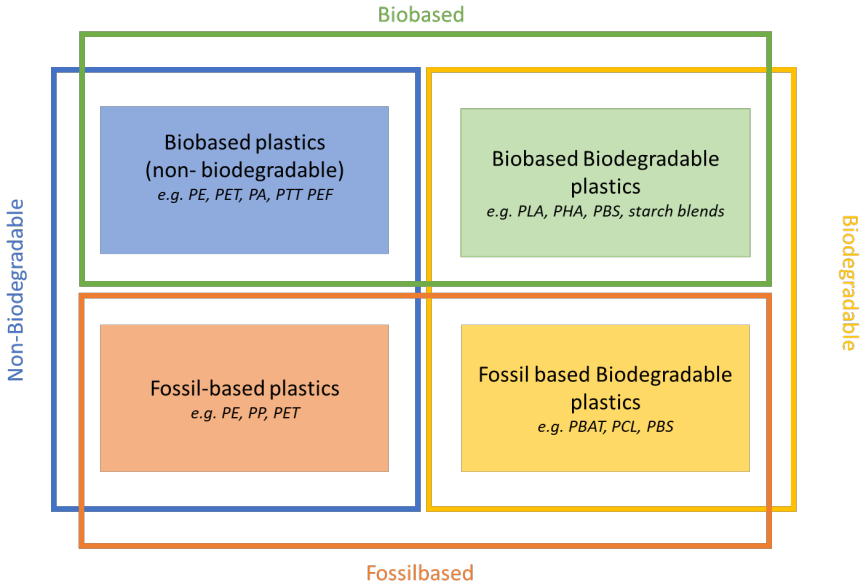
- Imposed by l
- Functional advantage
- Prevent or reduce pollution
- Reduce labour costs
- Carrier of organic waste
- Recycling is not an option

Biodegradable products are never an excuse for littering

Biodegradable plastics

- Biobased ≠ biodegradable
  - Biobased relates to origin
  - Biodegradable relates to end-of-life

Biodegradability should be measured at a product level



Polymer degradation

Photo-oxidative degradation

- All polymers incl. polyolefins
- Heat, oxygen, UV, catalysts

Hydrolysis

- Polyesters, nylons
- Water, heat, catalysts

Biodegradation

- Polyesters, natural polymers...
- Enzymes, water, (oxygen)

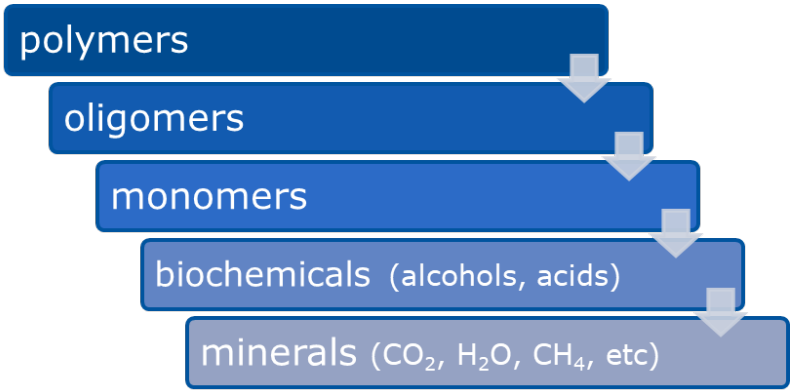
Ozone degradation

Thermal degradation

Mechanical degradation

Biodegradation mechanism

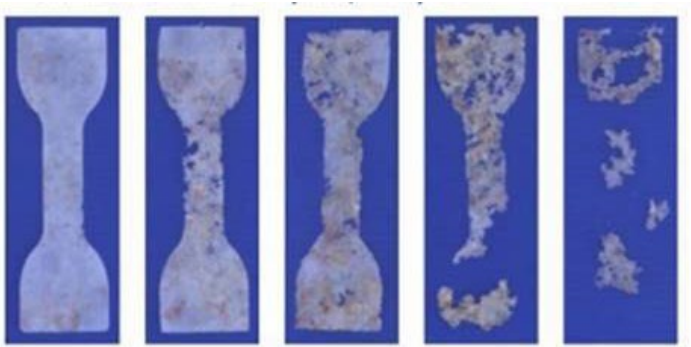
- Biodegradation = degradation catalysed by micro-organisms
- Biodegradation = mineralisation



Aerobic: $C_{POLYMER} + O_2 \rightarrow CO_2 + H_2O + C_{RESIDUE} + C_{BIOMASS}$

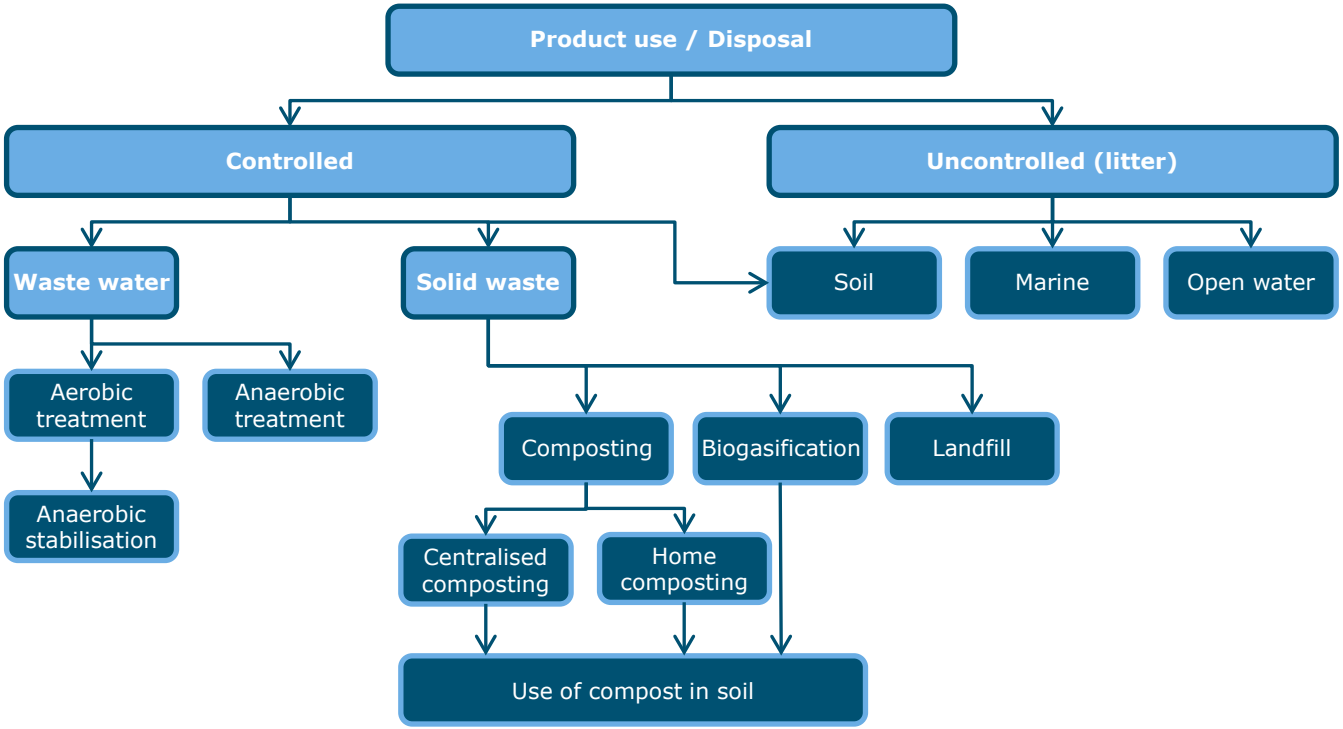
Anaerobic: $C_{POLYMER} \rightarrow CO_2 + CH_4 + H_2O + C_{RESIDUE} + C_{BIOMASS}$

Biodegradation depends on



- Chemistry of the polymer/product
- Activity of biological systems
  - the presence of micro-organisms
  - the availability of oxygen
  - the amount of available water
  - the temperature
  - the chemical environment (pH, electrolytes, etc.)

End-of-life: environmental niches

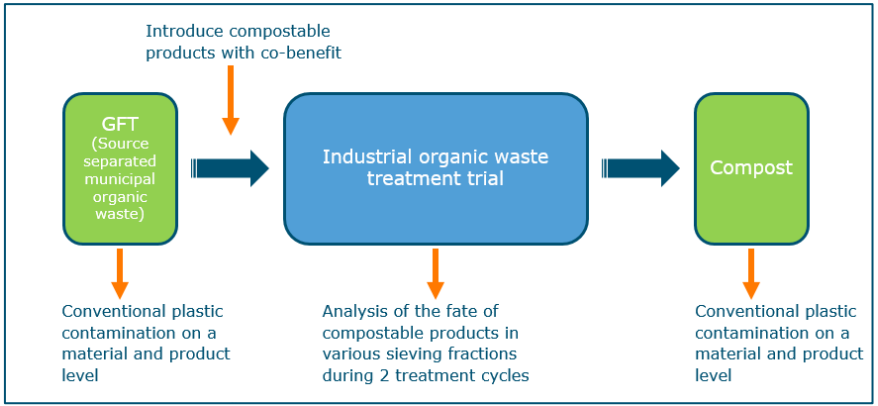


Biodegradable products

- Important aspects in determining biodegradability
  - Mineralisation
  - Disintegration
  - Environmental safety
- Standards and certificates are important; criteria!
  - Good example EN13432
  - Measured on a product level

How does EN13432 relate to current practice?

- The fate of (compostable) packaging products current organic waste treatment systems
    - Study by WFBR together with Waste treatment sector and Holland Bioplastics, sponsored by the Dutch government (Ministry LNV)



Some findings; installation with 11 days cycle

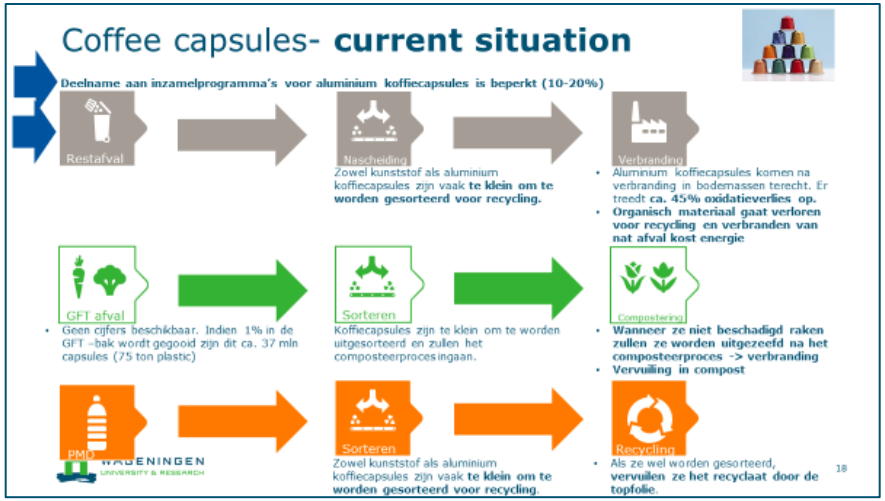
- ~ 20% of the reactor output is compost (<10mm)
- Residual fractions predominantly contain organic matter and some plastics
- These plastics fractions are predominantly non-compostable plastics
- Some plastics found in the compost fraction but no compostable products
- The 11 days cycle was sufficient for a PLA plant pot to completely disintegrate
- Certified compostable plastics behave like most organic waste

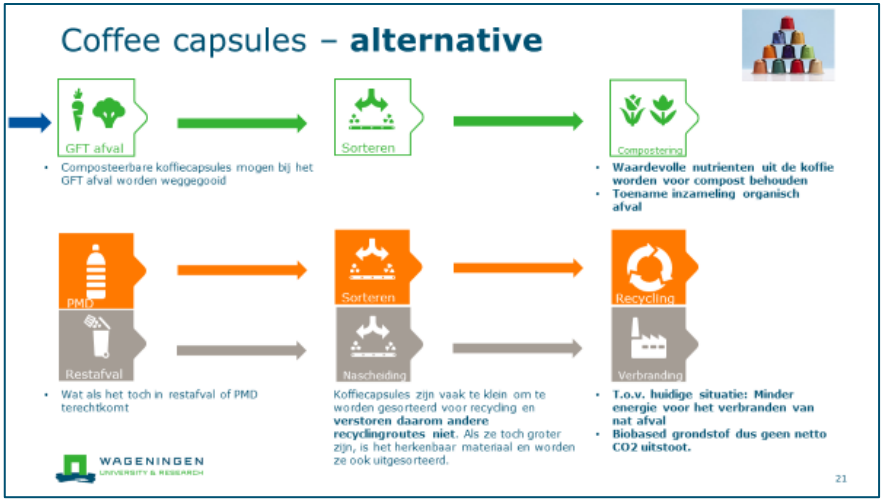
Compostable products

- Can have a positive effect on organic waste collection (biowaste collection bags)
- Can reduce contamination of compost (teabags, coffee capsules, plant pots, fruit stickers)
- Banning compostable products does not solve current issues with respect to plastic contamination in compost

Compostable products within waste management

- PPS project Circularity of bioplastics aims to find products that can help to solve current issues in current waste management systems





Soil biodegradability and product development

- Open environment; less controlled, slower and more difficult to validate via standardised biodegradation testing
- Typical applications in agriculture
    - Biodegradable mulch films; new standard (EN 17033)
    - Biodegradable tree protectors
    - Biodegradable plant plugs
- Balancing life time and functional properties with soil biodegradability

Biodegradable turf netting

Polypropylene based netting is typically used in industrial grass growing processes

Assist grass growth

Maintains turf rigidity

Plastic netting remains in soil

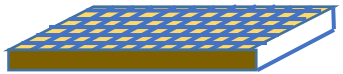
Project goal: development of netting that maintains functionality during lifetime and biodegrades after final application

Product development targets

BioPBS™ Compound & Net production

Transport and storage: <6 months

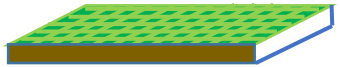
Net placement on open turf field



- No biodegradation
- Preservation of mechanical integrity

4 months

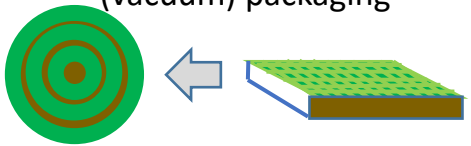
Net immersion in grass turf soil due to grass growth



- No biodegradation
- Preservation of mechanical integrity

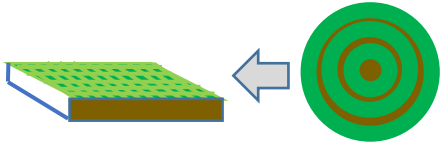
8 months

Turf Harvest + (vacuum) packaging



Grass turf and netting needs to be able to withstand harvest load

Grass turf placement



- No biodegradation
- Preservation of mechanical integrity

2-12 months

Grass turf use

- Biodegradation of netting can commence
- Loss of mechanical integrity allowed
- No release of harmful components

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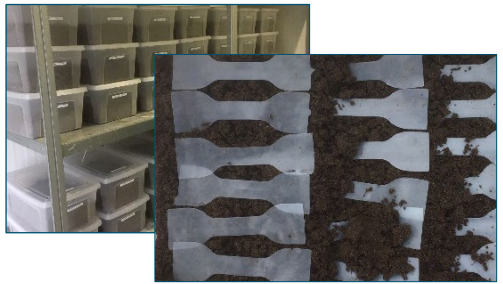
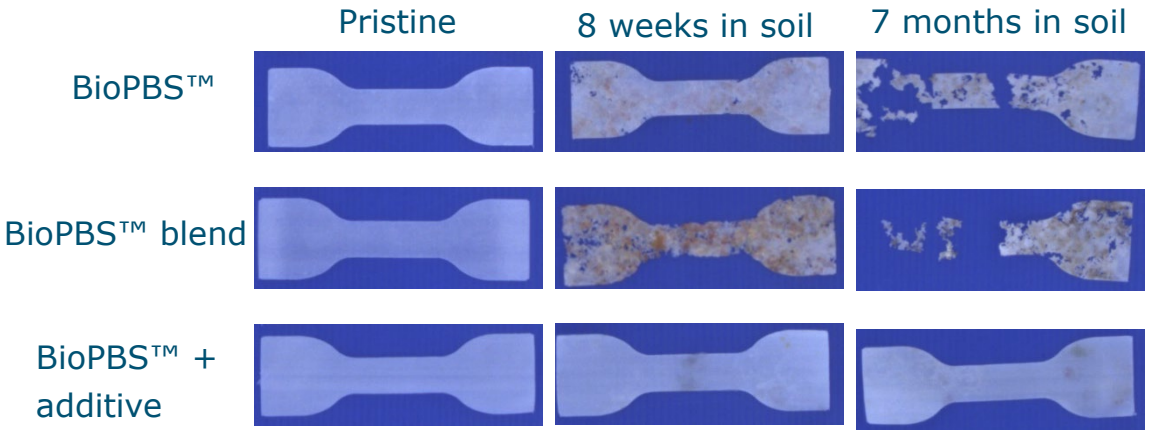
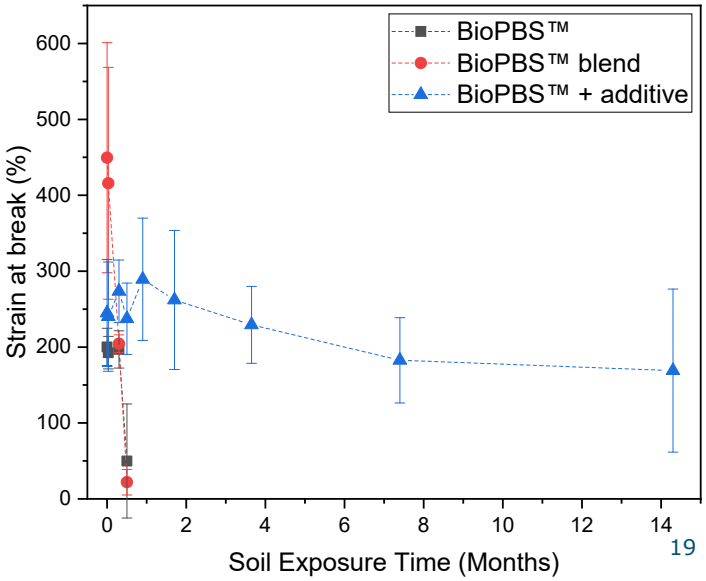
Biodegradation assessment in lab

- Disintegration trials in controlled lab environment
- 25°C, optimal moisture content, inoculated







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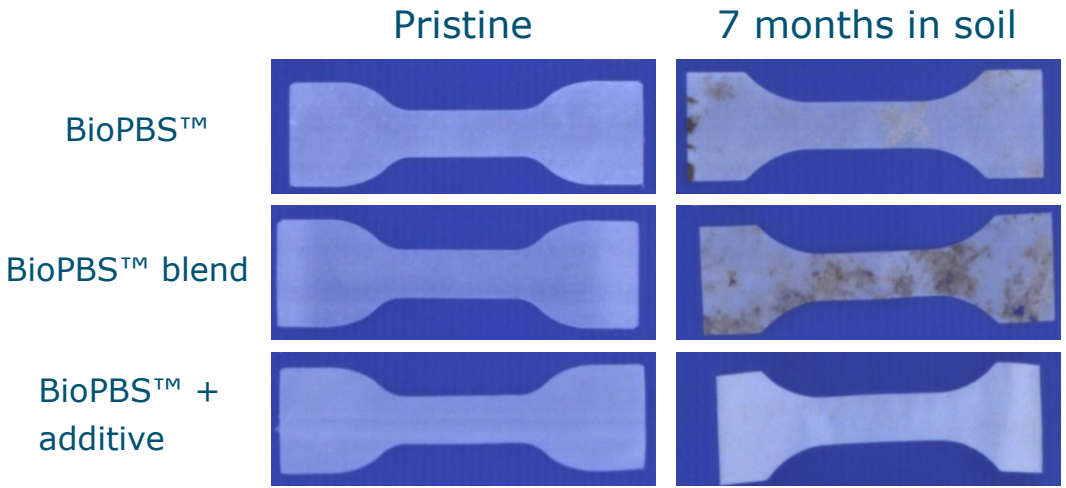
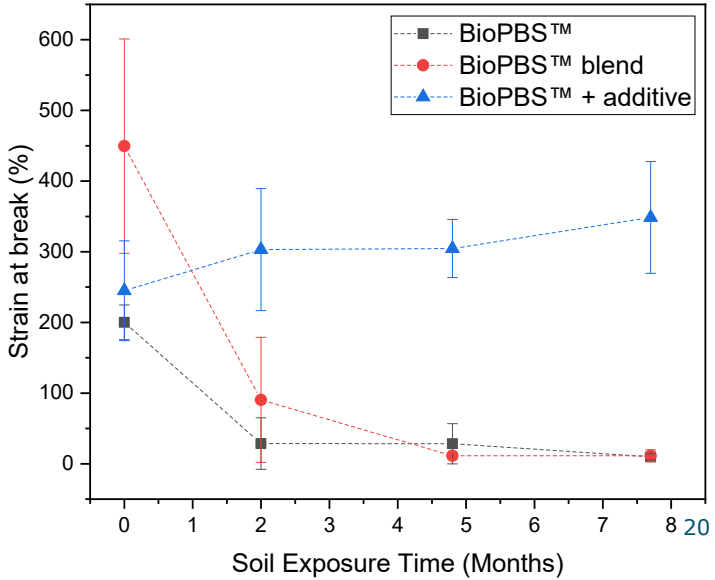
Biodegradation assessment on field

- Disintegration trials in field environment
- Samples placed in December
- Lower biodegradation rate compared to lab
- Same disintegration trends as in lab





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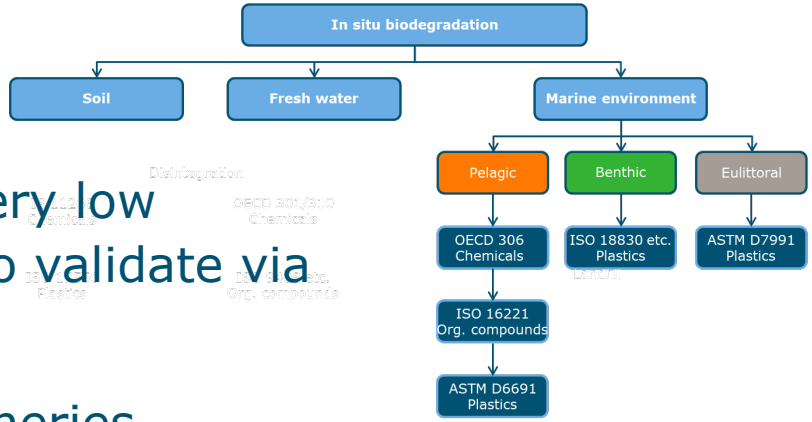
Conclusions and next steps

- Biodegradation rate of BioPBS™ can be both enhanced and delayed.
- Additives are required to postpone degradation onset for grass turf netting.
- Upcoming project on plastics in agriculture developing products and guidelines for:
    - Recycling of plastics (issues; soil and chemical contamination)
    - Use of compostable plastics (waste management in greenhouse)
    - Use of soil degradable plastics (tuning biodegradation rate)

Marine degradable plastics



- Open environment; uncontrolled, very low biodegradation rate that is difficult to validate via lab scale testing
- Can be useful for plastics used in fisheries
- Not a solution for the plastic soup
- Marine degradable products can cause issues during the time needed for biodegradation times

Marine litter and the SUP directive

- The objective of the SUP (single use plastics) is to tackle the issue of marine littering
- Based on 10 most found articles on the beach
- Ban on various plastic items: e.g. balloon sticks, straws, cotton bud sticks, cutlery, plates, ...
- Ban on oxo-degradable plastics

SUP: Biodegradable plastics vs paper products

- No exemption for biodegradable plastics, review in 2027
- No exemption for (plastic) coated paper, but allowed are:
    - Inks, varnishes, adhesives, additives (not considered plastics)
- Biodegradation standards have requirements for all components that are present in a product (>1%) and have additional toxicity requirements (e.g. heavy metals)
- Requirements for packaging components in paper and board products and toxicity requirements missing in the SUP directive.

Conclusions: Useful biodegrable products

- Biodegradability should match with disposal environment
- Need careful design and biodegradation need to be evaluated on a product level
- Powerful option to prevent plastic pollution when used with care
- No solution for issues like littering and plastic soup
- Studies are ongoing and needed to define “useful”
- From regulation perspective a difficult topic

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Important considerations: Claims

- The term BIODEGRADABLE has no meaning unless it defines the :
    - Disposal environment
    - Time/rate of degradation
    - Extent of degradation

CAUTION

- According to law in the State of California and U.S. Federal Trade Commission (FTC) green guides (a.o.): ‘Unqualified use of the term “biodegradable” is wrong, misleading, and deceptive’

Important considerations: Environmental fate

- A biodegradable food product
  - Does not undergo biodegradation in the freezer
  - Does this change the classification ‘ biodegradable” ?

Important considerations; Environmental impact

Biodegradable

but....

...it does not disappear instantaneously

...it can still be a considerable nuisance

Thank you

Research team:

- Maarten van der Zee
- Wouter Post
- Gerald Schennink
- Ingeborg Smeding

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