



Compostable plastics

Dr. Katharina Schlegel

24/06/2019

 **BASF**
We create chemistry



Introduction

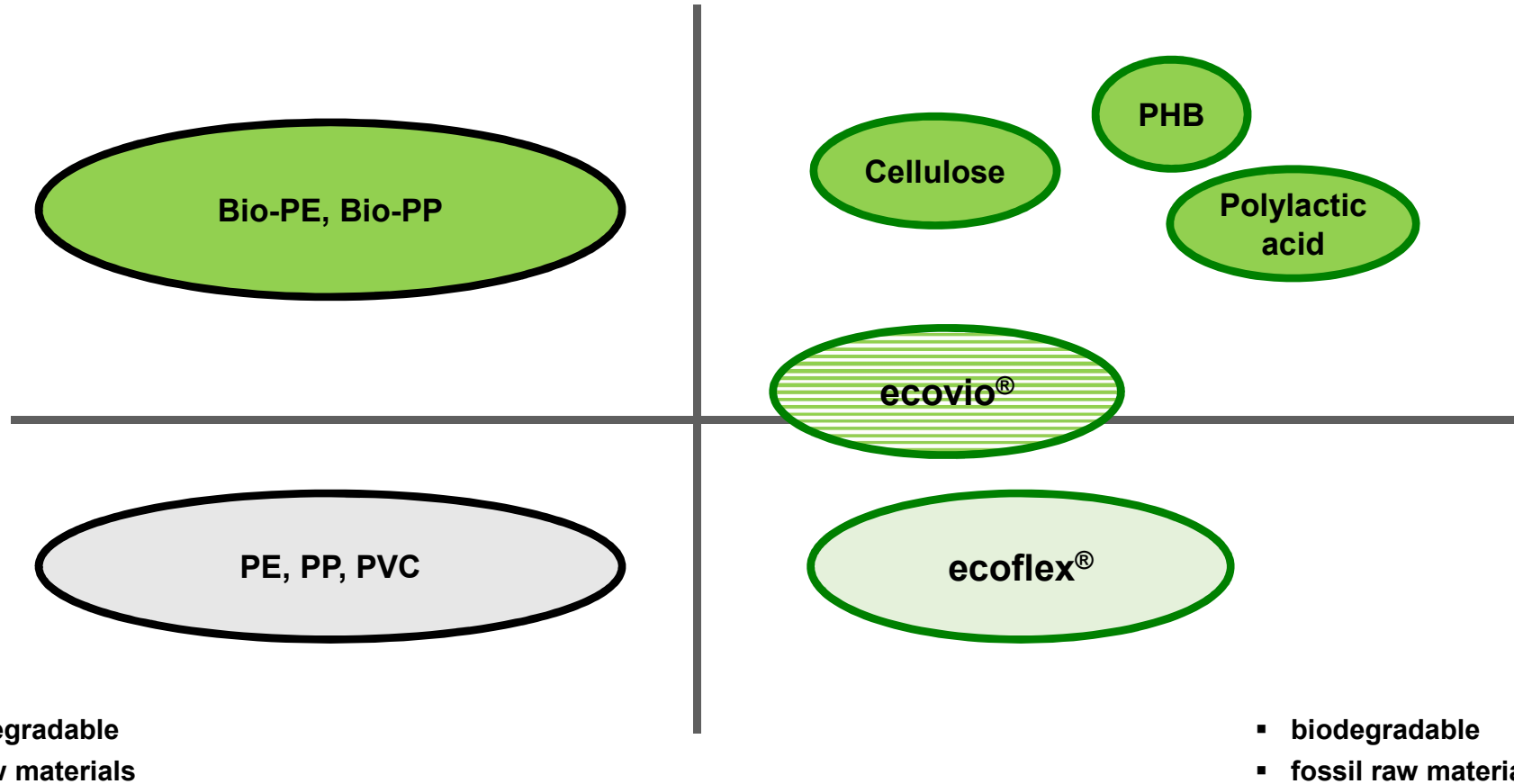
- What are biodegradable polymers?
- Biodegradable polymers in a circular economy



Biopolymer: Definition of bio based and biodegradable polymers

- not biodegradable
- renewable raw materials

- biodegradable
- renewable raw materials



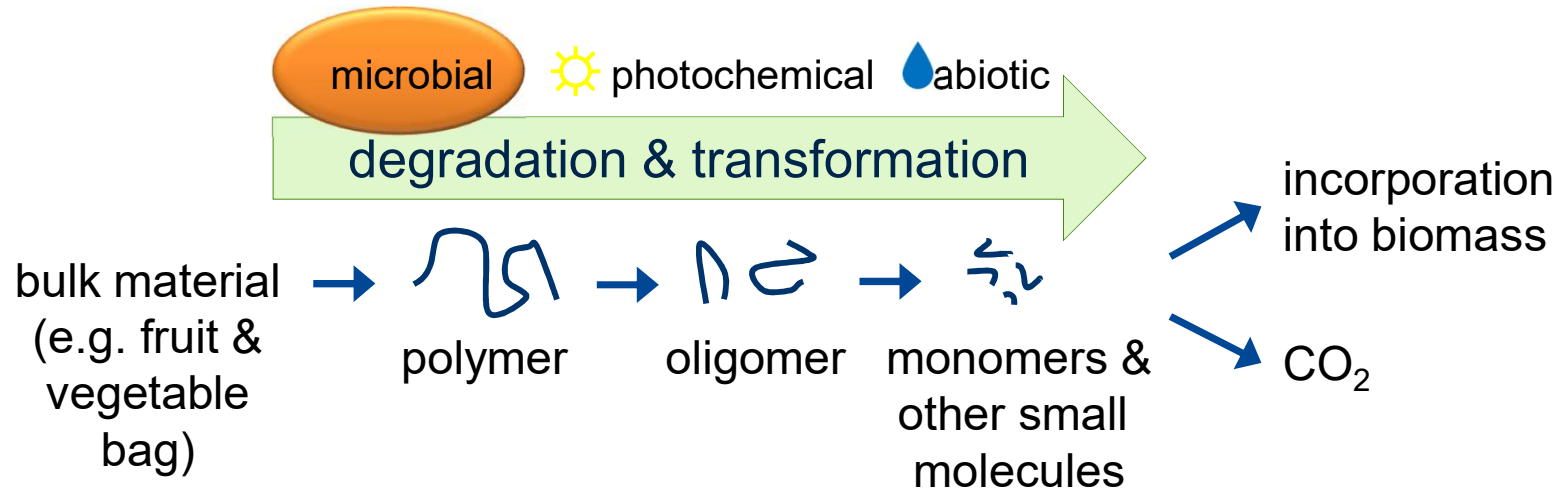
- not biodegradable
- fossil raw materials

- biodegradable
- fossil raw materials

→ Biodegradable polymers can be bio based on fossil or renewable raw materials.

Let's talk about end of life

Basics



Legend: Microbial: bacteria and fungi Abiotic: e. g temperature, water Photochemical: UV light
Biomass: mass of living biological organisms

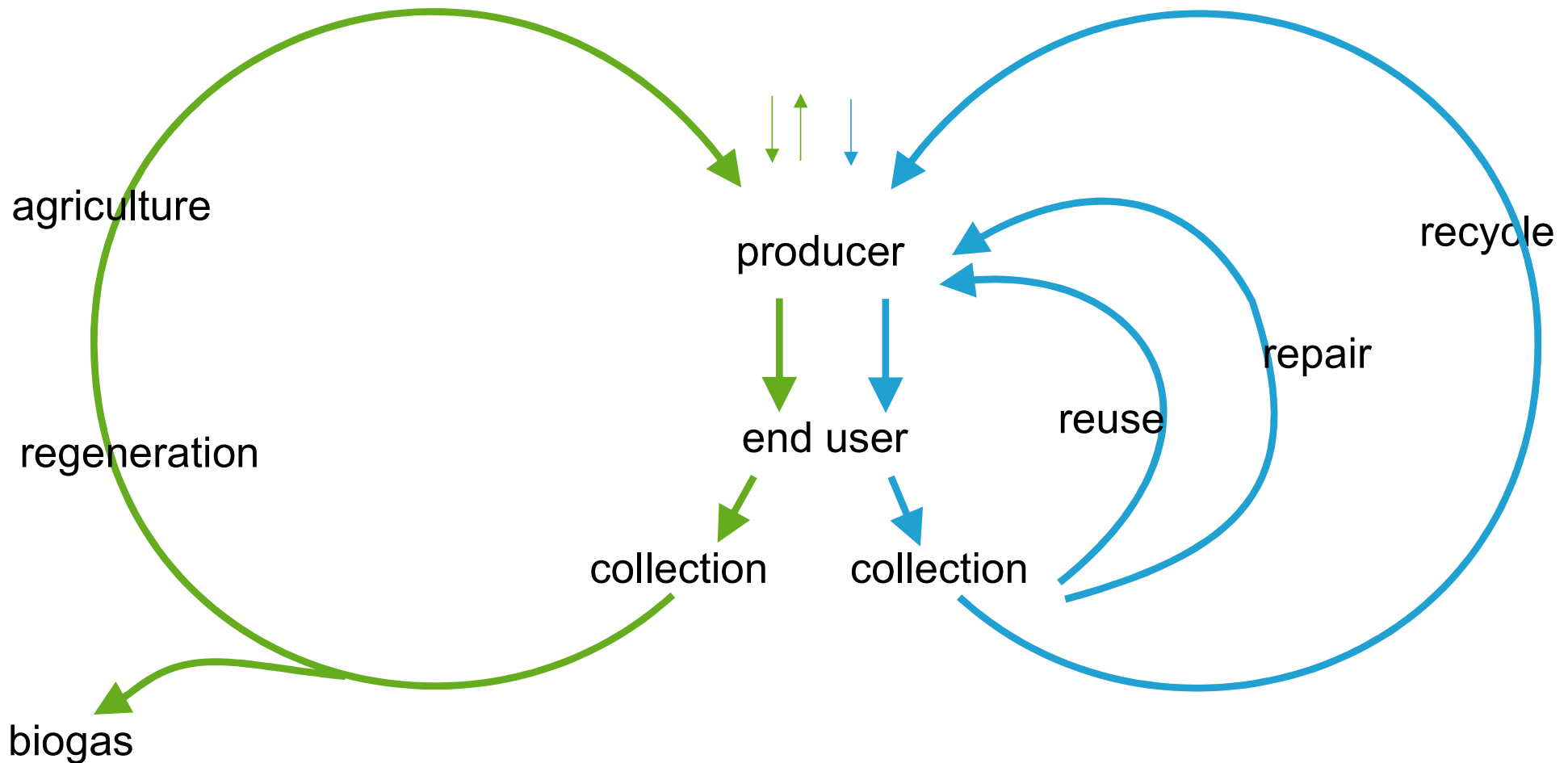
- Biodegradation by natural organisms to CO₂ and microbial biomass
- CO₂ is indicator for biodegradability measurement
- 10% of carbon is estimated to go into biomass, 90% of carbon goes in CO₂¹

¹ OWSnv (2016) EXPERT STATEMENT (BIO)DEGRADABLE MULCHING FILMS. (European Bioplastics e.V., <http://www.european-bioplastics.org/news/publications/>).

Rethinking Plastics: New plastics economy aligns with circular economy principles

Biological circle

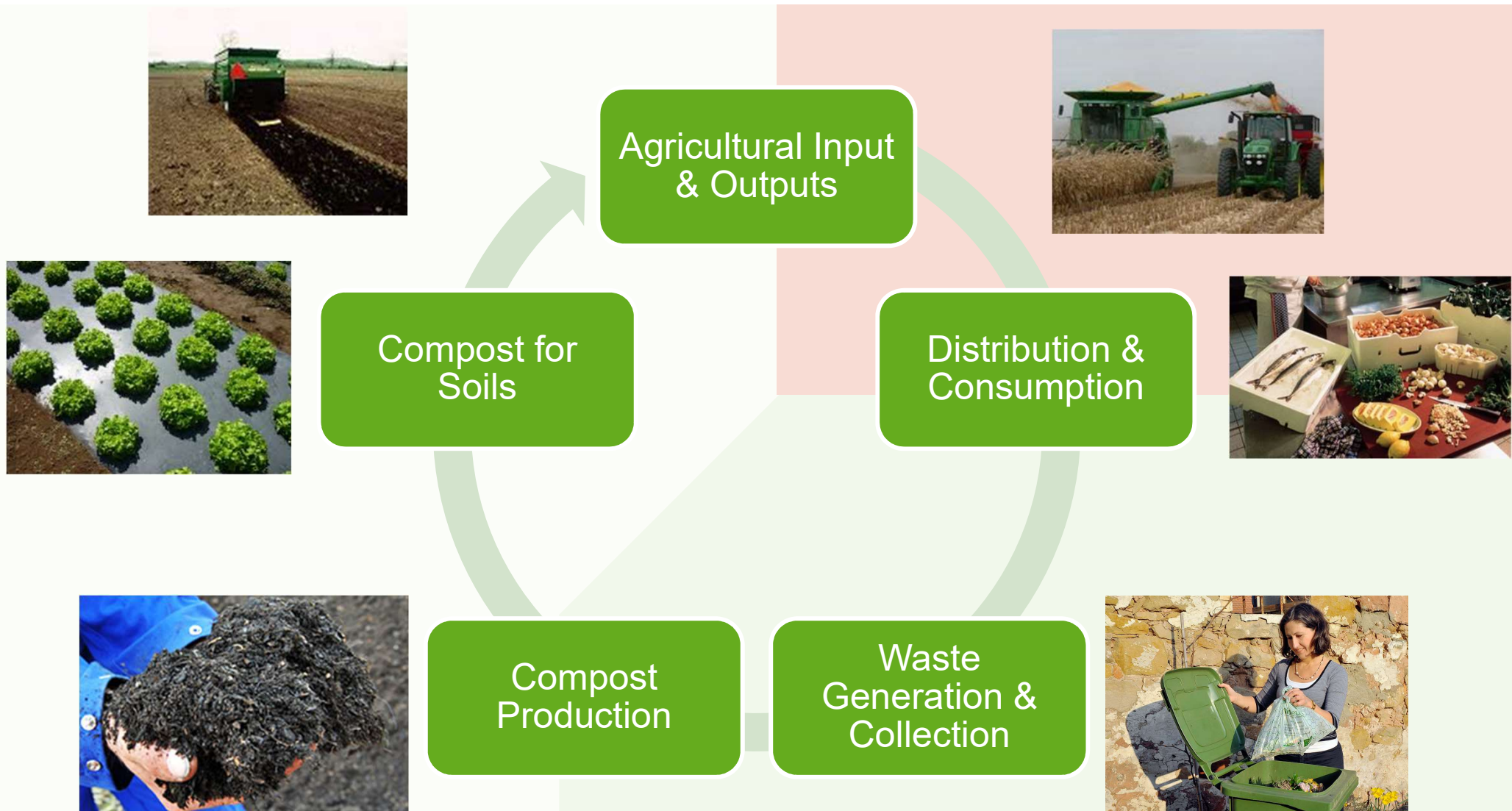
Technical circle



Simplified Graphic based on:

Source: Ellen MacArthur Foundation, SUN, and McKinsey Center for Business and Environment; Drawing from Braungart & McDonough, Cradle to Cradle (C2C).

Value proposition of biodegradable polymers: closing the food value chain





Sustainability

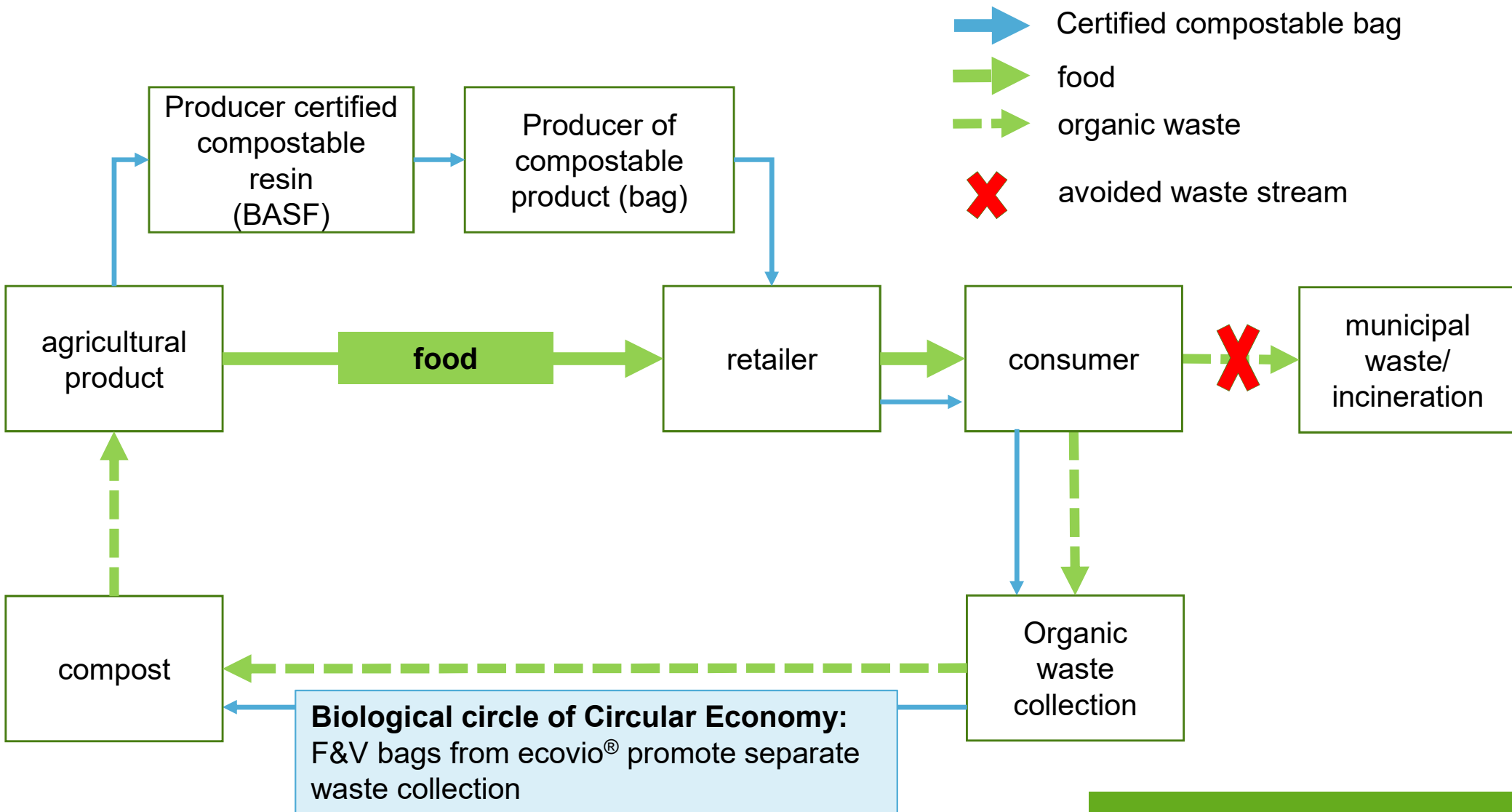
Example:

Improving food waste collection

How BASF solutions contribute to closing the nutrient loop towards a Circular Economy



Closing the loop: ecovio[®] fruit & vegetable (F&V) bag



Comparative Life Cycle Assessment

Take-away messages



► This study shows that the key benefits of **ecovio®** do not lie in material production, but instead in material properties, which enable the **product** use that **promotes the circular economy**.

► Provided that the consumer **re-uses** ecovio® Fruit & Vegetable bags to improve the **food waste collection** and recovery, compostable bags display a **better overall environmental performance** compared to traditional paper and PE bags.

How do compostable polymers behave within the plastic recycling of conventional plastics

■ Several studies on behavior performed so far

- ▶ Due to separation of polymers via density and NIR + low occurrence of compostable plastics **no negative impact** expected

(e.g. Impact of Bio-Based Plastics on Current Recycling of Plastics, Luc Alaerts, Michael Augustinus and Karel Van Acker, KU Leuven)

Further information: <https://www.european-bioplastics.org/new-studies-confirm-biodegradable-plastics-boost-organic-recycling-and-improve-mechanical-recycling/>



Adobe Acrobat
Document

03



Biodegradability



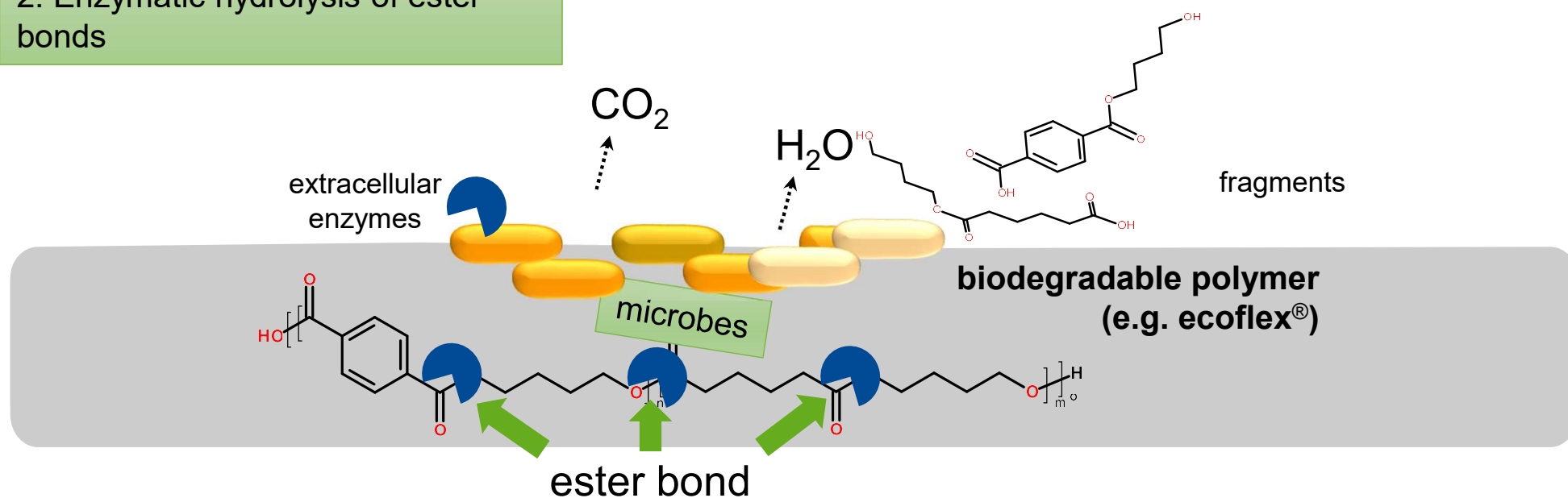
Process of biodegradation of biodegradable polyesters

1. Microbial colonization of the surface and excretion of enzymes (e.g. cutinases)

4. Uptake and metabolization by microbes

2. Enzymatic hydrolysis of ester bonds

3. Release of short fragments



Legend: Hydrolysis: Cleavage of molecules in presence of water

Compost

EN13432



Mineralization

- 90% converted to CO₂ at 58°C in mature compost in 6 month

Disintegration

- Less then 10% of the material is bigger than 2 mm particle size

Control of constituents

- regulated metals, regulated substances

Field behavior

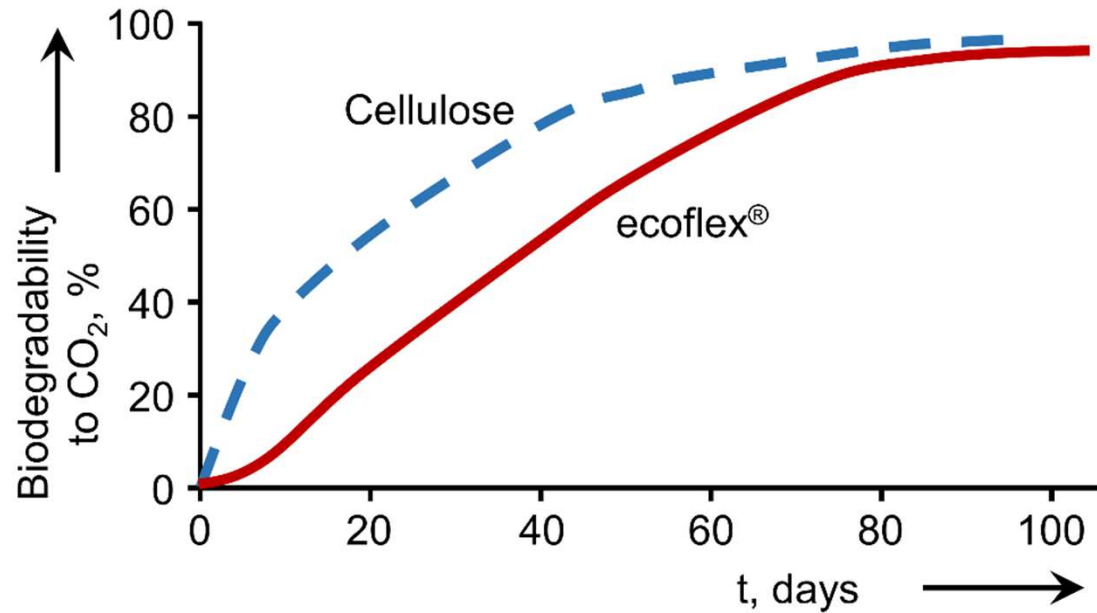
- No negative effect on composting process

Ecotoxicology

- No harm for plant growth

Biodegradation of ecoflex[®] in compost

Mineralisation



- ecoflex[®] is fully biodegraded after 90 days
- Comparable biodegradability to cellulose

How does the disintegration look like in field tests?

- Under industrial composting conditions– high temperature, defined water, oxygen and nutrient supply – the degradation takes only a few weeks



Degerdation of a compostable film in the first week...

... in the second week...

... in the forth week



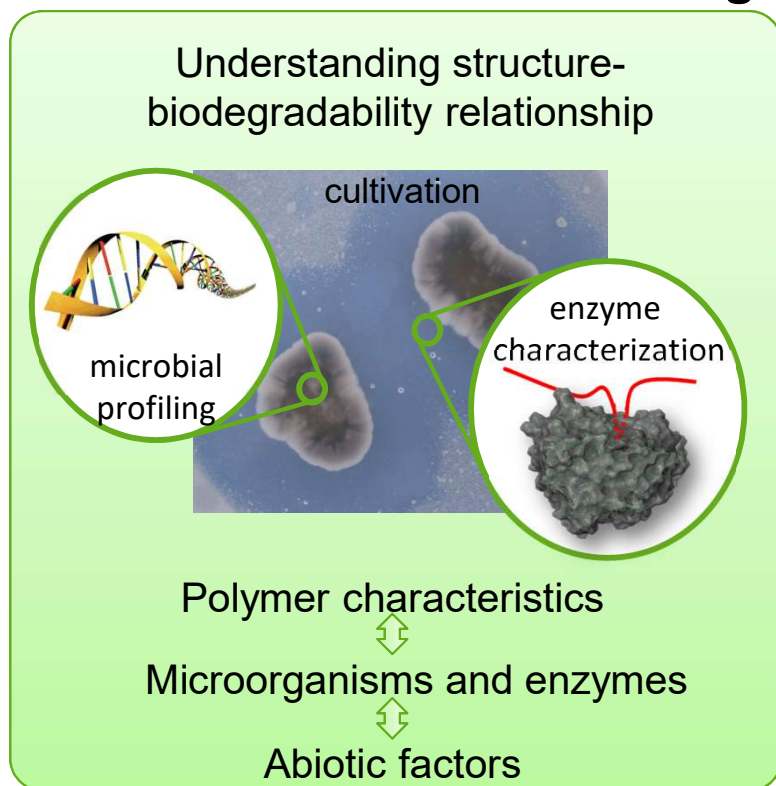
Dia 1

Quelle: Müll & Abfall, 2013/05, Georg Kosak

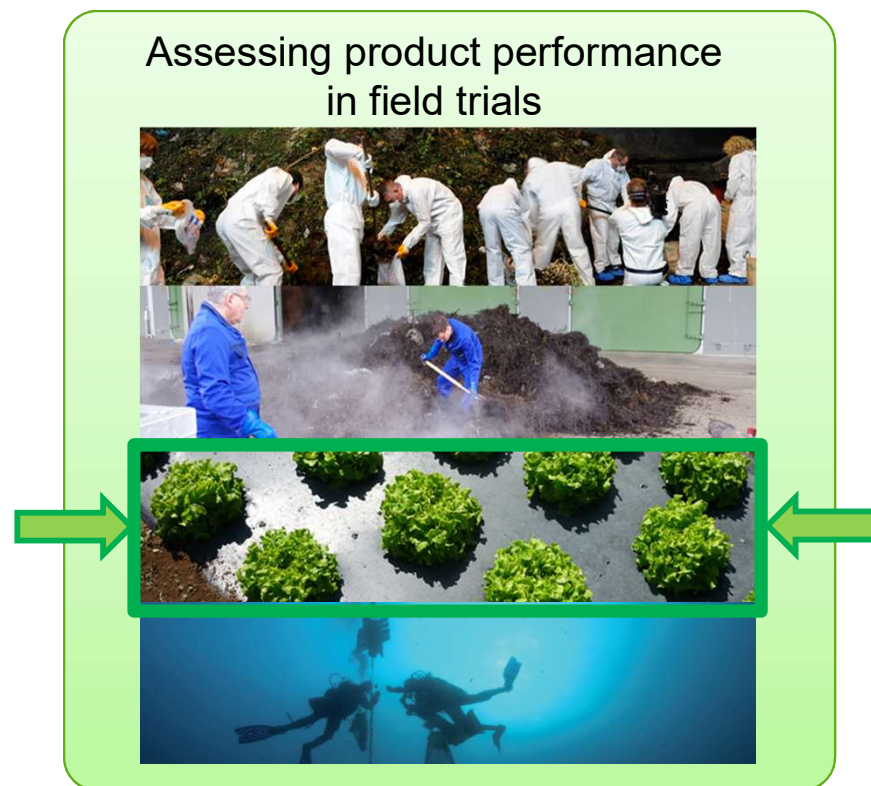
Independent certification according to EN13432 secures full industrial compostability!

Basic understanding and field evaluation are both needed to understand biodegradability

Fundamental understanding



Field evaluation



Cooperation ETH Zürich and BASF on biodegradation in soil

Rebekka Baumgartner¹, Michael T. Zumstein¹, Taylor Nelson¹, Melissa Maurer-Jones¹, Hans-Peter Kohler², Kristopher McNeill¹, Michael Sander¹

Glauco Battagliarin³, Katharina Schlegel³, Carsten Sinkel³, Ulf Küper³

1. Swiss Federal Institute of Technology (ETH), Department of Environmental Systems Science, **Environmental Chemistry**, Zurich, Switzerland
2. Swiss Federal Institute of Aquatic Science and Technology (Eawag), **Environmental Biochemistry**, Dübendorf, Switzerland
3. Advanced Materials & Systems Research – Biopolymers, BASF, Ludwigshafen, Germany

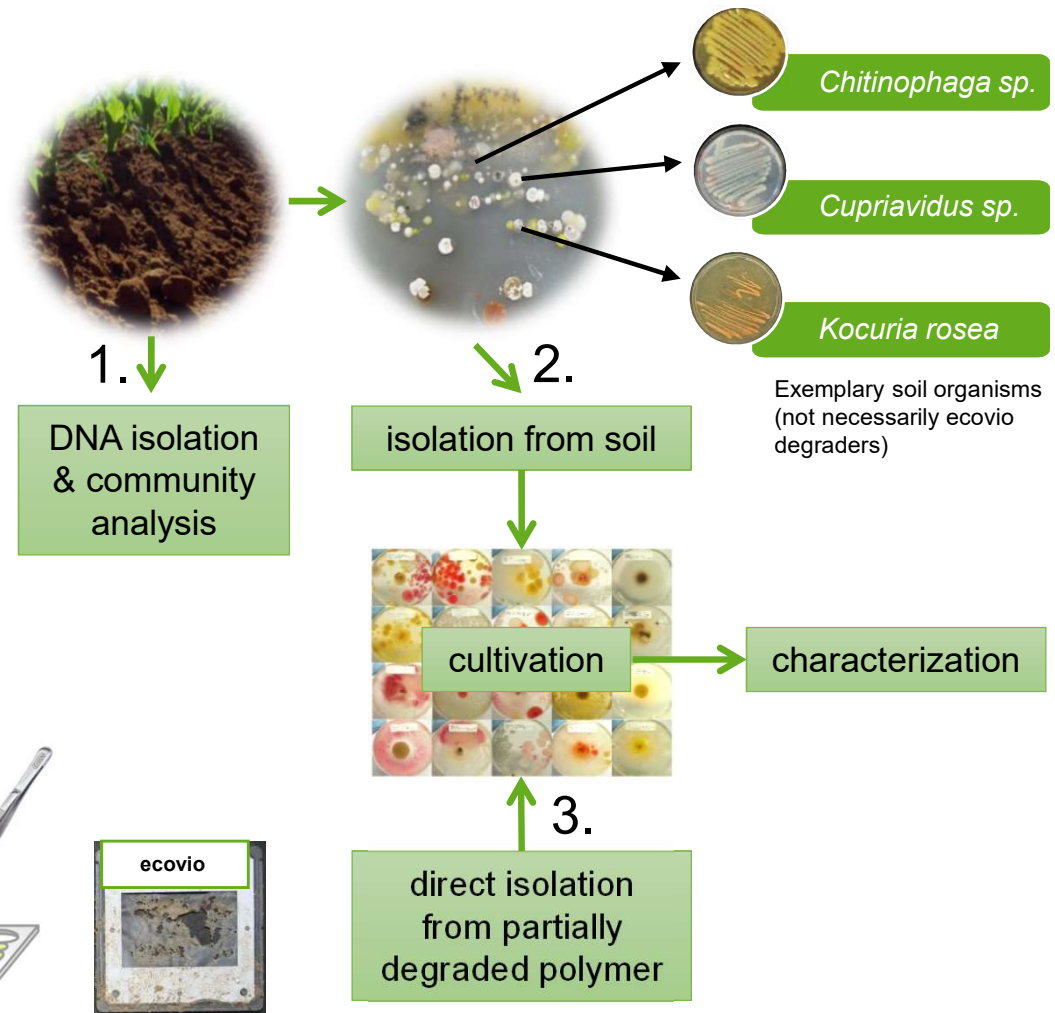
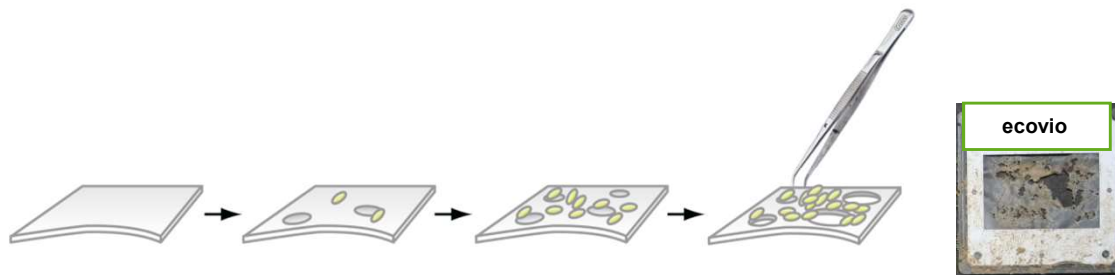
→ Landmarking cooperation for sustainable chemistry

Microbial characterization

Microflora is a dominating factor

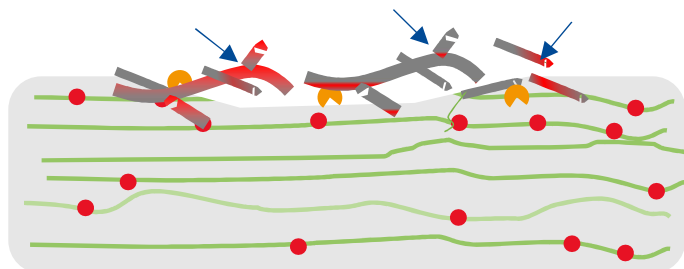
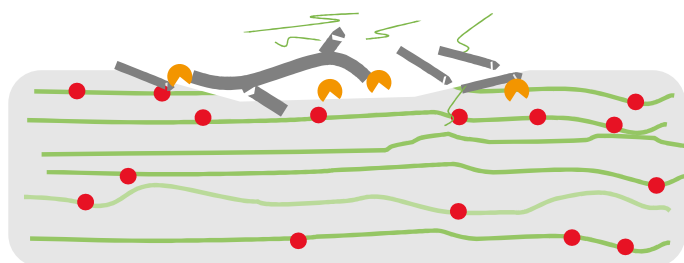
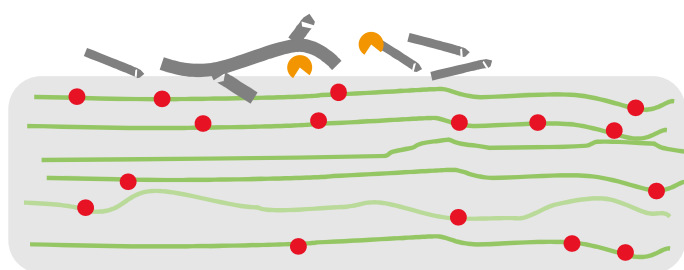
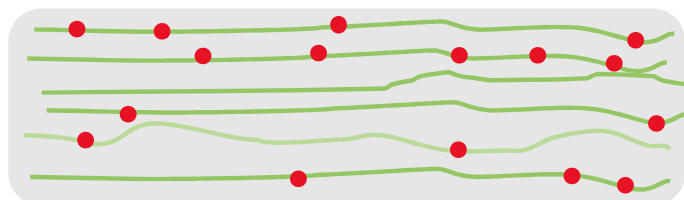
➔ Who is eating our product?

- Isolation of microorganisms directly from partial degraded polymer films (➔ more than 400 isolates, esp. fungi)
- ➔ Fungi have been identified to be the most potent but not exclusively degrading microorganisms in soil



Microbial metabolism

How to show the biomass formation?



Results published!

Zumstein et al., Science Advances, **Biodegradation of synthetic polymers in soils: Tracking carbon into CO₂ and microbial biomass**, 2018

1. Microbes colonize the surface and excrete enzymes (e.g. cutinases)

2. + 3. Enzymes break down the polymer and release of water-soluble fragments

4. Microbes digest the fragments and grow
→ **Formation of biomass from labelled carbon**

Labelled carbon



Polymer with labelled carbon



Fungal hypha and bacteria



Water soluble fragment with labelled carbon



Enzyme



Fungal hypha and bacteria with labelled biomass

04

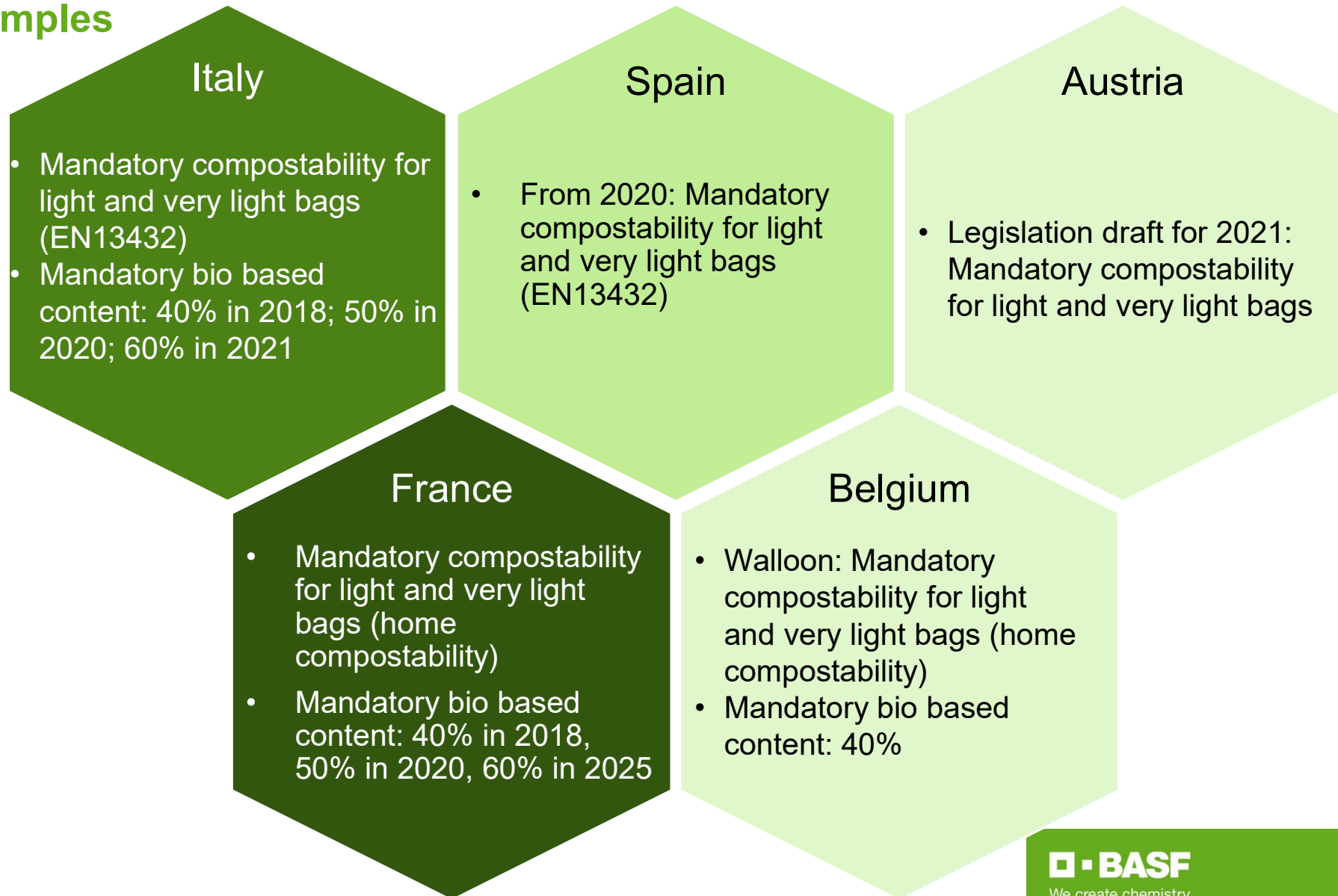


Conclusion



European legislation on certified compostable bags

Examples





We create chemistry