BIOPLASTICS – FACTS AND MYTHS

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Head of Department Bio-Based Plastics

5th Latin American Congress on
Biorefineries
From laboratory to industrial practice
January 7-9, 2019 - Concepción, Chile

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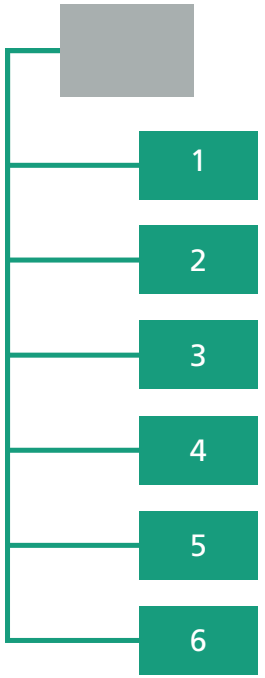
Content

- Plastics today
- Bioplastics – an overview
- Biodegradability
- Bioplastics – demystified



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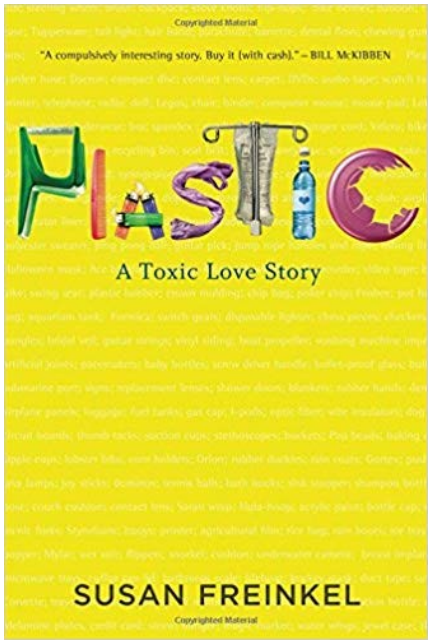
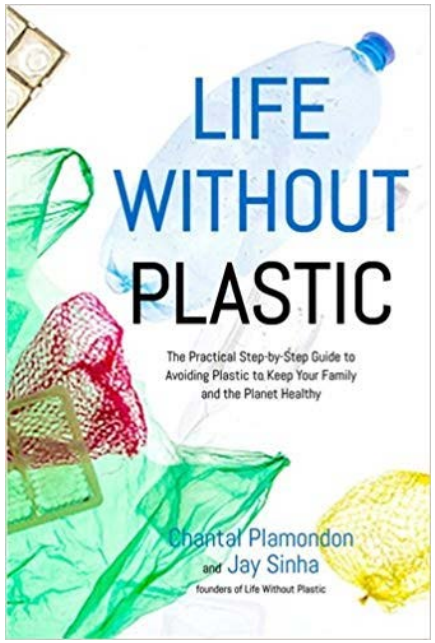
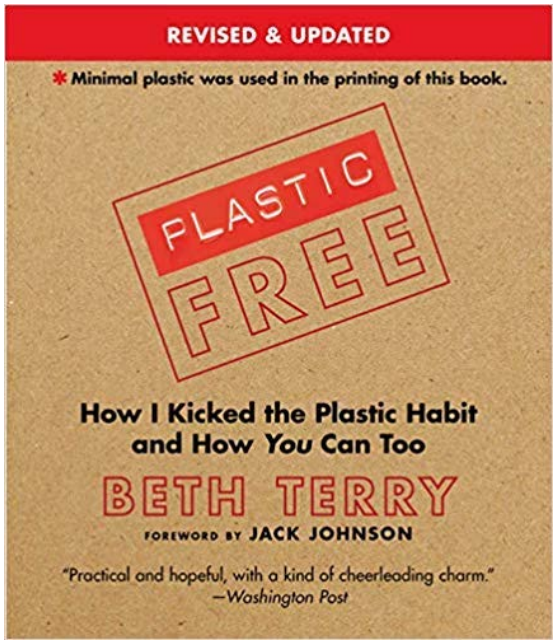
Plastics today







- First three suggestions from Amazon searching books with 'plastic'
  (2 January 2019; excluding 'plastic surgery' field)

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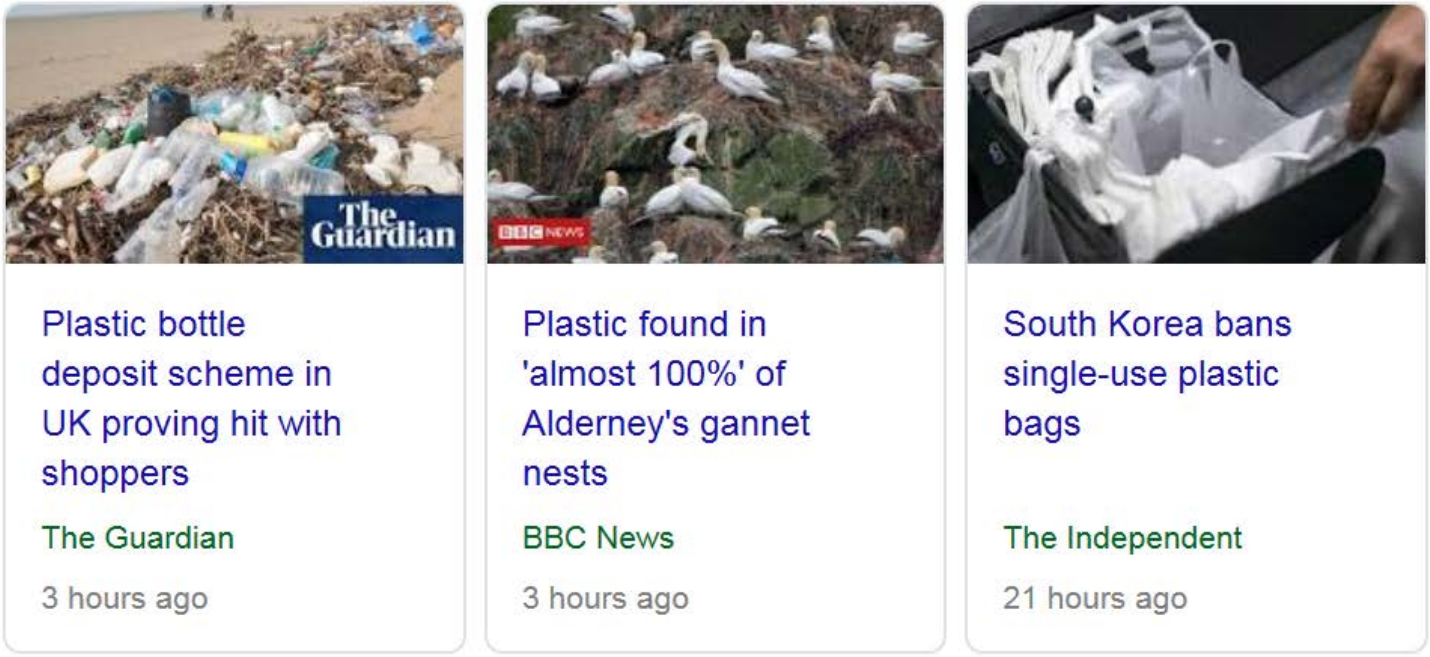
Plastics today



- First three top stories from Google searching for 'plastic'
  (2 January 2019; search language English)

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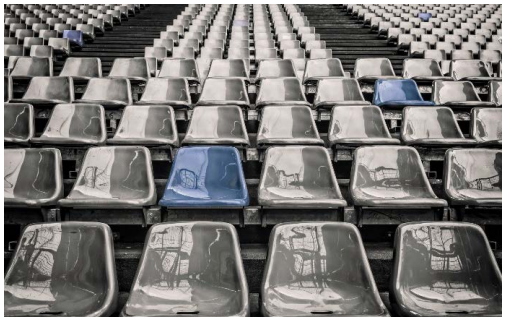
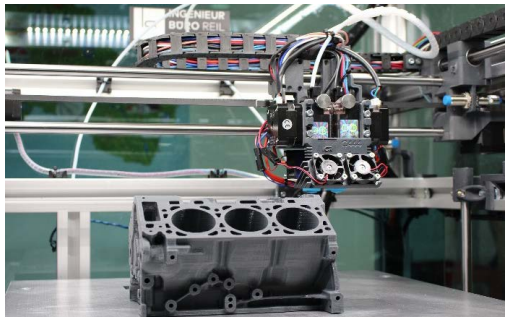
Plastics today

- Plastics or plastics products
  - are tremendously versatile
  - can be used for cheap mass production
  - seal and insulate our houses
  - help building lightweight vehicles
  - protect people and food
  - can easily be shaped
  - save energy and resources
  - or simply make fun






Source: Pixabay

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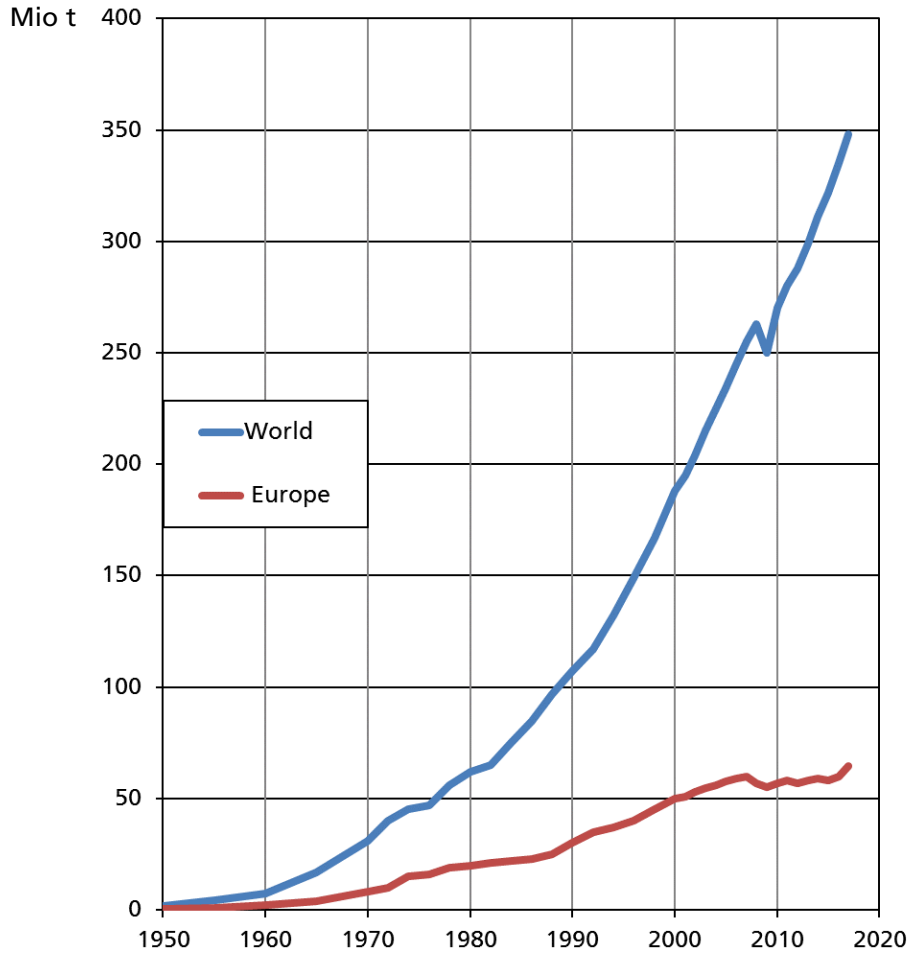
Plastics market

- Relating to production volume, plastics are a main product of chemistry industry
- Main application fields
  - Packaging (~30-40 %)
  - Building and construction (~20 %)
  - Automotive (~10 %)
  - Electro/Electronics (~6 %)
  - Agriculture (~5 %)



Own representation based on figures of Plastics Europe

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Solve the plastics problem

Source: Pixabay

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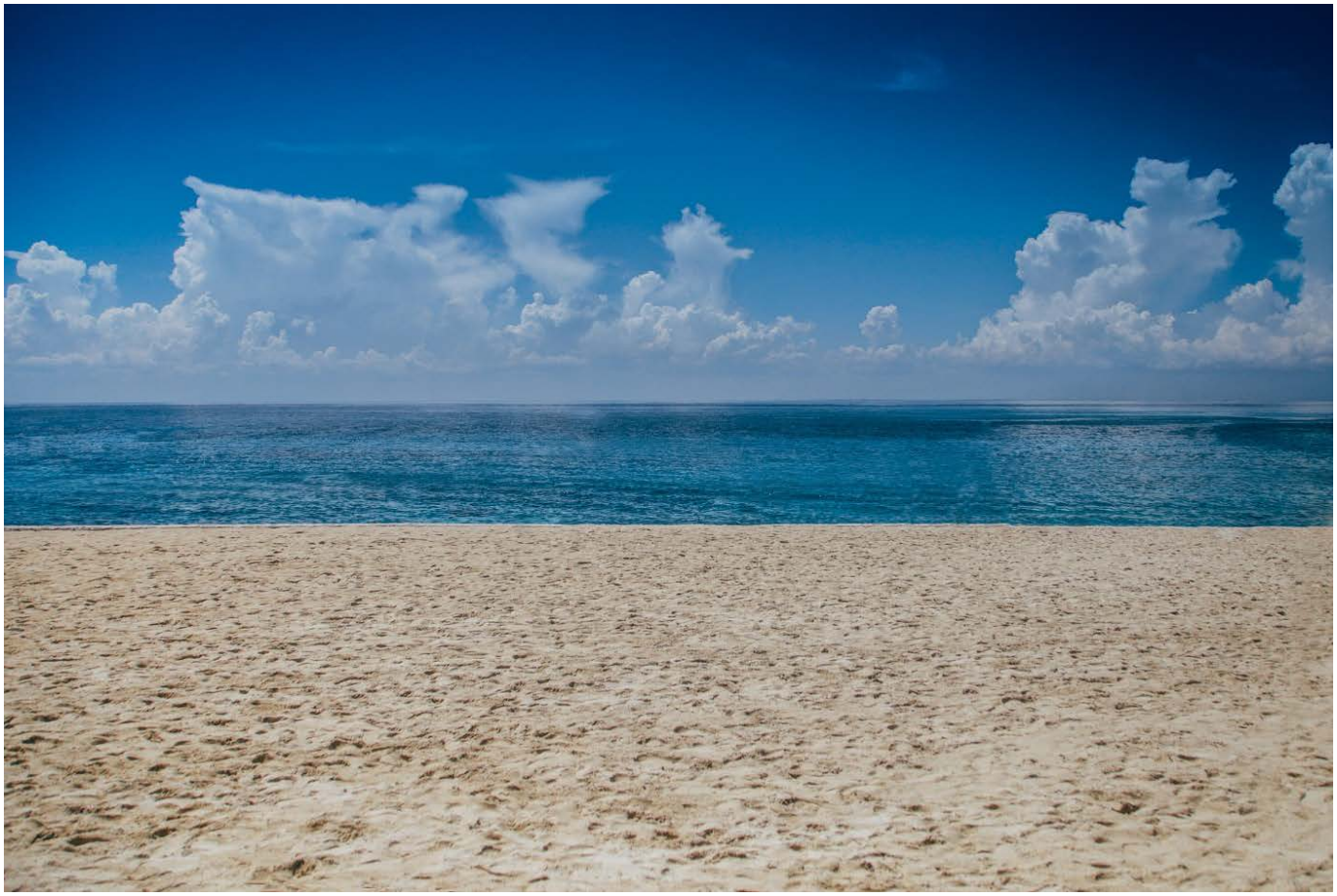
Use bioplastics! ???



Source: Pixabay

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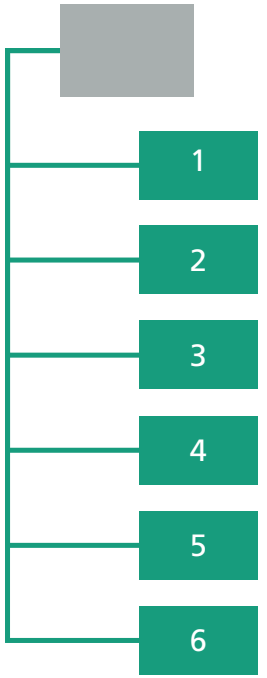

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Bioplastics – Definition

Bioplastics are bio-based or biodegradable or both[1]

Two criteria have to be distinguished:

- Plastics based on renewable resources (= Bio-based Plastics) **Origin**
- Biodegradable plastics **Property**

[1] Definition according to European Bioplastics and U.S. Plastics Industry Association

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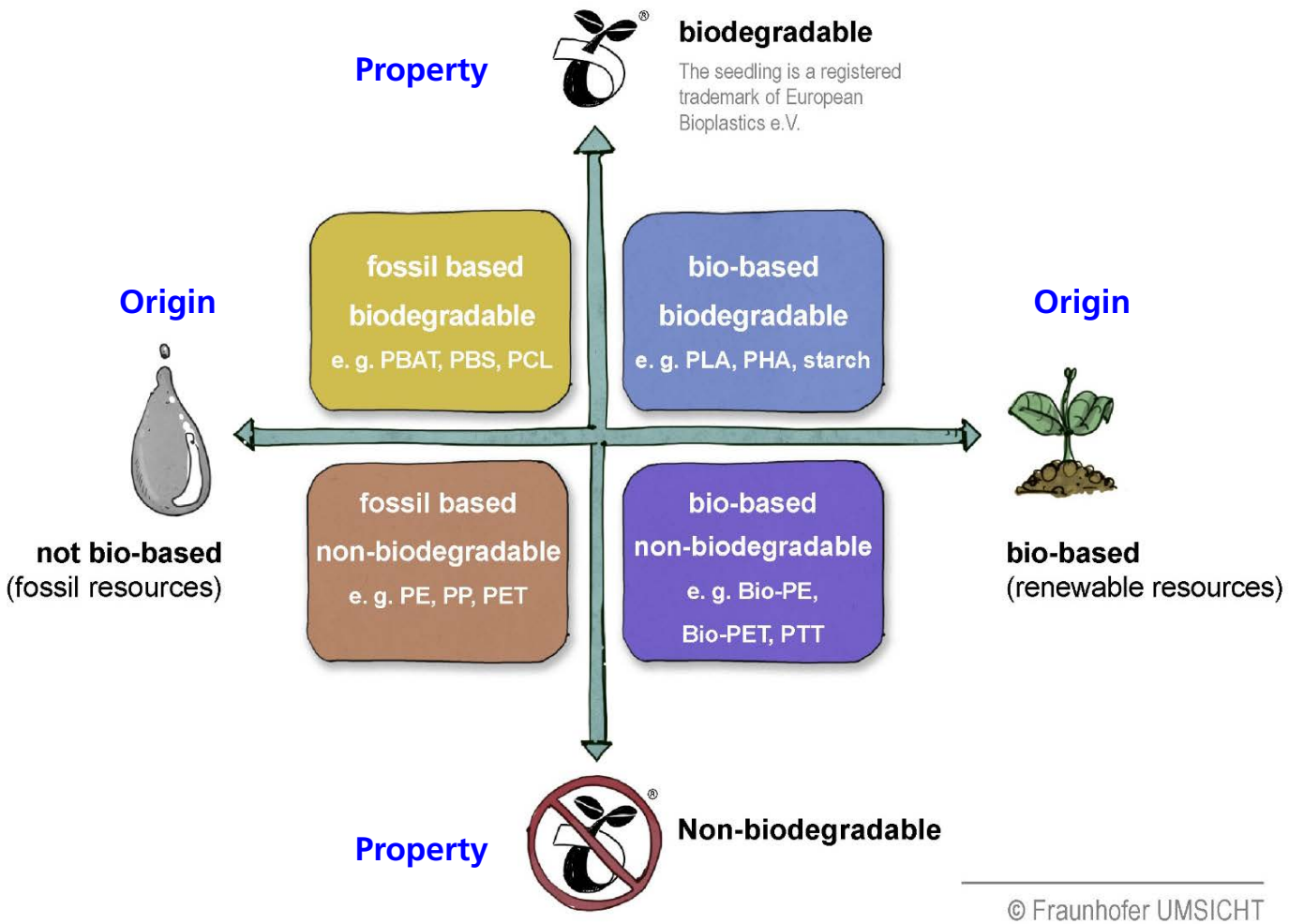
Bioplastics – Origin and Biodegradability



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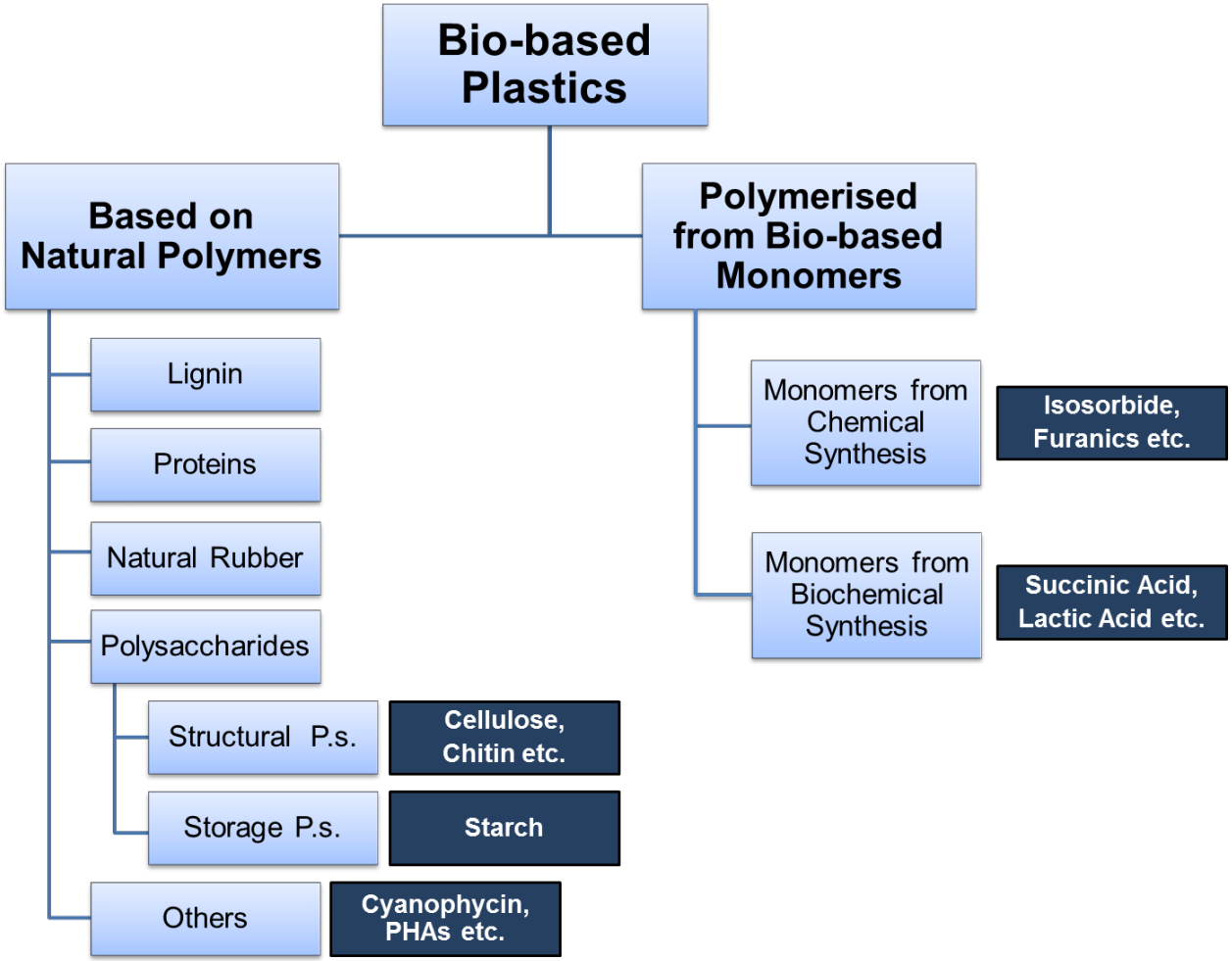
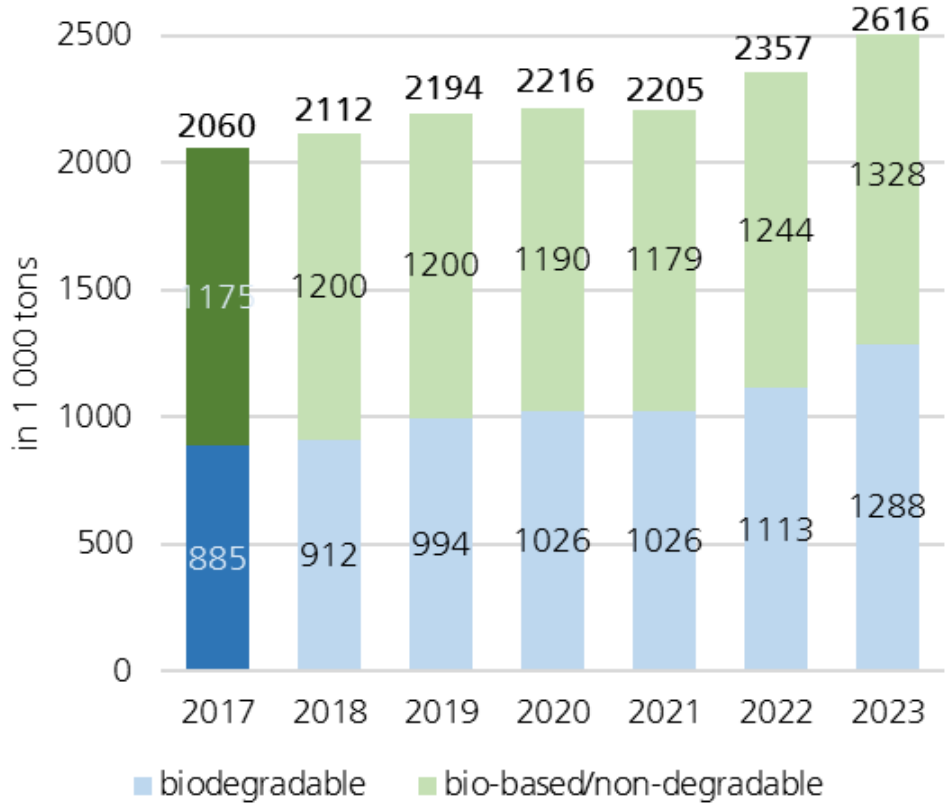
Typology



Worldwide production capacity of bioplastics

- Worldwide production capacity of bioplastics today:
  approx. 2 Mtons/year
- 0,6 % of the world plastics production



Own representation based on figures of European Bioplastics

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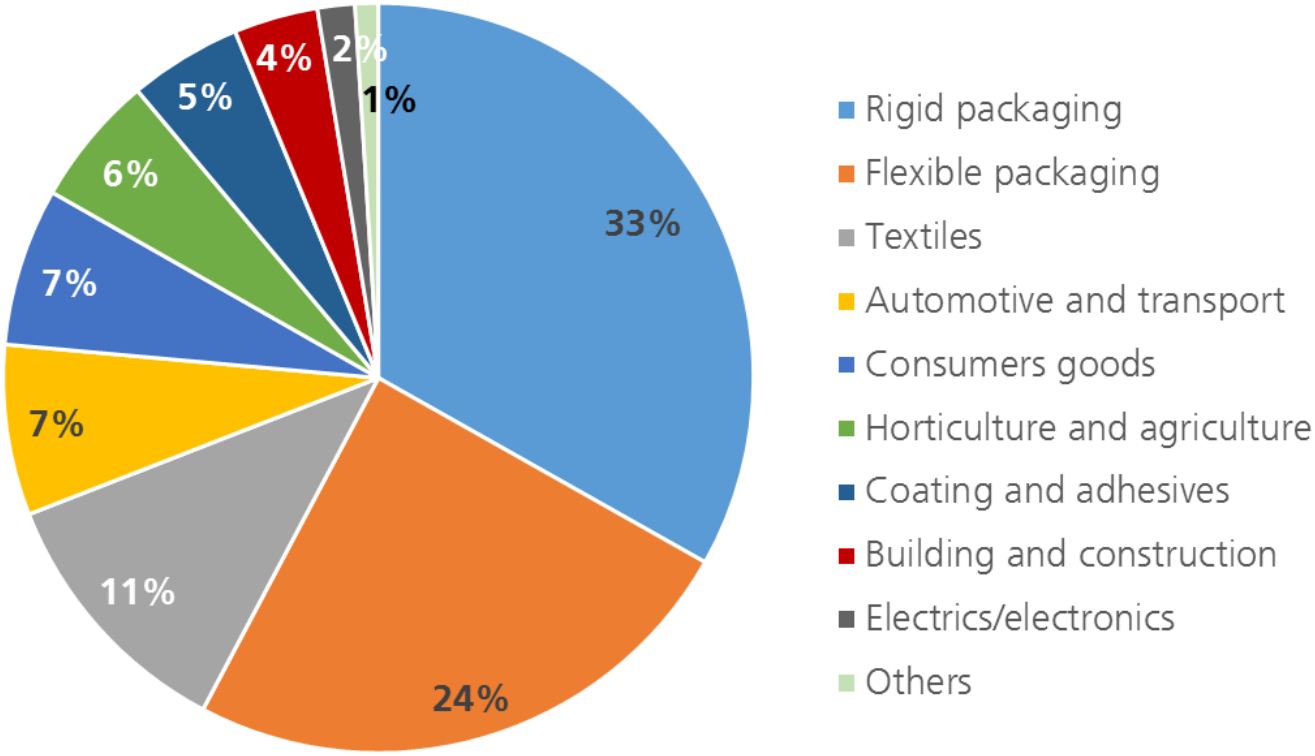
Use of Bioplastics in 2018



resentation based on figures of European Bioplastics

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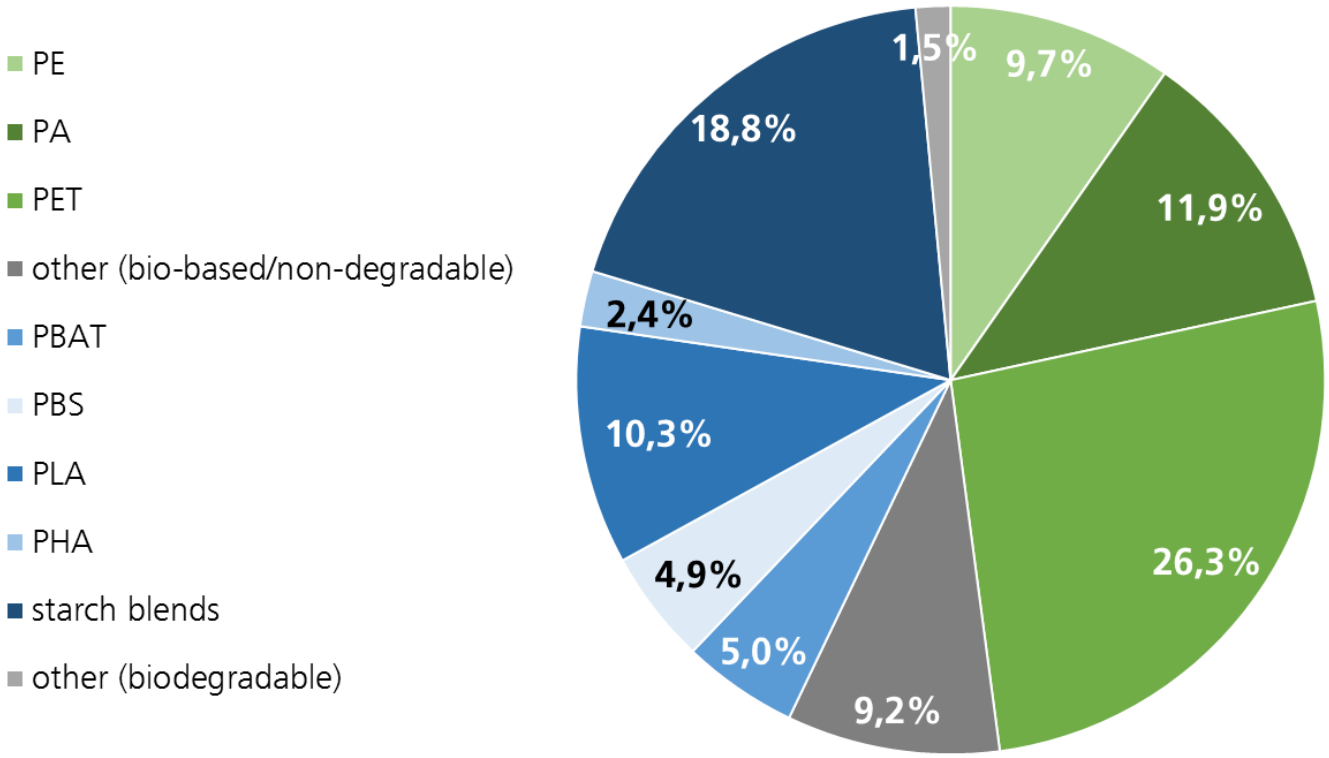
Types of Bioplastics in 2018



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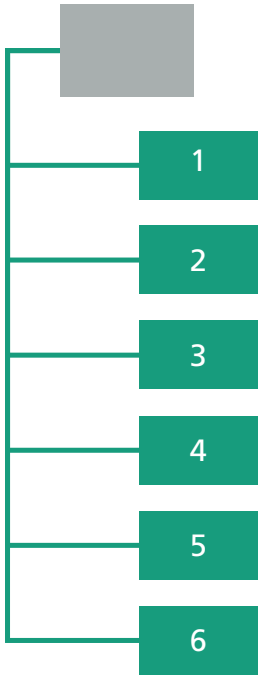

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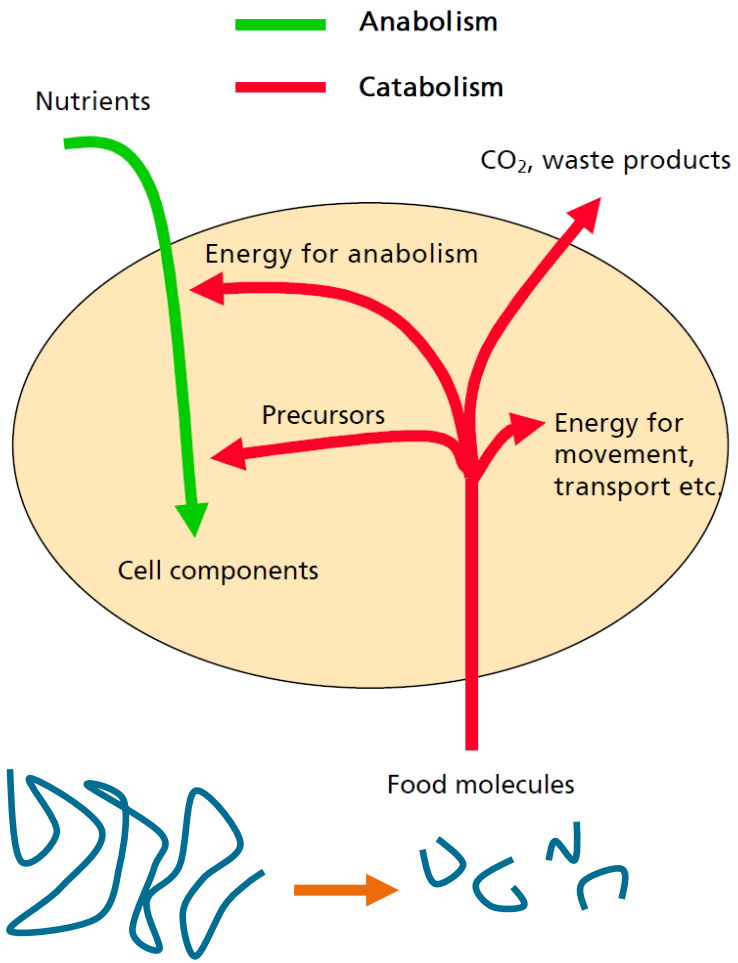
Biodegradability

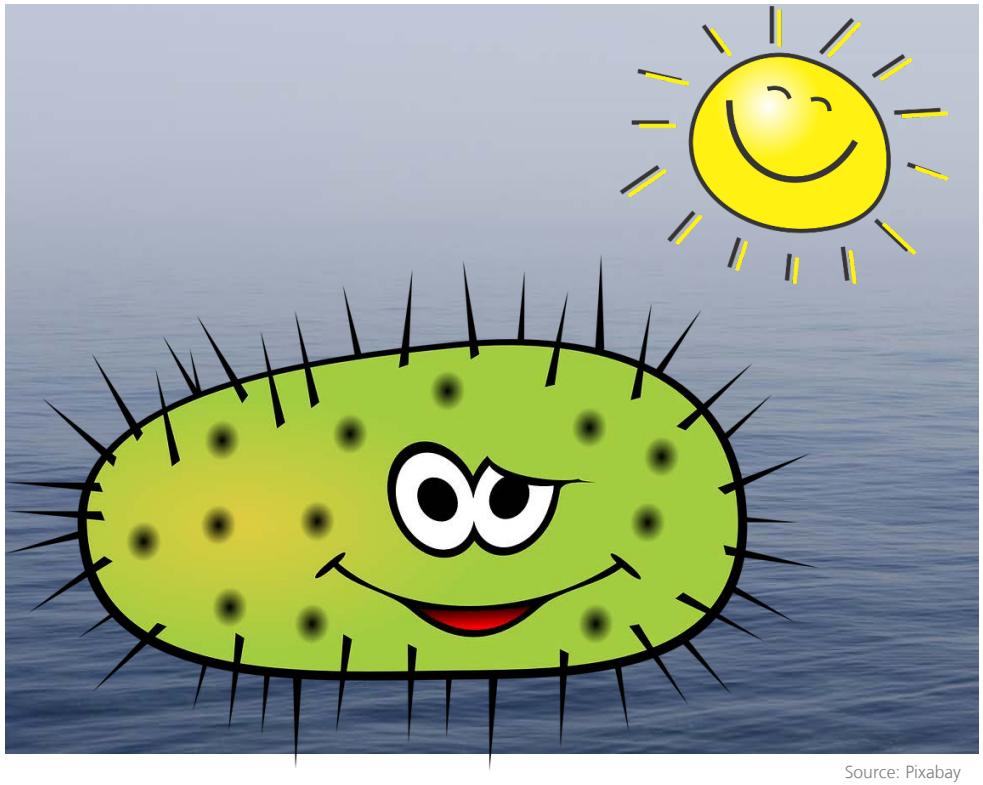
- Microorganisms utilize carbon substrates as “food” to extract chemical energy for their life processes
- Carbon substrates are transported inside their cells and:
  - under aerobic conditions, the carbon is biologically oxidized to CO_2
  - under anaerobic conditions, $CO_2 + CH_4$ are produced
- Large molecules like polymers must be chopped to resorbable pieces, mostly exo-enzymes are involved
- Measuring rate and amount of CO_2 or $CO_2 + CH_4$ evolved indicates carbon uptake of the microorganisms
- Comparison to theoretical values calculated from total carbon input yields degree of degradation
- Additionally, carbon uptake is used to produce biomass



Biodegradability

- Since biodegradation relies on microbial action, environmental parameters for micro-organisms are important for the progress of this process:
  - temperature, moisture, pH-value
  - oxygen availability, nutrient supply
- Degree of pre-existing microbial activity also influences biodegradation rate

→ Test schemes using controlled conditions were developed



Source: Pixabay

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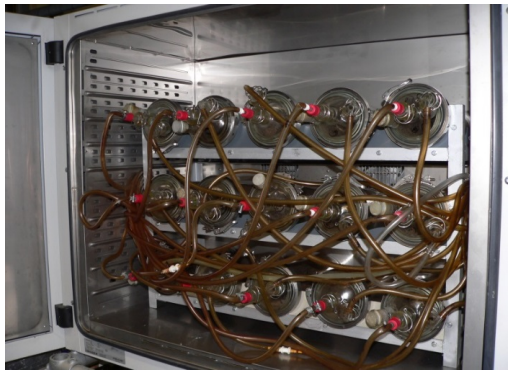
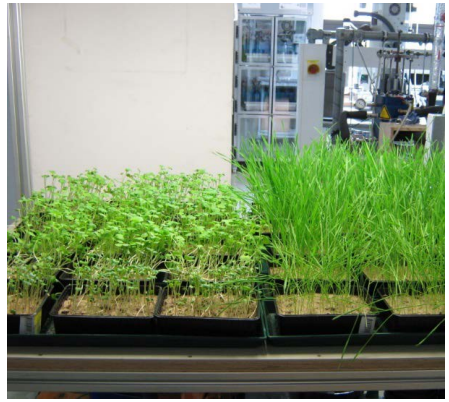
Example: DIN CERTCO – Certification program Industrial Compostability

- **Products from compostable polymers**; tests according to EN 13432; ASTM D6400, EN 14995, ISO 17088, ISO 18606, AS 4736
- **Chemical analysis**: Zn, Cu, Ni, Cd, Pb, Hg, Cr, Mo, Se, As, F
- **Ultimate aerobic biodegradability** in compost within at 55°C according to ISO 14855-1
  Pass: 90% biodegradation (absolute or related to reference substance) in 180 days (max.)
- **Disintegration in biowaste compost** after 3 month; test according to ISO 16929;
  Pass: max. 10% particles >2 mm remained
- **Ecotoxicity test** according to OECD 208

→ Products have to pass all of the tests!



Installations at Fraunhofer UMSICHT

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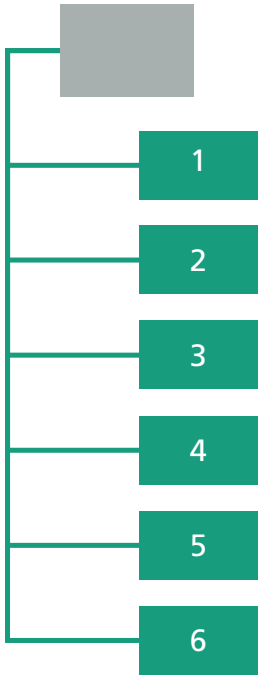

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Behavior of compostable plastics in the environment

- What are the consequences of these tests?

Seedling logo for certified industrially compostable materials (EN 13432)

Reg. Trademark of EuropeanBioplastics e. V.

Source: Pixabay

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Behavior of compostable plastics in the environment

- What are the consequences of these tests?
- Will a product with certified industrial compostability degrade after passing an industrial composting facility?

Source: Pixabay

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Behavior of compostable plastics in the environment

- What are the consequences of these tests?
- Will a product with certified industrial compostability degrade after passing an industrial composting facility? ☑
- Will it degrade after being thrown away into a river? ☒

Source: Pixabay

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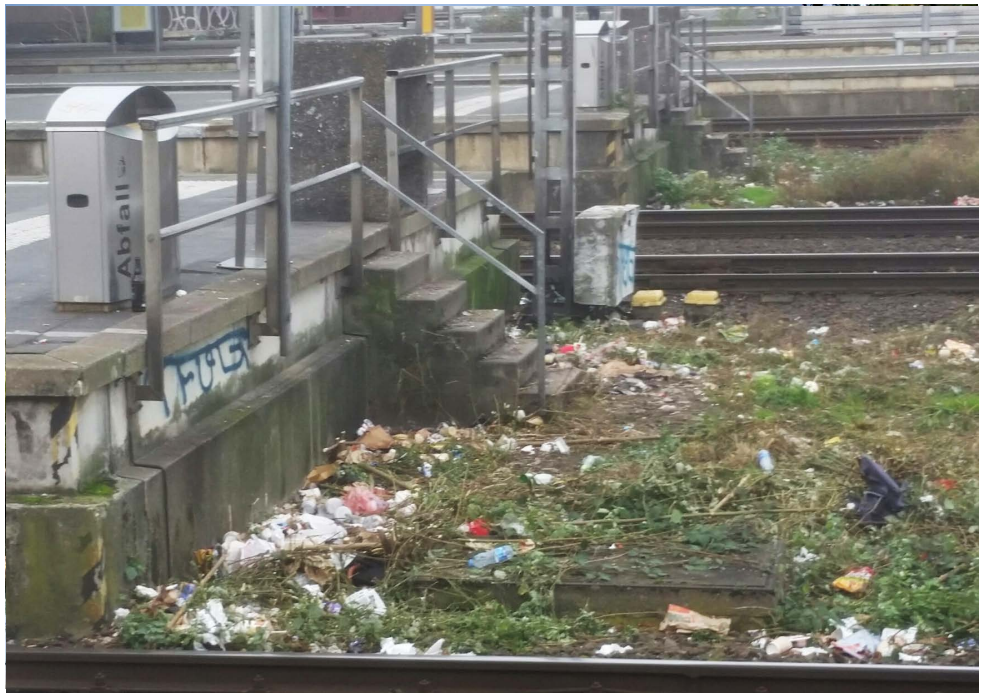
Behavior of compostable plastics in the environment

- What are the consequences of these tests?
- Will a product with certified industrial compostability degrade after passing an industrial composting facility? ☑
- Will it degrade after being thrown away into a river? ☒

→ Stop littering is the key!



Source: Pixabay

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End-of-Life Options for Bioplastics

- Recycling of many bioplastics (e. g. PLA) is technically possible
  → and the best option!
  - Due to insufficient quantities it is not performed today

Source: Pixabay

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End-of-Life Options for Bioplastics

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  - Due to insufficient quantities it is not performed today
- Composting is a favorable option for some products from certified compostable plastics like organic waste collection bags
  - They help in collecting more organic waste for closing nutrient cycles

Source: Pixabay

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End-of-Life Options for Bioplastics

- Recycling of many bioplastics (e. g. PLA) is technically possible
  → and the best option!
  - Due to insufficient quantities it is not performed today
- Composting is a favorable option for some products from certified compostable plastics like organic waste collection bags
  - They help in collecting more organic waste for closing nutrient cycles
- Energy recovery is preferable to landfilling

Source: Pixabay

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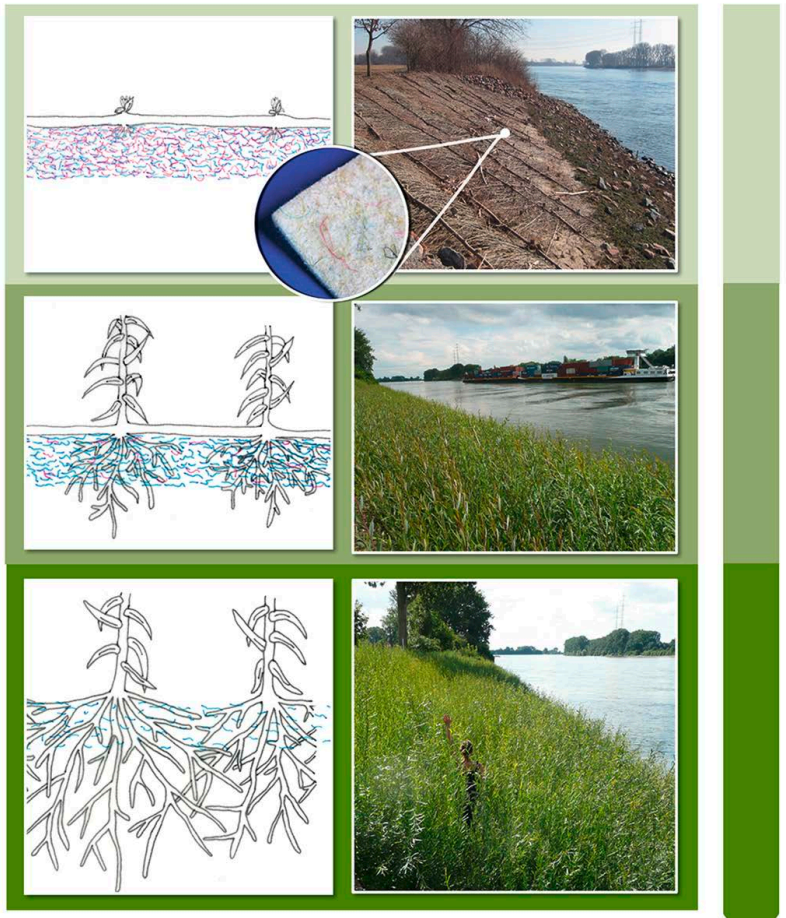
Exemplary Project Fraunhofer UMSICHT
Sequentially Biodegradable Geotextiles

- **Goals**
  - Geotextile systems based on biodegradable polymeric materials and natural fibers (hemp, flax, sisal, coconut fiber)
  - Goals: sequential degradability, permeability for roots, and stabilization of water banks
  - Determination of degradation rate of the prototypes in laboratory and field trials
- **Duration: 2016 - 2021**
- **Partners**
  - BNP Brinkmann GmbH & Co. KG, FKuR Kunststoff GmbH, BAW Bundesanstalt für Wasserbau, Trevira GmbH



Fotos: BAW

Stepwise biodegradability of geotextile filters (blue – biobased polymers, pink – natural fibers)

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Exemplary Project Fraunhofer UMSICHT
Recycling of Bioplastics – PLA

- **Results**
  - Bio-based plastics that are chemically identical to plastics made from fossil raw materials (drop-in bioplastics), such as bio-PET or bio-PE, can be recycled like their fossil equivalents
  - Production waste from bioplastics is recycled to a large extent
  - In post-consumer packaging waste, NIR identification and sorting of biobased plastics is possible
  - Up to 3 % PLA in post-consumer PP recyclate and up to 10 % in PS re-granulates have no negative effects
  - The recycling of bioplastics results in ecological advantages

  - Project summary available:
    http://publica.fraunhofer.de/eprints/urn_nbn_de_0011-n-4872831.pdf

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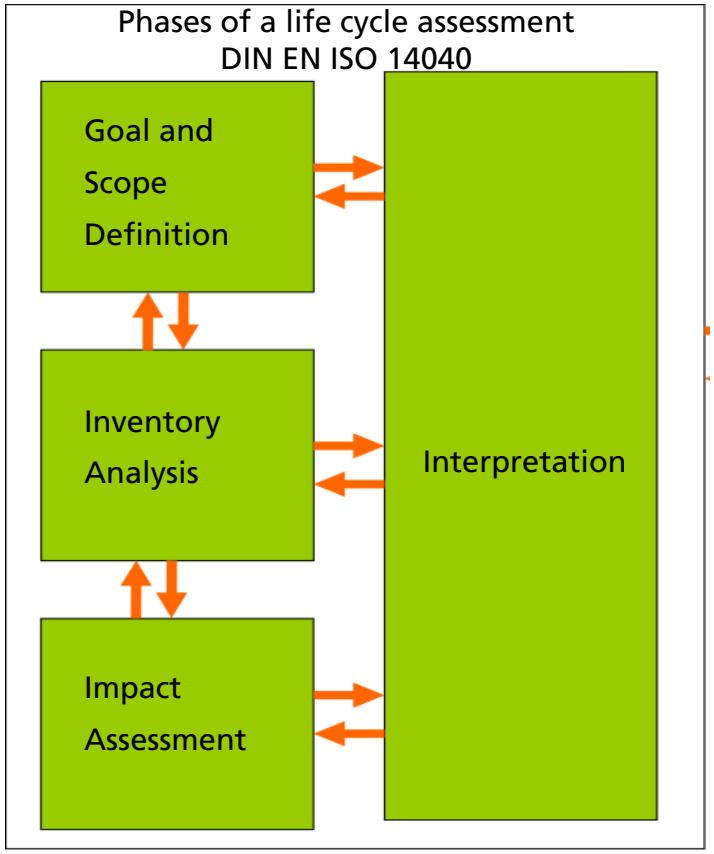
Life cycle assessments (LCA) of bioplastics
Service offered by Fraunhofer UMSICHT

- LCAs usually do not reveal clear environmental benefits
- The use of renewable raw materials (bio-based plastics) generally leads to the conservation of fossil resources and the improvement of the CO_2 balance
- However, agricultural activities usually lead to other negative effects (esp. eutrophication, evtl. biodiversity)
- LCA results strongly depend on the chosen framework conditions (e.g. energy source, disposal path)

Source MEV



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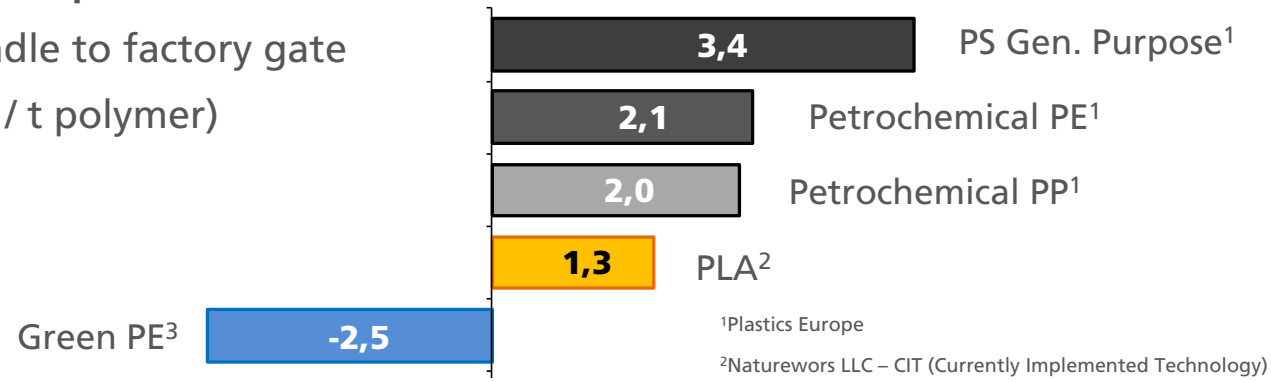
Example carbon footprint data

Carbon Footprint

From cradle to factory gate

(t $CO_{2\ eq.}$ / t polymer)

Source: Braskem



[1]Plastics Europe

[2]Naturewors LLC – CIT (Currently Implemented Technology)

[3]Preliminary Ecoeficiency Analysis - Espaço ECO Foundation

Another example

Fossile Polyamide – Bio-based Polyamide

7,3 - 4,6 t $CO_{2\ eq.}$ / t Polymer

Source: Evonik

→ Value proposition for bio-based plastics!

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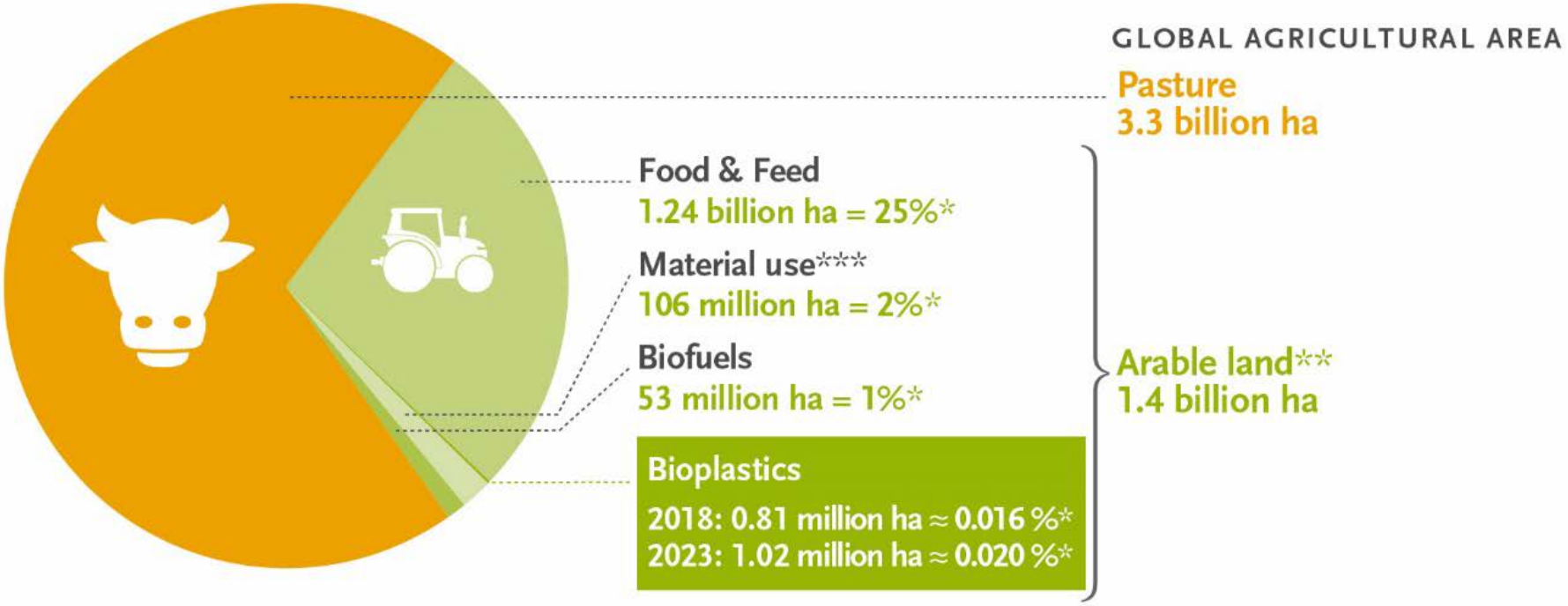
Land use estimation for bioplastics 2018 and 2023



Source: European Bioplastics (2018), FAO Stats (2014), nova-Institute (2018), and Institute for Bioplastics and Biocomposites (2016). More information: ***www.european-bioplastics.org***

** In relation to global agricultural area*
*** Including approx. 1% fallow land*
**** Land-use for bioplastics is part of the 2% material use*

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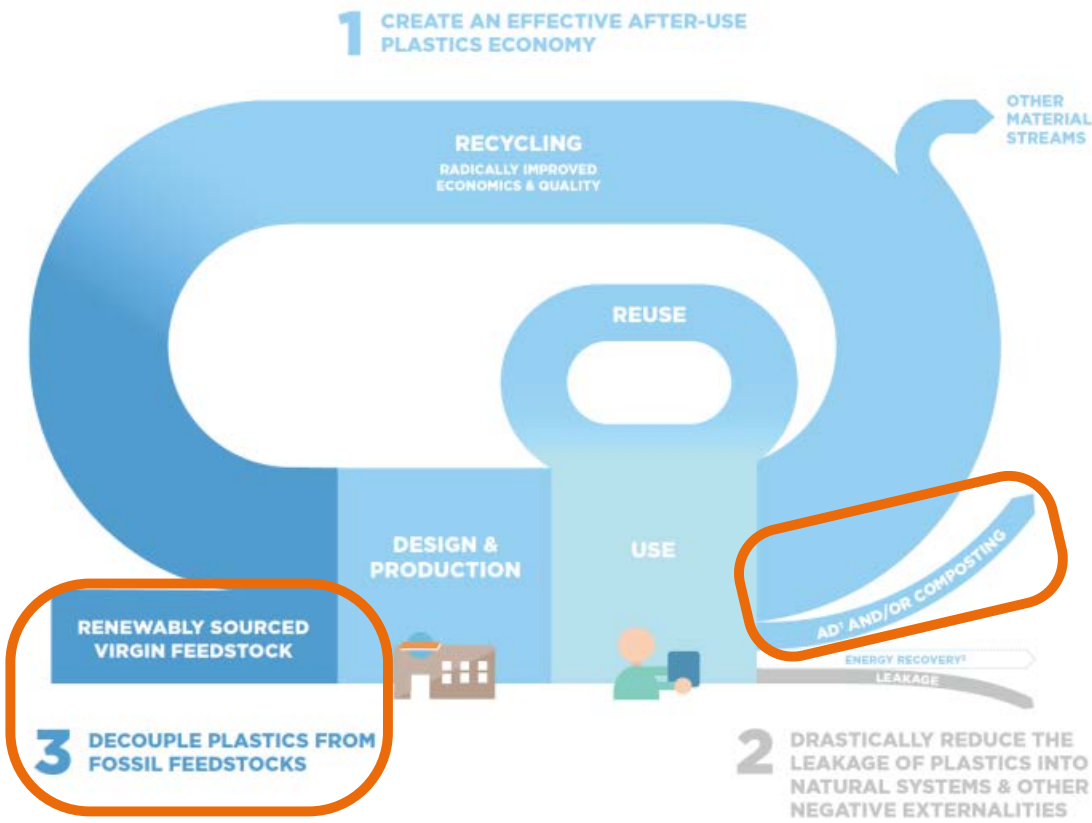
Summary and conclusions

- Use and disposal of plastics products must change
- We need to shape a circular plastics economy
- **Bioplastics can be a part of the solution**
- Ultimate goal is the development of new plastics materials –
  as functional and versatile as today's ones,
  while degrading in natural environments
  after reasonable time

  → Fraunhofer started working

  Fraunhofer Cluster of Excllence
  'Circular Plastics Economy'



Source: Ellen McArthur Foundation

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Fraunhofer Cluster of Excellence (CoE): Circular Plastics Economy (CPE)

Purpose

- Bundling of competencies and system services
- Excellence in depth, relevance in critical mass
- International thematic leadership

Goals

- To research fundamentals, know-how, structures, and system services for a knowledge-based circular plastics economy
- To optimize the value chain plastics by circular principles
- To develop products to circular product systems

Actors

Fraunhofer UMSICHT

Prof. Dr. Eckhard Weidner
Cluster Director

Fraunhofer IAP

Prof. Dr. Alexander Böker

Fraunhofer ICT

Prof. Dr. Peter Elsner

Fraunhofer IML

Prof. Dr. Uwe Clausen

Fraunhofer LBF

Prof. Dr. Tobias Melz

Structure

Photos: shutterstock.com

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THANK YOU FOR ATTENTION!

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