





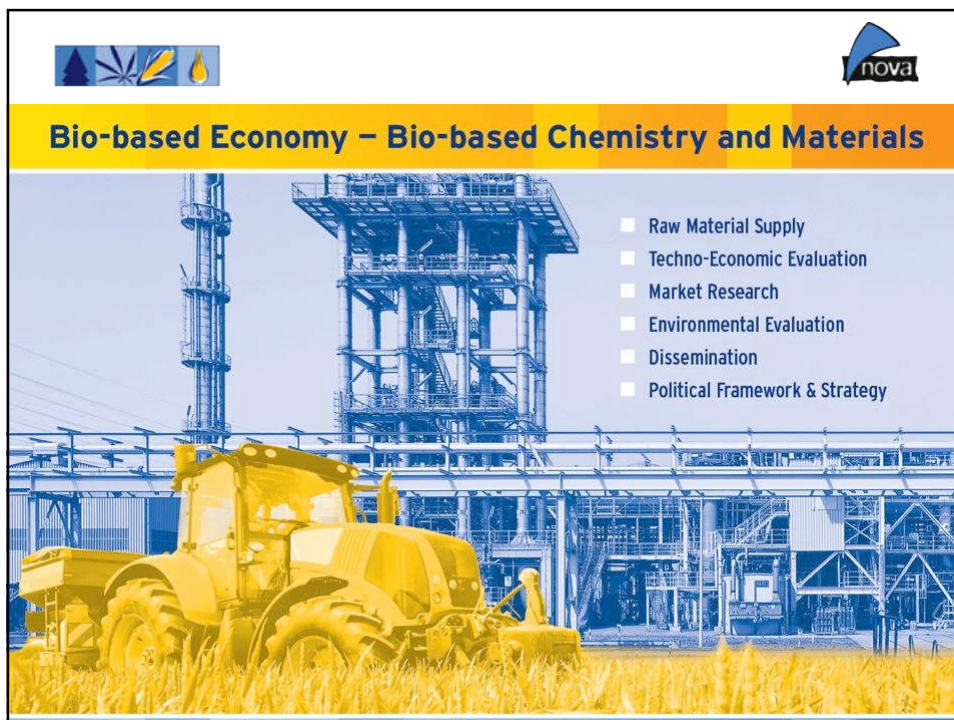
# Biokunststoffe als Lösung von Umweltproblemen?


Fachgespräch Biokunststoffe  
Berlin, 22. Mai 2015

Michael Carus  
(Geschäftsführer)

nova-Institut GmbH, Hürth (Cologne), Germany

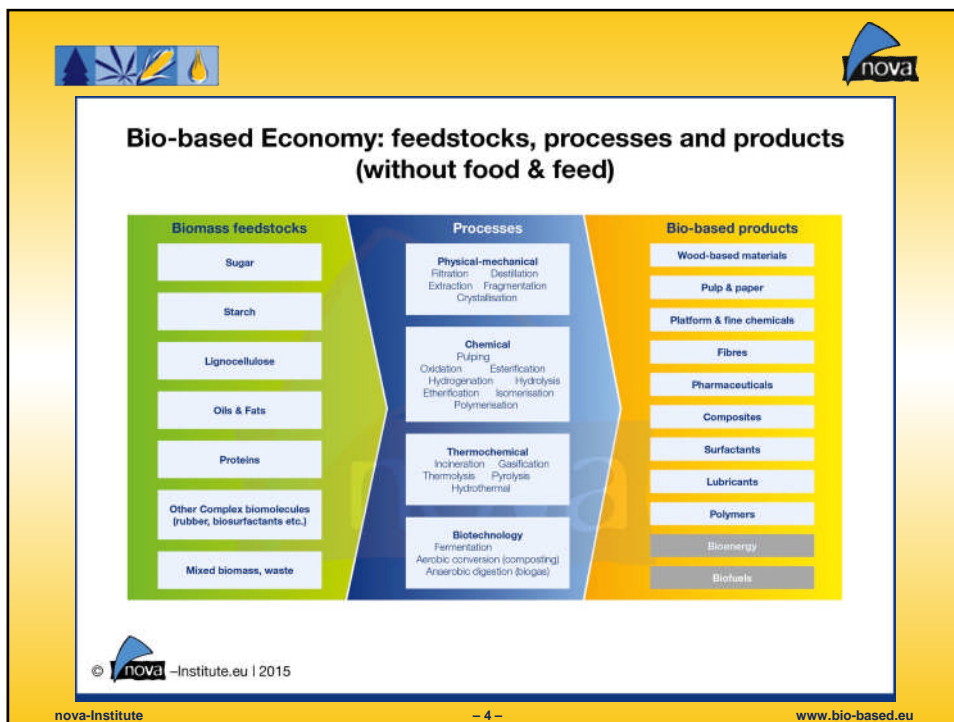
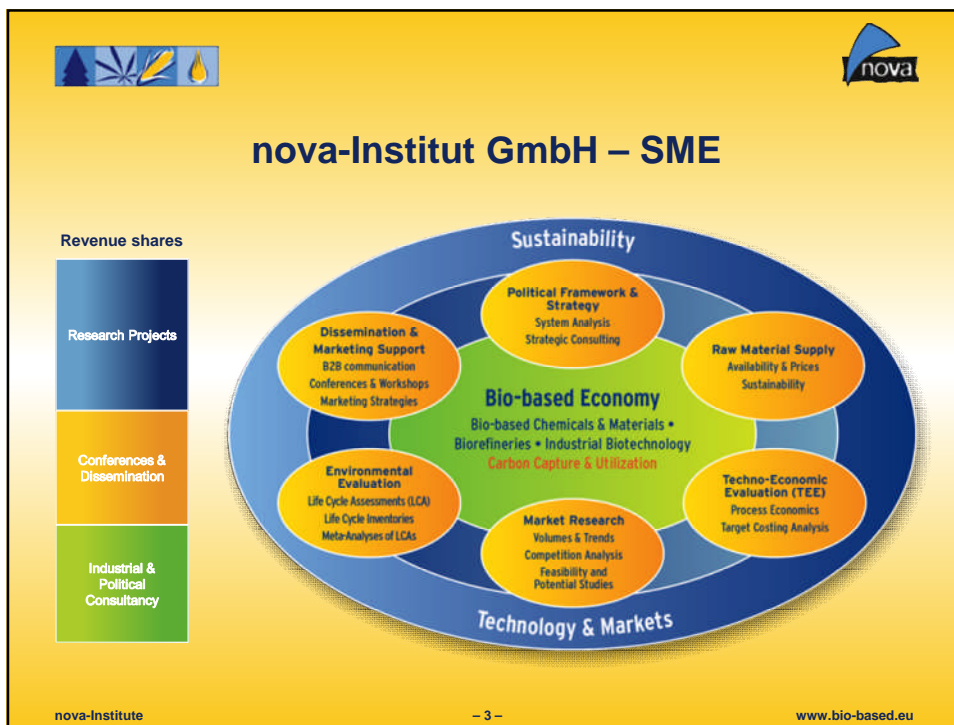
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## Bio-based Economy – Bio-based Chemistry and Materials

- Raw Material Supply
- Techno-Economic Evaluation
- Market Research
- Environmental Evaluation
- Dissemination
- Political Framework & Strategy



## Facts and Figures about nova-Institute

- Founded 1994 as a private and independent research institute
- 25 employees – interdisciplinary, international team
- Turnover of over 2 Mio. € / year
- Member of various associations & committees

CEN/TC 411, “Bio-based Expert Group” in DG Enterprise & Industry, technical group of the “bio-based panel” and advisory board of CLIB2021

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**Selected customers from industry, associations and public as well as political institutions**

**Automotive Industry:** Brose, BMW, Mercedes/Daimler, Dräxlmaier, Faurecia, Ford, Johnson Controls, Quadrant, VW

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**Engineering:** Coperion, FERROSTAAL, Reifenhäuser, Uhde-Inventa Fischer

**Consulting:** AFC Consulting (DE), BLEZAT CONSULTING (FR), Clever Consult (BE), ClouPartners (DE), Ernst & Young (FR/DE), KPMG (MY), meo Consulting (DE)

**Associations / Clusters/ NGOs:** AVK, CEFIC, CLIB2021, European Bioplastics, EIHA, IAR, VHI, WWF

**Ministries & Institutions:** BIN (DE), BMELV (DE), DBU (DE), DEFRA (UK), DECC (UK), European Commission, FAO, FNR (DE), GIZ (DE), KfW (DE), NIA (TH), UBA (DE), Netherlands Enterprise Agency (NL), Ministry of Economic Affairs (NL)

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### PUBLICATIONS

- ▶ Markets & Economy
- ▶ Policy
- ▶ Sustainability & Ecology
- ▶ Technology

### INFO

- ▶ Bio-based News daily news on bio-based economy
- ▶ IBIB International Business Directory for Bio-based Materials
- ▶ About nova Institute for ecology and innovation
- ▶ Press releases News from nova

### CONFERENCES

- ▶ 8th International Conference on Bio-based Materials ("Biowerkstoff-Kongress") Münster, Germany, 11-13 April 2015
- ▶ Open-Bio Workshop on Instruments for the Public Procurement of Bio-based Products (Side event to the 8th International Conference on Bio-based Materials) Münster, Germany, 14 April 2015
- ▶ 11th International Conference of the European Industrial Hemp Association Münster, Germany, 21-23 May 2015
- ▶ Open-Bio Mid-term Advisory Workshop CEI-CENIEC, Brussels, Belgium, 21 May 2015
- ▶ KBPPS Final Advisory Workshop The King's Mason, University of Derby, UK, 26 June 2015

- ▶ nova-Papers
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**MICROPLASTIC IN THE ENVIRONMENT**  
Sources, Impacts & Solutions

23 - 24 November 2015  
Maternushaus, Cologne, Germany

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Welcome to the international conference on  
**MICROPLASTIC IN THE ENVIRONMENT - SOURCES, IMPACTS & SOLUTIONS**  
23 - 24 November 2015, Maternushaus, Cologne, Germany  
+++ Register soon and benefit from the early bird rate +++  
+++ 15% off until end of June +++

Scientific studies have shown that plastics greatly contribute to the littering of oceans. In marine protection, plastic particles with a diameter smaller than 5 mm are referred to as microplastics. These can be secondary fragments created by the breaking up of larger pieces of plastic such as packaging materials, or fibres that are washed out of textiles. They can also be primary plastic particles produced in microscopic sizes. These include granulates used in cosmetics, washing powders, cleaning agents or in other applications.

The microplastic conference will:

- Identify sources of microplastics and quantify the amount ending up in nature
- Reveal impacts on marine ecosystems and human beings
- Propose solutions for current problems, such as prevention, recycling and biopolymers

The event will provide plenty of scope for discussion between producers, consumers, scientists, environmental organisations, governmental agencies and other interested stakeholders.

If you want to contribute as a speaker or like to become a partner/ media partner of this conference please get in contact with the nova team!

Conference Leaflet

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Michael Carus \*\*\* Achin Buchke \*\*\* Barbara Sonnenwirth \*\*\* Marlon Kapler

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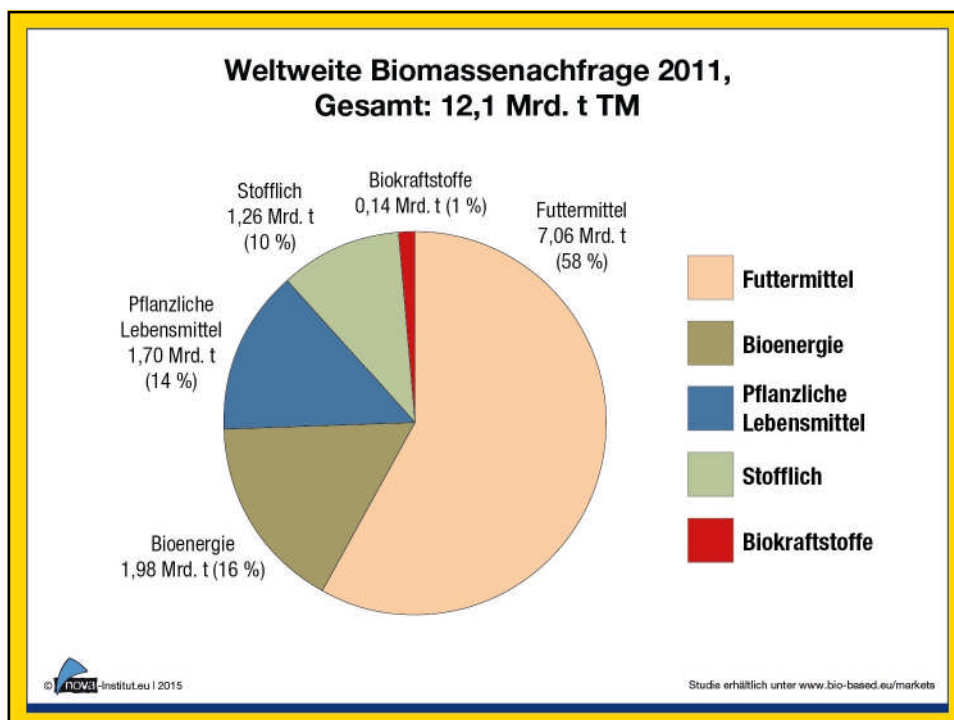
## Potenzial von Biokunststoffen

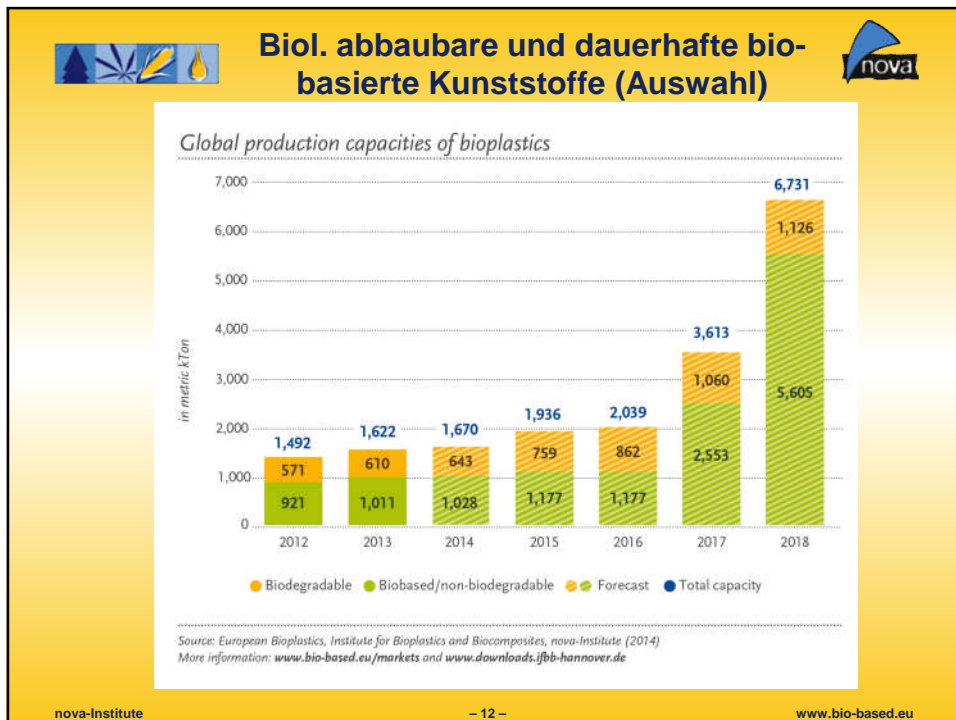
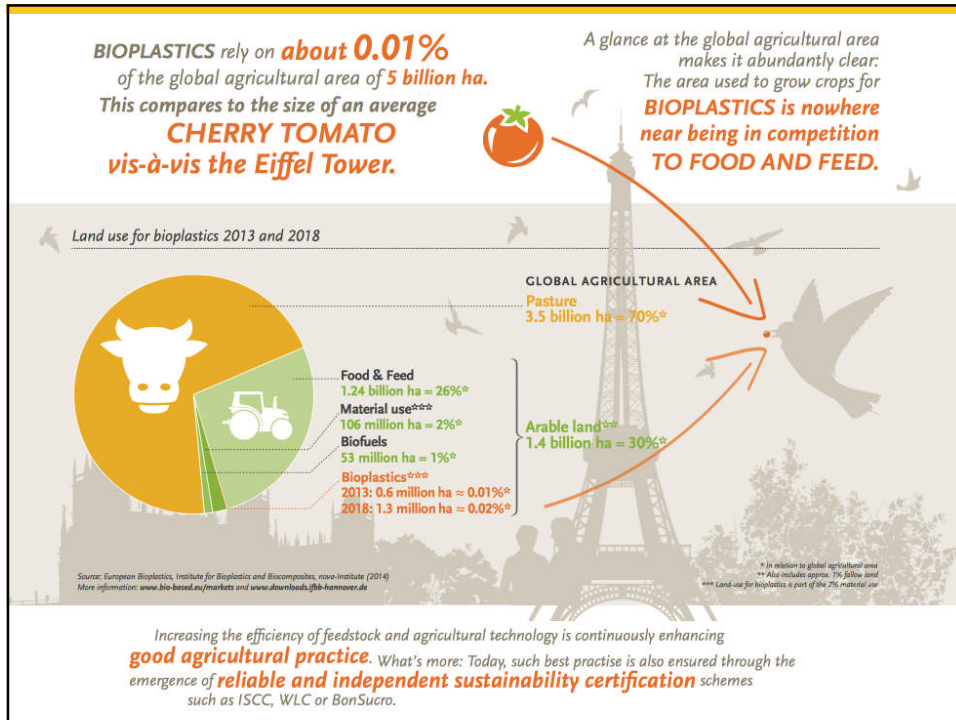


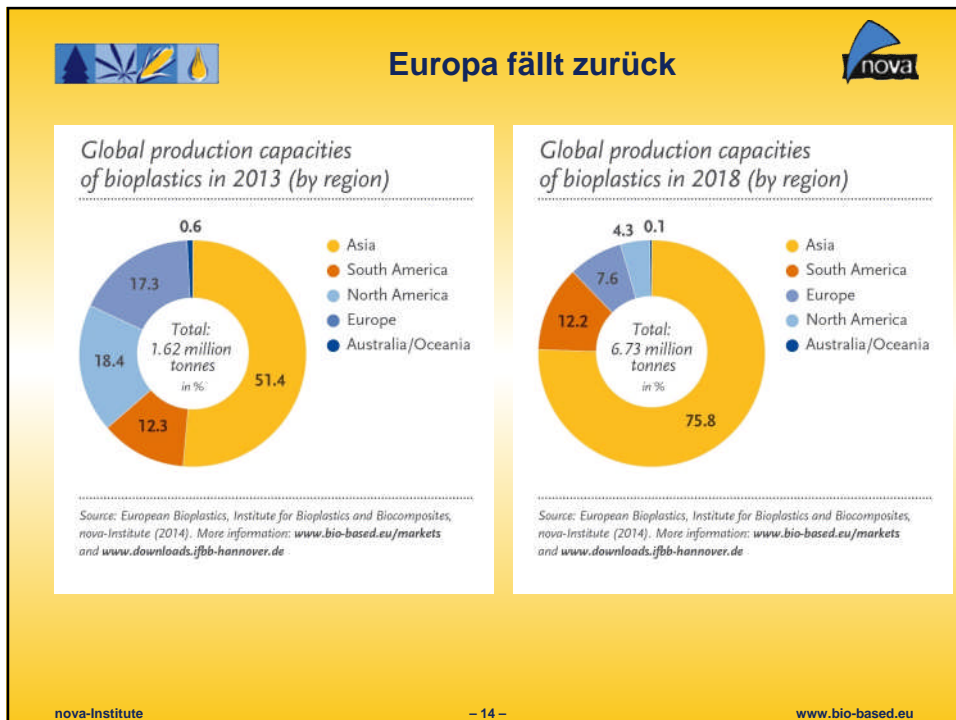
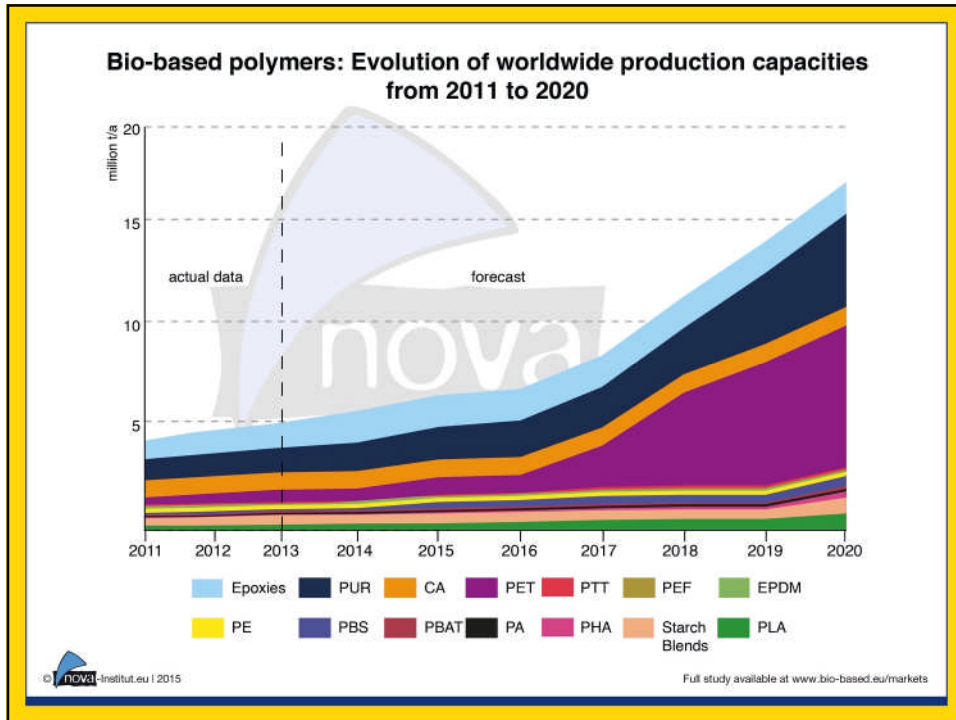
**Welche Potenziale haben Biokunststoffe („bio-basierte Kunststoffe“) für die Umwelt, Gesellschaft und Verbraucher?**


- Die meisten bio-basierten Kunststoffen haben einen **geringen Carbon-Footprint** als petrochemische Kunststoffe; und natürlich **einen geringen Verbrauch an fossilen, endlichen Rohstoffen**.
- Sie **schonen damit Klima und Ressourcen**.
- Die bio-basierten Kunststoffe, die **zusätzlich biologisch abbaubar sind, können weitere Umweltvorteile** generieren – in spezifischen Anwendungen („**Mikropartikel-Problem**“). Und sie haben neben Recycling und thermischer Verwertung eine weitere „End-of-life“ Option.
- Bio-basierte Kunststoffe haben **mehr Arbeitsplätze pro Tonne Kunststoffe**, vor allem durch Arbeitsplätze im Agrar- / Forstbereich.
- Gibt es auch Bedenken?**
  - **Konkurrenz zu Lebensmitteln?** (<0,1% der Agrarfläche – Fleisch 58%)
  - **Noch kein Recyclingsystem?** (können wir nie mehr einen neuen Kunststoff einführen?)

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## Wer alles wissen will ...





### Bio-based Building Blocks and Polymers in the World

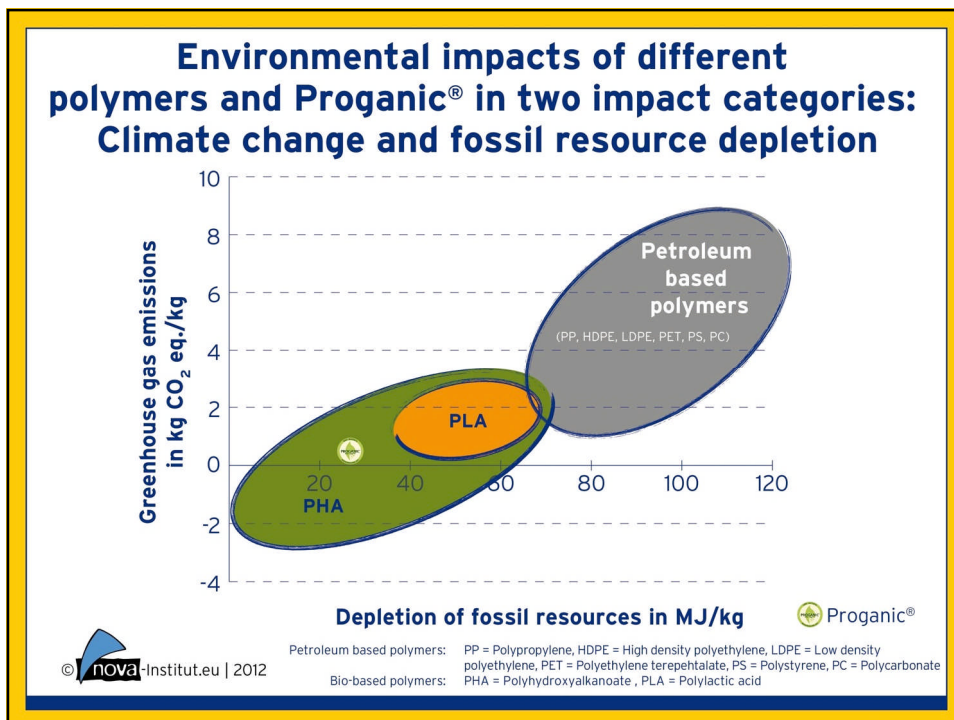
Capacities, Production and Applications:  
Status Quo and Trends towards 2020



Florence Aeschelmann, Michael Carus, Achim Raschka, Jan Ravenstijn, Wolfgang Saltus, Harald Kib, Howard Blum, Palmer Busch, Dirk Carrez, James Philip, Constance Ibrückler, Stefan Zepnik

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# Das Mikropartikel-Problem



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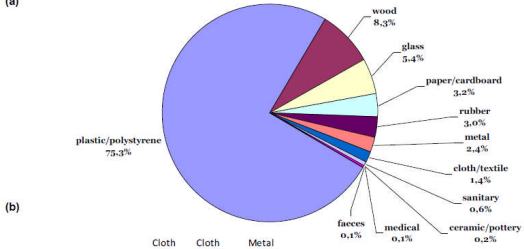


**Plastic debris is dominating the marine litter issue**

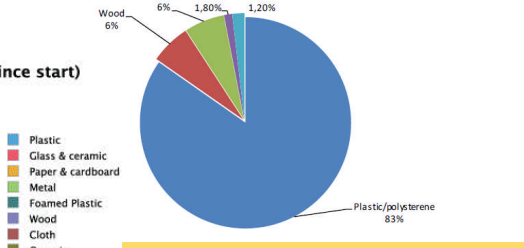


- OSPAR monitoring **North Sea** (2002-2008)
- ICC-Campaign **Mediterranean Sea** (2002-2006)
- MARLIN Project **Baltic Sea** (2011-2014)

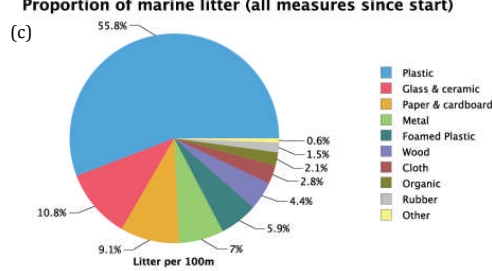
**(a)**



**(b)**




**(c) Proportion of marine litter (all measures since start)**




Source: Werner 2014

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### Comparison of size classes and designation of marine litter




Diameter of plastic marine litter	Term	Typical size of plastic in industrial applications
> 25 mm	<b>Macroplastic</b>	Pre-products and end-products
5 – 25 mm	<b>Mesoplastic</b>	Pre-products and granulates (pellets)
1 – 5 mm	<b>Large microplastic particles</b>	Granulates (pellets)
0.001 < 1 mm	<b>Small microplastic particles</b>	Microparticles in the cosmetics industry

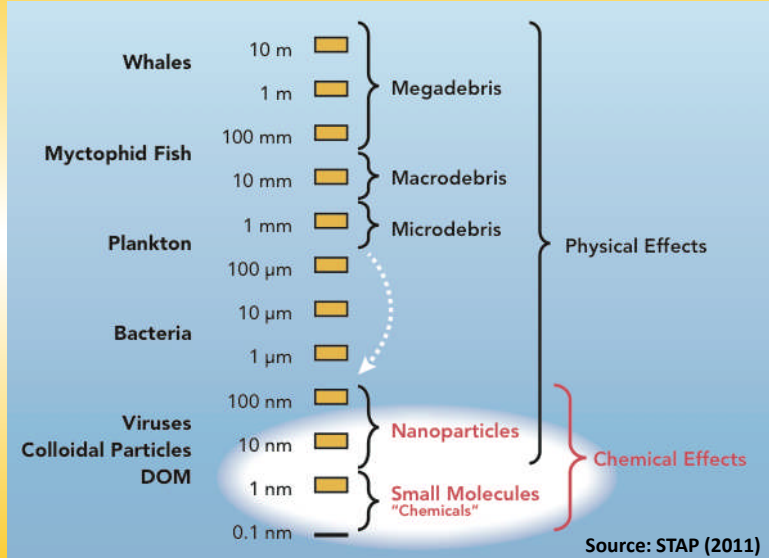
Source: Essel et al. 2014

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### Effects of marine plastic litter on animal life





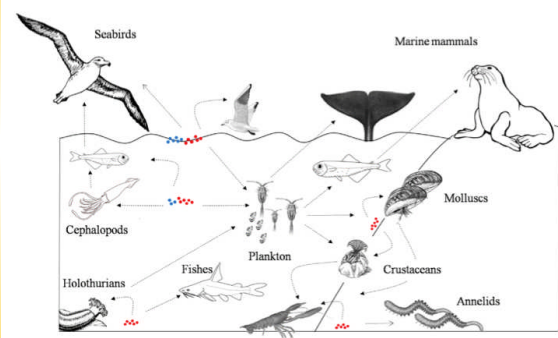
Source: STAP (2011)

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## Scientific evidence on negative impacts

- Negative impacts on 663 species reported (CBD 2012).
- Components can be toxic or cause endocrine disruption (Rochman et al. 2013)
- Absorption of persistent organic pollutants (Teuten et al. 2007)
- Accumulation of toxic substances in the food web (Cole et al. 2011)



Ivar do Sul & Costa (2014)


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## Microplastics in cultured shellfish



Are there consequences for the consumer of shellfish?



1 portion  
(250 g meat)  
→ 90 microplastics



1 portion  
(100g meat)  
→ 50 microplastics

Per capita yearly consumption of shellfish = **2.3 kg** (FAO 2012)  
± **1000 particles** ingested per year

Source: Mikroplastik in der Umwelt, 2014-06-01  
Laboratory of Environmental Toxicology and Aquatic Ecology, Environmental Toxicology Unit (GhEnToxLab)  
www.ecotox.ugent.be - Lisbeth.VanCauwenberghe@UGent.be

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# Quellen von Mikroplastik



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## Source of microplastics



Plastic litter

Synthetic clothing



Cosmetics

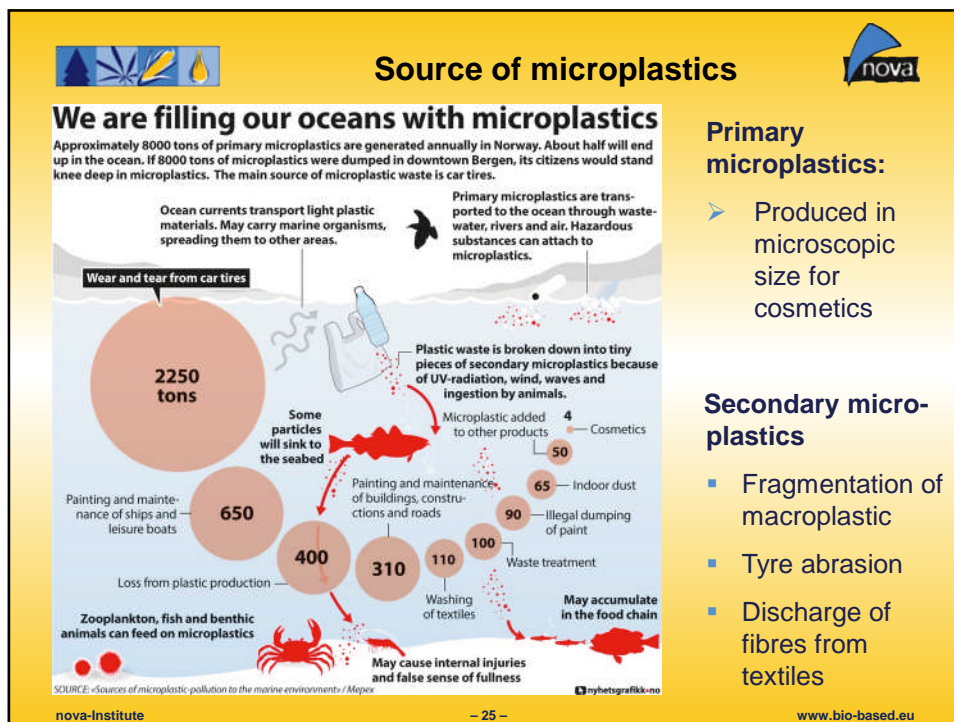
Domestic Wastewater

Degradation

Tiny plastic particles (< 1mm)

Source: Mikroplastik in der Umwelt, 01-06-2014 Laboratory of Environmental Toxicology and Aquatic Ecology, Environmental Toxicology Unit (GhEnToxLab) [www.ecotox.ugent.be](http://www.ecotox.ugent.be) - Lisbeth.VanCauwenberghe@UGent.be

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## Microplastic in cosmetic products

**Microplastic particles are used in**


- shower gels and liquid soaps
- skin care products
- toothpaste
- and many more products!

Typical inclusion levels of polyethylene microparticles reported in various cosmetic products range between:


0.05 % and 12 %

70 % of microplastic used in cosmetics is > 450 µm

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Sources for primary microplastics



### Amounts of microplastic in cosmetic products

Germany	Europe	Source
496	3,125	Essel et al. 2014
671	4,130	Gouin et al. 2015

\* in tonnes per year


**No precise data available for microplastics in other products:**

- detergents, cleaning and maintenance products, blasting agents, inks and paints, food coatings, in medicine etc.


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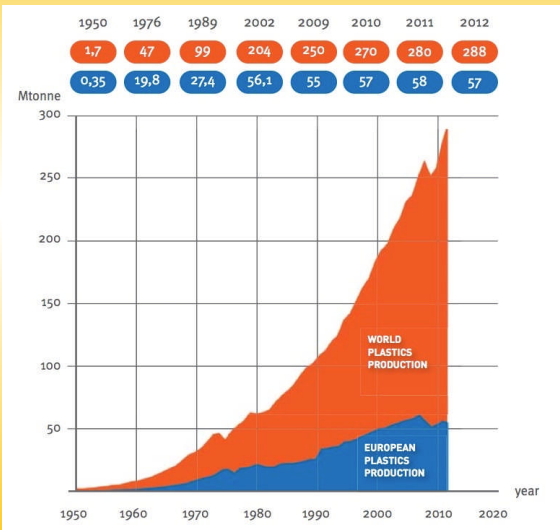
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Sources for secondary microplastics



### Fragmentation of macroplastic debris



Year	1950	1976	1989	2002	2009	2010	2011	2012
World Production (Mtonne)	1,7	47	99	204	250	270	280	288
European Production (Mtonne)	0,35	19,8	27,4	56,1	55	57	58	57

- Approx. **6.4 million tonnes** of plastic end up in the oceans every year (UNEP 2006)
- Wright et al. 2013) estimate that approx. **10%** of the annual plastics production end up in the oceans: up to **27 million tonnes per year**
- **8 million tonnes** (Jambeck et al. 2015)

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Source: Plastic Europe 2014

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Sources for secondary microplastics

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## Discharge of synthetic fibres from textiles

- A single garment can produce > **1.900 fibres per wash** (Browne et al. 2011)
- Around **35,6 billion laundry loads** are performed every year in Europe
- Approx. **120 Gramm per capita per year** are reported as emissions from households in Norway (Mepex 2014)
- Estimations for Germany report **9.600 tonnes per year**



[www.life-mermaids.eu](http://www.life-mermaids.eu)

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Sources for secondary microplastics

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## Abrasion of synthetic rubber tyres

- Most of the rubber elastomers used are a mixture of natural and synthetic rubber
- Around two thirds of synthetic rubber manufactured is made into tyres
- **60,000 - 111,000 tonnes** of microplastics can arise due to tyre abrasion in Germany each year




Source: Hillenbrand et al 2005; Fuchs et al. 2010

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### Sources of microplastic particles



#### City dust and road wear

In the first pilot studies of microplastic abundance in the coastal waters near Norway, in Skagerrak, both Norwegian and Swedish researchers have pointed out that a large fraction of particles found in the sea seem to be related to city dust, e.g. asphalt and car tyres<sup>124</sup>. City dust in urban runoff is known as a significant pollution to waterways<sup>125126</sup>. These particles have so far not been counted as microplastics. But they probably should be, because a substantial portion of the constituents of city dust is plastics from polymer based material e.g. tires and building materials. Researchers studying storm water runoffs from cities to Norwegian fjords, find they are substantial sources of a wide range of building surface and traffic related pollutants<sup>127</sup>.



**Origin:** City dust

**Number of sources:** every town or city has numerous sources.


**Plastic types:** Synthetic rubber, paint polymers.

**Haz.additives:** yes

**Particle size, mm:** city dust most easily transported in sewer often have median size around 0.1. Tyre dust 0.06-0.08 or smaller.

Source: MEPEX 2015

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### Sources of microplastic particles





Plastics are used also in road materials. In order to improve the properties (viscosity) of asphalt, polymers are added to some bitumen. The materials used are SBR (Styrene Butadiene) and SEBS (Styrene Ethylene Butylene Styrene Copolymer/ "SEBS Rubber"). In brief, the polymers make the asphalt stiffer on warm summer days and more flexible on cold winter days. The use is limited in Norway to some prioritized roads as these polymers are very expensive, and we have no data on volumes used.



Another abrasion surface made of plastics on the roads is the road marking paint/ yellow paint<sup>131</sup>. On Norwegian roads these are partly thermoplastic, partly polymer paints.

**Figure 6-9 Road marking paint**

Source: MEPEX 2015

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### Comparison of sources for primary and secondary microplastics

Source	Germany	Europe
Cosmetic products	496	3,125
Fragmentation of plastic debris	1,200,000 – 2,000,000	3,400,000 – 5,700,000
Tyre abrasion	60,000 – 111,000	375,000 – 693,750
Discharge of synthetic fibres	9,600	60,000


\* in tonnes per year

Essel et al. 2014


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### Was können bio-basierte Kunststoffe zur Lösung beitragen?



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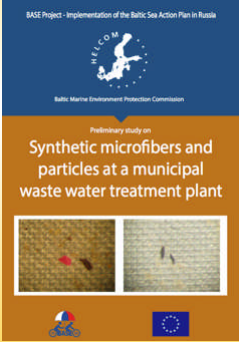


Solutions for microplastics



## How many microplastic particles are discharged with wastewater into the oceans?

- In Germany, over 90% of households are connected to the sewage system
- Initial, non-representative studies indicate that wastewater treatment plants **capture over 90%** of the microplastics found in wastewater (HELCOM 2014)
- Mintening et al. (2014) found that between 86 and 8,851 microplastics could be detected per cubic metre of purified water



Source: HELCOM 2014

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Mulchfolien, Clips und Obstaufkleber  
Umweltvorteile: Gebote und Verbote?














Pictures: BASF ecovio®, Metabolix, SAI BioTAK

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 **Rasentrimmer, Schmutzradierer, Brett**   
**Umweltvorteile: Gebote und Verbote?**



Pictures: nova-Institut

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 **Baumschutz, Waldschilder, Binder**   
**Umweltvorteile: Gebote und Verbote?**



Pictures: nova-Institut

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 **Geisternetze**  
**Schwierige Substitution** 



Verloren gegangenes Fischernetz: tödliche Falle für Meerestiere. Bild: imago/blickwinkel

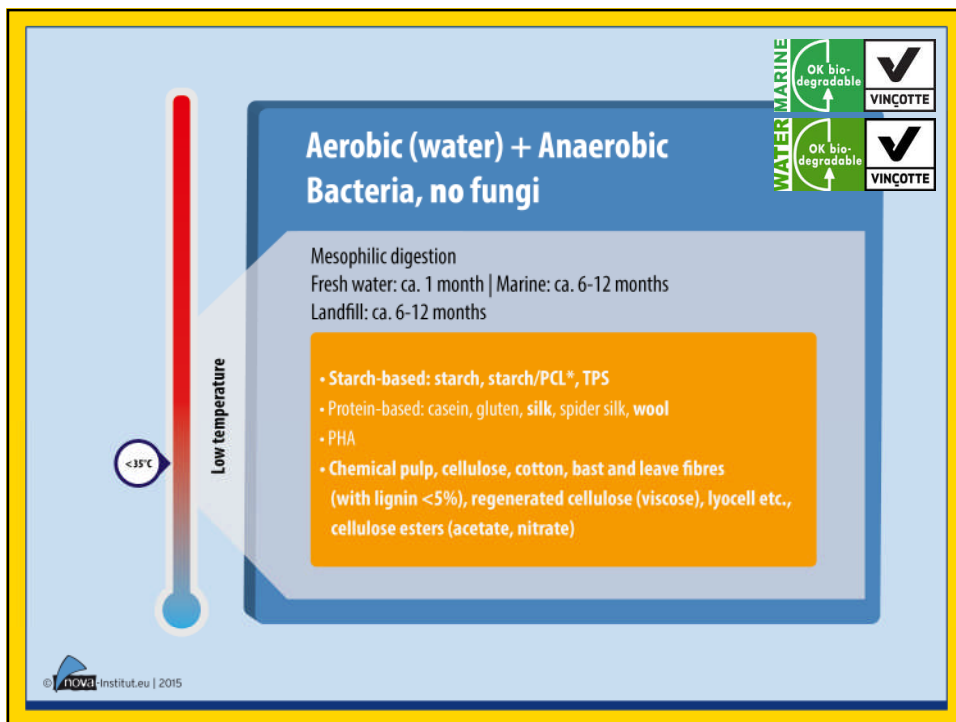
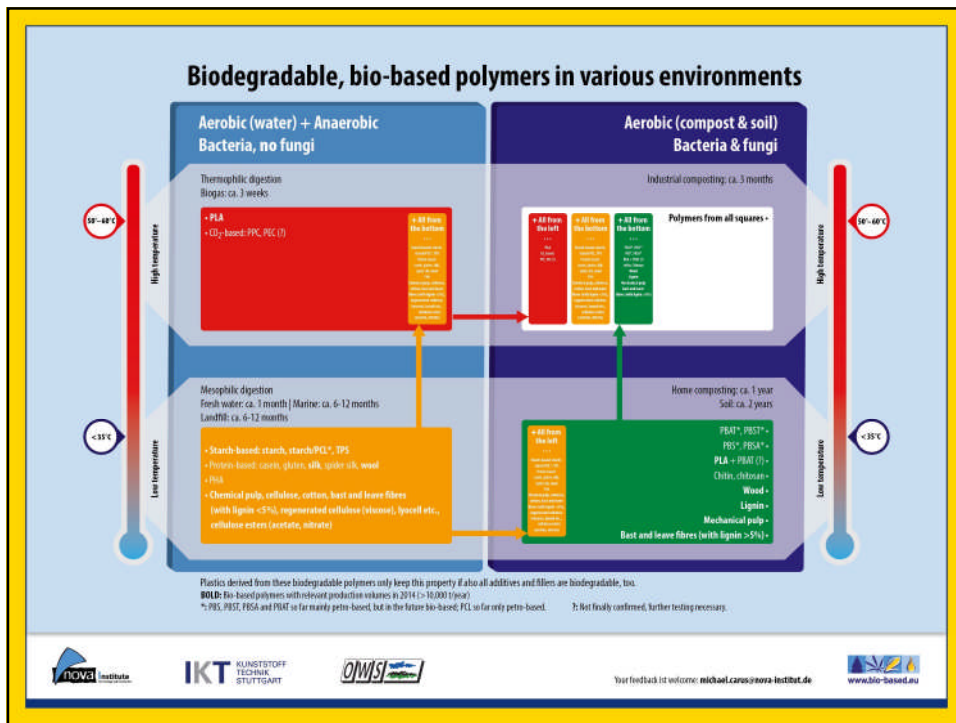
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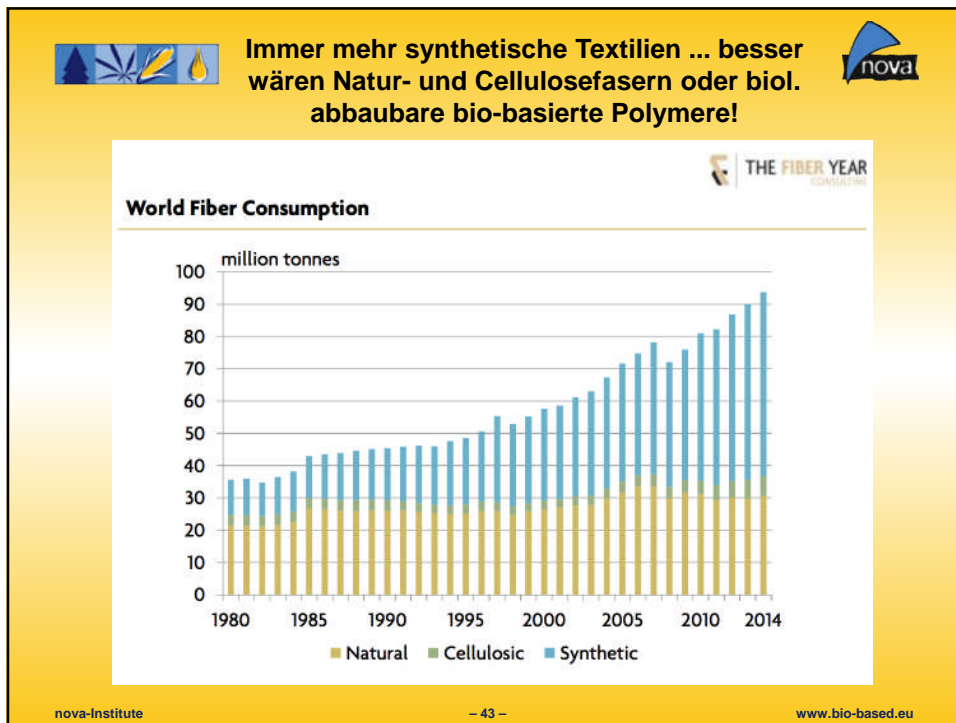




Die EU-Plastiktütenverordnung ist überflüssig

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**Aerobic (compost & soil)**  
**Bacteria & fungi**

Home composting: ca. 1 year  
Soil: ca. 2 years

**OK bio-degradable** VINÇOTTE  
**OK compost** VINÇOTTE  
DIN Geprüft

**+ All from the left**  
...  
Starch based starch  
Starch/POLY-TPS  
Protein based  
Casein, Zein, etc.  
Cotton, silk, wool  
Fur  
Chemical pulp, cellulose  
Carbon, bone and hair  
Hemicellulose (Lignin <10%),  
regenerated cellulose  
(Nylon, Lycra, etc.,  
cellulose acetate,  
polyurethane, nitrocellulose)

PBAT\*, PBST\*  
PBS\*, PBSA\*  
PLA + PBAT (?)  
Chitin, chitosan  
Wood  
Lignin  
Mechanical pulp  
Bast and leave fibres (with lignin >5%)

Low temperature <35°C

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**Aerobic (water) + Anaerobic Bacteria, no fungi**

Thermophilic digestion  
Biogas: ca. 3 weeks

High temperature

50°-60°C

- PLA
- CO<sub>2</sub>-based: PPC, PEC (?)

**+ All from the bottom**

...

Starch-based: starch, starch/PCL, TPS  
Protein-based: casein, gelatin, silk, collagen, silk, wool, wool  
PSU

Chemical poly. cellulose: cotton, hair and hair  
Biomass (with lignin < 5%): regenerated cellulose (Kuraray), lignin etc., cellulose esters (acetate, nitrate)

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**Aerobic (compost & soil) Bacteria & fungi**

Industrial composting: ca. 3 months

High temperature

50°-60°C

OK compost  
VINÇOTTE  
kompostcert  
DIN Geprüft

**+ All from the left**

...

PLA  
CO, basalt  
PC, PCL, PDI

**+ All from the bottom**

...

Starch-based: starch, starch/PCL, TPS  
Protein-based: casein, gelatin, silk, collagen, silk, wool, wool  
PSU

Chemical poly. cellulose: cotton, hair and hair  
Biomass (with lignin < 5%): regenerated cellulose (Kuraray), lignin etc., cellulose esters (acetate, nitrate)

**+ All from the top**

...

PSU, PETG, PPS, PPSA\*  
PLA + PBAE (I)  
DIN, Duretan  
Biomass  
Lignin  
Mechanical poly.  
Bam and paper  
Biomass (with lignin > 5%)

**Polymers from all squares •**

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23 - 24 November 2015  
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