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重塑塑膠產業以實現企業永續發展國際會議

International Conference on Greening our Future: Reshaping the Plastics Industry for Business Sustainability

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HKIE 香港工程師學會 Manufacturing, Industrial & Systems Division 製造·工業及系統分部
VTC
香港中華廠商聯合會 The Chinese Manufacturers' Association of Hong Kong
香港中小型企業聯合會 Hong Kong Small and Medium Enterprises Association
香港工業總會 FHKI
香港塑膠業協會 Hong Kong Plastics Industry Council
MDC Hong Kong Mould & Die Council 香港模具協會
環境工業協會 Environmental Industries Council
ESG Committee
香港汽車零部件工業協會 Hong Kong Auto Parts Industry Association
Hong Kong Aviation Industry Association 香港航空業協會
Shenzhen Polymer Industry Association 深圳市高分子行业协会
HKSC
ADSALE 雅式
RETHINK Sustainable Business Forum & Solutions Expo
Bling Bling Ocean Foundation

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Introduction

Environmental problems associated with plastic has risen to the top of the global environmental agenda due to the increasing ecological, social and economic impacts of this complex problem. With the rising tide of public concern on plastic crisis, plastic producers know that if concerns aren't addressed, they risk facing more stringent regulation and more pressure from customers.

Green transformation of the plastic industry is speeding up. Many different approaches are around to address to this problem. One of the most recent initiatives is to transform the plastics system to a net-zero and circular model through innovation by focusing on "3 strategic pillars", which covers Plastic Circularity, Net-zero Life Cycle Emission and Plastic Safety and Sustainability.

As a key member of Hong Kong's innovation and technology (I&T) ecosystem, and one of the city's five major public R&D institutions, HKPC is committed to leveraging advanced technologies and innovative service offerings to accelerate green transformation across industries. Our initiatives focus on developing sustainable and green materials, advancing recycling technologies, and promoting the use of biodegradable and bio-based plastics to reduce environmental impact.

In order to respond to market demand and actively promoting technology innovations to lead the green transformation and sustainable development of the Hong Kong plastics Industry, HKPC organised a strategic programme comprising a one-day conference and a mini showcase. The event brought together subject-matter experts, industry practitioners and trade associations to share experience and advanced technology solutions across Plastic Circularity, Net-zero Life Cycle Emissions and Plastic Safety and Sustainability. This e-proceeding compiled the summaries of the technological information collected in the conference.

Low carbon footprint of PLA with advance recycling

Mr Eddie Lin

Business Development Manager - Taiwan of Totalenergies Corbion

Mr Lin has 15 years' experience in chemical multinational companies serving plastic industry. He is delicated to sustainable material promotion by collaborating with value chain players and brand owners in Asia Pacific region since 2022


Seed to solution
Cultivating ideas into innovations
Biobased · Recyclable · Compostable · Innovative
TotalEnergies Corbion
In 2015, The Paris Agreement united the world to reduce the effects of climate change.
Around the same time, two forward-thinking companies joined forces to help meet that goal for the polymer sector. They embarked on a mission to bring to market a biopolymer solution that was:
• Versatile
• Familiar to consumers
• Better for the planet
UNITED NATIONS
PARIS CLIMATE AGREEMENT
3


Growing from idea to global operation
In less than 10 years, 50/50 joint venture TotalEnergies Corbion has become a leading global PLA producer with:
CO_2
GOLD | Top 5%
ecovadis
Sustainability Rating
JAN 2025
75,000-ton annual production capacity
98 million kg of CO_2 captured annually*
200+ tons of PLA recycled to make rPLA*
Gold EcoVadis Status
*Based on 2024 statistics


TotalEnergies Corbion
TotalEnergies Corbion works with partners along the whole value chain to develop solutions
Corbion
TotalEnergies
Corbion
Sugar feedstock
Lactic acid production
Lactide production
PLA production
Compounding Conversation
Brand owners Retailers
Consumer
EOL
NGOs & Government
BON SUCRO
Luminy®
PLA bioplastics
Technology push
• Innovation with our differentiated Luminy® PLA portfolio
• Superior quality with quality consistency
• Work with partners on Luminy® PLA applications development
• Support conversion to Luminy® PLA
Market pull
• PLA promotion, communication, and advocacy
• Create sustainability awareness
• Collaborate with leading corporations and NGOs
• Strong Luminy® brand recognition
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5


Luminy® PLA bioplastics
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Corbion


What is Luminy® PLA?
Polylactic acid
100% Biobased
Made from annually harvested renewable sugarcane plants
Compostable
Industrially composts faster than banana peels
Recyclable
Mechanically and chemically
Versatile
Used anywhere conventional plastics are used
Biobased · Recyclable · Compostable · Innovative
Corbion
7


Processing techniques
Luminy® PLA is used in many diverse applications
3D Printing
Blow Molding
Compression Molding
Extrusion
Film Casting
Injection Molding
Melt-blown & Spunbond
Thermoforming
Biobased · Recyclable · Compostable · Innovative
Corbion
8

End-of-life

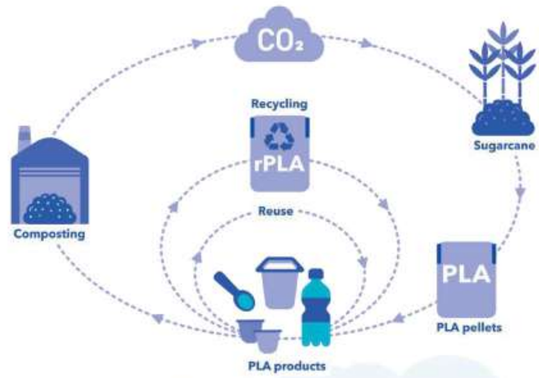
Biobased · Recyclable · Compostable · Innovative

Closing the loop

Luminy® PLA is reusable, recyclable, and compostable

PLA comes from plants, but there are more ways to keep it in the loop:

- Reusing durable products
- Recycling PLA into new items
- Composting it back to the earth



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10

Choosing the best option

Which end-of-life works best for your application?

For items made with rPLA or virgin PLA that get contaminated with organic waste during use, composting is the best option

Is there a high risk of the item being left in the environment at end-of-life?
- Yes → **Design for soil or marine biodegradation**
  - Mulch film
  - Fishing gear
- No → Are the items contaminated with organic waste?
  - Yes → **Design for composting**
    - Tea bags
    - Coffee capsules
    - Fruit labels
    - Contaminated food service ware
    - Bags that can be reused for biowaste collection
  - No → Is there a high risk of the item being disposed of into the organic waste collection?
    - Yes → **Design for composting**
    - No → **Design for reuse/recycling**
      - Food trays (in non-closed-loop environments)
      - Drink bottles
      - Cups
      - Cosmetic packaging
      - Electronic

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Composting Luminy® PLA
Back to earth
Corbion
11
PLA plant pot fully disintegrated after 11 days
22
PLA teabags fully disintegrated after 22 days
22
But orange peel and banana skins were still present after 22 days
Luminy® PLA is certified EN 13432 / ASTM D6400 in an industrial composter
Compostable packaging
Organic waste collection
Industrial composting
Rich nutrient compost
Source: WUR study for Dutch Environmental Ministry, published February 2020.
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12


Advanced Recycling Luminy® PLA
Stay in the cycle
Corbion
Advanced recycling combines start-of and end-of-life benefits
1
COLLECTION
PLA bottles are gathered via a specialized network
2
CONDITION CHECK
Bottles are checked and sorted
3
SHREDDING
Bottles are cleaned, flaked, and pelletized for advanced recycling
4
ADVANCED RECYCLING
PLA pellets undergo hydrolysis at the TotalEnergies Corbion Thailand plant, breaking the polymer into its monomers. These can then be repolymerized to create rPLA resin
5
READY FOR PRODUCTION
rPLA resin is ready to produce new bottles
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14


Real Case
Sansu PLA bottle close loop recycling in Korea
Corbion
Biobased · Recyclable · Compostable · Innovative
15

Recycling Luminy® PLA

How advanced recycling compares

Hydrolysis:
Luminy® PLA Advanced Recycling

- PLA hydrolysis requires water and a temperature of **~100°C** resulting in lactic acid
- A PLA hydrolysis reactor is an integrated part of the plant we operate in Thailand
- rPLA retains food contact approval like virgin PLA

Pyrolysis:
Conventional polymers recycling

- A pyrolysis unit produces oil at **450°C-700°C**, which is blended with naphtha or gas oil and fed into a steam pyrolysis unit at **~850°C**
- A pyrolysis unit is typically a "stand alone" unit requiring 100-200mm$ of investment

TotalEnergies Corbion offers 20%, 30%, and 100% Luminy® rPLA grades

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Our sustainability commitment

2025 LCA Update

Biobased · Recyclable · Compostable · Innovative

Made from plants

From raw sugarcane to Luminy® PLA resin

Sugarcane is the starting point for Luminy® PLA. The sugar extracted from sugarcane is fermented using microorganisms to produce lactic acid, an organic acid also produced by the human body.

85% lower carbon footprint*

*compared to conventional plastics when considering biogenic carbon

1.83 kg CO_2	0.04 m³ Water	1.8 m² Land	1,6 kg Raw sugar	1 kg PLA

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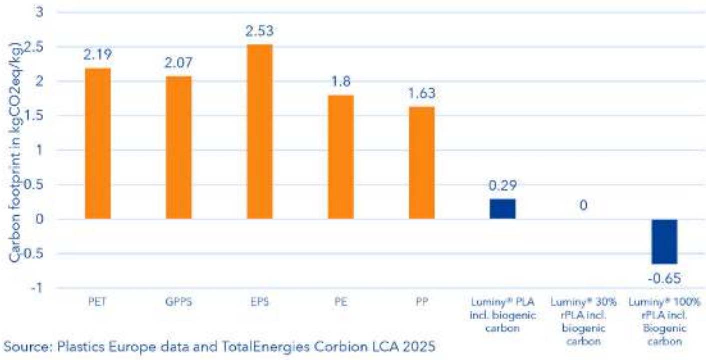
How Luminy® compares

Low GWP compared to conventional materials

85%+ Carbon footprint reduction with Luminy® PLA

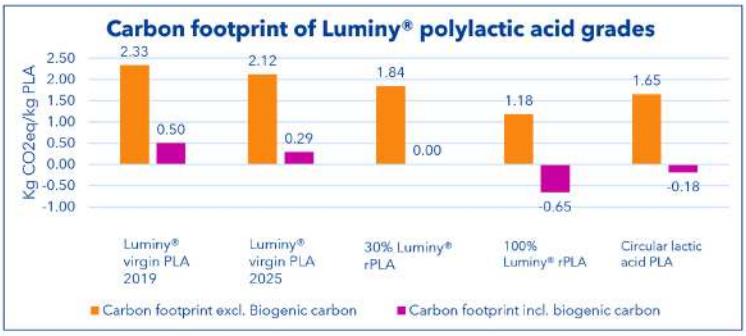
Cradle-to-gate Carbon Footprint for various polymers $kgCO_2eq/kg$ polymer



Source: Plastics Europe data and TotalEnergies Corbion LCA 2025

Climate change impact

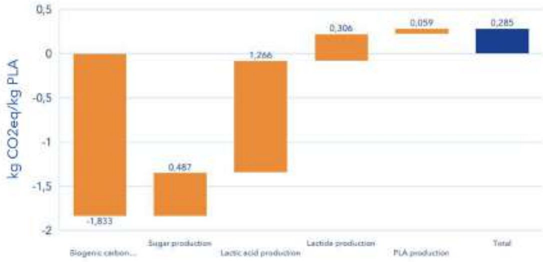
Carbon footprint



- 200kgCO2eq/ton PLA reduction compared to 2019 (0,5 – 0,3).
- **Carbon neutrality reached for 30% Luminy® rPLA**
- **Negative carbon footprint reached for 100% Luminy® rPLA**
- Carbon neutrality will be reached using the circular lactic acid.

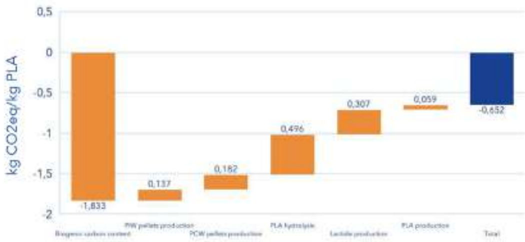
Climate change impact

Climate change impact of Luminy® PLA (including biogenic carbon)



- 60% GWP from lactic acid production
- 23% from sugar production

Climate change impact of Luminy® 100% rPLA (including biogenic carbon)



- 42% from hydrolysis
- 27% from waste preparation
- 26% from lactide production


Collaboration
Biobased · Recyclable · Compostable · Innovative


Corbion
Our partners
Luminy® PLA is the material of choice for many brand owners and consumers who want to move towards a more sustainable society. Our Application Development teams work with our customers to help them make the switch to Luminy® PLA. This can be integrated in a wide range of product applications.
Solutions
Converters
Brand owners
Bluepha
SULAPAC
CW
MITSUBISHI CHEMICAL
ATACAMA
SÜDPACK
naku
colorFabb
Taghleef Industries
earthfirst
biopolymer films by PSI
Spectrum
CHANEL
bridea medical
Sansu
PEPSICO
recozy+
DANONE
ARAPAHA
LACOPPA
ECO PRODUCTS
HYLO
Biobased · Recyclable · Compostable · Innovative
23


At **TotalEnergies Corbion**, we envision a world where we enable our customers to transition from 350 million metric tons of fossil-based plastics created annually **to sustainable and circular polymers.**
Let's work together to create a world that's sustainable for generations to come!

The Truth about Plastic Materials Plus Scientifically Proven Solutions

Dr Chris DeArmitt

President of Phantom Plastics LLC

Dr DeArmitt is a world-renowned plastic materials and microplastics expert, award-winning keynote speaker, and author. With over 5,000 studies reviewed, he exposes misinformation and champions science-based decisions on plastics and sustainability, helping industry leaders, lawmakers, and the public see through the myths to the real environmental evidence.

CHRIS DEARMITT PHD FRSC FIMMM CCHEM

President - Phantom Plastics LLC
Phone: +1 601 620 8080
E-mail: chris@phantomplastics.com

Dr. Chris DeArmitt is an internationally recognized scientist, author, and thought leader in materials science, known for his relentless commitment to uncovering and communicating the truth about plastics, microplastics and their environmental impact. With a career spanning decades and grounded in rigorous, peer-reviewed research, Dr. DeArmitt stands at the forefront of dispelling myths and correcting misinformation pervasive in today's environmental discourse.

Author of influential books such as "The Plastics Paradox" and "Shattering the Plastics Illusion," Dr. DeArmitt combines scientific depth with engaging clarity, revealing through meticulous analysis how conventional narratives about plastics and their ecological footprint often diverge dramatically from reality. His work is driven by a passion for scientific integrity, using evidence-based reasoning to challenge widely held beliefs and inform sustainable policies.

As the founder of the Plastics Research Council, Dr. DeArmitt has created an essential resource dedicated to educating policymakers, industries, and the public about scientifically validated environmental facts. He has reviewed over 5,000 scientific studies, becoming a leading authority whose insights influence both academic circles and global industries. The work is endorsed by professors world-wide.

Beyond academia and research, Dr. DeArmitt is a sought-after keynote speaker, adept at translating complex scientific concepts into compelling narratives that resonate with diverse audiences worldwide. His engaging presentations not only illuminate critical environmental truths but inspire thoughtful dialogue, driving meaningful change in how society perceives and interacts with plastics.

Dedicated to a future where environmental decisions are rooted in factual accuracy rather than misconceptions, Dr. DeArmitt continues to be an influential voice advocating for evidence-based environmental stewardship.

LIFE CYCLE ANALYSIS

- FACILITY
- FUNCTION
- REPAIRS
- RECYCLING
- RAW MATERIALS
- MANUFACTURING PROCESS
- TRANSPORTATION & PACKAGING

→ Carbon Dioxide
→ Energy Used
→ Water Used
→ Acid Rain
→ Toxicity
→ Eutrophication
→ Waste

LCA is the only proven way to know what is green

PLASTICS DISTRACTION | WHAT IS GREEN?

LIFE CYCLE ANALYSIS

Replacing plastic packaging increases harm

- WOOD
- PLASTIC PE, PP, PET
- PAPER/CARDBOARD
- STEEL
- ALUMINIUM
- GLASS

PLASTICS DISTRACTION | WHAT IS GREEN?

PLASTICS REDUCE CO_2

"We assess 16 applications where plastics are used across five key sectors: packaging, building and construction, automotive, textiles, and consumer durables.

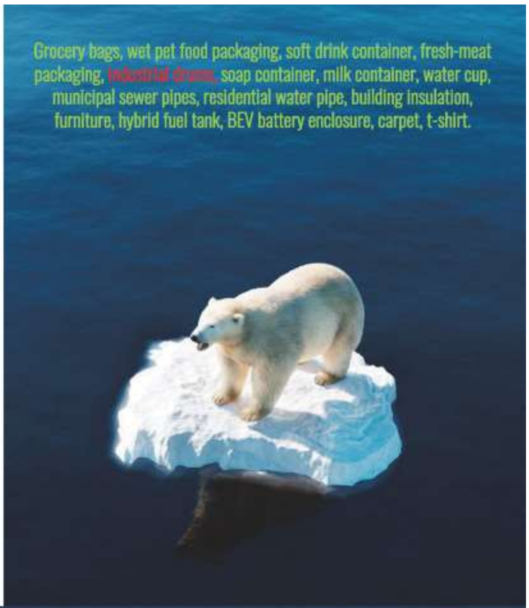
These sectors account for about 90% of the global plastic volume.

Our results show that in 15 of the 16 applications a plastic product incurs fewer GHG emissions than their alternatives.

In these applications, plastic products release 10% to 90% fewer emissions across the product life cycle."

PLASTICS MASSIVELY REDUCE CO_2

F. Meng et al., Replacing Plastics with Alternatives Is Worse for Greenhouse Gas Emissions in Most Cases, Environmental Science & Technology, January, 2022 https://doi.org/10.1021/acs.est.3c05191



PLASTICS DISTRACTION | WHAT IS GREEN?

LIFE CYCLE ANALYSIS

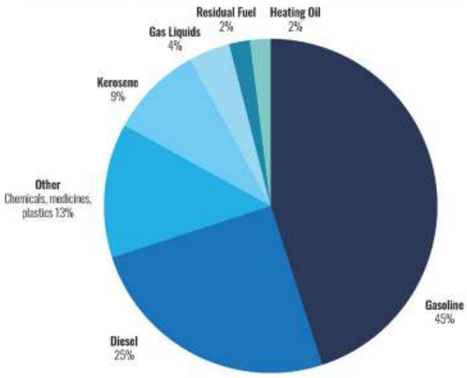
"Several studies have shown many materials used as alternatives to plastic in packaging, such as cotton, glass, metal or bioplastics, to have significantly higher CO_2 impact or water usage compared to plastic packaging. On average over current food packaging, replacing plastic packaging with alternatives, would increase the weight of the packaging by 3.6 times, the energy use by 2.2 times, and the carbon dioxide emissions by 2.7 times"

N. Voulvoulis et al., Examining Material Evidence – The Carbon Footprint, Centre for Environmental Policy, Imperial College London & Veolia UK, ACC, 2019

PLASTICS DISTRACTION | WHAT IS GREEN?

OIL USE

Plastics save more oil than they use



https://www.breakthroughfuel.com/blog/crude-oil-barrel
https://elements.visualcapitalist.com/visualizing-the-products-and-fuels-made-from-crude-oil/

PLASTICS DISTRACTION | OIL

LIFE CYCLE ANALYSIS

PET Plastic Has Least Impact

NAPCOR Beverage Container LCA Report, 2023

Compared with a 20 oz. PET Plastic Bottle	Solid Waste Generated	Energy Expended to Create	Global Warming Potential	Emissions Produced That Contribute to Acid Rain and Smog Formation
12 oz. Aluminum Can	3x more	3x more	2x more	2-3x more
12 oz. Glass Bottle	14x more	5x more	5x more	7-10x more

PLASTICS DISTRACTION | WHAT IS GREEN?

CONTAINERS - EPS

"This study has presented for the first time life cycle environmental impacts of most-commonly used takeaway containers: aluminium, EPS and PP. The results suggest that the use of aluminium containers leads to the highest depletion of elements and ozone layer as well as human, marine and terrestrial toxicities. The PP container is the worst alternative for the other seven impact categories considered."

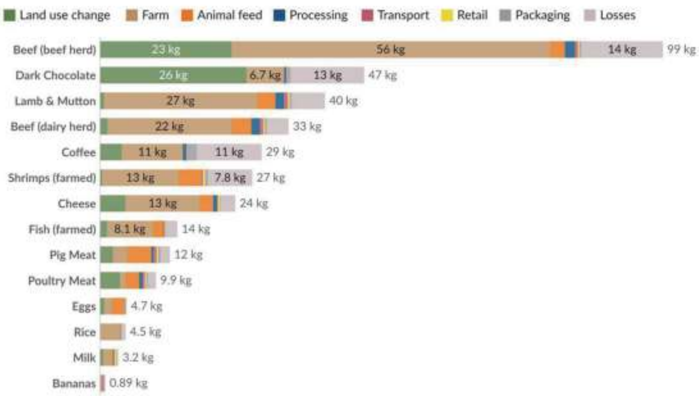
"The best option among the three is the EPS container with the lowest impacts across the 12 categories. Against the aluminium container, its impacts are 7% - 28 times lower and against the PP, 25% to six times better. The EPS is also the best option when compared to reusable takeaway PP containers, unless these are reused 3-39 times, depending on the impact."

EPS CAUSES LEAST IMPACT

A. Gallego-Schmid et al., Environmental impacts of takeaway food containers, Journal of Cleaner Production, 211, pp 417-427, 2019

PLASTICS DISTRACTION | WHAT IS GREEN?

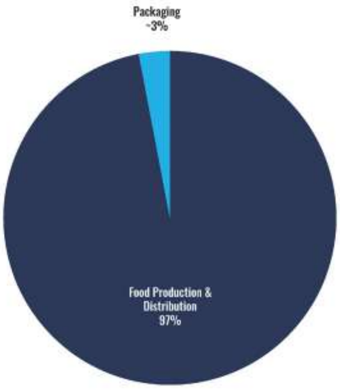
PACKAGING IMPACT (GHG)



J. Poore & T. Nemecek, Reducing food's environmental impacts through producers and consumers, Science, 360 (6392), pp. 987-992, 2018 Graphic from Our World in Data

PLASTICS DISTRACTION | GHG

PACKAGING IMPACT



Food Packaging Sustainability - A guide for packaging manufacturers, food processors, retailers, political institutions & NGOs denkstatt, 2020

Share of packaging in total carbon footprint	
Butter	0.4 %
Roast beef	0.5 %
Beef cuts	0.6 %
Ham	2-4 %
Cheese	1-3 %
Cucumber	2 %
Eggs	2.5 %
Bread	3 %
Milk	4 %
Beer	4%

PLASTICS DISTRACTION | GHG

CONSUMER PERCEPTION

		Glass bottles and jars	Paper and cardboard	Metal and beverage cans	Liquid cartons	Aluminum foil	PET[2] bottles	Other rigid plastic containers	Laminated packaging	Plastic films
North America	US	1	2	3	4	5	6	7	8	9
	Mexico	2	1	5	3	8	4	7	6	9
Europe	UK	2	1	3	4	6	5	7	8	9
	Germany	1	2	5	4	9	3	7	6	8
	France	1	3	2	6	7	4	5	8	9
	Italy	1	2	3	4	7	6	8	5	9
	Sweden	1	3	4	5	8	2	6	7	9
South America	Brazil	3	1	5	2	8	4	6	7	9
Asia	India	2	1	3	4	7	6	8	5	9
	China	3	1	2	4	6	7	8	5	9
	Japan	1	3	4	5	7	2	6	8	9

D. Nordigården et al., Sustainability in packaging 2025: Inside the minds of global consumers, McKinsey 2025

PLASTICS DISTRACTION | WHAT IS GREEN?

FOOD & PACKAGING CO_2

"Only 2% of British people consider plastic, compared to other materials used in packaging, to contribute the least greenhouse gases to the environment from its production, use, and post use treatment. Whilst in absolute numbers it is in fact the least impactful."

"If all plastic bottles used globally were made from glass instead, the additional carbon emissions would be equivalent to 22 large coal-fired power plants producing enough electricity for a third of the UK."

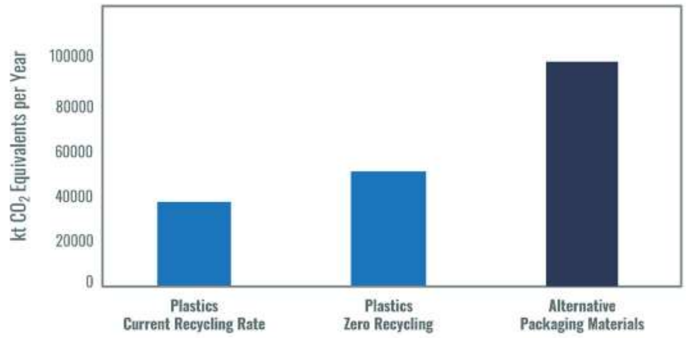
PLASTIC PACKAGING GREATLY REDUCES CO_2

N. Voulvoulis et al., Examining Material Evidence – The Carbon Footprint, Centre for Environmental Policy, Imperial College London & Veolia UK, ACC, 2019

PLASTICS DISTRACTION | GHG & PUBLIC OPINION

PLASTIC PACKAGING REPLACEMENTS

Replacing plastic packaging increases harm

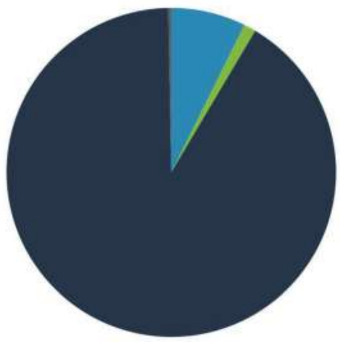


Denkstatt The impact of plastic packaging on life cycle energy consumption and greenhouse gas emissions in Europe, Executive Summary July, 2011

PLASTICS DISTRACTION | RECYCLING

EVENTS IMPACT

- Energy 7.3%
- Catering 1.2%
- Travel 91.1%
- Production 0.3%
- Waste 0.0%



800 people created the impact of 370 cars for one year

FOCUS ON TRAVEL NOT CUTLERY AND BOTTLES

SPC Impact 2024 Sustainability Report
https://sustainablepackaging.org/2024/07/22/spc-impact-2024-sustainability/

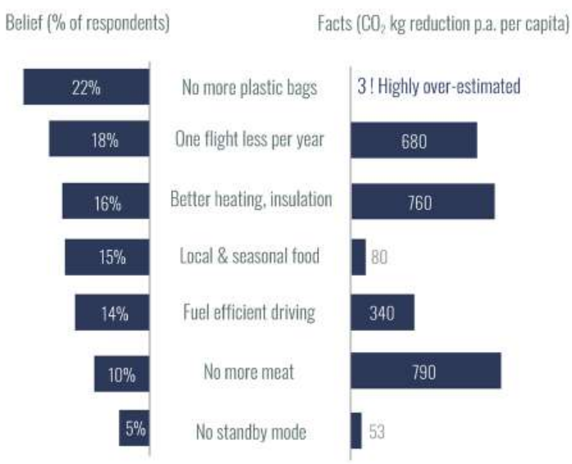
PLASTICS DISTRACTION | GHG

BELIEF VS REALITY

The focus on plastic bags is unjustified

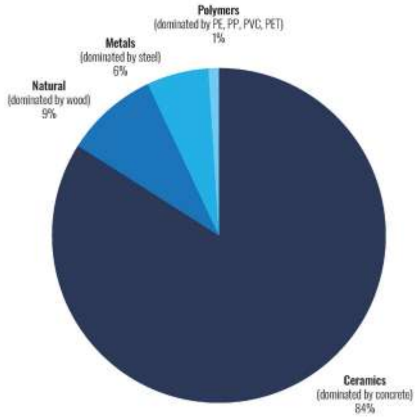
Are People Clueless When It Comes to Their Carbon Footprints?, Treehugger, 2019

"Here are the German results, with the beliefs compared to their actual facts about what works. The most surprising thing is the preoccupation with plastic bags. They may be made from fossil fuels, but their impact on carbon dioxide emissions is negligible."



PLASTICS DISTRACTION | PIPES

MATERIAL USE



Materials and the Environment: Eco-Informed Material Choice, Michael F. Ashby, Butterworth-Heinemann / Elsevier, Oxford, page 18, UK, 2009

Global consumption of materials is 90 Billion metric tons per year

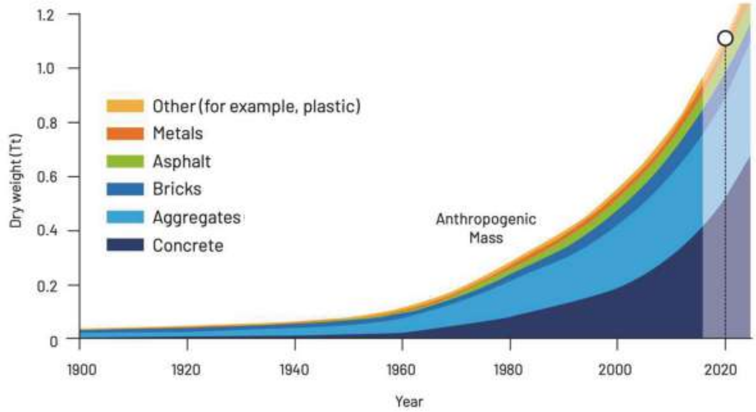
Global plastics consumption is 370 Million metric tons per year

Assessing Global Resource Use: A systems approach to resource efficiency and pollution reduction, Stefan Bringezu et al., UNEP, 2017

Global plastic production 1950-2019, Published by M. Garside, Statista, Dec 11, 2020

PLASTICS REPRESENT JUST ~0.4% BY WEIGHT AND <1% BY VOLUME OF THE MATERIALS WE USE

MATERIALS USE & GROWTH



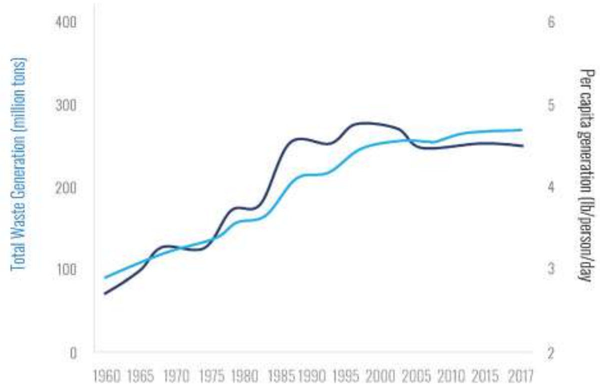
E. Elhacham et al., Global human-made mass exceeds all living biomass, Nature, Vol 588, p442, December 2020

SOLID MUNICIPAL WASTE

"The increase in plastic waste generation coincides with a decrease in glass and metal found in the MSW stream. In addition, calculating the material substitution rates for glass, metal and other materials with plastics in packaging and containers demonstrates an overall reduction by weight and by volume in MSW generation of approximately 58% over the same time period."

Graph source - https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials

D. A. Tsiamis, M. Torres, M. J. Castaldi, Role of plastics in decoupling municipal solid waste and economic growth in the U.S., Waste Management, 77, 147-155, 2018



PLASTICS DISTRACTION | WASTE

LITTER

Blaming materials is unjust

P. W. Schultz et al., Littering in Context: Personal and Environmental Predictors of Littering Behavior, Environment and Behavior, 45(1), pp 35-59, 2011

"

Of the 1,962 coded disposals, the most frequent were cigarettes (N = 340), mixed trash (N = 337), and paper (N = 272)."

"When combined, an estimated 81% of observed littering occurred with intent."

PLASTICS DISTRACTION | LITTER

MISPLACED BLAME

- 8 Billion printed every year for decades...
- How many have you seen on the beach?
- How many on the roadside?
- How many on the street?

LITTER IS CAUSED BY AND SOLVED THROUGH HUMAN BEHAVIOUR

PLASTICS DISTRACTION | LITTER

LITTER

- Two pieces of plastic
- One is dropped and the other never is
- Humans choose to litter cheap items
- Solutions are education, deposits and fines

PLASTICS DISTRACTION | LITTER

DEGRADABLE LITTER

"As was expected, the PET bottles were littered less than the Cartocans. Of the PET bottles, 2.6% was littered, while 5.8% of the Cartocans was littered..."

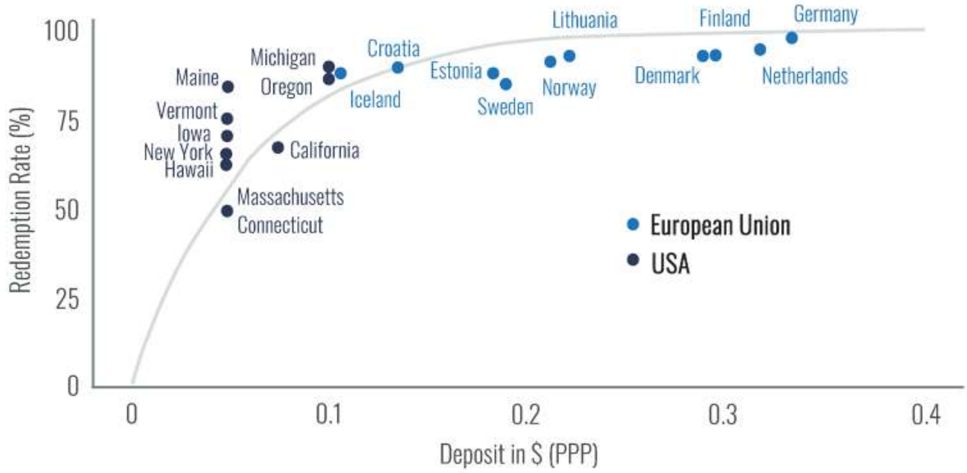
"In addition to this, 16 of the peel-off closures of the Cartocan were found littered, while none of the caps of the PET bottle were found separately."

PAPER LITTERED 2X MORE THAN PLASTIC

R. Wever et al., Influence of Packaging Design on Littering and Waste Behaviour, Packaging Technology and Science, 23, pp 239-252, 2010

PLASTICS DISTRACTION | LITTER

DEPOSITS WORK



PLASTICS DISTRACTION | LITTER

R. Basuhi et al., Evaluating strategies to increase PET bottle recycling in the United States, Journal of Industrial Ecology, 28, pp 916–927, 2024

RIVERS & OCEAN PLASTIC

"By linking worldwide data on solid waste, population density, and economic status, we estimated the mass of land-based plastic waste entering the ocean. We calculate that 275 million metric tons (MT) of plastic waste was generated in 192 coastal countries in 2010, with 4.8 to 12.7 million MT entering the ocean."

"Without waste management infrastructure improvements, the cumulative quantity of plastic waste available to enter the ocean from land is predicted to increase by an order of magnitude by 2025."

THIS WILD GUESS IS STILL QUOTED DAILY EVEN WHEN DISPROVEN OVER AND OVER AGAIN

J. R. Jambeck et al., Plastic waste inputs from land into the ocean, Science 347, 768–771, 2015

PLASTICS DISTRACTION | OCEANS

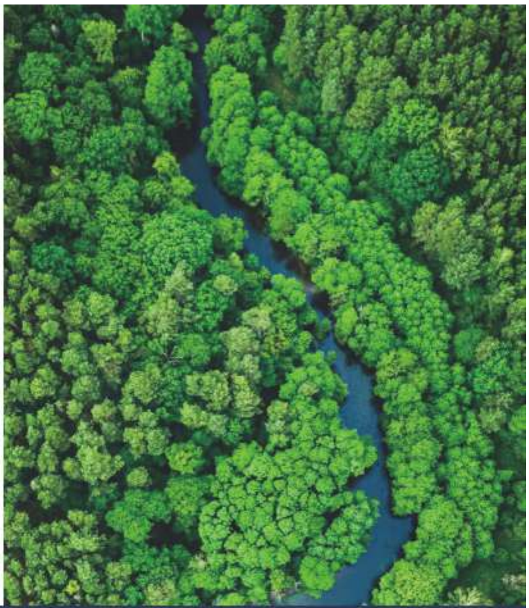
RIVERS & OCEAN PLASTIC

"Leakage from waste generation and inadequate disposal on land—i.e., mismanaged plastic waste (MPW)—was initially identified as the main driver for plastic discharge to the ocean, with a potential annual transfer of 4.8 to 12.7 million metric tons (Mt). Rivers are recognized as the principal conveyors in this transfer."

"On the basis of an in-depth statistical reanalysis of updated data on microplastics—a size fraction for which both ocean and river sampling rely on equal techniques—we demonstrate that current river flux assessments are overestimated by two to three orders of magnitude."

PLASTICS FROM RIVERS TO OCEANS 100-1000X LESS THAN THOUGHT AT ONLY ~6000 TONS PER YEAR

L. Weiss et al., The missing ocean plastic sink: Gone with the rivers, Science, 373 (6550), 107-111 2021
J. R. Jambeck et al., Plastic waste inputs from land into the ocean, Science 347, 768–771, 2015



PLASTICS DISTRACTION | RIVERS / OCEANS

OCEAN PLASTIC

"Our new results indicate that a significant fraction of these hard plastics may also be coming from fishing vessels. Adding to the mass of floating nets and ropes, this suggests that between 75 and 86% of the floating plastic mass (> 5 cm) in the NPGP could be considered abandoned, lost or otherwise discarded fishing gear."

6048 items – 0 grocery bags, 1 straw, 9 drink bottles

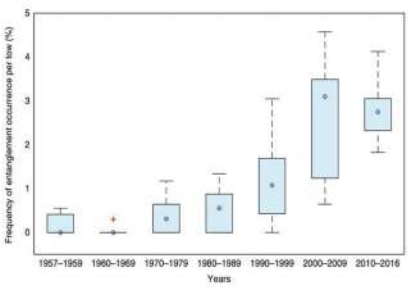
Grocery bags, straws and bottles 0.03% of total mass

OCEAN PLASTIC DOWN 33% IN 4 YEARS & MAINLY FISHING GEAR NOT FROM LAND

L. Lebreton et al, Industrialised fishing nations largely contribute to floating plastic pollution in the North Pacific subtropical gyre, Nature Scientific Reports, 12, 12666, 2022

PLASTICS DISTRACTION | OCEANS

OCEAN PLASTIC



ONE ITEM PER 18 000 MILES
ONE PLASTIC BAG EVERY 100 000 MILES

C. Ostle et al., The rise in ocean plastics evidenced from a 60-year time series, Nature Communications, 10 (1622), 2019

PLASTICS DISTRACTION | OCEANS

DEGRADATION

- There are thousands of scientific studies over decades
- Same degradation chemistry as wood, wool, cotton
- Plastics are degraded faster than most materials
- Degradation rate can be adjusted as needed
- $5BN a year on stabilizers to slow degradation

- FUNGI
- SUNLIGHT
- TEMPERATURE
- INSECTS
- WATER
- OXYGEN
- BACTERIA

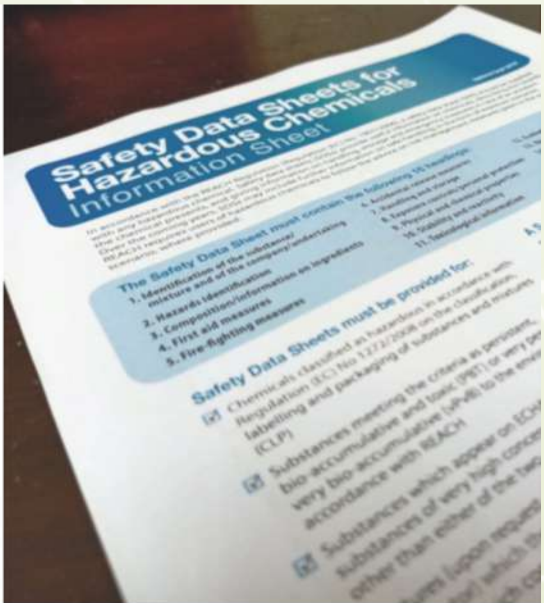
PLASTICS DEGRADE

W. L. Hawkins, Polymer Degradation & Stabilization, Springer Berlin / Heidelberg, 1984
Inamuddin, R. Mobin, M. I. Ahamed (Eds.), Degradation of Plastic Materials, Materials Research Forum, 2021
Y. Shashoua, Conservation of Plastics: Materials science, degradation and preservation, Routledge, 2008
S. Balasubramanian, Degradation of plastics by Microbes, Lambert Academic Publishing, 2018
M. Srikanth et al., Biodegradation of plastic polymers by fungi: a brief review, Bioresources & Bioprocessing, 9 (42), 2022
G. Weber, U. T. Bornscheuer, R. Wei (Eds.), Enzymatic Plastic Degradation (Methods in Enzymology, Volume 648), AP, 2021

PLASTICS DISTRACTION | DEGRADATION

Material / Substance	Acute Toxicity LD_{50} 70kg Person	Chronic Toxicity NOAEL 70kg Person
Sugar	~2000g	60g
Alcohol (ethanol)	~500g	~12g
Polyethylene	>350g	>70g
Polypropylene	>350g	>140g
Polyethylene terephthalate	>350g	>70g
PVC (unplasticized)	>350g	N/A
Calcium Carbonate - Filler	>350g	>70g
Talc Mineral - Filler	>350g	>60g
Calcium Stearate - Lubricant	>700g	>140g
Irgaphos® 168 - Stabilizer	>350g	140g
Irganox® 1076 - Stabilizer	>350g	70g
Irganox® 1010 - Stabilizer	>350g	100-200g
Irganox® 1330 - Stabilizer	>350g	35g
Iron Powder	>350g	14g
Table Salt	~200g	4g
Caffein	14g	0.25g
Copper Metal	30g	~1g
Cu Dissolved	3.5g	0.005g
Nicotine	0.7g	0.00006g

EPA toxicity ratings: Practically Non-Toxic Slightly Toxic Moderately Toxic Highly Toxic



PLASTICS DISTRACTION | SAFETY

MICROPLASTIC

"The results show that most scientific studies (67%) frame microplastics risks as hypothetical or uncertain, while 24% present them as established. In contrast, most media articles reporting on microplastic impacts (93%) imply that risks of microplastics exist and harmful consequences are highly probable."

SOME SCIENTISTS AND THE MEDIA ABANDON THE TRUTH FOR MONEY AND ATTENTION

C. Völker, J. Kramm and M. Wagner, On the Creation of Risk Framing of Microplastics Risks in Science and Media, Global Challenges, 4 (6), 1900010, 2020

PLASTICS DISTRACTION | MEDIA

MICROPLASTIC

"...the experimental design of most studies does not allow distinguishing plastic-specific effects from those caused by any other particles, such as clay and cellulose, which are ubiquitously present in the environment. We suggest that microplastic effects reported in recent ecotoxicological studies are similar to those induced by the natural particles."

PLASTIC PARTICLES AS SAFE AS NATURAL PARTICLES LIKE CLAY AND CELLULOSE

M. Ogonowskia, Z. Gerdesa & E. Gorokhova, What we know and what we think we know about microplastic effects – A critical perspective, Current Opinion in Environmental Science & Health, 1, 41–46, 2018

PLASTICS DISTRACTION | MICROPLASTIC

MICROPLASTIC REALISM

">80% of studies are identified as not reliable"

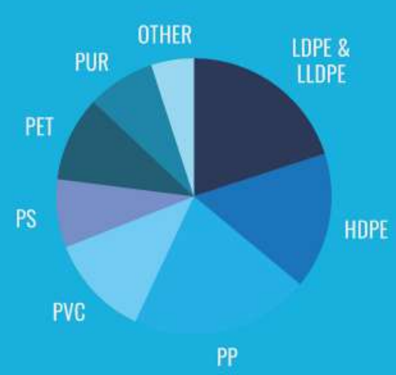
"...few studies provide information that support that the particles tested are representative of NMPs found in the environment, or that the concentrations tested are representative of environmentally relevant exposure scenarios."

~46% on polystyrene (of a special kind that doesn't exist in the environment)

10% of studies on PE, 5% PVC, 3% PP, 3% PET

SCIENTISTS ARE DOING INVALID STUDIES ON THE WRONG KINDS OF PARTICLE

T. Gouin et al., Screening and prioritization of nano- and microplastic particle toxicity studies for evaluating human health risks – development and application of a toxicity study assessment tool, Microplastics & Nanoplastics, 2 (2), 2022

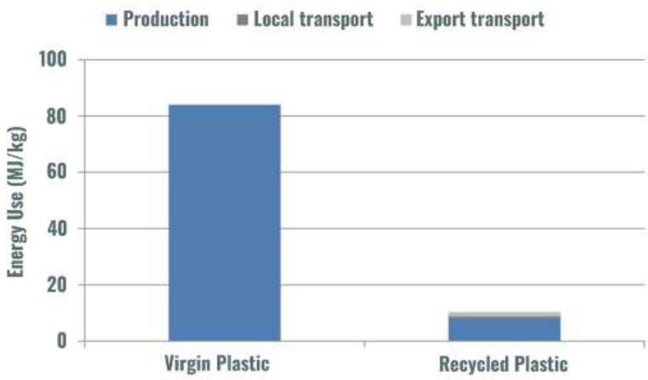


PLASTICS DISTRACTION | MICROPLASTIC

IS RECYCLING GREEN?

Mechanical Recycling Makes Plastics Even Greener

LDPE ~40x (100x) HDPE ~10x (50x) PET 10x PP ~5x (30x) Paper 3-7x



Life Cycle Impacts of Plastic Packaging Compared to Substitutes in the United States and Canada, Franklin Associates for The Plastics Division of the American Chemistry Council, 2018 C. Wong, A Study of Plastic Recycling Supply Chain, University of Hull, 2010

PLASTICS DISTRACTION | RECYCLING

RECYCLING PET BOTTLES

More than ten times

"75% rPET and 25% virgin PET were extruded in eleven cycles to simulate a recycling and production process. Samples underwent chemical, physical and biological analysis. The quality of the rPET material was not adversely affected.

A closed loop PET bottle recycling process using an rPET content of up to 75% was possible when following the proposed process, indicating that this level of recycled content can be maintained indefinitely without compromising quality."

E. Pinter et al., Circularity Study on PET Bottle-To-Bottle Recycling, Sustainability, 13, 7370, 2021

PLASTICS DISTRACTION | TOXINS

CARBON FOOTPRINT & COST

Material	Footprint kg/kg	Price $/ton
Gold	27,000	67,000,000
Platinum	15,000	30,000,000
Silver	100	800,000
Aluminium	11	2300
Plastic	2-3	1000-2000
Paper	0.7	1000-2000
Wood	0.5	700
Concrete	0.12	60
Limestone	0.02	35

Materials and the Environment: Eco-Informed Material Choice 3rd Edition, Michael F. Ashby, Butterworth-Heinemann / Elsevier, Oxford, page 232, UK, 2021

GREENER MATERIALS TEND TO BE CHEAPER AND THEREFORE LITTERED MORE & LESS ECONOMICALLY ATTRACTIVE TO COLLECT AND RECYCLE

PLASTICS DISTRACTION | GHG

CIRCULARITY

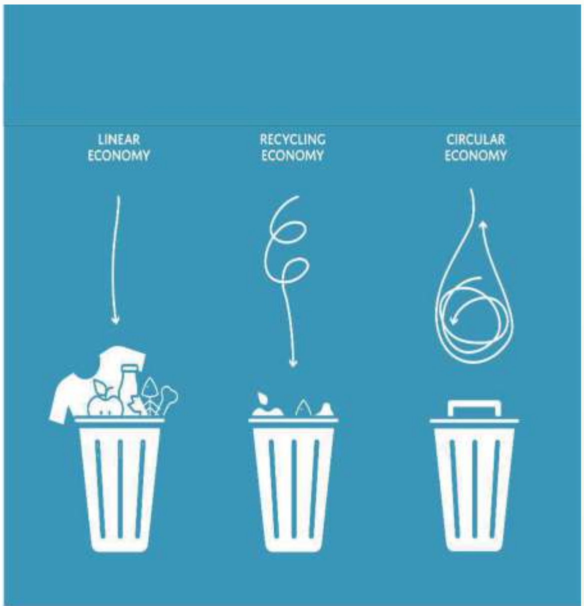
"...the circular economy risks turning into a hypothetico-normative (but self- serving) utopia that derails actual and well-intended efforts to reorganize production, consumption, and more generally material flows in ways that are more respectful of planetary boundaries and that work in favor of sustainability."

"Every loop around the circle creates dissipation and entropy, attributed to losses in quantity (physical material losses, by-products) and quality (mixing, downgrading). New materials and energy must be injected into any circular material loop, to overcome these dissipative losses."

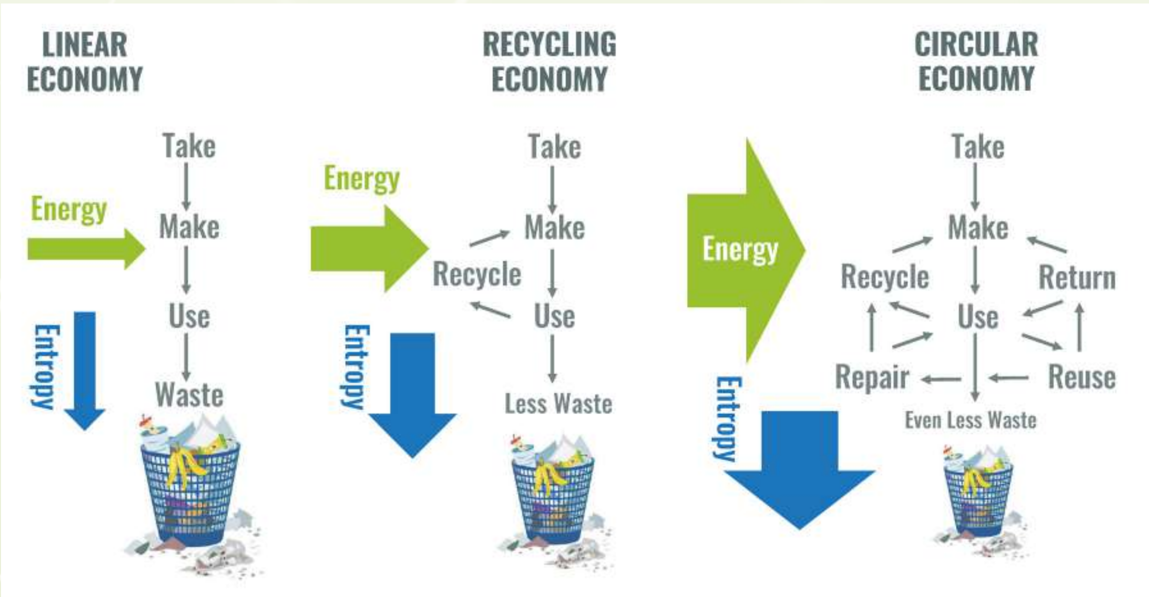
"For the most part, the novel solutions the CE purports to provide in the handling of materials merely shift impacts to the energy domain."

CIRCULARITY IS MISLEADING

H. Corvellec et al., Critiques of the circular economy, Journal of Industrial Ecology, 1–12, 2021
J. M. Cullen, Circular economy: Theoretical benchmark or perpetual motion machine?, Journal of Industrial Ecology, 21(3), 483–486, 2017



PLASTICS DISTRACTION | WHAT IS GREEN?



PLASTICS DISTRACTION | CIRCULARITY

RECYCLING

- Initiatives that involve recycling waste into something useful are gaining popularity.
- These initiatives potentially increase waste rather than preventing it.
- People may frame their waste as a contribution to the collective good that elicits a warm glow.

"In three experiments, we show how such initiatives can potentially increase waste rather than preventing it. Specifically, we show that when presented with such options people may come to psychologically frame their waste creation as a contribution to the collective good that makes them feel good about themselves (i.e. eliciting a warm-glow effect). We argue that such potential 'wasteful contribution' effects need to be considered in assessing the true sustainability benefits of certain recycling initiatives."

RECYLING DOWNSIDES

J. van Dorn & T. Kurz, The warm glow of recycling can make us more wasteful, Journal of Environmental Psychology, 77, 2021

PLASTICS DISTRACTION | RECYCLING

NGO SCORECARD

Topic	NGOs say problem is	Science says problem is	NGOs right or wrong?
Materials	Plastic	Concrete, wood, metals	Wrong
Waste	Plastic	Manufacturing, mining, oil, gas	Wrong
CO_2	Plastic	Metals, cement, paper	Wrong
Fossil fuel	Plastic	Iron, steel, cement	Wrong
Ocean plastic	Dangerous Increasing	"Negligible" Constant	Wrong
Turtles	Plastic	Trawling, fishing, boat strikes	Wrong
Whales	Plastic	Fishing gear, vessel strikes	Wrong
Birds	Plastic	Buildings, powerlines, cats	Wrong
Particles	Plastic	Soot, inorganics (quartz, Pb, Cd)	Wrong
Toxins	Plastic	Lead, mercury, cadmium, dioxins	Wrong

SO-CALLED "ENVIRONMENTAL" GROUPS ARE HARMING THE ENVIRONMENT WITH DISASTROUS ADVICE

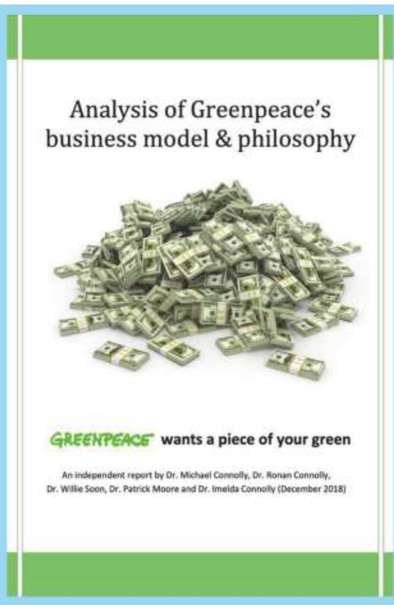
PLASTICS DISTRACTION | FACTS

“ENVIRONMENTAL GROUPS”

Greenpeace’s latest campaign on “the plastics crisis” is having the following effects:

- It is making people feel guilty and worried about a “crisis” which isn’t actually real.
- It is prompting people, governments and businesses to implement radical reforms without thinking through the consequences.
- It is hampering efforts to evaluate and deal with the genuine “ocean plastic pollution” concern.
- It is generating increased annual turnover for Greenpeace.

GREENPEACE wants a piece of your green. An independent report by Dr. Michael Connolly, Dr. Ronan Connolly, Dr. Willie Soon, Dr. Patrick Moore and Dr. Imelda Connolly, December 2018



PLASTICS DISTRACTION | FACTS

NGO CORRUPTION

License to sin

"This study explores why nongovernmental organizations (NGOs) engage in unethical behavior because of, and not despite, their perceived moral integrity."

"Our research reveals the dark side of moral idealization and confirms that the NGO halo effect is a risk factor for NGO unethical behavior."

"This paper is the first to establish that the NGO halo is positively related to NGO unethical behavior."

I. De Bruin Cardoso, Exploring the Dark Side of the NGO Halo: Relating NGO Mission, Morals, and People to NGO Unethical Behavior, Journal of Philanthropy, 30, e70000, 2025

PLASTICS DISTRACTION | NGOS

“REASONS” TO BE ANTI-PLASTIC

“Reason”	Reality
There’s too much plastic – we need to cut back	Plastics is <1% of materials we use and replacing them means using 4x more material
Too much plastic waste – we’re drowning in plastic	Plastic is <1% of total waste and replacing it means creating 4x more waste
Plastics are made of fossil fuel	Replacing plastic requires 2x more fossil fuel and using plastic saves more fossil fuel than it uses
Plastic create greenhouse gases	Replacing plastic creates 3x more greenhouse gas and using plastic saves more GHG than it creates
Plastic creates litter	Replacing plastic means more waste and litter – litter is created by people and solved by making them behave
Plastic is chocking the oceans	That claim is pure fiction – amounts were massively exaggerated
I sell paper, metal, cotton or glass and it pays my salary	Valid reason
I work for a corrupt environmental group and lies make me rich	Valid reason


KEYNOTE SPEAKER
Dispels Myths about Plastics & the Environment
THE PLASTIC PARADOX
Microplastics
Degradation
Toxicity
Ocean Plastics
Marine Animals
Life Cycle Analysis
Wise Policies
Bags, Straws & More!
As Seen on Radio & TV
60 MINUTES
BBC
sky news
I-M3 FELLOW
FELLOW CCHEM FRSC
chris@phantomplastics.com
+1 (601) 620 8080

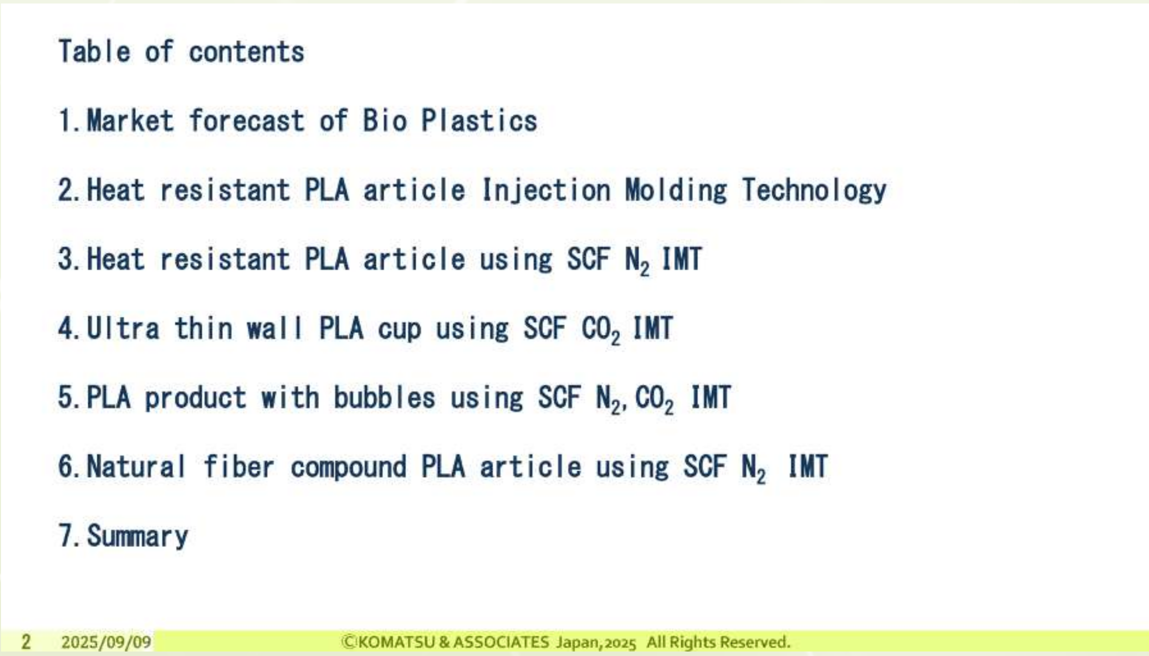

QUESTIONS
?

Cutting-edge examples of PLA injection molding technology in Japan

Mr Michio Komatsu

President of Komatsu & Associates

An expert in injection mold technology and bioplastics, Mr Komatsu graduated from the National Institute of Technology, Fukushima, and founded KOMATSU & ASSOCIATES. With 305 patented inventions in bioplastics, Mr Komatsu has received the Science and Technology Award, the Minister of MEXT Commendation and the Prime Minister's Award of Japan's Manufacturing Grand Award. He is also a Fellow of the Institution of Professional Engineers, Japan.



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3. Heat resistant PLA article using SCF N_2 IMT

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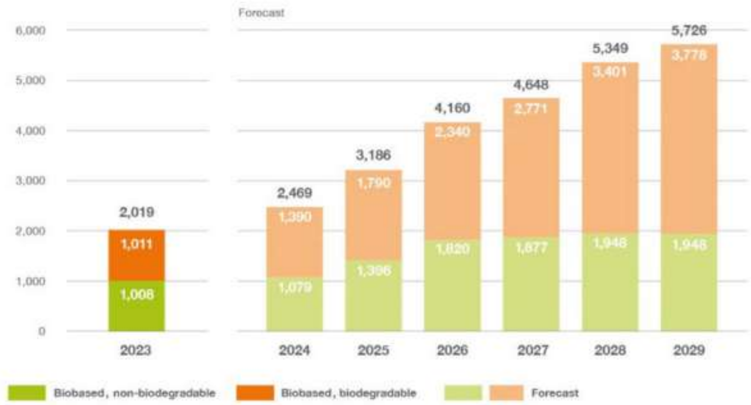
5. PLA product with bubbles using SCF N_2, CO_2 IMT

6. Natural fiber compound PLA article using SCF N_2 IMT

7. Summary

Global production capacities of bioplastics

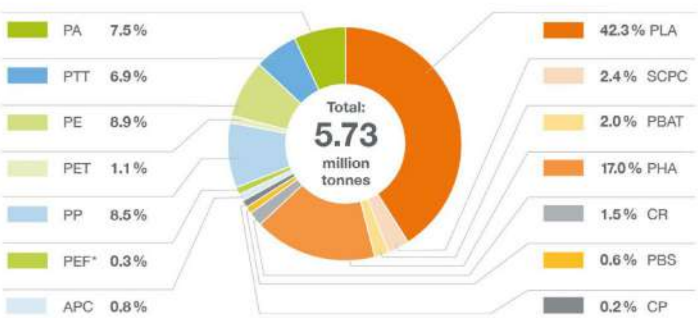
in 1,000 tonnes



Source: European Bioplastics, nova-Institute (2024)

Biobased, non-biodegradable
34.0 %

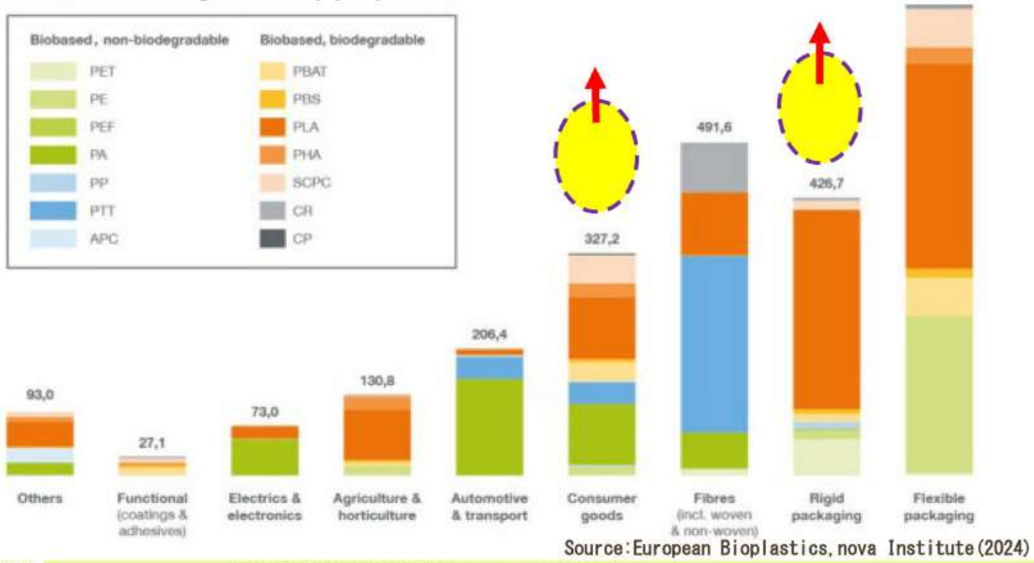
Biobased, biodegradable
66.0 %



APC	Aliphatic Polycarbonates	PBS	Polybutylene Succinate and Copolymers	PHA	Polyhydroxyalkanoates
CP	Casein Polymers	PE	Polyethylene	PLA	Polylactic Acid
CR	Cellulose Regenerates	PEF	Polyethylene Furanoate	PP	Polypropylene
PA	Polyamides	PET	Polyethylene Terephthalate	PTT	Polytrimethylene Terephthalate
PBAT	Poly(Butylene Adipate-co-Terephthalate)			SCPC	Starch Containing Polymer Compounds

* PEF available at commercial scale as of 2024
Source: European Bioplastics, nova-Institute (2024)

Global production capacities of bioplastics 2024(market segments by polymers)



Source:European Bioplastics, nova Institute(2024)

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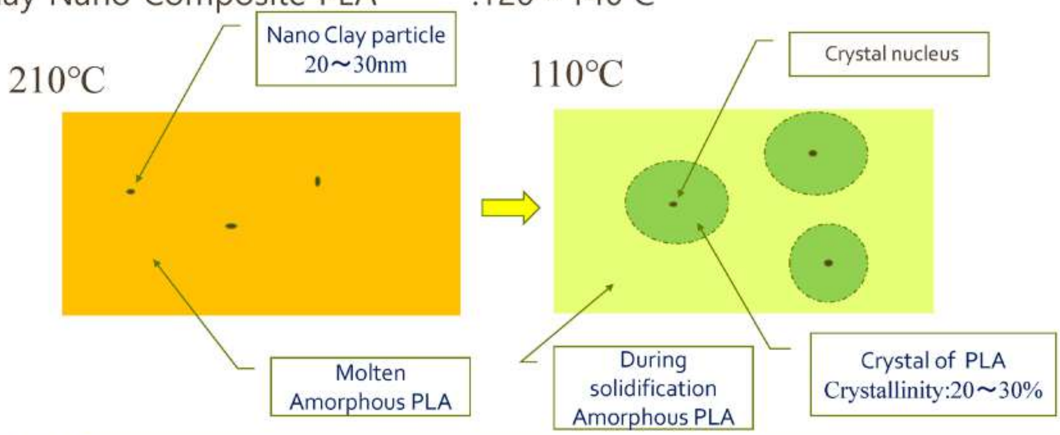
7. Summary

PLA Heat-resistant temperature :60 ~ 65℃

⇩

Clay Nano Composite PLA :120 ~ 140℃



N-PLAjet®

Specialized for PLA Injection Molding, Fully Electric Drive

©NISSEI PLASTIC INDUSTRIAL (2010, Japan)

HOEI®

JAPAN AIRLINE

Adopted in international first class lounges at Narita and Haneda airports

iiwan®

Hoei industry Co.,Ltd.

GOOD DESIGN AWARD 2011

Microwave and dishwasher safe!

HOEI®

iiwan®

Tablewares for Baby

GOOD DESIGN AWARD 2011

Iiwan®
Official Online Shop

Highly rated on Amazon, Rakuten !

Cosmetic soap container

TOWA KAGAKU(Yokohama, Japan)

Funeral urn for burial

Iwaki City(Japan)

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7. Summary

- Good heat retention
- Lightweight
- Beautiful texture surface

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7. Summary

The thinnest in the world
PLA Injection Molded Cup（0.65mm）@Nice, Mediterranean

SanYoshi

世界最薄0.53mm、PLAグラス & 四角形容器 IZ EARTH

超臨界CO_2成形の真骨頂！
世界最薄0.53mmグラス & 四角形容器をリリース
カクテルパーティーやスイーツ容器に最適！
軽さ、剛性、口当たりのバランスが◎

内容量：IZ EARTH グラス：約200ml
IZ EARTH 四角形容器(大)： 約160ml
IZ EARTH 四角形容器(小)： 約130ml

IZ EARTH公式
⇩製品紹介ページ⇩

SanYoshi

PLA & Natural lacquer
SHISUIHAI
紫翠盃

EXPO 2020 DUBAI UAE

JAPAN EXPO 2020 DUBAI

（SOURCE：JETRO）

EXPO2020 DUBAI
Adopted as Japan Pavilion VIP Commemorative item

SanYoshi

SDGs Ring

SAN-EI

PLA & Cashew nut paint（Biomass 99.9%)

植物由来成分のバイオプラスチック × 会津の蒔絵師

SANYOSHI
Official Online Shop⇩

21 2025/09/09

NISSIN THINK GLOBAL MAKE GLOBALLY

135mm,World's largest flow length

[Bio7Hepta]

350ml PLA GLASSE

◇Large volume drink glass made by CO_2 SCF Injection molding.

◇Bio7, heptagon shape design, Prime numbers Unbreakable, Lucky numbers

◇Ultra-thin but Unbreakable, Delicious to drink

22 2025/09/09

NISSIN THINK GLOBAL MAKE GLOBALLY

23 2025/09/09

50cc x 4 levels, also useful as a measuring device
[4Tiers]

PLA GLASSE

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7. Summary

Beer bubbles become finer
by Glass surface fine dimples caused by SCF CO_2 or N_2.

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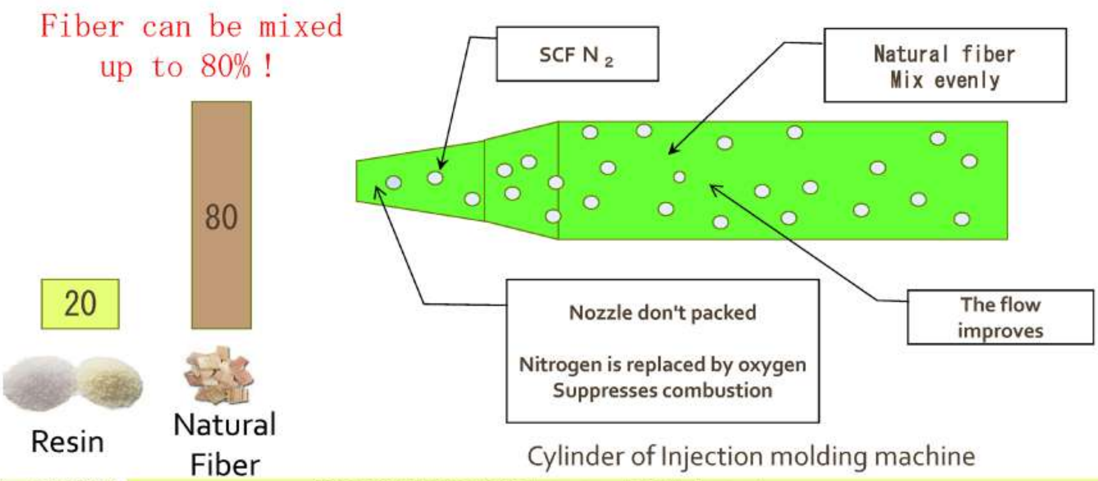
7. Summary

Injection molding becomes possible when supercritical nitrogen is mixed into resin containing natural fiber



Foam made by mixing wood fiber and PLA with SCF N2

The resin viscosity can be reduced for filling.

The foam size can be controlled by core back and core push process.

The fragrance of wood can last for a long time

Camino New Sustainable Alternative to Petroleum-based Plastic
Made Purely with Paper & Biodegradable Plastic (PLA)

PAPLUS®

Camino

Paper powder × PLA

PAPLUS®

GOOD DESIGN AWARD 2023

PAPLUS®
Food Tray

PAPLUS®
Multi Purpose Tray

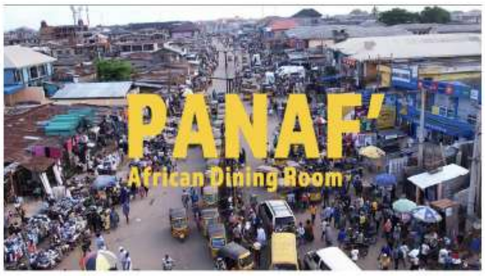
Paper powder & SCF N_2 creates natural color and stream patterns.

Straight Design without gradient fits comfortably in your hand.

EXPO2025 OSAKA

New Sustainable Alternative to Petroleum-based Plastic
Made Purely with Paper & Biodegradable Plastic (PLA)

PAPLUS®



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7. Summary

PLA Resin producing country
USA, Thailand, Germany, CHINA, DUBAI Low Material Cost

Main product item/ Low Value Products: Sheet, Textile, Vacume molded goods

JAPAN:100% Import High Material Cost, Weak Yen

Main product item/High Value Products by Injection molding
: Heat resistant tableware, Ultra Thin wall glass, SCF application, Waste Recycle
:Technologies/ Valve gate system, SCF system, Multi cavity mold,
All electric injection molding machine , Sensing system
Patents & KnowHow, Mold design

MATERIAL x Technology ⇒Consumer market

It all starts at K

The World's No. 1 Trade Fair for Plastics and Rubber

8-15 OCTOBER 2025, Düsseldorf, Germany

The Power of Plastics!
Green – Smart – Responsible

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Integrated Waste Treatment and Carbon (CO2) Capture and Conversion Technologies

Dr Grzegorz Lisak

Associate Professor of School of Civil and Environmental Engineering, Nanyang Technological University

Dr Lisak is a tenured associate professor at the School of Civil and Environmental Engineering, Nanyang Technological University (NTU) Singapore. He is a director of Residues and Resources Reclamation Center and Deputy Executive Director at Nanyang Environment and Water Research Institute, NTU. He is co-editor-in-chief of Environmental Research journal, Elsevier.


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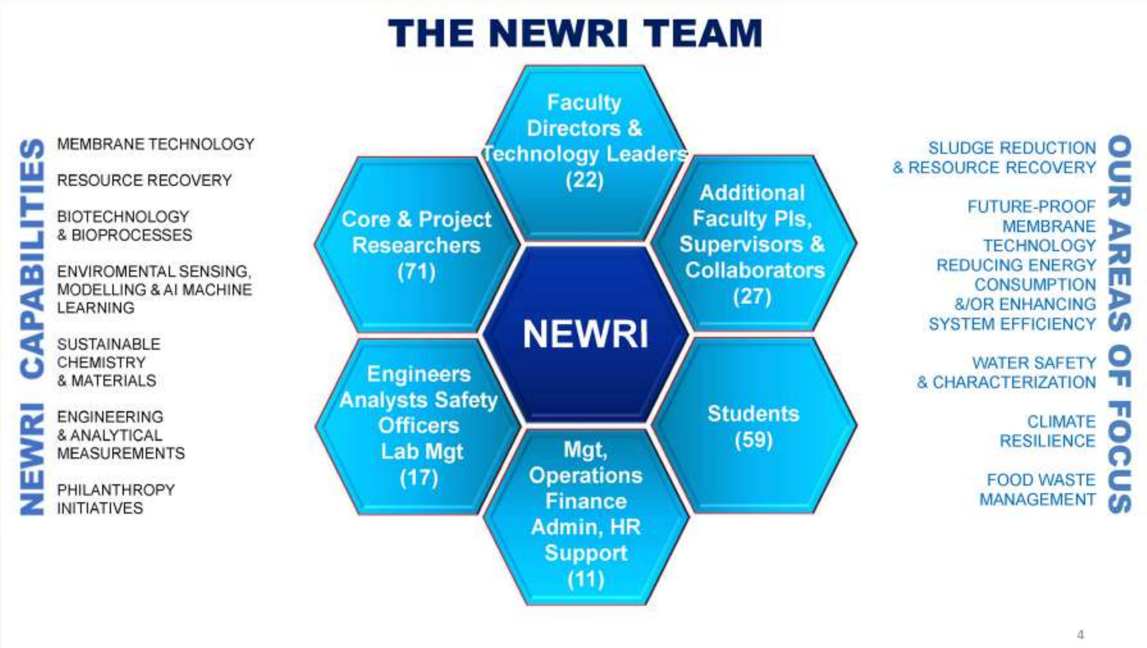
FUTURE-PROOF MEMBRANE TECHNOLOGY REDUCING ENERGY CONSUMPTION &/OR ENHANCING SYSTEM EFFICIENCY
WATER SAFETY & CHARACTERIZATION
CLIMATE RESILIENCE
FOOD WASTE MANAGEMENT
OUR AREAS OF FOCUS
3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ENGINEERING & ANALYTICAL MEASUREMENTS
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Students (59)
Mgt, Operations Finance Admin, HR Support (11)
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FUTURE-PROOF MEMBRANE TECHNOLOGY REDUCING ENERGY CONSUMPTION &/OR ENHANCING SYSTEM EFFICIENCY
WATER SAFETY & CHARACTERIZATION
CLIMATE RESILIENCE
FOOD WASTE MANAGEMENT
OUR AREAS OF FOCUS
4


BIOTECHNOLOGY & BIOPROCESSES
ENVIRONMENTAL CHEM. & MATERIALS
RESOURCE RECOVERY
MODELLING & AI
NEWRI
Diverse strength for innovation
ENGINEERING & ANALYTICS
MEMBRANE TECHNOLOGY
5

FOCUSED ON NATIONAL & GLOBAL NEEDS

6

GLOBAL PLASTIC WASTE PROBLEM: Understanding challenges related to the plastic waste

>90% non-recyclable plastic waste

14 million tonnes of plastic waste enter our oceans every year

Expensive to collect and process. When collected, it is incinerated or dumped in landfills

IMPACT OF PLASTICS ON CLIMATE CHANGE

Incineration:

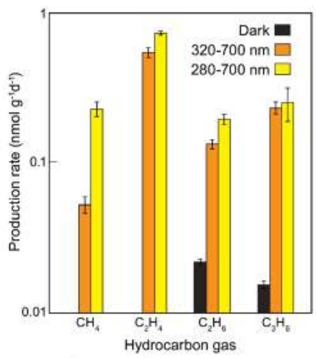
3.2 tonne CO_2e/tonne plastic waste

924,000 tonnes plastics incinerated in Singapore in 2021

~3,000,000 tonne CO_2e emissions/year

Greenhouse gas protocol: ghgprotocol.org
National Environment Agency, Singapore: nea.gov.sg

Plastics leaked into the environment:



doi.org/10.1371/journal.pone.0200574

Can we change this to make a **positive impact?**

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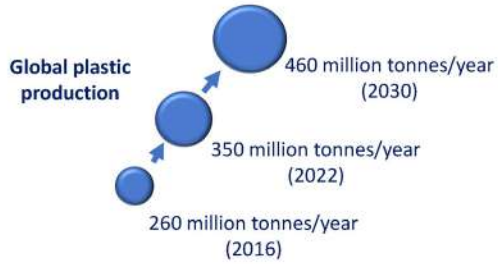
OUTLOOK ON PLASTICS PRODUCTION AND PLASTIC WASTE MANAGEMENT

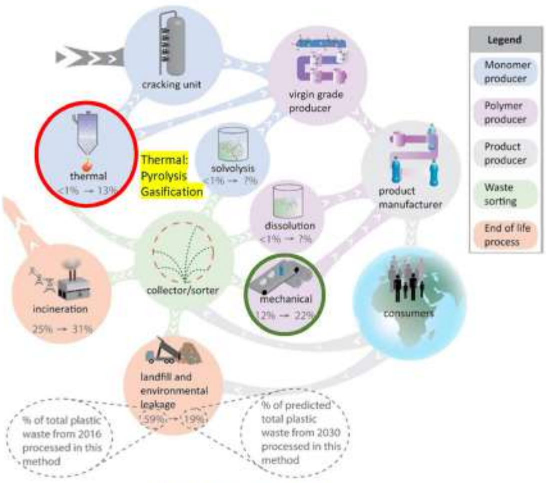


Growth in profit pool (2016 to 2030)

Pyrolysis (chemical recycling): $25.4 billion

Mechanical recycling: $23.1 billion

Incineration: $0.2 billion



Plastic value chain

https://verra.org/programs/plastic-waste-reduction-standard/

doi.org/10.1002/anie.201915651

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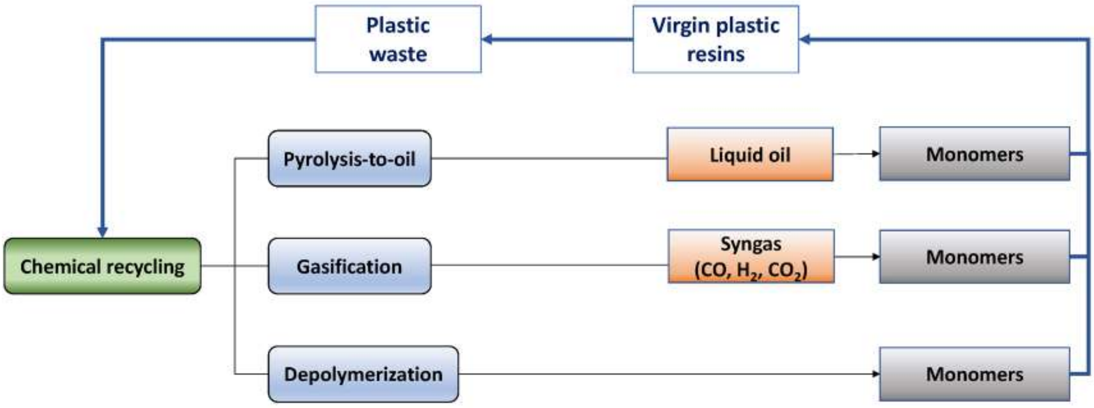
CHEMICAL RECYCLING TECHNOLOGIES FOR PLASTIC WASTE

Closed-loop chemical recycling (back-to-monomer)



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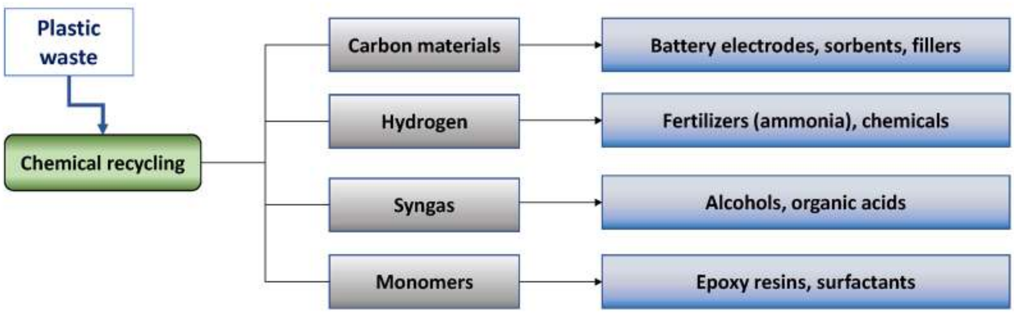
CHEMICAL RECYCLING TECHNOLOGIES FOR PLASTIC WASTE

Open-loop chemical recycling (upcycling)

Plastics are converted into outputs that exit plastic utilization loop, they may or may not enter a new loop



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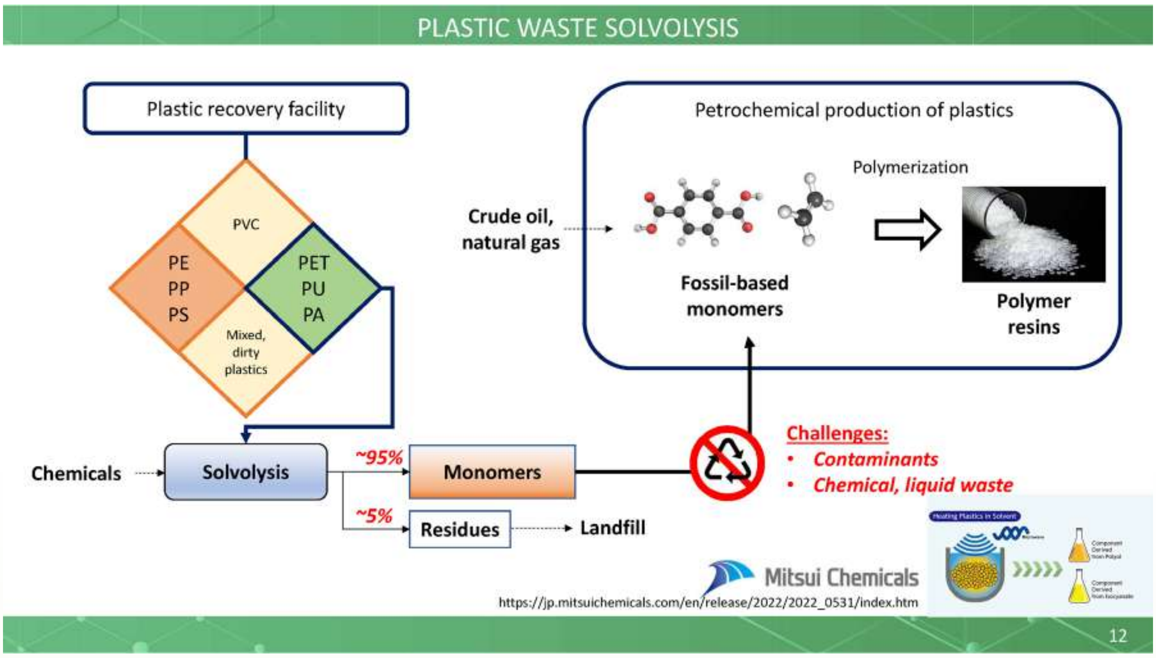
PLASTIC WASTE SOLVOLYSIS
Plastic recovery facility
PVC
PE
PP
PS
PET
PU
PA
Mixed, dirty plastics
Chemicals
Solvolysis
~95%
Monomers
~5%
Residues
Landfill
Crude oil, natural gas
Petrochemical production of plastics
Polymerization
Fossil-based monomers
Polymer resins
Challenges:
• Contaminants
• Chemical, liquid waste
Mitsui Chemicals
https://jp.mitsuichemicals.com/en/release/2022/2022_0531/index.htm
Heating Plastics in Solvent
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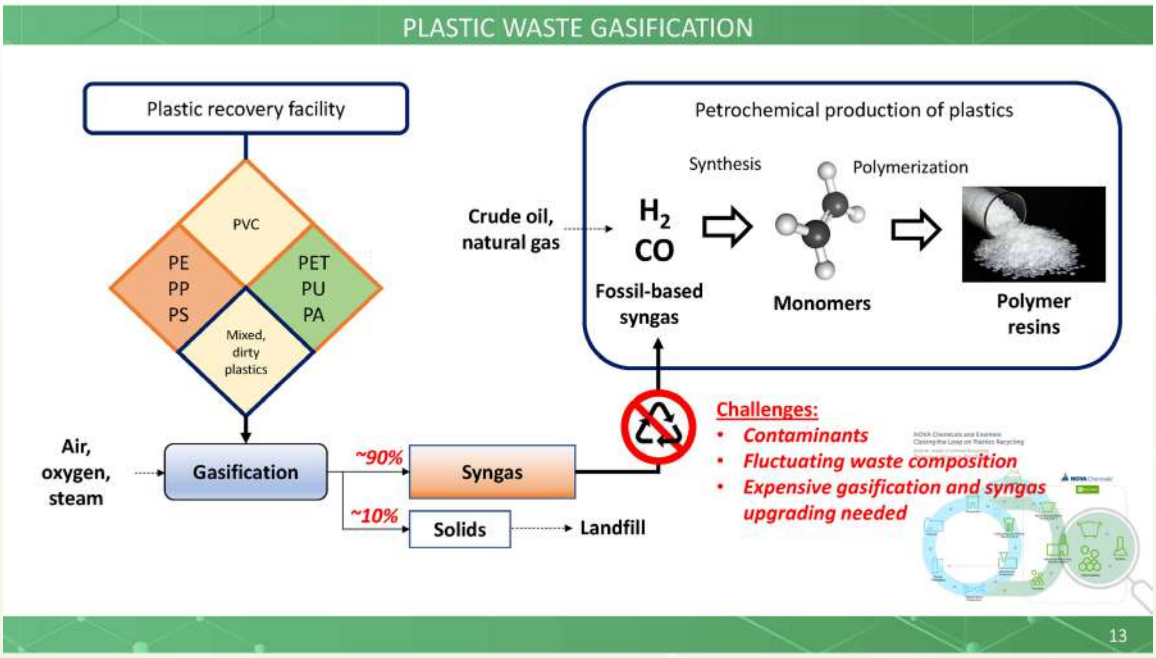
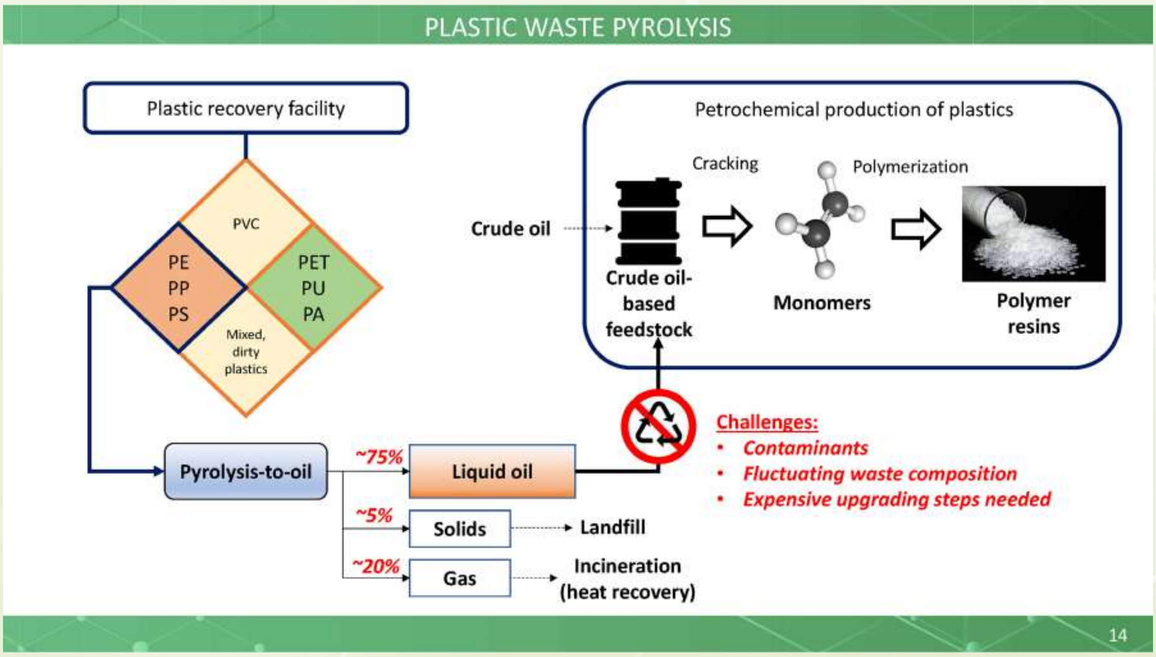

PLASTIC WASTE GASIFICATION
Plastic recovery facility
PVC
PE
PP
PS
PET
PU
PA
Mixed, dirty plastics
Air, oxygen, steam
Gasification
~90%
Syngas
~10%
Solids
Landfill
Crude oil, natural gas
Petrochemical production of plastics
Synthesis
Polymerization
H_2
CO
Fossil-based syngas
Monomers
Polymer resins
Challenges:
• Contaminants
• Fluctuating waste composition
• Expensive gasification and syngas upgrading needed
13


PLASTIC WASTE PYROLYSIS
Plastic recovery facility
PVC
PE
PP
PS
PET
PU
PA
Mixed, dirty plastics
Pyrolysis-to-oil
~75%
Liquid oil
~5%
Solids
Landfill
~20%
Gas
Incineration (heat recovery)
Crude oil
Petrochemical production of plastics
Cracking
Polymerization
Crude oil-based feedstock
Monomers
Polymer resins
Challenges:
• Contaminants
• Fluctuating waste composition
• Expensive upgrading steps needed
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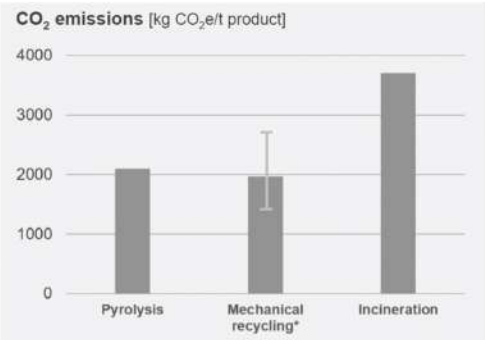
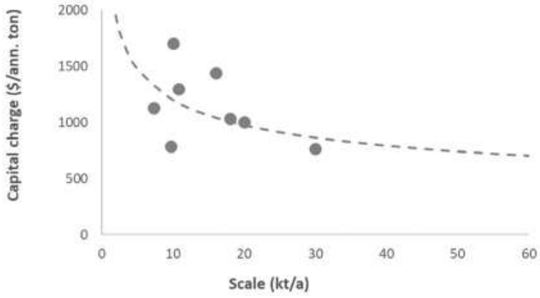
CARBON FOOTPRINT OF PLASTICS FROM PYROLYSIS OIL



CO_2 emissions of various end-of-life scenarios for polyolefins



Effect of economies of scale on investment cost

doi.org/10.1021/acssuschemeng.1c05013

CERTIFIED PLASTIC WASTE PYROLYSIS PLANTS IN ASIA

ISCC-PLUS-Cert-US201-70601689	Delta-Energy Group, Natchez, Mississippi, United States	CP, PYP	end-of-life ...	--	2022-07-26	2023-07-25	SCS	
ISCC-PLUS-Cert-US201-70601476	Bolder Industries, Maryville, MO, United States	PO, CP, PYP, MRP, WH	end-of-life ...	--	2022-04-04	2023-04-03	SCS	
ISCC-PLUS-	ARCUS Greencycling	PYP	Mixed		2022-	2023-	DIN	

Country	Company	Chemical recycling	Plastic type
Thailand	Circular Plas Company Limited	Pyrolysis	Mixed plastic waste
	Sepco Industries Company	Pyrolysis	Mixed plastic waste
	Corsair Bangkok Company Limited	Pyrolysis	Mixed plastic waste
Malaysia	Heng Hiap Industries Sdn Bhd	Pyrolysis	Mixed plastic waste
Singapore	Environmental Solutions (Asia) Pte Ltd	Pyrolysis	Mixed plastic waste
China	Poseidon Global Industries, Corp Ltd	Pyrolysis	Mixed Plastic waste
	ENRESTEC	Pyrolysis	Mixed plastic waste
	BASF Chemicals Company Limited (BACH)	Pyrolysis	Mixed plastic waste

PLASTIC WASTE PYROLYSIS IN SINGAPORE

Environmental Solutions Asia Pte Ltd, Singapore

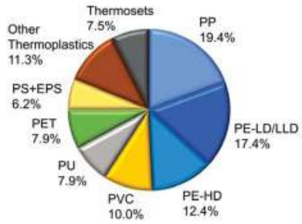
Market Feasibility
Prototyping
Feedstock Trials

Partnerships
ISCC Plus Certification
1st Commercial ISCC Isotank to offtaker
300TA Proof of Concept

Feedstock Security
10KTA Capacity Industrial Scale build up
Expansion into other sites (domestic and regional)

Information provided by Environmental Solutions Asia Pte Ltd

	Pyrolysis-to-oil	Gasification	Solvolysis
Usable feedstock	PP, LDPE, HDPE	PP, LDPE, HDPE, PET, PU, others, except PVC	PET, PU, PA
Percent of plastics that can be used	~60%	~90%	~18%
Recovered products	Liquid oil (naphtha)	Syngas (H_2 + CO)	Monomers
Challenges	• Contaminants (PVC, food residues, paper, etc.) • Fluctuations in waste composition • Expensive upgrading	• Contaminants (PVC) • Fluctuations in waste composition • Expensive gasification and syngas upgrading	• Contaminants (everything) • Chemicals, waste



Reason 1: To overcome technical challenges

Multi-layered materials

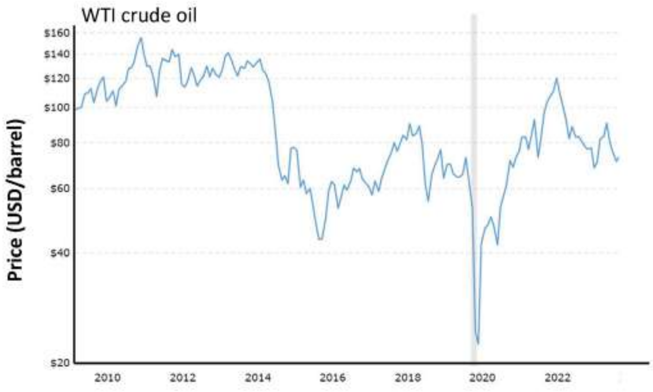
Food contaminated packaging

Plastics from the environment

Day 0 Day 57 Day 183 Day 390

Biofouling on PP cup in seawater
(doi.org/10.1038/s41598-020-67927-1)

Reason 2: To diversify product portfolio and increase business resilience



Fluctuation of crude oil prices

WHY THERE IS INTEREST TO OPEN-LOOP TECHNOLOGIES?

Reason 3: To have alternative solutions for scale up


An official website of the European Union How do you know?

European Commission

English Search Search

Home > Press corner > Political agreement on stronger control of exports of waste

Available languages: English

PRESS RELEASE | 17 November 2023 | Brussels

Commission welcomes political agreement on stronger control of exports of waste

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- Quote(s)
- Related topics
- Print friendly pdf
- Contacts for media

The Commission **welcomes the political agreement** reached last night between the European Parliament and the Council on waste shipments, which will ensure that the **EU takes greater responsibility for its waste** and does not export its environmental challenges to third countries. The rules will also facilitate the use of waste as a resource. The agreement is a contribution to the goal of the European Green Deal of reducing pollution and advancing the circular economy.

Export of plastic waste from the EU to non-OECD countries will be prohibited. Only if strict environmental conditions are met, individual countries may receive such waste five years after the entry into force of the new rules. In the light of the global problems of soaring amounts of plastic waste and the challenges to its sustainable management, with this measure the EU legislators aim to prevent environmental degradation and pollution in third countries caused by

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CRUCIAL SUCCESS FACTORS

Processing contaminated waste	Economic viability	Environmental impact
Larger quantities of recyclable plastics	Product diversification Products with higher value	Lower carbon footprint Recover more products

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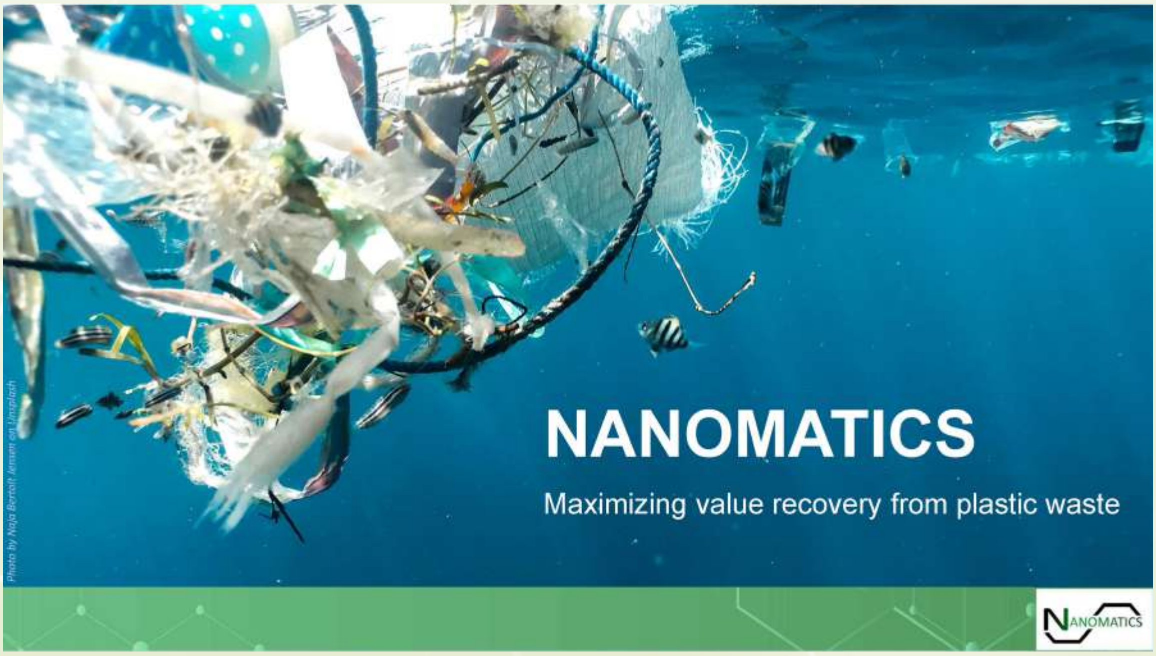

GLOBAL PLASTIC WASTE PROBLEM

- **Diverse** plastic waste **composition**.
- **Contamination** by food, paper, inks, etc.
- **Expensive** to collect and process. The **value** of products is **too low** to cover the recycling cost.

2015	Start of research at Nanyang Technological University on plastic waste upcycling
2021	Lab-scale technology development was completed
2021	Nanomatics Pte Ltd was founded to scale up the technology and create positive impact on sustainability
2024	Demonstration plant (Tuas, Singapore)

Nanomatics 2025 24

DEVELOPING NEXT GENERATION PYROLYSIS-BASED TECHNOLOGY

Nanomatics Pte Ltd, Singapore

Hard to recycle plastic waste →

Pyrolysis oil +

Solid carbon (carbon nanotubes) +

H_2

Low-carbon hydrogen

Robust process
Suitable for:
Mixed household waste
Marine plastic litter
Flexible laminate packaging

High market price
Solid carbon and hydrogen prices > pyrolysis oil price

Cleaner fuel
Cleaner than hydrogen from natural gas

Nanomatics 2024 25

THERMO-CVD TECHNOLOGY: MAXIMIZING VALUE RECOVERY FROM PLASTIC WASTE

Total SGD 11,800 from 1 tonne plastic waste
Estimated Product Value

Mixed plastic waste
Marine plastic litter
1,000 kg

Heating source · Proprietary catalyst · Fuel gases

Shredding → Pyrolysis reactor → Oil condenser → CVD reactor → Gas purification

Aluminum	Oil	Carbon nanotubes	Hydrogen
20-30 kg	300-500 kg	200-300 kg	30-40 kg
SGD 100	SGD 600	SGD 11,000	SGD 100

Carbon savings
CO_2

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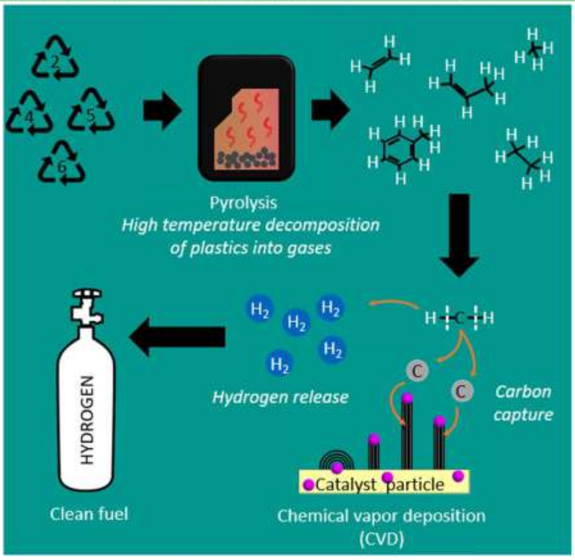
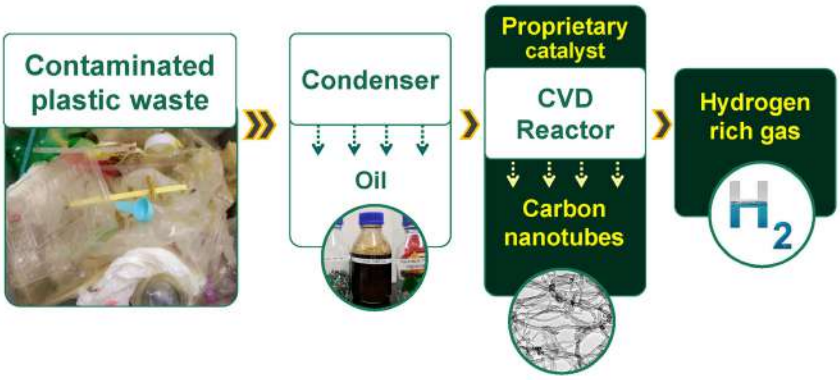
HOW THERMO-CVD TECHNOLOGY WORKS

Plastic	Hydrogen (wt.%)	Carbon (wt.%)
2 HDPE	12-15	84-87
4 LDPE	10-13	70-86
5 PP	12-14	77-88
6 PS	7-8	83-93



OUR TECHNOLOGY



Outputs with industrial demand

Deployment in zones with plastic waste pollution

Plastic waste reduction solution

Alignment with circular economy and ESG targets


NEWNANO
Sustainable Carbon Nanotubes


APPLICATIONS
3D printed parts from SLA resin with MWCNTs
Plastic composites
Li-Ion
Li-ion battery electrodes
NEWNANO Carbon nanotubes from plastic waste
Polyamide/MWCNT thread and textile
Textile
EVA midsole with 0.5 wt.% carbon nanotubes (Nanomatics)
Rubber
Nanomatics 2025
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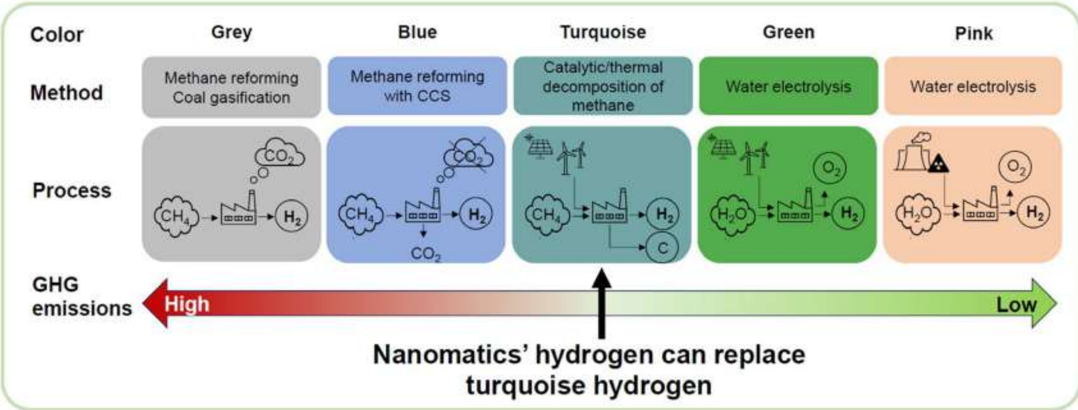
HYDROGEN
Key resource for the
decarbonization of economy

HYDROGEN FROM PLASTIC WASTE



Replaces H_2 made from natural gas | **Eligible for ISCC PLUS certification**

MAKING IMPACT ON SUSTAINABILITY

Suitable for
mixed contaminated plastics
with **minimum pre-processing**
(marine plastic litter, mixed plastics)

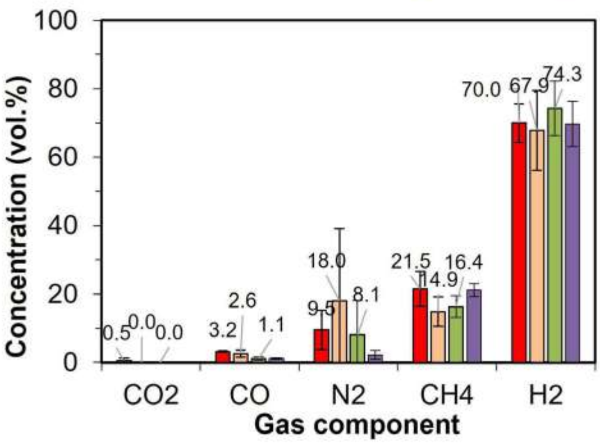
↓ **CO_2 emissions** by **70%** compared to incineration

↓ **waste disposal** by **90%**

HYDROGEN FROM PLASTIC WASTE

How much hydrogen can be recovered?

1,000 kg plastic waste gives 40-60 kg hydrogen



Type of plastic feedstock
- Marine plastic litter (Lombok, ID)
- Post-consumer household plastics (Pasir Ris, SG)
- Pure PP+PE resins

Post-consumer plastic
Pasir Ris, SG

Marine plastic
Lombok, ID

Data provided by Nanyang Technological University, Singapore

Summary

- Plastic is challenging material with high environmental consequences
- The integration of chemical recycling into waste management practices offers maximization of resource recovery
- Plastic chemical recycling offers opportunities beyond only treatment of plastic and obtaining the pyrolytic oil
- Recovery of carbon nanomaterials from plastic waste provides new view how to make pyrolysis technology economically viable.

BUILDING BETTER FUTURE TOGETHER

Let's change the world!

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Grzegorz Lisak, M.Eng., Ph.D.,

Associate Professor

■ **Residues and Resource Reclamation Centre (R3C)**
Nanyang Environment & Water Research Institute (NEWRI)
Nanyang Technological University.

■**School of Civil and Environmental Engineering (CEE), Nanyang Technological University.**

■Contact:
Email: g.lisak@ntu.edu.sg
Room: CEE, N01-01c-77; CleanTech One #06-08

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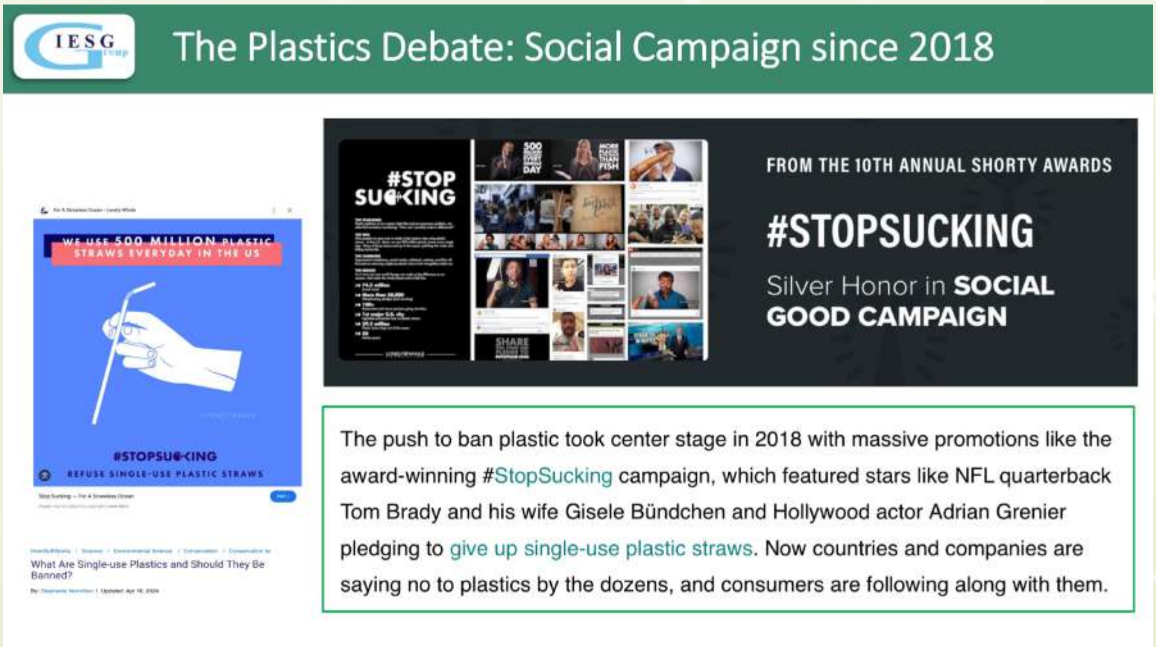
The Challenges and Opportunities of Plastic Circularity, Life Cycle Net-Zero Environmental Footprint and Sustainability

Prof Elvis Au, BBS

Adjunct Professor of the University of Hong Kong and Co-founder of IESG Technologies Ltd

Ir Prof Au, BBS, is the former Deputy Director of Environmental Protection Department of the HKSAR Government and an Adjunct Professor of HKU, focusing on sustainability, circular economy, decarbonisation and life cycle assessment. He is the former President of International Association for Impact Assessment. He has over 40 years of experiences and has masterminded many environmental policies, including the EIA Ordinance, green building and green procurement policies and large waste to energy facilities. He is a co-founder of IESG Technologies Ltd., utilising artificial intelligence and digital technologies for decarbonisation and circular economy.



The Challenges and Opportunities of Plastic Circularity, Life Cycle Net Zero Environmental Footprint and Sustainability

Global Plastic Treaty Talks in August 2025 Failed

The Challenges and Opportunities of Plastic Circularity, Life Cycle Net Zero Environmental Footprint and Sustainability

Controversies over the Global Treaty Talks

The Issues	Points of Contentions or Views
Trust and sincerity in reaching an agreement	Dennis Clare, of Micronesia: while it was always difficult to negotiate shared goals in a multilateral forum with almost 200 countries, it was "especially difficult if there is no meeting of the minds on what the goals are," he said. (The Guardian)
Core Dividing Line: Different Foci and Diverse views Caps on plastic production globally	The core dividing line between countries: whether the treaty should **tackle plastics at source** – by reducing production –**or** focus on **managing the pollution** that comes from it. ."***There remained a split between a group of about 100 nations calling for curbs on production of plastic, and oil states pushing for a focus on recycling.***" (BBC)
Confidence in recycling to solve the problems	"***Even if we manage to boost that over the next few decades to 15, 20, 30%, it would remain a substantial amount that is polluting the environment and damaging human health,***" said Dr Costas Velis, associate professor in Waste and Resource Engineering at Imperial College London.

The Challenges and Opportunities of Plastic Circularity, Life Cycle Net Zero Environmental Footprint and Sustainability

The Problems with Plastics: Science, Values, Perceptions, Myths & Politics

KEY FACTS: THE PROBLEM WITH PLASTICS

PLASTIC EXPLOSION

- The amount of plastic produced has grown rapidly over the last few decades
- It is used in thousands of products, from sewage pipes to life-saving medical equipment
- In 1950 two million tonnes was produced
- By 2022 that had risen to **475 million tonnes**, equivalent to the weight of about 250 million cars

THE PROBLEM

- When it enters the environment, most plastic breaks down into tiny pieces - known as **microplastics**
- Microplastics are found across all geographical ranges, from the deep sea to mountain tops

IMPACT: THE PLANET

- Microplastics cause a particular problem in oceans and other marine environments, where **wildlife can ingest it**
- Scientists are learning more and more about the full impact
- "When we [get] accumulation of plastic in tissues we start seeing inflammation, cell damage, hormonal changes...they get weaker and weaker, and sicker and sicker, and either become diseased or die," said Dr Alice Horton, research scientist at the National Oceanography Centre

IMPACT: HUMANS

- Plastics can contain more than **16,000 chemicals** such as dyes and flame retardants, some of which are toxic and cancer-causing
- Plastics are a "grave, growing and under-recognised danger" for human health, according to the Lancet Countdown report
- The impact on humans ranges from air pollution from the production of plastic, through to elevated risk of cancer, respiratory illnesses and miscarriages from plastic contamination in our bodies

Source: BBC

"Plastics are fundamental for modern life - they go in everything," said Ross Eisenberg, president of America's Plastic Makers, a trade association for the plastic production industry in the United States."Focusing on ending plastic pollution should be the priority here, not ending plastic production," he added, warning that attempts to substitute plastics with other materials could lead to "unintended consequences".

But many researchers warn that this approach is fundamentally flawed. Global recycling rates are estimated at only about 10%, with limits on how far that can rise…Despite the benefits of plastic to almost every sector, scientists are particularly concerned about potentially toxic chemicals they contain, which can leach out as plastics break down into smaller pieces. Microplastics have been detected in soils, rivers, the air and …the human body.

The Challenges and Opportunities of Plastic Circularity, Life Cycle Net Zero Environmental Footprint and Sustainability

Common Misunderstanding: Differences between "Resource" and "Waste"

	Resource	Waste
Definition	Used for needs/wants EU EFRAG Draft ESRS E5: *"Asset from which a product is sourced, produced, supplied or utilised."* Oxford English Dictionary *"A means of supplying a deficiency or need….."*	Unwanted after use Article 3(1) of the EU WFD defines waste as *'any substance or object which the holder discards or intends or is required to discard'*. **Any substance or object is either waste or non-waste. The EU WFD's concepts 'by-product' and 'end-of-waste' introduce a distinction between waste and non-waste.** HKSAR Waste Disposal Ordinance: *"waste means any substance or article which is abandoned……"*
Usage	Productive/Consumptive	Disposal/Transformation
Impact	Can be beneficial/harmful	Generally negative, but can be transformed
Management	Conservation, extraction	Recycling, disposal

Plastic Pollution: The Need for a Balanced Approach

"Turning off the Tap. How the world can end plastic pollution and create a circular economy"

Plastics, in many ways, contribute positively to society. There is, however, a dark side: the way we produce, use and dispose of plastics is polluting ecosystems, creating risks for human and animal health and destabilizing the climate.

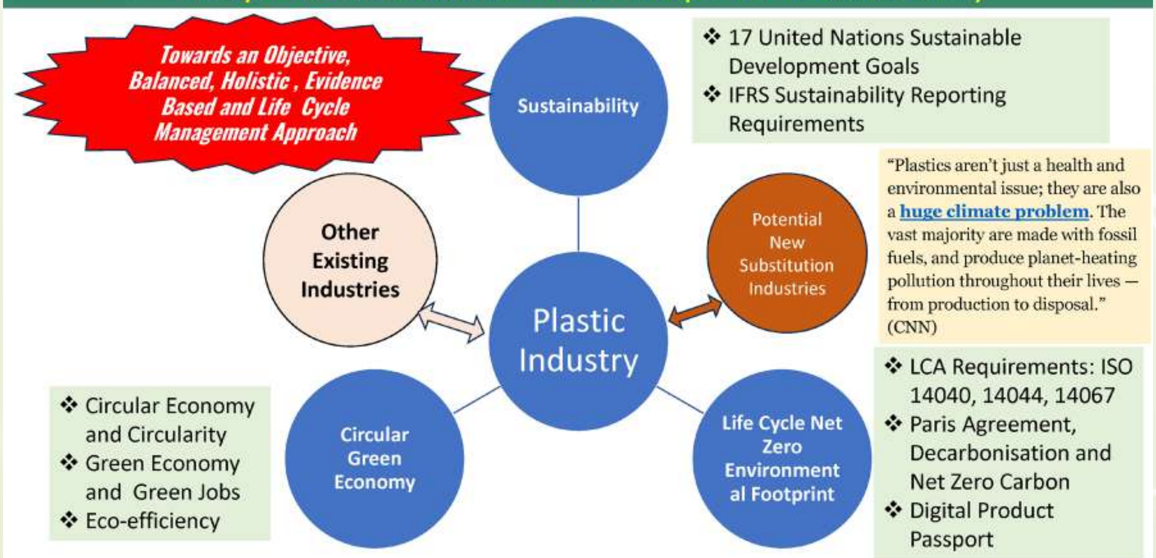
For these reasons, the international community is negotiating a deal to end plastic pollution, which is due by 2024. This report, *Turning off the Tap: How the world can end plastic pollution and create a circular economy*, is designed to inform negotiations and help end this pervasive and growing threat.

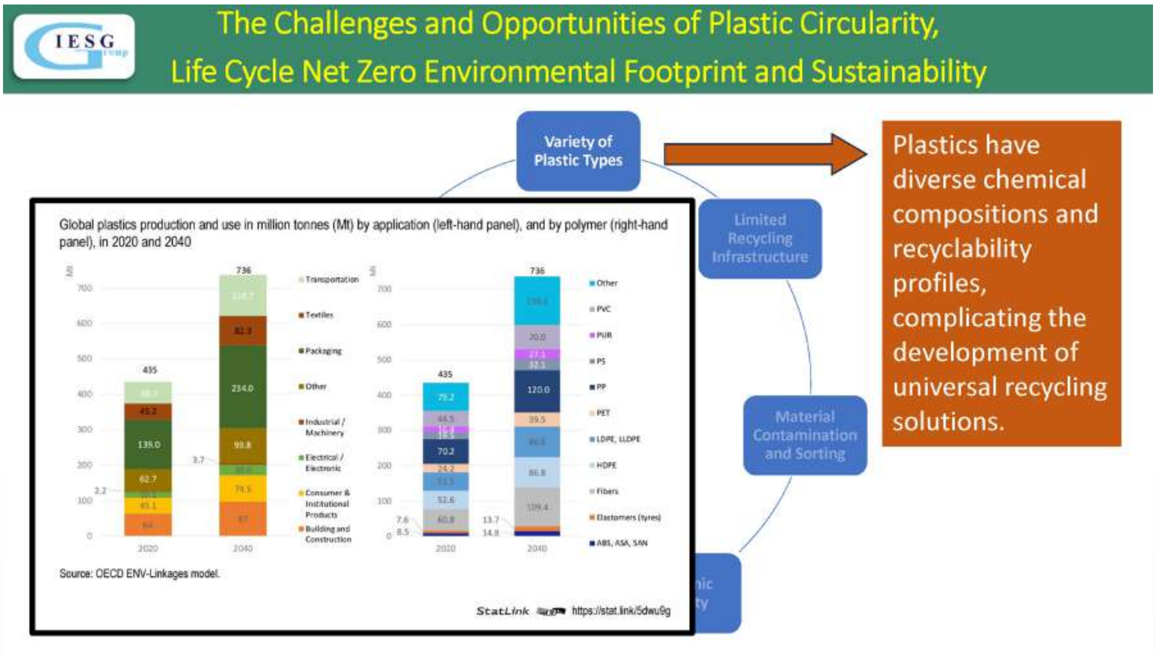
Inger Andersen
Executive Director, UNEP

The call for a balanced approach towards Plastics: Positive Contribution Vs the Dark Side

Plastic pollution - defined broadly as the negative effects and emissions resulting from the production and consumption of plastic materials and products across their entire life cycle. This definition includes plastic waste that is mismanaged (e.g. open-burned and dumped in uncontrolled dumpsites) and leakage and accumulation of plastic objects and particles that can adversely affect humans and the living and non-living environment (UNEP/PP/INC.1/7).

The Challenges and Opportunities of Plastic Circularity, Life Cycle Net Zero Environmental Footprint and Sustainability





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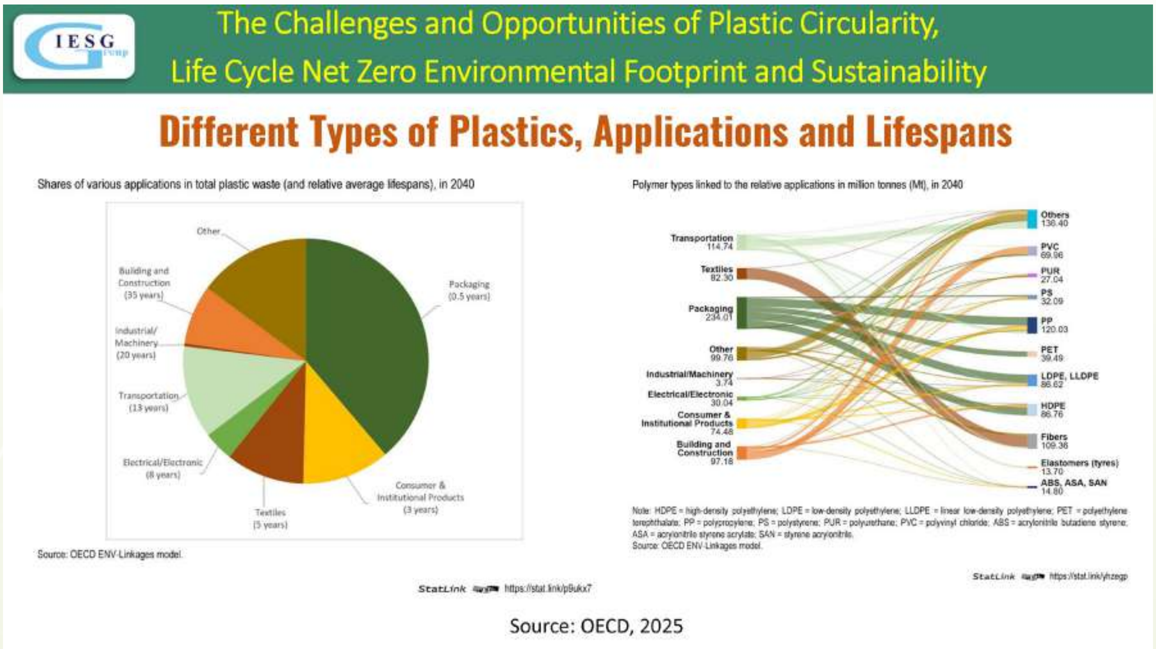
The Challenges and Opportunities of Plastic Circularity,
Life Cycle Net Zero Environmental Footprint and Sustainability
Variety of Plastic Types
Limited Recycling Infrastructure
Material Contamination and Sorting
Plastics have diverse chemical compositions and recyclability profiles, complicating the development of universal recycling solutions.
Global plastics production and use in million tonnes (Mt) by application (left-hand panel), and by polymer (right-hand panel), in 2020 and 2040
Transportation
Textiles
Packaging
Other
Industrial / Machinery
Electrical / Electronic
Consumer & Institutional Products
Building and Construction
Other
PVC
PUR
PS
PP
PET
LDPE, LLDPE
HDPE
Fibers
Elastomers (tyres)
ABS, ASA, SAN
Source: OECD ENV-Linkages model.
StatLink https://stat.link/5dwu9g



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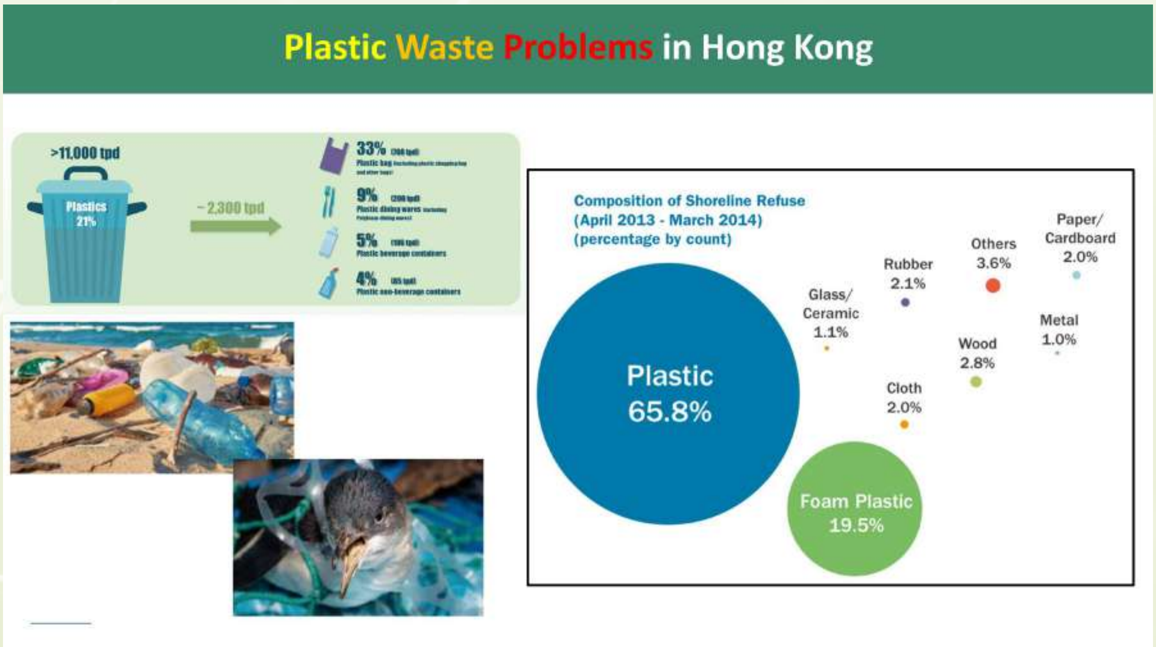
The Challenges and Opportunities of Plastic Circularity,
Life Cycle Net Zero Environmental Footprint and Sustainability
Different Types of Plastics, Applications and Lifespans
Shares of various applications in total plastic waste (and relative average lifespans), in 2040
Other
Building and Construction (35 years)
Industrial/ Machinery (20 years)
Transportation (13 years)
Electrical/Electronic (8 years)
Textiles (5 years)
Consumer & Institutional Products (3 years)
Packaging (0.5 years)
Source: OECD ENV-Linkages model.
StatLink https://stat.link/p9ukx7
Polymer types linked to the relative applications in million tonnes (Mt), in 2040
Transportation 114.74
Textiles 82.30
Packaging 234.01
Other 99.76
Industrial/Machinery 3.74
Electrical/Electronic 30.04
Consumer & Institutional Products 74.48
Building and Construction 97.18
Others 130.40
PVC 69.96
PUR 27.04
PS 32.09
PP 120.03
PET 39.49
LDPE, LLDPE 86.62
HDPE 86.76
Fibers 109.36
Elastomers (tyres) 13.70
ABS, ASA, SAN 14.80
Note: HDPE = high-density polyethylene; LDPE = low-density polyethylene; LLDPE = linear low-density polyethylene; PET = polyethylene terephthalate; PP = polypropylene; PS = polystyrene; PUR = polyurethane; PVC = polyvinyl chloride; ABS = acrylonitrile butadiene styrene; ASA = acrylonitrile styrene acrylate; SAN = styrene acrylonitrile.
Source: OECD ENV-Linkages model.
StatLink https://stat.link/yhzegp
Source: OECD, 2025



Plastic Waste Problems in Hong Kong
>11,000 tpd
Plastics 21%
~2,300 tpd
33%
9%
5%
4%
Composition of Shoreline Refuse
(April 2013 - March 2014)
(percentage by count)
Plastic 65.8%
Foam Plastic 19.5%
Glass/ Ceramic 1.1%
Rubber 2.1%
Others 3.6%
Paper/ Cardboard 2.0%
Metal 1.0%
Wood 2.8%
Cloth 2.0%


The Challenges and Opportunities of Plastic Circularity,
Life Cycle Net Zero Environmental Footprint and Sustainability
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Variety of Plastic Types
Policy and
Limited Recycling Infrastructure
Material Contamination and Sorting
Viability
Maturity:
Only about 9% of global plastic waste is recycled due to inadequate collection, sorting, and recycling systems, particularly in low- and middle-income countries.


The Challenges and Opportunities of Plastic Circularity,
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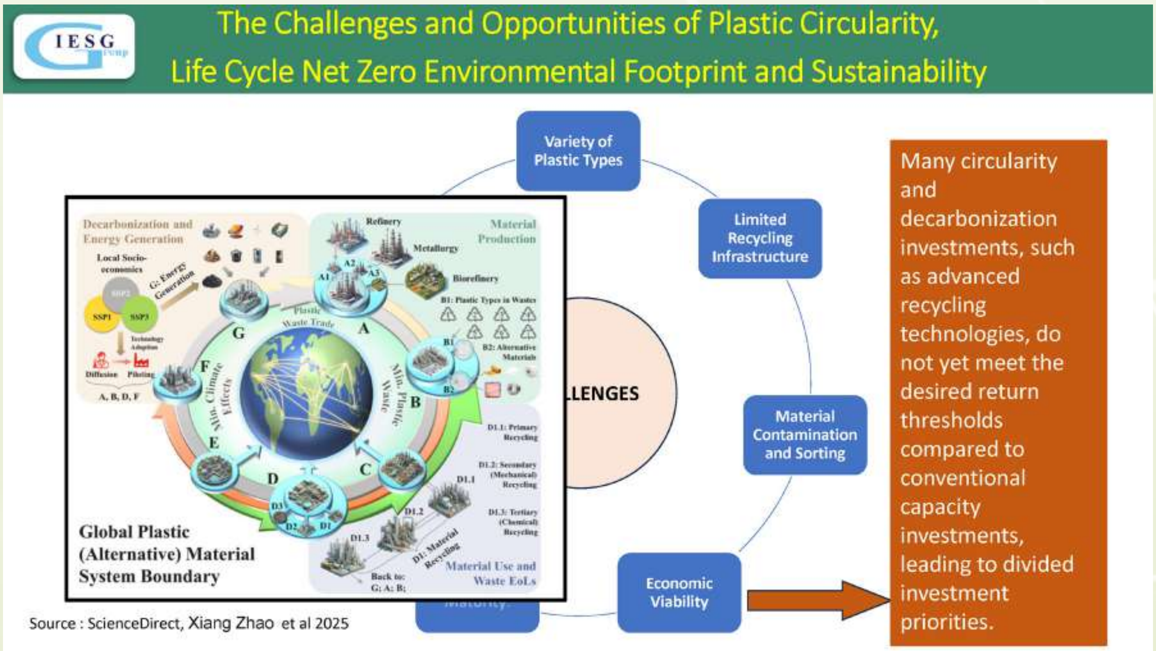
IESG
Variety of Plastic Types
Limited Recycling Infrastructure
Material Contamination and Sorting
Mixed plastics and contamination reduce the quality and efficiency of recycling, hindering short-loop recycling systems that offer the highest carbon savings.


The Challenges and Opportunities of Plastic Circularity,
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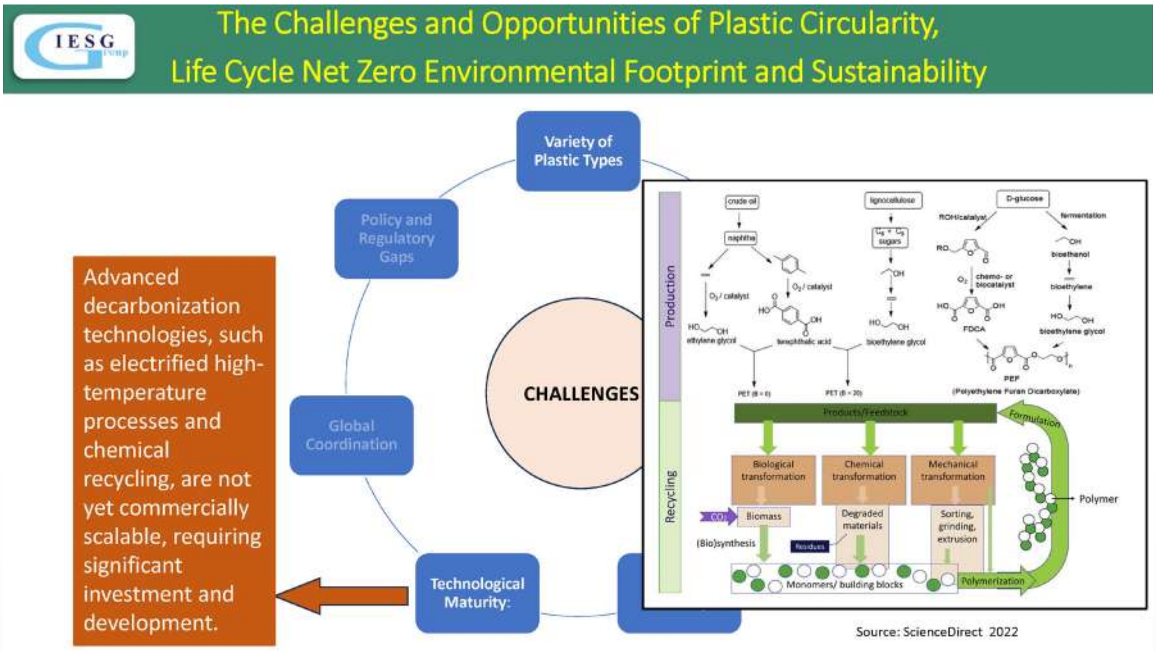
IESG
Variety of Plastic Types
Limited Recycling Infrastructure
Material Contamination and Sorting
Economic Viability
Decarbonization and Energy Generation
Material Production
Refinery
Metallurgy
Biorefinery
Min. Climate Effects
Min. Plastic Waste
Material Use and Waste EoLs
Global Plastic (Alternative) Material System Boundary
Source : ScienceDirect, Xiang Zhao et al 2025
Many circularity and decarbonization investments, such as advanced recycling technologies, do not yet meet the desired return thresholds compared to conventional capacity investments, leading to divided investment priorities.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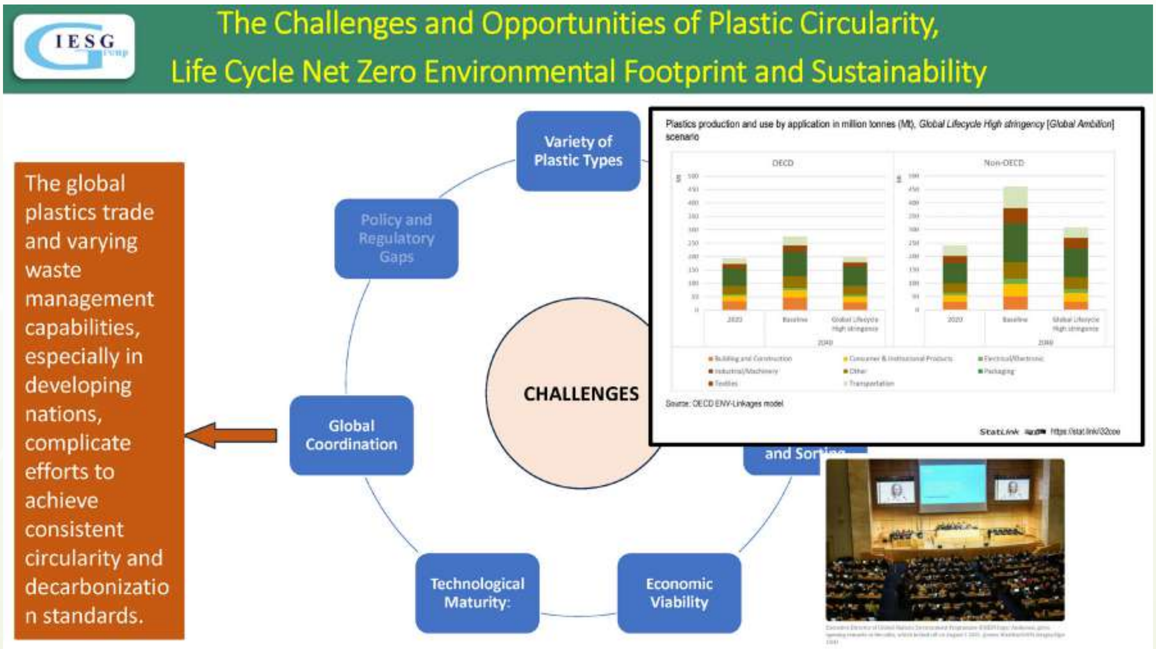
The Challenges and Opportunities of Plastic Circularity,
Life Cycle Net Zero Environmental Footprint and Sustainability
Variety of Plastic Types
Policy and Regulatory Gaps
Global Coordination
Technological Maturity:
CHALLENGES
Advanced decarbonization technologies, such as electrified high-temperature processes and chemical recycling, are not yet commercially scalable, requiring significant investment and development.
Production
Recycling
Products/Feedstock
Formulation
Biological transformation
Chemical transformation
Mechanical transformation
Biomass
Degraded materials
Sorting, grinding, extrusion
(Bio)synthesis
Polymer
Monomers/ building blocks
Polymerization
Source: ScienceDirect 2022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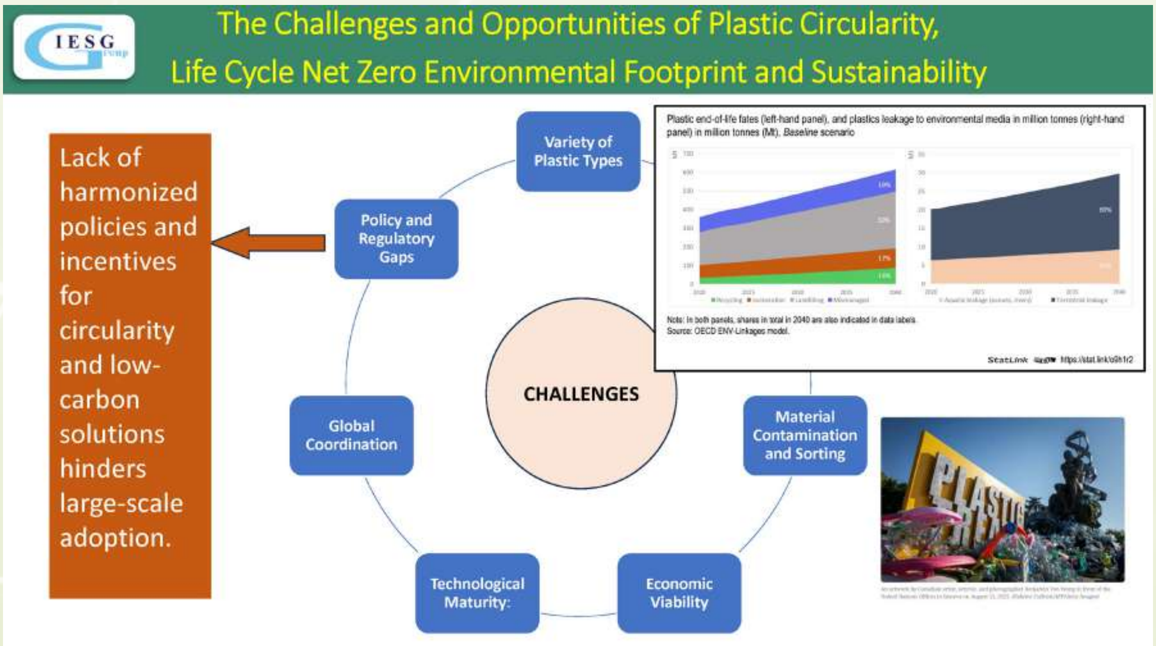
Technological Maturity:
Economic Viability
CHALLENGES
The global plastics trade and varying waste management capabilities, especially in developing nations, complicate efforts to achieve consistent circularity and decarbonization standards.
Plastics production and use by application in million tonnes (Mt), Global Lifecycle High stringency [Global Ambition] scenario
OECD
Non-OECD
Source: OECD ENV-Linkages model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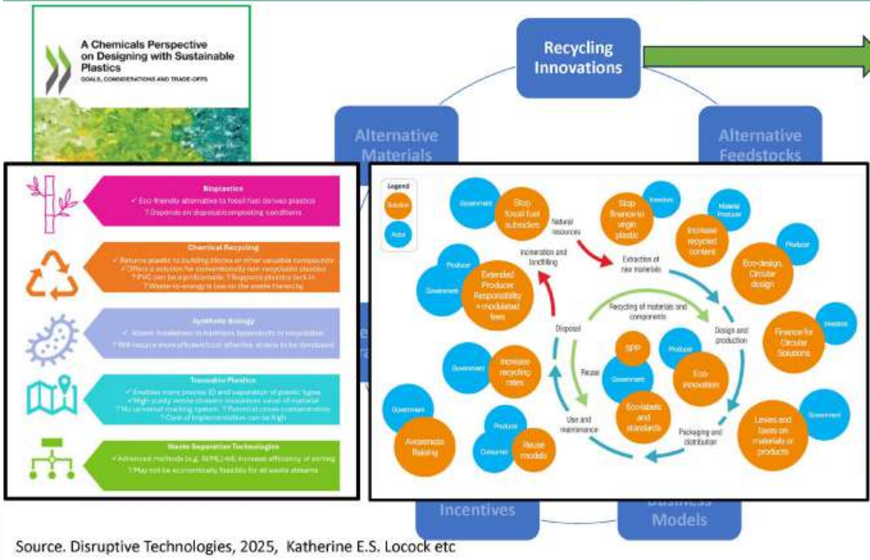
Technological Maturity:
Economic Viability
Material Contamination and Sorting
CHALLENGES
Lack of harmonized policies and incentives for circularity and low-carbon solutions hinders large-scale adoption.
Plastic end-of-life fates (left-hand panel), and plastics leakage to environmental media in million tonnes (right-hand panel) in million tonnes (Mt). Baseline scenario
Note: In both panels, shares in total in 2040 are also indicated in data labels.
Source: OECD ENV-Linkages model.

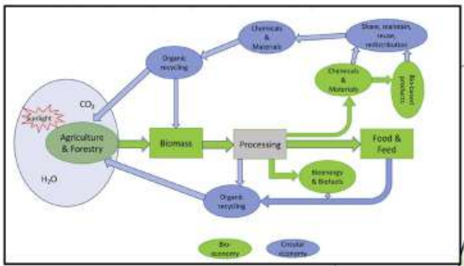
The Challenges and Opportunities of Plastic Circularity, Life Cycle Net Zero Environmental Footprint and Sustainability

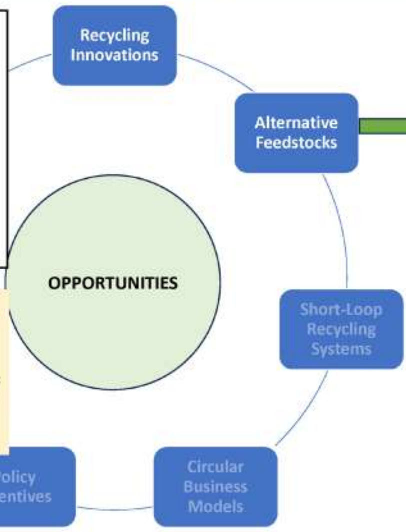


Advances in mechanical and chemical recycling can bypass energy-intensive production steps and reduce reliance on fossil feedstocks, potentially cutting emissions by up to 90% by 2050.

Source. Disruptive Technologies, 2025, Katherine E.S. Locock etc

The Challenges and Opportunities of Plastic Circularity, Life Cycle Net Zero Environmental Footprint and Sustainability



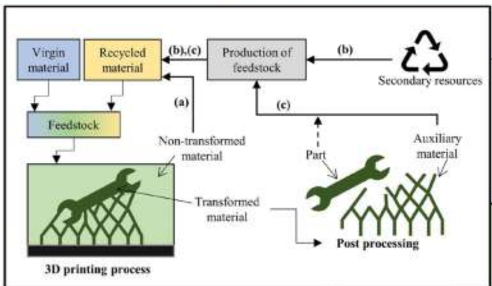


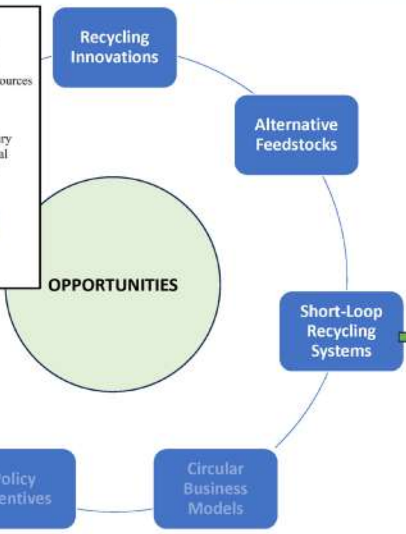
"…….the life cycle assessments of several plastics made of fossil and non-fossil feedstocks have shown that the production of and use of non-fossil-based plastics would be greener in terms of energy consumption and reducing green- house gases emissions."

Using biomass, CO2, and recycled waste as raw materials can produce net-zero emission plastics, reducing dependence on crude oil and mitigating environmental pollution

Source: ScienceDirect 2022

The Challenges and Opportunities of Plastic Circularity, Life Cycle Net Zero Environmental Footprint and Sustainability



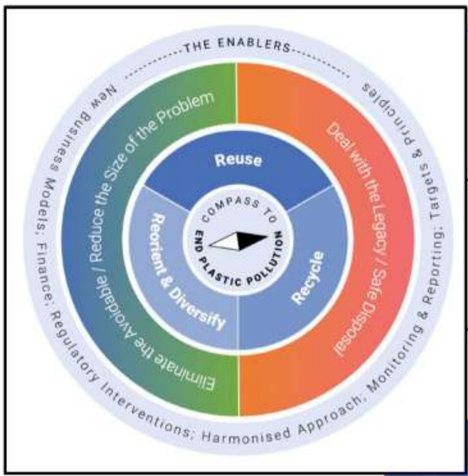


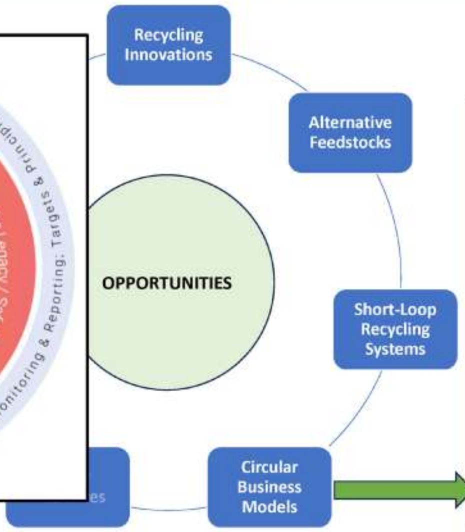
"…..The main advantage of short-loop recycling is to eliminate the collection and transportation phases "

Optimizing short-loop recycling, where plastics are reused with minimal processing, can significantly lower carbon footprints.

Source: Progress in Additive Manufacturing, Mattia Mele, 2023

The Challenges and Opportunities of Plastic Circularity, Life Cycle Net Zero Environmental Footprint and Sustainability





Implementing deposit return schemes, waste banks, and design-for-recycling principles can enhance plastic waste diversion from landfills.

The Challenges and Opportunities of Plastic Circularity, Life Cycle Net Zero Environmental Footprint and Sustainability

"Decarbonizing and building circularity into plastics will require alignment across the entire plastics value chain."


McKinsey & Company

Aligning the value chain to decarbonize plastics

- **"Plastics production** accounts for about **3 percent of humanity's global carbon emissions footprint**. In addition, about **1.0 billion to 1.2 billion metric tons of fossil CO_2** is bound up in plastic per year and may be released at the end of that plastic's life if not treated in a circular way or buried, according to McKinsey analysis.
- Plastics are **used in almost every industry**, in products as simple as plastic bottles and as complex as rocket ships. **Decarbonizing plastics, therefore, is in the best interest of society at large.**
- "Today, the stage is almost set to decarbonize plastics. Technologies for producing lower-carbon plastics exist, but the systems to decarbonize plastics and make them circular **lack clear demand signals and coordination across the value chain**, which are prerequisites for investments to provide the fuel necessary for this infrastructure-heavy industry."

The Challenges and Opportunities of Plastic Circularity, Life Cycle Net Zero Environmental Footprint and Sustainability

Plastics' Emissions Footprint—and Its Reduction Potential

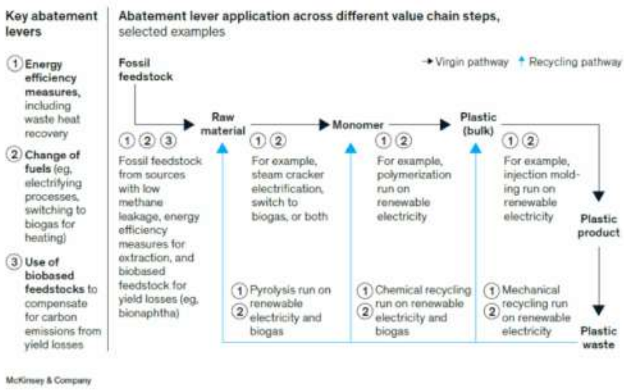
Where Emissions Occur in the Plastics Lifecycle

Emissions in the plastics value chain arise at multiple stages:

- Feedstock extraction and processing contribute roughly 20%.
- Monomer production, especially steam cracking, accounts for 25–50%.
- Polymerization and modifying processes represent 30–55% of emissions.

Source: McKinsey, 2025

Shorter Loops, Bigger Impact: Key Abatement Levers



The Challenges and Opportunities of Plastic Circularity, Life Cycle Net Zero Environmental Footprint and Sustainability

Decarbonization Levers in Reach

Category	Strategy or Technology	Impact on Emissions	Challenges	Stage of Adoption
Production Efficiency	Energy optimization & heat recovery	Moderate	Requires system upgrades	Widely available
Energy Transition	Fuel switching (e.g., renewables)	High	Infrastructure and cost	Growing
Feedstock Shift	Biobased inputs (e.g., bionaphtha)	High	Feedstock availability and competition	Emerging
Process Electrification	Electrified steam cracking	Very high	High capex, early-stage technology	Pilot phase
Recycling	Mechanical recycling	Moderate to high	Contamination, material quality	Established

Category	Strategy or Technology	Impact on Emissions	Challenges	Stage of Adoption
Recycling	Chemical recycling	High	Energy intensive, cost	Early commercialization
Circular Design	Short-loop recycling systems	Very high (if optimized)	Design-for-recycling, logistics	In development
Feedstock Access	Postconsumer waste recovery	High (if scaled)	Sorting infrastructure, quality limitations	Underutilized
Market Coordination	Aggregating demand for low-carbon materials	Indirect but enabling	Requires cross-sector alignment	Needs scale-up

These levers can be applied to both virgin and recycled plastic production pathways and should be prioritized by industry leaders now, not later.

Source: McKinsey, 2025

The Challenges and Opportunities of Plastic Circularity, Life Cycle Net Zero Environmental Footprint and Sustainability

Unlocking Feedstock from Postconsumer Waste

- A critical barrier remains: **postconsumer plastic recovery** is still far too limited.
- Key opportunities lie in recovering materials from:
  - Consumer goods packaging
  - Automotive plastics
  - Construction materials, despite contamination challenges

What Comes Next?

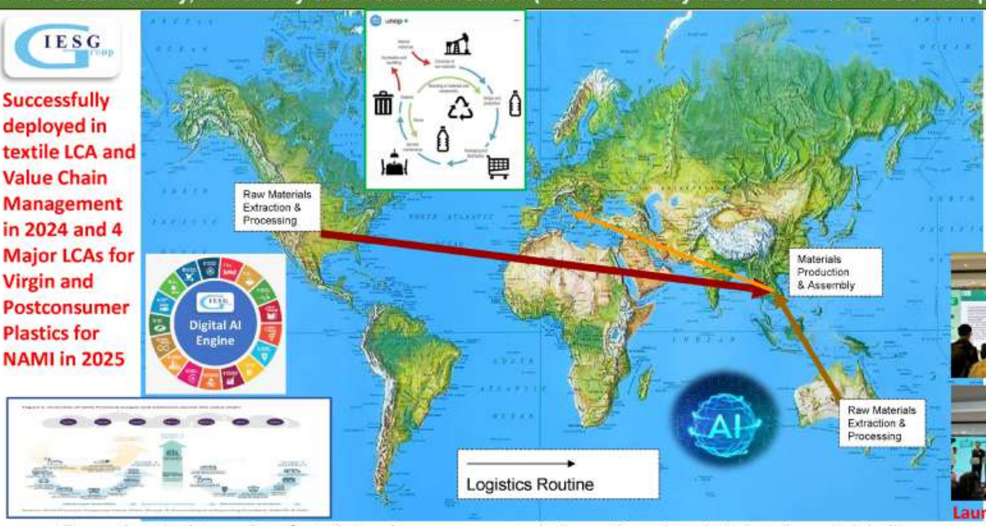
Plastics stakeholders should:

- Prioritize energy efficiency over capacity expansion.
- Launch pilot projects using breakthrough technologies.
- Aggregate cross-sector demand to spur investment in low-carbon alternatives.

Source: McKinsey, 2025

Major Breakthrough: Ai-enabled Value Chain and Scope 3 Carbon Modelling And Management System (AVC3) For Sustainability, Circularity and Decarbonisation (Patent Filed by IESG Tech Ltd in US& Europe in 2024)

Successfully deployed in textile LCA and Value Chain Management in 2024 and 4 Major LCAs for Virgin and Postconsumer Plastics for NAMI in 2025



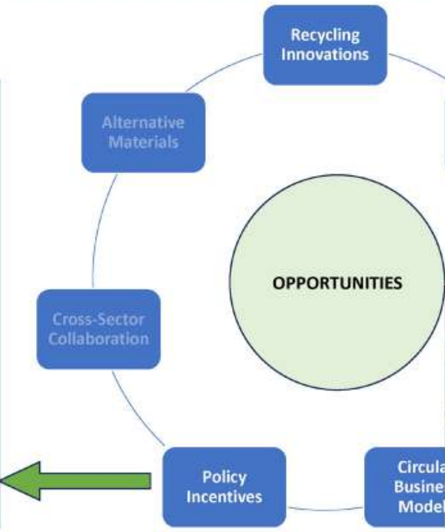
AI-enabled "Climate Change Co-pilot" for "Value Chain Management Green Revolution"

Launch of AVC3 with Afontane Use Case,10/4/2024)

- Promptly calculate carbon footprint and resource usage in the entire value chain locally and globally
- Clearly visualize the logistics of materials/products across value chain and enable circular economy
- Easier to enhance performance; optimize workflows, carbon footprints & decarbonisation options; reduce costs/manpower

The Challenges and Opportunities of Plastic Circularity, Life Cycle Net Zero Environmental Footprint and Sustainability

Plastics Policies like extended producer responsibility, single-use plastic bans, and mandatory recycled content targets can drive investment in circular and low-carbon technologies.



The Challenges and Opportunities of Plastic Circularity, Life Cycle Net Zero Environmental Footprint and Sustainability

"Global action across the plastics lifecycle could nearly eliminate plastic leakage by 2040" (OECD, 2025)

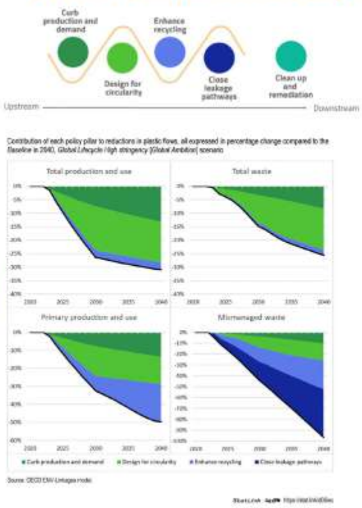
- This OECD report, published as countries near the final stages of negotiations to establish a global plastics treaty, models **alternative policy scenarios** honing in on different areas for action.
- This includes **curbing production and demand, promoting eco-design, enhancing recycling and closing leakage pathways**.
- It provides insights into the potential environmental benefits and economic consequences of different levels of ambition towards ending plastic pollution by 2040, according to which countries act, how stringent policies are and what stages of the plastics lifecycle they cover.

The Challenges and Opportunities of Plastic Circularity, Life Cycle Net Zero Environmental Footprint and Sustainability

Various Policy Incentive Options Available

Global Lifecycle High stringency

Source: OECD, 2025



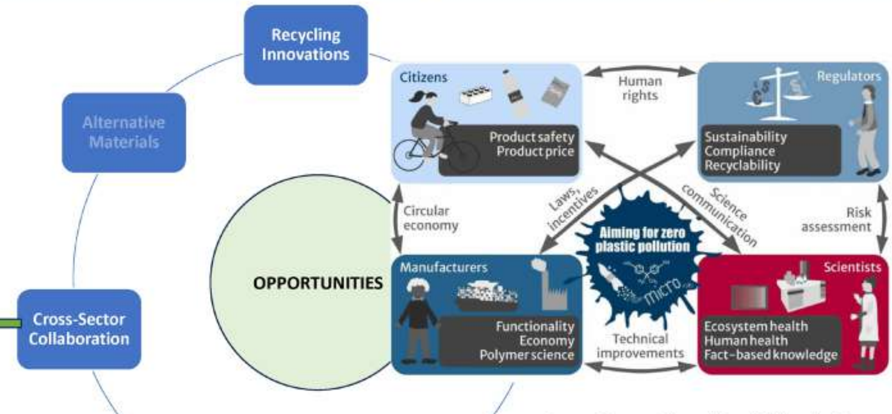
	Curb production and demand		Design for circularity		
Policy instrument	Packaging plastics tax	Non-packaging plastics tax	Eco-design for durability and repair	Bans on select single-use plastics	Substitute away from plastics
Stringency modelled in Global Lifecycle High stringency [Global Ambition]	**Global:** USD 1 000/tonne by 2030, doubling by 2040	**Global:** USD 750/tonne by 2030, doubling by 2040	**Global:** 15% lifespan increase by 2030, constant after; 10-20% decrease in demand for durables by 2030, constant after; like increase in demand for repair services	**Global:** Phase-out of primary plastics for selected consumer products by 2030	**Global:** 17% reduction of plastics use in production by 2030 with compensating increase in use of other inputs, constant thereafter

	Enhance recycling			Close leakage pathways	
Policy instrument	Recycled content targets	Enhance recycling rates	EPR for packaging, electronics, automotive and wearable apparel	Improved waste collection	Improved litter management
Stringency modelled in Global Lifecycle High stringency [Global Ambition]	**Global:** 30% target by 2040	Targets: **EU, Japan, Korea:** 60% by 2030, 80% by 2060 **Rest of OECD, China:** 60% by 2040 **Rest of non-OECD:** 45% by 2040	**Global:** Tax on plastics inputs USD 300/tonne by 2030, constant after; 30% point increase in recycling by 2040; waste sector subsidy such that instrument is budget neutral	**Global:** All waste is adequately collected and managed by 2040	**Global:** increase in collection rates between 5%-points (high-income countries) and 10%-points (low-income countries) by 2040

Note: The choice of policy instruments modelled in the policy scenarios is not intended to be prescriptive, but rather indicative of a potential set of effective instruments that could be implemented. For instance, the packaging tax translates into roughly EUR 0.90 per kilogramme, and could be interpreted as a shadow-price for alternative instruments to curb production and demand. Furthermore, in the pillar "Design for circularity", the ban on single-use plastics models measures to restrict or reduce the use of avoidable or unnecessary plastics. In the policy scenarios that include it, the measure is modelled as a 20% global reduction in the use of polypropylene (PP) in consumer and institutional products, based on a representative set of consumer products covered by the European Union's Single Use Plastic Directive (e.g. plastic bags, straws, cutlery). In practice, measures to restrict avoidable or unnecessary plastics could have a coverage that varies across different countries.
Source: Authors' own elaboration.

The Challenges and Opportunities of Plastic Circularity, Life Cycle Net Zero Environmental Footprint and Sustainability

Partnerships across the value chain can aggregate demand for low-carbon materials, improve recycling infrastructure, and foster innovation.



Source: Perspective article: Multisectoral considerations to enable a circular economy for plastics, Annika Jahnke et al, 2025

The Challenges and Opportunities of Plastic Circularity, Life Cycle Net Zero Environmental Footprint and Sustainability

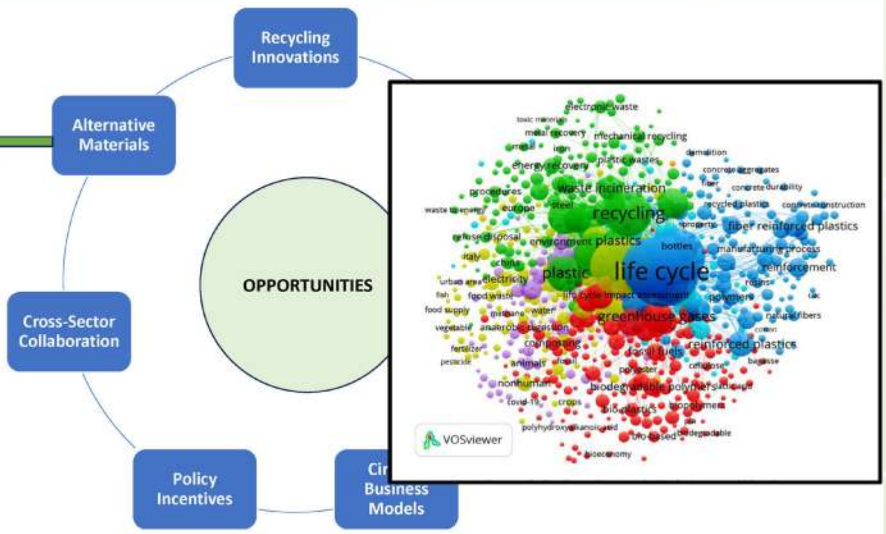
ReShaping Plastics: Pathways to a Circular, Climate Neutral Plastics System in Europe

- Commissioned by Plastics Europe, this independent report aimed to critically evaluate current progress and assess the potential of **different levers to help transition towards the EU's net zero carbon emissions and circularity goals by 2050**.
- ReShaping Plastics provides a **science-based, practical roadmap** based on a similar approach and scientific methodology developed for the ground-breaking report: Breaking the Plastic Wave.

- The European plastics system is already adapting to address the challenges of climate change mitigation and circularity, but not yet fast enough...
- There is **no 'silver bullet' solution** to significantly reduce waste disposal and GHG emissions. Upstream and downstream solutions are complementary
- **Ambitious adoption of circular economy approaches in the plastics value chain**....can drive significant reductions in GHG emissions and waste disposal in the next decade and beyond.
- ......there are **multiple less mature pathways** to develop and deploy innovative technologies and approaches that further decrease GHG emissions and tend to decouple plastic from fossil fuel feedstocks.
- The next three to five years are a critical window for action.

The Challenges and Opportunities of Plastic Circularity, Life Cycle Net Zero Environmental Footprint and Sustainability

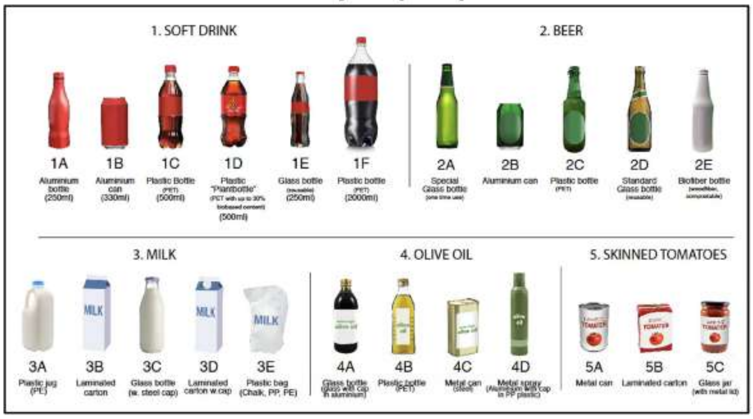
Opportunity to clarify through objective Life Cycle Assessment whether Plant-based, compostable materials, and other substitutes MAY reduce the environmental footprint of packaging



The Challenges and Opportunities of Plastic Circularity, Life Cycle Net Zero Environmental Footprint and Sustainability

Sustainability: Myths, Truths or Mixture of Both ?

Which beverage container has a lesser impact or is more sustainable from a life cycle perspective ?



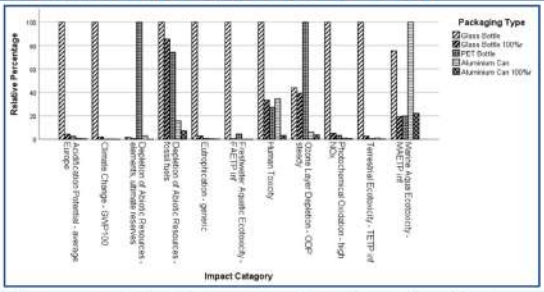
The Challenges and Opportunities of Plastic Circularity, Life Cycle Net Zero Environmental Footprint and Sustainability

Which beverage container has a lesser impact or is more sustainable from a life cycle perspective ? Aluminium (best), Glass (worst)

The Scope and Approach of a 2020 Study by University of Southampton in UK

Glass bottles amongst the most environmentally impactful says Southampton study

- Scientists from *University of Southampton* publish life cycle assessment (LCA) estimated primarily environmental impacts of five types of packaging across three beverage categories;
- Included glass bottles, aluminium cans, milk cartons, Tetra Paks, polyethylene terephthalate (PET) bottles, and high-density polyethylene (HDPE) bottles.
- The LCA considered processes related to the extraction of virgin materials, manufacturing of the packaging article, and end of life treatment (including landfill, incineration, and recycling based on UK disposal rates).
- The study found lowest impacts caused by recycled aluminum cans for pressurized drinks, Tetra Pak for fruit juices, cartons for milk.



"All beverage packaging that we assessed showed some form of environmental impacts and both the milk carton and Tetra Pak, despite being less impactful than the plastic bottles, still contain plastic elements," co-author Alice Brock said.

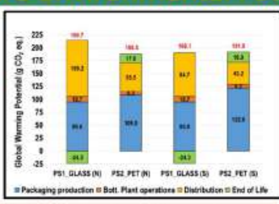
*"Based on the evidence, society needs to **move away from single-use beverage packaging** in order to reduce environmental harm and embrace the regular everyday use of reusable containers as standard practice."*

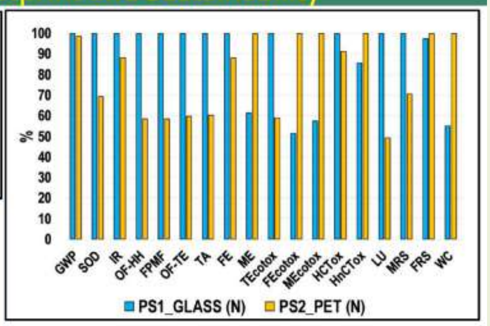
Source: LIFE CYCLE ASSESSMENT OF BEVERAGE PACKAGING Alice Brock and Ian Williams, University of Southampton, Faculty of Engineering and the Environment, University Rd, Highfield, Southampton SO17 1BJ, United Kingdom, 2020

The Challenges and Opportunities of Plastic Circularity, Life Cycle Net Zero Environmental Footprint and Sustainability

Which beverage container has a lesser impact or is more sustainable from a life cycle perspective ? PET better than Glass in an Italian case, but LCA is needed for each specific case

LCA of Glass Versus PET Mineral Water Bottles: An Italian Case Study 2021





- Context: due to the serious problem of plastic pollution in aquatic environment, many people rejected plastic packaging in favour of glass containers which are considered more sustainable.
- To avoid misjudgements, an sustainability assessment of packaging alternatives was carried out for an Italian case with a life cycle thinking approach.
- The study presented a comparative Life Cycle Assessment (LCA) of two alternative packaging systems for drinking water: reusable glass bottles and polyethylene (PET) bottles.
- The case study was performed considering the real data of an Italian mineral water company that bottles and distributes both natural and sparkling water.
- The PET bottle is the most sustainable alternative for natural water for many impact categories; while, in the case of sparkling water, the environmental impacts of the two packaging systems are similar and the most environmentally sound solution can vary depending on the impact category.

- The most significant aspects of the analysis are: **(1) the number of reuses of a single glass bottle; (2) the distribution distance.** Their variation can determine which packaging is the most sustainable.
- **A life cycle assessment approach is needed for each specific case.**

Source: LCA of Glass Versus PET Mineral Water Bottles: An Italian Case Study, by Carmen Ferrara, Giovanni De Feo andVincenzaPicone, Department of Industrial Engineering (DIIN), University of Salerno, via Giovanni Paolo, 2021.

The Challenges and Opportunities of Plastic Circularity, Life Cycle Net Zero Environmental Footprint and Sustainability

Which beverage container has a lesser impact or is more sustainable from a life cycle perspective ? PET better than Aluminium

Napcor released in 2023 Life Cycle Assessment for beverage container systems

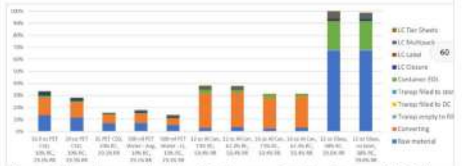


Figure 5. Water Consumption (liters) for Beverage Container Systems, 1,000 Gallon Basis, System Expansion

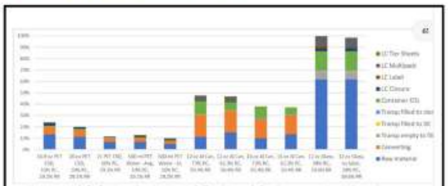


Figure 6. Global Warming Potential (kg CO₂ eq) for Beverage Container Systems, 1,000 Gallon Basis, System Expansion

- The National Association for PET Container Resources (Napcor) released a Life Cycle Assessment (LCA) that compares PET, glass and aluminium carbonated soft drink (CSD) and still water beverage container systems.
- The study was completed by Franklin Associates, a leading LCA consulting firm and pioneer in the field, and went through an extensive peer review and verification process.

- The assessment found that PET plastic bottles, when compared to aluminium cans and glass bottles, are significantly better for the environment.
- Compared to glass and aluminium beverage containers, PET plastic bottles create less solid waste, use less water during production and generate fewer emissions that contribute to acid rain and smog.

The Challenges and Opportunities of Plastic Circularity, Life Cycle Net Zero Environmental Footprint and Sustainability

Which beverage container has a lesser impact or is more sustainable from a life cycle perspective ?

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Article

Replacing Plastics with Alternatives Is Worse for Greenhouse Gas Emissions in Most Cases

Fanran Meng, Miguel Brandão,* and Jonathan M Cullen*

Cite This: Environ. Sci. Technol. 2024, 58, 2716−2727
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Table 1. Climate Impact of 16 Plastic and Nonplastic Alternative Applications[a]

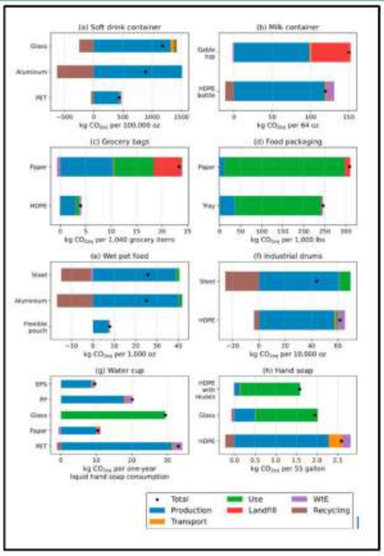
Sector	Application	Plastic	Next-best alternative	% GHG emission difference	Main drivers	Plastic favorable? w/ indirect	Plastic favorable? w/o indirect
Packaging	Grocery bag	HDPE	Paper	80		Yes	Yes
	Wet pet food packaging	PET/PP	Aluminum/steel	70		Yes	Yes
	Soft drink container	PET	Aluminum	50		Yes	Yes
	Fresh meat packaging	EPS/PVC	Paper	35		Yes	No
	Industrial drums	HDPE	Steel	−30		No	No
	Soap container	HDPE	Glass	15		Yes	Yes
	Milk container	HDPE	Paper*	20		Yes	Yes
	Water cup	PS	Paper*	0		Yes	Yes
Building and construction	Municipal sewer pipe	PVC	Concrete/ductile iron	35−45		Yes	Yes
	Residential water pipe	PEX	Copper	25		Yes	Yes
	Insulation	PU	Fiberglass	80		Yes	No
Consumer goods	Furniture	PP	Wood	50		Yes	Yes
Automotive	Hybrid fuel tank	HDPE	Steel	90		Yes	Yes
	BEV battery top enclosure	PP/glass fiber	Steel	10		Yes	No
Textile	Carpet	PET/nylon	Wool	80		Yes	Yes
	T-shirt	PET	Cotton	15		Yes	Yes

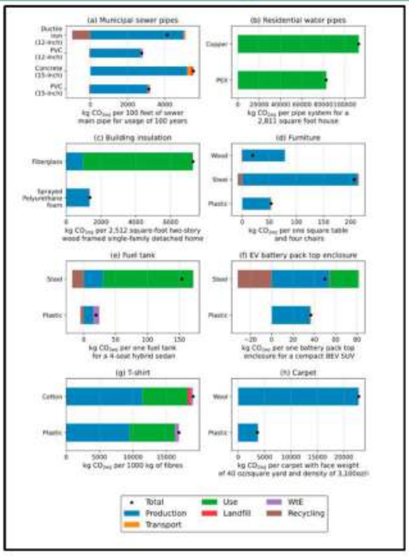
[a]EPS (expanded polystyrene), HDPE (high-density polyethylene), PET (polyethylene terephthalate), PEX (cross-linked polyethylene), PP (polypropylene), PU (polyurethane), and PVC (polyvinyl chloride). * denotes plastic-enabled mixed materials.

The Challenges and Opportunities of Plastic Circularity, Life Cycle Net Zero Environmental Footprint and Sustainability

Which material causes lesser greenhouse gas impact ?

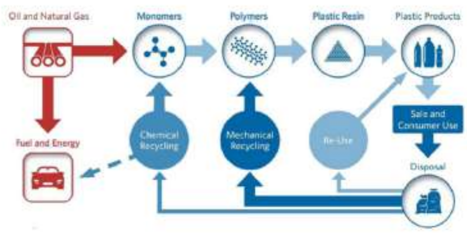
Perceptions versus Realities !





The Challenges and Opportunities of Plastic Circularity, Life Cycle Net Zero Environmental Footprint and Sustainability

In Summary, a new journey of plastics: Towards a circular and low carbon future: Objective and Transparent LCA "A Must"



Source: Adapted from ScienceDirect (2025) by Bin Li, Yichun Ma, Hui Li

- The plastic pollution to the environment, especially to the ocean, has drawn a lot of attention from the public which results some negative impact to the **entire value chain of plastic industry.**
- Circularity and low carbon have been perceived as the solution to tackle these challenges. Efforts required from the feedstock, polymerization, **product design** and recycling, are all need to be considered.
- **Shifting to the low carbon feedstock** is key to reduce the total emission of plastics, while make it recyclable is crucial to achieve low carbon emission for the entire life cycle of plastics.
- **Mechanical recycling** aims to make more post-consumer recycles (PCR) being used to some high-end applications to incentivize more plastics being collected and regenerated.
- **Subject to further detailed comparison through LCA and economic viability analysis**, the advanced recycling is the last stop for those unrecyclable, avoiding them to the incineration or landfill, and **generate value** through the pyrolysis or gasification process. The **scale** is key to make it profitable and sustainable.

The Challenges and Opportunities of Plastic Circularity, Life Cycle Net Zero Environmental Footprint and Sustainability

Fundamentally, A Matter of Professional, Policy and Political Choices

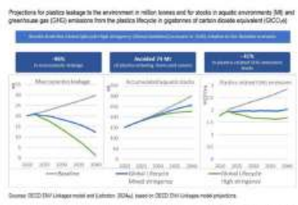
Policy Choices and the Associated Trade-offs

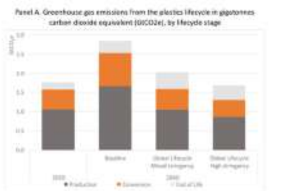
Indicator	Curb production and demand: Primary plastics use	Design for circularity: Plastics intensity	Enhance recycling: Recycling rate	Close leakage pathways: Macroplastic leakage
Global Downstream High stringency	**Global:** Current policies	**Global:** Current policies	**Global:** Quadruple to 42%	**Advanced economies:** Eliminate; **Other economies:** 30% below 2020
Advanced economies Lifecycle High stringency	**Advanced economies:** Stabilise below 2020; **Other economies:** Current policies	**Advanced economies:** 25% below 2020; **Other economies:** Current policies	**Advanced economies:** Quadruple to 48%; **Other economies:** Current policies	**Advanced economies:** Eliminate; **Other economies:** Current policies
Global Lifecycle Low stringency	**Advanced economies:** 15% above 2020; **Other economies:** 65% above 2020	**Global:** 10% below 2020	**Advanced economies:** Triple to 29%; **Other economies:** Double to 22%	**Advanced economies:** Eliminate; **Other economies:** 25% above 2020
Global Lifecycle Mixed stringency	**Advanced economies:** Stabilise below 2020; **Other economies:** 65% above 2020	**Advanced economies:** 25% below 2020; **Other economies:** 10% below 2020	**Global:** Quadruple to 42%	**Advanced economies:** Eliminate; **Other economies:** 30% below 2020
Global Lifecycle High stringency [Global Ambition]	**Global:** Stabilise below 2020	**Global:** 25% below 2020	**Global:** Quadruple to 42%	**Global:** Eliminate

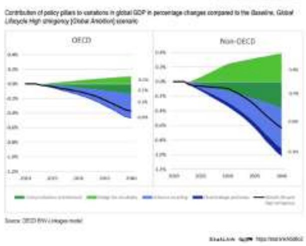
Limited ambition scenarios / Integrated, high-ambition scenarios

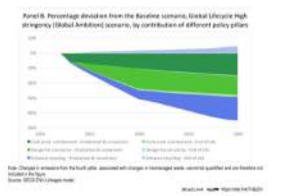
Notes: 1. "Advanced econ." reflects the group of countries that have a high ambition level in the *Advanced economies Lifecycle High stringency* scenario; they are by assumption approximated as OECD and non-OECD European Union in the model. "Other econ." reflects countries not included in the "Advanced economies" group.
2. Plastics intensity (tonnes/USD) refers to the intensity of plastics use relative to GDP. It is a normalised indicator that allows for comparison of plastics use across countries and regions and over time.
Source: Authors' own elaboration.

Greenhouse Gas Reduction









Source: OECD, 2025

The Challenges and Opportunities of Plastic Circularity, Life Cycle Net Zero Environmental Footprint and Sustainability

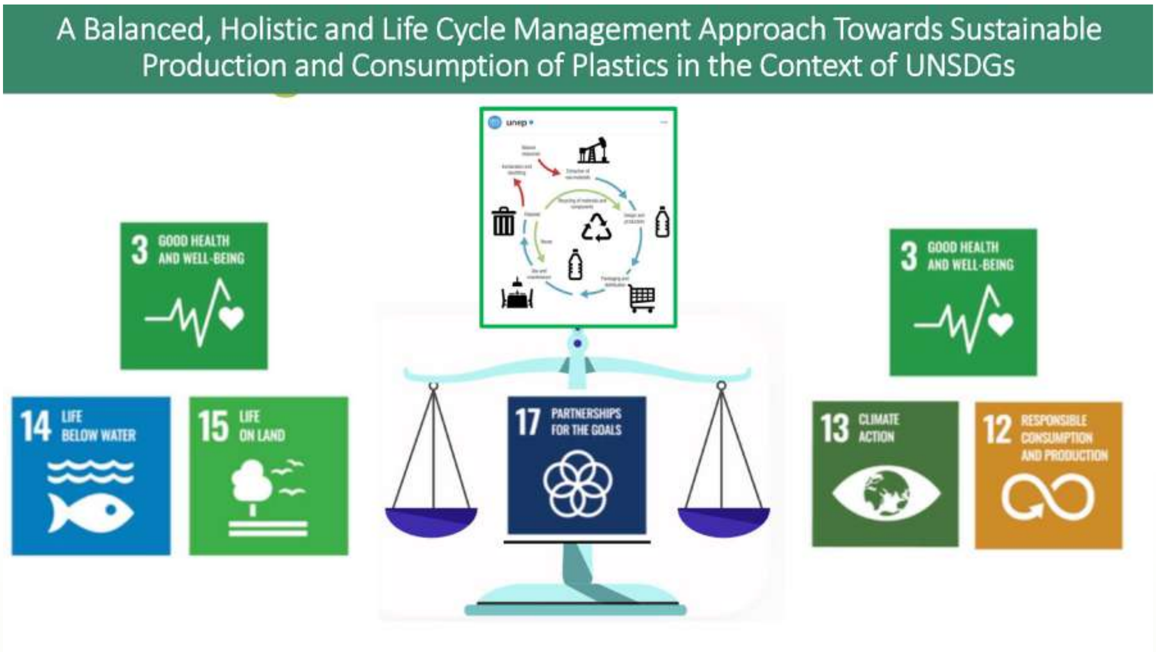
Recent Personal Observation: Urgent Call for Very Stringent Enforcement Globally and Locally

Plastics Everywhere in Urban Areas

Very Difficult to Find a Single Plastic Bottle Disposed of in Kenya National Reserve as A Result of Very Strict Enforcement and Control

Despite many visitors, land cruisers and animals ,

Because every visitor is strictly required to take away every piece of rubbish and plastic bottle or the tour guide/driver's licence be cancelled


A Balanced, Holistic and Life Cycle Management Approach Towards Sustainable Production and Consumption of Plastics in the Context of UNSDGs
3 GOOD HEALTH AND WELL-BEING
14 LIFE BELOW WATER
15 LIFE ON LAND
17 PARTNERSHIPS FOR THE GOALS
3 GOOD HEALTH AND WELL-BEING
13 CLIMATE ACTION
12 RESPONSIBLE CONSUMPTION AND PRODUCTION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The Challenges and Opportunities of Plastic Circularity,
Life Cycle Net Zero Environmental Footprint and Sustainability
A Balanced, Holistic, 360 Degree and Life Cycle Perspective on Plastics
SUSTAINABLE DEVELOPMENT GOALS INFOGRAPHIC
(a) Avoiding harm through sustainable and optimal production and consumption and strict enforcement
(b) Building synergies with UNSDGs
(c)Fostering cross-sectoral collaboration

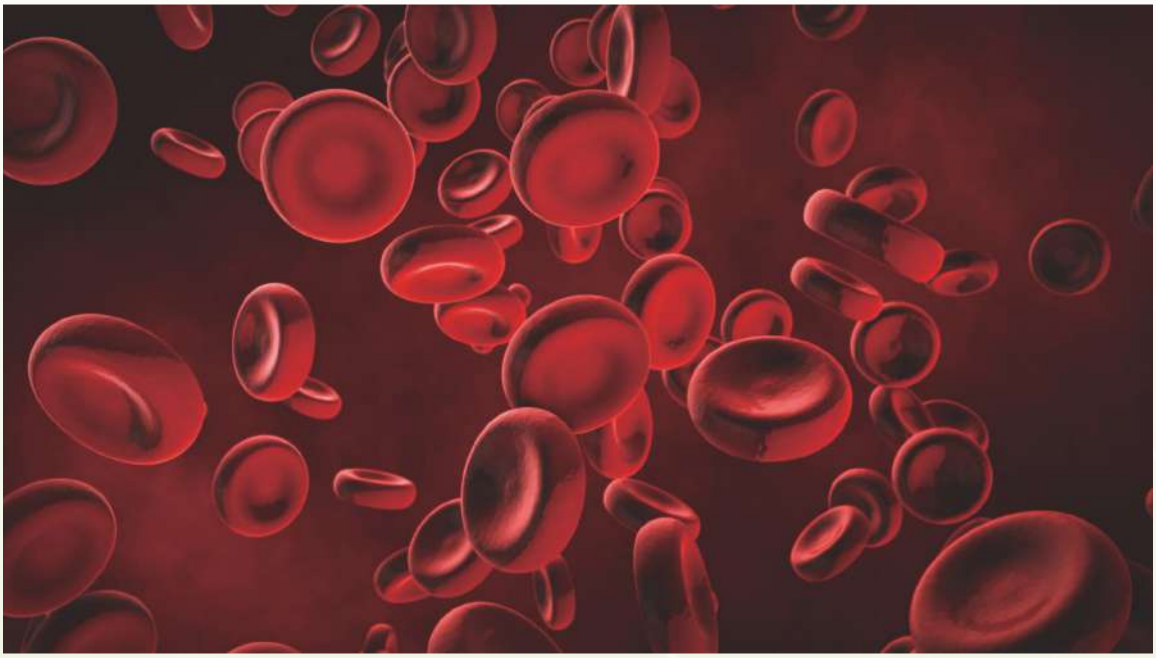

IESG
The Challenges and Opportunities of Plastic Circularity,
Life Cycle Net Zero Environmental Footprint and Sustainability
Call for Industry-Wide Alignment and Collaboration
"The race toward net-zero plastics it isn't just about innovation, It's about collaboration. ....value chain players who move early to secure renewable feedstocks, circular materials, and clean technologies will not only cut emissions—they'll also build long-term resilience and brand value. As decarbonization accelerates across industries, the plastics sector must step forward not only with ideas, but with action."
Plastics Engineering (2025), Juliana Montoya | August 7, 2025, based on McKinsey 2025 report
Thank You !
Welcome Any Collaboration (ewkau@hotmail.com)

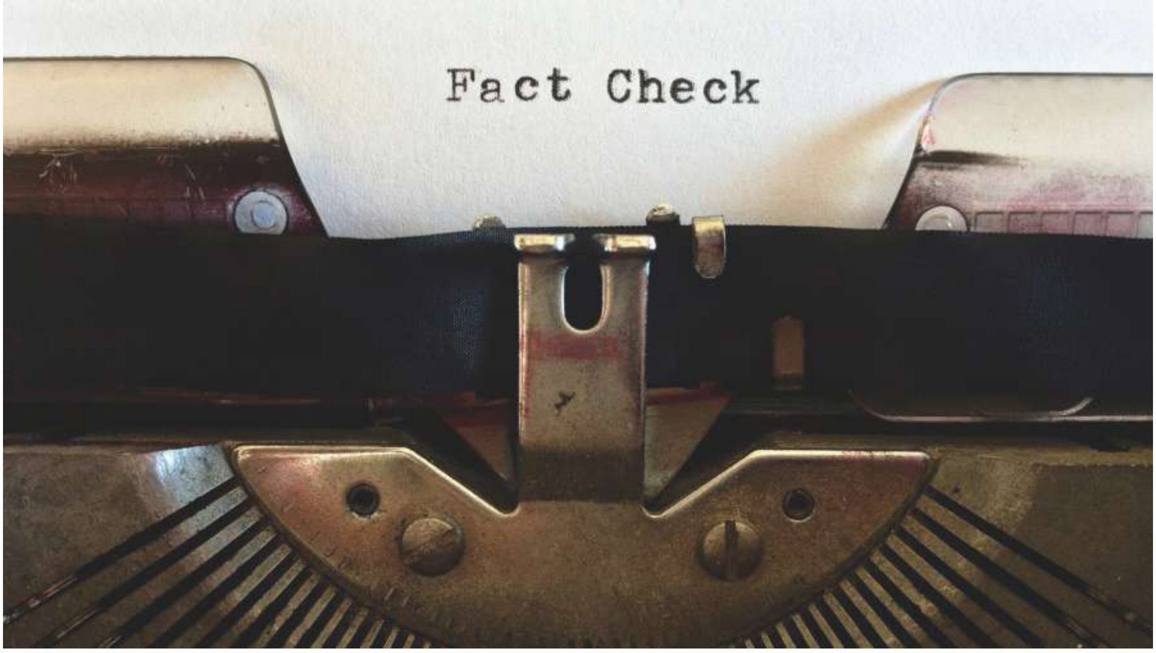
Microplastics - Would you Rather be Informed or Afraid?

Dr Chris DeArmitt

President of Phantom Plastics LLC

Dr. DeArmitt is a world-renowned plastic materials and microplastics expert, award-winning keynote speaker, and author. With over 5,000 studies reviewed, he exposes misinformation and champions science-based decisions on plastics and sustainability, helping industry leaders, lawmakers, and the public see through the myths to the real environmental evidence.




Fact Check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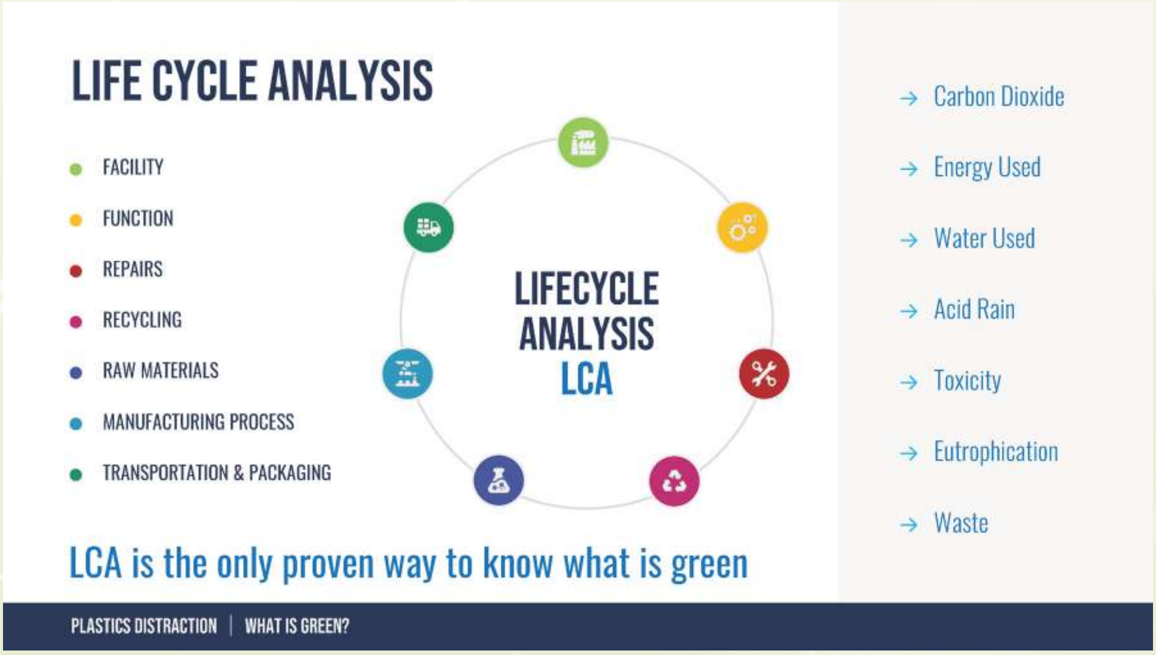
The Washington Post
USA TODAY
CHRIS DEARMITT PHD FRSC FIMMM CCHEM
President - Phantom Plastics LLC
Phone: +1 601 620 8080
E-mail: chris@phantomplastics.com
Dr. Chris DeArmitt is an internationally recognized scientist, author, and thought leader in materials science, known for his relentless commitment to uncovering and communicating the truth about plastics, microplastics and their environmental impact. With a career spanning decades and grounded in rigorous, peer-reviewed research, Dr. DeArmitt stands at the forefront of dispelling myths and correcting misinformation pervasive in today's environmental discourse.
Author of influential books such as "The Plastics Paradox" and "Shattering the Plastics Illusion," Dr. DeArmitt combines scientific depth with engaging clarity, revealing through meticulous analysis how conventional narratives about plastics and their ecological footprint often diverge dramatically from reality. His work is driven by a passion for scientific integrity, using evidence-based reasoning to challenge widely held beliefs and inform sustainable policies.
As the founder of the Plastics Research Council, Dr. DeArmitt has created an essential resource dedicated to educating policymakers, industries, and the public about scientifically validated environmental facts. He has reviewed over 5,000 scientific studies, becoming a leading authority whose insights influence both academic circles and global industries. The work is endorsed by professors world-wide.
Beyond academia and research, Dr. DeArmitt is a sought-after keynote speaker, adept at translating complex scientific concepts into compelling narratives that resonate with diverse audiences worldwide. His engaging presentations not only illuminate critical environmental truths but inspire thoughtful dialogue, driving meaningful change in how society perceives and interacts with plastics.
Dedicated to a future where environmental decisions are rooted in factual accuracy rather than misconceptions, Dr. DeArmitt continues to be an influential voice advocating for evidence-based environmental stewardship.


LIFE CYCLE ANALYSIS
FACILITY
FUNCTION
REPAIRS
RECYCLING
RAW MATERIALS
MANUFACTURING PROCESS
TRANSPORTATION & PACKAGING
LIFECYCLE ANALYSIS LCA
Carbon Dioxide
Energy Used
Water Used
Acid Rain
Toxicity
Eutrophication
Waste
LCA is the only proven way to know what is green
PLASTICS DISTRACTION | WHAT IS GREEN?

PLASTICS REDUCE CO_2

"We assess 16 applications where plastics are used across five key sectors: packaging, building and construction, automotive, textiles, and consumer durables.

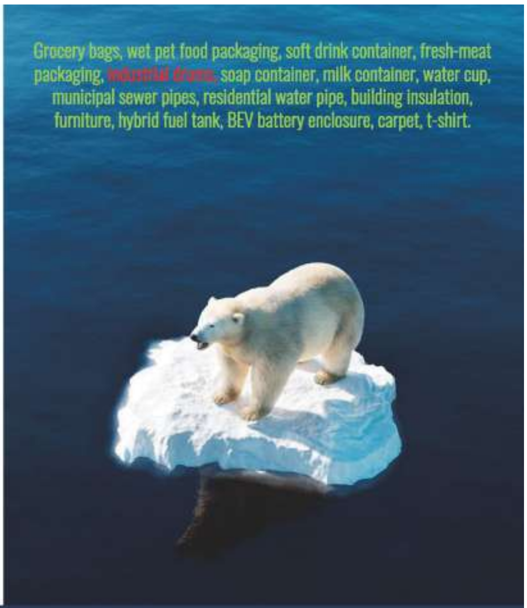
These sectors account for about 90% of the global plastic volume.

Our results show that in 15 of the 16 applications a plastic product incurs fewer GHG emissions than their alternatives.

In these applications, plastic products release 10% to 90% fewer emissions across the product life cycle."

PLASTICS MASSIVELY REDUCE CO_2

F. Meng et al., Replacing Plastics with Alternatives Is Worse for Greenhouse Gas Emissions in Most Cases, Environmental Science & Technology , January, 2022 https://doi.org/10.1021/acs.est.3c05191



PLASTICS DISTRACTION | WHAT IS GREEN?

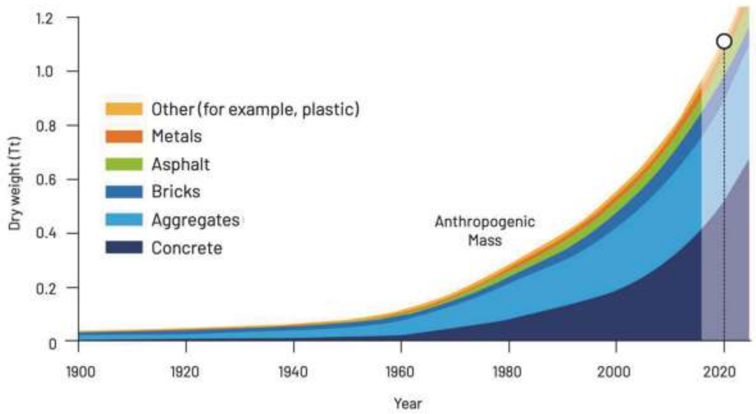
LIFE CYCLE ANALYSIS

"Several studies have shown many materials used as alternatives to plastic in packaging, such as cotton, glass, metal or bioplastics, to have significantly higher CO_2 impact or water usage compared to plastic packaging. On average over current food packaging, replacing plastic packaging with alternatives, would increase the weight of the packaging by 3.6 times, the energy use by 2.2 times, and the carbon dioxide emissions by 2.7 times"

N. Voulvoulis et al., Examining Material Evidence – The Carbon Footprint, Centre for Environmental Policy, Imperial College London & Veolia UK, ACC, 2019

PLASTICS DISTRACTION | WHAT IS GREEN?

MATERIALS USE & GROWTH



E. Elhacham et al., Global human-made mass exceeds all living biomass, Nature, Vol 588, p442, December 2020

PLASTICS DISTRACTION | MATERIALS

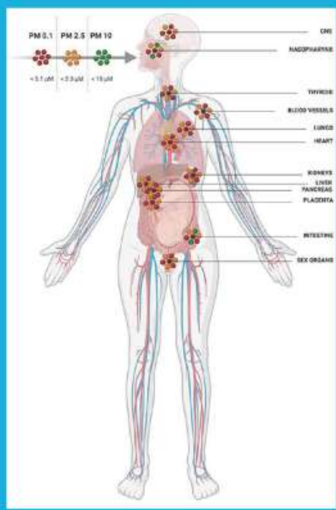
DUST DANGER

"Nine out of 10 people breathe air that does not meet World Health Organization pollution limits. Air pollutants include gasses and particulate matter and collectively are responsible for ~8 million annual deaths. Particulate matter is the most dangerous form of air pollution, causing inflammatory and oxidative tissue damage."

"It is well documented that PM is associated with harmful outcomes to animal and human health. In addition to direct exposure of the respiratory system, airborne particulates can cross endothelial barriers, enter circulation, and accumulate in multiple organ systems."

PARTICLES ARE A REAL AND PRESENT DANGER TO HUMAN HEALTH

J. T. Pryor et al., The Physiological Effects of Air Pollution: Particulate Matter, Physiology and Disease, Frontiers in Public Health, Volume 10, Article 882569, 2022

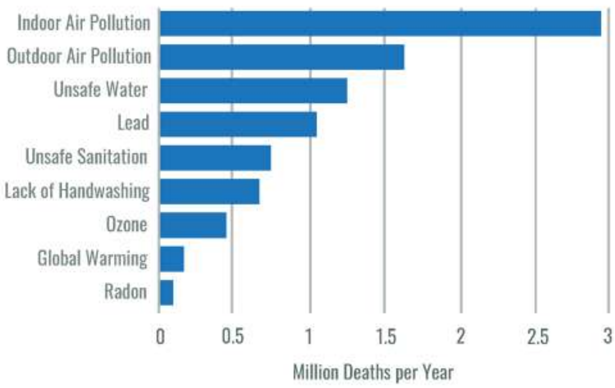


PLASTICS DISTRACTION | MICROPLASTIC

ENVIRONMENTAL DANGER

Plastics and microplastics not a factor

B. Lomborg, Welfare in the 21st century: Increasing development, reducing inequality, the impact of climate change, & the cost of climate policies, Technological Forecasting & Social Change, 156 (119981), 2020



PLASTICS DISTRACTION | DANGER

DUST

"Microorganisms, microfungi, endotoxins, allergens (mite, dog, cat), macro molecular organic compounds, water, fibers, aldehydes, plasticizer, human and animal skin fragments, paper fibers, glass wool, wood and textile fibers, inorganic (quartz, calcite, feldspar, gypsum and rocksalt) and metal particles."

PLASTICS ARE NOT MENTIONED AS A SIGNIFICANT COMPONENT OF DUST

L. Mølhave et al., House dust in seven Danish Offices, Atmospheric Environment, 34, pp 4767-4779, 2000

DUST

"The respirable fraction was obtained in a yield of 0.6% with a specific surface area of 2.5 m^2/g and a Mass Median Aerodynamic Diameter of 3.73 ± 0.15 μm. Aluminum and zinc were the dominating metals measured in the dust, whereas the major mineral components were found to be silicon dioxide and calcium carbonate. The fraction of organic matter in the dust was measured to be 69 ± 1%. The organic matrix contained bacterial and fungi and a presence of skin fragments."

DUST CONTAINS MANY TYPES OF PARTICLE SOME OF WHICH ARE PROBLEMATIC

Å. Gustafsson et al., Isolation and characterization of a respirable particle fraction from residential house-dust, Environmental Research, 161, pp 284-290, 2018

PLASTICS DISTRACTION | MICROPLASTIC

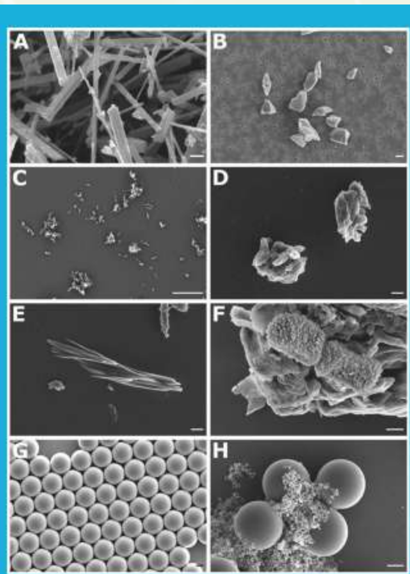
DUST DANGER

A **Asbestos** 100 000 deaths per year
B **Crystalline Silica** Causes Cancer >13 000 deaths per year
C **Soot** Causes Cancer
D **Oak wood** Causes Cancer
E **Cotton** Inflammation, bacteria, fungi
F **Hay** Microorganisms, endotoxins, and mycotoxins
G **Polystyrene** (of a type not found in actual dust)
H **Polystyrene** in Salt Water (of a type not found in actual dust)

Other particles show a real, proven threat but plastics do not

SOME PARTICLES ARE A REAL DANGER

S. Wieland et al., From properties to toxicity: Comparing microplastics to other airborne microparticles, Journal of Hazardous Materials, 428,128151, 2022



PLASTICS DISTRACTION | MICROPLASTIC

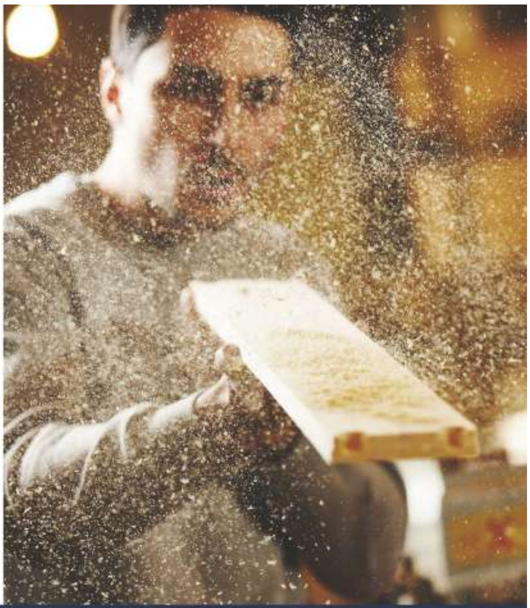
DUST

"Wood dust was classified as carcinogenic to humans."

"Strong and consistent associations with cancers of the paranasal sinuses and nasal cavity have been observed both in studies of people whose occupations were associated with wood-dust exposure and in studies that directly estimated wood-dust exposure."

NATURAL PARTICLES LIKE WOOD DUST ARE MORE DANGEROUS THAN PLASTIC

IARC Monographs on the Evaluation of Carcinogenic Risks to Humans Volume 62
https://www.cancer.gov/about-cancer/causes-prevention/risk/substances/wood-dust



PLASTICS DISTRACTION | MICROPLASTIC

DUST INGESTION

"Respirable quartz measurements from the South African farm ranged from not detectable to 626 μg m^{-3} and confirmed the quartz risk as some concentrations exceeded generally accepted occupational exposure limits in all jobs evaluated..."

"Twelve of 138 respirable dust measurements (9%) and 18 of 138 respirable quartz measurements (13%) exceeded commonly used occupational exposure limits of 2 mg^{-3} and 100 μg m^{-3}, respectively. The highest time weighted average respirable quartz concentration of 626 μg m^{-3} was during wheat planting activities. Fifty-seven percent of the respirable quartz measurements exceeded the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) of 25 μg m^{-3}. Quartz percentages of the respirable dust ranged from 0.3 to 94.4% with an overall median of 13.4%."

QUARTZ EXPOSURE CAUSES CANCER

A. J. Swanepoel et al., Quartz exposure in agriculture: literature review and South African Survey, Annals of Occupational Hygiene, 54 (3), pp 281–292, 2010

PLASTICS DISTRACTION | MICROPLASTIC

DEGRADATION

- There are thousands of scientific studies over decades
- Same degradation chemistry as wood, wool, cotton
- Plastics are degraded faster than most materials
- Degradation rate can be adjusted as needed
- S5BN a year on stabilizers to slow degradation

PLASTICS DEGRADE

- FUNGI
- SUNLIGHT
- TEMPERATURE
- INSECTS
- WATER
- OXYGEN
- BACTERIA

W. L. Hawkins, Polymer Degradation & Stabilization, Springer Berlin / Heidelberg, 1984
Inamuddin, R. Mobin, M. I. Ahamed (Eds.), Degradation of Plastic Materials, Materials Research Forum, 2021
Y. Shashoua, Conservation of Plastics: Materials science, degradation and preservation, Routledge, 2008
S. Balasubramanian, Degradation of plastics by Microbes, Lambert Academic Publishing, 2018
M. Srikanth et al., Biodegradation of plastic polymers by fungi: a brief review, Bioresources & Bioprocessing, 9 (42), 2022
G. Weber, U. T. Bornscheuer, R. Wei (Eds.), Enzymatic Plastic Degradation (Methods in Enzymology, Volume 648), AP, 2021

PLASTICS DISTRACTION | DEGRADATION

REBRANDING DUST

Solids fragment into microparticles as they age and degrade e.g. metals, sand, rock, glass, leaves

There are no hits for "microwood, micrometal, microglass, micropaper"

ALL SOLIDS CREATE DUST PARTICLES

Nur Hazimah Mohamed Nor, Lifetime Accumulation of Microplastic in Children and Adults, Environ. Sci. Technol., 55 (8), pp 5084–5096, 2021
R. C. Heindel et al., Atmospheric Dust Deposition Varies by Season and Elevation in the Colorado Front Range, USA, JGR Earth Surface, 125(5), April, 2020
A. Gustafsson et al., Isolation and characterization of a respirable particle fraction from residential house-dust Environmental Research 161, pp 284–290, 2018
Silica Dust, Crystalline, in the Form of Quartz or Cristobalite, IARC Monographs 100C

PLASTICS DISTRACTION | MICROPLASTIC

REBRANDING DUST

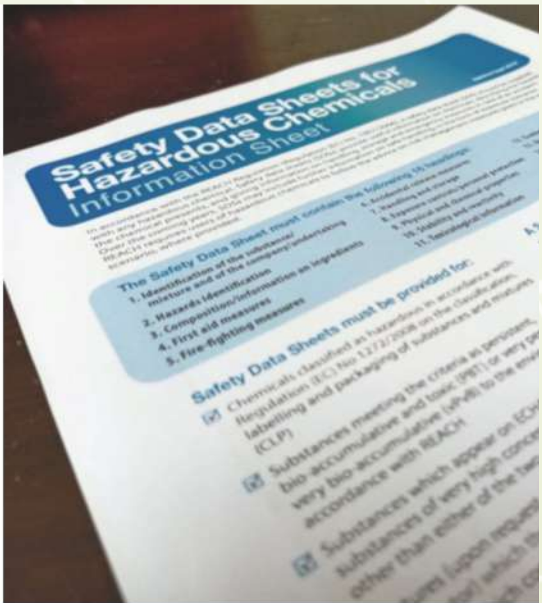
Leaves degrade and crumble into particles & no-one cares
Rocks crumble and degrade into particles & no-one cares
Paper degrades into particles & no-one cares
Plastic degrades into particles & everyone panics
Why?
They think it's some new, unrecognized threat
But it's not new, not unrecognized and not a threat
Plastic is a tiny, non-toxic fraction of dust
50 years of science and the FDA agree

ALL SOLIDS CREATE DUST PARTICLES

PLASTICS DISTRACTION | MICROPLASTIC

Material / Substance	Acute Toxicity LD_{50} 70kg Person	Chronic Toxicity NOAEL 70kg Person
Sugar	~2000g	60g
Alcohol (ethanol)	~500g	~12g
Polyethylene	>350g	>70g
Polypropylene	>350g	>140g
Polyethylene terephthalate	>350g	>70g
PVC (unplasticized)	>350g	N/A
Calcium Carbonate - Filler	>350g	>70g
Talc Mineral - Filler	>350g	>60g
Calcium Stearate - Lubricant	>700g	>140g
Irgaphos® 168 - Stabilizer	>350g	140g
Irganox® 1076 - Stabilizer	>350g	70g
Irganox® 1010 - Stabilizer	>350g	100-200g
Irganox® 1330 - Stabilizer	>350g	35g
Iron Powder	>350g	14g
Table Salt	~200g	4g
Caffein	14g	0.25g
Copper Metal	30g	~1g
Cu Dissolved	3.5g	0.005g
Nicotine	0.7g	0.00006g

EPA toxicity ratings: Practically Non-Toxic Slightly Toxic Moderately Toxic Highly Toxic



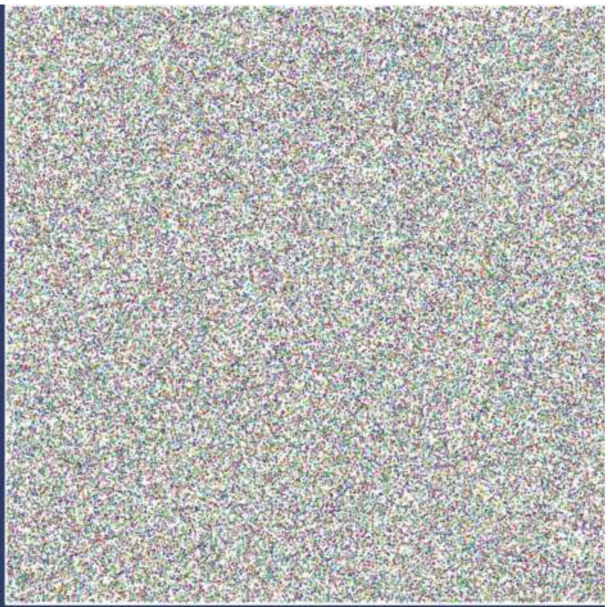
PLASTICS DISTRACTION | SAFETY

MICROPLASTICS
"Insignificant"

"

It is estimated that the dietary intake of these particles is about 40 mg/capita/day in the U.K. Comparing our findings with the intake of other particles, MP mass intake rates are insignificant, as they make up for only 0.001% of these particles. However, this comparison does not imply that the toxicological profiles of these particles are similar."

Nur Hazimah Mohamed Nor et al., Lifetime Accumulation of Microplastic in Children and Adults, Environ. Sci. Technol., 55 (8), pp 5084–5096, 2021



MICROPLASTIC

Packaging type	Overall particle number	Particle size (µm)	Percentage	Size-related particle number	Mass of particles (µg)	Overall concentration (µg/l)
Multi-use PET bottles (Schymanski et al. 2018)	118 ± 88 (range 28–241)	>100	1%	1.18	4.94	7.3
		50–100	2%	2.36	1.24	
		20–50	12%	14.2	0.93	
		10–20	29%	34.2	0.14	
		5–10	56%	66.1	0.03	
Multi-use PET bottles (Oßmann et al. 2018)	4890 ± 5430	>10	1.7%	83.1	0.35	0.6
		5–10	2.9%	142	0.07	
		1.5–5	48.4%	2370	0.15	
		1–1.5	47.8%	2330	0.004	
Single-use PET bottles (Schymanski et al. 2018)	14 ± 14 (range 2–44)	>100	2%	0.28	1.17	1.8
		50–100	5%	0.70	0.37	
		20–50	27%	3.08	0.39	
		10–20	30%	4.20	0.02	
		5–10	41%	5.74	0.003	
Single-use PET bottles (Oßmann et al. 2018)	2600 ± 2860	>10	0.0%	0.0	0.00	0.1
		5–10	1.7%	45.0	0.02	
		1.5–5	44.7%	1180	0.08	
		1–1.5	53.6%	1420	0.003	
Cardboard (Schymanski et al. 2018)	11 ± 8 (range 5–20)	>100	7%	0.77	3.23	3.9
		50–100	10%	1.10	0.58	
		20–50	16%	1.76	0.12	
		10–20	28%	3.08	0.01	
		5–10	39%	4.29	0.002	
Glass bottles (Schymanski et al. 2018)	50 ± 52 (range 4–155)	>100	3%	1.50	6.28	8.7
		50–100	7%	3.50	1.83	
		20–50	14%	7.00	0.46	
		10–20	32%	16.0	0.07	
		5–10	45%	22.5	0.01	
Glass bottles (Oßmann et al. 2018)	6290 ± 10,500	>10	6.9%	434	1.82	2.6
		5–10	15.4%	969	0.51	
		1.5–5	61.4%	3860	0.25	
		1–1.5	16.4%	1030	0.002	

1µG/L IS 0.001 PPM OR 0.0000001%
ADDITIVES 0.0000000001%

F. Welle & R. Franz, Microplastic in bottled natural mineral water – literature review and considerations on exposure and risk assessment, Food Additives & Contaminants: Part A, 35 (12), pp 2482-2492, 2018

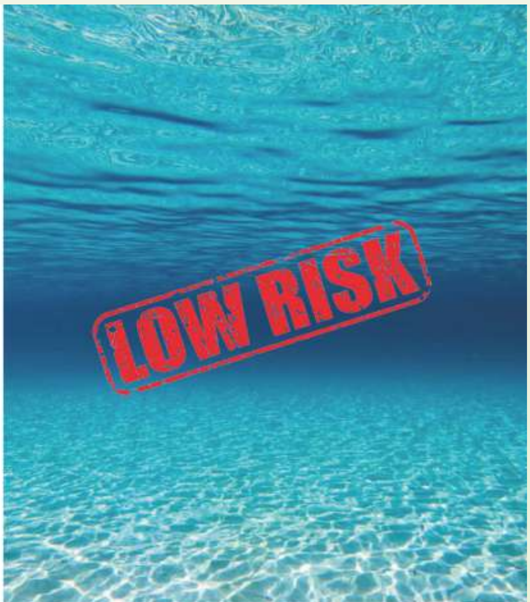
OCEAN PLASTIC

"We conducted an ecological risk assessment of MP in the global ocean by comparing the thresholds of biological effects with the probability of exposure to those concentrations..."

"Levels of MP from 100 to 5000 µm span from < 0.0001 to 1.89 mg/L, whereas the most conservative safe concentration is 13.8 mg/L, and probability of exposure is p = 0.00004. Therefore large MP pose negligible global risk."

"NEGLIGIBLE" RISK FROM MICROPLASTICS

R. Beiras & M. Schönemann, Currently monitored microplastics pose negligible ecological risk to the global ocean, Nature Scientific Reports, 10, 22281, 2020

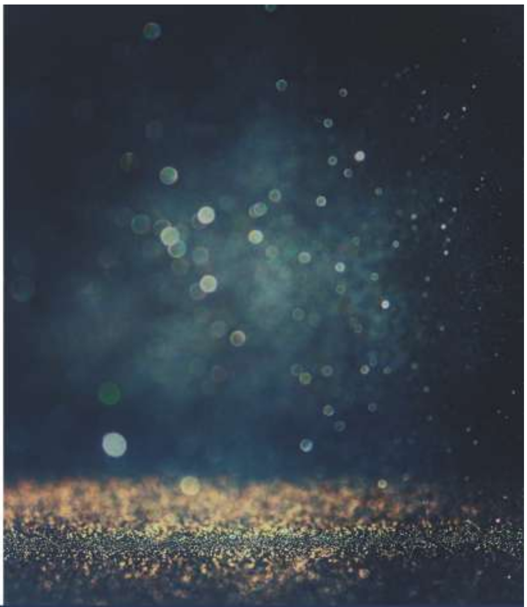


DUST TOXICITY

Material	Safety
Polyethylene PE	Non-toxic
Polypropylene PP	Non-toxic
Polyester PET	Non-toxic
Cement dust	Respiratory effects
Coffee dust	Respiratory effects
Metal dust	Respiratory effects
Quartz dust	Carcinogenic
Wood dust	Carcinogenic
Leather dust	Carcinogenic
Soot	Carcinogenic

J. A. Styles & J. Wilson, Comparison between in vitro toxicity of polymer and mineral dusts and their fibrogenicity, The Annals of Occupational Hygiene., November, 16 (3), pp 241-250, 1973

IARC Monographs Volume 100 A Review of Human Carcinogens, World Health Organization, 2012



PLASTICS DISTRACTION | MICROPLASTIC

MICROPLASTIC

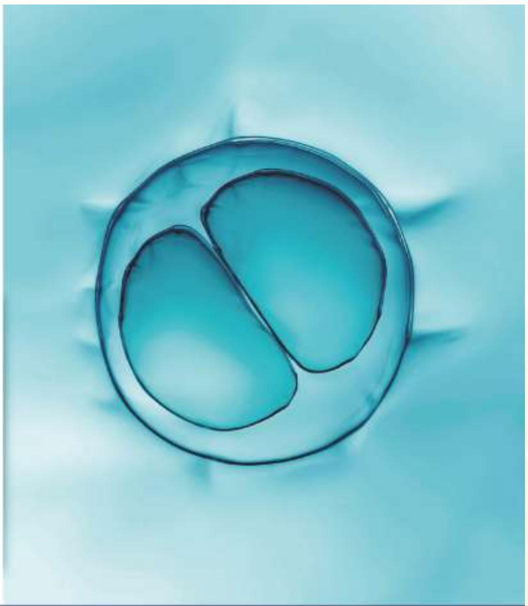
"This work for the first time investigated and compared the intestinal uptake and cytotoxicity of microplastic particles of the commonly produced materials PE, PP, PVC and PET in vitro."

"None of the particles triggered acute toxic effects, regardless of their shape and material."

"Only excessively high concentrations far beyond realistic dietary exposure of consumers induce cytotoxic effects."

NO PROBLEM FOUND FOR INGESTED PE, PP, PET OR PVC

V. Stock et al., Uptake and cellular effects of PE, PP, PET and PVC microplastic particles, Toxicology in Vitro, 70, 105021, 2021



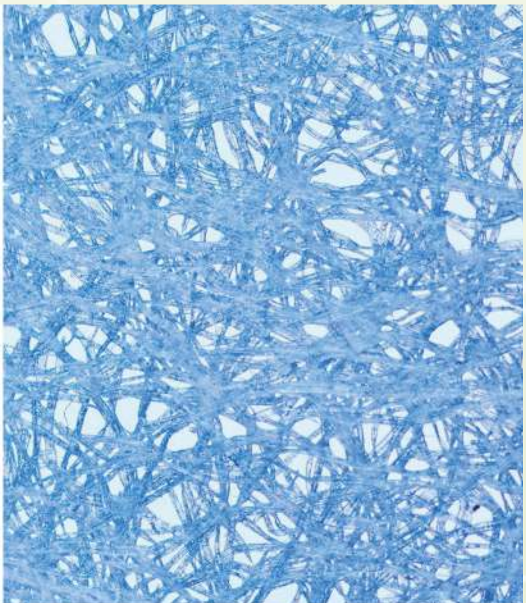
PLASTICS DISTRACTION | MICROPLASTIC

MICROPLASTIC FIBERS

"These results demonstrate that repeated daily ingestion of a spunbond, nonwoven polymer fabric consisting of polyethylene and polyethylene terephthalate for up to 13 weeks is well tolerated in rats, with no apparent target-organ toxicity at dietary levels up to 5%, and that fabric extracts are not mutagenic in a bacterial reverse mutation assay."

SYNTHETIC FIBERS ARE SAFE

J. A. Merski et al., Oral Toxicity and Bacterial Mutagenicity Studies with a Spunbond Polyethylene and Polyethylene Terephthalate Polymer Fabric, International Journal of Toxicology, 27, pp 387–395, 2008



PLASTICS DISTRACTION | MICROPLASTIC

PTFE TOXICITY

PTFE Teflon is non-toxic

"

There is strong evidence supporting the biological safety of PTFE, including specifically for ingestion purposes. Large volume ingestion of PTFE, at levels of 25% of the diet, is generally recognized as safe based on extensive animal feeding trials and the extreme inertness of the material.

Animal feeding trials showed that rats fed a diet of 25% PTFE for 90 days had no signs of toxicity and that the rats lost weight."

R. Naftalovich et al., Polytetrafluoroethylene Ingestion as a Way to Increase Food Volume and Hence Satiety Without Increasing Calorie Content, Journal of Diabetes Science & Technology, 10 (4), pp. 971-976, 2016

PLASTICS DISTRACTION | TOXICITY

MICROPLASTIC

"...the experimental design of most studies does not allow distinguishing plastic-specific effects from those caused by any other particles, such as clay and cellulose, which are ubiquitously present in the environment. We suggest that microplastic effects reported in recent ecotoxicological studies are similar to those induced by the natural particles."

PLASTIC PARTICLES AS SAFE AS NATURAL PARTICLES LIKE CLAY AND CELLULOSE

M. Ogonowska, Z. Gerdesa & E. Gorokhova, What we know and what we think we know about microplastic effects – A critical perspective, Current Opinion in Environmental Science & Health, 1, 41–46, 2018

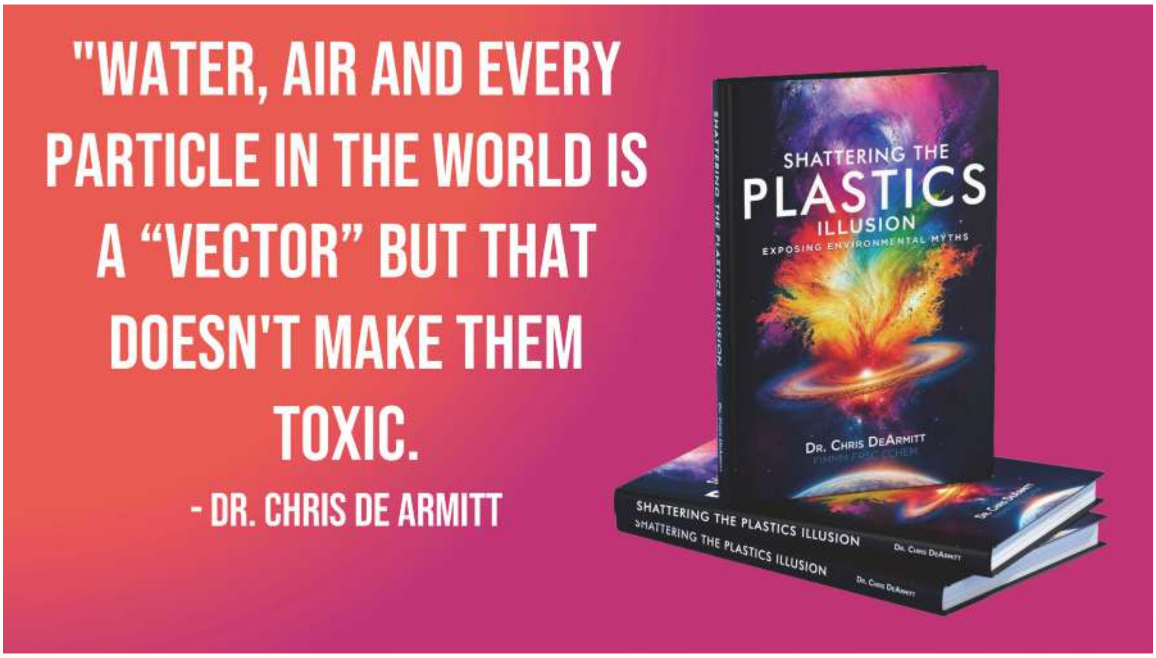
PLASTICS DISTRACTION | MICROPLASTIC

MICROPLASTICS NOT A HEALTH THREAT

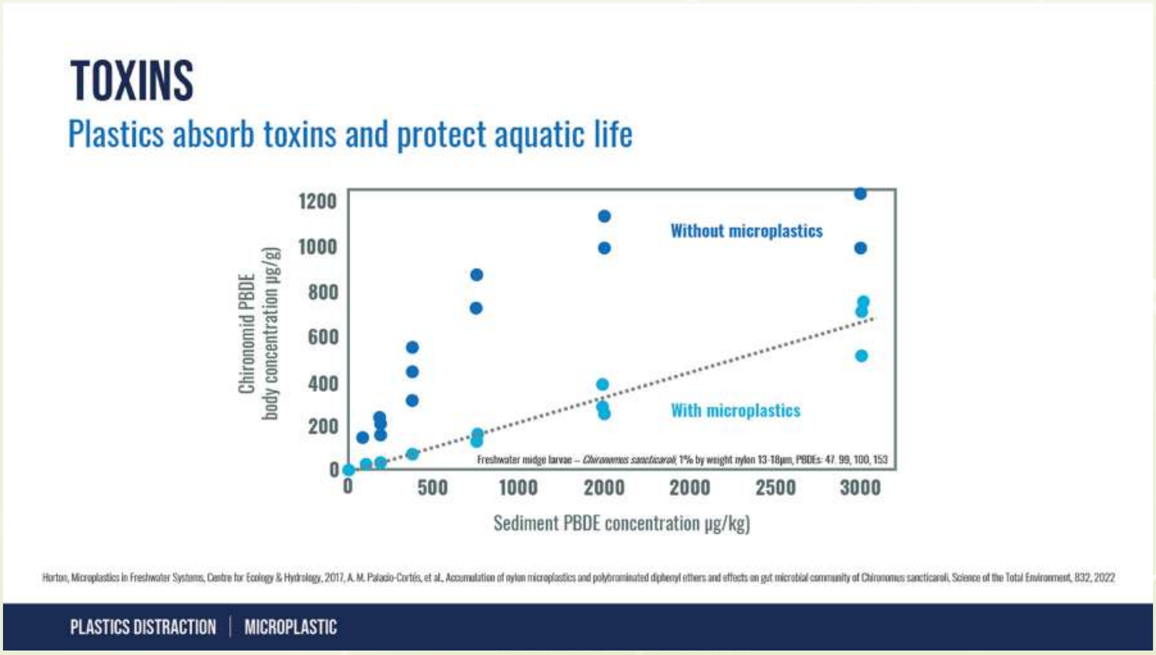
"Environmental exposure to synthetic particles is ubiquitous and may increase due to their environmental persistence and the increased use of these materials. However, observable health effects from this exposure are not likely to happen at current concentrations."

J.C. Prata in T. Rocha-Santos, M. Costa, C. Mouneyrac (eds), Handbook of Microplastics in the Environment, Springer Switzerland, pp 177-202, 2022

PLASTICS DISTRACTION | MICROPLASTIC


"WATER, AIR AND EVERY PARTICLE IN THE WORLD IS A "VECTOR" BUT THAT DOESN'T MAKE THEM TOXIC.
- DR. CHRIS DE ARMITT
SHATTERING THE PLASTICS ILLUSION
EXPOSING ENVIRONMENTAL MYTHS
DR. CHRIS DEARMITT
SHATTERING THE PLASTICS ILLUSION


CLEAN MICROPLASTICS
MICROPLASTICS WITH ABSORBED TOXINS
Fish swimming in toxic ocean water
Fish swimming in cleaner ocean water
PLASTICS DISTRACTION | MICROPLASTIC


TOXINS
Plastics absorb toxins and protect aquatic life
Chironomid PBDE body concentration µg/g)
1200
1000
800
600
400
200
0
Without microplastics
With microplastics
Freshwater midge larvae – Chironomus sancticaroli, 1% by weight nylon 13-18µm, PBDEs: 47, 99, 100, 153
0
500
1000
2000
2000
2500
3000
Sediment PBDE concentration µg/kg)
Horton, Microplastics in Freshwater Systems, Centre for Ecology & Hydrology, 2017, A. M. Palacio-Cortés, et al., Accumulation of nylon microplastics and polybrominated diphenyl ethers and effects on gut microbial community of Chironomus sancticaroli, Science of the Total Environment, 832, 2022
PLASTICS DISTRACTION | MICROPLASTIC

EATING MICROPLASTIC

WWF-funded study says we eat up to a credit card of plastic per week (5g)
Newer independent study says that would actually take over 20 000 years!

"Comparing our findings with the intake of other particles, MP mass intake rates are insignificant, as they make up for only 0.001% of these particles."

MICROPLASTICS ARE JUST 0.001% OF INGESTED PARTICLES AND "INSIGNIFICANT"

K. D. Cox et al., Human Consumption of Microplastics, Environ. Sci. Technol., 53, 12, 7068–7074, 2019
Nur Hazimah Mohamed Nor et al., Lifetime Accumulation of Microplastic in Children and Adults, Environ. Sci. Technol., 55, 8, 5084–5096, 2021

PLASTICS DISTRACTION | MICROPLASTIC

MICROPLASTIC & FOOD

"Apples had one of the highest microplastic counts in fruit, with an average of 195,500 plastic particles per gram, while pears averaged around 189,500 plastic particles per gram. Broccoli and carrots were shown to be the most contaminated vegetables, averaging more than 100,000 plastic particles per gram."
Greenpeace East Asia

3 Everyday Foods that Contain Microplastics, Greenpeace East Asia, July 21st, 2020 www.greenpeace.org/eastasia/blog/6016/3-everyday-foods-that-contain-microplastics/

Shockingly, they did not detect plastic at all - they assumed there was plastic without evidence!

G. O. Conti et al., Micro- and nano-plastics in edible fruit and vegetables - The first diet risks assessment for the general population, Environmental Research 187, 109677, 2020

PLASTICS DISTRACTION | MICROPLASTIC

MICROPLASTIC REALISM

">80% of studies are identified as not reliable"

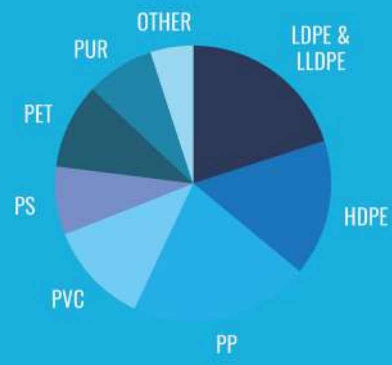
"...few studies provide information that support that the particles tested are representative of NMPs found in the environment, or that the concentrations tested are representative of environmentally relevant exposure scenarios."

~46% on polystyrene (of a special kind that doesn't exist in the environment)

10% of studies on PE, 5% PVC, 3% PP, 3% PET

SCIENTISTS ARE DOING INVALID STUDIES ON THE WRONG KINDS OF PARTICLE

T. Gouin et al., Screening and prioritization of nano- and microplastic particle toxicity studies for evaluating human health risks – development and application of a toxicity study assessment tool, Microplastics & Nanoplastics, 2 (2), 2022



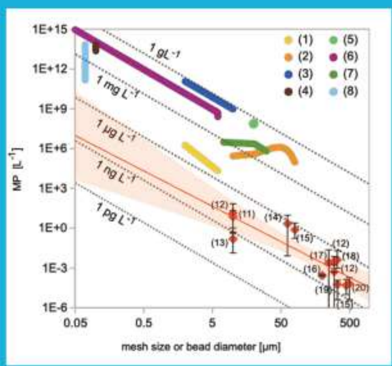
MICROPLASTIC REALISM

"Microplastic research is an emerging field, and there is a lot of misunderstanding and in some cases over-reaction or misinterpretation of results from MP science in the public. We therefore strongly suggest that future studies of MP impact on marine ecosystems should also include concentrations that have been documented in the environment to yield more realistic estimates of sublethal effects."

"Experimental exposure concentrations tend to be between two to seven orders-of-magnitude higher than environmental levels."

ABSURDLY HIGH CONCENTRATIONS ARE USED TO SCARE AND DECEIVE THE PUBLIC

R. Lenz, K. Enders, and T. G. Nielsen, Microplastic exposure studies should be environmentally realistic, Proceedings of the National Academy of Sciences, 113 (29), E4121–E4122, 2016



MICROPLASTIC IN DUST

Misleading the public

Average concentration of microplastic ~150 particles per mg dust
Average particle diameter ~50 microns
Average particle mass 60ng
Plastic is < 1% of the total dust
They threw away >99% of the dust including the toxic and carcinogenic particles

Studies throwing away >99% of the sample mislead us

H. Khalid Ageel et al., Microplastics in settled indoor dust: Implications for human exposure, Emerging Contaminants, 11, 100506, 2025

N. Yakovenko et al., Human exposure to PM$_{10}$ microplastics in indoor air, PLoS One, 20 (7), e0328011, 2025

TRANSLOCATION OF PARTICLES SINCE 1844

"The earliest known report of particle entry into intestinal lymphatics was cited in 1844 when Herbst observed starch granules in the blood and lymph vessels of dogs 3 h after they had been fed orally. Oesterlan recapitulated the same process after feeding coal particles to dogs."

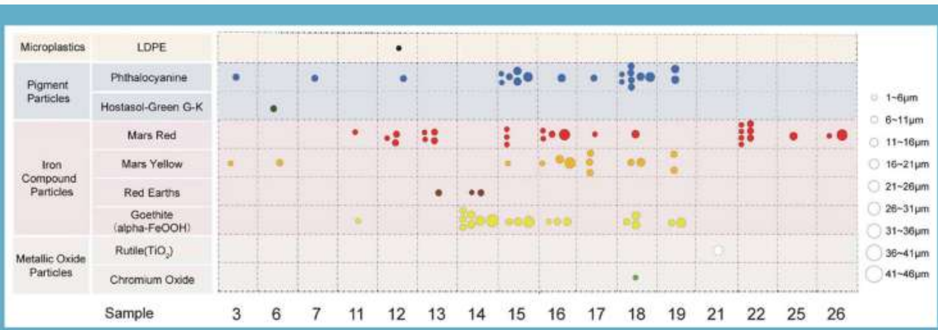
N. Hussain et al., Recent advances in the understanding of uptake of microparticulates across the gastrointestinal lymphatics, Advanced Drug Delivery Reviews, 50, pp 107-142, 2001

N. Hussain et al. / Advanced Drug Delivery Reviews 50 (2001) 107–142 109

Table 2
Selected examples of inert particulate matter translocated by the mammalian gut

Particle	Investigators (Ref.)	Year	Size	Animal
Starch	Herbst [20]	1844	3–50 μm?	Dog
Carbon	Oesterlan [21]	1846	?	Dog
Starch	Hirsch [22]	1906	7–100 μm	Dog
Starch	Verzar [23]	1911	?	Dog
Erythrocytes	Kumagai [4]	1926	5 μm	Rabbit
Latex	Sanders and Ashworth [202]	1961	200 nm	Rat
Starch	Volkheimer et al. [29]	1965–1977	8–150 μm	Human
Latex	Lefevre and Joel [26]	1977–1989	2–16 μm	Mice
Lead	Brosig et al. [86]	1977	40 μm	Rat
Percoll	Matsuno et al. [197]	1983	0.03 μm	Mice
PMMA	Nefzger et al. [196]	1984	130 nm	Rat
Gold	Fukai et al. [65]	1987	40 nm	Rat
Latex	Wells et al. [89]	1988	1 μm	Rat
Latex	Pappo and Ermak [132]	1989	1 μm	Rabbit
Latex	Jani et al. [69]	1990	0.05–3 μm	Rat
Latex	Ebel [203]	1990	2–10 μm	Mice
Liposomes	Childers et al. [91]	1990	1 μm	Mice
PLGA	Eldridge et al. [83]	1991	1–10 μm	Rat
Latex	McMinn et al. [177]	1996	2 μm	Rat
Polyanhydride	Mathiowitz et al. [124]	1997	0.1–10 μm	Rabbit
Latex, dyes	Szentkuti [79]	1997	0.01–1 μm	Rat
Dendrimer	Florence et al. [191]	1999	2.5 nm	Rat
Titanium	Bockman et al. [34]	2000	160–380 nm	Human

PLASTICS DISTRACTION | MICROPLASTIC



"Among twenty-six thrombi, sixteen contained eighty-seven identified particles ranging from 2.1 to 26.0 μm in size. The number of microparticles in each thrombus ranged from one to fifteen with the median reaching five. All the particles found in thrombi were irregularly block-shaped. Totally, twenty- one phthalocyanine particles, one Hostasol-Green particle, and one low-density polyethylene microplastic, which were from synthetic materials, were identified in thrombi. The rest microparticles included iron compounds and metallic oxides."

D. Wu et al., Pigment microparticles and microplastics found in human thrombi based on Raman spectral evidence, Journal of Advanced Research, 49, pp 141–150, 2023

PLASTICS DISTRACTION | MICROPLASTIC

DUST

Silver, silica, carbon, alumina, cerium oxide, diesel exhaust, quantum dots, platinum, titanium dioxide, gold, iron oxide, polystyrene, fullerenes, zinc oxide, zirconium oxide, carbon nanotubes...

VARIOUS PARTICLES FOUND IN PLACENTA

E. Bongaerts et al., Translocation of (ultra)fine particles and nanoparticles across the placenta: a systematic review on the evidence of in vitro, ex vivo, and in vivo studies, Particle & Fibre Toxicology, 17 (56), 142235, 2020

T. Buerki-Thurnherr et al., Knocking at the door of the unborn child: engineered nanoparticles at the human placental barrier, Swiss Medicinal Weekly, 142, 2012

PLASTICS DISTRACTION | MICROPLASTIC

BRAIN SPOON OF PLASTIC

"However, unknown organic molecules likely remain and influence the resultant Py-GC/MS spectra. Lipids have been noted as a potential source of interference in Py-GC/MS analysis of PE."

"It was concluded that Py-GC-MS is currently not a suitable analysis method for PE and PVC in biological matrices due to the presence of interferences and nonspecific pyrolysis products."

Takes thousands of years to ingest the amount of plastic claimed, so it's impossible to have 6g in the body.

SCARE STORIES TURN OUT TO BE FALSE

A. J. Nihart et al., Bioaccumulation of microplastics in decedent human brains, Nature Medicine, 31, pp. 1114-1119, 2025

C. Rauert et al., Assessing the Efficacy of Pyrolysis-Gas Chromatography-Mass Spectrometry for Nanoplastic and Microplastic Analysis in Human Blood, Nanomaterials, 13, 1404, 2023

PLASTICS DISTRACTION | MICROPLASTIC

Microplastics

Ingestion & Accumulation

MP intake 0.0000035g per week and there are ~3600 weeks in 70 years.

So total lifetime exposure to microplastic by ingestion is ~0.01g.

The vast majority (~99.7%) of small particles ingested pass right through us.

So, we can calculate the total amount not expelled over 70 years as 0.0001g.

Even that tiny fraction is attacked and destroyed by the body's defences.

Nur Hazimah Mohamed Nor, Lifetime Accumulation of Microplastic in Children and Adults, Environmental Science & Technology, 55 (8), pp 5084-5096, 2021
J. J. Powell et al., Origin and fate of dietary nanoparticles and microparticles in the gastrointestinal tract, Journal of Autoimmunity, 34, pp 226-233, 2010

MICROPLASTICS IN PETS

Very low amounts & no effect

"

The preliminary results of 24 cats and 25 dogs from the Porto metropolitan area reveal the presence of none to low concentrations of microplastics (median 0 MP g^{-1})."

"In this study, PET was found in median concentrations of 61,000 and 30,000 ng g^{-1} in cat and dog feces, respectively."

"While limited by sample size, no evidence was found to support accumulation in older animals nor relation to the cause of death."

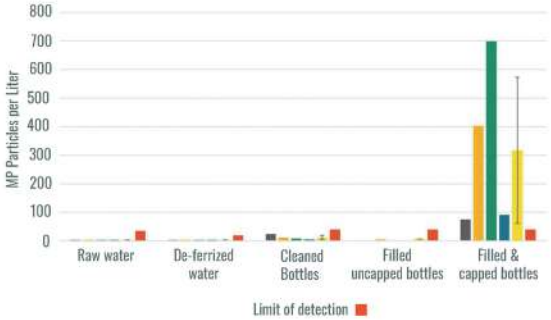
J. C. Prata et al., Microplastics in Internal Tissues of Companion Animals from Urban Environments, Animals, 12 (15), p 1979, 2022

PLASTICS DISTRACTION | MICROPLASTIC

MICROPLASTIC FORMATION

"The assumption, that MP particles particularly enter re-usable bottles during the bottle cleaning process, could not be confirmed: cleaned, unfilled bottles were found to be nearly free of MP in the size range analyzed (≥11 µm), even though the caustic bottle cleaning solution contained thousands of MP per L. It seems that carryover of MP particles from the caustics into the bottles was prevented by fresh water jetting."

"Instead, a drastic increase in MP numbers was found when comparing un-capped and capped bottles, hinting at capping and bottle opening to be the main entry paths for MP in bottled mineral water. Cap sealing materials should therefore be tested for abrasion resistance."



MICROPLASTICS FORMED BY CAPPING

J. Weisser et al., From the Well to the Bottle: Identifying Sources of Microplastics in Mineral Water, Water, 13, 841, 2021

PLASTICS DISTRACTION | MICROPLASTIC

POLYESTER VS COTTON

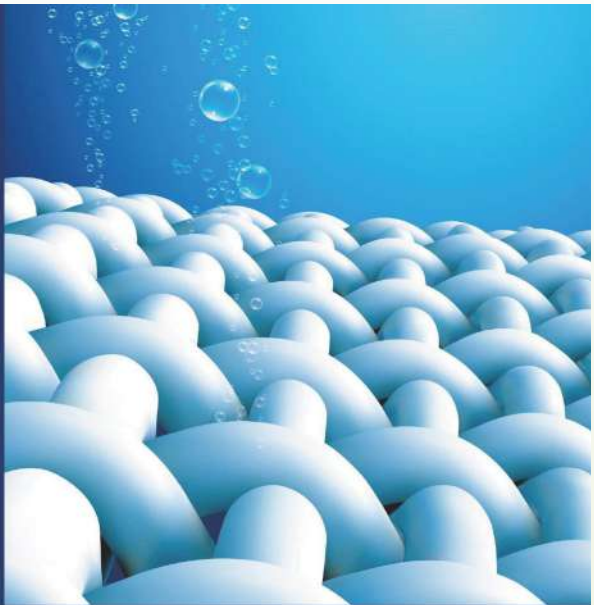
Polyester reduces fibers

"

Our results demonstrate for the first time that direct release of microfibres from garments to air as a consequence of wear is of equal importance to releases to water."

"FTIR analyses of subsamples of the microfibres collected in the Petri dishes during the tests revealed that they were all polyester for the polyester garments PES-Knit-Filament, PES-Woven-Filament and PES-Knit-Staple. Alternatively, in the case of PES/COT-Knit-Staple, results pointed out that only 1 of the 32 analysed fibres were polyester, while the others were all of cellulosic nature."

F. De Falco et al., Microfiber Release to Water, Via Laundering, and to Air, via Everyday Use: A Comparison between Polyester Clothing with Differing Textile Parameters, Environmental Science & Technology, 54 (6), 2020



PLASTICS DISTRACTION | MICROPLASTICS

POLYESTER VS COTTON

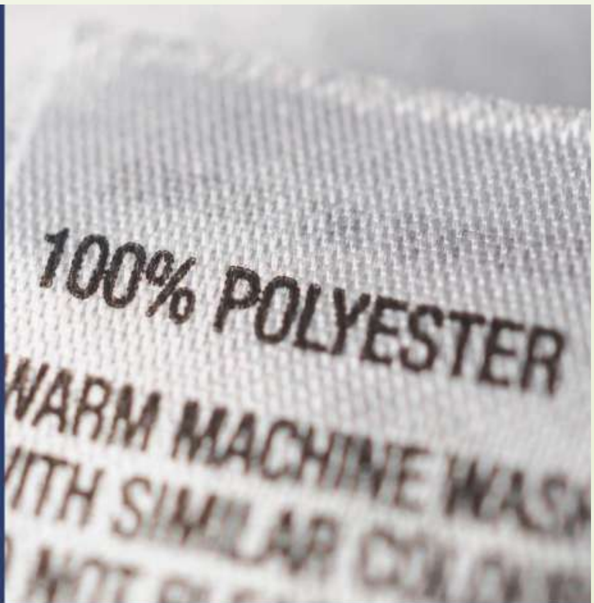
Polyester reduces impact & fibers

"

Polyester garments have lower GHG emissions and LU compared to the default (due to lower weight and longer lifetime). However, because polyester fabrics contribute to environmental pollution through the release of microplastics, we decided not to select polyester as an environmentally-friendly material."

They excluded the lowest impact option for a "reason" that is false because polyester massively reduces fiber release.

J. Koch et al., Reducing environmental pressure through a more circular consumption of clothes, Sustainable Production and Consumption 58, pp. 396–411, 2025



PLASTICS DISTRACTION | MICROPLASTICS

MICROPLASTIC & EVEREST

NATIONAL GEOGRAPHIC

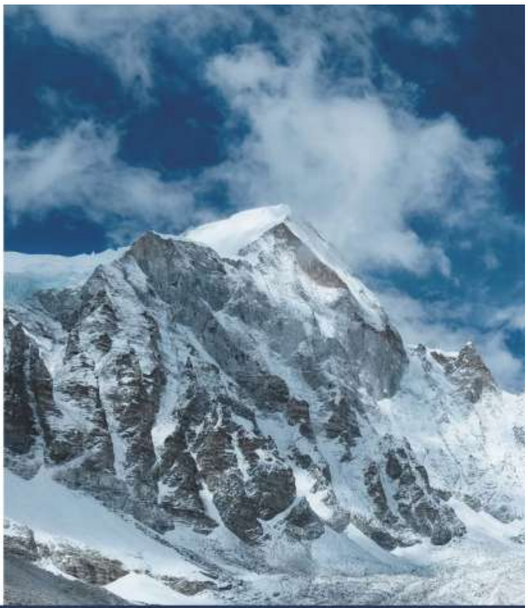
ENVIRONMENT | PERPETUAL PLANET

Microplastics found near Everest's peak, highest ever detected in the world

Since when was "I found dust" news? Dust is everywhere.

SPURIOUS NEWS IS MISLEADING US

E. Napper et al., Reaching New Heights in Plastic Pollution—Preliminary Findings of Microplastics on Mount Everest, One Earth, 3 (5), pp 621-630, 2020



PLASTICS DISTRACTION | MICROPLASTIC

MICROPLASTIC

"The results show that most scientific studies (67%) frame microplastics risks as hypothetical or uncertain, while 24% present them as established. In contrast, most media articles reporting on microplastic impacts (93%) imply that risks of microplastics exist and harmful consequences are highly probable."

SOME SCIENTISTS AND THE MEDIA ABANDON THE TRUTH FOR MONEY AND ATTENTION

C. Völker, J. Kramm and M. Wagner, On the Creation of Risk: Framing of Microplastics Risks in Science and Media, Global Challenges, 4 (6), 1900010, 2020

PLASTICS DISTRACTION | MEDIA

NGO SCORECARD

Topic	NGOs say problem is	Science says problem is	NGOs right or wrong?
Materials	Plastic	Concrete, wood, metals	Wrong
Waste	Plastic	Manufacturing, mining, oil, gas	Wrong
CO_2	Plastic	Metals, cement, paper	Wrong
Fossil fuel	Plastic	Iron, steel, cement	Wrong
Ocean plastic	Dangerous Increasing	"Negligible" Constant	Wrong
Turtles	Plastic	Trawling, fishing, boat strikes	Wrong
Whales	Plastic	Fishing gear, vessel strikes	Wrong
Birds	Plastic	Buildings, powerlines, cats	Wrong
Particles	Plastic	Soot, inorganics (quartz, Pb, Cd)	Wrong
Toxins	Plastic	Lead, mercury, cadmium, dioxins	Wrong

SO-CALLED "ENVIRONMENTAL" GROUPS ARE HARMING THE ENVIRONMENT WITH DISASTROUS ADVICE

PLASTICS DISTRACTION | FACTS

Closing the loop and the circular economy in a bottle-to-bottle model

Mr Frank Schepers

General Director of TML Plastic Mongolia

Mr Schepers brings 30+ years of recycling expertise. Formerly at Swire Coca-Cola, he led strategies for 30 - 50% rPET integration. His leadership spans global and local circular economy initiatives, including Hong Kong's New Life Plastics, driving sustainability, cost efficiency, and operational excellence across the sector.

CLOSING THE LOOP: ACHIEVING SUSTAINABILITY, EFFICIENCY, AND EXCELLENCE IN THE CIRCULAR PET BOTTLE-TO-BOTTLE ECONOMY

Innovative recycling model enhancing environmental and business goals

AGENDA OVERVIEW

- Introduction to the Circular Economy and PET Bottle-to-Bottle Recycling
- Mapping the Full PET Value Chain: From Consumer to Bottle
- Extended Producer Responsibility (EPR) and Global Collection Best Practices
- Processing Journey: From Collected PET to Food-Grade Bottles
- Value Creation and Value Sharing Across the Chain
- Operational Excellence, Sustainability Metrics, and Inspirational Success Stories

INTRODUCTION TO THE CIRCULAR ECONOMY AND PET BOTTLE-TO-BOTTLE RECYCLING

DEFINING THE CIRCULAR ECONOMY AND ITS SIGNIFICANCE

Concept of Circular Economy

The circular economy emphasizes eliminating waste through continuous reuse of materials in production processes.

Contrast with Linear Economy

Unlike the linear economy, the circular model promotes recycling and reuse to minimize resource consumption.

Environmental and Resource Benefits

Circular economy reduces environmental impact by conserving resources and lowering waste generation.

OVERVIEW OF THE PET BOTTLE-TO-BOTTLE MODEL

Collection of Used PET Bottles

Used PET bottles are collected from consumers to initiate the recycling and reuse process, reducing landfill waste.

Processing into Food-Grade Recycled PET

Collected bottles are processed and purified into food-grade recycled PET suitable for manufacturing new bottles.

Manufacturing New Bottles

Food-grade recycled PET is used to manufacture new bottles, creating a sustainable closed-loop system that reduces virgin plastic use.

BENEFITS FOR SUSTAINABILITY, EFFICIENCY, AND BUSINESS

Environmental Benefits

The model reduces carbon footprint and conserves natural resources to protect the environment.

Operational Efficiency

Closed-loop processes improve efficiency by minimizing waste and optimizing resource use.

Economic Opportunities

Businesses and stakeholders benefit economically through new sustainable business models and growth.

MAPPING THE FULL PET VALUE CHAIN: FROM CONSUMER TO BOTTLE

CONSUMER RESPONSIBILITY AND AWARENESS

Proper Disposal of PET Bottles

Consumers must dispose of PET bottles correctly to reduce environmental pollution and promote recycling efficiency.

Participation in Recycling Programs

Active involvement in community recycling programs helps conserve resources and supports sustainability efforts.

Raising Consumer Awareness

Educating consumers about recycling benefits motivates responsible behaviors and fosters a circular economy.

COLLECTION MODELS: DEPOSIT RETURN SCHEMES, CURBSIDE COLLECTION, AND REVERSE VENDING

Deposit Return Schemes

Deposit return schemes encourage consumers to return containers for a refund, increasing recycling rates and material quality.

Curbside Collection

Curbside collection offers convenient pickup of recyclables at homes, improving participation in recycling programs.

Reverse Vending Machines

Reverse vending machines automate returns of recyclable items, streamlining collection and reducing contamination.

ROLE OF STAKEHOLDERS IN THE VALUE CHAIN

Stakeholder Collaboration

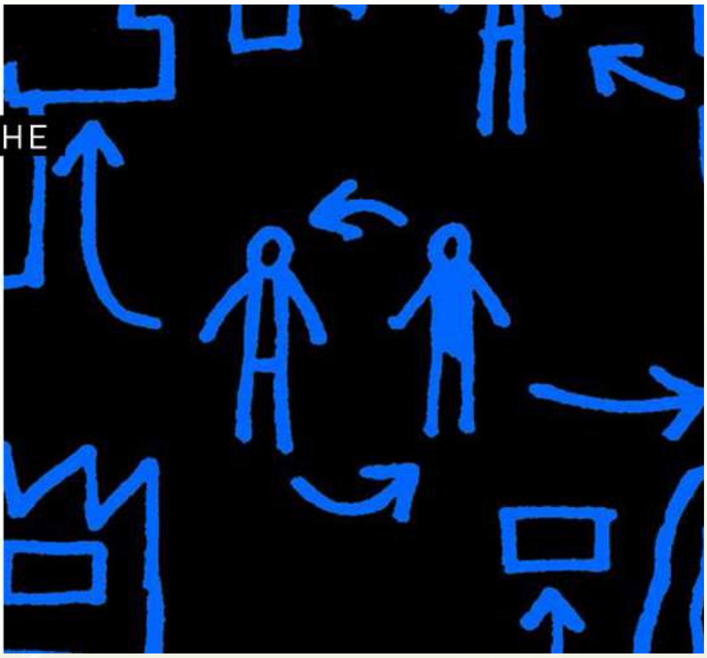
Effective collaboration among all stakeholders ensures efficient collection and sorting of recyclable materials.

Optimizing Recycling Processes

Optimized recycling processes maximize resource recovery and environmental benefits.

Role of Policymakers

Policymakers create regulations that support sustainable waste management and recycling initiatives.



EXTENDED PRODUCER RESPONSIBILITY (EPR) AND GLOBAL COLLECTION BEST PRACTICES

PRINCIPLES OF EPR AND ITS IMPACT ON RECYCLING RATES

Producer Responsibility

EPR requires producers to finance or manage recycling, promoting accountability in waste management.

Design for Recyclability

EPR encourages product design that facilitates easier recycling, improving overall sustainability.

Improved Recycling Infrastructure

EPR enhances recycling collection and processing facilities, boosting recycling rates effectively

Regulatory Frameworks

Europe and Asia use strong regulations to support Extended Producer Responsibility and enhance PET bottle recycling rates.

Stakeholder Engagement

Collaboration among governments, businesses, and communities is vital to successful EPR programs in both continents.

Innovative Collection Schemes

Creative approaches to collecting PET bottles improve recycling efficiency and participation in Europe and Asia.

IMPLICATIONS FOR POLICY, BRANDS, AND RECYCLERS

Policy Development Impact

EPR influences the creation and enforcement of policies promoting sustainable resource management across industries.

Brand Strategy Alignment

Brands adapt strategies to develop sustainable packaging and meet EPR compliance for environmental responsibility.

Recycler Operational Efficiency

Recyclers optimize processes to ensure compliance with EPR and improve material recovery efficiency.

PROCESSING JOURNEY: FROM COLLECTED PET TO FOOD-GRADE BOTTLES

SORTING AND CLEANING COLLECTED PET BOTTLES

Effective Material Sorting

Sorting removes contaminants and separates PET bottles from other materials to ensure purity in recycling.

Thorough Cleaning Process

Cleaning eliminates residues on PET bottles, essential for producing high-quality recycled material.

ADVANCED RECYCLING TECHNOLOGIES AND QUALITY CONTROL

Infrared Sorting Technology

Infrared sorting enables precise identification and separation of PET from other materials, enhancing recycling efficiency.

Washing and Decontamination

Advanced washing lines and decontamination processes remove impurities, improving the purity of recycled PET.

Quality Control Standards

Rigorous quality control procedures ensure recycled PET meets strict food safety compliance standards.

PRODUCTION OF PREFORMS AND NEW FOOD-GRADE RECYCLED PET BOTTLES

Recycled PET Processing

Clean recycled PET material is processed carefully to ensure quality for reuse in bottle production.

Preform Molding

Recycled PET is molded into preforms, the intermediate form before becoming bottles.

Bottle Production

Preforms are blown into new food-grade bottles, completing the closed-loop recycling process.

Sustainability Benefits

This closed-loop system reduces virgin plastic use and minimizes waste, supporting sustainability goals.

VALUE CREATION AND VALUE SHARING ACROSS THE CHAIN

ECONOMIC BENEFITS FOR EACH STAKEHOLDER

Consumer Cost Savings

Consumers benefit from lower costs due to efficient recycling and reuse of PET bottles in the circular system.

Job Creation

The circular PET system creates jobs across collection, recycling, and manufacturing sectors, boosting employment.

Market Opportunities

Manufacturers and communities benefit from new market opportunities created by sustainable PET bottle reuse and recycling.

COST EFFICIENCY THROUGH CLOSED-LOOP PROCESSES

Reduction in Raw Material Costs

Closed-loop recycling significantly lowers the need for raw materials, cutting material procurement expenses.

Waste Management Savings

Efficient waste reuse decreases disposal costs and minimizes environmental impact.

Operational Expense Reduction

Improved resource efficiency across the supply chain lowers overall operational costs.

Incentives for Value Sharing

Incentives motivate stakeholders to actively participate in value sharing, enhancing circular economy practices.

Collaborative Partnerships

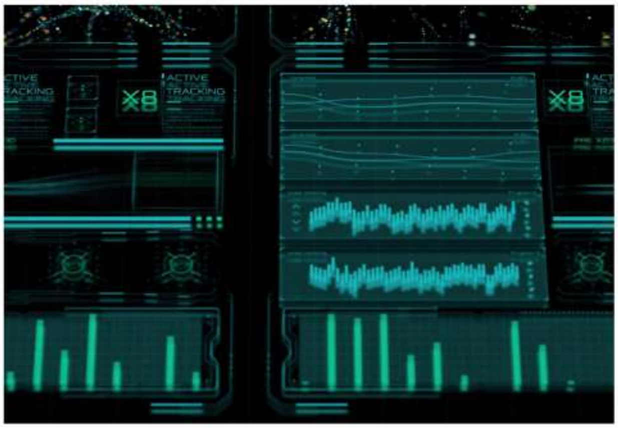
Partnerships foster collaboration and resource sharing for stronger innovation and sustainability outcomes.

Community Impact

Shared value initiatives improve social and environmental conditions in local communities.

OPERATIONAL EXCELLENCE, SUSTAINABILITY METRICS, AND INSPIRATIONAL SUCCESS STORIES

OPERATIONAL BEST PRACTICES AND CONTINUOUS IMPROVEMENT



Standardized Processes

Adopting uniform procedures ensures consistency and efficiency in PET recycling operations.

Performance Monitoring

Tracking key metrics helps identify improvement areas and maintain high operational standards.

Fostering Innovation

Encouraging creative solutions supports overcoming challenges in the circular economy.

SUSTAINABILITY KPIS: CARBON FOOTPRINT, WATER USE, AND WASTE REDUCTION

Carbon Footprint Tracking

Measuring greenhouse gas emissions helps organizations assess environmental impact and reduce carbon output.

Water Consumption Monitoring

Tracking water use enables efficient management and conservation of this vital resource.

Waste Reduction Metrics

Measuring waste generation supports strategies to minimize landfill and promote recycling.

EYE-CATCHING EXAMPLES OF SUCCESSFUL BOTTLE-TO-BOTTLE INITIATIVES

Global Collaborative Efforts

Worldwide collaborations between governments and industries boost circular bottle-to-bottle recycling programs.

Innovative Recycling Technologies

Advanced technologies improve PET bottle recycling efficiency and quality for reuse.

Effective Policy Support

Policies and regulations incentivize sustainable recycling and circular economy practices worldwide.

CONCLUSION

Circular Economy Model

The PET bottle-to-bottle model exemplifies sustainability by promoting reuse and reducing waste in production.

Collaboration and Innovation

Successful implementation relies on partnership and innovative approaches across the entire value chain.

Commitment to Closing the Loop

Continuous commitment is essential to efficiently close the loop and achieve business excellence.