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Business with Birmingham

EPSRC
Engineering and Physical Sciences Research Council

University of Birmingham Business Club Breakfast Briefing

The Challenge of Plastics Recycling

18 June 2019

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Engineering and Physical Sciences Research Council

Professor Stefan Krause

University of Birmingham

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Fate and Transport of Microplastics in Freshwater Ecosystems

The 100 Plastic Rivers Project

Stefan Krause

Holly Nel, Jennifer Drummond, Iseult Lynch, Jesus Gomez-Velez, Greg Sambrook Smith, Anna Kukkola


Dr. H. Nel


Dr. J. Drummond


Prof. J. Gomez-Velez

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clean seas ODYSSEY

Birmingham Water Council

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THE INSTITUTE FOR GLOBAL INNOVATION

Motivation:
Global Plastic Pollution

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[https://www.wwf.org.uk/fight-plastic-pollution]

[https://www.telegraph.co.uk/business/2018/02/01/pick-winners-war-plastic/]

BBC Sign in

NEWS

Science & Environment

'A single piece of plastic' can kill sea turtles, says study

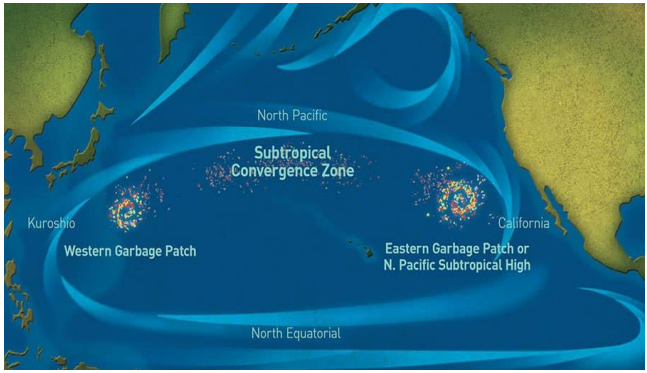
By Matt McGrath
Environment correspondent

13 September 2018 Share

Motivation:
Global Plastic Pollution

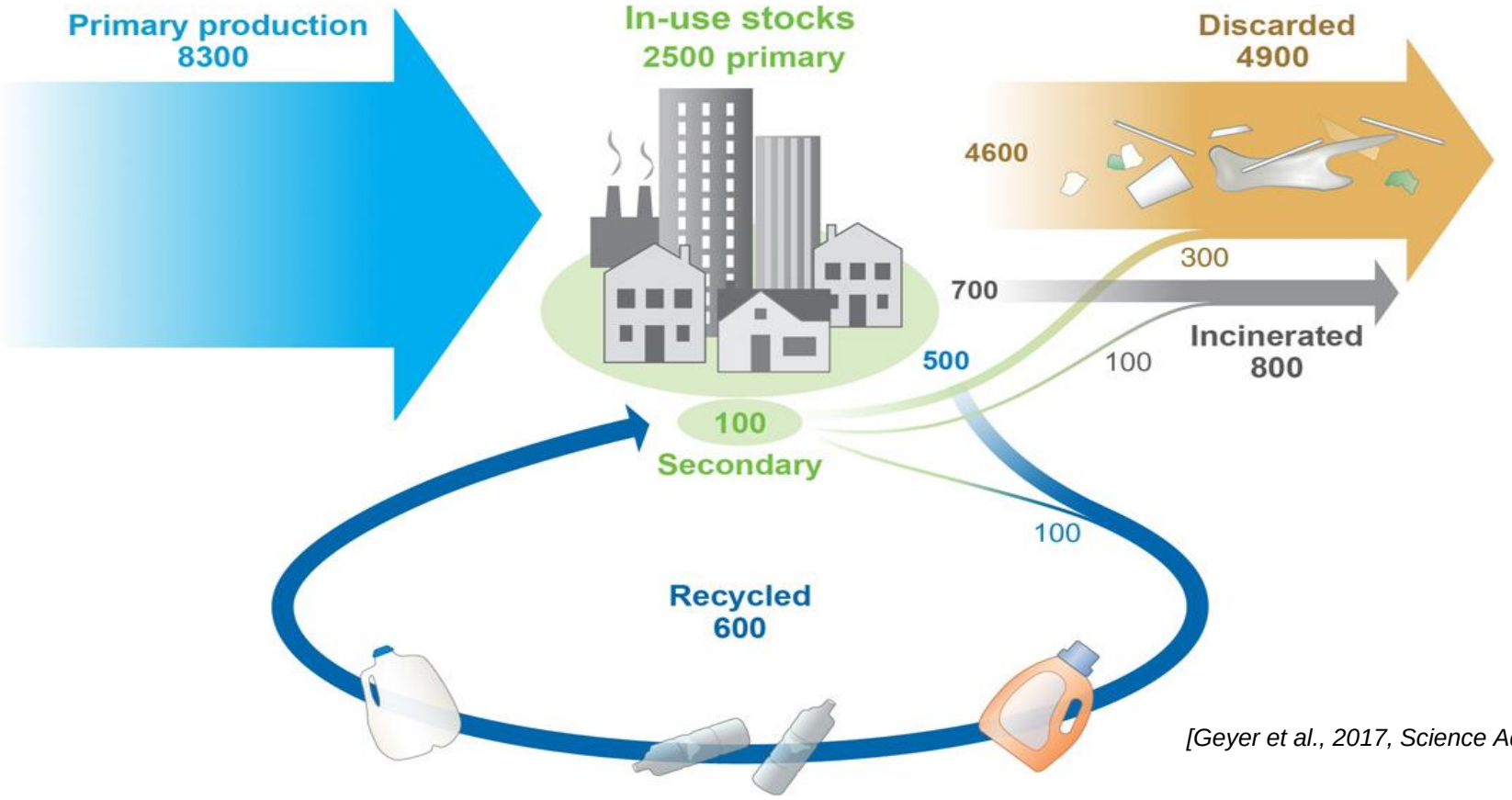
[THE TIMES - https://www.thetimes.co.uk/article/plastic-waste-blue-planet-effect-was-behind-new-green-levy-f8s57zq7t]

Ocean gyres:



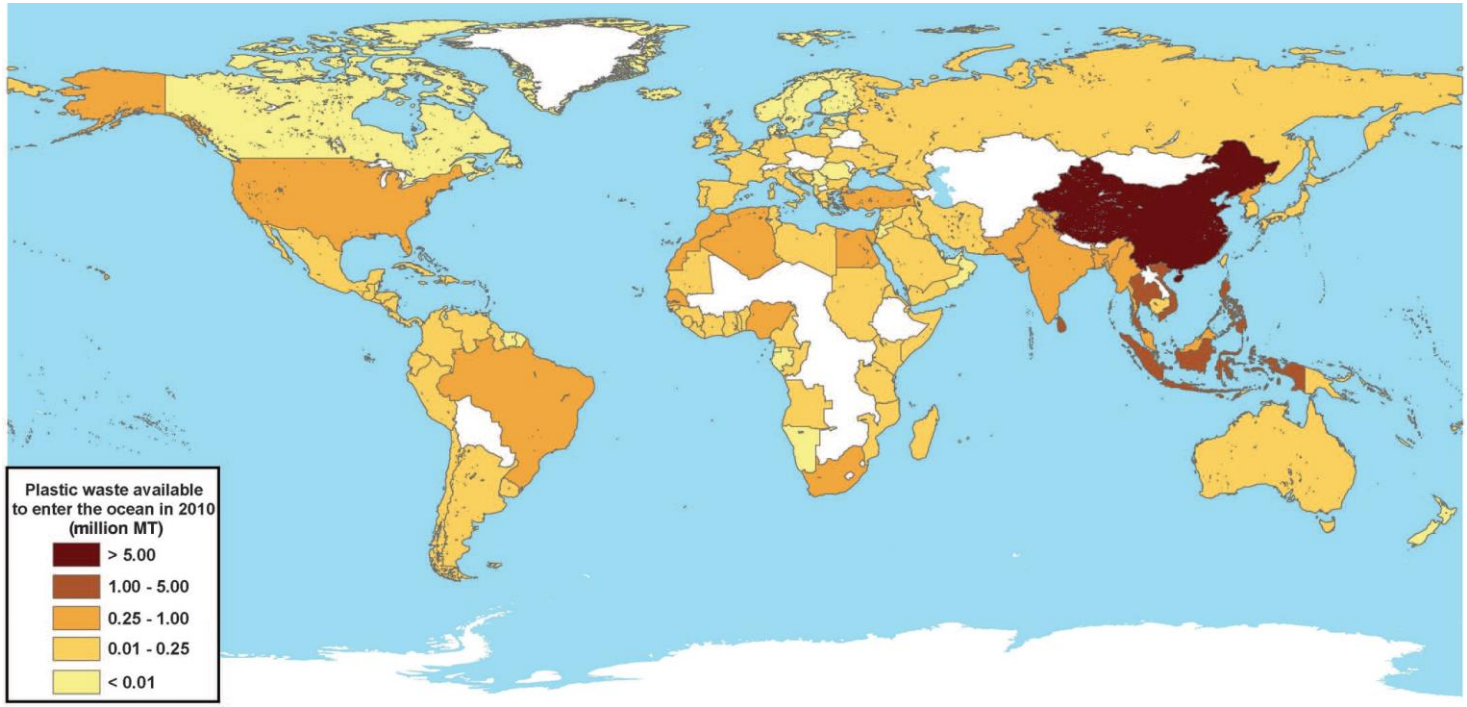
[https://oceanservice.noaa.gov/podcast/mar18/nop14-ocean-garbage-patches.html]

Motivation:
(Discrepancies in) Global Plastic Budgets



[Geyer et al., 2017, Science Advances]

Motivation:
(Discrepancies in) Global Plastic Budgets



[Jambeck et al., 2015, Science]

2010:

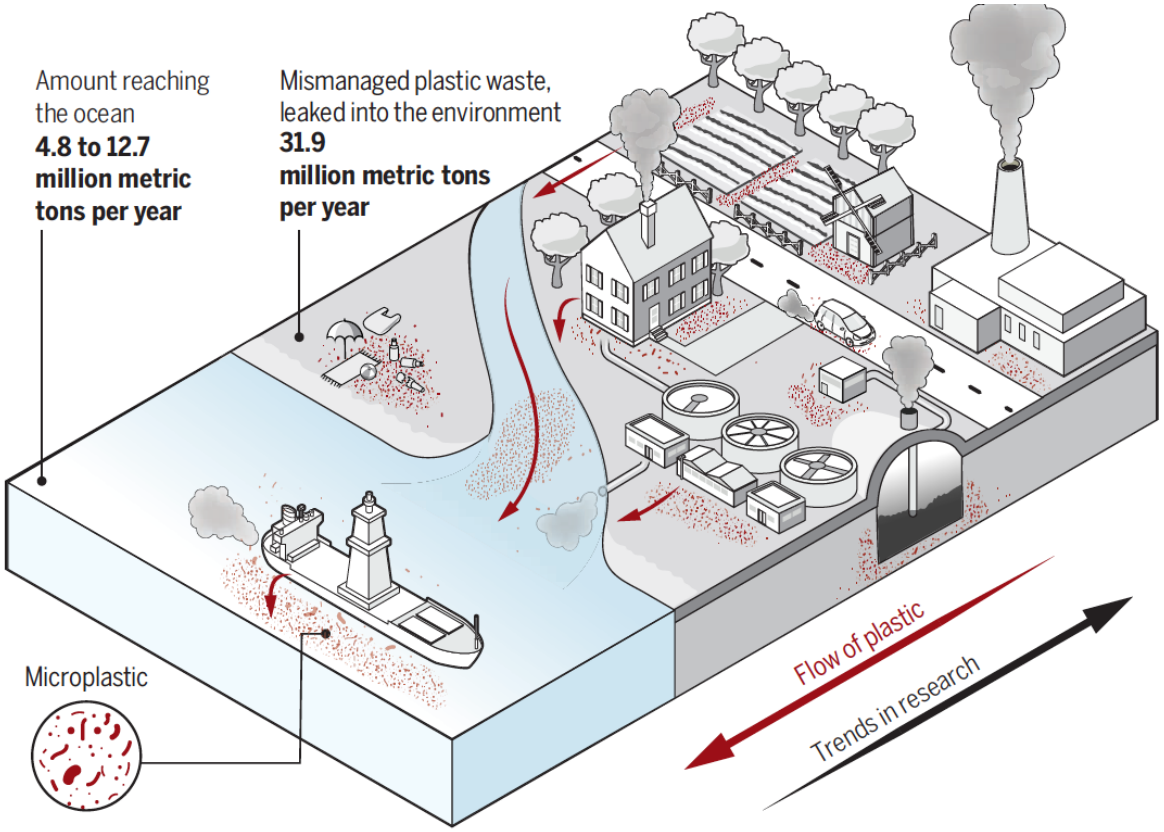
192 countries - 275 million MT of plastic waste

4.8 - 12.7 million MT entering the ocean

f: population size, quality of waste management

< 50km from coast!

Motivation:
(Discrepancies in) Global Plastic Budgets



[Rochman et al., 2019, Science]

Ocean Surface:

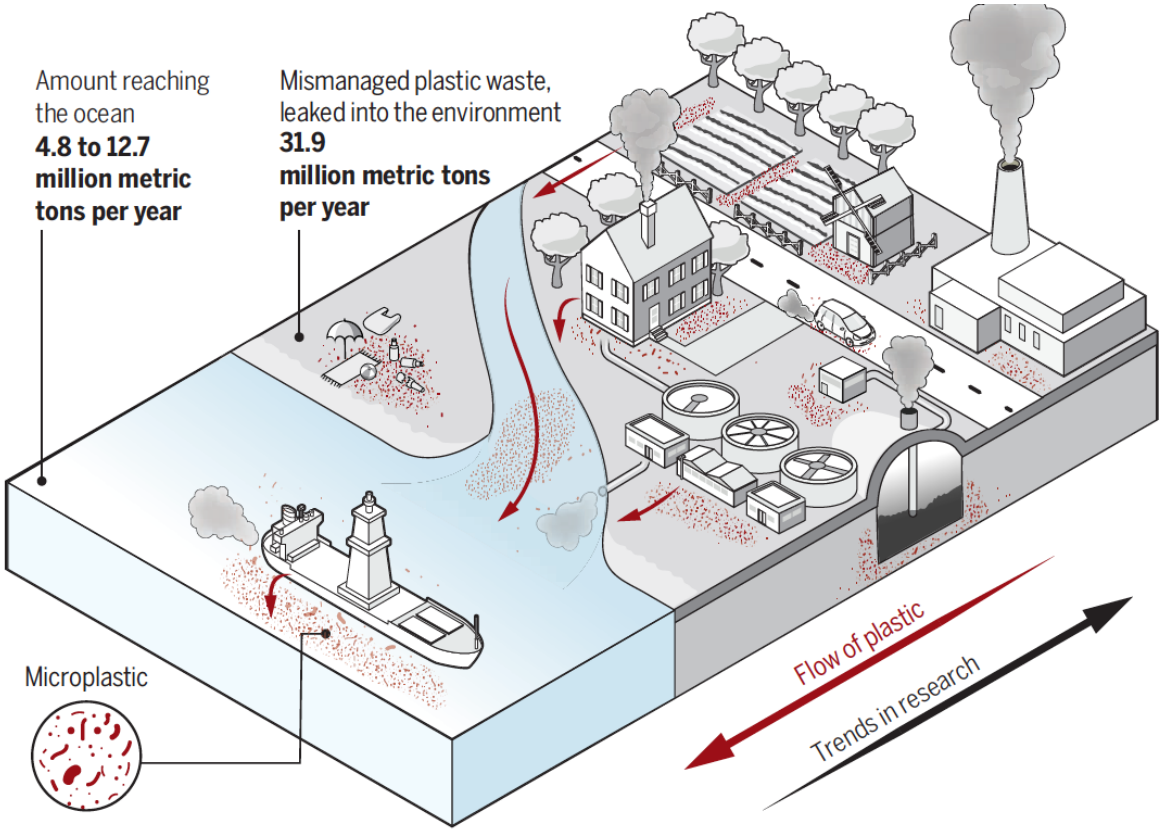
5 - 50 trillion plastic particles

=

32,000 to 236,000 metric tonnes

[van Sebille et al., 2015]

Motivation:
(Discrepancies in) Global Plastic Budgets



[Rochman et al., 2019, Science]

99% of plastics missing!

[Sebile et al., 2015; Bond et al., 2018]

- **Accumulation in sewage treatment works, river and estuarine sediments and along shorelines**
- **Settling of nonbuoyant polymers into the deep-sea**
- **Fragmentation of both buoyant and non-buoyant polymers into particles smaller than captured by existing experimental methods**

Microplastics accumulation in exorheic river networks
[log10(millions MT)]

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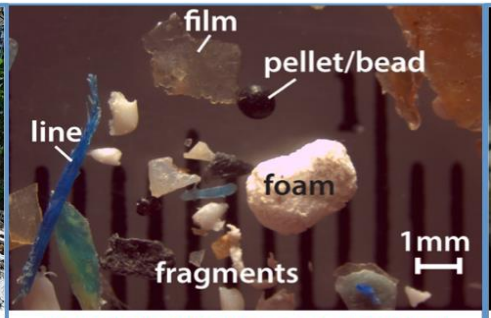
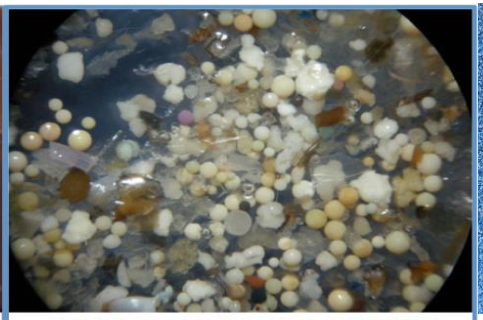
River macroplastics, Kerala, India (Yajaprakash)

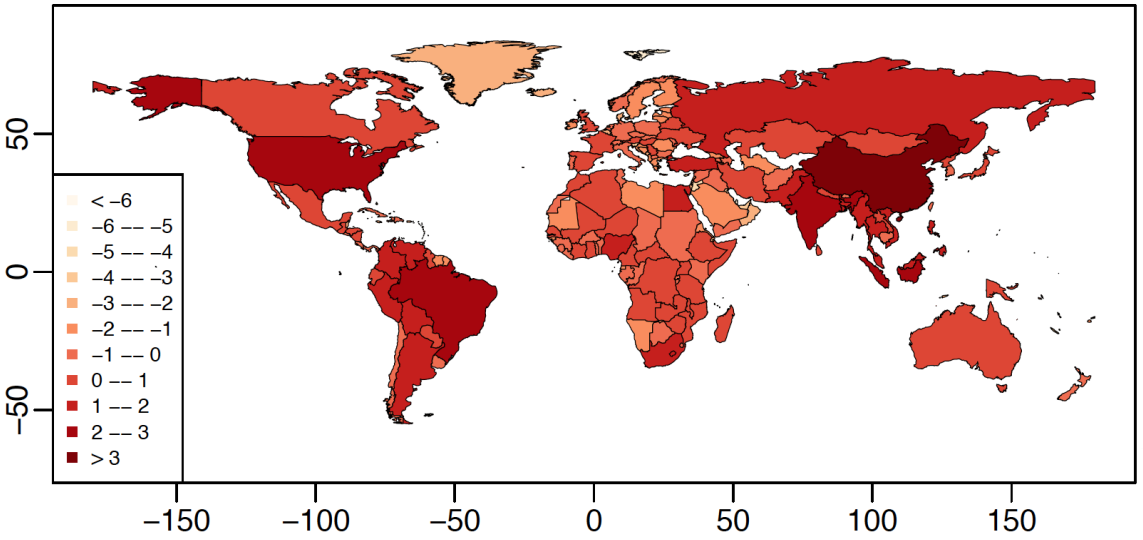


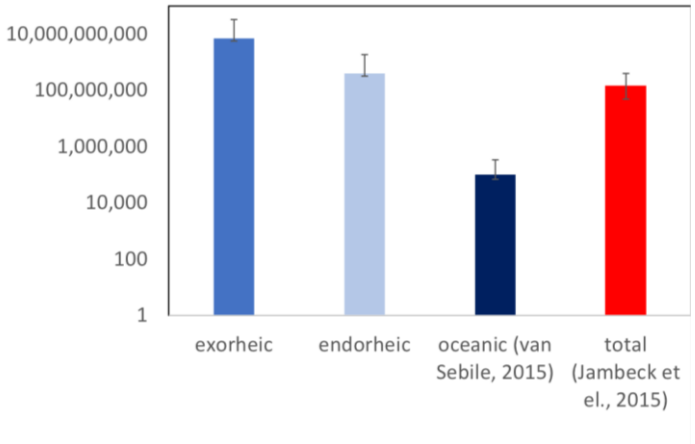
Fox River, USA (Baldwin et al., ES&T 2016)



River Rhine sediments, Germany (T. Mani)

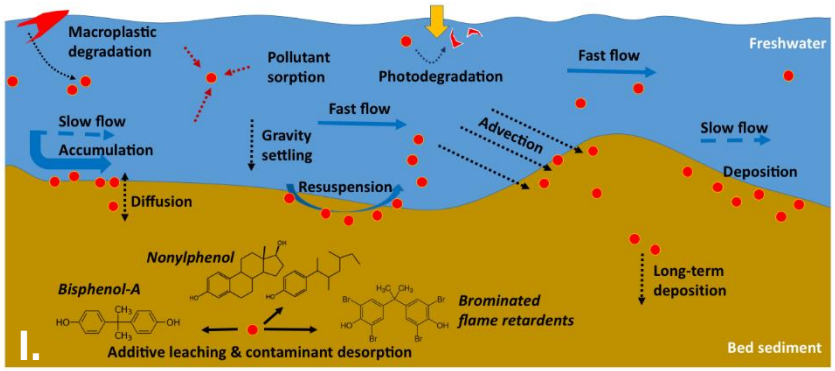
Microplastic losses from sports/playground

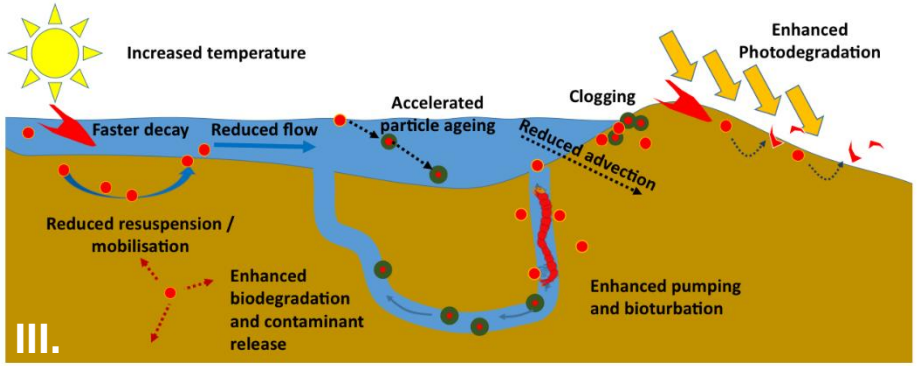


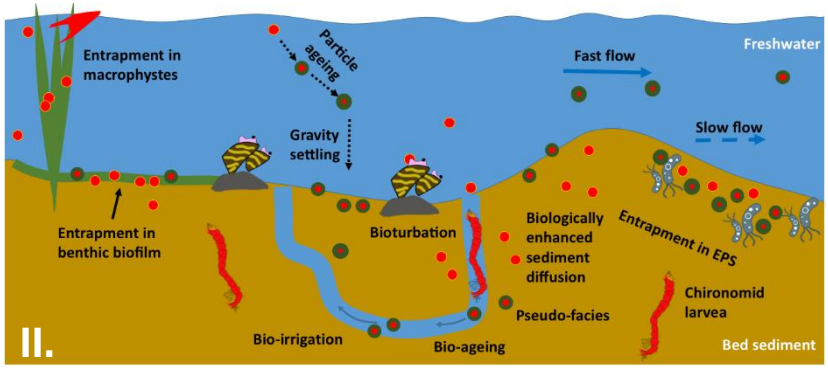


[Gomez-Velez & Krause, in prep.]

Fate and transport of microplastics in rivers







I. **Property dependent transport / accumulation / breakdown**

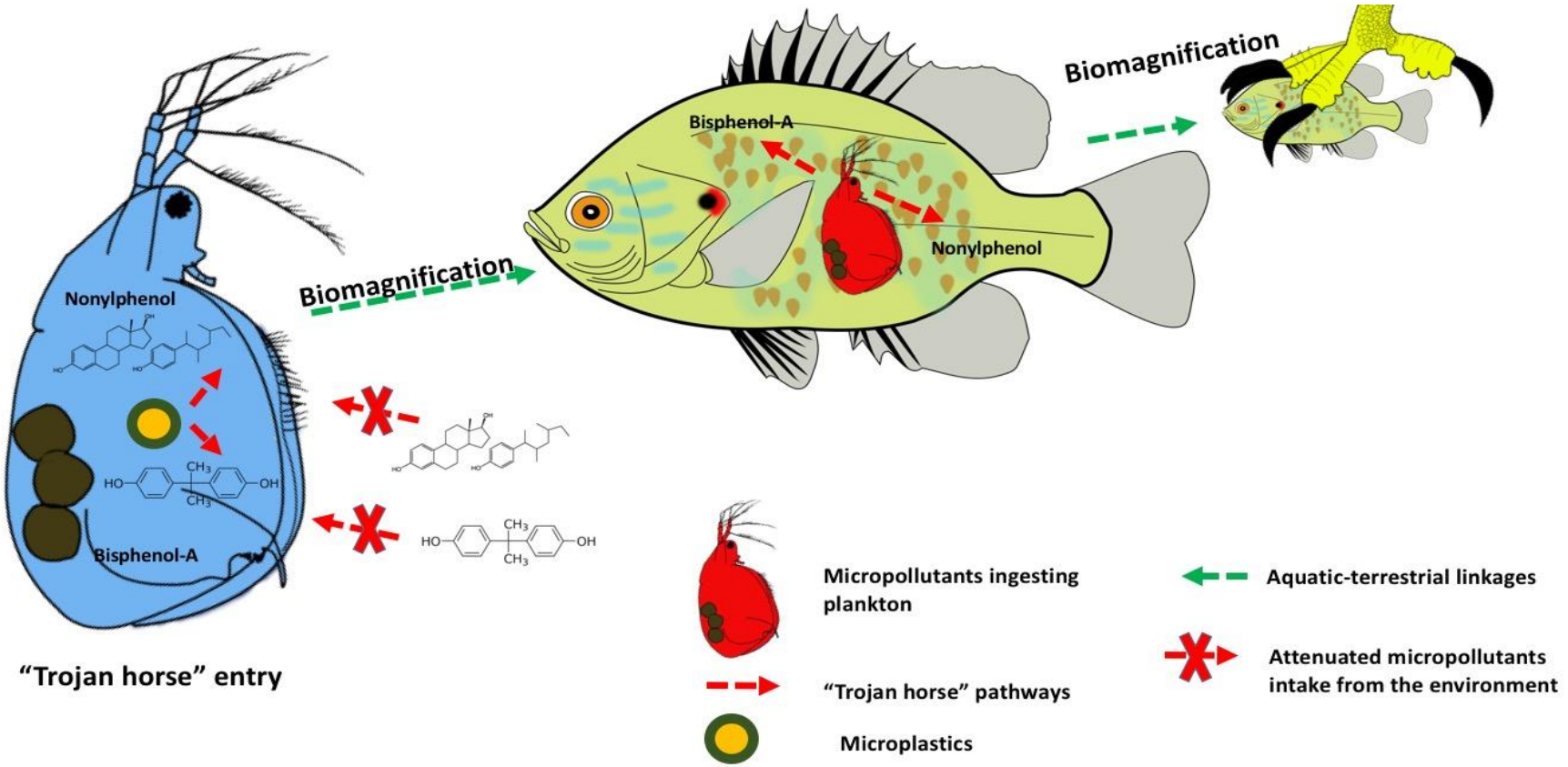
II. **'Ageing' of microplastic in freshwater ecosystems**

→ **Impacts on fate, transport and breakdown**

III. **Biological controls on plastics transport / deposition**

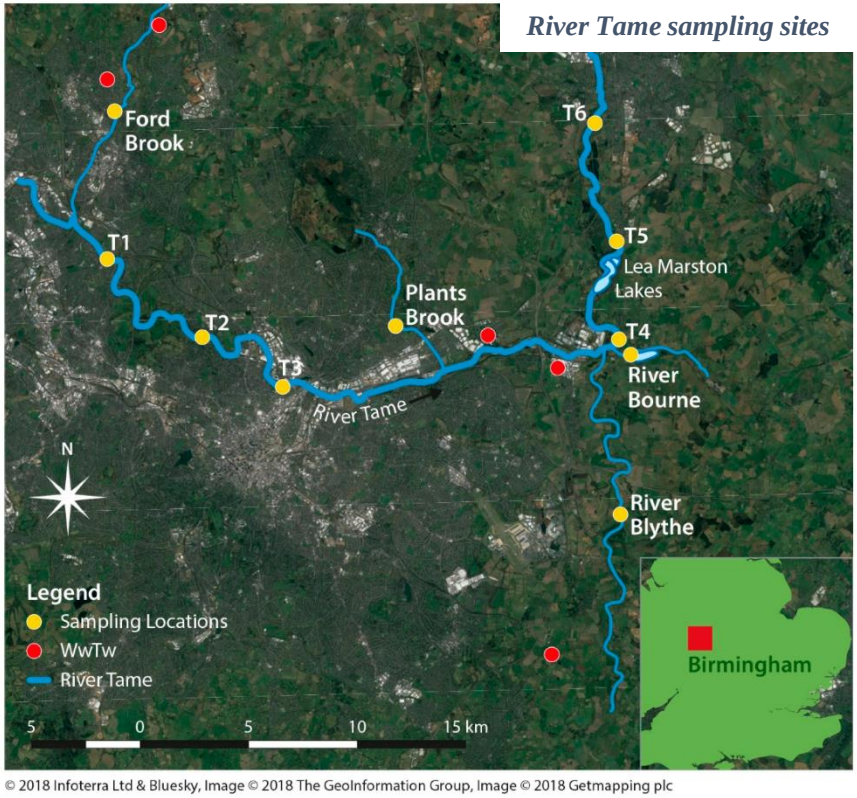
→ **Impacts on organisms and ecosystem functioning**

Fate and transport of microplastics in rivers

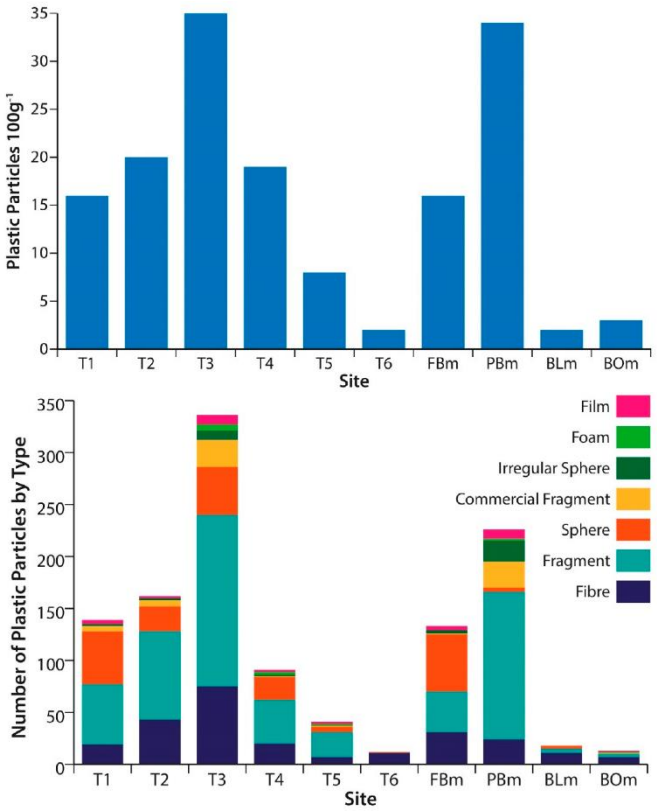


Case Study – River Tame (UK)

River Tame – Birmingham, UK



River Tame sampling sites



Tibbets et al., 2018

River Contributions to Global Plastic Pollution

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Lack of data / method inter-comparability

Study Location	Microplastic Count	Citation
River Tame, UK	16.5 particles 100 g^{-1} (mean)	This study
River Thames, UK	35 particles 100 g^{-1} (mean)	Horton et al. [1]
Mersey/Irwell, UK	281–635 particles 100 g^{-1} (temporal range)	Hurley et al. [2]
Ottawa River	22 particles 100 g^{-1} (mean)	Vermaire et al. [30]
Rhine-Main area	22.8–376 particles 100 g^{-1} (spatial range)	Klein et al. [31]
Beijing River	17.8–54.4 particles 100 g^{-1} (spatial range)	Wang et al. [45]
Bloukrans River	0.6–16 particles 100 g^{-1} (temporal range)	Nel et al. [32]
Elbe, Mosel, Neckar, and Rhine	3.4–6.4 particles 100 g^{-1} (mean)	Wagner et al. [44]

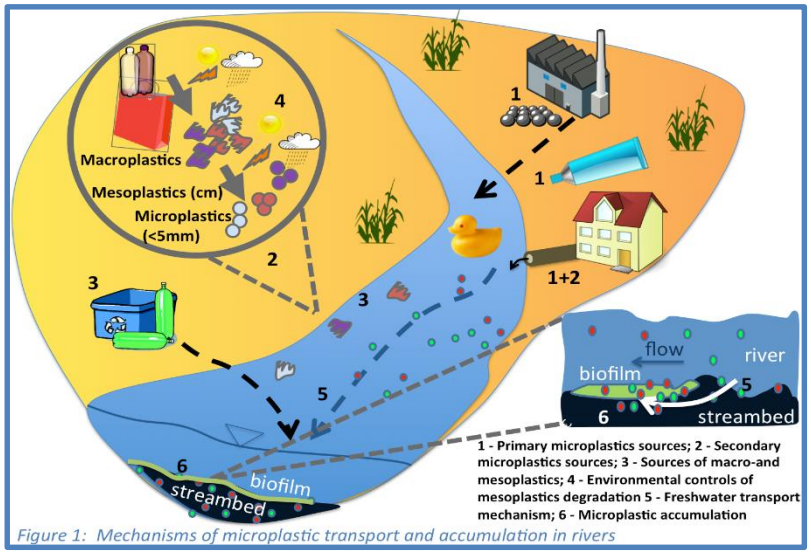

Figure 1: Mechanisms of microplastic transport and accumulation in rivers

Tibbets et al., 2018

100 Plastic Rivers Programme

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100 Plastic Rivers

THE ROYAL SOCIETY

HORIZON 2020

LEVERHULME TRUST

clean seas ODYSSEY

DFG Deutsche Forschungsgemeinschaft

100 Plastic Rivers Programme

clean seas ODYSSEY

175–1104 particles kg^{-1}

River Fowey (N=4)

Plymouth Sound (N=2)

121–411 particles kg^{-1}

The River Fal (N=4)

150–628 particles kg^{-1}

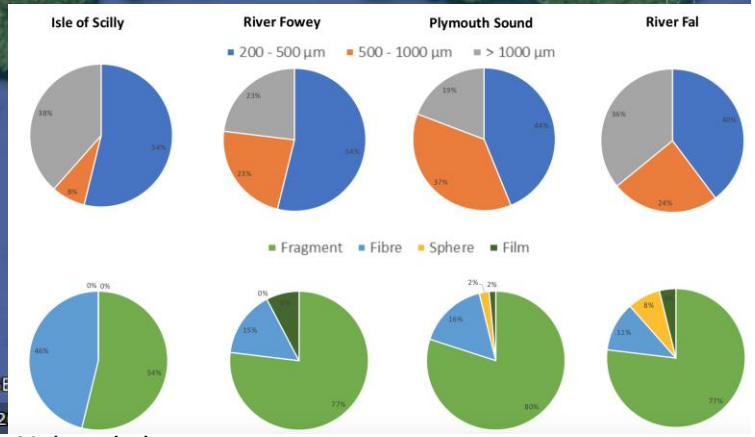
Isles of Scilly (N=2)

127–281 particles kg^{-1}

Image Landsat / Copernicus

Data SIO, NOAA, U.S. Navy, NGA, GE

Imagery Date: 12/14/2



Nel et al., in prep

100 Plastic Rivers Programme

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Density Separation (extraction efficiency between 85 and 100 %)

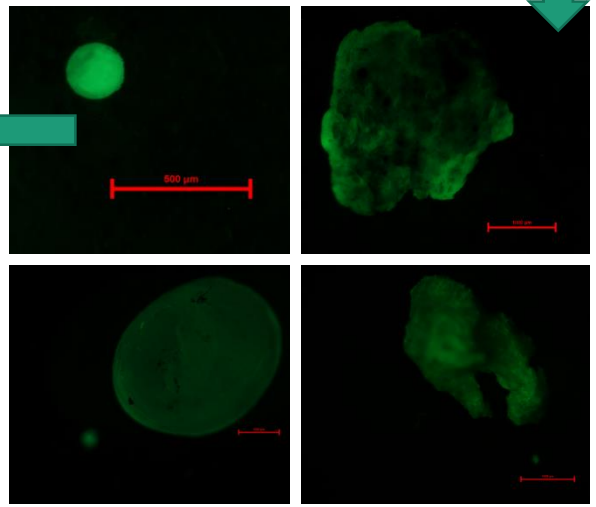
Coppock et al., 2018

Extraction

Digestion

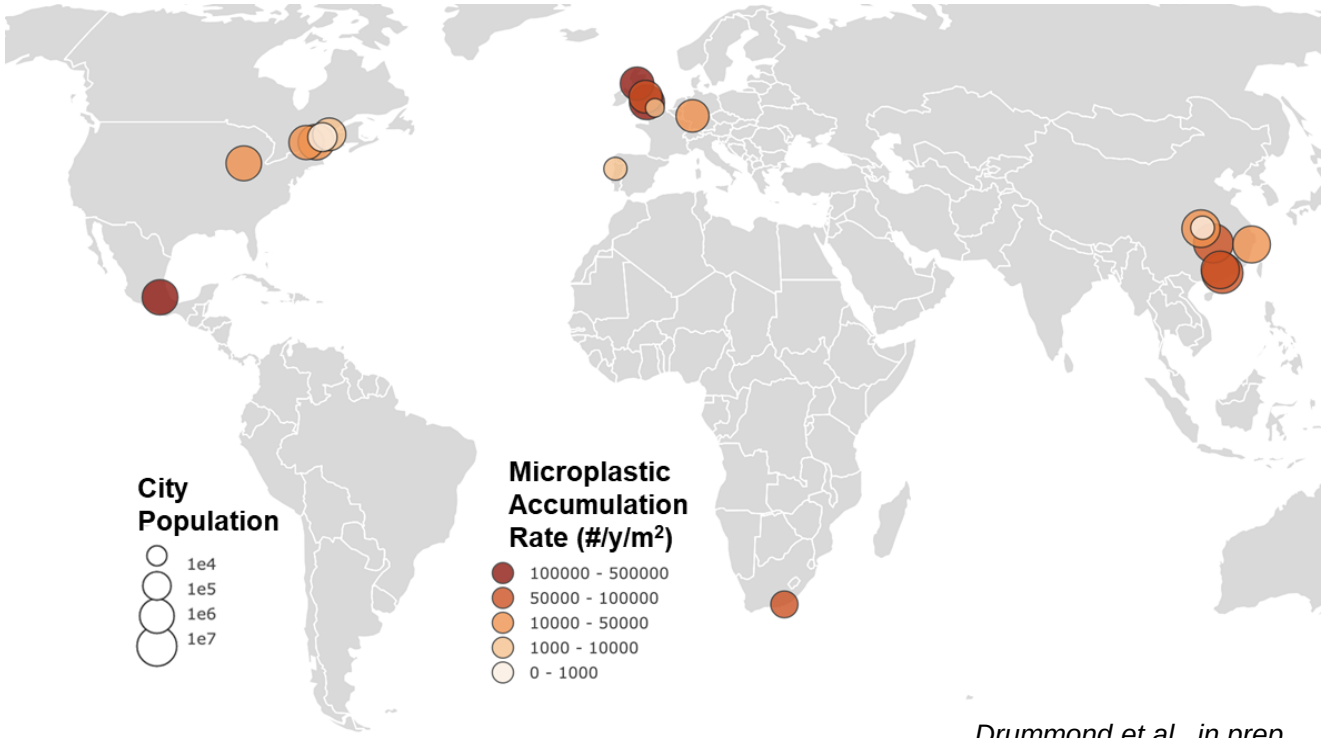
Nile Red Staining

Morphological Characterisation



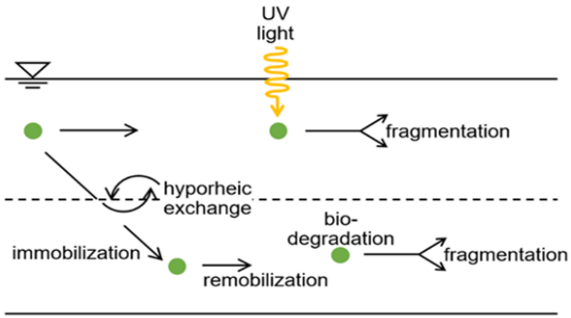
Chemical Specification

Predicting Global Plastic Accumulation in Rivers



Drummond et al., in prep

Mobile-immobile model
(*Drummond et al.*, 2014)



Predicting Global Plastic Accumulation in Rivers

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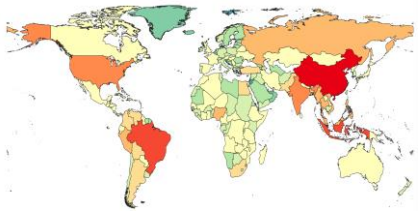
Global Plastic River Program

Fate and Transport in Major Rivers



Predictive Global Models

Fate and Transport of Emerging Pollutants

Environmental Change Outdoor Laboratory (EcoLab)

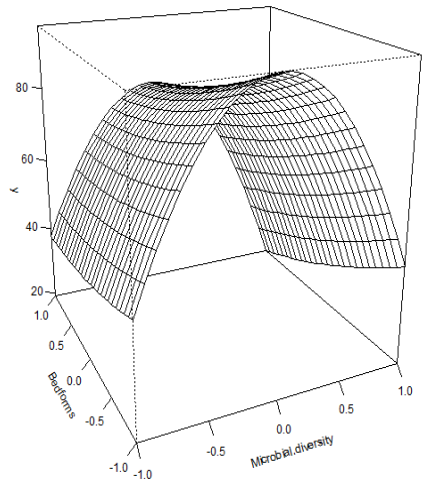
96 recirculating flumes (2.8m)

24 long recirculating flumes (15m)

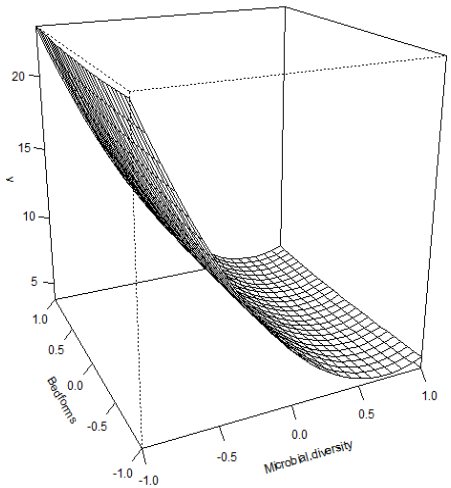
Fate and Transport of Emerging Pollutants

Contaminant multi-stressor response matrices:

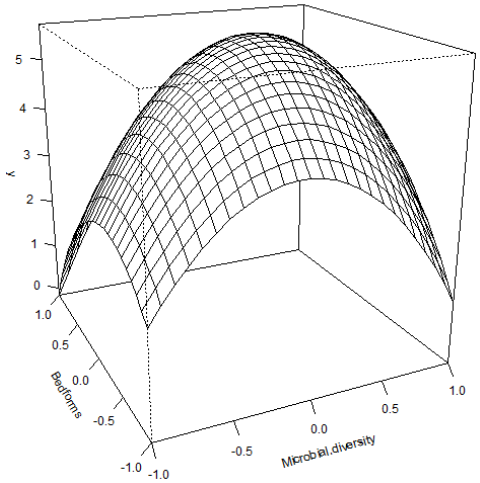
Benzotriazole



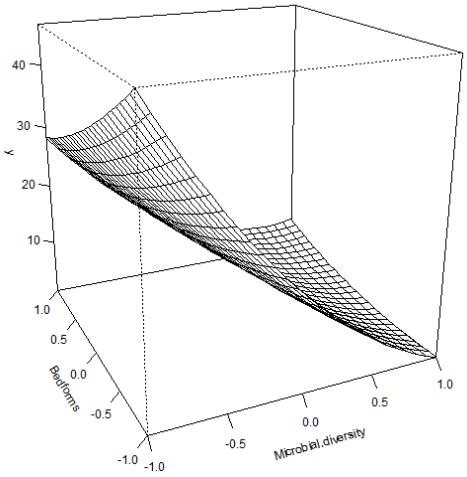
Sitagliptin



Metformin



Acesulfame



Poselt et al., *Environmental Science and Technology, in review*

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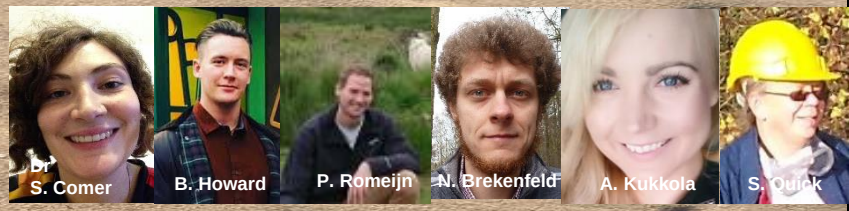
Plastic Impacts on Ecosystem Functioning and Health

EcoLab - Environmental Change Outdoor Laboratory

- ***Leaching of contaminants (Additives, POPs, pathogens, viruses, AMR…)***
- ***Uptake and propagation in food webs***
- ***Impact on ecosystem functioning and health***

Thank You!



THE ROYAL SOCIETY

NERC SCIENCE OF THE ENVIRONMENT

LEVERHULME TRUST

HORIZON 2020

Environmental Risks to Infrastructure Innovation Programme

NERC SCIENCE OF THE ENVIRONMENT

GCRF Global Challenges Research Fund

Newton Fund

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clean seas ODYSSEY

BWC Birmingham Water Council

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Business with Birmingham

EPSRC
Engineering and Physical Sciences Research Council

Dr Sally Beken

Knowledge Transfer Network

UK CIRCULAR PLASTICS NETWORK

Government supported opportunities for working sustainably with plastics

Dr Sally Beken, KTN
Lead - UK Circular Plastics Network

Birmingham Business Breakfast Club, June 18th 2019

Innovate UK
Knowledge Transfer Network

Witches and Demons

Innovate UK
Knowledge Transfer Network

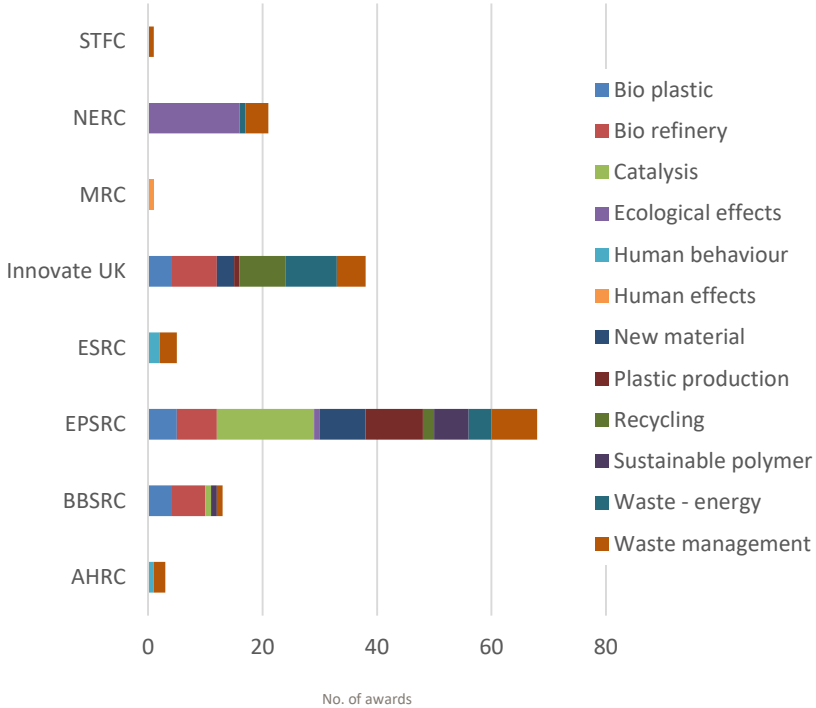
ktn-uk.org @KTNUK

Plastic saves lives and food waste

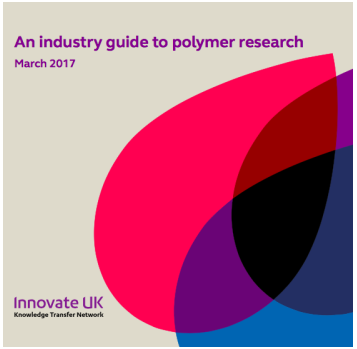
Innovate UK
Knowledge Transfer Network

ktn-uk.org @KTNUK

UKRI Investment

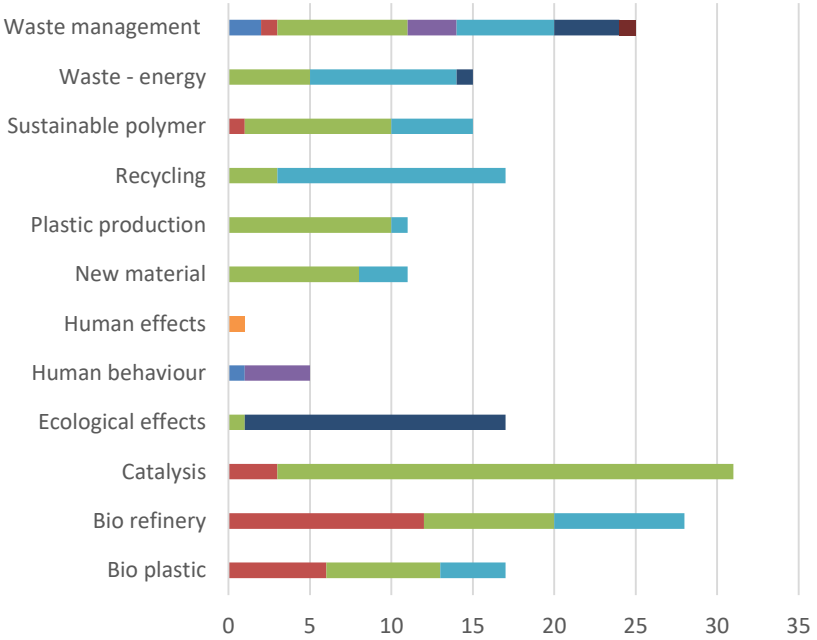


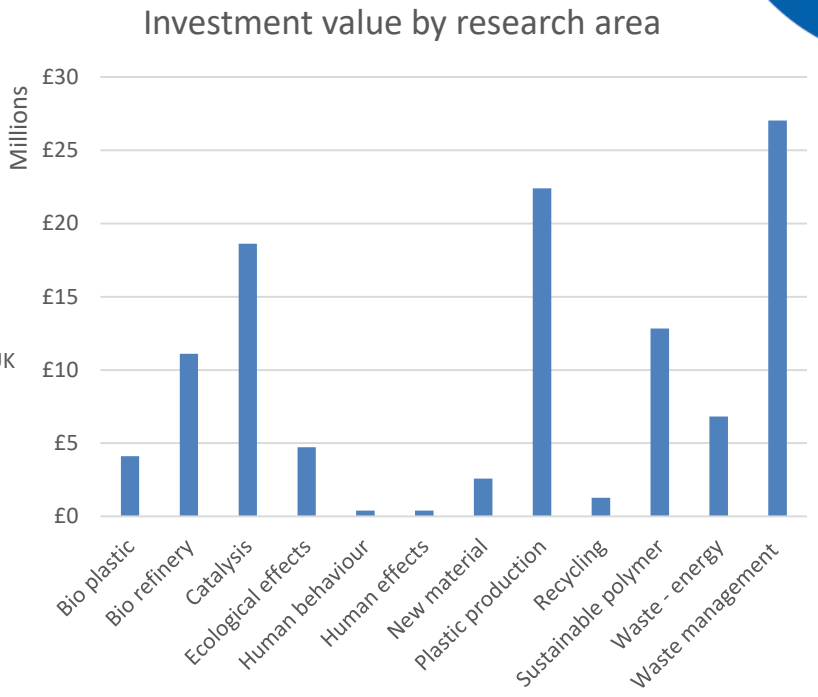
Approx. £140M across Research Councils and Innovate UK in last 3yrs.

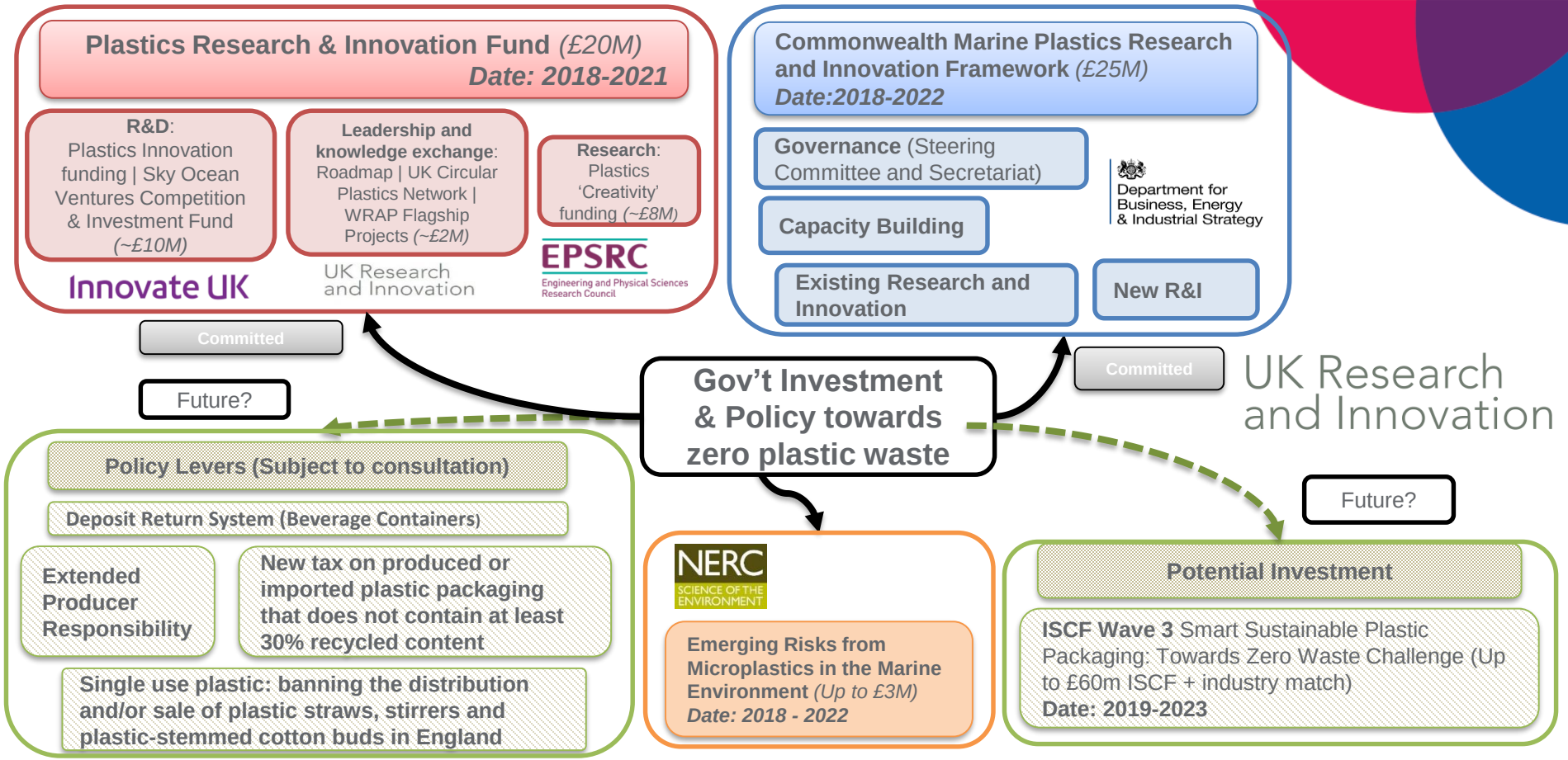


UKRI Investment

Approx. £140M across Research Councils & Innovate UK in the last 3 yrs.






Plastics Research & Innovation Fund (£20M)
Date: 2018-2021
R&D: Plastics Innovation funding | Sky Ocean Ventures Competition & Investment Fund (~£10M)
Leadership and knowledge exchange: Roadmap | UK Circular Plastics Network | WRAP Flagship Projects (~£2M)
Research: Plastics 'Creativity' funding (~£8M)
Innovate UK
UK Research and Innovation
EPSRC
Engineering and Physical Sciences Research Council
Commonwealth Marine Plastics Research and Innovation Framework (£25M)
Date:2018-2022
Governance (Steering Committee and Secretariat)
Capacity Building
Existing Research and Innovation
New R&I
Department for Business, Energy & Industrial Strategy
Committed
Future?
Gov't Investment & Policy towards zero plastic waste
Committed
UK Research and Innovation
Policy Levers (Subject to consultation)
Deposit Return System (Beverage Containers)
Extended Producer Responsibility
New tax on produced or imported plastic packaging that does not contain at least 30% recycled content
Single use plastic: banning the distribution and/or sale of plastic straws, stirrers and plastic-stemmed cotton buds in England
NERC
SCIENCE OF THE ENVIRONMENT
Emerging Risks from Microplastics in the Marine Environment (Up to £3M)
Date: 2018 - 2022
Future?
Potential Investment
ISCF Wave 3 Smart Sustainable Plastic Packaging: Towards Zero Waste Challenge (Up to £60m ISCF + industry match)
Date: 2019-2023

Plastics Research & Innovation Fund

UK Research and Innovation

£20m
March 2018

UK CIRCULAR PLASTICS NETWORK

Innovations

- **BLUE CASTLE**

In-cycle Ltd

CRALEY Group
Innovators in Smart Infrastructure

PVOH POLYMERS LTD
Soluble Polymers for innovation

LUCIDEON
insight creating advantage

Circular economy specialists

Collaborative R&D

UKCPN runs events and activities to bring together the diverse users of plastic products and realise the best outcomes for eliminating plastic waste.

UK CIRCULAR PLASTICS NETWORK

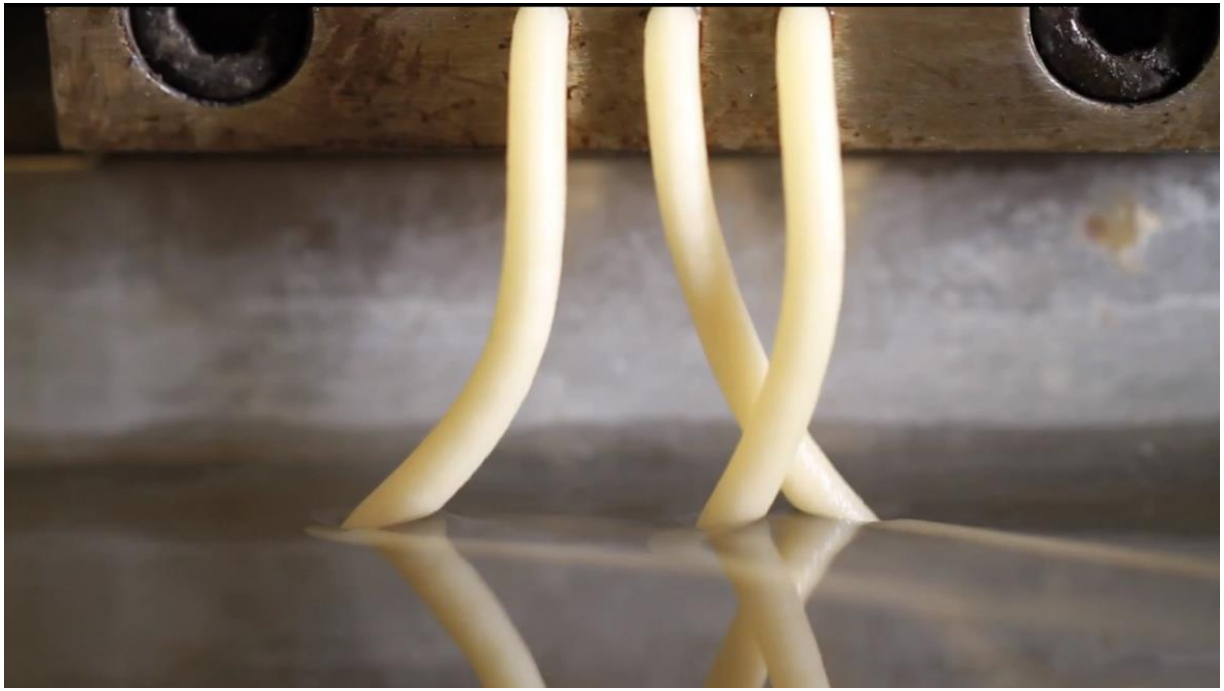
The UK Circular Plastics Network (UKCPN) aims to bring together the diverse users of plastic products and realise the best outcomes for eliminating plastic waste through a programme of networking and knowledge-sharing events and related support activities.

- Membership free
- Free events
- Newsletter
- Funding alerts
- Landscape map
- Host roadmap
- workshops

ukcpn.co.uk

@UKCPNetwork

New polymers



New designs

New recycling processes

New recycling processes

New manufacturing processes

New models & behaviors

FULL-SIZED 75CL

FLAT WINE BOTTLE

Garçon Wines

40% SPATIALLY **SMALLER** THAN ROUND WINE BOTTLES

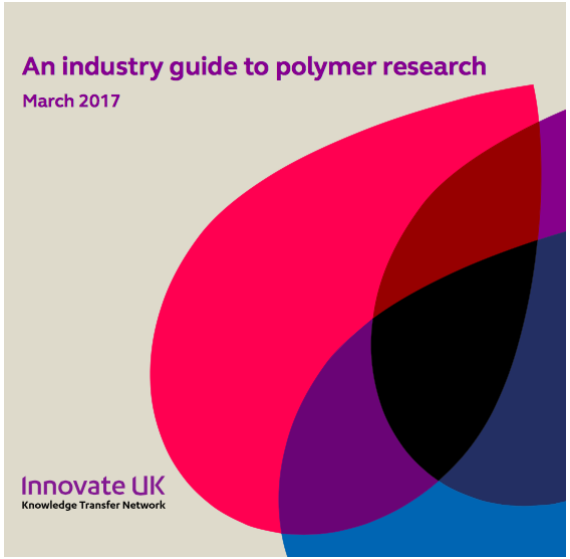
UK PACKAGING AWARDS 2018 WINNER

87% **LIGHTER** THAN GLASS WINE BOTTLES

2018 PACKAGING AWARDS 30TH DIAMOND FINALIST WINNER

Academic work - PRIF

Eight new academic projects, have £8 million funding behind them:



- Designing-out Plastic Waste (University College London): bacteria-based recycling technology for plastics.
- Evolving a circular plastics economy (University of Hull): this seeks to develop biodegradable biopolymers.
- RE3 – Rethinking Resources and Recycling (Manchester): graphene membrane filters for the removal of micro-plastics in water and a chemical-method of recycling mixed soft plastic.
- Exeter Multidisciplinary Plastics Research hub: ExeMPLaR (University of Exeter)
- UKRI Circular Economy Approaches to Eliminate Plastic Waste (University of Cambridge)
- Advancing Creative Circular Economies for Plastics via Technological-Social Transitions (Queen's University of Belfast)
- Plastics: Redefining Single-Use (University of Sheffield)
- Holistic integration of technology, design and policy for a greener plastic future (Imperial College London)

Food scraps could be turned into environmentally friendly plastic packaging

INDUSTRIAL STRATEGY

UK to lead the world in development of sustainable packaging thanks to new government funding.

Published 5 December 2018
From: Department for Business, Energy & Industrial Strategy and The Rt Hon Claire Perry MP

- UK to lead the world in development of sustainable packaging thanks to up to £60 million of new government funding, including food scraps potentially being transformed into environmentally-friendly plastic bags and cups
- smart labels on packaging could end confusion over what rubbish goes in which recycling bin and sustainable packaging with a living sell-by-date could show consumers when food is going off to reduce food waste
- new bioeconomy sector strategy and world-leading standards to help boost the bioeconomy as we move to a greener, cleaner economy – part of our modern Industrial Strategy launched almost a year ago

UK CIRCULAR PLASTICS NETWORK

Upcoming Events

12th June:	Bow Arts Centre, London
18th June:	Birmingham Business Club
19th June:	SCI – Plastics from Cradle to Grave, London
3rd July:	Portsmouth
4th July:	Designing for Re-use, New Designers, London
9th July:	Bradford
9th July:	Huddersfield
11-12th September:	RWM: NEC Birmingham
11-12th September :	Packaging Innovations, Olympia, London
6th November:	Re-use, The Studio, Birmingham
21st November:	Chemistry/IB circularity, Manchester

UK CIRCULAR PLASTICS NETWORK

ukcpn.co.uk

sally.beken@ktn-uk.org

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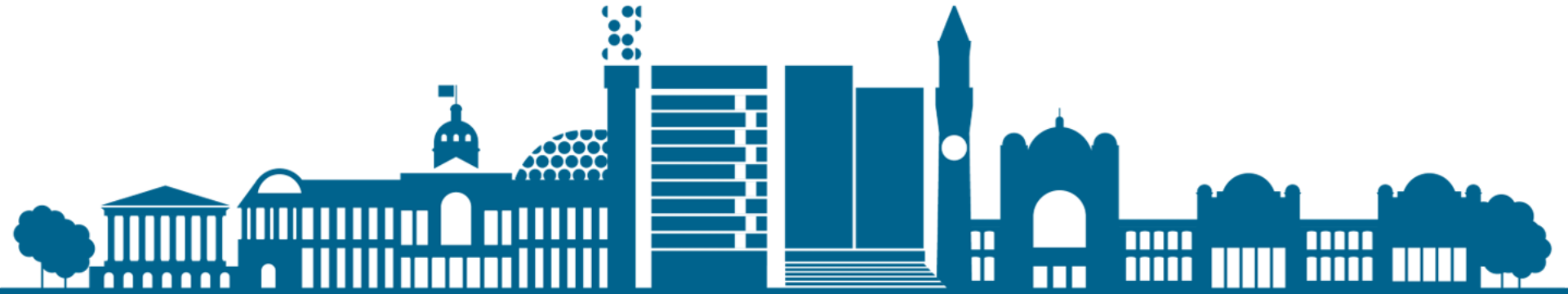
Business with Birmingham

EPSRC
Engineering and Physical Sciences Research Council

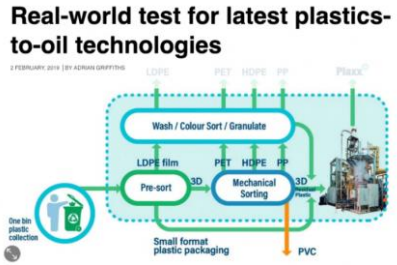
Professor Jonathan Seville

University of Birmingham



Collaboration with Recycling Technologies https://recyclingtechnologies.co.uk/

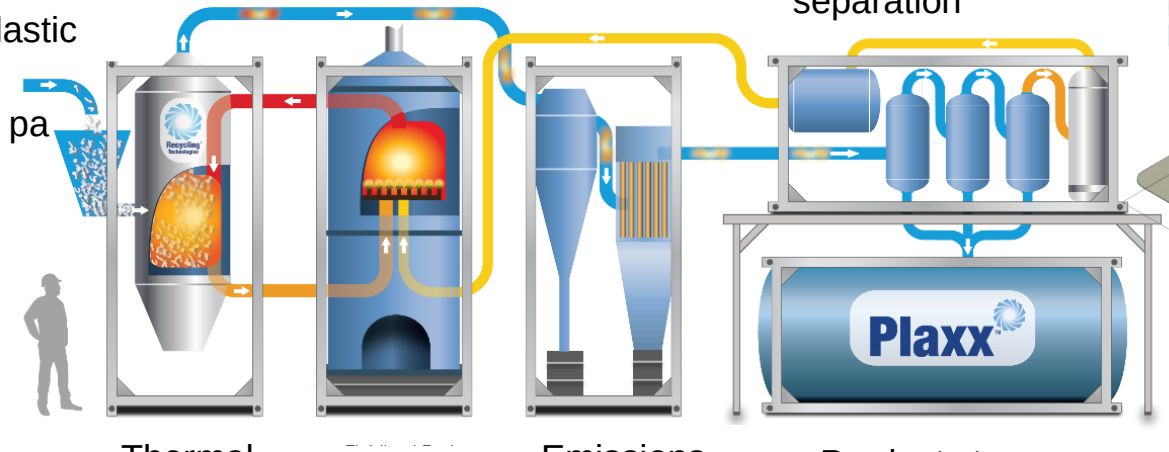
- Pyrolysis of mixed plastic waste to fossil-substitute chemical feedstocks and products
- Based on a Warwick University spinout in 2010, now employing ~40 people, based in Swindon
- Jonathan Seville is co-founder; he and Gary Leeke are on the Technical Advisory Board; + Kit Windows-Yule using PEPT
- Previous funding from BEIS EEF5, British Council, Innovate EC4 (all Leeke) and current application plans to Innovate KTP, RAEng, EPSRC…
- 700 tpa large pilot in Swindon, plus research centre
- 7000 tpa modular design for Zero Waste Scotland
- Design for circular economy….



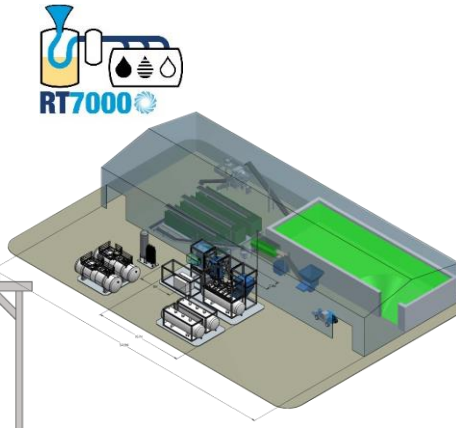
The Process Overview

Prepared end-of-life plastic

7000t pa



Contaminant removal; product refining and separation

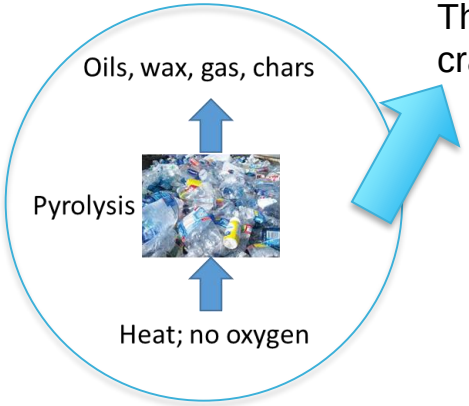


Thermal cracking

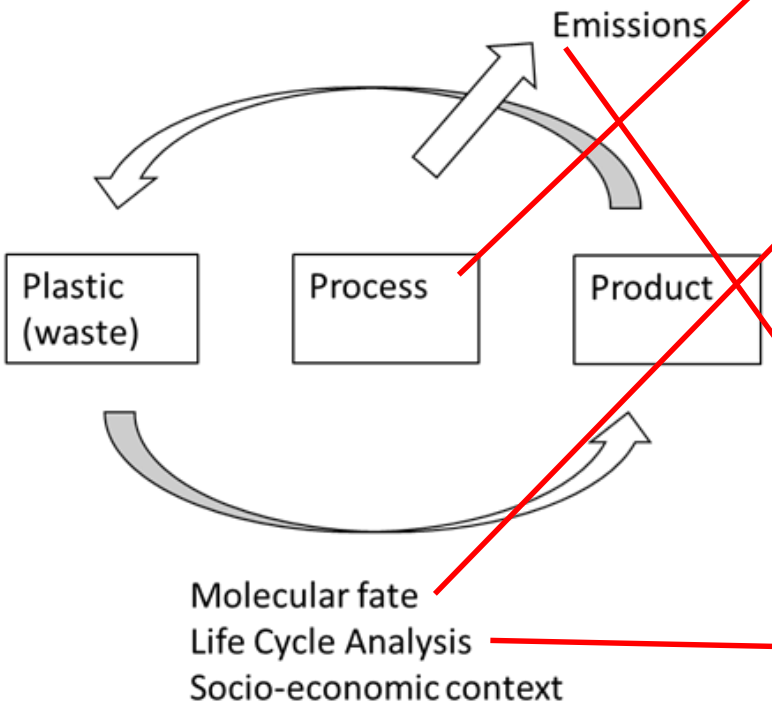
Regeneration

Emissions capture

Product storage



Towards a circular economy:



The conversion process: pyrolysis chemistry; solids handling; reactor design; product refining; overall process design; process control

Molecular/atomic fate: Where do the "unwanted" atoms go? How do they participate in the conversion process?

Emissions control: How best to contain emissions and deal with them optimally?

Life Cycle Analysis: How to optimise the process within its LCA boundaries?

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Pitches

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Jon Roberts

Alternative Raw Materials with Low Impact (ARLI)

University of Birmingham

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Engineering and Physical Sciences Research Council

Richard Baines

Accelerating Thermal Energy Technology Adoption (ATETA)

University of Birmingham

ATETA Assistance

Free to SMEs operating in the Birmingham Area

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ateta energising profitability

European Union
European Regional Development Fund

ATETA Expertise

- **Chemical Engineering**
- Mechanical Engineering
- Electronic, Electrical and Systems Engineering
- Techno-economic assessment

Thermal Energy Storage

Sensible

Latent

Chemical

Dr Helena Navarro

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When is waste a raw material?

Waste disposal is a **cost** → Products generate **revenue**

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Phase Change Materials

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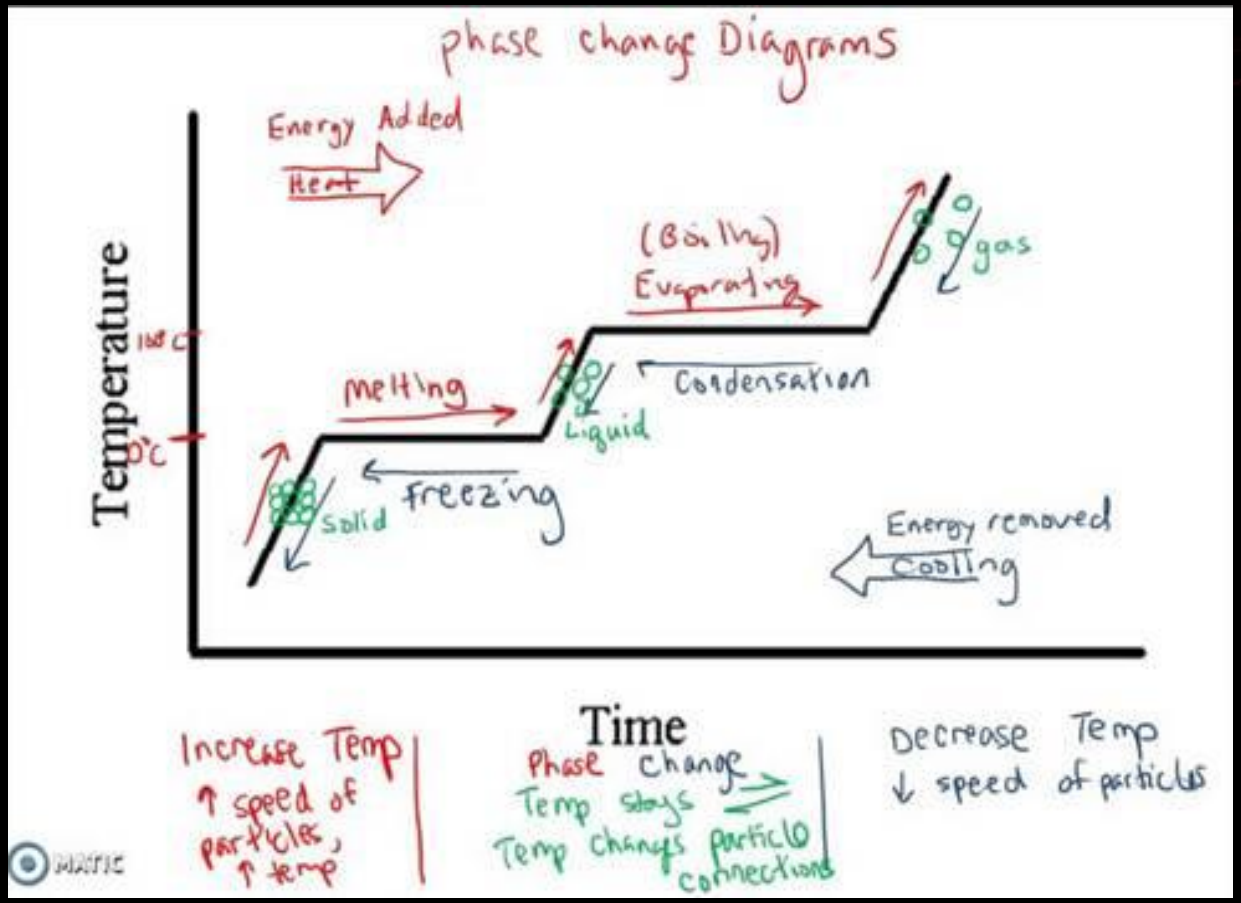
Latent Heat



Energy Absorbed and Stored in RED text – Energy released in green grey text

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European Regional Development Fund

ATETA Assistance

- Reducing friction
- Finding faults
- Chemical analysis
- Physical properties
- Clean fuels
  - Production
  - Storage
  - Transportation
  - Use

- Hydrogen
- Fuel Cells
- Electrolysers
- Power systems
- Power management
- Cold engines
- … and more

……. who you gonna call?

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EPSRC
Engineering and Physical Sciences Research Council

Syeda Shah

Inquisitive Explorers Ltd

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University of Birmingham Business Club Breakfast Briefing

Thank you