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Microplastics in freshwater systems: current and future research priorities

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Overview of presentation

- General introduction
- Transport processes
- Inputs to freshwater systems
- Microplastic ingestion
- Chemical associations
- Microplastics in terrestrial systems

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Microplastics - why study them?

- Microplastics are everywhere!

- Rivers and land recognised as sources but little studied compared to oceans

- Can be ingested by organisms

- May act as vectors for transport of persistent organic pollutants (POPs)

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Public perception of microplastics

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Science & Environment

Microplastics 'pose toxic threat to marine biodiversity'

By Mark Kinver
Environment reporter, BBC News

2 December 2013 | Science & Environment Share

Tiny particles of waste plastic that are ingested by shoreline "eco-engineer" worms may be negatively affecting biodiversity, a study says.

So-called microplastics may be able to transfer toxic pollutants and chemicals into the guts of lugworms, reducing the animals' functions.

An estimated 150 million tonnes vanish
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Plastic fibres found in tap water around the world, study reveals

Exclusive: Tests show billions of people globally are drinking water contaminated by plastic particles, with 83% of samples found to be polluted

We are living on a plastic planet. What does it mean for our health?

72,462 1,619

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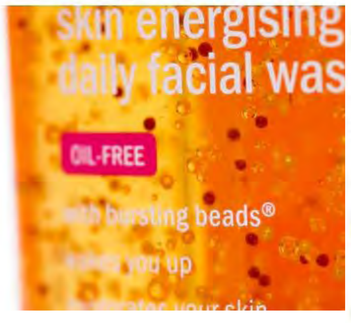
Plastics

UK to investigate human
of microplastics

Chief medical officer for England Prof Dame Sally D
health impacts of tiny particles of plastic consumed



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Monday 14 November 2016 09.11 GMT

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Science & Environment

Plastic from tyres 'major source' of ocean pollution

By Helen Briggs
BBC News

22 February 2017 | Science & Environment Share

Tyres can give off plastic particles, that can end up in the ocean

Particles of debris from car tyres are ending up in the ocean as "plastic soup", conservationists warn.

Microplastics from tyres and textiles are a bigger source of marine pollution than

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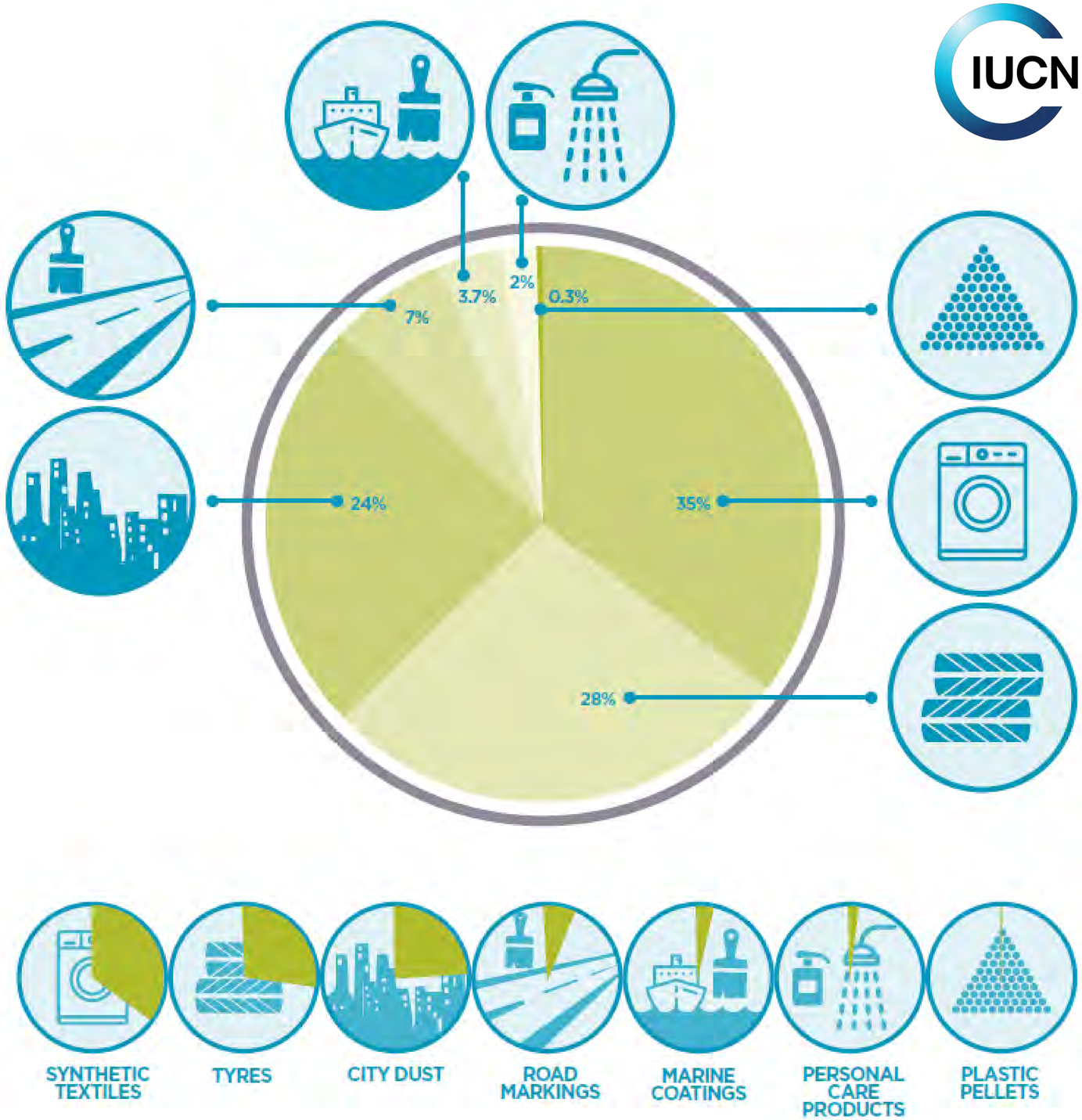
UK microbead ban

Department for Environment Food & Rural Affairs

IUCN



Proposals to ban the use of plastic microbeads in cosmetics and personal care products in the UK and call for evidence on other sources of microplastics entering the marine environment

Summary of responses

July 2017

Llywodraeth Cymru
Welsh Government

Department of Agriculture, Environment and Rural Affairs
www.daera-ni.gov.uk

Scottish Government
Riaghaltas na h-Alba
gov.scot

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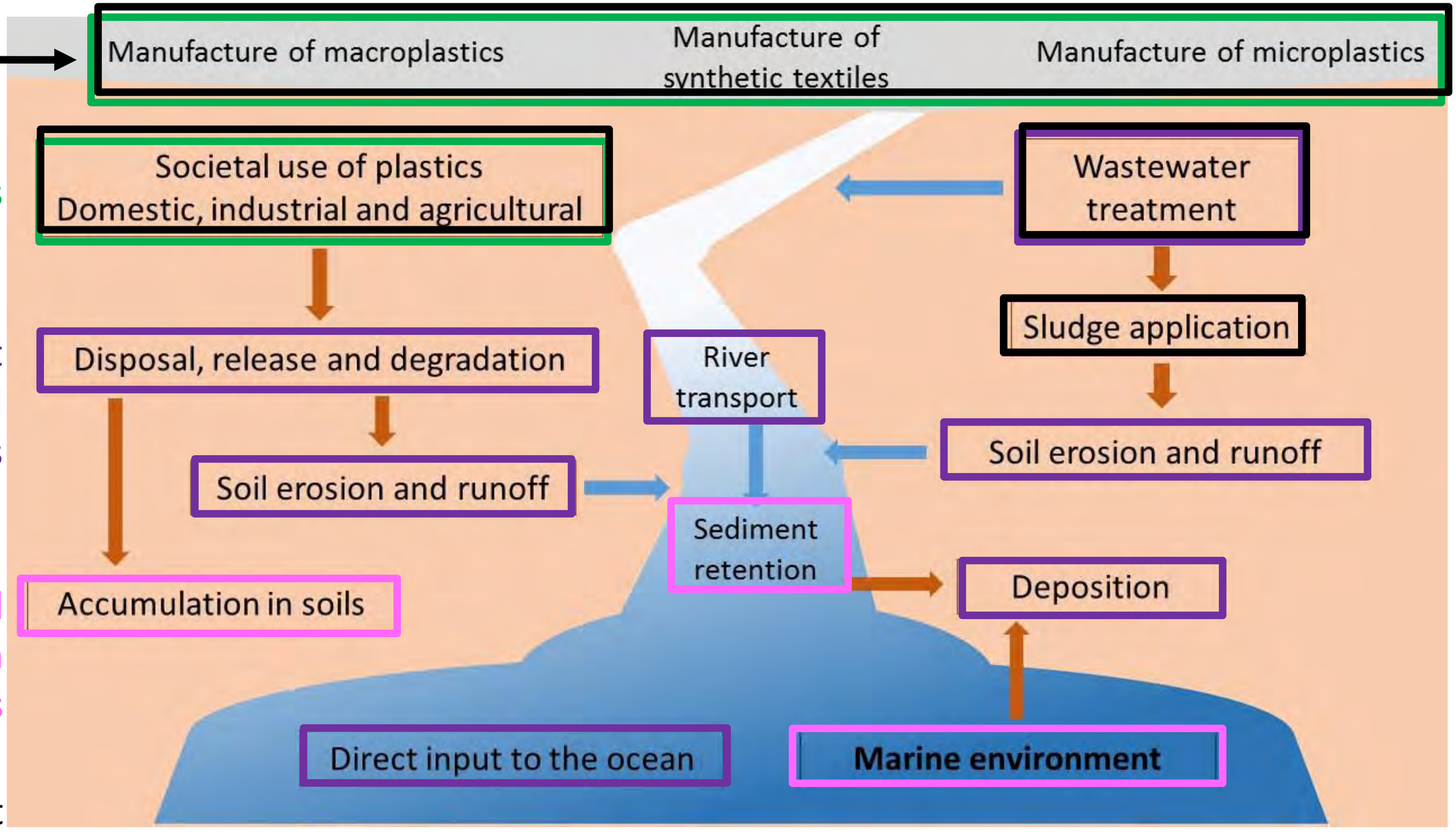
Microplastic transport processes

Sources

Transport volume and dynamics

Fate and effects on organisms

Management



Horton et al (2017). Science of the Total Environment

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Inputs to rivers in the UK

- Storm drain input
- Effluent input (‘grey water’)
- Combined Sewage Overflows (raw sewage)
- Land runoff
- Drainage ditches (agricultural)
- Litter

Photo: James Miller

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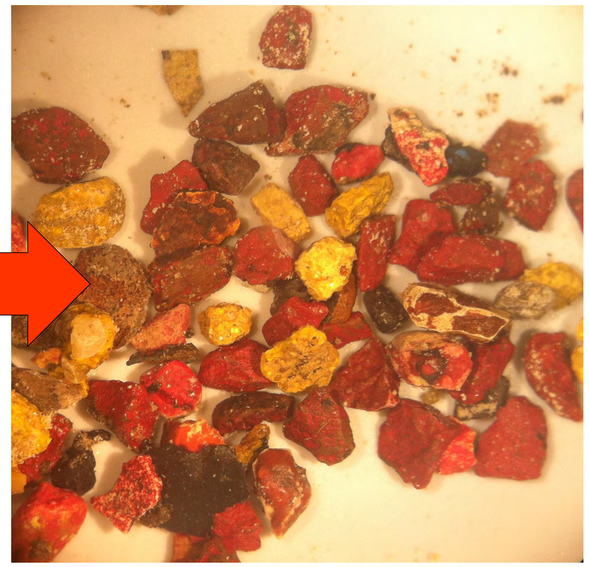
Inputs to rivers in the UK



Horton et al (2017). Marine Pollution Bulletin

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Microplastics in wastewater and sewage sludge

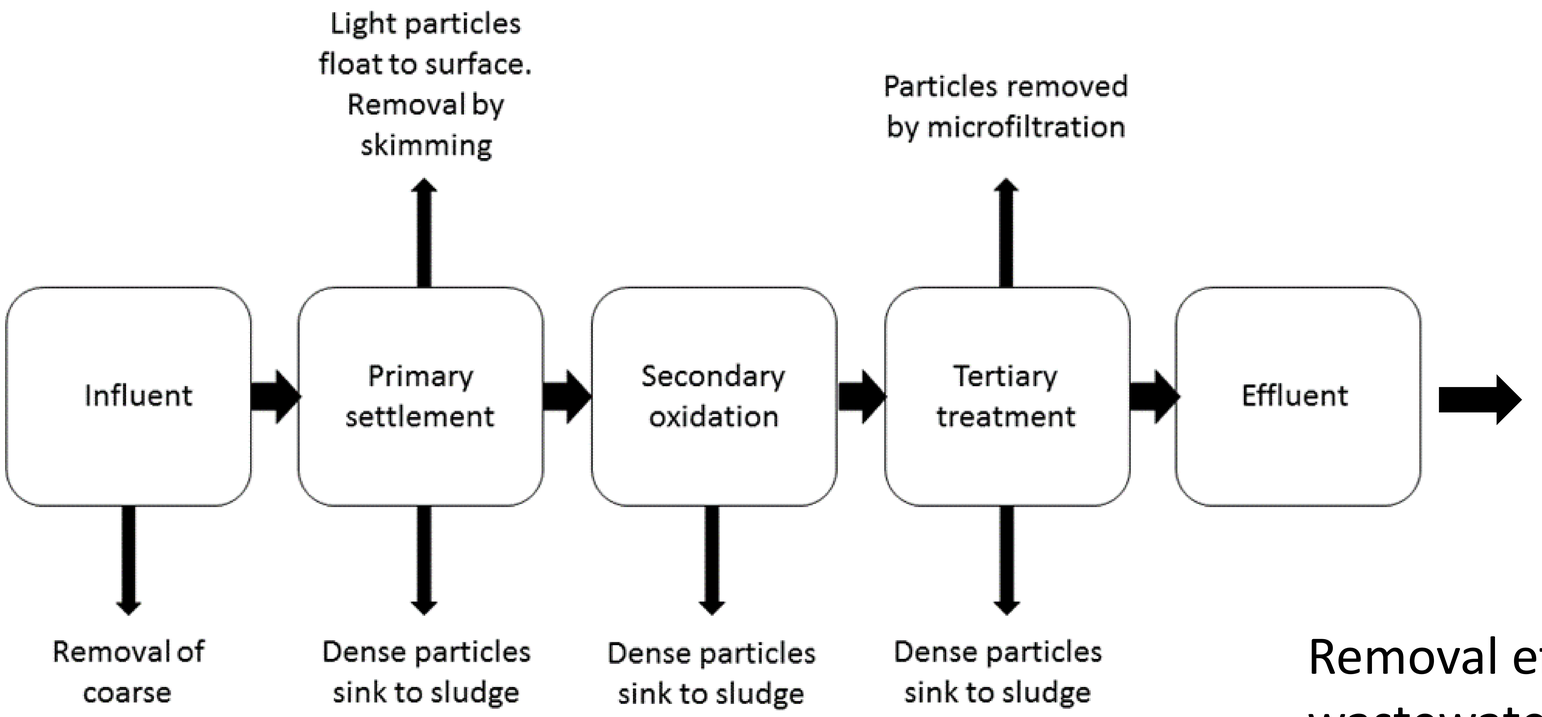

Photo: Rachel Mackay-Austin

Removal efficiency of microplastics following wastewater treatment processes:

- 99% (Magnusson and Norén 2014)
- 98% (Murphy et al, 2016)
- 95% (Talvitie et al, 2017)
- 97% (Mintenig et al, 2017)

However due to large volumes processed, **one large STW could still release up to 4000,000,000 MPs per day!**

(Ziajahromi et al 2017)

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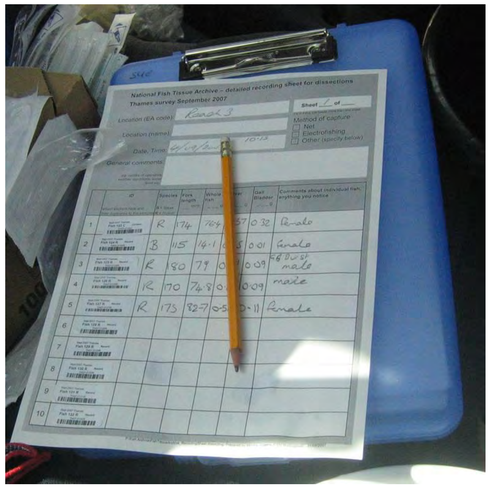
Our approach to fish sampling:

The UK National Fish Tissue Archive

In 2007, CEH and the UK Environment Agency (EA) began to build an archive of fish tissue samples from a selection of English rivers.

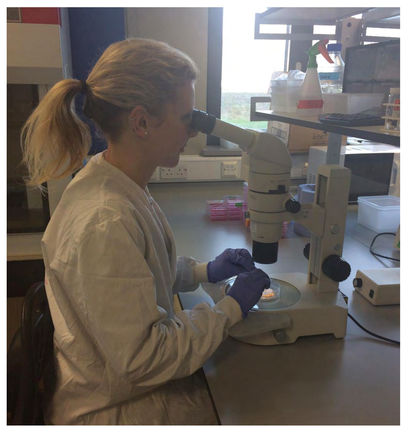
- EA monitor fish stocks annually
- normally: throw all back
- now: give us 10 roach (10 cm+) from selected sites



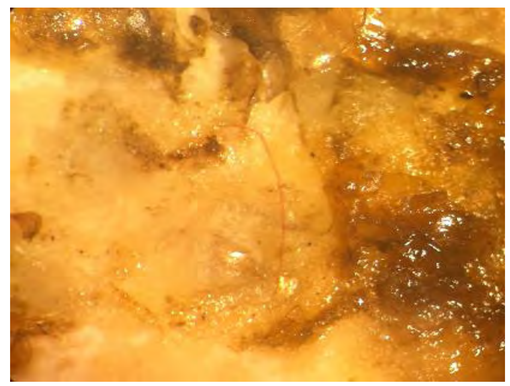
Size, weight and gender recorded

Frozen on site (liquid N_2)

Vacuum packed and stored at -80°C



Fish dissected and gut removed



Gut contents analysed for microplastics

Slide adapted from Monika Juergens

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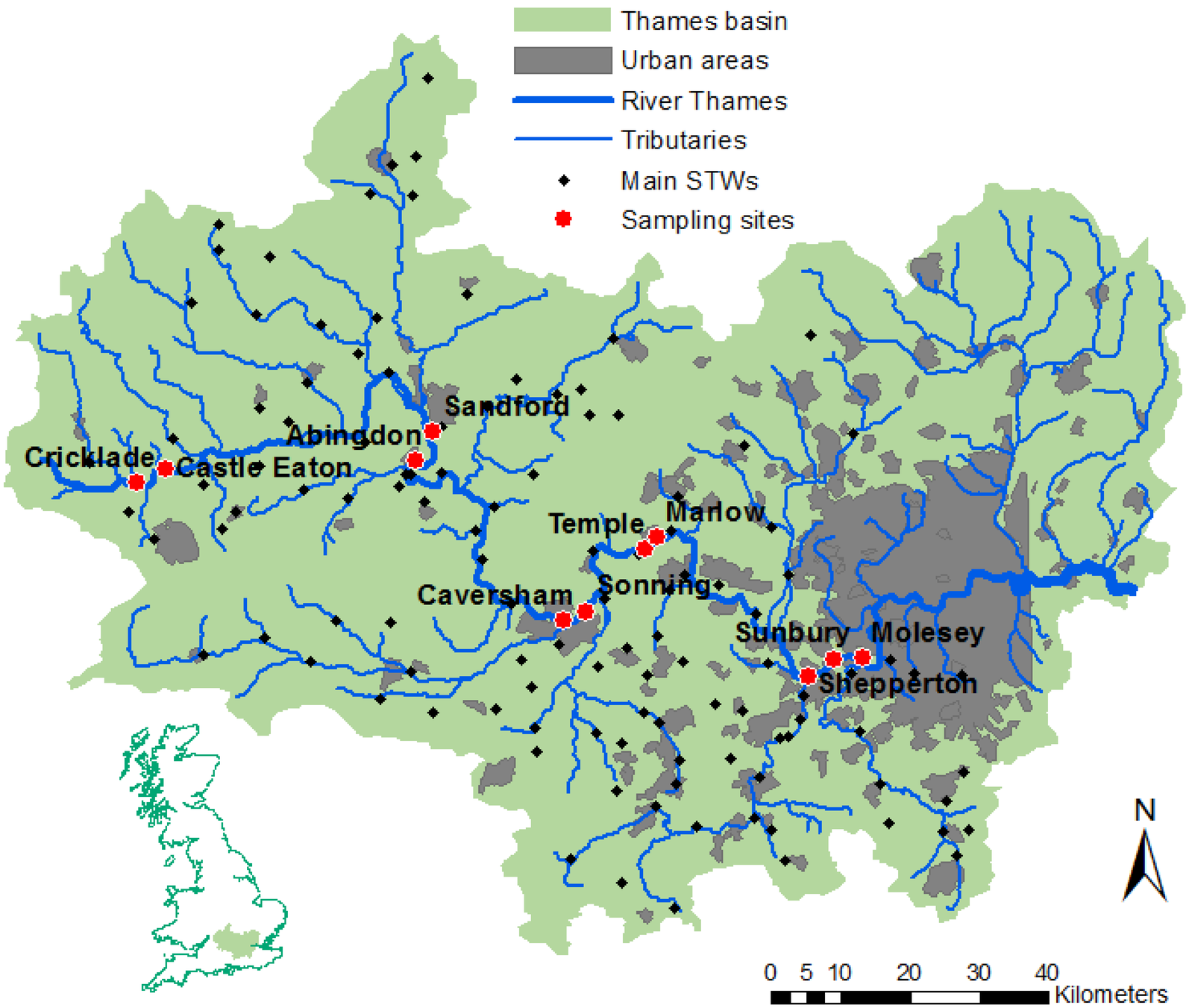
Common roach in the Thames - fish gut analysis



Location	Distance downstream
Cricklade	36.047
Castle Eaton	42.619
Sandford-Abingdon	105.915
Caversham-Sonning	161.511
Temple-Marlow	186.949
Shepperton-Sunbury	234.155
Sunbury-Molesey	238.729

Horton et al (2017). Under review

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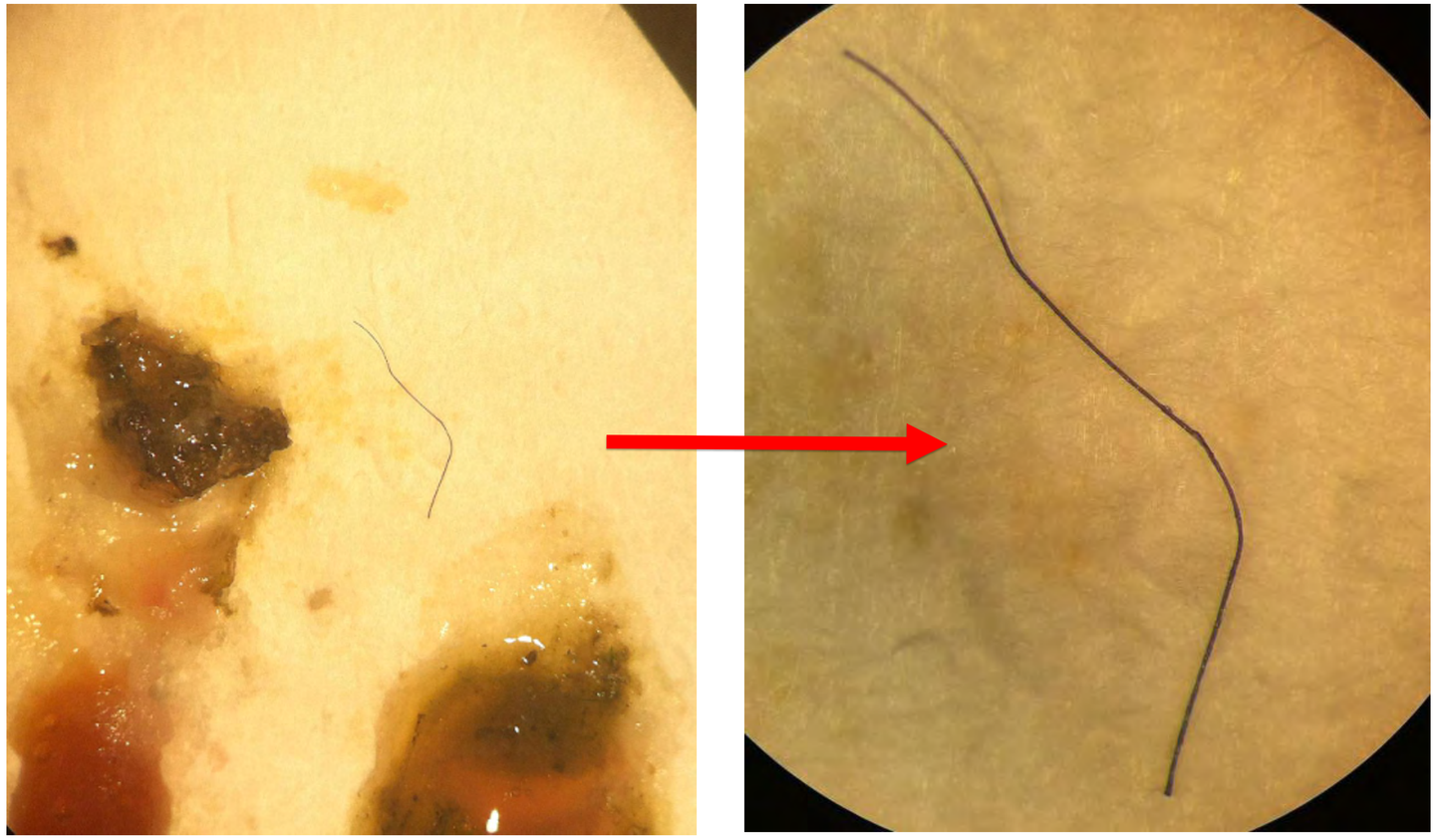
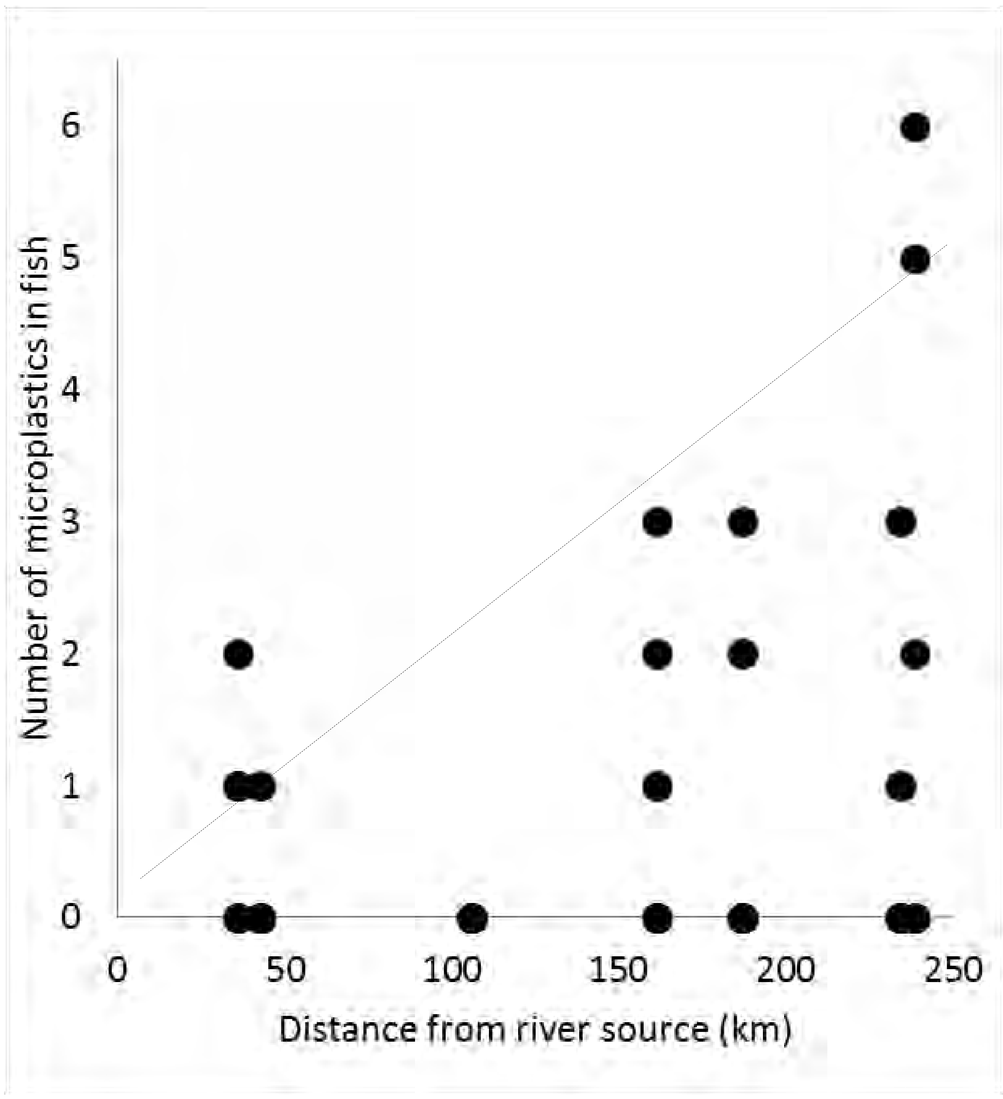
Roach gut analysis - results



Polymers identified as:
Polyethylene
Polypropylene
Polyester

Microplastics are ingested!



Differences in ingestion based on:
1. Size of fish
2. Distance from the source

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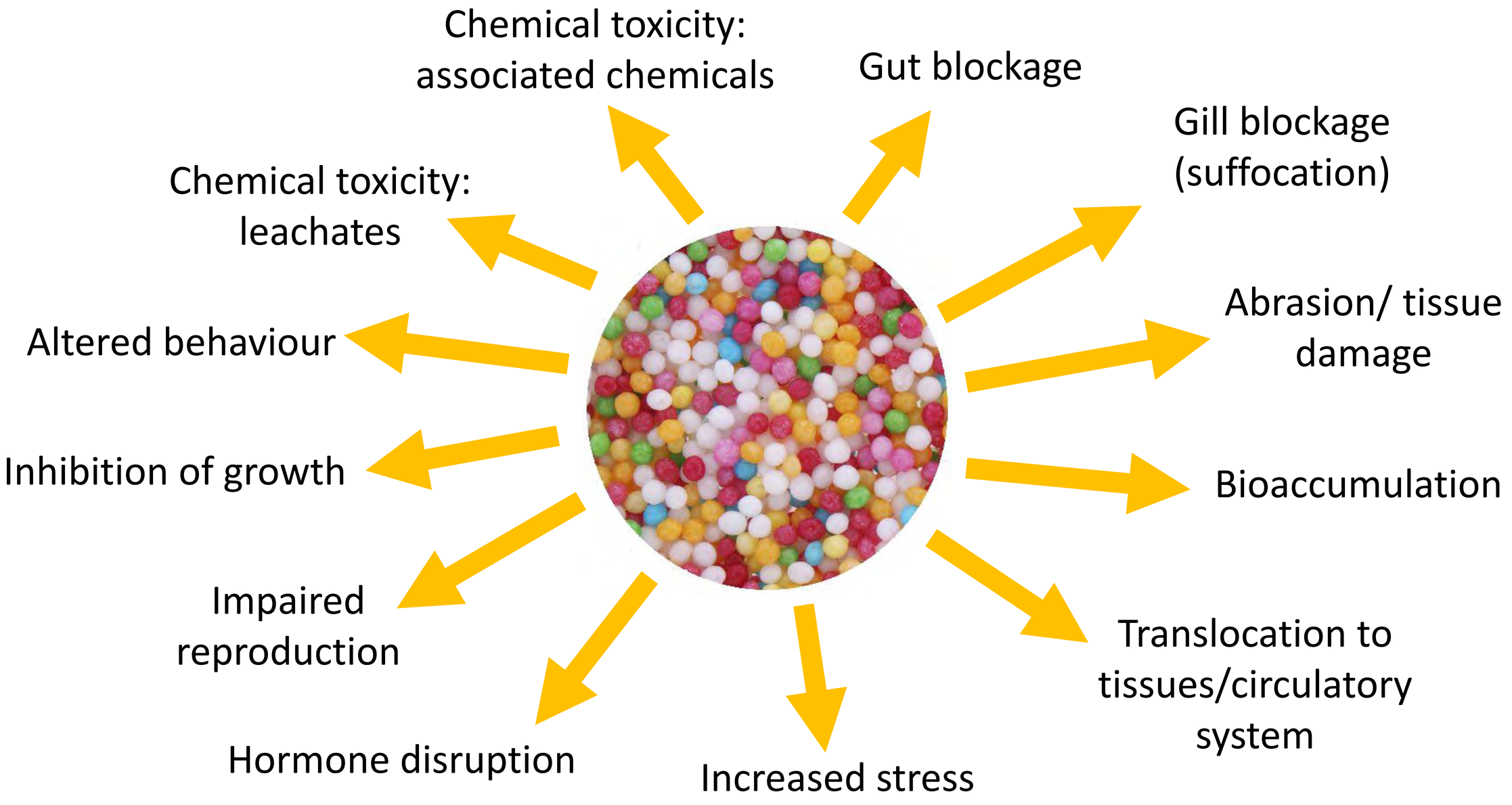
Ecological effects of microplastics



Wright et al. (2013) Environmental Pollution

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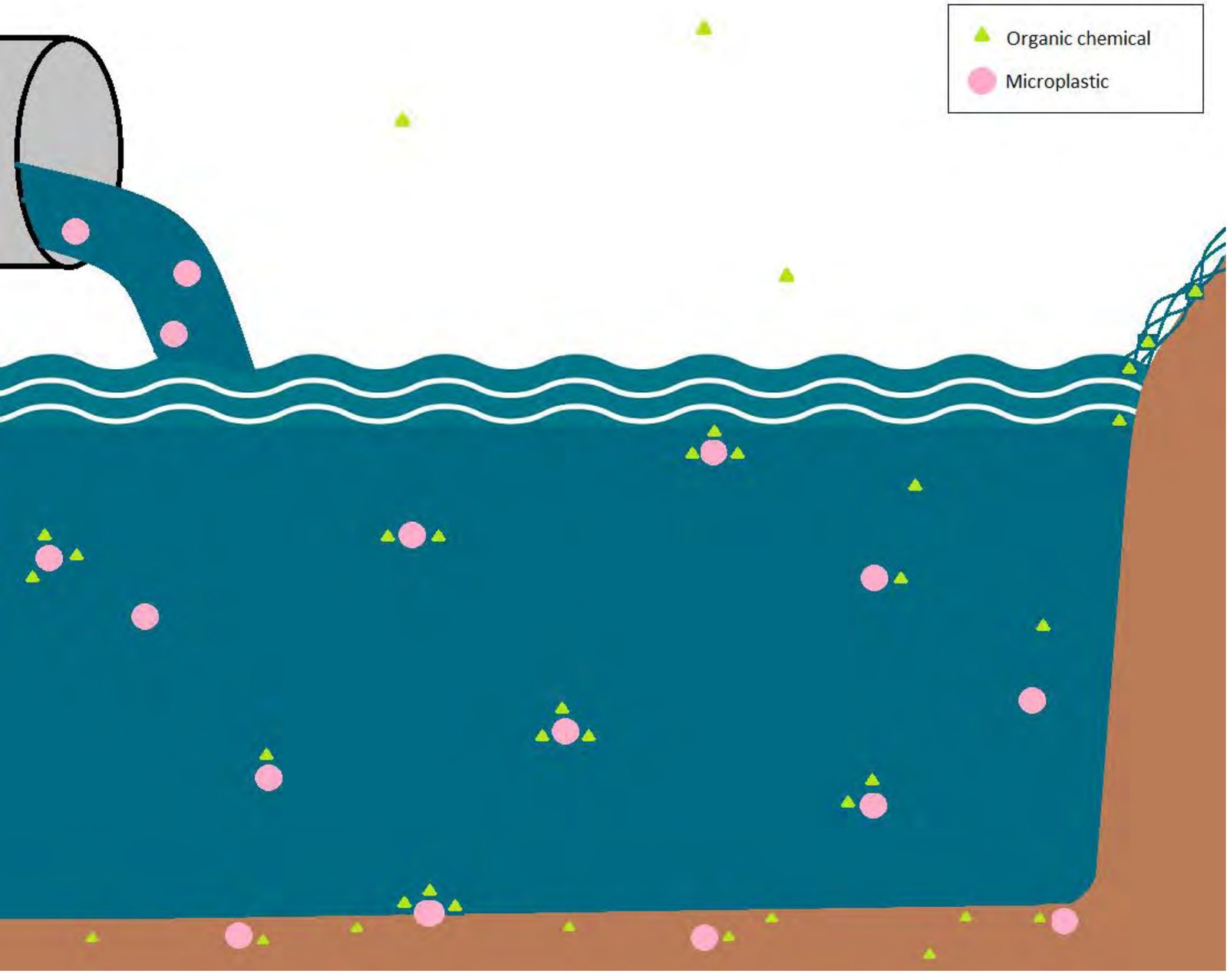
Microplastics + chemical binding



3 possible scenarios:

1. Ingestion enhances bioaccumulation and toxicity (Rochman et al 2013)

2. Binding reduces bioaccumulation and toxicity (Beckingham and Ghosh 2016)

3. Chemical transfer from plastics to organisms is negligible compared to from organic matter and sediment (Koelmans et al 2016)

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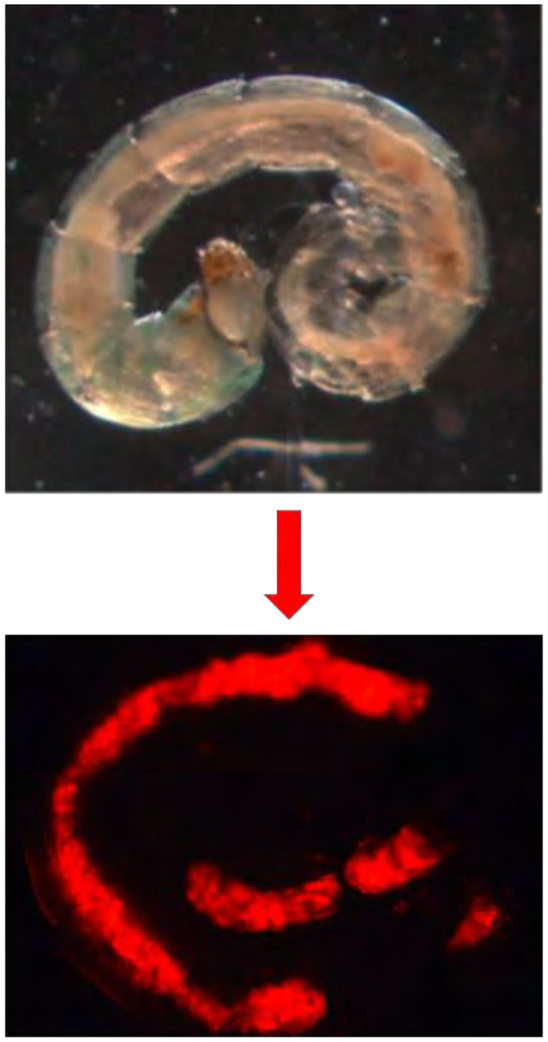
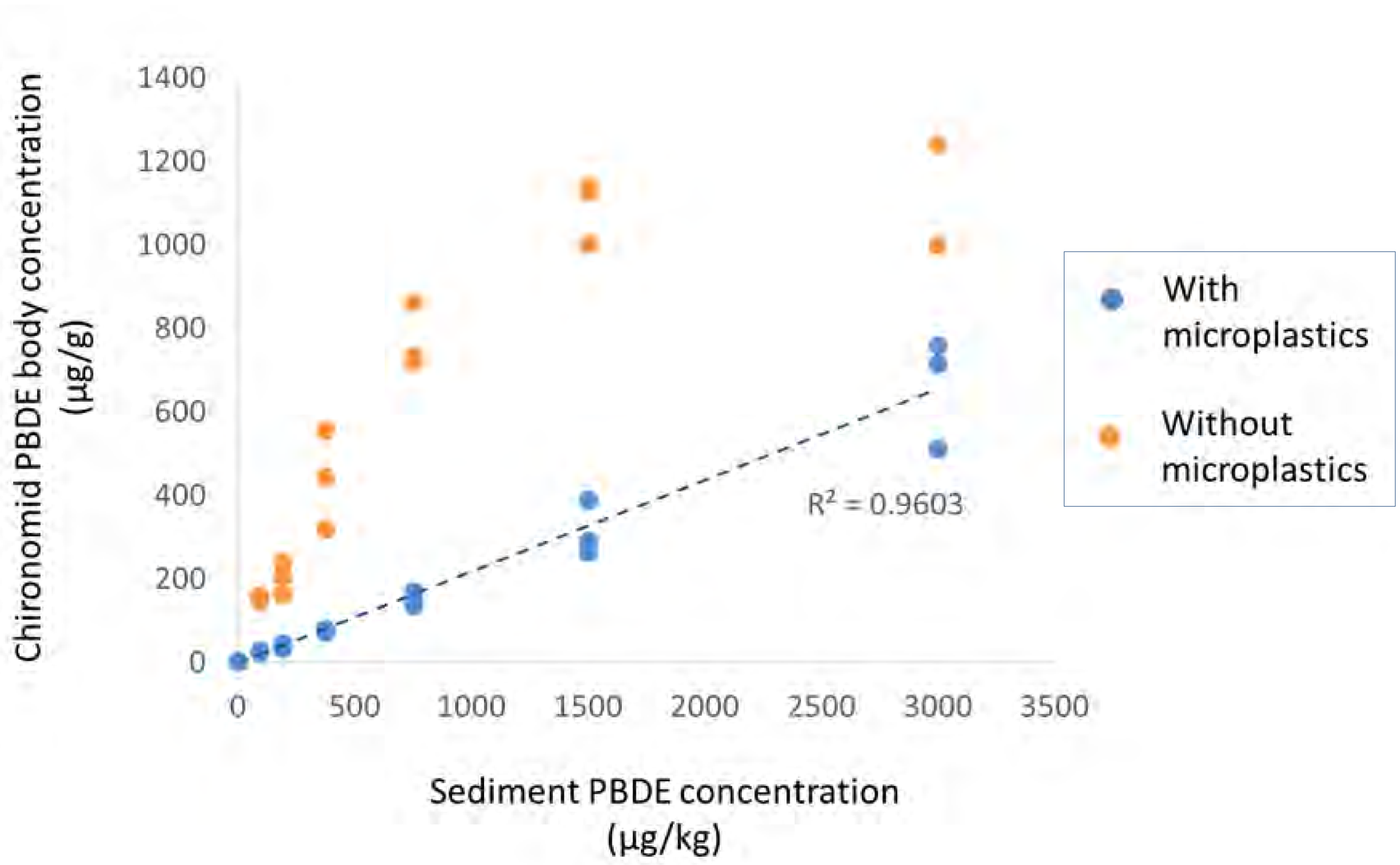
Ingestion of microplastics and chemical bioaccumulation



Images showing ingestion of microplastics by freshwater midge larvae *(Alice Horton)*

- Freshwater midge larvae – *Chironomus sancticaroli*
- 1% by mass nylon, 13-18 µm
- PBDEs: 47, 99, 100, 153



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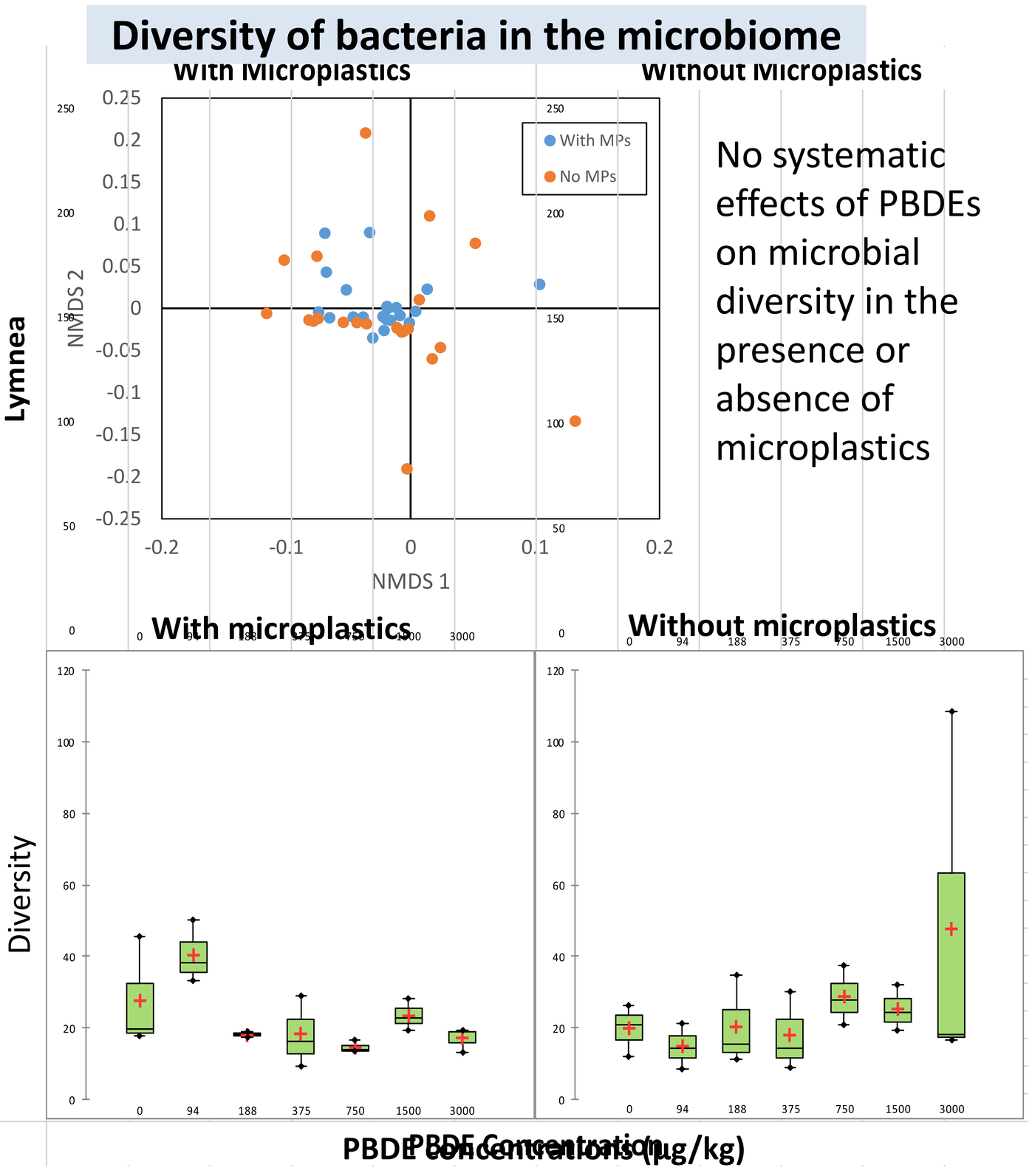
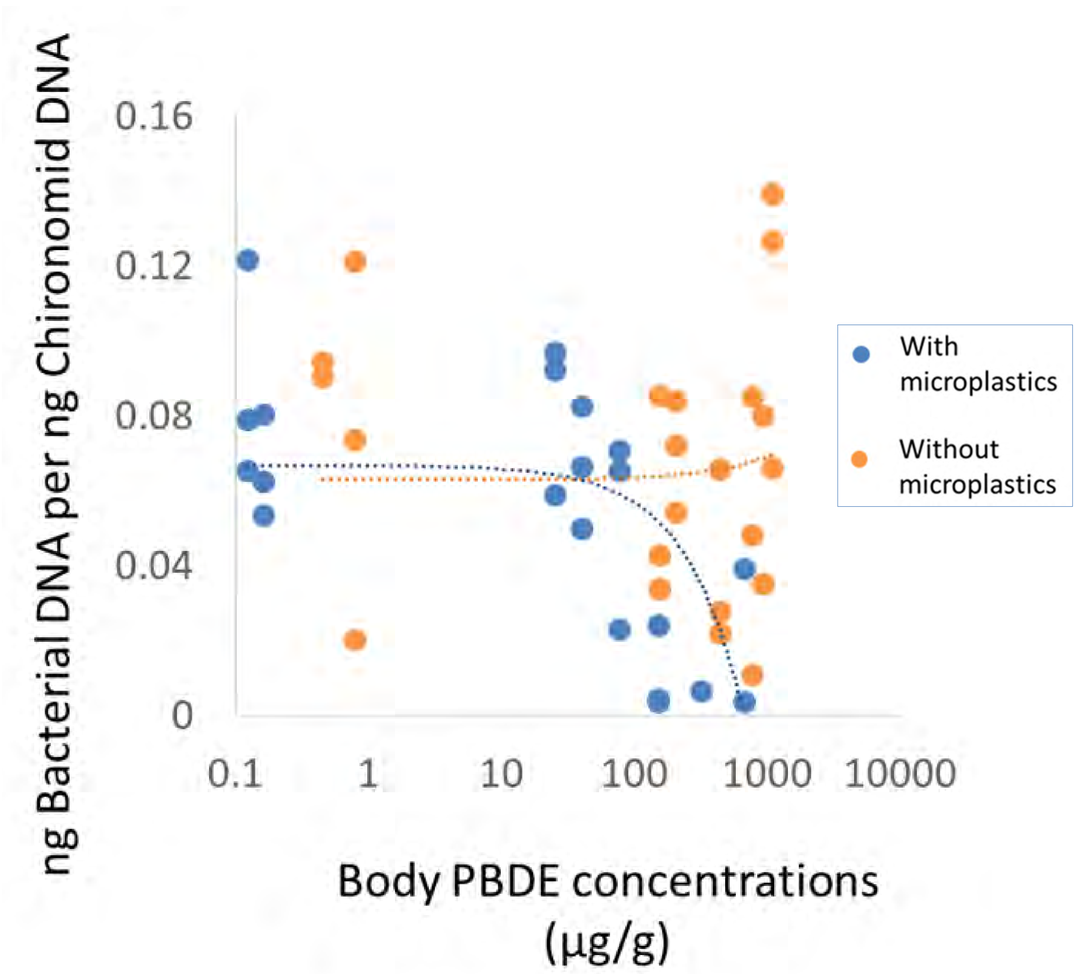
Ingestion of microplastics and microbiome change

Diversity of bacteria in the microbiome



No systematic effects of PBDEs on microbial diversity in the presence or absence of microplastics

Bacterial DNA in the microbiome



Amount of microbial DNA decreases in the presence of microplastics.

More analysis needed!

Slide adapted from Elma Lahive

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Microplastics in terrestrial environments

- No known studies quantifying microplastics in the terrestrial environment
- Plastic litter breaks down in the environment
- Microplastics enter terrestrial environment via sewage sludge application to land
- Microplastics → waterways via runoff

Photo: Alice Horton

Photo: Alex Walton

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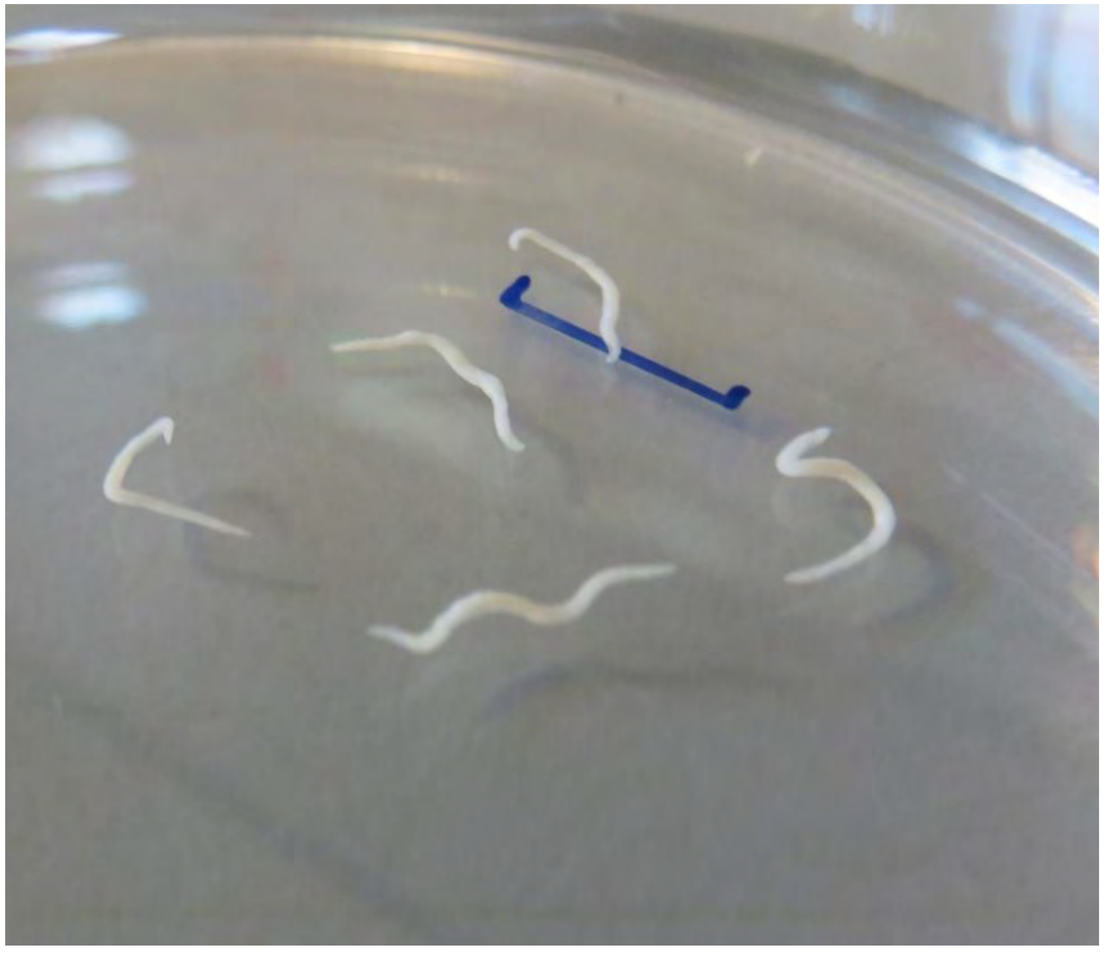
Microplastics + terrestrial organisms

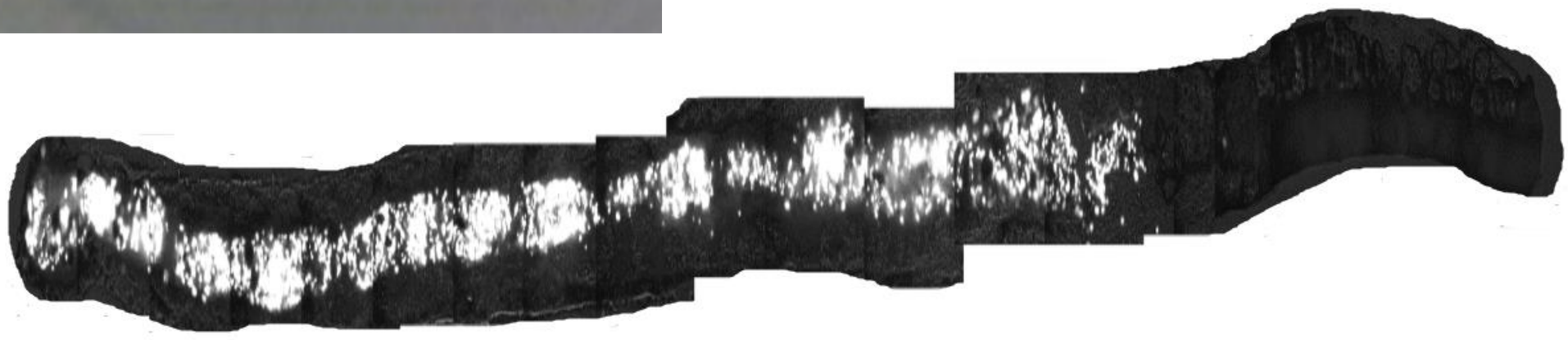


Enchytraeus crypticus ~ 1 cm in length.

Earthworms ecologically important functional group

Exposed to fluorescently labelled nylon particles for 21 days

Number of juveniles produced counted as a measure of reproductive output



Study carried out by Alex Walton

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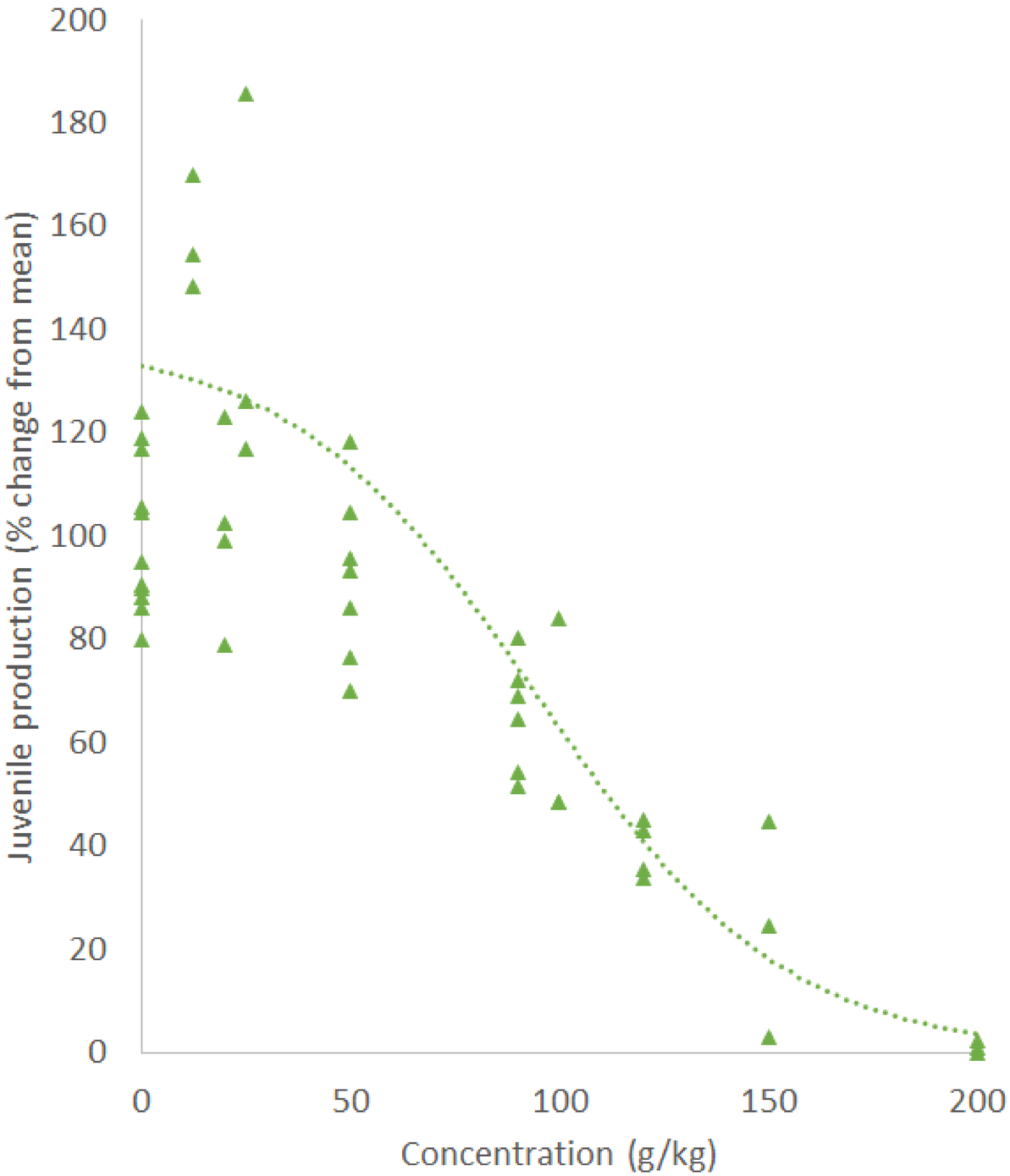
Microplastics and enchytraeids - results



- No effect of on survival.
- Significant effect on reproduction (reduced output).
- Ingestion of nylon particles reduces organism energy budgets and reduces reproductive output.
- Realism of exposure scenario is unknown for terrestrial environment.

Study carried out by Alex Walton

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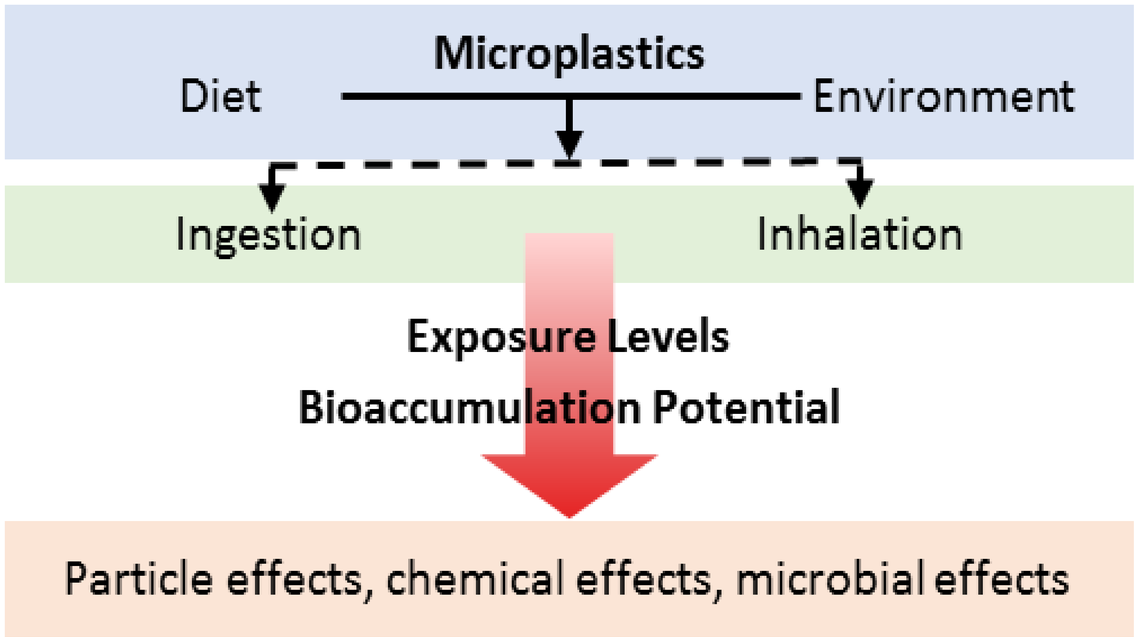
Microplastics and human health



Wright and Kelly (2017)

Microplastics detected in:

- Air
- Beer
- Seafood
- Honey
- Salt
- Tap water

No studies yet on health implications

But could lead to:

- Accumulation
- Immune response
- Respiratory problems
- Chemical leaching

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Microplastics as a research priority

- How do different polymer characteristics affect behaviour and ecological effects of microplastics?
- Where do microplastics accumulate within the environment – can we link this to specific environmental conditions?
- Which species are most vulnerable to harm from microplastics and how will this affect ecosystems?
- To what extent do microplastics act as vector for bioaccumulation of organic chemicals?
- What are the human health consequences of microplastics?

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NERC Knowledge Exchange fellowship '<u>UK Microplastics Network</u>'

Aims:

1. Developing links between academia, government, industry, charities and the commercial sector
2. Sharing of knowledge
3. Identification of skills
4. Building of ideas
5. Interdisciplinary collaborations
6. Expert contributions to reports, proposals and calls for evidence

Starting November 2017

Please get in touch with suggestions, ideas or contacts:

Email: alihort@ceh.ac.uk
Twitter: @UK_Microplastic

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