Nora Domrös, Leila Mégevand, Valeria Peßler
Global Change Ecology & Fluvial Ecosystems

MICROPLASTICS ARE NOT FANTASTIC

Microplastics in lakes and rivers: an issue of emerging significance to limnology
D'Avignon, G., Gregory-Eaves, I., Ricciardi, A. (2024)

AGENDA

- Introduction
- Hydrology
- Biogeochemistry
- Ecology
- Conclusion

MICROPLASTICS

All field surveys found MP

Nearly 80 % of all plastics ever created in environment

Ratios up to 30:1 for MP and plankton

Marine studies dominate

METHODOLOGY

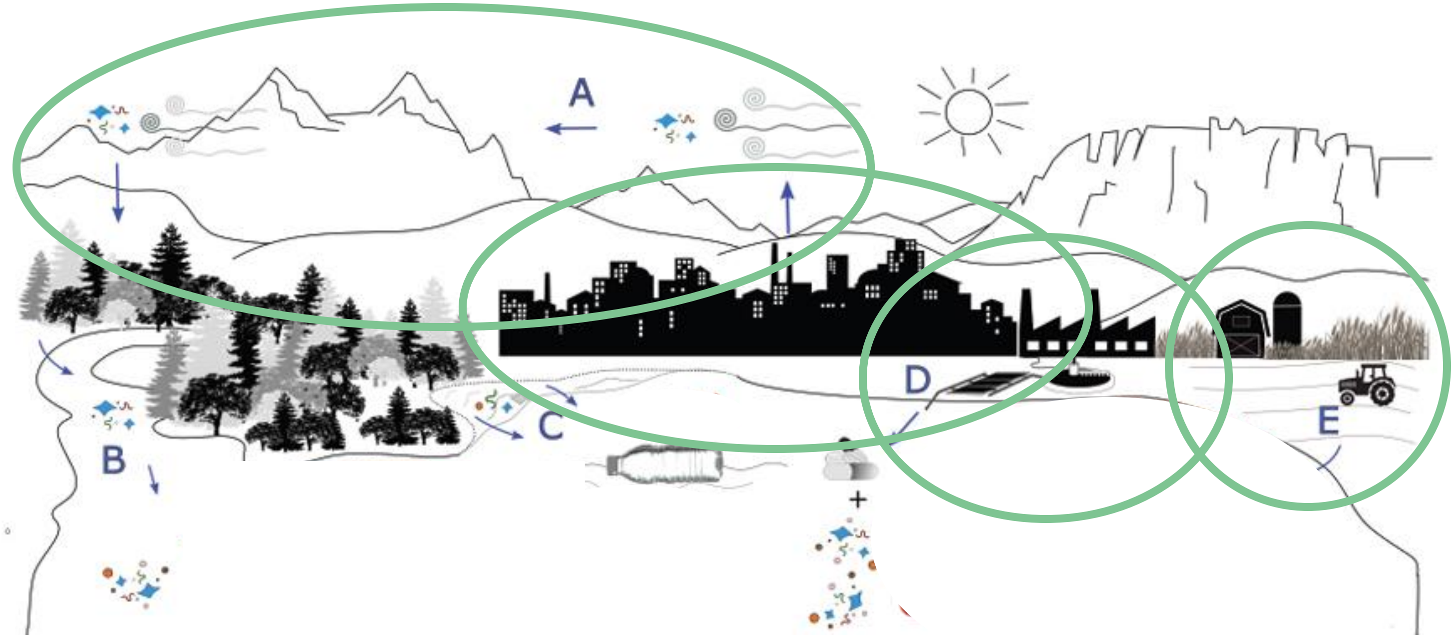
- Meta study: systematic literature review of 3731 articles
- Goal: standardized limnological protocols to compare spatio-temporal variation in the concentration of microplastics within and across watersheds
- MP = synthetic particles ≤ 5 mm in size

MPS & HYDROLOGY

1. How do microplastics <u>enter</u> freshwater environments?

2. How are microplastics <u>transported through</u> freshwater systems?

HOW ARE MPS ENTER FRESHWATERS?



Waste Water

- WWTP can remove 40-99% of MP
- 80% of wastewater world-wide is untreated

Urban Runoff

- 42% of MPs in European rivers are tire and road wear particles

Agricultural Runoff

Atmospheric Deposition

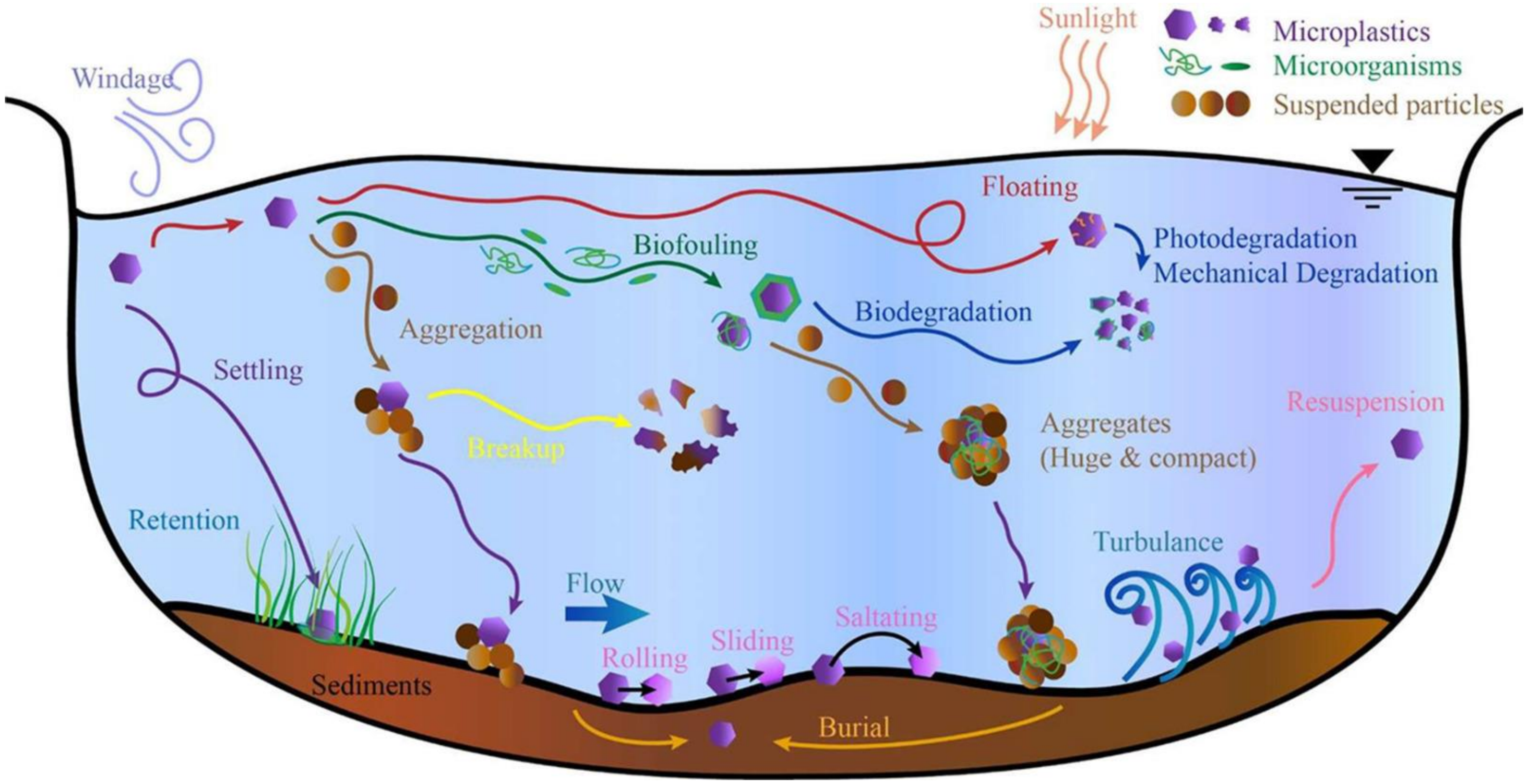
- Brings Microplastics to the most remote & pristine catchement areas

Recreational Activities

MP TRANSPORT

Hydrological Drivers:

1. Flow velocity
2. Turbulence
3. Sediment Interactions

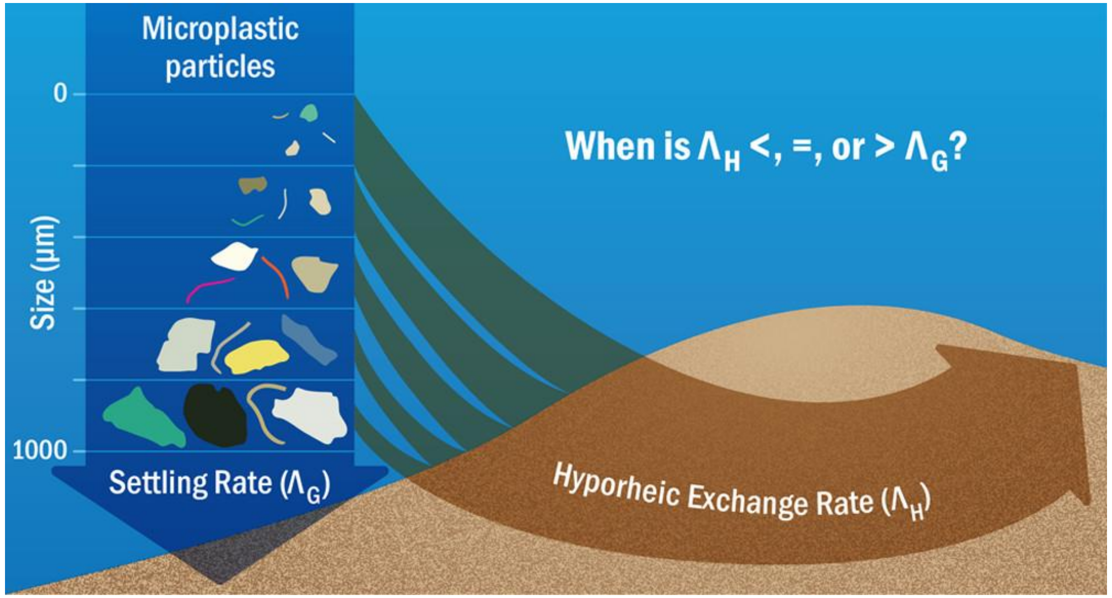


MP TRANSPORT

CONTAMINANTS IN AQUATIC AND TERRESTRIAL ENVIRONMENTS | August 20, 2020

Significance of Hyporheic Exchange for Predicting Microplastic Fate in Rivers

Jennifer D. Drummond*, Holly A. Nel, Aaron I. Packman, and Stefan Krause



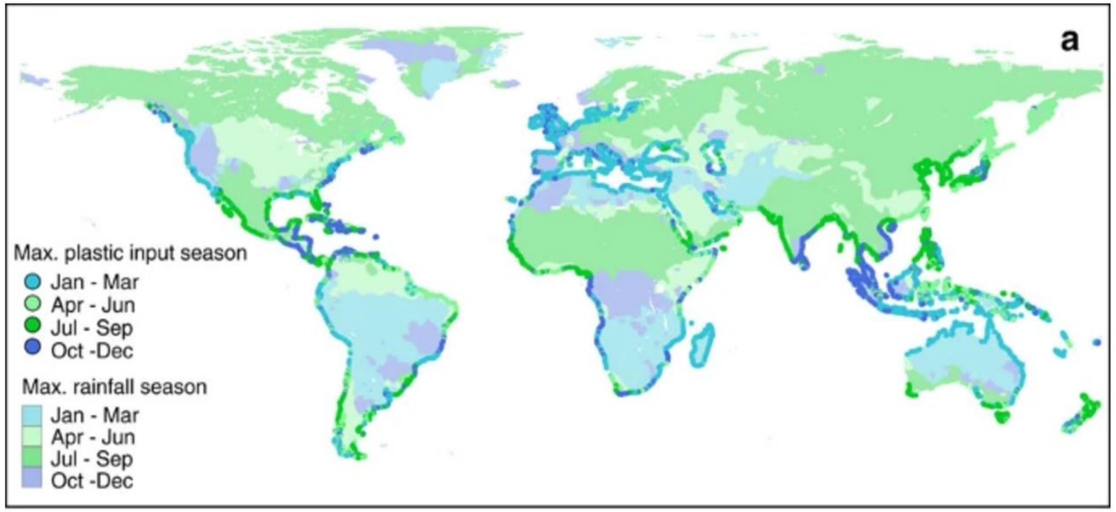
- 23% of all MP combinations have a hyporheic exchange rate that is higher than selling rates
- Model without exchange underestimate the **deposition, retention, and long-term** accumulation of microplastics

Article | Open access | Published: 07 June 2017

River plastic emissions to the world's oceans

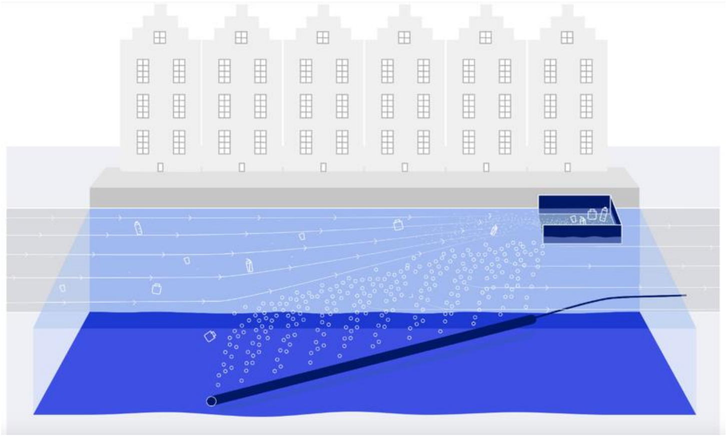
Laurent C. M. Lebreton, Joost van der Zwet, Jan-Willem Damsteeg, Boyan Slat, Anthony Andrady & Julia Reisser

Figure 3: Seasonality of regional inputs of river plastic to oceans.



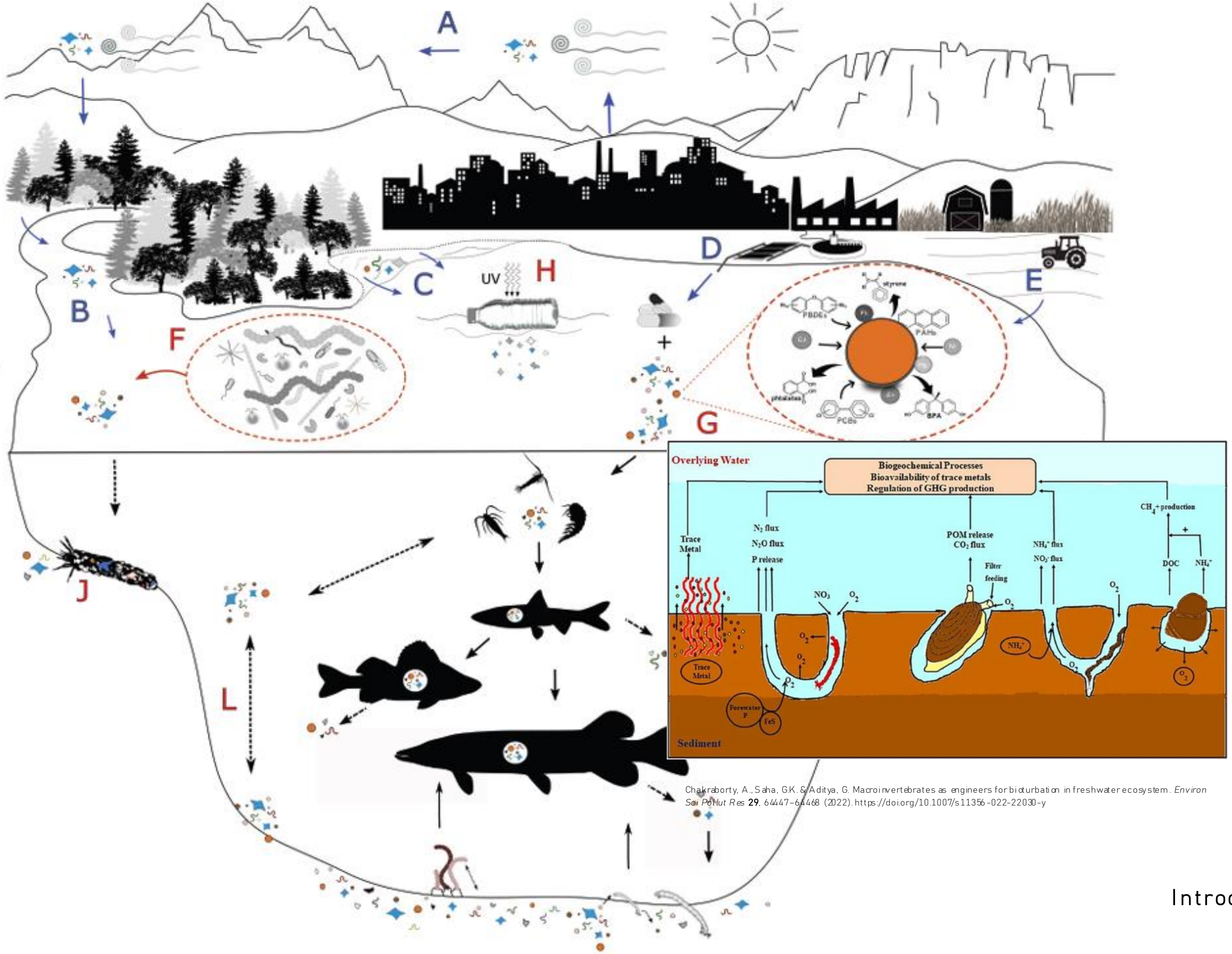
- Flood, and large hydrological events drive the resuspension of deposited MPs, allowing them to be transported over long distances.

AMSTERDAM: THE GREAT BUBBLE BARRIER



IMPACTS OF MICROPLASTICS ON BIOGEOCHEMICAL CYCLING

IMPLICATIONS ON SEDIMENTATION PROCESSES



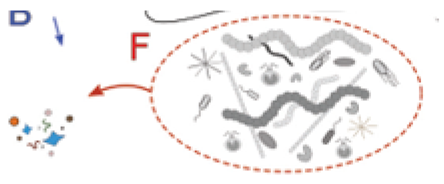
Chakraborty, A., Saha, G.K. & Aditya, G. Macroinvertebrates as engineers for bioturbation in freshwater ecosystem. *Environ Sci Pollut Res* **29**, 64447–64468 (2022). https://doi.org/10.1007/s11356-022-22030-y

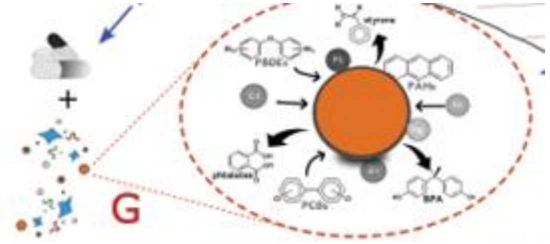
- Less density: slower sedimentation
- Species responsible for sedimentation: in presence of MP: carry less particles downwards
- Species responsible for bioturbation: impacted in size by MP → less bioturbation

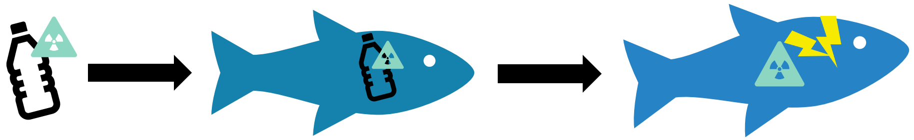
→ Changes in nutrient, carbon and oxygen availability in different parts of the water

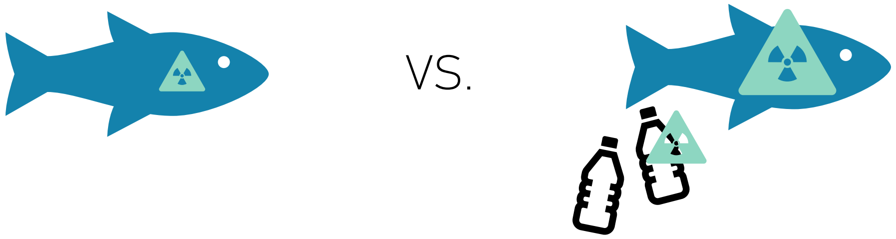
IMPLICATIONS ON CONTAMINANT CYCLING

- Bigger Area/Volume ratio → Sorbtion of contaminants & microbial colonization
- Toxicity: particles, biofilm, heavy metals that were adsorbed to it, chemicals/additives leaching out of polymer
- Sorption/desorption processes depend on pH, salinity, DOM content in water
- Desorption of contaminants in stomach → MP as transport mean for contaminants to the food web
- Contamination transfer to fish x 2.6 times in presence of plastics than without









ECOLOGICAL IMPACTS OF MICROPLASTICS

ECOLOGICAL IMPACTS

INGESTION

- Feeding
- Drinking
- Respiration
- Swimming
- Random adherence
- Other processes

ECOLOGICAL IMPACTS

ECOTOXICOLOGY

Physical and Physiological Effects

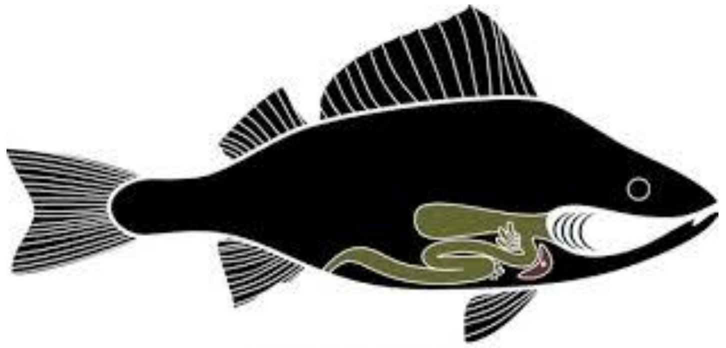
Movement
Feeding and digestion
Respiration
Growth and development
Predatory performance
Protection/defence
Cell/organ damage
Reproduction

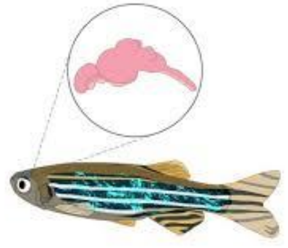
Toxicity

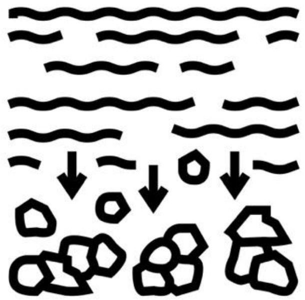
Mortality
Oxidative Stress
Inflammation
Metabolic activities
Gene damage
Neurotoxicity

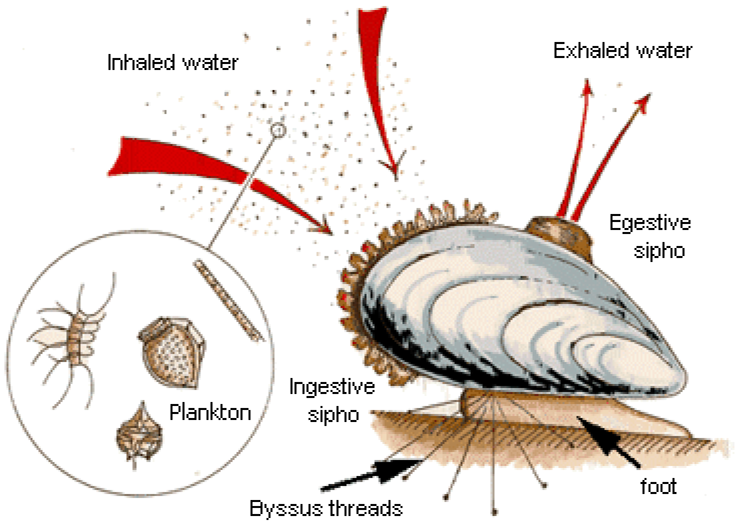
Ecological Effects

Productivity
Nutrient cycling
Toxic blooms
Trophic transfer
Ontogenic transfer
Bioaccumulation





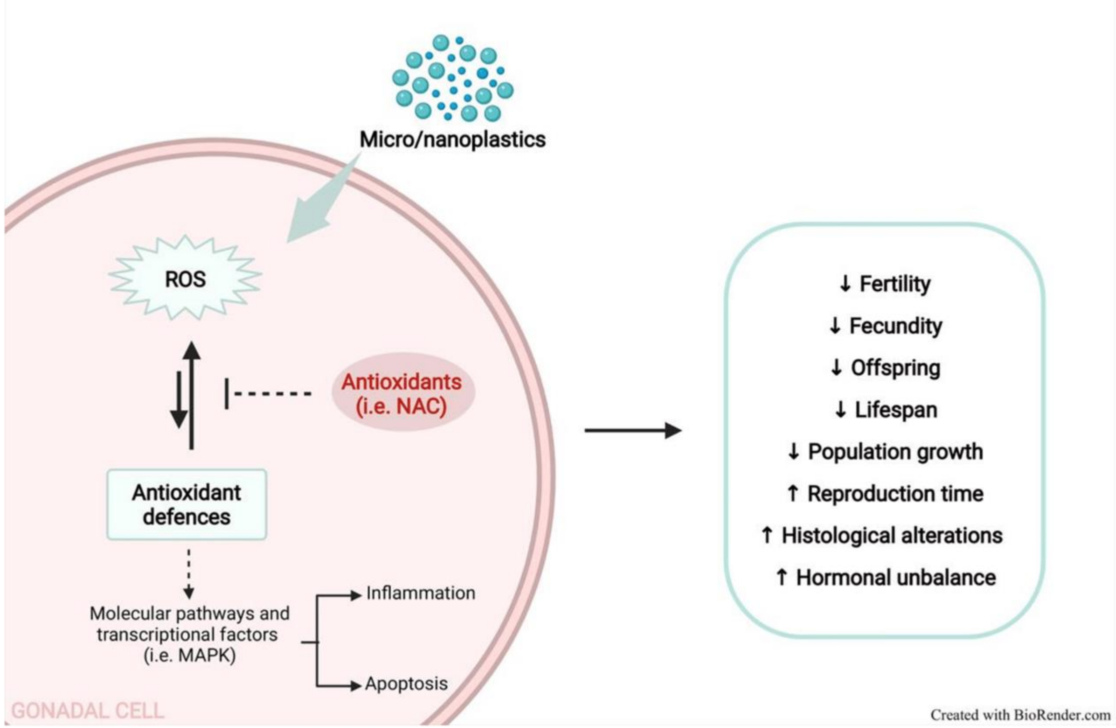




PHYSICAL AND PHYSIOLOGICAL EFFECTS

- Physical Obstruction
- Behavioral Changes
- Habitat Alteration
- Accumulation on biomass

TOXICITY

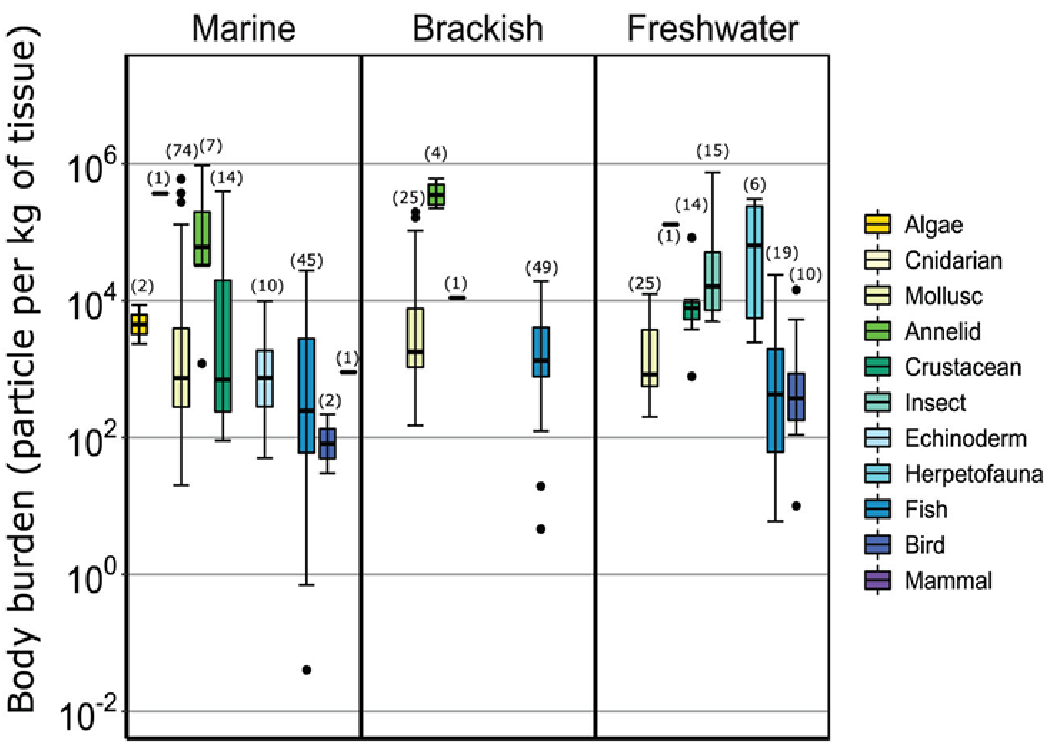


- Leaching of **additives** and **sorbed contaminants** (e.g., pollutants, pharmaceuticals, …)
- **Shape** affects toxicity
  - Fibers: Greater toxicity, longer duration in intestinal tract
  - Smaller particles: Greater hazard
- **Oxidative stress**: main toxicity mechanism
- Excessive ROS: inflammation, **lipid peroxidation**, cell membrane/DNA/protein damage, cell death
- **Combined** pollutants' effects: antagonistic, additive, synergistic

IMPACTS ON ECOSYSTEM FUNCTIONS

Contamination and Presence

- Freshwater and estuarine species have **contamination levels similar to marine species**
- **Freshwater fish have more plastics** in their guts and higher microplastic loads than marine fish
- Tiny plastic particles can be found in the **livers and filets of freshwater fish**; very small particles can **enter the bloodstream** and stay there for 20-48 days



IMPACTS ON ECOSYSTEM FUNCTIONS

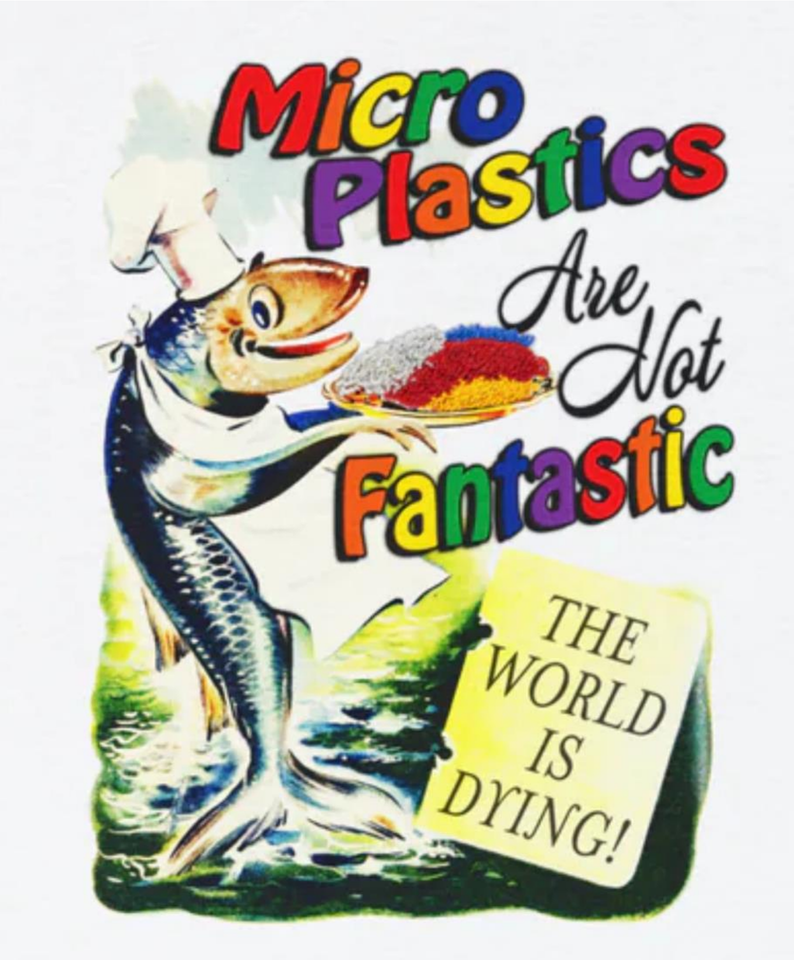
Interactions, Retention and Transfers

- Microplastics affect organisms and ecosystems **biologically and chemically**
- Plastics can be **re-ingested or transferred between organisms**
- Organisms act as **temporary reservoirs**, transferring plastics through food webs
  - **Plastic retention varies** by particle size, shape, metabolism, and digestive complexity
- Plastics can transfer from mosquito larvae to adults: **insect emergence can be delayed**, reducing adult numbers
- Response varies by feeding dose, mechanisms and habitat
  - **Riverbed invertebrates being highly vulnerable**
  - Algae and causing **toxic algal blooms**

CONCLUSIONS

Main Takeaways

- MPs are ubiquitous at every level of freshwaters environments
- Transport driven by hydrodynamics and sediment interactions
- MPs act as vectors for contaminants, disrupting nutrient and carbon cycles
- Ecological impacts: ingestion, biofilm formation, physiological stress, disrupting food webs and ecosystems



CONCLUSIONS

Future Implications

- Integrate microplastic **monitoring into standard limnological protocols** to track distribution and impacts
- Develop models to **account for transport, retention, and resuspension** of MPs in fluvial systems
- **Address microplastic pollution at the source** with improved wastewater treatment, and reduced reliance on single-use plastics.

THANK YOU