# How do microplastics distribute through freshwater ecosystems?

*Important points to note when sampling and reporting microplastic abundances*

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# A brief history of plastic

- A series of monomers
- Stacked together into polymer chains (Jansen, 2016)
- Each chain significantly different
- Additives included (Jansen, 2016)

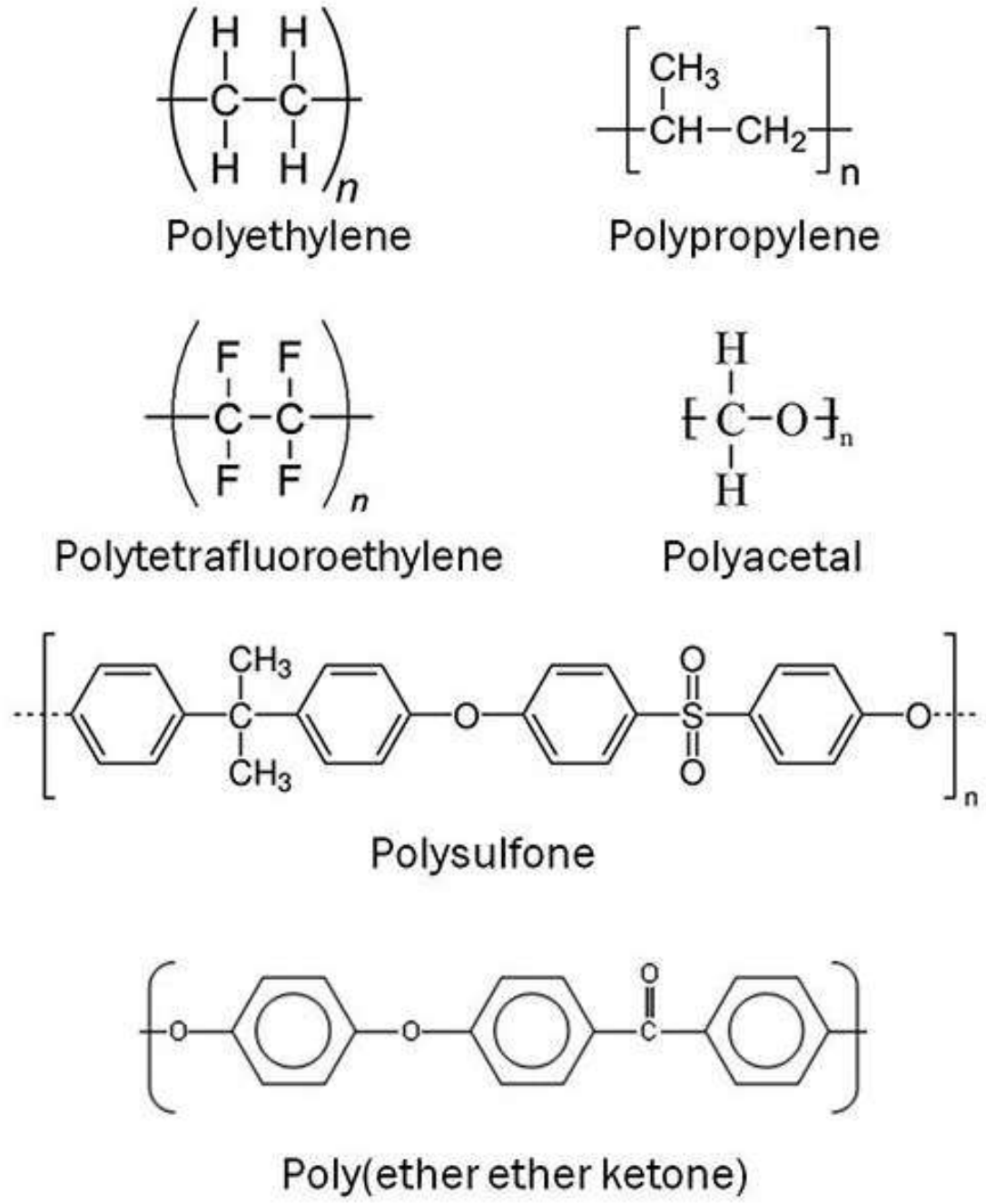



Fig 1: Various plastic polymers

# A brief history of plastic

- 1920 the first modern plastic
- Plasticiser added to PVC (Jansen, 2016)
- Was initially too brittle
- Additive made it usable (Jansen, 2016)
- Today no new polymers, just add additives

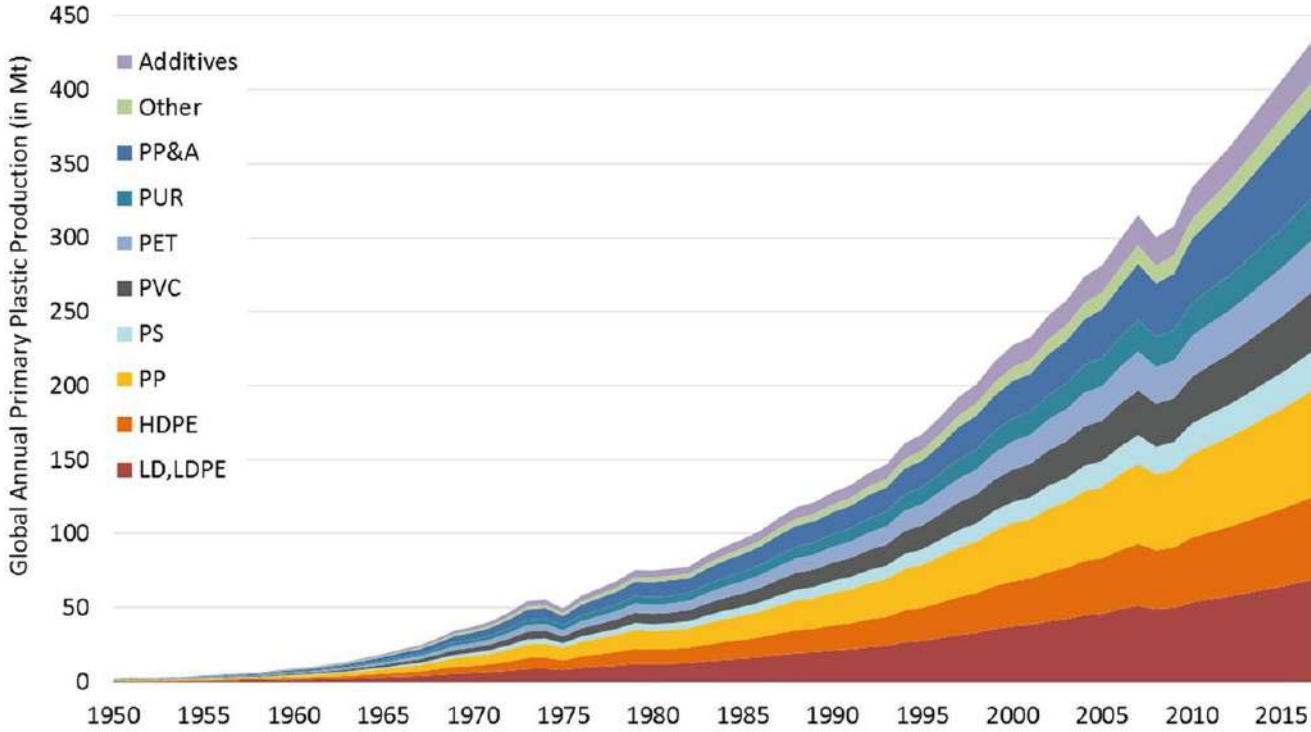



Fig 2: Increased use of plastic and additives since 1950s

# A brief history of plastic

- After WW2 cheap materials were needed

  (Jansen, 2016)
- Plastic was a convenient replacement
- The impact was not considered
- Poor waste management systems

Fig 3: Scarce resources created a gap that was filled by plastic

# Warnings, more plastic, more warnings, even more plastic…

- Silent Spring 1962
- Environmental harm of DDT
- What about plastic?
- Plastic reaches exponential growth

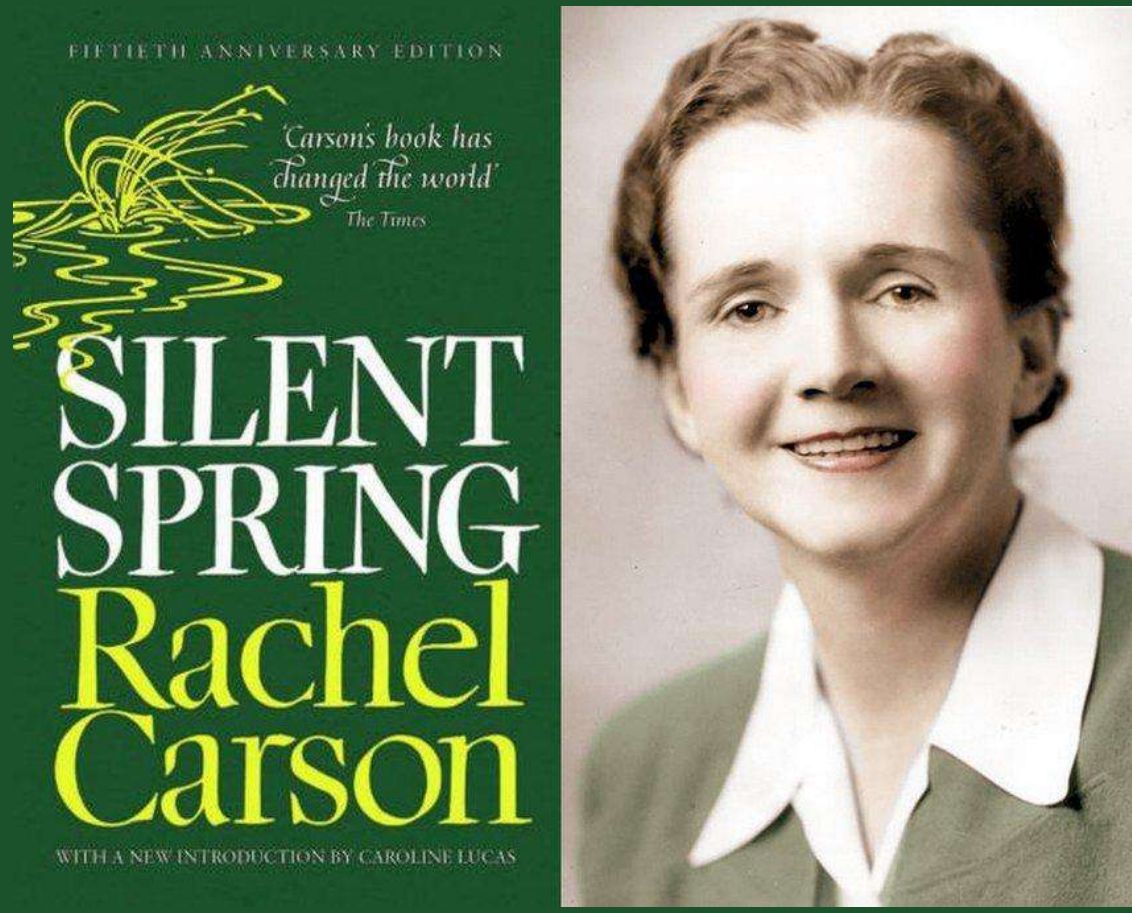



Fig 4: Rachel Carson “Silent Spring”

# Warnings, more plastic, more warnings, even more plastic…oh no….

- 1972 Carpenter et al. found plastic in the oceans (0.25 – 0.5 cm)
- 1990 Ryan recorded and termed “Microplastics” coast of South Africa
- 2004 Thompson et al. ”Godfather of microplastics”?
- Plastic is everywhere

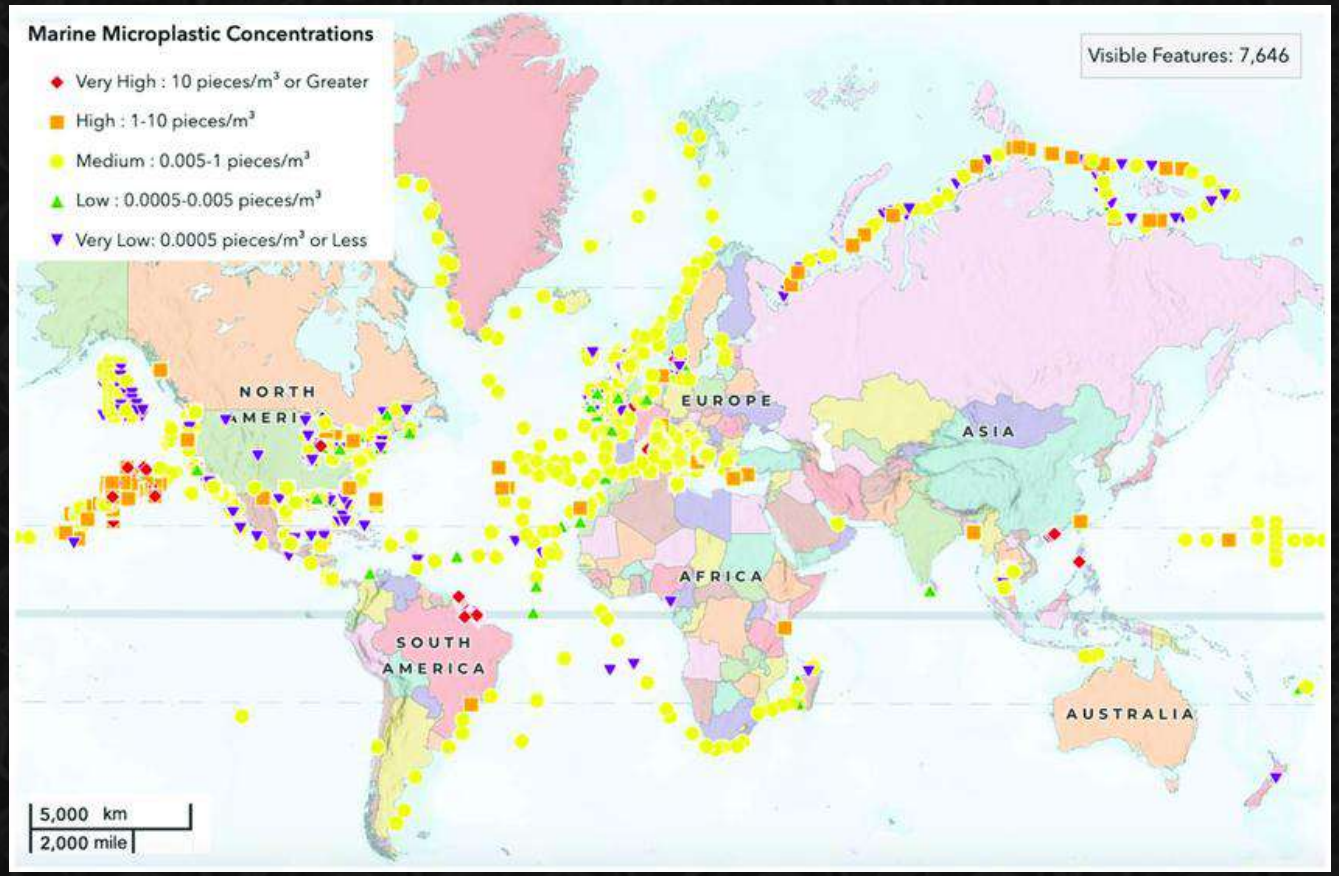



Fig 5: World map of ocean microplastics

# Microplastic research in the environment

- Marine environments clearly favoured (Blettler et al., 2018)
- Has been a recent increase in freshwater microplastic research

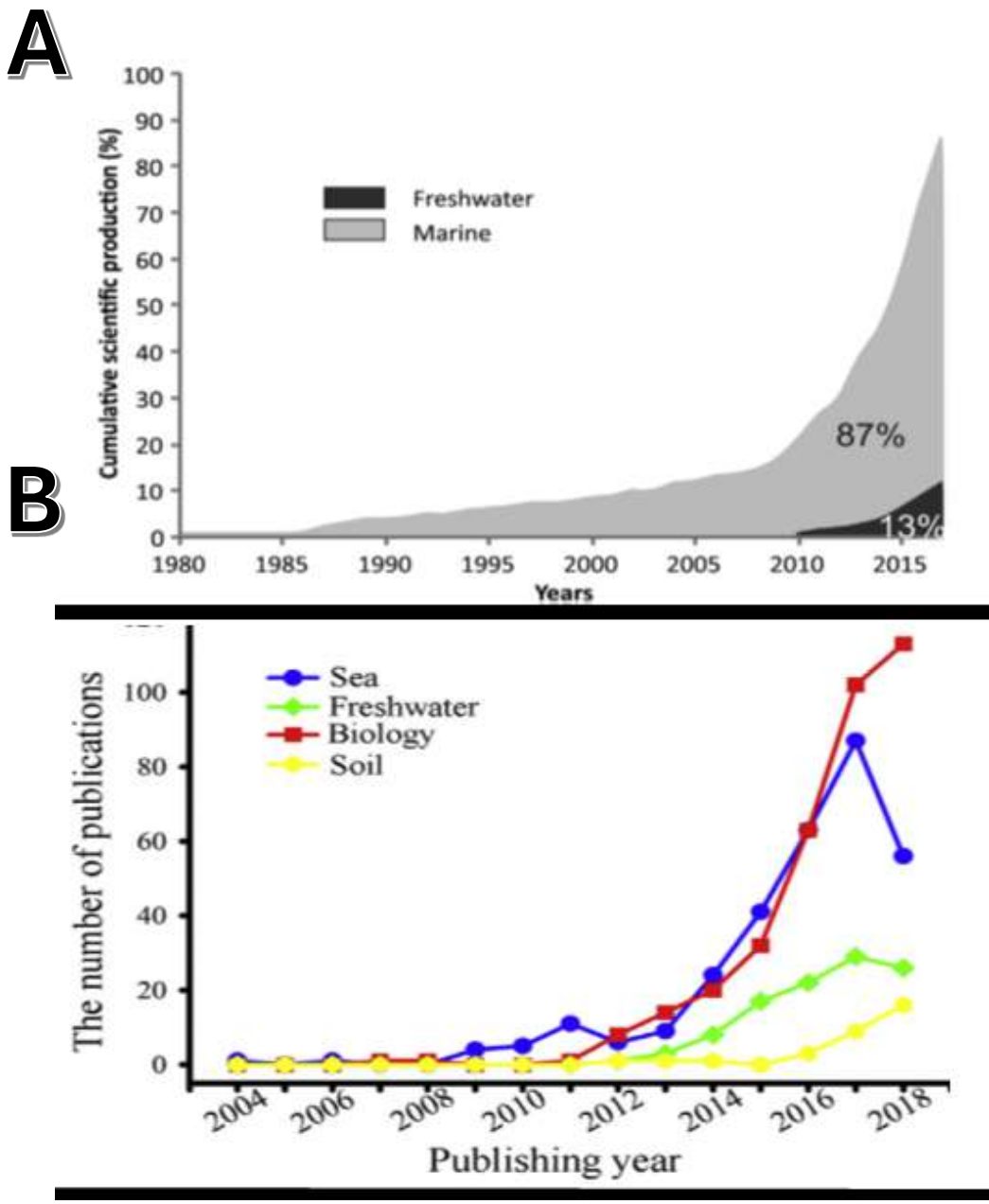



Fig 6: A clear bias of marine vs freshwater research in microplastics

# Microplastics in rivers

- 5 rivers = 80% ocean plastics (Schmidt et al., 2017)
- 47 rivers = 80% ocean plastics (Lebreton et al., 2017)
- Small stream/rivers underestimated (Meijer et al., 2021)
- Estimated today at 1656 rivers (Meijer et al., 2021)

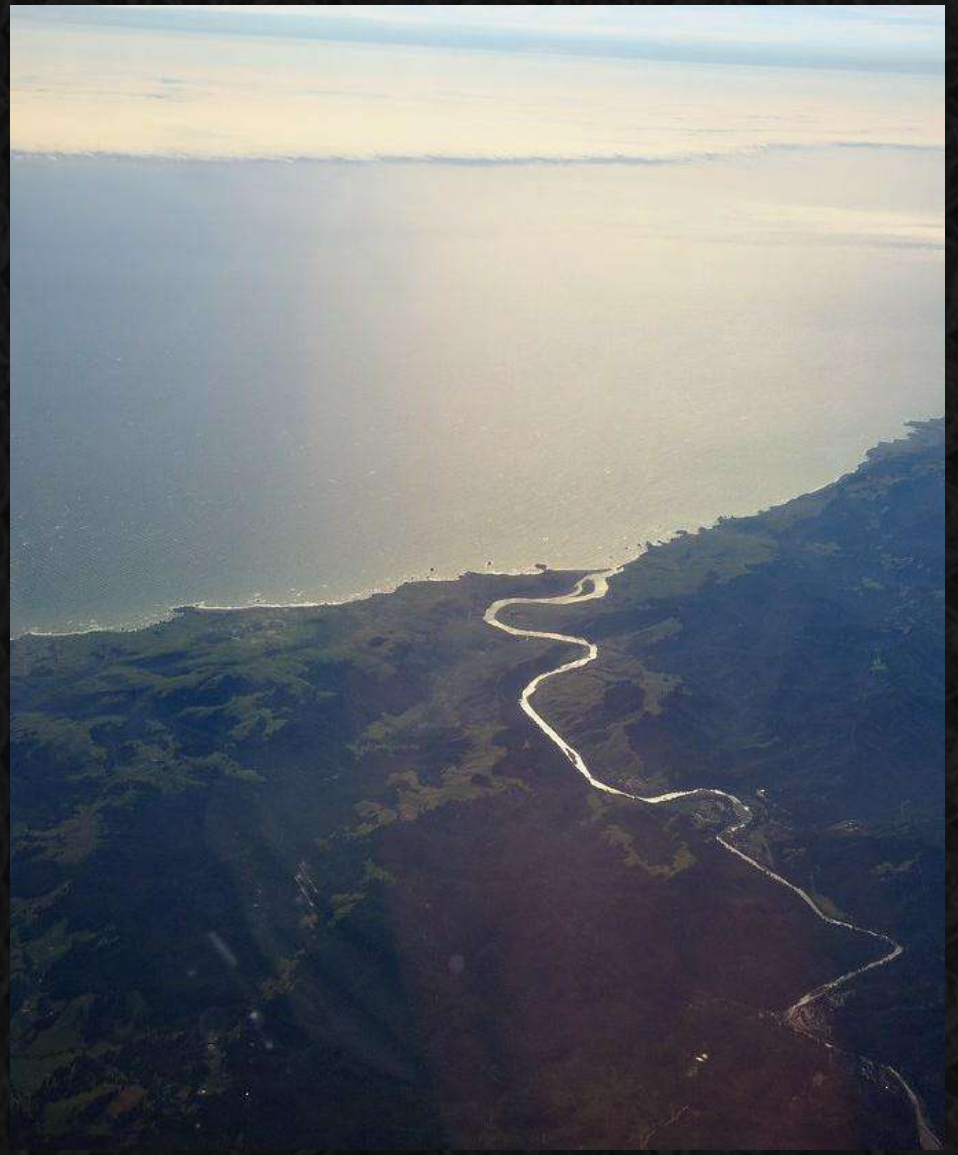


Fig 7: Plastic transported from rivers to oceans

# Microplastics in rivers

- Microplastics don’t simply float down river
- Limited long-distance transfer (Weideman et al., 2020)
- Dams can act as sinks (Watkins et al., 2019)

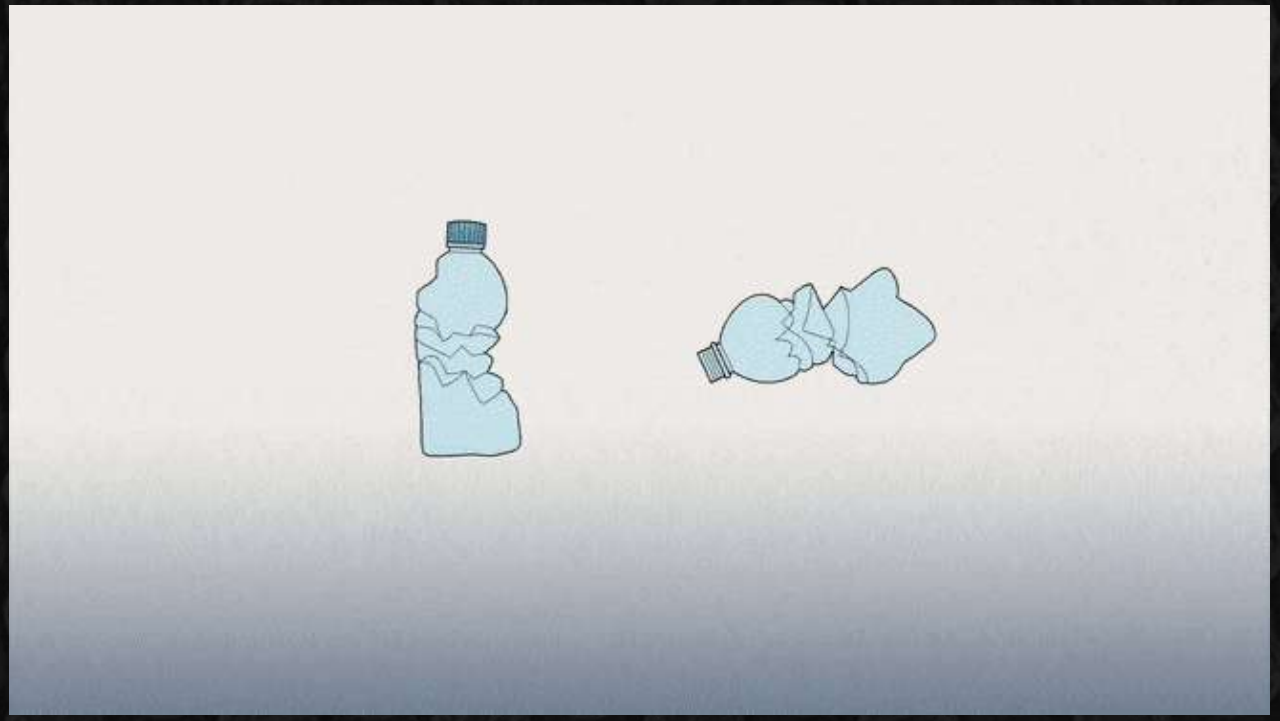
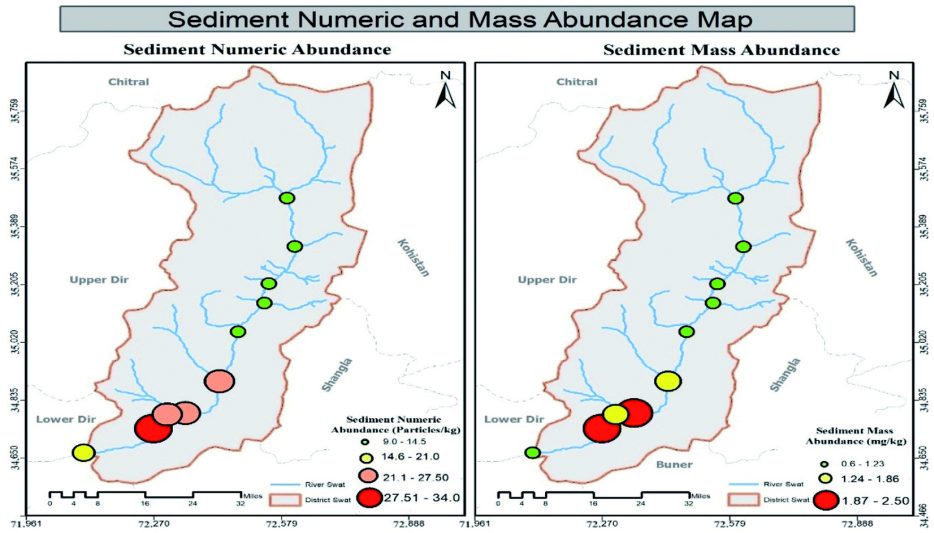
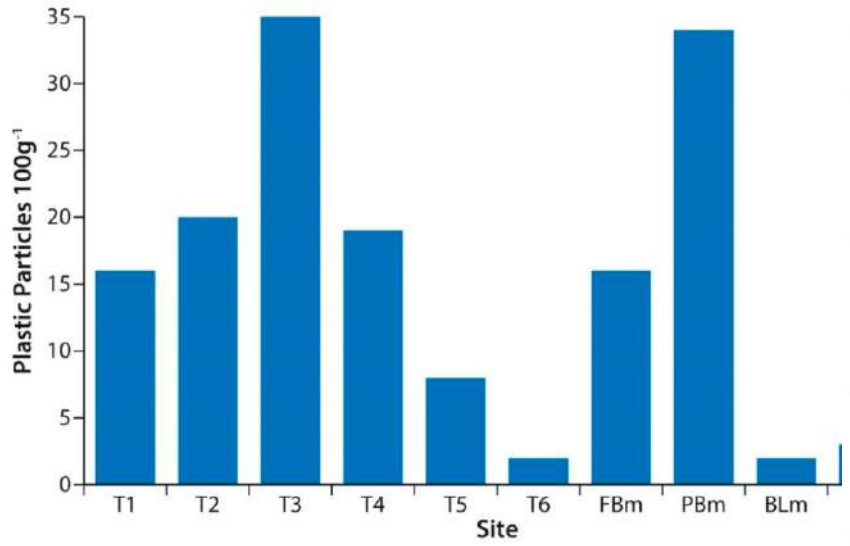
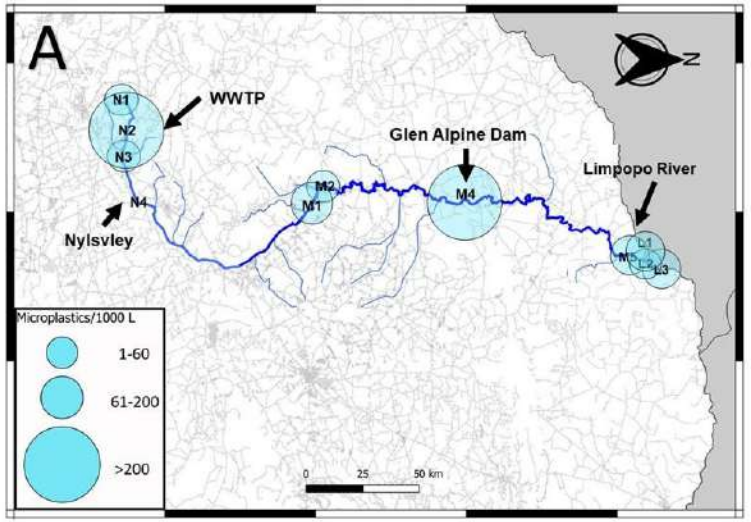
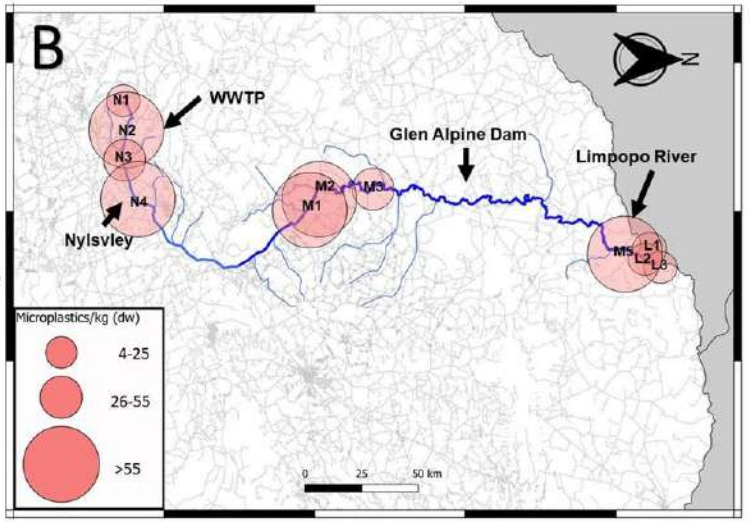


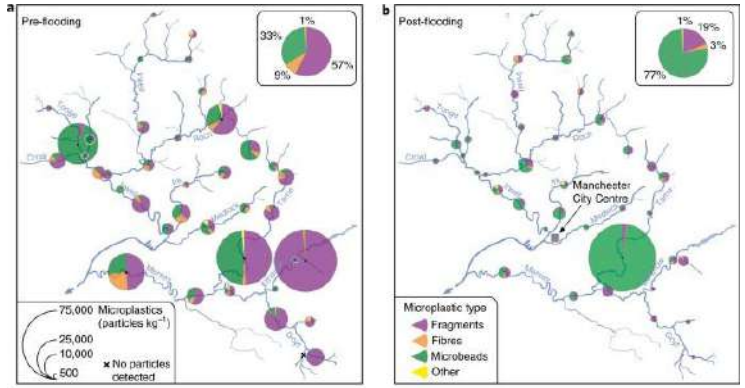
Fig 8: Plastic transported from rivers to oceans

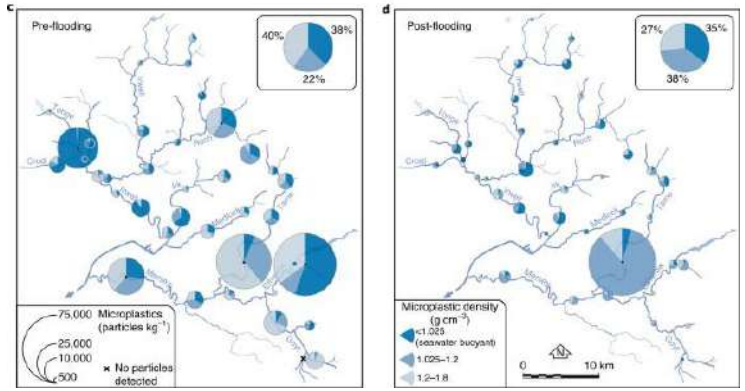

Sediment Numeric and Mass Abundance Map
Sediment Numeric Abundance
Sediment Mass Abundance
Chitral
Upper Dir
Lower Dir
Kohistan
Shangla
Buner
Sediment Numeric Abundance (Particles/kg)
9.0 - 14.5
14.6 - 21.0
21.1 - 27.50
27.51 - 34.0
Sediment Mass Abundance (mg/kg)
0.6 - 1.23
1.24 - 1.86
1.87 - 2.50
River Swat
District Swat

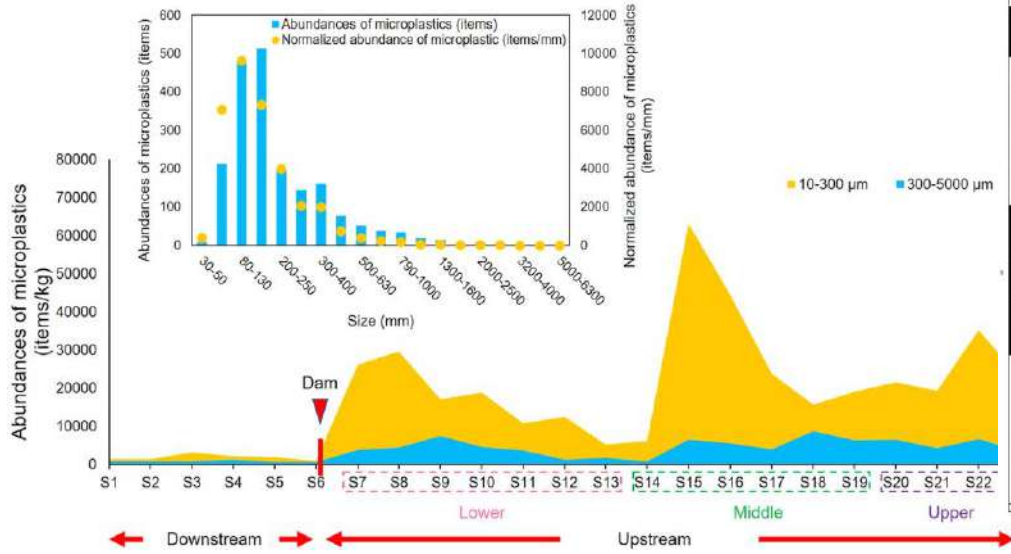

Plastic Particles 100g⁻¹
T1
T2
T3
T4
T5
T6
FBm
PBm
BLm
Site

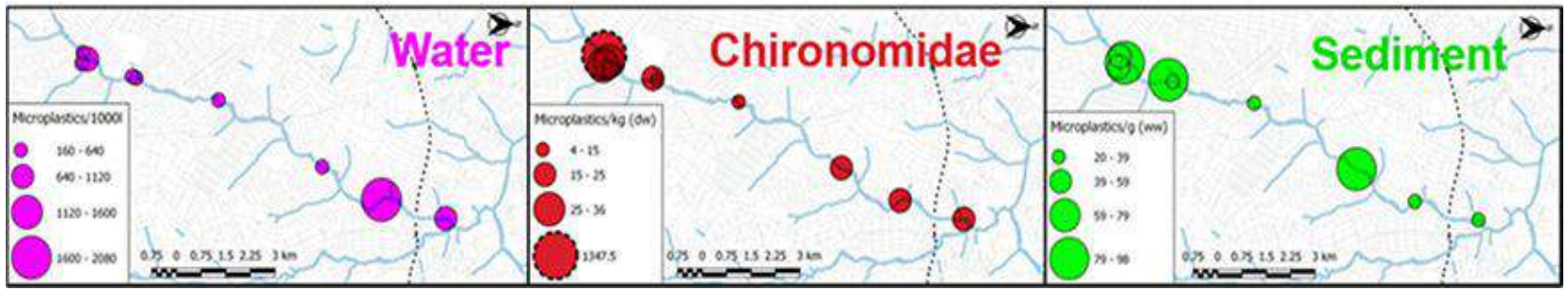

A
WWTP
Glen Alpine Dam
Limpopo River
Nylsvley
N1
N2
N3
N4
M1
M2
M4
M5
L1
L2
L3
Microplastics/1000 L
1-60
61-200
>200


B
WWTP
Glen Alpine Dam
Limpopo River
Nylsvley
N1
N2
N3
N4
M1
M2
M3
M5
L1
L2
L8
Microplastics/kg (dw)
4-25
26-55
>55


a
Pre-flooding
b
Post-flooding
Manchester City Centre
Microplastic type
Fragments
Fibres
Microbeads
Other
75,000 Microplastics (particles kg⁻¹)
25,000
10,000
500
No particles detected


c
Pre-flooding
d
Post-flooding
Microplastic density (g cm⁻³)
<1.025 (seawater buoyant)
1.025–1.2
1.2–1.8
10 km


Abundances of microplastics (items)
Normalized abundance of microplastic (items/mm)
Size (mm)
Abundances of microplastics (items/kg)
10-300 µm
300-5000 µm
Dam
Lower
Middle
Upper
Downstream
Upstream


Water
Chironomidae
Sediment
Microplastics/1000l
Microplastics/kg (dw)
Microplastics/g (ww)

# Microplastics in rivers

- River Continuum Concept (Vannote, 1980)
- Rivers are heterogeneous
- Environment changes
- Changes in river morphology
- Changes plants and biota (Dobbs and Maasri, 2022)
- Microplastics similarly adhere

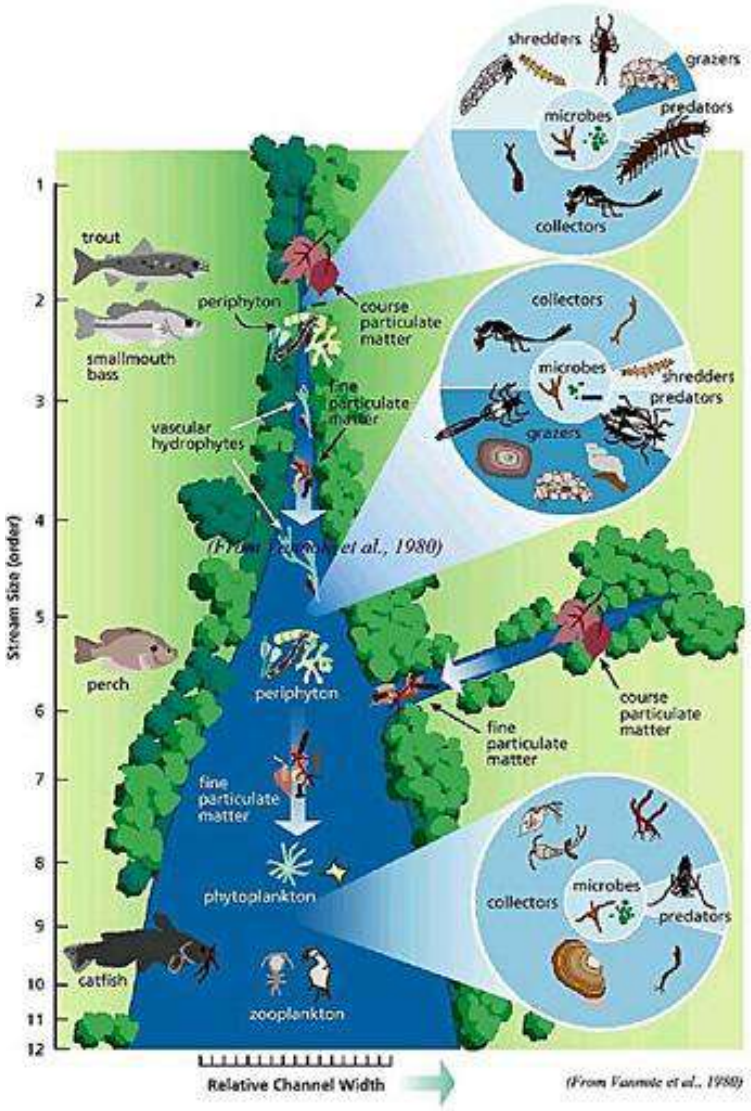
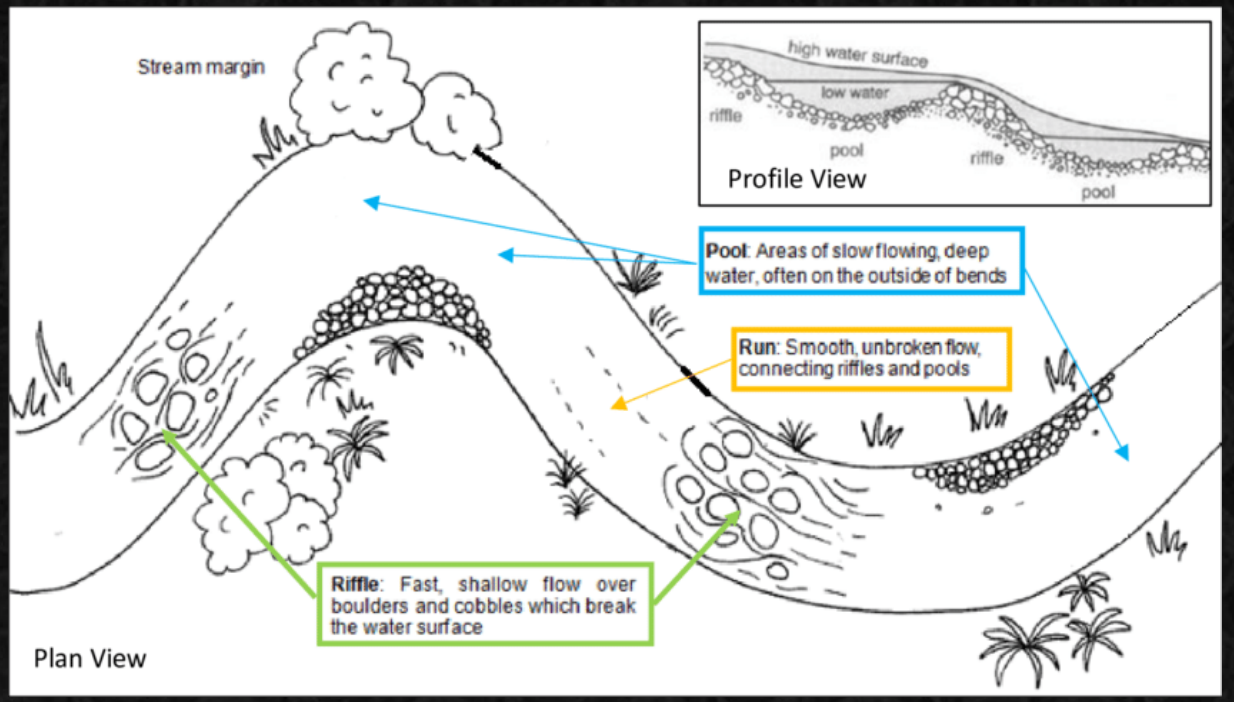



Fig 9: The River Continuum Concept

**Two primary role players**

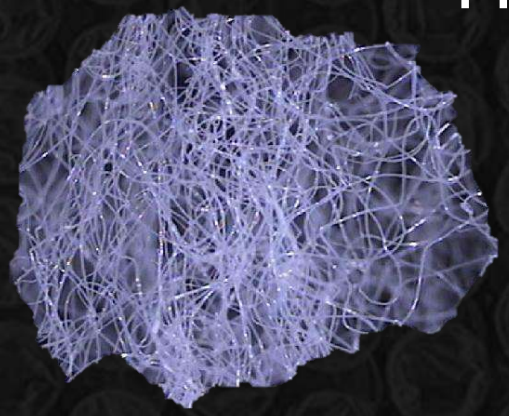
## Anthropogenic activities

## River habitat



# Anthropogenic

## Hydrological



One piece of clothing can release = 1000 microplastics per wash
(Mcllwraith et al., 2015)

Clothing made from plastic, poor filters on washing machines

Some WWTPs ineffective at removing all microplastics
(Guo and Wang, 2019)

Up to 8 billion particles can be released into rivers daily (Li et al., 2018)

# Atmospheric and Terrestrial

Sea spray

Rainfall

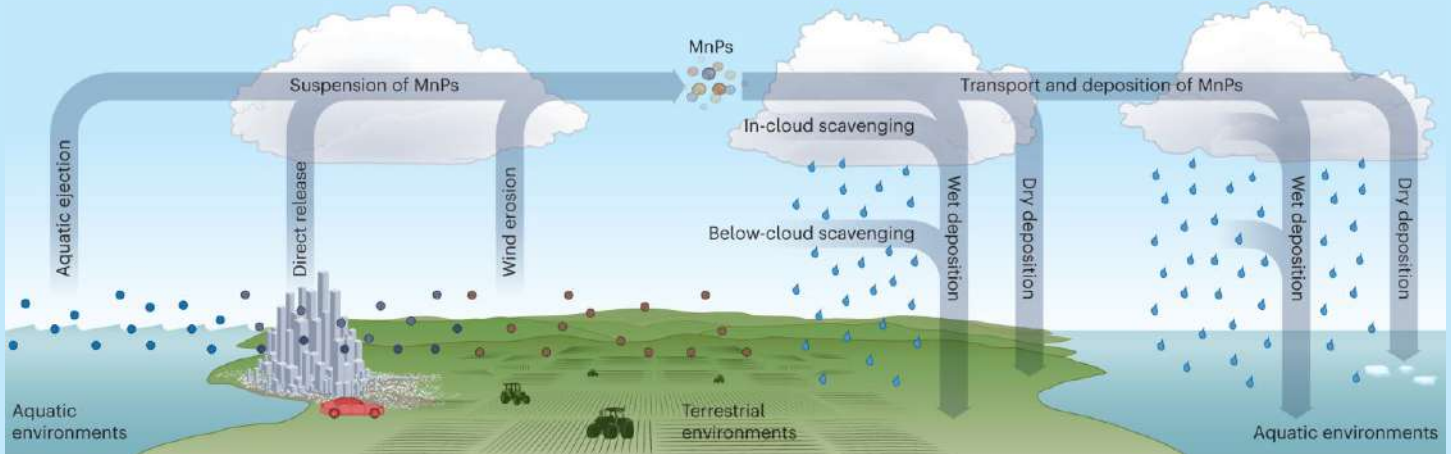
Contamination


Road dust

Migratory birds

Indoor dust

Spider web



# Atmospheric and Terrestrial

Sea spray

Contamination

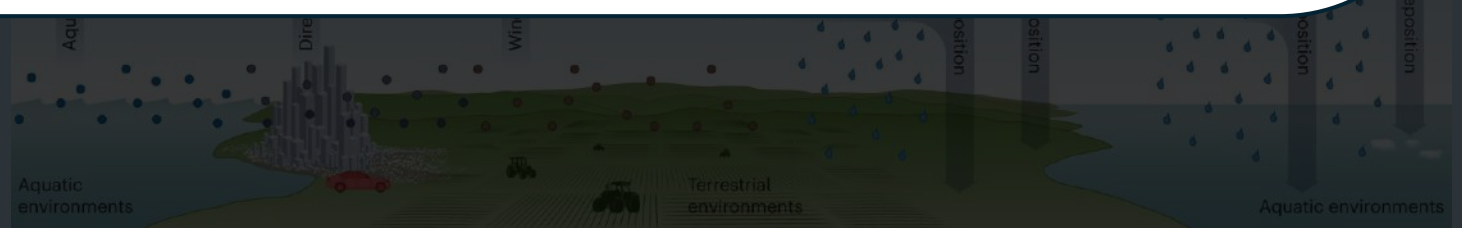
Rainfall

Road dust

Spider web

## Key point

New microplastics entering the system

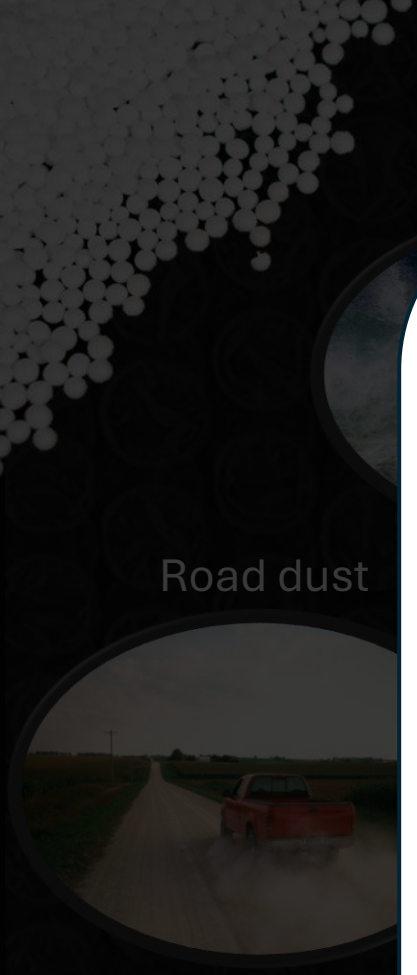


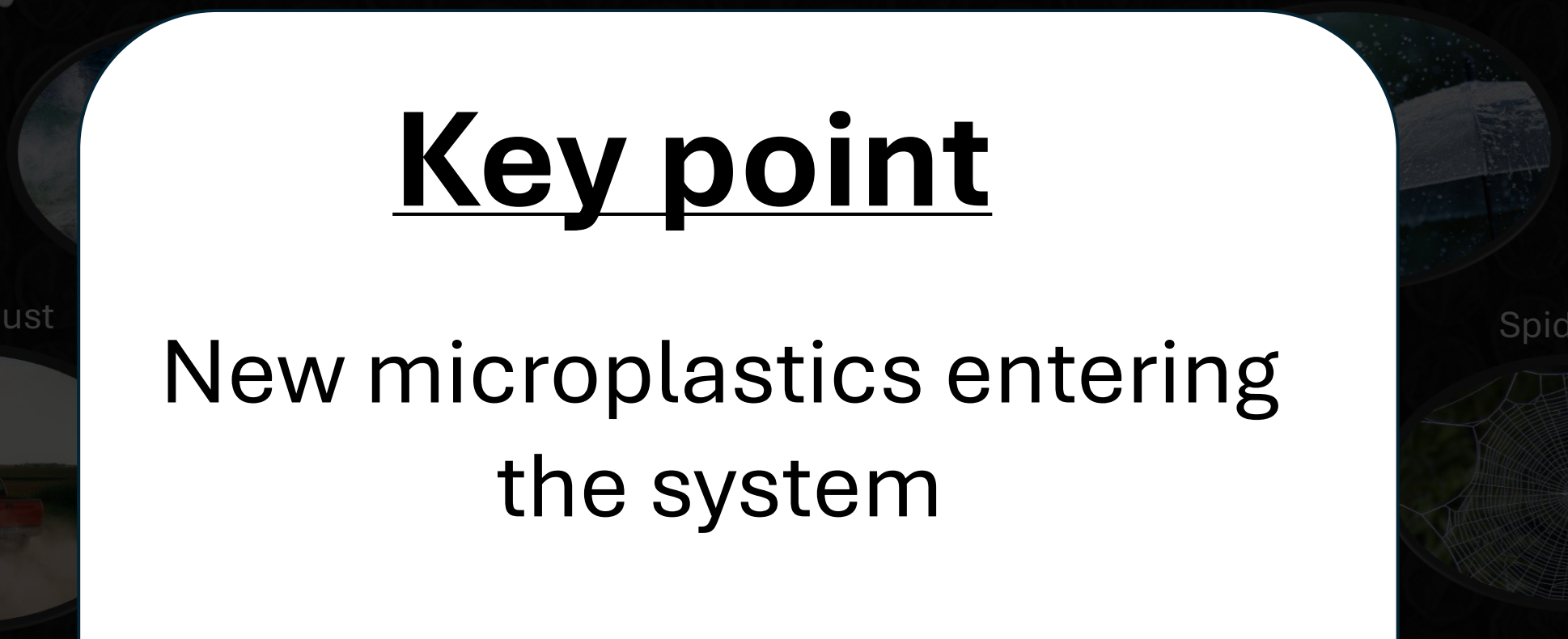
# Atmospheric and Terrestrial

Sea spray

Contamination

Rainfall





Road dust

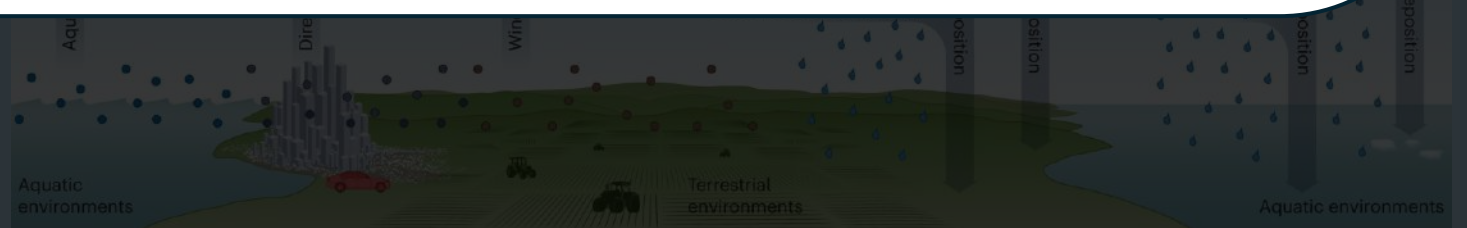


Spider web

## Key point

New microplastics entering the system

→ Once in the system, what then?

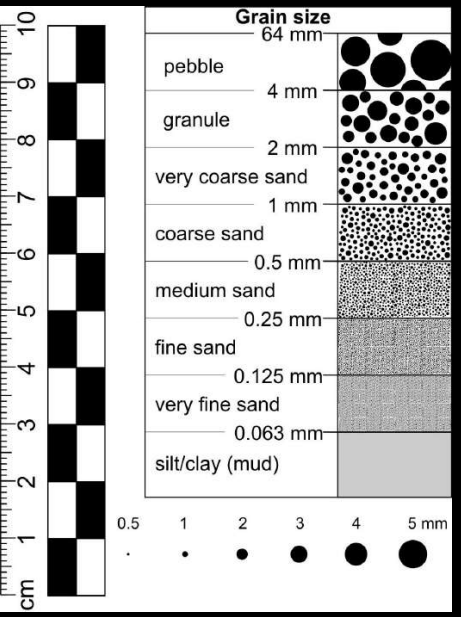


# Environmental

Water quality

Velocity

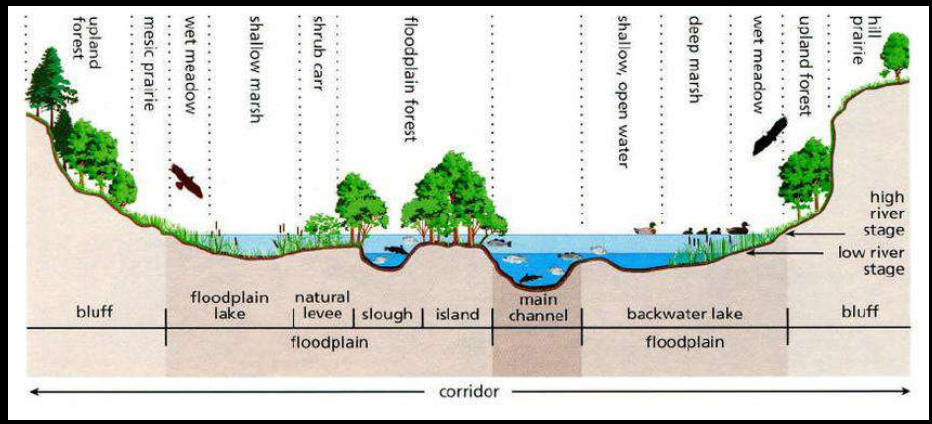
Sediment grain sizes




Organic content

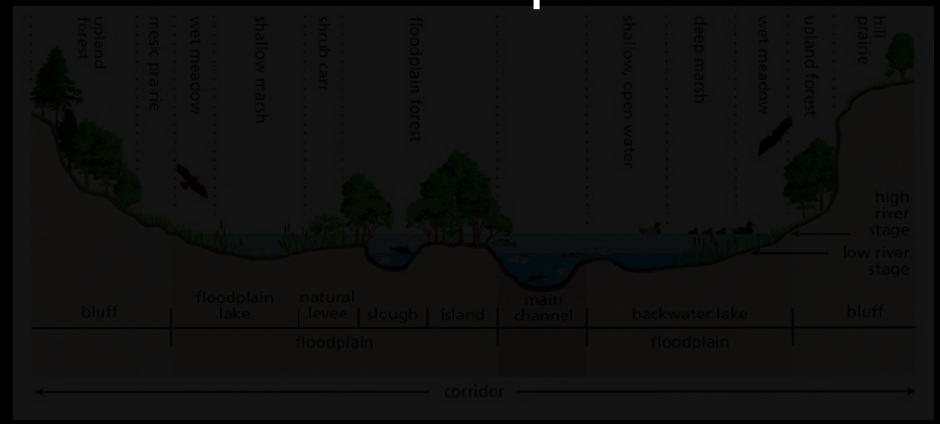
Vegetation

Depth



# Water quality

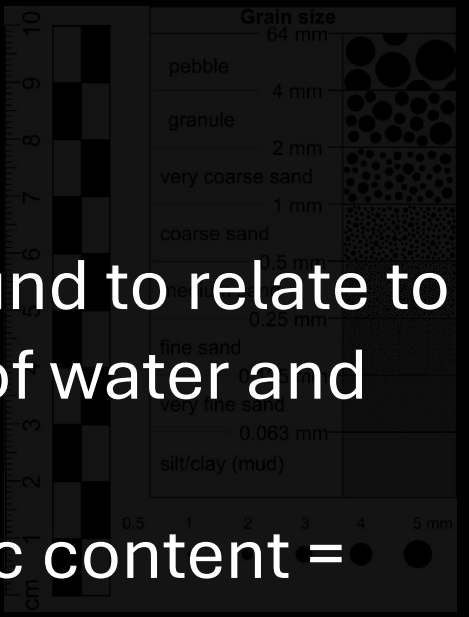
- Microplastics found to relate to water quality
- Poor water quality = higher microplastic abundances
- Possibly related to poor water/waste management
- WWTP=more microplastics

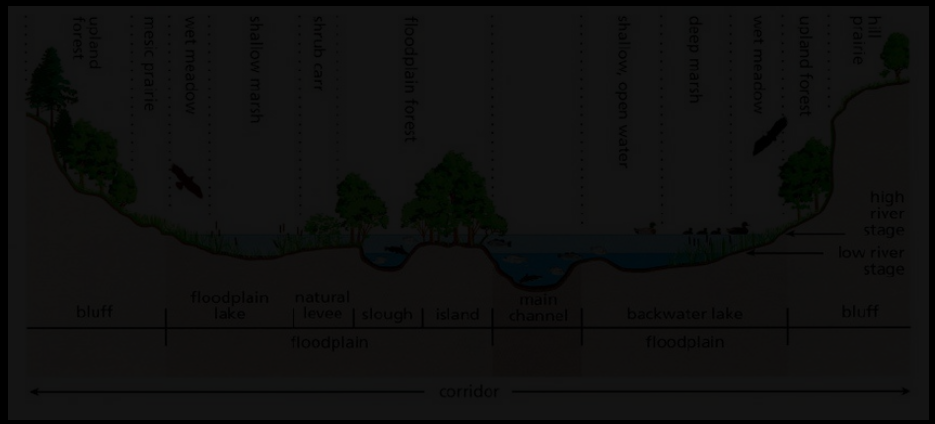



- Nel et al., 2018
- Dahms et al., 2020
- Huang et al., 2020
- Park et al., 2020
- Tien et al., 2020
- Cheng et al., 2021
- Liu et al., 2022
- Owowenu et al., 2023

# Organic content

- Microplastics found to relate to organic content of water and sediment
- Increased organic content = increased microplastics

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- Tien et al., 2020
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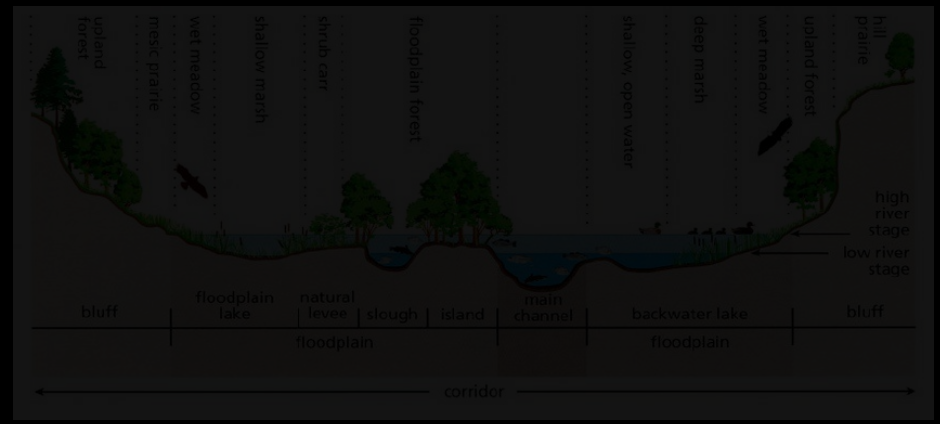
# Vegetation

- Microplastics impacted by vegetation
- Increased vegetation = increased microplastic deposition
- Plant life act as filters for microplastics in water

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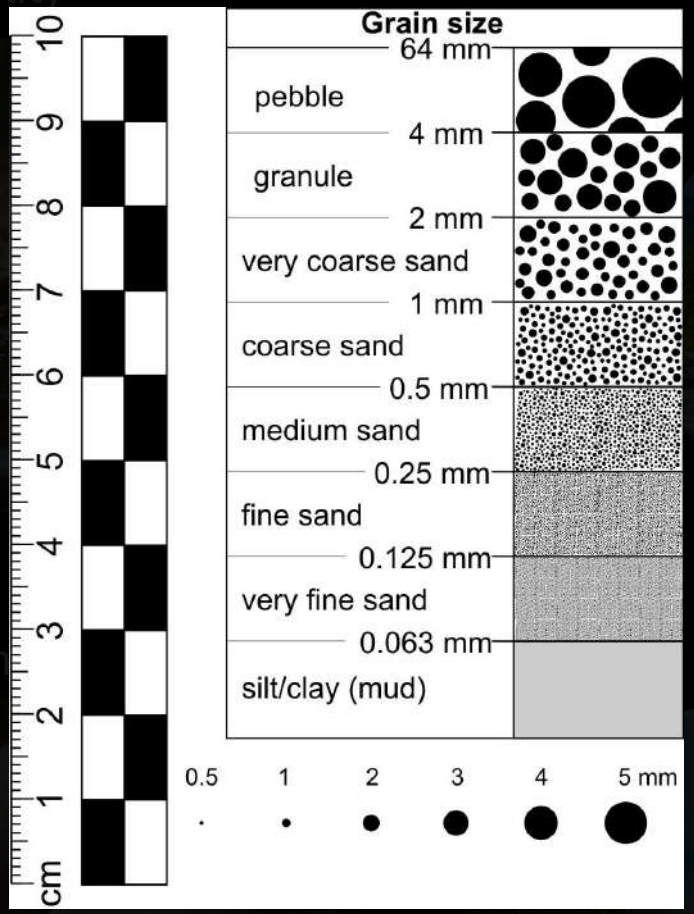
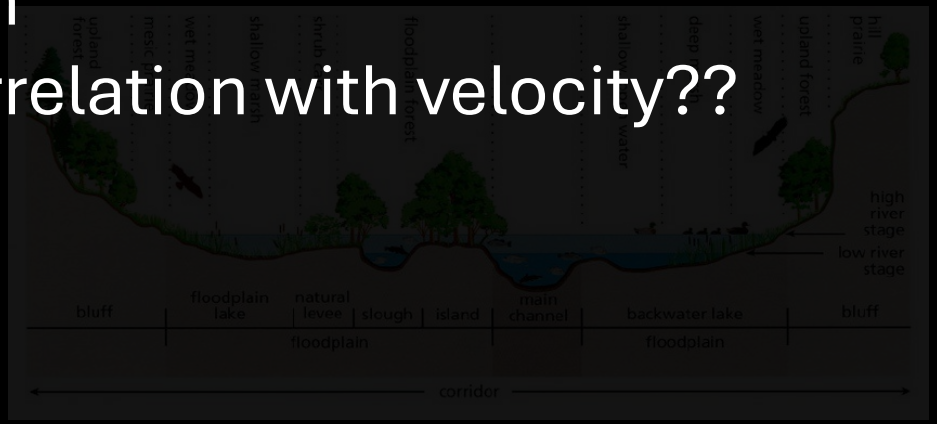
# Sediment grain sizes




- Microplastics increase in areas with finer sediment
- Increased grain sizes = reduced microplastics
- Finer sediment trapping microplastics
- Larger sediment allowing easier resuspension
- Or due to correlation with velocity??

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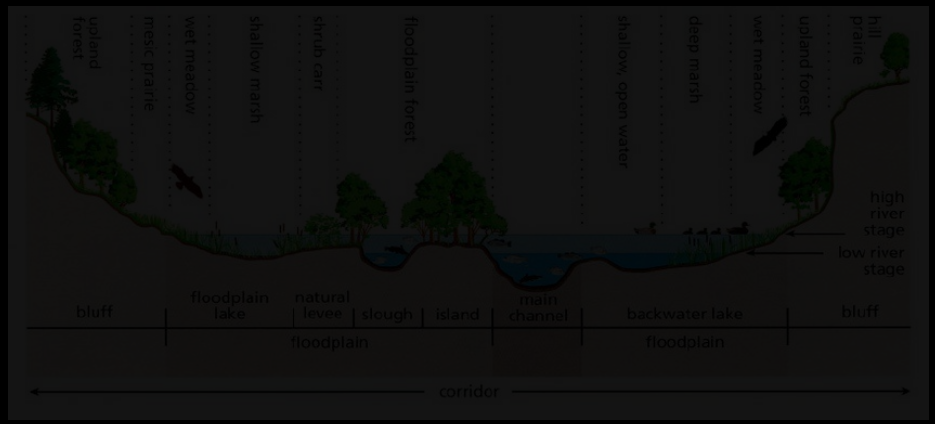
- Huang et al., 2020
- Park et al., 2020
- Tien et al., 2020
- Cheng et al., 2021
- Liu et al., 2022
- Owowenu et al., 2023

# Velocity

- Microplastics found to relate to water velocity
- Increased velocity = increased resuspension of microplastics
- Reduced velocity = increased deposition of microplastics

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- Cheng et al., 2021
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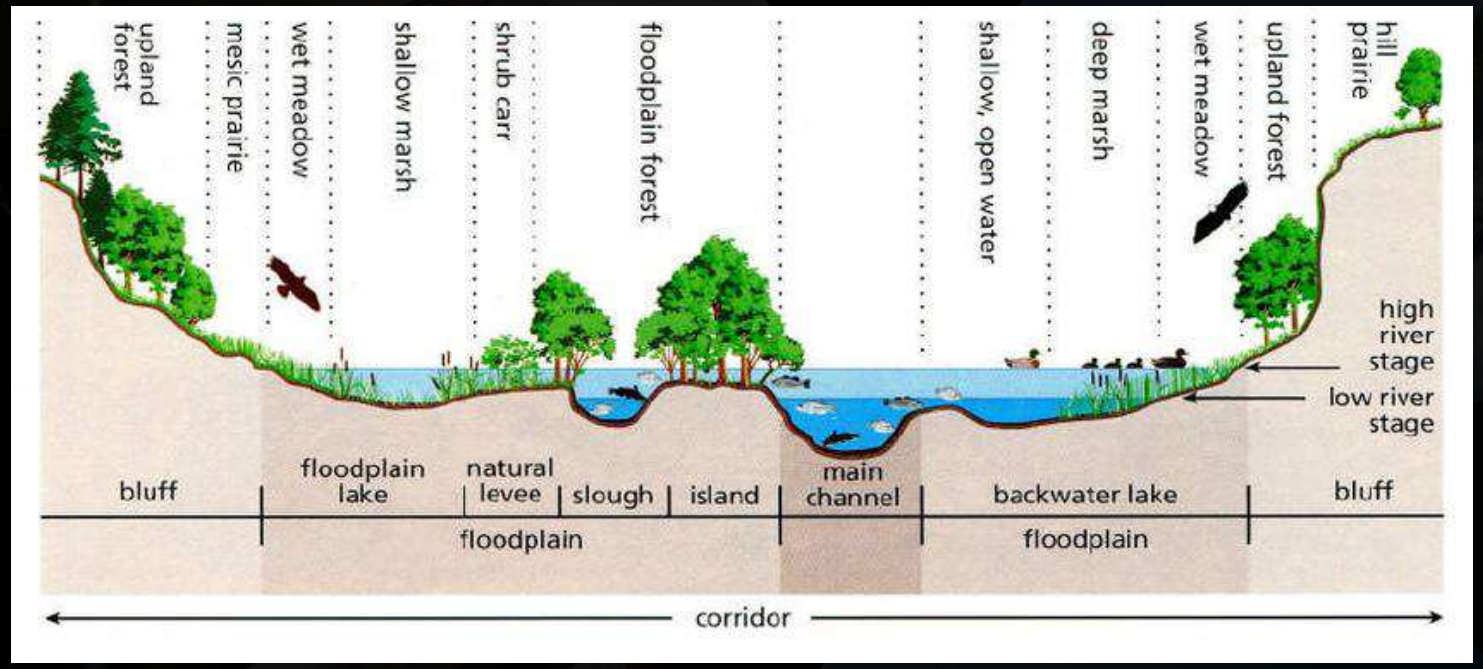
# Depth




- Increased depth = increased microplastic deposition
- Loss of velocity
- Harder to resuspend

- Nel et al., 2018
- Dahms et al., 2020
- Huang et al., 2020
- Park et al., 2020
- Tien et al., 2020
- Cheng et al., 2021
- Liu et al., 2022
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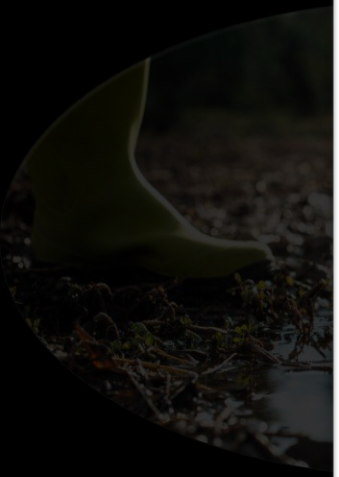
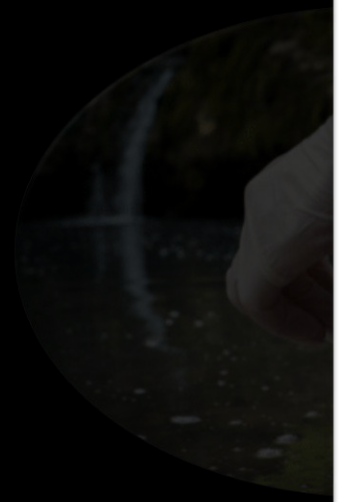
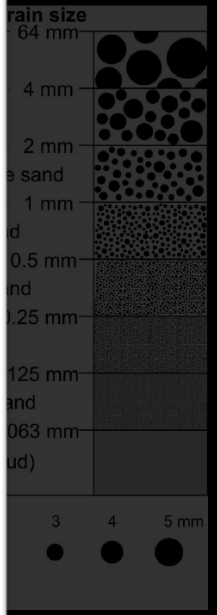
Water qu

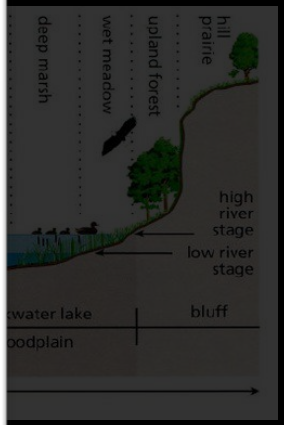


Organic c

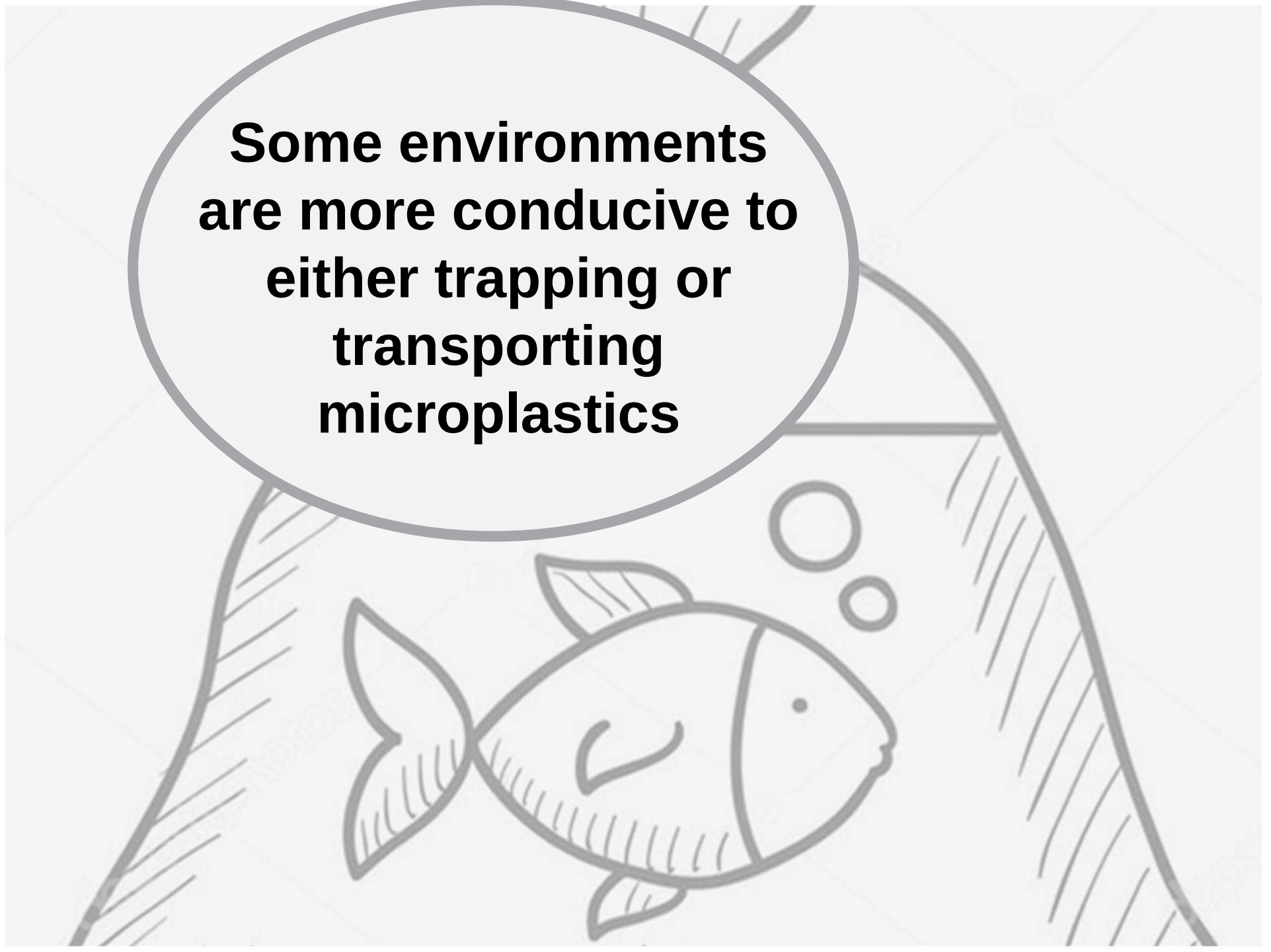


rain sizes

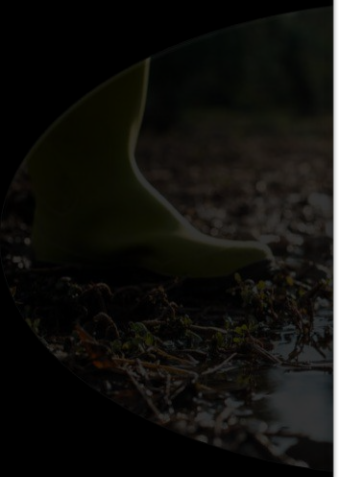


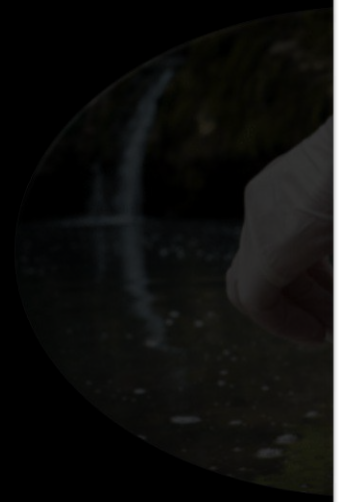

**Some environments are more conducive to either trapping or transporting microplastics**



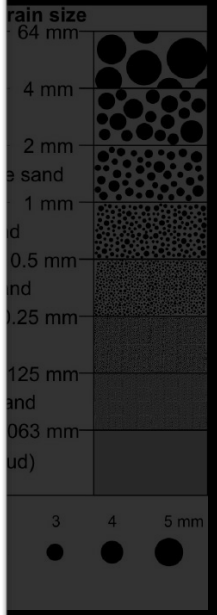
Water qu

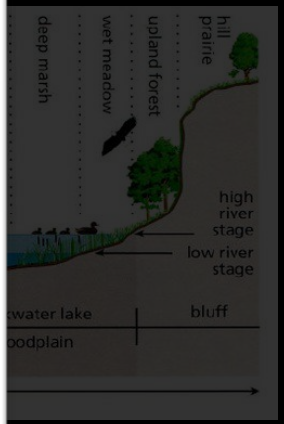


Organic c



rain sizes

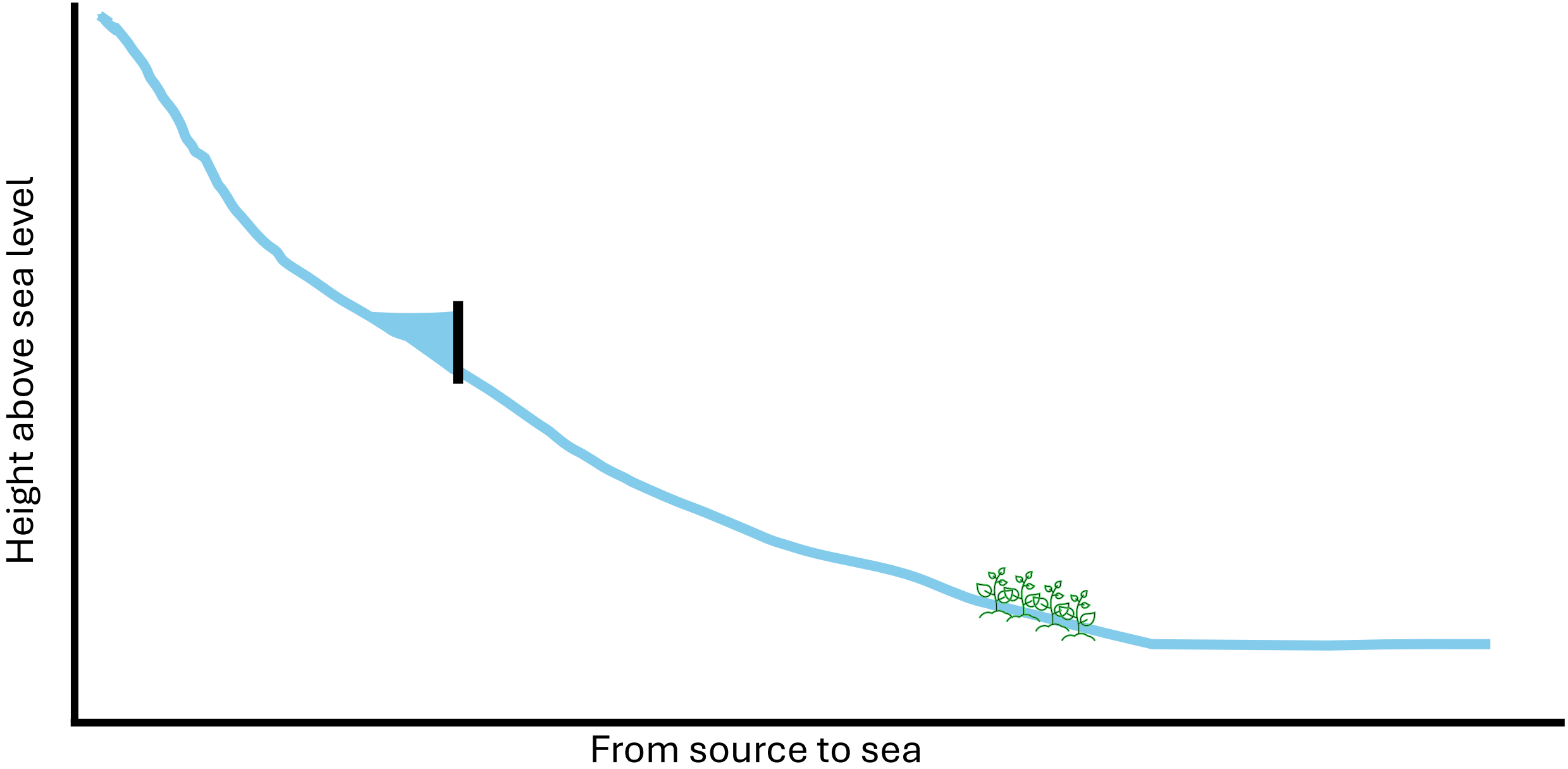


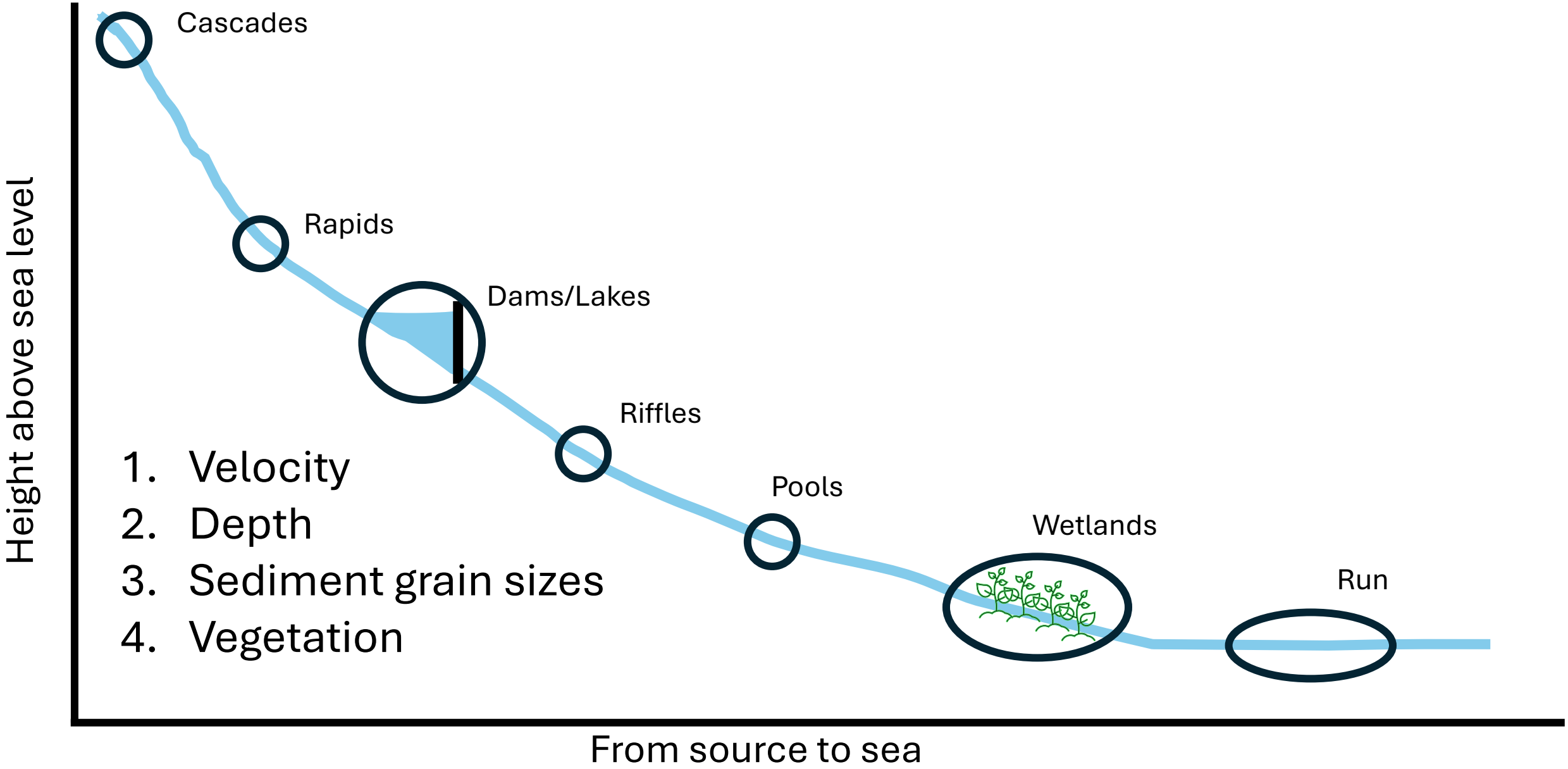

**So which environments should we look at?**

Fig 10: Rivers are exceptionally heterogenous environments

# Longitudinal profile of a river



# Longitudinal profile of a river



# Longitudinal profile of a river

Cascades

Height above sea level

1. Velocity ⬆
2. Depth ⬇
3. Sediment grain sizes ⬆
4. Vegetation ⬇

From source to sea

Dahms et al., 2020; Owowenu et al., 2023

# Longitudinal profile of a river

Rapids

Height above sea level

1. Velocity ⬆
2. Depth ⬇
3. Sediment grain sizes ⬆
4. Vegetation ⬇

From source to sea

Dahms et al., 2020; Owowenu et al., 2023

# Longitudinal profile of a river

Dams/Lakes

Height above sea level

1. Velocity ⬇
2. Depth ⬆
3. Sediment grain sizes ⬇
4. Vegetation ⬆

From source to sea

Watkins et al., 2019; Weideman et al., 2019; 2020; Dahms et al., 2022

# Longitudinal profile of a river

Dams/Lakes

Height above sea level

1. Velocity ⬆
2. Depth ⬇
3. Sediment grain sizes ⬆
4. Vegetation ⬇

From source to sea

Dahms et al., 2020; Owowenu et al., 2023

# Longitudinal profile of a river

Riffles

Height above sea level

1. Velocity ⬆
2. Depth ⬇
3. Sediment grain sizes ⬆
4. Vegetation ⬇

From source to sea

Dahms et al., 2020; Owowenu et al., 2023

# Longitudinal profile of a river

Pools

Height above sea level

1. Velocity ⬇
2. Depth ⬆
3. Sediment grain sizes ⬇
4. Vegetation ⬆

From source to sea

Watkins et al., 2019; Weideman et al., 2019; 2020; Dahms et al., 2020; 2022

# Longitudinal profile of a river

Wetlands

Height above sea level

1. Velocity ⬇
2. Depth ⬆
3. Sediment grain sizes ⬇
4. Vegetation ⬆

From source to sea

Liu et al., 2022; Owowenu et al., 2023; Dahms et al., 2024

# Longitudinal profile of a river

Run

Height above sea level

1. Velocity ⬇
2. Depth ⬆
3. Sediment grain sizes ⬇
4. Vegetation ⬆

From source to sea

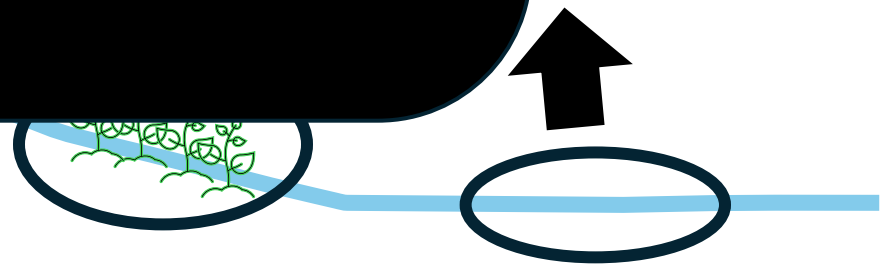
Weideman et al., 2019; 2020; Dahms et al., 2020; 2022

# Longitudinal profile of a river

Seasonality!
A season to deposit and a season to resuspend

Height above sea level

1. V
2. D
3. Sed
4. Vegetation ⬆



From source to sea

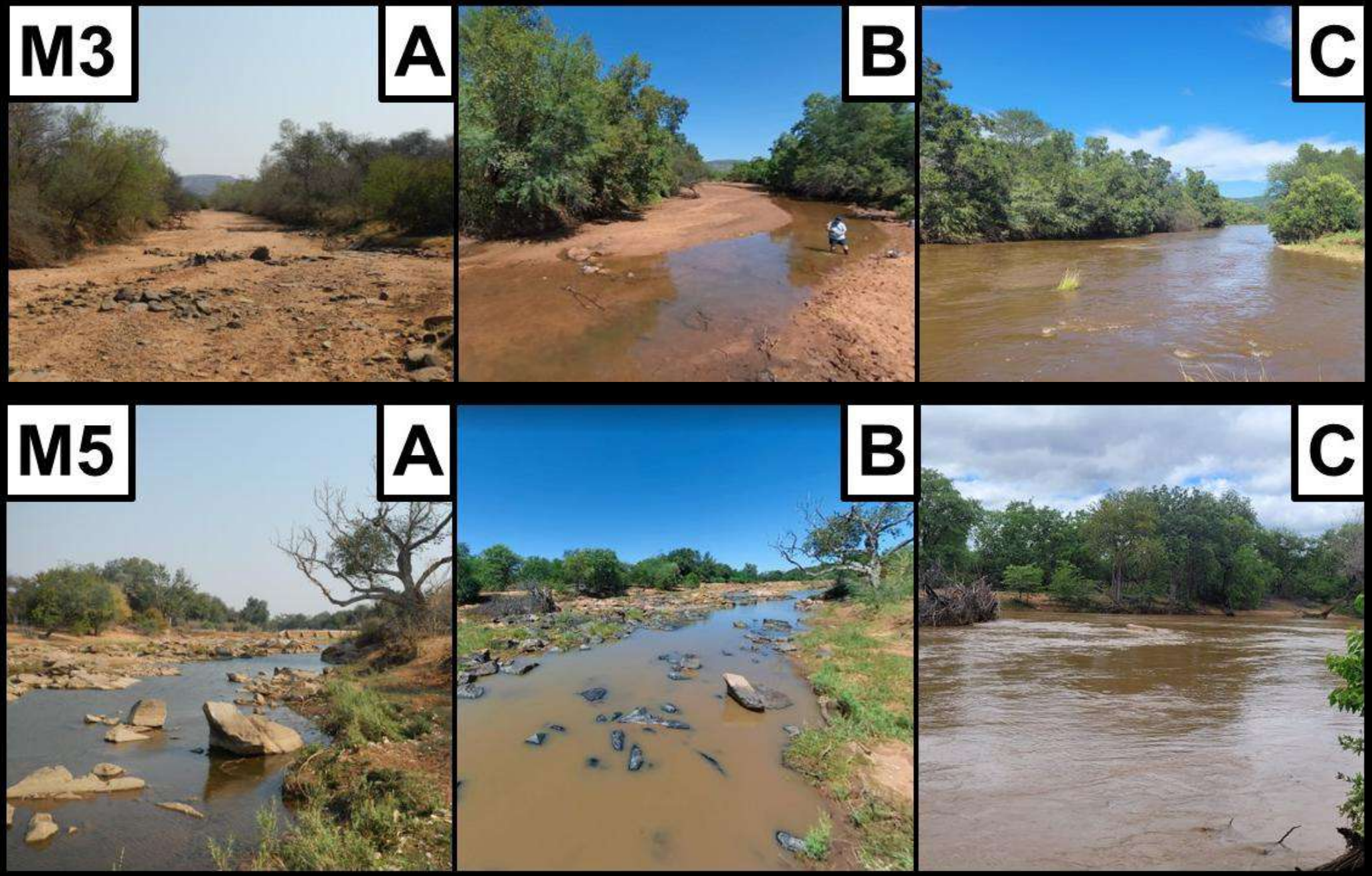



Fig 11: Some rivers can have extreme seasonal differences

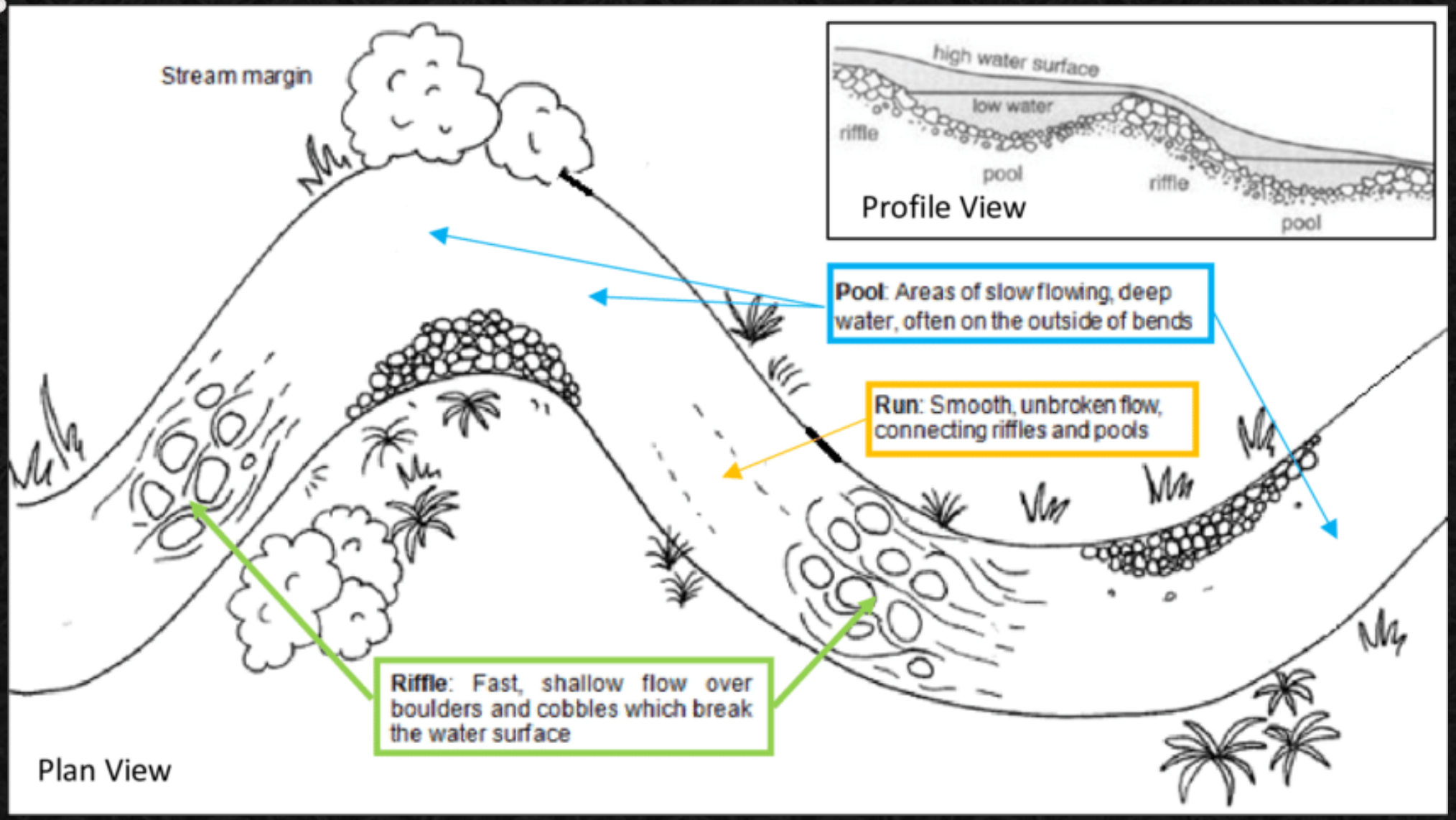



Fig 12: Schematic representation of a river consisting of multiple different river habitats

# Selected site with river habitats

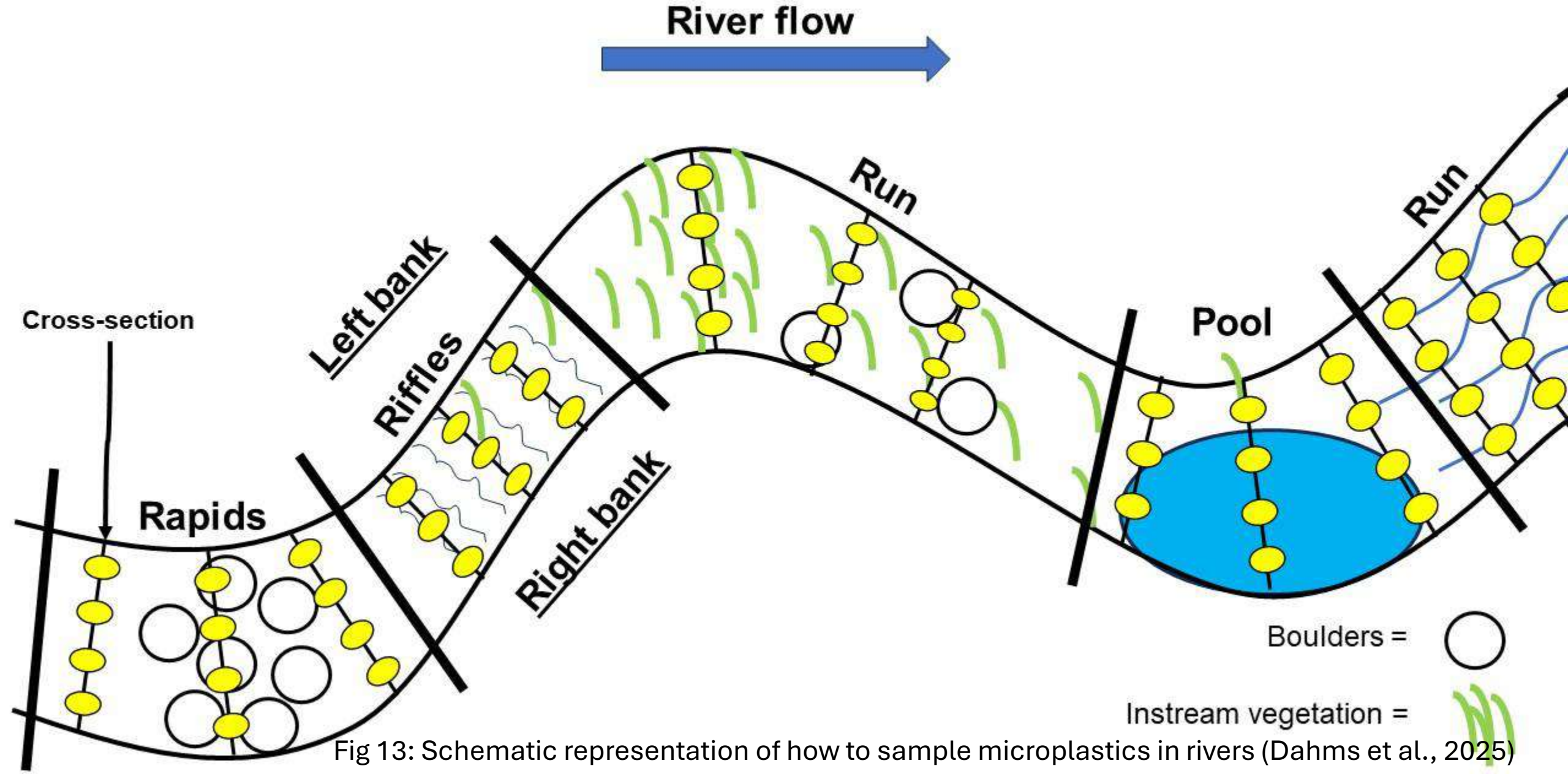



Fig 13: Schematic representation of how to sample microplastics in rivers (Dahms et al., 2025)

# Selected site with river habitats

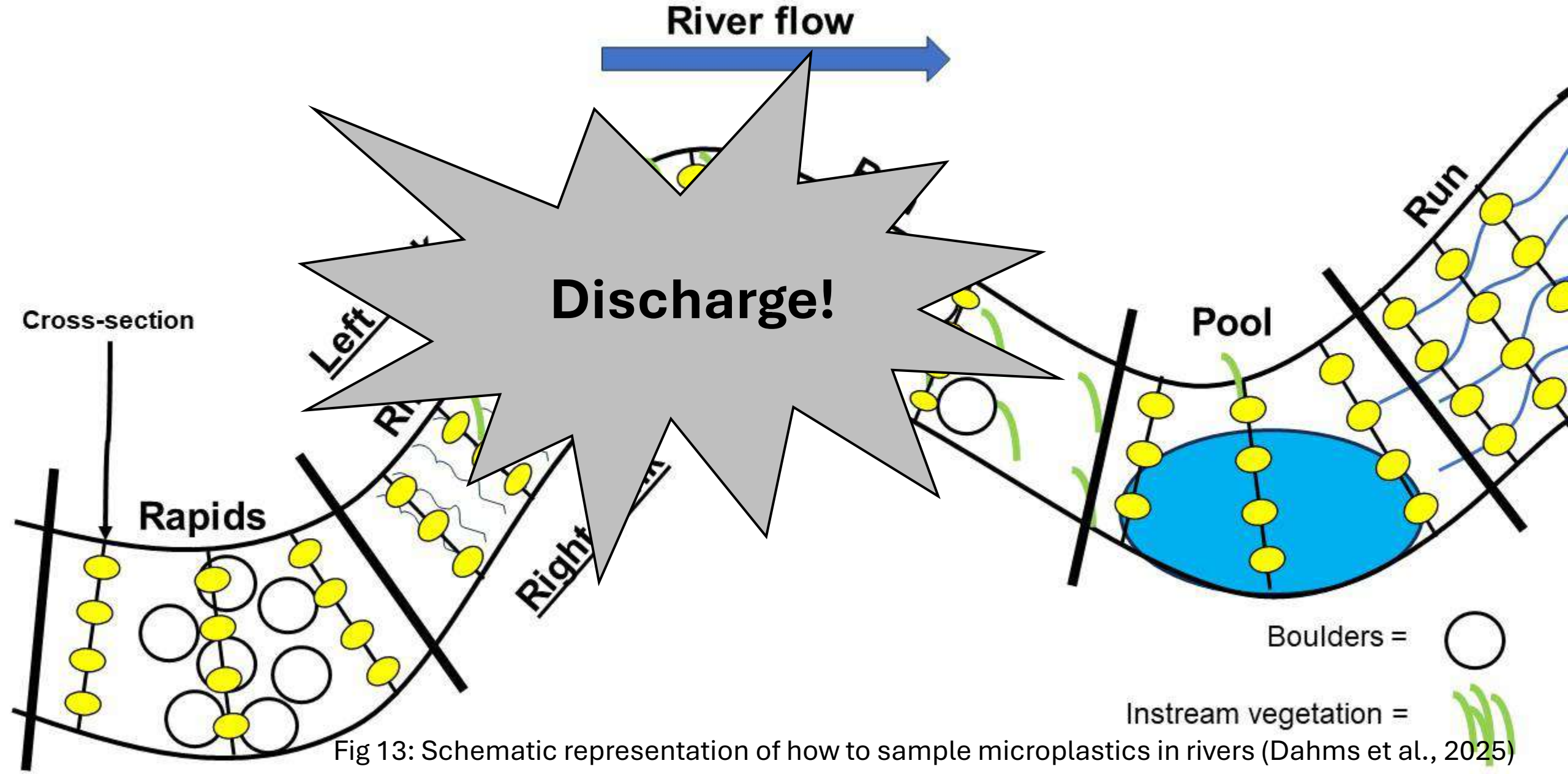
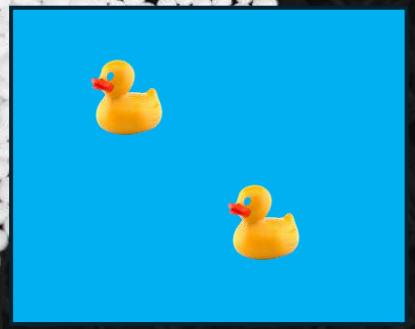



Fig 13: Schematic representation of how to sample microplastics in rivers (Dahms et al., 2025)

## Site 1



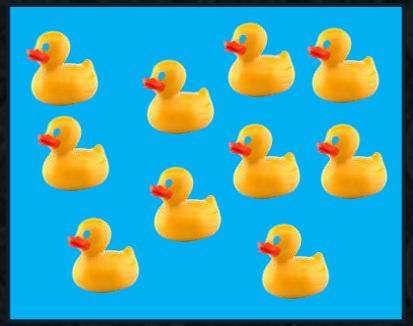
= 1 $m^{-3}$ of water

= 2 particles.$m^{-3}$

Discharge = 5 $m^{-3}.s^{-1}$

MDU= 10 particles. $s^{-1}$

## Site 2



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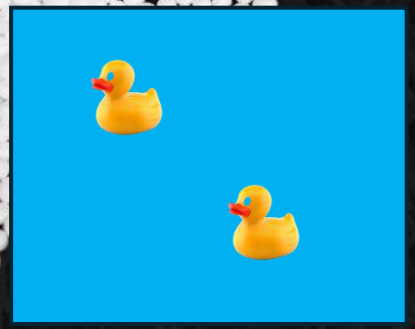

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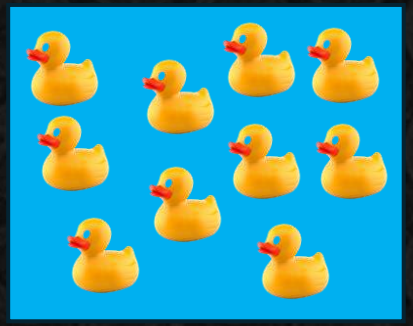
## Site 2



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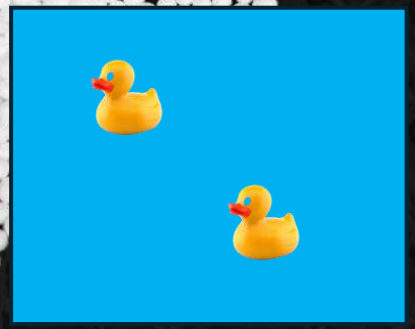

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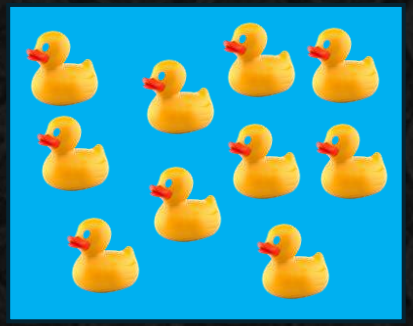

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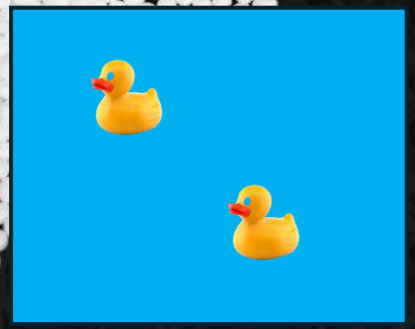

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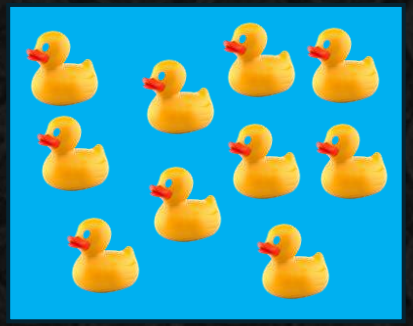

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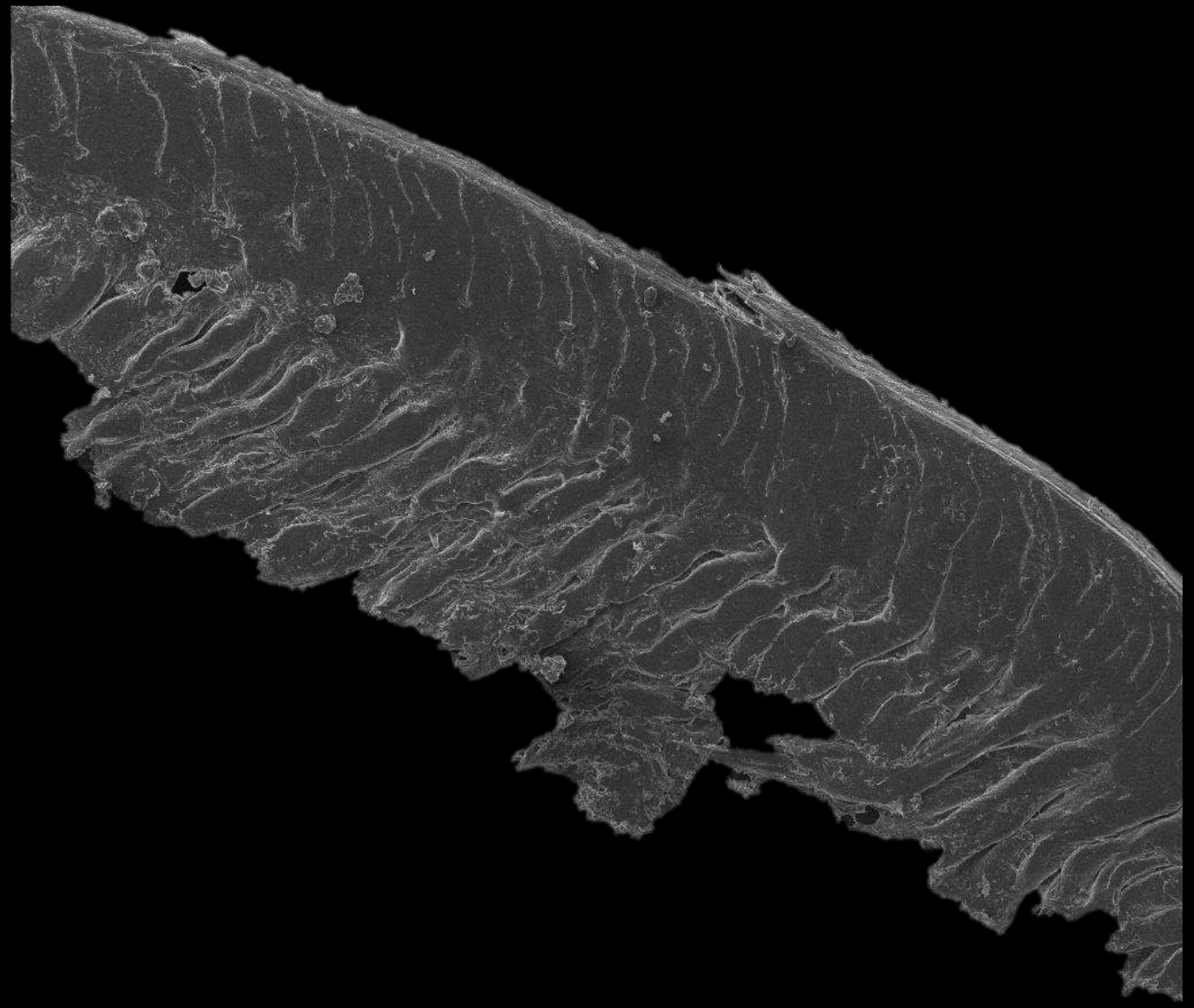



**Fig 14: Scanning Electron Microscopy photomicrograph of microplastic particle**

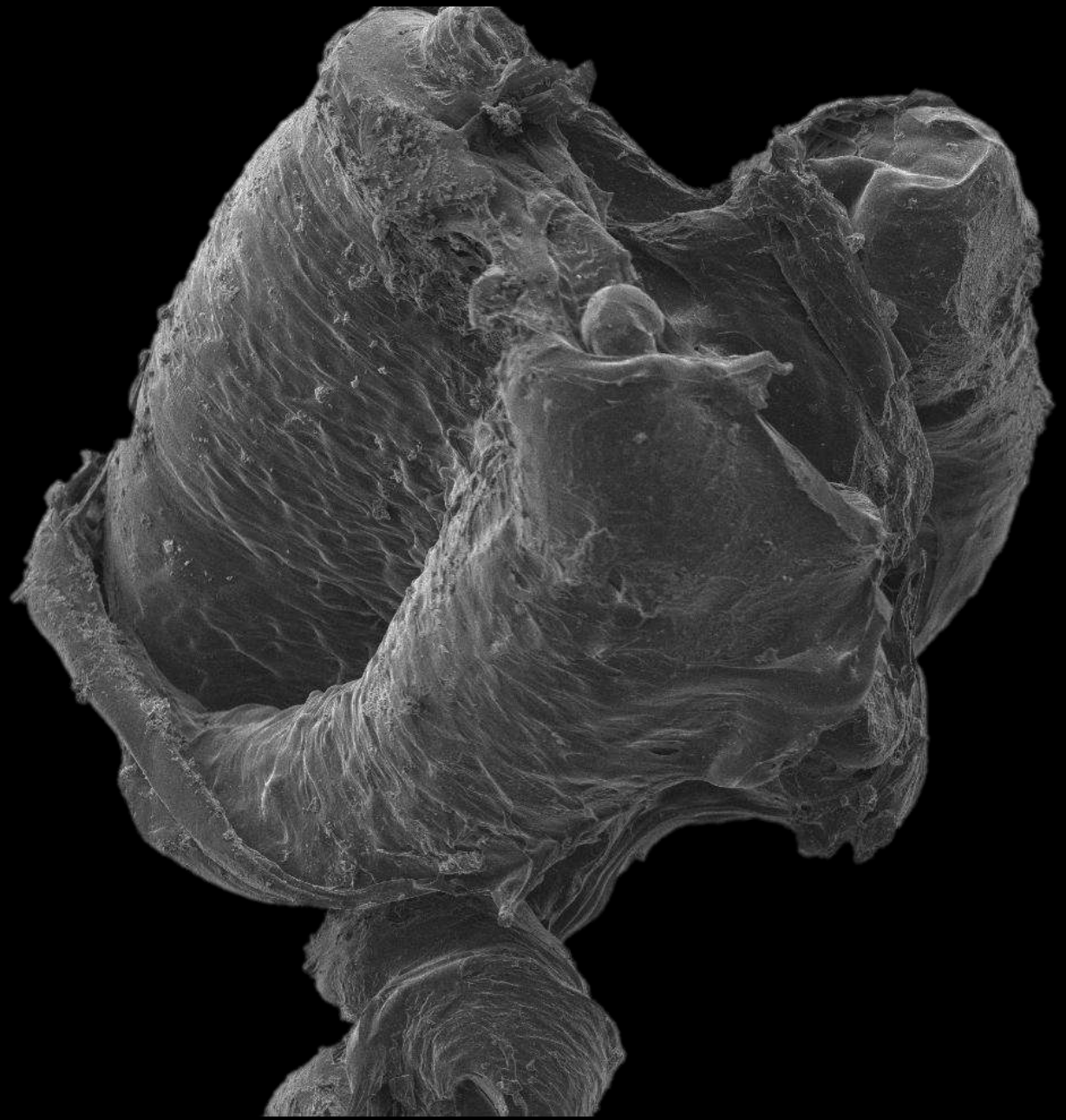



**Fig 15: Scanning Electron Microscopy photomicrograph of microplastic particle**

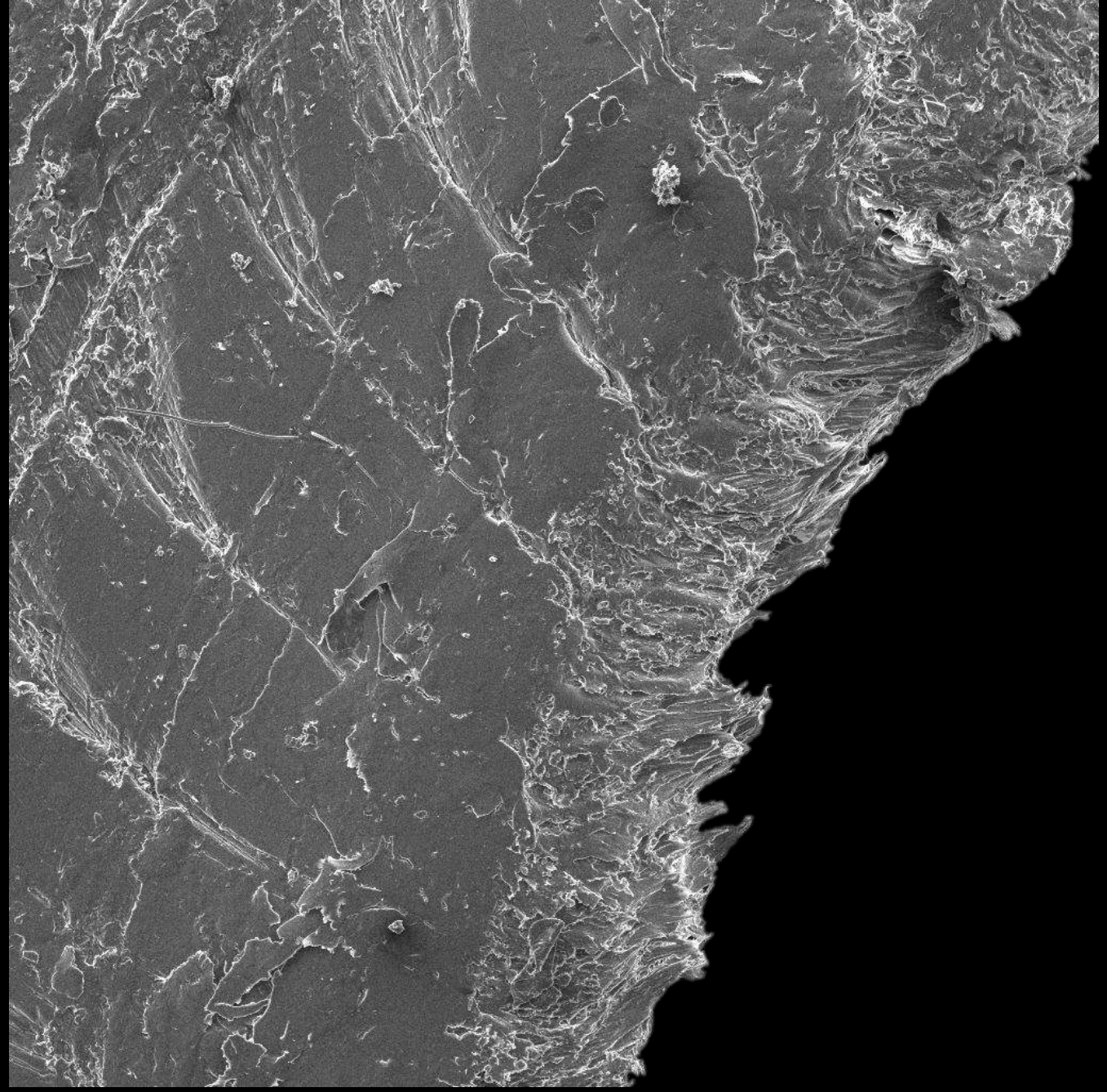



**Fig 16: Scanning Electron Microscopy photomicrograph of microplastic particle**

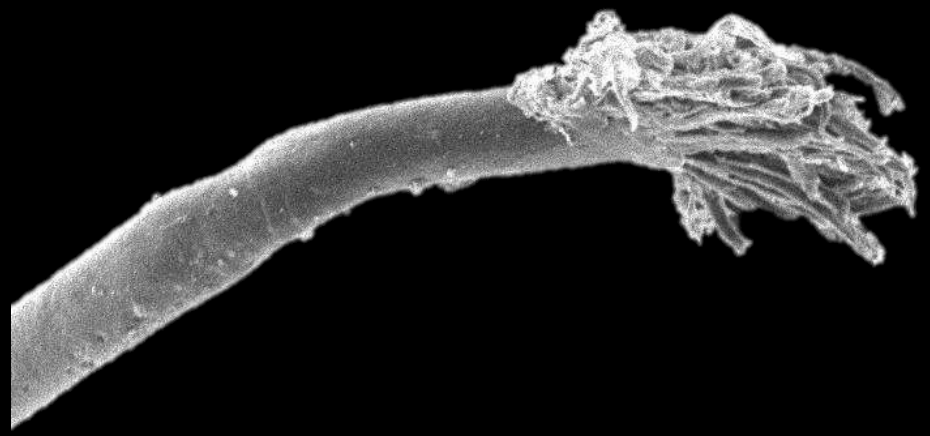
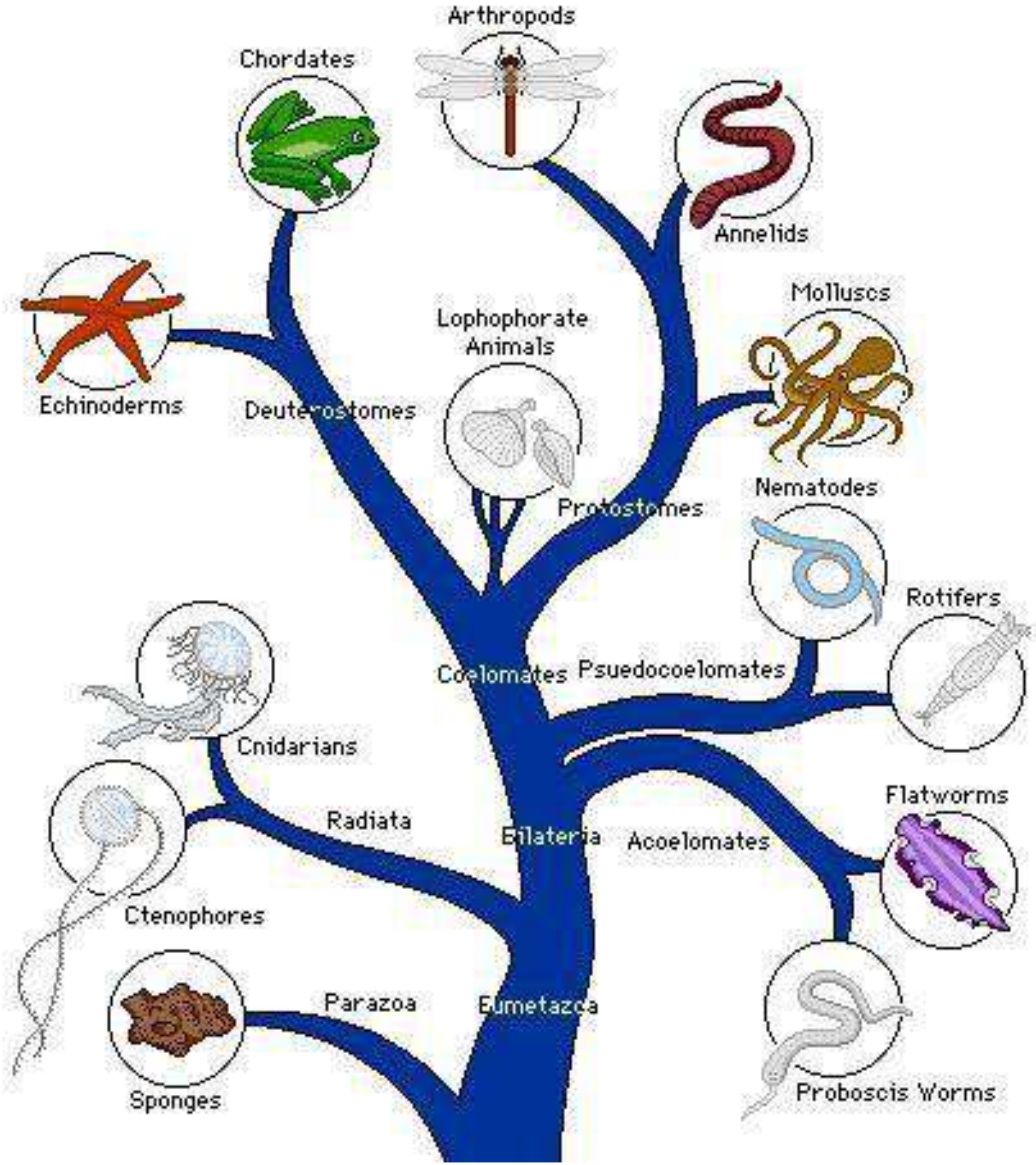


Fig 17: Scanning Electron Microscopy photomicrograph of microplastic particle

# The animal kingdom



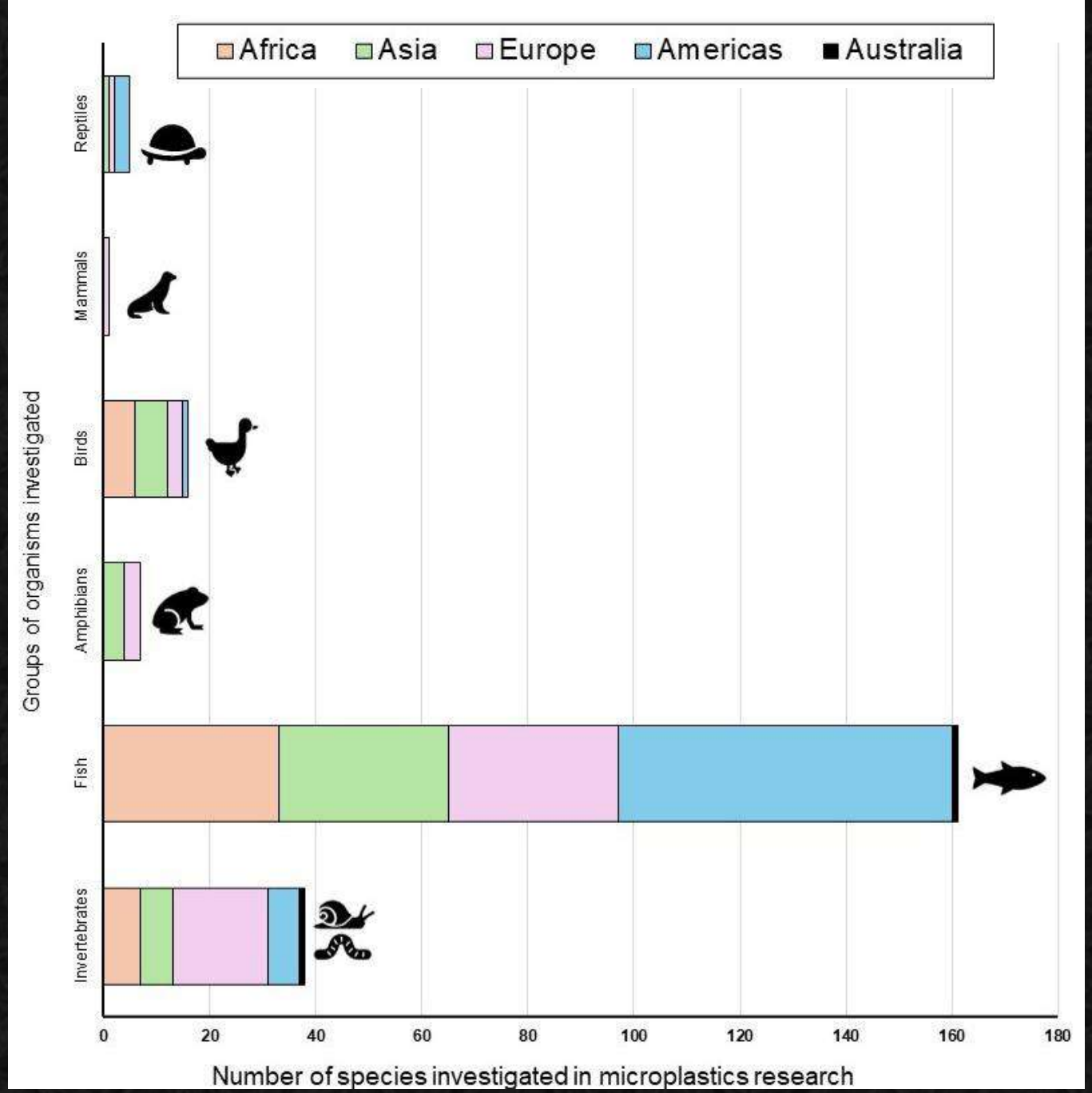



Fig 18: Literature review of number of freshwater species investigated and found to have ingested microplastics

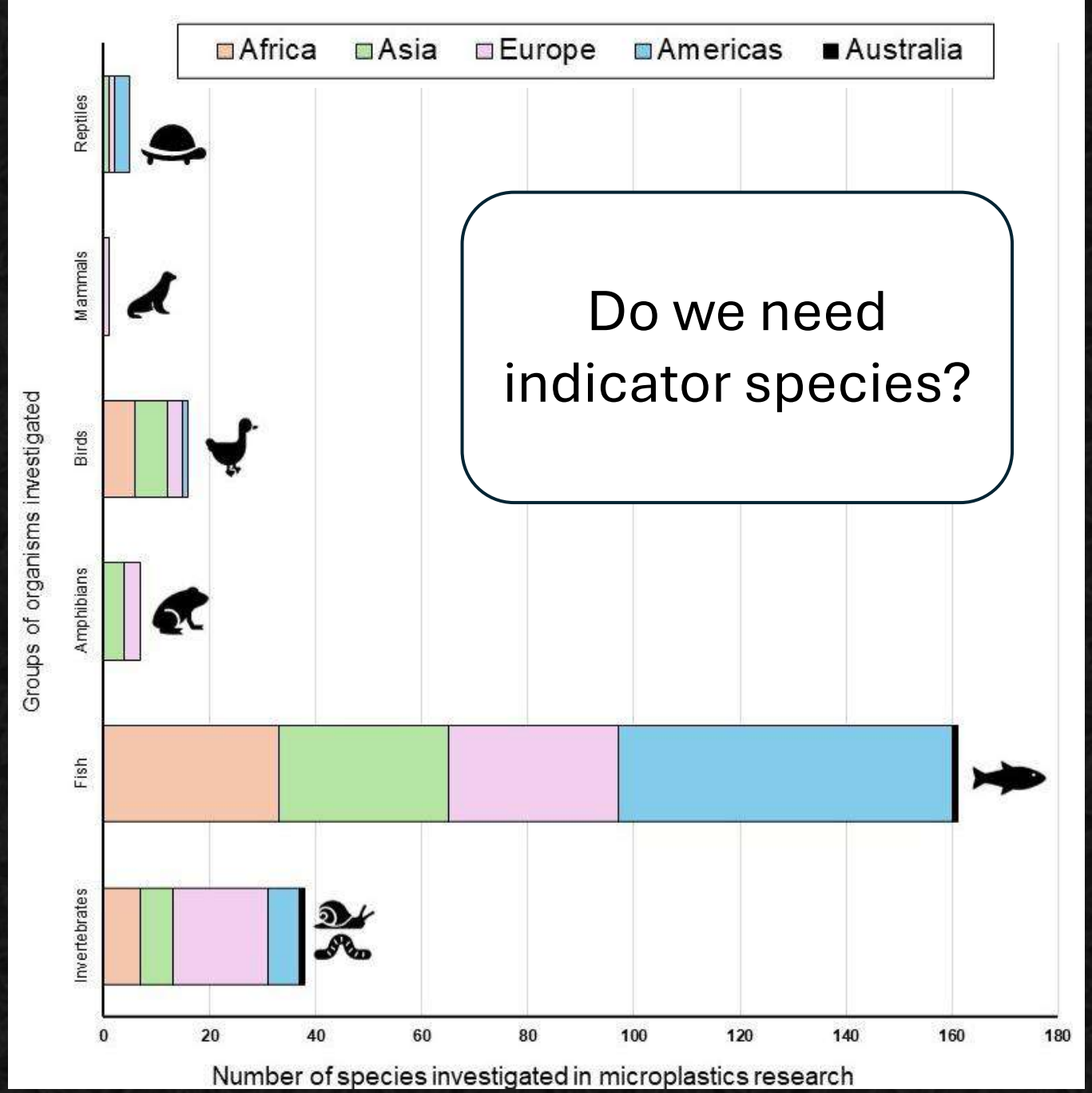


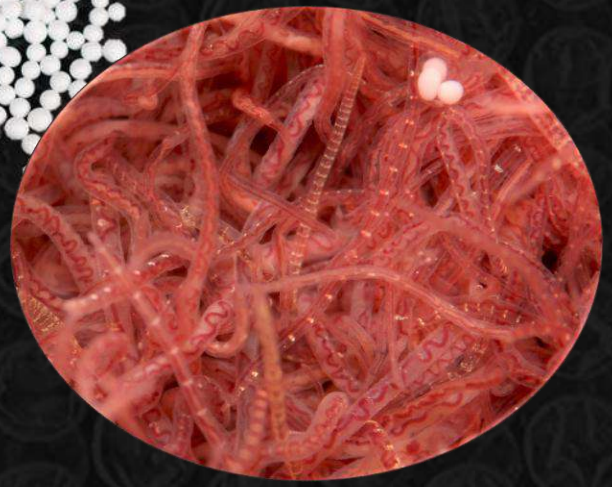

Fig 18: Literature review of number of freshwater species investigated and found to have ingested microplastics

## *Cyprinus carpio*

- Omnivorous species
- 7 different studies
- 0.4 to 48 particles per fish
- Africa, Asia, Americas
- Is present in Europe
- Vacuums riverbed
- Invasive

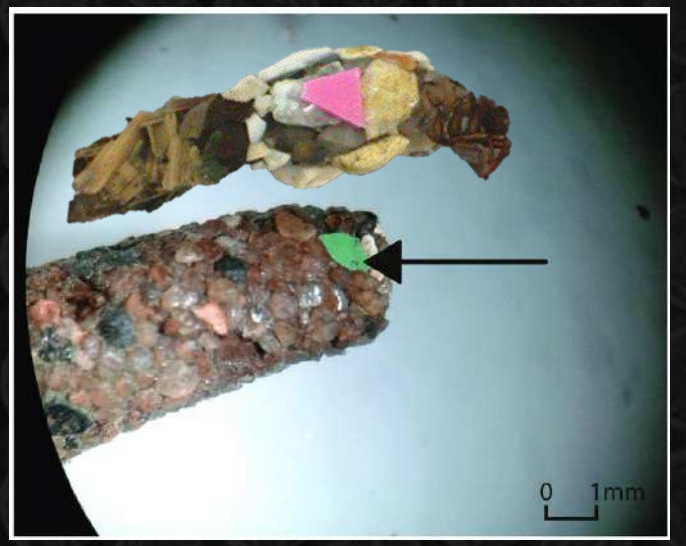
- Omnivorous species
- 6 different studies
- 1 to 58 particles per fish
- Only Asia and Africa
- Can be found in Americas
- Warmer environments
- Invasive

## *Oreochromis niloticus*



- 129 ± 65.4 particles per gram
- Detritivore
- Discussed as possible bioindicator

*Tubifex* sp.




- Known to break plastic down for shells
- Ingestion of plastic
- 0.62 particles per individual

Trichoptera

- 3+ studies
- 53 to 291 particles per g
- Wide distribution
- Relatable to sediment microplastic levels

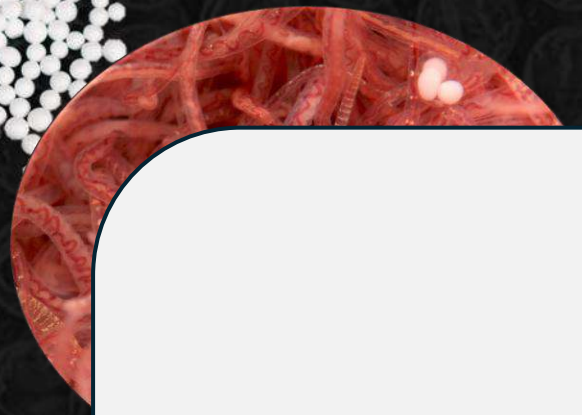
Chironomidae

- Long term bioindicator (including other bivales)
- Filter feeding
- Possible ingestion from water and sediment
- Universal distribution?
- Human impact?

*Corbicula fluminea*

- 0.74 particles per individual
- Shorter lifespan = more time accurate measurement
- Easier to sample large quantities
- Polluted systems?

Ephemeroptera



- 129 ± 65.4 particles per gram

- Known to break plastic down for shells
- gestion of plastic
- ? particles per
- vidual

# More research specifically aimed at bioindicators needed

- particles per
- idual
- ter lifespan =
- e time accurate
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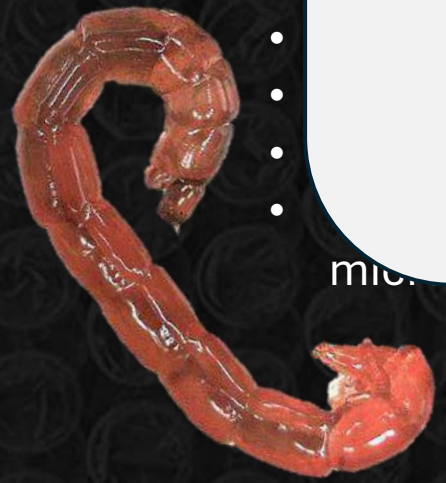
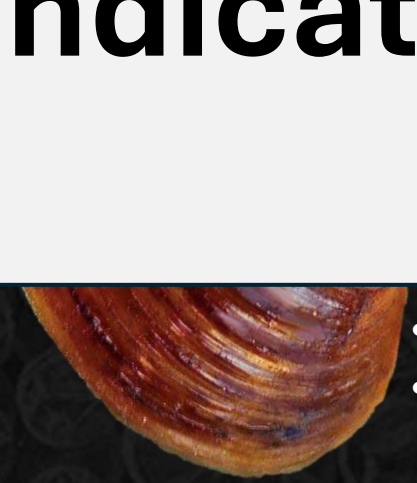
- Easier to sample large quantities
- Polluted systems?



Chironomidae



- Universal distribution?
- Human impact?

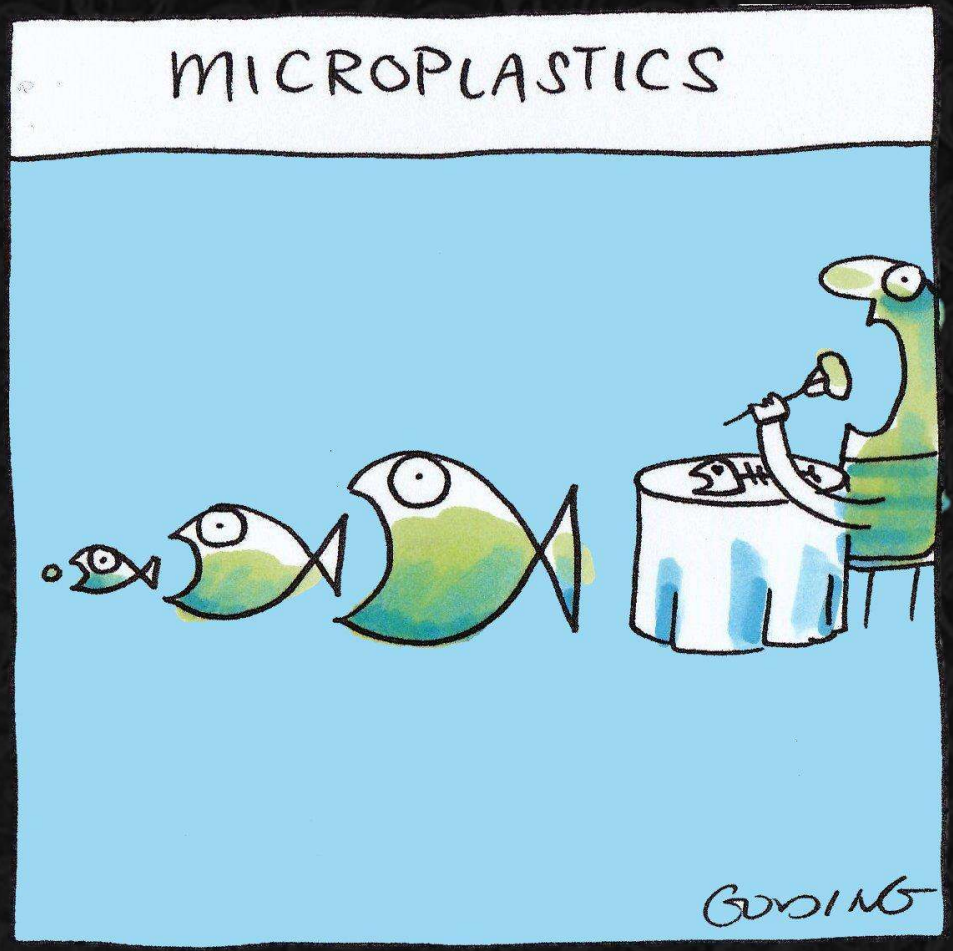
*Corbicula fluminea*

Ephemeroptera

# Conclusion

- Microplastics could have been in the environment for  over 100 years
- Microplastics are physical particles and distribute dependent on the environment
- This needs to be considered when sampling occurs
- Fish remain the most investigated group of animals
- A bioindicator species would close the gap between studies

# Thank you!



For the list of references, please contact the presenter

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