Workshop “Micro- and nanoplastic in the environment”
PlasticFree EFRE-1018 Bolzano/Bozen - 17th October 2024

Comprehensive multi-level analysis of plastic pollution impacts in freshwater ecosystems

Giulia Cesarini[1,2]

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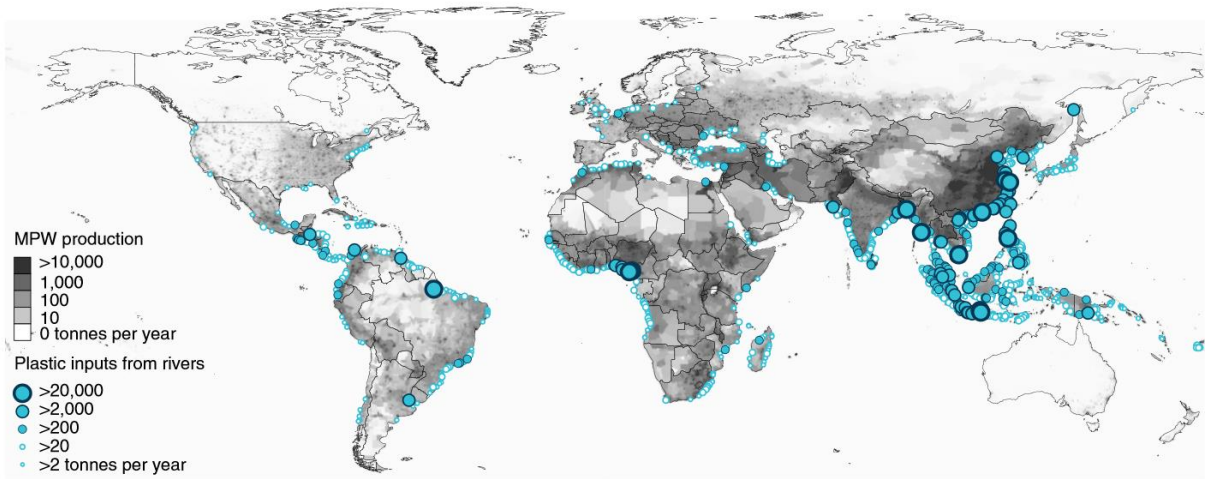
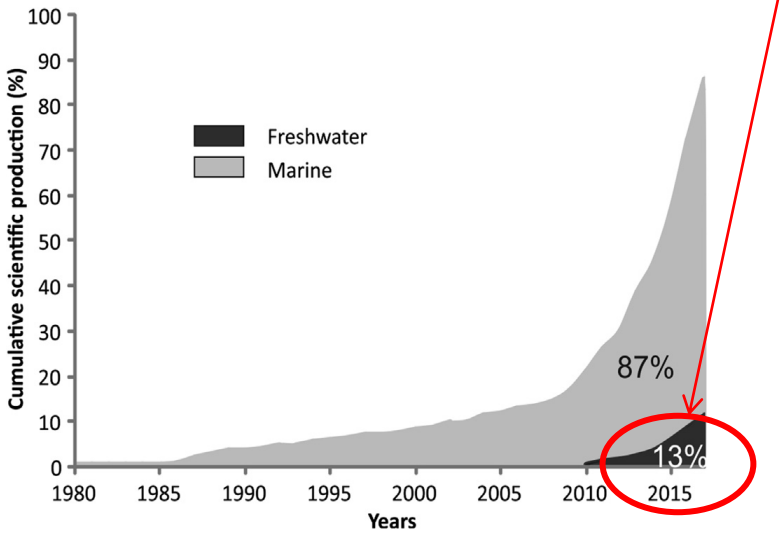
(2) Department of Sciences, University of Roma Tre, Viale G. Marconi 446, 00146 Rome, Italy

Why study plastic pollution in freshwaters?

Global river networks are responsible for transferring **1.15-2.41 MT** of plastic pollution to marine environments every year.

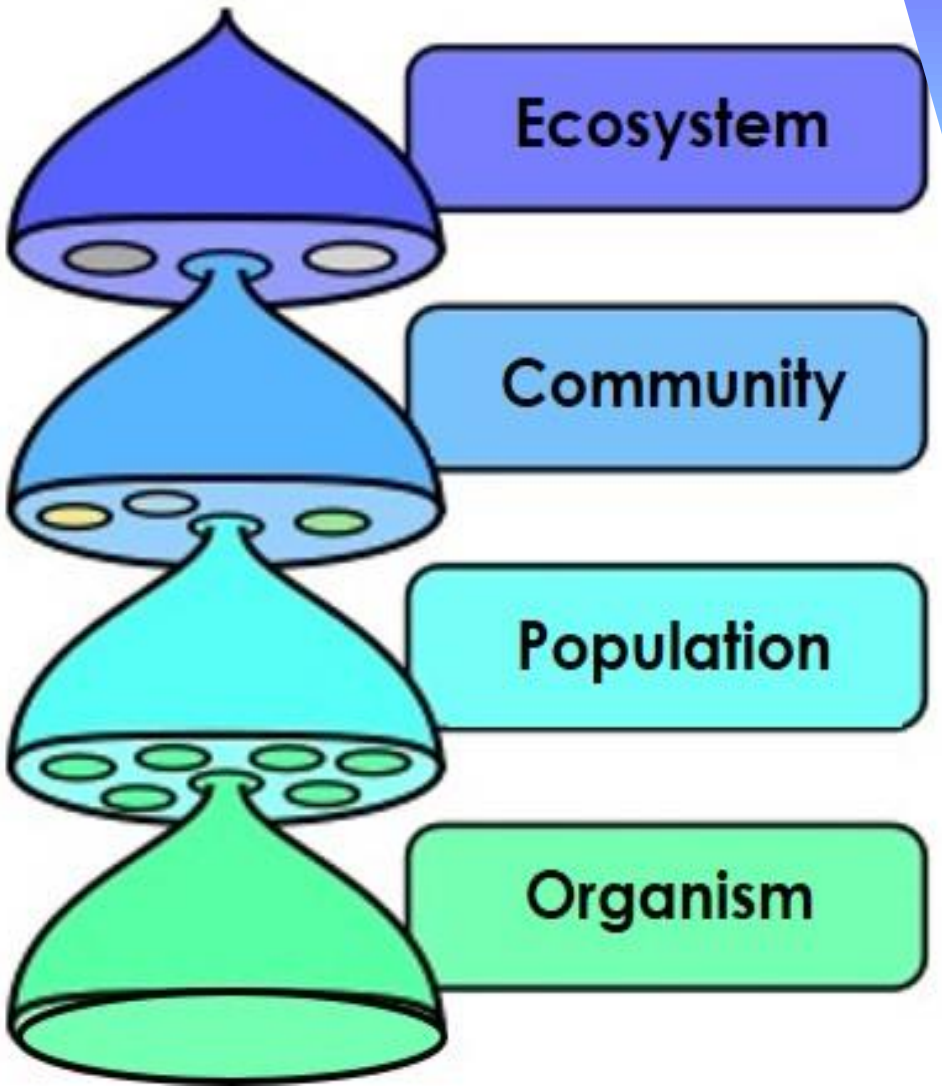


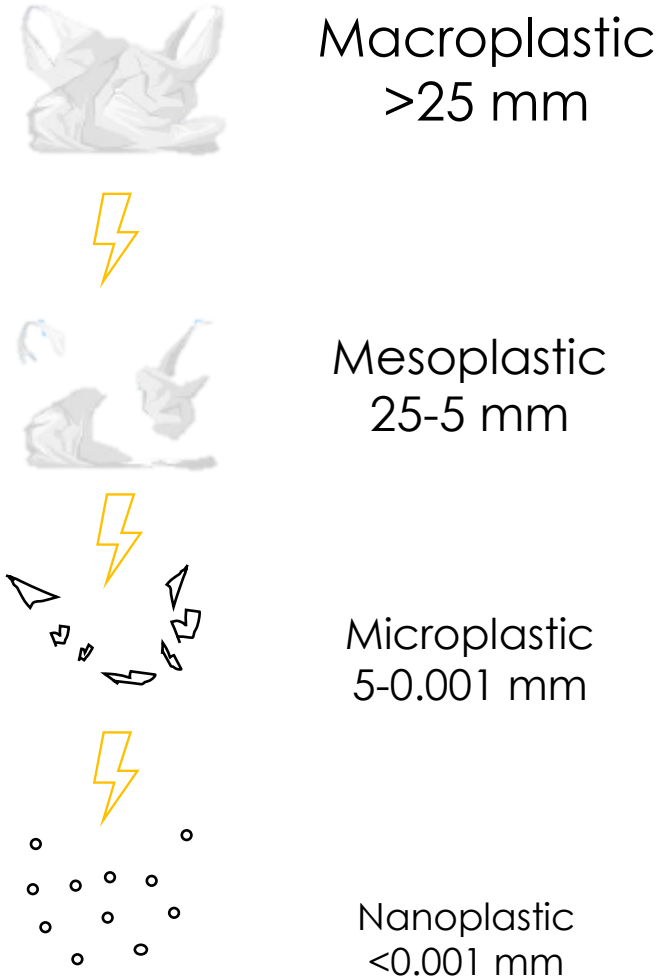
13% OF PUBLICATIONS WERE ON FRESHWATERS IN 2018

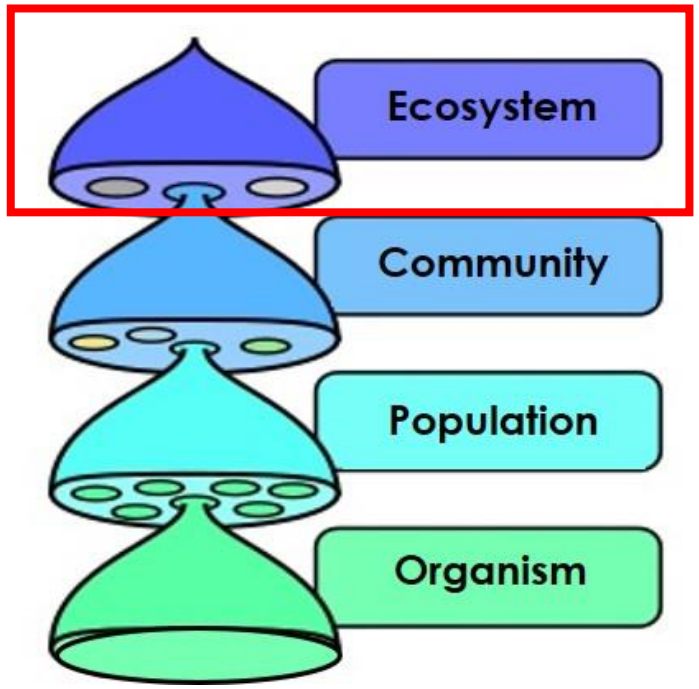


(Lebreton et al., 2017; Blettler et al., 2018)

Aim


Ecosystem
Community
Population
Organism


Macroplastic
>25 mm
Mesoplastic
25-5 mm
Microplastic
5-0.001 mm
Nanoplastic
<0.001 mm



GOAL 1

Science of the Total Environment 857 (2023) 159713

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

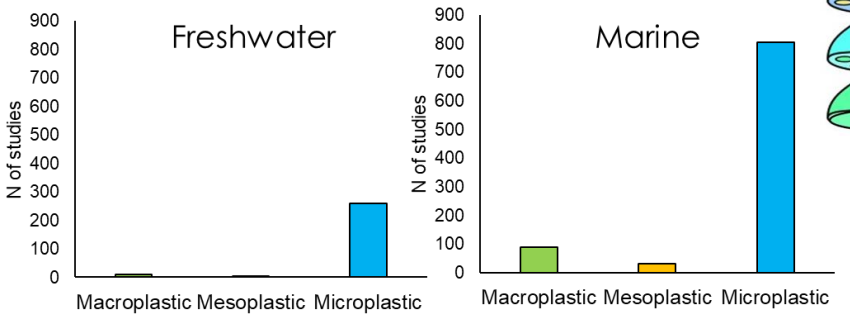
From city to sea: Spatiotemporal dynamics of floating macrolitter in the Tiber River

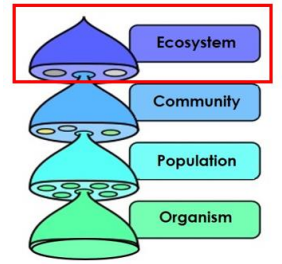
Giulia Cesarini [a,*], Roberto Crosti [b], Silvia Secco [a], Luca Gallitelli [a], Massimiliano Scalici [a]

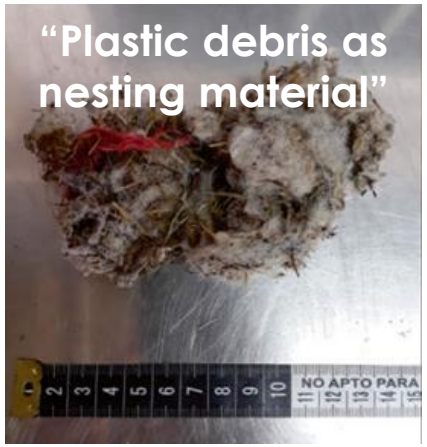
[a] Department of Sciences, University of Roma Tre, viale G. Marconi 446, 00146 Rome, Italy
[b] ISPRA, Dipartimento BIO, Via Brancati 48, 00144 Rome, Italy

Rationale

- Macroplastics are poorly investigated despite possible impacts







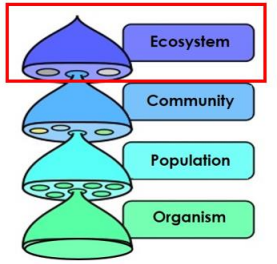
(Blettler et al., 2020; Azevedo-Santos et al., 2021; Blettler and Mitchell, 2021; Cesarini and Scalici, 2021; Gallitelli and Scalici, 2022)

Experimental design

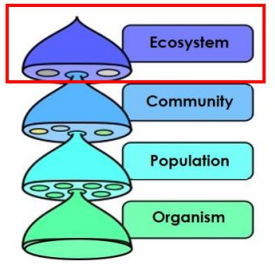
- **Quantification** and **characterization** of macrolitter (>2.5 cm)
- **Spatial pattern** of plastic in the potamal tract of Tiber River
- **Seasonal dynamics** of plastic transport

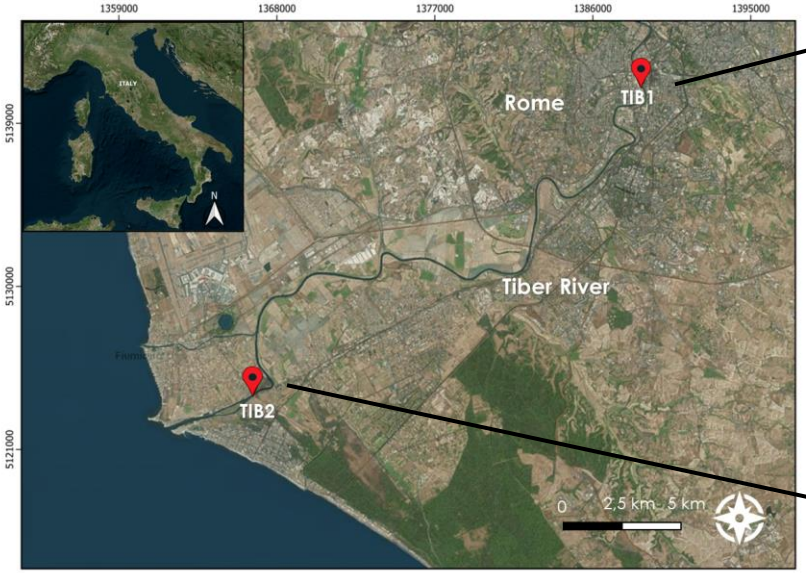
RIMMEL project

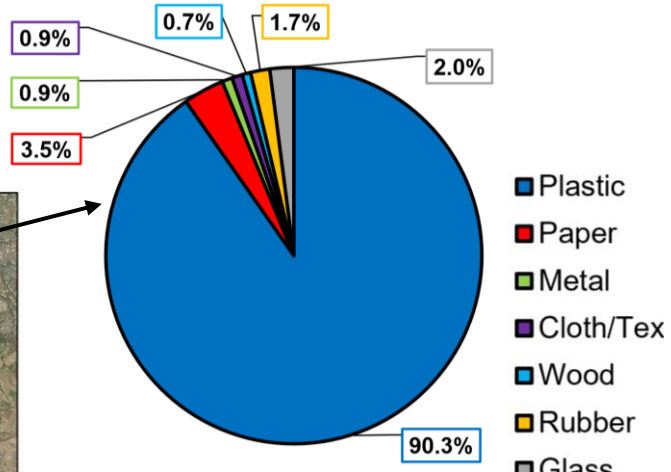
ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

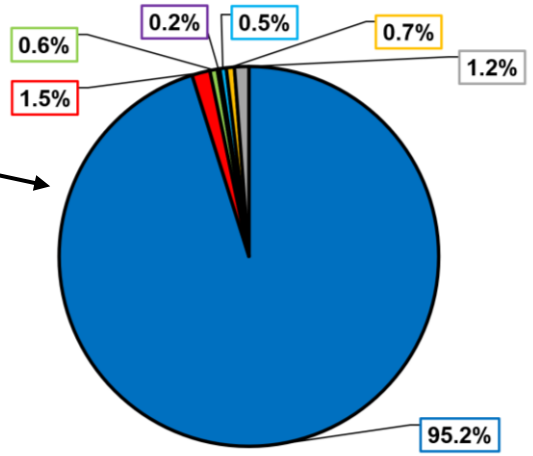


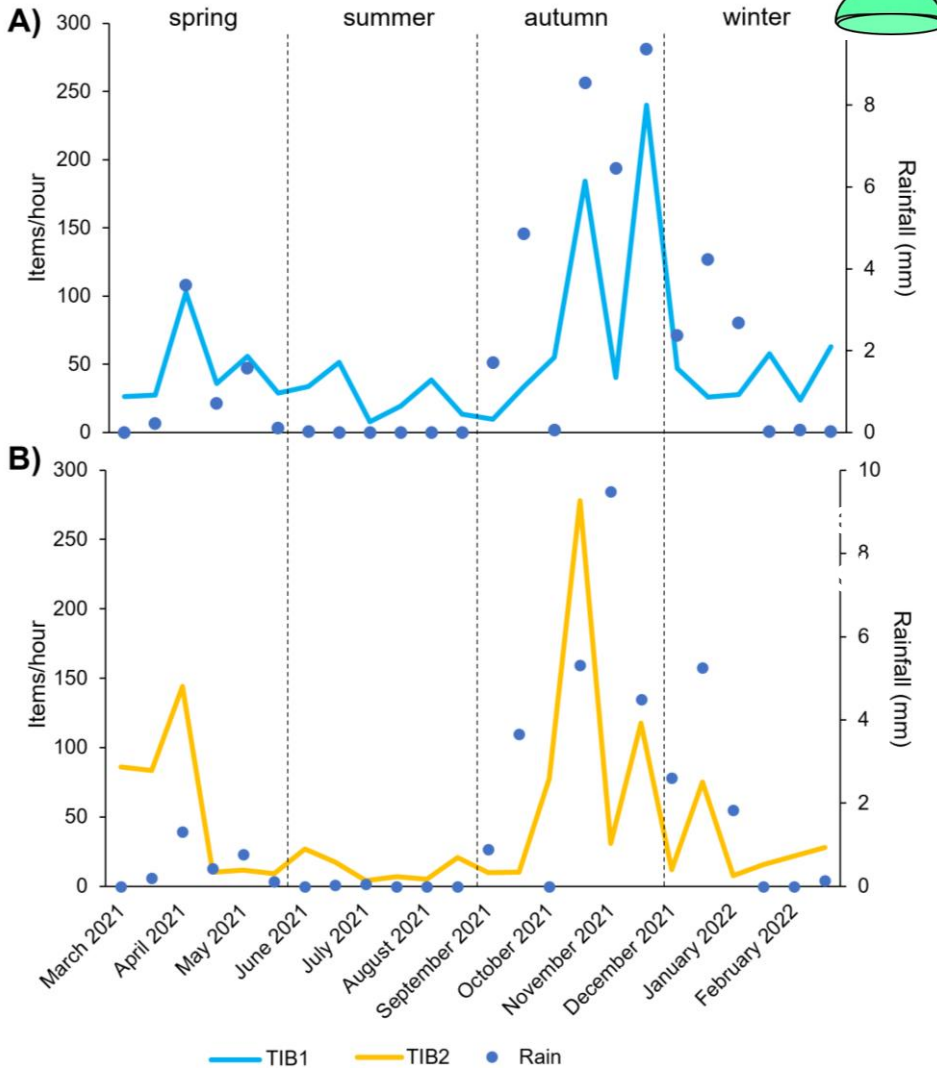
Main findings



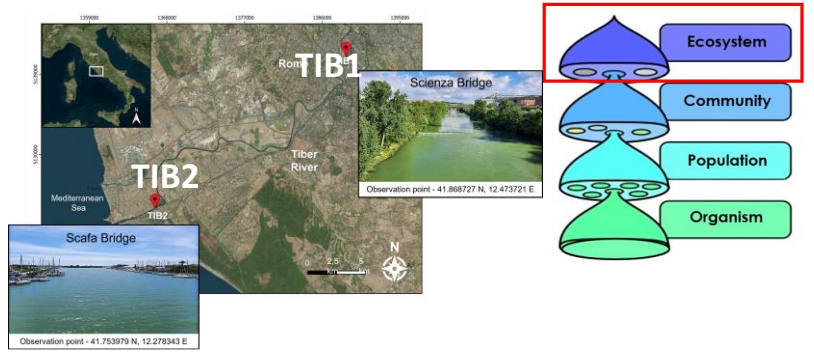




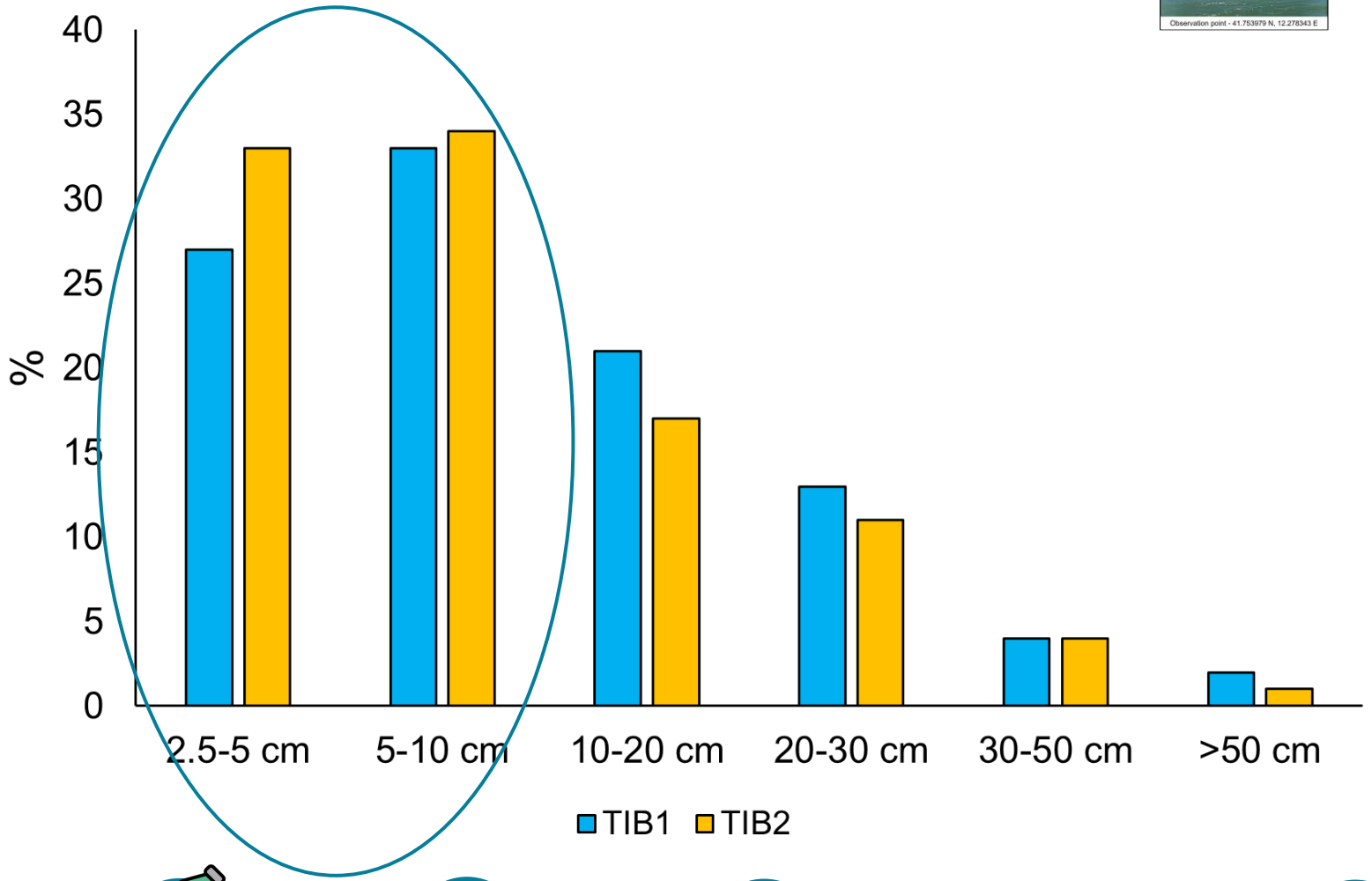


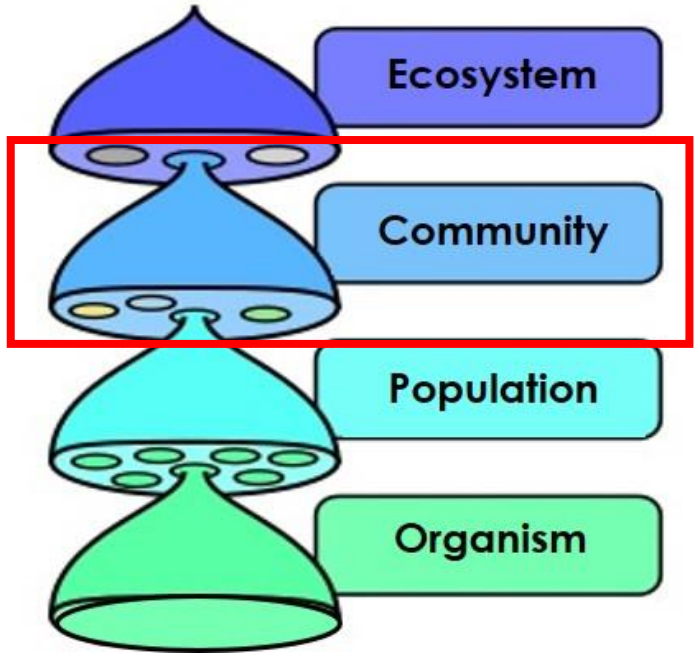


Main findings



Size classes of litter





GOAL 2

Environmental Pollution 292 (2022) 118410

Contents lists available at ScienceDirect

Environmental Pollution

journal homepage: www.elsevier.com/locate/envpol

Riparian vegetation as a trap for plastic litter☆

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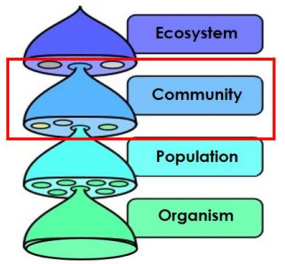
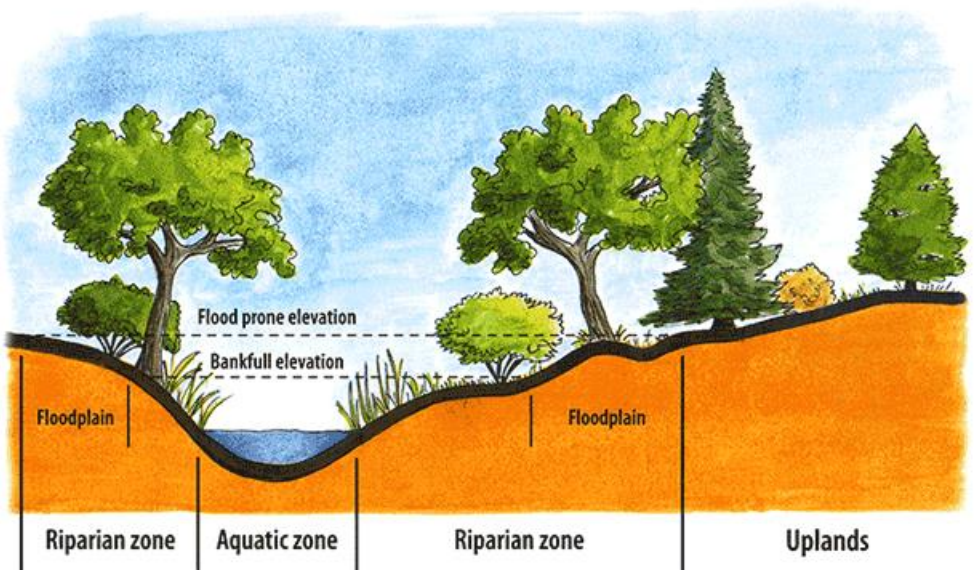
Department of Sciences, University of Roma Tre, Viale G. Marconi 446, 00146, Rome, Italy

Rationale



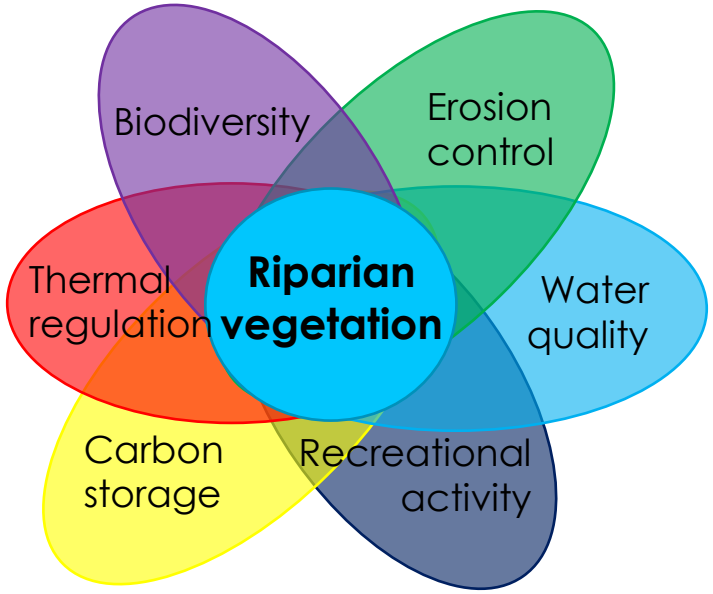
Among freshwater habitats considered in the literature, riparian zones are under-represented, but these habitats could significantly influence the transport of plastics

ECOTONE



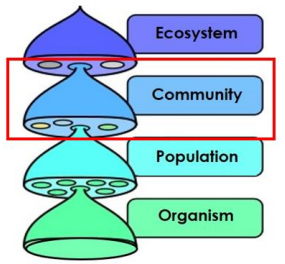
RIPARIAN ZONE

ECOSYSTEM SERVICES



(Williams and Simmons, 1999; Bletter et al., 2018; Windsor et al., 2019Liro et al., 2020; van Emmerik et al., 2020)

Experimental design



1° STEP: set up of field card

ROMA TRE UNIVERSITÀ DEGLI STUDI — SCIENZE Dipartimento di Eccellenza

SCHEDA DI CAMPO

RILEVAMENTO PLASTICHE

Data del rilevamento: ..... Fiume indagato: .....

Sito del rilevamento: ..... Sigla identificativa: .....

INFORMAZIONI SUL SITO

Bacino idrografico di appartenenza	
Latitudine	
Longitudine	

CARATTERISTICHE GENERALI

Morfologia generale		
Idrologia generale		
valore	1=non alterato; 2= poco alterato; 3= molto alterato	
Vegetazione ripariale	Specie	%
Canneto		
Roveto		
Arborea		
Arbustiva		
Erbacea		
Uso del territorio	1=assente; 2=presente; 3=diffuso	
Boschivo		
Agricolo		
Urbano		
Industriale		
Uso ricreativo		

OSSERVAZIONI PLASTICHE

Presenza di plastiche	1=assente; 2=presente; 3=diffusa							
Sulla vegetazione ripariale	canneto	%	roveto	%	arbusti	%	erbacee	%
Nelle anse								
Trasportata dalla corrente								
Tipologia di plastiche	Descrizione (Colore, dimensione, altre caratteristiche)							%
Bottiglie								
Buste								
Altri oggetti in plastica								
Oggetti non in plastica								

2° STEP: compilation of field card and identification of riparian vegetation structure

 arboreal

 shrubby

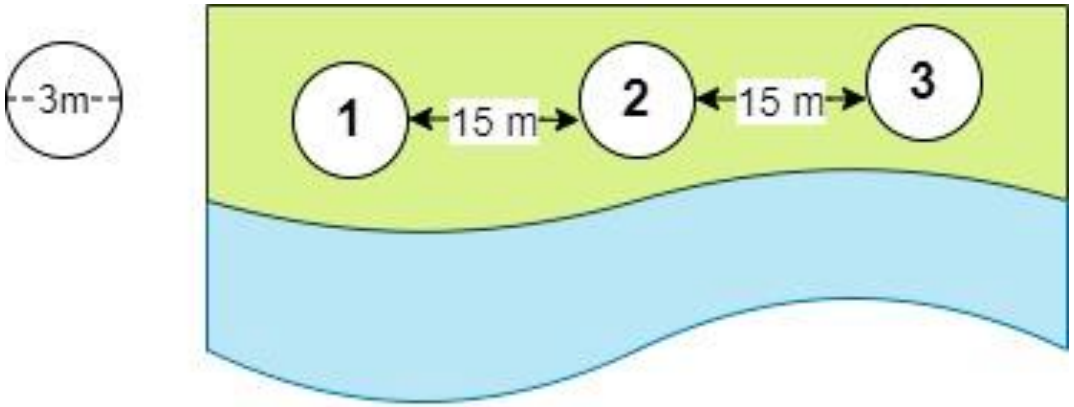
 herbaceous

 reed

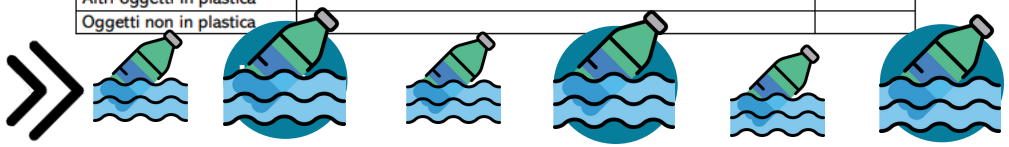
 bush

 unvegetated

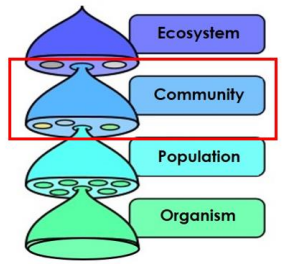
3° STEP: plastic sampling

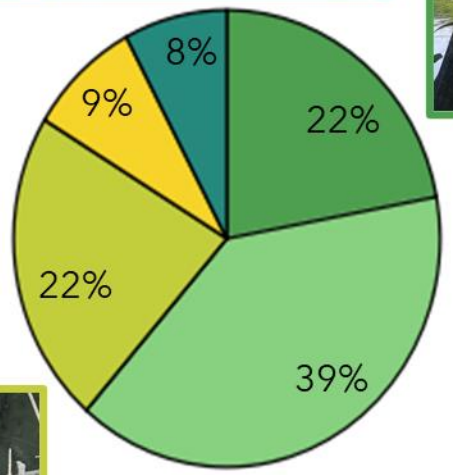


III IV V Concl



Results: riparian vegetation as a trap for plastic

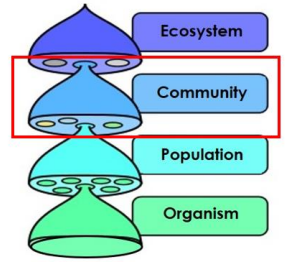


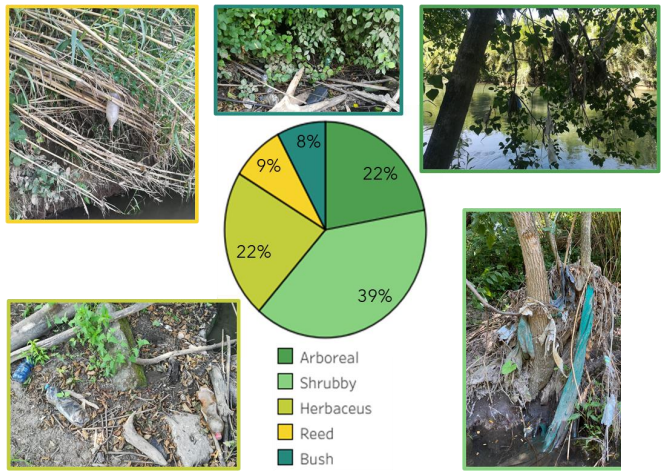


"Christmas tree effect"

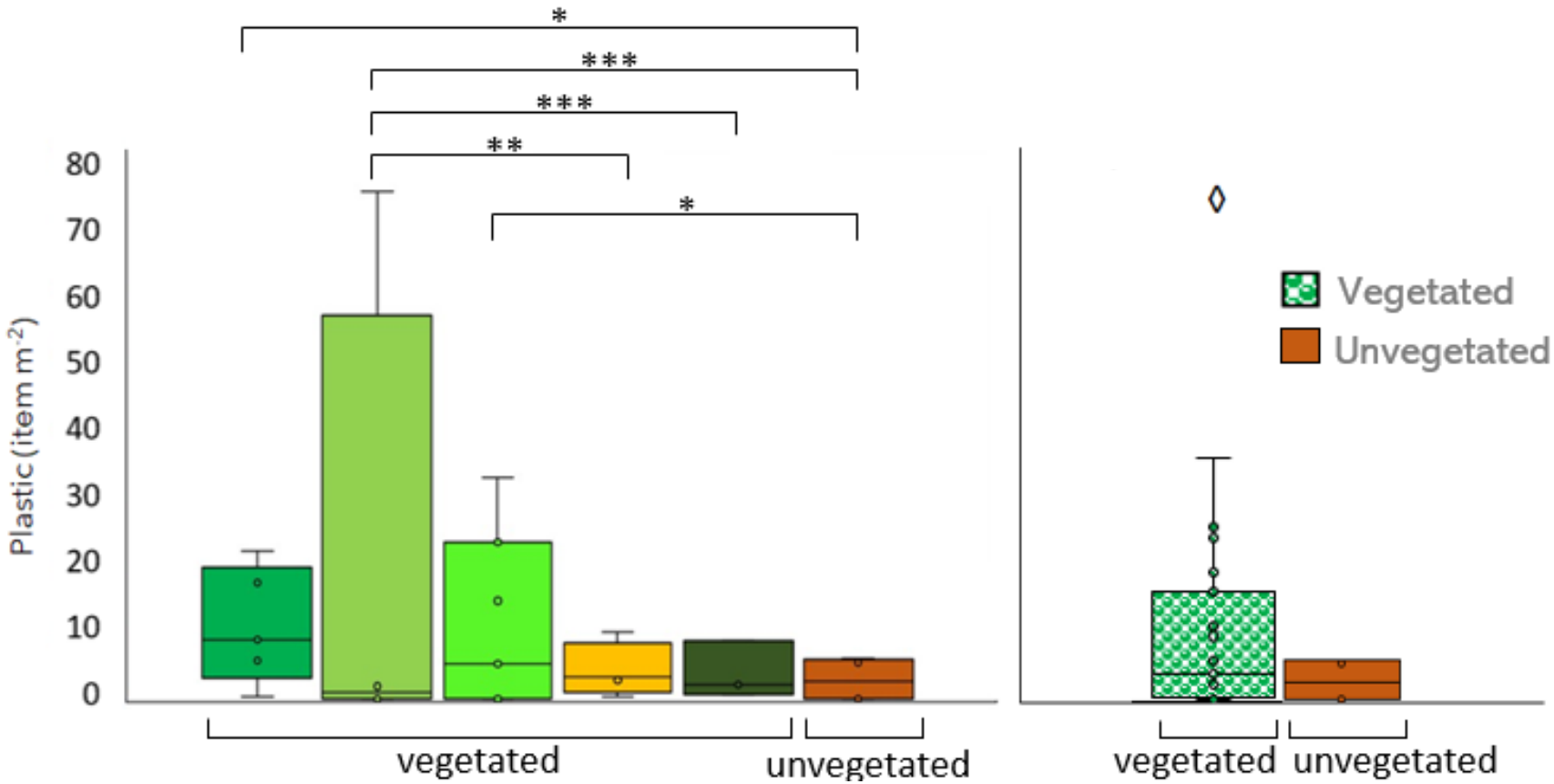
(Williams and Simmons, 1996, 1999)

Results: plastic density trapped by different riparian types

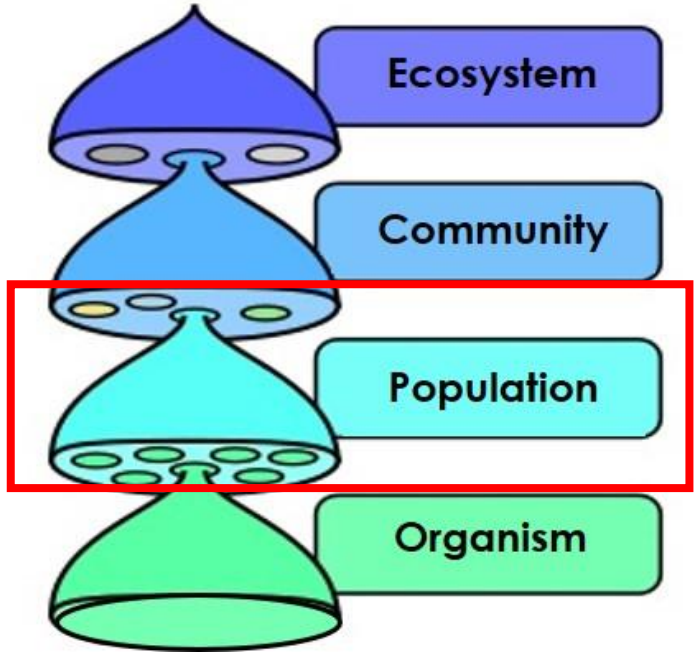




"Christmas tree effect"
(Williams and Simmons, 1996, 1999)



(* = <0.05; ** = <0.01; *** = <0.001)



GOAL 3

water

MDPI

Article

Microplastics, Additives, and Plasticizers in Freshwater Bivalves: Preliminary Research of Biomonitoring

Giulia Cesarini [1,2,*], Fabiana Corami [3,4], Beatrice Rosso [4] and Massimiliano Scalici [1]

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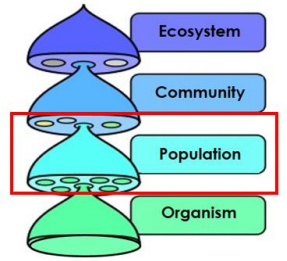
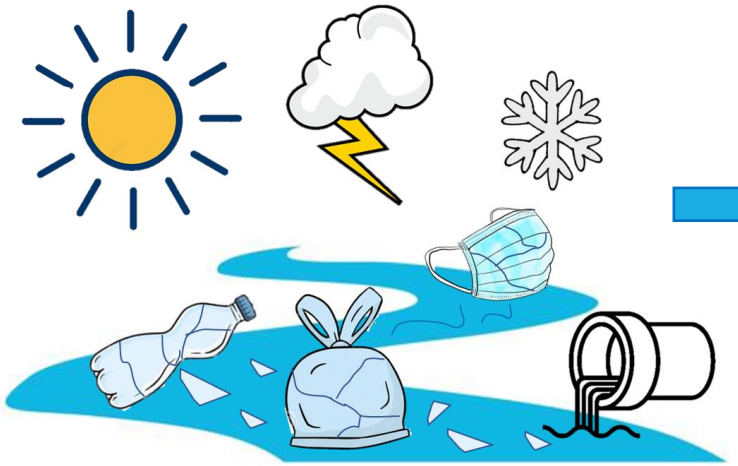
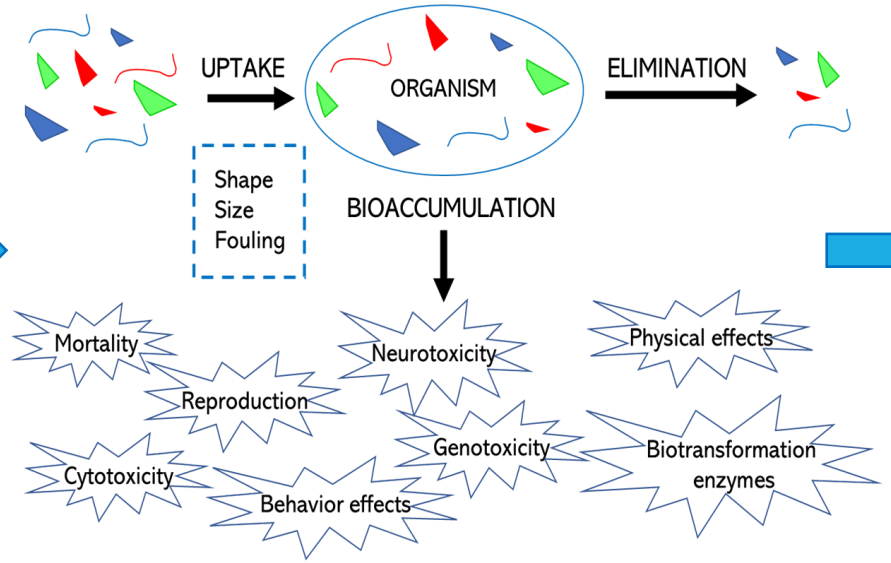
2 Water Research Institute, CNR-IRSA, L.go Tonolli 50, 28922 Verbania, Italy
3 Institute of Polar Sciences, CNR-ISP, Campus Scientifico, Ca' Foscari University of Venice, Via Torino 155, 30172 Venezia, Italy; fabiana.corami@cnr.it
4 Department of Environmental Sciences, Informatics, and Statistics, Ca' Foscari University of Venice, Via Torino 155, 30172 Venezia, Italy; beatrice.rosso@unive.it
* Correspondence: giulia.cesarini@uniroma3.it; Tel.: +39-0657336355; Fax: +39-065733632

Rationale

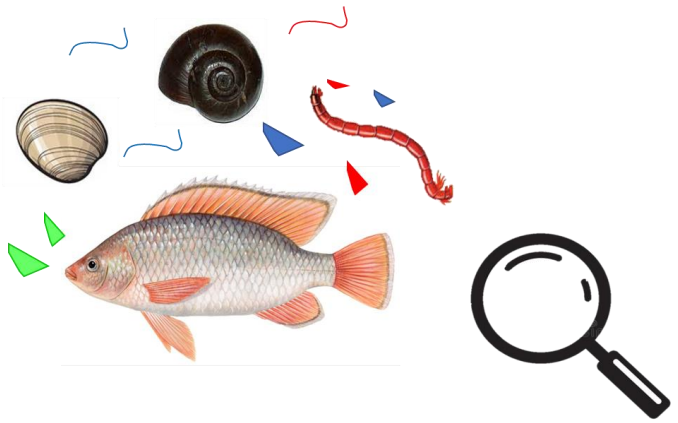




Microplastics (MPs, 1 µm-5 mm) **primary** and **secondary**

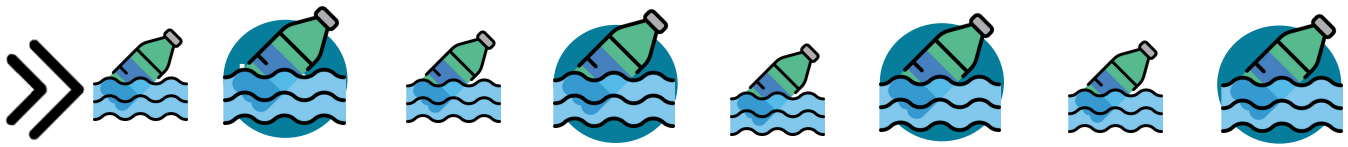


Small MPs (**SMPs**, <100 µm) similar to the size of seston



Need to find **sentinel organisms** of MP pollution in freshwaters

(de Sá et al., 2018; Wagner and Lambert, 2018; Li et al., 2019; Kukkola et al., 2021; Corami et al., 2022)

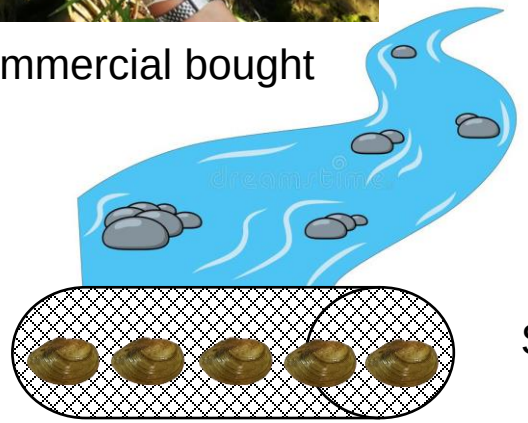


IV V Concl

Experimental Design

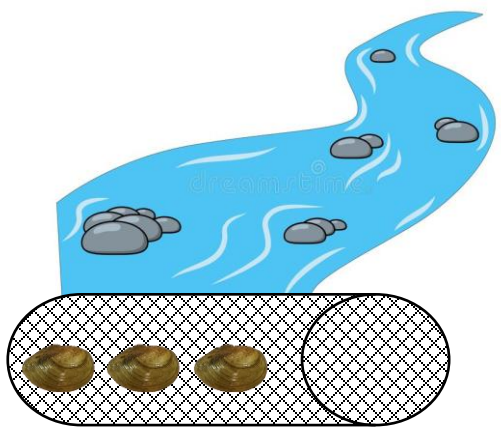
Commercial bought

Environmental exposure



Short term (1 month)

collection

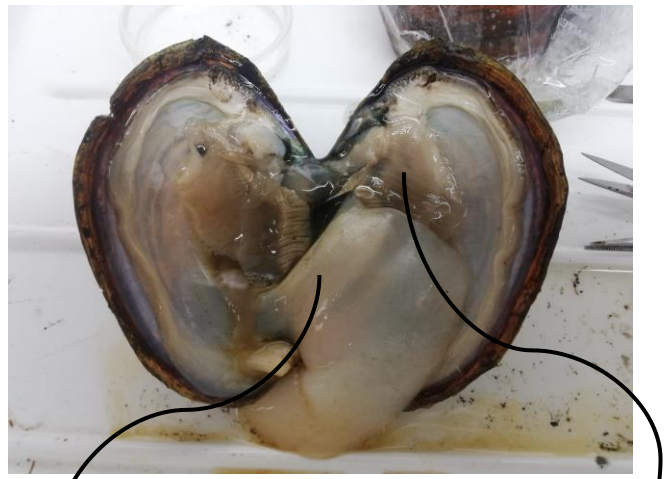


Long term (3 months)

collection

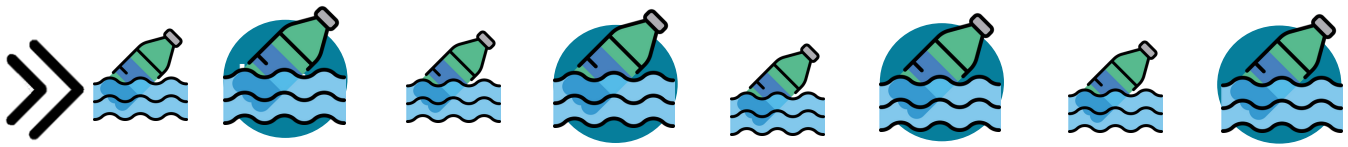
Anodonta cygnea (Linnaeus, 1758)

dissection and removal of



gastrointestinal tract

gills

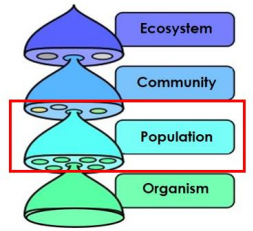


IV

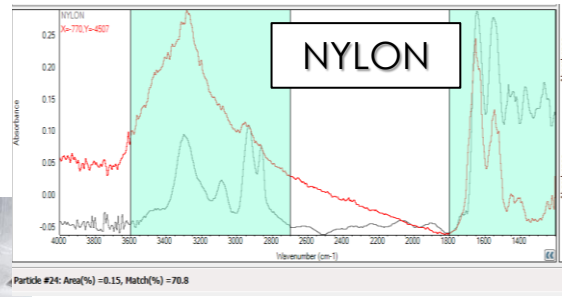
V

Concl

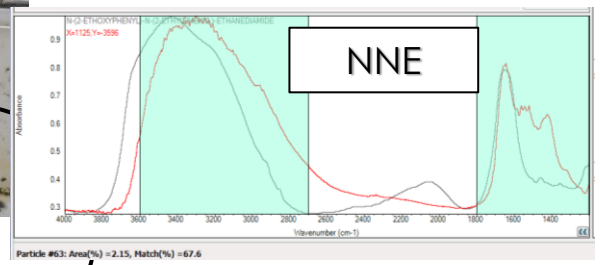
Main findings



Small microplastics <100 µm

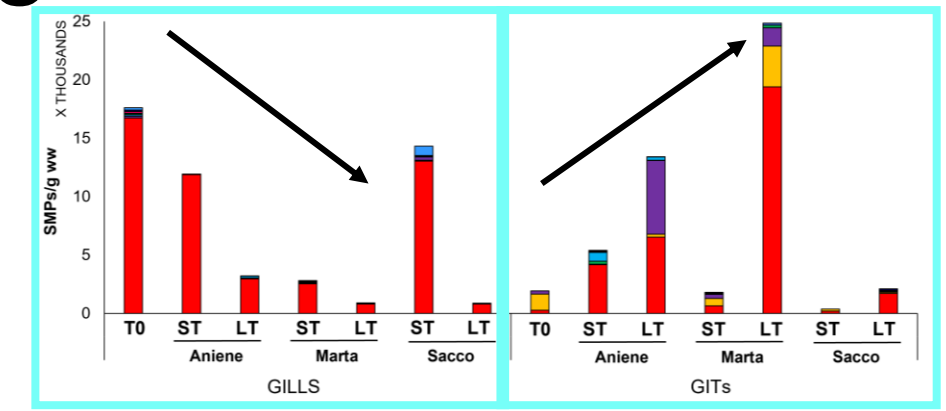


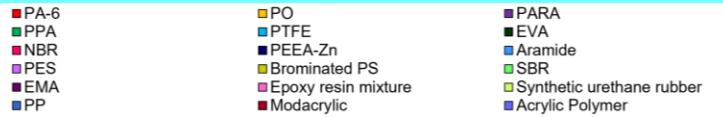
Additives and plasticizers

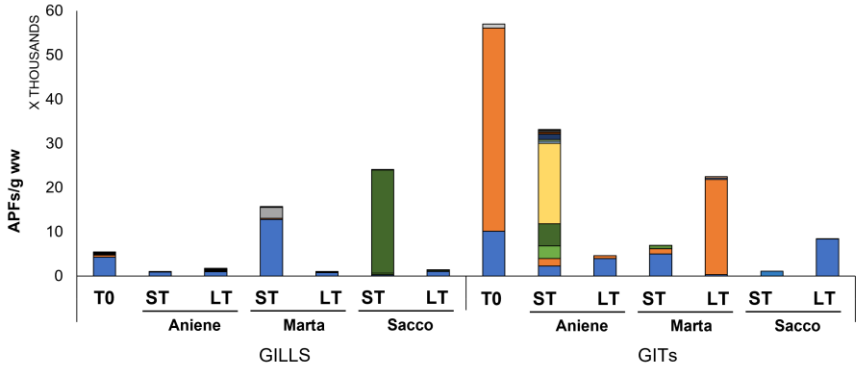


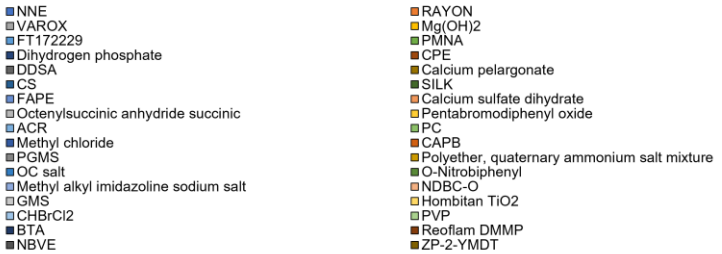
gastrointestinal tract

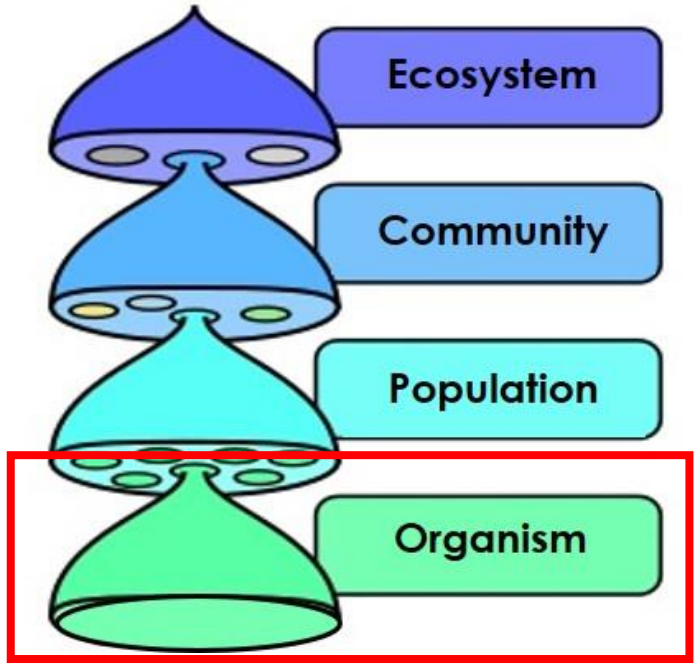
gills











GOAL 4.1

Science of the Total Environment 898 (2023) 165564

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

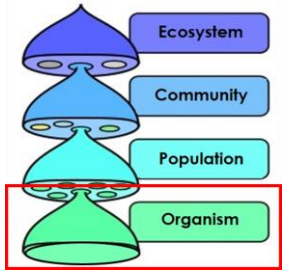
Teratogenic effects of environmental concentration of plastic particles on freshwater organisms

Giulia Cesarini [a], Silvia Secco [a], Davide Taurozzi [a], Iole Venditti [a], Chiara Battocchio [a], Stefania Marcheggiani [b], Laura Mancini [b], Ilaria Fratoddi [c], Massimiliano Scalici [a,*], Camilla Puccinelli [b,*]

[a] Department of Sciences, University of Roma Tre, Viale G. Marconi 446, 00146 Rome, Italy
[b] Department of Environment and Health, Italian National Institute of Health (ISS), Viale Regina Elena, 299, 00161 Rome, Italy
[c] Department of Chemistry, Sapienza University of Rome, P.le A. Moro 5, 00185 Rome, Italy

Rationale

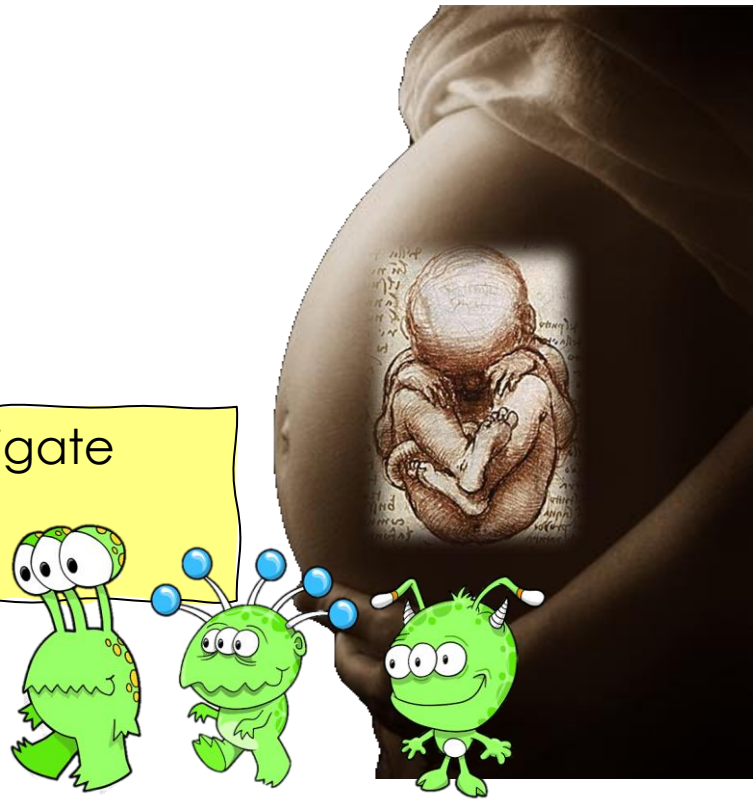
Nanoplastics
1-100 nm Ø



Often, in lab studies, the exposure conditions are **not representative of environmental plastic pollution** considering...

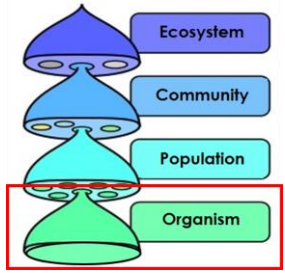
- unrealistic concentrations
- shapes less expected to find in field conditions
- single trophic level tested

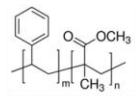
Until now, the attention to NP was mainly focused to investigate ingestion, while other aspects are **little investigated**..
NP exposure to **early life stages and teratogen effects**.



(Stapleton, 2019; Kukkola et a., 2021; Zhang et al., 2021)

Experimental design





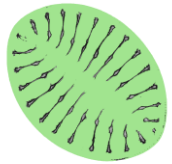
poly(styrene-co-methyl methacrylate) nanoplastics

Nanoplastic contamination of freshwaters

NPs exposure

CTL
0.1 µg/L
1 µg/L
100 µg/L
10000 µg/L

NP characteristics:
Polystyrene-co-methyl methacrylate
Irregular shape
Average size 96 nm Ø



Cocconeis placentula var lineata Ehrenberg 1885
1.0 x 10^4 cells/ml for each treatment

Teratogenicity assay

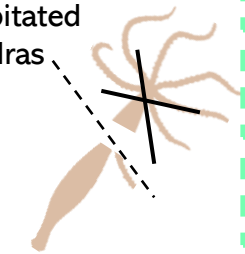
Growth inhibition

Collection of samples once a week

28 days of NPs exposure

Hydra vulgaris
Pallas 1766
5 hydras for each treatment

Decapitated hydras



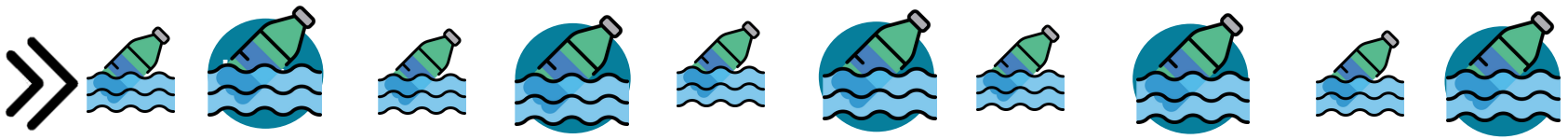
Teratogenicity assay

Feeding assay

Tentacles' reactivity

CUT

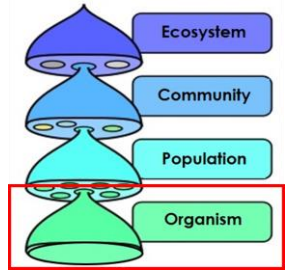
4 days of NPs exposure



V

Concl

Teratogenic Risk Index (TRI)



NEW

Aberration Frequency (AF)

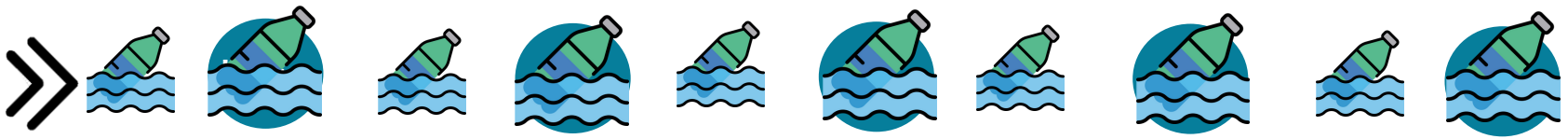
Regeneration Rate (RR)	0.00-0.19	0.20-0.39	0.40-0.59	0.60-0.79	0.80-1.00
3.50-4.00	10	9	6	4	1
3.00-3.49	10	8	6	4	1
2.50-2.99	8	7	5	3	1
2.00-2.49	7	6	5	3	1
1.50-1.99	5	5	4	2	1
1.00-1.49	4	3	3	2	0
0.50-0.99	2	1	1	0	0
0.00-0-49	0				

Teratological Frequency (TF)

Growth Rate (GR)	0.00-0.19	0.20-0.39	0.40-0.59	0.60-0.79	0.80-1.00
0.80-0.89	10	9	6	4	1
0.70-0.79	10	8	6	4	1
0.60-0.69	8	7	5	3	1
0.50-0.59	7	6	5	3	1
0.30-0.49	5	5	4	2	1
0.20-0.29	4	3	3	2	0
0.10-0.19	2	1	1	0	0
0.00-0.09	0				

(Traversetti et al., 2017)

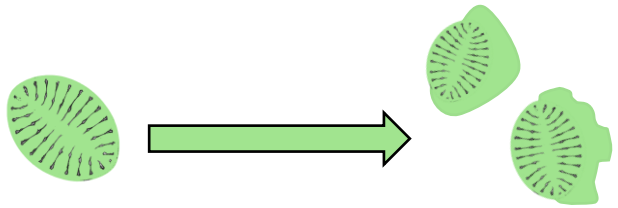
score	class	risk level
10	I	none
9 - 7	II	low
6 - 4	III	moderate
3 - 2	IV	high
1	V	very high

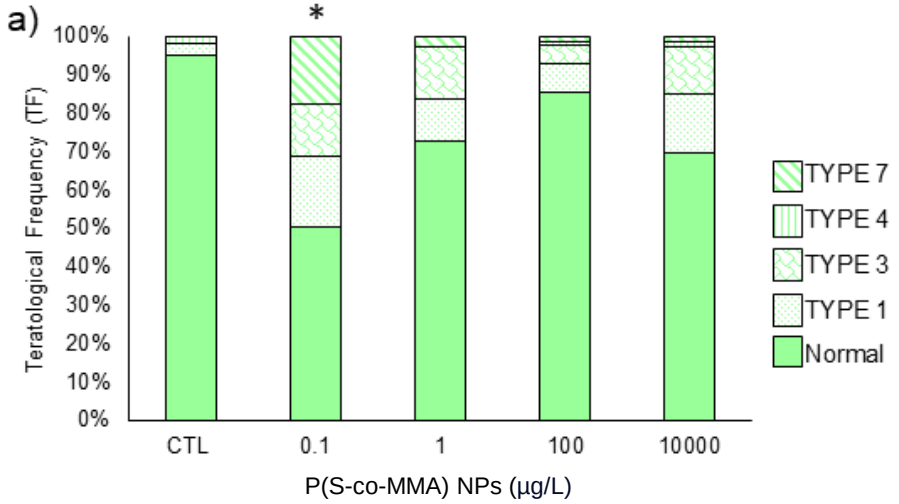


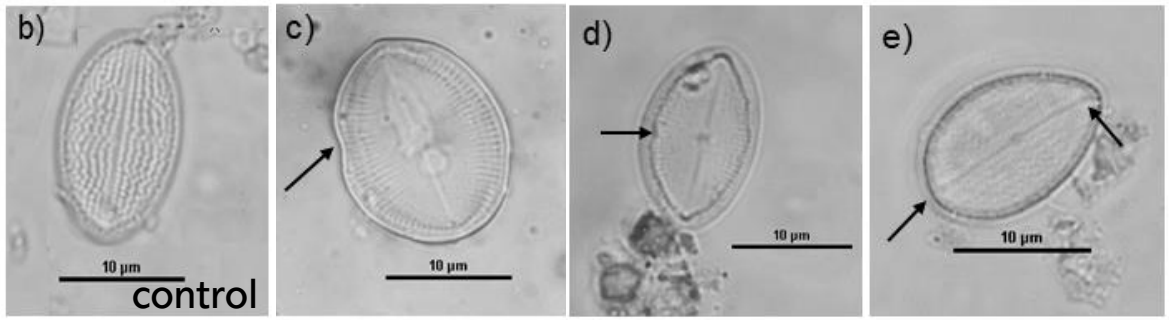
V

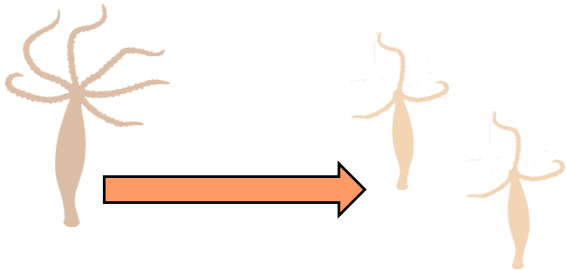
Concl

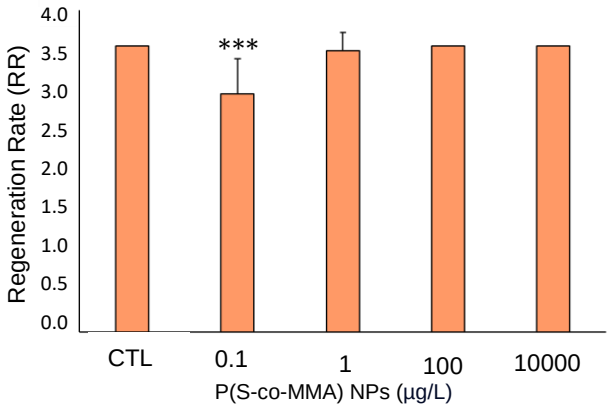
Main findings

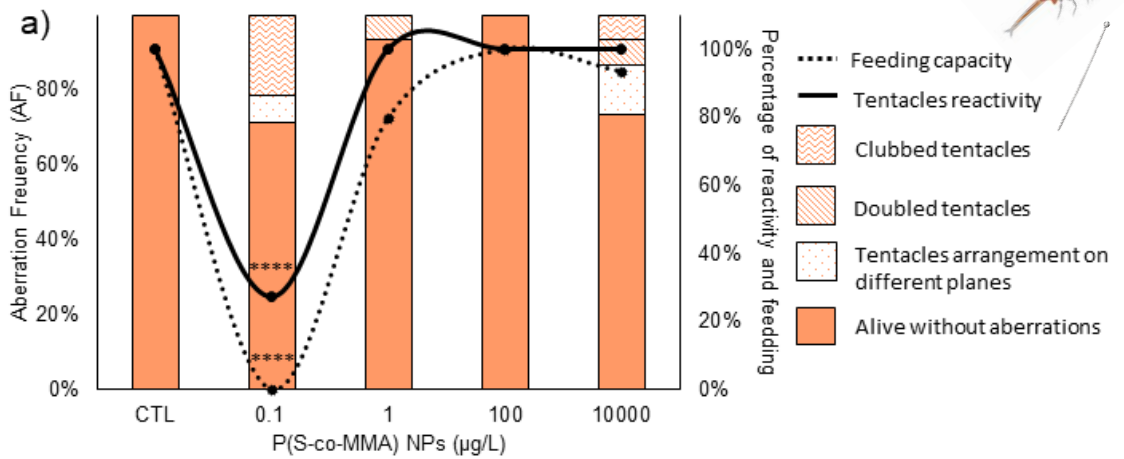


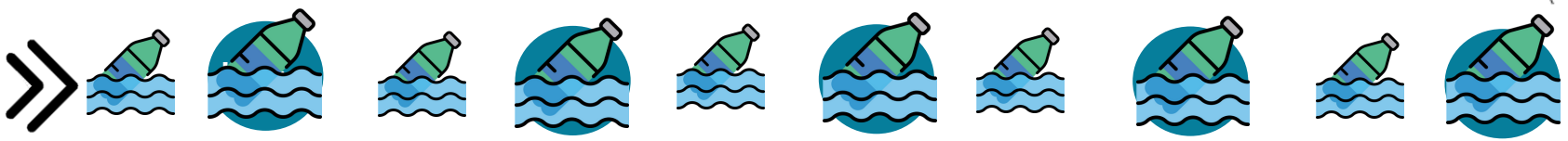








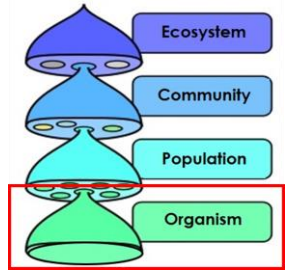




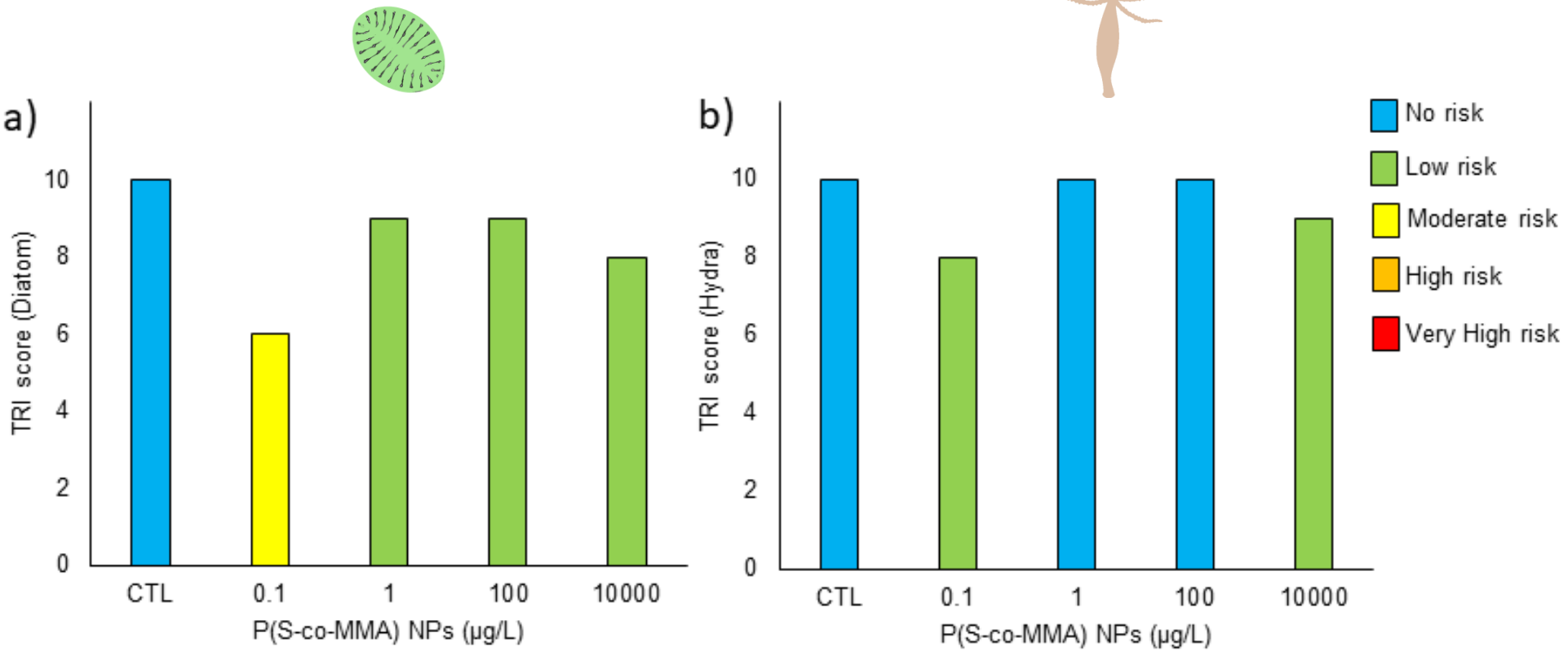
V

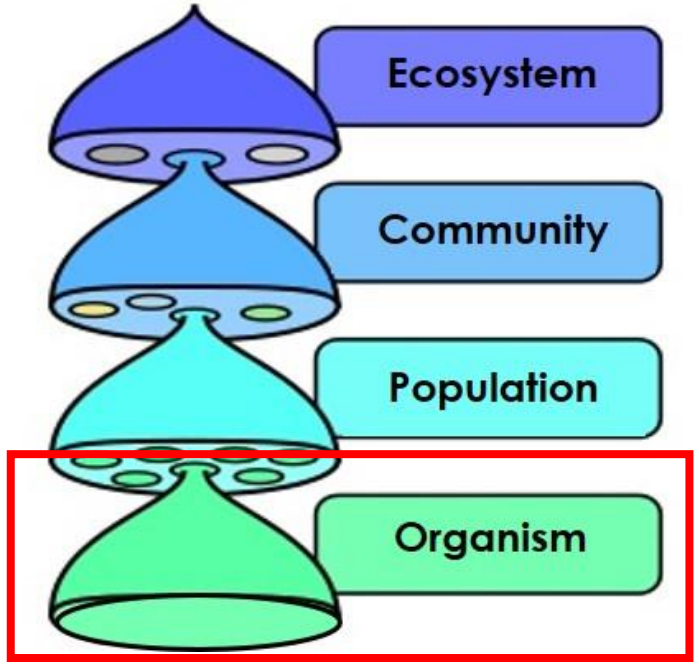
Concl

Main findings



Teratogenic Risk Index (TRI)





GOAL 4.2

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Nanoplastic exposure inhibits feeding and delays regeneration in a freshwater planarian☆

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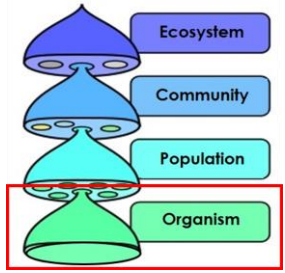
Concl

Experimental design



Intact planarians

Girardia tigrina Girard, 1850

Change of the medium every 2 days

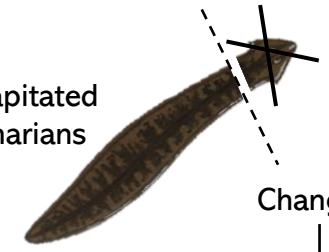
10 days of NPs exposure

CTL
10 µg/L
100 µg/L
1000 µg/L
10000 µg/L

Locomotion

12 planarians for each treatment

Decapitated planarians



Regeneration

Change of the medium every 2 days

CUT

8 days of NPs exposure

CTL
10 µg/L
100 µg/L
1000 µg/L
10000 µg/L

Feeding

10 planarians for each treatment

NP characteristics:
Polystyrene-co-methyl methacrylate
Irregular shape
Average size 96 nm Ø

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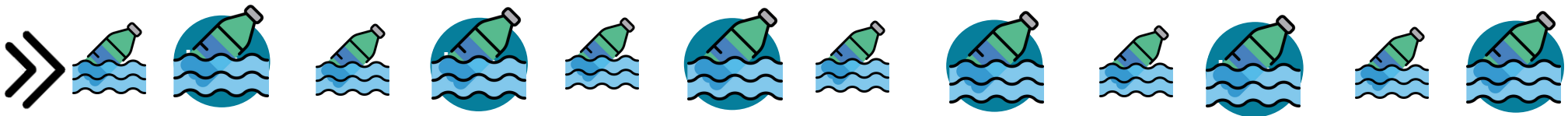
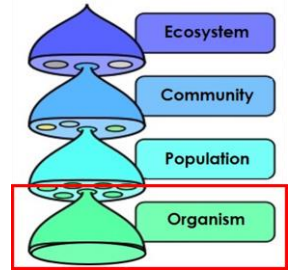
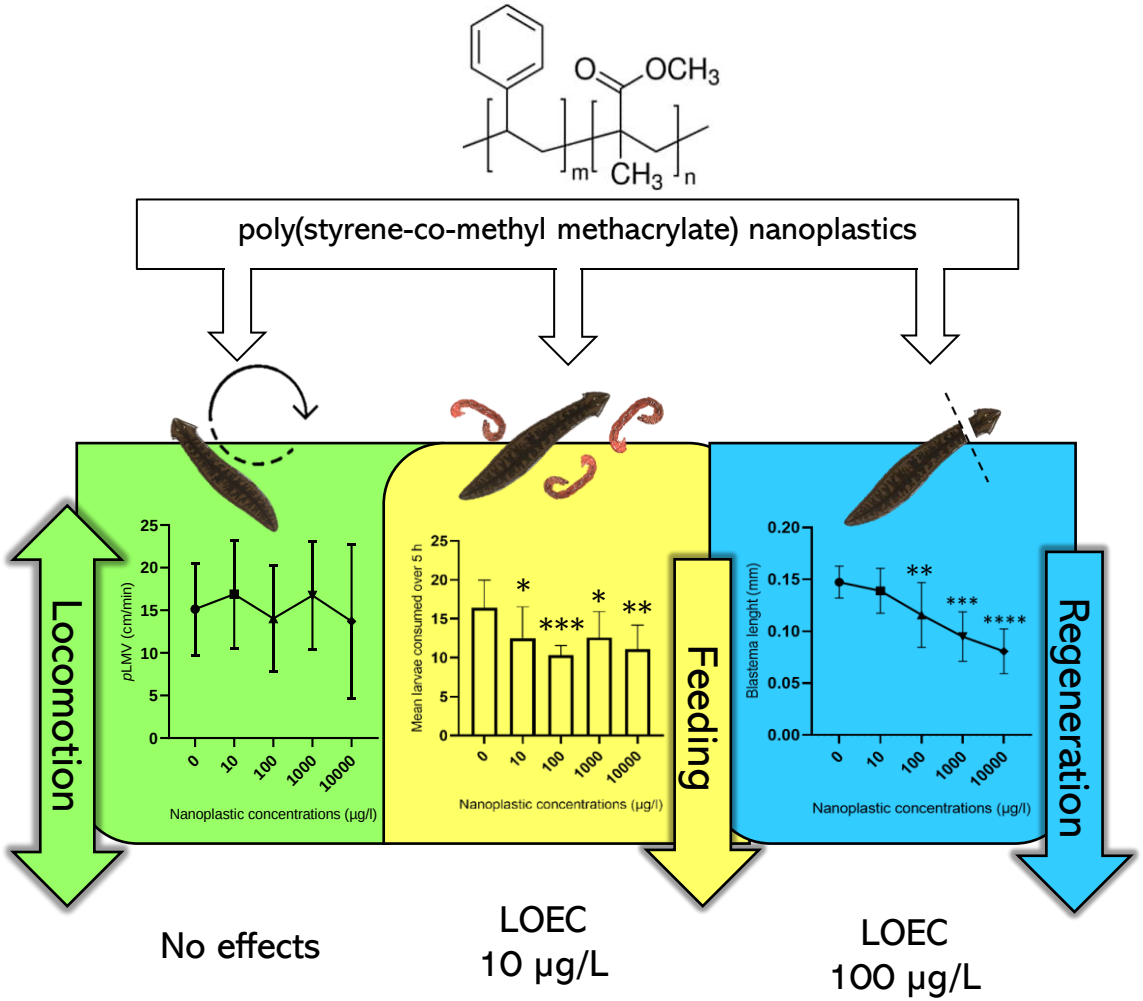
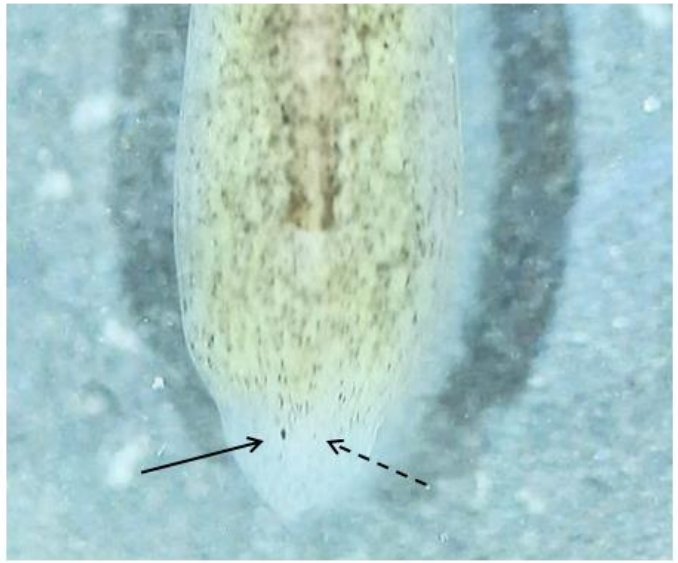


Concl

Main findings



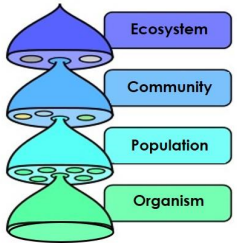




- **No malphormation** observed **at the end of exposure**

Concl

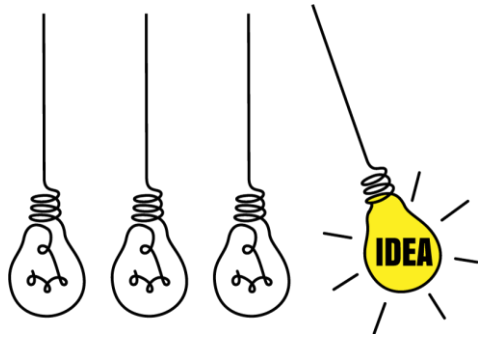
Conclusions: message in a (plastic) bottle



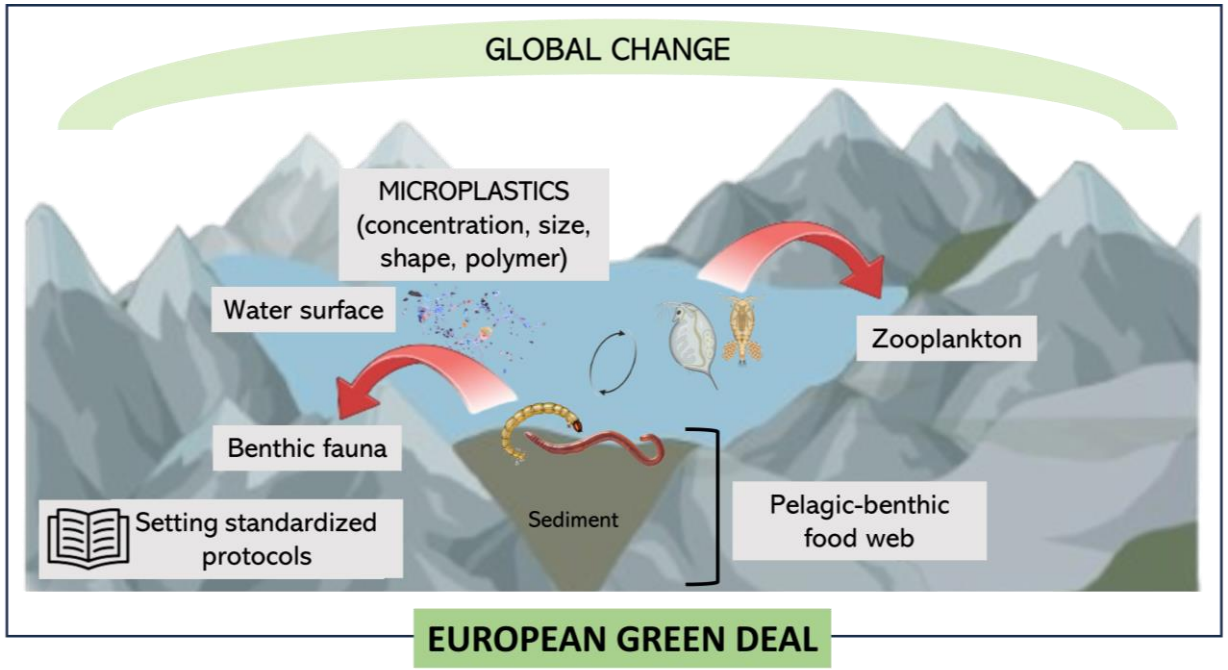
MULTILEVEL APPROACH

- At **macroplastic level** → filed data on **floating macrolitter transport** in river ecosystem
- Temporarily deposited on the riverbank and riparian vegetation → acts as a **trap for plastics**
- Floating plastics and plastics stocked in riparian vegetation → **secondary MPs and NPs**
- Accumulation of small **microplastics and additives in freshwater bivalves** *Anodonta cygnea*
- At **nanoplastic level** → **teratogenic effects** were found according to the sensitivity of the **organism**
- **All plastic sizes have an impact** → rethink plastic pollution from MACRO to nanoscale

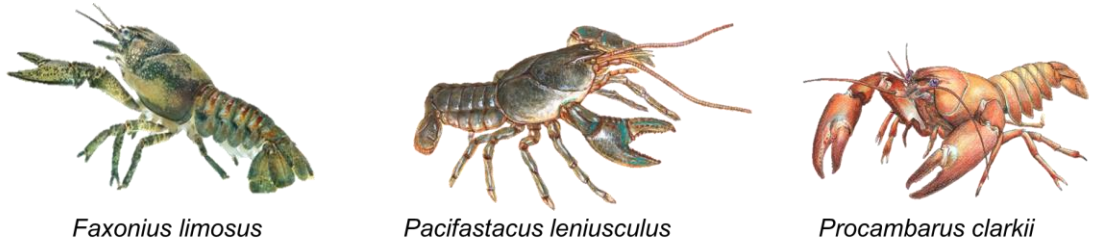
Ongoing research

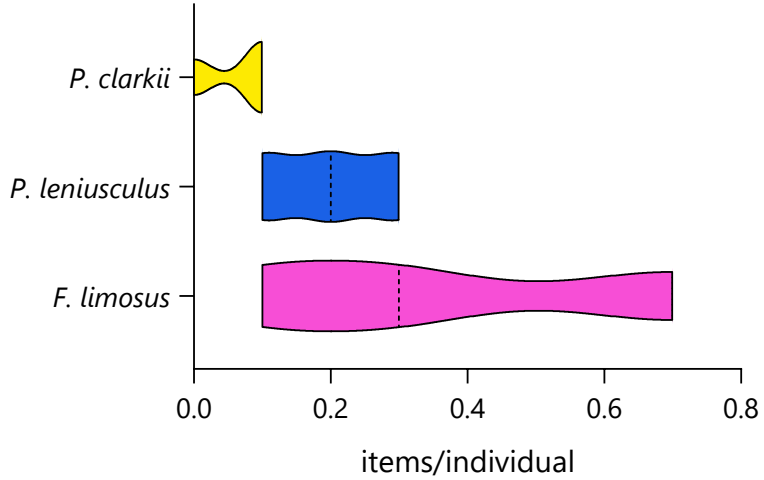


- Occurrence of MPs in remote ecosystems

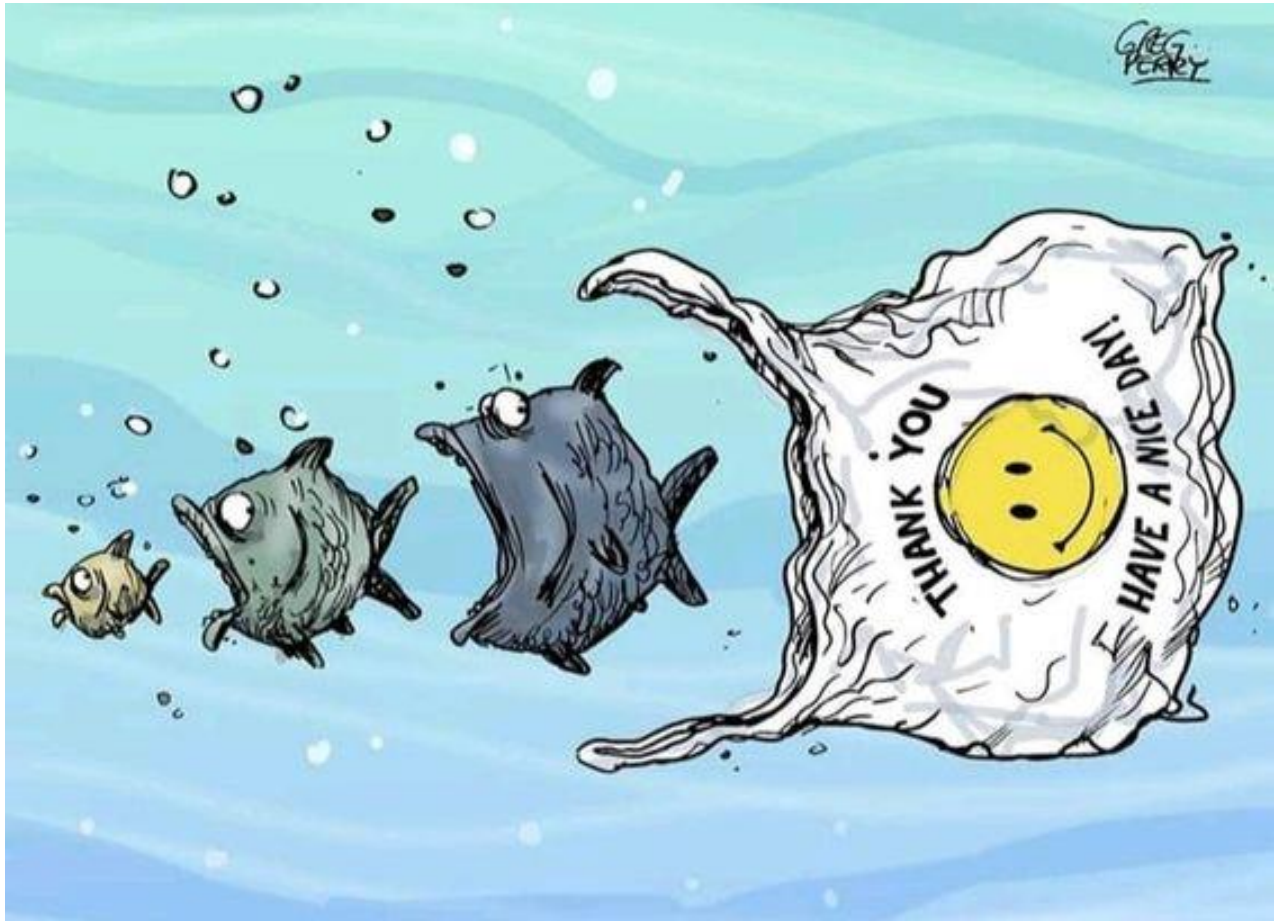


- Accumulation of MPs in invasive species





Any questions?



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