UNESCO-IWRA ONLINE CONFERENCE
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3RD IN THE IWRA ONLINE CONFERENCE SERIES

Emerging Pollutants: Protecting Water Quality for the Health of People and the Environment

Bioavailability quantification and uptake mechanisms of pyrene associated with different-sized microplastics to *Daphnia magna*

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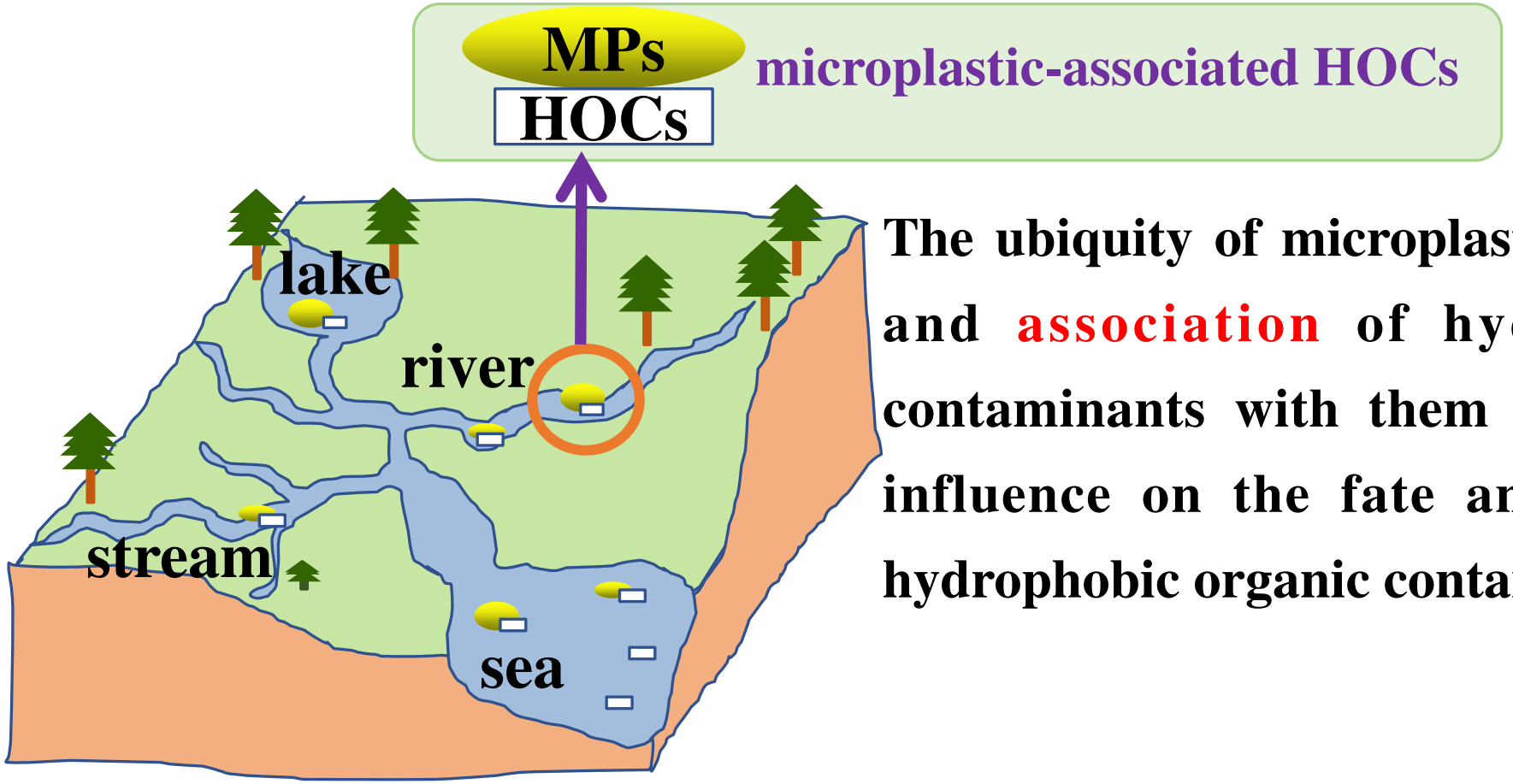
unesco
Programme hydrologique intergouvernemental

IWRA International Water Resources Association

Introduction

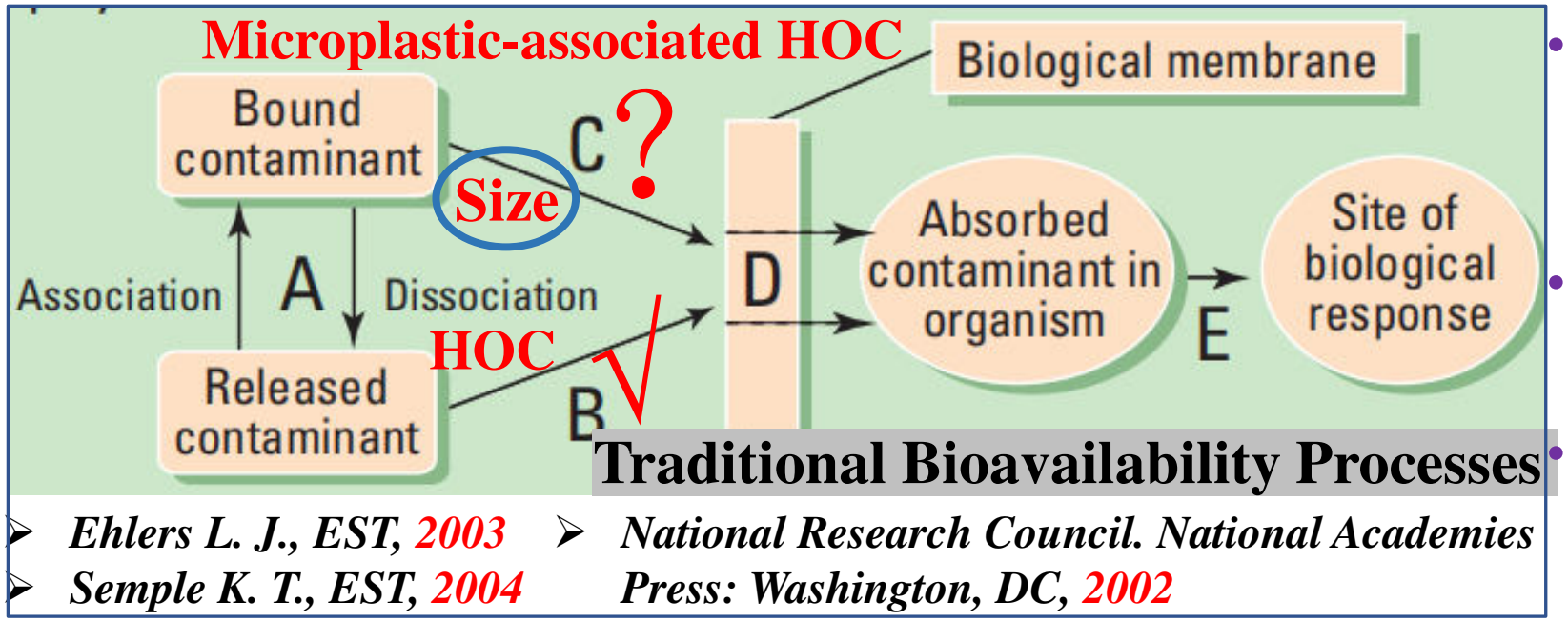
The problem of microplastic pollution in water has attracted worldwide attention.

Introduction



The ubiquity of microplastics in natural waters and association of hydrophobic organic contaminants with them can exert significant influence on the fate and bioavailability of hydrophobic organic contaminants

Introduction



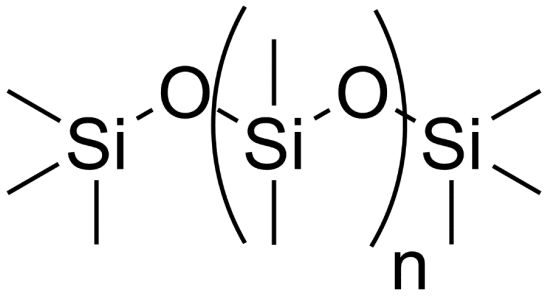
- *Ehlers L. J., EST, 2003*
- *Semple K. T., EST, 2004*
- *National Research Council. National Academies Press: Washington, DC, 2002*

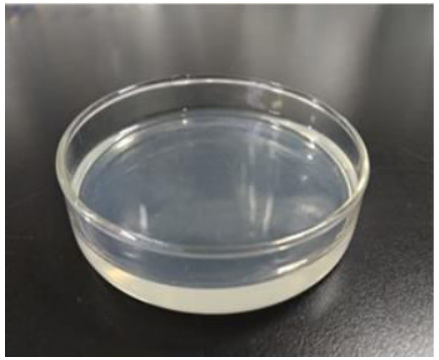
- whether the microplastic-associated HOCs are bioavailable?
- how to quantify their bioavailability ?
- the key influencing factor of their bioavailability ?

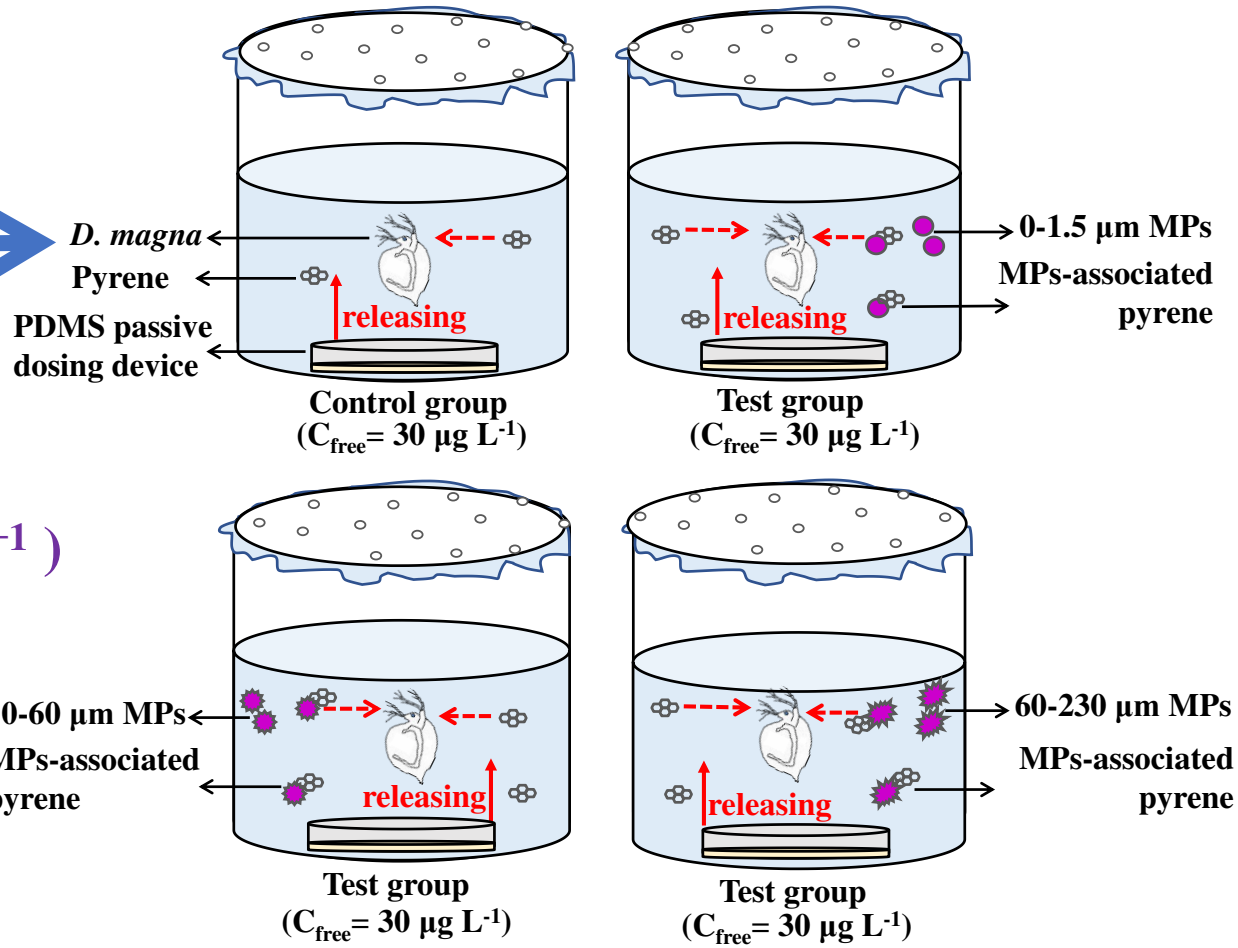
The previous reports put more emphasis on the toxicity and bioavailability of HOCs in the freely dissolved phase and the effect of MPs on it.

Influence of microplastics on *D. magna* immobilization in the presence of pyrene

PDMS passive dosing device (60 mm)





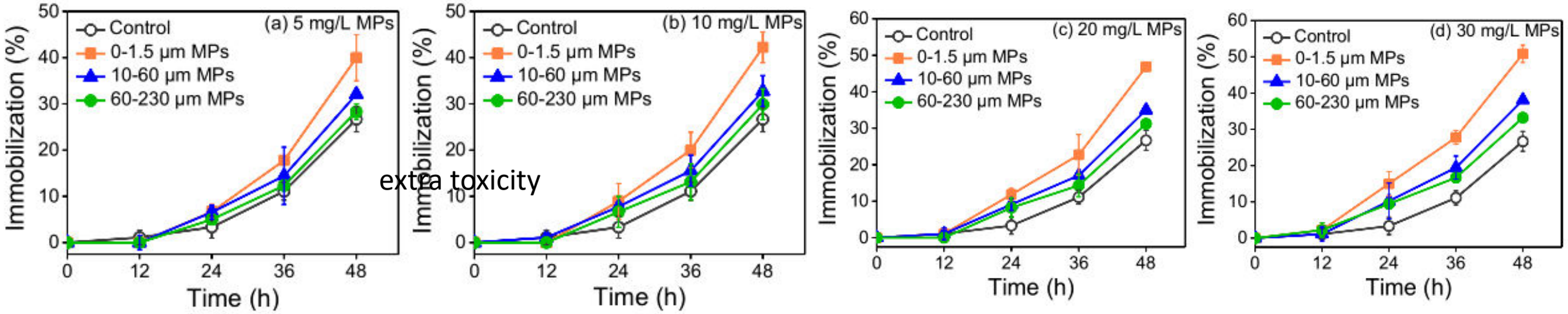


Control C_{pyrene} in the dissolved phase (30 µg L^{-1})

- ✓ **test:** microplastic-associated pyrene +freely dissolved pyrene
- ✓ **control:** freely dissolved pyrene

Influence of microplastics on *D. magna* immobilization in the presence of pyrene

Effects of PS microplastics on *D. magna* immobilization in the presence of pyrene



Concentrations of microplastic associated pyrene

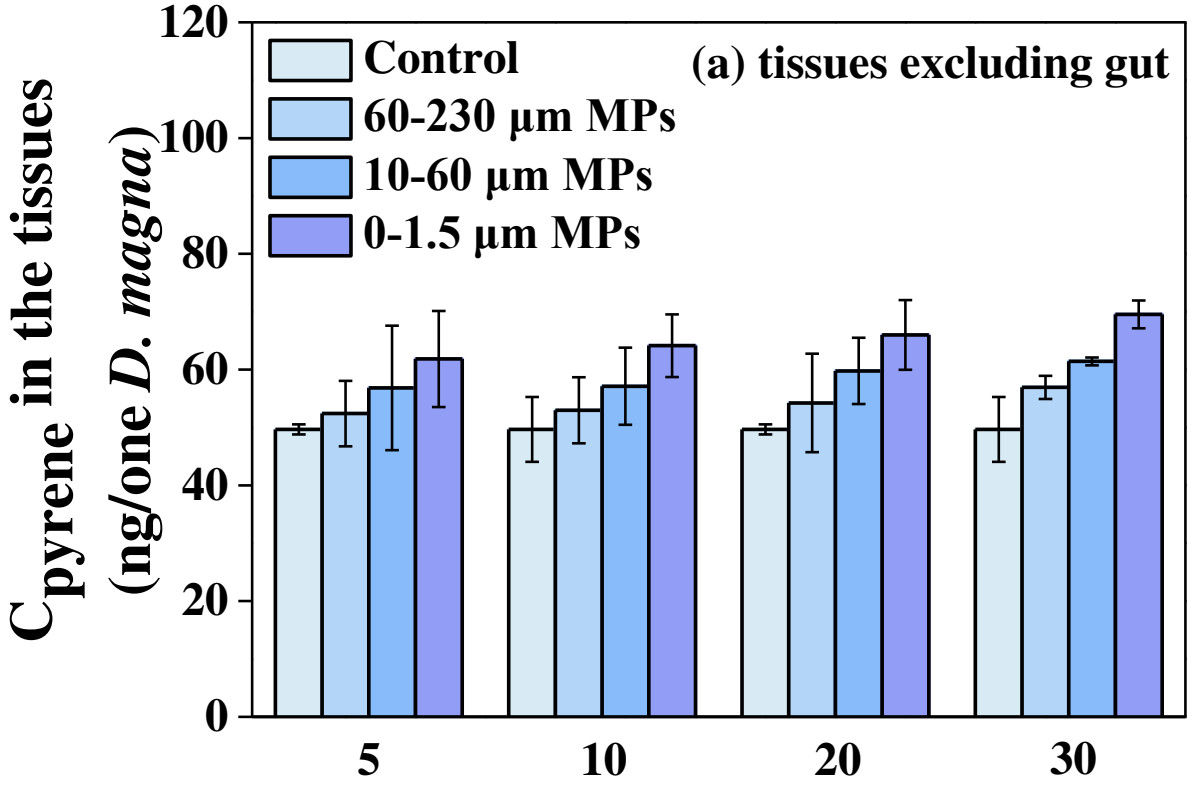
- 0–1.5 μm: 1.90×10^4
- 10–60 μm: 1.72×10^4
- 60–230 μm: 1.52×10^4 mg kg^{-1}

Size effect

- ***D. magna* immobilization: test > control groups**
- **the enhancement changed with the sizes of MPs (90.6%, 42.9%, and 24.6%)**

microplastic associated pyrene caused extra toxicity

Influence of MPs on the pyrene content in *D. magna* tissues in the presence of pyrene

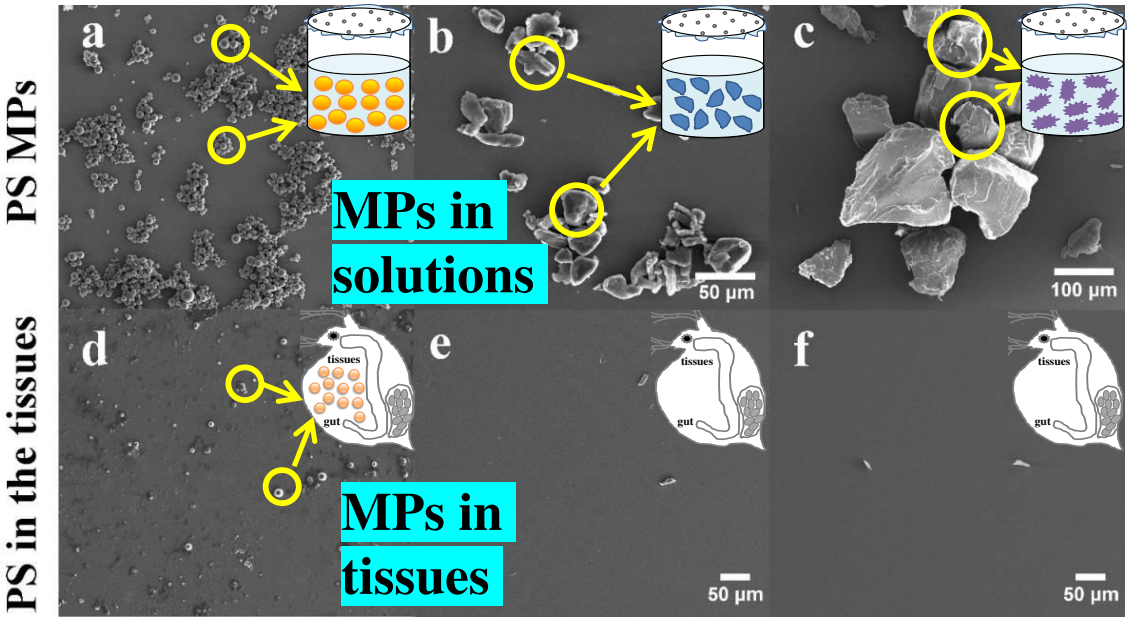


Pyrene content in the tissues

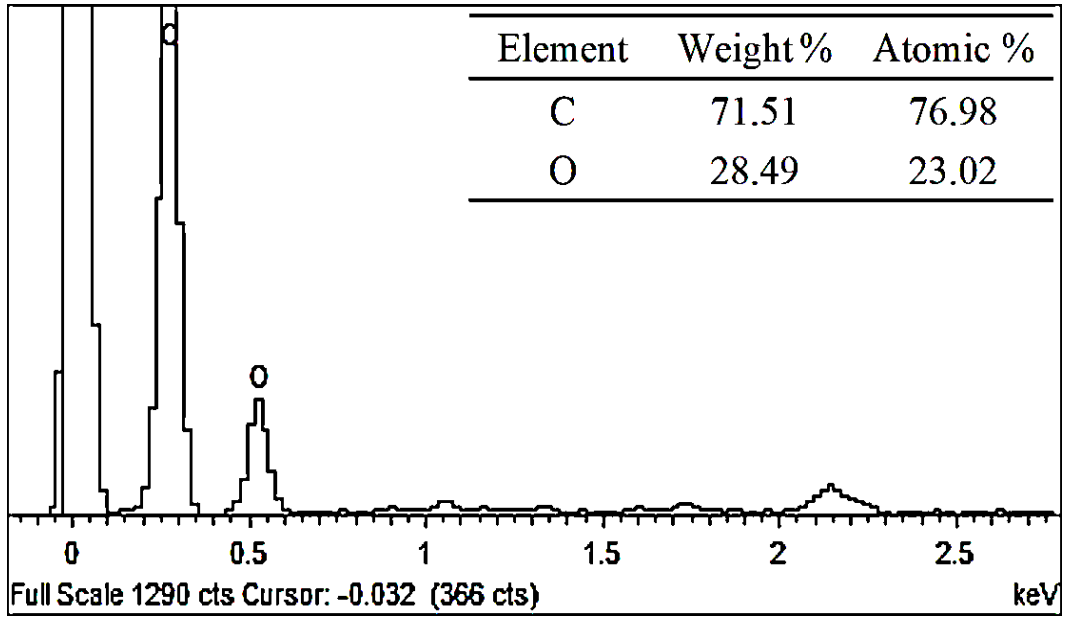
- 0–1.5 μm: 40%; 10–60 μm: 23.7%; 60–230 μm: 14.6%
- MPs of different sizes elevated the pyrene bioaccumulation in *D. magna*

Size effect

Uptake mechanisms of microplastic-associated pyrene by *D. magna*



SEM images of PS microplastics in exposure solutions and PS microplastics extracted from the tissues

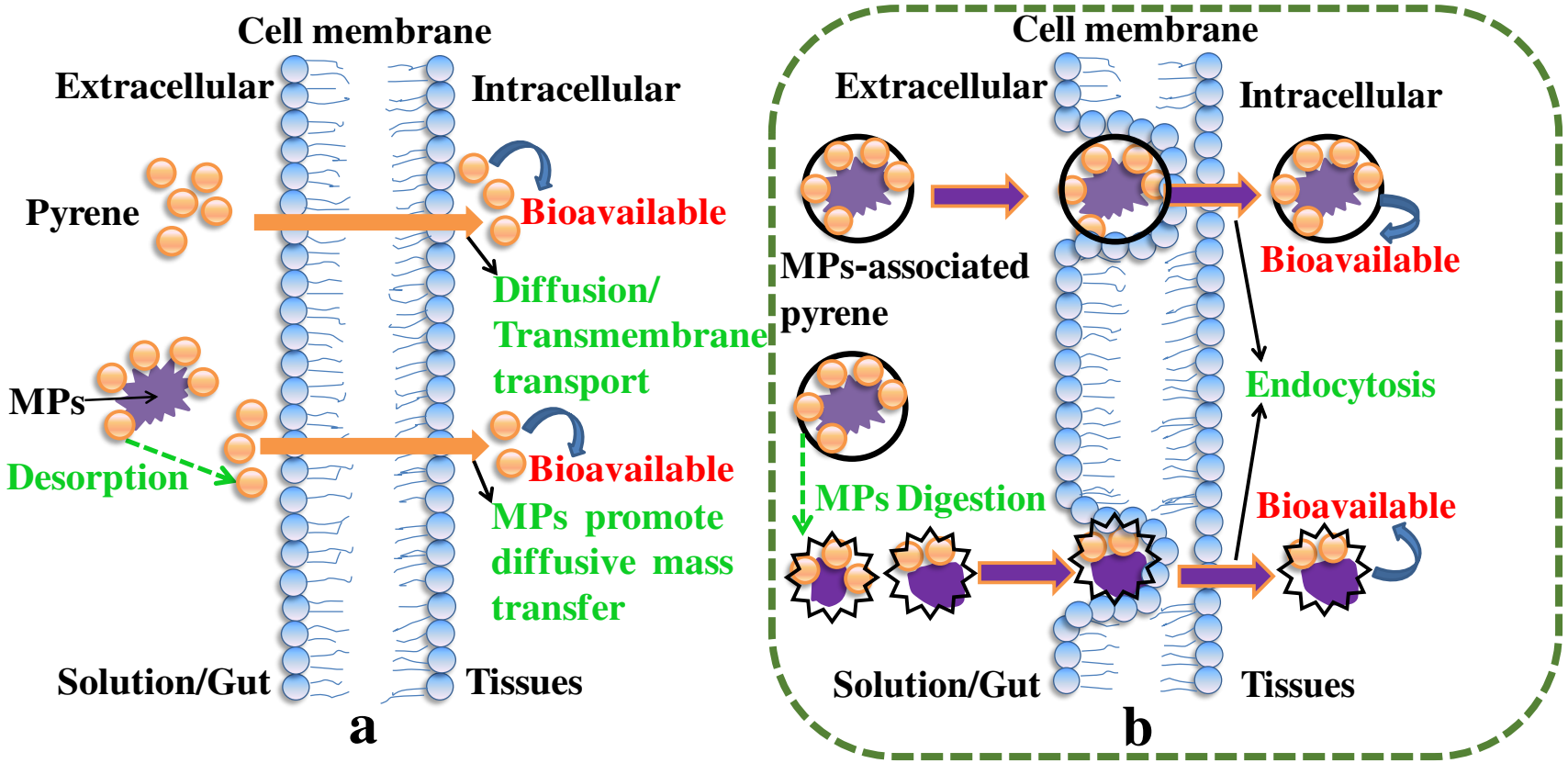


Element	Weight %	Atomic %
C	71.51	76.98
O	28.49	23.02

Energy spectrum of PS microplastics (0-1.5 μm) on field emission scanning electron microscopy (SEM)

Only a part of 0–1.5 μm PS microplastics existed in *D. magna* tissues

Uptake mechanisms of microplastic-associated pyrene by *D. magna*



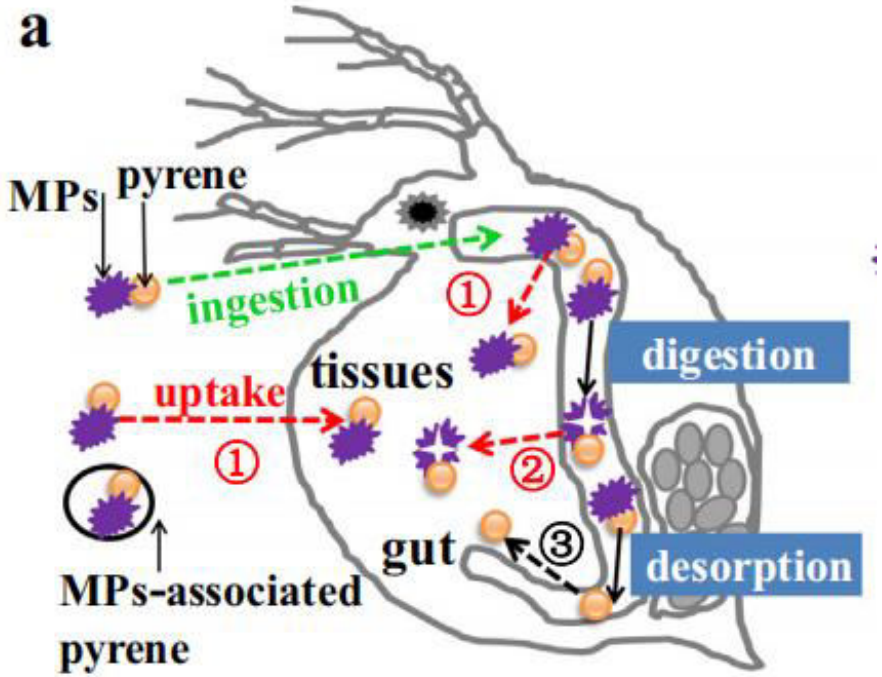
Schematics of bioavailability processes (a: traditional uptake mechanisms of pyrene, b: new uptake mechanisms of pyrene).

Whether microplastic-associated pyrene is bioavailable?

Depend on the size of MPs

- **diffusion (pyrene)**
- **endocytosis (0-1.5 μm MPs)**

Uptake mechanisms of microplastic-associated pyrene by *D. magna*



Mechanism one: for 0-1.5 μm MPs

microplastic-associated pyrene: a new speciation of pyrene

route①: cross membrane by endocytosis (enter the tissues)

digested into new fragments

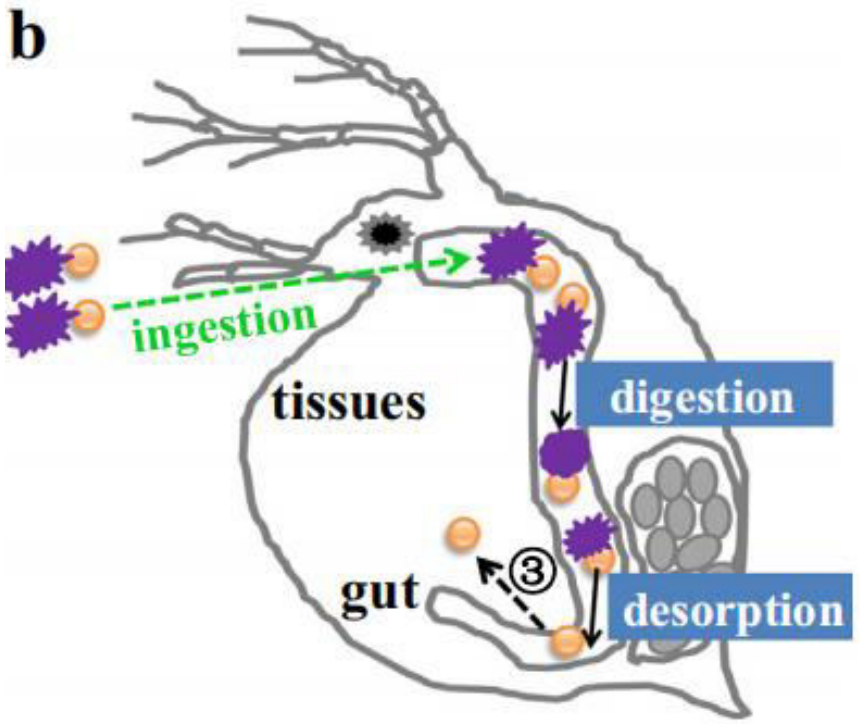
route②: the new fragment-associated pyrene (enter the tissues)

pyrene desorb from the microplastics in the intestine

route③: pyrene cross the intestinal barrier (enter the tissues)

increase the steady-state concentration level of total pyrene in *D. magna* tissues

Uptake mechanisms of microplastic-associated pyrene by *D. magna*



Mechanism two: For MPs (10–60 and 60–230 μm)

pyrene associated with bigger size MPs: could not pass through the cell membrane by endocytosis

the only way: pyrene desorb from the MPs in the gut, cross the intestinal barrier of *D. magna* (route ③)

increase the steady-state concentration level of total pyrene in *D. magna* tissues

Quantify bioavailability of pyrene associated with microplastics of different sizes

Microplastic size (μm)	C_{free} of pyrene (μg L^{-1})	Concentration of MPs (mg L^{-1})	Bioavailable fractions of microplastic-associated pyrene (%) (48 h)	
			Based on the pyrene content of *D. magna*	Based on *D. magna* immobilization
0–1.5	30	5	21.1	20.3
		10	21.6	20.0
		20	20.0	20.7
		30	21.2	21.1
10–60	30	5	13.8	11.2
		10	13.0	11.0
		20	13.6	10.7
		30	13.8	12.2
60–230	30	5	6.0	6.6
		10	6.4	8.1
		20	7.0	7.9
		30	9.8	9.0

Maximum

Minimum

Calculation based on BCF

$$BCF = \frac{C_{tissue}}{C_{free}} = \frac{C'_{tissue}}{C_{effective}}$$

$$F_{MPs} = \frac{C_{effective} - C_{free}}{C_{MPs\text{-}associated\ pyrene}} \times 100\%$$

$$F'_{MPs} = \frac{C'_{effective} - C_{free}}{C_{MPs\text{-}associated\ pyrene}} \times 100\%$$

Bioavailability

0–1.5 μm > 10–60 μm > 60–230 μm PS MPs

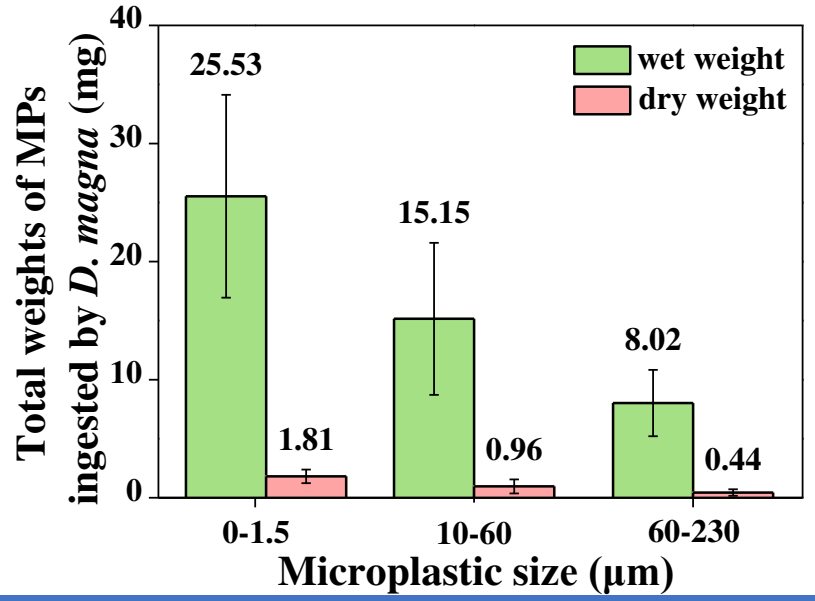
Bioavailability of pyrene associated with microplastics of different sizes

Bioavailabiltiy of pyrene associated with microplastics of different sizes:

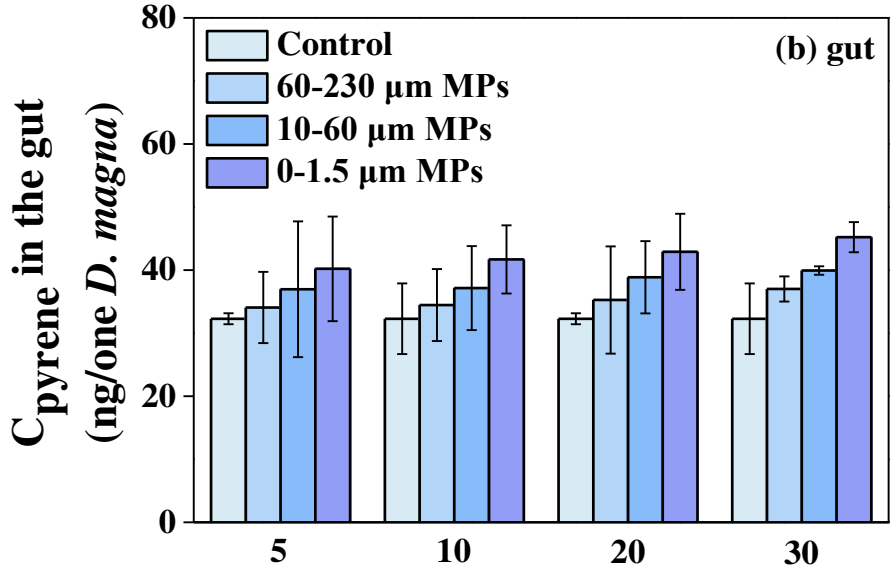
0–1.5 μm > 10–60 μm > 60–230 μm PS MPs **Why?**

Mechanism one/Tree ways **Mechanism two/one way**

Weight of ingested MPs



pyrene content in the gut



Group Introduction (China)

Xinghui Xia
My PhD supervisor
Beijing Normal Univ.

Hui Lin (presenter)
1. Nanchang hangkong Univ. (2019-2022)
2. Gannan Normal Univ. (2023-)

focus on
1. Bioavailability of POPs and MPs
2. Degradation of BPA, DOC, and MPs

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Thank you!