



Microplastics in interaction with pollutants – Insights on impacts on freshwater fauna



Saskia Rehse, Andrea Zikova, Wibke Kleiner,
Werner Kloas, Christiane Zarfl

Microplastics (MP) in aquatic ecosystems

Microplastics (MP) in aquatic ecosystems



Size



Shape

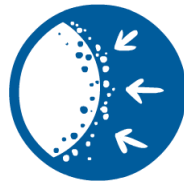
Microplastics (MP) in aquatic ecosystems



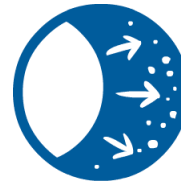
Size



Shape



Sorption



Mobility

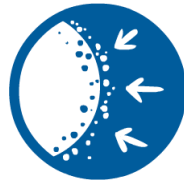
Microplastics (MP) in aquatic ecosystems



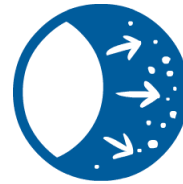
Size



Shape



Sorption



Mobility

Characteristics

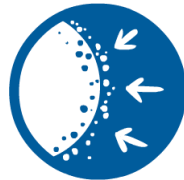
Microplastics (MP) in aquatic ecosystems



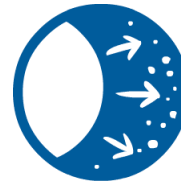
Size



Shape



Sorption



Mobility



Uptake



Effects

Characteristics

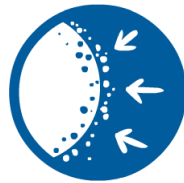
Microplastics (MP) in aquatic ecosystems



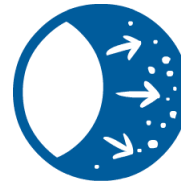
Size



Shape



Sorption



Mobility

Characteristics



Uptake



Effects

**Environmental
relevance**

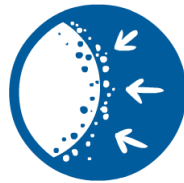
Microplastics (MP) in aquatic ecosystems



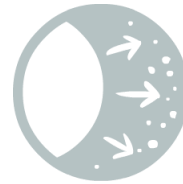
Size



Shape



Sorption



Mobility

Characteristics



Uptake



Effects

**Environmental
relevance**

Microplastics (MP) in aquatic ecosystems



How do MP influence effects of chemical pollutants?

Microplastics (MP) and chemical pollutants

● MP

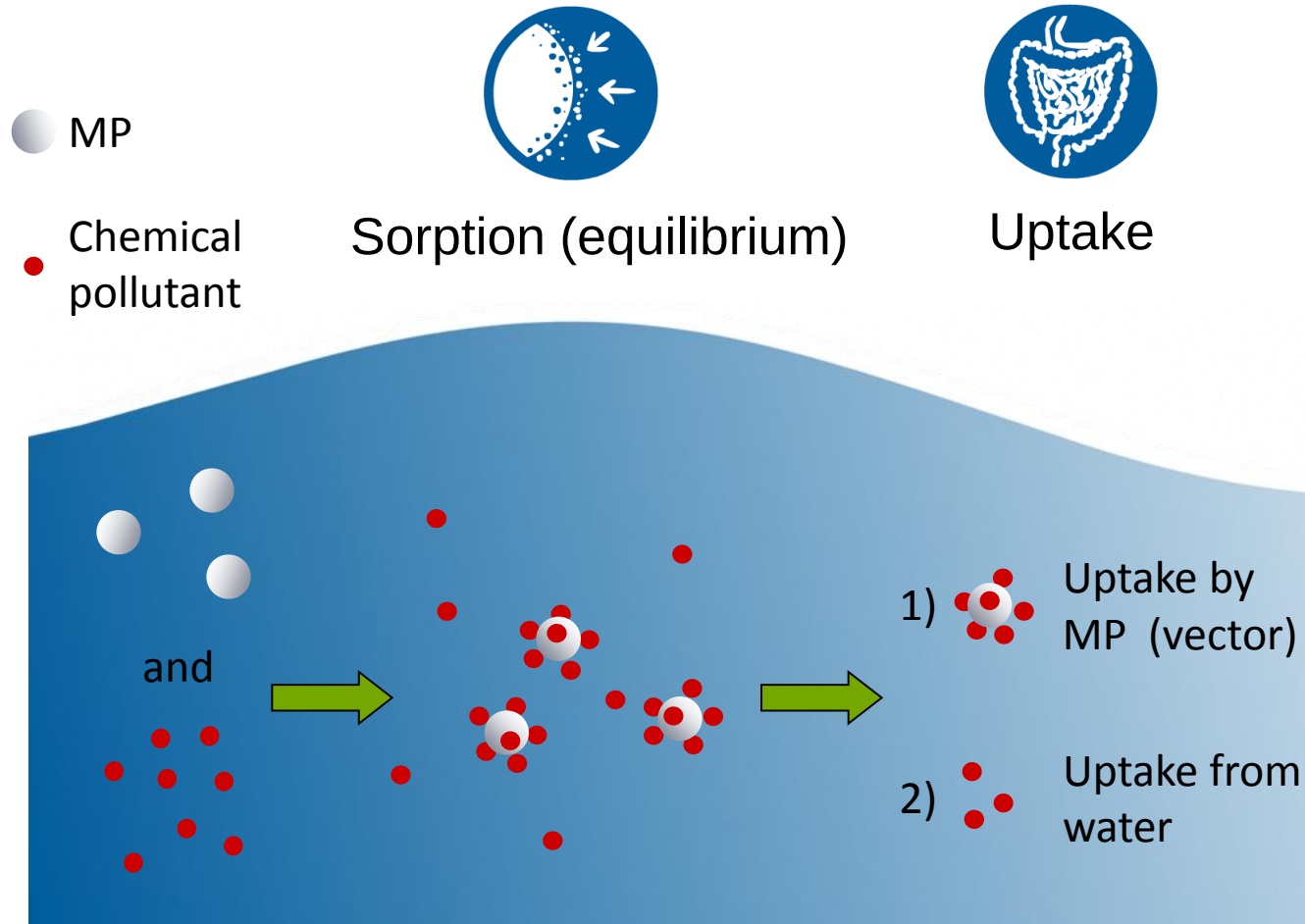
● Chemical
pollutant



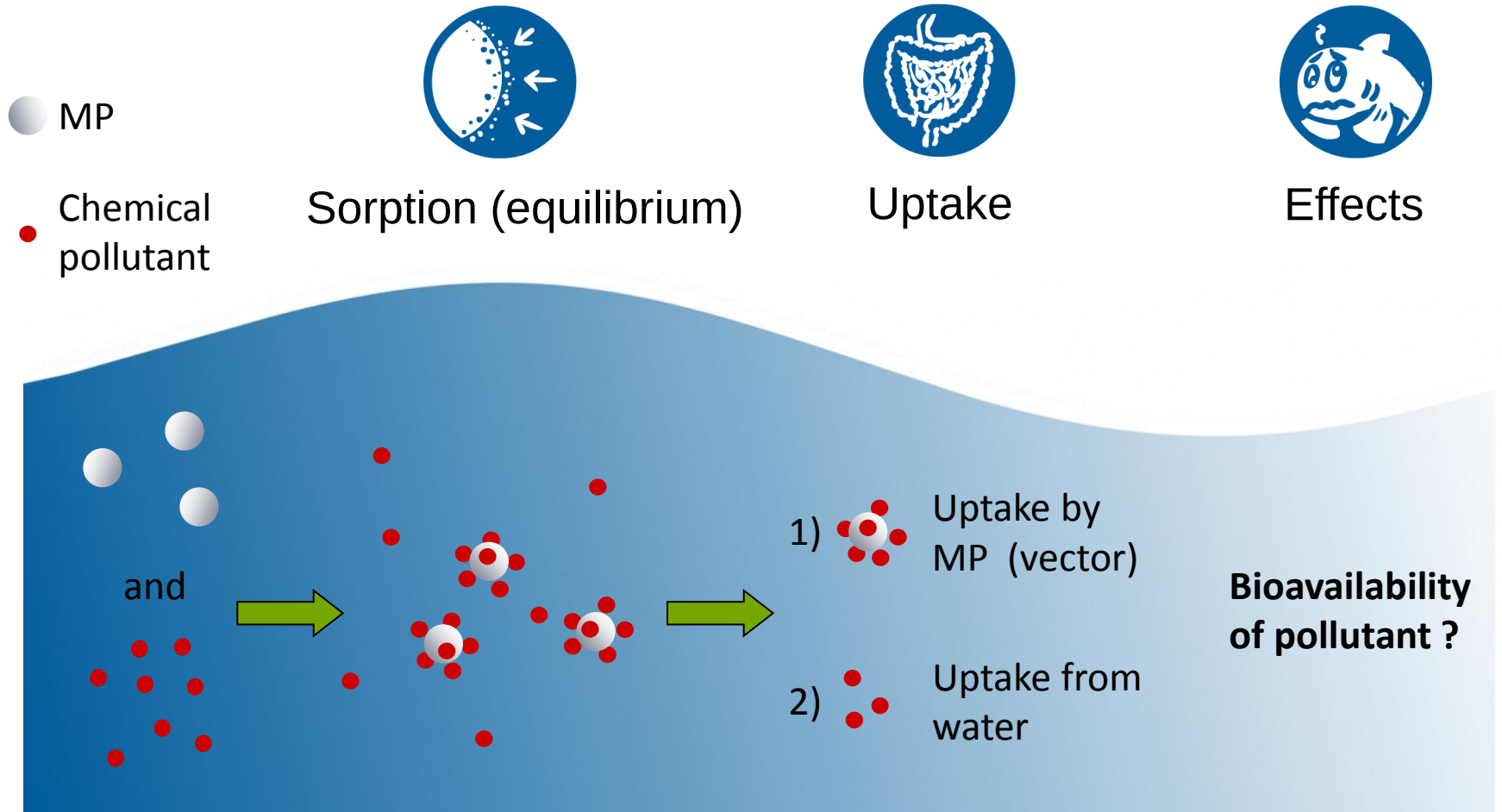
Microplastics (MP) and chemical pollutants



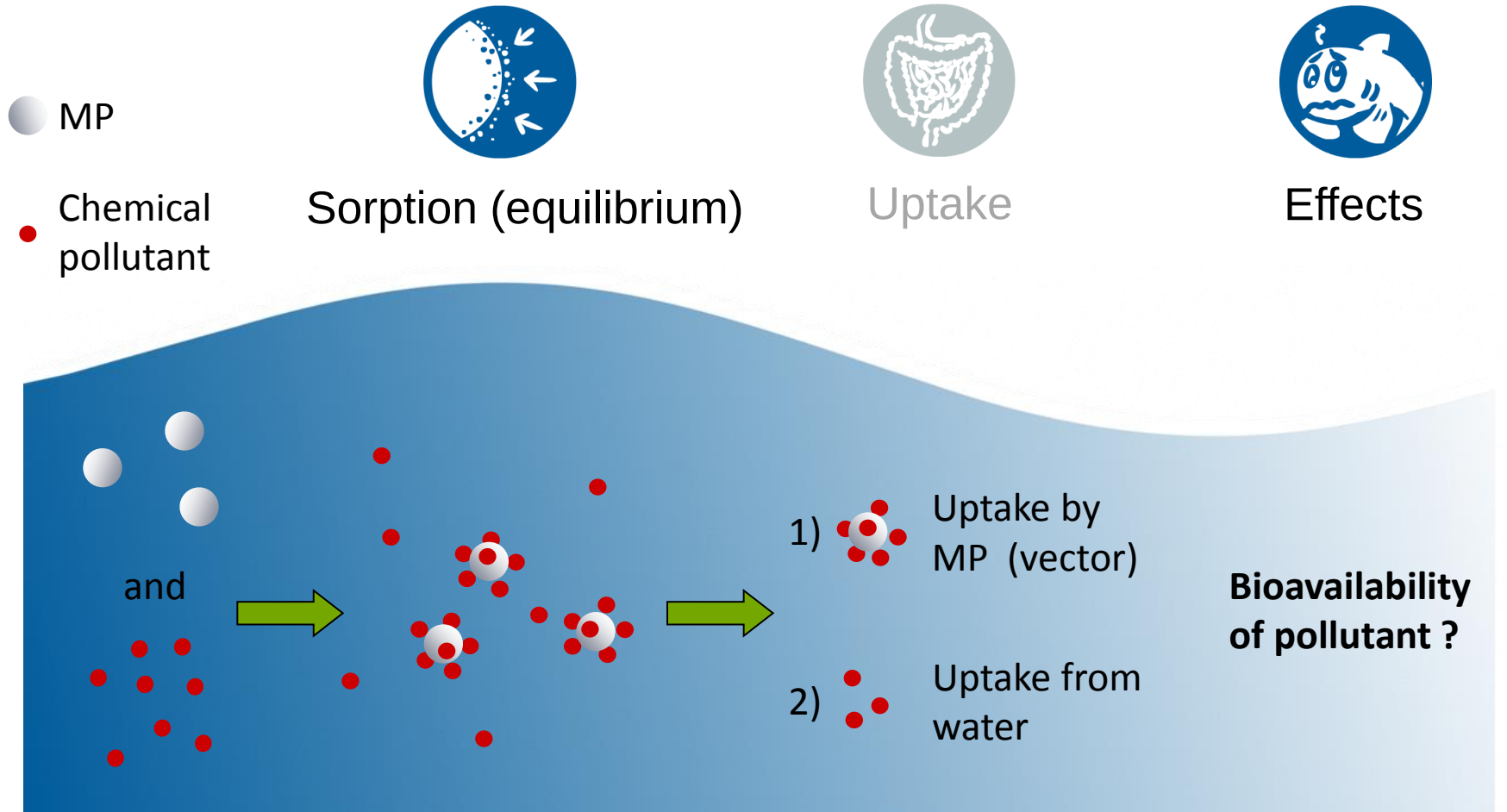
Microplastics (MP) and chemical pollutants



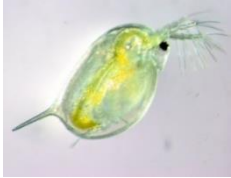
Microplastics (MP) and chemical pollutants



Microplastics (MP) and chemical pollutants



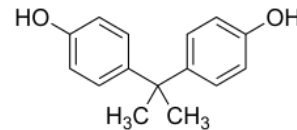
Mixture effects on limnic zooplankton



Daphnia magna



polyamide (PA) particles
15-20 μm , 200 mg L^{-1}

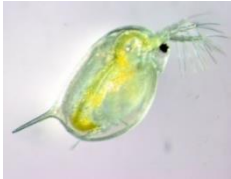


bisphenol A (BPA)
5-20 mg L^{-1}

24 h
48 h

short-term exposure,
acute effects

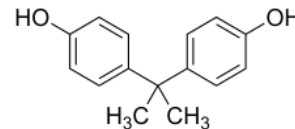
Mixture effects on limnic zooplankton



Daphnia magna



polyamide (PA) particles
15-20 μm , 200 mg L^{-1}



bisphenol A (BPA)
5-20 mg L^{-1}

24 h
48 h

short-term exposure,
acute effects

Batch experiments with exposure of

Shaking of mixtures for 48 h prior to exposure **until sorption equilibrium** reached.

1) only PA

One PA concentration and varying BPA concentrations.

2) only BPA

Immobilisation as criterion for acute effects.

3) mixture of PA + BPA

PA-particles alone do **not induce immobilisation**.

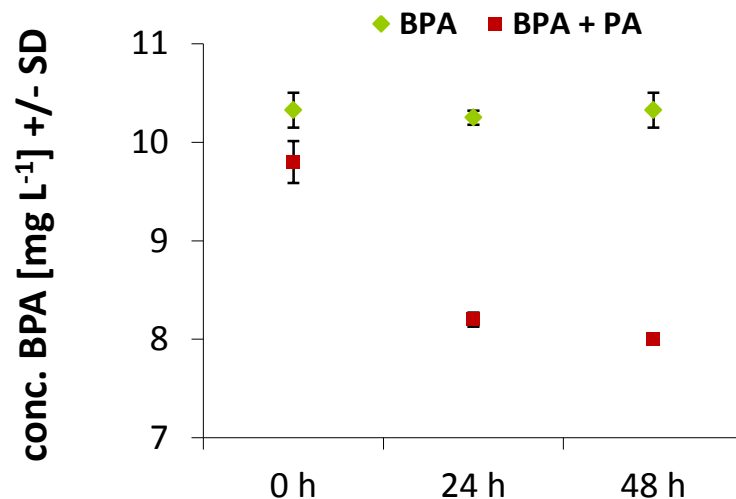
4) control with only water

Mixture effects on limnic zooplankton

Shaking prior to exposure

Sorption of BPA to PA particles with equilibrium after 48 hours.

Concentration of BPA in water lower for
BPA + PA.

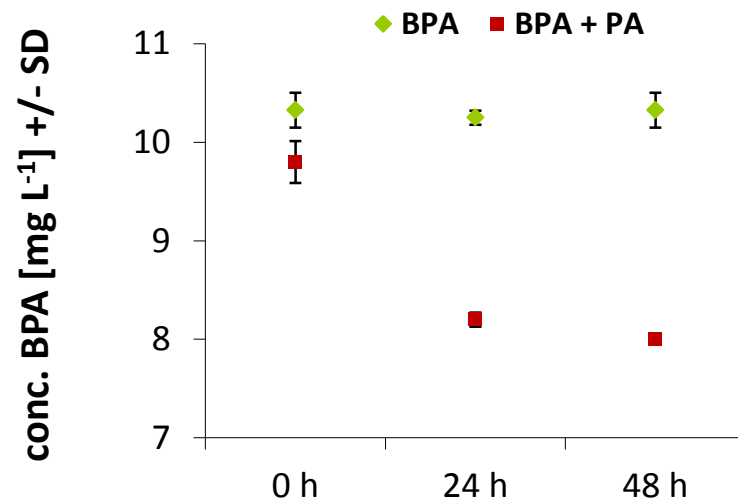


Mixture effects on limnic zooplankton

Shaking prior to exposure

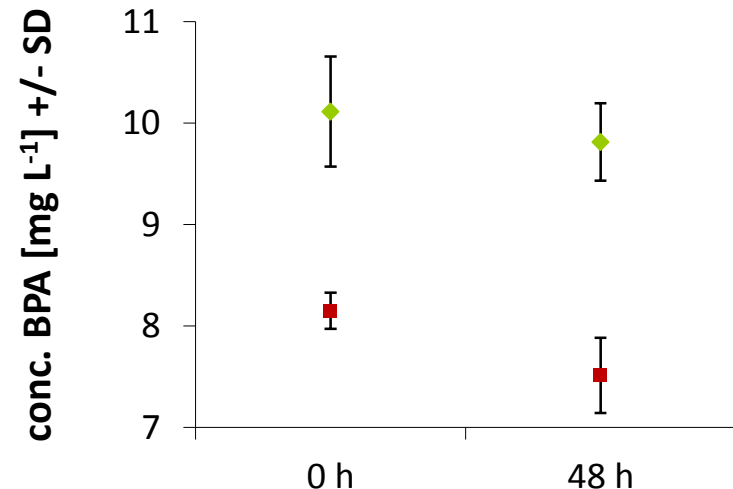
Sorption of BPA to PA particles with equilibrium after 48 hours.

Concentration of BPA in water lower for **BPA + PA**.



During exposure

Concentrations of BPA in water at the end of exposure slightly decreased compared to the beginning.



Mixture effects on limnic zooplankton

Particles are **ingested** within the first 24 hours.

BPA alone causes typical dose-dependent immobilisation.

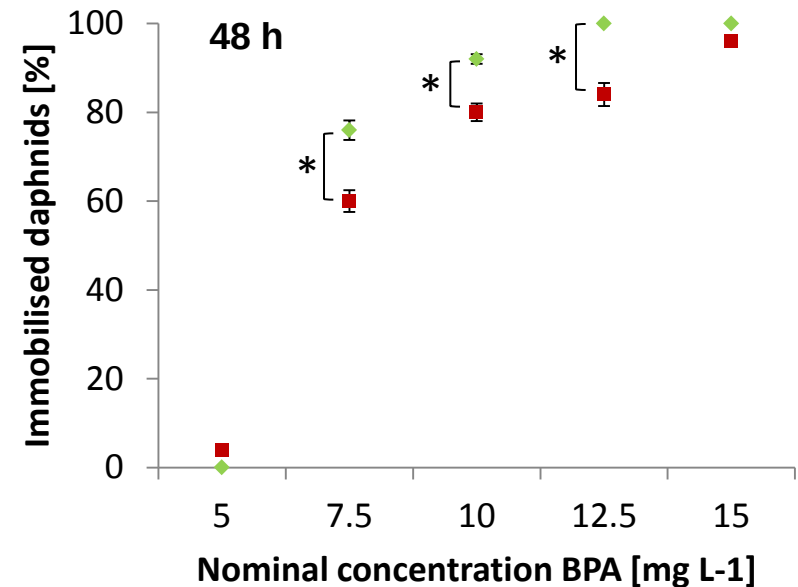
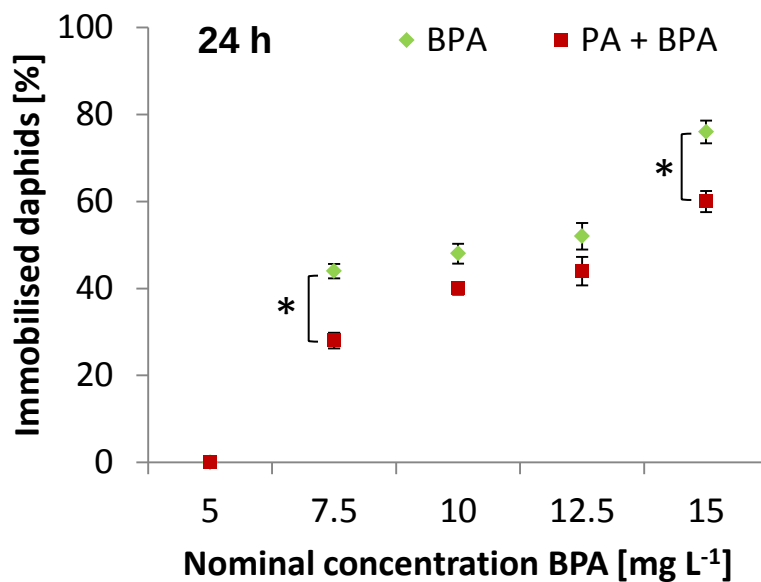
Immobilisation lower for **BPA + PA** compared to **BPA alone**.

Mixture effects on limnic zooplankton

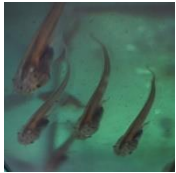
Particles are **ingested** within the first 24 hours.

BPA alone causes typical dose-dependent immobilisation.

Immobilisation lower for **BPA + PA** compared to **BPA alone**.



Mixture effects on amphibians



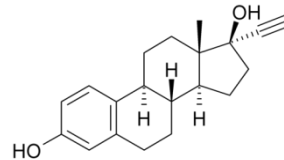
Xenopus laevis



PA particles

1 mg L⁻¹ (low)

100 mg L⁻¹ (high)

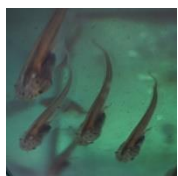


17 α -ethinylestradiol
(EE2), 2.96 μ g L⁻¹

7 d
21 d

short- and long-term
exposure

Mixture effects on amphibians



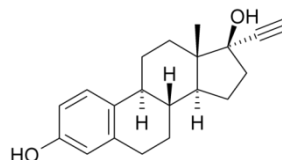
Xenopus laevis



PA particles

1 mg L⁻¹ (low)

100 mg L⁻¹ (high)



17 α -ethinylestradiol
(EE2), 2.96 μ g L⁻¹

7 d

21 d

short- and long-term
exposure

Batch experiments with

- 1) PA low
- 2) PA high
- 3) EE2
- 4) PA low + EE2
- 5) PA high + EE2
- 6) control with only water

General endpoints

Larval development (growth, larval stage),
stress hormones

EE2 specific endpoints (endocrine disruption)

Sexual development (morphology gonads),
biomarkers from liver, pituitary and gonads

Mixture effects on amphibians

PA-particles are infiltrated, no effects on general endpoints (stress, growth etc.).

Feminization of males in treatments with EE2.

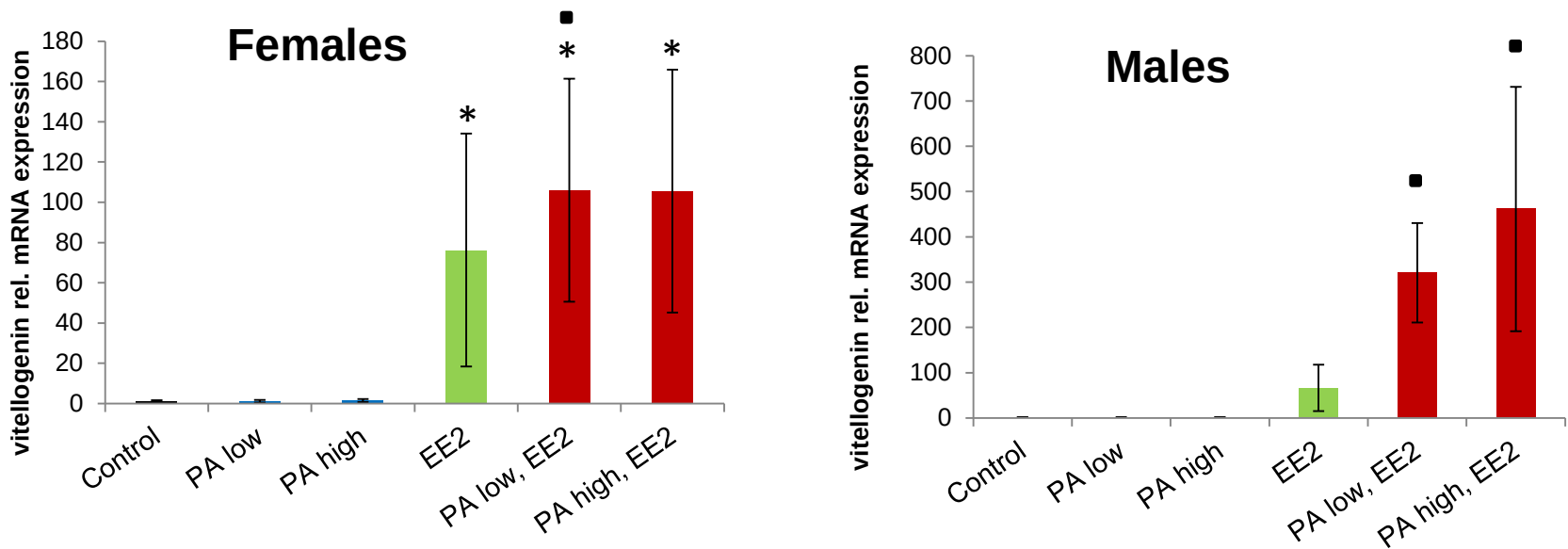
Concentration of EE2 lower in water for PA + EE2; vitellogenin levels indicate higher exposure for EE2.

Mixture effects on amphibians

PA-particles are infiltrated, no effects on general endpoints (stress, growth etc.).

Feminization of males in treatments with EE2.

Concentration of EE2 lower in water for **PA + EE2**; vitellogenin levels indicate higher exposure for EE2.



Mean +/- SD, n = 4-9,

Significant differences ($p < 0.05$) compared to control * and to PA low ■
Kruskal-Wallis with Dunn's multiple comparison test

Overall conclusions

In equilibrium and at high pollutant and MP concentrations the concentration of the pollutant (here BPA) in water is crucial for the rate of effects on zooplankton.

Bioavailability of BPA is reduced in the presence of MP, although MP loaded with BPA are ingested.

MP themselves do not cause physical effects in tadpoles, but increase the effects of EE2 on vitellogenin as sensitive biomarker for endocrine disruption.



EBERHARD KARLS
UNIVERSITÄT
TÜBINGEN



sponsored by



Deutsche
Bundesstiftung Umwelt

www.dbu.de

Special thanks to:

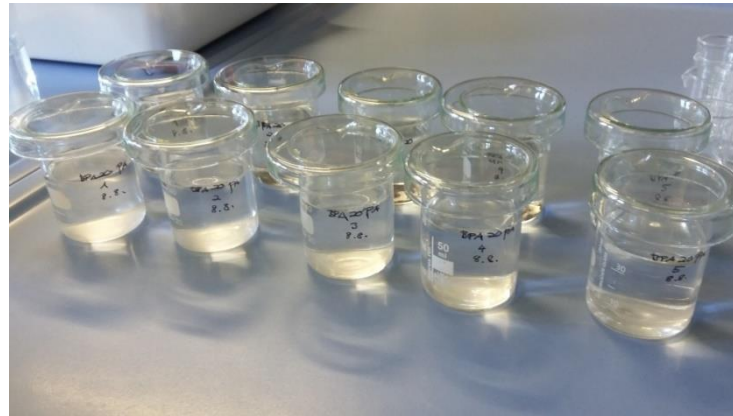
Christiane Zarfl and Werner Kloas

Wibke Kleiner, Andrea Zikova, Nadine Possnien, Antje Tillack, Claudia Lorenz, Angela Krüger and Claudia Theel

The DAAD for funding of conference attendance

Combined effects of MP and chemical pollutants

Exposure of daphnids with PA and BPA, experimental setup

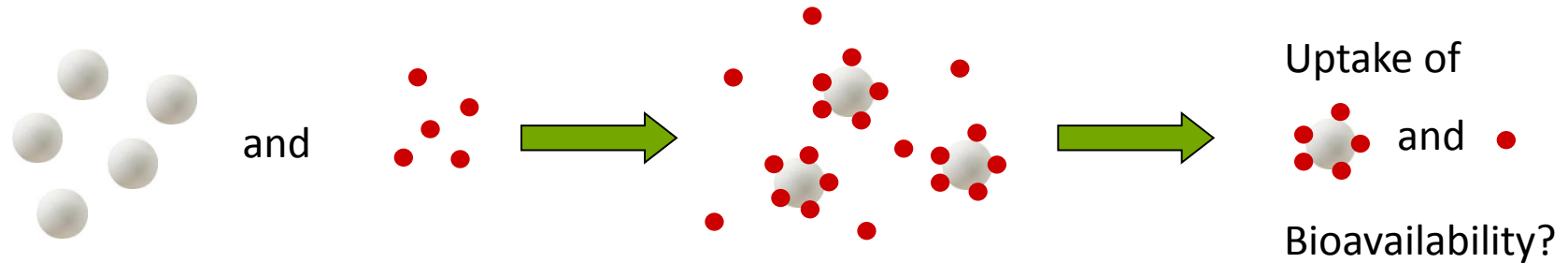


Combined effects of MP and chemical pollutants

Exposure of tadpoles with PA and EE2, experimental setup



Combined effects of MP and chemical pollutants



Hypotheses for effects of chemical pollutant on organisms:

Lower pollutant concentration of pollutant in water due to sorption to MP leads to lower effects of pollutant on organisms.

MP act as vector for pollutants and lead to increased bioavailability in organisms.

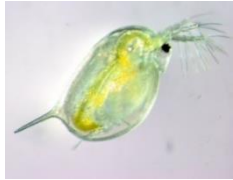
Processes balance each other leading to the same bioavailability and effect rates.

Combined effects of MP and chemical pollutants

Overview of general and specific endpoints for exposure of *X. laevis*

Effects on	Single endpoint	7 d	21 d
growth, general development	weight	x	x
	length total	x	x
	length snout-vent	x	x
	length leg	x	-
	developmental stage	x	x
physical effects PA	histology intestines	x	x
	histology head with gills	x	-
stress	corticosterone, aldosterone	x	x
genexpression of biomarkers	liver: vitellogenin	(x)	x
	pituitary: LH, FSH	(x)	x
	gonad + kidney: aro, P450, S1, S2, stAR	-	x
genetical sex	DNA from tail	-	x
morphological sex	gross-morphology gonads	-	x
morphological sex	gross-morphology gonads	-	x

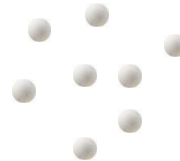
Physical effects of MP on zooplankton



Daphnia magna



100 and 1 µm
polyethylene (PE) particles



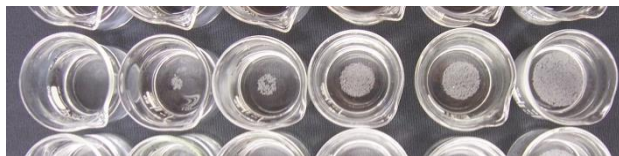
12.5-400 mg L⁻¹

24 h
48 h
72 h
96 h

short-term exposure,
acute effects

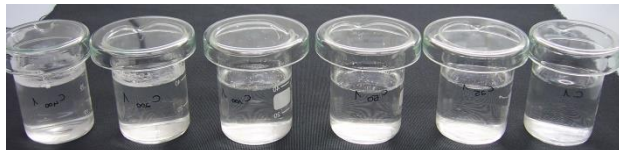
Particle behaviour determines exposure scenario for daphnids

100 µm



→ Particles floating at water surface

1 µm



→ Particles present in water column

Concentration

Physical effects of MP on zooplankton

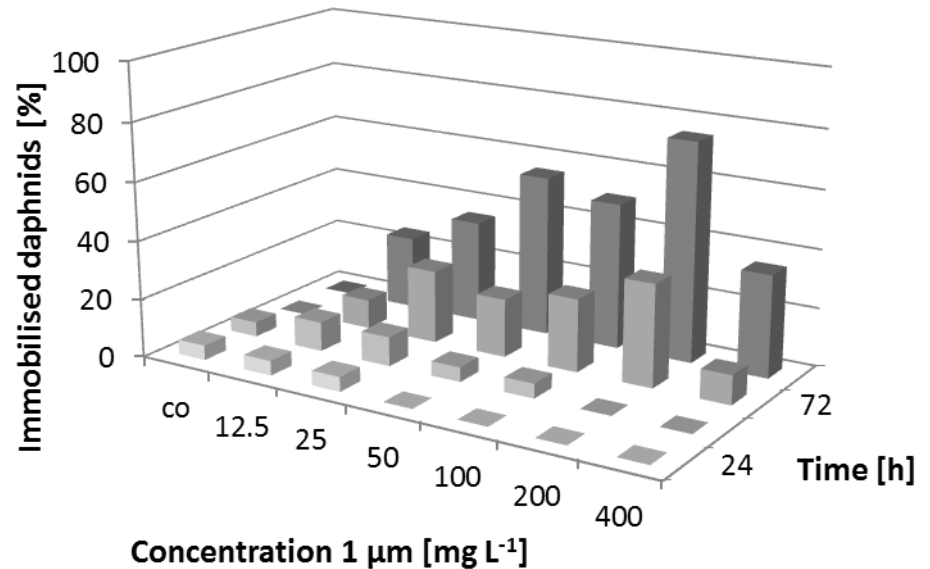


Control after 96 h



1 µm, 400 mg L⁻¹, 96 h

Both figures from Rehse et al. 2016, Chemosphere 153, 91-99



Uptake of 1-µm PE-particles within the first 24 hours.

No uptake of 100-µm particles.

Increased immobilisation with increasing concentrations and longer exposure 1-µm particles.

No effects for 100-µm particles.