

# Centrum environmentálního výzkumu: Odpadové a oběhové hospodářství a environmentální bezpečnost

WP 1.B NOVÉ DRUHY ODPADŮ  
A TECHNOLOGIÍ  
WP 2.B KONTAMINACE HORNINOVÉHO PROSTŘEDÍ

konference  
Životní prostředí – Prostředí pro život  
2. – 3. 11. 2023, NTK Praha



T A  
Č R

Tento projekt je spolufinancován se státní podporou Technologické agentury ČR a Ministerstva životního prostředí v rámci Programu Prostředí pro život.

[www.tacr.cz](http://www.tacr.cz)   [www.mzp.cz](http://www.mzp.cz)



# Negativní vliv mikroplastů na životní prostředí

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Univerzita Karlova, Benátská 2, 128 01 Praha 2*





# Původ mikroplastů



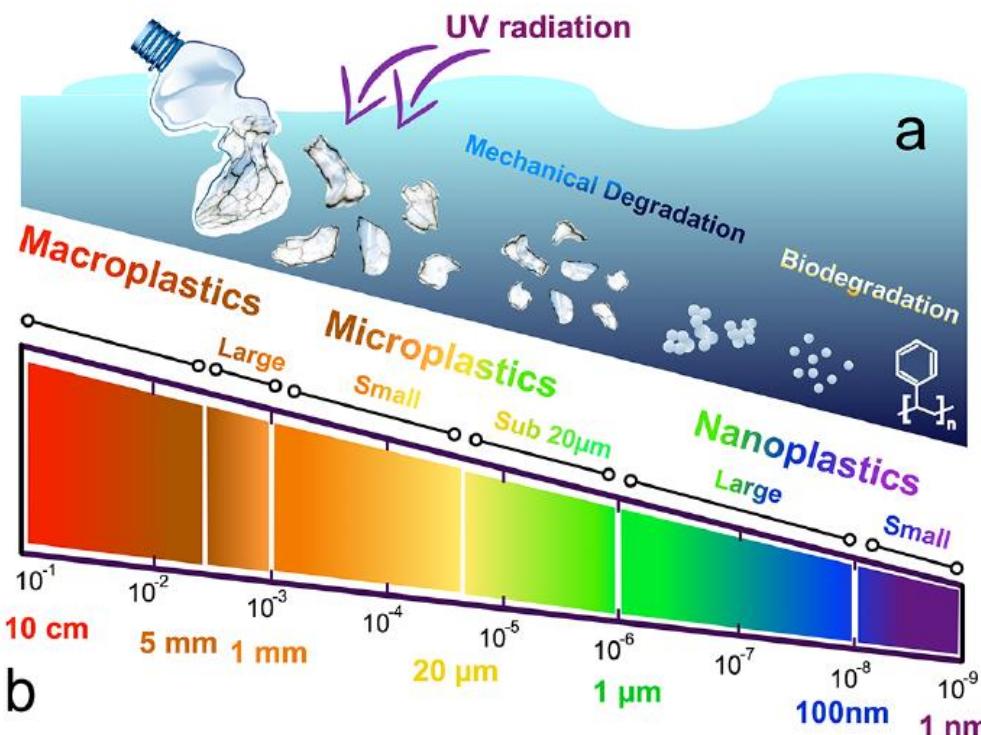
## PRIMÁRNÍ MIKROPLASTY

do životního prostředí vstupují  
v podobě mikročástic

## SEKUNDÁRNÍ MIKROPLASTY

vznikají z životního prostředí rozpadem  
větších plastových předmětů

### Proces degradace plastů a dělení částic dle velikosti



Gillibert, R. et al. (2019) 'Raman tweezers for small microplastics and nanoplastics identification in seawater', *Environmental Science and Technology*, 53(15), pp. 9003–9013. doi: 10.1021/acs.est.9b03105.

### TYPES OF MICROPLASTICS | Overview



Fibres



Pellets



Films



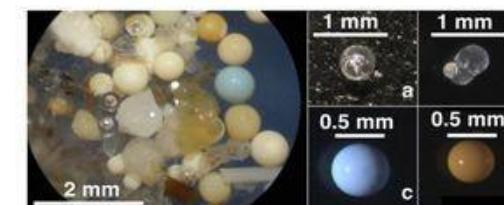
Fragments



Foam



Microbeads

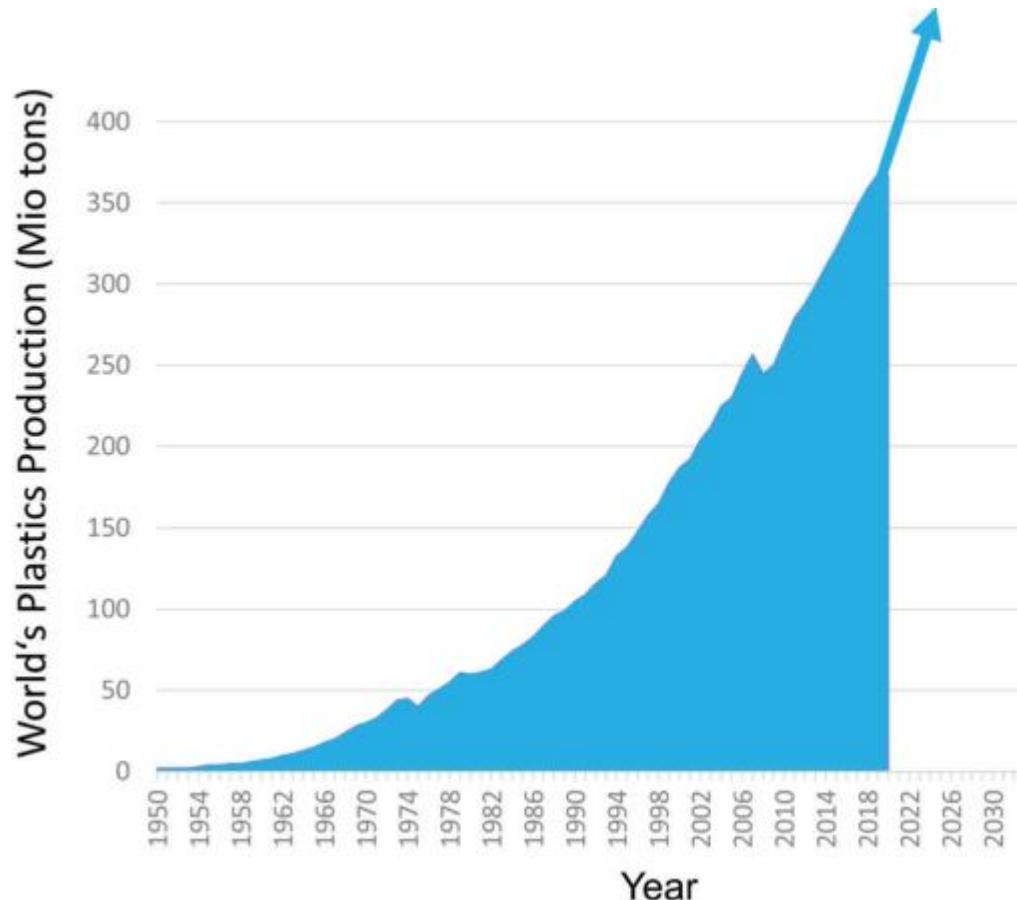




# Celosvětová produkce plastů



Od počátků



V posledních letech

## World plastics production\* evolution

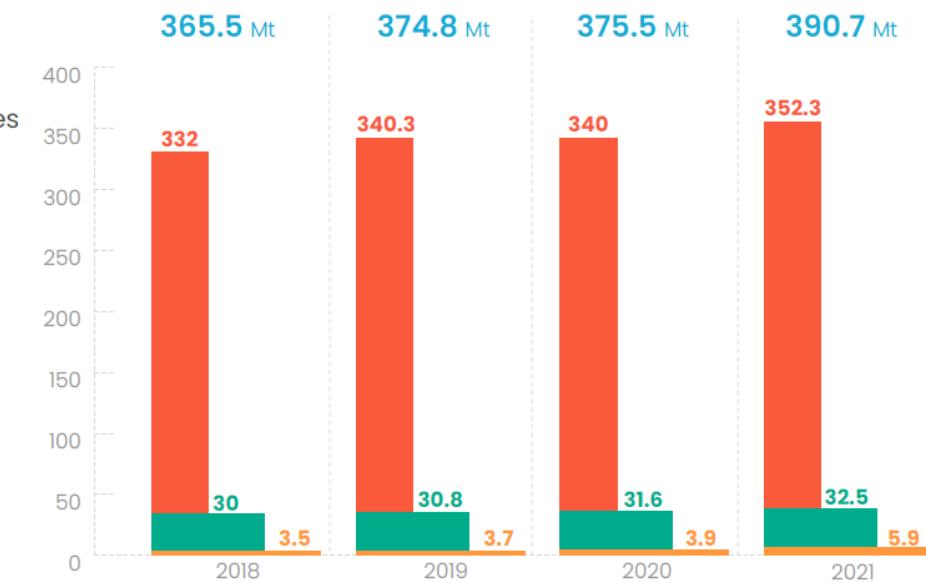
After a stagnation in 2020 due to the Covid-19 pandemic, the global plastics production increased to 390.7 million tonnes in 2021.

in million tonnes

Fossil-based plastics<sup>1</sup>

Post-consumer recycled plastics<sup>2</sup>

Bio-based plastics (including bio-attributed plastics in 2021 data)<sup>3</sup>



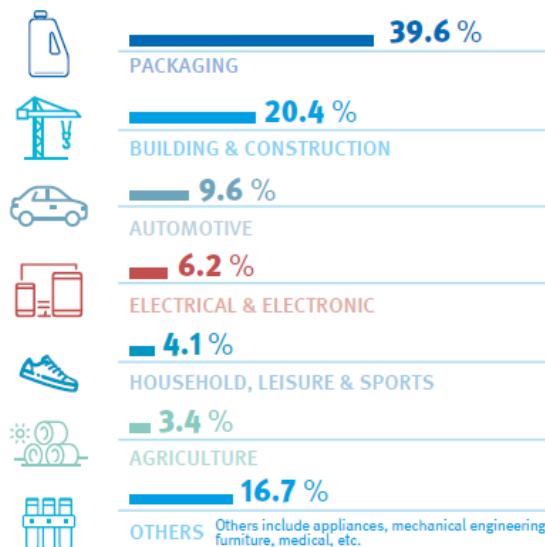


# Využití plastů x čas jejich rozkladu



## PLASTICS DEMAND BY SEGMENT 2019

Distribution of European (EU28+NO/CH) plastics converters demand by segment in 2019. Packaging and building & construction by far represent the largest end-use markets. The third biggest end-use market is the automotive industry.

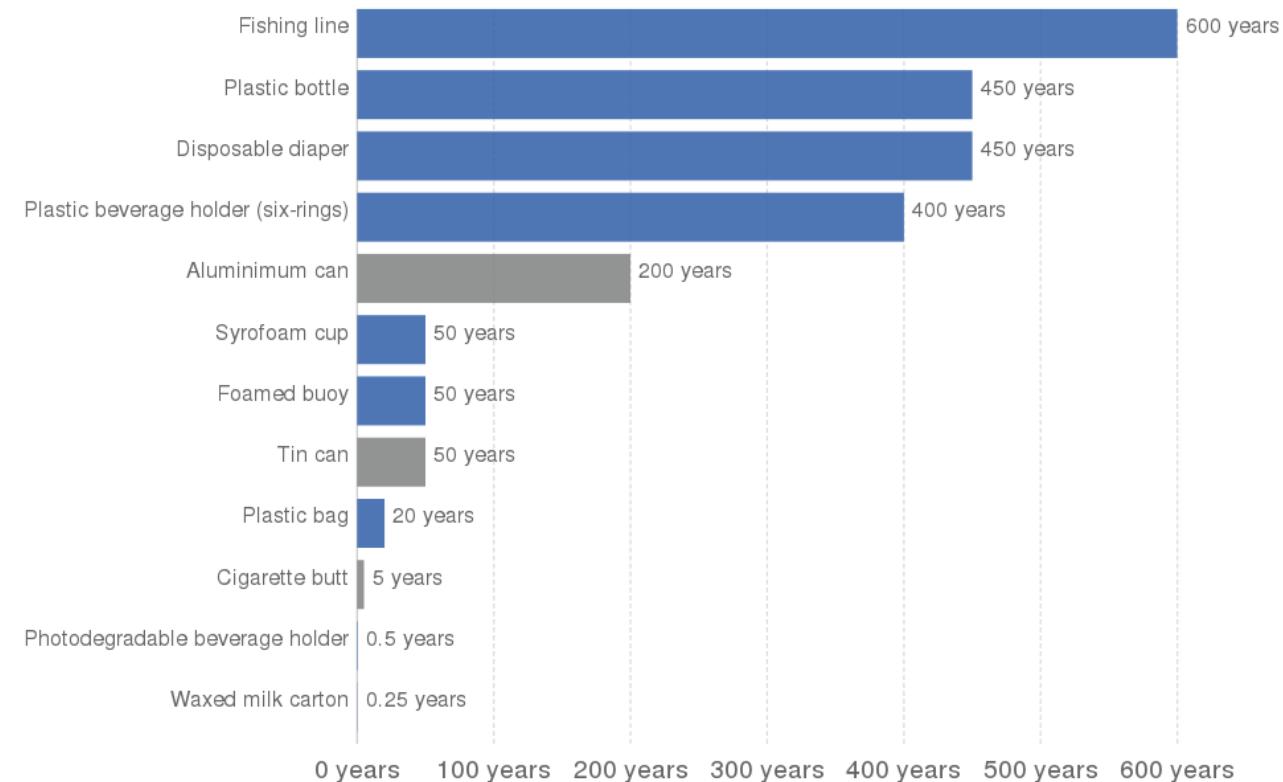


SOURCE: PlasticsEurope  
Market Research Group  
(PEMRG) and Conversio  
Market & Strategy GmbH

50.7 Million tonnes  
Total European  
plastics converters  
demand

## Decomposition rates of marine debris items

Average estimated decomposition times of typical marine debris items. Plastic items are shown in blue.



PlasticsEurope (2019) Plastics – the Facts 2019 An analysis of European plastics production, demand and waste data.

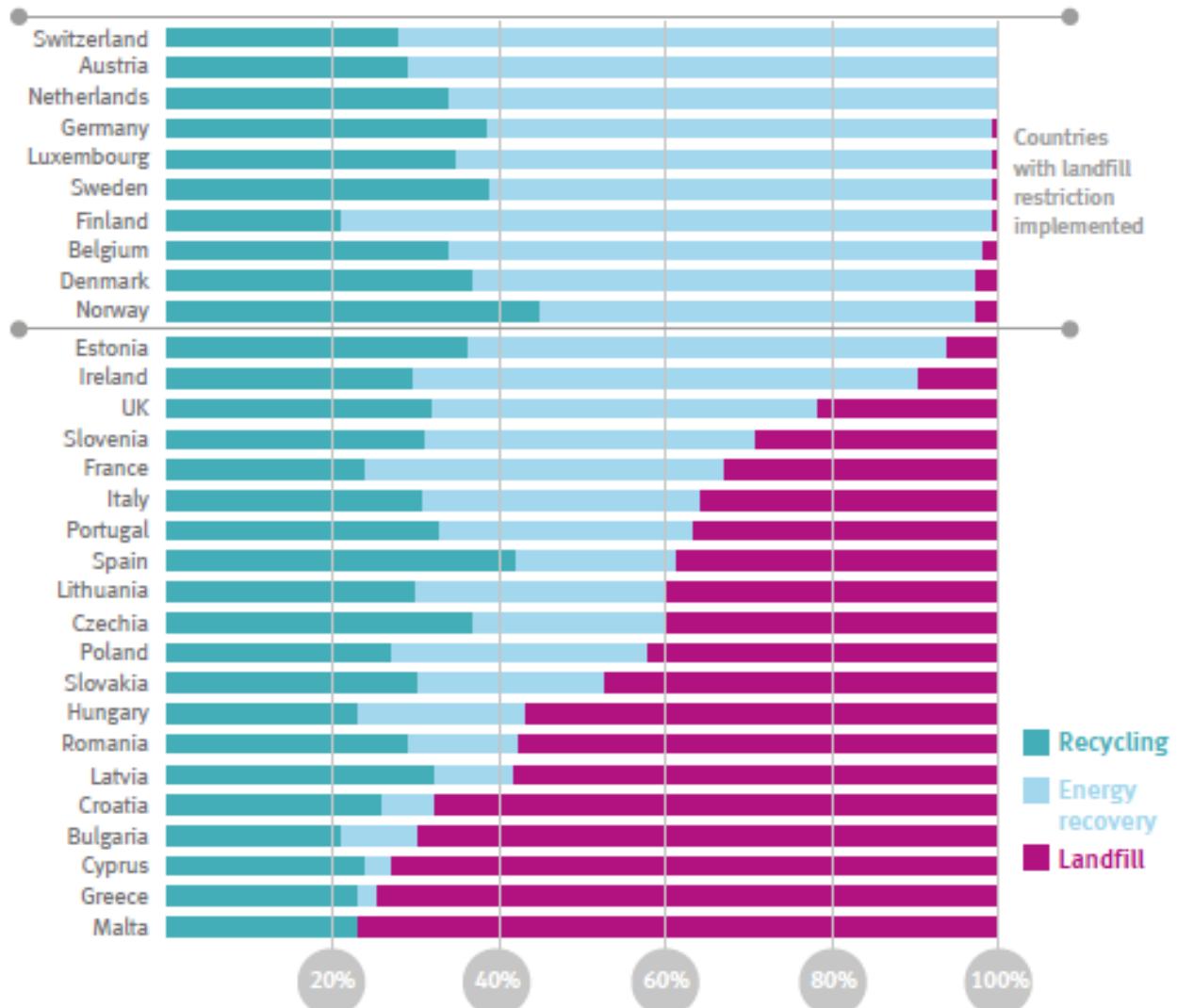
Source: U.S. National Park Service; Mote Marine Lab; National Oceanic and Atmospheric Administration Marine Debris Program



# Nakládání s plastovým odpadem



Plastic post-consumer waste rates of recycling, energy recovery and landfill per country in 2018



Zero  
landfilling  
is needed  
to achieve  
the circular  
economy  
of plastics

Countries with landfill  
restrictions of recyclable  
and recoverable waste  
have, on average,  
higher recycling rates of  
plastic post-consumer  
waste.

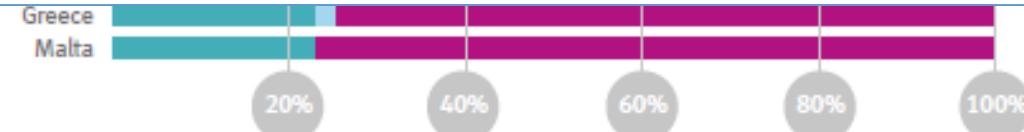
SOURCE: Conversio Market  
& Strategy GmbH



# Nakládání s plastovým odpadem



Plastic post-consumer waste rates of recycling, energy recovery  
and landfill per country in 2019



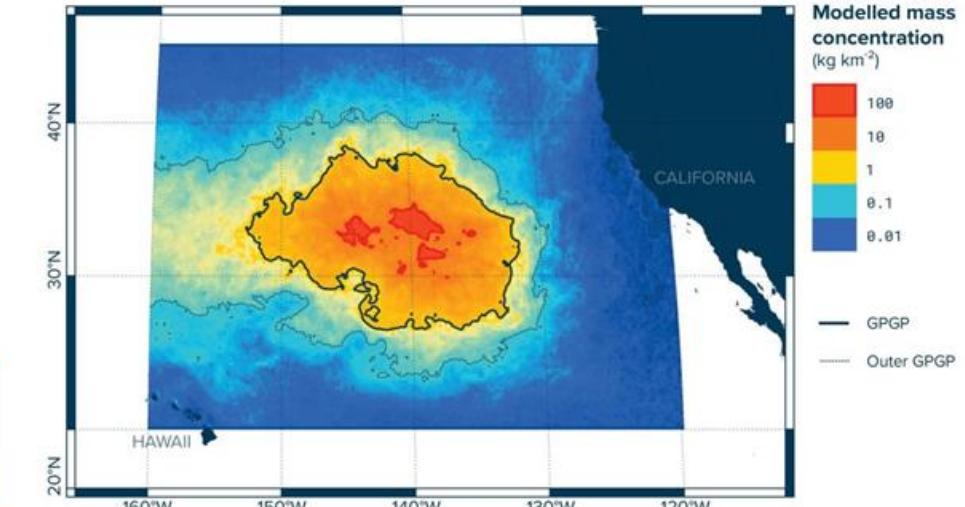
SOURCE: Conversio Market  
& Strategy GmbH



# Nakládání s plastovým odpadem



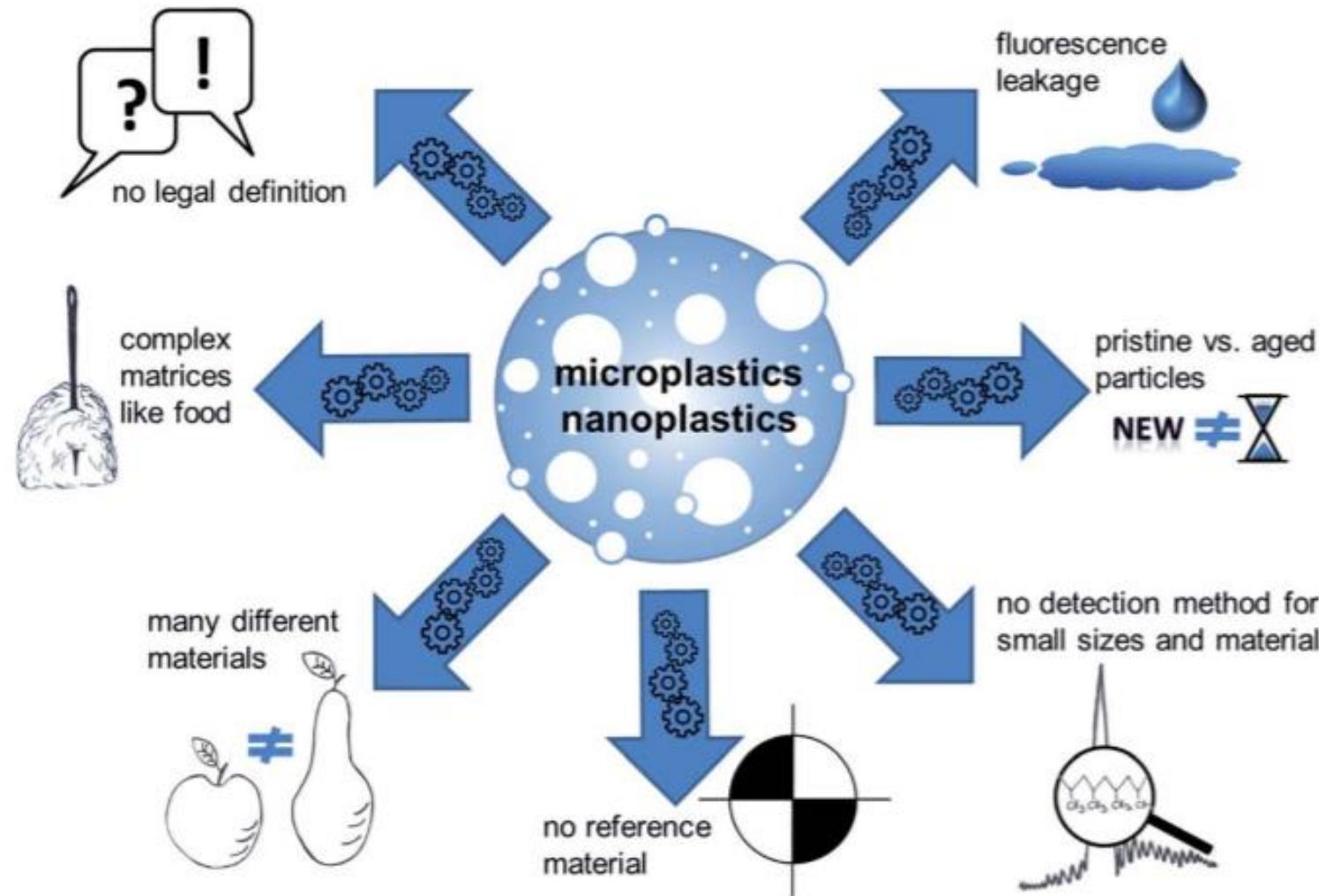
## Velká tichomořská odpadková skvrna



<https://www.thesun.co.uk/news/5878949/great-pacific-garbage-patch-plastic-dump-growing/>

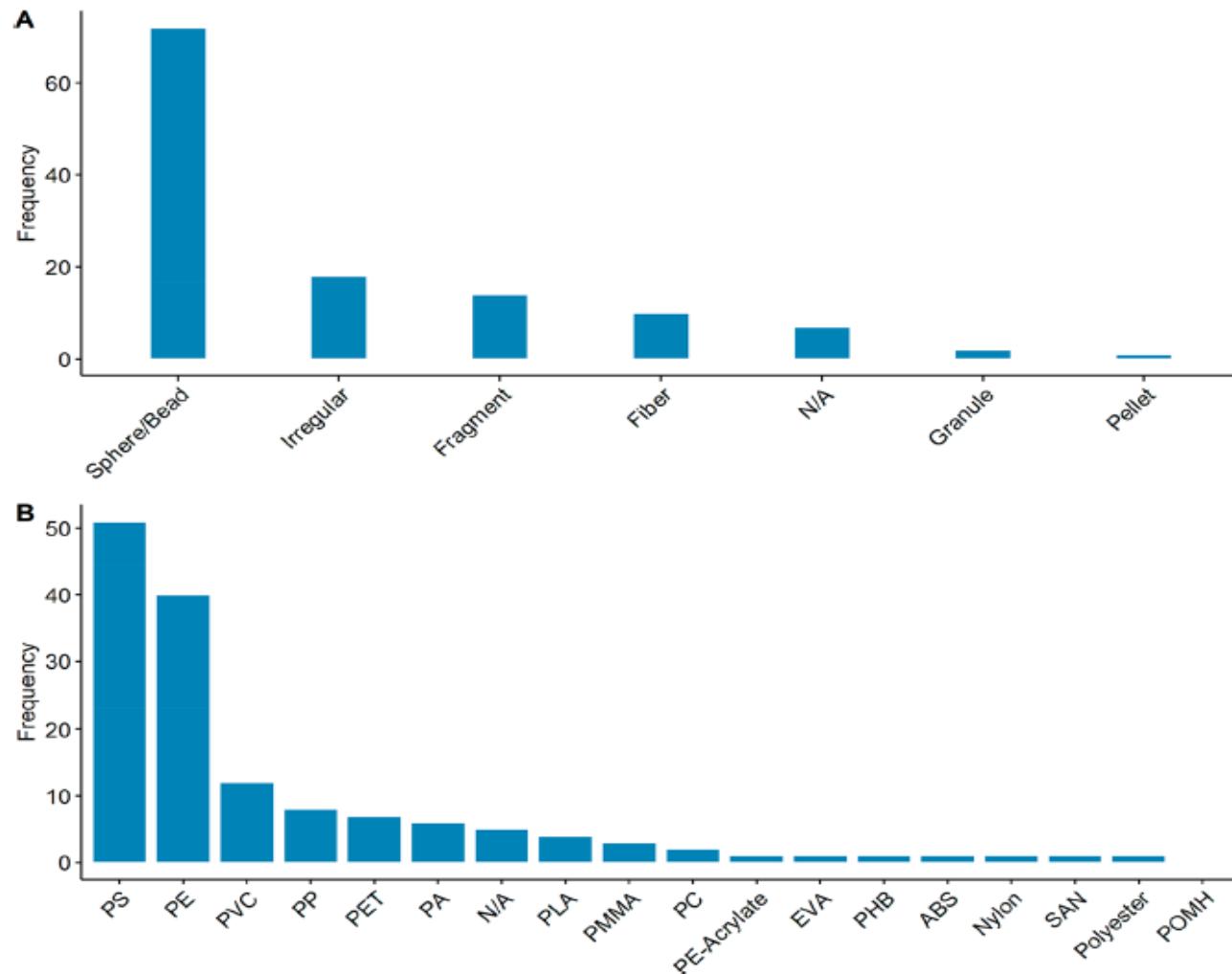


# Výzvy a nástrahy výzkumu mikro- a nanoplastů





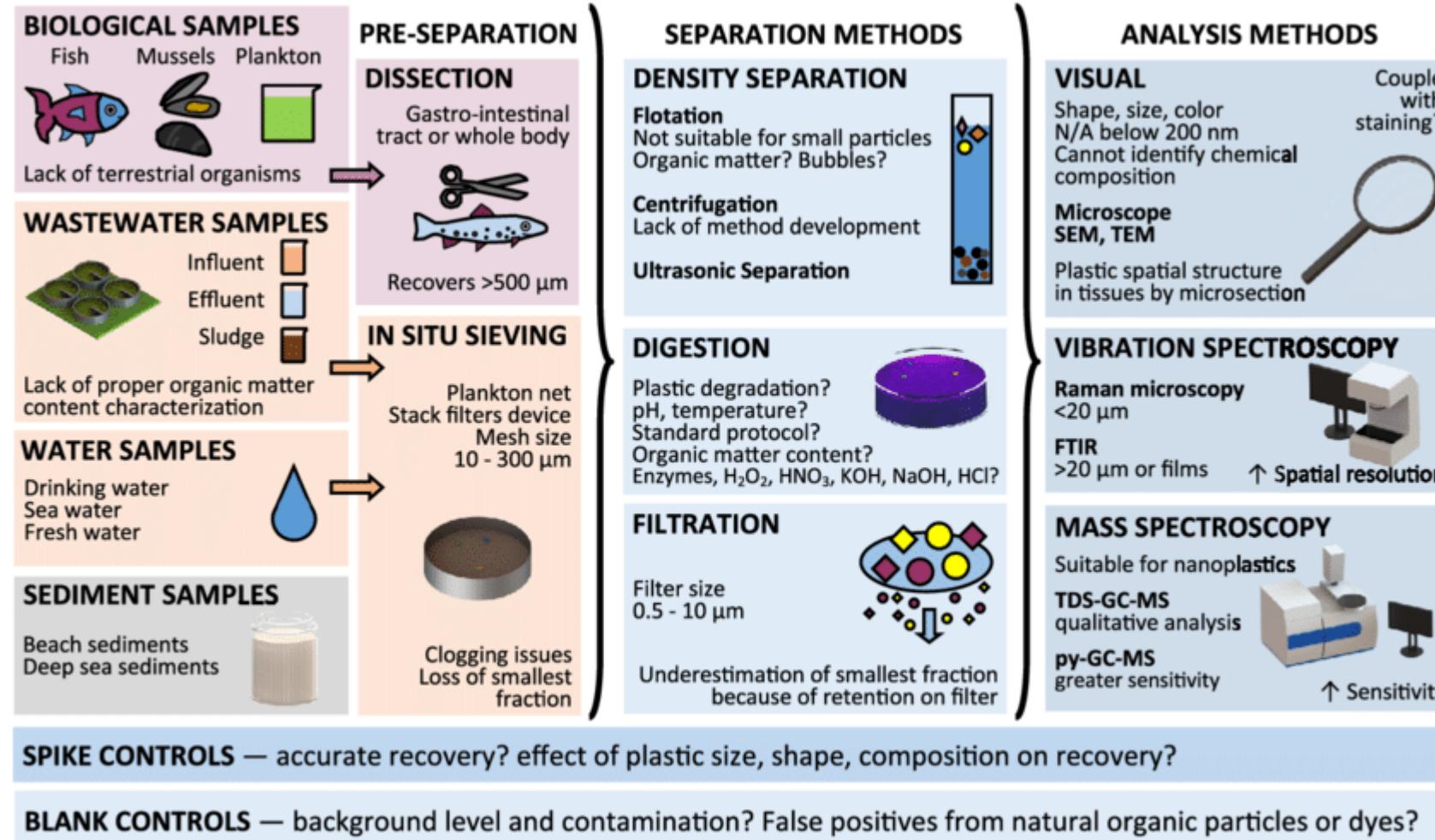
# Nástrahy výzkumu mikroplastů: tvar a materiál



**Figure 2.** Number of studies reporting a particular shape (A) or polymer type (B) for the microplastics used in the exposure tests (from a total of 124 records for shapes and 145 records for polymer types). PS = polystyrene, PE = polyethylene, PVC = polyvinyl chloride, PP = polypropylene, PET = terephthalate, PA = polyamide, N/A = not analyzed, PLA = polylactic acid, PMMA = poly(methyl methacrylate), PC = polycarbonate, PE-Acrylate = polyethylene-Acrylate, EVA = ethylene-vinyl acetate, PHB = polyhydroxybutyrate, ABS = acrylonitrile butadiene styrene, SAN = styrene acrylonitrile resin, and POMH = polyoxymethylene-homopolymer.



# Metody detekce mikroplastů



Overview of microplastics and nanoplastics separation and analysis methods in simple and complex matrices

Nguyen, B. et al. (2019) 'Separation and Analysis of Microplastics and Nanoplastics in Complex Environmental Samples'. doi: 10.1021/acs.accounts.8b00602.



# Kde byly mikroplasty nalezeny?



(Liebezeit and Liebezeit al., 2013, 2014)

(Schymanski et al., 2018)



(Li et al., 2015)

(Hernandez et al., 2019)

(Yang et al., 2015)



# Kde byly mikroplasty nalezeny?



## Moře plná mikroplastů

Podle dat OSN z roku 2018 plave v mořích a oceánech na **51 bilionů kusů mikroplastů (naprosto podhodnocené)**.

(Schymanski et al., 2018)



To je pětsetkrát více, než kolik je v naší galaxii hvězd.

Co se týče všech plastů, každoročně jich v mořích končí 9,5 milionu tun.



(Li et al., 2015)

(Hernandez et al., 2019)



(Yang et al., 2015)



# Mikroplasty



## První studie o výskytu plastů v oceánu – 70. léta (Fowler, 1987; Carpenter et al., 1972; Carpenter and Smith, 1972; Colton and Knapp, 1974)

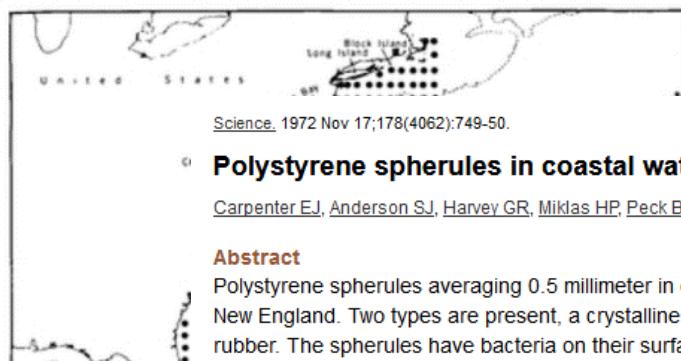
### Plastic Particles in Surface Waters of the Northwestern Atlantic

The abundance, distribution, source, and significance of various types of plastics are discussed.

John B. Colton, Jr., Frederick D. Knapp, Bruce R. Burns

The occurrence of plastic particles has recently been reported in the Sargasso Sea (1) and in coastal waters of southern New England (2, 3). These reports were based on a small number of samples within limited geographic areas, but the observers suggested that plastics might be more widely distributed. We confirm, after examination of neuston (surface) net samples taken in July–August 1972, that plastic particles do occur over a wide area of the North Atlantic.

These samples were collected on the first multiship MARMAP (4) ichthyoplankton survey of coastal and oceanic waters from Cape Cod to the Caribbean. The three National Oceanic and Atmospheric Administration research vessels participating in this survey were the *Albatross IV*, *Delaware II*, and *Oregon II*. The plankton sampling locations for each vessel are shown in



### Polystyrene spherules in coastal waters.

Carpenter EJ, Anderson SJ, Harvey GR, Miklas HP, Peck BB.

#### Abstract

Polystyrene spherules averaging 0.5 millimeter in diameter (range 0.1 to 2 millimeters) are abundant in the coastal waters of southern New England. Two types are present, a crystalline (clear) form and a white, opaque form with pigmentation resulting from a diene rubber. The spherules have bacteria on their surfaces and contain polychlorinated biphenyls, apparently absorbed from ambient seawater, in a concentration of 5 parts per million. White, opaque spherules are selectively consumed by 8 species of fish out of 14 species examined, and a chaetognath. Ingestion of the plastic may lead to intestinal blockage in smaller fish.

spherules containing gaseous voids (5); mean diameter, 1.5 mm; range in diameter, 0.9 to 2.5 mm; mean weight, 0.0014 g; range in weight, 0.0004 to 0.0039 g; density, < 1.000 g/cm<sup>3</sup> (Fig. 2B).

3) Opaque to translucent polyethylene cylinders or disks (5); mean diameter, 3.4 mm; range in diameter, 1.7 to 4.9 mm; mean thickness, 2.0 mm; range in thickness, 1.1 to 3.4 mm; mean weight, 0.0138 g; range in weight, 0.0106 to 0.0250 g; density, < 1.000 g/cm<sup>3</sup> (Fig. 2C).

4) Pieces of Styrofoam (Fig. 2D).  
5) Sheets of thin, flexible wrapping material (Fig. 2E).

6) Pieces of hard and soft, clear and opaque plastics of various thicknesses which appear to be parts of plastic containers, toys, and so forth (Fig. 2F).

Science, 1972 Mar 17;175(4027):1240-1.

### Plastics on the Sargasso sea surface.

Carpenter EJ, Smith KL Jr.

#### Abstract

Plastic particles, in concentrations averaging 3500 pieces and 290 grams per square kilometer, are widespread in the western Sargasso Sea. Pieces are brittle, apparently due to the weathering of the plasticizers, and many are in a pellet shape about 0.25 to 0.5 centimeters in diameter. The particles are surfaces for the attachment of diatoms and hydroids. Increasing production of plastics, combined with present waste-disposal practices, will undoubtedly lead to increases in the concentration of these particles. Plastics could be a source of some of the polychlorinated biphenyls recently observed in oceanic organisms.



### Marine Pollution Bulletin

Volume 18, Issue 6, Supplement B, June 1987, Pages 326-335



### Marine debris and northern fur seals: A case study

Charles W. Fowler

Show more

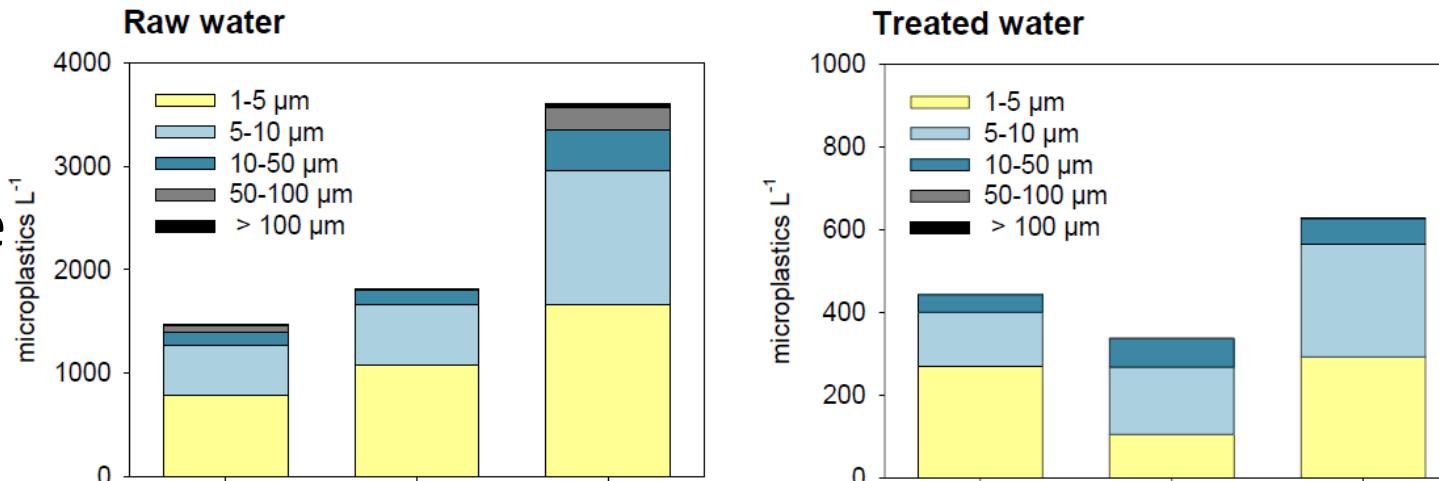
[https://doi.org/10.1016/S0025-326X\(87\)80020-6](https://doi.org/10.1016/S0025-326X(87)80020-6)

Get rights and content

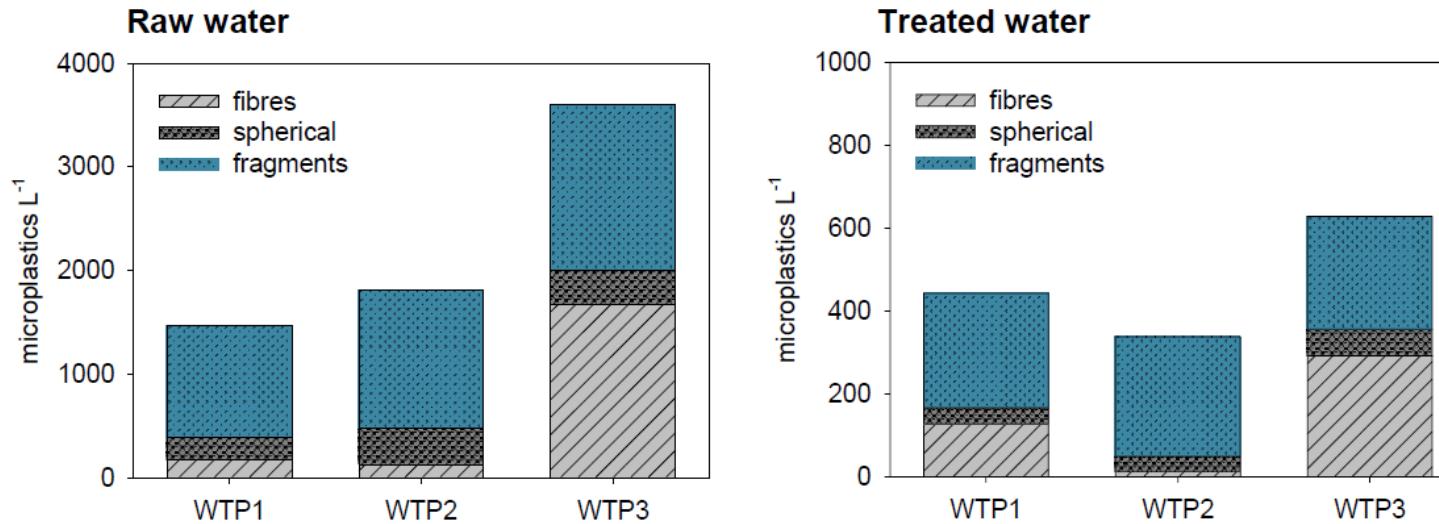


# Mikroplasty v pitných vodách v České republice

## Velikostní distribuce

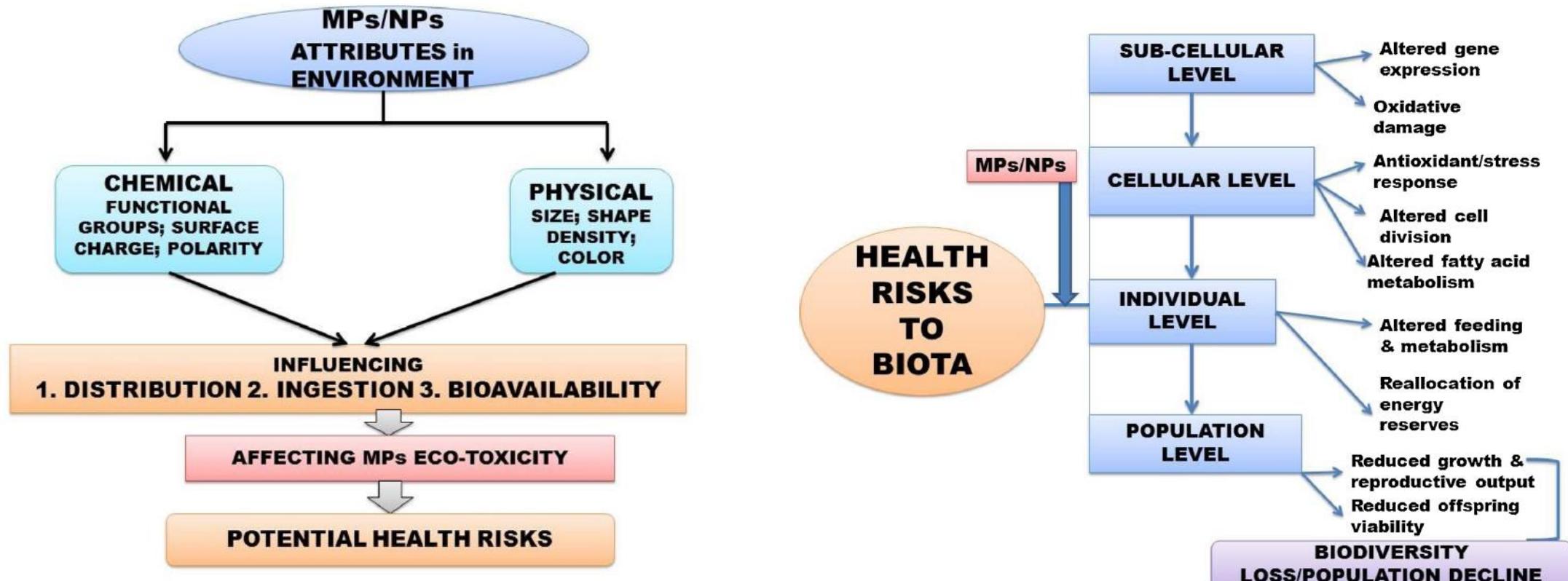


## Tvarová distribuce





# Toxicita mikroplastů



Fyzikálně chemické vlastnosti plastových částic ovlivňující jejich chování, ekotoxicitu, osud a transport v životním prostředí

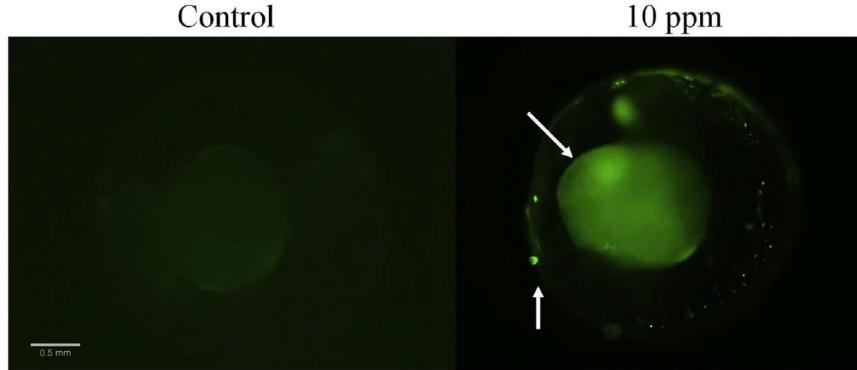
Zdravotní rizika expozice mikroplastům a nanoplastům:  
od molekulární po ekosystémovou úroveň



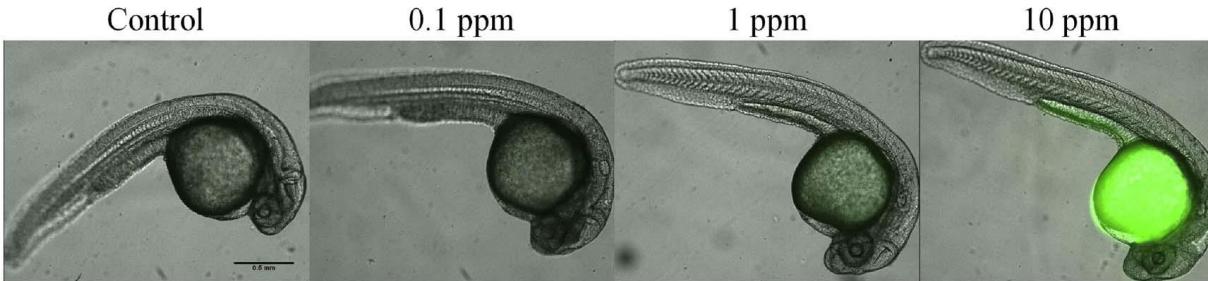
# Toxicita mikroplastů – biodostupnost

PS 51 nm

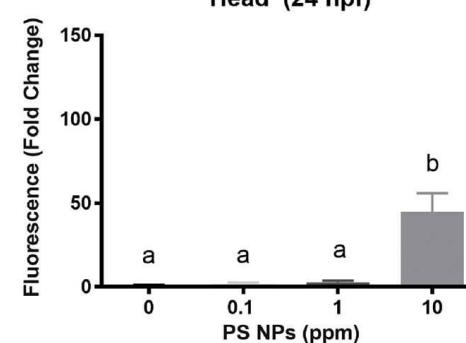
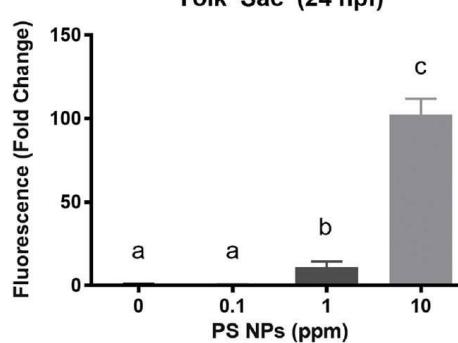
A



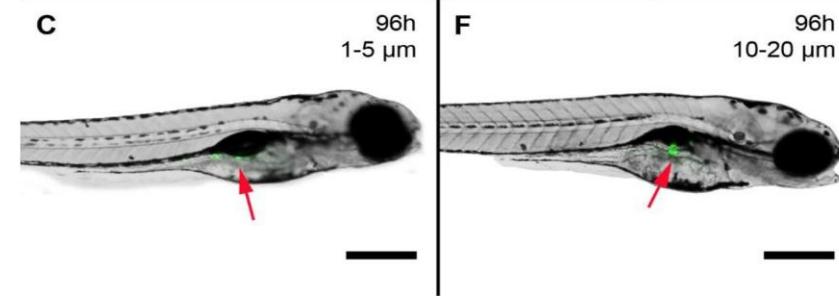
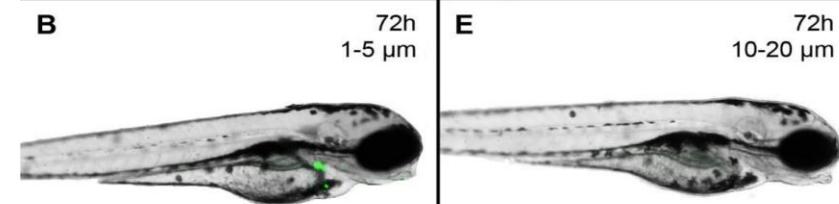
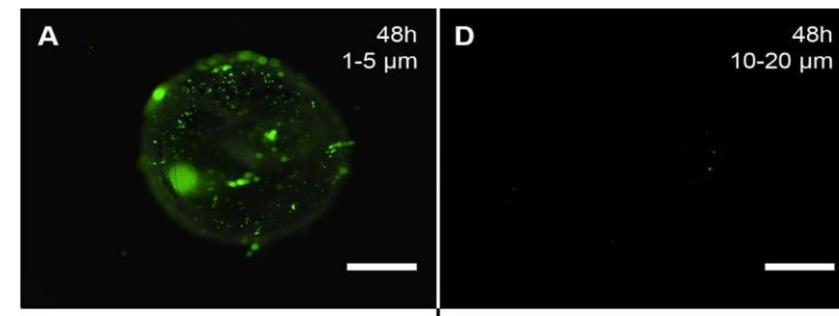
B



C

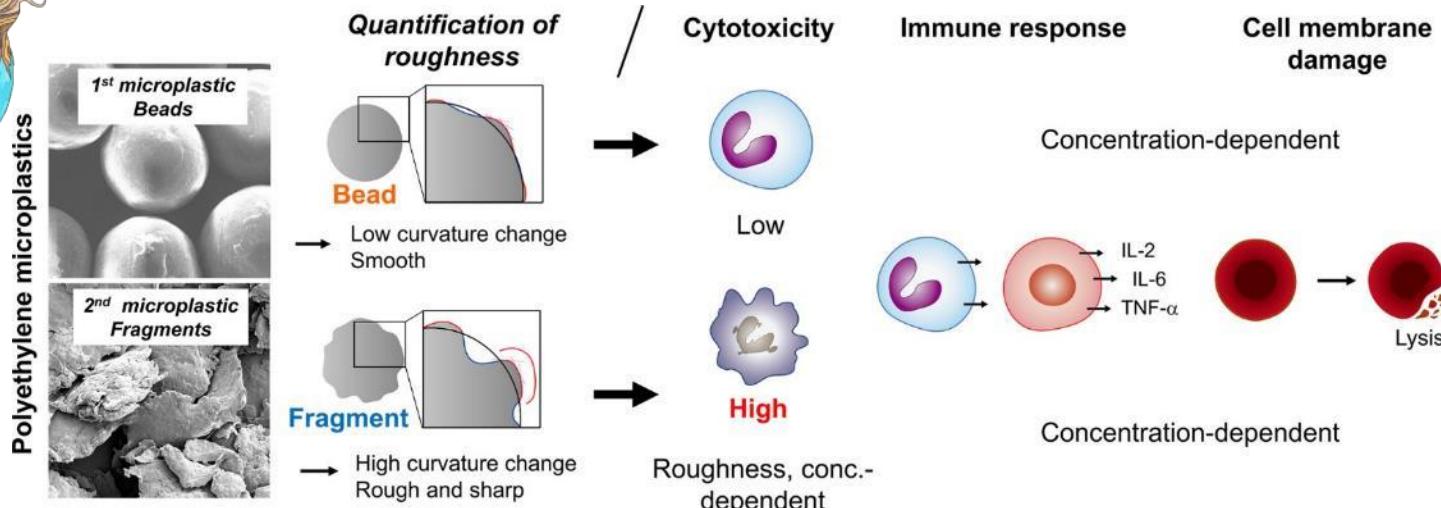


PE



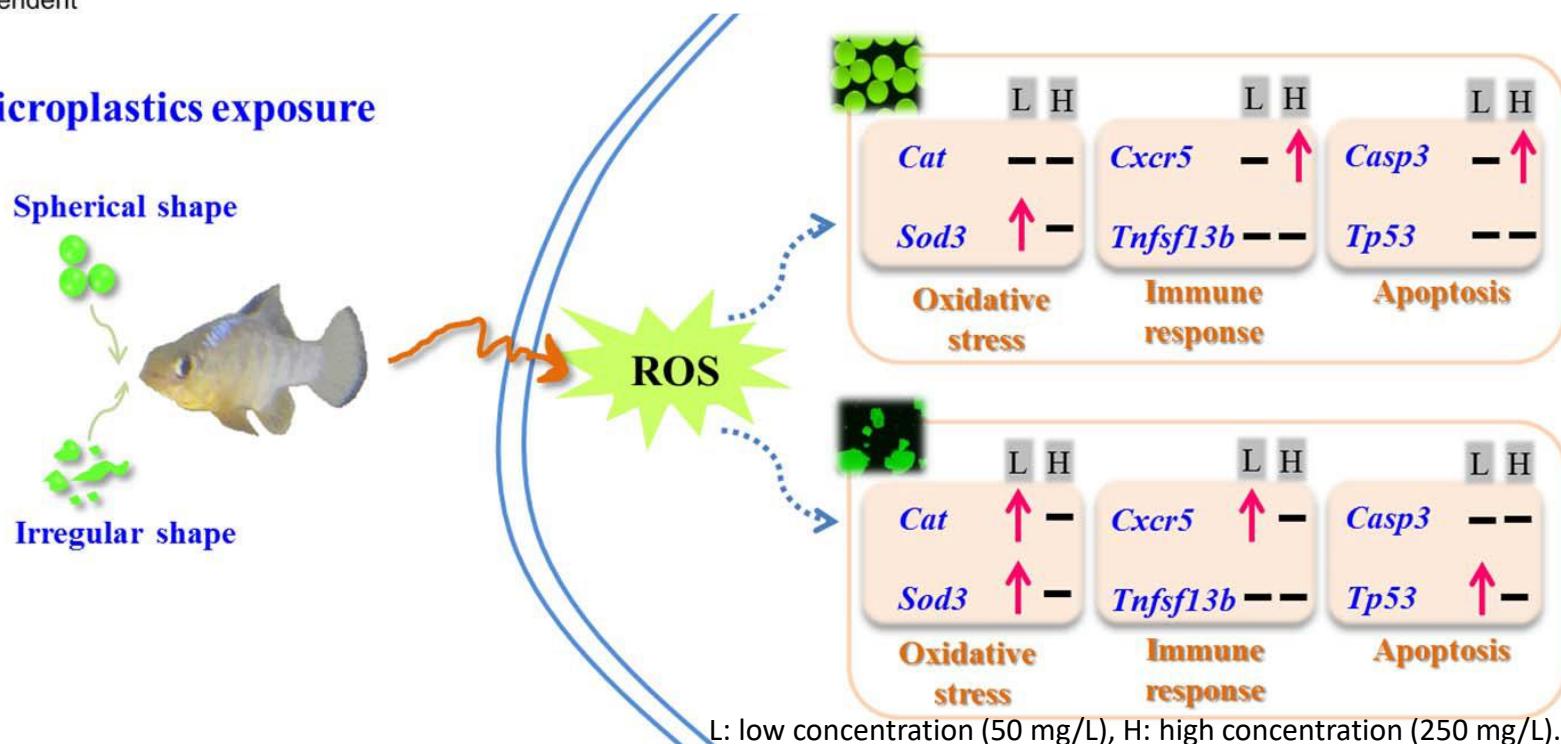


# Toxicita mikroplastů – vliv tvaru



Choi, J. S. et al. (2018) 'Toxicological effects of irregularly shaped and spherical microplastics in a marine teleost, the sheepshead minnow (*Cyprinodon variegatus*)', *Marine Pollution Bulletin*. Elsevier Ltd, 129(1), pp. 231–240. doi: 10.1016/j.marpolbul.2018.02.039.

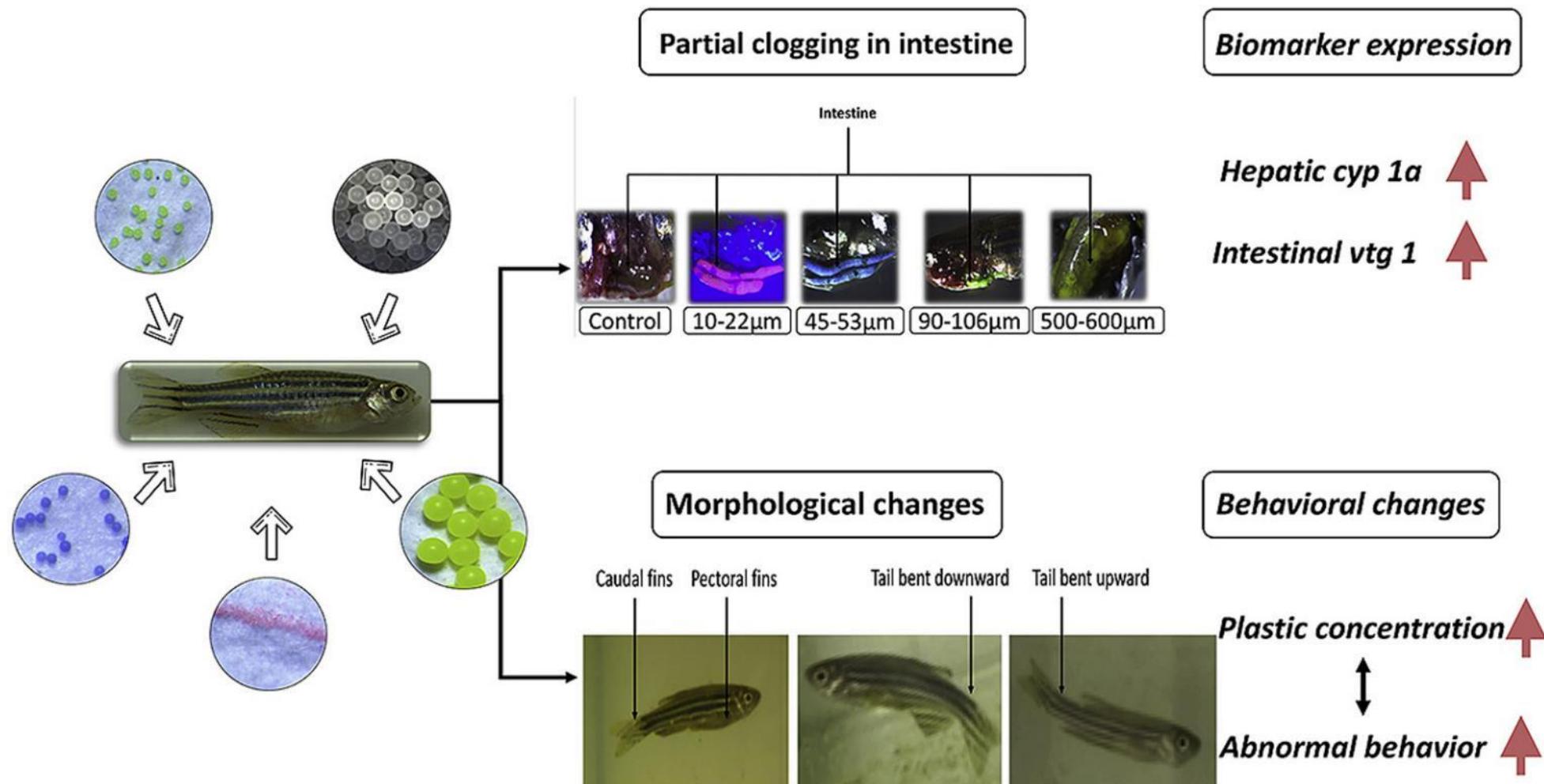
## Microplastics exposure





# Toxicita mikroplastů – *in vivo*

## Toxický efekt mikročástic polyethylenu na dospělé *Danio rerio*

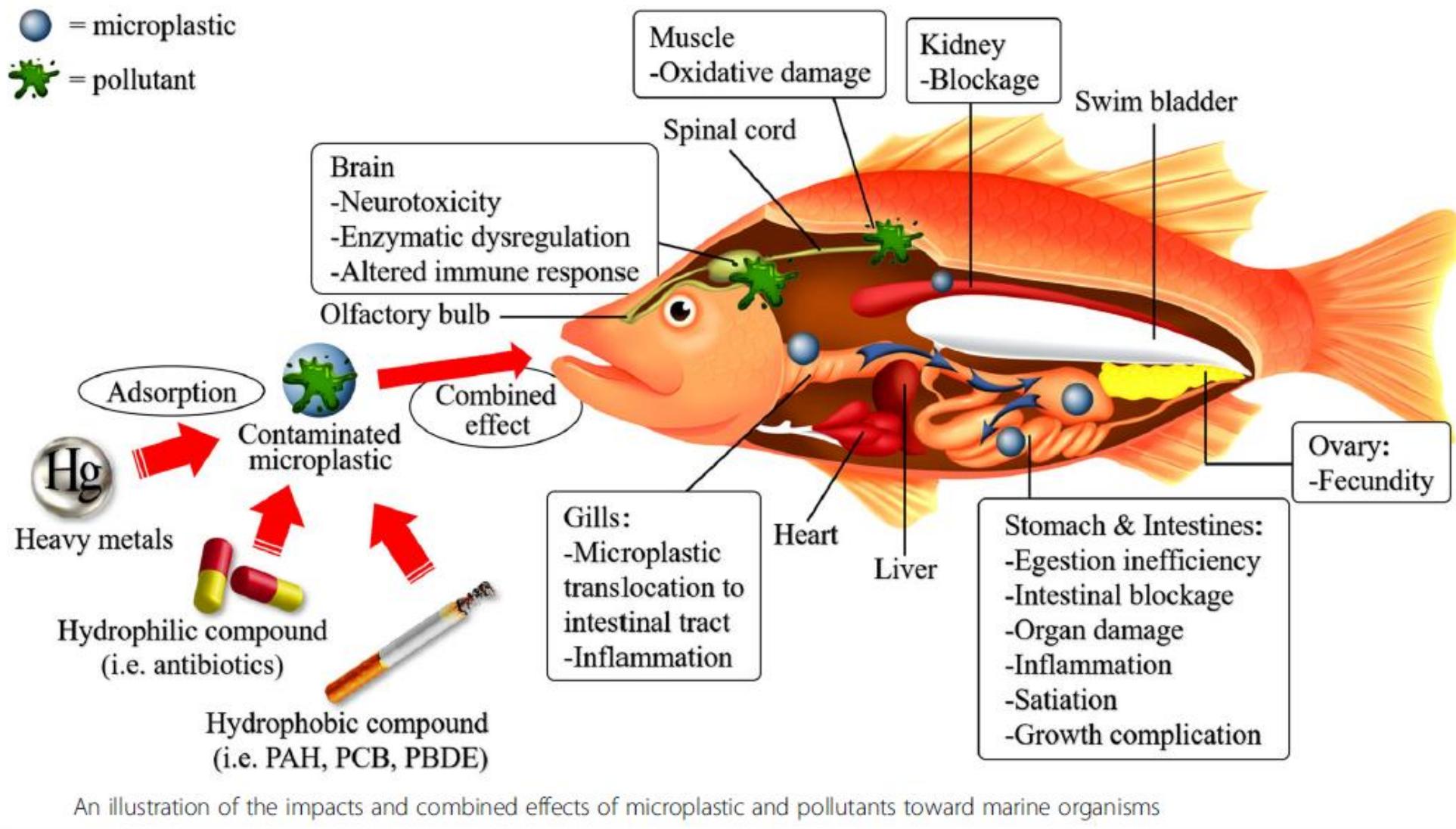


Mak, C. W., Ching-Fong Yeung, K. and Chan, K. M. (2019) 'Acute toxic effects of polyethylene microplastic on adult zebrafish', *Ecotoxicology and Environmental Safety*, 182, p. 109442. doi: 10.1016/j.ecoenv.2019.109442.



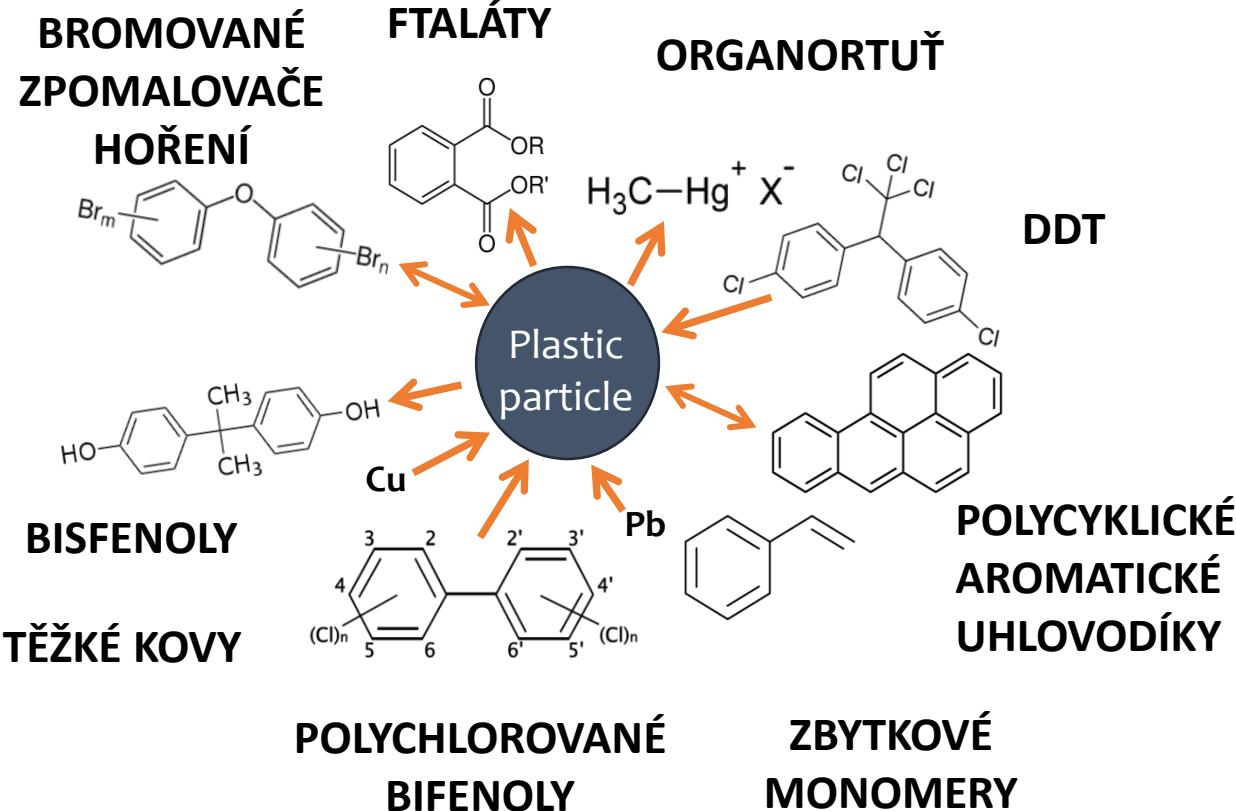
# Toxicita mikroplastů

● = microplastic  
✖ = pollutant





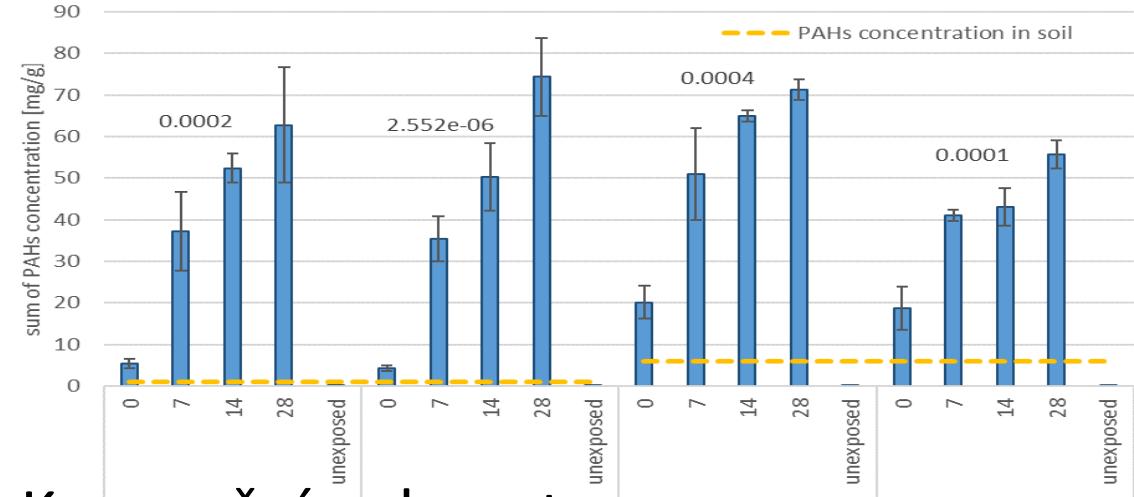
# Toxicita mikroplastů a dalších polutantů - akumulace



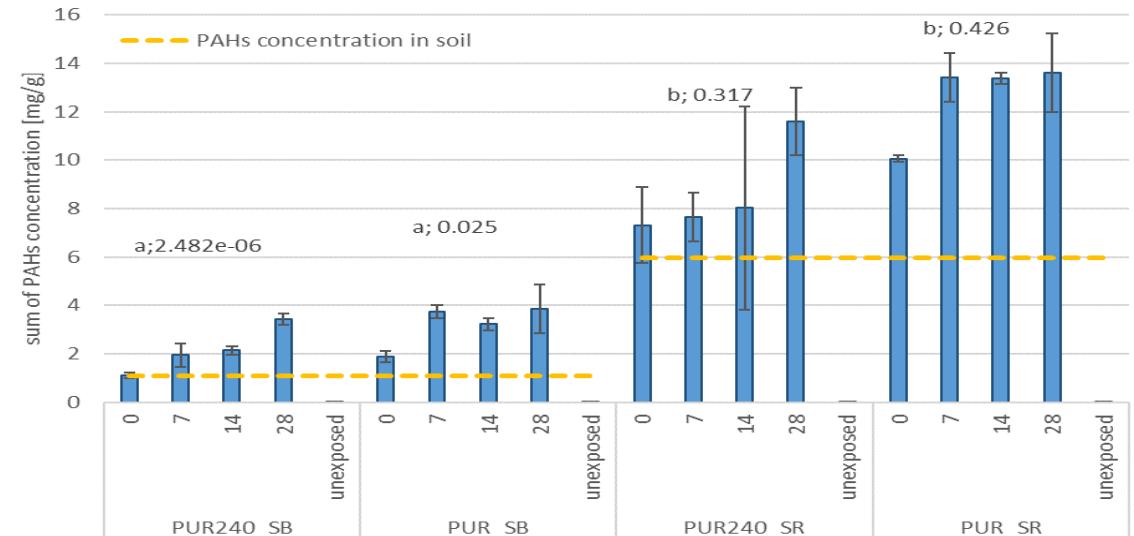
## Accumulation of polycyclic aromatic hydrocarbon in microplastics

Cerna T. et al., 2021. Polycyclic aromatic hydrocarbon accumulation in aged and unaged polyurethane microplastics in contaminated soil. *Science of the Total Environment* 770, 14525.

## Biodegradabilní polyuretan



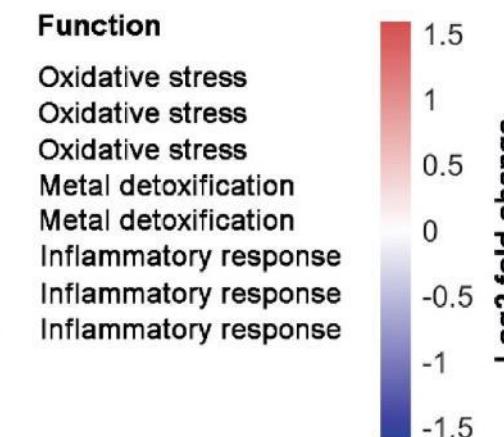
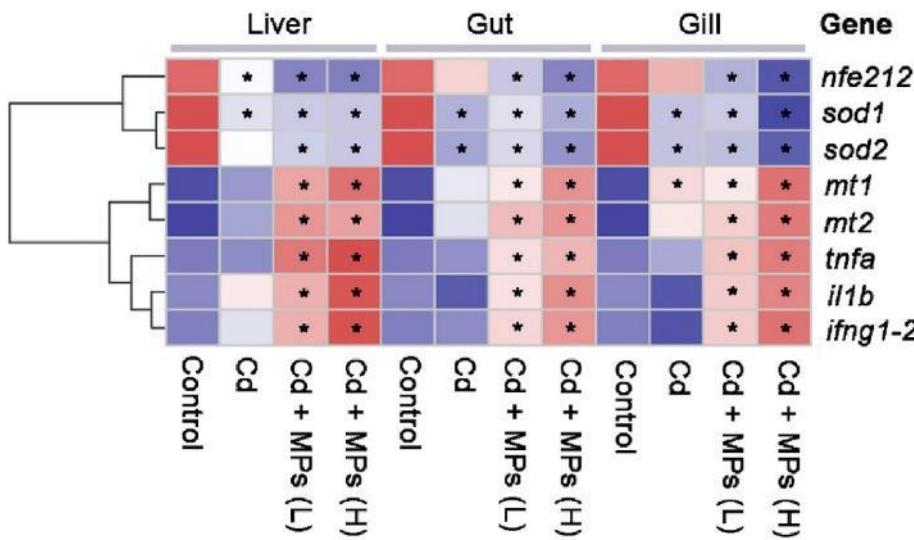
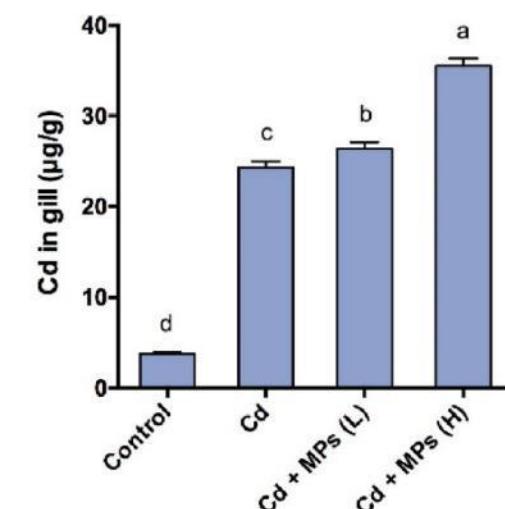
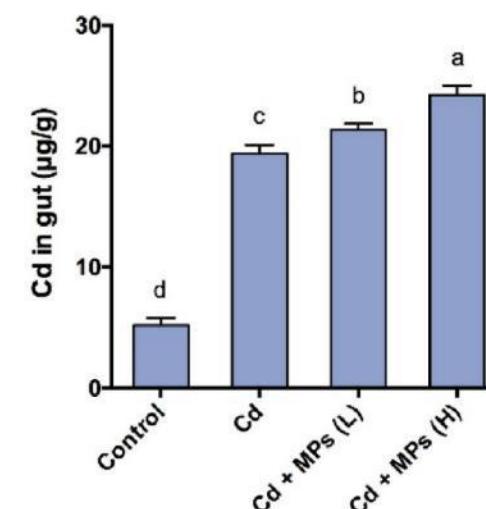
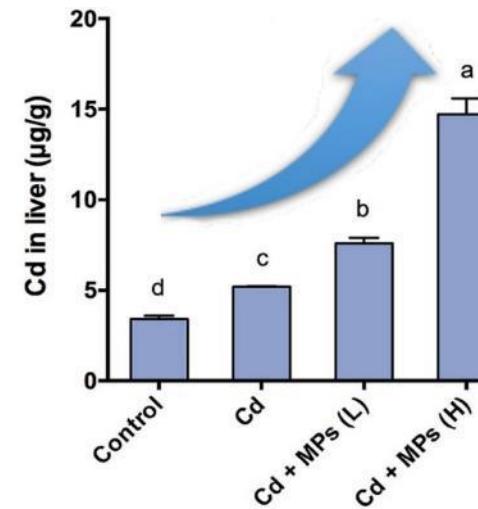
# Konvenční polyuretan





# Akumulace polutantů – zvýšení toxicity

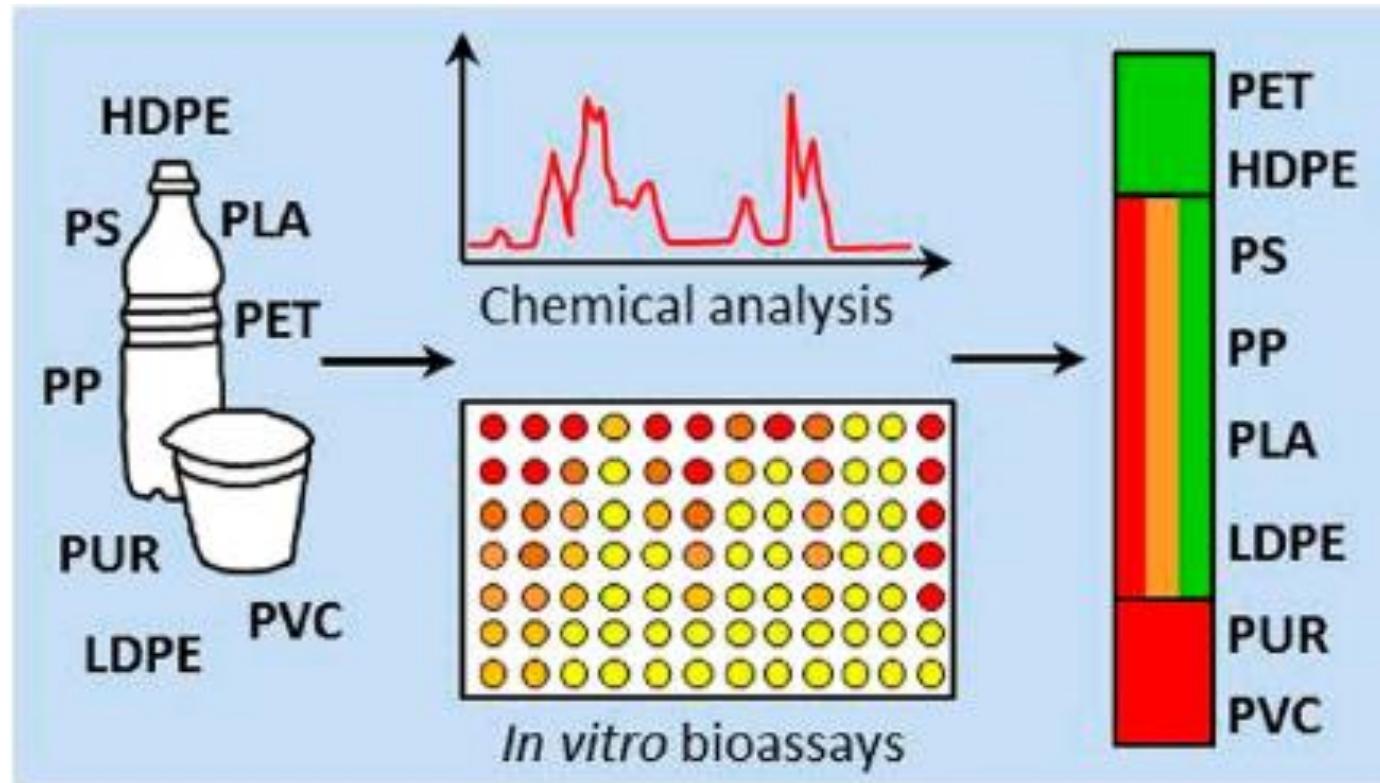
$\text{Cd}^{2+}$   
MPs  
 $\text{Cd}^{2+}$   
MPs  
 $\text{Cd}^{2+}$



Differential expression of functional genes in different tissues determined by qRT-PCR according to the 2DDCtcomparative method ( $n=45$ ). Gene differential expression were identified based absolute log<sub>2</sub>fold change 1.2 and  $p<0.05$  versus control group (marked with \*).



# Plasty a uvolňování toxických aditiv



Zimmermann, L. et al. (2019) 'Benchmarking the in Vitro Toxicity and Chemical Composition of Plastic Consumer Products - Supplementary', Environmental Science and Technology, 53(19), pp. 1–40. doi: 10.1021/acs.est.9b02293.

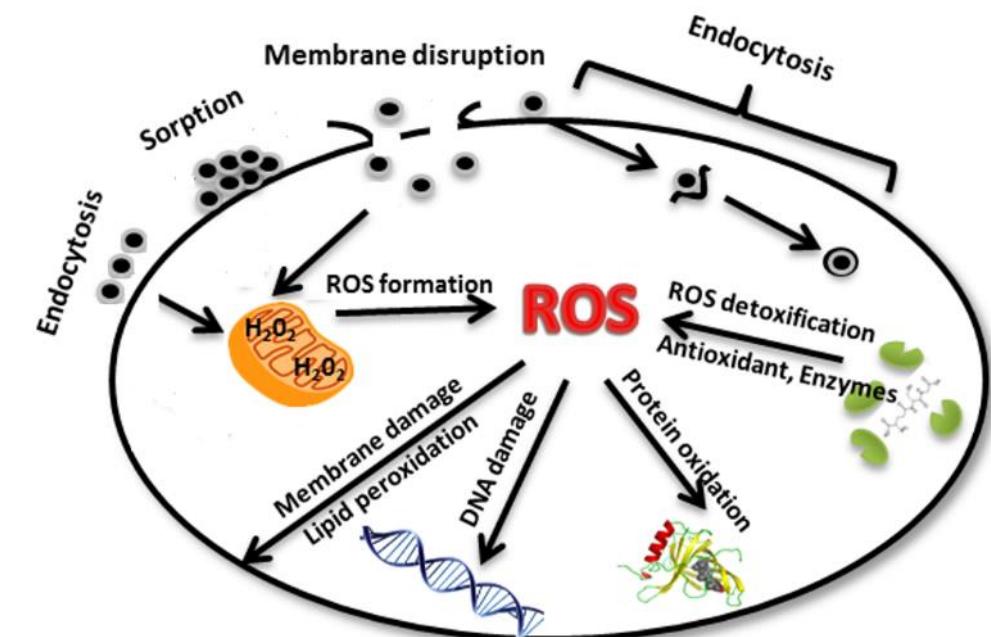
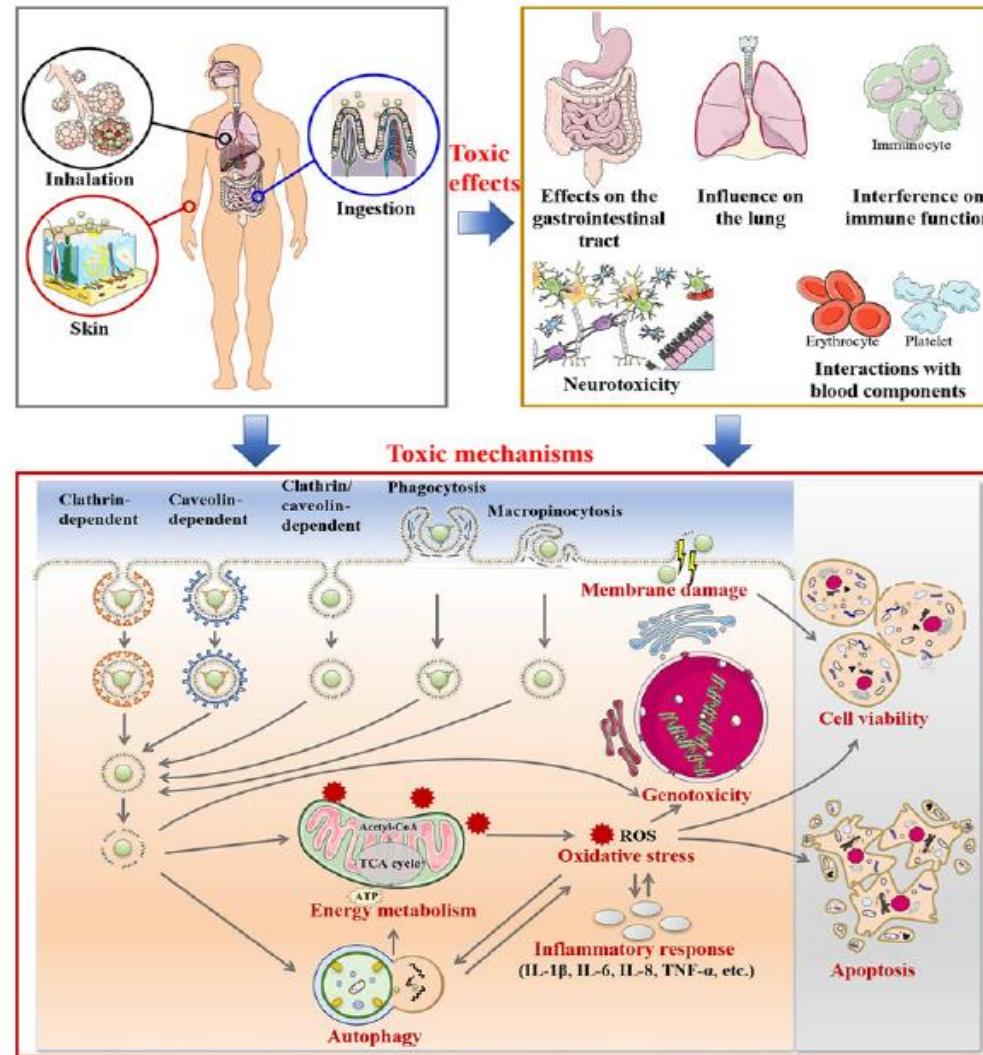
Skupiny potenciálně nebezpečných látek s endokrinně disruptivním efektem spojované s plastovým materiálem:

**BISFENOLY**  
**PARABENY**  
**FTALÁTY**  
**BENZOFENONY**  
**PESTICIDY**  
**FUNGICIDY**  
**ORGANOCÍNY**

Rai, P. K. et al. (2021) 'Environmental fate, ecotoxicity biomarkers, and potential health effects of micro- and nano-scale plastic contamination', *Journal of Hazardous Materials*. Elsevier B.V., 403, p. 123910. doi: 10.1016/j.jhazmat.2020.123910.



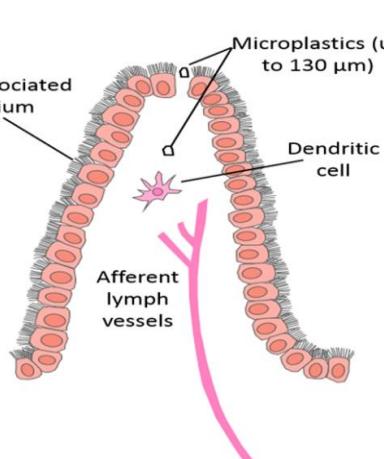
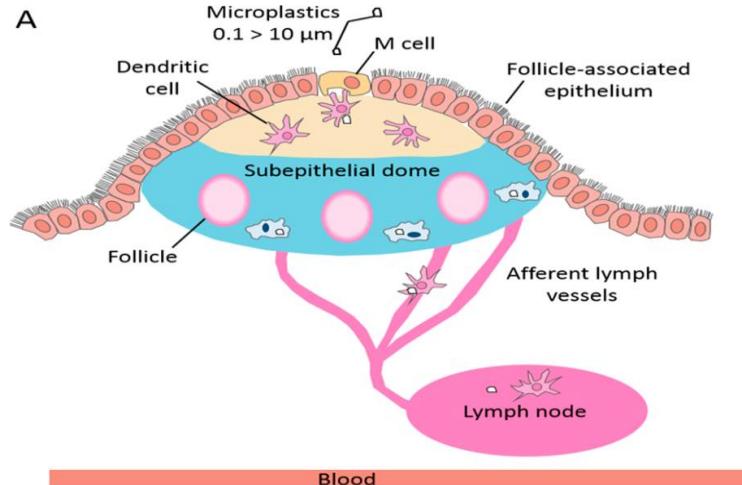
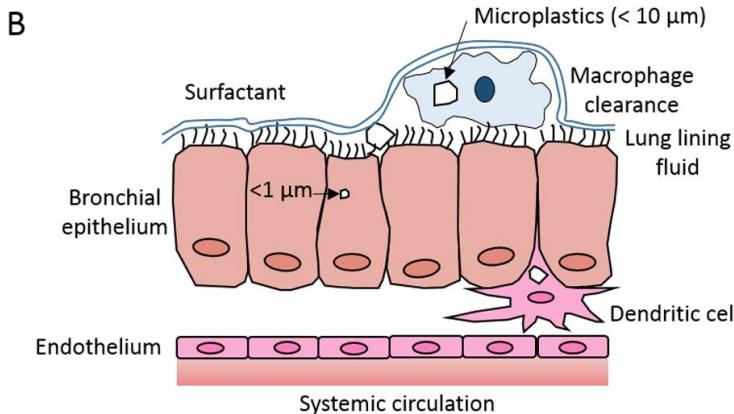
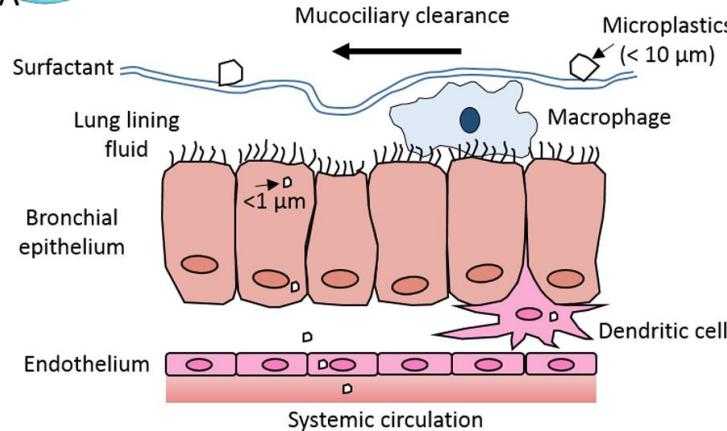
# Vliv mikroplastů na lidské zdraví



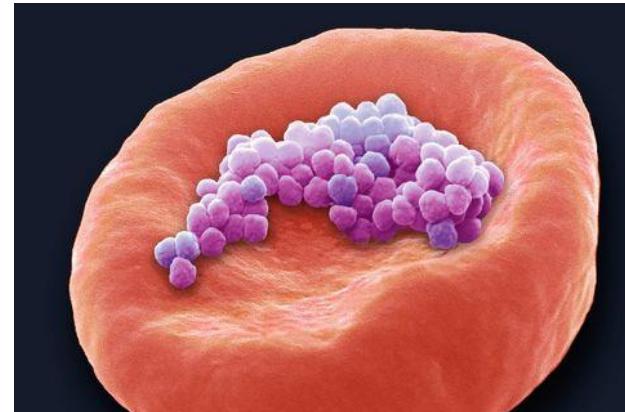
Appl Microbiol Biotechnol  
(2016) 100:9809–9819

# Možnosti vstupu mikroplastů do organismu

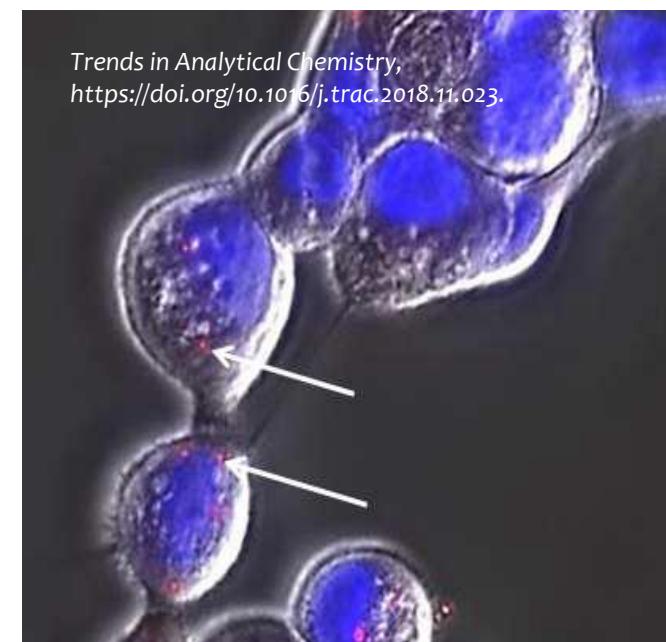
## ... a výsledky



Environ. Sci. Technol. 2017, 51, 6634–6647



Snímek z elektronového mikroskopu (Steve Gschmeissner)



Lidské keratinocyty obsahující červené polystyrenové částice ( $0.25 \pm 0.06 \mu\text{m}$ ). Jádra buněk jsou obarvena modře pomocí Hoechst 33342.



# Děti a expozice mikroplastům

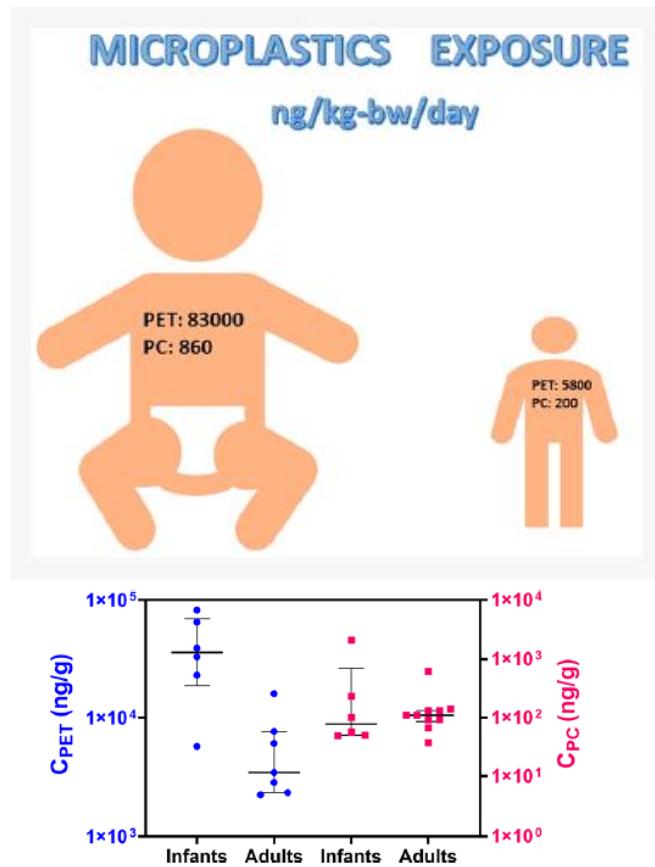


Figure 1. Concentrations (dry weight) of polyethylene terephthalate (PET) and polycarbonate (PC) microplastics in infant ( $n = 6$ ) and adult feces ( $n = 10$ ). Dots represent individual samples. Upper and lower lines represent interquartile ranges. Middle lines represent median values.

Zhang, J. et al. (2021) 'Occurrence of Polyethylene Terephthalate and Polycarbonate Microplastics in Infant and Adult Feces', *Environmental Science & Technology Letters*. doi: 10.1021/acs.estlett.1c00559.

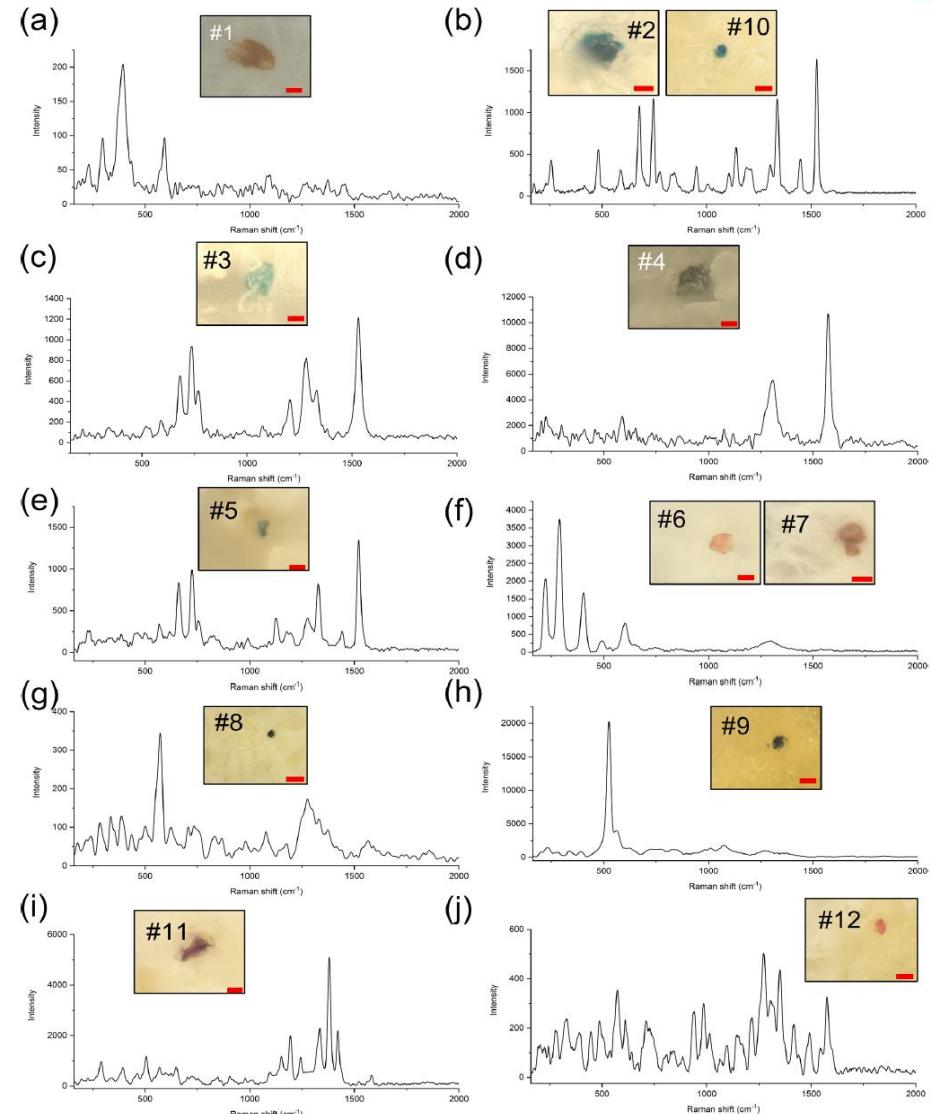


Fig. 2. Microphotographs and Raman spectra of the microplastics found in human placenta: (a) Particle #1 (scale bar 5 µm); (b) Particles #2 and #10 (scale bar 5 µm for #2 and 10 µm for #10); (c) Particle #3 (scale bar 5 µm); (d) Particle #4 (scale bar 5 µm); (e) Particle #5 (scale bar 5 µm); (f) Particles #6 and #7 (scale bar 10 µm for #6 and 5 µm for #7); (g) Particle #8 (scale bar 10 µm); (h) Particle #9 (scale bar 10 µm); (i) Particle #11 (scale bar 5 µm), and (l) Particle #12 (scale bar 10 µm).

Ragusa, A. et al. (2021) 'Plasticenta: First evidence of microplastics in human placenta', *Environment International*. Elsevier Ltd, 146, p. 106274. doi: 10.1016/j.envint.2020.106274.



# Děkuji Vám za pozornost!

