Food and Agriculture Organization
of the United Nations

What do we know about microplastics in food commodities?

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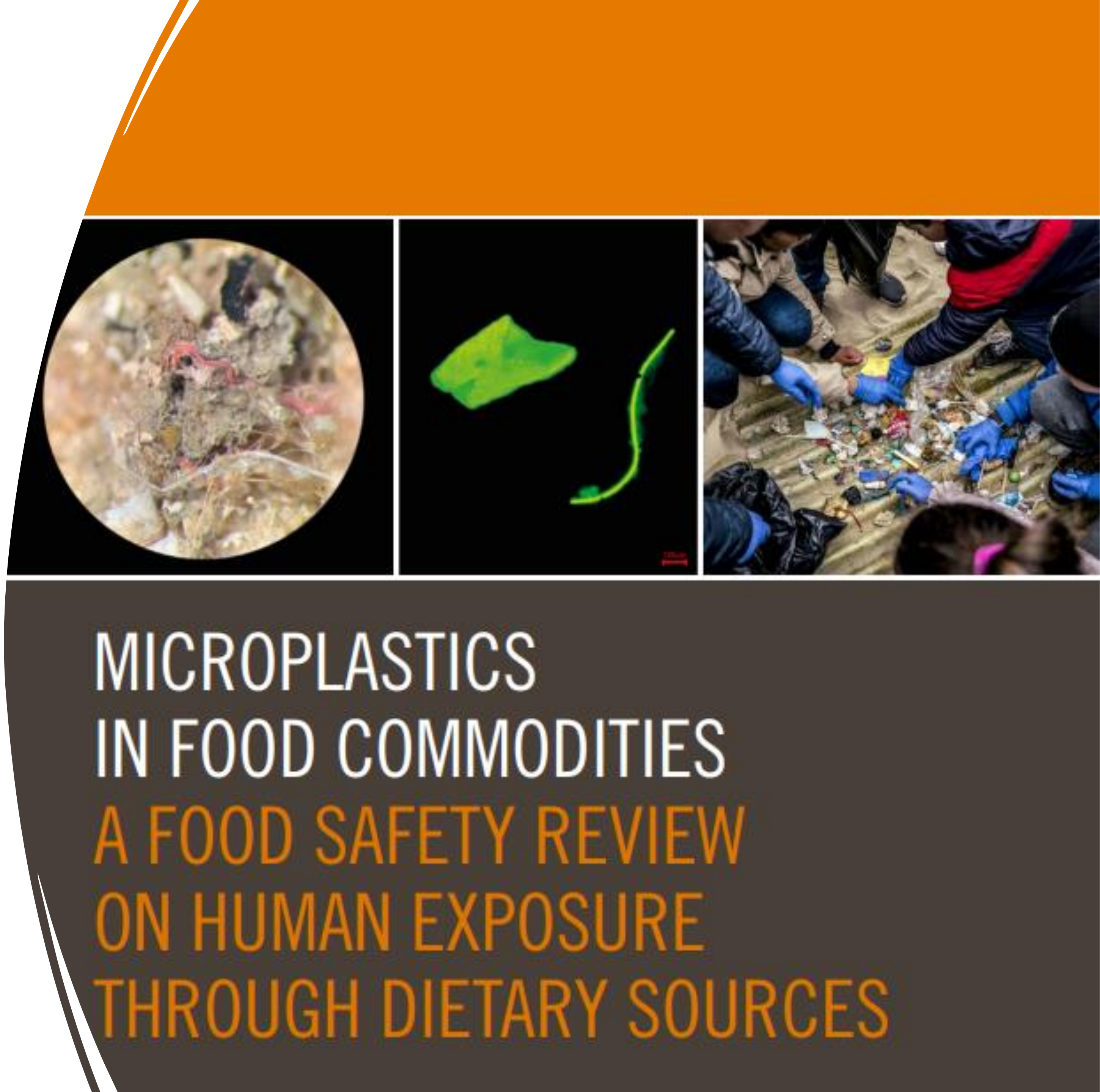
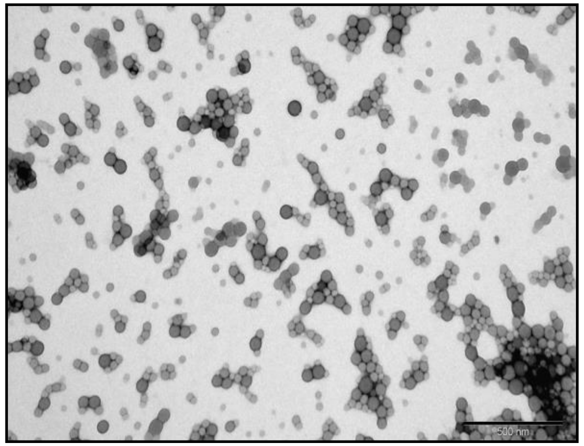


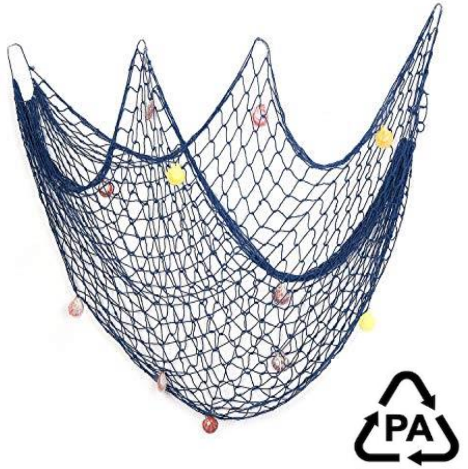
Microplastics – Definition

- micro- (5 mm–0.1 µm)
- nanoplastics (< 0.1 µm)



Microplastics composition

POLYMERS



Microplastics composition

Plastic additives: antioxidants, plasticizers, heat and UV stabilizers, flame retardants, processing aids, colorants, fillers, surfactants and biocides

Plastic contaminants from the environment: POPs and PAHs

Microbial biofilms

Sources of microplastics in primary production

Most of plastic (39%) is used for packaging.
10% of annual production ends up at sea

Sources of MPs in the processing environment

Dietary exposure to microplastics in different food commodities

COMMODITY	NUMBER OF SAMPLES	PARTICLE AMOUNT
Honey **Sugar (refined)** **Cane sugar (unrefined)**	19 5	——
Beer	24	2–79 fibres /L 12–109 fragm/L 2–66 granules/L
Honey	47	10–336 fibres /kg 2–82 fragm/kg
Salt	15	Sea: 550–681 MP/kg Lake: 43–364 MP/kg Rock: 7–204 MP/kg
Salt	16	1–10 MP/kg
Salt	11	Italy: 22–594 MP/kg Croatia: 13 500–19 800 MP/kg
Salt	8	56±49 -103±39 MP/kg
Salt **Beer** **Tap water** **Bottled water**	12 12 159 3	46.7±0.58 – 806±15.3 MP/kg 0–14.3 MP/L 0–61 MP/L 1.8–5.4 MP/L
Bottled water	30	3.16x10 – 1.1x10 MP/L
Salt	16	Sea: 16-84 MP/kg Lake: 8-102 MP/kg Rock: 9-16 MP/kg
Salt	39	Sea: 0–1674 MP/kg Lake: 28–462 MP/kg Rock: 0–148 MP/kg
Water	24	0–0.007 MP/L

Dietary exposure to microplastics in different food commodities

COMMODITY	NUMBER OF SAMPLES	PARTICLE AMOUNT
Water	12 10 3 9	Reusable: 118 ± 88 MP/L (28–241 MP/L) Single-use: 14 ± 14 MP/L (2-44 MP/L) Beverage cartons: 11 ± 8 MP/L (5–20 MP/L) Glass: 50 ± 52 MP/L (4–156 MP/L)
Water	27 L of raw water 27 L of treated water	Raw: 1383–4464 MP/L Treated: 243–684 MP/L
Water	32	Reusable: 4889±5432 MP/L Single-use: 2649± 2857 MP/L Glass: 6292± 10521 MP/L Max: 35436 MP/L
Water	259	325 MP/L (0–10390 MP/L)
Water	17	15.6 MP/50L (4-30 MP/50L)
Salt	21	Well: 115–185 MP/kg Sea: 50±7–280±3 MP/kg
Salt **Salt** **Tea bags**	23 brands n/a 4 plastic teabag	0.67 ± 1.15 - 3.42 ± 4.94 MP/kg 23–115 MP/g (200 g) 1.6 billion MPs/cup of tea or beverage
Apples **Pears** **Broccoli** **Lettuce** **Carrots**	6 samples each	52600–307750 MP/g 98325–302250 MP/g 65025–201750 MP/g 26375–75425 MP/g 72175–130500 MP/g

Dietary exposure to microplastics in different food commodities

SPECIES	SAMPLE NUMBER	PARTICLE AMOUNT
5 mesopelagic and 1 epipelagic fish species	670	1–83 MP/ fish (2.1 ± 5.78 MP/fish)
10 species of fish (5 pelagic, 5 demersal)	504	1–15 MP/fish (1.90 ± 0.10 items/fish)
Mytilus edulis *Crassostrea gigas*	72 21	0.36 ± 0.07 MP/g ww 0.47 ± 0.16 MP/g ww
Mytilus edulis	45	Wild: 34 MP/ind 106–126 MP/ind Cultured: 75 MP/ind 178 MP/ind
26 species of commercial fish	263	1.40 ± 0.66 MP/ fish or 0.27±0.63 MP/fish
9 species of commercial bivalves	144	4.3–57.2 MP/ ind 2.1–10.5 MP/g ww
Indonesia: 11 fish species United States of America: 12 fish species and *Crassostrea gigas*	152	Indonesia: 0–21 MP/ fish (1.4±3.7 MP/fish) United States of America: 0–10 MP/ fish, 0–2 MP/ oyster (0.5 ± 1.4 MP/ind)
Crangon crangon	165	0.68 ± 0.55 MP/ g ww Max: 1.92 ± 0.61 MP/g ww 1.23 ± 0.99 MP/ind
Mytilus edulis *Arenicola marina*	n.s.	0.2 ± 0.3 MP/g ww Max 1.1 MP/g ww 1.2 ± 2.8 MP/g Max 11.3 MP/g ww
5 fish species (3 demersal and 2 pelagic)	290	0.03 ± 0.18 MP/fish 0.19 ± 0.61 MP/fish (pelagic)
Mytilus edulis	12–30 per 22 sites	1.5–7.6 MP/ind (4 MP/ind) 0.9–4.6 MP/g ww (2.2 MP/g ww)

MAXIMUM P95 CONSUMER FOOD CONSUMPTION FOR SELECTED FOODS (G/DAY)

FOOD	COUNTRY	AGE CLASS	MAX P95 (G/DAY)[1]
MUSSELS	China	Adults and elderly	250
CLAMS	Italy	Adults and elderly	162
SHRIMPS AND PRAWNS	Malaysia	Adults and elderly	162
OYSTERS	China	Children and adolescents	133
SALT	Burkina Faso	Adults and elderly	222
HONEY	China	Children and adolescents	83
SUGAR	Burkina Faso	Adults and elderly	168
WATER	Mexico	Adults and elderly	2669

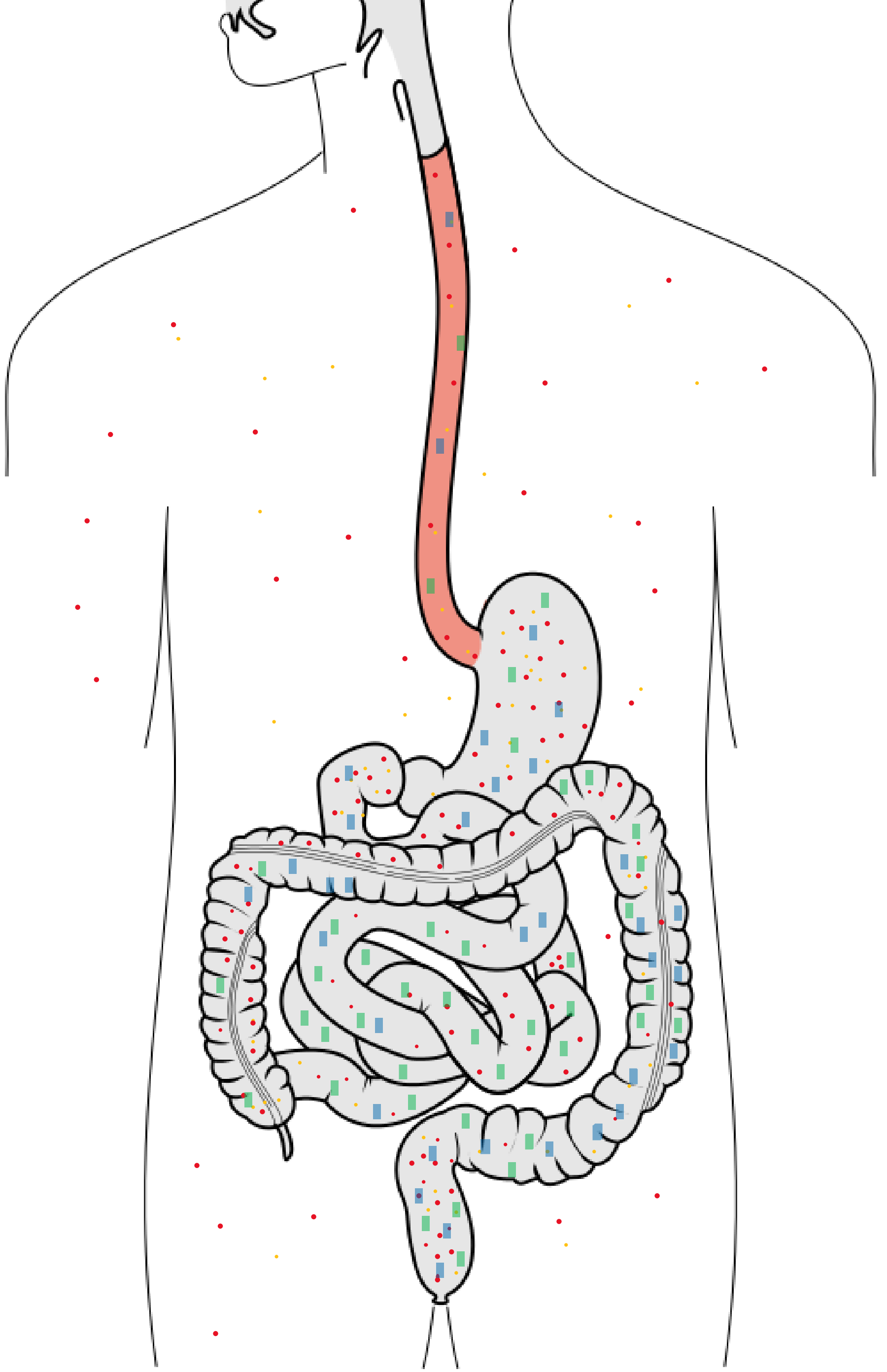
[1] Estimates of the P95 food consumption level based on less than 20 consumers were not considered.

Sources: FAO/WHO, 2022.

ESTIMATES OF DIETARY EXPOSURE TO MICROPLASTICS FROM CONSUMPTION OF SELECTED FOODS

FOOD	MAXIMUM MICROPLASTIC CONCENTRATION (MP/G)	MAXIMUM P95 CONSUMER CONSUMPTION (G/DAY)	ESTIMATED DIETARY EXPOSURE	
			MP/DAY[1]	MP/YEAR[2]
MUSSELS	12.8	250	3 200	1 168 000
CLAMS	10.5	162	1 701	620 865
SHRIMPS AND PRAWNS	4.88	162	791	288 554
OYSTERS	7.2	133	958	349 524
SALT	19.8	222	4 396	1 604 394
HONEY	0.66	83	55	19 995
SUGAR (REFINED)	0.39	168	66	23 915
WATER (TAP)	0.06	2669	160	58 451

[1] MP/day calculated as: Microplastic concentration (MP/g) x food consumption (g/day)
[2] MP/year calculated as: MP/day x 365
Source: Authors' own elaboration



Dietary exposure

The human body is expected to eliminate more than 90 percent of micro- and nanoplastics ingested

Toxicity of microplastics and nanoplastics

Accumulation in liver, kidney and gut

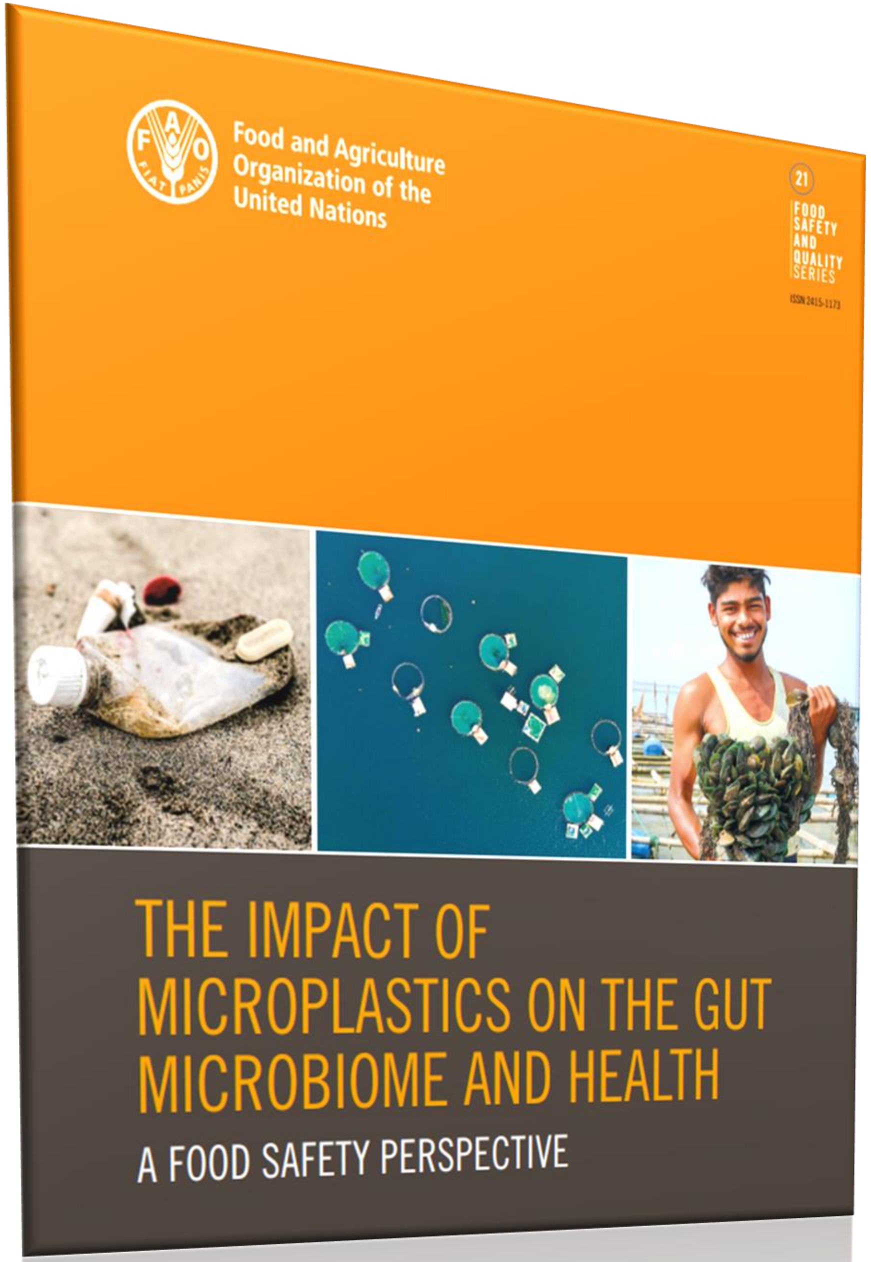
Decreased liver weight, inflammation and lipid accumulation

Neurotoxicity

Oxidative stress

Lung inflammation

ORGANISM	CONCENTRATION OF MP	EXPOSURE TIME	POLYMER	SIZE	EFFECTS	APPLICABLE TO HUMAN HEALTH TOXICITY
Mouse macrophages J774	25, 125, 250 particles/ macrophage	0–24 h	UHMWPE	0.5–2 µm	• Immunological response (induction of TNF-α release) • Apoptosis (proteolytic PARP cleavage)	
• **Human brain cells (T98G)** • **Epithelial cells (HeLa)**	0.05, 0.1, 1, 10 mg/mL 10 ng/mL–10 µg/mL	24, 48 h	PE PS	3, 16 µm, 100, 600 nm 10 µm, 40, 250 nm	• Oxidative stress (ROS production)	YES
Mouse	1 mg/mL	4, 24 h	PS	64, 202 nm 1.1, 4.7 µm	• Activation of the innate immune system (accumulation and activation of phagocytes) • Inflammatory responses (TNF-α, IL-1β, MIP-2, MCP-1)	
Human cell lines: PBMCs, RAW 264.7, HDF, HMC-1	10, 50, 100, 250, 300, 500, 1000, 1 500, 4 500 µg/mL	6 h, 12 h, 48 h, 72 h or 4 days	PP	~20, 25, 200 µm	• Oxidative stress (ROS production) • Histamine release • Stimulation of the immune system (inflammation, release of cytokines TNF-α and IL-6)	YES
***Mytilus galloprovincialis* haemocytes**	1, 5, 50 µg/mL	30 min to 4 hours	NH2-PS	50 nm	• Lysosomal membrane destabilization • Oxidative stress (ROS and NO production) • Induction of apoptosis • Inflammatory responses (decreased phagocytosis and increased lysozyme activity)	YES
Rat	125 µg, 1 mg	24 h	PS	64, 202, 535 nm	• Lung inflammation (IL-8 gene expression and release) • Increased entry of extracellular Ca++ • Oxidative stress	
Human cells (PBMN)	100 µm3	12 h, 24 h	UHMWPE, PS	0.1, 1, 10 µm 20 nm, 40 nm, 200 nm, 1 µm	• Increased activity of osteoclasts (osteolytic cytokine release: TNF-α, IL-1β, IL-6, IL-8)	YES



Biological relevance of the microbial alterations described in those studies is not clear

Compound	Highest concentration in microplastics (see section 5.6) (ng/g)	Calculated intake from microplastics (pg/kg bw/day)	Total intake from the diet (pg/kg bw/day)	Ratio intake microplastic/total dietary intake (%)
Contaminants				
Non-dioxin like PCBs	2 970	0.3		
EFSA, 2012			4 300[a]	0.007
JECFA, 2016			1 000[a]	0.03
PAHs	44 800	4.5		
EFSA, 2008			28 800[b]	0.02
JECFA, 2006			4 000[c]	0.1
DDT	2 100	0.2		
EFSA, 2006			5 000[d]	0.004
JECFA,1960			100 000 000[j]	0.0000002
Additives/monomers				
Bisphenol A	200	0.02		
EFSA, 2015a			130 000[e]	0.00002
FAO/WHO, 2011			400 000[f]	0.000005
PBDEs	50	0.005		
EFSA, 2011			700[g]	0.0007
JECFA, 2006			185[h]	0.003
NP	2 500	0.3	NA[i]	
OP	50	0.005	NA[i]	

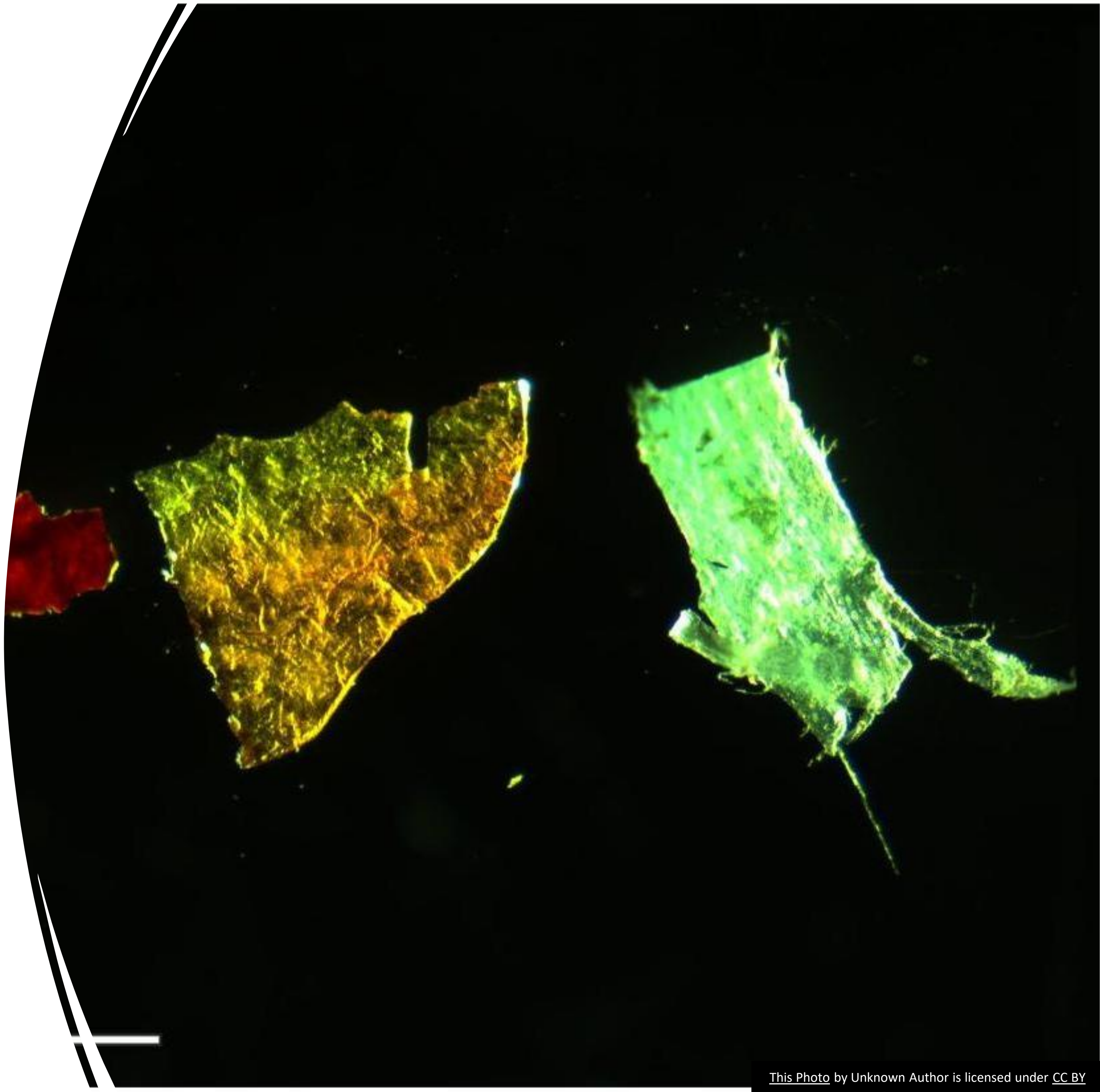
What do we know then?

- Despite the many laboratory tests involving virgin polymers, this may not be indicative of actual environmental exposure.

- Organisms are exposed to a mixture of microplastics, plastic additives and environmental contaminants in the natural environment.

Challenges for food safety standard setting

- Lack of standardized lab materials to compare data
- Lack of toxicological data
- Lack of studies to understand the overall exposure to microplastics via diet



Way forward

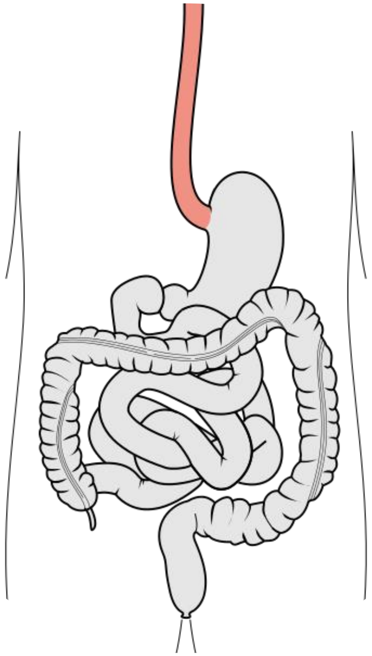
- Analytical methods for the detection and quantification of microplastics in the environment (water, sediments and biota) and food should be standardized, with a focus on the smaller (less than 150 µm) particles.
- After this, occurrence data, including particle size, must be generated, to be used for exposure assessment of dietary intake.

Way forward

- Toxicological data on microplastics must be generated and the most common polymers need to be considered during this process.
- The smaller particles (less than 150 μm) are potentially more hazardous and their study should be prioritized.

Way forward

- Further data on translocation of microplastics containing the most common polymers should be generated for aquatic organisms and humans.
- Studies on microplastics as sources of pathogens to fisheries and aquaculture products and humans need to be carried out.



Way forward

- No data are available on the impact of cooking or processing seafood at high temperature on the potential toxicity of microplastics.

- Data are required on the resultant physical and chemical changes in microplastics, as well as on the chemical interactions between nutrients and microplastics.

Way forward

- We can't wait to reduce plastic use
- We can't wait to implement more efficient waste management systems
- We can't wait to find alternatives to plastics