

Environment and Safety Series

Microplastics: A Profile

PEP Review 2025-08

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Glossary

ABS	Acrylonitrile-butadiene-styrene
ACH	Acetylcholine
ADHD	Attention-deficit/hyperactivity disorder
ALK	Alkyd
AM	Additive manufacturing
AOP	Advanced oxidation process
ASR	Aquifer storage and recovery
ATP	Adenosine triphosphate
AV	Arginine vasopressin
BCE	Blue carbon ecosystem
BFD	Block flow diagram
BFR	Brominated flame retardant
BHT	Butylated hydroxytoluene
BHET	Bis(2-hydroxyethyl) terephthalate
BPA	Bisphenol A
BWP	Brake wear particle
°C	Degrees Celsius
CC	Cornado Cays
CEC	Cation exchange capacity
CEPA	Canadian Environmental Protection Act
CFC	Chlorofluorocarbon
cm	Centimeters
CoA-SH	Coenzyme A
COPD	Chronic obstructive pulmonary disease
CPCB	Central Pollution Control Board
CPP	Casted polypropylene
Da	Daltons
DAPI	4',6-diamidino-2-phenylindole
DBP	Dibutyl phthalate
DCD	1,2-Dihydroxy-3,5-cyclohexadiene-1,4-dicarboxylate
DCHP	Dicyclohexyl phthalate
DDT	Dichloro-diphenyl-trichloroethane
DEHP	Di(2-ethylhexyl) phthalate
DEP	Diethyl phthalate
DIHP	Diisooheptyl phthalate
DINP	Diisononyl phthalate
\$/m ²	Dollars per square meter
\$/m ³	Dollars per cubic meter
DMEP	Bis(2-methoxyethyl) phthalate
DNA	Deoxyribonucleic acid
DOA	Dioctyl adipate
DOC	Dissolved organic carbon
DOP	Dioctyl phthalate
DPP	Dipentyl phthalate
\$/t	Dollars per metric ton
DVD	Digital video disc
EA	Environment Assembly
EC	European Commission
ECHA	European Chemicals Agency
EDC	Endocrine-disrupting chemicals
EFSA	European Food Safety Authority
EG	Ethylene glycol
EOL	End-of-life
EPP	Expandable polypropylene
EPR (in Figure 3.4)	Ethylene-propylene rubber

EPR	Extended producer responsibility
EPS	Extracellular polymeric substance
EU	European Union
EVA	Ethylene-vinyl acetate
FAO	Food and Agriculture Organization of the United Nations
FDA	Food and Drug Administration
fibers/m ² day ⁻¹	Fibers per square meter per day
FSH	Follicle-stimulating hormone
FSSAI	Food Safety and Standards Authority of India
g	Grams
GAC	Granular activated carbon
GC	Glucocorticoid
g/cm ³	Grams per cubic centimeter
GC-MS	Gas chromatography-mass spectrometry
GDP	Gross domestic product
GESAMP	International Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
GHG	Greenhouse gas
GI	Gastrointestinal (tract)
g/kg	Grams per kilogram
g/ml	Grams per milliliter
Gt	Gigatons
GtCO ₂ eq	Billion metric tons of CO ₂ equivalent
Gt/y	Gigatons per year
GWP	Global warming potential
HAC	High-ambition coalition
HBCD	Hexabromocyclododecane
HDPE	High-density polyethylene
HELCOM	Helsinki Convention
HIC	High-income country
HP	House Paper
HPLC	High-performance liquid chromatography
HVAC	Heating, ventilation and air conditioning
IARC	International Agency for Research on Cancer
IMO	International Maritime Organization
INC	Intergovernmental Negotiating Committee
IQR	Interquartile range
ISO	International Organization for Standardization
items/kg	Items per kilogram
ITRC	Interstate Technology Regulatory Council
IV	Intravenous
kg	Kilograms
kgCO ₂ eq	Kilograms of CO ₂ equivalent
kg/y	Kilograms per year
km ²	Square kilometers
LCA	Lifecycle assessment
LD	Legislative document
LDIR	Laser direct infrared imaging
LDL	Low-density lipoprotein
LDPE	Low-density polyethylene
LH	Luteinizing hormone
LIC	Low-income country
LRTAP	Long-range Transboundary Air Pollution
μ-FTIR	Fourier-transform infrared spectroscopy
μg/L	Micrograms per liter
μg/g	Micrograms per gram
μm	Micrometers
μ-Raman	Raman spectro-microscopy

m	Meters
m ³	Cubic meters
MA	Muconic acid
MAPK	Mitogen-activated protein kinase
MAR	Managed aquifer recharge
MARPOL 73/78	The International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978
Max	Maximum
MBI	Market-based instrument
MBR	Membrane bioreactor
m ⁻² day ⁻¹	(Particles) per square meter per day
mg/kg	Milligrams per kilogram
mg/L	Milligrams per liter
MHET	Mono-(2-hydroxyethyl) terephthalate
MHETase	Mono-(2-hydroxyethyl)terephthalic acid hydrolase
Min	Minimum
ml	Milliliters
mm	Millimeters
Mt, MMt	Million metric tons
MMtCO ₂ eq	Million metric tons of CO ₂ equivalent
MMt/y	Million metric tons per year
MoEFCC	Ministry of Environment, Forest and Climate Change
MoEJ	Ministry of the Environment, Japan
MoES	Ministry of Earth Sciences
MoFAH&D	Ministry of Fisheries, Animal Husbandry and Dairying
MP	Microplastic
MSFD	Marine Strategy Framework Directive
MSW	Municipal solid waste
Mt	Thousand metric tons
N	North (in N Atlantic)
NA	Not available
N/A	Not applicable
NAAQS	National Ambient Air Quality Standards
nd	Non-detect
NE	Northeast
ng/g	Nanograms per gram
ng/kg-bw/day	Nanograms per kilogram of body weight per day
ng/ml	Nanograms per milliliter
NHM	Natural History Museum, London
nm	Nanometers
NMF	Nimitz Marine Facility
NOAA	National Oceanic and Atmospheric Administration
NSW	North South Wales
OECD	Organisation for Economic Co-operation and Development
OEHHA	Office of Environmental Health Hazard Assessment
OpMic	Optical microscopy
P	Microplastic present
PA	Polyamide
PAA	Polyacrylic acid
PAC	Polymeric additives and coatings
PAH	Polycyclic aromatic hydrocarbon
PAN	Polyacrylonitrile
particles/kg	Particles per kilogram
particles/(m ⁻² day ⁻¹)	Particles per square meter per day
PB	Polybutylene
PBDE	Polybrominated diphenyl ether
PBS	Polybutylene succinate
PBT	Polybutylene terephthalate

PC	Polycarbonate
PCA	Protocatechuic acid
PCB	Polychlorinated biphenyl
PCL	Polycaprolactone
PCOS	Polycystic ovarian syndrome
pcs/L	Total discharge of microplastics per liter
PE	Polyethylene
PEF	Polyethylene furanoate
PEG	Polyethylene glycol
PEI	Polyetherimide
PEP	Process Economics Program
PES	Polyester
PET	Polyethylene terephthalate
PETase	Polyethylene terephthalate hydrolase
PFAS	Per- and polyfluoroalkyl substances
PFBA	Perfluorobutanoic acid
PFDA	Perfluorodecanoic acid
PFHxS	Perfluorohexane sulfonic acid
PFNA	Perfluorononanoic acid
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonic acid
PGA	Polyglycolic acid
PGPR	Plant growth-promoting rhizobacteria
PHA	Polyhydroxyalkanoate
PHB	Polyhydroxybutyrate
PLA	Polylactic acid
PMMA	Polymethyl methacrylate
POP	Persistent organic pollutant
PP	Polypropylene
PPE	Personal protective equipment
PS	Polystyrene
PTFE	Polytetrafluoroethylene
PU, PUR	Polyurethane
PVA	Polyvinyl acetate
PVC	Polyvinyl chloride
Pyr-GC/MS	Pyrolysis-gas chromatography mass spectrometry
RAC	Committee for Risk Assessment
R&D	Research and development
REACH	Registration, Evaluation and Authorisation of Chemicals
ROS	Reactive oxygen species
RY	Rayon
SA	Styrene acrylonitrile
SBR	Styrene-butadiene rubber
SDG	Sustainable Development Goal
SEAC	Committee for Socio-economic Analysis
SEM	Scanning electron microscopy
SEM-EDS	Scanning electron microscopy with energy dispersive spectroscopy
SI	Shelter Island
SOM	Soil organic matter
SOS 2.0	Save Our Seas Act 2.0
SUPPR	Single-use Plastics Prohibition Regulations
SW	Southwest
t	Metric tons
TBBPA	Tetrabromobisphenol A
TCA	Tricarboxylic acid cycle
TCCP	Tris(2-chlorisopropyl)phosphate
TED-GC/MS	Thermal extraction and desorption gas chromatography/mass spectrometry

TNNP	Tris(nonylphenyl)phosphite
TPA	Terephthalic acid
TRWP	Tire and road wear particle
TWP	Tire wear particle
t/y	Metric tons per year
UB	University of Barcelona
UN	United Nations
UNEA	United Nations Environment Assembly
UNEP	United Nations Environment Programme
US EPA	US Environmental Protection Agency
UV	Ultraviolet
VCoC	Voluntary Code of Conduct on the Sustainable Use and Management of Plastics in Agriculture
WHO	World Health Organization
W_s	Sinking velocity
w/w	Weight by weight
WWF	World Wide Fund for Nature (formerly World Wildlife Fund)
WWTP	Wastewater treatment plant

Abstract

Microplastics are solid synthetic plastic particles, typically between 1 nanometer (nm) and 5 millimeters (mm), and composed of mixtures of polymers, functional additives, and other intentionally and unintentionally added chemicals. They are often intentionally manufactured and added to products for specific purposes, but they are also unintentionally formed from the fragmentation of macroplastic debris in the environment. Research shows that microplastics are widely distributed in the environment. They have been found in marine, freshwater, and terrestrial ecosystems, in indoor and outdoor air, and in seafood, plants, salt, and bottled water. Evidence is also growing on the potential adverse effects on human and wildlife health, as well as the social, ecological, and ecosystem service impacts.

As public concern about microplastics grows, the regulatory landscape for these contaminants has also changed. Microplastics are more frequently mentioned in policy frameworks and regulations today, with several countries banning the manufacture and sale of personal care products containing microplastics. Others have introduced restrictions on the sale of single-use plastics, aiming to reduce plastic waste from entering the environment. If the momentum is maintained, we may see regulations targeting reductions in plastic production, enhancing recycling and waste management, and investing in sustainable alternatives.

This review in the Process Economics Program (PEP)'s Environment and Safety Series consolidates the current state of microplastic research from information available in the public literature and answers the following questions:

- What are microplastics?
- Why should we be concerned about microplastics?
- Where are microplastics used and from where do they originate?
- How do microplastics enter the environment?
- What are the human, environmental, and socioeconomic effects of microplastics?
- What is the regulatory landscape surrounding microplastics?
- What are the ways to abate and mitigate microplastic pollution?

The review also emphasizes the necessity of taking action to address microplastic pollution to mitigate its potential risks to human and environmental health. Additionally, it calls for interdisciplinary research and collaboration, building scientific justification for addressing the entire plastic lifecycle, including interventions at the source, development of alternatives, and strong international regulatory frameworks to manage the transboundary microplastic pollution.

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