



PLASTICS RESEARCH COUNCIL

FACTS FOR A BRIGHTER FUTURE

MICROPLASTICS IN BOTTLED BEVERAGES

A Comprehensive Evidence & Risk Assessment

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August 2026



COMPREHENSIVE RISK ASSESSMENT

Microplastics in Bottled Beverages

Evidence, dose, analytical limits, packaging comparisons and public-health context

August 2026

Prepared by the Plastics Research Council

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Independent, unpaid evidence synthesis | No external funding or third-party input

Executive summary

This review examined every PDF in the 65-study curated collection, together with five supplemental oral-toxicology studies, two focused source-recovery/context sources, supplied reports and current WHO, FDA and EFSA material. Three independent evidence streams—measured mass exposure, study-specific oral toxicology and authoritative assessments—support a bounded conclusion: current evidence does not identify a microplastic-related health concern from compliant PET-bottled drinks under ordinary use. The large external-dose separations are reassuring, but no single universal PET NOAEL is justified, and uncertainty remains about the smallest particles, particle form, weathering, surface chemistry, bioavailability and chronic internal dose. Focused source recovery confirms that Otaka et al. 1978 tested aggressive PET chloroform extracts rather than PET particles and adds bounded historical polyethylene context for HDPE closures; neither finding changes the principal dose comparison. On the evidence available through 26 July 2026, with source recovery through 27 July 2026, routine regulatory monitoring, warning labels or mandated reduction are not scientifically justified as health-protection measures solely because microplastics are detectable. [23, 27, 29, 32, 51–57]

Bottom line

Current evidence does not identify a microplastic-related health concern from compliant PET-bottled drinks under ordinary use. Recent average mass-based exposure is approximately 440,000-fold below the lowest author-reported PET NOAEL retained as low-confidence contrary evidence and 400–500 million-fold below the PE/PET component doses tolerated when administered together in the 13-week Merski study. Even the maximum measured-concentration scenario remains approximately 140,000-fold and 128–159 million-fold below those respective values. These are cross-study dose-separation ratios, not statutory limits, acceptable daily intakes or universal safe-intake limits. Detection alone does not justify routine health monitoring, warning labels or mandated reduction. Glass is not particle-free and four studies found more plastic particles in at least one glass comparison. Where safe water is unavailable, correctly used PET-bottle SODIS reduces diarrhoeal disease and can save lives. Evidence cutoff: 26 July 2026.

- Zuri et al. estimated average adult HDPE intake from bottled water at 0.004 µg/kg body weight/day. This is approximately 437,500-fold below the lowest author-reported PET NOAEL retained here as low-confidence contrary evidence (1.75 mg/kg/day) and 400–500 million-fold below the approximately 1.6–2.0 g/kg/day PE and PET component doses tolerated when administered together in the 13-week Merski study. These are cross-study scale comparisons, not drinking-water limits or formal margins of exposure. [12, 32, 51]
- Even using Zuri et al.'s maximum total polymer concentration and assuming two litres consumed daily, the dose is approximately 140,000-fold below the lowest author-reported PET value and 128–159 million-fold below the Merski PE/PET component range. The lower PET value and the mixture-qualified Merski result have different designs and limitations; neither is a universal PET threshold. [12, 32, 51]

- Mass-based studies report nanograms per litre to sub-micrograms per litre in normal bottled water. Very large particle-number estimates are driven mainly by the lower size cutoff and can still represent a very small mass dose.
- No robust human study demonstrates disease caused by bottled-drink exposure. FDA states that detected levels in foods have not been shown to pose a human health risk; WHO does not recommend routine drinking-water monitoring at present; EFSA reports that release from food-contact materials is much lower than some earlier studies suggested. [\[3, 23, 27, 29\]](#)
- Four studies found more microplastics in at least one glass comparison; one also found enormously more pigment particles in glass. Substituting glass therefore does not reliably reduce particle exposure. [\[6, 10, 15, 19\]](#)
- Because no health-based action threshold, risk requiring control or demonstrated health benefit from reduction has been established, special monitoring, warning labels and exposure-reduction programs based solely on detectability are not justified at current measured exposure.
- SODIS addresses a different and much more immediate hazard. In the southern India trial, water exposed to sunlight in PET bottles reduced diarrhoea incidence from 2.7 to 1.7 episodes per child-year (incidence-rate ratio 0.64) and severe diarrhoea by about half. [\[18, 30\]](#)
- “No demonstrated harm” does not mean “not studied.” Relevant polymer, particle, occupational, biomaterials and food-contact toxicology spans more than six decades, and the dedicated microplastics literature is now extensive. Under qualitative Bayesian reasoning, repeated failure to find a reproducible realistic-dose adverse effect—combined with very large separation from selected study-specific toxicology doses—makes a large, common health effect progressively less plausible. This is not a numerical probability and does not make risk impossible. [\[37, 39, 41, 51–55\]](#)
- Size, shape, surface charge, hydrophobicity, persistence, chemical sorption and biofilm formation are not unique to plastic. They are general particle properties shared by clay, cellulose, mineral dust, soot, pollen and many other materials. This removes any basis for presuming a uniquely plastic hazard; a plastic-specific concern must be supported by comparative evidence of greater toxicity at a realistic dose. [\[37, 38, 41\]](#)

Key conclusions at a glance

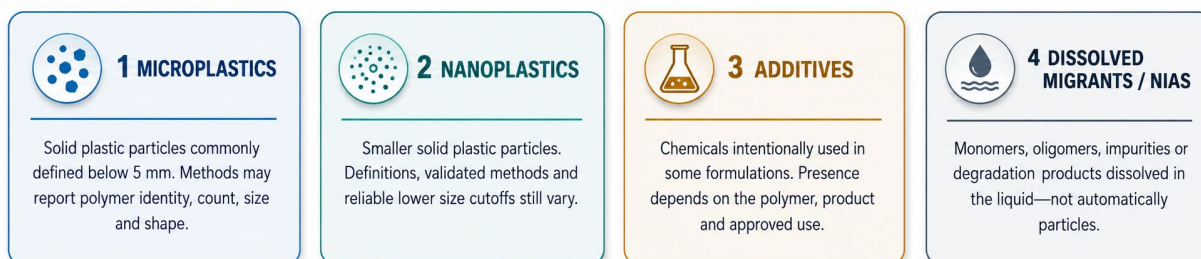
Question	Evidence-based answer
Are particles detected?	Yes. Detection establishes occurrence; biological relevance requires identity, exposure and dose-response evidence.
Does PET necessarily dominate?	No. PE and PP from caps, non-PET polymers, cellulose, pigments and background particles are common.
Is glass particle-free?	No. Four studies in the reviewed evidence found higher microplastic counts in glass than in PET/plastic comparators; closures, liners, coatings, labels and processing are important sources.
Do large particle counts equal a large dose?	No. Particle number is strongly method- and size-cutoff dependent. It must be interpreted with particle identity, size, mass, exposure and dose-response.
Has harm at bottled-water exposure been shown?	No causal human health effect has been established at measured exposure. Hazard studies at high or poorly characterized doses cannot be read as an exposure risk assessment.
How large is the dose separation?	Average exposure is approximately 440,000-fold below the lowest author-reported PET value retained as low-confidence evidence and 400–500 million-fold below the Merski PE/PET component range. These are scale comparisons, not formal safety margins.
Is monitoring or reduction needed?	No health-based case is established for routine monitoring, warning labels or reduction targets based solely on detection in compliant bottled drinks at current measured exposure.
Is PET-bottled water safe?	Yes, with the normal qualification that products comply with applicable food-contact and drinking-water requirements. Current evidence does not identify a microplastic-related health concern under ordinary use.
Can PET bottles save lives?	Yes, in context: correctly used PET-bottle SODIS can reduce waterborne disease where safe water is unavailable; “can save lives” is a public-health inference from disease prevention, not a mortality endpoint in the cited trial.
Does “no demonstrated harm” mean the subject is unstudied?	No. Relevant polymer and particle science spans decades. With no reproducible realistic-dose adverse signal and very large margins, a large common effect becomes less plausible; no numerical probability is claimed.
Are the cited properties unique to plastic particles?	No. Size, shape, charge, hydrophobicity, sorption, persistence and biofilms are shared. Non-uniqueness does not prove harmlessness; a plastic-specific claim requires comparative realistic-dose evidence.

Reader's guide

This report separates occurrence from risk. The terms below are used consistently so that a large count, a chemical signal and a biologically relevant dose are not treated as interchangeable.

Four different evidence questions

Do not turn a particle result into a chemical claim—or a chemical signal into proof of an intact particle.



Each category needs its own measurement → exposure estimate → toxicology → risk assessment

Reader-guide diagram. Microplastics and nanoplastics are solid-particle categories; additives and dissolved migrants are chemical categories. Detection in one category is not evidence for another. [3, 23]

Term	Plain-language meaning
PET bottle system	The PET bottle wall plus a closure that is often HDPE or PP, a liner, label, coatings, filling equipment and the original water or beverage. A particle in the drink is not automatically from the PET wall.
Microplastics / nanoplastics	Microplastics are commonly defined as plastic particles below 5 mm; nanoplastic definitions vary by authority and method. The smaller the analytical cutoff, the larger the possible particle count.
Particle count	The number of detected objects. Counts are strongly affected by size cutoff, blanks, recovery and identification rules and cannot be compared casually across methods.
Polymer mass	The quantity of polymer-associated material, usually reported as ng/L or µg/L. Mass provides essential dose context but may not preserve particle size or shape.
Hazard versus risk	Hazard asks whether something can cause harm under some condition. Risk asks whether harm is expected at the actual dose and route of exposure.
External versus internal dose	External dose is swallowed material. Internal dose is the fraction absorbed and reaching tissue; it is generally smaller and is less certain for the smallest particles.
Units	1 µg = 1,000 ng; 1 mg = 1,000 µg. Two litres at 0.439 µg/L contains 0.878 µg—less than one-millionth of a gram.

Interpretive rule: a numerical result is meaningful only when the measurand, size window, blanks, recovery, exposure assumptions and relevant adverse-effect evidence are stated.

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Evidence cutoff: 26 July 2026; focused thermoplastic source recovery through 27 July 2026.

1. Scope and review method

1.1 Review question and scope

The review question was: what does the total evidence say about microplastic and nanoplastic occurrence in PET-bottled water and other drinks, the contribution of packaging relative to other sources, comparative performance of glass, potential health implications, and the public-health value of PET bottles in SODIS? The scope includes direct occurrence and source studies, analytical-method papers, reviews and risk assessments, relevant oral toxicology, packaging comparisons, lifecycle context and SODIS evidence.

1.2 Evidence identification and selection

The local evidence base began with a recursive PDF catalogue. Duplicate copies were consolidated by DOI and normalized title while retaining every file location. All 65 unique, readable full-text PDFs in the curated PET-bottled-drinks collection were included: 27 direct bottled-water or beverage studies; 16 methods, reviews or risk-assessment documents; 5 drinking-water or tap-water comparators; 8 packaging, chemistry and lifecycle context papers; and 9 newly added essential studies. Five supplemental oral-toxicology studies were subsequently incorporated to correct and broaden the PET and closure-polymer dose context. A focused source-recovery update then added Sheftel 2002 for historical common-polymer context and the primary Otaka et al. 1978 PET-extract study. Bibliographies were checked for missing foundational sources, DOI metadata were verified, and targeted online checks were made for current WHO, FDA and EFSA material. The general evidence cutoff was 26 July 2026, with focused thermoplastic source recovery through 27 July 2026.

Search concepts combined microplastic*, nanoplastic*, PET, polyethylene terephthalate, bottled water, bottled beverage, cap, closure, glass, Raman, FTIR, pyrolysis, exposure, toxicology, risk and SODIS. Eligible items had to be readable in full text and materially relevant to occurrence, measurement, source attribution, exposure, hazard, comparison or public-health context. Supplied reports were used to identify claims, themes and references but were not treated as independent experimental evidence. This is a structured evidence synthesis, not a registered or formal systematic review, meta-analysis, product-specific compliance assessment or substitute for regulatory review.

Evidence hierarchy used

Greatest weight was given to measured mass exposure, study-specific repeated-dose oral toxicology, transparent external-dose separation and authoritative risk assessments. Discordant or method-limited toxicology findings were retained rather than forced into a single PET threshold. Particle-count studies were used to describe occurrence and sources, not as evidence of health risk.

1.3 Data extraction and critical appraisal

For each included item, the review recorded citation, DOI or stable link, study design, sample frame, analytical method, particle-size window, polymer-confirmation approach, main findings and principal limitations. Appraisal considered procedural and field blanks, contamination control, recovery,

subsampling or filter extrapolation, chemical confirmation, representativeness, external-dose relevance and whether an adverse effect—not merely a biomarker or association—was demonstrated. No composite quality score was applied; limitations are reported explicitly in Appendix A.

1.4 Publication status and declarations

- Prepared by: Plastics Research Council. Author: Dr. Chris DeArmitt, Founder of the Plastics Research Council and President of Phantom Plastics LLC.
- Funding and support: none. The work was unpaid. The Plastics Research Council, Dr. DeArmitt and Phantom Plastics received no payment, research funding, sponsorship or other financial or material support for preparing or publishing this report.
- Independence and external input: no client, plastics manufacturer, trade association, advocacy organization, donor, government agency, academic institution or other third party commissioned, directed or controlled the work, and no external organization reviewed or approved it before publication.
- Competing interests: none declared. Phantom Plastics is a disclosed professional affiliation and does not manufacture, market or sell plastics or plastic products. This report has not undergone formal journal peer review.
- Version control: August 2026 edition; evidence cutoff 26 July 2026, with focused thermoplastic source recovery through 27 July 2026.

1.5 Author, affiliations and independence

This report was prepared by the Plastics Research Council as an independent, unpaid evidence synthesis, authored and directed by Dr. Chris DeArmitt. Dr. DeArmitt is a polymer scientist, Founder of the Plastics Research Council and President of Phantom Plastics LLC. Phantom Plastics is an independent technical consultancy and does not manufacture, market or sell plastics or plastic products.

No government body, company, client, plastics manufacturer, trade association, advocacy organization, donor, academic institution or other third party commissioned, sponsored, directed, reviewed, approved or controlled this work. No external funding or material support was received, and no external party influenced the report's scope, study selection, interpretation, conclusions, wording, graphics or publication. The scientific literature and cited regulatory assessments were the evidentiary basis for its scientific conclusions.

AI-assisted tools, including OpenAI ChatGPT, supported structured extraction, consistency checking, source triage, calculation checking, drafting, revision and adversarial review. They were not treated as scientific authorities or independent reviewers and did not conduct primary research or generate experimental data. Dr. DeArmitt retained responsibility for source selection, evidence appraisal, interpretation, wording, citations and every final conclusion.

2. Why detection does not establish risk

2.1 Particle counts can obscure differences in dose

Particle counts rise sharply as instruments detect smaller sizes: one large fragment can become thousands or millions of small particles with little change in total mass. This is why studies report values ranging from tens per litre to very large nanoscale estimates. Particle number can describe occurrence, but it is insufficient for risk interpretation unless the size distribution, material identity, mass, bioavailability and relevant dose-response are also considered. The Qian–Materić exchange over blank treatment further shows why a high count should not be converted directly into a health claim. [\[16, 35, 36\]](#)

A risk conclusion therefore requires a chain of evidence: the detected material must be confirmed as plastic, exposure must be realistic, and an adverse effect must be demonstrated at that dose. Most occurrence studies establish only the first step—presence—and cannot by themselves establish danger.

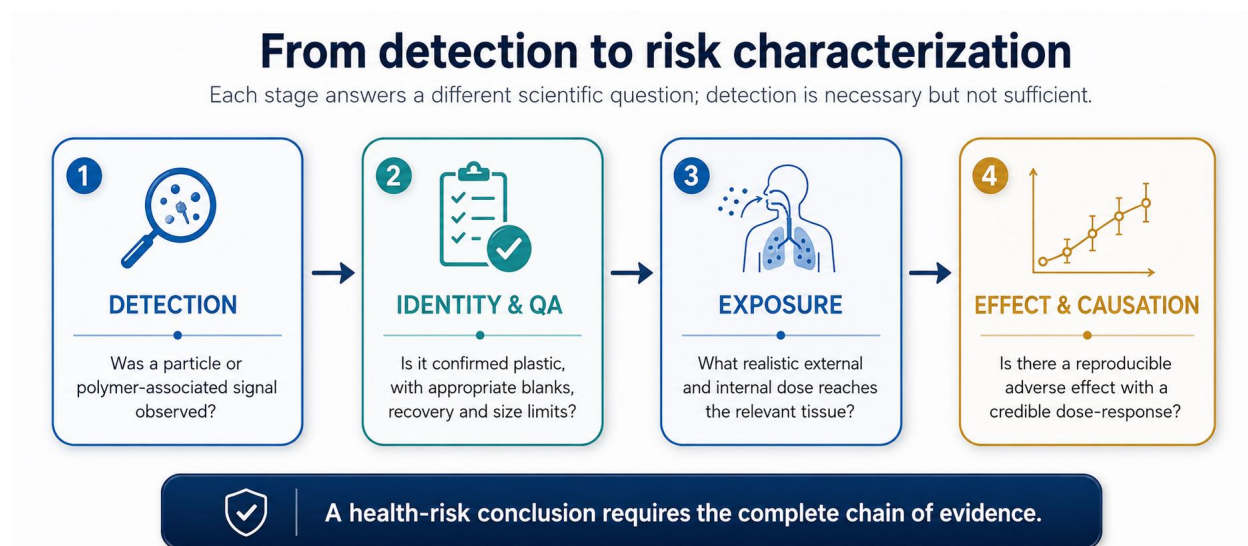


Figure 1. From detection to risk characterization. Occurrence, identity and quality assurance, exposure, and adverse effect or causation are distinct evidentiary stages.

2.2 Mass provides essential dose context

Vega-Herrera et al. reported a median sum of polymer markers of 359 ng/L in Spanish bottled waters. Zuri et al., using high-resolution pyrolysis GC-MS across 40 brands in five countries, reported total quantified polymer mass of 0.016–0.439 µg/L. HDPE from caps was more frequently detected than PET, and PET was below that method’s quantification limit. These are trace quantities. Even two litres at the maximum reported concentration would contain less than 0.9 µg of total quantified polymer mass. [\[24, 32\]](#)

The governing principle

Routine health-protection monitoring is most useful when a measurement can be linked to a credible adverse-effect level, a validated action threshold and an intervention known to reduce risk. The reviewed bottled-drink exposure is remote from all selected study-specific oral toxicology doses, including the lowest author-reported PET value retained with major limitations. Detectability alone supplies no scientific trigger for control.

2.3 What the main analytical methods actually measure

No single method provides particle identity, number, size, shape and mass across the full micro-to-nano range. Spectroscopic imaging preserves individual-particle information but has size, fluorescence and throughput constraints. Thermal methods provide polymer-associated mass but destroy morphology. Fluorescence and light-scattering methods can be sensitive but are not inherently polymer-specific. Results therefore describe an operationally defined fraction rather than a universal “true” concentration. [\[32–36\]](#)

Method	Primary output	Principal strength	Key limitation
μFTIR / Raman imaging	Chemically assigned particles; count, size and shape within the scanned window	Polymer-specific spectra on individual particles	Lower size cutoff, fluorescence, library rules, sampled filter area and throughput can dominate results
Nile Red fluorescence	Fluorescent object count and size estimate	Fast and relatively inexpensive screening	Hydrophobic non-plastic material may fluoresce; confirmatory spectroscopy is needed
SERS / stimulated Raman	Nanoscale chemical signatures or high-speed chemical images	Extends chemical imaging below conventional Raman limits	Substrate, blank and classification choices are still developing; population estimates remain method-sensitive
NTA / light scattering	Number and hydrodynamic size of light-scattering objects	Sensitive to nanoscale objects in suspension	Not polymer-specific; dissolved and non-plastic particles can contribute
Py-GC-MS / Orbitrap-MS	Polymer-associated chemical markers converted to mass	Direct mass context and polymer discrimination for validated targets	Destroys particles and cannot by itself report intact-particle number, size or shape

Table 1. Complementary analytical methods and the measurands they support. Cross-study comparisons require harmonized size windows, blanks, recovery and identification rules.

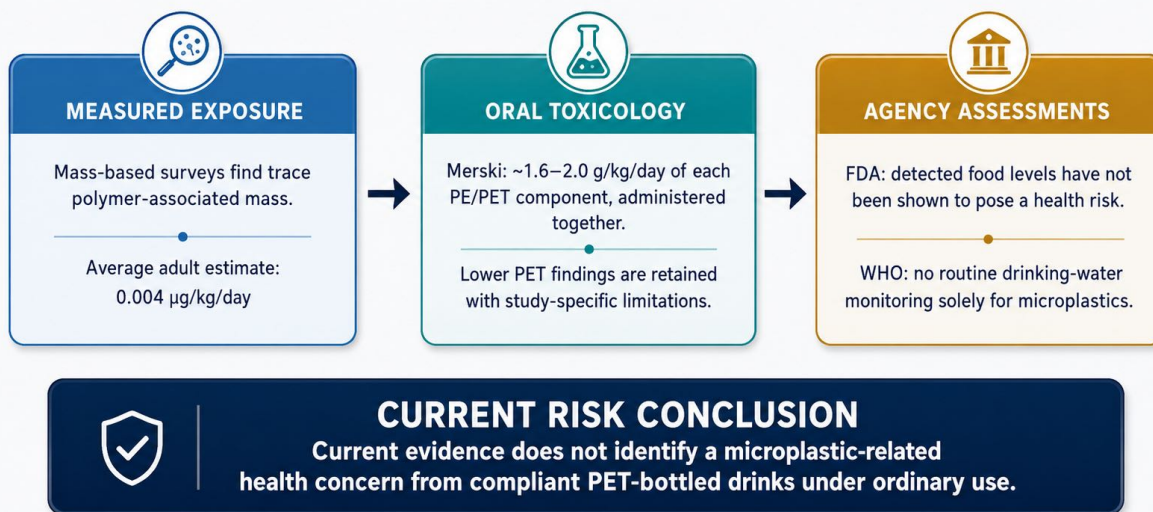
2.4 Evidence convergence, not a single reassuring study

The risk conclusion does not depend on dismissing particle detections or selecting one favorable experiment. Three different kinds of evidence answer different parts of the question and point in the same direction. Mass-based surveys quantify a very small ingested dose. Oral studies provide a heterogeneous but highly separated toxicology context: the 13-week Merski PE/PET mixture tolerated approximately 1.6–2.0 g/kg/day of each component administered together, while newer PET studies report lower, study-specific findings with important methodological limitations. WHO and FDA do not identify a demonstrated current health risk at detected exposure, while EFSA is still developing a full

food risk assessment and emphasizes major data gaps. Uncertainty warrants research, but it does not convert occurrence into evidence of harm. [3, 12, 23, 27, 29, 51–55]

Three independent evidence streams converge

The toxicology evidence is heterogeneous; no single universal PET threshold is claimed.



Dose separation is contextual—not a statutory limit, acceptable daily intake or universal safe-intake threshold.

Figure 2. Independent exposure, heterogeneous study-specific toxicology and agency evidence converge on the same bounded risk conclusion. No universal PET threshold is claimed; full sources appear in the references.

3. What has been found in PET-bottled drinks

3.1 Bottled water

Across the collection, most bottled-water surveys detect at least some particles, but reported concentrations vary by many orders of magnitude. Mason et al. found 93% of 259 bottles positive and reported means of 10.4 particles/L above 100 μm and 325/L in the 6.5–100 μm fluorescently tagged range. Schymanski et al., using micro-Raman down to 1 μm , reported 14 ± 14 particles/L in single-use PET, 118 ± 88 /L in reusable PET and 50 ± 52 /L in glass. Oßmann et al., analyzing still smaller particles and extrapolating from a small filter area, reported thousands per litre. Nizamali et al. found a mean of 96/L (range 7–364; median 44) above 10 μm across nine bottles after blank correction and a recovery near 59%. Al-Mansoori et al. reported 37 ± 11 /L in UK bottled water and 40 ± 16 /L in tap water, a statistically indistinguishable difference. [\[1, 11, 14, 15, 19\]](#)

The apparent conflict is mainly methodological. Different size cutoffs, sample volumes, filter areas, polymer-confirmation rules and blank treatments produce different numerical universes. The defensible cross-study conclusion is presence with substantial heterogeneity—not a single global concentration.

3.2 Nanoplastics

Zhang et al. used a surface-enhanced Raman substrate to provide chemical evidence of PET nanoplastics with a mean measured size near 88 nm. Their nanoparticle-tracking estimate of approximately 10^8 particles/mL is not polymer-specific and should not be treated as a chemically confirmed PET count. Qian et al. used stimulated Raman scattering to image multiple polymers at small sizes and reported a high total particle estimate, but the subsequent exchange over blanks and detection limits remains unresolved. These studies demonstrate analytical capability and support nanoscale PET occurrence in some samples; they do not yet establish a stable population exposure estimate or a validated dose-response relationship. [\[16, 31, 35, 36\]](#)

3.3 Soft drinks and other beverages

Studies of soft drinks, cold tea, energy drinks and other non-alcoholic beverages also report microplastics. Interpretation is harder than for water because sugars, colorants, pulp, proteins, carbonation and other matrix components complicate digestion, filtration and spectroscopy. Packaging type, filling conditions and beverage formulation are often confounded. The evidence supports occurrence, but does not justify assuming that every detected particle originated from the PET wall or that one beverage category is uniformly higher than another.

Study example	Reported finding	Interpretive caution
Mason et al. 2018	Global bottled-water survey; most bottles positive; mean 10.4/L >100 µm and 325/L at 6.5–100 µm.	Nile Red screening; only a subset chemically confirmed; broad brand/lot variability.
Schymanski et al. 2018	Single-use PET 14 ± 14/L; reusable PET 118 ± 88/L; glass 50 ± 52/L.	Counts apply to 1–500 µm Raman window; blank 14 ± 13/L.
Oßmann et al. 2018	Single-use PET 2,649 ± 2,857/L; glass 6,292 ± 10,521/L; >90% below 5 µm.	Only 5 mm ² of a 113 mm ² filter analyzed, then extrapolated; high variance and non-zero blanks.
Al-Mansoori et al. 2025	Tap 40 ± 16/L; bottled 37 ± 11/L; no significant concentration difference.	µFTIR window and UK sampling frame; bottled particles were smaller on average.
Vega-Herrera et al. 2023/2024	Median sum of polymer markers 359 ng/L.	Mass-based operational fraction; local copy is a preprint version.
Zuri et al. 2025	0.016–0.439 µg/L total quantified polymer mass across 40 brands; HDPE dominant.	Mass, not number; method-specific quantification limits.

Table 2. Representative results illustrating why values should not be pooled without harmonization.

4. Where the particles come from

4.1 Source water and the filling environment

Bottled water begins as groundwater, spring water or treated municipal water. Low but measurable particles may already be present. Treatment can remove particles but can also introduce material through filters, pipes, tanks and airborne deposition. “From the well to the bottle” studies show that source and bottling stages both matter. A polymer not used in the bottle wall is an immediate warning against assigning every particle to PET.

4.2 Bottle wall

PET fragments are found in some products and can be released by surface degradation, abrasion or prolonged photochemical stress. The amount varies with wall morphology, crystallinity, thickness, age and treatment history. In ordinary single-use products, however, several studies find relatively few PET particles compared with closure polymers or other material. Mass-based studies also show that PET may be below quantification even when other polymers are detected.

4.3 Cap and bottleneck

The closure is a well-supported source. Winkler et al. observed increasing damage and particles on PET necks and HDPE caps after repeated opening and closing, with large brand differences. Singh measured an average generation rate of 553 ± 202 particles/L per open–close cycle above $4.7 \mu\text{m}$ under the study conditions. Al-Mansoori et al. found a correlation between PE cap material and the predominant bottled-water polymer, while Zuri et al. found HDPE to be the dominant quantified polymer mass. This explains occurrence; it does not establish a harmful dose or a health need to redesign closures. [\[1, 20, 26, 32\]](#)

4.4 Labels, pigments, washing and reuse

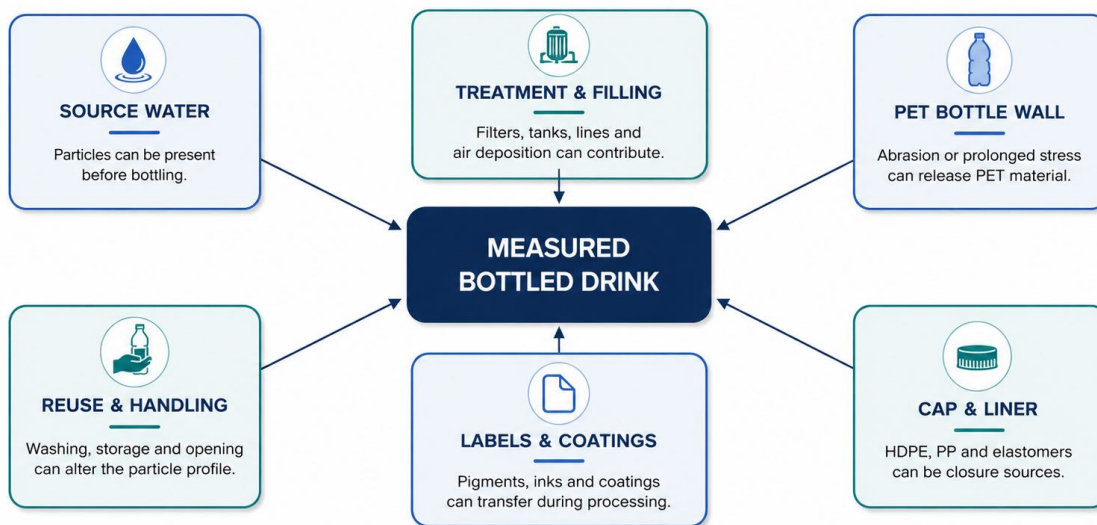
Oßmann et al. detected pigment chemistries matching printed labels, especially in reusable, paper-labelled systems. Reusable bottles also pass through collection, washing and refilling loops, creating opportunities for cross-transfer from labels, crates, caps, cleaning and line equipment. This explains why reusable packaging can have a higher particle count than a new single-use bottle without implying that reuse is undesirable overall; environmental performance must include transport, washing, breakage and reuse rate.

4.5 Source attribution requires matched evidence

A measured particle may originate before bottling, during treatment and filling, from the bottle wall or closure, or during transport, opening, reuse and washing. Strong attribution uses matched stage-by-stage samples, polymers that plausibly correspond to the suspected component, appropriate field and procedural blanks, and replication across bottles or lots.

Potential contributors to particles in a bottled drink

A detected polymer can indicate a material source without proving the exact release stage.



Strong attribution requires matched sampling across stages, confirmed polymers and appropriate blanks.

Figure 3. Potential contributors to particles measured in a bottled drink. A polymer identity can support a source hypothesis without proving the exact release stage.

5. PET compared with glass and reusable packaging

Glass is not a particle-free control

The contents of a glass bottle can still contact a plastic or elastomeric cap liner, closure, coating, label, bottling line and wash system. Glass packaging can therefore contain microplastics even though the bottle body is inorganic. Pigment particles and trace elements from decorated glass are additional, separate issues.

Four studies in the reviewed evidence found higher microplastic counts in glass packages than in PET or plastic comparators. They used different methods and sampling frames, so their values should not be pooled, but together they show that the result is reproducible across more than one laboratory and analytical window: [\[6, 10, 15, 19\]](#)

Study	Glass result	PET/plastic comparison	Interpretation
Schymanski et al. 2018	50 ± 52 MP/L	Single-use PET 14 ± 14/L; reusable PET 118 ± 88/L	Glass exceeded single-use PET, but not reusable PET; closure/processing polymers were present.
Oßmann et al. 2018	6,292 ± 10,521 MP/L	Single-use PET 2,649 ± 2,857/L; reusable PET 4,889 ± 5,432/L	Glass was highest; only 3.6% of glass-bottle polymers were PET.
Gambino et al. 2023	8.65 ± 5.39 MP/L	Virgin PET 5.09 ± 3.28/L; rPET 3.31 ± 1.34/L	Low concentrations overall; PE with additives in glass pointed to caps. Different brands/source waters limit causal comparison.
Chaib et al. 2025	Water 4.5 ± 1.2 MP/L; glass soft drinks often ~86–112/L	Plastic-bottled water 1.6 ± 1.7/L; plastic soft drinks often ~1.5–2.2/L	Painted metal caps were implicated; broad beverage survey, not a perfectly matched package trial.

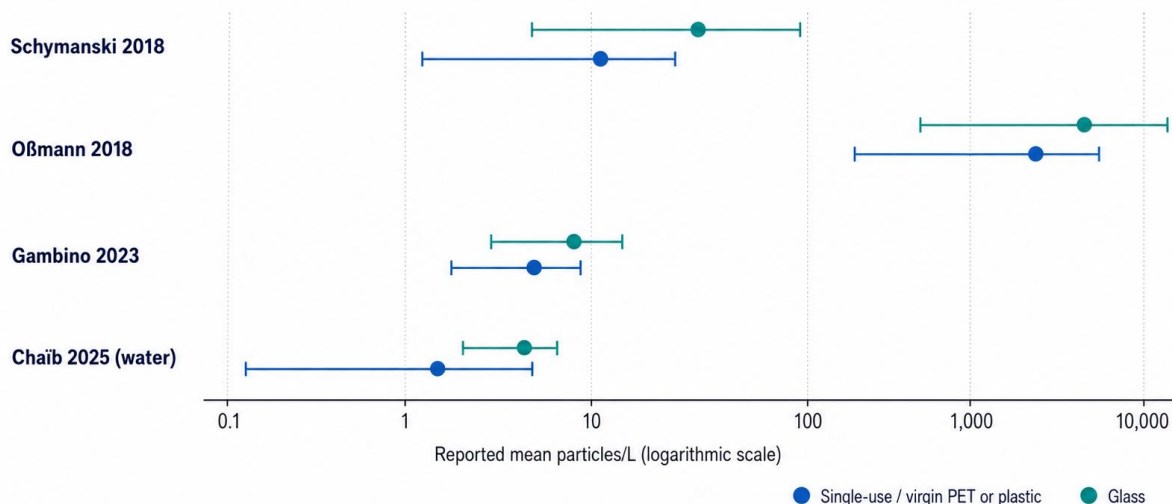
Table 3. Four studies reporting more microplastics in at least one glass-versus-PET/plastic comparison. The direction is not universal for every glass comparison; study design and reuse status matter.

The two German mineral-water comparisons are especially detailed. In Oßmann et al., PE, PP and styrene–butadiene were prominent in glass-bottled water, pointing to closures and processing rather than the glass wall. The French ANSES study extended the pattern to beverages: glass-bottled water averaged 4.5 ± 1.2 particles/L versus 1.6 ± 1.7 /L in plastic, while glass-bottled colas, teas and lemonades were far higher than their plastic or canned comparators. The authors traced many particles to the color and polyester/alkyd composition of painted metal caps.

The pigment contrast was much larger. Oßmann et al. reported means of $195,047 \pm 330,810$ pigment particles/L in glass, $23,594 \pm 25,518$ /L in reusable paper-labelled PET and $1,175 \pm 1,179$ /L in single-use PET. Pigments matched label printing, supporting transfer during reuse and washing. The study's very high variability, 5 mm² analyzed area and 90.4-fold extrapolation prevent universalizing the exact values; nevertheless, it decisively refutes the idea that switching to glass guarantees fewer particles.

Four study-specific comparisons of mean particle counts

Glass and single-use/virgin PET or plastic are shown separately; the studies cannot be pooled.



Points show reported means; whiskers show reported standard deviations. Lower whiskers are truncated above zero for log display. Different packages, waters, methods and sample frames prevent a universal material ranking.

Figure 4. Study-specific means and reported standard deviations for four glass-versus-PET/plastic comparisons. The logarithmic scale preserves the large between-study spread; the studies are not pooled.

Chemical comparisons also complicate “glass versus plastic.” Reimann et al. found packaging-related elemental differences among glass, hard PET and soft PET waters. Turner reported heavy metals in enamels and decorated consumer glass. These findings do not establish that glass is unsafe; they show why packaging alternatives should be compared across the whole product system rather than by assuming “non-plastic” means “contaminant-free.”

6. Stress studies and normal use

Heat, sunlight, shaking, freezing and repeated opening can increase particle counts under experimental conditions. Hussain et al., for example, reported a nine-fold nanoparticle increase after repeated cycles involving 60 °C heat and 200 rpm agitation; Folarin et al. exposed bottles to sunlight for ten weeks. These studies demonstrate that severe treatment can alter a surface. They do not show that normally handled bottled drinks are unsafe, and they do not establish that consumers need special microplastic-reduction behavior. [\[4, 8, 21\]](#)

Ordinary product instructions—such as avoiding prolonged extreme heat and using food containers as intended—remain sensible for general product quality. They should not be presented as precautions against a demonstrated microplastic health hazard, because no such hazard has been shown at measured exposure.

7. Exposure and health interpretation

7.1 Presence is not risk

Risk assessment asks whether a dose reaching relevant tissues is sufficient to cause an adverse effect. The bottled-drink literature is dominated by occurrence studies, not human outcome studies. In vitro and animal papers often use pristine spheres, narrow polymer types, high concentrations or routes that do not match drinking-water exposure. They can identify possible mechanisms, but they cannot by themselves demonstrate risk from a beverage.

WHO's 2019 drinking-water assessment concluded that, on the evidence then available, microplastics in drinking water did not appear to pose a health risk at current levels, while emphasizing substantial data limitations and the need for better studies. WHO's 2022 broader assessment again identified major uncertainties, especially for the smallest particles. EFSA's April 2026 topic page states that dietary exposure and health knowledge remain limited, that nanoplastic data are particularly scarce, and that EFSA has not yet completed a full food risk assessment. EFSA also reports that its 2025 food-contact literature review found release at much lower levels than some earlier studies suggested. [\[3, 23, 27, 29\]](#)

This distinction between hazard and risk is essential. A concentrated laboratory exposure can help reveal a possible mechanism, but it does not establish that the same response occurs at the far smaller, mixed and intermittent exposure encountered in ordinary life.

Interpreting laboratory hazard studies

A biological response is informative only after its relevance to real-world exposure is assessed.

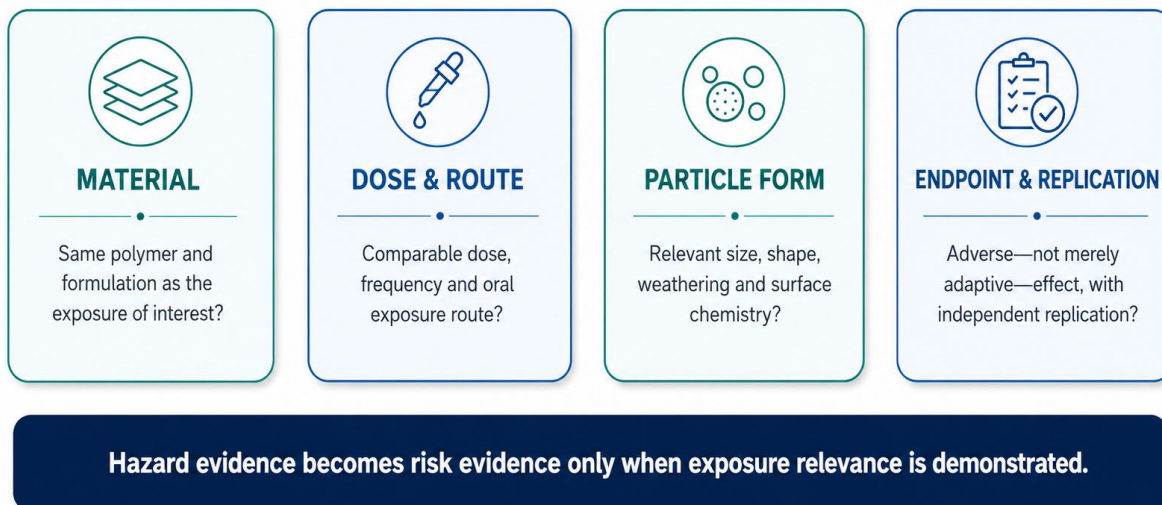


Figure 5. Laboratory hazard studies can identify hazards under experimental conditions; they do not establish everyday human risk without a realistic dose comparison.

7.2 Why accumulated evidence matters

The phrase “no demonstrated harm” is not used here to mean that the relevant work has not been done. Polymer toxicology, occupational and environmental particle research, biomaterials testing and food-contact assessment extend back more than sixty years; the newer literature explicitly labelled “microplastics” now contains thousands of publications. A raw publication count is not proof of safety. What matters is whether the most informative studies—those with credible identity, exposure, controls, dose and adverse endpoints—produce a reproducible signal at a realistic dose. [37, 39, 41]

Bayesian updating provides a useful interpretation. If a large, common health effect existed at ordinary exposure, increasingly sensitive and relevant evidence would be expected to reveal a consistent dose-related signal. As independent lines of evidence continue not to do so—and measured exposure remains many orders of magnitude below selected study-specific oral toxicology doses—the plausibility of such an effect should be updated downward. No numerical posterior probability is calculated because study sensitivity, particle form, endpoints and exposure realism differ, and uncertainty remains greatest for the smallest particles.

Prata and colleagues reached a similarly bounded conclusion for airborne synthetic particles, writing that “observable health effects from this exposure are not likely to happen at current concentrations.” That chapter concerns inhalation rather than PET-bottled drinks, so it is supporting particle-dose context rather than direct oral evidence. [39]

The supplied MP73 synthesis expresses the exposure perspective as plastic particles being approximately one hundred-thousandth of adult soil-plus-dust ingestion by mass in a bounded cross-domain comparison. This is not a universal composition constant. The underlying Mohamed Nor model estimated median adult total microplastic intake of 583 ng/day across multiple foods and inhalation, and a modeled retained mass of 40.7 ng by age 70 for a narrower 1–10 µm domain. Because the external-intake and retained-burden models use different size domains, their ratio is a diagnostic scale comparison rather than a measured human retention fraction. [40]

Swallowed mass is not the same as retained tissue burden

The Mohamed Nor et al. values below are model estimates—not direct measurements in a person.

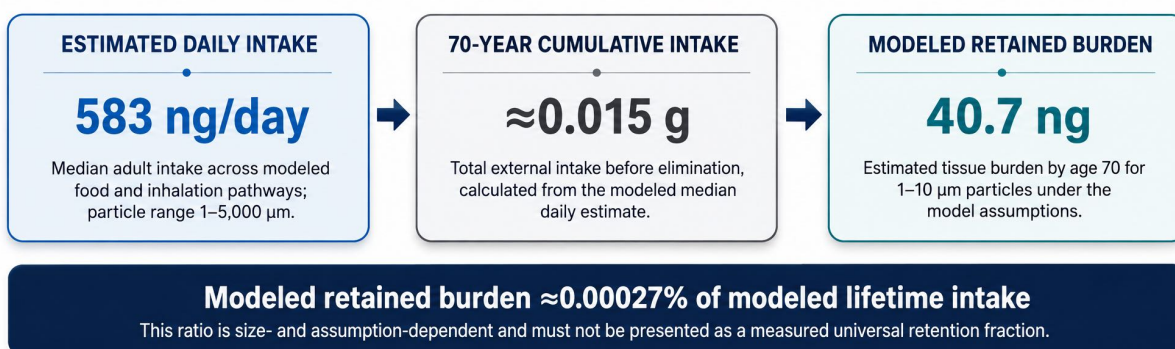


Figure 6. Mohamed Nor et al.’s model separates external intake from estimated retained tissue burden. The values use different size domains and are model-derived, not direct human measurements or a measured retention fraction. [40]

Public claim check: “one credit card per week”

Pletz re-examined the widely repeated 0.1–5 g/week estimate and identified serious problems in combining particle-size and particle-count data from different sources. The Mohamed Nor median corresponds to approximately 4.1 µg/week, not grams. This corrects the exposure scale; it is not proof of zero hazard. [\[40\]](#) [\[50\]](#)

7.3 Plastic-specific hazard must be demonstrated, not assumed

No commonly cited physical property provides a unique toxicological signature for plastic. Small size, irregular or fibrous shape, surface charge, hydrophobicity, large surface area, persistence, chemical sorption and biofilm formation all occur among natural and anthropogenic non-plastic particles. Wieland et al. showed that size, shape and surface charge are general determinants across airborne particle classes; chemical identity and actual exposure still matter, but the label “plastic” does not establish a distinct mechanism. [\[41\]](#)

Ogonowski, Gerdes and Gorokhova emphasized that most experimental designs “do not allow distinguishing plastic-specific effects from those caused by any other particles.” Their ecotoxicological review found that clay, cellulose and other natural particles can produce similar responses and called for non-plastic reference particles in experiments. The direct implication for this report is not that every polymer particle must be harmless; it is that special concern cannot be inferred from generic particle properties. Comparative studies must show that plastic produces a greater adverse effect than an appropriate reference particle at the same biologically relevant dose. [\[37\]](#)

These are particle properties—not plastic signatures

The properties often invoked for microplastics are shared by many natural and anthropogenic particles.

**Scientific implication: shared properties remove any basis for presuming a uniquely plastic hazard.**

They do not prove universal harmlessness. A plastic-specific claim requires comparative evidence of greater toxicity at a realistic dose.

Figure 7. Commonly invoked microplastic properties are not unique; comparative toxicology is still required.

Microfibres are not synonymous with microplastics

Dris et al. found that 67% of analysed fibres in three indoor environments were natural material, mainly cellulosic. Suaria et al. chemically characterized about 2,000 fibres from 916 ocean-surface samples and found only 8.2% synthetic. These are setting-specific composition results—not universal proportions or evidence of harmlessness—but they show why microscopy alone cannot classify every fibre as plastic. [\[48\]](#) [\[49\]](#)

A later meta-analysis by Ogonowski et al. provides an important boundary. Its estimates were highly uncertain, but their central tendency suggested that microplastics could be marginally more hazardous than suspended sediments for aquatic organisms in the 1–1,000 µm range. This is an ecological hazard comparison—not evidence of human oral risk from bottled drinks—and the authors reported that systematic design differences can inflate apparent microplastic hazard. It prevents an absolute claim that no difference could ever exist, while reinforcing the need for matched reference particles and realistic exposure. [\[38\]](#)

7.4 Human evidence

Reports of plastic-associated particles in human tissues demonstrate analytical interest but do not establish that bottled drinks are the source or that detected material caused disease. Exposure occurs through air, food, household dust, textiles and many products. The curated collection does not contain a robust prospective human study linking consumption of PET-bottled drinks to a clinical endpoint. A small 2024 blood-pressure avoidance pilot cannot isolate bottle material, was not blinded, and is hypothesis-generating rather than causal evidence.

7.5 Updated oral toxicology and dose comparison

Updated Merski interpretation. Merski et al. conducted a 13-week OECD/GLP dietary study using cryogenically milled spunbond fabric composed of 50% polyethylene and 50% polyethylene terephthalate. No apparent target-organ toxicity was detected at the highest target concentration of 5% of the diet, measured as 4.7%. For the 50:50 composition, the high diet contained approximately 2.35% measured PE and 2.35% measured PET. Using the reported food-consumption and body-weight trajectory, approximately 1.6–2.0 g/kg body weight/day of each polymer component was administered, with PE and PET given together. This is a mixture- and preparation-specific highest dose without apparent adverse effects, not an independently established pure-PE or pure-PET NOAEL. [\[12\]](#)

Historical Welle–Franz screening calculation. Welle and Franz previously converted the top treatment to approximately 375 mg/kg/day in male rats and 500 mg/kg/day in females, then applied a 100-fold factor to create a 5 mg/kg/day screening comparator. That deliberately conservative secondary-review calculation is not the formal or source-derived Merski NOAEL, a human NOAEL, an acceptable daily intake or a validated action threshold. It is retained as historical context but removed from the principal figure and dose table. [\[25\]](#)

New PET evidence broadens but does not simplify the dose-response picture. Kim et al. reported sex-specific PET NOAELs of 1.75 mg/kg/day in males and 7 mg/kg/day in females, but particle identity within the reported lung lesions was not chemically co-localized, pathology was not quantitatively scored and tissue examination was limited. Lu et al. gavaged male mice with irregular 6–12 µm PET at 5, 50 or 500

µg/day for 17 weeks; no significant liver pathology or liver-function change was reported at 5 µg/day, while hepatic effects increased at 50 and 500 µg/day. Lewis et al. reported mild, sex-dependent responses after a single 5 or 50 mg/kg dose, and Mierzejewski et al. reported pancreatic gene-expression and oxidative-stress changes in piglets after 0.1 or 1 g/day for four weeks. These studies are useful hazard evidence, but none establishes a robust general PET NOAEL. [51–54]

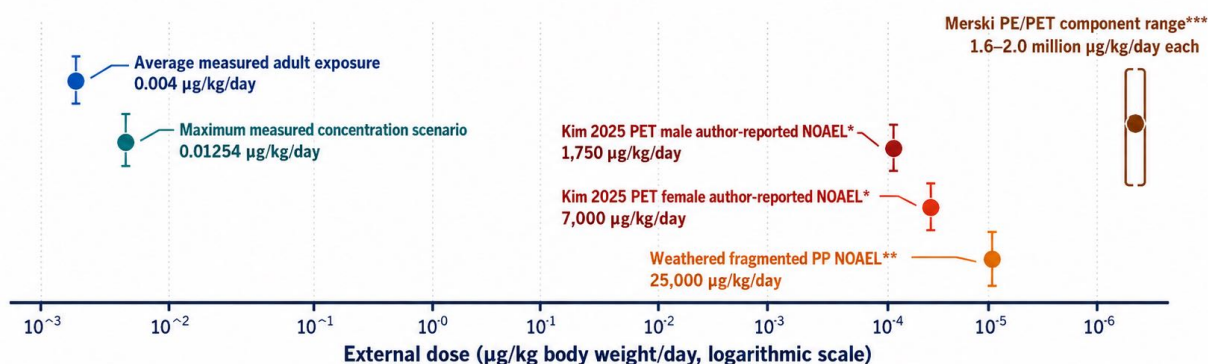
PP closure-material context. Some bottle closures are polypropylene. A 28-day GLP rat study of weathered irregular PP fragments established a formal study NOAEL of 25 mg/kg/day, the highest feasible dose tested. This value does not apply to PET or HDPE, but it provides material-specific context for PP closure particles. [55]

HDPE closure-material structure-activity and historical context. Polyethylene is the high-molecular-mass limit of the saturated-hydrocarbon series. Its chemically stable carbon-carbon and carbon-hydrogen backbone, negligible volatility and extremely low water solubility provide a mechanistic basis for very low intrinsic chemical toxicity and low molecular bioavailability. This is supporting evidence rather than a substitute for direct particle toxicology; it does not imply that every alkane is non-toxic or that every PE formulation, particle size or exposure condition is harmless. A historical secondary record describes rats fed 1.25%, 2.5% or 5% PE in the diet for 90 days without reported adverse effects. Because the original experimental report has not been independently recovered, 5% of the diet remains a secondary-cited highest tested concentration, not a formal PE NOAEL and not a comparator in Figure 8. [25, 56]

Comparative in-vitro evidence. Stock et al. tested PE, PP, PET and PVC particles in human intestinal Caco-2 cells and liver-cell systems. Uptake and transport depended on particle material and size, while cytotoxicity appeared only at concentrations the authors described as far beyond realistic dietary exposure. The work usefully extends the evidence beyond polystyrene beads, but its short-term cell-culture design cannot establish a human safe-intake threshold. [43]

Measured exposure is far below selected toxicology doses

Logarithmic external-dose comparison; study-specific values are not interchangeable thresholds.



Average measured exposure is approximately 440,000-fold below the lowest author-reported PET value and 400–500 million-fold below the Merski component range

* Low-confidence, study-specific PET value. ** PP closure-material context only. *** PE and PET were administered together; not pure-polymer NOAELs.

Cross-study scale comparison only—not a formal margin of exposure, human threshold or regulatory limit.

Figure 8. Measured adult exposure compared with selected study-specific oral toxicology doses on a logarithmic scale. The lower PET values are retained with major limitations; the Merski PE/PET component range was administered as a mixture. All ratios are cross-study scale comparisons, not formal margins of exposure.

Exposure scenario	Estimated dose	Below 1.75 mg/kg/day PET value*	Below 1.6–2.0 g/kg/day PE/PET component range**
Zuri average adult HDPE exposure	0.004 µg/kg/day	437,500-fold	400–500 million-fold
Zuri maximum total polymer concentration; 2 L/day, 70 kg adult	0.01254 µg/kg/day	~140,000-fold	128–159 million-fold
Welle–Franz deliberately high beverage scenario: 10 µg/L	0.1667 µg/kg/day	~10,500-fold	9.6–12.0 million-fold
Welle–Franz deliberately high infant scenario: 10 µg/L	2.0 µg/kg/day	875-fold	800,000–1,000,000-fold

Table 4. External-dose separation. Calculations compare bottled-drink exposure with the lowest author-reported PET NOAEL (1.75 mg/kg/day), retained as low-confidence contrary evidence, and with the approximately 1.6–2.0 g/kg/day PE/PET component range tolerated when the polymers were administered together in the Merski study. These are transparent cross-study scale comparisons, not regulatory limits, acceptable daily intakes or proof that particle forms are biologically equivalent.

The average modern mass-based exposure estimate is approximately 437,500-fold below the lowest author-reported PET value and 400–500 million-fold below the mixture-qualified Merski component range. The maximum measured-concentration scenario remains approximately 140,000-fold and 128–159 million-fold below those values, respectively. The large separation is reassuring, but the toxicology evidence is heterogeneous and does not define one universal PET point of departure. PET itself was below Zuri et al.’s quantification limit; HDPE closure material dominated. Tested HDPE leachates produced no loss of HepG2 cell viability or increase in reactive oxygen species under the reported conditions. [12, 32, 51]

What can be said confidently

The dose separation is not narrow or borderline. Measured bottled-drink exposure is far below all selected study-specific oral toxicology doses, including the lowest author-reported PET value retained with major limitations. The evidence does not establish a universal PET threshold, but it also does not identify a dose-based health rationale for routine measurement, warning labels or exposure-reduction programs at current measured exposure.

Additive perspective. Welle and Franz did not report a measured PET-specific additive percentage in the drink. They instead modelled a deliberately conservative upper scenario: 10 µg/L of total microplastics containing 2% additives, with complete transfer of those additives. The resulting exposure was 0.2 µg/L—about $2 \times 10^{-8}\%$ by mass for a drink of approximately 1 kg/L, or roughly one part in five billion. They concluded that this conservative exposure would not raise a safety concern for adults, toddlers or infants. This is a screening calculation across possible microplastic additives, not a measurement of

every PET formulation; its strength is that even the complete-transfer assumption remains extremely small. [25]

PET chemical-migration context. Bach et al. exposed PET-bottled waters to natural sunlight for 2, 6 and 10 days. Some aldehyde and antimony migration changed with water type and exposure, but no unpredictable NIAS were identified and the concentrated extracts produced no cytogenotoxic, estrogenic or anti-androgenic activity in vitro at relevant consumer-exposure levels. This was a two-brand migrant/extract study—not a microplastic-particle study—and its bioassays do not exclude every possible endpoint or formulation. [42]

Recovered PET-extract toxicology. Otaka et al. administered chloroform extracts of titanium- or germanium-catalyzed PET resin to rats by gavage for 90 days; they did not administer PET particles or the intact high-molecular-mass polymer. Highest doses were 400 mg/kg/day for the titanium-catalyzed-resin extract and 180 mg/kg/day for the germanium-catalyzed-resin extract, with no treatment-related adverse effects identified under the study conditions. These values apply to aggressive solvent extractables and are not PET-polymer or microplastic NOAELs, so they are excluded from Figure 8 and Table 4. The paper cites an earlier direct PET-resin dietary study, Haskell Laboratory Report 17-73, Medical Research Project 1609, but that report has not been recovered and is not used quantitatively. [57]

7.6 Chemical-carrier claims require a dose comparison

Plastic particles can sorb hydrophobic chemicals, but sorption alone does not show that they materially increase human chemical dose. A credible vector claim must quantify the chemical mass carried, demonstrate release under relevant gastrointestinal conditions, compare particle-mediated exposure with direct exposure from food, water, air and dust, and show an adverse effect at a realistic particle concentration. Chemicals originally present in a formulation and environmental contaminants sorbed later are also separate exposure questions.

The available experimental evidence shows that direction and magnitude are system-dependent. In aquatic models, Beckingham and Ghosh found lower PCB uptake from polypropylene-associated PCBs than from contaminated sediment; Beiras et al. found that polyethylene particles did not increase uptake or toxicity of two hydrophobic chemicals; Rehse et al. reported reduced short-term BPA effects in the presence of polyamide particles; and Gerdes et al. demonstrated reverse transfer of one PCB congener from contaminated daphnids to particles under high experimental concentrations. These studies do not establish human oral safety or prove that particles are beneficial. They show that the simple “Trojan horse” narrative is incomplete and that a vector effect must be demonstrated quantitatively rather than inferred from sorption. [44] [45] [46] [47]

7.7 External dose, bioavailability and internal dose

The calculations above use external oral dose—the polymer-associated mass swallowed. Risk at a target tissue depends on internal dose: the fraction that crosses gastrointestinal barriers, persists, distributes and reaches that tissue. Most larger ingested particles are expected to remain within the gastrointestinal tract, but size-specific absorption and fate are less certain toward the nanoscale. The cross-study dose-separation calculations do not incorporate toxicokinetics, and the selected studies

differ in species, particle form, dosing method, duration and endpoints. These uncertainties prevent a universal threshold from being claimed, but they do not justify treating the full swallowed trace mass as tissue dose. [12, 25, 29, 51–55]

7.8 Authoritative assessments reinforce the dose evidence

FDA's current food-safety page states that scientific evidence does not demonstrate that the levels of microplastics or nanoplastics detected in foods pose a human health risk. It also says there is insufficient evidence to show that particles from plastic food packaging migrate into foods and beverages, and it emphasizes the lack of standardized, validated analytical methods. WHO's 2019 drinking-water assessment did not recommend routine monitoring at that time and advised water suppliers to prioritize proven hazards, particularly microbial pathogens and known chemicals. EFSA's 2025 food-contact review concluded that actual release is much lower than many published results, while also finding that the evidence is not yet sufficient to estimate exposure from food-contact materials. These bodies continue to support research; none treats analytical detection by itself as a health-based trigger for routine product control. [3, 23, 27]

7.9 Boundaries of the conclusion and decision triggers

The conclusion is deliberately bounded: it applies to microplastic exposure from compliant PET-bottled drinks under ordinary use and to evidence identified through 26 July 2026, with focused thermoplastic source recovery through 27 July 2026. It does not certify every brand, every handling condition or every possible particle form.

- Analytical uncertainty is greatest below the micrometre scale, and validated cross-laboratory methods remain limited.
- The oral toxicology evidence does not provide one universal PET benchmark. The Merski result is mixture-qualified, and lower PET findings are study-specific and method-limited.
- The recovered Otaka 1978 study tested PET chloroform extractables, not PET particles, and therefore does not supply a PET microplastic NOAEL. Its cited Haskell 17-73 direct resin-feeding report remains unrecovered.
- The conclusion should be revisited if reproducible evidence demonstrates an adverse effect at realistic oral exposure, materially narrows the present dose separation, or supports a validated health-based action threshold.

7.10 What is known, what remains uncertain, and what would change the conclusion

Area	Reasonably established	Remaining uncertainty or decision trigger
Occurrence and source	Particles and polymer-associated signals occur; bottle wall is only one possible source.	Matched source-to-product studies across more lots, products and handling conditions.
Analytical measurement	Method and lower size cutoff materially change counts; methods measure different quantities.	Validated interlaboratory methods, reference materials and harmonized reporting, especially below 1 µm.
External exposure	Recent mass-based estimates are trace and yield very large external-dose separations from all selected study-specific toxicology doses.	Representative age-specific intake distributions and broader polymer coverage.

Area	Reasonably established	Remaining uncertainty or decision trigger
Toxicology and internal dose	Merski tolerated approximately 1.6–2.0 g/kg/day of each PE/PET component administered together. Lower PET studies are discordant; no single general PET point of departure is established.	Guideline studies of pure, characterized PET; toxicokinetics; matched particles; chemically co-localized pathology and adverse apical endpoints.
Human health	No causal disease outcome has been established from PET-bottled-drink exposure.	Reproducible human evidence with measured exposure, temporality, confounding control and a credible dose-response.
Reassessment trigger	Current evidence does not identify a health concern under ordinary use.	A validated health-based action level, reproducible realistic-dose harm, or evidence that materially narrows the present dose separation.
Plastic-specific hazard	Generic particle properties are shared; no uniquely plastic effect is demonstrated at realistic human oral exposure.	Matched realistic-dose comparisons showing greater toxicity than relevant reference particles.

Table 5. Evidence boundaries and pre-specified triggers for reassessment.

8. Why routine monitoring or reduction is not justified

Monitoring is useful when a result can be compared with a validated action level and can trigger an intervention known to reduce risk. The present microplastics evidence does not supply that chain. Methods count different size ranges, mass and particle number are not interchangeable, no health-based bottled-drink threshold has been established, and no clinical benefit has been demonstrated from lowering an already trace exposure. A program can therefore generate precise-looking numbers without answering whether a product is safe or what action should follow.

Risk-management requirement	Evidence reviewed	Decision implication
Credible adverse-effect level	Selected oral toxicology doses remain far above measured exposure, but the evidence is heterogeneous and no universal PET threshold or clinical effect level exists for bottled drinks.	Current exposure is remote from all selected dose ranges; a health-based action threshold has not been established.
Reliable exposure metric	Mass-based dose is trace; particle counts vary by method and lower size limit.	Use mass and dose for risk; do not regulate raw counts as though comparable.
Action threshold	No validated health-based microplastic limit for bottled drinks.	A detection result has no risk-based pass/fail meaning.
Demonstrated intervention benefit	No evidence that reducing trace bottled-drink particles improves health.	A reduction target lacks a measurable health outcome.
Safer practical substitute	Four studies found more particles in at least one glass comparison; glass adds weight, breakage and system trade-offs.	Material substitution cannot be presumed to reduce exposure or overall harm.

Table 6. The essential elements of a risk-based monitoring program are absent for microplastics in compliant PET-bottled drinks at measured exposure.

This does not mean analytical research has no value. Research can improve methods, source attribution and toxicological understanding. It does mean that exploratory measurement should not be presented as a necessary safety program. Without a health-based trigger, routine testing encourages the false equation “detected = dangerous,” diverts attention from microbial and established chemical hazards, and can prompt substitutions that do not reduce particle exposure.

Risk-management decision

Do not mandate special microplastic monitoring, warning labels or reduction targets for compliant PET-bottled drinks on the basis of detection alone. Reconsider only if credible evidence identifies an adverse effect at a dose that materially narrows the present dose separation, or establishes a validated health-based action threshold.

9. Safety conclusion

On the total evidence reviewed, current evidence does not identify a microplastic-related health concern from compliant PET-bottled water and beverages under ordinary use. This bounded conclusion rests on five mutually reinforcing points. It reflects decades of relevant polymer and particle science, the failure of realistic-dose evidence to establish a reproducible adverse signal, very large external-dose separations from heterogeneous study-specific toxicology findings, and the absence of a particle property or mechanism that is uniquely plastic. Those points lower the plausibility of a large common health effect; they do not claim zero risk for every polymer, particle form or use condition.

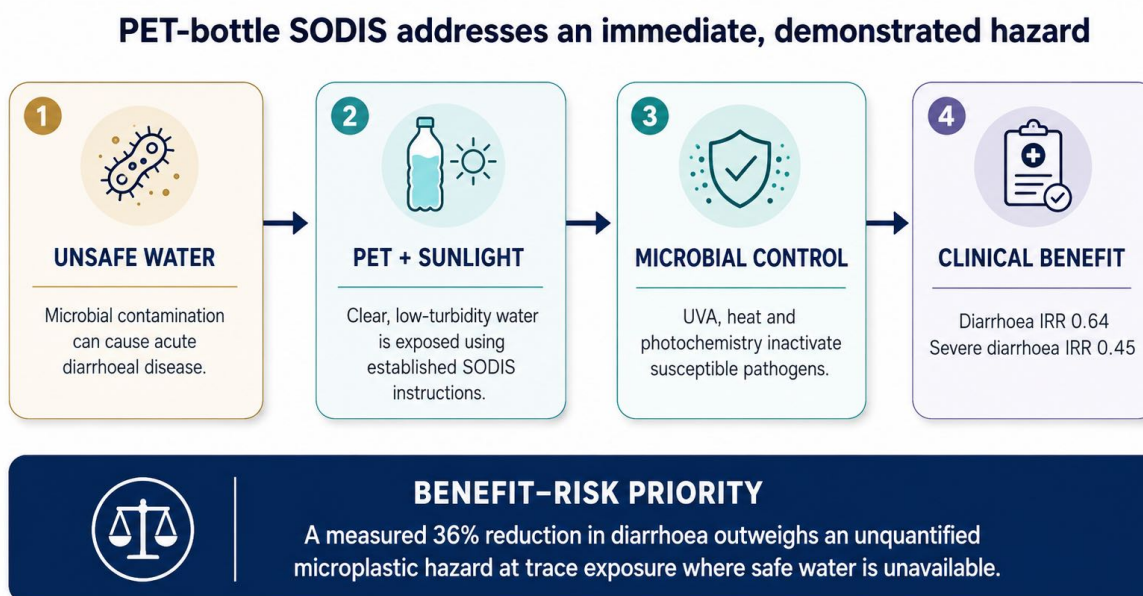
- measured polymer mass is very small in the strongest recent mass-based studies;
- average adult exposure is approximately 440,000-fold below the lowest author-reported PET value retained as low-confidence evidence and 400–500 million-fold below the mixture-qualified Merski PE/PET component range;
- no causal human disease outcome has been established at bottled-drink exposure;
- authoritative assessments identify uncertainty and research needs, not a demonstrated current drinking-water hazard;
- alternative packages and water sources are not particle-free and can introduce their own contaminants and environmental trade-offs.

The absence of a special statutory microplastic limit does not imply an unregulated danger. The present evidence does not establish a health-based case for a separate limit because exposure is remote from all selected study-specific toxicology doses and no adverse outcome has been demonstrated at bottled-drink exposure. Existing food-contact, chemical and microbiological requirements remain the relevant protections. Measuring ever smaller particles without a risk-based trigger would add analytical data, but no demonstrated consumer-health benefit.

10. SODIS and the public-health benefit of PET bottles

10.1 What SODIS is

Solar water disinfection (SODIS) is a household treatment method in which clear, low-turbidity water is placed in transparent containers—commonly 1–2 L PET beverage bottles—and exposed to sunlight. UVA radiation, photochemical processes and temperature act together to inactivate susceptible bacteria; effectiveness for viruses and protozoa varies and depends on spectrum, dose and organism. PET is used because it is transparent to much of the relevant UVA range, inexpensive, light, robust and widely available. Glass can work optically but is heavier, breakable and may be less accessible. [\[7, 13, 18\]](#)



Rose et al. (2006); WHO (2022): microbial contamination remains the most significant drinking-water risk.

Figure 9. PET-bottle SODIS controls an immediate microbial hazard and produced a measured reduction in diarrhoeal disease in the southern India trial.

10.2 Evidence of disease reduction

In the southern India field trial, 100 children aged 6–59 months received drinking water disinfected in PET bottles and 100 age- and sex-matched children served as controls. Over six months, diarrhoea incidence was 1.7 versus 2.7 episodes per child-year; the incidence-rate ratio was 0.64 (95% CI 0.48–0.86). Severe diarrhoea requiring intravenous rehydration was also lower, with an incidence-rate ratio of 0.45. The authors reported good acceptability despite use of untreated water outside the intervention. [\[18\]](#)

The global context is not theoretical. In June 2026, WHO again described microbial contamination as the most significant drinking-water risk and reported that 2.1 billion people still lacked safely managed drinking-water services, including 106 million people drinking directly from untreated surface-water sources. In those settings, preventing infectious disease is a concrete and urgent health objective; a hypothetical microplastic effect at trace dose should not be allowed to displace it. [\[30\]](#)

The broader SODIS literature is not uniformly positive. The McGuigan review describes successful trials and trials in which low compliance weakened or eliminated statistical benefit. Correct exposure time, adequate sunlight, low turbidity, clean and unscratched bottles, and consistent use are essential. SODIS does not remove dissolved chemicals and should not replace a reliable treated supply where one exists.

10.3 “Can save lives” — the precise meaning

Public-health conclusion

PET-bottle SODIS can save lives because it can prevent or reduce waterborne diarrhoeal disease in populations exposed to unsafe water, and severe diarrhoea can be fatal—especially in young children. The cited southern India study measured morbidity and need for intravenous rehydration, not mortality. The life-saving statement is therefore a well-grounded public-health inference, not a claim that this single trial counted deaths prevented.

In this context, the risk comparison is not between an ideal particle-free world and a PET bottle. It is between drinking microbiologically unsafe water and using an accessible treatment that has demonstrated disease reduction. Present evidence does not support allowing an unproven microplastic hazard at trace exposure to displace a proven intervention against an immediate infectious hazard.

11. Environmental and practical trade-offs

Safety, litter and climate impact are distinct questions. PET's low weight can reduce transport energy and breakage relative to glass, while recycled content and collection can reduce virgin material demand. Glass can perform well in high-return, short-distance reuse systems, but repeated transport and washing are consequential. The lifecycle studies in the collection show that outcomes depend on bottle mass, recycled content, trip distance, return rate, number of reuse cycles and energy mix; no package is environmentally superior in every scenario. [\[5\]](#)

Replacing one material with another is therefore not automatically an environmental improvement. A defensible comparison must include transport mass, breakage, product loss, washing and water use, reuse rates, recycled content, waste and greenhouse-gas emissions across the whole delivery system.

Whole-system packaging comparison

Material choice is only one input to overall performance.



Figure 10. Material substitution should be judged by whole-system lifecycle performance rather than by material identity alone.

Litter and environmental persistence remain serious reasons to collect and recycle PET and to prevent leakage. The conclusion that PET-bottled water is safe to drink is not an argument for unnecessary packaging or poor waste management. Conversely, environmental concern does not justify exaggerating a human health risk that has not been demonstrated.

12. Proportionate implications

For consumers and public communication

- Current evidence does not identify a microplastic-related health concern from compliant PET-bottled water and beverages under ordinary use. Consumers do not need to avoid them or adopt special handling solely to reduce microplastic exposure.
- Do not infer toxicity from detection. At modern analytical sensitivity, presence is expected; dose determines risk.
- Do not assume glass eliminates microplastics or pigments. Choose packaging using the whole system—water quality, reuse logistics, breakage, recycling and transport—not material symbolism.
- Where reliable safe water is available, use it according to local advice; where it is not, use a validated household treatment. Apply SODIS only with established instructions for sunlight, turbidity, exposure time and bottle condition.

For policy and regulation

- Do not mandate routine microplastic monitoring, warning labels or reduction targets merely because particles are detectable.
- Require a risk-based trigger: a credible adverse-effect level, reliable exposure estimate and evidence that materially narrows the present external-dose separation.
- Keep proven priorities ahead of hypothetical ones—microbiological safety, established chemical limits, access to safe water and effective waste management.
- If further research is commissioned, prioritize toxicological relevance and exposure mass rather than ever-lower detection limits.

13. Overall conclusion

The conclusion rests on converging risk evidence, not merely on an absence of reported harm. The question is not unstudied: relevant polymer and particle toxicology spans decades, and the dedicated microplastics literature is extensive. Measured polymer-associated mass in bottled water is very small; selected oral toxicology doses—including a mixture-qualified 13-week PE/PET component range and lower, method-limited PET findings—remain many orders of magnitude higher; authoritative bodies do not identify detected levels as a demonstrated human health risk; and four independent comparisons show that glass does not reliably reduce particle counts. In addition, the physical properties most often invoked—size, shape, charge, hydrophobicity, persistence, sorption and biofilms—are shared by many ordinary particles. Under qualitative Bayesian reasoning, this accumulated, largely non-positive realistic-dose evidence makes a large common effect progressively less plausible. Together, these findings support a clear, bounded conclusion: current evidence does not identify a microplastic-related health concern from compliant PET-bottled water and beverages under ordinary use, and special monitoring or mandated reduction is not justified as a health measure at current measured exposure. [12, 23, 27, 29, 37–41, 51–55]

Focused source recovery did not identify a lower applicable PET-particle point of departure. The recovered Otaka study concerns PET chloroform extractables rather than PET particles, while the historical PE evidence supports low intrinsic chemical toxicity of closure polymer but remains secondary-cited and is not used as a formal NOAEL. These classifications strengthen source accuracy without changing the exposure ratios or the bounded safety conclusion. [25, 56, 57]

The proportionate public-health response is to maintain existing food-contact and drinking-water compliance, control established microbial and chemical hazards, manage litter and recycling as environmental issues, and communicate dose honestly. Where safe water is unavailable, PET has an additional, direct benefit: it enables SODIS, an inexpensive intervention with demonstrated reduction in diarrhoeal disease. Policy should be guided by comparative risk and real health outcomes, not by the mere ability of increasingly sensitive instruments to find smaller particles.

14. References

Numbered references support the principal factual claims in the report; bracketed in-text citations link to source records where available. Appendix A documents all 65 curated PDFs reviewed, five supplemental oral-toxicology studies and two focused source-recovery/context sources. Evidence cutoff: 26 July 2026; focused source recovery through 27 July 2026.

1. Al-Mansoori M, Stephenson M, Harrad S, Abdallah MAE. Synthetic microplastics in UK tap and bottled water: Implications for human exposure. *Emerging Contaminants*. 2025;11:100417. <https://doi.org/10.1016/j.emcon.2024.100417>
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Appendix A. Linked citations and concise study summaries

The following records summarize every PDF in the 65-study curated collection used for this review, together with five supplemental oral-toxicology studies incorporated in the 26 July 2026 correction and two focused source-recovery/context sources added on 27 July 2026. Each entry gives the complete publication citation, a DOI or stable source link, the study design, the principal finding, its relevance to the risk assessment and the main interpretive limitation. Summaries distinguish particle occurrence from polymer mass, analytical capability, direct-polymer toxicology, extractables toxicology, hazard evidence and demonstrated risk.

Direct bottled-water and beverage studies

Shadi Taheri, Bahareh Shoshtari-Yeganeh, Hamidreza Pourzamani & Karim Ebrahimpour. 2022. Investigating the pollution of bottled water by the microplastics (MPs): the effects of mechanical stress, sunlight exposure, and freezing on MPs release. *Environmental Monitoring and Assessment* 195(1):62.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: FTIR; SEM/EDS; Microscopy / visual.

Findings: Twenty-three Iranian bottled-water brands contained widely varying particle counts. Most reported particles were 1-10 micrometres; mechanical stress and sunlight increased release in the test system, while freezing did not produce a significant change.

Risk relevance: Supports occurrence or source characterization. Detection or experimentally induced release does not by itself demonstrate an adverse effect at ordinary consumer exposure.

Key limitations: The smallest reported particles were assigned from SEM imagery and FTIR supported likely polymers rather than identifying every particle; stressed conditions are not normal storage.

Catalogue ID: STUDY-00042. **DOI/link:** [10.1007/s10661-022-10697-2](https://doi.org/10.1007/s10661-022-10697-2)

Pathissery John Sarlin, Sancia Morris, Gayathry Savitha, Archa Gopan & E. K. Radhakrishnan. 2024. Occurrence and characterization of microplastics in bottled drinking water. *Discover Environment* 2(1):102.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: FTIR; Raman spectroscopy; Microscopy / visual.

Findings: Ten bottled-water brands contained 3-9 particles/L, chiefly fibres, with particles below 500 micrometres. Micro-Raman analysis identified several polymers, showing that the detected material was not attributable solely to the PET bottle wall.

Risk relevance: Supports occurrence or source characterization. Detection or experimentally induced release does not by itself demonstrate an adverse effect at ordinary consumer exposure.

Key limitations: The local PDF was readable, but results remain limited by the study-specific sample frame, detection window and quality controls.

Catalogue ID: STUDY-00084. **DOI/link:** [10.1007/s44274-024-00129-y](https://doi.org/10.1007/s44274-024-00129-y)

David O. Omole, Kagiso Moima & Neo Matsietsa. 2026. Microplastics in South Africa's bottled water: Risk metrics and potential health impact. *Cleaner Water* 5:100226.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: FTIR; SEM/EDS; Nile red / fluorescence; Microscopy / visual.

Findings: Six leading South African bottled-water products contained 5-25 particles/L, with a mean near 14 particles/L. The paper also calculated screening-style exposure and risk metrics, but these are not health-based regulatory thresholds.

Risk relevance: Supports occurrence or source characterization. Detection or experimentally induced release does not by itself demonstrate an adverse effect at ordinary consumer exposure.

Key limitations: Only six products were tested, and the paper's risk indices are screening constructs rather than validated toxicological thresholds.

Catalogue ID: STUDY-00105. **DOI/link:** [10.1016/j.clwat.2026.100226](https://doi.org/10.1016/j.clwat.2026.100226)

Abdullah Altunışık. 2023. Prevalence of microplastics in commercially sold soft drinks and human risk assessment. Journal of Environmental Management 336:117720.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: FTIR; Microscopy / visual.

Findings: Microplastics were reported in all ten Turkish soft-drink brands at 5-15 particles/L, averaging about nine particles/L. Counts were numerically higher in PET than carton packages, but the packaging difference was not statistically significant.

Risk relevance: Supports occurrence or source characterization. Detection or experimentally induced release does not by itself demonstrate an adverse effect at ordinary consumer exposure.

Key limitations: Study-specific size cutoff, blanks and sampling frame.

Catalogue ID: STUDY-00242. **DOI/link:** [10.1016/j.jenvman.2023.117720](https://doi.org/10.1016/j.jenvman.2023.117720)

Iseline Chaïb, Périne Doyen, Pauline Merveillie, Alexandre Dehaut & Guillaume Duflos. 2025. Microplastic contaminations in a set of beverages sold in France. Journal of Food Composition and Analysis 144:107719.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: FTIR; Microscopy / visual.

Findings: A French survey found mean concentrations from 2.9 particles/L in waters to 82.9 particles/L in beers. Glass bottles were the most contaminated container group in this dataset, and closures were identified as a plausible particle source.

Risk relevance: Supports occurrence or source characterization. Detection or experimentally induced release does not by itself demonstrate an adverse effect at ordinary consumer exposure.

Key limitations: The authors explicitly described the French beverage set as non-exhaustive; package and closure source attribution remains inferential.

Catalogue ID: STUDY-00246. **DOI/link:** [10.1016/j.jfca.2025.107719](https://doi.org/10.1016/j.jfca.2025.107719)

V.C. Shruti, Fermín Pérez-Guevara, I. Elizalde-Martínez & Gurusamy Kutralam-Muniasamy. 2020. First study of its kind on the microplastic contamination of soft drinks, cold tea and energy drinks - Future research and environmental considerations. Science of The Total Environment 726:138580.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: Raman spectroscopy; SEM/EDS; Microscopy / visual.

Findings: Among 57 Mexican soft drinks, energy drinks, teas and beers, 48 contained particles and the highest mean was reported in beer at about 28 particles/L. Fibres and fragments predominated, with polyamide and polyester-related spectra among the identified materials.

Risk relevance: Supports occurrence or source characterization. Detection or experimentally induced release does not by itself demonstrate an adverse effect at ordinary consumer exposure.

Key limitations: The local PDF was readable, but results remain limited by the study-specific sample frame, detection window and quality controls.

Catalogue ID: STUDY-00349. **DOI/link:** [10.1016/j.scitotenv.2020.138580](https://doi.org/10.1016/j.scitotenv.2020.138580)

Huan LI, Long ZHU, Mindong MA, Haiwen WU, Lihui AN & Zhanhong YANG. 2023. Occurrence of microplastics in commercially sold bottled water. Science of The Total Environment 867:161553.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: Raman spectroscopy; Microscopy / visual.

Findings: Laser direct infrared imaging found more particles in bottled water than tap water in this sample set; 10-50 micrometre particles dominated. Cellulose and PVC were prominent, illustrating that a bottled-water particle count is not automatically a PET-particle count.

Risk relevance: Supports occurrence or source characterization. Detection or experimentally induced release does not by itself demonstrate an adverse effect at ordinary consumer exposure.

Key limitations: Counts are tied to the LDIR size window and classification library; cellulose-rich results should not be presented as PET release.

Catalogue ID: STUDY-00377. **DOI/link:** [10.1016/j.scitotenv.2023.161553](https://doi.org/10.1016/j.scitotenv.2023.161553)

Megan N. Jamison Hart & John J. Lenhart. 2026. What's in your water? A comparative analysis of micro- and nanoplastics in treated drinking water and bottled water. *Science of The Total Environment* 1011:181148.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: FTIR; Raman spectroscopy; Py-GC/MS; GC-MS; SEM/EDS; Microscopy / visual.

Findings: Using the same submicron-capable method on six bottled waters and four treated waters, bottled water had higher particle-number concentrations, especially at small sizes. Estimated mass concentrations were not significantly different, demonstrating how number and mass can lead to different impressions.

Risk relevance: Provides evidence context and interpretation. Its numerical conclusions remain dependent on the analytical windows and quality of the underlying studies.

Key limitations: Only one sample per product or treatment plant was analysed; number-to-mass conversion depends on particle geometry and density assumptions.

Catalogue ID: STUDY-00404. **DOI/link:** [10.1016/j.scitotenv.2025.181148](https://doi.org/10.1016/j.scitotenv.2025.181148)

Darena Schymanski, Christophe Goldbeck, Hans-Ulrich Humpf & Peter Fürst. 2018. Analysis of microplastics in water by micro-Raman spectroscopy: Release of plastic particles from different packaging into mineral water. *Water Research* 129:154-162.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: Raman spectroscopy; Microscopy / visual.

Findings: Micro-Raman analysis of water from plastic, carton and glass packages found small particles in every packaging class. Reusable PET had higher counts than single-use PET, while glass exceeded single-use PET in this dataset but not reusable PET.

Risk relevance: Shows that packaging alternatives have their own particle, chemical or environmental profiles; it does not imply that all materials or hazards are equivalent.

Key limitations: Results depend on a 1-micrometre Raman cutoff, blank correction and the sampled packages; package association does not prove the origin of every particle.

Catalogue ID: STUDY-00417. **DOI/link:** [10.1016/j.watres.2017.11.011](https://doi.org/10.1016/j.watres.2017.11.011)

Barbara E. Oßmann, George Sarau, Heinrich Holtmannspötter, Monika Pischetsrieder, Silke H. Christiansen & Wilhelm Dicke. 2018. Small-sized microplastics and pigmented particles in bottled mineral water. *Water Research* 141:307-316.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: FTIR; Raman spectroscopy; Microscopy / visual.

Findings: Small particles were reported in single-use PET, reusable PET and glass-bottled mineral water. Mean microplastic counts were highest in glass, and glass also contained very large numbers of pigment particles derived from caps, coatings or decoration.

Risk relevance: Provides evidence context and interpretation. Its numerical conclusions remain dependent on the analytical windows and quality of the underlying studies.

Key limitations: Between-bottle variation was large, and pigment particles are a separate category from microplastics.

Catalogue ID: STUDY-00418. **DOI/link:** [10.1016/j.watres.2018.05.027](https://doi.org/10.1016/j.watres.2018.05.027)

P. Zuccarello, M. Ferrante, A. Cristaldi, C. Copat, A. Grasso, D. Sangregorio, M. Fiore & G. Oliveri Conti. 2019. Exposure to microplastics (<10 µm) associated to plastic bottles mineral water consumption: The first quantitative study. *Water Research* 157:365-371.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: SEM/EDS; Nile red / fluorescence; Microscopy / visual.

Findings: The study reported very high numbers of particles below 10 micrometres in plastic-bottled mineral water and converted the counts into intake estimates. It broadened the measured size window but relied heavily on fluorescence-based screening rather than chemical confirmation of every object.

Risk relevance: Supports occurrence or source characterization. Detection or experimentally induced release does not by itself demonstrate an adverse effect at ordinary consumer exposure.

Key limitations: Nile-Red fluorescence can count non-plastic hydrophobic particles; chemical identity was not established for every object.

Catalogue ID: STUDY-00420. **DOI/link:** [10.1016/j.watres.2019.03.091](https://doi.org/10.1016/j.watres.2019.03.091)

Anna Winkler, Nadia Santo, Marco Aldo Ortenzi, Elisa Bolzoni, Renato Bacchetta & Paolo Tremolada. 2019. Does mechanical stress cause microplastic release from plastic water bottles?. Water Research 166:115082.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: GC-MS; SEM/EDS; Microscopy / visual.

Findings: Repeated opening and closing produced visible wear particles on PET necks and HDPE caps, with substantial brand differences. Squeezing did not significantly increase particles in the water, and the evidence pointed to the cap-neck interface rather than the bottle wall under the tested mechanical stress.

Risk relevance: Supports occurrence or source characterization. Detection or experimentally induced release does not by itself demonstrate an adverse effect at ordinary consumer exposure.

Key limitations: Three brands and up to 100 opening cycles were tested; surface wear does not directly quantify material swallowed in ordinary use.

Catalogue ID: STUDY-00421. DOI/link: [10.1016/j.watres.2019.115082](https://doi.org/10.1016/j.watres.2019.115082)

Yalin Chen, Haiyin Xu, Yuanling Luo, Yuting Ding, Junguo Huang, Honghui Wu, Jianing Han, Linjing Du, Anqi Kang, Meiying Jia, Weiping Xiong & Zhaohui Yang. 2023. Plastic bottles for chilled carbonated beverages as a source of microplastics and nanoplastics. Water Research 242:120243.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: FTIR.

Findings: In controlled carbonated-beverage experiments, polypropylene released more particles than polyethylene or PET. Increasing carbonation and repeated freeze-thaw cycles raised reported micro- and nanoparticle release, while the tested conditions were more severe than ordinary consumption.

Risk relevance: Provides evidence context and interpretation. Its numerical conclusions remain dependent on the analytical windows and quality of the underlying studies.

Key limitations: Carbonation and repeated freeze-thaw protocols are controlled stress tests, and nanoplastic counts are especially method-dependent.

Catalogue ID: STUDY-00425. DOI/link: [10.1016/j.watres.2023.120243](https://doi.org/10.1016/j.watres.2023.120243)

Virginia Gálvez-Blanca, Carlos Edo, Miguel González-Pleiter, Francisca Fernández-Piñas, Francisco Leganés & Roberto Rosal. 2024. Microplastics and non-natural cellulosic particles in Spanish bottled drinking water. Scientific Reports 14(1):11089.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: FTIR; Raman spectroscopy; Nile red / fluorescence; Microscopy / visual.

Findings: Five Spanish bottled-water brands contained median microplastic and artificial-cellulose mass concentrations of about 1.61 and 1.04 micrograms/L, respectively. Polyester and polyethylene particles were common, and the mass results provided useful context alongside particle counts.

Risk relevance: Supports occurrence or source characterization. Detection or experimentally induced release does not by itself demonstrate an adverse effect at ordinary consumer exposure.

Key limitations: The market sample comprised five brands and excluded particles outside the analytical window.

Catalogue ID: STUDY-00559. DOI/link: [10.1038/s41598-024-62075-2](https://doi.org/10.1038/s41598-024-62075-2)

Nickolas D. Polychronopoulos & John Vlachopoulos. 2023. On the origin of microplastics in bottled water. AIP Conference Proceedings 2884:180001.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: FTIR; Raman spectroscopy; Py-GC/MS; GC-MS; SEM/EDS; Nile red / fluorescence; Microscopy / visual.

Findings: This engineering synthesis proposed manufacturing flash, gate marks, surface porosity, factory dust and cap abrasion as plausible bottled-water particle sources. It framed testable mechanisms but did not add a new controlled occurrence dataset.

Risk relevance: Provides evidence context and interpretation. Its numerical conclusions remain dependent on the analytical windows and quality of the underlying studies.

Key limitations: This is a conference synthesis and mechanistic argument, not a controlled exposure or toxicology study.

Catalogue ID: STUDY-00606. DOI/link: [10.1063/5.0168577](https://doi.org/10.1063/5.0168577)

Naixin Qian, Xin Gao, Xiaoqi Lang, Huiping Deng, Teodora Maria Bratu, Qixuan Chen, Phoebe Stapleton, Beizhan Yan & Wei Min. 2024. Rapid single-particle chemical imaging of nanoplastics by SRS microscopy. *Proceedings of the National Academy of Sciences* 121(3):e2300582121.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: Microscopy / visual.

Findings: Stimulated Raman scattering imaging was applied to three bottled-water brands and reported roughly 240,000 micro- and nanoplastic particles/L, most below 1 micrometre. Polyamide was prominent; the absolute abundance later became the subject of a published dispute over blank selection.

Risk relevance: Defines what a method can and cannot measure. Results should not be pooled directly with studies using different size cutoffs, identification rules or measurands.

Key limitations: Only three brands were studied, and the absolute count is affected by the unresolved procedural-blank debate documented in the two PNAS letters.

Catalogue ID: STUDY-00610. **DOI/link:** [10.1073/pnas.2300582121](https://doi.org/10.1073/pnas.2300582121)

Mary Kosuth, Sherri A. Mason & Elizabeth V. Wattenberg. 2018. Anthropogenic contamination of tap water, beer, and sea salt. *PLOS ONE* 13(4):e0194970.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: FTIR; Microscopy / visual.

Findings: A survey of 159 tap waters, 12 beers and 12 salts found anthropogenic particles in 81% of tap-water samples and every beer and salt brand. More than 98% of the observed material was fibrous, and only a subset received spectroscopic identification.

Risk relevance: Places bottled-water findings against other water sources. The observed direction and magnitude are study-specific rather than a universal tap-versus-bottle ranking.

Key limitations: Most particles were visually classified fibres and only a subset was spectroscopically examined, so anthropogenic debris is not synonymous with confirmed plastic.

Catalogue ID: STUDY-00718. **DOI/link:** [10.1371/journal.pone.0194970](https://doi.org/10.1371/journal.pone.0194970)

Twisha Singh. 2021. Generation of microplastics from the opening and closing of disposable plastic water bottles. *Journal of Water and Health* 19(3):488-498.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: FTIR; Raman spectroscopy; Nile red / fluorescence; Microscopy / visual.

Findings: Particle counts above 4.7 micrometres increased with repeated cap cycles at an estimated 553 +/- 202 particles/L per cycle. The result supports abrasion at the cap-bottleneck interface as a source under the tested protocol.

Risk relevance: Supports occurrence or source characterization. Detection or experimentally induced release does not by itself demonstrate an adverse effect at ordinary consumer exposure.

Key limitations: The study used Nile Red above 4.7 micrometres and repeated cycles; it does not establish a health effect or a universal release rate for all caps.

Catalogue ID: STUDY-00735. **DOI/link:** [10.2166/wh.2021.025](https://doi.org/10.2166/wh.2021.025)

Kate Albi, Leigh-Anne Krometis, Erin Ling, Alasdair Cohen, Kang Xia, Austin Gray, Emerald Dudzinski & Kimberly Ellis. 2025. Comparing in-home and bottled drinking water quality: regulated and emerging contaminants in rural Central Appalachia. *Journal of Water and Health* 23(9):1078-1094.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: FTIR; Raman spectroscopy; Microscopy / visual; Thermal analysis.

Findings: In rural Central Appalachia, 23 in-home waters, four spring waters and 36 bottled waters were tested for regulated and emerging contaminants. Bottled water met the regulated criteria, although its median microplastic count was higher than the in-home-water count; some samples in both groups contained very low PFAS levels.

Risk relevance: Supports occurrence or source characterization. Detection or experimentally induced release does not by itself demonstrate an adverse effect at ordinary consumer exposure.

Key limitations: This regional cross-sectional comparison cannot separate source, packaging, handling and laboratory contributions or establish health effects.

Catalogue ID: STUDY-00736. **DOI/link:** [10.2166/wh.2025.073](https://doi.org/10.2166/wh.2025.073)

Sherri A. Mason, Victoria G. Welch & Joseph Neratko. 2018. Synthetic Polymer Contamination in Bottled Water. *Frontiers in Chemistry* 6:407.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: FTIR; Nile red / fluorescence; Microscopy / visual.

Findings: Across 259 bottles from 11 brands purchased in nine countries, particles were reported in 93% of samples. Corrected counts varied greatly by brand and package, and polymer profiles included materials associated with bottles, closures and environmental contamination.

Risk relevance: Provides evidence context and interpretation. Its numerical conclusions remain dependent on the analytical windows and quality of the underlying studies.

Key limitations: Nile-Red screening, the lower size cutoff and spectroscopic confirmation of only selected particles make counts method-specific.

Catalogue ID: STUDY-00754. DOI/link: [10.3389/fchem.2018.00407](https://doi.org/10.3389/fchem.2018.00407)

Arianna Crosta, Marco Parolini & Beatrice De Felice. 2023. Microplastics Contamination in Nonalcoholic Beverages from the Italian Market. *International Journal of Environmental Research and Public Health* 20(5):4122.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: FTIR; Raman spectroscopy; GC-MS; Nile red / fluorescence; Microscopy / visual.

Findings: Italian soft drinks and cold teas contained a mean of about 9.2 particles/L, mainly fibres. The study expanded beverage coverage but did not establish the package as the source of every detected fibre.

Risk relevance: Supports occurrence or source characterization. Detection or experimentally induced release does not by itself demonstrate an adverse effect at ordinary consumer exposure.

Key limitations: Mass and count endpoints are not interchangeable.

Catalogue ID: STUDY-00806. DOI/link: [10.3390/ijerph20054122](https://doi.org/10.3390/ijerph20054122)

Eleonora Brancalone, Daniela Mattei, Valentina Fuscoletti, Luca Lucentini, Gabriele Favero, Giancarlo Cecchini, Alessandro Frugis, Valentina Gioia & Marco Lazzazzara. 2024. Microplastic in Drinking Water: A Pilot Study. *Microplastics* 3(1):31-45.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: FTIR; Raman spectroscopy; Microscopy / visual.

Findings: This pilot Raman survey found some drinking-water samples with no detected microplastics and others with low-to-moderate counts. Results differed by water matrix, reinforcing that occurrence is heterogeneous rather than universal at one concentration.

Risk relevance: Provides evidence context and interpretation. Its numerical conclusions remain dependent on the analytical windows and quality of the underlying studies.

Key limitations: Study-specific size cutoff, blanks and sampling frame.

Catalogue ID: STUDY-00820. DOI/link: [10.3390/microplastics3010003](https://doi.org/10.3390/microplastics3010003)

Liesa Geppner, Sophie Grammatidis, Harald Wilfing & Maja Henjakovic. 2024. First Evidence of the Possible Influence of Avoiding Daily Liquid Intake from Plastic and Glass Beverage Bottles on Blood Pressure in Healthy Volunteers. *Microplastics* 3(3):419-432.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study.

Findings: Eight healthy volunteers avoided bottled beverages for four weeks. A change in right-arm systolic pressure was reported among women, but no consistent bilateral or male effect was found and no microplastic exposure was measured.

Risk relevance: Shows that packaging alternatives have their own particle, chemical or environmental profiles; it does not imply that all materials or hazards are equivalent.

Key limitations: The uncontrolled, unblinded sample contained only eight people, exposure was not measured, and multiple arm/sex/time comparisons make the result hypothesis-generating only.

Catalogue ID: STUDY-00825. DOI/link: [10.3390/microplastics3030026](https://doi.org/10.3390/microplastics3030026)

Jana Weissner, Irina Beer, Benedikt Hufnagl, Thomas Hofmann, Hans Lohninger, Natalia P. Ivleva & Karl Glas. 2021. From the Well to the Bottle: Identifying Sources of Microplastics in Mineral Water. *Water* 13(6):841.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: FTIR; Nile red / fluorescence; Microscopy / visual.

Findings: Sampling at four mineral-water bottlers traced particles from raw water through washing, filling and capping. Counts rose sharply after capping, from below 1 particle/L to about 317 +/- 257 particles/L, and many particles resembled cap or closure polymers.

Risk relevance: Provides evidence context and interpretation. Its numerical conclusions remain dependent on the analytical windows and quality of the underlying studies.

Key limitations: Four bottlers and particles above 11 micrometres were studied; polymer resemblance supports but does not prove an exact source for every particle.

Catalogue ID: STUDY-00862. **DOI/link:** [10.3390/w13060841](https://doi.org/10.3390/w13060841)

Witold Nocoń, Katarzyna Moraczewska-Majkut & Ewa Wiśniowska. 2023. Microplastics in bottled water and bottled soft drinks. Desalination and Water Treatment 312:64-69.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: FTIR; Microscopy / visual.

Findings: All tested Polish bottled waters and soft drinks contained microplastics, regardless of packaging material. Bottled waters contained more particles than soft drinks, and the detected shapes and spectra suggested largely secondary contamination.

Risk relevance: Supports occurrence or source characterization. Detection or experimentally induced release does not by itself demonstrate an adverse effect at ordinary consumer exposure.

Key limitations: Study-specific size cutoff, blanks and sampling frame.

Catalogue ID: STUDY-00876. **DOI/link:** [10.5004/dwt.2023.29946](https://doi.org/10.5004/dwt.2023.29946)

Ayushi Singh & Meghana B. Talpade. 2024. Presence of Microplastic in Bottled Water from Mumbai Market. UTTAR PRADESH JOURNAL OF ZOOLOGY 45(14):340-348.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: Nile red / fluorescence; Microscopy / visual.

Findings: Five bottled-water brands from Mumbai showed fluorescent particle-like material in every sample, with a reported mean size of 82 +/- 22 micrometres. The work demonstrated possible occurrence but did not chemically verify every counted object.

Risk relevance: Provides evidence context and interpretation. Its numerical conclusions remain dependent on the analytical windows and quality of the underlying studies.

Key limitations: The small regional sample relied on fluorescence and visual counting without polymer-specific confirmation for each particle.

Catalogue ID: STUDY-00894. **DOI/link:** [10.56557/upjoz/2024/v45i144211](https://doi.org/10.56557/upjoz/2024/v45i144211)

Dharnidhar Choudhary, Caneon Kurien & Ajay Kumar Srivastava. 2020. Microplastic Contamination and Life Cycle Assessment of Bottled Drinking Water. Springer Transactions in Civil and Environmental Engineering:41-48.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: Raman spectroscopy; Microscopy / visual.

Findings: This exploratory book chapter combined bottled-water particle screening with life-cycle considerations. It highlighted possible contamination and packaging trade-offs but supplied less methodological detail than the stronger occurrence studies.

Risk relevance: Provides evidence context and interpretation. Its numerical conclusions remain dependent on the analytical windows and quality of the underlying studies.

Key limitations: As a short conference-derived chapter, the source provides limited sampling, blank and validation detail compared with primary occurrence studies.

Catalogue ID: STUDY-01021. **DOI/link:** [10.1007/978-981-32-9956-6_4](https://doi.org/10.1007/978-981-32-9956-6_4)

Muneera Al-Mansoori, Mia Stephenson, Stuart Harrad & Mohamed Abou-Elwafa Abdallah. 2025. Synthetic Microplastics in UK tap and bottled water; Implications for human exposure. Emerging Contaminants 11(1):100417.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: Micro-FTIR imaging and microscopy with procedural blanks.

Findings: A same-method comparison of 177 UK tap-water and 85 bottled-water samples found statistically indistinguishable mean counts: 40 +/- 16 and 37 +/- 11 particles/L. Bottled particles were smaller on average, and cap material correlated with the predominant bottled-water polymer.

Risk relevance: Places bottled-water findings against other water sources. The observed direction and magnitude are study-specific rather than a universal tap-versus-bottle ranking.

Key limitations: Micro-FTIR did not capture nanoplastics; the result is a UK snapshot and the exposure calculation is particle-number based, not a health threshold.

Catalogue ID: ESSENTIAL-003. **DOI/link:** [10.1016/j.emcon.2024.100417](https://doi.org/10.1016/j.emcon.2024.100417)

Junjie Zhang, Miao Peng, Enkui Lian, Lu Xia, Alexandros G. Asimakopoulos, Sihai Luo & Lei Wang. 2023. Identification of Poly(ethylene terephthalate) Nanoplastics in Commercially Bottled Drinking Water Using Surface-Enhanced Raman Spectroscopy. *Environmental Science & Technology* 57(22):8365-8372.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: Surface-enhanced Raman spectroscopy (SERS), SEM and nanoparticle tracking analysis (NTA).

Findings: Surface-enhanced Raman spectroscopy detected PET nanoscale material with a reported mean size near 88 nm. Nanoparticle tracking analysis estimated about 10^8 particles/mL, but that bulk count did not chemically identify every counted object as PET or even as plastic.

Risk relevance: Supports occurrence or source characterization. Detection or experimentally induced release does not by itself demonstrate an adverse effect at ordinary consumer exposure.

Key limitations: SERS supports PET identity in collected nanoscale material, but NTA is not polymer-specific and cannot prove that every counted particle was plastic.

Catalogue ID: ESSENTIAL-004. DOI/link: [10.1021/acs.est.3c00842](https://doi.org/10.1021/acs.est.3c00842)

Jenny Nizamali, Svenja M. Mintenig & Albert A. Koelmans. 2023. Assessing microplastic characteristics in bottled drinking water and air deposition samples using laser direct infrared imaging. *Journal of Hazardous Materials* 441:129942.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: LDIR chemical imaging ($>10\ \mu\text{m}$) and ATR-FTIR; recovery and blank correction.

Findings: Nine bottles from three brands averaged 96 particles/L above 10 micrometres after polymer-specific blank correction. The study showed that recovery rose from about 59% to 79% with additional washing and therefore quantified how sample preparation changes reported abundance.

Risk relevance: Defines what a method can and cannot measure. Results should not be pooled directly with studies using different size cutoffs, identification rules or measurands.

Key limitations: Nine bottles were analysed, particles below 10 micrometres were excluded and initial recovery was only about 59%.

Catalogue ID: ESSENTIAL-005. DOI/link: [10.1016/j.jhazmat.2022.129942](https://doi.org/10.1016/j.jhazmat.2022.129942)

Hannah Folarin, Nyiri Hajian, Kirby Hill & Alexander Laskin. 2025. Photodegradation-driven microparticle release from commercial plastic water bottles. *Soft Matter* 21(33):6603-6612.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: Flow immersion microscopy, ATR-FTIR and TPD-DART high-resolution mass spectrometry.

Findings: Seventy PET bottles exposed to natural sunlight for 70 days showed increasing microparticle release for about 30 days followed by a plateau. Calculated mass reached roughly 14-20 micrograms/L, and spectroscopic evidence supported photochemical degradation of PET.

Risk relevance: Supports occurrence or source characterization. Detection or experimentally induced release does not by itself demonstrate an adverse effect at ordinary consumer exposure.

Key limitations: The ten-week sunlight protocol is prolonged stress, and reported mass was modelled from microscopy rather than directly weighed polymer.

Catalogue ID: ESSENTIAL-006. DOI/link: [10.1039/d5sm00469a](https://doi.org/10.1039/d5sm00469a)

Kazi Albab Hussain, Haoyu Dong, Alex Tamayo-Aguilar, Seulki Kim, Cesar Augusto Gomez Pena, Silvia Foss, Lucia Fernandez-Ballester, Yongfeng Lu & Yusong Li. 2026. Everyday storage and handling of PET bottled water increase human exposure to nano- and microplastics: Influence of socio-economic factors. *Water Research* 295:125569.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: NTA, optical microscopy, Raman spectroscopy, AFM-IR, DSC and survey analysis.

Findings: Eight US brands exposed to heat, shaking and temperature cycling released more counted particles, with the largest nanoparticle increase under combined heat and agitation. Raman and AFM-IR identified PET, PE and PP in selected particles, consistent with bottle and cap contributions.

Risk relevance: Supports occurrence or source characterization. Detection or experimentally induced release does not by itself demonstrate an adverse effect at ordinary consumer exposure.

Key limitations: The 60 C heat and strong shaking scenarios are severe; NTA and optical microscopy also count non-plastic particles, while chemical identification covered a subset.

Catalogue ID: ESSENTIAL-007. DOI/link: [10.1016/j.watres.2026.125569](https://doi.org/10.1016/j.watres.2026.125569)

Albert Vega-Herrera, Maria Garcia-Torné, Xavier Borrell-Díaz, Esteban Abad, Marta Llorca, Cristina M. Villanueva & Marinella Farré. 2023. Exposure to micro(nano)plastics polymers in water stored in single-use plastic bottles. *Chemosphere* 343:140106.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: HPLC-HRMS double-suspect screening and multi-QSAR prioritisation.

Findings: A mass-based screen of 20 Spanish bottled waters reported a median summed polymer concentration of 359 ng/L. PE was most frequently quantified, PET produced the highest individual concentration, and 28 additives were tentatively identified for follow-up.

Risk relevance: Supports occurrence or source characterization. Detection or experimentally induced release does not by itself demonstrate an adverse effect at ordinary consumer exposure.

Key limitations: The supplied file is a prepublication manuscript, and HPLC-HRMS measures polymer markers after processing rather than counting intact particles.

Catalogue ID: ESSENTIAL-008. DOI/link: [10.1016/j.chemosphere.2023.140106](https://doi.org/10.1016/j.chemosphere.2023.140106)

Giuseppina Zuri, Carmen Bedia, Christina S. Spitieri, Vassiliki Vassilatou, Angeliki Karanasiou & Sílvia Lacorte. 2025. Quantification of microplastics in bottled water by Pyr-GC-Orbitrap-MS, human exposure, and in vitro hepatotoxicity assessment. *Food Control* 178:111489.

Design: Bottled-water or beverage occurrence, release, exposure or analytical study. Reported analytical approach: Pyr-GC-Orbitrap-MS, stereomicroscopy and HepG2 viability/ROS assays.

Findings: Across 40 brands from five countries, quantified polymer mass was 0.016-0.439 micrograms/L in 31 samples. Cap-associated HDPE dominated, PET was below its method quantification limit, and tested HDPE leachates did not alter HepG2 viability or reactive oxygen species.

Risk relevance: Supports occurrence or source characterization. Detection or experimentally induced release does not by itself demonstrate an adverse effect at ordinary consumer exposure.

Key limitations: Pyrolysis provides polymer mass but destroys particle size and shape information; the cell work tested leachates, one cell line and two short-term endpoints.

Catalogue ID: ESSENTIAL-009. DOI/link: [10.1016/j.foodcont.2025.111489](https://doi.org/10.1016/j.foodcont.2025.111489)

Methods, reviews and risk assessment

Darena Schymanski, Barbara E. Oßmann, Nizar Benismail, Kada Boukerma, Gerald Dallmann, Elisabeth von der Esch, Dieter Fischer, Franziska Fischer, Douglas Gilliland, Karl Glas, Thomas Hofmann, Andrea Käßler, Sílvia Lacorte, Julie Marco, Maria EL Rakwe, Jana Weisser, Cordula Witzig, Nicole Zumbülte & Natalia P. Ivleva. 2021. Analysis of microplastics in drinking water and other clean water samples with micro-Raman and micro-infrared spectroscopy: minimum requirements and best practice guidelines. *Analytical and Bioanalytical Chemistry* 413(24):5969-5994.

Design: Review, evidence assessment or analytical-method study. Reported analytical approach: FTIR; Raman spectroscopy; SEM/EDS; Microscopy / visual.

Findings: A consensus paper from 12 European laboratories set minimum requirements and best-practice guidance for spectroscopic analysis of microplastics in clean water. It emphasized contamination control, representative subsampling, spectral confirmation and transparent size cutoffs.

Risk relevance: Provides evidence context and interpretation. Its numerical conclusions remain dependent on the analytical windows and quality of the underlying studies.

Key limitations: The local PDF was readable, but results remain limited by the study-specific sample frame, detection window and quality controls.

Catalogue ID: STUDY-00028. DOI/link: [10.1007/s00216-021-03498-y](https://doi.org/10.1007/s00216-021-03498-y)

Isabel S. Jüngling, Lucas Schmitt, Filippo De Franceschi, Paulo A. Da Costa Filho, Lei Lei, Laureen Coic, Nizar Benismail, Stephane Dubascoux, Mark E. Ambühl & Natalia P. Ivleva. 2026. Challenges and solutions in the analysis of micro- and nanoplastics down to 500 nm with automated Raman microspectroscopy: suitable filters, accuracy in the detection, identification, and quantification. *Analytical and Bioanalytical Chemistry*.

Design: Review, evidence assessment or analytical-method study. Reported analytical approach: FTIR; Raman spectroscopy; Py-GC/MS; GC-MS; Nile red / fluorescence; Microscopy / visual; Flow cytometry.

Findings: Automated Raman microscopy was evaluated down to 500 nm. Silicon and aluminium-coated polycarbonate filters performed best, while filter roughness, spectral interference, particle agglomeration and automation settings affected recovery and identification.

Risk relevance: Defines what a method can and cannot measure. Results should not be pooled directly with studies using different size cutoffs, identification rules or measurands.

Key limitations: Performance with standards and selected filters does not guarantee equal recovery in every real matrix, and automated results remain sensitive to spectral libraries and settings.

Catalogue ID: STUDY-00029. **DOI/link:** [10.1007/s00216-026-06567-2](https://doi.org/10.1007/s00216-026-06567-2)

Dafne Eerkes-Medrano, Heather A. Leslie & Brian Quinn. 2019. Microplastics in drinking water: A review and assessment. Current Opinion in Environmental Science & Health 7:69-75.

Design: Review, evidence assessment or analytical-method study. Reported analytical approach: FTIR; Raman spectroscopy; SEM/EDS; Microscopy / visual.

Findings: The review organized evidence around occurrence in drinking water, entry routes and human toxicology, and offered an early exposure assessment. It concluded that important evidence gaps prevented confident health-risk conclusions.

Risk relevance: Provides evidence context and interpretation. Its numerical conclusions remain dependent on the analytical windows and quality of the underlying studies.

Key limitations: Secondary synthesis; inherits source-study heterogeneity.

Catalogue ID: STUDY-00109. **DOI/link:** [10.1016/j.coesh.2018.12.001](https://doi.org/10.1016/j.coesh.2018.12.001)

Barbara E Oßmann. 2021. Microplastics in drinking water? Present state of knowledge and open questions. Current Opinion in Food Science 41:44-51.

Design: Review, evidence assessment or analytical-method study. Reported analytical approach: FTIR; Raman spectroscopy; Py-GC/MS; GC-MS; SEM/EDS; Microscopy / visual.

Findings: This state-of-knowledge review compared reported drinking-water occurrence, treatment and health evidence. It stressed that inconsistent definitions, sampling, size windows and identification methods prevent a single representative concentration or firm risk estimate.

Risk relevance: Provides evidence context and interpretation. Its numerical conclusions remain dependent on the analytical windows and quality of the underlying studies.

Key limitations: Mass and count endpoints are not interchangeable.

Catalogue ID: STUDY-00110. **DOI/link:** [10.1016/j.cofs.2021.02.011](https://doi.org/10.1016/j.cofs.2021.02.011)

Ling Yang, Shichang Kang, Xi Luo & Zhaoqing Wang. 2024. Microplastics in drinking water: A review on methods, occurrence, sources, and potential risks assessment. Environmental Pollution 348:123857.

Design: Review, evidence assessment or analytical-method study. Reported analytical approach: FTIR; Raman spectroscopy; Py-GC/MS; GC-MS; Nile red / fluorescence; Microscopy / visual.

Findings: A systematic review found widespread reports of microplastics in drinking water but very large differences in concentration. Fibres and fragments were common, and the authors identified standard methods and better source-to-tap studies as priority needs.

Risk relevance: Provides evidence context and interpretation. Its numerical conclusions remain dependent on the analytical windows and quality of the underlying studies.

Key limitations: Mass and count endpoints are not interchangeable.

Catalogue ID: STUDY-00197. **DOI/link:** [10.1016/j.envpol.2024.123857](https://doi.org/10.1016/j.envpol.2024.123857)

L. Maurizi, L. Iordachescu, I.V. Kirstein, A.H. Nielsen & J. Vollertsen. 2023. It matters how we measure - Quantification of microplastics in drinking water by μ FTIR and μ Raman. Heliyon 9(9):e20119.

Design: Review, evidence assessment or analytical-method study. Reported analytical approach: FTIR; Raman spectroscopy; GC-MS; Microscopy / visual.

Findings: The same Danish waterworks samples produced different removal estimates when analysed by micro-FTIR and micro-Raman. When a common size range was imposed, results converged, directly demonstrating that analytical cutoff can dominate apparent treatment performance.

Risk relevance: Defines what a method can and cannot measure. Results should not be pooled directly with studies using different size cutoffs, identification rules or measurands.

Key limitations: The comparison is specific to one waterworks and two analytical windows; neither method alone defines a universal true concentration.

Catalogue ID: STUDY-00229. **DOI/link:** [10.1016/j.heliyon.2023.e20119](https://doi.org/10.1016/j.heliyon.2023.e20119)

Md. Iftakharul Muhib, Md. Khabir Uddin, Md. Mostafizur Rahman & Guilherme Malafaia. 2023. Occurrence of microplastics in tap and bottled water, and food packaging: A narrative review on current knowledge. Science of The Total Environment 865:161274.

Design: Review, evidence assessment or analytical-method study.

Findings: This narrative review summarized microplastics reported in tap water, bottled water and food-contact packaging. It found broad occurrence but high methodological heterogeneity and insufficient evidence for a simple package-to-health causal chain.

Risk relevance: Shows that packaging alternatives have their own particle, chemical or environmental profiles; it does not imply that all materials or hazards are equivalent.

Key limitations: Secondary synthesis; inherits source-study heterogeneity.

Catalogue ID: STUDY-00375. DOI/link: [10.1016/j.scitotenv.2022.161274](https://doi.org/10.1016/j.scitotenv.2022.161274)

Albert A. Koelmans, Nur Hazimah Mohamed Nor, Enya Hermesen, Merel Kooi, Svenja M. Mintenig & Jennifer De France. 2019. Microplastics in freshwaters and drinking water: Critical review and assessment of data quality. Water Research 155:410-422.

Design: Review, evidence assessment or analytical-method study.

Findings: Fifty freshwater and drinking-water studies were scored against quality criteria. Reported concentrations spanned roughly ten orders of magnitude, and only a small minority met all proposed quality requirements, making uncritical pooling inappropriate.

Risk relevance: Provides evidence context and interpretation. Its numerical conclusions remain dependent on the analytical windows and quality of the underlying studies.

Key limitations: The review reflects evidence available through 2019, and its quality score is a proposed framework rather than a formal regulatory standard.

Catalogue ID: STUDY-00419. DOI/link: [10.1016/j.watres.2019.02.054](https://doi.org/10.1016/j.watres.2019.02.054)

Frank Welle & Roland Franz. 2018. Microplastic in bottled natural mineral water – literature review and considerations on exposure and risk assessment. Food Additives & Contaminants: Part A 35(12):2482-2492.

Design: Review, evidence assessment or analytical-method study. Reported analytical approach: FTIR; Raman spectroscopy; Microscopy / visual.

Findings: The review converted bottled-mineral-water particle results into mass and exposure context. Under its conservative assumptions, migration of associated substances and ingestion of the particles did not indicate a safety concern, while major data gaps remained for very small particles.

Risk relevance: Provides evidence context and interpretation. Its numerical conclusions remain dependent on the analytical windows and quality of the underlying studies.

Key limitations: Mass and intake estimates require assumptions about particle geometry, density, additives and gastrointestinal uptake, especially below the measured size range.

Catalogue ID: STUDY-00615. DOI/link: [10.1080/19440049.2018.1543957](https://doi.org/10.1080/19440049.2018.1543957)

Honghao Liu, Rongqing Sun, Xiaohui Zhang, Lin Song, Yang Fan, Jun Li, Pingfan Zhou & Jinjiang Yang. 2024. Microplastics in Drinking Water: Current Knowledge, Quality Assurance and Future Directions. Polish Journal of Environmental Studies 33(5):5507-5519.

Design: Review, evidence assessment or analytical-method study. Reported analytical approach: FTIR.

Findings: The review summarized occurrence in source and finished drinking water, removal by treatment units and quality-assurance needs. It called for standardized QA/QC and better mechanistic research rather than treating heterogeneous counts as directly comparable.

Risk relevance: Provides evidence context and interpretation. Its numerical conclusions remain dependent on the analytical windows and quality of the underlying studies.

Key limitations: The local PDF was readable, but results remain limited by the study-specific sample frame, detection window and quality controls.

Catalogue ID: STUDY-00721. DOI/link: [10.15244/pjoes/183443](https://doi.org/10.15244/pjoes/183443)

Eric Barthélémy, Ronan Cariou, Laurence Castle, Riccardo Crebelli, Emma Di Consiglio, Thomas Hemy Dumas, Roland Franz, Konrad Grob, Claude Lambré, Evgenia Lampi, Maria Rosaria Milana, Irene Munoz Guajardo Marja Pronk, Gilles Rivière, Maria da Silva, Thomas Tietz, Emmanouil Tsochatzis & Els Van Hoeck. 2025. Literature review on micro- and nanoplastic release from food contact materials during their use. EFSA Supporting Publications 22(10).

Design: Review, evidence assessment or analytical-method study. Reported analytical approach: FTIR; Raman spectroscopy; Nile red / fluorescence; Microscopy / visual.

Findings: EFSA's systematic review found that release from food-contact materials appears lower than some earlier studies suggested. However, methodological weaknesses and limited comparable data prevented a reliable overall exposure estimate.

Risk relevance: Provides evidence context and interpretation. Its numerical conclusions remain dependent on the analytical windows and quality of the underlying studies.

Key limitations: The reviewed food-contact studies were heterogeneous and often methodologically weak; the review did not establish a single PET-specific exposure value.

Catalogue ID: STUDY-00749. **DOI/link:** [10.2903/sp.efsa.2025.en-9733](https://doi.org/10.2903/sp.efsa.2025.en-9733)

Isabella Gambino, Francesco Bagordo, Tiziana Grassi, Alessandra Panico & Antonella De Donno. 2022. Occurrence of Microplastics in Tap and Bottled Water: Current Knowledge. International Journal of Environmental Research and Public Health 19(9):5283.

Design: Review, evidence assessment or analytical-method study. Reported analytical approach: FTIR; Raman spectroscopy; Py-GC/MS; GC-MS; SEM/EDS; Microscopy / visual.

Findings: A narrative review of 21 studies reported microplastics in tap and bottled water, with counts tending to rise as the lower size cutoff fell. Reusable PET and glass sometimes had higher counts, but heterogeneity prevented a universal package ranking or health-risk conclusion.

Risk relevance: Provides evidence context and interpretation. Its numerical conclusions remain dependent on the analytical windows and quality of the underlying studies.

Key limitations: Mass and count endpoints are not interchangeable.

Catalogue ID: STUDY-00802. **DOI/link:** [10.3390/ijerph19095283](https://doi.org/10.3390/ijerph19095283)

World Health Organization. 2019. Microplastics in drinking-water. Geneva: World Health Organization. ISBN 978-92-4-151619-8.

Design: Review, evidence assessment or analytical-method study.

Findings: WHO reviewed drinking-water occurrence, treatment, particle toxicology and chemical or biofilm concerns. It found no reliable evidence of a health concern at then-current exposure, did not recommend routine monitoring, and prioritized better methods and control of established water hazards.

Risk relevance: Provides broader chemical, toxicological or public-health context rather than a direct estimate of bottled-drink microplastic risk.

Key limitations: The assessment was based on evidence available in 2019 and identified substantial gaps, particularly for nanoplastics and chronic particle-specific toxicology.

Catalogue ID: STUDY-00914. **DOI:** none assigned. **Source link:** [open official report](#)

Clementina Vitali, Ruud J.B. Peters, Hans-Gerd Janssen, Anna K. Undas, Sandra Munniks, Francesco Simone Ruggeri & Michel W.F. Nielen. 2024. Quantitative image analysis of microplastics in bottled water using artificial intelligence. Talanta 266:124965.

Design: Review, evidence assessment or analytical-method study. Reported analytical approach: FTIR; Raman spectroscopy; SEM/EDS; Nile red / fluorescence; Microscopy / visual.

Findings: A Nile-Red fluorescence workflow used supervised machine learning to automate particle segmentation and was validated with standards before application to 20 bottled waters. The approach improved speed and repeatability and produced counts ranging from below detection to 7,237 items per 500 mL.

Risk relevance: Defines what a method can and cannot measure. Results should not be pooled directly with studies using different size cutoffs, identification rules or measurands.

Key limitations: Nile-Red fluorescence and machine segmentation do not chemically confirm every counted object; model performance depends on training data, filters and thresholds.

Catalogue ID: STUDY-01169. **DOI/link:** [10.1016/j.talanta.2023.124965](https://doi.org/10.1016/j.talanta.2023.124965)

Qun Zhang, Elvis Genbo Xu, Jiana Li, Qiqing Chen, Liping Ma, Eddy Y. Zeng & Huahong Shi. 2020. A Review of Microplastics in Table Salt, Drinking Water, and Air: Direct Human Exposure. Environmental Science & Technology 54(7):3740-3751.

Design: Review, evidence assessment or analytical-method study.

Findings: The review compiled direct human exposure estimates from table salt, drinking water and air. It showed that estimates depend strongly on regional data and analytical cutoffs and that the available evidence could not support a precise total intake.

Risk relevance: Provides evidence context and interpretation. Its numerical conclusions remain dependent on the analytical windows and quality of the underlying studies.

Key limitations: Secondary synthesis; inherits source-study heterogeneity.

Catalogue ID: STUDY-01179. **DOI/link:** [10.1021/acs.est.9b04535](https://doi.org/10.1021/acs.est.9b04535)

Ann-Kathrin Kniggendorf, Christoph Wetzel & Bernhard Roth. 2019. Microplastics Detection in Streaming Tap Water with Raman Spectroscopy. Sensors 19(8):1839.

Design: Review, evidence assessment or analytical-method study. Reported analytical approach: FTIR; Raman spectroscopy; Nile red / fluorescence; Microscopy / visual.

Findings: A custom Raman flow cell detected introduced polymer particles in water flowing at 1 L/hour. The work demonstrated a possible route to online monitoring of clear water but was a proof of concept rather than a field survey.

Risk relevance: Provides evidence context and interpretation. Its numerical conclusions remain dependent on the analytical windows and quality of the underlying studies.

Key limitations: The proof-of-concept used introduced particles under controlled conditions and was not a validated field-monitoring system.

Catalogue ID: STUDY-01442. **DOI/link:** [10.3390/s19081839](https://doi.org/10.3390/s19081839)

Dušan Materić. 2024. Nanoplastics measurements must have appropriate blanks. Proceedings of the National Academy of Sciences 121(48):e2411099121.

Design: Scientific correspondence / methodological critique. Reported analytical approach: Methodological critique of SRS microscopy blank selection and detection-limit calculation.

Findings: Materić argued that the high-count SRS bottled-water study should have used the processed Milli-Q sample as its procedural blank; because its count was comparable to bottled-water counts, he considered the absolute result unreliable.

Risk relevance: Defines what a method can and cannot measure. Results should not be pooled directly with studies using different size cutoffs, identification rules or measurands.

Key limitations: This is a methodological letter, not a new occurrence experiment, and it states one side of an unresolved blank-control interpretation.

Catalogue ID: ESSENTIAL-001. **DOI/link:** [10.1073/pnas.2411099121](https://doi.org/10.1073/pnas.2411099121)

Naixin Qian, Phoebe Stapleton, Beizhan Yan & Wei Min. 2024. Reply to Materić: Appropriate blanks should avoid major contamination sources in the lab. Proceedings of the National Academy of Sciences 121(48):e2415874121.

Design: Scientific correspondence / methodological response. Reported analytical approach: Methodological response concerning SRS microscopy blanks and contamination controls.

Findings: Qian and colleagues replied that the Milli-Q water was itself contaminated and therefore unsuitable as a clean blank, defending clean filters as the relevant control. The exchange left the absolute count method- and blank-sensitive rather than independently resolved.

Risk relevance: Supports occurrence or source characterization. Detection or experimentally induced release does not by itself demonstrate an adverse effect at ordinary consumer exposure.

Key limitations: This is a response letter rather than an independent replication with certified particle-free water.

Catalogue ID: ESSENTIAL-002. **DOI/link:** [10.1073/pnas.2415874121](https://doi.org/10.1073/pnas.2415874121)

Packaging, lifecycle and tap-water comparators

Razegheh Akhbarizadeh, Sina Dobaradaran, Torsten C. Schmidt, Iraj Nabipour & Jörg Spitz. 2020. Worldwide bottled water occurrence of emerging contaminants: A review of the recent scientific literature. *Journal of Hazardous Materials* 392:122271.

Design: Systematic review / meta-analysis. Reported analytical approach: Raman spectroscopy; Microscopy / visual.

Findings: This systematic review covered microplastics and several classes of emerging chemical contaminants in bottled water. It found generally low measured concentrations but inconsistent source attribution and insufficient exposure and toxicity data for broad risk conclusions.

Risk relevance: Provides evidence context and interpretation. Its numerical conclusions remain dependent on the analytical windows and quality of the underlying studies.

Key limitations: Secondary synthesis; inherits source-study heterogeneity.

Catalogue ID: STUDY-00248. DOI/link: [10.1016/j.jhazmat.2020.122271](https://doi.org/10.1016/j.jhazmat.2020.122271)

S.M. Mintenig, M.G.J. Löder, S. Primpke & G. Gerdt. 2019. Low numbers of microplastics detected in drinking water from ground water sources. *Science of The Total Environment* 648:631-635.

Design: Review. Reported analytical approach: FTIR; Raman spectroscopy; Microscopy / visual; Thermal analysis.

Findings: Groundwater and groundwater-derived drinking water contained 0-7 particles per cubic metre above 20 micrometres, with an overall mean of 0.7/m³. The results showed that very low counts are possible when stringent spectroscopic identification and contamination control are used.

Risk relevance: Provides evidence context and interpretation. Its numerical conclusions remain dependent on the analytical windows and quality of the underlying studies.

Key limitations: The analysis excluded particles below 20 micrometres and covered a limited groundwater-derived system.

Catalogue ID: STUDY-00340. DOI/link: [10.1016/j.scitotenv.2018.08.178](https://doi.org/10.1016/j.scitotenv.2018.08.178)

Marlon Ferraz, Amanda Leticia Bauer, Victor Hugo Valiati & Uwe Horst Schulz. 2020. Microplastic Concentrations in Raw and Drinking Water in the Sinos River, Southern Brazil. *Water* 12(11):3115.

Design: Review. Reported analytical approach: Nile red / fluorescence; Microscopy / visual.

Findings: Raw Sinos River water averaged 330 particles/L and treated household water 106 particles/L by Nile-Red fluorescence microscopy. Treatment reduced the count substantially, although fibres remained common and the exact particle pathways were unresolved.

Risk relevance: Provides evidence context and interpretation. Its numerical conclusions remain dependent on the analytical windows and quality of the underlying studies.

Key limitations: Nile-Red fluorescence microscopy did not chemically verify every counted particle and can overcount non-plastic hydrophobic material.

Catalogue ID: STUDY-00860. DOI/link: [10.3390/w12113115](https://doi.org/10.3390/w12113115)

Louise Feld, Vitor Hugo da Silva, Fionn Murphy, Nanna B. Hartmann & Jakob Strand. 2021. A Study of Microplastic Particles in Danish Tap Water. *Water* 13(15):2097.

Design: Field / observational. Reported analytical approach: FTIR; Nile red / fluorescence; Microscopy / visual.

Findings: Across 17 Danish tap-water locations, only seven spectroscopically confirmed microplastics were found. Fibre-like material also occurred in blanks, and total sample concentrations could not be distinguished confidently from background contamination.

Risk relevance: Places bottled-water findings against other water sources. The observed direction and magnitude are study-specific rather than a universal tap-versus-bottle ranking.

Key limitations: The main survey covered particles above 100 micrometres, with only selected samples assessed down to 10 micrometres.

Catalogue ID: STUDY-00863. DOI/link: [10.3390/w13152097](https://doi.org/10.3390/w13152097)

Xiangying Sun, Yunjie Zhu, Lihui An, Yan Liu, Yin Zhuang, Yubang Wang, Mingdong Sun & Qiujin Xu. 2024. Microplastic Transportation in a Typical Drinking Water Supply: From Raw Water to Household Water. *Water* 16(11):1567.

Design: Review.

Findings: A source-to-household survey found 2.3-17.3 particles/L in raw water, 12.0-25.3 in treated water and 8.0-19.7 in household water. The pattern showed that particles can be removed, introduced, retained or remobilized across the supply system.

Risk relevance: Provides evidence context and interpretation. Its numerical conclusions remain dependent on the analytical windows and quality of the underlying studies.

Key limitations: The study represents one supply system and cannot be generalized to every plant, distribution network or premise-plumbing configuration.

Catalogue ID: STUDY-00865. **DOI/link:** [10.3390/w16111567](https://doi.org/10.3390/w16111567)

Cristina Bach, Xavier Dauchy, Isabelle Severin, Jean-François Munoz, Serge Etienne & Marie-Christine Chagnon. 2014. Effect of sunlight exposure on the release of intentionally and/or non-intentionally added substances from polyethylene terephthalate (PET) bottles into water: Chemical analysis and in vitro toxicity. Food Chemistry 162:63-71.

Design: Experimental packaging migration and in-vitro toxicity.

Findings: Natural-sunlight exposure altered migration of aldehydes and antimony depending on water chemistry, especially carbonation. No cytotoxic, genotoxic, estrogenic or anti-androgenic response was detected in the tested PET-water extracts at relevant exposure levels.

Risk relevance: Defines what a method can and cannot measure. Results should not be pooled directly with studies using different size cutoffs, identification rules or measurands.

Key limitations: The study concerns dissolved migrants and in-vitro extracts, not intact microplastic particles; sunlight and water-matrix conditions were specific.

Catalogue ID: CONTEXT-001. **DOI/link:** [10.1016/j.foodchem.2014.04.020](https://doi.org/10.1016/j.foodchem.2014.04.020)

Lisa Zimmermann, Georg Dierkes, Thomas A. Ternes, Carolin Völker & Martin Wagner. 2019. Benchmarking the in Vitro Toxicity and Chemical Composition of Plastic Consumer Products. Environmental Science & Technology 53(19):11467-11477.

Design: In-vitro toxicity and chemical characterization.

Findings: Extracts from 34 plastic consumer products showed widely differing in-vitro chemical and biological profiles. PET and HDPE products produced no or low activity compared with several other polymer classes, demonstrating that findings for one plastic cannot be generalized to all.

Risk relevance: Provides broader chemical, toxicological or public-health context rather than a direct estimate of bottled-drink microplastic risk.

Key limitations: Bioassays used concentrated product extracts and identify hazard potential, not consumer dose or risk from bottled water.

Catalogue ID: CONTEXT-002. **DOI/link:** [10.1021/acs.est.9b02293](https://doi.org/10.1021/acs.est.9b02293)

Clemens Reimann, Manfred Birke & Peter Filzmoser. 2010. Bottled drinking water: Water contamination from bottle materials (glass, hard PET, soft PET), the influence of colour and acidification. Applied Geochemistry 25(7):1030-1046.

Design: Packaging-material comparison.

Findings: Matched waters sold in glass and PET showed material-specific elemental migration. PET water had more antimony, while glass water had more lead, aluminium and many other elements; colour and washing also altered the glass results.

Risk relevance: Shows that packaging alternatives have their own particle, chemical or environmental profiles; it does not imply that all materials or hazards are equivalent.

Key limitations: The endpoints were dissolved elements rather than microplastics, so the study provides packaging context rather than particle exposure.

Catalogue ID: CONTEXT-003. **DOI/link:** [10.1016/j.apgeochem.2010.04.009](https://doi.org/10.1016/j.apgeochem.2010.04.009)

M KRACHLER & W SHOTYK. 2009. Trace and ultratrace metals in bottled waters: Survey of sources worldwide and comparison with refillable metal bottles. Science of The Total Environment 407(3):1089-1096.

Design: Packaging-material comparison.

Findings: Analysis of 132 bottled-water brands from 28 countries found most trace-metal concentrations below health-based guideline values, with a few source- or container-specific exceptions. Tests of refillable metal bottles likewise showed that migration is not unique to plastics.

Risk relevance: Provides broader chemical, toxicological or public-health context rather than a direct estimate of bottled-drink microplastic risk.

Key limitations: The work addresses trace metals and selected containers, not microplastic occurrence or particle toxicology.

Catalogue ID: CONTEXT-004. **DOI/link:** [10.1016/j.scitotenv.2008.10.014](https://doi.org/10.1016/j.scitotenv.2008.10.014)

Bikram Gautam. 2020. Chemical Evaluation of Trace Elements in Bottled Water. Journal of Healthcare Engineering 2020:1-16.

Design: Bottled-water chemical analysis.

Findings: One hundred bottled-water samples were analysed for physicochemical properties and trace elements. The measured products met the comparison criteria used by the study, providing chemical-quality context rather than evidence about microplastic particles.

Risk relevance: Provides broader chemical, toxicological or public-health context rather than a direct estimate of bottled-drink microplastic risk.

Key limitations: This is a regional chemical-quality survey and does not attribute measured elements to a specific package or address particles.

Catalogue ID: CONTEXT-005. **DOI/link:** [10.1155/2020/8884700](https://doi.org/10.1155/2020/8884700)

Franklin Associates. 2023. Life Cycle Assessment of Predominant U.S. Beverage Container Systems for Carbonated Soft Drinks and Domestic Still Water. Final peer-reviewed report prepared for the National Association for PET Container Resources.

Design: Life-cycle assessment.

Findings: The peer-reviewed US life-cycle assessment compared PET, glass and aluminium beverage systems. PET bottles generally had lower energy, emissions and material burdens in the model, although results depended on container size, recycled content, transport and recycling assumptions.

Risk relevance: Shows that packaging alternatives have their own particle, chemical or environmental profiles; it does not imply that all materials or hazards are equivalent.

Key limitations: The report was industry-funded and model results depend on system boundaries, market data, recycling allocation and transport assumptions.

Catalogue ID: CONTEXT-006. **DOI:** none assigned. **Source link:** [open official report](#)

David Amienyo, Haruna Gujba, Heinz Stichnothe & Adisa Azapagic. 2012. Life cycle environmental impacts of carbonated soft drinks. The International Journal of Life Cycle Assessment 18(1):77-92.

Design: Life-cycle assessment.

Findings: A cradle-to-grave UK assessment found packaging to be the major impact hotspot for carbonated drinks. The 2-L PET bottle had the lowest impacts for most categories, while single-use glass was generally highest unless reuse materially improved its performance.

Risk relevance: Informs whole-system material choice. Life-cycle results should be evaluated alongside safety, function, transport, reuse and recycling rather than particle detection alone.

Key limitations: The UK model reflects the data and packaging systems available at the time; reuse and recycling assumptions materially affect rankings.

Catalogue ID: CONTEXT-007. **DOI/link:** [10.1007/s11367-012-0459-y](https://doi.org/10.1007/s11367-012-0459-y)

Andrew Turner. 2019. Heavy Metals in the Glass and Enamels of Consumer Container Bottles. Environmental Science & Technology 53(14):8398-8404.

Design: Packaging-material chemical analysis.

Findings: UK beverage-bottle glass and enamel decorations contained lead, cadmium and chromium at variable concentrations. The most mobile lead and cadmium were associated with some enamels, illustrating that glass packages can introduce distinct chemical and end-of-life concerns.

Risk relevance: Shows that packaging alternatives have their own particle, chemical or environmental profiles; it does not imply that all materials or hazards are equivalent.

Key limitations: The landfill-style leaching test is not a beverage-consumption exposure test, and the study did not measure microplastics.

Catalogue ID: CONTEXT-008. **DOI/link:** [10.1021/acs.est.9b01726](https://doi.org/10.1021/acs.est.9b01726)

Additional contextual studies incorporated in this revision

Cristina Bach, Xavier Dauchy, Isabelle Severin, Jean-François Munoz, Serge Etienne & Marie-Christine Chagnon. 2014. Effect of sunlight exposure on the release of intentionally and/or non-intentionally added substances from polyethylene terephthalate (PET) bottles into water: Chemical analysis and in vitro toxicity. *Food Chemistry* 162:63–71.

Design and findings: Natural-sunlight exposure of PET-bottled waters for 2, 6 and 10 days was combined with chemical analysis and in-vitro cytogenotoxicity and endocrine-activity assays. Migration varied with water type, no unpredictable NIAS were identified, and the tested extracts produced no cytogenotoxic, estrogenic or anti-androgenic activity at the reported consumer-relevant exposure.

Risk relevance and limitations: Provides PET migrant and mixture-bioassay context, not microplastic-particle toxicology. Two brands and water types were tested, and in-vitro endpoints cannot exclude every formulation or effect. DOI/link: <https://doi.org/10.1016/j.foodchem.2014.04.020>

Valerie Stock, Cecilia Laurisch, Josephin Franke, et al. 2021. Uptake and cellular effects of PE, PP, PET and PVC microplastic particles. *Toxicology in Vitro* 70:105021.

Design and findings: Human intestinal and liver-cell systems were exposed to several particle sizes and four common polymers. Uptake and transport were material- and size-dependent, while cytotoxicity appeared only at concentrations described by the authors as far beyond realistic dietary exposure.

Risk relevance and limitations: Useful comparative mechanistic evidence beyond polystyrene beads, but a short-term in-vitro experiment cannot define a human safe-intake threshold or long-term risk.

DOI/link: <https://doi.org/10.1016/j.tiv.2020.105021>

Barbara Beckingham & Upal Ghosh. 2017. Differential bioavailability of polychlorinated biphenyls associated with environmental particles: Microplastic in comparison to wood, coal and biochar. *Environmental Pollution* 220:150–158.

Design and findings: PCB partitioning, gut-fluid solubilization and uptake in sediment worms were compared across polypropylene, sediment and several natural or anthropogenic carbonaceous particles. PCB uptake was lower when associated with polypropylene than with contaminated sediment.

Risk relevance and limitations: Shows that sorption does not determine vector significance by itself. The experiment concerns aquatic sediment organisms and PCBs, not human ingestion of PET-bottled drinks.

DOI/link: <https://doi.org/10.1016/j.envpol.2016.09.033>

Ricardo Beiras, Soledad Muniategui-Lorenzo, Rosario Rodil, et al. 2019. Polyethylene microplastics do not increase bioaccumulation or toxicity of nonylphenol and 4-MBC to marine zooplankton. *Science of the Total Environment* 692:1–9.

Design and findings: Marine copepod and sea-urchin larvae ingested polyethylene particles, but the particles did not increase bioaccumulation or toxicity of the two hydrophobic model chemicals under the test conditions.

Risk relevance and limitations: Challenges a universal chemical-vector assumption but remains an aquatic laboratory study at specified particle and chemical concentrations; it is not human oral-safety evidence. DOI/link: <https://doi.org/10.1016/j.scitotenv.2019.07.106>

Saskia Rehse, Werner Kloas & Christiane Zarfl. 2018. Microplastics Reduce Short-Term Effects of Environmental Contaminants. Part I: Effects of Bisphenol A on Freshwater Zooplankton Are Lower in

Presence of Polyamide Particles. *International Journal of Environmental Research and Public Health* 15(2):280.

Design and findings: *Daphnia* exposed to BPA and polyamide particles showed reduced aqueous BPA and lower acute immobilization when the particles were present, despite particle ingestion.

Risk relevance and limitations: Demonstrates context-dependent sorption and short-term bioavailability in freshwater zooplankton; it does not show that particles are beneficial or address human exposure from PET bottles. DOI/link: <https://doi.org/10.3390/ijerph15020280>

Zandra Gerdes, Martin Ogonowski, Inna Nybom, et al. 2019. Microplastic-mediated transport of PCBs? A depuration study with *Daphnia magna*. *PLOS ONE* 14(2):e0205378.

Design and findings: PCB-contaminated daphnids were fed algae with or without microplastics. One high-molecular-weight PCB congener was removed more efficiently with particles, illustrating that contaminant transfer can run from organism to particle as well as in the opposite direction.

Risk relevance and limitations: The PCB burdens and particle exposures greatly exceeded environmental concentrations, and the aquatic depuration experiment cannot establish human oral risk. DOI/link: <https://doi.org/10.1371/journal.pone.0205378>

Rachid Dris, Johnny Gasperi, Cécile Mirande, et al. 2017. A first overview of textile fibers, including microplastics, in indoor and outdoor environments. *Environmental Pollution* 221:453–458.

Design and findings: Sampling in two apartments, one office and one outdoor site found higher indoor than outdoor fibre concentrations. Of analysed indoor fibres, 67% were natural material, primarily cellulosic, and 33% contained petrochemicals.

Risk relevance and limitations: Supports chemical identification before fibres are labelled microplastics. The small, site-specific study focused on relatively large fibres and does not estimate bottled-drink exposure or toxicity. DOI/link: <https://doi.org/10.1016/j.envpol.2016.12.013>

Giuseppe Suaria, Aikaterini Achtypi, Vonica Perold, et al. 2020. Microfibers in oceanic surface waters: A global characterization. *Science Advances* 6:eay8493.

Design and findings: Across 916 seawater samples from six ocean basins, micro-FTIR characterization of about 2,000 fibres identified 8.2% as synthetic, 79.5% as cellulosic and 12.3% as animal origin.

Risk relevance and limitations: Strongly supports chemical confirmation of fibre identity, but the proportions describe sampled ocean-surface fibres and are not a universal environmental or human-exposure ratio. DOI/link: <https://doi.org/10.1126/sciadv.aay8493>

Martin Pletz. 2022. Ingested microplastics: Do humans eat one credit card per week? *Journal of Hazardous Materials Letters* 3:100071.

Design and findings: This methodological reanalysis traced the widely repeated 0.1–5 g/week estimate to problematic combinations of particle-size, count and consumption data from different studies and concluded that the mass estimate was overstated by several orders of magnitude.

Risk relevance and limitations: Corrects an exposure-estimation claim rather than testing toxicology. Its alternative scale remains dependent on available occurrence data, size distributions and conversion assumptions. DOI/link: <https://doi.org/10.1016/j.hazl.2022.100071>

Focused source-recovery and historical polymer context added 27 July 2026

Sheftel VO. 2002. Indirect Food Additives and Polymers: Migration and Toxicology. CRC Press.

Design and findings: Secondary toxicology compendium integrating Western and Russian food-contact and polymer literature, including historical polyethylene, PET and other polymer records. For polyethylene, the book provides mechanistic and historical context but many entries are acute, extract-based, formulation-specific or incompletely reported.

Risk relevance: Supports a bounded structure-activity explanation for the very low intrinsic chemical toxicity expected for high-molecular-mass polyethylene and identifies otherwise obscure source leads.

Key limitations: It is a 2002 secondary source containing pre-GLP and difficult-to-verify records. It does not justify the claim that all alkanes are non-toxic, and secondary historical concentrations are not treated as formal modern NOAELs without primary-source recovery. Citation: Sheftel 2002.

Otaka T, Miyoshi K, Komai Y, Nakayoshi H. 1978. Safety evaluation of polyethylene terephthalate resins (I): Studies on the acute and subacute (3 months) toxicities by oral administration in rats. Journal of the Food Hygienic Society of Japan 19(5):431–442.

Design: Acute and 90-day rat gavage study of chloroform extracts from titanium- and germanium-catalyzed PET resins. The study tested extracted low-molecular-mass material, not PET particles or intact PET resin.

Findings: No toxic signs followed a single 10 g/kg dose. In the 90-day study, no treatment-related adverse effects were identified at up to 400 mg/kg/day for the titanium-catalyzed PET extract and 180 mg/kg/day for the germanium-catalyzed PET extract.

Risk relevance: Provides aggressive PET-extractables and food-contact chemistry context. It does not supply a PET-particle or PET-polymer NOAEL and is not included in the principal microplastic dose comparison.

Key limitations: Extract composition was method- and resin-specific, gavage differs from ordinary migration exposure, and the cited direct PET-resin Haskell Laboratory Report 17-73 has not been recovered. DOI/link: <https://doi.org/10.3358/shokueishi.19.431>

Supplemental oral-toxicology studies incorporated in the 26 July 2026 correction

Kim D, Kim D, Kim H-K, et al. 2025. Organ-specific accumulation and toxicity analysis of orally administered polyethylene terephthalate microplastics. Scientific Reports 15:6616.

Design: Four-week oral gavage mouse study of fragmented PET averaging approximately 5.6 µm at 1.75, 7 and 28 mg/kg/day, with a separate labelled biodistribution arm.

Findings: The authors reported sex-specific NOAELs of 1.75 mg/kg/day in males and 7 mg/kg/day in females based on pulmonary granulomatous findings.

Risk relevance: Important lower-dose PET evidence and the lowest author-reported PET NOAEL retained in the dose-separation table.

Key limitations: Particles in lesions were presumed rather than chemically co-localized; pooled-lung Raman was not lesion-specific; pathology was not quantitatively scored; only one slide per organ was examined. The value is therefore low-confidence and not a general PET threshold.

DOI/link: <https://doi.org/10.1038/s41598-025-91170-1>

Lu T, Liu H, Yuan X, et al. 2025. Chronic exposure to polyethylene terephthalate microplastics induces gut microbiota dysbiosis and disordered hepatic lipid metabolism in mice. Ecotoxicology and Environmental Safety 298:118330.

Design: Seventeen-week gavage study in male mice using irregular 6–12 µm PET at 5, 50 or 500 µg/day.

Findings: No significant liver pathology or liver-function changes were reported at 5 µg/day, while concentration-related hepatic injury and metabolic changes were reported at 50 and 500 µg/day.

Risk relevance: Longer-duration PET dose-response evidence that broadens the toxicology context beyond short-term studies.

Key limitations: Non-guideline design, one sex, gavage exposure, a dose expressed per animal rather than directly as mg/kg/day, focused hepatic/mechanistic endpoints and no matched nonplastic-particle comparator. The 5 µg/day result is not a general PET NOAEL.

DOI/link: <https://doi.org/10.1016/j.ecoenv.2025.118330>

Lewis AA, Biales AD, Miller C, et al. 2026. A single oral exposure to polyethylene terephthalate microplastics causes mild metabolic and gastrointestinal disruption: Dose and sex as effect modifiers. Drug and Chemical Toxicology:1–18.

Design: Single-dose oral gavage study at 5 or 50 mg/kg with approximately 18 hours of follow-up.

Findings: Mild, sex-dependent and partly non-monotonic metabolic, platelet, LDL and duodenal gene-expression changes were reported.

Risk relevance: Acute mechanistic PET evidence.

Key limitations: A single exposure with short follow-up cannot establish a repeated-dose or chronic NOAEL; some findings were non-monotonic and adversity was limited.

DOI/link: <https://doi.org/10.1080/01480545.2026.2643619>

Mierzejewski K, Kurzyńska A, Golubska M, et al. 2025. Oral exposure to PET microplastics induces the pancreatic immune response and oxidative stress in immature pigs. BMC Genomics 26:578.

Design: Four-week dietary/oral study in approximately 20 kg piglets receiving 0.1 or 1 g/day PET, with five animals per group.

Findings: The low dose changed one pancreatic gene, while the high dose changed 86 genes and selected oxidative-stress indicators.

Risk relevance: Large-animal mechanistic evidence with a route relevant to ingestion.

Key limitations: Small groups, grams/day dose metric, gene-expression emphasis, limited apical adversity and no matched nonplastic-particle comparator prevent a robust general PET NOAEL.

DOI/link: <https://doi.org/10.1186/s12864-025-11760-1>

Kim JS. 2021. Acute and subacute repeated oral toxicity study of fragmented microplastics in Sprague-Dawley rats. *Ecotoxicology and Environmental Safety* 228:112964.

Design: GLP acute and 28-day oral study of irregular weathered PP fragments made from bulk resin by cryogenic milling, sieving, heat and UV-B exposure.

Findings: No treatment-related adverse clinical, hematological, biochemical, organ-weight, histopathological or micronucleus effects were detected at 25 mg/kg/day, the highest feasible dose tested.

Risk relevance: Provides material-specific oral context for polypropylene closure particles.

Key limitations: The formal study NOAEL is 25 mg/kg/day because no higher dose was tested; the result is preparation- and duration-specific and does not apply to PET or HDPE.

DOI/link: <https://doi.org/10.1016/j.ecoenv.2021.112964>

Appendix B. Dose calculations, assumptions and sensitivity analysis

Purpose. This appendix makes the report's external-dose comparisons reproducible. It does not create a regulatory limit and does not assume that every polymer, particle size, shape, surface or weathering state has identical biological behavior.

Unit key: 1 mg = 1,000 µg; 1 µg = 1,000 ng. Dose in µg/kg/day = concentration (µg/L) × intake (L/day) ÷ body weight (kg).

Scenario	Inputs and calculation	External dose	Separation from 1.75 mg/kg/day PET value*	Separation from 1.6–2.0 g/kg/day component range**
Zuri average adult HDPE estimate	Published estimate used directly	0.004 µg/kg/day	1,750 ÷ 0.004 = 437,500-fold	1,600,000–2,000,000 ÷ 0.004 = 400–500 million-fold
Zuri maximum total quantified polymer; adult	0.439 µg/L × 2 L/day ÷ 70 kg	0.01254 µg/kg/day	1,750 ÷ 0.01254 ≈ 139,600-fold	≈128–159 million-fold
Welle–Franz deliberately high adult scenario	10 µg/L × 1 L/day ÷ 60 kg	0.1667 µg/kg/day	≈10,500-fold	≈9.6–12.0 million-fold
Welle–Franz deliberately high infant scenario	Published scenario used directly	2.0 µg/kg/day	875-fold	800,000–1,000,000-fold

Table B1. Reproducible external-dose calculations used in the report.

Assumptions and sensitivity. The adult maximum scenario assumes two litres every day and a 70 kg body weight. The adult high scenario assumes one litre every day and 60 kg. The infant scenario is intentionally conservative and produces the smallest displayed separation. These are external doses: absorption, distribution and clearance are not modelled. The 1.75 mg/kg/day value is the lowest author-reported PET NOAEL from Kim et al. 2025 and is retained as low-confidence contrary evidence because lesion identity and pathology quantitation were limited. The approximately 1.6–2.0 g/kg/day values are component exposures from the Merski 50:50 PE/PET mixture, not independently established pure-polymer NOAELs. Neither comparator is an acceptable daily intake, human safe-intake limit or validated regulatory threshold. Welle and Franz's historical 500 mg/kg/day and derived 5 mg/kg/day screening values are no longer used as principal comparators. The Otaka 1978 values are excluded because the administered material was a chloroform extract of PET resin rather than PET particles or intact polymer. The polyethylene structure-activity and historical 5%-diet evidence are also excluded from the numerical table because they provide qualitative or secondary-cited context rather than a verified compatible point of departure.

DISCLAIMER

This report is provided for informational and educational purposes only. It summarizes and interprets scientific evidence available at the time of publication. It is not medical, legal, or regulatory advice, and should not be relied upon as a substitute for professional guidance. While every effort has been made to ensure accuracy, completeness cannot be guaranteed and scientific understanding may evolve over time. Readers should consult original sources and qualified professionals before making decisions based on this report.

Dr. Chris DeArmitt

August 2026

