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MICROPLASTICS AND TAP WATER

*Plastic drinking-water pipes, alternative pipe materials,
and what the evidence actually shows*

COMPREHENSIVE EVIDENCE REVIEW



Dr. Chris DeArmitt

August 2026

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Comprehensive evidence review

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Evidence base: 138 unique tap-water and pipe records, supplemented by nine contextual exposure, toxicology and life-cycle sources

Central conclusion

Plastic pipes can release particles under sufficiently severe ageing, oxidation, stagnation, scouring or biofilm conditions, just as other solid pipe materials can release matter through wear, corrosion, scaling or degradation. The best field evidence does not show plastic pipes to be a meaningful source of microplastic exposure in ordinary tap water. Total real-world microplastic exposure is extremely small by mass, common pipe polymers have low inherent toxicity, and no adverse human health effect has been demonstrated at realistic tap-water exposure. Any contribution specifically attributable to plastic pipes is therefore a still smaller subset and, on current evidence, is not toxicologically meaningful.

Purpose and limits. This is a scientific evidence review, not a regulatory risk assessment, medical diagnosis or product certification. Studies are judged by particle identity, contamination control, realistic dose, source attribution, mass context, reproducibility and whether conclusions match the data. The conclusion should change if strong new evidence demonstrates confirmed pipe-derived particles at realistic exposure causing reproducible harm.

Author, affiliations, independence and funding.

Dr. Chris DeArmitt is a polymer scientist, Founder of the Plastics Research Council and President of Phantom Plastics LLC, an independent technical consultancy. Phantom Plastics does not manufacture, market or sell plastics or plastic products. This report was prepared as unpaid work for the Plastics Research Council. Neither Dr. DeArmitt nor Phantom Plastics received payment, research funding, sponsorship or other financial or material support for preparing or publishing the report. No client, plastics manufacturer, trade association, advocacy organization, donor, government agency, academic institution or other third party commissioned, directed, reviewed, approved or controlled its evidence selection, scientific interpretation, wording, conclusions, graphics or publication.

Competing interests.

The author declares no competing financial or non-financial interests in relation to this report. Professional expertise in polymer science is disclosed as relevant author background and qualification.

AI assistance and author responsibility.

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

Review status.

This report is an independent Plastics Research Council evidence synthesis and has not undergone formal journal peer review. Conclusions are limited to the evidence identified by the stated cutoff date and should be reconsidered if reliable new evidence materially changes the assessment.

Executive summary

The available evidence does not justify avoiding plastic drinking-water pipes because of microplastics. No reviewed study demonstrates harm from tap-water microplastics at measured exposure, and the strongest field studies do not identify plastic pipes as a major net particle source above their analytical cutoffs.

People routinely inhale and ingest mineral dust, cellulose, skin cells, food particles, pollen, soot, rust, fibres, glass, ceramics, scale, corrosion products and biological material. In the drinking-water studies that measured the broader particulate background, confirmed plastic was generally a small fraction. Toxicological significance depends on polymer, particle size and shape, associated chemicals, route, bioavailability and dose - not detection alone.

Drinking water is one contributor to total particle exposure, tap water is a subset of drinking-water exposure, and any fraction attributable specifically to plastic pipes is smaller again. The best mass-based model estimated median adult intake from all evaluated food and inhalation sources at about 583 ng/day, about 0.015 g over 70 years before elimination, and a modelled tissue burden of about 40.7 ng by age 70.

Water treatment generally removes most incoming particles. Strong field investigations report finished-water concentrations in the hundredths of a confirmed particle per litre above 25-50 µm. A ten-facility study found more than 97.5% removal, while two Catalanian plants reported 85% and 99.5% removal. Differences among studies largely reflect size thresholds, sample volumes, blanks and identification methods.

Real networks do not support the claim of continuous contamination from plastic pipes. Feld et al. found no confirmed PE or PVC in Danish tap water; Dalmau-Soler et al. reported 0.01 confirmed particle/L with no consistent network increase; Sun et al. found fewer particles at household taps than in treated water entering distribution; and Adediran et al. reported about 0.025 particle/L.

Laboratory studies demonstrate release potential under oxidation, heat, UV, prolonged stagnation, hydraulic scouring and biofilm-associated deterioration. They identify mechanisms, not ordinary consumer exposure, and several of the largest counts rely on methods that did not confirm each object as the pipe polymer. No claim is made that release is literally zero; the evidence instead shows that a meaningful pipe-derived dose has not been demonstrated.

Alternative materials are not particle-free. Iron and steel form rust and iron-rich deposits; copper, lead, cementitious systems, stainless steel, coatings and linings introduce their own particulate or chemical issues. Material selection must compare complete toxicology, corrosion, microbial performance, reliability, service life and environmental impact.

No reviewed tap-water occurrence or pipe-release study demonstrates human disease at measured exposure. Selected repeated-dose animal studies reported study-specific NOAELs for PE/PET and PP materials whose simple 70-kg adult mass equivalents are about 300 million and 240 million times the modelled 583 ng/day median intake from evaluated food and inhalation pathways; the amount attributable to tap water and plastic pipes is smaller still. These comparisons provide dose-scale context, not human safe-intake limits. The defensible conclusion is no demonstrated toxicologically meaningful pipe contribution at current measured.

Sources: Mohamed Nor et al. 2021; WHO 2019, 2022; Feld et al. 2021; Dalmau-Soler et al. 2022; Adediran et al. 2024; Sun et al. 2024; Balkenbusch et al. 2025; Merski et al. 2008; Lee et al. 2023; Archana et al. 2018; Stock et al. 2021; Styles & Wilson 1973.

Key findings

- **Plastic is one component of a much broader particle background.** All solid materials can generate particles. Common pipe polymers are not classified as hazards equivalent to silica, asbestos or lead, but particle toxicity still depends on material, size, associated chemicals and dose.
- **Tap water is a minor exposure pathway.** Food, air and household dust contribute a larger total particle background, while treatment removes a substantial fraction of particles entering waterworks.
- **Real-world concentrations are generally very low.** The strongest large-volume studies commonly report hundredths of a confirmed particle per litre above their size thresholds.
- **Plastic identity is frequently overestimated.** Visual sorting and Nile Red staining can count cellulose, biological material or other hydrophobic particles as plastic unless followed by validated chemical confirmation.
- **Distribution systems can remove as well as add particles.** Scale, settling and adsorption may retain particles, while maintenance, hydraulic disturbance, corrosion, fittings and premise plumbing can intermittently introduce material.
- **Field evidence does not establish plastic pipes as a major source.** No PE or PVC was confirmed in the Danish field study, and several source-to-tap investigations show no net increase through distribution.
- **Pipe-release experiments demonstrate possibility, not population dose.** Accelerated oxidation, prolonged stagnation and biofilm studies identify mechanisms but often use severe conditions or non-specific counting methods.
- **Alternative pipe materials shed their own matter.** Corrosion products, mineral scale, metals, coatings, lining debris and biofilm-associated material are established components of distribution-system particles.
- **Particle count is not dose.** Large numbers of very small particles can represent only nanograms of material. Risk assessment requires mass, size, identity, route, retention and demonstrated effect.
- **Animal-study NOAELs are hundreds of millions of times above estimated intake.** For PE/PET and PP materials, calculated safe intake levels (NOAELs) are hundreds of millions times more than the actual intake of 583 ng/day intake and pipe-attributable exposure is smaller still.
- **No adverse human effect has been demonstrated at measured tap-water exposure.** Any pipe-specific contribution is a subset of total microplastic exposure and has not been shown to be toxicologically meaningful on the available evidence.

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1. Scope, review question and evidence base

Review question

Do plastic drinking-water pipes contribute microplastic particles to tap water at levels that are materially important for human exposure or health, when compared with treatment, source water, deposits, premise plumbing and alternative pipe materials?

Evidence base

The evidence corpus contains 138 unique records after DOI- and normalised-title deduplication. It includes 23 direct plastic-pipe, ageing or pipe-scale papers; 16 source-to-tap or distribution field studies; 35 tap-water and household occurrence studies; 34 treatment studies; 6 analytical-method papers; 17 reviews or official guidance documents; and 7 peripheral comparison sources. Twenty-five full papers were reviewed, including seven previously identified priority studies.

Evidence class	Records	Primary contribution
Direct pipe release, ageing and pipe scale	23	Can release occur, by what mechanism, and under what severity?
Source-to-tap and distribution field studies	16	Does concentration increase, decrease or remain stable through actual networks?
Tap-water and household occurrence	35	What is detected at taps, subject to method and contamination limits?
Treatment and removal	34	How much of the incoming particle load is removed or transformed?
Analytical methods and QA/QC	6	How do size threshold, blanks and identification method determine the result?
Reviews and official guidance	17	What does the broader evidence synthesis support?
Peripheral comparison/context	7	How do bottled water, environmental particles and other materials inform interpretation?

Review method

Sources were assembled from the supplied full papers, backward citation chaining from primary studies and systematic reviews, and targeted publisher and database searches completed in July 2026. Records were deduplicated by DOI and normalised title. The core corpus contains 138 unique tap-water, treatment, distribution, pipe-release, pipe-scale, method and review records; nine additional sources provide exposure, toxicology and life-cycle context.

Each source was accepted only for what its design could establish. A source-to-tap study can show whether concentrations change through a network, but cannot identify a pipe resin as the source without matched infrastructure and polymer evidence. An accelerated pipe experiment can establish release potential or mechanism, but cannot estimate consumer dose unless its conditions, release rate, mass and water consumption are translated to normal service.

Evidence hierarchy

Evidence was weighted by its ability to answer the pipe-source and health-risk questions, not by journal prestige or whether the result appeared favourable or unfavourable to plastics.

- 1. Strong field evidence.** Large-volume, repeated source-to-tap sampling with strong blanks and spectroscopic confirmation.
- 2. Moderate field evidence.** Validated local occurrence studies with fewer sites or limited source attribution.
- 3. Mechanistic laboratory evidence.** Controlled ageing, oxidation, stagnation, abrasion, biofilm or scale experiments that establish whether release can occur.
- 4. Analytical development.** Studies defining what methods can and cannot measure.
- 5. Hazard screening.** Cell or animal experiments at the tested dose; often not representative of tap-water exposure.
- 6. Health-risk evidence.** Realistic exposure, validated dose-response and adverse human outcome. This evidence is absent for tap-water microplastics.

Interpretive rule

A tap-water detection is not automatically pipe-derived, and a pipe-release experiment is not automatically a health-risk study. Source attribution and toxicological significance require separate evidence chains.

Sources: Koelmans et al. 2019; Schymanski et al. 2021; WHO 2019; Hermesen et al. 2018; Cowger et al. 2020; Plastics Research Council 2026.

2. The correct scientific frame: particles first, plastic second

Particles are an unavoidable consequence of living in a physical world. Every solid material wears, abrades, corrodes, fractures, scales, weathers or sheds. At sufficiently small size, we call the material dust or particulate matter. Soil, clay, concrete, paper, wood, skin cells, pollen, spores, fibres, road dust, glass, ceramics, rust, paint and plastic all contribute to the particle background.

All solids shed particles

Particles are a normal consequence of living in a physical world.



Figure 1. All solids shed particles. Plastic is one small subset of a much larger particle background.

The modern microplastics discussion often reverses the correct analytical sequence. A study searches selectively for plastic, reports the number found and then implies unusual importance because the much larger non-plastic denominator is omitted. The proper sequence is: identify all particles, establish the plastic fraction, quantify mass and size, determine the source, and then test whether the realistic dose produces harm.

A hierarchy of diminishing exposure

Level	Meaning
1. All particles encountered	Mineral, biological, organic, metallic, glass, ceramic, combustion, food, textile and plastic particles.
2. Plastic particles	A small, low-mass subset of the total particle background.
3. Particles associated with water	Only part of total ingestion; food and air remain important particle sources.
4. Particles in tap water	A subset of drinking-water exposure after treatment and distribution.
5. Particles attributable to plastic pipes	A smaller source-specific subset that must be demonstrated chemically and by source-to-tap mass balance.

The denominator matters

At each step down the hierarchy, the relevant dose becomes smaller. A claim about microplastics in general cannot be transferred automatically to tap water, and a tap-water detection cannot be attributed automatically to a plastic pipe.

Sources: Mohamed Nor et al. 2021; Wieland et al. 2022; WHO 2019, 2022; Plastics Research Council 2026.

3. What is present in tap water?

Drinking-water systems are complex particle environments. Raw water can contain mineral matter, organic debris, microorganisms, fibres and anthropogenic particles. Treatment removes much of this load. Distribution adds settling, adsorption, scale growth, corrosion, biofilms, maintenance, repairs and intermittent hydraulic disturbance. A particle collected at a tap can therefore originate from source water, treatment materials, storage, mains, service lines, premise plumbing, fixtures, indoor air, sampling equipment or the laboratory.

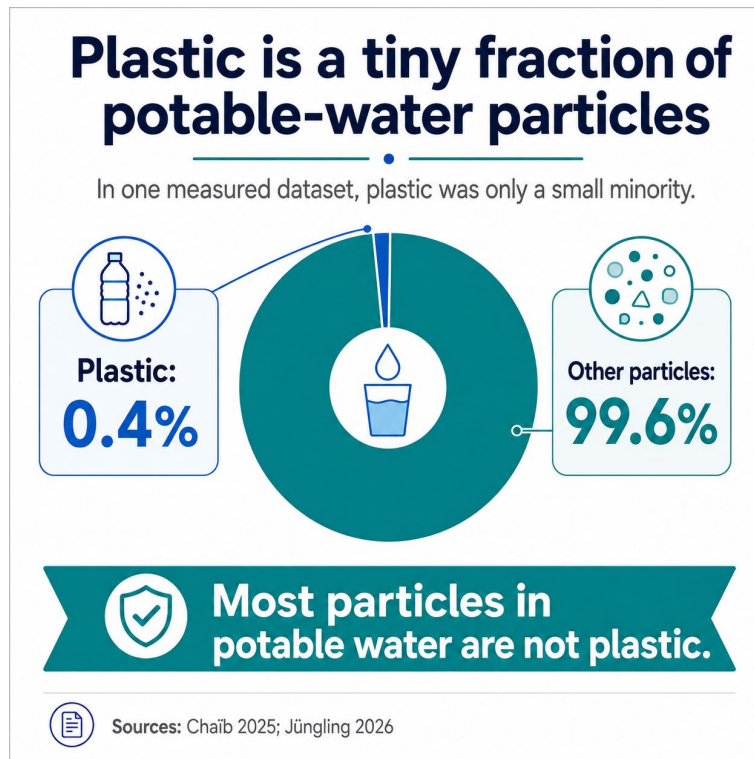


Figure 2. In one measured potable-water dataset, plastic represented about 0.4% of particles. The exact fraction is system- and method-dependent; the stable conclusion is that most particles are not plastic.

Ordinary distribution-system particles

- **Mineral scale.** Calcium carbonate, silicates, phosphates and other precipitates formed from the water itself.
- **Corrosion products.** Iron oxides and hydroxides, copper compounds, lead-bearing scale, nickel- or chromium-containing material and debris from fittings or valves.
- **Organic deposits and biofilms.** Biological material, extracellular polymeric substances and trapped debris.
- **Fibres and cellulose.** Paper, textiles, natural fibres and airborne contamination introduced during sampling or use.
- **Treatment and infrastructure debris.** Filter media, coatings, seals, pumps, storage tanks, repair materials and lining fragments.
- **Plastic particles.** Possible fragments or fibres that require polymer-specific confirmation, blank correction and source attribution.

Chemical confirmation is decisive. In the 2026 Milan supply-chain study, cellulose accounted for 76% of visually pre-selected particles, whereas confirmed plastic accounted for 8%. Only 8% of the visually suspected particles were confirmed as plastic. This is a direct demonstration that visual sorting can overstate plastic by more than an order of magnitude.

Sources: Binelli et al. 2026; Wiercik et al. 2026; Gauthier et al. 2001; Carrière et al. 2005; Mussared et al. 2019; Feld et al. 2021.

4. What real drinking-water studies show

The most informative occurrence studies follow water through treatment and distribution, use substantial sample volumes, include field and procedural blanks and chemically confirm polymer identity. Taken together, they generally show substantial removal and low finished-water concentrations above study-specific cutoffs. They do not show a consistent pattern of accumulation through distribution. These studies measure occurrence and source trends; they are not designed to prove or disprove health effects.

Study	Design	Key result
Feld et al. 2021, Denmark	17 geographically distributed tap sites; μ FTIR and extensive contamination control.	Confirmed plastics were rare; no PE or PVC was confirmed even though many networks used those materials. Most suspected particles were cellulose or non-plastic.
Johnson et al. 2020, England/Wales	Large-volume treatment-works sampling.	Low potable-water concentrations and substantial removal; treatment materials can occasionally contribute particles.
Semmouri et al. 2022, Belgium	Nine plants and nine taps; $\geq 25 \mu\text{m}$.	Means of about 0.02 particle/L at plants and 0.01 particle/L at taps.
Dalmau-Soler et al. 2022, Barcelona	In-line large-volume network sampling; $> 50 \mu\text{m}$; μ FTIR.	Detected in 38% of samples; mean 0.01 particle/L; no consistent increase through a network serving about three million people.
Adediran et al. 2024, Britain	Seven water companies; works outlets, reservoirs and taps; $> 25 \mu\text{m}$.	Average about 0.025 particle/L; authors described absolute numbers as extremely low.
Sun et al. 2024, China	Raw, treated and household water.	Household water contained fewer particles than treated water entering distribution, consistent with retention or adsorption on scale.
Balkenbusch et al. 2025	Ten conventional and advanced facilities; consistent method; $> 2 \mu\text{m}$.	More than 97.5% removal across municipal facilities.
Expósito et al. 2025, Catalonia	Two treatment plants and individual treatment stages.	85% and 99.5% removal; finished water about 0.059 and 0.022 particle/L; dietary contribution judged not relevant.
Binelli et al. 2026, Milan	Aquifer, treatment, public fountain and ten household taps.	Household mean 1.9 ± 1.4 confirmed particles/L; cellulose dominated; plastic was only 8% of selected particles.
Ramirez Arenas et al. 2022	Pilot drinking-water plant; labelled polystyrene nanoplastics; sand, GAC and coagulation.	Filtration removed 88.1%; inclusion of coagulation increased overall removal to 99.4%. Model particles demonstrate treatment capability, not ambient concentration.
Pulido-Reyes et al. 2022	Laboratory and pilot filtration with palladium-labelled nanoplastics plus full-scale treatment modelling.	99.5% retained in the first 0.9 m of pilot sand; consecutive filtration stages modelled above three-log removal. Mechanistic rather than occurrence evidence.
Brancaleone et al. 2024	Pilot occurrence study across drinking-water matrices using Raman microspectroscopy.	Below 2 to about 5 ± 1.5 particles/L; some samples had no detections. Informative mainly above approximately 20-30 micrometres.

Treatment is a major determinant

Coagulation, flocculation, sedimentation, granular filtration, activated carbon, membrane filtration and managed aquifer recharge remove or attenuate many particles. Removal efficiency depends on particle size, density, shape, surface chemistry, source water and plant design. Finished-water values cannot be compared without a common size threshold and analytical method.

Two controlled nanoplastics studies strengthen the treatment-removal mechanism. Ramirez Arenas et al. reported 88.1% removal of positively charged polystyrene nanoplastics by sand and granular activated-carbon filtration in a pilot drinking-water plant, increasing to 99.4% when coagulation was included. Pulido-Reyes et al. found 99.5% retention within the first 0.9 m of a pilot sand filter and modelled removal exceeding three log units across consecutive rapid-sand, activated-carbon and slow-sand stages. Both studies used engineered, labelled model particles, so they demonstrate treatment capability and mechanism rather than ambient finished-water concentration.

The field evidence is inconsistent with the claim that particles simply accumulate as water passes through a network. Some systems show small increases at selected points, often associated with premise plumbing, fittings, maintenance or disturbance. Others show no change or a decrease. That pattern is expected for a multi-source system containing settling, adsorption, scale retention and intermittent release.

Recent Raman-confirmed pilot evidence is consistent with low occurrence. Brancalone et al. examined several drinking-water matrices and reported concentrations from below 2 to approximately 5 +/- 1.5 particles/L, principally in the 30-100 micrometre range; some samples had no detected microplastics. The result is informative above the method cutoff but does not constrain smaller particles.

FROM SOURCE WATER TO THE HOUSEHOLD TAP

Particles can be removed, retained, added or remobilised along the way.

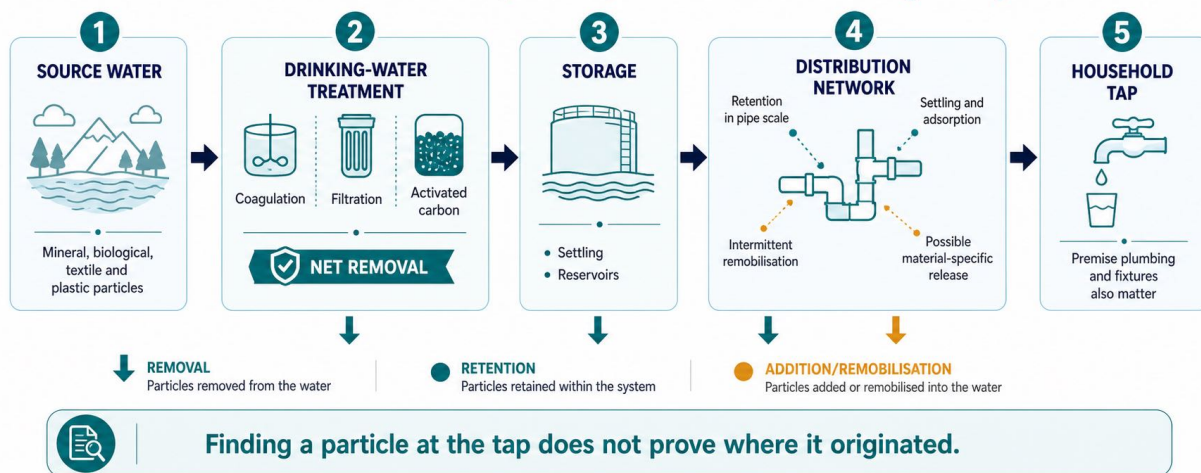


Figure 3. Particles detected at a tap may have been removed, retained, added or remobilised at several points; tap detection alone does not establish origin.

Field evidence carries the greatest weight

Actual networks integrate normal flow, water chemistry, pipe age, treatment, deposits and consumer use. Accelerated laboratory studies remain valuable for mechanism, but they cannot replace field measurements when estimating exposure.

Sources: Feld et al. 2021; Dalmau-Soler et al. 2022; Adediran et al. 2024; Sun et al. 2024; Johnson et al. 2020; Semmouri et al. 2022; Balkenbusch et al. 2025; Expósito et al. 2025; Binelli et al. 2026; Ramirez Arenas et al. 2022; Pulido-Reyes et al. 2022; Brancalone et al. 2024.

5. Do plastic pipes release microplastics?

Release can occur under selected conditions; current evidence does not establish a clinically meaningful pipe-derived exposure under ordinary service.

RELEASE MECHANISM IS NOT THE SAME AS EXPOSURE

A pipe can be capable of shedding without creating a meaningful consumer dose.

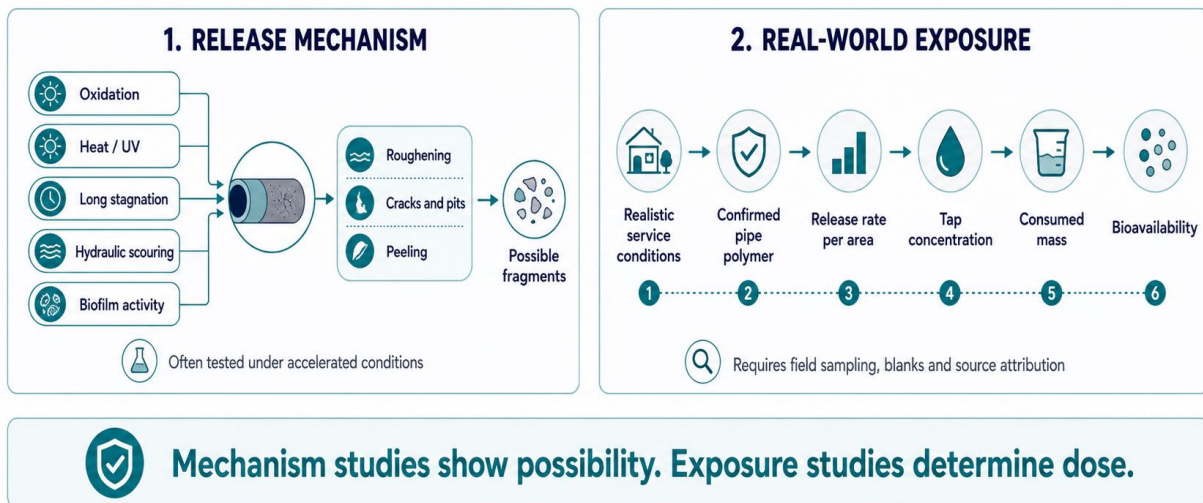


Figure 4. Mechanistic evidence establishes whether release can occur; exposure assessment additionally requires realistic service conditions, confirmed polymer identity, release rate, tap concentration, consumed mass and bioavailability.

What materials science predicts

PE, uPVC and PP/PPR are not perfectly immutable. Oxidation, thermal ageing, UV exposure, strong disinfectant conditions, abrasion, hydraulic scouring, prolonged stagnation and biological surface activity can change morphology and eventually produce fragments. The same principle applies to non-plastic materials through corrosion, erosion, scale formation, delamination and coating failure.

A 2019 viewpoint by Xu et al. framed pipe-derived micro- and nanoplastics as a plausible but then-unresolved question. It supplied no occurrence measurements; its value is historical and hypothesis-generating rather than evidential proof of release.

What direct pipe studies establish

- **Long-service surfaces can deteriorate.** Świetlik and Magnucka documented cracking, pitting and exfoliation on aged PE and PVC transmission pipes. This establishes release potential, not consumer dose.
- **Accelerated oxidation can generate particles.** Ji et al. and Liu et al. linked severe ozone, chlorine, heat, UV or oxidative treatment to surface damage and particle release. Their conditions are intentionally much harsher than normal service.
- **Prolonged stagnation can change comparative release.** Sheng et al. reported high Nile-Red/flow-cytometry counts from PVC after 15 days, while PE was similar to stainless steel. Polymer identity was not confirmed for each counted object.
- **Biofilm-associated deterioration is plausible.** Xiu et al. showed progressive roughening, cracking and pores on PPR surfaces over 150 days. The surface evidence is stronger than the particle-count attribution because counts were based on Nile Red and flow cytometry.

- **Water chemistry may influence release.** Hammodat et al. varied pH, chlorine and time, but visual microscopy and a 0.45-µm filter could not establish nanoplastics or reliable polymer-specific totals.
- **Deposits retain mixed particles.** Yang et al. and Magnucka et al. found many polymer types in operating scales, including polymers unrelated to the pipe substrate. This supports retention and possible re-release, not direct pipe-wall origin.

Why capability is not exposure

A study can prove that a pipe surface is capable of shedding without proving that consumers receive a meaningful dose. Translation requires realistic disinfectant concentration, temperature, flow, stagnation duration, pipe age, surface-to-volume ratio, release rate per area, household water consumption, polymer confirmation, blank correction and mass. Most laboratory papers do not complete this chain.

Critical distinction

The strongest mechanistic studies establish that severe ageing can cause release. The strongest field studies establish that ordinary network concentrations are very low and do not show plastic pipes as a major net source. Both findings can be true at the same time.

Sources: Świetlik & Magnucka 2025; Ji et al. 2025; Liu et al. 2025; Sheng et al. 2025; Xiu et al. 2026; Hammodat et al. 2023; Yang et al. 2023; Magnucka et al. 2024.

6. Detailed appraisal of the key pipe and network studies

Dalmau-Soler et al. 2022 - Barcelona supply network

Design and result. Large-volume water was filtered in-line at network sampling cabinets serving approximately three million people. μ FTIR confirmed particles $>50\text{ }\mu\text{m}$. Microplastics occurred in 38% of samples at a mean of 0.01 particle/L; PP, polyester and polyamide were identified.

Evidence assessment. Strong field evidence for the measured size range. In-line sampling and blanks reduce contamination. There was no consistent increase through distribution. The study provides affirmative evidence against a material network contribution above $50\text{ }\mu\text{m}$, but cannot address smaller particles.

Feld et al. 2021 - Danish tap water

Design and result. Seventeen geographically distributed sites with differing source waters, water ages and networks containing PE and PVC were studied using extensive contamination control and μ FTIR.

Evidence assessment. Confirmed particles were rare, most suspected particles were cellulose, and no PE or PVC was confirmed. This is strong evidence that normal presence of PE/PVC infrastructure does not imply measurable release at the study cutoff.

Adediran et al. 2024 - British distribution networks

Design and result. Seven water companies were sampled at treatment works, service reservoirs and customer taps for particles $>25\text{ }\mu\text{m}$. Mean concentration was about 0.025 particle/L.

Evidence assessment. Strong large-network occurrence evidence. It indicates extremely low absolute concentrations and intermittent spatial variability, not continuous accumulation or a dominant plastic-pipe source.

Sun et al. 2024 - source to household

Design and result. Raw water, treated water leaving plants and household water after distribution were compared.

Evidence assessment. Household concentrations were lower than treated-water concentrations. This contradicts the simple expectation of a major net pipe source in this system and is consistent with retention on scale.

Hammodat et al. 2023 - PVC, PE and PPR loops

Design and result. Pipe loops varied material, pH 5-9, free chlorine 0.5-1.5 mg/L and 24-72 h contact. Counts were mainly visual at 20x-40x after $0.45\text{-}\mu\text{m}$ filtration; FTIR was applied to selected particles.

Evidence assessment. Exploratory only. The method cannot identify nanoplastics and cannot support dependable polymer-specific totals or rankings. Blank subtraction is a strength, but optical counting and small datasets limit source attribution.

Yang et al. 2023 - particles in operating pipe scale

Design and result. Five 30-L water samples and 16 scale samples were analysed by LDIR with blank correction. Water contained 1.74-20.88 particles/L and scale 0.03-3.48 particles/cm².

Evidence assessment. Useful field evidence that deposits capture, store and may re-release particles. Thirty-five polymer types in scale and 27 in water indicate mixed sources. The study does not show that the pipe wall generated the particles.

Ji et al. 2025 - accelerated PVC ageing

Design and result. PVC was exposed to ozone up to 30 mg/L, chlorine up to 260 mg/L and heat up to 80 °C. Maximum reported releases were about 1,058-1,303 particles/L, with pitting, peeling and increased carbonyl index.

Evidence assessment. The oxidation-fragmentation mechanism is credible. Conditions are deliberately extreme and unsuitable for estimating routine exposure. The supplied manuscript was a preprint; the final journal record should be cited.

Liu et al. 2025 - PVC hydrophilicity and scouring

Design and result. New PVC was aged for 20-60 days using 10 mg/L KMnO_4 , 500 mg/L NaClO or UV, then scoured up to 168 h. FTIR-confirmed fragments increased with surface damage and lower contact angle.

Evidence assessment. Stronger particle identification than fluorescence-only studies and a coherent mechanism. The oxidative conditions and multi-day scouring are accelerated. The regression does not establish a normal-service release rate.

Sheng et al. 2025 - four pipe materials under stagnation

Design and result. PPR, PVC, PE and stainless-steel sections were held stagnant for 3, 7 and 15 days at initial chlorine residuals of 0.25 or 1.5 mg/L. Nile-Red/flow-cytometry counts were highest for PVC and lowest for PE, which did not differ significantly from stainless steel.

Evidence assessment. Relevant to extreme building stagnation, but absolute counts and material ranking require polymer-specific confirmation. Baseline tap water already produced hundreds of counted objects/L. Separate effects tests used 100 mg/L of large added particles and are not representative of ordinary exposure.

Xiu et al. 2026 - biofilm effects on PPR

Design and result. A simulated PPR system was followed for 150 days. SEM showed roughening by 60 days, cracks by 90 days and later pores. Fluorescence/flow counts were reported 2.1-fold above control.

Evidence assessment. Time-resolved surface deterioration is persuasive. The released objects were not individually confirmed as PPR, so the magnitude of pipe-derived release remains provisional. Milled-particle biodegradation experiments should not be treated as ordinary drinking-water conditions.

Świetlik & Magnucka 2025 - aged transmission pipes

Design and result. Long-service PE and PVC transmission pipe surfaces were examined for degradation, cracking, pitting and exfoliation.

Evidence assessment. High value for establishing real aged-surface deterioration and release potential. The design does not measure water concentration or consumer dose.

Magnucka et al. 2024 - corrosion deposits in metal pipes

Design and result. Raman-confirmed particles retained in deposits from steel and cast-iron pipes were mainly PE, PET and polyamide; no PVC was identified.

Evidence assessment. Supports pipe scale as a sink and possible secondary source. Polymer identity unrelated to the metal substrate shows why deposits cannot be assumed to prove pipe-wall origin.

Effect on the combined conclusion

The full papers strengthen evidence that aged or severely stressed plastic surfaces can shed. They also weaken confidence in several large numerical claims because the counted objects were not all polymer-confirmed. None of the key studies demonstrates a meaningful health dose or a dominant contribution from plastic pipes in ordinary tap water.

7. Pipe scale, deposits and particle fate

Distribution systems do not behave as simple open tubes. Scale, corrosion layers, biofilms and loose deposits can capture particles from incoming water, retain them for varying periods and release them during hydraulic or chemical disturbance. This explains why downstream concentrations can fall, remain stable or show intermittent pulses.

Scale as a sink

Chu et al., Yang et al. and related scale experiments demonstrate adsorption and retention of model and environmental particles. Sun et al. interpreted lower household concentrations as non-targeted removal during distribution, possibly through adsorption on scale. Magnucka et al. found plastic particles in deposits from metal pipes, showing that plastic in scale can originate upstream rather than from the pipe wall.

Scale as a possible secondary source

Hydraulic changes, flushing, stagnation, disinfectant shifts or corrosion destabilisation may remobilise deposited material. A temporary increase at a tap therefore does not identify the original source. Source attribution requires matched upstream samples, hydraulic records, pipe-material inventories and polymer fingerprints.

The established non-plastic denominator

Distribution science documented suspended particles and loose deposits long before microplastics became a named research topic. Carrière et al. reported loose deposits containing 38-72% iron corrosion products, 14-24% organic matter and 7-16% silico-aluminium compounds. Wiercik et al. characterised complex mineral, metallic and organic scale. These materials are often the dominant particulate load.

Sources: Gauthier et al. 2001; Carrière et al. 2005; Mussared et al. 2019; Chu et al. 2022, 2024; Yang et al. 2023; Magnucka et al. 2024; Sun et al. 2024; Wiercik et al. 2026.

8. Why published particle counts vary so widely

Drinking-water results span orders of magnitude, but this does not mean actual water quality varies by the same factor. The literature often measures different size ranges, sample volumes and analytical endpoints. A method stopping at 100 µm cannot be compared directly with one extending to 1 µm; a one-litre grab is not equivalent to filtering hundreds of litres; polymer mass from Py-GC/MS is not a count of intact particles.

Method choice	What it changes	Risk of over-interpretation
Minimum particle size	Counts rise rapidly as the cutoff falls.	Large counts of tiny particles can still represent negligible mass.
Sample volume and timing	Small grabs can miss rare particles or capture a transient event.	A single sample may not represent a network or household.
Field and procedural blanks	Air, clothing, tubing, filters and laboratory materials introduce fibres and polymers.	Failure to correct blanks creates false positives.
Visual identification	Colour and shape are useful for screening.	They cannot prove plastic identity; cellulose and biological matter are easily misclassified.
Nile Red staining	Screens hydrophobic particles and supports automated counting.	It also stains non-plastic hydrophobic material and must be followed by chemical confirmation.
µFTIR / µRaman / LDIR	Can identify individual particles within validated size and spectral limits.	Results depend on match thresholds, fluorescence, library quality, particle size and operator decisions.
Py-GC/MS	Measures polymer-associated thermal fragments and approximate mass.	It destroys the sample and does not prove particle number, size or intact morphology.
Risk indices	Rank concentration using assumed polymer hazard scores.	They do not demonstrate disease or quantify actual human risk.

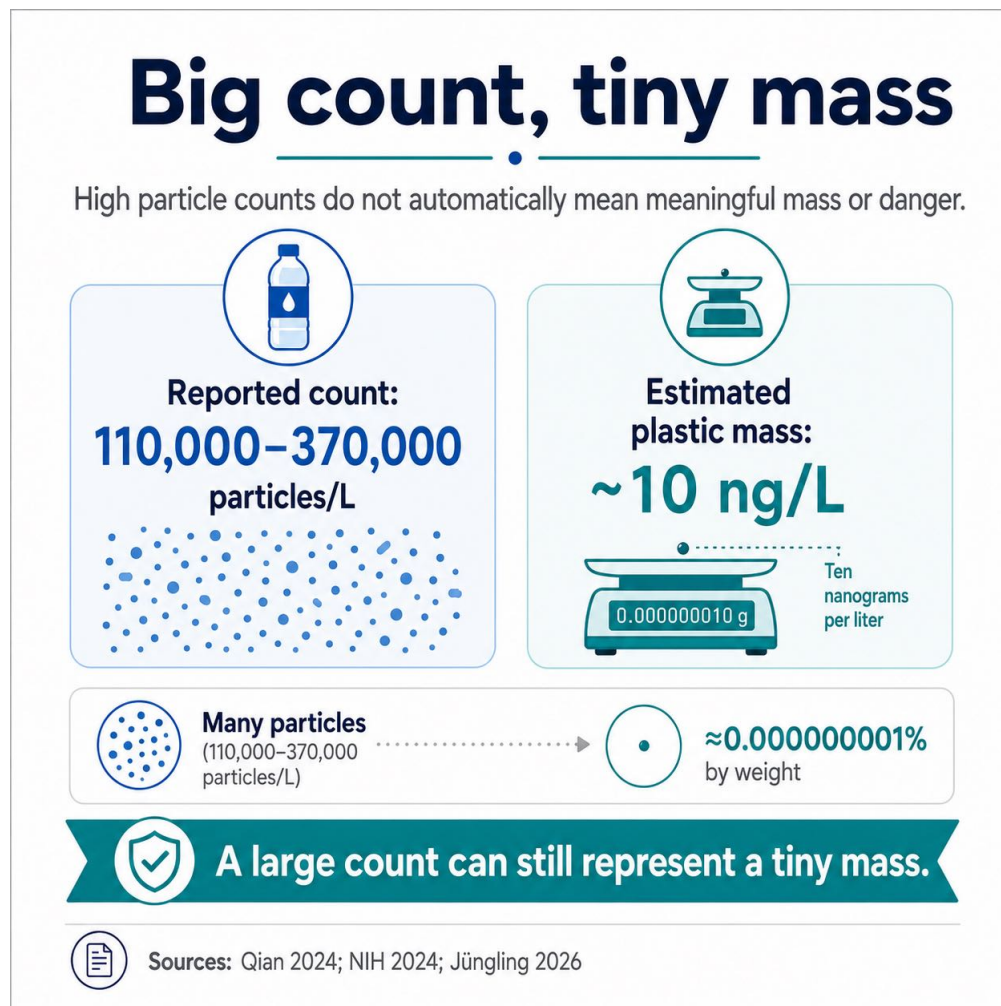


Figure 5. Particle number is not dose. Very high nanoplastic counts can correspond to only nanograms of material.

The methodological lesson is not that every high count is wrong. It is that counts are method-defined and cannot be interpreted as exposure or risk without size, mass, identity and contamination context. Studies using fluorescence or visual counting should not be assigned the same source-attribution weight as studies confirming individual particles spectroscopically.

Kniggendorf et al. demonstrated proof-of-concept Raman detection of individual microplastic particles in flowing tap water. Because the system used added particles and fluorescent contaminants, it supports future continuous-monitoring method development but is not evidence of real-world tap-water occurrence.

Sources: Maurizi et al. 2023; Schymanski et al. 2021; Koelmans et al. 2019; EFSA 2025; Aves et al. 2026; Stanton et al. 2019; Qian et al. 2024; Jüngling et al. 2026; Kniggendorf et al. 2019.

9. Exposure and human-health significance

Health interpretation requires dose, identity, bioavailability and effect - not detection alone. No reviewed pipe or tap-water occurrence study demonstrates adverse human effects at the exposure it measured.

Available mass-based exposure estimates are low

Mohamed Nor et al. estimated median total adult microplastic intake at about 583 ng/day across the 1-5,000 μm range, or roughly 0.015 g over 70 years before elimination. The same model estimated an adult tissue burden of about 40.7 ng by age 70. The modelled retained mass is therefore approximately 0.00027% of lifetime intake; more than 99.999% is not retained as tissue burden.

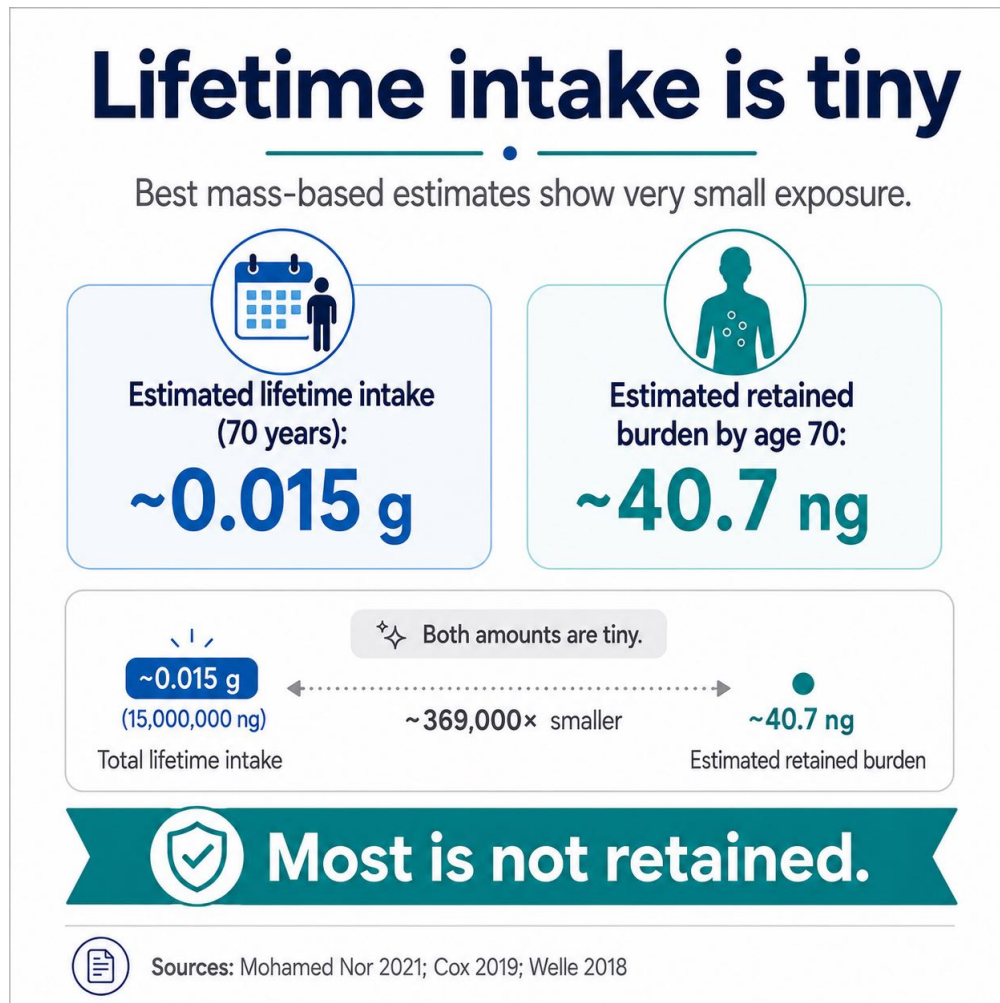


Figure 6. One mass-based model estimates low lifetime intake and nanogram-scale retained burden; uncertainty remains, especially below current size cutoffs.

Pipe-attributable exposure is a smaller subset

The 583 ng/day value is a modelled median covering the food and inhalation pathways evaluated by Mohamed Nor et al.; it is not a universal measurement of every particle size or exposure route. Tap water is one component of total exposure, and the fraction attributable specifically to plastic pipe walls is smaller than the total tap-water contribution. Mixed polymer fingerprints and upstream detections make the conservative assumption that every tap particle came from the pipe implausible.

Toxicity evidence must be interpreted in dose and material context

PE, PP/PPR and uPVC are chemically distinct materials, and microplastic particles are not a single toxicological entity. Long-term oral studies and comparative particle or cell experiments provide dose-scale context, but their particles, formulations and endpoints do not map perfectly onto pipe-derived exposure. They are not drinking-water limits and do not replace a formal pipe-specific risk assessment. Within those limitations, reported effect levels remain far above the mass-based exposure estimate used in this review.

Animal-study NOAELs versus estimated intake

Selected repeated-dose animal studies reported study-specific NOAELs at the highest tested doses of about 2,500 mg/kg body weight/day for a PE/PET polymer fabric and at least 2,000 mg/kg body weight/day for fragmented PP microplastics. Simple 70-kg adult mass equivalents are roughly 175 and 140 g/day - about 300 million and 240 million times the modelled 583 ng/day median intake from evaluated food and inhalation pathways. Tap-water exposure is only a subset, and pipe-attributable mass is smaller still. These are animal-study comparisons, not human safe-intake limits, and simple body-mass scaling is not a formal risk-assessment conversion.

Detection is not a health endpoint

Detection does not equal danger

Finding a particle is only the first step.

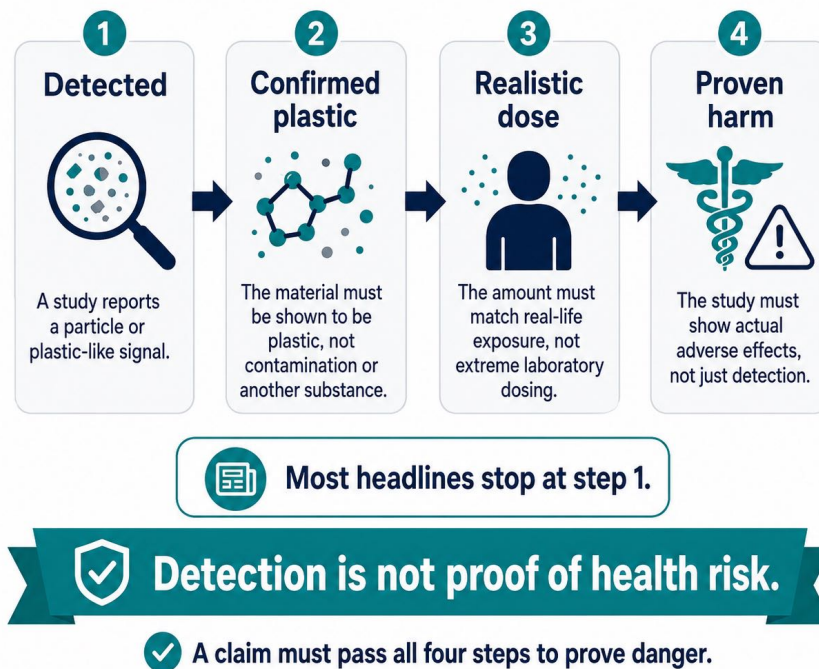


Figure 7. A health-risk claim requires confirmed identity, realistic dose and proven adverse effects; detection alone is only the first step.

No causal human disease has been demonstrated from microplastics in tap water at measured concentrations. Reports of inflammation, oxidative stress or microbial effects generally arise from separate experiments using laboratory particles, higher concentrations, forced exposure or endpoints not directly comparable with human tap-water intake. Such studies may identify hazards under the tested conditions, but extrapolation to drinking-water risk requires realistic dose, particle identity, bioavailability and reproducible adverse outcomes.

WHO and weight of evidence

WHO concluded in its 2019 and 2022 assessments that the available evidence did not indicate a health concern from physical particles at measured drinking-water levels and judged associated chemicals and biofilms to be of low concern. WHO also emphasised major evidence limitations. Later occurrence and method studies improve measurement and geographic coverage, but they still do not provide causal evidence of human disease from tap-water exposure.

Health conclusion

The available evidence supports a strong and proportionate conclusion: normal exposure to microplastics from tap water, including any contribution from plastic pipes, has not been shown to be toxicologically significant and has not been shown to cause human disease.

What remains uncertain - and what does not

Important uncertainties remain in the precise number, size distribution and source apportionment of particles below the cutoffs used by the strongest field studies. Water chemistry, pipe age, stagnation, premise plumbing and hydraulic events vary among systems. Nanoplastic measurements remain especially method-dependent.

Still uncertain	Supported by the present evidence
The exact fraction of particles below 25-50 µm attributable to pipe walls in every network.	Confirmed concentrations above study cutoffs are generally very low in the strongest field studies.
A universal release rate covering all pipe ages, formulations, water chemistries and hydraulic regimes.	Severe ageing, oxidation, stagnation and biofilm conditions can damage plastic surfaces and permit release.
Routine submicron particle counts and mass because available methods are not yet fully harmonised.	Distribution systems can retain as well as intermittently release particles; a tap detection is not automatic proof of pipe-wall origin.
The precise individual exposure for every consumer.	No reviewed study demonstrates harm at measured tap-water exposure, and pipe-attributable exposure is a subset of an already very small total mass.

Measurement uncertainty should widen confidence intervals, not be treated automatically as evidence either of safety or of harm. A positive risk conclusion still requires confirmed identity, realistic dose, bioavailability and reproducible adverse effects.

Sources: Mohamed Nor et al. 2021; Merski et al. 2008; Lee et al. 2023; Archana et al. 2018; Stock et al. 2021; Styles & Wilson 1973; WHO 2019, 2022; FDA 2024; Koelmans et al. 2022; Wieland et al. 2022.

10. Comparison with alternative pipe materials

The scientifically relevant comparison is among real alternatives. Every pipe material interacts with water and changes over time. Non-plastic does not mean inert, particle-free or safer. The correct comparison covers particulate release, dissolved chemicals, corrosion, microbiology, reliability and life-cycle performance.

Material	Typical particle/deposit issue	Chemical issue	Corrosion	Evidence-based interpretation
PE / HDPE	Possible abrasion or aged-surface fragments; often absent in real tap samples.	Low-molecular-weight leachates are a separate compliance question.	No electrochemical corrosion.	Field evidence indicates very low particle contribution and low toxicity.
uPVC	Fragments possible under aggressive oxidation, cutting or prolonged stagnation.	Residuals and additives controlled by potable-water standards.	No metal corrosion.	Release is condition-dependent; health risk from particles not demonstrated.
PP / PPR	Biofilm/oxidative ageing can roughen surfaces in controlled studies.	Leachates must be evaluated separately from particles.	No metal corrosion.	Mechanism evidence exists; population harm at normal use does not.
Iron / steel	Rust, tubercles, iron-rich scale and discolouration particles.	Iron and associated metals may enter water.	Expected unless controlled or lined.	Large, established non-plastic particle source; operational and aesthetic effects common.
Copper	Copper-bearing corrosion products and scale.	Excess copper has established toxicity; old lead solder may matter.	Water-chemistry dependent.	Known chemical hazard at sufficient dose; requires corrosion control.
Lead	Lead-bearing scale and dissolved/particulate lead.	Lead is a proven neurotoxin with no desirable exposure.	Strongly affected by water chemistry and disturbance.	Clearly greater toxicological concern than ordinary plastic particles.
Cement / concrete	Mineral particles, carbonate scale and lining debris.	Can alter pH and alkalinity; formulation matters.	Chemical degradation and leaching occur.	Not particle-free; performance depends on age and water chemistry.
Stainless steel	Generally low release, but metal particles/ions remain possible.	Nickel/chromium release depends on grade and conditions.	Highly resistant, not immune.	Useful benchmark; not automatically zero-release or zero-risk.
Lined / coated pipe	Coating particles, scale at defects and underlying corrosion products.	Coating and repair materials must comply.	Depends on coating integrity.	System performance depends on installation and ageing, not only base material.

Replacing a functioning plastic system solely to avoid hypothetical microplastics can increase other risks and impacts, including corrosion, toxic-metal exposure, leakage, weight, installation energy, maintenance and life-cycle emissions. The best material is the one that performs best for the complete application, not the material with the most reassuring label.

Sources: Carrière et al. 2005; Wiercik et al. 2026; Kimbell et al. 2020; WHO 2019; Meng et al. 2024; Voulvoulis et al. 2019; Plastics Research Council 2026.

11. Implications for utilities, regulators and material selection

For water utilities and regulators

- Measure total particulate matter as well as the plastic subset, with polymer-confirmed results after blank correction.
- Use large-volume, repeated sampling at source, finished water, reservoirs and taps to distinguish treatment from distribution effects.
- Report mass alongside count where feasible, with explicit size range, recovery efficiency, detection limits and contamination budget.
- Continue prioritising established hazards such as lead, copper, pathogens, disinfection performance and corrosion.
- Compare pipe materials using whole-system health, reliability, cost and life-cycle evidence rather than a particle-free assumption.
- Do not treat risk-index scores or visual particle counts as evidence of disease.

For pipe and material decisions

1. **Public-health protection.** Compare demonstrated toxicants and realistic exposure, not simply detectable particles.
2. **Water quality.** Consider taste, odour, discolouration, metals, dissolved leachates, scale and microbiology.
3. **Reliability.** Evaluate pressure, temperature, joints, installation damage, soil movement and service life.
4. **Operations.** Include corrosion control, flushing, repair frequency, energy and leakage.
5. **Environmental performance.** Use life-cycle evidence covering mass, transport, energy, emissions, durability and replacement.
6. **Evidence quality.** Prefer field measurements with blanks and chemical confirmation over accelerated release alone.

Decision rule

Do not replace a well-performing plastic drinking-water pipe because a laboratory can generate particles under accelerated conditions. Replace or redesign when complete evidence shows that an alternative improves health, reliability and environmental performance under actual service conditions.

For households

Current evidence does not support avoiding municipal tap water or replacing functioning plastic plumbing solely because of microplastics. Follow ordinary water-quality guidance: use the cold tap for drinking and cooking, flush water that has stood for long periods where local guidance recommends it, maintain fixtures and address verified contaminants such as lead through appropriate testing and remediation. Select a home filter for a defined water-quality objective and maintain it according to the manufacturer; the evidence reviewed here does not establish a medical necessity for microplastic filtration.

If a household nevertheless chooses particle removal, device design matters. Cherian et al. found high removal of spiked PVC and PET fragments and nylon fibres in point-of-use devices containing membrane barriers, with the smallest nominal pore size performing best. A device using only granular activated carbon and ion exchange sometimes discharged more particles than entered it. This controlled challenge study does not establish a medical need for filtration; it shows that membrane-based devices can remove particles when correctly operated and replaced.

12. Research priorities and the definitive study design

The central uncertainty is precise source apportionment and size-resolved release under normal service, particularly below the cutoffs of the strongest field studies. Current evidence does not demonstrate a health hazard at measured exposure, but improved exposure data would narrow uncertainty and strengthen future risk assessment. A definitive study should contain the following elements.

1. **Matched longitudinal sampling.** Collect the same water at raw source, post-treatment, reservoir, multiple distribution points and household taps, including first-draw and flushed samples.
2. **Infrastructure metadata.** Record pipe polymer, age, diameter, lining, fittings, service connection, premise plumbing, water age, disinfectant residual, temperature and hydraulic disturbances.
3. **Validated particle identification.** Use individual-particle spectroscopy where feasible; report polymer mass separately; include field, procedural and laboratory blanks, recovery tests and contamination budgets.
4. **Size-resolved reporting.** Pre-specify lower size limits and size bins. Do not compare totals generated by materially different cutoffs.
5. **Source apportionment and mass balance.** Compare polymer fingerprints with known infrastructure and treatment materials and test whether changes exceed uncertainty and blank-corrected variability.
6. **Realistic ageing and hydraulics.** Pair accelerated tests with aged field coupons and normal flow, stagnation and disinfectant conditions. Report release per pipe surface area and water volume.
7. **Alternative-material controls.** Run matched stainless steel, copper, iron/cementitious and lined-pipe controls and quantify total particles and known chemical hazards.
8. **Health interpretation.** Keep exposure measurement separate from hazard testing. Any risk conclusion requires realistic dose, bioavailability, validated endpoints and a reproducible adverse outcome.
9. **Model-to-environment bridging.** Test whether results obtained with pristine, spherical or labelled model particles hold for irregular, weathered particles and mixed polymers at environmentally relevant concentrations.

What would change the conclusion?

A conclusion of meaningful health risk would require confirmed pipe-derived particles, realistic and reproducible exposure, measured mass, a biologically plausible retained dose, adverse effects at that dose, causation rather than association and independent replication. The current literature does not meet that standard.

13. Conclusions

The evidence supports a clear conclusion: plastic pipes are not a demonstrated microplastics health threat at currently measured exposure.

Particles are normal in drinking-water systems. Plastic is only one small component alongside mineral scale, cellulose, corrosion products, metals, organic deposits and biological material. A particle at a tap cannot be attributed to a plastic pipe without matched upstream evidence and polymer-specific source apportionment.

Plastic pipes can shed under selected conditions. Accelerated oxidation, heat, UV, prolonged stagnation, scouring and biofilm-associated deterioration demonstrate mechanisms of surface damage and possible release. These experiments do not establish routine consumer dose. Several of the largest counts are analytically provisional because fluorescence or visual methods did not confirm each object as pipe polymer.

The strongest real-world evidence does not identify plastic pipes as a major net source above the studies' analytical cutoffs. PE and PVC were not confirmed in a broad Danish tap-water study. A major Barcelona network averaged 0.01 confirmed particle/L above 50 µm without a consistent network increase. British networks averaged about 0.025 particle/L above 25 µm. In one source-to-household study, concentrations fell during distribution. These findings cannot exclude smaller particles or intermittent local release.

Treatment removes most particles, and pipe scales can retain them. Distribution systems may also produce intermittent material from deposits, fittings, corrosion, repairs and premise plumbing. The evidence therefore describes a multi-source particle system, not continuous contamination from plastic pipe walls.

Health significance depends on dose, particle identity and bioavailability. One mass-based model estimated nanograms per day and hundredths of a gram over a lifetime before elimination across the pathways it evaluated; the estimate does not cover every size range or route. The simple adult mass equivalents of study-specific animal NOAELs for selected PE/PET and PP materials are about 300 million and 240 million times the modelled 583 ng/day median intake, and pipe-attributable mass is smaller still. Animal NOAELs are study-specific and do not establish human safe-intake limits. Tap water is a subset of total exposure, and pipe-derived particles are a smaller subset of tap-water exposure. No causal human disease has been demonstrated from tap-water microplastics at measured concentrations.

Alternatives are not particle-free and may introduce established hazards. Iron, copper, lead, cementitious materials, stainless steel, coatings and linings all release or interact with particles and chemicals. Material choice should be based on whole-system evidence, not fear of the word plastic.

Final finding

Normal exposure to microplastics from tap water, including any contribution from plastic pipes, has not been shown to cause human disease and is not shown to be toxicologically significant in the context of total particle exposure and the low inherent toxicity of common pipe polymers. The available evidence supports proportionate monitoring and sound material selection - not public fear, unnecessary filtration or avoidance of plastic drinking-water pipes.

Appendix A. Evidence hierarchy for tap-water and pipe claims

Evidence level	Characteristics	What it can establish	Typical limitation
Strong field evidence	Large-volume, repeated, network-scale sampling; blanks; polymer confirmation; source-to-tap design.	Actual concentrations, treatment performance and distribution trends.	Still observational; rare-event variability and size cutoff.
Moderate field evidence	Smaller samples or fewer sites with validated identification and controls.	Local occurrence and preliminary source patterns.	Limited representativeness and statistical power.
Mechanistic laboratory evidence	Controlled ageing, stagnation, abrasion, disinfectant or biofilm tests.	Whether release can occur and under which mechanisms.	May not represent real flow, exposure or dose.
Analytical development	Comparison of μ FTIR, Raman, LDIR, Py-GC/MS, AFM-IR or staining.	Method performance, limits and uncertainty.	Does not establish population exposure or harm.
Hazard screening	Cells or animals exposed to particles.	Possible biological response at the tested dose.	Often extreme dose, artificial particles and no exposure relevance.
Health-risk evidence	Realistic exposure plus validated dose-response and adverse outcome.	Whether normal exposure causes disease.	Currently absent for tap-water microplastics.

Appendix B. Key study evidence table

The table below summarises the studies carrying the greatest weight for the pipe-source question. It is deliberately selective and uses complete, concise descriptions rather than truncated extracts. Full bibliographic details appear in the comprehensive references.

Study	Evidence class / design	Principal finding	Limitation and evidential weight
Feld et al. 2021	Strong field; 17 Danish tap sites, μ FTIR and extensive blanks	Confirmed plastics were rare; no PE or PVC was confirmed despite those materials being present in many networks.	Strong evidence against necessary measurable PE/PVC release at the study cutoff; does not address all smaller particles.
Dalmau-Soler et al. 2022	Strong field; large-volume in-line network sampling, $>50\ \mu\text{m}$	Mean 0.01 confirmed particle/L; no systematic increase through a network serving about three million people.	High value for network-wide addition above $50\ \mu\text{m}$; no inference below the cutoff.
Adediran et al. 2024	Strong field; seven British water companies, works-to-tap, $>25\ \mu\text{m}$	Mean about 0.025 particle/L; spatial variability suggested intermittent pulses rather than continuous accumulation.	Strong occurrence evidence; limited resin-specific source attribution.
Sun et al. 2024	Field source-to-household comparison	Household concentrations were lower than treated-water concentrations entering distribution.	Moderate evidence against a major net network source in that system; mechanism of loss not proven.
Johnson et al. 2020	Large-volume treatment-works field study	Low potable-water concentrations and substantial removal; treatment materials could occasionally contribute particles.	Strong treatment context; indirect for distribution-pipe release.
Balkenbusch et al. 2025	Ten-facility treatment study using a consistent method, $>2\ \mu\text{m}$	More than 97.5% removal across conventional and advanced facilities.	Strong multi-facility removal evidence; not a direct pipe-source study.
Binelli et al. 2026	Aquifer-to-tap field study with μ FTIR confirmation	Cellulose dominated selected particles; only 8% of visually suspected particles were confirmed as plastic.	High analytical relevance; local concentrations cannot be generalised to every system.
Ramirez Arenas et al. 2022	Pilot treatment; labelled PS nanoplastics; sand, GAC and coagulation	88.1% removal by filtration; 99.4% with coagulation.	Strong mechanistic treatment evidence; engineered charged particles do not establish ambient nanoplastic concentration.
Pulido-Reyes et al. 2022	Laboratory and pilot filtration with labelled nanoplastics plus modelling	99.5% retained in the first 0.9 m of pilot sand; multi-stage removal modelled above three log units.	Strong treatment-mechanism evidence; model-particle and modelling assumptions limit direct environmental extrapolation.
Brancaleone et al. 2024	Pilot occurrence study; multiple drinking-water matrices; Raman	Below 2 to about 5 ± 1.5 particles/L; some samples had no detections.	Moderate local occurrence evidence, principally above approximately 20-30 micrometres.

Study	Evidence class / design	Principal finding	Limitation and evidential weight
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Cherian et al. 2023	Controlled point-of-use device challenge with spiked PET, PVC and nylon	Membrane devices removed most tested particles; GAC/IX alone sometimes increased effluent counts.	Useful device-performance evidence; spiked water does not demonstrate ambient exposure or medical necessity.
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Study	Evidence class / design	Principal finding	Limitation and evidential weight
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Świetlik & Magnucka 2025	Real aged PE and PVC transmission-pipe surfaces	Observed cracking, pitting and exfoliation compatible with particle formation after long service.	High for real-world release potential; no water concentration or consumer dose.
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Ji et al. 2025	Accelerated PVC ageing by ozone, chlorine and heat	Severe treatment caused pitting, peeling, oxidation and particle release.	High for oxidation-fragmentation mechanism; very low value for routine service dose because conditions were extreme.
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Liu et al. 2025	Accelerated PVC oxidation followed by prolonged hydraulic scouring	FTIR-confirmed fragments increased with surface damage and reduced contact angle.	Stronger identification than fluorescence-only studies; conditions do not establish a normal-service rate.
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Sheng et al. 2025	PPR, PVC, PE and stainless steel under 3-15 days stagnation	Highest fluorescence/flow-cytometry counts from PVC; PE was similar to stainless steel.	Useful comparative stagnation evidence; absolute counts and ranking require particle-by-particle polymer confirmation.
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Xiu et al. 2026	150-day simulated PPR system with biofilm development	SEM showed progressive roughening, cracks and pores; fluorescence counts rose relative to controls.	Persuasive surface deterioration evidence; released objects were not individually confirmed as PPR.
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Hammodat et al. 2023	PVC, PE and PPR loops varying pH, chlorine and contact time	Suggested water chemistry and material effects under controlled conditions.	Exploratory: visual counting and a 0.45-µm filter cannot establish nanoplastics or dependable polymer-specific totals.
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Yang et al. 2023	Operating-system water and pipe-scale samples analysed by LDIR	Many polymer types occurred in water and scale; stagnant zones showed greater abundance.	High for retention and possible re-release; low for proving pipe-wall origin.
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Magnucka et al. 2024	Raman analysis of deposits from steel and cast-iron pipes	Deposits contained mainly PE, PET and polyamide; no PVC was identified.	Supports scale as a sink and secondary source; polymer identity unrelated to metal substrate demonstrates upstream origins.
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Wiercik et al. 2026	FTIR and ICP-OES characterisation of pipe scales	Confirmed complex mineral, metallic and organic deposits in multiple pipe materials.	Strong non-plastic denominator and method context; not direct evidence of plastic-pipe shedding.
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