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# Exploring Everyday Microplastic Exposures

Recent evidence of products  
delivering microplastic to humans

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*SUMMARY REPORT of findings and conclusions to accompany the full report,*

## **Exploring Everyday Microplastic Exposures**

### **Recent evidence of products delivering microplastic to humans**

A scoping report reviewing scientific evidence for everyday human exposure to microplastics.

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## The Problem

Is there a plastic product that will not release any microplastics during its lifetime?

Probably not. As it turns out, that is a tall order for plastic products. They all shed microplastic at some stage of the product lifecycle.

Microplastics are not simply tiny plastic shreds. There are thousands of chemicals associated with them. These chemicals form the ‘sauce’ around the polymer architecture inside microplastics. The health and safety of long-term exposures to microplastics and associated chemicals has yet to be proven. Science takes time.

So, risks are uncertain. Though it is scientifically plausible that adverse effects arise from certain exposure scenarios. Toxicological and epidemiological evidence is slowly being gathered to elucidate the nature and scale of potential effects. That includes determining how much exposure is needed before any effects become noticeable and problematic.

Meanwhile, society is interested in two main questions: *What’s my microplastic exposure?* And, *How bad is it?* After all, people interested in protecting their health ultimately want to mitigate exposures to unhealthy substances. And some are willing to take precautions with substances with ‘safety signals’ - in other words, when early indicators of a potential risk have surfaced, as is the case for certain microplastics.

This report dives into the first question, and asks how much of these tiny plastic shreds are typically released in the indoor and outdoor spaces where we spend our time?

## Illustrating the broad scope of our day-to-day microplastic exposure

This report sketches the contours of real-world mixtures of a very large number of microplastic contaminants in everyday human exposure scenarios. The question whether humans are exposed to a multitude of microplastics in their daily lives can be answered with a resounding, evidence-based yes.

*A compilation of exposures to billions of microplastics in ways you knew and didn’t know.*

Microplastics are pervasive, abundant, invisible, chemical-mixture-carrying pollutants that are lurking in every corner of our lives, starting before birth.

Referencing peer-reviewed scientific literature, evidence is presented showing that common consumer plastic products are collectively shedding billions of microplastics to the human living environment and food system during normal use.

In a society replete with plastic, many people are already aware of ‘microplastics’. Advocacy groups, scientists and the media have made many of us aware of microplastics in cosmetics, and have reported on food packaging and water bottles leaching microplastics and chemicals into what we eat and drink.

This report covers both these and some of the lesser-known categories of microplastic shedding plastic applications. These sources act in concert to create the real-world sum microplastic exposures that contemporary humans are facing, whether they know it or not.

## Key findings

The science is showing conclusively that there is significant microplastic release across all five categories that this report has reviewed: food and food-related sources, indoor sources, outdoor sources/recreation, children's products, and personal/health care.

**Highlights and examples from the full report are summarized below.** Microplastics abbreviated as MP. Measured concentrations are snapshots of products sampled and analysed by laboratories across the world using a variety of methods. Microplastic contamination is a dynamic parameter that ranges per brand and even per batch of the same product. While data requirements for determination of precise ranges per product category for millions of brands and product batches are prohibitively high, (those data would take decades to collect at current rates) the highlighted examples provide a scope of the kinds of microplastics exposures we can expect.

### Browse the full report to find out more about microplastics delivered via:

Paint. Tattoo ink. Permanent makeup. Processed food. Seafood. Meat. Vegetables. Rice. Salt. Honey. Teabags. Milk. Soft drinks. Tap water. Beer. Dietary supplements. Chewing gum. Sponges. Cloths. Brushes. Bowls. Chopping boards. 'Food lube'. Tea kettles. Non-stick cookware. Microwaved plastic containers. Toys. Baby mats. Pens. Erasers. Human breast milk. Baby bottles. Breast milk storage bags. Baby formula. Infused neonatal parenteral nutrition circuits. Indoor air of schools, apartments, offices, and hospital rooms. Household dust. Air conditioning units. Outdoor air. Building materials. Insulation. Pipes. Stratospheric aerosol injections. Tires. Granular infill material on artificial sports fields. Polyester, nylon and spandex workout clothing. Swimming pool water. 3D printers. Synthetic textiles. Bedding. Laundry. Cosmetics. Shampoo. Toothpaste. Toothbrushes. Soap. Nail polish. Sunscreen. Creams. Wet wipes. Women's sanitary products. Nasal irrigation bottles. Nasal swabs. Surgical masks. Blood contact tubing. Cardiac catheters. Drug delivery polymeric nano-carriers. Cardiopulmonary bypass circuits. Medical injectables. Silicone breast implants. Orthopedic implants. Contact lenses.

## Food, food packaging and food preparation sources\*

52 to 134 MP/g on strawberries

31 MP/100 g chicken nuggets (processed)

32 MP/100 g plant-based nugget (processed)

Undetectable MP to 119 MP/100 g chicken breast

120 MP/100 g breaded shrimp (processed)

4 MP/100 g fresh shrimp

117 to 534 MP/g sugar and undetectable MP to 1280 MP/kg honey

45 to 317 µg MP/g rice; washing rice before cooking reduced MP residues

Undetectable MP up to 19,800 MP/kg salt, depending on source

637 MP/g chewing gum were reported to be released into the saliva

2 MP/L Dutch tap water, 31 MP/L cola and 45 MP/L lemonade

83 MP/L beer and 8 MP/L wine

4.0 to 18.7 MP/kg fresh meat stored in plastic; MP identical to packaging material type

2.3 million MP/cup of tea, released by synthetic teabags (and over a billion nanoplastics)

Up to 1 million MP released from take-out trays after being microwaved

5 to 35 million MP released from plastic kettles (which decreases with kettle use)

331 to 898 MP/bowl released by plastic mixing bowls

Approximately hundreds of MP per cut can be released from plastic chopping boards.

An average adult consumes about 1 kg of food and 2 kg of beverages on a daily basis, commonly packaged and prepared with plastic materials which the data shows to significantly increase observed microplastic contamination of food.

## Indoor sources

Textiles: Polyester garments released 108 to 347 MP/g garment in tests simulating normal wear. When woven polyester garments were tested, the microplastic release dropped significantly to around 1 MP/g.

Airborne polyester fiber concentrations of 70,000 MP/m<sup>3</sup> were reported in the air of a garment factory, and 26,000 MP/m<sup>3</sup> in office air.

*\*note different units in different studies*

Plastic particles are a main component of contemporary synthetic paints. A coat of paint covering 100 m<sup>2</sup> was estimated to contain 17–68 quadrillion (10<sup>15</sup>) polymeric paint particles. These start to be released when paint wear down and when old layers are scraped off. Emissions of 260 tonnes were attributed to the wearing of paint layers and 210 tonnes to the removal of old paint layers in the Netherlands.

Spray paint: 50 to 60% of the total paint volume sprayed typically does not reach the surface, becomes airborne microplastic and eventually falls out.

110,00 to 290,000 MP/kg soil have been reported near Berlin's famous graffiti walls.

3D printing uses a range of different polymers. Between 1000 and 1 million ultrafine particles of these polymers are released per cm<sup>3</sup> of air during the printing.

Emissions of 2 to 4 billion nanoABS particles per second to the air of 3D printing rooms have been reported. ABS is a popular type of plastic used toys, electronics and many other consumer products.

## Outdoor sources and recreation

The estimated world-wide emission of rubber tire particles calculated using data on mileage and number of vehicles on the planet comes to a staggering 5,917,518 tonnes/year.

Artificial turf football fields covered with granular infill contribute one of Europe's largest intentionally added microplastic issues. On the order of 100 tonnes of tire crumbs are applied to an average field. Between 2433 to 5067 MP/L have been measured in field stormwater runoff.

Atmospheric fallout: 575 to 1008 MP/m<sup>2</sup>/d were measured in the air of London UK. An earlier study in Paris air detected 2 to 355 particles/m<sup>2</sup>/day, of which one third were plastic. French researchers estimated 3 to 10 tonnes of fibers being deposited in the Paris region (2500 km<sup>2</sup>) annually. It's raining tonnes of microplastics there.

Multiple patents exist describing the application of microplastics in Stratospheric Aerosol Injection (SAI) - a form of solar geoengineering. The polymeric microparticles between 2 and 20 microns in size are designed to be released at altitudes of 10 or 20 km. This forms a yet unquantified but potentially 'terascale' source of intentionally added airborne microplastics and fallout, since SAI programs typically use units of 'teragrams per year' to express the volume of particles injected into the air (1 Tg is equivalent to 1 billion kilograms).

## Children's products

Human breast milk analysis showed milk to contain between 0.20 and 2.74 MP/g milk.

Breast milk stored in plastic storage bags was shown to contain higher amounts 20.2 MP/g, possibly due to microplastic release from the bags.

Baby bottles released 1465–5893 MP/L milk. Heating baby formula bottles doubled the amount of microplastics released.

Over a dozen different polymers have been reported in baby formula. Reported concentrations in China were around 17 MP/g. depending on the formula, babies may be drinking between 23 to 104 MP/day, not including particles released from bottles.

Thousands up to hundreds of thousands of plastic particles per mm<sup>2</sup> were released from toy building blocks after 10 cycles of assembling and disassembling.

1.45 to 27 MP/m<sup>2</sup> per day were released from baby play mats made of PET (polyethylene terephthalate). UV light exposure on the mats doubled the MP release.

Upon skin contact with pen grips, 160 million submicron particles of PVC plastic were reported; from erasers, 600 million to 1.2 billion synthetic rubber particles were reported to be released.

Airborne microplastics in a Portuguese classroom were measured to be 21 MP/m<sup>3</sup>. Concentrations of 1 and 2 MP/m<sup>3</sup> were reported in samples of Australian classroom childcare center air.

As children naturally ingest more settled dust during play and breathe in more air per kilogram bodyweight, their exposure is proportionally higher than adults.

## Personal care and health care

Oral care: up to 39 MP per day were released from plastic toothbrush bristles.

Average individual exposure estimates of 1.2 million MP per year from toothpaste use and an average of at least 2.3 million particles per year from the toothbrush bristles were reported in China.

Plastic contact lenses released an average of 4258 MP per lens after 30 days of simulated wear, and 9590 MP per lens over a 90-day period. A contact lens wearer may be exposed to 90,000 MP annually via this source.

Around 7500 polypropylene microplastics (1 to 62 µm in size) were detected in fluids for intravenous injection into the patient bloodstream.

Patients with wrist, elbow and finger implants experienced microplastic release directly into tissue: between 0.99 and 25 million silicone MP per gram tissue were measured.

Advanced ultra high molecular weight polyethylene materials appear to wear less and shed less plastic debris, although the particles being released are smaller than other implants (and possibly more active).

Clinical studies also detected polydimethylsiloxane particles around 0.2 mm in size released from breast implants, visible in both breast tissue and lymph nodes.

Polymeric nanocarriers are common applications in drug delivery, enabling active ingredients to be transported to different areas of the body. These nano-format plastics such as poly(methyl methyl-acrylate), polystyrene, polyethylene are administered via tablets or aerosols and add to patients' exposures to microplastics in a medication-volume dependent manner.

Polymers are applied in medicine as excipients (pharmacologically inactive ingredients in drug formulations), often functioning as binders and coatings. These form an another unexpected microplastic exposure route, specifically for humans.

In cardiopulmonary bypass surgeries, the patient's blood circulates through plastic tubing that releases a reported 48 to 60 MP per liter blood, per hour, depending on the machine model.

Over 70,000 MP were determined to be circulating in intravenous fluid during heart surgeries, based on a measurement of 51 MP/mm<sup>2</sup> filter after one recirculation period.

Hospital rooms are places we hope to heal in, however they are subject to airborne microplastics eventually depositing on floors and surfaces too. Concentrations in operation rooms ranged from undetectable up to 9258 MP/m<sup>2</sup>, for different 12-h sampling periods.

## The polymers and copolymers of microplastic exposure

identified from the studies cited in the full report

polyester	polyacrylates	acrylonitrile butadiene styrene
polyamide/nylon	polysulfone	polyethylene terephthalate
polystyrene	polyethylene	poly(methyl methylacrylate)
polyurethane	polypropylene	polytetrafluoroethylene
polybutadiene	polycarbonate	cellulose acetate and triacetate
polypropylene	polyoxymethylene	ethylene vinyl acetate copolymer
polyvinyl chloride	polylactic acid	chlorinated polyethylene
polypropylene diene	Tritan polyester	styrene-acrylonitrile copolyester
styrene-acrylonitrile	polyvinyl alcohol	ethylene acrylic acid copolymer
epoxy resin	alkyd	acrylic/acrylates polymers
melamine	phenoxy resin	ethylene-propylene-diene-monomer
polyphthalamide	polyurethane-polyurea	polyurethane/polyether-urethane
copolyester	methylacrylate	polystyrene-polyacrylonitrile
polyvinylpyrrolidone	polyvinylidene fluoride	polybutylene terephthalate
polyurethane-nylon	ultra high molecular weight polyethylene	poly(ethylene-propylene) diene monomer
polyethylene-nylon	silicone hydrogel	polydimethylsiloxane
polyether	polypropylene-polyethylene	hydroxy ethyl methylacrylate hydrogel
polydiallyl phthalate	polyethylene vinyl acetate	poly(butylmethacrylate-co-(2-dimethylaminoethyl)methacrylate-co-methylmethacrylate)

## Could the microplastic exposure evidence be wrong?

The analytical chemistry being applied to measure microplastics is constantly advancing and maturing, as methodologies always do. The fact that these methodologies are not yet fully standardized and that some are semi-quantitative has created concern that microplastics data being generated might not carry much real meaning.

Uncertainty in real-world data sets is common and does not mean the data are useless or wrong. In microplastics research, uncertainties imbedded in sampling and analysis procedures makes us aware of the limitations that the methodologies have so we can work with them, neither overestimate nor underestimate their significance, and understand the range of outcomes of the scientific studies in the public domain.

*Improvements in analytical quality control will not fundamentally change the conclusion that plastic products are shedding microplastics and creating significant sum exposure scenarios.*

Analytical laboratories have developed a broad array of checks and balances for their analytical work. The peer reviewed studies cited in this report have applied basic quality control measures to avoid false positives. Many of the studies cited did not have to detect tricky, trace levels because microplastics levels readily exceeded limits of detection and quantification of the methods used, with only a few 'non-detects' in certain source categories. Many nonexperts are familiar with the concept of margin of error, and may be aware that 100% accuracy and precision is extremely rare for any type of analysis.

Judging data quality is context-dependent since we must decide if the data carries enough quality for the purpose they are being used for.

The thousands of data points presented in the roughly 350 articles reviewed here represent real-world data that firmly reject any hypothesis that humans are unexposed to microplastics via their products. This report does not pin down all-source exposure levels for specific human populations or individuals because of the enormity of such an exercise and extremely high data volume required for that. Instead, this report scopes out the everyday

exposure hot spots, and uniquely collates a wide variety of sources which may not yet be on the radar of key stakeholders.

*The question whether humans are exposed to a multitude of microplastics in their daily lives can be answered with a resounding, evidence-based yes.*

The high volume of peer-reviewed data collected from hundreds of laboratories worldwide using a variety of state-of-the-art technologies provides strong, compelling evidence of significant, widespread, multiple-source microplastics exposure in the human population.

When these multiple sources are considered collectively, the everyday exposure levels humans are experiencing are projected by these researchers to reach as high as billions of particles due to inhalation, ingestion and the use of several particularly high microplastics releasing products such as ultra-processed foods, tea bags, plastic food packaging, paint, textiles, and products whose microplastic releases are exacerbated by heat, UV light, mechanical wear and aging processes. Large exposure ranges are expected, depending on geographies, age groups, occupations and lifestyle factors, among others.

## Why these findings are important

These findings affirm that modern lifestyles feature an all-encompassing exposure to microplastics due to a wide variety of plastic applications releasing microplastics.

Because these human exposure measurements indicate a positioning of microplastics near the body, for example to be swallowed or inhaled, it creates an imperative to assess the hazards and health risk implications of a rampant exposure of humankind to materials that have not been adequately safety tested prior to their global distribution in the 20th century.

As the global plastic production volume of around 400 Mt per year grows to a projected 1.3 billion tonnes by 2060, so will microplastic exposures. These exposures require continued monitoring and research to inform decision making on multiple levels.

## Ignoring the signals since the 1960s...

The widespread contamination of the living environment with microplastics attests to the fact that signals have been ignored by regulators since the 1960s, when the first reports of microplastic environmental pollution were published. The inaction has presumably been maintained through lack of political will, the power of special interest groups, and in some cases ‘paralysis by analysis’ - waiting decades for large data sets to form before making any decisions.

In an era of high and growing awareness of a critical mass of people, the status quo is now being challenged more than ever, and change is in the air.

## Calling for resourceful advocacy to reduce microplastics exposures

The **precautionary principle** is warranted and calls for acting to mitigate our exposure to microplastics now.

**The health risk is still uncertain, but so is the safety of microplastics.** The risks are scientifically plausible, potentially serious, and ‘inequitable to present and future generations’.

*Knowing where microplastics come from holds the keys to mitigating our everyday exposures.*

At the time this requires **filling scientific knowledge gaps** related to microplastic risk to underpin the mitigation strategies that go beyond ‘low hanging fruit’ and budget neutral or quick techno fixes.

It is prudent to focus on product systems to continue **learning about the release patterns so we can mitigate** those, while measuring microplastics in human biomonitoring initiatives and microplastics in close proximity to humans (e.g. food basket studies and air quality studies) for assessing exposure and risk.

The sense of urgency to team up and take action comes from the recent everyday microplastic release data presented here, coupled with safety signals emerging from toxicological laboratories and the large existing body of evidence that known hazardous chemicals are associated with microplastic.

From systems thinking guides, we know that changing the rules of the game could be highly effective in designing microplastic exposure out of product systems, making high level policy making one of the important paths to lasting change. Preparing politically feasible actions and leveraging policy windows to drive change can be very long process.

*Plastic is no longer the answer to every design choice. Functional substitutions provide an array of viable alternatives.*

People who are unwilling to wait decades for adequate policy changes are using the option of acting at other levels too: learning and sharing information, joining like-minded groups, and aligning their professional and personal choices with a will to limit microplastic pollution.

If government regulators remain unable to adequately address microplastic exposure on the short term, and manufacturers continue with business as usual, **individuals may already start regulating for themselves what they bring into their homes and workplaces.** We can refuse any plastic that does not respect our health. Purchasing a product is like voting for it, so the resistance is about simply not buying what you do not want anymore. We are more powerful than we think.

This report presents **data with a cause**, because knowledge is needed to act. We cannot solve a problem we cannot see clearly. Hand in hand with **individual action** goes the (long-term) **collective action** needed to ensure systemic microplastic pollution is adequately controlled.

## Recommendations for microplastics research

The more we learn about microplastic exposure in the living environment, the more we want learn. Some knowledge gaps and areas for future research for microplastics and health are listed for inspiration.

- Studies of how healthy, relatively low-exposed human populations avoid microplastics and how this impacts their health status.
- Feasibility and effectiveness studies of mitigation measures for short, medium and long term for groups of stakeholders.
- In addition to small sample size '*guerrilla studies*' that are useful for scoping, a move to larger sample sizes will reduce margins of error and produce even harder evidence.
- Continued advances in sampling and analytical methods, quality control tools, reference materials, proficiency testing, and the peer review process.
- Human exposure assessments for selected product categories, living environments and vulnerable populations (such as babies, children, occupationally exposed workers, patients receiving healthcare), and populations with different lifestyles, diets, policies, and geographies.
- Human toxicological effect assessment for microplastics: advancing methods, tools and data collection.
- Epidemiological assessment for microplastics: seek to demonstrate causality of health outcomes resulting from exposures
- Continue to work towards a full human health risk assessment for microplastics.

