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REVIEW ARTICLE

Microplastics in the air and potential health risks – a narrative review

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Summary

AIM: Microplastics, defined as plastic particles smaller than 5 mm and larger than 1 micrometer, along with nanoplastics (in the 1–1000 nm range), are ubiquitous environmental contaminants originating from both primary production and secondary fragmentation. Little is known about exposure to microplastics in ambient air and their health effects. This review summarises current knowledge regarding microplastics in ambient air and their potential health effects.

METHODS: To capture the limited available evidence on airborne microplastics exposure and human health, a search strategy using five complementary approaches was designed and implemented across multiple databases and timeframes through September 2024.

RESULTS AND DISCUSSION: In Switzerland and globally, major sources of airborne microplastics include tyre wear, textile fibres, and the degradation of plastics from various sectors. Exposure measurements reveal that microplastics are present in both indoor and outdoor air, with indoor exposure generally exceeding outdoor exposure. Exposure in cities is higher than in rural areas, thus depending on proximity to human activity. Based on calculations derived from various studies, an adult might inhale from 1,200 microplastic particles per year in remote locations to over 1.5 million particles per year in highly polluted urban areas. Human biomonitoring confirms the presence of microplastics across multiple tissues and bodily fluids, including the lungs, blood, placenta, breast milk, faeces, and, more recently, brain tissue, with evidence suggesting that microplastics can cross biological barriers, including the blood-brain barrier. While epidemiological studies specifically addressing airborne microplastic exposure are lacking, occupational health studies from textile and rubber industries report respiratory symptoms, impaired lung function, and an increased risk of respiratory diseases. Studies examining non-exhaust traffic emissions (as proxies for tyre wear particles) suggest associations with respiratory effects, increased mortality risk, cardiovascular impacts, and potential links to cancer and neurodevelopmental disorders. However, both approaches to understanding and deriving health effects from airborne microplastics have limitations. Additional research challenges include non-standardised measurement methods, a limited understanding of biokinetics, and difficulty differentiating microplastic effects from general particulate matter exposure.

CONCLUSION: Despite these limitations, microplastics likely contribute to health effects similar to those of particulate matter pollution, with potential additional concerns related to their specific composition and chemical additives. The proportion of microplastics in ambient particulate matter may increase with decreasing exhaust emissions and increasing use of plastic products, emphasising the need for interdisciplinary research on exposure assessment and health implications.

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Introduction

Plastics are all around us. They are used in almost every sector, including product and food packaging, building and construction materials, textiles, consumer products such as cosmetics, transportation, electrical and electronics sectors, and industrial machinery [1]. Plastic use is increasing worldwide; of particular concern, the global plastics treaty, which aimed to address growing plastic pollution, did not reach an agreement [2]. Additionally, this “plastic crisis” is accompanied by growing concerns regarding emissions and exposure across the plastic lifecycle and their potential adverse effects on the environment and health [3]. Microplastics are tiny plastic particles smaller than 5 mm and larger than 1 micrometer, whereas nanoplastics are defined as either 1–100 nm or 1–1000 nm [4]. Herein, we refer to both sizes as microplastics.

Microplastics are classified as either primary microplastics, which are produced intentionally (e.g. for cosmetics), or as secondary microplastics, which are formed through the fragmentation or abrasion of larger plastics or plastic waste [5]. Microplastics have been studied in water and soil for a while [6]. However, few studies have measured microplastics in the air [5].

The Swiss Federal Office for the Environment commissioned a report summarising the state of knowledge regarding the health effects of microplastics in ambient air from LUDOK – the literature database and services on health effects of ambient air pollution at the Swiss Tropical and Public Health Institute (https://www.swisstph.ch/de/projects/ludok). This review summarises key findings of the larger report published in German in February 2025 [7].

Methods

The systematic collection and selection of studies regarding exposure and possible health effects of microplastics in the air were based on the work and expertise of LUDOK. LUDOK systematically searches for, collects, and summarises important research on ambient air pollution and health since 1985 [8].

The literature search for the microplastics review used five complementary approaches to find relevant literature on the topic.

1. Since January 2022, the systematic LUDOK search has been screening and earmarking relevant microplastics literature through its ongoing monthly PubMed search and its hand searches of major journals [8].
2. Routine LUDOK searches were complemented by a systematic search in the Web of Science up to May 2023, combining keywords for microplastics, airborne exposure, and human health. It focused on reviews published from 2021 onwards and on highly cited studies.
3. Reference lists were consulted to identify additional relevant studies in a snowballing approach.
4. Occupational studies in the rubber industry examining cardiovascular endpoints were systematically searched in PubMed until September 2024.
5. Because the previous search strategies did not reveal any epidemiological studies regarding airborne microplastics exposure and health, the LUDOK database was additionally searched in July 2023 for epidemiological studies that considered exposure to non-tailpipe or non-exhaust emissions or road dust as a potential proxy for tyre wear particle exposure (appendix 1).

Studies and reviews reporting on measured exposure to microplastics in ambient or indoor air, or on microplastics detected in the human body (biomonitoring data) were included, along with studies examining the health effects of (micro)plastics in occupational settings and the health effects of non-exhaust emissions with a focus on the indicator metals copper, zinc, and barium for tyre wear [9–11]. Microplastics from tyre wear are an important component of non-exhaust traffic emissions, alongside brake and road wear [11, 12]. Because this study was interested in the health effects of microplastics in ambient air, it was hypothesised that, as in research on the health effects of particulate air pollution or its components, studies in occupational settings and studies that analysed non-exhaust traffic-related air pollution could provide insights into the potential health effects of airborne microplastics.

Results and discussion

What are microplastics? Where do microplastics (in the air) come from?

Microplastics in the environment are a highly complex mixture of materials and chemicals that differ in size, shape, material composition, additives, and surface properties, depending on their origin or source and the process through which they are formed.

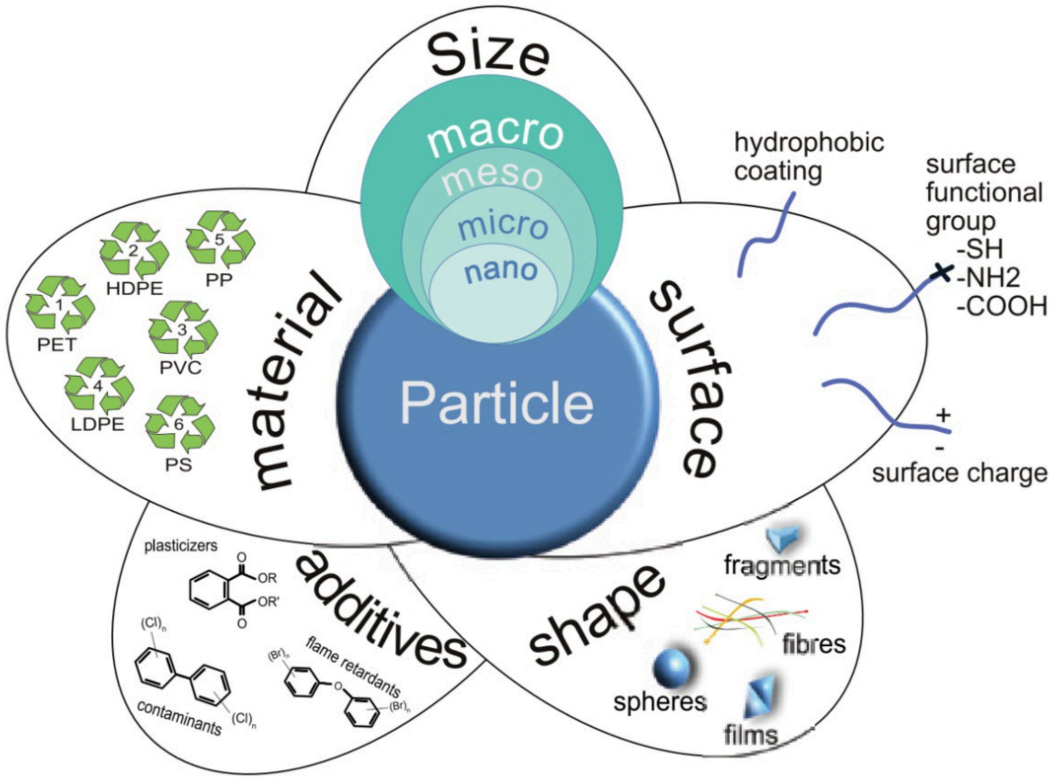
In Switzerland, the improper disposal of plastics, such as littering or plastics in organic waste disposal, is the primary source of macroplastics (>5 mm) in the environment. Due to communal cleaning services, most of these plastics are removed and burned in waste incineration plants. In Switzerland, the largest sources of microplastics that are contaminating water, soil, and air are tyre wear and the degradation of plastics used in agriculture, construction, and households [13, 14]. In other countries, relevant microplastic sources mentioned include tyre abrasion from road and air traffic, artificial turf, road markings (thermoplastics), waste incineration, construction, landfills, industrial emissions, and tumble dryer exhaust [15, 16], as well as the fragmentation and abrasion of macroplastics by wind, the resuspension of tyre, brake, and road surface abrasion, and the abrasion of textile furnishing and synthetic clothing by human movement [17]. The dispersion of microplastics from water bodies through sea spray or on the surface of water bodies is also mentioned [18]. However, the contribution of water bodies to airborne microplastics has recently been challenged, with evidence indicating that it is overestimated [19]. No reliable statements can be made on the quantitative contributions of all these sources [18].

Estimates suggest that tyre wear contributes between 0.1% and 10% of PM10 air pollution in the form of microplastics [5]. Manoli and Voutsa [20] estimated that 28% of particulate matter in PM10 corresponds to resuspended road dust, including tyre wear. Wik and Dave [21] estimated that approximately 5% of tyre abrasion can enter the air. Grigoratos and Martini [11] and Kole and Lohr [22] estimated that 0.1–10% of PM10 and 3–7% of PM2.5 in the air consists of tyre and road abrasion, which is likely to be at the upper limit. For Switzerland, Rausch and Jaramillo-Vogel [23] quantified tyre abrasion particles at an urban road site (NABEL monitoring station Bern-Bollwerk) and at an urban background site (NABEL monitoring station Zurich-Kaserne). The proportion of tyre abrasion particles in PM10 was 11% at the road site and 2% at the urban background site, with values of 2.24 and 0.28 $\mu g/m^3$, respectively. Measurements in indoor and outdoor air identifying plastic fibres in air samples suggest that the wear and tear of synthetic textiles and furniture finishings are also important contributors to airborne microplastic exposure [24, 25].

Regarding the processes leading to ever smaller plastic particles, the degradation depends on parameters such as temperature, wind, relative humidity, colonisation by microbes, additives, surface area, size, and shape. Photo-oxidative degradation is the most important mechanism in the air and requires sunlight (UV radiation). Degradation is generally very slow [4]. This leads to plastic accumulation in the environment that is expected to persist for hundreds to thousands of years, depending on the plastic type [26]. Air is therefore considered not a sink but a transport medium [13]. Prevailing meteorological parameters, including wind, temperature, relative humidity, and rainfall, along with particle solubility, shape, size, and structures, affect the transport of atmospheric microplastics [4].

The World Health Organisation [27] has summarised the different attributes of microplastics in a figure (figure 1). Toxicity can vary depending on these characteristics. Some authors additionally mention the ageing of the materials or colonisation by bacteria as traits influencing toxicity [28].

Figure 1: Attributes of microplastics that are relevant for assessing both exposure and hazard (from: WHO. Dietary and inhalation exposure to nano- and microplastic particles and potential implications for human health. Geneva: World Health Organization, 2022 [27], under Creative Commons licence CC BY-NC-SA 3.0).



Are we exposed to microplastics?

Challenges of measuring microplastics in the air

There are no standardised measurement methods for microplastics in the air. Depending on the research question, such as differentiating between sizes, quantities, shapes, or chemical features of plastics, different methods for sampling, pre-treatment, and identification are used. A review by Luo and Wang [29] provides a good overview of existing methods. Because of the variety of methods, it is difficult to compare measurements [30]. Additionally, there are major challenges in terms of quality assurance, for example, in avoiding sample contamination [31].

Exposure measurement studies from Europe, North America, the Middle East, and Asia indicate that microplastics are present in the air. Pollution is higher in areas with greater human activity, which means that higher levels are observed in cities than in rural areas [25] (appendix 2). The fact that microplastics are also found in remote areas, such as glaciers, and that their number has increased in recent years, indicates that they are transported by wind and removed from the atmosphere by dry and wet deposition, and that emissions have increased [32]. The number of inhalable particles (i.e. particles smaller than 10 µm in diameter, PM10) is unclear. However, to date, microplastics likely only account for a small fraction of human exposure to particulate pollution in PM2.5 or PM10. Indoor exposure, particularly from textile fibres, is higher than ambient exposure because of indoor air sources and closed rooms with minimal air exchange [33–35].

Exposure of humans

Taking the results of various measurement studies and assuming an average breathing volume of 15 m^3 per day for an adult [27], the inhaled quantity of microplastics per day and year was estimated (table 1).

Exposure studies from Europe report an annual average exposure of a few thousand particles (3285-5091 particles/year, with 1259 particles at a remote location such as the Pic Du Midi). Asian studies generally show larger numbers, which can partly be attributed to the inclusion of the total load, including large particles. Nevertheless, the average pollution in five major cities in China remains high, with over 900,000 particles, when taking into account that about 61% (over 1.5 million particles) were smaller than 30 µm [36].

Table 1: Calculation of the annual exposure to the number of microplastic particles or fibres based on selected exposure measurement data (assumption of a daily breathing volume of an adult of 15 m^3 per day).

Reference	Place /country	Particle size	Concentration (particles/m^3)	Dailye exposure (particles/day)	Annual exposur (particles inhaled/year)
[32]	Pic du Midi, Pyrenees, France	More than half ≤10 µm	0.23 (range: 0.09–0.66)	3.45 (range: 1.35–9.9)	1259.25 (range: 492–3613)
[37]	Indoor air, Aarhus, Denmark	Median: 21 and 36 µm (smaller/ larger particles)	Avg. 9.3 ± 5.8 (range: 1.7–16.2)	Avg. 139.5 (range: 25.5–243)	Avg. 50917 (range: 9307–88695)
[34]	Coastal California, USA	Fibres: 616 µm (30%: 100–300 µm), Fragments: 104 µm	Fibres: 0.6, Fragments: 5.6	Fibres: 9, Fragments: 84	Fibres: 3285, Fragments: 30660
[33]	Paris, France	Outdoor air fibres <1650 µm	0.9 (range: 0.3–1.5)	13.5 (range: 4.5–22.5)	4927 (range: 1642–8212)
[38]	Asaluyeh, Iran	<100 – >1000 µm (air: 2–100 µm, dust: 75% <100 µm)	1 (range: 0.3–1.1)	15 (range: 4.5–16.5)	5475 (range: 1642–6022)
[39]	Nagpur, Central India	n/a	Residential: 116.25 particles/day, Industrial: 99.25 particles/day	Same as concentration	Residential: 42431, Industrial: 36226
[40]	Beijing, China	80%: 5–20 µm, range: 5–200 µm	14100–16700 fibres/m^3	211500–250500 fibres/day	77197500–91432500
[41]	Wenzhou, China	5–1794 µm (65.1% <30 µm, 29.4%: 30–100 µm)	188.7	2830.5	1033132
[36]	5 major cities in China	5.9–1475 µm, 61.6% <30 µm	Range: 104–650, Avg: 282	Range: 1560–9750, Avg: 4230	1543950 (range: 569400–3558750)
[42]	Shanghai, China	23.07–9955 µm, Avg: 597.5 µm at 1.7m	0–4.18, Avg: 1.42	0–62.7, Avg: 21.3	7774 (range: 0–22885)
[43]	Shanghai, China	Avg: 246.52 µm (12.35–2191.32)	0–2, Avg: 0.41	0–30, Avg: 6.15	2244 (range: 0–10950)

Abbreviations: Avg, average; n/a, not available; µm, micrometre; m, metre; m^3, cubic metre.

There are various alternative calculations of the total human exposure to microplastics, which produce very different figures depending on the assumptions and models used. Cox and Covernton [44] calculated that a North American ingests 39,000–52,000 particles per year via food and that the total exposure increases to 74,000–121,000 particles if exposure via respiration is taken into account (based on numbers from [33] and [45]). Zhang and Xu [46] calculated an intake through food, specifically from salt and water, of up to 77,700 particles and over 30 million through respiration. These figures are subject to great uncertainty. Whether the consumption of water drunk from plastic bottles is added can make a huge difference (up to 90,000 additional particles per year [44]). What is striking, however, is that estimated exposures from air can play a major role in total exposure, given that microplastics can enter the organism both through inhalation via the lungs and through the gastrointestinal tract by swallowing particles removed by the respiratory tract's cleaning mechanisms.

Human biomonitoring data

Humans are exposed to microplastics via food, air, and skin, whereby, depending on the authors, food [13] and (indoor) air [47] are discussed as the main routes of exposure. Airborne microplastics can (1) be inhaled, (2) be inhaled and trapped in the mucus of the lining of the upper respiratory system and removed by mucociliary transport to be swallowed, and (3) settle on meals [48] or surfaces. The latter is especially relevant for the exposure of infants, who can ingest microplastics through typical mouthing behaviours [49]. The latter two mechanisms result in exposure of the gastrointestinal tract.

In general, inhalable particles larger than 10 µm in aerodynamic diameter are deposited mainly in the extrathoracic region, whereas particles under 10 µm can reach the tracheobronchial regions of the lung [50]. Small particles measuring less than 2.5 µm can reach the alveolar region of the lung, where clearance mechanisms are not as successful [15]. Particles below 1–1000 nanometers (nanoplastics) can cross the alveolar-capillary barrier [51] and, once in the bloodstream, can also cross the blood-brain or placental barrier [52].

The detection of microplastics in various organs and body fluids indicates exposure and transport within the body. Microplastics were first detected in human lung tissue of workers in the textile industry in 1975 [53]. Since then, microplastics have also been found in the lung tissues of the general population [54–56] and in other organs, such as blood [57–59], the gut [60], liver tissue [61], faeces [62, 63], breast milk [64], the placenta [65, 66], and the first stool of a newborn (meconium) [67, 68]. This suggests that microplastic particles are transferred via the placenta and the umbilical cord. Reviews by Jung and Sampath [69], Prata [70], and Barceló and Picó [71] cover important studies on the detection of microplastics in the human body.

Table 2 shows the types of microplastics that have been detected in different organs and body fluids.

Table 2: Types of plastic detected that have passed the human body's biological barriers or were excreted (adapted from: Krause S, Ouellet V, Allen D, Allen S, Moss K, Nel HA, et al. The potential of micro- and nanoplastics to exacerbate the health impacts and global burden of non-communicable diseases. Cell Rep Med. 2024 Jun;5(6):101581 [51] under Creative Commons licence CC BY-NC-SA 4.0).

Type of microplastic	Placenta	Meconium	Breast milk	Blood	Faeces
Polyamide	X	X	X	X	X
Polyurethane	X	X	X	X	X
Polyethylene	X	X	X	X	X
Polyethylene terephthalate	X	X	X	X	X
Polypropylene	X	X	X	X	X
Polyvinyl chloride	X	X	X	–	X
Polyoxymethylene	X	X	–	–	X
Ethylene vinyl acetate copolymer	X	X	–	–	X
Polytetrafluoroethylene	X	X	–	–	X
Chlorinated polyethylene	X	X	–	–	X
Polybutadiene	X	X	–	–	X
Polycarbonate	–	–	X	–	–
Polystyrene	–	–	X	–	X
Polymethyl methacrylate	X	X	–	X	X
Polylactic acid	X	X	–	X	X
Polysulfones	X	X	–	X	X
Nitrocellulose	–	–	–	X	–
Sizes detected	*5–10 µm/50–240 nm*	*>50 µm*	*2–50 µm*	*~700 nm*	*infant: 20–50 µm, adult: 50–500 µm*

X indicates that the plastic type has been detected, whereas cells with dashes (–) indicate that no evidence of the presence of the microplastic type was found in the corresponding medium.
Abbreviations: µm, micrometres; nm, nanometres

More recently, microplastics have been detected in the olfactory nerve [72] and in the brain, sparking discussion on their potential role in the development of dementia, as a greater accumulation of microplastics was observed in a cohort of decedent brains with a documented dementia diagnosis than in those without a diagnosis. Notable deposition was observed in cerebrovascular walls and immune cells [73]. The authors confirmed the presence of microplastics in the human kidney, liver, and brain using robust complementary methods for detecting microplastics. Most of the total mass consisted of polyethylene, with lesser but relevant concentrations of other polymers. In brain tissues, they observed the highest proportions of polyethylene, which are presented largely as nanoscale, shard-like fragments. Plastic concentrations in these decedent tissues were not influenced by age, sex, race/ethnicity, or cause of death. The time of death (2016 vs 2024) was a significant factor, with increasing microplastic concentrations over time in both liver and brain samples [73].

However, no reliable statement can be made about the general level and distribution of exposure. Similar to the challenges of measurement of microplastics in ambient air, measurements of microplastics in body fluids are not based on standardised methods either [52].

Do airborne microplastics affect our health?

Microplastics are a mixture of materials and additives that can have very different effects depending on their size, shape, composition, age, and surface properties or the materials present on their surface. It is virtually impossible to separate the effects of chemicals and particles [74].

Various mechanisms of action can lead to damage and impaired health. These include physical or chemical irritation by the particles themselves, as well as adhering chemicals from production or components such as proteins or heavy metals accumulated from the environment or within the body [38, 75, 76]. Non-toxic material that is inert per se can accumulate and trigger inflammatory reactions and systemic changes, such as in the microbiome [77].

To date, no reliable epidemiological studies on the general population are available that describe a connection between environmental exposure to microplastic particles and health consequences for humans, including exposure from air. Occupational health studies and studies investigating non-exhaust components of particulate matter are used here as proxies for airborne microplastic exposure and suggest comparable effects to those described for exposure to particulate matter, as described below.

Occupational health studies, typically from the textile, flocking, tyre producing, or vinyl (PVC) industry, have primarily described respiratory symptoms such as allergic or asthma-like reactions, (chronic) cough, bronchitis, changes in lung function, wheezing, inflammation of the airways, pulmonary fibrosis [53, 78], and even lung cancer [79, 80]. Cancers of the liver, bladder, and digestive tract have been reported [81, 82]. Increased mortality from respiratory diseases [83] and cancer [79, 84] has also been described. However, according to a WHO report [27], the evidence for a link between microplastic exposure and cancer is still inadequate. Individual studies additionally point to links with mortality from cardiovascular diseases and possible effects on the brain (dementia) [85, 86].

Occupational studies point to possible health effects. However, their results cannot be transferred to the general population, which includes susceptible people such as children, pregnant women, individuals with pre-existing conditions, and older adults. Exposure in the general population is often characterised by long-term exposure to low levels of pollution, whereas occupational exposure typically is characterised by higher exposure levels over shorter time periods, with recovery time when not working. In addition, it is difficult to assess exposure-response relationships in occupational studies and rule out effects from other co-pollutants in the workplace or other confounding factors.

Epidemiological studies that examine exposure from traffic using specific metals in particulate matter as indicators for (brake and) tyre wear (e.g. zinc and barium), or that use other methods to calculate the contribution of non-exhaust emissions from traffic to PM exposure, might be considered proxies for microplastics exposure from ambient air. The 90 studies selected from the LUDOK database describe various health endpoints.

Respiratory effects related to pneumonia [87, 88] and reduced lung function [89, 90] were found to be associated with non-exhaust particles and zinc in adults and children. Results on asthma and wheezing were mixed, with some studies showing increased risks of asthma, as well as increased symptoms [91–93] or emergency events [94]; however, these associations were not observed in other studies examining asthma-related emergencies [95–98].

The mortality risk in the general population was increased in association with long-term exposure to zinc in PM or non-exhaust emissions in Rome [99] and Massachusetts (USA) [100], as well as in the European studies ESCAPE [101] and ELAPSE [102, 103] and in heart patients [104]. However, a UK study in the general population in London found no association with non-exhaust primary particles (PM2.5 and PM10) [105].

The ELAPSE study observed an increased lung cancer risk associated with zinc [106], and the ESCAPE study found increased risk with copper, zinc, and nickel [107]. Zinc in PM was also found to increase liver cancer risk in the ELAPSE study [108], but no associations were found regarding brain [109] or breast cancer risk in the ESCAPE study [110].

A review of toxicological studies found that microplastics affected cardiac function and caused toxicity at (micro)vascular sites. Direct cardiac toxicity included abnormal heart rate, cardiac function impairment, pericardial oedema, and myocardial fibrosis. At (micro)vascular sites, microplastics induced haemolysis, thrombosis, blood coagulation, and vascular endothelial damage [111]. Epidemiological studies with indicators of non-exhaust traffic exposure have found mixed results regarding heart rate variability [112–114] and for effects on hospital admissions or emergency events related to cardiovascular diseases [94, 98], stroke [115, 116], mortality due to CVD [99, 117] or of patients with CVD [104, 118], and the development of CVD [88, 119, 120].

Microplastics may alter hormonal balance and metabolism. In particular, the additives bisphenol A and phthalates are known endocrine disruptors that may lead to lower birth weight, preterm birth, insulin resistance, high blood pressure, and obesity [69]. Only a few individual studies in

LUDOK support these findings regarding non-exhaust exposures. A Spanish study found higher risks for preeclampsia in association with traffic and brake dust exposure [121]. Studies conducted in London and Sweden found lower term birth weight with non-exhaust emissions [122, 123].

Recently, as mentioned above, the migration and accumulation of microplastic particles in the brain have been discussed, and a higher content of microplastics has been observed in the brains of individuals with a diagnosis of dementia than in those without a diagnosis [73]. A cohort study in children found a higher risk for autism diagnoses with non-exhaust emissions during pregnancy [124]. Flame retardants, another common additive in plastics, have also been discussed in association with neurodevelopmental diseases [125]. Mortality from dementia was non-significantly elevated in association with zinc in PM in the ELAPSE study [126], but dementia incidence was not associated with traffic exposure in London [127]. Cognitive function in children was not associated with zinc in PM in the ESCAPE study [128] or the Spanish BREATHE study [129]. Other health endpoints that may be associated with microplastics exposure include altered digestion due to an altered gut microbiome [130–132], as well as altered liver and kidney function [133] and alterations in the immune system [49, 69].

Overall, epidemiological studies examining the effects of non-exhaust traffic emissions and indicators of tyre wear show similar effects to those reported in occupational studies. However, the results are often mixed, and the number of studies investigating a specific outcome is too low to draw firm conclusions. Additionally, the interpretation of the results of the occupational and epidemiological studies mentioned above as proxies for the harmful effects of ambient airborne microplastics should be approached with caution. Epidemiological studies that allow linking exposure to ambient airborne microplastics with acute and chronic preclinical and clinical phenotypes are lacking and urgently needed, but face several challenges.

Challenges in assessing airborne microplastic-health associations

Microplastic pollution in the air and its association with health and diseases remain poorly understood because of several challenges.

First, the measurement and characterisation of microplastics in the air are still in their infancy. Major challenges remain in the areas of sampling, identification, measurement, and characterisation of microplastics [5]. The lack of comprehensive standardisation of measurement and analysis methods with proper quality assurance, as well as representative reference materials, impairs both the comparison of results from different regions and their general reproducibility [27, 31]. The focus of research on airborne microplastics should be specifically on the particle fraction of <10 µm, which is the most relevant to health [29]. However, only a few studies in Europe or North America [32, 35, 134–137] and Asia [36, 39–41, 138] have examined this.

Second, it is generally considered unlikely that, currently, without extensive standardisation, representative reference materials, and the inclusion of physico-chemical properties and associated substances, a realistic assessment of human health risks is possible [26]. Additionally, the biokinetics of the absorption, distribution, metabolism, and excretion of these particles are still poorly understood [139]. This also relates to the understanding of the ability of microplastics to overcome barriers such as the epithelia of the respiratory tract and the digestive tract [140].

Third, the complex mixtures of different chemicals found in environmental samples of microplastics present a very high hurdle for separating the different effects of combinations of chemicals and particles [26]. It requires an exposome science approach to connect health effects to single chemicals or mixtures thereof, given that humans are exposed to numerous chemicals from a multitude of sources [141].

The fourth challenge, which is linked to those above, is that it remains very challenging to study the effects of microplastics in the air in epidemiological studies, which would provide insights into exposure under real-world conditions over longer time frames and into effects in susceptible populations.

Given the potentially increasingly diverse composition of ambient particulate matter, it is crucial that efforts in air pollution research investigate particle composition and sources and take microplastics into consideration. The chemical composition and context, as well as the level of exposure, in part driven by the availability of exposure adaptation measures (e.g. masks carried in occupational settings), differ substantially depending on the context of exposure (occupational settings versus general population settings; non-tailpipe traffic-derived versus textile-derived particles). Therefore, occupational studies or studies on non-exhaust traffic exposure do not allow for clear conclusions regarding the health effects of microplastic exposure in the general population.

The population health effects of ambient air microplastic exposure for estimating their risk burden and supporting targeted policies require novel, fine-grained exposure models and their application in large-scale cohorts with associated biobanks to facilitate exposome science [142, 143].

Key findings

Sources

- Sources are known and partially quantified: tyre wear, plastic film products from agriculture, and littering
- The contribution to air pollution levels is unclear and is higher near roads
- Abrasion of textiles appears to be relevant for indoor and outdoor air pollution

Measurement

- Microplastics have been detected in the air: indoor air exposure > outdoor air; levels are dependent on human activity (cities > rural areas)
- No standardised measurement methods – quantification is difficult
- So far, microplastics constitute only a small proportion of particulate matter

Exposure

- Exposure occurs via food and air (indoor air and outdoor air)
- Microplastics have been detected in lungs, blood, faeces, urine, breast milk, and brains

Dosage

- Unclear biokinetics: uptake, distribution, metabolism, and excretion are poorly studied
- Different behaviour depending on plastic type, mixture, form, etc.

Health effects

- No epidemiological studies are available
- A variety of health effects are possible in different target organs
- There are plausible mechanisms similar to those of particulate matter
- Accumulation in tissues and organs cannot be ruled out

Conclusions

Microplastic pollution is linked to human activity. Textile wear is an important source of microplastics, particularly indoors. In outdoor air, tyre wear and the abrasion and decomposition of materials from the agricultural and construction industries or larger plastics (e.g. littering) are also important sources. Exact quantification remains difficult, but biomonitoring and pathology studies indicate that the general public is exposed to microplastics from air and food. Although occupational health studies, animal studies, and studies from medical and implant research cannot replace epidemiological studies in the general population, the diverse adverse health effects observed raise concerns despite their limitations. The extent to which microplastic particles and their additives are more toxic than other particles remains an important focus of environmental research.

With the decrease in particulate matter pollution from exhaust gases, it can be assumed that the contribution and proportion of microplastics from tyre wear will increase in future. Additionally, increased use and disposal of plastics and increasing levels of microplastics in human tissue suggest that plastic pollution (from the air) might become more important in future. Interdisciplinary research is urgently needed to better understand the level of exposure and health effects of microplastic pollution from ambient air.

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Appendix

Supplement 1: Search strategy and results

A.1 Search strategy Web of Science Core Collection Search date 7 June 2023

#	Search Query	Results
1	"synthetic fiber*"(Topic)	3681
2	polyamide*(Topic)	36189
3	PVC*(Topic)	35671
4	polymer*(Topic)	2020148
5	polyester*(Topic)	62483
6	polycarbonat*(Topic)	27931
7	resin*(Topic)	238107
8	polyvinyl*(Topic)	85735
9	polyurethan*(Topic)	66961
10	polystyren*(Topic)	112715
11	polypropylen*(Topic)	85887
12	polyethylen*(Topic)	217440
13	nylon*(Topic)	29043
14	tire(Topic)	40445
15	plastic*(Topic)	678326
16	microplastic*(Topic)	15375
17	nanoplastic*(Topic)	2496
18	#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14 OR #15 OR #16 OR #17	3186644
19	dust(Topic)	177609
20	atmospher*(Topic)	749260
21	"air-borne"(Topic)	2378
22	airborne(Topic)	93113
23	"air pollution"(Topic)	108297
24	air(Topic)	1150938
25	#19 OR #20 OR #21 OR #22 OR #23 OR #24	1942587
26	#18 AND #25	111652
27	maternal(Topic)	349809
28	cohort*(Topic)	944817
29	father*(Topic)	84732
30	mother*(Topic)	325497
31	veteran*(Topic)	62147
32	resident*(Topic)	397694
33	smoker*(Topic)	101078
34	husband(Topic)	18941
35	wife(Topic)	24992
36	spouse*(Topic)	26865
37	survivor*(Topic)	181182
38	population*(Topic)	3075901
39	patient*(Topic)	7675196
40	elderly(Topic)	359578
41	female*(Topic)	1303910
42	male(Topic)	1418695
43	woman OR women(Topic)	1733442
44	man OR men(Topic)	1127091
45	person*(Topic)	1418937

#	Search Query	Results
46	infant*(Topic)	522853
47	newborn*(Topic)	178358
48	pupil*(Topic)	62268
49	preschooler*(Topic)	18890
50	student*(Topic)	1010133
51	toddler*(Topic)	21409
52	bab*(Topic)	148157
53	boy*(Topic)	199873
54	girl*(Topic)	197688
55	*natal*(Topic)	583616
56	postnatal*(Topic)	132798
57	*school*(Topic)	837332
58	pediatric*(Topic)	433851
59	prenatal(Topic)	133736
60	preterm(Topic)	119964
61	birth(Topic)	443915
62	gestational(Topic)	140097
63	pregnan*(Topic)	620068
64	fetal(Topic)	297394
65	foetus*(Topic)	9749
66	embryo*(Topic)	490913
67	adolsecent*(Topic)	23
68	child*(Topic)	2263541
69	human*(Topic)	4832720
70	adult*(Topic)	1992928
71	#27 OR #28 OR #29 OR #30 OR #31 OR #32 OR #33 OR #34 OR #35 OR #36 OR #37 OR #38 OR #39 OR #40 OR #41 OR #42 OR #43 OR #44 OR #45 OR #46 OR #47 OR #48 OR #49 OR #50 OR #51 OR #52 OR #53 OR #54 OR #55 OR #56 OR #57 OR #58 OR #59 OR #60 OR #61 OR #62 OR #63 OR #64 OR #65 OR #66 OR #67 OR #68 OR #69 OR #70	21308293
72	#26 AND #71 AND (PY==("2023" OR "2022"))	
73	#26 AND #71 AND Highly Cited Papers	
74	#72 OR #73	1620

A.2 Search strategy in LUDOK. Search date 18 July 2023

(Reifen AND 1F) OR (nicht-abgas AND 1F) OR (abrieb AND 1F) OR (gummi AND 1F)

90 Treffer

A.3 Complementary search in PubMed on occupational studies. Search date 17 September 2024

To supplement occupational health studies in the field of tire/rubber manufacturing with a focus on endpoints that did not examine the respiratory tract or cancer.

(((("Air Pollutants, Occupational/analysis"[MAJR]) OR ("Occupational Exposure/adverse effects"[MAJR])) OR ("Air Pollutants, Occupational/adverse effects"[MAJR])) AND ((rubber) OR (tire OR tyre))) AND ("Humans"[MeSH]) →368 Hits

((((("Air Pollutants, Occupational/analysis"[MAJR]) OR ("Occupational Exposure/adverse effects"[MAJR])) OR ("Air Pollutants, Occupational/adverse effects"[MAJR])) AND ((rubber) OR (tire OR tyre))) AND ("Humans"[MeSH])) AND ("Cardiovascular Diseases"[Mesh]) → 15 Hits

- ➔ 5 studies selected

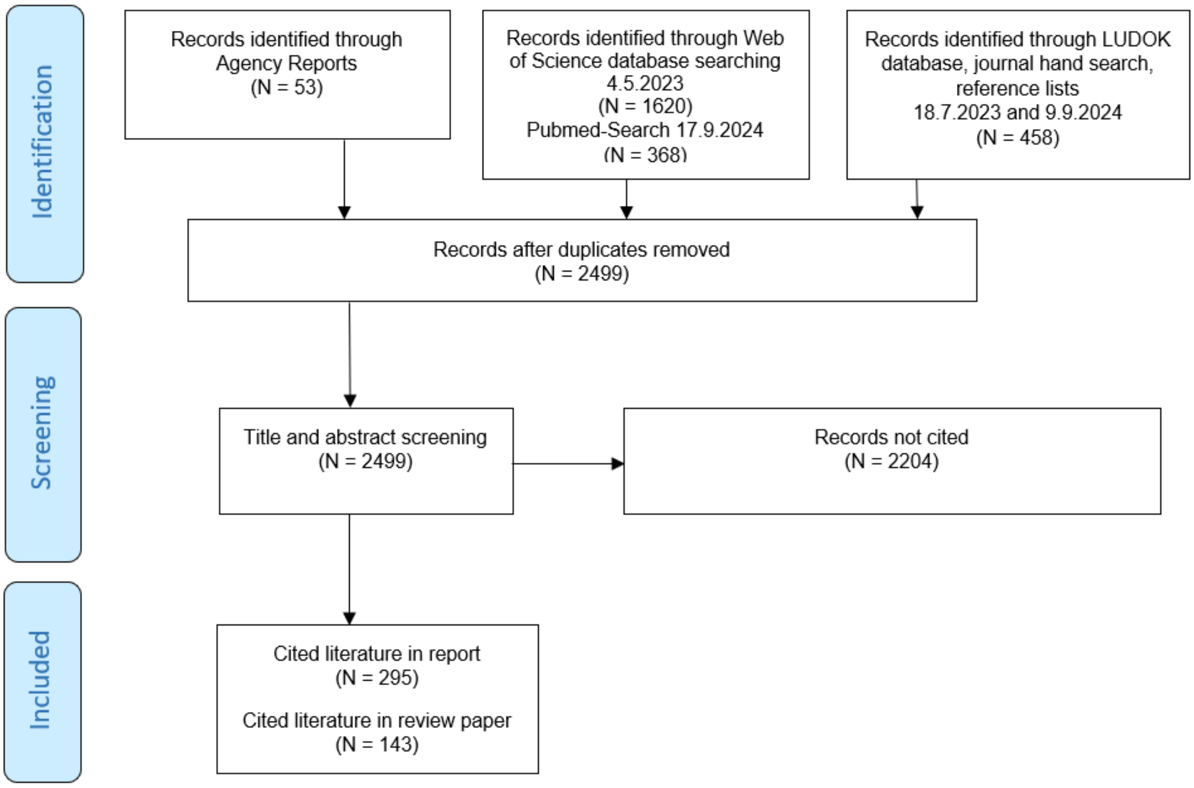
More specific search regarding studies on the digestive microbiome or neurocognitive outcomes

((gut OR microbiome OR dementia OR brain OR cognition OR cognitive) AND (((rubber) OR (tire OR tyre)) OR (plastic OR "synthetic fibres" OR textile OR PVC))) AND ((("Air Pollutants, Occupational/analysis"[MAJR]) OR ("Occupational Exposure/adverse effects"[MAJR])) OR ("Air Pollutants, Occupational/adverse effects"[MAJR]))→48

- ➔ No microbiome studies on workers

A.4 PRISMA Flow-Chart

Flow chart (according to Preferred Reporting Items For Systematic Reviews and Meta-Analysis – PRISMA)



Supplementary Material 2: Studies that measured microplastics in air

*Results of studies that actively measured microplastics in **outdoor air** (separately for Europe and North America, as well as the rest of the world). Translated from the original German-language table 3 in the report with assistance from Claude (Anthropic, 2024), with subsequent verification by the authors.*

Reference	Location / Country	Year	Sample Type	Lower detection limit	Particle Size	Concentration or sedimentation rate	Shape	Plastic or polymer types	Analytical method
Europe, North America, Australia									
(Harrison et al., 2012)	Central London, UK	2007, 2009, 2010, 2011	Outdoor air, street dust	1 µm	0.9−11.5 µm	38.1 ± 9.7% resuspended dust, 55.3 ± 7.0% brake wear, 10.7 ± 2.3% tire wear in PM10-2.5		11% tire wear particles	Active sampling ICP-MS
(Panko et al., 2019)	Los Angeles, USA, London, UK, Tokyo, Japan	Jul 2014-Sep 2015	Air, roadside	PM2.5	n/a	<0.004-0.10 µg/m3 tire and road wear in PM2.5, average proportion 0.27%	Sausages and granules	<1% tire wear	Active sampling, Py-GC/MS
(Rahman et al., 2021)	Montreal, Canada	2007-2008	Air (outdoor and indoor air)	PM2.5	Nylon fibers 4-80 µm, PUR 0.33-3.2 µm, CPE 2.9 µm, PE 0.43 µm, PVC 2.1-4.7 µm	utdoor air: 0.32-288 particles/µg or 2-456 µg/filter vs. Indoor air: 228-313 µg/filter	Fibers, fragments	PA/Nylon fibers, particles: PP, PE, CPE, styrene copolymer, PVC, PUR	Active sampling, microscopy, Raman
(Costa-Gómez et al., 2023)	Cartagena, Southeast Spain	May-Aug 2021	Air	PM10, PM2.5	<2.5 and 10 µm	2.09 ng polystyrene/m3 in PM10 and 1.81 ng polystyrene/m3 in PM2.5	n/a	PS	Active sampling, TGA-MS
(S. Allen et al., 2021)	Pic du Midi, Pyrenees, France	Jun-Oct 2017	Air	3.5 µm	over half ≤10 µm	0.23 (range: 0.09-0.66) particles/m3	70% fragments, 30% fibers	44% PE, 18% PS, 15% PVC, 14% PET, 10% PP	Active sampling, µ-Raman, microscopy

Reference	Location / Country	Year	Sample Type	Lower detection limit	Particle Size	Concentration or sedimentation rate	Shape	Plastic or polymer types	Analytical method
(González-Pleiter et al., 2021)	Madrid and rural areas, Spain	2019/2020?	Air at flight altitude 700-3496 m.a.s.l.	10 µm	Fiber length: range 84-1709 µm, average 662 µm; fiber width: 4-97 µm, average 25.4 µm Fragments: 42-815 µm, average 204 µm, width 17-408 µm, 103 µm	Rural: 1.5 particles/m3, Urban: 13.9 particles/m3 Deposition rate: 0.1-10 particles/m2 per day	Rural area: 84% fibers, urban: 67% fibers	PES, wool, acrylic, PA, PE, PP, polyolefins, cotton, polybutadiene (tire rubber)	Active sampling, stereomicroscopy, µ-FTIR
(Peñalver et al., 2021)	Southeast Spain	May-Dec 2019	Air (roof)	PM10	PM10	33.45-39.40 ng/m3	n/a	only PS investigated, main source: agriculture	Active sampling, TGA-MS
(Vianello et al., 2019)	Aarhus, Denmark	Nov-Dec 2017	Indoor air	11 µm	median 21 or 36 µm for smaller and larger sizes	Average 9.3 ± 5.8 microplastic particles/m3 inhaled over 24 hours, range 1.7-16.2 particles/m3. In total, up to 272 microplastic particles were inhaled per day.	13% fibers, 87% fragments	4% synthetic particles: 81% PES, 6% PE, 5% PA, 2% PP, 6% others (e.g. PS, acrylates, PU, ...); 95% non-synthetic: 91% proteins, 4% cellulose	Active sampling through a doll simulating human breathing and indoor activities, µFTIR
(Gaston et al., 2020)	Californian coast, USA	Jan-Mar 2019	Air (outdoor and indoor air)	20 µm	Indoor air: fibers 641 µm; fragments 58.6 µm Outdoor air: fibers 616 µm (about 30% 100-300 µm; fragments 104 µm	Indoor air: 3.3 fibers/m3, 12.6 fragments/m3 Outdoor air: 0.6 fibers/m3, 5.6 fragments/m3	Fragments	Indoor air: PE, PET Outdoor air: PVC, acrylic	Active sampling, microscopy, fluorescence microscopy, µ-Raman, µ-FTIR
(Dris et al., 2017)	Paris, France	4 months 2015	Air (outdoor and indoor air) and roof deposition	50 µm	Fibers outdoor air < 1650 µm, indoor air larger <3250 µm	Outdoor air 0.9 (range: 0.3-1.5) fibers/m3 < indoor air 5.4 (range 0.4-59.4) fibers/m3 Deposition rate: 2.1-355 < Indoor air 1600-11'000 fibers/m2 per day	only fibers investigated	33% of fibers contained PET	Active and passive sampling, microscopy, µ-FTIR

Asia and Other Countries									
(Asrin, 2019)	Surabaya, Indonesia	2017	Air and street dust	1.6 µm	mainly: 1000 µm-1500 µm	Depending on location 132-175 particles/m3	> 90% fibers, remainder: fragments, films	PES, PET and cellophane (wood-based plastic) Sources: clothing, glass fiber, rubber fibers	Active sampling, digital microscopy, µ-FTIR
(Abbasi et al., 2019)	Asaluyeh, Iran	Aug. 2017	Air and street dust	2 µm	<100 - >1000 largest proportion air 2-100 µm dust 75% <100 µm	1 (0.3-1.1) particles/m3, 900 particles/15 g and 250 microrubber/15g	74% spheres, 14% films, microrubber consisted of 61% fragments and 35% fibers only one spherical particle	n/a	Passive and active sampling (TSP), microscopy, SEM-EDRS, and HPLC (oxidative potential)
(Narmadha et al., 2020)	Nagpur, Central India	Nov 2019-Feb 2020	Air	PM2.5, PM10	n/a	Residential area: 116.25 particles/day, Industrial area: 99.25 particles/day	Predominantly fibers, remainder: fragments, films More fragments in PM10, more films in PM2.5	PE, Rayon, rubber fibers, PS, PA, polyaniline, polyolefin, PVS. In residential area, cellulose fibers were dominant.	Active sampling, stereomicroscopy, FTIR, ATR and SEM
(Li et al., 2020)	Beijing, China	Oct. 2018	Air	3 µm	80% 5-20 µm, range 5-200 µm	14100-16700 fibers/m3	Fibers	MP-fibers 34.6%, MMMFs 40.3%, calcium sulfate fibers 7.2%, natural fibers 4.5%, asbestos 7.8%, metal fibers 5.6%	Active sampling, SEM-EDRS
(Liao et al., 2021)	Wenzhou, China	Jul-Aug 2019	Air	5 µm	5-1794 µm (< 30 µm: 65.1% 30-100 µm: 29.4%)	188.7 particles/m3	5.8% fibers, 94.2% fragments	> 20 polymer types in 738 MP: PE 26.8%, PS 17.8%, PES 17.2%	Active sampling, microscopy, µ-FTIR
(K. Liu, T. Wu, et al., 2019)	Eastern Chinese Sea-West Pacific	Nov 2018-Jan 2019	Air over sea	12 µm	Range: 16.14-2086.69 µm, average: 318.53 µm	Range: 0-1.37 particles/m3, day>night, coast>open sea	60% fibers, 31% fragments, 8% granules, 1% microbeads	PET 57%, epoxy resin 10%, PE-PP 10%, others: PES, alkyd resin, EP, PA, PAN, Phe, PMA, PP, PS, PVA, PVC	Active sampling, stereomicroscopy, µ-FTIR
(Zhu et al., 2021)	5 major cities in China: Beijing, Tianjin	Aug-Sep 2019	Air	5.9 µm	Range 5.9-1475 µm, 61.6% < 30µm	Range: 104-650 particles/m3, average 282 particles/m3 North>Southeast	88.2% fragments, different shares depending on size 98.4% 5-30 µm, 79.1% 30-100 µm Fibers dominated larger particles 80% 100-300 µm, 86.6% 300-1000 µm	PE, 26.6%, PET 16.0%, PS 14.9%, PP, 13.6%, PA, 7.3%, PVC, 6.6%	Active sampling, microscopy, µ-FTIR
(K. Liu, X. Wang, T. Fang, et al., 2019)	Shanghai, China	Mar-Apr 2018	Air	12 µm	Range: 23.07-9955 µm, Average: 597.5 µm at 1.7m height	Range: 0-4.18 particles/m3, average: 1.42 particles/m3	72% fibers, 27% fragments, 1% granules	Non-fibers: 49% PET, PE and PES; PAN, PAA (12%), RY 9%, EVA 15%, EP, alkyd resin Fibers: Synthetic PET 50%, PAN 17%, PAA	Active sampling, stereomicroscopy, µ-FTIR

								17%, RY 2%, PES 46% cotton and silk)	
(K. Liu, X. Wang, N. Wei, et al., 2019)	Shanghai, China	May-Jun 2019	Air	12 µm	246.52 (range 12.35-2191.32) µm	Average: 0.41 (range: 0-2) particles/m3 Deposition rate: 450'000 (range: 9940-650000) particles/m2 per day	42% fibers, 48% fragments, 9% beads	PET (51%), EP (19%), PE (12%), and alkyd resin (8%); PET-fibers (87%)> PE > Rayon	Active sampling, stereomicroscopy, µ-FTIR
(Choi et al., 2022)	South Korea	Jun, Sep, Dec 2020	Air (outdoor and indoor air)	20 µm	Indoor air: 20.1-6801.2 µm Outdoor air: 20.3-4497.4 µm Size 20-100 µm made up 48-96%	Range 0.45-6.64 particles/m3, Indoor air> Outdoor air: 7% or 2% of all particles	Only 7% fibers, rest: fragments and others Indoor air 10.2% fibers, outdoor air 3.6%	65%: PE and PP, rest: PA, PES, AR, PS	Active sampling FTIR
(Wang et al., 2020)	Pearl River delta to South China Sea and East Indian Ocean	Mar-Apr 2019	Air	20 µm	Fibers: 288.20-2251.54 µm Fragments: 58.59-286.10 µm	Range: 0-7.7 particles/100m3, average: 1 particle/100m3	88.89% fibers, 11.11% fragments	77% natural origin (cotton, cellulose, rayon (50%) cellophane), 21% plastic (PE, PET, PP, others like epoxy resin, PAN, PAA, PEP, PEVA, PA)	Active sampling, µ-FTIR
(Kaya et al., 2018)	Sakarya Province, Turkey	Dec 2016-May 2017	Air and deposition (street)	50 µm	50-500 µm	0.3-12.9 particles/l and 18-29 particles/g	Majority fibers, 1/4 fragments	mainly PA and PES	Active sampling, light microscopy, µ-FTIR with infrared spectroscopy
(Syafei et al., 2019)	Surabaya, Indonesia	n/a	Air and deposition (roadside)	500 µm	<500 to 1500 µm	Range: 55.9-175 particles/m3, 58 fibers/m3	majority fibers, some fragments and film	PET, PES, cellophane, majority of polymers was film (cellophane, 58.3%)	Active sampling, digital microscopy, FTIR

Abbreviations: **AR**, Acrylic; **ATR**, attenuated total reflection; **BW**, cotton; **CPE**, chlorinated polyethylene; **EP**, ethylene propylene; **EVAC**, ethylene vinyl acetate copolymer; **FTIR**, Fourier transform infrared spectroscopy; **g**, gram; **ICP-MS**, inductively coupled plasma mass spectrometry; **(HP)LC-MS/MS**, liquid chromatography with mass spectrometry coupling; **n/a**, data/information; **MP**, microplastic; **µg,** microgram; **µm**, micrometer; **m**, meter; **m3**, cubic meter; **MMMF**, man-made mineral fibers; **ng**, nanogram; **PA**, polyamide; **PAA**, poly-N-methylacrylamide; **PAN**, polyacryl; **PE**, polyethylene; **PEP**, polyethylene-co-propylene; **PES**, polyester; **PET**, polyethylene terephthalate; **Phe**, phenoxy resin; **PM2.5**, particles with size ≤ 2.5 µm; **PM10**, particles with size ≤ 10 µm; **PM10-2.5**, particles with size 2.5-10 µm; **PMA**, polymethyl acrylate; **PMMA**, polymethyl methacrylate; **PP**, polypropylene; **PS**, polystyrene**; PU(R)**, polyurethane**; PVA(C)**, polyvinyl acetate; **PVC**, polyvinyl chloride; **PVS**, polyvinyl stearate**; Py-GC/MS**, pyrolysis with gas chromatography and mass spectrometry; RY, rayon; SEM, scanning electron microscopy; SEM-EDRS, energy dispersive X-ray spectroscopy; **TGA-MS,** thermogravimetry with mass spectrometry; **TSP**, total suspended particulates.

*Results of studies that have measured the **deposition of microplastics** with a focus on outdoor air samples or in combination with indoor air samples.*

Reference	Location / Country	Year	Sample type	Lower detection limit	Particle Sizte	Deposition rate	Shape	Plastic or polymer types	Analytical method
(Allen et al., 2019)	Pyrenees, France	Nov 2017-Mar 2018	Outdoor air	1 µm	Majority > 50 µm Fiber length predominantly 100-200 µm and 200-300 µm (max. 3000 µm), Films: 50-200 µm --> max. up to 3000 µm	Deposition rate: 365 (297-162) particles/m² per day	Fragments > Fibers > Films	PS (as fragments), followed by PE	Passive sampling, light microscopy, µ-Raman
(Sommer et al., 2018)	High-trafficed roads, Germany	2013	Outdoor air, road dust	> 10 µm	n/a	Tire wear particles predominant among measured particles (<90% of volume)		MP = 54% volume	Passive sampling, SEM-EDRS
(Wright et al., 2020)	Central London, UK	Jan-Feb 2018	Outdoor air, roof	20 µm	Fibers: 400–500 µm most frequent, number of fibers increased with decreasing length Fragments: 164 µm average, 75-100 µm most frequent	712 fibers/m² per day, 59 non-fibers/m² per day	Fibers	17% of fibers synthetic: mainly PAN, PET, PA. 69% of fibers cellulose	Passive sampling, fluorescence microscopy, µ-FTIR, µ-Raman
(D. Allen et al., 2021)	Lake Arbu, Central Pyrenees; France	Summer 2017	Outdoor air, soil	20 µm	In soil: over half ≤30 µm, more recently more smaller particles ≤20 µm Fibers 20-200 µm (predominantly 100-150 µm)	1960s: <5 (±1) particles/m² per day 2015-2020: 178 (±72) particles/m² per day	Fibers, fragments	16% PE, 28% PP, 8% PS, 10% PVC, 28% PET/PES	Passive sampling, fluorescence microscopy, µ-Raman
(Brahney et al., 2020)	11 National Parks, Western USA	2017-2019	Outdoor air	10 µm	Particles 4-188 µm, of which 30% microbeads 5-30 µm, fibers 20 µm-3 mm	Deposition rate: 132 (range: 48-435) particles/m² per day	30% microbeads	Cotton, PES, nylon, polyolefin, PET, PE, Valbond 6053, PP, PVAC/latex, ethyl acrylate, PMMA	Passive sampling, microscopy, FTIR
(Dehghani et al., 2017)	Tehran center, Iran	2015 ?	Outdoor air, road dust	50 µm	100 µm - 5 mm	88-605 particles per/30 g dry house dust	16.9-44.3% fibers,	n/a	Passive sampling, fluorescence

Reference	Location / Country	Year	Sample type	Lower detection limit	Particle Sizte	Deposition rate	Shape	Plastic or polymer types	Analytical method
					33.7% of counted plastic particles 250-500 µm		granules, fragments		microscopy, SEM-EDRS
(Patchaiyappan et al., 2021)	Chennai, India	May 2019	Outdoor air, road dust	50 µm	n/a	227.94 ± 91.37 particles/100 g	92.5% fragments, 7.5% fibers	24% PVC, 19% cellulose, 14% PTFE, 14% Superflex 200	Passive sampling, Raman spectroscopy, SEM-EDS
(C. G. Liu et al., 2019)	China (39 cities)	Nov 2017-Jan 2018	Outdoor air (windowsill) + indoor air (bedroom)	50 µm	50-2000 µm	Indoor air: PET 1550-120,000 mg/kg, median 2780 mg/kg, PC 4.6 mg/kg Outdoor air: PET 212–9020 mg/kg, PC 2.0mg/kg	Indoor air: 88.0% Outdoor air: 73.3% fibers, also granules	PET and PC	Passive sampling, microscopy, µ-FTIR, LC-MS/MS
(Dris et al., 2016)	Paris, France	2015	Outdoor air, roof	50 µm	Fibers 200–400 µm and 400–600 µm most frequent	Deposition rate: depending on location 53-110 (range: 2-355) particles/m² per day	Only fibers investigated	50% natural fibers (cotton/wool), 29% artificial fibers	Passive sampling, stereomicroscopy, µ-FTIR
(Dris et al., 2015)	Paris, France	Feb-May 2014	Outdoor air, roof	100 µm	Fibers 100-5000 µm (1000-5000 µm most frequent)	Deposition rate: 118 (range: 29-280) particles/m² per day	90% fibers, remainder: fragments and film	n/a	Passive sampling, stereomicroscopy
(Zhou et al., 2017)	Yantai, Shandong Province, East China	Jan 2014-Mar 2015	Outdoor air	50 µm	Range: 50-5000 µm, largest proportion (62%) of <0.5mm particles was 100−300 µm, <50 µm lowest frequency	Not reported	95% fibers, 4% fragments, +% films and foams	Mainly PET as fibers, PVC as fibers and films, PE as fragments, PS as foams	Passive sampling, stereomicroscopy, FTIR
(Amato-Lourenço et al., 2022)	São Paulo, Brazil	2020 ?	Outdoor air / indoor air	50 µm	>50 µm	Deposition rate average Indoor air: 309.40±214.71 particles/m² per day, Outdoor air: 123.20 ± 47.09 particles/m² per day	Indoor air: 64% fragments, Outdoor air: 74% fragments	Outdoor air: 76% PES fibers, 67% PE, 25% PET Indoor air: 100% PES fibers, 59% PE, 26% PP	Passive sampling, microscopy, FTIR

Reference	Location / Country	Year	Sample type	Lower detection limit	Particle Sizte	Deposition rate	Shape	Plastic or polymer types	Analytical method
(Soltani et al., 2021)	Sydney, Australia	2019	Indoor air	50 µm	50 – 600 µm	22-6169 fibers/m² per day = 0.2 mg per kg body weight per year, 12,891 (SD 4472) fibers/year	99% fibers	39% were plastic fibers: PE, PES, PA, PAA, PVC and PS	Passive sampling, stereo- and fluorescence microscopy, µ-FTIR
(Klein & Fischer, 2019)	Hamburg, Germany	Dec 2017-Mar 2018	Outdoor air	63 µm	Fibers 95% 300-5000 µm, fragments <63 µm	Deposition rate: 275 (136.5-512) particles/m² per day	Depending on size: 95% fragments <63 µm, majority fibers 300-5000 µm	49% PE, 22% EVAC, only 1 fragment identified as Teflon PTFE and PVA. All fibers (9.8%) were synthetic origin and PET	Passive sampling, fluorescence microscopy, Gamma-Raman
(O'Brien et al., 2021)	Queensland, Australia	Apr-Jun 2020	Road dust	100 µm	<250-5000 µm 25% of mass (largest proportion) consisted of particles <250 µm	Rural: 0.5 mg/g, rural residential: 0.8 mg/g, traffic: 1.2 mg/g, industrial: 2.4 mg/g, urban: 5.9 mg/g	n/a	Polyethylene 21%, most frequent therein PVC 29% and PET 29%, PP 10%, PMMA 7.6%, PS 1.1%	Passive sampling, Py-GC/MS, no tire wear
(Yukioka et al., 2020)	Kasatsu, Japan, Dang Nang Vietnam, Kathmandu Nepal	Sep-Nov 2017	Road dust	100 µm	100-5000 µm Average 791-1400 µm	2.0-19.7 particles/m²	68-81% fragments, 8-13% films, 7-10% fibers, 4-10% granules	PE, PP, PS, PET, PAK, PVS, EPC, SBR, EPDM, PU More rubber particles than packaging particles	Passive sampling, stereomicroscopy, FTIR
(Stanton et al., 2019)	Stoke-on-Trent, Nottinghamshire, UK	Nov 2017-Jul 2018	Outdoor air, roof	150 µm	n/a	Deposition rate: 2.90-128.42 particles/m² per day	100% fibers	2.1% synthetic (97.7% natural)	Passive sampling, stereomicroscopy, FTIR
(Cai et al., 2017)	Dongguan, South China	Oct-Dec 2016	Outdoor air	200 µm	<200 to >4200 µm	36 ± 7 particles/m² per day (microplastics only)	Fibers > foams, fragments, films	73% cellulose fibers, 14% PE, 9% PP, 4% PS	Passive sampling, microscopy, µ-FTIR, SEM

Abbreviations: **EP**, Ethylene propylene; **EPDM**, Ethylene-propylene-diene; **EVAC**, Ethylene-vinyl acetate copolymer; **FTIR**, Fourier-transform infrared spectroscopy; **g**, gram; **(HP)LC-MS/MS**, Liquid chromatography with mass spectrometry coupling; **kA**, no data available; **kg**, kilogram; **MP**, microplastic; **µm**, micrometer; **m**, meter; **m3**, cubic meter; **mg**, milligram; **PA**, polyamide; **PAA**, Poly-N-methylacrylamide; **PAN**, polyacryl; **PAK**, polycyclic aromatic hydrocarbons; **PC**, polycarbonate; **PE**, polyethylene; **PES**, polyester; **PET**, polyethylene terephthalate; **PMMA**, polymethyl methacrylate (Plexiglas); **PP**, polypropylene; **PS**, polystyrene; **PTFE**, polytetrafluoroethylene; **PU(R)**, polyurethane; **PVA(C)**, polyvinyl acetate; **PVC**, polyvinyl chloride; **PVS**, polyvinyl stearate; **Py-GC/MS**, pyrolysis with gas chromatography and mass spectrometry; **SBR**, styrene-butadiene rubber; **SEM**, scanning electron microscopy; **SEM-ED(R)S**, energy-dispersive X-ray spectroscopy or energy-dispersive X-ray analysis.

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