

Microplastic Particles in Personal and Indoor Air

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Key Findings

1. The mean breathing-zone concentration of MPs among participants wearing polyester T-shirts was 1,957 particles/m³—42% higher than when they wore cotton T-shirts and 40% higher than the concentration measured in bedroom air.
2. Most detected MPs (67%–77%) were smaller than 300 µm.
3. Almost all the identified MPs (>99%) were polyethylene terephthalate (PET) fibers.

Conclusion: Personal exposure to airborne microplastic particles was dominated by small PET fibers and was substantially higher when participants wore polyester T-shirts.

Sampling and analysis methods

The sampling program included ten participants for personal and indoor air sampling. For each participant, a 12-hour personal sample was collected during active daytime hours while the participant wore a 100% cotton T-shirt. The sampling procedure was then repeated with the same participant wearing a polyester T-shirt. In addition, a 12-hour indoor sample was collected in each participant's bedroom during sleeping hours. In addition, one field blank and two duplicate indoor samples were collected for quality control.

Airborne particles were collected using an Ultrasonic Personal Air Sampler (UPAS v2.1, Access Sensor Technologies, Fort Collins, Colorado, USA) equipped with an open inlet. For personal sampling, the sampler was fixed on the chest or arm using an appropriate harness. For indoor sampling, the sampler was fixed on the top of a tripod in the center of the room. Particles were collected on 37-mm quartz fiber filters. The flow rate was 1 L/min, and the nominal sample volume was 0.720 m³ per sample for a 12-hour sampling duration.

MPs collected on the filters were identified and morphologically characterized by micro-Fourier-transform infrared spectroscopy (μ -FTIR) using a Thermo Scientific Nicolet iN10 MX imaging microscope with OMNIC Picta software.

Estimated concentration was calculated as the observed 30%-filter particle count divided by 0.30 and then by 0.720 m³.

Results

Concentrations of MPs in personal and indoor air

Personal-mixed samples had the highest mean concentration (1,957/m³) and a median concentration of 1,806/m³ (IQR: 990-2,772). Bedroom-Mixed and Personal-Cotton means were similar at 1,394 and 1,381/m³, respectively. The Personal-Mixed mean was approximately 40% higher than the Bedroom-Mixed mean and 42% higher than the Personal-Cotton mean, although variability was also greatest in Personal-Mixed samples.

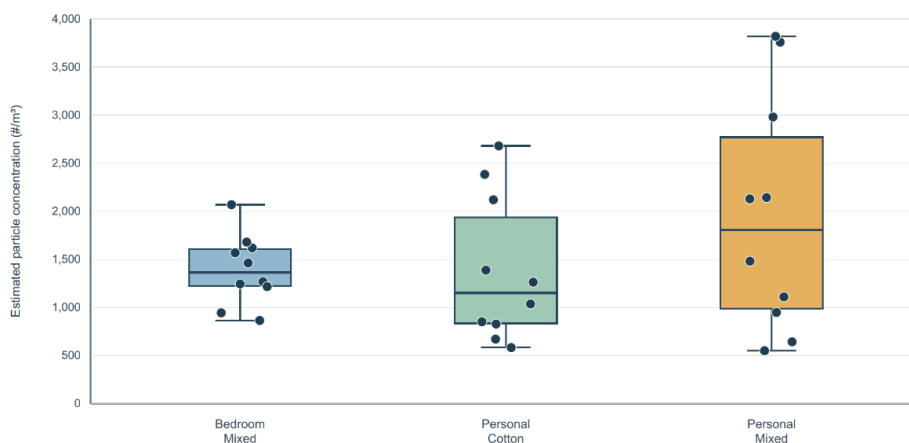


Figure 1: MP concentrations (#/m³) by sample type. Boxes show the median and interquartile range; points represent individual samples.

Fragments contributed to a higher mean concentration than fibers in every group. Mean fragment and fiber concentrations were 718/m³ and 677/m³ in Bedroom-Mixed samples, 762/m³ and 619/m³ in Personal-Cotton samples, and 1,191/m³ and 766/m³ in Personal-Mixed samples. The greatest morphology-specific burden was therefore observed for fragments in the Personal-Mixed group.

Table 1: Estimated particle concentration stratified by sample group and morphology

Sample group	Morphology	Mean concentration (SD) (#/m ³)	Median concentration (IQR) (#/m ³)
Bedroom - Mixed	Fiber	677 (183)	660 (596-773)
Bedroom - Mixed	Fragment	718 (213)	708 (583-877)
Personal - Cotton	Fiber	619 (364)	493 (368-859)
Personal - Cotton	Fragment	762 (403)	664 (466-1,079)
Personal - Mixed	Fiber	766 (505)	664 (426-1,179)
Personal - Mixed	Fragment	1,191 (725)	1,086 (564-1,620)

Particle-size distribution

The dominant size band differed by sample group. The 150-300 µm band contributed the greatest average concentration in Bedroom-Mixed and Personal-Cotton samples at 606/m³ (44%) and 590/m³ (43%), respectively. In Personal-Mixed samples, the 0-150 µm band was dominant at 841/m³ (43%), followed by 150-300 µm at 665/m³ (34%). Thus, the higher Personal-Mixed burden was driven primarily by the smallest particles.

Table 2: Average estimated concentration and pooled particle-size distribution within each primary sample group

Size category (µm)	Bedroom-Mixed	Personal-Cotton	Personal-Mixed
0-150	327 (23.4%)	418 (30.2%)	841 (43.0%)
150-300	606 (43.5%)	590 (42.7%)	665 (34.0%)
300-450	257 (18.5%)	222 (16.1%)	249 (12.7%)
450-600	98 (7.0%)	71 (5.2%)	95 (4.8%)
>600	106 (7.6%)	81 (5.8%)	107 (5.5%)
Total	1,394 (100%)	1,381 (100%)	1,957 (100%)

Morphology-specific size patterns

Personal-Mixed fragments in the 0-150 µm band contributed 615/m³ and represented 51.7% of fragments in that group, compared with 225/m³ and 29.4% among Personal-Mixed fibers. In contrast, larger particles were more prominent among fibers; for example, particles >600 µm represented 13.6% of Bedroom-Mixed fibers but only 1.9% of Bedroom-Mixed fragments.

Figure 2: Average MP concentrations ($\#/m^3$) stratified by morphology and size category.

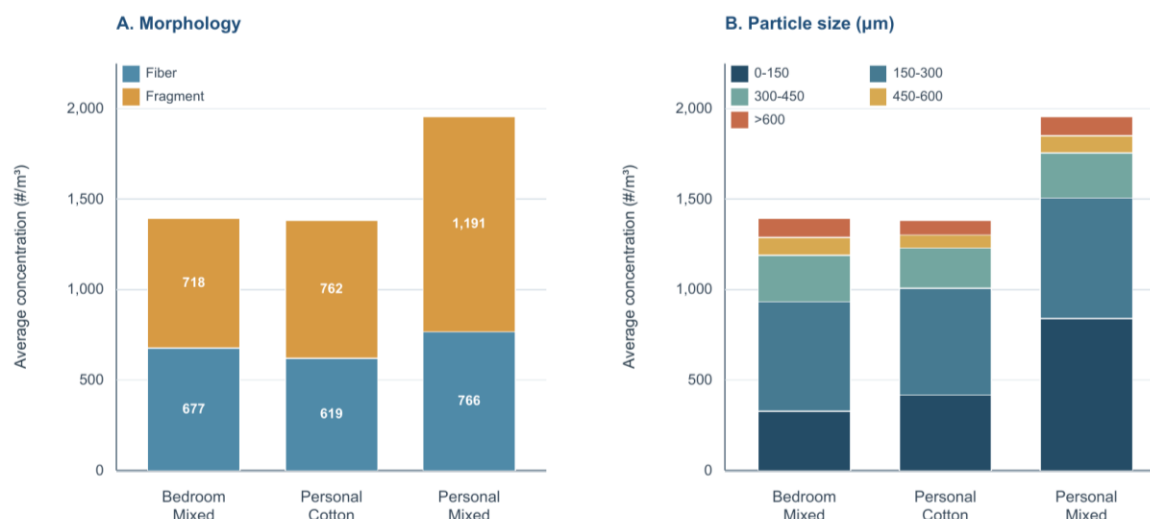


Table 3: Average estimated concentration by particle size within morphology and sample group

Sample group	Morphology	0-150	150-300	300-450	450-600	>600	Total
Bedroom - Mixed	Fiber	88 (12.9%)	277 (41.0%)	150 (22.1%)	70 (10.4%)	92 (13.6%)	677 (100%)
Bedroom - Mixed	Fragment	239 (33.4%)	329 (45.8%)	108 (15.0%)	28 (3.9%)	14 (1.9%)	718 (100%)
Personal - Cotton	Fiber	125 (20.2%)	253 (40.8%)	127 (20.5%)	45 (7.3%)	69 (11.2%)	619 (100%)
Personal - Cotton	Fragment	293 (38.4%)	337 (44.3%)	95 (12.5%)	26 (3.4%)	11 (1.5%)	762 (100%)
Personal - Mixed	Fiber	225 (29.4%)	282 (36.9%)	127 (16.6%)	54 (7.0%)	77 (10.1%)	766 (100%)
Personal - Mixed	Fragment	615 (51.7%)	382 (32.1%)	122 (10.3%)	41 (3.5%)	30 (2.5%)	1,191 (100%)

FTIR component assignments

The micro-FTIR component field was overwhelmingly classified as PET fiber across all sample groups. Average PET-fiber concentrations were $1,387/m^3$ in Bedroom-Mixed samples, $1,369/m^3$ in Personal-Cotton samples, and $1,946/m^3$ in Personal-Mixed samples. PET fiber accounted for 99.47%, 99.13%, and 99.46% of particles in these groups, respectively, and 99.36% overall.

Table 4: Average estimated concentration and pooled percentage by FTIR component and sample group

Component assignment	Bedroom-Mixed	Personal-Cotton	Personal-Mixed	Overall
PET fiber	1,387 (99.47%)	1,369 (99.13%)	1,946.3 (99.46%)	1,567.4 (99.36%)
Cellulose Acetate	4.6 (0.33%)	5.1 (0.37%)	5.6 (0.28%)	5.1 (0.32%)
crumb rubber	2.3 (0.17%)	6.0 (0.44%)	4.6 (0.24%)	4.3 (0.27%)
PA66	0.5 (0.03%)	0.5 (0.03%)	0.5 (0.02%)	0.5 (0.03%)
R-PET	0.0 (0.00%)	0.5 (0.03%)	0.0 (0.00%)	0.2 (0.01%)
Total	1,394.4 (100%)	1,381.0 (100%)	1,956.9 (100%)	1,577.5 (100%)

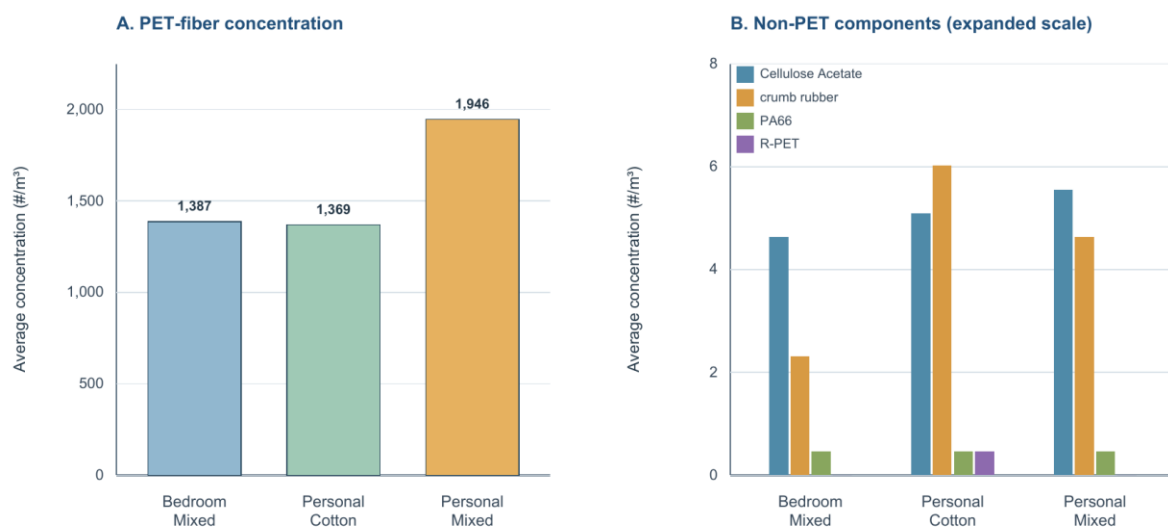


Figure 3: Average estimated FTIR component concentration ($\#/m^3$) by sample group. Panel B uses an expanded scale to display the rare non-PET assignments.