Greenpeace Research Laboratories Technical Report

Microplastic fibres and fragments in a composite sample of indoor and outdoor air, Geneva, Switzerland, July 2025

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Introduction

A growing body of evidence points to the widespread presence of airborne microplastics in the environment, including in indoor and outdoor settings. The evidence is international and includes observations made in a variety of settings. Examples of the abundances of airborne microplastics observed in some recent studies (the majority so far conducted outdoors) are presented in Table 1.

As a result of their presence as contaminants in air, humans can be exposed to microplastic fibres and fragments when breathing normally. Understanding of the health implications from inhalation of microplastics remains at an early stage. As a result, there is currently no widely recognised health-based standard for air quality with respect to suspended microplastics.

The second part of the fifth session of the Intergovernmental Negotiating Committee to develop an international legally binding instrument on plastic pollution under the United Nations (INC-5.2) is taking place from 5 to 14 August 2025 at the Palais des Nations in Geneva, Switzerland. In the context of this meeting, a small experiment was designed to measure the abundance of airborne microplastics in a single composite sample of air collected over an 8 hour period across a variety of indoor and outdoor public spaces in Geneva. Given that microplastics have already been reported as contaminants in both indoor and outdoor environments internationally, the intention of this work was more to illustrate the commonality of exposure by investigating the extent to which an individual can be exposed to microplastics suspended in the air during a routine day in the city, rather than to make a more representative statistical assessment of their presence in the study area.

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Table 1. Typical counts, sizes and concentrations (Indoor air samples shown in **bold**)

Location	Microplastics/m^3	References
Wenzhou, Eastern China	189 ± 85	(Liao et al., 2021)
Wenzhou, Eastern China	**1583 ± 1180**	(Liao et al., 2021)
Ahvaz City, Iran	0–0.017	(Abbasi et al., 2023)
Beijing, China	4500–7200	(Li et al., 2020)
Paris, France	**1–60**	(Dris et al., 2017)
Paris, France	0.3–1.5	(Dris et al., 2017)
Shanghai, China	1.42 ± 1.42	(P. Liu et al., 2019)
Surabaya, Indonesia	55.93–174.97	(Syafei et al., 2019)
West Pacific Ocean	0–1.37	(K. Liu et al., 2019)
Tempe, USA	0.2 (0.02–1.1)	(Chandrakanthan et al., 2023)
International literature review	<1 to >1000	(O'Brien et al., 2023)
International literature review	**<1-1583 (± 1181)**	**(O'Brien et al., 2023)**

Methodology

A sample of suspended atmospheric particles was collected over a continuous period of 8-hours in Geneva, Switzerland on 17th July 2025, using a Thermo Scientific pDR-1500 optical particle counter as a personal air sampling device to collect total suspended particles. The sample was then returned to the Greenpeace Research Laboratories at the University of Exeter (UK) for analysis using a combination of optical and Fourier-Transform-Infrared (FT-IR) microscopy to determine the presence and abundance of microplastics and other synthetic and semi-synthetic materials (fibres and fragments).

The pDR-1500 allows for the use of a replaceable particle filter which is designed to collect airborne particles for subsequent analysis. For the purposes of this study, the usual glass fibre filter was replaced with a silver membrane filter (Sterlitech, 37mm diameter, 5 µm pore size) to enable subsequent direct analysis of the particles (fibres and fragments) collected on the filter surface using infrared (FT-IR) microscopy. In addition, to prevent the build up of static around the filter during sample collection, which can otherwise interfere with the collection of plastic fragments and fibres on the filter surface, the usual plastic filter holder was replaced with a specially manufactured brass filter holder.

The single composite sample was collected across a range of indoor and outdoor environments in central Geneva (Table 2). A map showing the approximate locations of the indoor environments visited during sampling is provided in Figure 1. Locations were selected with the intention that the sample represents a possible 'day in the life' of a Geneva resident or visitor. It included environments representing the workplace (office and co-working space), leisure (cafe and restaurant), shopping (clothes store) and travel (Public transport and walking). As noted above, this composite sample is therefore intended as an illustration of possible exposure to airborne microplastics across a variety of settings, and not as a generalisable sample for use characterising typical daily exposures in Geneva.

During sampling the pDR-1500 was positioned on the chest of the operator close to the breathing zone. When the operator was seated it was placed onto an appropriate desk or table, but remained close to the operator.

Table 2. Sampling location details.

Time	Location	Approximate duration	Description
9:30	Greenpeace Switzerland office	0:05	Indoor office environment
9:35	Street	0:05	Outdoor pedestrian
9:40	Public Transport (Bus)	0:10	Indoor vehicle cabin
9:50	Co-working space	1:10	Indoor office environment
11:00	Railway station main hall	0:15	Indoor public space
11:15	Public Transport (Tram)	0:05	Indoor vehicle cabin
11:20	Clothes shops	1:00	Indoor commercial environment
12:20	Public Transport (Tram)	0:15	Indoor vehicle cabin
12:35	Restaurant	1:15	Indoor restaurant
13:50	Cafe	1:20	Indoor cafe
15:10	Street	0:10	Outdoor pedestrian
15:20	Public Transport (Tram)	0:15	Indoor vehicle cabin
15:35	Indoor shopping centre (Supermarket)	0:10	Indoor commercial environment
15:45	Indoor shopping centre (Electronics, entertainment)	0:30	Indoor commercial environment
16:15	Indoor shopping centre (Cafe)	1:00	Indoor cafe
17:15	Public Transport (Tram)	0:15	Indoor vehicle cabin
17:30	Street	0:10	Outdoor pedestrian
17:40	Greenpeace Switzerland office	0:05	Indoor office environment

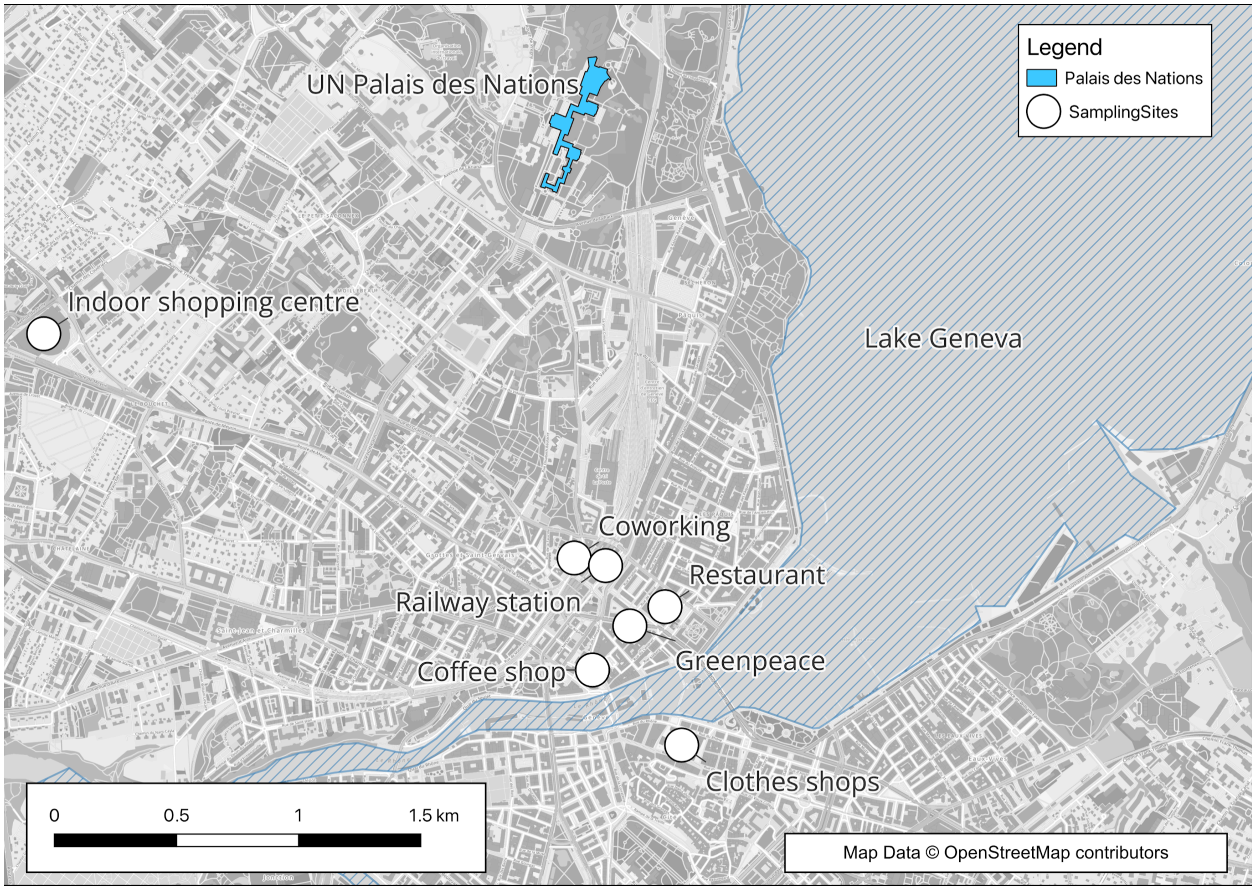

Figure 1. Approximate locations of the indoor environments visited during sampling

Silver filters were prepared in advance at the Greenpeace Research Laboratories, in a laboratory held under slight positive pressure and which receives filtered air. All surfaces in a 1 m^2 work area were cleaned with 5 µm filtered ethanol and lint-free tissues prior to filter preparation. Each silver filter used in the study was carefully inspected under a dissecting light microscope at low and high magnification in order to verify that the surfaces were free from any visible particles (>10 µm). In order to provide further protection for the surfaces of the filters before sample collection, and to protect the integrity of the samples after collection, a second verified-clean silver filter was placed upside down on the surface of the first in each case. Each set of two filters was wrapped in clean aluminum foil (which had been subject to the same level of inspection and verification as the filters) using steel forceps (cleaned with ethanol and inspected for cleanliness under high magnification) before being placed into small glass petri dishes (also subject to the same cleaning and inspection protocols) and wrapped in a further layer of clean foil.

In further preparation for sampling, the pDR-1500 air sampling device was run for 10 minutes at a flow rate of 3.5 l per minute in the laboratory with a HEPA filter in line upstream from the optical particle counting chamber and with a conventional glass fibre filter in the filter holder chamber after the counting chamber. This was done in order to flush any remaining particulates from previous use of the instrument out of the optical counting chamber and on to the glass fibre filter using HEPA-filtered air. The brass filter holder was then removed from the device, the glass fibre filter

discarded, the brass rings of the filter holder cleaned with filtered ethanol and inspected under the dissecting microscope to verify the cleanliness of all surfaces. The inner surfaces of the pDR-1500 filter chamber were cleaned using lint-free tissues soaked in ethanol, before the brass filter holder was reinstalled, holding a fresh, clean glass fibre “keeper” filter to protect the instrument during transit. A layer of clean foil was used around the pDR-1500 instrument itself to prevent passive contamination of the optical chamber and, thereby, the sample chamber during transit.

At the sampling location, working on a fresh sheet of aluminium foil in a clean, indoor area, the brass filter holder was removed from the instrument, the glass fibre filter removed and replaced with the lower of the two silver filters from one of the petri dishes using clean steel forceps that had been prepared in the laboratory and wrapped in foil. The filter holder was immediately reinstalled into the pDR-1500 to minimise contamination. While installing the silver filter, the operator took the following precautions to prevent contamination; they wore clothing made from natural fibres, hands were washed prior to handling filters and dried with an air-drier, gloves were not worn (as these have been found in previous trials to attract particles of dust to the hands during use). The outer surface of the pDR-1500 and all tools were cleaned with a lint-free lens cleaning tissue prior to handling the sample filter. All equipment and silver filters were kept wrapped in aluminum foil when not in use.

Airborne particles were then collected over a continuous 8-hour period. The flow rate was 3.5 L/min, giving a total sample volume of 1.7 m^3. Upon completion of the sampling, back at the same location at which it had been installed, the silver filter was carefully removed from the filter holder, placed in the foil in which it was initially wrapped, covered with the same clean capping filter and the two filters together were wrapped in the aluminium foil and petri dish layers as it had been prior to sampling. The sample was then transported to our laboratory for analysis as described below

As a field blank to control for accidental passive contamination of the filter surfaces during handling, the lower filter of a second set of cleaned silver filters was inserted into the brass filter holder in the same way as the filter used for sampling. The filter holder was installed into the pDR-1500 as above and then removed again after 10 minutes without the device having been turned on. Once again, this filter was covered with its capping filter, repackaged and returned for analysis.

On receipt at the Greenpeace Research Laboratories, working in the same pre-cleaned area, both the sample filter and capping filter were transferred to cleaned, verified brass filter holders and carefully wrapped in fresh, verified-clean aluminium foil. The filter surfaces were then immediately inspected under the light microscope, at both a low and high magnification, to locate all the visible fibres and fragments that had been collected. As some of the particles had transferred from the lower (sample) filter to the upper (capping) filter during transit, as was expected, both filters now formed the entirety of the sample.

The position of every visible fibre and fragment was marked on each filter using a light scratch of the silver membrane surface with a fine dissecting needle, in order to prevent double counting and to aid their subsequent location for analysis under the

infrared microscope. This approach also ensured that any fibres or fragments that subsequently appeared on the filters, in positions other than those marked in the first inspection, could be excluded from the analysis. In practice, only one small fibre, which had deposited at the edge of one of the filters post-mark-up, had to be rejected from the analysis.

All located fibres and fragments were photographed individually under a Leica dissecting light microscope immediately after mark-up in order to record their locations and for subsequent determination of their dimensions.

Individual fibres and fragments were subsequently examined using a PerkinElmer Spotlight 400 FT-IR Imaging System (MCT detector, KBr window) initially operating in reflectance mode across a wavenumber range from 4000 to 750 cm^{-1} and with a resolution of 4 cm^{-1}. This method allows the investigation of microplastic fragments and fibres measuring approximately 10 µm and above in each dimension.

A total of between 4 and 16 spectral scans were collected for each fragment and from at least two sections of each candidate fibre. The infrared spectra were acquired, processed and analysed using PerkinElmer Spectrum software (version 10.5.4.738), with polymers being identified by a combination of automated matching against a number of commercially available spectral libraries (including both polymers and additives) and expert judgment to verify the quality of the proposed matches with reference to the locations and relative areas of specific diagnostic peaks in the spectra. Only those fibres and fragments yielding match qualities greater than 70%, and for which the quality of the match could then be verified by the analyst as described above, were accepted as having been positively identified.

Fibres or fragments yielding lower match qualities, or for which the analyst rejected the initial >70% identification on visual inspection of the spectral match, were initially recorded as “unidentified”. In these cases, wherever it was physically possible, each fibre or fragment was transferred individually from the filter surface to a diamond compression cell (pre-cleaned with ethanol and lint-free tissues), using a fine dissecting needle to lift and place the particle and working under a dissecting microscope at a range of magnifications. The fibre or fragment was then compressed between the diamond windows to enable its re-analysis on the FT-IR microscope in transmittance rather than reflectance mode (i.e. passing the infrared light through the sample rather than detecting reflected infrared wavelengths from the sample surface). Although a slower and more complex procedure, the recording of transmittance spectra can often help achieve higher match qualities than reflectance spectra because of the light scattering and interference from surface contamination that can influence reflectance mode. The same acceptance criteria as for reflectance spectra were applied in all cases.

Figure 2 illustrates some of the equipment used for sample processing and analysis, including the PerkinElmer Spotlight 400 FT-IR microscopy system used for the identification of all fibres and fragments, initially in reflectance mode, and a diamond compression cell used with the same system where it was necessary to confirm identities using transmittance FT-IR.

During the laboratory analysis filters were kept covered in petri dishes and with fresh aluminium foil when not in use, cotton lab-coats were worn throughout sample handling, and work areas on benches and microscopes were cleaned with ethanol and lint-free tissues immediately before each procedure.

Both a field blank filter (see above) and two laboratory blank filters were included in the analysis. Laboratory blank filters were verified-clean silver filters placed in verified-clean glass petri dishes on the bench adjacent to both the dissecting light microscope and FT-IR microscope during sample handling, to verify that there was minimal or no deposition of fibres or fragments from the air during analysis. Field and laboratory blank filters were analysed in the same way as the main sample filters.

Figure 2. Left: The PerkinElmer Spotlight 400 FT-IR microscopy system used for FT-IR analysis and Right) a diamond compression cell used for transmittance FT-IR microscopy where necessary to confirm identities.

Results

In total more than 165 fibres and fragments measuring 10 µm and above, were detected on the sample filter and capping filter combined using the dissecting light microscope to inspect the entire filter surfaces at both low and high magnification. Of these, 94 were fragments and 71 were fibres. All were analysed under the FT-IR microscope, initially in reflectance mode and, for those that could not be reliably identified, subsequently in transmittance mode (Table 3).

The fragments varied in size from <20 microns in all dimensions (generally black or dark brown) up to a few hundred microns (often transparent or translucent white). Of the 94 fragments, the identity of a large majority (72) of them could not be reliably determined using FT-IR. Of those 72 unidentified fragments, 51 were small, approximately round or more irregular black fragments, 11 were of a similar size and shape but brown, 5 were dark blue, 4 were transparent and 1 was red. The black and brown fragments were clearly organic in nature and may well be coarse "black carbon" or soot particles.

A further 9 of the fragments were identified as cellulose-based materials, including 4 blue, 3 red, 1 brown and 1 transparent fragment, with some roughly cylindrical (perhaps small fragments of fibres) while others were more irregular in shape.

5 fragments, in the larger size range, were identified as being proteinaceous material, most likely fragments of skin.

A total of 71 fibres were found, varying in both length and diameter. Fibres ranged from a few 10s of microns to a few mm in length, and from around 10 microns to more than 100 microns in diameter. Most fibres were transparent, with black fibres the next most common, followed by blue, red/orange, brown and purple.

Of these 71 fibres, 47 were identified as cellulose-based material, including 20 transparent fibres, 11 black, 9 blue, 5 red, 1 brown and 1 purple. Many of the transparent cellulose fibres were likely of natural origin, given their colour, rough surface texture, non-uniform cross section and frayed ends. Other cellulose fibres appeared to have been modified through an industrial process, given their much smoother surface texture and uniform cross-section and, in many cases, strong colouration.

The identities of 17 fibres (10 transparent, 3 black, 3 blue, 1 red) could not be reliably determined using FT-IR microscopy.

The identities of those fibres (other than modified cellulose fibres) and fragments confirmed to be synthetic in nature are summarised in Table 4.

In total, the presence of 12 microplastics was confirmed on the filters, including:

- 4 fibres of polyester (2 transparent, 1 blue and 1 black)
- 1 pale brown fibre of nylon (PA)
- 1 black fibre of another polyamide (PA)
- 1 brown fragment of chlorosulphonated polyethylene
- 1 black fragment of a vinyl ether copolymer
- 1 orange fragment of chlorinated polyethylene
- 1 black fragment of a vinyl acetate copolymer
- 1 transparent fragment of cellulose acetate
- 1 transparent fragment of polyethylene (PE)

A further two fragments captured on the filter also gave strong spectral matches to synthetic polymers, but are reported here as tentative identifications given their relatively unexpected presence as contaminants in air. This included a pale blue,

roughly spherical fragment, which gave a strong spectral match to the substance polyacrylamide, and a transparent fragment which matched the spectrum for polyvinyl alcohol (PVA).

Finally, a single brown fibre gave a strong spectral match specifically to methyl cellulose, possibly a fibre of a paper product that had been treated with methyl cellulose.

Examples of semi-synthetic and synthetic fibres from the composite sample during FT-IR analysis, including with the diamond compression cell and the spectra obtained for each are shown in Figure 3. Figure 4 shows examples of synthetic microplastic fragments during FT-IR analysis in reflectance mode.

Table 3. Numbers of fibres and fragments (both natural and synthetic)

Sample location		**Geneva city centre**
Volume filtered (m^3)		1.7
Total fibres and fragments		165
Fibres	**Total fibres**	71
	Cellulose (Natural and semi-synthetic)	47
	Synthetic	7*
	Unidentified	17
Fragments	**Total fragments**	94
	Cellulose	9
	Proteinaceous	5
	Synthetic	8*
	Unidentified	72

*Including tentative identifications

Table 4: summary of the identities of non-cellulosic synthetic fibres and of synthetic fragments as determined by FT-IR microscopy analysis (combination of reflectance and, where necessary and practicable, transmittance FT-IR).

Non-cellulosic synthetic fibres	**Synthetic fragments**
4 x fibres of polyester (2 transparent, 1 blue, 1 black) 1 x pale brown fibre of nylon (PA) 1 x black fibre of another polyamide (PA) Tentative 1 x brown fibre, methyl cellulose	1 x brown fragment of chlorosulphonated polyethylene 1 x black fragment of a vinyl ether copolymer 1 x orange fragment of chlorinated polyethylene 1 x black fragment of a vinyl acetate copolymer 1 x transparent fragment of cellulose acetate 1 x transparent fragment of polyethylene (PE) Tentative 1 x pale blue, most likely polyacramide 1 x transparent poly vinyl alcohol

On the field blank filters, only a total of 6 small, dark coloured fragments and no fibres were identified. It was not possible to determine the identity of any of those fragments by FT-IR microscopy in reflectance mode, and it was physically impossible to transfer any of the fragments to the diamond compression cell for analysis in transmittance mode, both because of their small size (in the range of 10-15 µm) and because they appeared to disintegrate when attempting to lift them with the dissecting needle. Although it has not therefore been possible to determine either the nature or origin of these particles, it seems unlikely that either the processes of installing and removing the silver filter from the filter holder or that of installing and removing the filter holder from the pDR-1500 would have contributed significantly to the overall numbers and ranges of fibres and fragments located on the sample filter itself. It is, therefore, safe to conclude that the vast majority of the 165 particles on the sample filters were collected from the air during the 8 hour experiment.

Inspection of the laboratory blank filters placed next to the microscopes during sample handling revealed the deposition over a number of hours of just one white fibre on one of the filters and of one white and one dark blue fibre on the other. All were determined to be cellulosic in nature and may well have come from cotton clothing being worn in the laboratory. In any case, such fibres are relatively easy to distinguish from fibres collected on the sample filter during the experiment as they are in a larger size range and do not sit flat against the surface of the filter, but instead rest lightly on the surface in three dimensions.

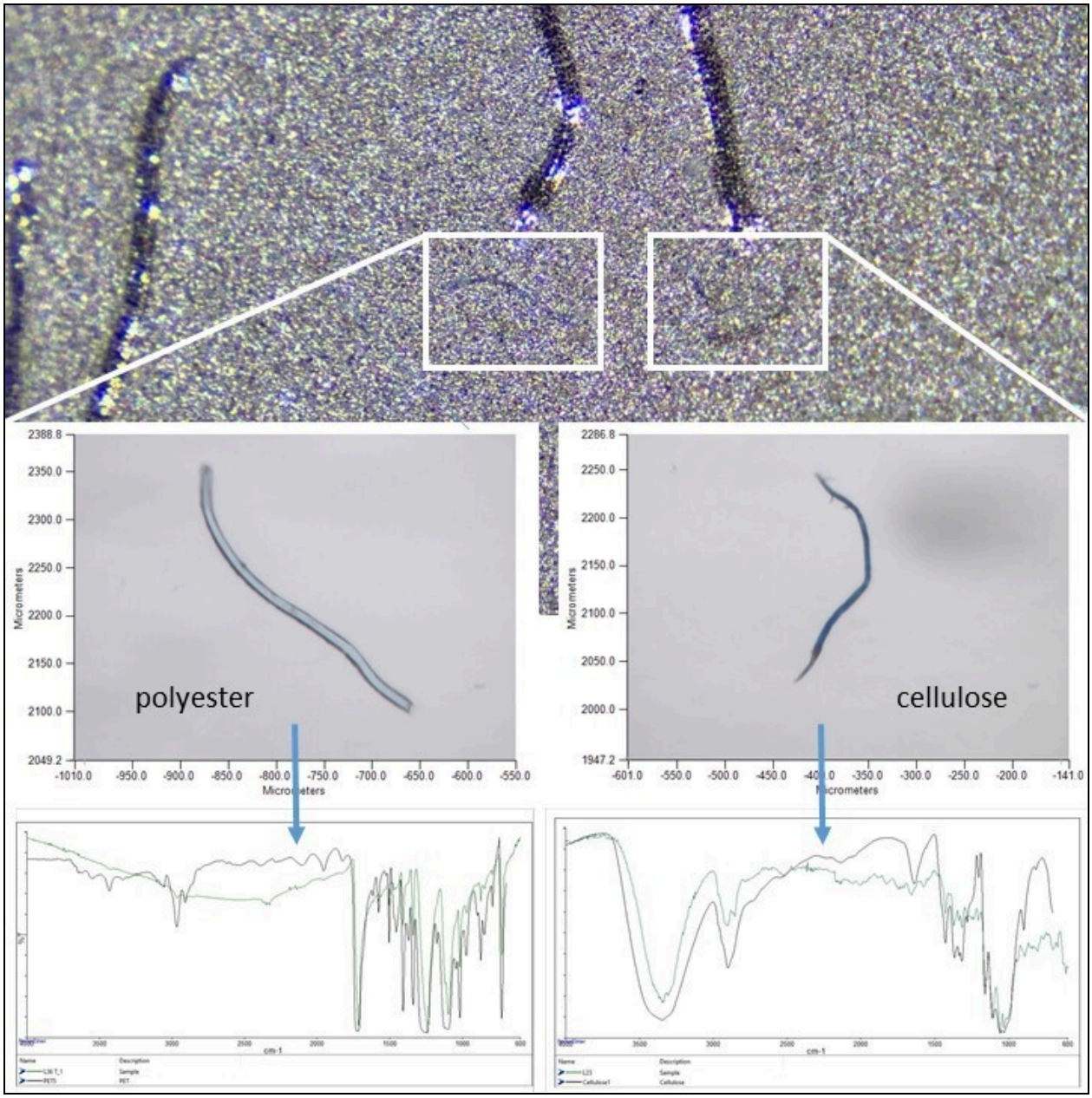

Figure 3. Examples of semi-synthetic and synthetic fibres found in the composite air sample, showing their initial locations of two typical fibres on the silver filter during FT-IR analysis in reflectance mode, the two separate fibres following transfer to the diamond compression cell for confirmatory FT-IR analysis in transmittance mode and the spectra obtained for each, compared to library spectra. The broader markings visible on the surface of the silver filter adjacent to the fibres are the scratch marks made with a fine needle to indicate the positions of candidate particles for FT-IR analysis during initial examination under the light microscope (see Methods section above).

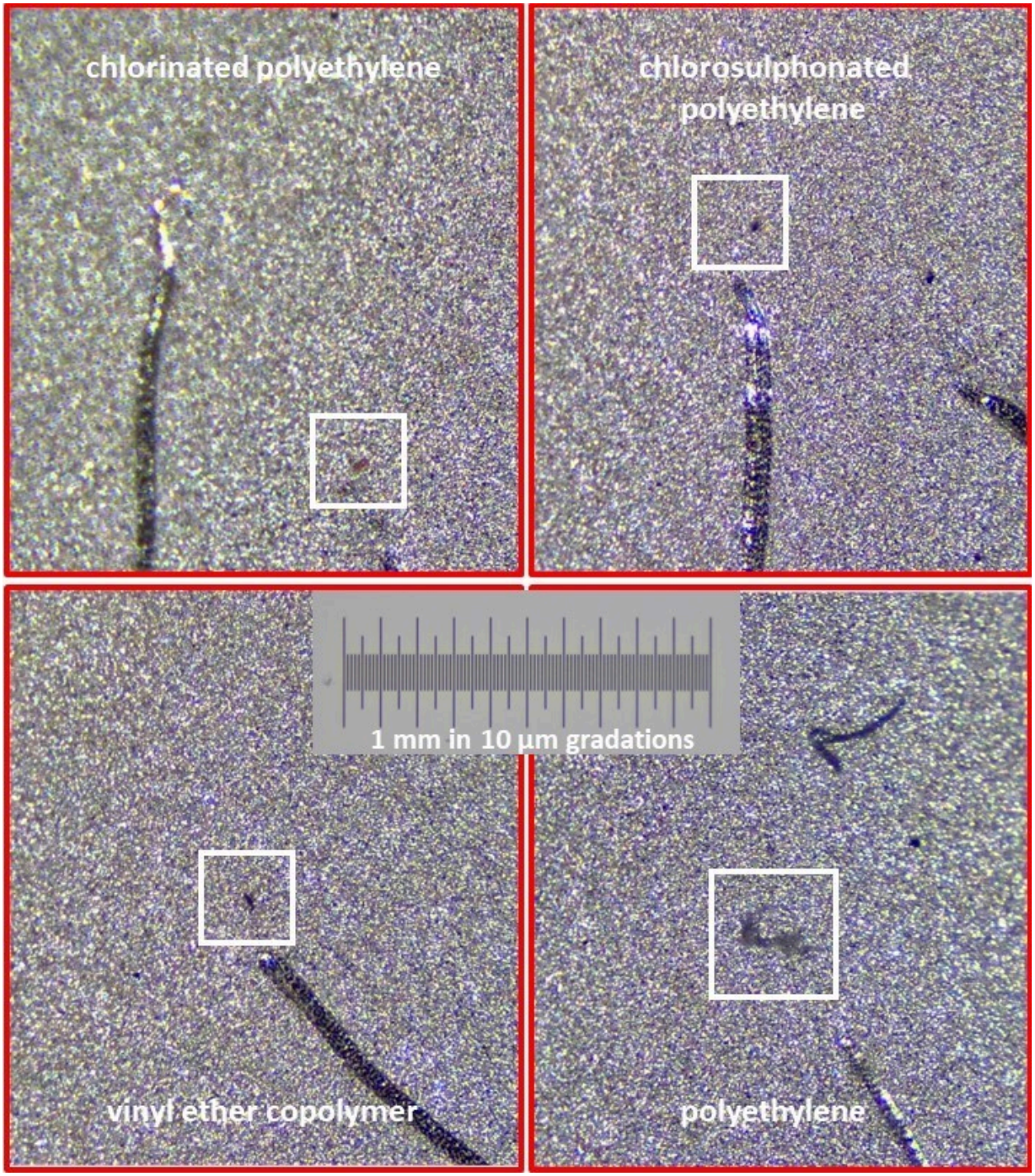

Figure 4. Examples of synthetic microplastic fragments found in the composite air sample, showing their size, shape and colour on the silver filter during FT-IR analysis in reflectance mode.

Conclusion

The single composite sample analysed in this study serves to illustrate the presence of microplastic contamination in the air in Geneva during the period and within the combination of locations sampled. The snap-shot this study provides clearly cannot be considered to be representative of levels of contamination typical of the areas sampled or of Geneva as a whole, and is insufficient in itself for use in intercomparison between different locations.

Nonetheless, the results do provide an insight into the range and abundances of microplastics in an urban environment. Based on a sample size of 1.7 m^3, the test identified approximately 7 synthetic microplastic fibres and fragments per cubic meter of air. Although previous studies report a wide range of results depending on the experiment location, the number of microplastic particles identified per volume of air in our study is within the range that would be expected.

The methods employed in this study can only identify particles of 10 µm and above. Fragments smaller than this, which may be even more abundant, would not have been detectable using the methods employed, but do warrant further investigation and characterisation through future studies.

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