

Perfluorocarbon Tracer Experiments on a 2 km Scale in Manchester Showing Ingress of Pollutants into a Building

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Cyclic perfluorocarbons (PFCs) have been used to measure the passage of air in urban and rural settings as they are chemically inert, non-toxic and have low background concentrations. The use of pre-concentrators and chemical ionisation gas chromatography enables concentrations of a few parts per quadrillion (ppq) to be measured in bag samples. Three PFC tracers were used in Manchester, UK in the summer of 2015 to map airflow in the city and ingress into buildings: perfluoromethylcyclohexane (PMCH), perfluoro-2-4-dimethylcyclohexane (mPDMCH) and perfluoro-2-methyl-3-ethylpentene (PMEP).

A known quantity of each PFC was released for 15 minutes from steel canisters using pre-prepared PFC mixtures. Release points were chosen to be upwind of the central sampling location (Simon Building, University of Manchester) and varied in distance up to 2.2 km. Six releases using one or three tracers in different configurations and under different conditions were undertaken in the summer. Three further experiments were conducted in the Autumn, to more closely investigate the rate of ingress and decay of tracer indoors.

In each experiment, 10 litre samples were made over 30 minutes into Tedlar bags, starting at the same time as the PFC release. Samples were taken in 11 locations chosen from 15 identified areas including three in public parks, three outside within the University of Manchester area, seven inside and five outside of the Simon building and two outside a building nearby. For building measurements, receptors were placed inside the buildings on different floors; outside measurements were achieved through a sample line out of the window. Three of the sample positions inside the Simon building were paired with samplers outside to allow indoor-outdoor comparisons.

PFC concentrations varied depending on location and height. The highest measured concentrations occurred when the tracer was released at sunrise; up to 330 ppq above background (11 ppq) of PMCH was measured at the 6th floor of the Simon Building from a release 1.9 km away. One experiment sampled for an additional two 30 minute periods in four locations inside and one location outside the Simon Building in order to investigate how long it took for air to enter and leave the building. For this measurement, 1.3 g of PMCH was released 1.9 km away and average roof level wind speed was 7.8 m/s. The highest measurement of PMCH outside was 54 ppq above background, and 46 ppq inside. After the first 30 minutes, the PFC concentration returned to background levels outside, but other internal rooms still had elevated PFC concentrations between 10 and 16 ppq above background an hour after release demonstrating that pollutants may persist within buildings having passed outside. In the final experiment, the wind direction changed so the sampling locations were not directly downwind of the release point, but nevertheless a small amount of PFC tracer above background was detected at the highest sampling point on the 6th floor of the Simon Building (14 ppq above background), and a smaller amount at street level.