Indoor Air Quality Particulate Concentrations

B.Sc. (Honours) in Environmental Science and Sustainable Technology

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Background to Project

What is Particulate Matter (PM)

Very small particles of solids and/or liquids suspended in the air. The particles have varying chemical composition and particle size and shape.
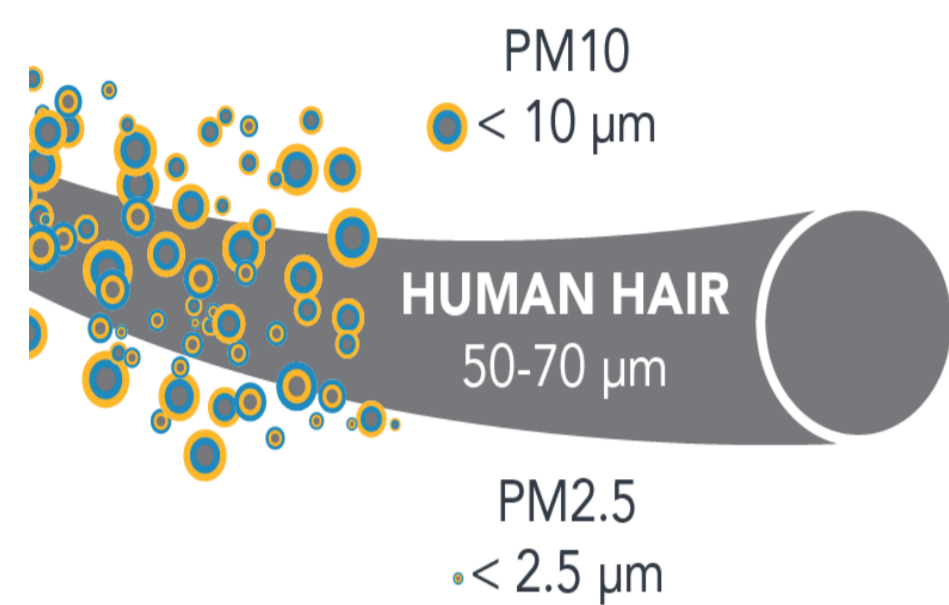
Fig 1. Particulate size comparison (California Air Resources Board, 2022)

Harmful Effects

Small particulate pollution has health impacts even at very low concentrations – indeed no threshold has been identified below which no damage to health is observed (WHO, 2021).

In 2016, it is estimated that 6 million worldwide deaths were related to air pollution and 4.1 million of theses related to ambient PM (National Academies of Sciences, Engineering, and Medicine and National Academy of Engineering, 2022).

In Ireland, the EPA (2020) estimate that 1,300 premature deaths are caused by particulate matter from the burning of solid fuel.

Air Quality Guidelines

WHO (2021) guideline averages

PM$_{2.5}$ µg/m3		PM$_{10}$ µg/m3	
Annual	24 hour	Annual	24 hour
5	15	15	45

Band	Index	PM2.5 (µg/m³) 24 HOUR MEAN	PM10 (µg/m³) 24 HOUR MEAN
Good	1	0 - 11	0 - 16
	2	12 - 23	17 - 33
	3	24 - 35	34 - 50
Fair	4	36 - 41	51 - 58
	5	42 - 47	59 - 66
	6	48 - 53	67 - 75
Poor	7	54 - 58	76 - 83
	8	59 - 64	84 - 91
	9	65 - 70	92 - 100
Very Poor	10	71 or more	101 or more

Fig 2. EPA Air Quality Index

Indoor PM

Indoor levels of particulate matter are generally not monitored and there is less research on the subject.
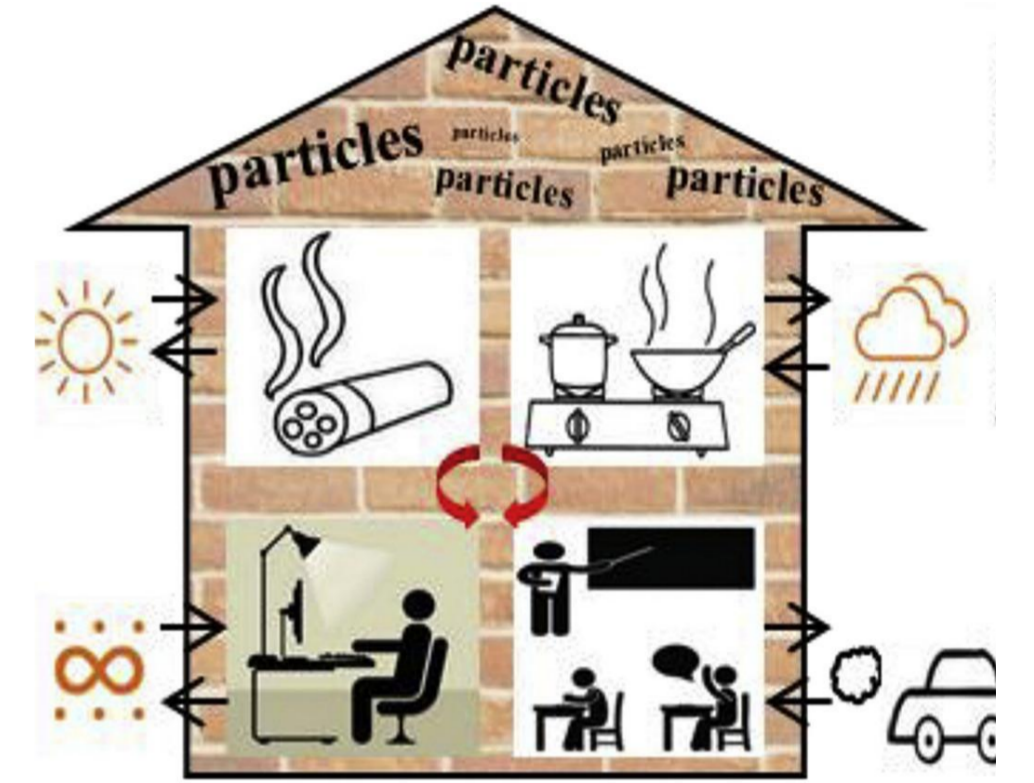
Fig 3. Graphical representation of some sources of indoor PM (Hu et al., 2018)

Methodology

Testing with PurpleAir PA-II

Fig 4. PurpleAir PA-II with wood burning open fire

Home Setting

Open fires – coal & wood burning

Stove – wood burning

Cooking

Candles

Effect of room size

Effect of ventilation

College Setting

Canteen Kitchen

Canteen

Permeation from Outdoors

Home Setting

College Setting

Fig 5. Tea light burning experiment
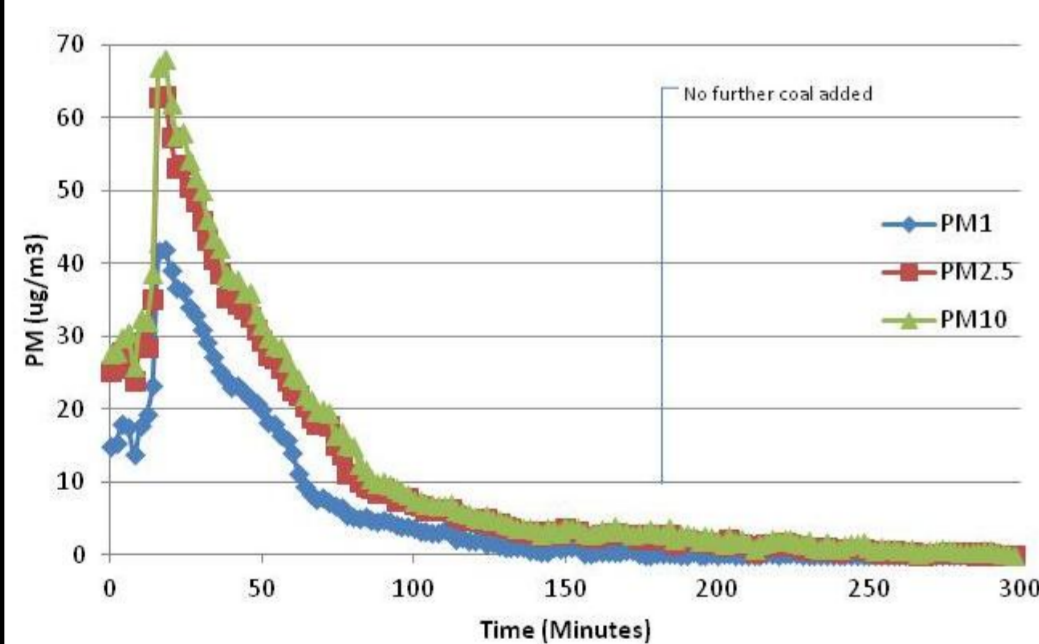
Results

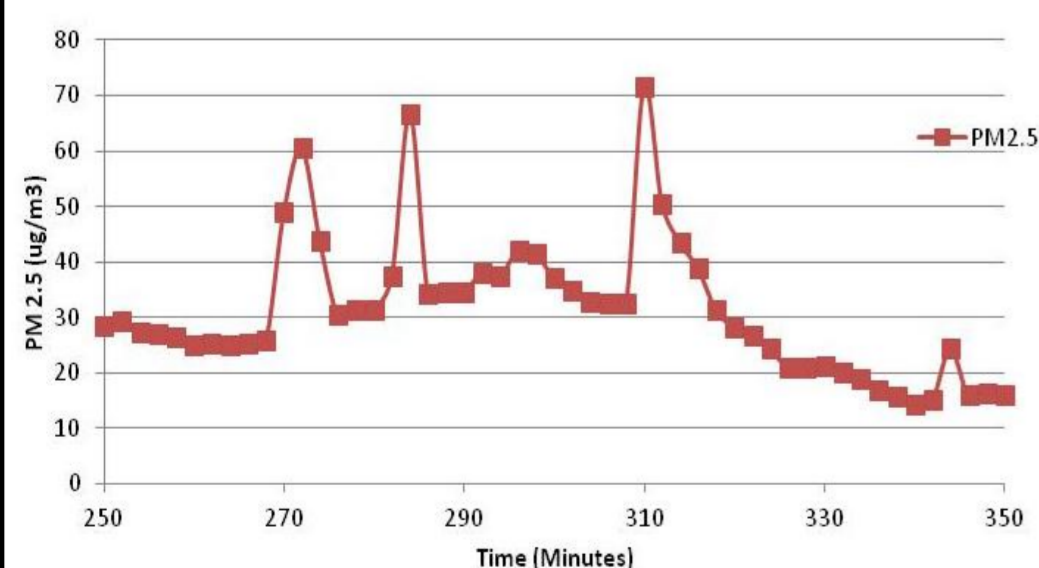Fig 6. PM from coal burning open fire

Fig 7. PM from wood burning stove

Key Findings

Coal open fire – initial peak followed by tapering off despite further coal added.

Wood open fire – peaks when further wood added.

Wood stove – peaks when door opened / wood added.

Oven cooking – produced little PM.

Frying pan – produced PM, but reduced with extract hood.

Candles – one produced PM similar to a fire. 3 tea lights in a small room produced incredibly high levels of PM. Reduced dramatically by opening window.

MTU kitchen produced PM, but extract systems kept this under control.

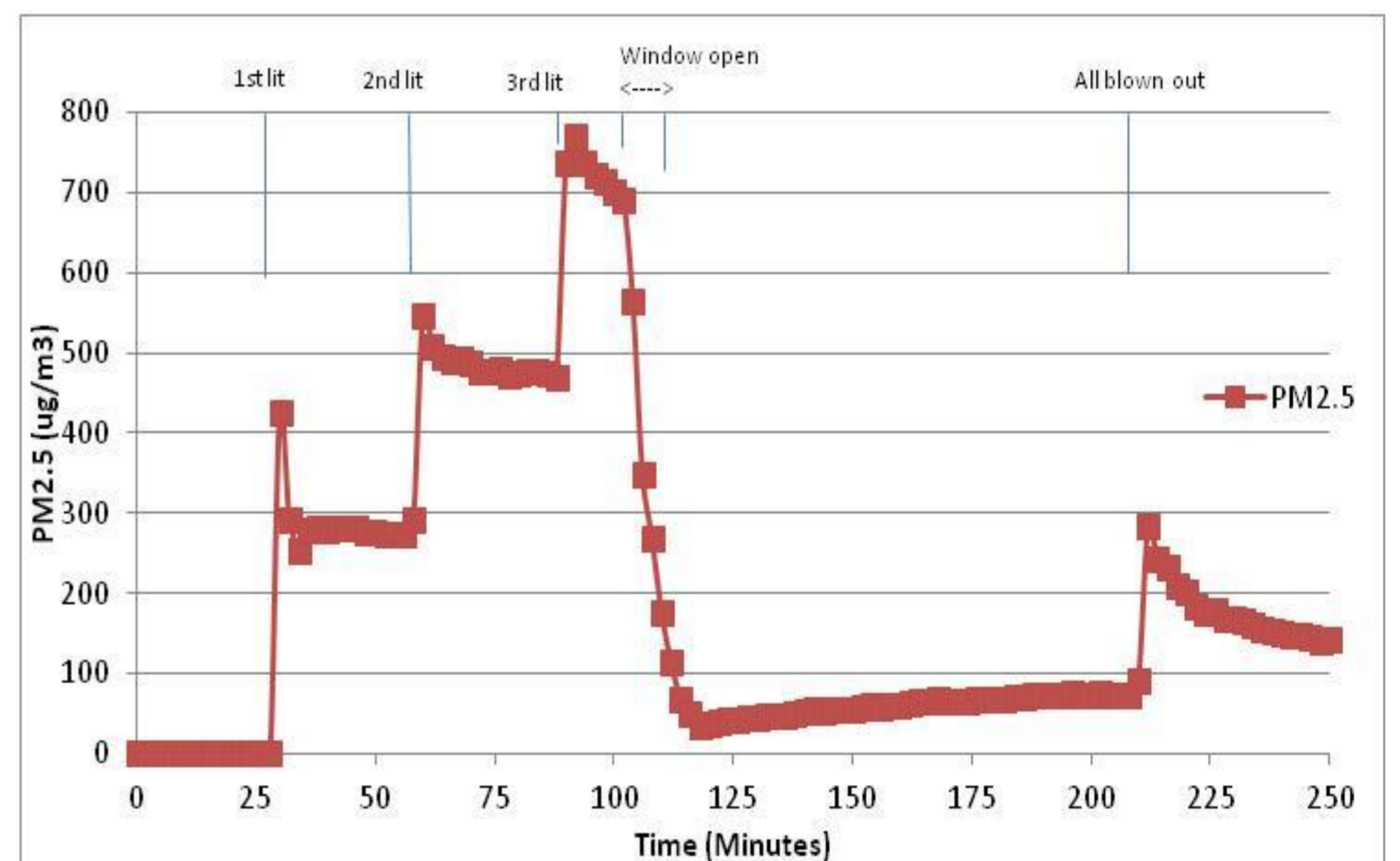Being indoors generally gave a degree of protection from outdoor PM, but not always.

Fig 8. PM from burning of 3 tea lights in a small room (including effect of ventilation)

Note: The US EPA Air Quality Index highest category 24-hour PM$_{2.5}$ (ug/m^3) is 301-500 'Hazardous'

References

California Air Resources Board (2022) *Inhalable particulate matter and health* (PM2.5 and PM10). https://ww2.arb.ca.gov/resources/inhalable-particulate-matter-and-health. Access date April 2022.

EPA (2020) *Air Quality in Ireland 2019*, Wexford: EPA.

Hu et al. (2018) Exposure to air particulate matter with a case study in Guangzhou: Is indoor environment a safe haven in China? *Atmospheric Environment 191*, 351-359

National Academies of Sciences, Engineering, and Medicine and National Academy of Engineering. (2022) *Indoor Exposure to Fine Particulate Matter and Practical Mitigation Approaches: Proceedings of a Workshop*. Washington, DC: The National Academies Press.

WHO (2021) *Global air quality guidelines. Particulate matter (PM$_{2.5}$ and PM$_{10}$), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide*. Geneva, WHO.