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TRANSMISSION OF POLLUTANTS BETWEEN INDOOR AND OUTDOOR ENVIRONMENT

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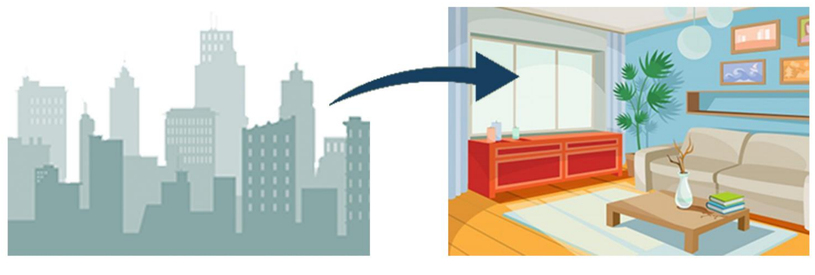
Introduction

Epidemiological studies have established a strong relationship between poor air quality and deteriorating human health. The *Global Burden of Disease* [1] indicates that about 1.6 million premature deaths occurred in 2017 due to poor IAQ. Specifically, **indoor pollution is more critical**, and the outdoor environment significantly contributes to it. The strength depending on various parameters such as ventilation strategy and outdoor source strength.

Additionally, the pandemic has **transformed indoor space usage** demanding an in-depth **analysis of the indoor/outdoor interface** and appraisal of intervention strategies.

Aims & Objectives

- Understand the **links between indoor and outdoor** pollution and **factors that modify the relationship.** Appraisal of the tools and methods of investigation.
- Develop an indoor-outdoor **combined numerical model** and simulate air flow and diffusion of pollutants using **Computational Fluid Dynamics** (CFD).
- Test building façades, and canyon design alternatives, on the likely impact on Indoor Air Quality (IAQ).
- Sensitivity analysis to establish the relative **contribution of each factor**.
- Investigate **control strategies** and improve fenestration design

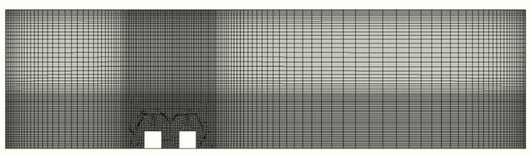


Research Gap

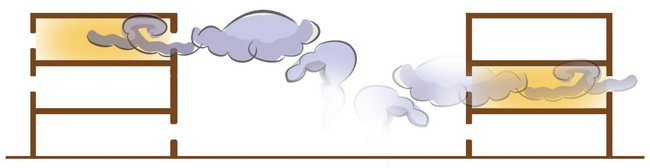
- Most studies are unable to account for the diverse range of modifying factors and instead, focus on a few. There is a need to **simultaneously assess the contribution of each factor** and its relative magnitude.
- More research is needed to **understand the sheltering mechanism of building and fenestration design**, and gauge how they can prevent air contamination in episodic scenarios, for instance- volcanic eruptions.
- The **difference in air exchange mechanism** between various window style and configuration needs to be understood and accounted for in building construction.
- The use of **CFD as a potential tool for quantifying indoor pollutant of outdoor origin** is significantly lacking [2]. Most studies on CFD either focus on urban level or canyon dispersion. A coupled indoor-outdoor simulation may reveal finer details of the transmission mechanism.

Methodology

Stage 1: A validated numerical model of an urban canyon with a pollutant source was developed. This enabled **replicating an ideal street environment** and investigating the impact of emission in its precincts. The aerodynamic interaction was simulated on **FLUENT**.



Stage 2: Internal rooms were modeled in the adjoining buildings of the canyon. This linking allowed **interaction between the canyon and indoor air** domain, prompting an exchange of pollutants between them.



Stage 3: Environmental parameters, including **wind, humidity, and radiation**, were varied. Additionally, urban parameters, including **building height, depth, ventilation mode** etc. were parametrised to assess its impact on the air quality.

Stage 4: The final stage involved modifying the internal environment and the interface, i.e. the building fabric, and **parametrically assessing** its impact on IAQ and air exchange rate. This was followed by **testing a few strategies** to limit the transmission of pollutants.

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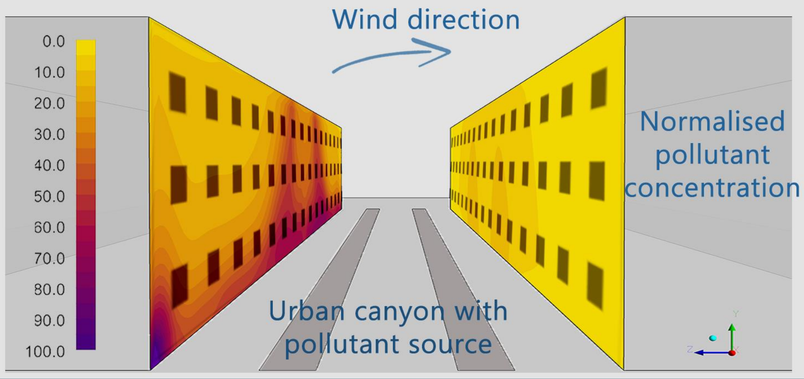
Factors

Factors which affect the IAQ are shown in the image on the left.

A - Prevailing wind
B - Radiation
C - Flow separation
D - Recirculation
E - Amplification due to local elements
F - Local sources (such as cars)
G - Convection due to surface heating
H - Cross contamination
I - Natural ventilation
J - Mechanical ventilation intake
K - Infiltration

Initial Results

Initial simulations have highlighted that the pollutant concentration is highest near the centre of the leeward facing wall in the street canyon. The **concentration increases with decreasing distance between the two buildings**. Pollution is highest when air flow in the canyon does not interact with free stream air flow above the canyon. Improvements in the form of better air flow and higher air exchange is ideal.



Conclusion & Future Work

- There is uncertainty between the fluctuations in the determinants and their consequent impact on transmission.
- Episodic scenarios, such as the recent pandemic, has highlighted the **fear of airborne transmission and contamination**.
- The proposed project aims to **quantify the transmission** of pollutant and understand the role of these determinants using **CFD**.
- Future work involves detailing the indoor design and **modelling the building facade** to replicate various penetration coefficient and ventilation mode.

References

1. GBD 2017 Risk Factor Collaborators. 2018. https://doi.org/10.1016/ S0140-6736(18)32225-6
2. Milner, James, Sotiris Vardoulakis, Zaid Chalabi, and Paul Wilkinson. 2011. https://doi.org/10.1016/j.envint.2010.08.015.

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