Indoor Air Quality as Affected by the Urban Environment

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UK HOUSING STOCK

- An estimated 23.1 million dwellings in England
- People in the UK spend around 90% of their time indoors
- Around 60% of that time is spent in their homes
- Therefore, dwellings are an important modifier for population exposure to the external environment (weather, pollution, etc).

Current Projects
- AWESOME - Air pollution and WEather-related health impacts: methodological study based on Spatio-temporally disaggregated multi-pollutant models for present-day and future
BUILDING SIMULATION

1. Building Characteristics
2. Occupancy Behaviour
3. External Conditions
4. Pollutant Characteristics

Dynamic Thermal Simulation (EnergyPlus)
Indoor/Outdoor Pollutant Ratios
Absolute Indoor Concentrations

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OUTLINE

Initial Research

• Existing building stock information
• Outdoor pollution levels
• Comparison of results between archetypes
• Mapped results
• Preliminary results for indoor sources

AWESOME Project

• Development of nationally representative housing stock
• Indoor/Outdoor ratios for pollution
• Pollution from indoor sources
• Overheating risk
INITIAL RESEARCH GREATER LONDON AUTHORITY

Develop a building stock model suitable to estimate indoor levels of pollution from outdoor sources

GIS Sources
- OS Address Layer 2
- The Geoinformation Group (Cities Revealed) Building Class Database

English Housing Survey (EHS)
- Regular survey of around 17,000 dwellings in England
- Includes interview of occupants
- Representative subset have home surveyed by qualified surveyor, physical characteristics noted.

Standard Assessment Procedure (SAP)
- Methodology for estimating the permeability of buildings based on characteristics derived from the EHS.
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INITIAL RESEARCH  LONDON ARCHETYPES

**Code: H1**
- Structure: Terrace with large T
- Age: 1902 - 1913
- Frequency: 11.4%
- Building Fabrics: Cavity Masonry 16% (16%)
  Solid Masonry 84% (2%)

**Code: H2**
- Structure: Simple Terrace
- Age: 1942 - 1945
- Frequency: 14.5%
- Building Fabrics: Cavity Masonry 56% (45%)
  Solid Masonry 42% (4%)
  Concrete 2% (30%)

**Code: H3**
- Structure: Large Semi detached
- Age: 1914 - 1945
- Frequency: 1.8%
- Building Fabrics: Cavity Masonry 67% (36%)
  Solid Masonry 31% (4%)

**Code: H4**
- Structure: Purpose Built
- Age: 1960 - 1979
- Frequency: 5.7%
- Building Fabrics: Cavity Masonry 66% (37%)
  Solid Masonry 5% (19%)
  Concrete 28% (12%)

**Code: H5**
- Structure: Simple Terrace
- Age: 1942 - 1945
- Frequency: 5.5%
- Building Fabrics: Cavity Masonry 16% (16%)
  Solid Masonry 84% (2%)

**Code: H6**
- Structure: Purpose Built
- Age: 1946 - 1959
- Frequency: 4.7%
- Building Fabrics: Cavity Masonry 50% (34%)
  Solid Masonry 13% (9%)
  Concrete 26% (14%)
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INITIAL RESEARCH LONDON ARCHETYPES

**Code: H7**  
Structure: Purpose Built  
Age: 1980 - 2008  
Frequency: 3.6%  
Building Fabrics:  
- Cavity Masonry 89% (54%)  
- Solid Masonry 2% (69%)  
- Concrete 9% (42%)

**Code: H8**  
Structure: Terrace with Attic  
Age: 1902 - 1913  
Frequency: 2.9%  
Building Fabrics:  
- Cavity Masonry 16% (14%)  
- Solid Masonry 84% (2%)

**Code: H9**  
Structure: Bungalow  
Age: 1914 - 1945  
Frequency: 2.4%  
Building Fabrics:  
- Cavity Masonry 62% (34%)  
- Solid Masonry 35% (7%)

**Code: H10**  
Structure: Semidetached  
Age: 1960 - 1979  
Frequency: 2.4%  
Building Fabrics:  
- Cavity Masonry 79% (41%)  
- Solid Masonry 7% (23%)  
- Concrete 9% (14%)  
- Timber Frame 5% (21%)

**Code: H11**  
Structure: Purpose Built  
Age: 1960 - 1979  
Frequency: 2.3%  
Building Fabrics:  
- Cavity Masonry 66% (17%)  
- Solid Masonry 5% (19%)  
- Concrete 28% (12%)

**Code: H12**  
Structure: Purpose Built  
Age: 1914 - 1945  
Frequency: 2.1%  
Building Fabrics:  
- Cavity Masonry 29% (22%)  
- Solid Masonry 67% (2%)  
- Concrete 3% (0%)
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<tbody>
<tr>
<td>Structure: Terrace with Shops Below</td>
<td>Cavity Masonry 89% (54%)</td>
<td>Structure: Step Linked Terrace</td>
<td>Cavity Masonry 82% (49%)</td>
<td>Structure: Purpose Built</td>
<td>Cavity Masonry 59% (34%)</td>
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<tr>
<td>Age: 1980 - 2008</td>
<td>Solid Masonry 2% (69%)</td>
<td>Age: 1946 - 1959</td>
<td>Solid Masonry 7% (15%)</td>
<td>Age: 1946 - 1959</td>
<td>Solid Masonry 15% (9%)</td>
</tr>
<tr>
<td>Frequency: 2.1%</td>
<td>Concrete 6% (43%)</td>
<td>Frequency: 1.5%</td>
<td>Concrete 10% (25%)</td>
<td>Frequency: 1.8%</td>
<td>Concrete 36% (14%)</td>
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**INITIAL RESEARCH**  OUTDOOR LEVELS OF POLLUTION

**PM$_{2.5}$ chosen as pollutant to model**

In London, PM$_{2.5}$ causes mortality equivalent of 4,267 deaths (2008) (Miller, 2010).

Modelled with spatial variation in background levels from DEFRA (2010) and temporal (time of day-month) from London Air (2014).

Penetration factor of 0.8 when windows closed, 1.0 when open.

Deposition rate 0.18h$^{-1}$
INITIAL RESEARCH: OUTCOMES

Key findings

• The I/O Ratio increases in summer if the windows are allowed to open when indoor temperature rise above thresholds.
• While I/O Ratios rise, the outdoor PM levels tend to fall during the summer.

Example: I/O Ratios and average outdoor levels for bungalows over a year.
Key findings

There an almost two-fold difference in I/O ratios between archetypes, indicating that buildings may have a large impact of population exposure to outdoor PM$_{2.5}$.
INITIAL RESEARCH: OUTCOMES

Key findings

Modern flats have lower infiltration rates, meaning lower amounts of outdoor PM$_{2.5}$ indoors.
High density of flats in Central London may reduce exposure.
INITIAL RESEARCH: INDOOR SOURCES - COOKING

Key findings

Trends when indoor sources are modelled are the opposite of what is observed with outdoor sources.
AWESOME: NATIONAL OVERHEATING AND IAQ

Develop a national building stock model suitable to estimate indoor levels of pollution from indoor and outdoor sources

English Housing Survey (EHS)

- Regular survey of around 17,000 dwellings in England
- Includes interview of occupants
- Representative subset have home surveyed by qualified surveyor, physical characteristics noted.

Homes Energy Efficiency Database

- Continuously updated database of individual dwellings in UK from survey and installations data.
- Contains at least one piece of information from ~50% of UK dwellings
- Physical characteristics only (e.g. Wall type, window type)

Standard Assessment Procedure (SAP)

- Methodology for estimating the permeability of buildings based on characteristics derived from the EHS.
FUTURE WORK

• Adjust national I/O ratios by local levels of pollution to calculate absolute indoor pollution from outdoor sources.
• Metamodel to scale overheating results by more local temperatures.
• Match indoor pollution levels (indoor and outdoor sources) and overheating data with postcode health data, socioeconomic data.
REFERENCES


Questions?

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