



# The Impact of Indoor Environment on Health and Wellbeing

#### Dr Ed Suttie, BRE

Building a better world together



- Why is Indoor Environment Quality important?
- What factors can cause poor IEQ?
- How may good IEQ be achieved?
  BRE activity
- Measurement
- Understanding occupants
- Research



#### What defines a great indoor environment?



- Indoor Environment Quality = the quality of a building or space's environment when considering the health and wellbeing of the occupants within it
- We spend on average 90% of our time indoors some up to 100% of time indoors (including those most vulnerable to poor IEQ)
- Poor indoor environments can affect:
  - Comfort
  - Health & Wellbeing (physical, mental)
  - Performance & productivity
  - Learning
  - Healing and recuperation
  - Buildings and materials
  - .....and all impact on the bottom line



The inside story: Health effects of indoor air quality on children and young people

- Systematic review of the science of indoor pollution, and conversations with children, young people and families.
- Recommendations for Government and local authorities, and guidance for families







Royal College of Paediatrics and Child Health

Leading the way in Children's Health



- Poor IEQ has the potential to affect building occupants
  - Deleterious effects can range in severity
  - They may be acute or chronic
  - Chronic effects may be cumulative over the course of a lifetime

#### **Poor IEQ –** *some* **contributory factors**

- Design & planning issues
- HVAC systems
  - Incompatibility/incorrect sizing
  - Controls
  - Installation & maintenance
- Construction products, furnishings, cleaning agents
- Lighting strategy
- Building acoustics
- Occupant behaviour







- Airtightness (for energy efficiency) without efficacious ventilation may lead to:
  - Poor IAQ
  - Excess heat
  - Dampness/mould
- Contractual processes e.g. amount/timing of heating supplied
- Balance of control building operator vs. building occupant
- Effects due to new buildings, developments and processes nearby





- Careful consideration of location, orientation, nearby buildings
- Choice/specification of materials
- Strategies for HVAC, lighting and other key building systems
- Fit out and design

- Monitoring of internal conditions
- Occupant feedback
  - Needs, behaviour, habits, interactions
- Level of building management & control
- Maintenance and cleaning





# bretrust

- Measurement and validation
- Understanding occupants
- Research



### **Measurement and validation**









- Product/system testing, assurance, proof of concept
- Chambers, test rooms & mock-ups
- IEQ sensor devices
  - Specialist use (e.g. medical, industry)
  - Commercial use (e.g. building sensors, measurements for environmental assessment schemes)
  - Consumer use (e.g. low-cost monitors widely available)



#### 30m<sup>3</sup> IAQ Chamber







Air Oual Atmos Health DOI 10.1007/s11869-017-0518-4

#### Testing the single-pass VOC removal efficiency of an active green wall using methyl ethyl ketone (MEK)

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become more prevalent. Whilst green walls are often utilised within the built environment for their biophilic effects, there is little evidence demonstrating the efficacy of active green wall (VOCs) at concentrations found within an interior environ- the indoor environment. ment. The current work describes a novel approach to quantifying the VOC removal effectiveness by an active living green Keywords Biofiltration - Indoor air - Indoor plants - Air wall, which uses a mechanical system to force air through the pollution · CADR · Phytoremediation substrate and plant foliage. After developing a single-pass efficiency protocol to understand the immediate effects of the system, the active green wall was installed into a 30-m3 chamber representative of a single room and presented with the contaminant 2-butanone (methyl ethyl ketone; MEK), a Airpollution is a major worldwide public health issue, with air VOC commonly found in interior environments through its use in textile and plastic manufacture. Chamber inlet levels of in 2014 (World Health Organisation (W.H.O) 2014). Whilst a MEK remained steady at 33.91 ± 0.541 ppbv. Utilising a portion of an individual's pollution exposure is directly linked forced-air system to draw the contaminated air through a to outdoor air (Lawin et al. 2017), a growing body of evidence green wall based on a soil-less growing medium containing activated carbon, the combined effects of substrate media and

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Abstract In recent years, research into the efficacy of indoor botanical component within the biofiltration system showed air biofiltration mechanisms, notably living green walls, has statistically significant VOC reduction, averaging 57% singlepass removal efficiency over multiple test procedures. These results indicate a high level of VOC removal efficiency for the active green wall biofilter tested and provide evidence that biofiltration for the removal of volatile organic compounds active biofiltration may aid in reducing exposure to VOCs in

#### Introduction

pollution exposure attributed to seven million deaths globally identifies indoor air pollutants as having significant health impacts on humans within the built environment (Gibson et al. 2013), spaces in which contemporary urban populations spend 90% of their lives (EPA 2014). Volatile organic compounds (VOCs) are largely anthropogenic pollutants commonly associated with poor-quality indoor air (Lai et al. 2004; Lu et al. 2012; Steinemann 2015; Su et al. 2011). The health effects of VOC exposure are well studied (Rumchev et al. 2004); many VOCs are labelled as category 1 human

carcinogens (Bernstein et al. 2008; Mitchell 2013). Consequently, there is a priority to reduce VOC exposure in the built environment (Ayala et al. 2012). indoor VOCs, including adsorption filters, photocatalytic

Whilst many filtration technologies exist for reducing oxidation purifiers, ozone generators, and ionisers (Ren et al. 2017; Zhang et al. 2011), such techniques are often

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#### 40m<sup>3</sup> IEQ Chamber





- Chamber can be occupied for IEQ studies
- Ability to 'plug and play' with furnishings, finishes, etc.
- Twin office rooms



### **Understanding Occupants**



- Designing workspaces that have a positive impact on health, well-being and productivity is not easy
- How do we know we are getting it right?
- Pre and Post Occupancy Evaluation (PPOE) measures performance throughout building's lifecycle







BRE have collaborated with Interface and Oliver Heath Design to develop a new guide.

**Creating Positive Spaces by Measuring the Impact of Your Design** explores how to assess how your building is performing using pre and post occupancy evaluation (PPOE)





The guide covers:

- What is Pre- and Post-Occupancy Evaluation (POE) & what are the benefits
- What a POE process looks like
- How to get started

It is available as a free download from the BRE and Interface websites and via the QR code on the poster today



'Who's doing it' case studies include POE of BRE's B18 office refurbishment



### Research





Grow and deepen the evidence base for health, wellbeing and productivity impacts of restorative office refurbishment where het rough













Health, Wellbeing & Productivity in Offices





4% reduction at cooler temperatures
6% reduction at warmer temperatures
46 mins more sleep per night on average

for office workers with windows

**66%** drop in performance when exposed to distracting noise





- What **practical interventions** can office owners implement to improve health and wellbeing?
- Can these be **quantified** as part of the decision making process?
- Measures of **better business outcomes** occupant productivity?
- Provision of practical guidance to engage refurbishment contractors, real estate owners and designers





**Project Team** 



The office

- Study office
  - 1984 concrete framed
  - Three business teams
- Control office
  - 1978 concrete framed
  - Three business teams
- Longitudinal study





The low-energy office at the Building Research Establishmen









#### Materials and services inventory



- Continuous monitoring using Tinytag loggers

- Temperature and RH
- CO<sub>2</sub> level

- Periodic monitoring
  - Ventilation rate (ACH using tracer gas)
  - VOC (total and individual compounds by ISO 16000 & 16017 methods)











#### **Acoustic environment**

- Modelling of acoustic environment:
  - Reverberation time
- Characterising acoustic environment
  - Walk through survey
- Noise monitoring:
  - Decibels in office
  - Background
  - External









- Computer modelling of daylight:
  - Daylight distribution across office space
  - Annual profiles of daylight illuminance at eye level, working plane level and window level
- Daylight monitoring:
  - Outdoor level of daylight roof-mounted light sensor plus internally mounted power supply and data logger
  - Indoor level of daylight
  - Personal daylight exposure









- Psychology: Questionnaires, tools, cognitive tasks, interviews
- Physiology: Biomarkers, wearables
- "Productivity" measures











Choose the figure that completes the series.

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#### **Economic aspects**

- "Productivity" better business outcomes
- Data analysis
  - Engagement Survey
  - Absenteeism
  - Timesheets
  - Staff retention & turnover
  - Private Medical services accessed
  - Monthly reports targets vs work produced
  - Customer Satisfaction
  - Complaints received
  - SLA data & reports
  - Annual Leave



#### - Indoor Air Quality:

- TVOC content: below BREEAM Hea02 limit Most VOCs attributable to occupants.
- Temperature and humidity: mostly within the acceptable limits
- Baseline CO<sub>2</sub> monitoring: build up during the day and a decline overnight

#### - Acoustic:

- Higher noise levels: generally linked to office activities
- Unoccupied noise levels: within current recommended ranges

#### - Lighting:

Generally below CIBSE recommended standards and EN standards

#### - Occupant survey:

- Majority rated overall office look and feel as poor
- 70% would not be happy to show clients and colleagues their office
- 73% rated the temperature as unstable







#### **Phase 2: Refurbishment**





#### **Dissemination partners**





#### **Biophilic office demonstrator**



#### **BRE ZERO BILLS HOUSE**

CONCEPT & OUTLINE DESIGN





#### **Biophilic office demonstrator**





- IEQ is inextricably linked to our health and wellbeing
- It is vital to understand (measures and impacts)
- Occupants are key to the understanding and can unlock positive change
- Evidence being generated to enable more to take action
- Products, solutions and sensor testing provides compelling data and fosters innovation
- Increasing wealth of deep forensic studies





**Future** 





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### Thank you

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