Indoor Air Quality Assessments in High-Performing Buildings

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Disclaimer

The views expressed in this paper are those of the authors and do not necessarily reflect those of the U.S. Environmental Protection Agency or the National Institute of Standards and Technology. In addition, the mention of any trade names or products does not imply endorsement.

Introduction

- Defining a “high-performing building” is challenging.
- Characterizing IAQ is especially difficult.
- Measured data on IAQ in high-performing buildings are both very limited and inconsistently collected.
- More uniform studies are needed to document and enable comparisons of IAQ performance.

IAQ in Green Building Certifications

- Wei et al. (2015) reviewed the IAQ requirements in 31 green building programs worldwide.
  - The average contribution of IAQ was only 7.5 %.
  - Indoor air measurements were included in about two-thirds.
  - Formaldehyde, other VOC, and CO_2 were the most commonly considered indoor air contaminants.

IAQ in Published High-Performing Building Case Studies

- Teichman et al. (2015) reviewed how IAQ was addressed in ASHRAE's "High Performing Buildings" magazine.
  - While most of the case studies mentioned IAQ, they did not address IAQ in a comprehensive manner.
  - The authors suggested candidate IAQ performance data that could be collected to demonstrate IAQ performance.

Table 1 Candidate IAQ Performance Data (subset)

Parameter	Notes
Outdoor Air Intake	• Measure in each ventilation system in each operating mode (minimum outdoor air, economizer, etc.) for one week at least once per season
Carbon Dioxide	• Measure in main return of each air handling system; report peak hourly value for each day of one week at least once per season • For naturally ventilated buildings, measure in occupied space • Include outdoor concentration with indoor values
Formaldehyde	• Measure in two occupied space locations for each air handling system after at least 4 h of occupancy; report value once per season
$PM_{2.5}$	• Measure in two occupied space locations for each air handling system; report average value over occupied portion of day for one week at least once per season • Include average outdoor concentrations with indoor values
Post-Occupancy Evaluation	• Administer an IAQ survey to building occupants at least once per season

Data in High-Performing Buildings in North America

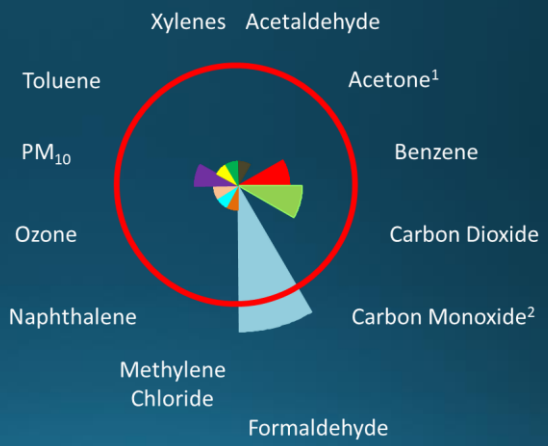
- Emmerich et al. (2016) reviewed field studies of IAQ in high-performance commercial buildings.
- The authors concluded there is wide variation in the measurements taken.
  - For example, only one study directly measured ventilation rates.
  - Many of the studies were of a single building, and nearly all of the studies were a single snapshot in time.

To Understand IAQ Performance in Buildings…

- Measure pollutants under different building operating conditions
- Report the number of occupants and their activities
- Provide the basis for pollutant comparisons, e.g., “low” or “high” compared to…

A Graphical Approach to IAQ Performance

- Teichman et al. (2016) described an approach to illustrating IAQ performance in buildings.
- Data from Fowler et al. (2011) are shown using this approach.



[1] Measured, but no reference value
[2] Reference value, but not measured

Extending the Approach to Overall Building Performance

- Non-IAQ candidate building performance data could be collected and plotted:
  - Energy Use Index
  - Carbon Footprint
  - Water Use Index
  - Waste Diverted During Construction
  - Waste Recycled During Occupancy
  - Thermal Comfort Lighting
  - Acoustics
  - Overall Building Post-Occupancy Evaluation

Extending the Approach to Overall Building Performance

- Including measurements of these parameters would enable evaluations/comparisons among:
  - Sustainable building programs
  - Existing buildings
  - Different building designs

Conclusion

- Measured data on indoor air quality performance in high performing buildings are limited and vary widely.
- More uniform studies in buildings are needed.
- One approach to achieving uniformity would be to draw upon proposals for documenting IAQ in high-performing buildings.
- To document and allow comparisons of overall building performance among buildings, studies should include building parameters in addition to IAQ.

Advantages of the Graphical Approach

- Rather than subjectively, and perhaps questionably, combining IAQ parameters into a single metric, the approach preserves the robustness of the data.
- The approach displays the “IAQ performance footprint” of a building.
- *The approach relies on the judicious choice of contaminants to be considered and the availability of accepted reference values.*

Challenges to Characterizing IAQ Performance

- How do we know which are the most important contaminants needed to characterize IAQ performance?
- Do the contaminants have an accepted reference value appropriate for the anticipated indoor exposure period?
- It is important to distinguish which benchmarks are enforceable standards and which are recommendations or guideline values.

Challenges to Characterizing IAQ Performance (cont.)

- Comparing health benchmarks across contaminants also poses a challenge.
- Our bodies are exposed to contaminants in combination, and such exposures can have synergistic impacts.
- Comparisons of contaminant concentrations in buildings of the same type should be made with caution.