A Study of Indoor Environmental Quality Parameters in a South Central Kentucky Daycare Facility

Emmanuel Iyiegbuniwe, Ph.D.
Western Kentucky University
Bowling Green, KY 42101
Introduction

- Rapid advances in pediatric health are shaping our understanding of the role the environment plays in childhood and infant diseases and illnesses.
- To develop rational policies and effective interventions, policy-makers increasingly rely on measurements of risk factors for disease and their distribution among socioeconomic groups.
Introduction, cont...

- Children are uniquely vulnerable to environmental toxins
- They are more susceptible than adults
- Their organs are not fully developed
- They absorb and metabolize chemicals differently when compared to adults
Indoor Climate Problems

Problems with energy conservation have resulted in...

- tighter buildings and greater insulation
- reduced or increased temperatures and higher air exchange rates
- increased efficiencies and recirculation rates
Indoor Climate Problems, cont…

- Most people in the developed world spend the bulk (~90%) of their time indoors
- Increased levels of pollutants from synthetic materials in buildings
- Unforeseen or unsuspected hazards - asbestos, radon, environmental tobacco smoke, etc.
Significance of IAQ Problems

Worldwide

- 1.1 billion people are exposed to high levels of respirable particulate matter
- Over 3 million excess deaths due to indoor air pollution
- Over 300,000 excess deaths due to urban air pollution
- Increasing prevalence of building-related illnesses (e.g., asthma) and sick-building syndromes
Causal Factors of Comfort and Perception of IAQ

Factors that affect comfort and perception

- Thermal Comfort Parameters (Temp & RH)
- Ventilation Rates
- Chemical and Biological Contaminants
- Others: Noise, Lighting, Ergonomics, etc.
- Psychosocial or work organization factors
What is Acceptable IAQ?

- ASHRAE’s definition (1999)
- Air in which there are no known contaminants at harmful concentrations as determined by cognizant authorities and with which a substantial majority, 80% or more of the people exposed do not express dissatisfaction
Building Description

- Single story, 47,061 ft\(^2\) circular building built in 1969
- AHUs with VAV boxes and thermostat-controlled pneumatic dampers
- HVAC system not connected to central control
- Offices have carpets and classrooms have half carpets & half vinyl floor tiles
Methodology

1. Measurement of Environmental Parameters
   • Carbon Dioxide, Temperature, Relative Humidity, and Dew Point
   • Descriptive Statistics
2. Respirable Particulate Matter
   • Indoor and outdoor samples
3. Bacteria and Fungal Concentrations
   • Viable and non-viable (bioaerosol) samples
   • Indoor and outdoor samples
   • Qualitative and quantitative results
# Data Collection

## Basic IAQ Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Particulate Matter</th>
<th>Bacteria &amp; Fungi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Dioxide (ppm)</td>
<td>0.3µm</td>
<td>Viable</td>
</tr>
<tr>
<td>Relative Humidity (%)</td>
<td>0.5µm</td>
<td>Non-viable</td>
</tr>
<tr>
<td>Temperature (°F)</td>
<td>0.7µm</td>
<td></td>
</tr>
<tr>
<td>Dew Point (°F)</td>
<td>1.0µm</td>
<td></td>
</tr>
<tr>
<td>Carbon Monoxide (ppm)</td>
<td>2.0µm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5.0µm</td>
<td></td>
</tr>
</tbody>
</table>

**Quest AQ 5001 Pro™**

**ARTI™ HHP-6**

**Microbial Impactor**

**Air-O-Cell Cassette**
Results
Campus Childcare (CCC), 2006

- 129 children, ages 0–4 years
- 49 males and 80 females
- Family incomes: $2,000 - $70,000
- Daily hours of operation: 7:30 am to 5:30 pm
- Early care offered from 7:00 am
Results, cont… CCC
Demographics, 2006

Age Distribution

- 0 - 1.5 yrs: 20
- 1.5 - 2 yrs: 18
- 3 yrs: 45
- 4 yrs: 46
Results, cont…
CCC Demographics, 2006

Racial Distribution

- White: 70
- Black: 51
- Hispanic: 5
- Asian: 2
Results, cont...

Environmental Parameters

- CO$_2$ levels were slightly higher in winter (avg=898) than summer (avg=826)
- CO$_2$ levels showed considerable swings, higher in winter than summer, but generally within ASHRAE’s and OSHA’s guidelines
- Indoor-outdoor CO$_2$ differential varied within building and between seasons - occasionally exceeding 700 ppm ASHRAE’s benchmark
Results, cont…

Environmental Parameters

- **Temperatures**
  - were within acceptable range (69°F-75°F)
  - showed no significant seasonal variations

- **Relative Humidity**
  - Summer: consistently at the high end of acceptable range (30%-60%)
  - Winter: consistently at the lower end of acceptable range & generally below 30%
  - Summer levels about twice winter levels
## Daily Avg Concentrations of Measured Parameters (Summer, 2004)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Descriptive Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>Indoor CO₂ (ppm)</td>
<td>826</td>
</tr>
<tr>
<td>Outdoor CO₂ (ppm)</td>
<td>380</td>
</tr>
<tr>
<td>Temp (°F)</td>
<td>73</td>
</tr>
<tr>
<td>RH (%)</td>
<td>55</td>
</tr>
<tr>
<td>Dew Point (°F)</td>
<td>55</td>
</tr>
<tr>
<td>Parameter</td>
<td>Descriptive Statistic</td>
</tr>
<tr>
<td>----------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>Indoor CO₂ (ppm)</td>
<td>898</td>
</tr>
<tr>
<td>Outdoor CO₂ (ppm)</td>
<td>416</td>
</tr>
<tr>
<td>Temp (°F)</td>
<td>72</td>
</tr>
<tr>
<td>RH (%)</td>
<td>29</td>
</tr>
<tr>
<td>Dew Point (°F)</td>
<td>37</td>
</tr>
</tbody>
</table>
CO$_2$ Concentrations (ppm)
Temperature Levels (°F)
Dew Point Levels (°F)

- 2006 (WINTER)
- 2004 (SUMMER)

- Dew Point Levels (°F)
Results, cont…
Respirable Particulate Matter

- Outdoors consistently higher than indoors for all 6 respirable particles
- In general, summer levels were higher than winter for 0.3µm, 0.5µm, & 0.7µm
- Indoor levels for larger particle sizes (1.0µm, 2.0µm, and 5.0µm) showed considerable seasonal swings
Respirable Particles (0.5µm)
Respirable Particles (0.7µm)
Respirable Particles (1.0µm)
Respirable Particles (2.0µm)
Respirable Particles (5.0µm)
Results, cont...

Fungi

- Indoor levels of fungi ranged from 14-169 CFM/m³
- Indoor fungi were less than outdoors but more varieties were isolated indoors than outdoors
- *Penicillium* sp higher indoors than outdoors
- Laundry room had the highest spore counts
- Most prevalent fungi were *Alternaria*, *Penicillium*, *Aspergillus*, *Cladosporium*, and *Scopulariopsis*
- *Alternaria*, *Penicillium* & *Aspergillus* are known allergen and toxin producers
Indoor vs Outdoor Fungi (Summer, 2004)

- Acremonium species: 28 CFU/m³ Indoor, 113 CFU/m³ Outdoor
- Alternaria species: 14.2 CFU/m³ Indoor, 14.2 CFU/m³ Outdoor
- Aspergillus niger: 14 CFU/m³ Indoor, 14 CFU/m³ Outdoor
- Basidiomycete: 7.1 CFU/m³ Indoor, 14.2 CFU/m³ Outdoor
- Cladosporium species: 35 CFU/m³ Indoor, 590 CFU/m³ Outdoor
- Non-sporulating fungi: 14 CFU/m³ Indoor, 28 CFU/m³ Outdoor
- Penicillium species: 14.2 CFU/m³ Indoor, 14.2 CFU/m³ Outdoor
- Pithomyces species: 14.2 CFU/m³ Indoor, 14.2 CFU/m³ Outdoor
- Pseudogymnoascus species: 14.2 CFU/m³ Indoor, 14 CFU/m³ Outdoor
- Rhodotorula species: 7.1 CFU/m³ Indoor, 14 CFU/m³ Outdoor
- Fusarium species: 7.1 CFU/m³ Indoor, 14 CFU/m³ Outdoor
Bacteria

- Indoor bacterial concentrations were less than outdoors and ranged from 21-42 CFM/m$^3$
- Predominantly human-shed species of Corynebacterium, Micrococcus, Staphylococcus, Bacillus species, and Aerobic actinomycetes
Conclusion

- Measured comfort environmental parameters were generally within ASHRAE’s acceptable levels.
- Avg CO₂ levels by far exceeded levels of occupant complaints reported in the EPA’s BASE study.
- Alternaria, Penicillium & Aspergillus sp isolated from classrooms are known allergen and toxin producers.
- Prevention is key to reducing the risks of daycare children to environmental toxins and contaminants.
Acknowledgments

The project was supported in part by
- WKU Summer Faculty Fellowship
- Dean of CHHS and Provost’s Office

THANK YOU FOR YOUR ATTENTION!