Indoor Air Quality in Schools

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Indoor Air Quality in Schools

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February 15th, 2018
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Eastern Kentucky University

Problem:
• Contacted by a school with teachers complaining about sickness they associated with poor indoor air quality at work…..AGAIN.

What do we do?

About the School
• GOAL: Net Zero School
  • Radon Monitors
  • Carbon Dioxide Sensors
  • Temp and Relative Humidity Controls
Introduction

- Required by law in the US
- **Huge gap in identifying, tracking, and remediating** environmental health threats in school\(^1\)

\(^1\)Paulson and Barnett (2016)

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Indoor Air Quality (IAQ) Concerns

- Schools are subject to relatively unique
  - pollutant exposure
  - health
  - comfort concerns\(^2\)
    - mechanically ventilated
    - high occupant densities\(^2\)

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Indoor Air Quality

- Attributes of indoor air affecting a person’s wellbeing
  - Pollutant level
  - Air temperature
  - Humidity
  - Air velocity
  - Odors
  - Etc.
IAQ Methods

- Visual Survey
  - Visible signs of past or present water damage
  - Visible fungal growth
  - Possible points of water and pollutant intrusion

- Indoor Environmental Quality Survey
  - Faculty and Staff

IAQ Methods

- Radon Sampling
  - Charcoal canister

- Comfort Parameter Sampling
  - VelociCalc 9555-P Multi-Function Ventilation Meter
    - Carbon Dioxide (ppm)
    - Carbon Monoxide (ppm)
    - Relative Humidity (%)
    - Temperature (°F)
Major Indoor Air Pollutants

- These pollutants have been identified as potential health risks in buildings:
  - Asbestos
  - Radon
  - Combustion by-products (CO, CO₂)
  - Aldehydes
  - VOCs
  - Mold

ACM Example

Figure 2: ACM Example

Figure 3: How radon enters a house

13,000 – 16,000 lung cancer deaths a year
CO Health Effects

- Long-term exposure can lead to increased risk of heart disease.4

<table>
<thead>
<tr>
<th>Percent CO in Blood</th>
<th>Typical Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>None</td>
</tr>
<tr>
<td>3-20</td>
<td>Slight headache</td>
</tr>
<tr>
<td>21-30</td>
<td>Headache, slight increase in respiration, drowsiness</td>
</tr>
<tr>
<td>31-40</td>
<td>Headache, impaired judgment, shortness of breath, increased heart rate, nausea</td>
</tr>
<tr>
<td>41-50</td>
<td>Pounding headache, confusion, marked shortness of breath, marked drowsiness, increasing blurring of vision</td>
</tr>
<tr>
<td>&gt;100</td>
<td>Unconsciousness, eventual death if victim is not removed from source of CO</td>
</tr>
</tbody>
</table>

Figure 4: CO health symptoms

Table 1. CO2 PPM and Health Problems

<table>
<thead>
<tr>
<th>PPM</th>
<th>Health Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000-2000</td>
<td>Drowsiness and poor air</td>
</tr>
<tr>
<td>2000-5000</td>
<td>Headaches, sleepiness, and stagnant, stale, stuffy air. Poor concentration, loss of attention, increased heart rate, and nausea</td>
</tr>
<tr>
<td>5000</td>
<td>Oxygen deprivation could occur</td>
</tr>
</tbody>
</table>

Formaldehyde (HCHO)

- Widely used industrial and commercial chemical
- Found in pressed wood materials2
- Potent mucous membrane irritant
- Chronic exposure may cause CNS issues
Volatile Organic Compounds (VOCs)
- Emitted from a variety of sources:
  - Building materials and furnishings
  - Consumer products
  - Building maintenance materials
  - Office equipment
  - Tobacco smoke

Mold
- Widely found in building environments
  - Face paper of gypsum board
  - Ceiling tiles
  - Processed wood fiber materials

<table>
<thead>
<tr>
<th>Date</th>
<th>Morning</th>
<th>Afternoon</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 9</td>
<td>138</td>
<td>167</td>
</tr>
<tr>
<td>January 10</td>
<td>139</td>
<td>173</td>
</tr>
<tr>
<td>January 11</td>
<td>142</td>
<td>166</td>
</tr>
<tr>
<td>January 12</td>
<td>143</td>
<td>173</td>
</tr>
<tr>
<td>January 13</td>
<td>139</td>
<td>169</td>
</tr>
</tbody>
</table>
Weather

<table>
<thead>
<tr>
<th>Date</th>
<th>Low Temp °F</th>
<th>High Temp °F</th>
<th>Precipitation in inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 9</td>
<td>17</td>
<td>37</td>
<td>0</td>
</tr>
<tr>
<td>January 10</td>
<td>36</td>
<td>53</td>
<td>0.12</td>
</tr>
<tr>
<td>January 11</td>
<td>44</td>
<td>60</td>
<td>0.28</td>
</tr>
<tr>
<td>January 12</td>
<td>41</td>
<td>67</td>
<td>0.35</td>
</tr>
<tr>
<td>January 13</td>
<td>36</td>
<td>41</td>
<td>0.15</td>
</tr>
<tr>
<td>January 14</td>
<td>38</td>
<td>45</td>
<td>0.4</td>
</tr>
<tr>
<td>January 15</td>
<td>37</td>
<td>41</td>
<td>0.14</td>
</tr>
<tr>
<td>January 16</td>
<td>41</td>
<td>62</td>
<td>0.06</td>
</tr>
<tr>
<td>January 17</td>
<td>45</td>
<td>67</td>
<td>1.22</td>
</tr>
</tbody>
</table>

Visual Observations

Water Damage

Leak Residue

Open Containers

Mold Growth
Visual Observations

Additional Observations
• Vents not operable by teachers
• Chemistry lab without vents/hoods
• Chemical storage without ventilation
• Humidifiers in classrooms, labs, and offices

Comfort Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit/Range</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>°C (°F)</td>
<td>ASHRAE Standard 55-2017</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>30% to 65%</td>
<td>ASHRAE Standard 55-2017</td>
</tr>
<tr>
<td>Air Movement</td>
<td>3.5A (1.5 A peak)</td>
<td>ASHRAE Standard 55-2017</td>
</tr>
<tr>
<td>Ventilation (fresh air)</td>
<td>25 to 30 air changes per hour, depending on type of use</td>
<td>ASHRAE Standard 62.1-2010</td>
</tr>
<tr>
<td>Ventilation (CO₂)</td>
<td>About 700 ppm ever carbon dioxide</td>
<td>ASHRAE Standard 62.1-2010</td>
</tr>
</tbody>
</table>

Figure 10: Air Quality Guidelines
Impact of Relative Humidity

- Relative humidity levels below 40 percent
  - Increased discomfort
  - Drying of the mucous membranes,
    - Coughing
    - Itching
    - Sore throats
  - High humidity may provide a growth medium for bacteria and fungi.

School Results (RH and Temp)

- Most rooms below recommended RH of 40%
  - 30-60% is desired
- Several rooms and hallways below recommended comfort temperature
  - For winter (68-78°F)

Radon

- Three spaces with action levels higher than 4

<table>
<thead>
<tr>
<th>4 pCi/L (148 Bq/m³) or greater</th>
<th>Below 4 pCi/L (148 Bq/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>If the testing indicates radon concentrations equal to or greater than 4 pCi/L in any office area, classroom, exercise facility, meeting room, dining area, or other common area, reduce the radon to below 4 pCi/L. The higher the radon concentration, the more quickly action should be taken to reduce the concentration.</td>
<td>Radon concentrations below 4 pCi/L still pose risk to occupants. Consider fixing the building if test results indicate radon concentrations between 2 and 4 pCi/L (74 and 148 Bq/m³). Note that reducing and accurately confirming radon concentrations of about 2 pCi/L or below may be difficult. If test results are below the action level, confirm the low results by testing again at least every 5 years and whenever significant changes to the building’s structure or mechanical systems occur.</td>
</tr>
</tbody>
</table>
Carbon Dioxide ($\text{CO}_2$)

- Ambient concentration: 300-400 ppm
- Indoor concentration greater than 1000 ppm possibility of inadequate ventilation and complaints
  - Headaches
  - Fatigue
  - Eye and throat irritation
Indoor Environmental Quality Survey

Presence of carpet on all or most of the workstation floor

- Yes: 17%
- No: 83%

Survey-takers who work with a computer

- Yes: 92%
- No: 8%

Survey-takers who consider themselves especially sensitive to:

- Tobacco Smoke: 50%
- Other Chemicals in the Air: 42%
Indoor Environmental Quality Survey

- Stayed Same
- Got Better

Environmental Conditions

- Every or Almost Every Workday
- Less than 4 hours
- Air too dry
- Temperature too cold
- Impaired chemical senses
- Temperature too hot
- Other impaired senses (e.g., body odors, food odors, perfumes)
Environmental Conditions

Themes for Health and Environment

Short Term Follow-up

- Follow-up short-term radon measurements for caretaker’s apartment.
- Clean ceiling of possible microbial growth above windows
- Replace water damaged ceiling tiles.
- Remove personal dehumidifiers from offices, classrooms, and labs.
- Keep area in front of CO₂ sensors clear.
- The school CO₂ sensors are out of calibration.
- Improve housekeeping and minimize pet dander.
Short Term Recommendations

- Currently the relative humidity for the building is set at 35%, set it to 40%.
- Replace paint booth filters and contact paint booth manufacturer to determine optimal operating pressure.
- Develop a preventative maintenance plan and filter change schedule for the paint booth.
- Sampling for VOCs and welding fumes.

EPA Guidance on School IAQ

- Conduction in most IAQ investigations
- Surface Dust Sampling
- Airborne concentrations of
  - Gases
  - Vapors
  - Biological Contaminants
IAQ Management

- Exclusion
  - Avoid use of contaminant emitting products (e.g. HCHO-free)
  - Low-emitting products (e.g. Low levels of HCHO)
- Source Removal
- Source Treatment
  - Treated or modified to reduce contaminant emissions
    - Encapsulate furniture containing HCHO
- Ventilation
  - Infiltration and exfiltration
  - Natural (e.g. open doors and windows)
  - Mechanical (e.g. general dilution and local exhaust ventilation)

Addressing risks from IAQ

- One study laid out five ways to address air quality:
  - Type I: Raise Awareness
  - Type II: Change Behavior
  - Type III: Change products/materials and places of activities
  - Type IV: Make technical and technological changes
  - Type V: Make structural changes

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23rd Annual EKU Environmental Health Symposium

When: March 27th, 2018
Time: 9:00 AM – 5:00 PM
Where: Perkins Building (EKU Campus)
Cost: Professionals and Non Students ($35.00)

***Includes lunch and CEUs***

References


References