2018

Indoor Air Quality in Schools

Clint Pinion Jr.
Eastern Kentucky University, clint.pinion@eku.edu

Indoor Air Quality in Schools

KyEHA Annual Education Conference
February 15th, 2018
Clint Pinion, Dr.PH, RS
Eastern Kentucky University

EKU College of Health Sciences ENVIRONMENTAL HEALTH

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)

EKU College of Health Sciences ENVIRONMENTAL HEALTH

Indoor Air Quality (IAQ) Concerns

- Schools are subject to relatively unique
  - ❖pollutant exposure
  - ❖Health
  - ❖comfort concerns[2]
    - mechanically ventilated
    - high occupant densities[2]

EKU College of Health Sciences ENVIRONMENTAL HEALTH

Indoor Air Quality

- Attributes of indoor air affecting a person's wellbeing
  - ❖Pollutant level
  - ❖Air temperature
  - ❖Humidity
  - ❖Air velocity
  - ❖Odors
  - ❖Etc.

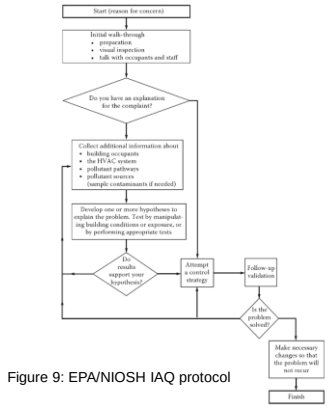


Figure 9: EPA/NIOSH IAQ protocol

- Investigating IAQ Issues

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, CO_2)
  - ❖Aldehydes
  - ❖VOCs
  - ❖Mold

EKU College of Health Sciences ENVIRONMENTAL HEALTH

ACM Example

Figure 2: ACM Example

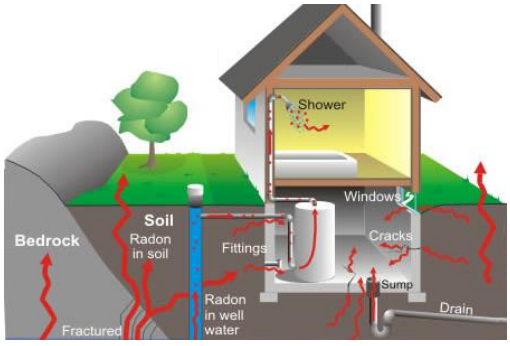


Figure 3: How radon enters a house[3]

13,000 – 16,000 lung cancer deaths a year

CO Health Effects

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

Percent CO in Blood	Typical Symptoms
<10	None
10-20	Slight headache
21-30	Headache, slight increase in respirations, drowsiness
31-40	Headache, impaired judgment, shortness of breath, increasing drowsiness, blurring of vision
41-50	Pounding headache, confusion, marked shortness of breath, marked drowsiness, increasing blurred vision
>51	Unconsciousness, eventual death if victim is not removed from source of CO

Figure 4: CO health symptoms

EKU College of Health Sciences ENVIRONMENTAL HEALTH

Table 1. CO2 PPM and Health Problems

PPM	Health Problems
1000-2000	Drowsiness and poor air
2000-5000	Headaches, sleepiness, and stagnant, stale, stuffy air. Poor concentration, loss of attention, increased heart rate, and nausea
5000	Oxygen deprivation could occur

Formaldehyde (HCHO)

- Widely used industrial and commercial chemical
  - Found in pressed wood materials[2]
- Potent mucous membrane irritant
- Chronic exposure may cause CNS issues

EKU College of Health Sciences ENVIRONMENTAL HEALTH

Volatile Organic Compounds (VOCs)

- Emitted from a variety of sources:
  - ❖Building materials and furnishings
  - ❖consumer products
  - ❖building maintenance materials
  - ❖office equipment
  - ❖tobacco smoke

EKU College of Health Sciences ENVIRONMENTAL HEALTH

Mold

- Widely found in building environments
  - ❖face paper of gypsum board
  - ❖ceiling tiles
  - ❖processed wood fiber materials

EKU College of Health Sciences ENVIRONMENTAL HEALTH

Student Numbers

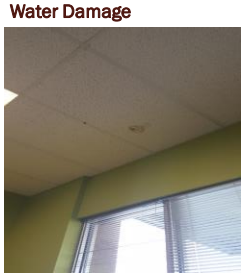
Date	Morning	Afternoon
January 9	130	167
January 10	139	173
January 11	142	166
January 12	143	172
January 13	139	169

Weather

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

Visual Observations

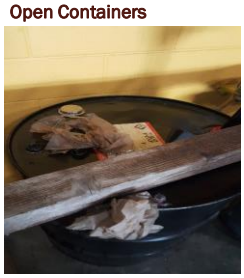
Water Damage



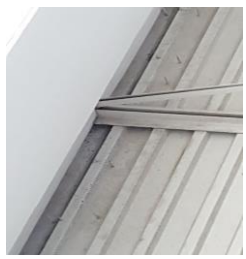
Leak Residue

Visual Observations

Open Containers



Mold Growth



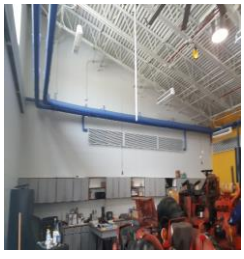
Visual Observations

Open Containers

Inadequate Filters

Visual Observations

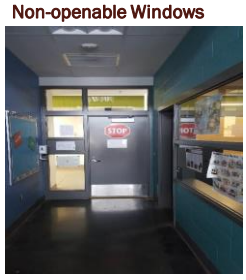
Wrong Ventilation



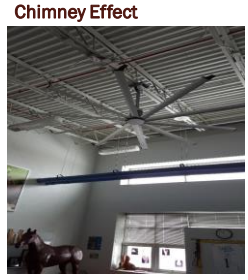
Inadequate Ventilation

Visual Observations

Non-openable Windows



Chimney Effect



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

Air Quality Guidelines

Parameter	Limit/Range	Reference
Temperature	Summer 74 to 82°F (23 to 28°C) Winter 68 to 78°F (20 to 25.5°C)	ASHRAE Standard 55-2010 ISO 7730
Relative Humidity	30% to 65%	ASHRAE Standard 55-2010 ISO 7730
Air Movement	0.8 ft/s or 0.25 m/s	WHO ISO 7730
Ventilation (fresh air)	15 to 60 cfm/person minimum depending on type of space	ASHRAE Standard 62.1-2010
Ventilation (CO_2)	About 700 ppm over outdoor ambient	ASHRAE Standard 62.1-2010

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)

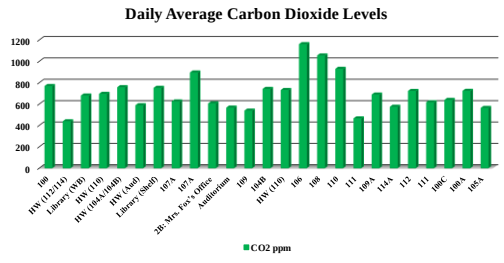
Radon

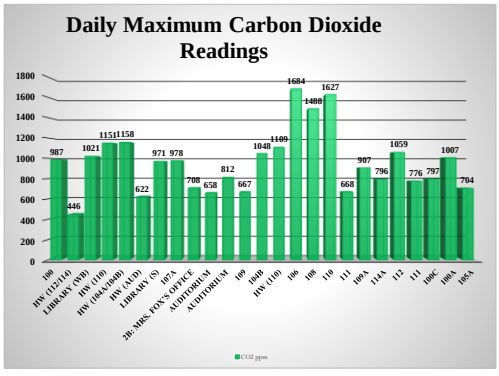
- Three spaces with action levels higher than 4

4 pCi/L (148 Bq/m^3) or greater	**Below 4 pCi/L (148 Bq/m^3)**
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 concentrations.	Radon concentrations below 4 pCi/L still pose a risk to occupants. Consider fixing the building if test results indicate radon concentrations between 2 and 4 pCi/L (74 and 148 Bq/m^3). 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.

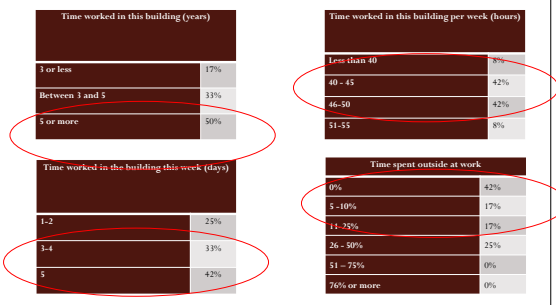
Carbon Dioxide (CO_2)

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

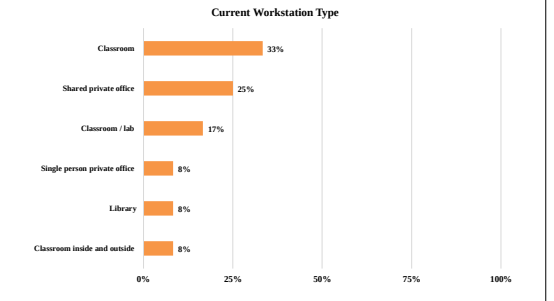




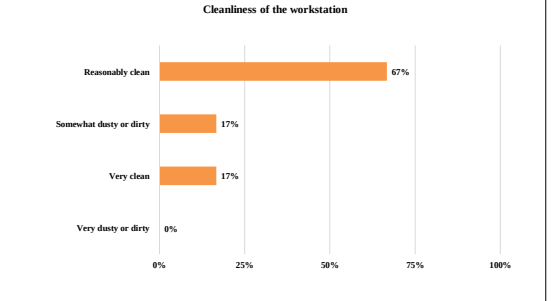
Indoor Environmental Quality Survey



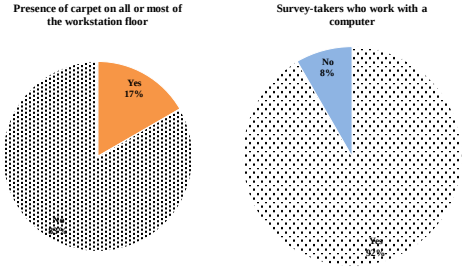
Indoor Environmental Quality Survey



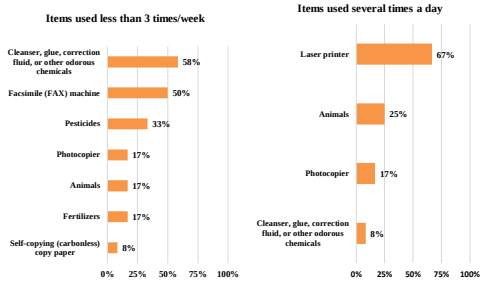
Indoor Environmental Quality Survey



Indoor Environmental Quality Survey



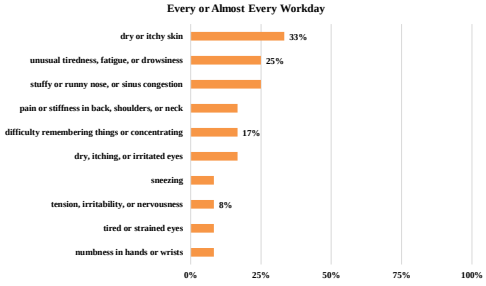
Indoor Environmental Quality Survey



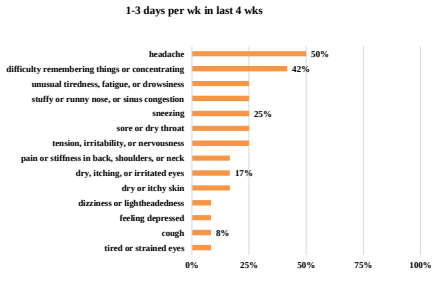
Indoor Environmental Quality Survey

Survey-takers who consider themselves especially sensitive to:	
Tobacco Smoke	50%
Other Chemicals in the Air	42%

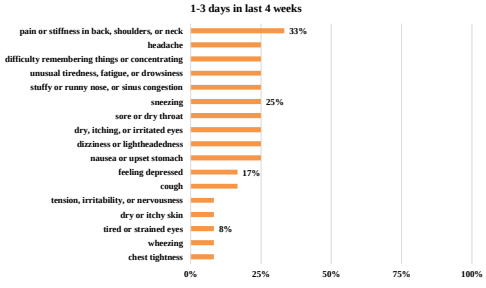
Indoor Environmental Quality Survey



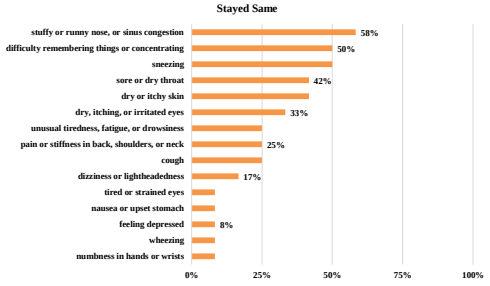
Indoor Environmental Quality Survey



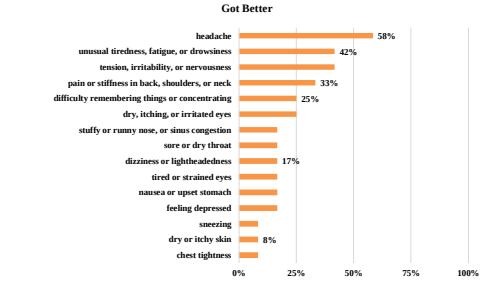
Indoor Environmental Quality Survey



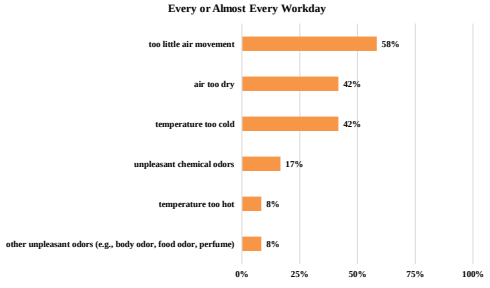
Indoor Environmental Quality Survey



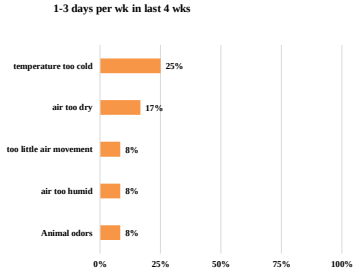
Indoor Environmental Quality Survey



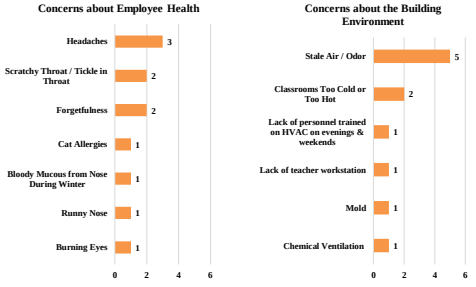
Environmental Conditions



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 CO_2 sensors clear.
- The school CO_2 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

Figure 6: Framework for Effective School Indoor Air Quality Management[5]

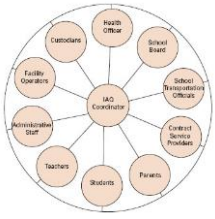


Figure 7: Forming an IAQ Team[6]

Measurement of Indoor Contaminants

- Conducted 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[7]

EKU College of Health Sciences ENVIRONMENTAL HEALTH

CONTACT INFO:

Dr. Clint Pinion
clint.pinion@eku.edu

EKU College of Health Sciences ENVIRONMENTAL HEALTH

Clint Pinion, Dr.PH, RS
Assistant Professor
Environmental Health Sciences
Eastern Kentucky University
P: (859) 622-6330

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

EKU
College of Health Sciences
ENVIRONMENTAL HEALTH

References

1. Paulson JA, Barnett CL. 2016. Public Health Stops at the School House Door. Environ Health Perspect 124(10): A171-A175
2. Godish T, Davis WT, Fu JF. 2014. Air Quality, Fifth Edition. Taylor & Francis Inc, Bosa Roca.
3. Hendricks B. 2017. Why You Should Get a Radon Test in Louisville. ABI Home Inspection Service. Available: http://abihomeservices.com/louisville-radon-testing/ [accessed 27 September 2017].
4. 2016. Carbon Monoxide Poisoning. Centers for Disease Control and Prevention. Available: https://ephtracking.cdc.gov/showCoRisk.action [accessed 27 September 2017].
5. 2016. The Framework for Effective School Indoor Air Quality Management: Key Drivers. EPA. Available: https://www.epa.gov/iaq-schools/framework-effective-school-indoor-air-quality-management-key-drivers [accessed 27 September 2017].
6. 2016. Coordinator's Guide for Indoor Air Quality. EPA. Available: https://www.epa.gov/indoor-air-quality-iaq/printable-version-coordinators-guide-indoor-air-quality [accessed 27 September 2017].

EKU College of Health Sciences ENVIRONMENTAL HEALTH

References

7. Sa JP, Branco PTBS, Alvim-Ferrz MCM, Martins FG, Sousa SIV. 2017. Evaluation of Low-Cost Mitigation Measures Implemented to Improve Air Quality in Nursery and Primary Schools. Int J Environ Res Public Health 14(6): 585.
8. Poulin P, Leclerc J-M, Dessau J-C, Deck W, Gagnon F. 2012. Radon Measurement in Schools Located in Three Priority Investigation Areas in the Province of Quebec, Canada. Radiat Prot Dosimetry 151(2): 278-289.
9. de Gennaro G, Farella G, Marzocca A, Mazzone A, Tutino M. 2013. Indoor and Outdoor Monitoring of Volatile Organic Compounds in School Buildings: Indicators Based on Health Risk Assessment to Single out Critical Issues. Int J Environ Res Public Health 10: 6273-6291.
10. Godwin C, Batterman S. 2006. Indoor air quality in Michigan schools. Indoor Air 17: 109–121.
11. Lazovic I, Stevanovic Z, Jovasevic-Stojanovic M, Zivkovic M, Banjac M. 2016. Impact of CO2 concentration on indoor air quality and correlation with relative humidity and indoor air temperature in school buildings in Serbia. Thermal Science 20: 297–307.

References, continued

12. Madureira J, Paciência I, Pereira C, Teixeira JP, Fernandes EDO. 2015. Indoor air quality in Portuguese schools: levels and sources of pollutants. Indoor Air 26: 526–537.
13. Seo S, Ji YG, Yoo Y, Kwon MH, Choung JT. 2015. Submicron fungal fragments as another indoor biocontaminant in elementary schools. Environ. Sci.: Processes Impacts 17: 1164–1172.
14. Massawe E, Vasut L. 2013. Promoting Healthy School Environments: A Step-by-Step Framework to Improve Indoor Air Quality in Tangipahoa Parish, Louisiana. Advancement of the Science 76: 22–30.
15. Finell E, Haverinen-Shaughnessy U, Tolvanen A, Laaksonen S, Karvonen S, Sund R, et al. 2017. The associations of indoor environment and psychosocial factors on the subjective evaluation of Indoor Air Quality among lower secondary school students: a multilevel analysis. Indoor Air. 27: 329–337.
16. Ervasti J, Kivimaki M, Kawachi I, Subramanian SV, Pentti J, Oksanen T, et al. 2012. School environment as predictor of teacher sick leave: data-linked prospective cohort study. BMC Public Health 12:770
17. 2012. Student Health and Academic Performance. Environmental Protection Agency. Available: https://www.epa.gov/sites/production/files/2014-08/documents/student_performance_findings.pdf [accessed 27 September 2017].