

# Residential Air Studies and Evaluation of the Potential for Health Effects in Homes with Chinese Drywall

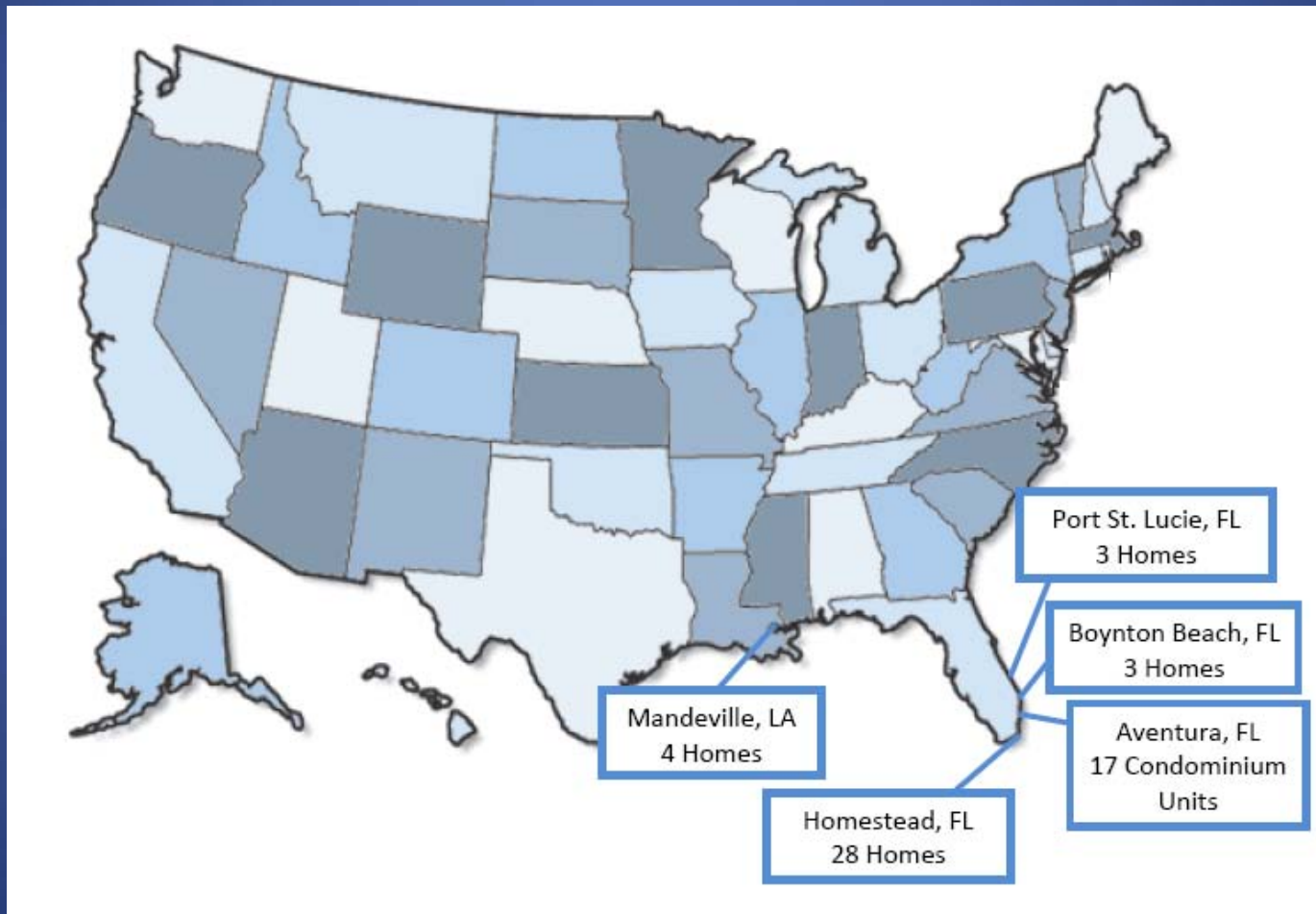
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# Introduction

- The Center for Toxicology and Environmental Health, L.L.C. (CTEH<sup>®</sup>) was retained by Knauf Plasterboard Tianjin (KPT) to conduct an independent, third-party indoor air quality investigation of residential units thought to contain drywall manufactured in China.

# Locations of home sampling



# Methods

- **Subject Homes:** Units with documented presence of Chinese drywall, reported odors, copper discoloration, and/or HVAC coil discoloration (42 homes).
- **Control Homes:** Units without the above conditions (13 homes).

# Methods cont.

- Indoor and outdoor air samples were analyzed for:
- **Aldehydes (NIOSH Method 2016)**
  - SKC pumps and Sorbent tubes used to collect 24-hour samples.
- **Volatile organic chemicals (USEPA Method TO-15 for VOCs)**
  - SUMMA canister 24-hour samples

# Methods cont.

- **Sulfur-containing chemicals (ASTM Method D5504)**
  - **Initial Sampling**
    - 26 Homestead, FL homes and 3 Boynton Beach, FL homes
    - SKC pumps and both SKC and Zefon Tedlar bags used for “grab” and 24-hour samples
    - However, artifact testing showed that SKC pumps and SKC Tedlar bags emitted low levels of carbon disulfide and carbonyl sulfide

# Methods cont.

- **Sulfur-containing chemicals (ASTM Method D5504)**
  - **Subsequent Sampling**
    - 17 Aventura, FL condominium units, 3 Port St. Lucie, FL homes, 4 Mandeville, LA homes, and 2 Homestead, FL homes
    - “Lung” box and Zefon Tedlar bags used for “grab” samples
    - Only Lung box samples discussed below
    - EPA TO-15
    - Teledyne 102E Real Time Continuous Total Reduced Sulfur (TRS)

# Quality Control/Quality Assurance

- QA/QC measures were conducted to ensure that results were reliable, reproducible and defensible
  - Used proper sampling methods
  - Equipment inspected
  - Samples uniquely identified
  - Chain of custody
  - Co-located samples and field blanks
  - Laboratory QA/QC
  - Data validation

# ASTM D5504 Analytes

- 2,5-Dimethylthiophene
- 2-Ethylthiophene
- 3-Methyl Thiophene/n-Butyl Mercaptan/Ethyl Methyl Sulfide
- 3-Methylthiophene
- Benzothiophene
- Bromothiophene
- Carbon Disulfide
- Carbonyl Sulfide
- Diethyl Disulfide
- Diethyl Sulfide
- Dimethyl Disulfide
- Dimethyl Sulfide
- Ethyl Mercaptan
- Ethyl Methyl Sulfide
- Hydrogen Sulfide
- Isobutyl Mercaptan
- Isopropyl Mercaptan
- Methyl Mercaptan

# ASTM D5504 Analytes

- Methylethylsulfide
- n-Butyl Mercaptan
- n-Propyl Mercaptan
- Phenyl Sulfide
- sec-Butyl Mercaptan
- Sulfur Dioxide
- tert-Butyl Mercaptan
- Tetrahydrothiophene
- Thiophene
- Thiophenol
- Total Reduced Sulfur as Hydrogen Sulfide
- Unidentified Sulfur

Method Detection Limit Range for ASTM D5504 Compounds – <1.0 to <12 ppbV

# EPA TO-15 Sulfur Compounds

- 2-(ethylthiol)-propane\*
- 2-furfurylthiol\*
- 2-methyl-3-furanthiol\*
- 3-methyl-2-butene-1-thiol\*
- Butyl ethyl sulfide\*
- Carbon disulfide
- Carbonyl sulfide
- Carbonyl sulfide\*
- Diethyl sulfide\*
- Diethylthiophene\*
- Diisopropyl disulfide\*
- Ethanethiol\*
- Ethyl isopentyl disulfide\*
- Ethyl isopropyl disulfide
- Isobutyl isopropyl disulfide\*
- Methyl ethyl disulfide\*
- Methyl mercaptan
- Propanethiol\*

\*Indicates a Tentatively Identified Compound (TIC)

Method Detection Limit Range for EPA TO-15 Sulfur Compounds – <0.5 to <50 ppbV

# Natural Sources of Sulfur-Containing Chemicals

Ocean Water	Vegetation and Forests
Salt Marshes	Wetlands
Soil	Biomass Burning
Human Breath	Human Diet (protein metabolism; food flavorings)

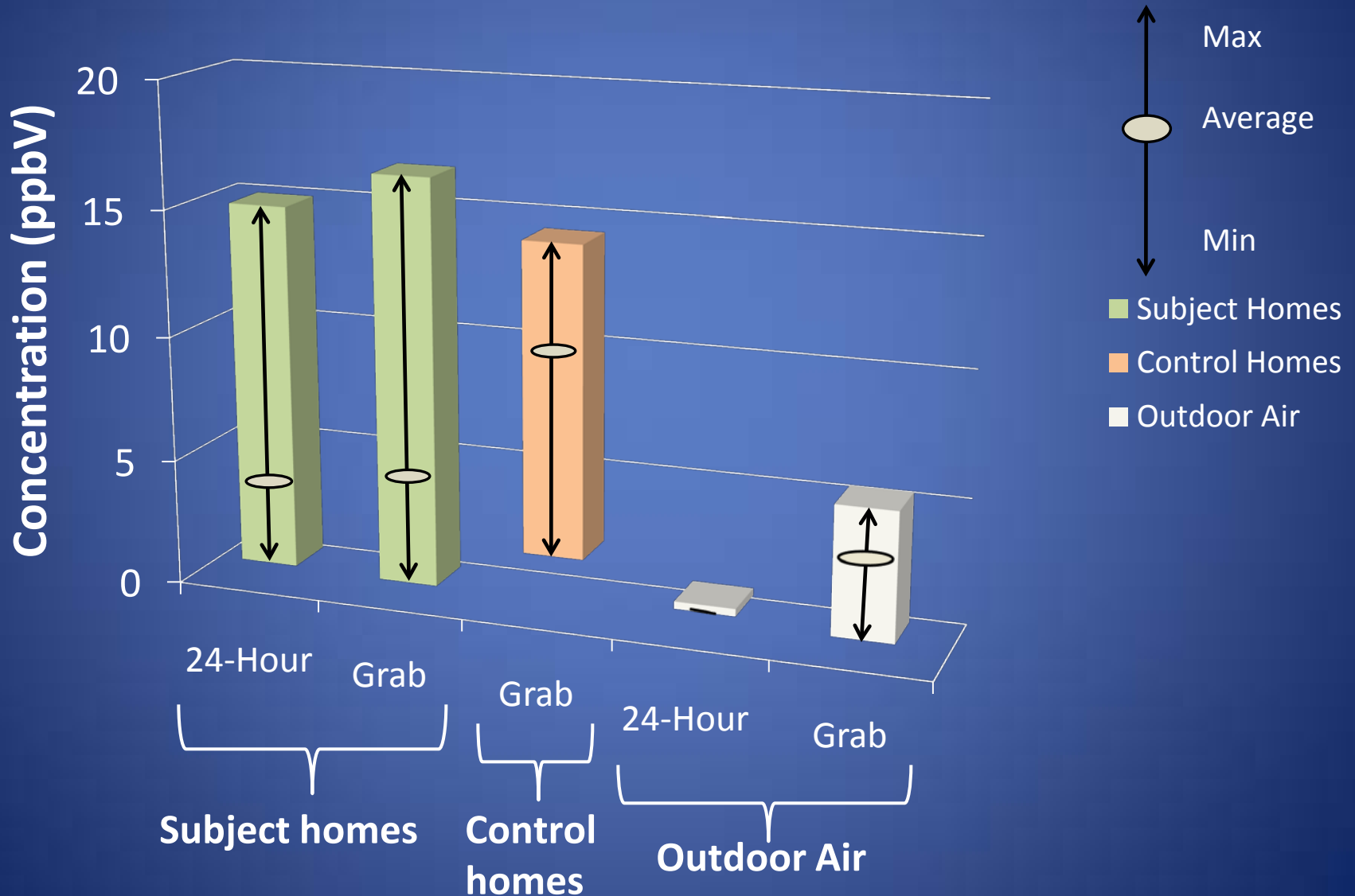
# Results

# Sulfur compound detections

		<b>Subject Homes</b>	<b>Control Homes</b>	<b>Outdoor Air</b>
<b>Carbonyl Sulfide (ppbV)</b>	Homes w/detects/ Homes tested	<b>20/23</b>	<b>5/6</b>	<b>9/27</b>
	Average* (range)	<b>3.0</b> <b>(0.5-16.6)</b>	<b>8.1</b> <b>(2.3-14.5)</b>	<b>1.6</b> <b>(0.5-5.6)</b>
<b>Carbon Disulfide (ppbV)</b>	Homes w/detects/ Homes tested	<b>7/42</b>	<b>1/12</b>	<b>1/34</b>
	Average* (range)	<b>1.6</b> <b>(0.8-3.2)</b>	<b>1.4</b> <b>(1.3-1.5)</b>	<b>2.1</b> <b>(2.1-2.1)</b>

\*Average of detections

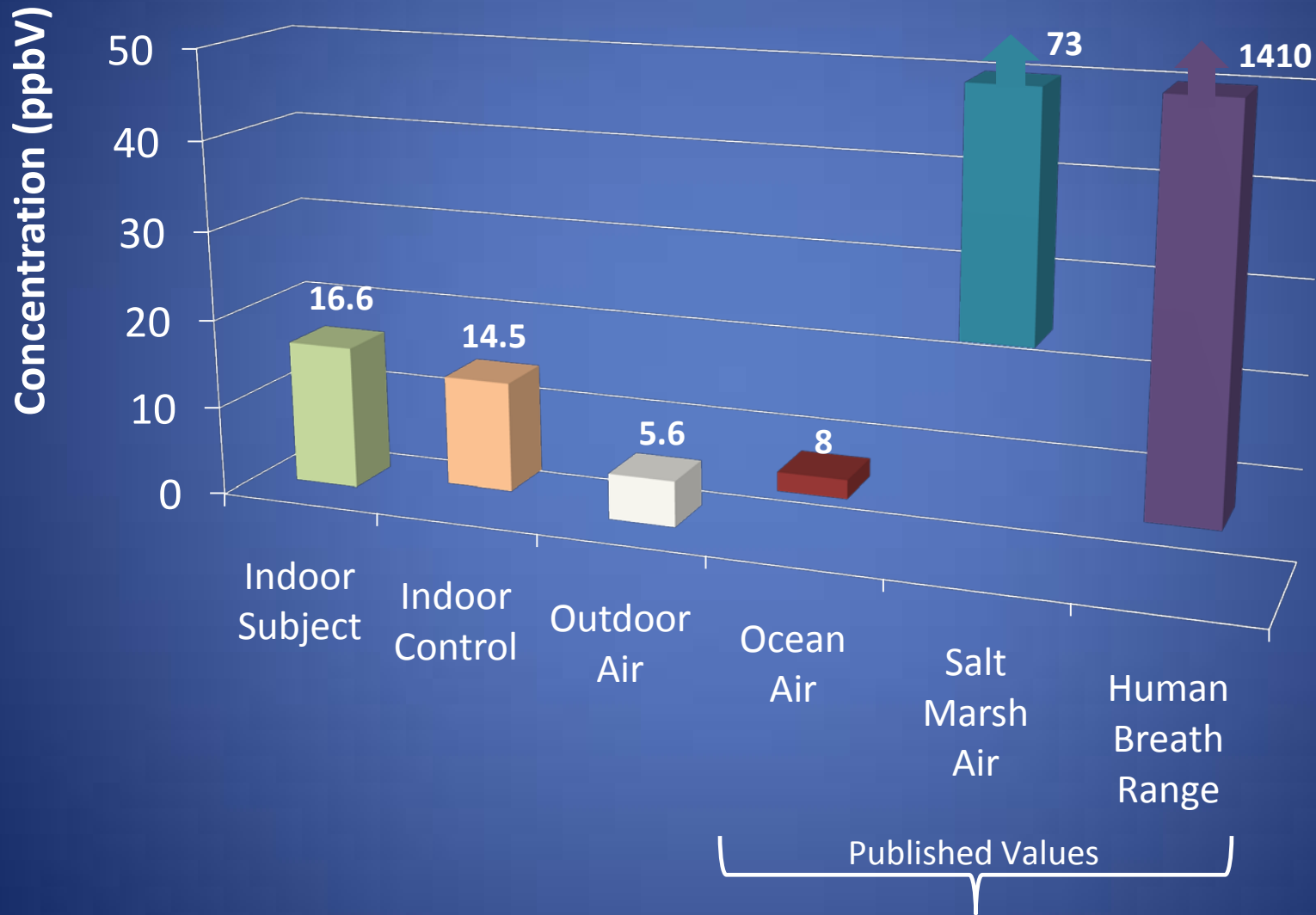
# Comparison of Indoor Carbonyl Sulfide Concentrations and Outdoor Air



# Carbonyl Sulfide

- Subject Home Maximum Reading 16.6 ppbV
- Detected in 20/23 Subject homes at levels similar to Control homes
- Detection limit range from <0.5 to <5 ppbV
- Present in normal human breath: Average 92 ppbV (range 7.3 to 1410 ppbV) (*Sehnert et al., 2002; personal communication with Dr. Risby, 2009*)
- Found in ocean air at 6 - 8 ppbV (*Kelly and Smith, 1990*)
- Found in air over salt marshes at 24 – 73 ppbV (*Kelly, 1990*)
- Occurs in foods such as cheese and grains (*Dias and Weimer, 1999; Ren and Desmarchelier, 2001*)

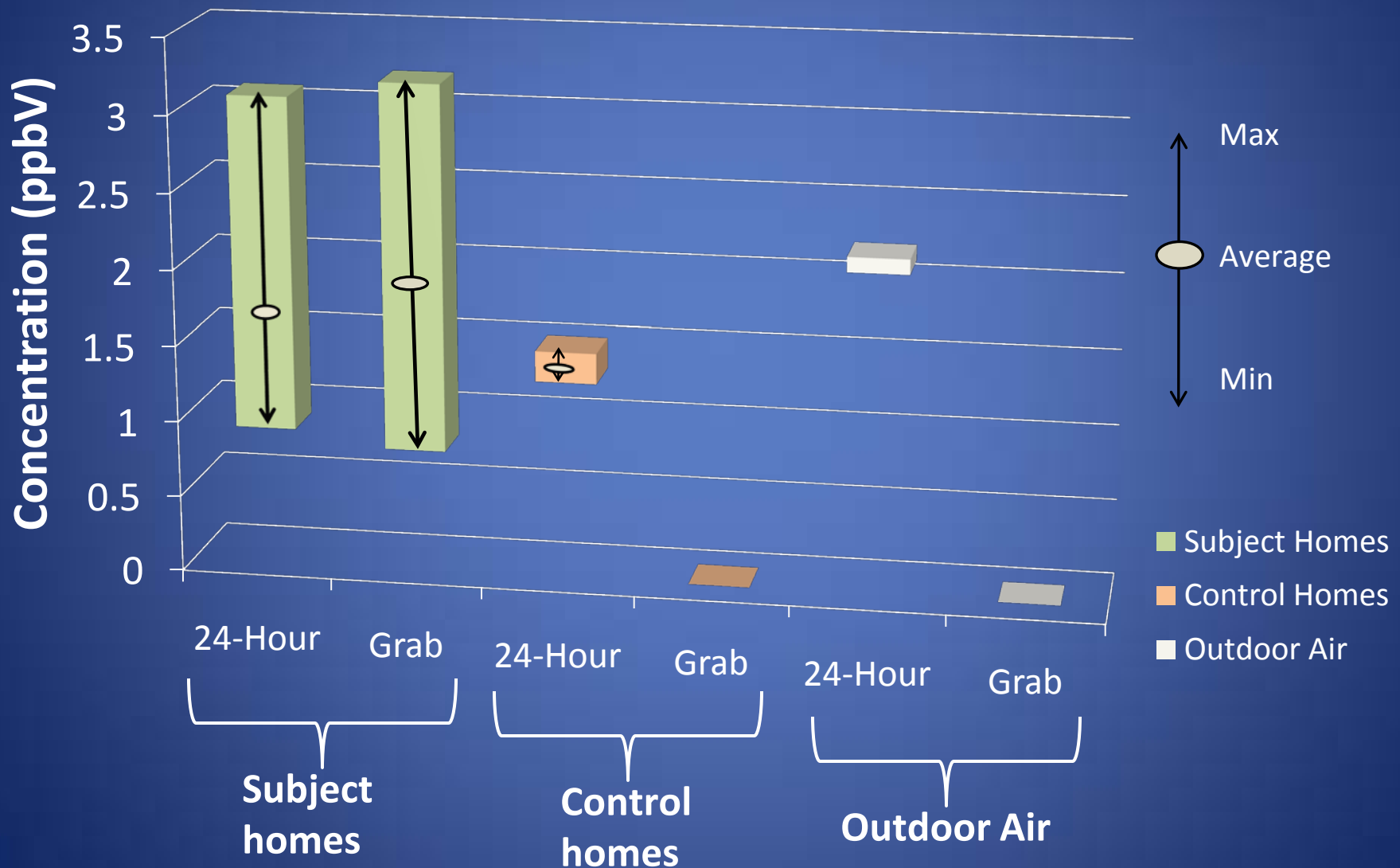
# Carbonyl Sulfide Air Concentrations and Comparison to Published Levels



# Carbonyl Sulfide

- There are no regulatory or occupational guidelines established
- Animals have shown **no effect** when exposed to 200,000 to 300,000 ppbV for six hours a day, five days a week for 12 weeks. (*Morgan et al, 2004; Bartholomaeus and Haritos, 2005*)
- The highest level found in indoor air is hundreds of times below the levels that causes no effect in animals.
- Levels do not pose a public health concern
- No correlation with the presence or absence of Chinese drywall

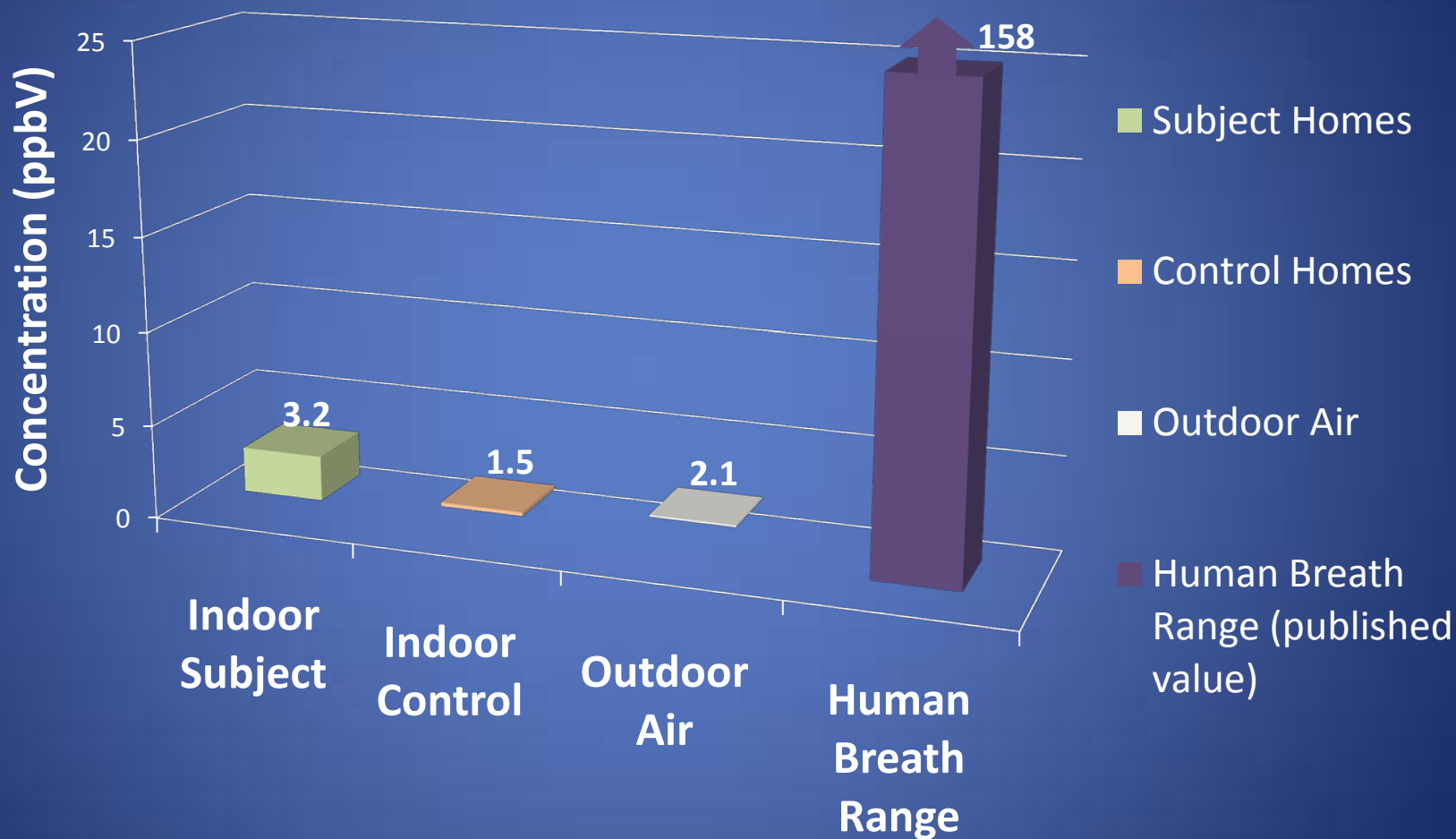
# Comparison of Indoor Carbon Disulfide Concentrations and Outdoor Air



# Carbon Disulfide

- Subject Home Maximum Reading: 3.2 ppbV
- Detected in 7/42 Subject homes
- Detection limit range from <0.5 to <49.9 ppbV
- Measured levels similar in Subject and Control Homes and Outdoor Air
- Released into atmosphere from oceans. *(HSDB 2009)*
- Found in normal human breath at an average of 24 ppbV (range 0.24 – 158 ppbV). *(Sehnert et al, 2002)*
- A concentration of 32 ppbV can be found above new carpeting. *(Sollinger et al, 1994)*

# Carbon Disulfide Air Concentrations Human Breath Comparison



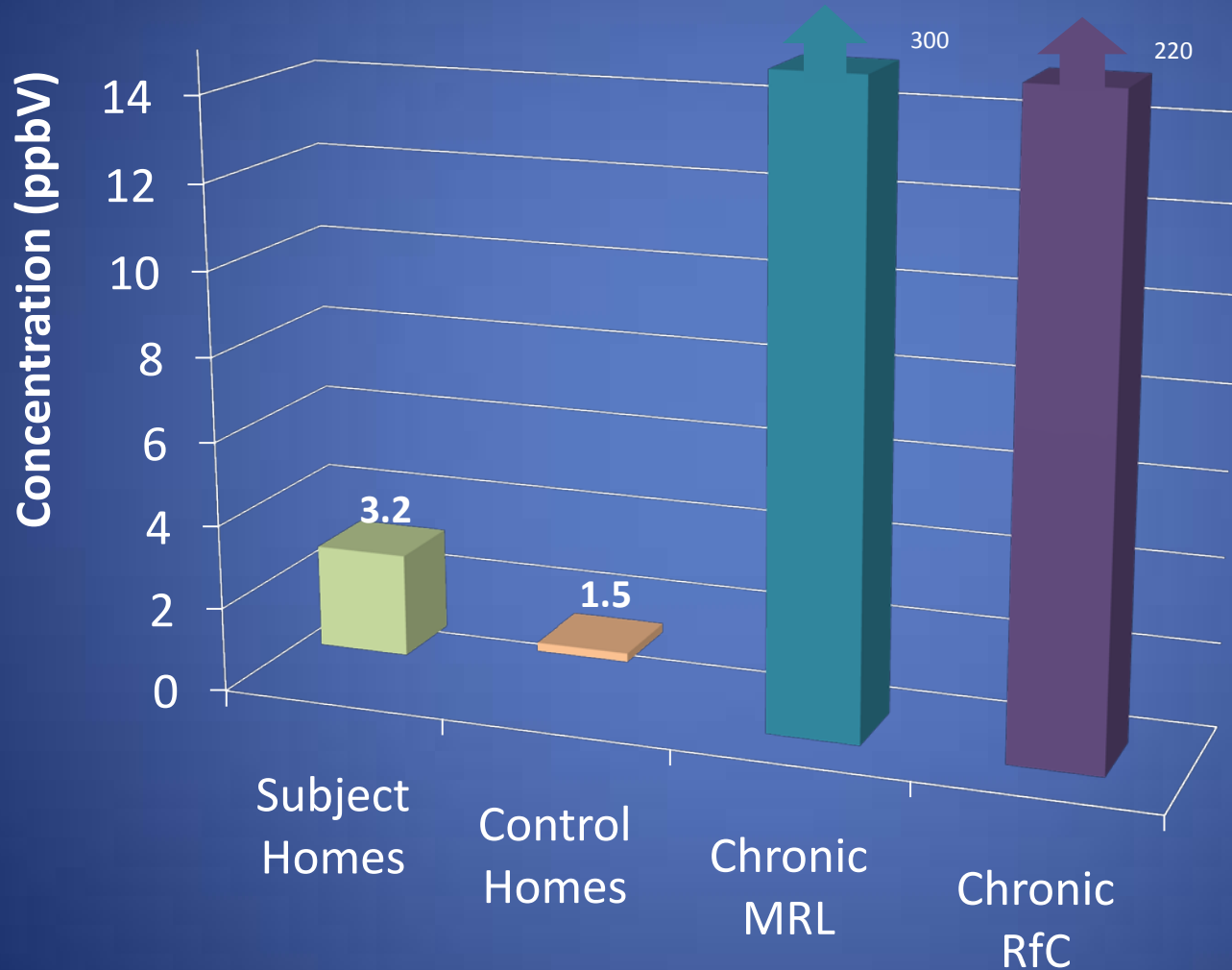
# Carbon Disulfide

- Chronic Minimal Risk Level (MRL) = 300 ppbV
- MRL is “an estimate of daily human exposure to a substance that is likely to be **without** an appreciable risk of adverse effects (noncarcinogenic)” following an exposure lasting a year or longer. *(ATSDR, 1996; emphasis added)*

# Carbon Disulfide

- Chronic Reference Concentration (RfC) = 220 ppbV.
- Chronic RfC is “an estimate, with uncertainty spanning perhaps an order of magnitude, of a daily [inhalation] exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime” (USEPA, 2009)

# Carbon Disulfide Levels Compared to Health Guidelines



# Carbon Disulfide

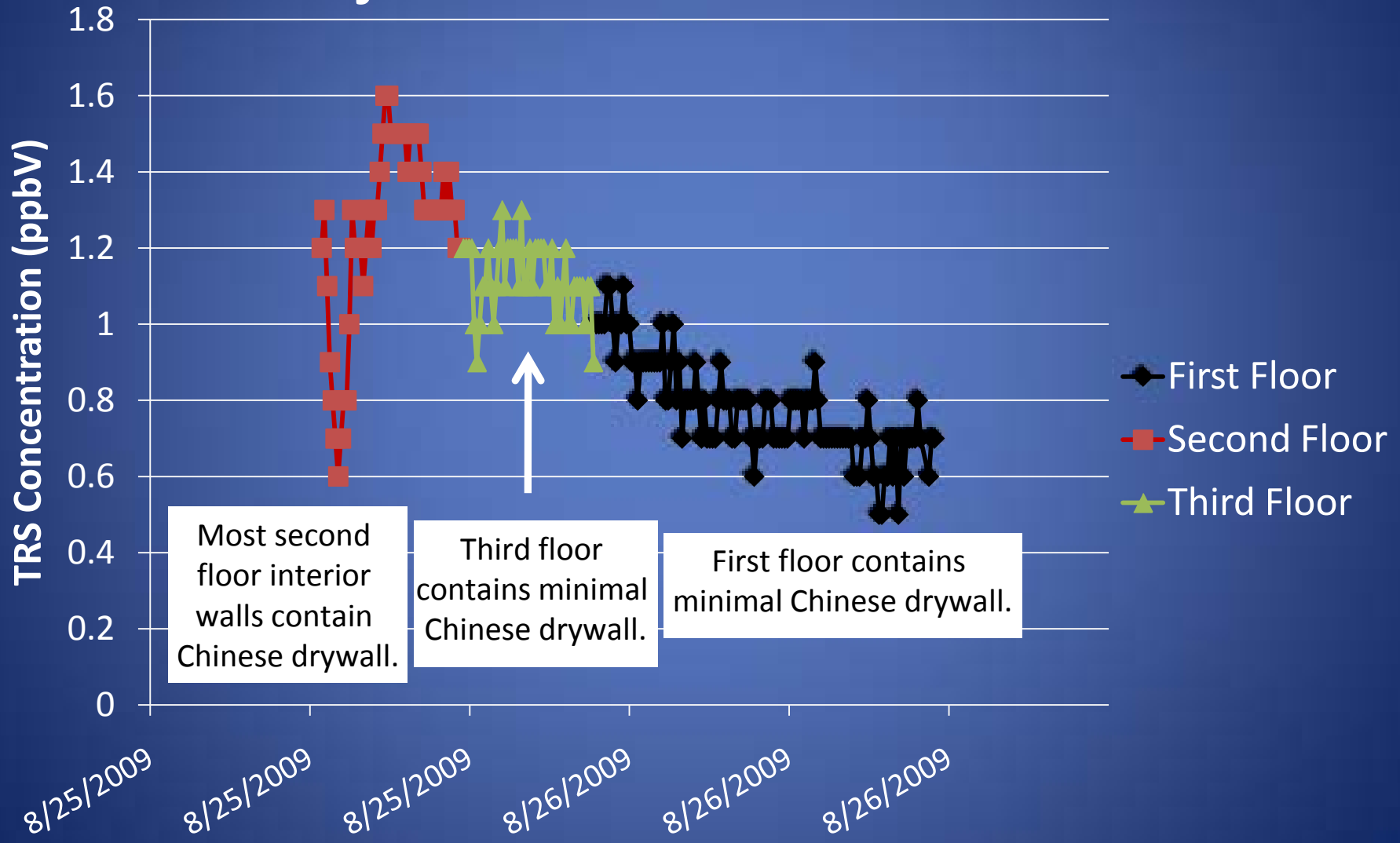
- All carbon disulfide levels were well below published health guidelines.
- Levels do not pose a public health hazard.

# Sulfur Compound Detections

		Subject Homes	Control Homes	Outdoor Air
<b>Methyl Mercaptan (ppbV)</b>	Homes w/detects/ Homes tested	2/42	1/13	7/39
	Average*	4.9	6.9	5.5
	(range)	(1.6-10)	(5.2-9.1)	(1.8-9.6)
<b>Sulfur Dioxide (ppbV)</b>	Homes w/detects/ Homes tested	2/18	0/7	2/12
	Average*	2.4	<1.0	3.1
	(range)	(1.6-4.0)	(<1.0-<1.0)	(2.6-3.7)

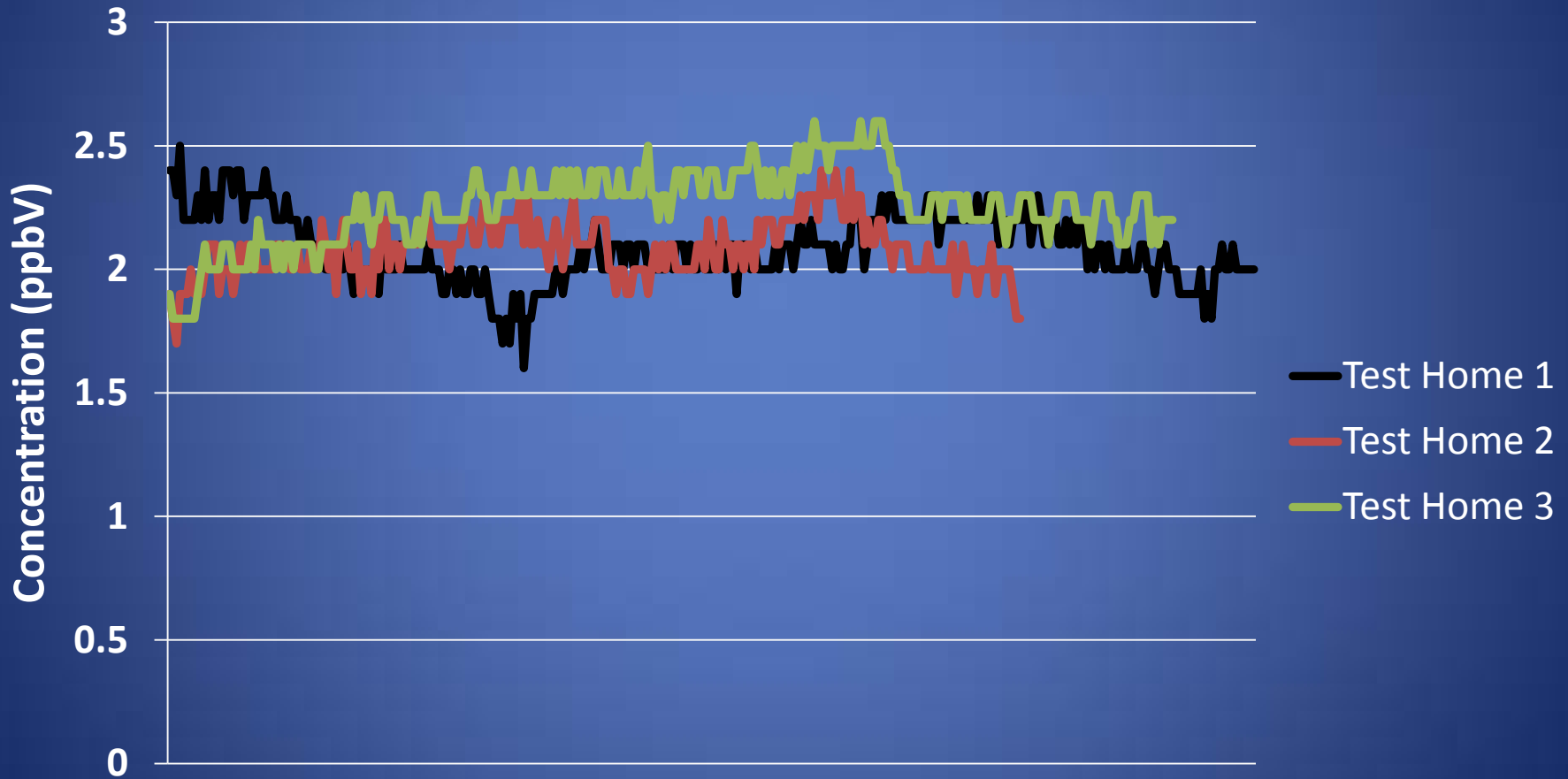
\*Average of detects

# TRS Concentrations in a Three Level Subject Townhouse in Louisiana



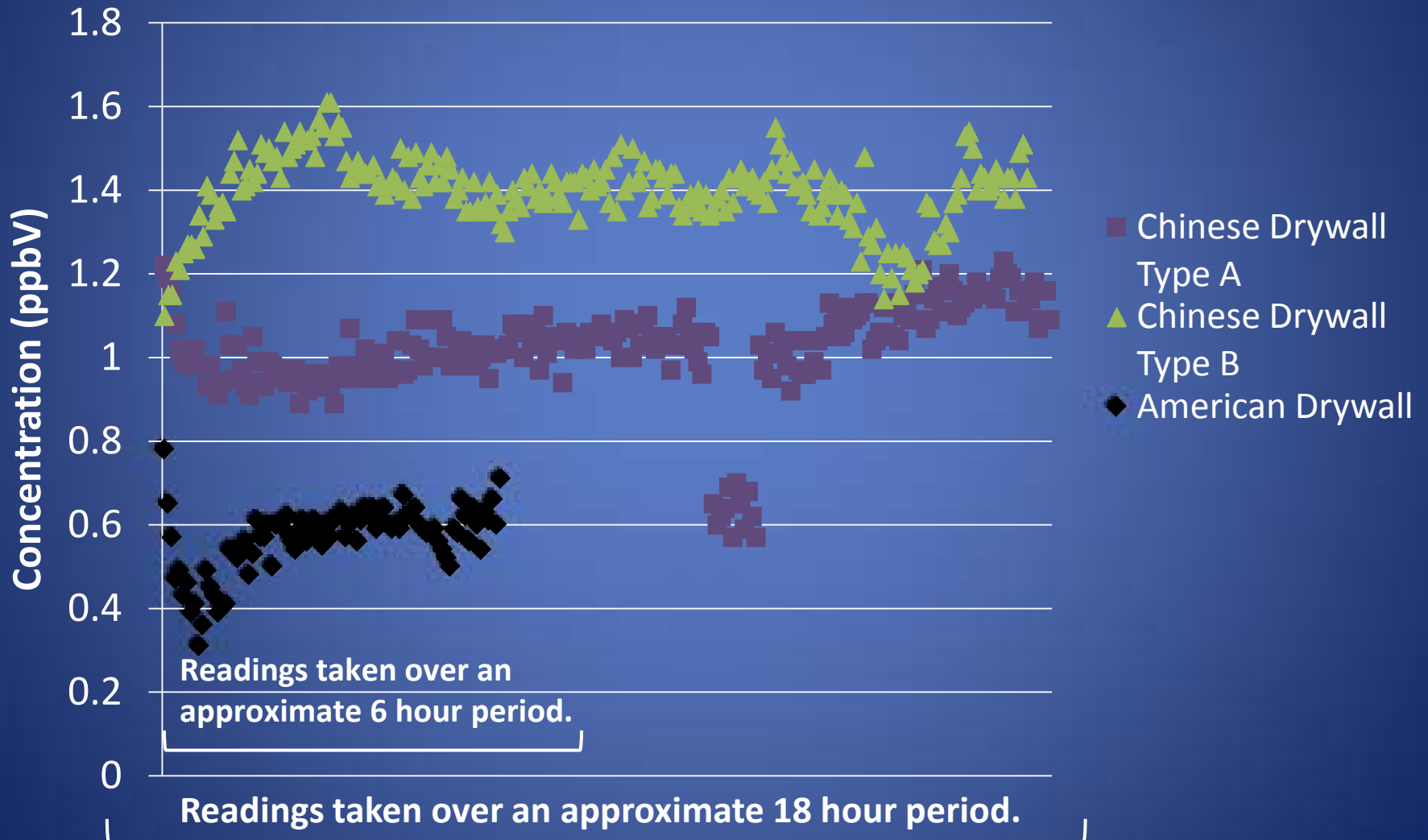
# TRS Comparison of Three Test Homes in Port St. Lucie, Florida

(all homes contain at least some Chinese drywall)



Readings taken over an approximate 24-hour period.

# TRS Comparison of Chinese and American Made Drywall in Florida Condominiums



# Total Reduced Sulfur Compounds

- Maximum level in Subject homes was 4.2 ppbV
- The Nebraska Department of Environmental Quality TRS standard is 100 ppb as a 30-minute rolling average
- A study of TRS in a community showed no association with respiratory hospital admissions at air levels up to 8 ppb (*Luginaah et al, 2005*)

# Hydrogen sulfide (A component of TRS)

	Subject Homes	Control homes	Outdoor Air
# of homes tested	41	13	-
# of samples taken	126	31	29
# of detections	1 (4.0 ppbV)	1 (1.7 ppbV)	0

# Hydrogen Sulfide (a component of TRS)

- Hydrogen sulfide detected in 1/41 Subject homes and 1/13 Control homes
- Detection limit range of <1 to <5 ppbV
- No connection between Chinese drywall and H<sub>2</sub>S detections
- Naturally found in foods such as beef, onion, cabbage, coffee and chicken
- Found in air above wine at levels up to 14.6 ppbV  
*(Lopez et al, 2007; Fang and Qian, 2005)*

# Hydrogen Sulfide (a component of TRS)

- Community evaluations conducted by ATSDR consistently find no public health concern for H<sub>2</sub>S levels ranging up to approximately 20-30 ppbV

# Hydrogen Sulfide (a component of TRS)

- ATSDR minimal Risk Level (MRL) for a 1 year exposure is 20 ppbV (*ATSDR, 2006*)
- EPA Subchronic RfC (7 year exposure) is 7 ppbV (*RAIS, 2009*)
- EPA chronic RfC (lifetime exposure) is 1.4 ppbV (*EPA, 2009*)
- One hour Ambient Air Guidelines for several states are generally in the 10-30 ppbV range

# Total Reduced Sulfur and Hydrogen Sulfide

- Concentrations of TRS and H<sub>2</sub>S detected in homes are not a public health concern

# VOCs

- Some VOCs were higher in Subject vs. Control homes
- VOCs detected are commonly found in household products, except for Freon 22.
- Levels of all VOCs below established health guidelines and/or within known levels for indoor air
- VOC levels in homes are not a public health concern

# Conclusions

- Levels of detected sulfur compounds, carbon disulfide, carbonyl sulfide, sulfur dioxide, methyl mercaptan, hydrogen sulfide, and TRS, were all below levels associated with health effects
- Individual chemical levels not related to the presence or absence of Chinese drywall
- Levels of VOCs were also below levels associated with health effects
- Chemical levels in the air of homes with Chinese drywall do not present a public health concern