

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

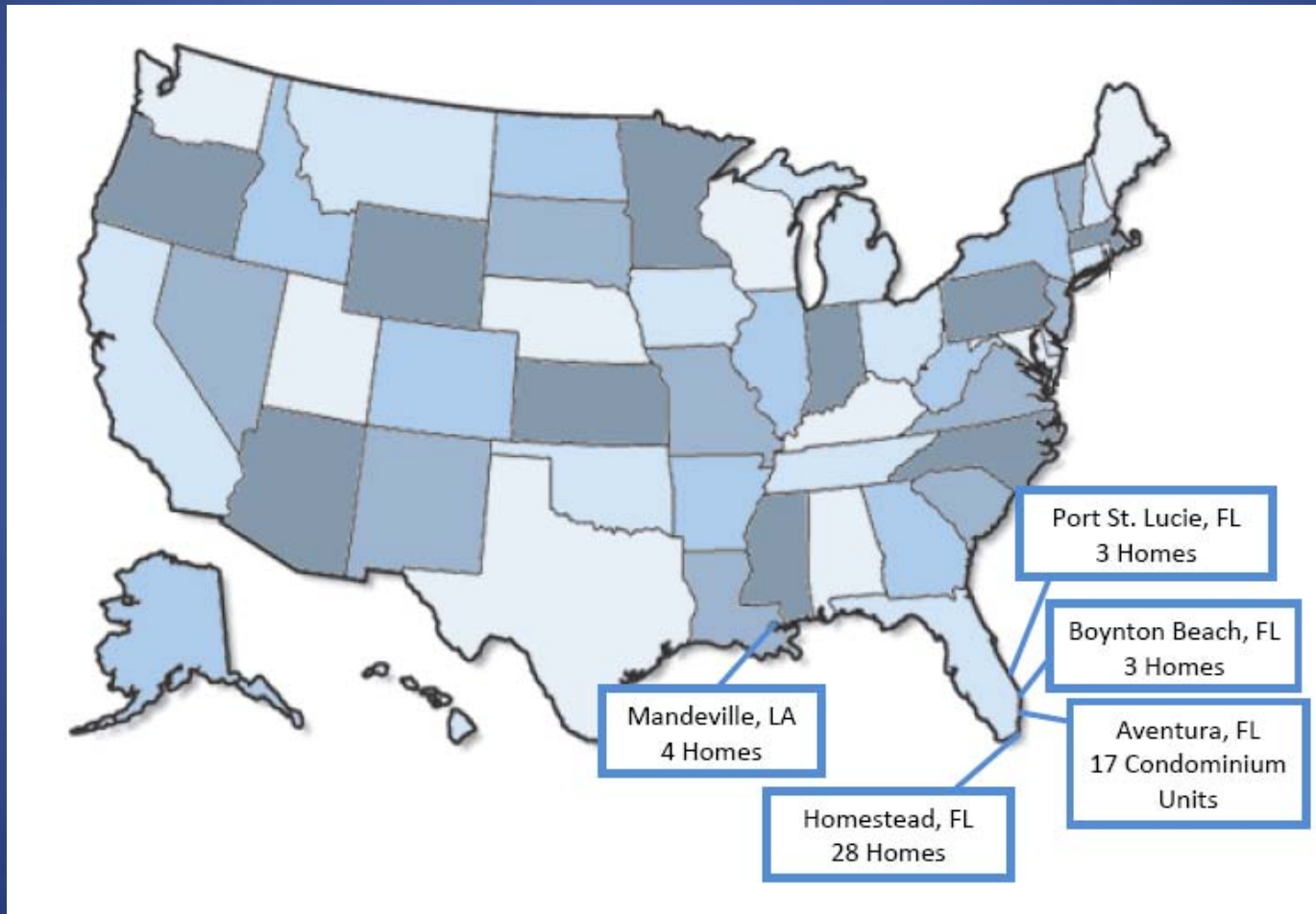
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(CTEH®)

Introduction

- The Center for Toxicology and Environmental Health, L.L.C. (CTEH[®]) 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)

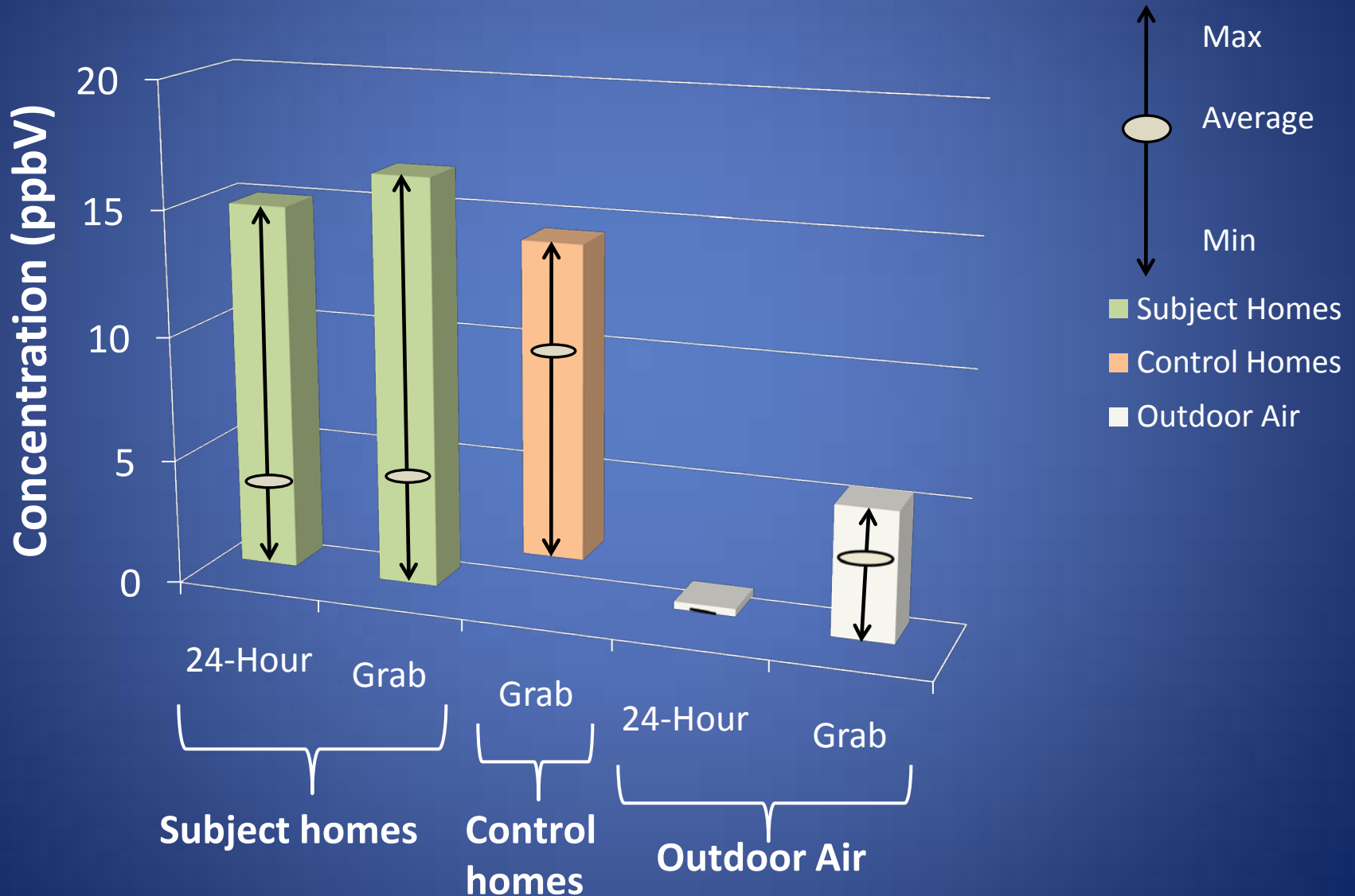
Results

Sulfur compound detections

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

*Average of detections

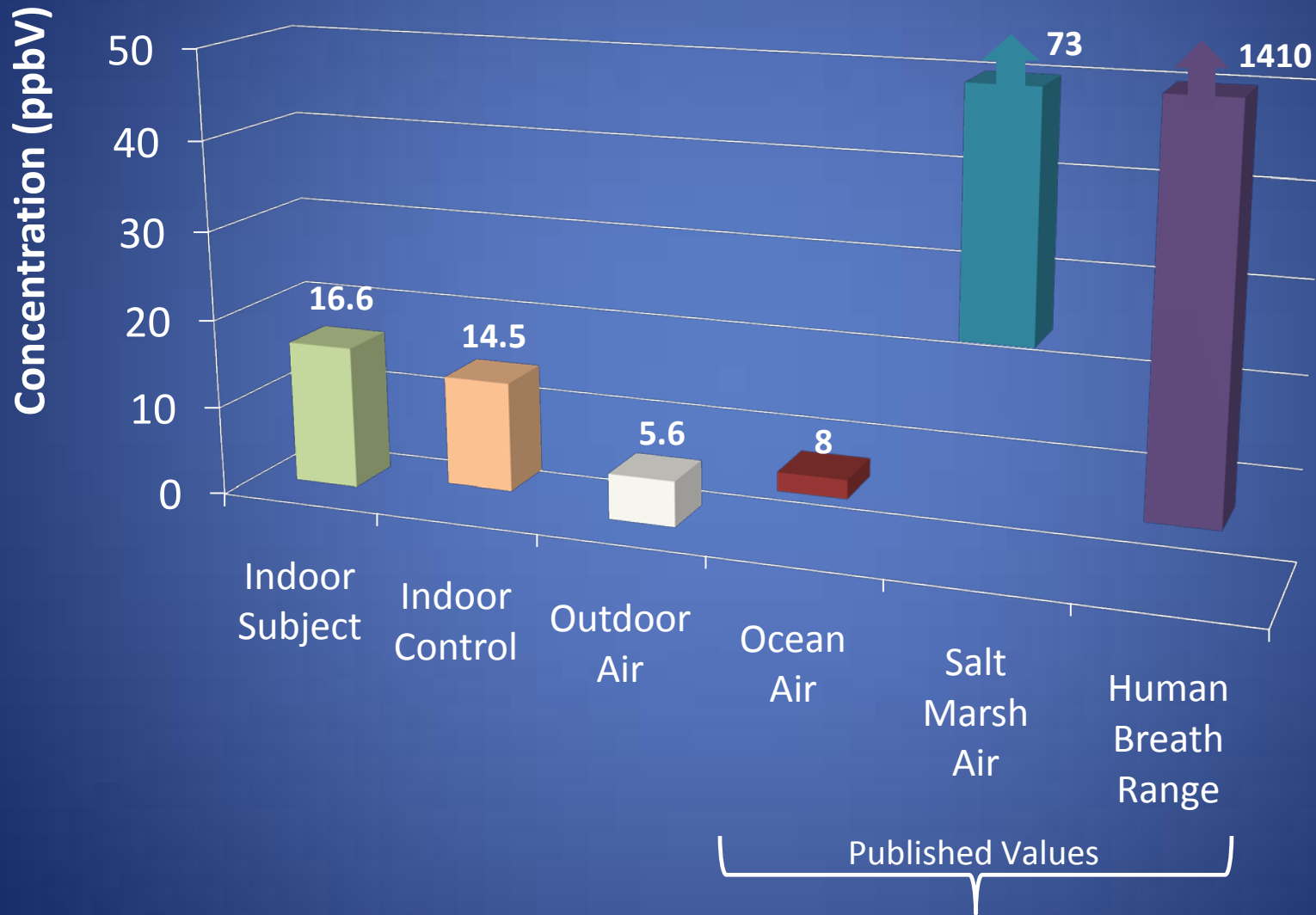
Comparison of Indoor Carbonyl Sulfide Concentrations and Outdoor Air



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*)

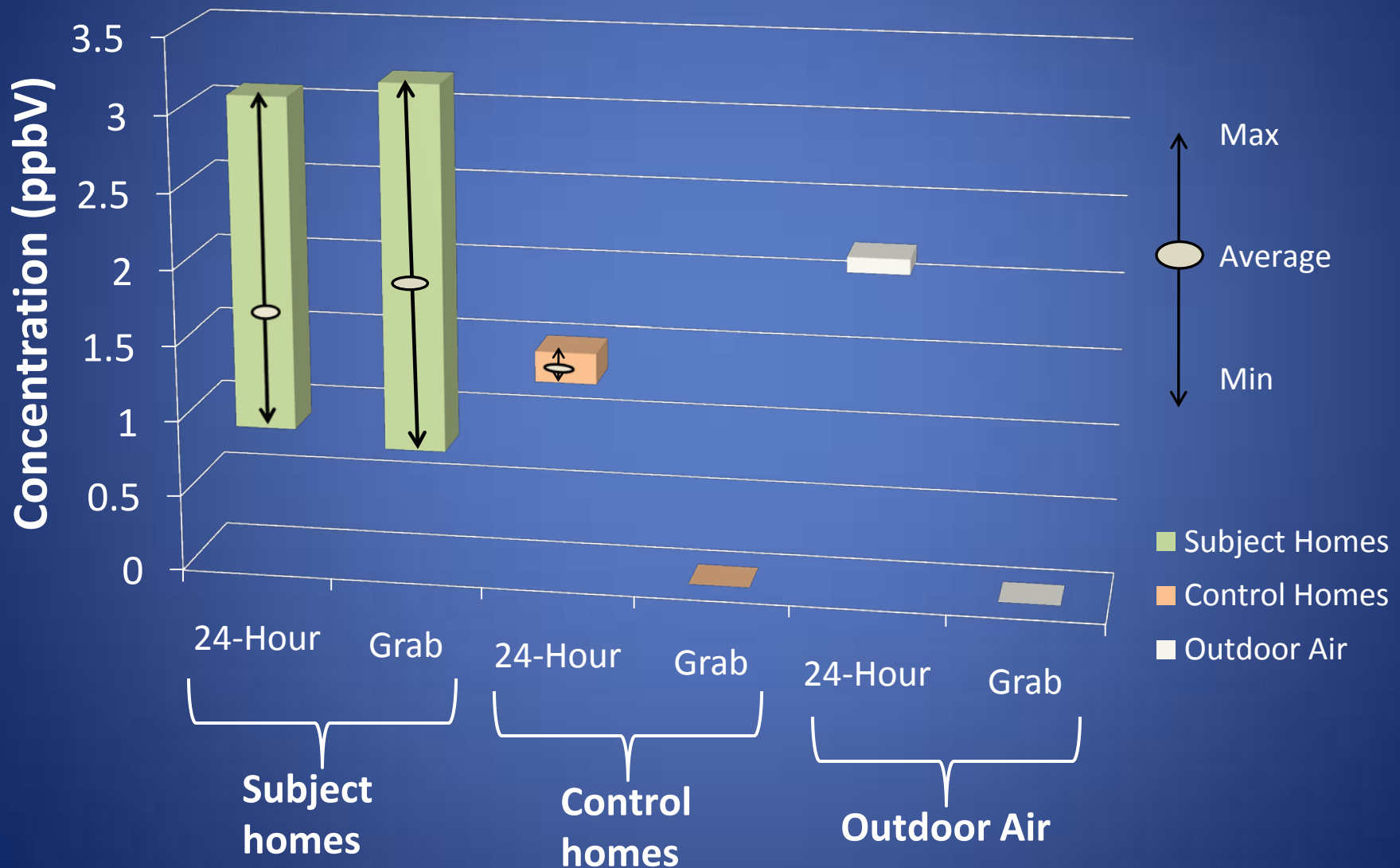
Carbonyl Sulfide Air Concentrations and Comparison to Published Levels



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

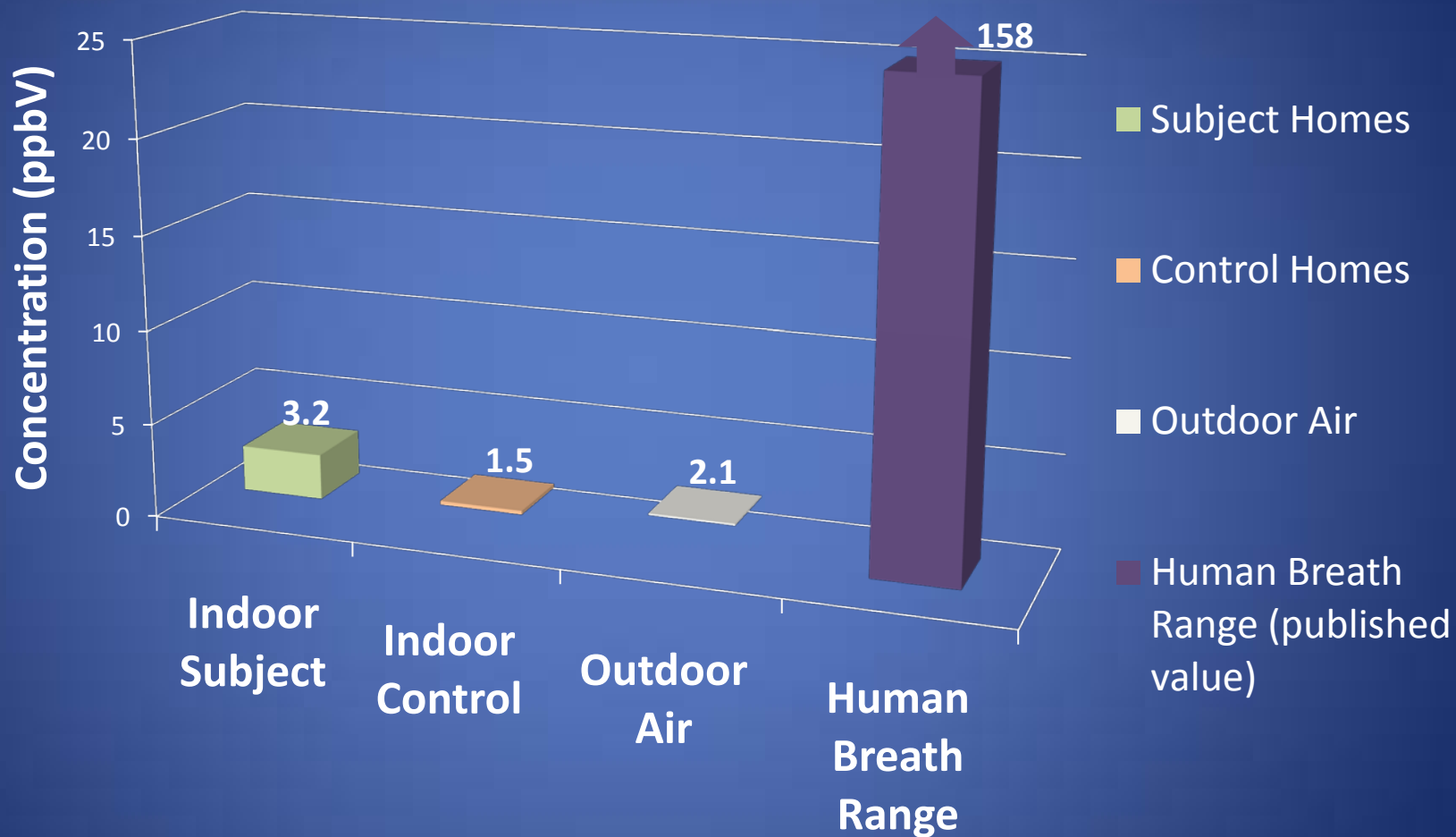
Comparison of Indoor Carbon Disulfide Concentrations and Outdoor Air



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



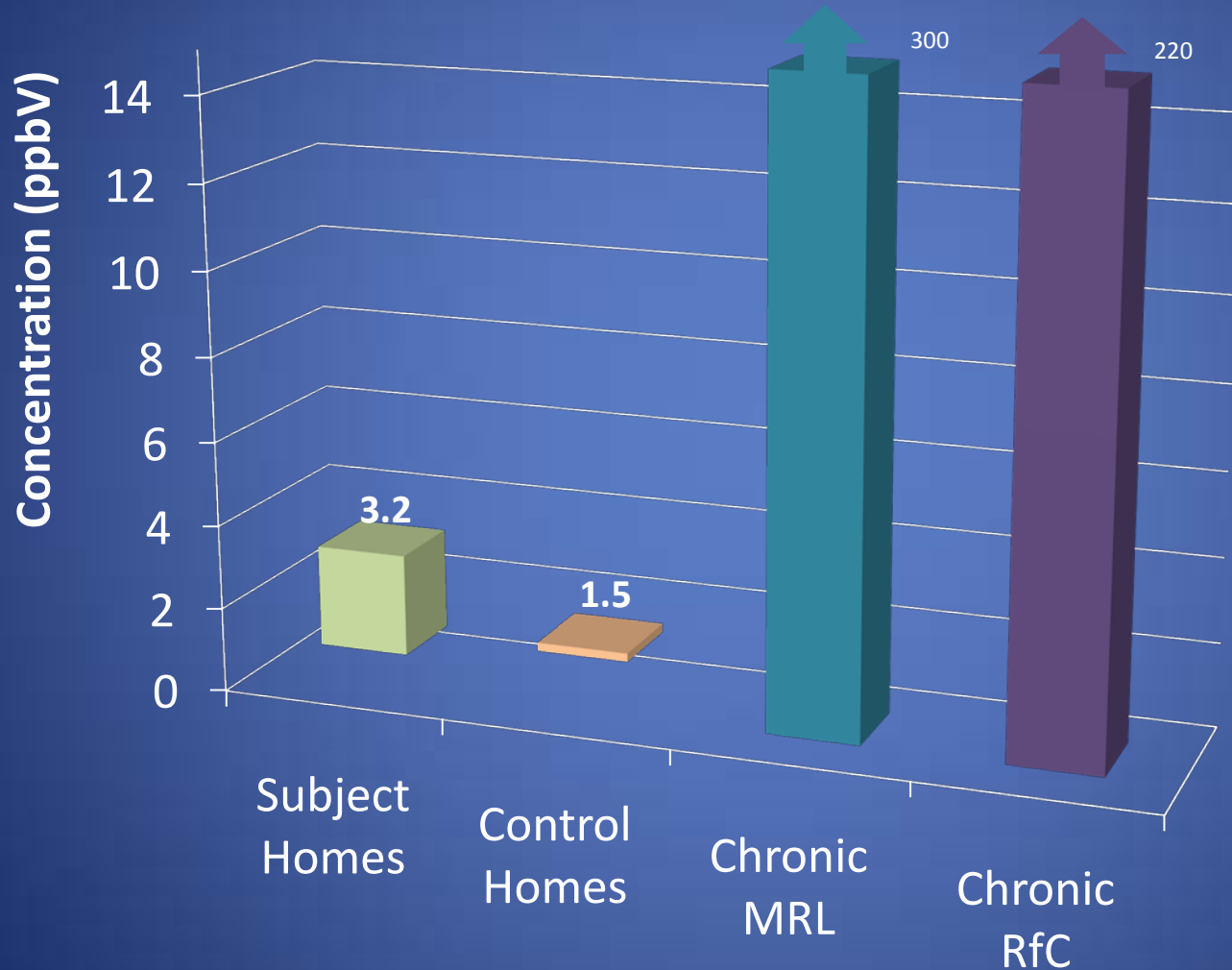
Carbon Disulfide

- 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

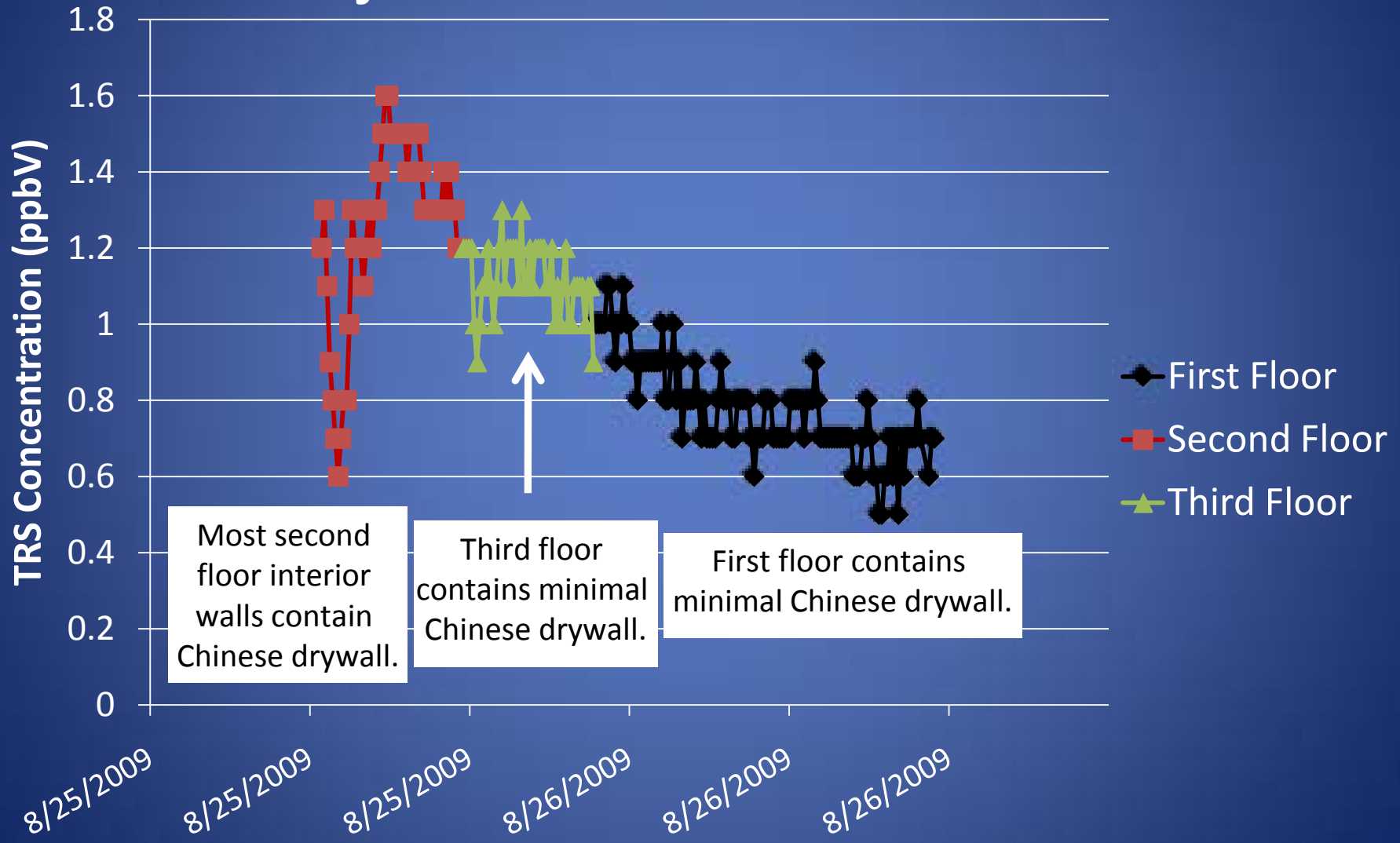
- All carbon disulfide levels were well below published health guidelines.
- Levels do not pose a public health hazard.

Sulfur Compound Detections

		Subject Homes	Control Homes	Outdoor Air
Methyl Mercaptan (ppbV)	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)
Sulfur Dioxide (ppbV)	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)

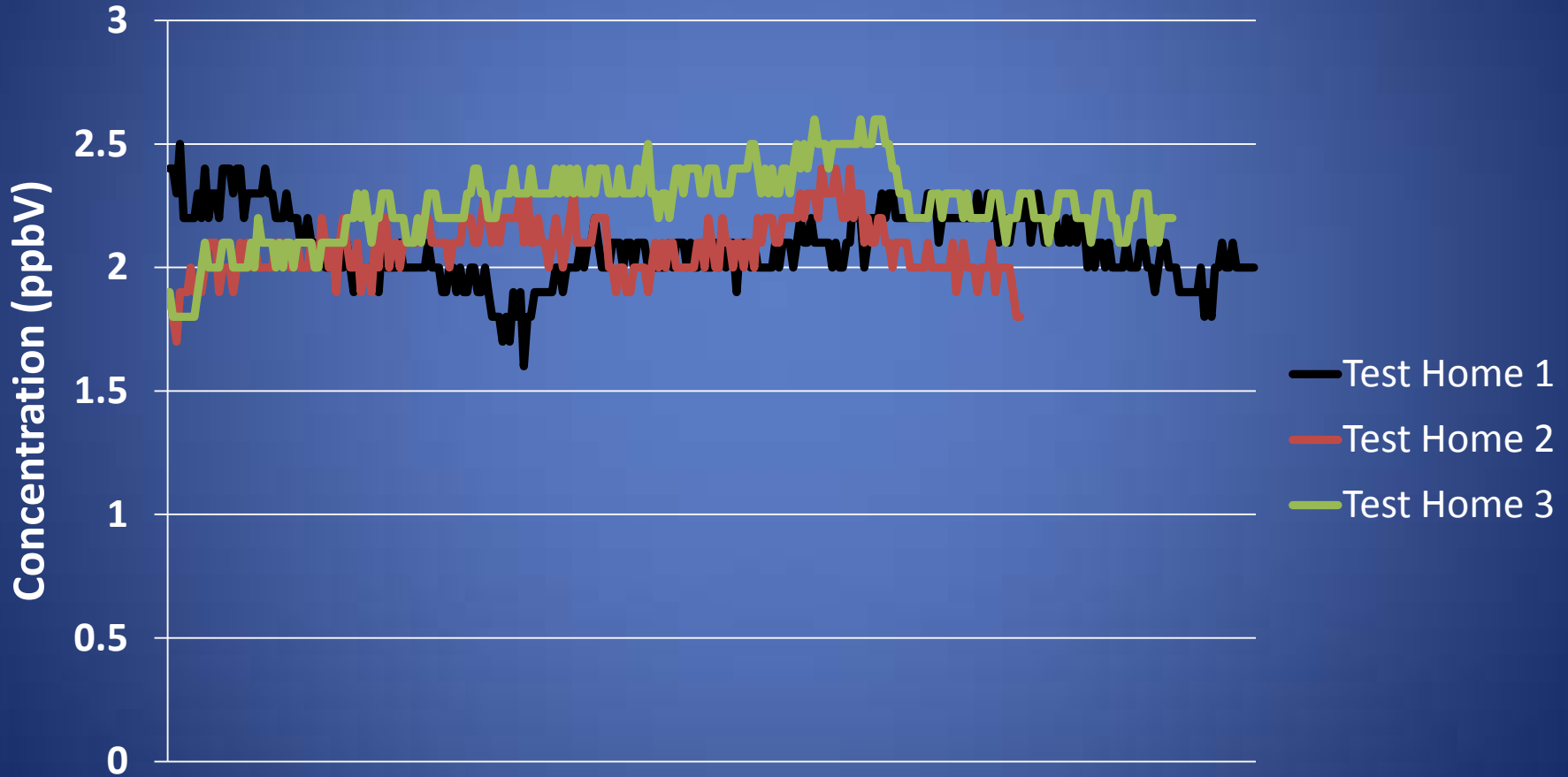
*Average of detects

TRS Concentrations in a Three Level Subject Townhouse in Louisiana



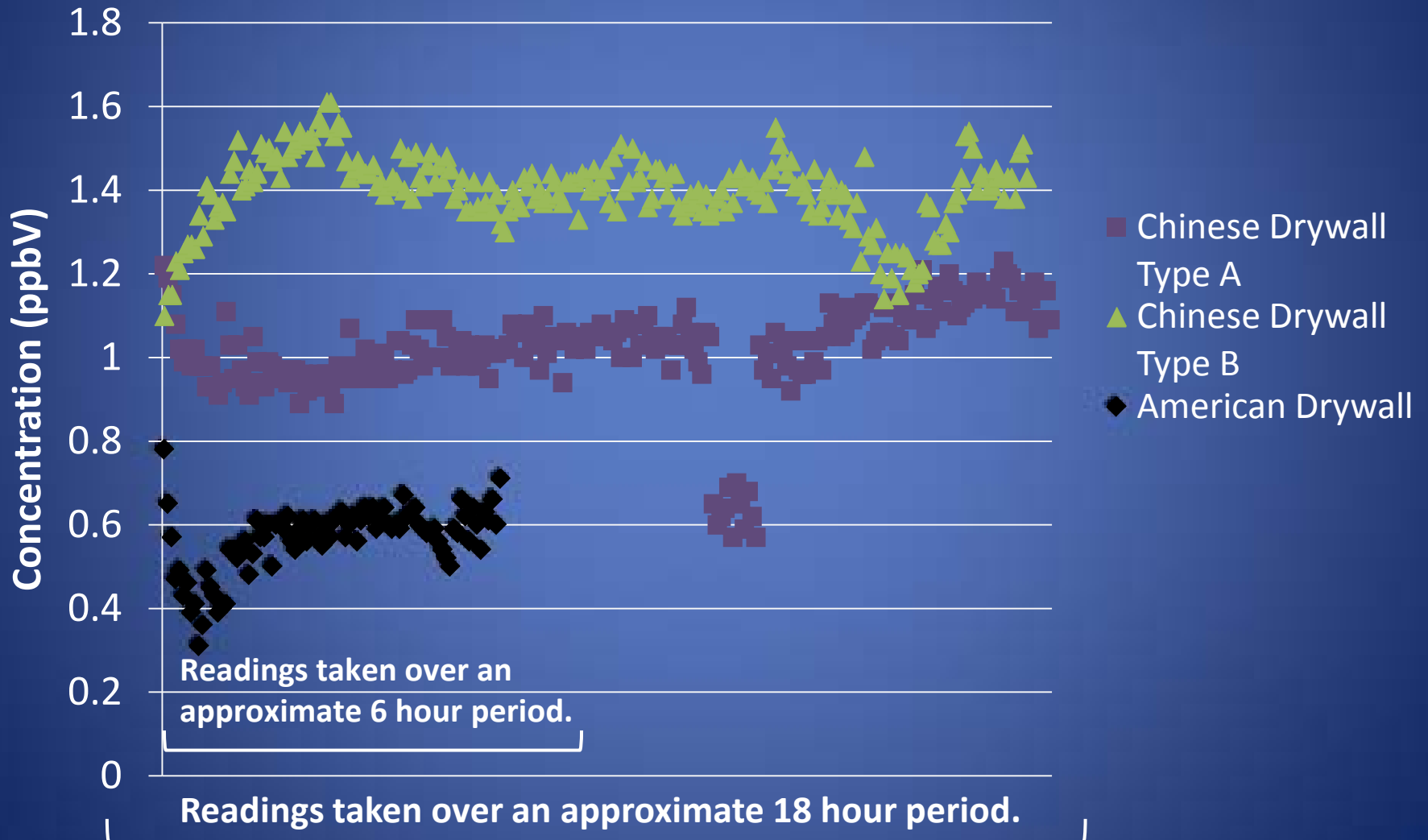
TRS Comparison of Three Test Homes in Port St. Lucie, Florida

(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 H₂S 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 H₂S 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 H₂S 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