Monitoring of indoor and outdoor levels of BTEX and petroleum tracer compounds in Edmonton homes

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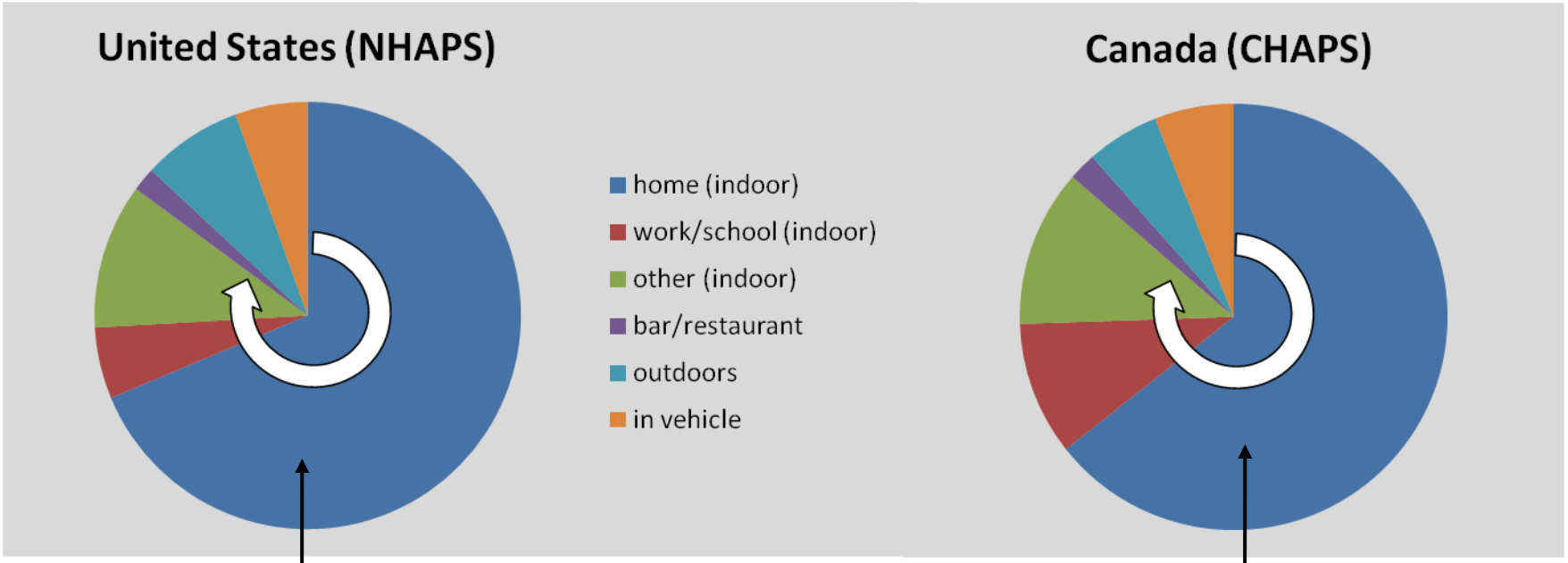
Background

- **Indoor air quality is an important determinant of health.**
- **Several studies have been conducted across Canada (e.g., Quebec City, Windsor, Regina, Halifax etc.) in order to compare baseline data and upgrade Health Canada's Indoor Air Quality Guidelines.**
- **Most epidemiological studies assume outdoor air as a risk factor and are not free from bias because they ignore exposure from indoor air quality.**

Indoor Environment and Time-Activity – Mean Amounts of Time Spent in Various Microenvironments for North American Adults



87% total time indoors
69% time at home

88% total time indoors
64% time at home

Leech et al. 2002. J. Exp. Anal. Environ. Epidemiol., 12, 427-432

BTEX and petroleum-related VOCs

BTEX	Lifetime
Benzene	9.5 d
Toluene	2.1 d
Ethylbenzene	1.7 d
m,*p*-Xylene	12 h
o-Xylene	20 h

Alkane	Lifetime
Ethane	47 d
Propane	11 d
Butane	4.9 d
Isobutane	5.5 d
Pentane	3.0 d
Isopentane	3.2 d
Hexane	2.2 d
2-Methylpentane	2.2 d
3-Methylpentane	2.2 d

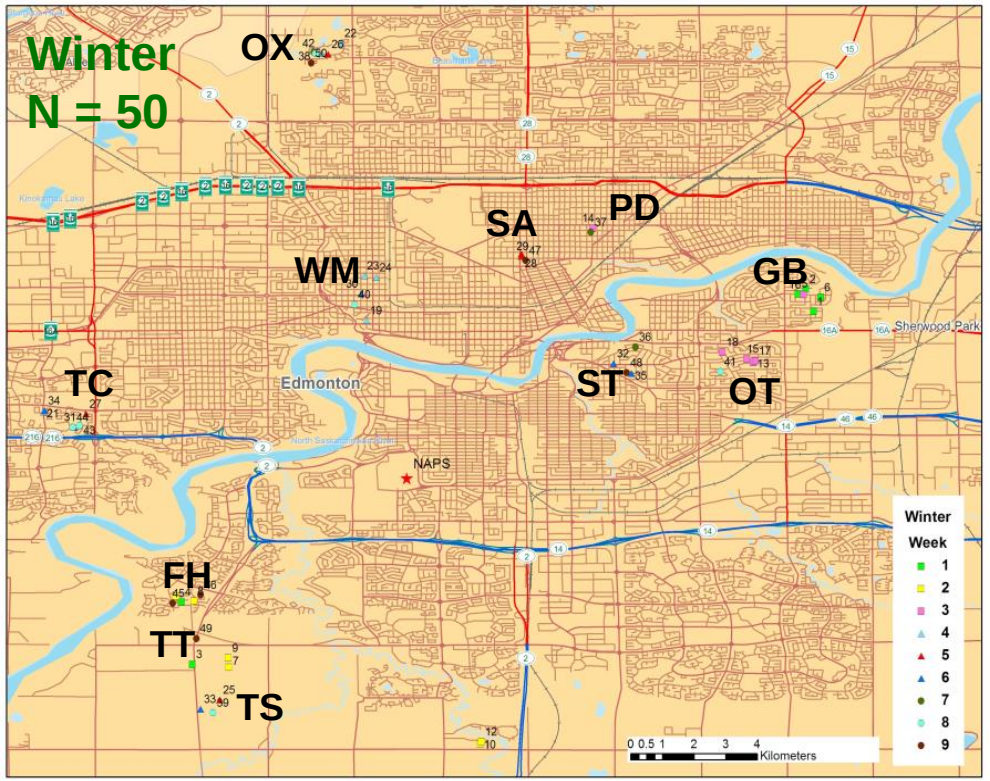
Alkene	Lifetime
Ethene	1.4 d
1-Butene	8.8 h
cis-2-Butene	4.9 h
1,3-Butadiene	4.2 h

Objective

To characterize indoor and outdoor exposure to BTEX and petroleum tracer compounds in Edmonton homes.

Methodology: sampling and analysis

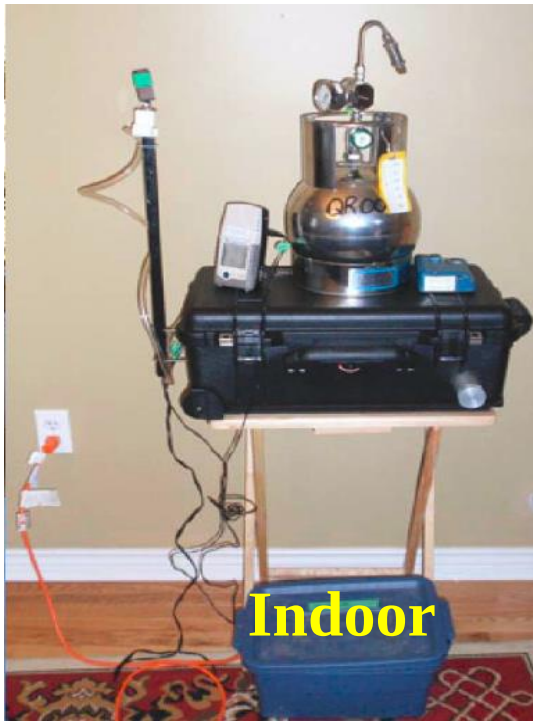
- **Winter and summer 2010.**
- **Nine consecutive 7-day sampling period per season (5-6 homes per period).**
- **Homes sampled were stratified by age – residences grouped into five construction year strata.**
  - **≤ 1946**
  - **1946 – 1960**
  - **1961 – 1980**
  - **1981 – 2000**
  - **≥ 2001**



OX- Oxford
WM-Westmount
SA-Spruce Avenue
PD-Parkdale
TC-Thorncliff
GB-Gold Bar
OT-Ottewell
ST-Strathearn
FH-Falconer Heights
TT-Terwillegar Towne
TS-Terwillegar South

Methodology: sampling and analysis

- **VOCs sampled for 24 h using Summa canisters.**
- **A total of 193 VOC species were analyzed by gas chromatography-mass spectrometry (GC-MS)**



Methodology: Questionnaires

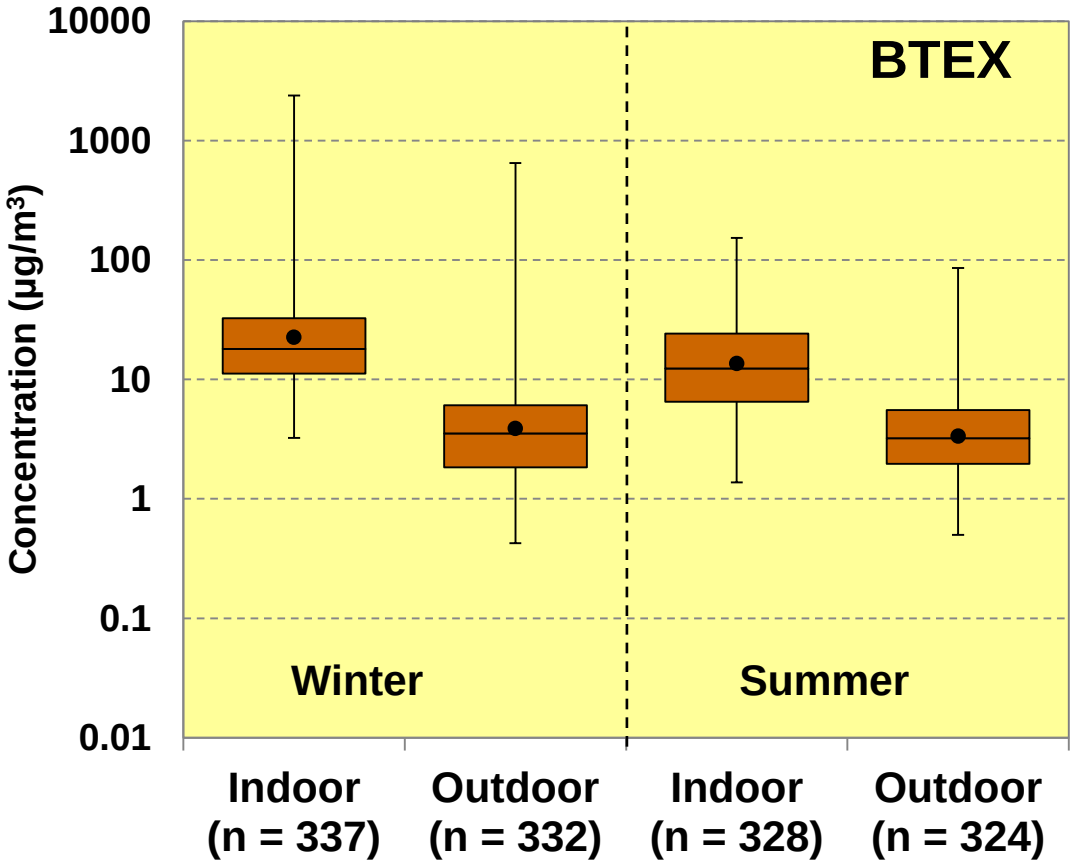
Baseline Questionnaire data:

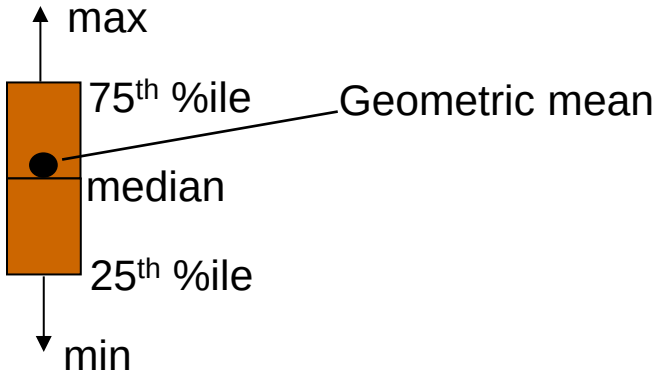
- Year of construction.
- Heating and cooking systems.
- Renovations, e.g. painting, varnishing.
- Purchase of furniture.
- Nearby outdoor sources.
- Storage of paints and solvents.

Daily Diary Questionnaire data:

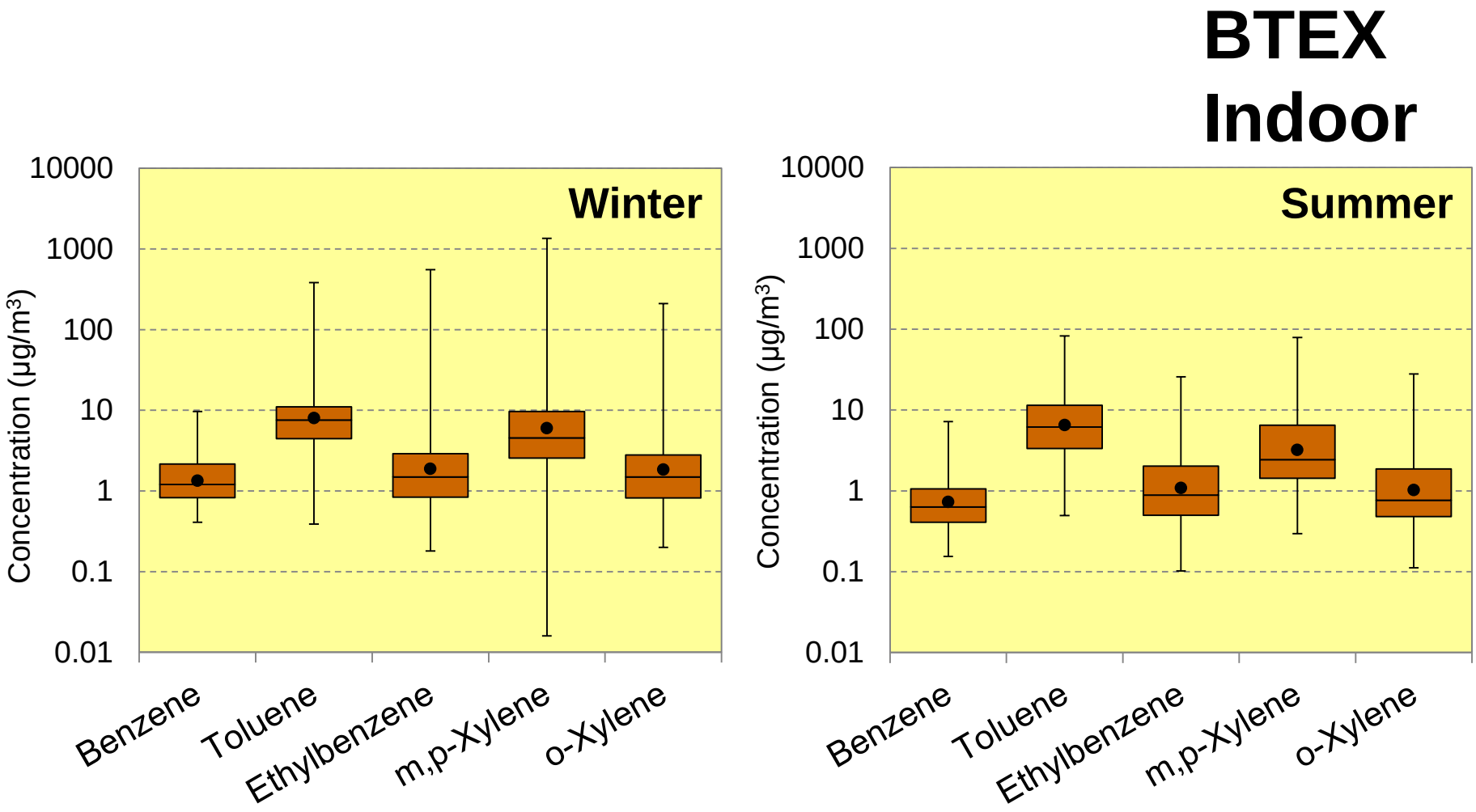
- Environmental Tobacco Smoke (ETS); burning of candles, incense.
- Use of moth repellents.
- Use of cleaning products and air fresheners.
- Window opening and air conditioner use.
- Cooking (type, duration) and use of exhaust fan.
- Use of dishwasher, laundry.

Results – BTEX levels at Edmonton homes

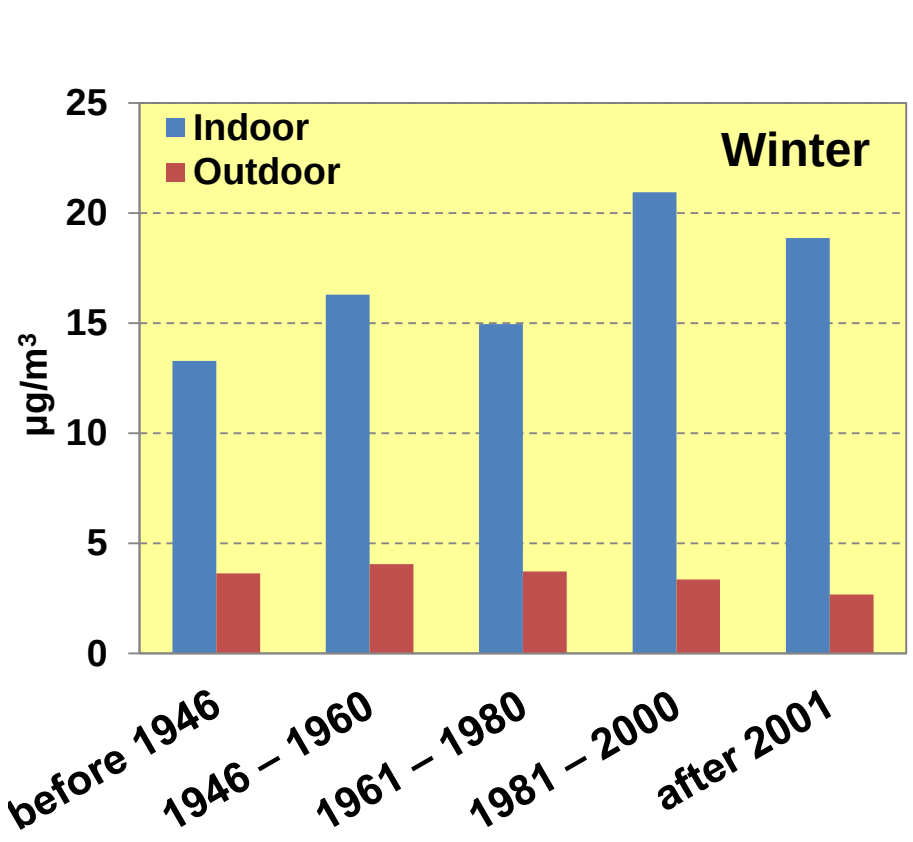




Indoor BTEX levels at Edmonton homes

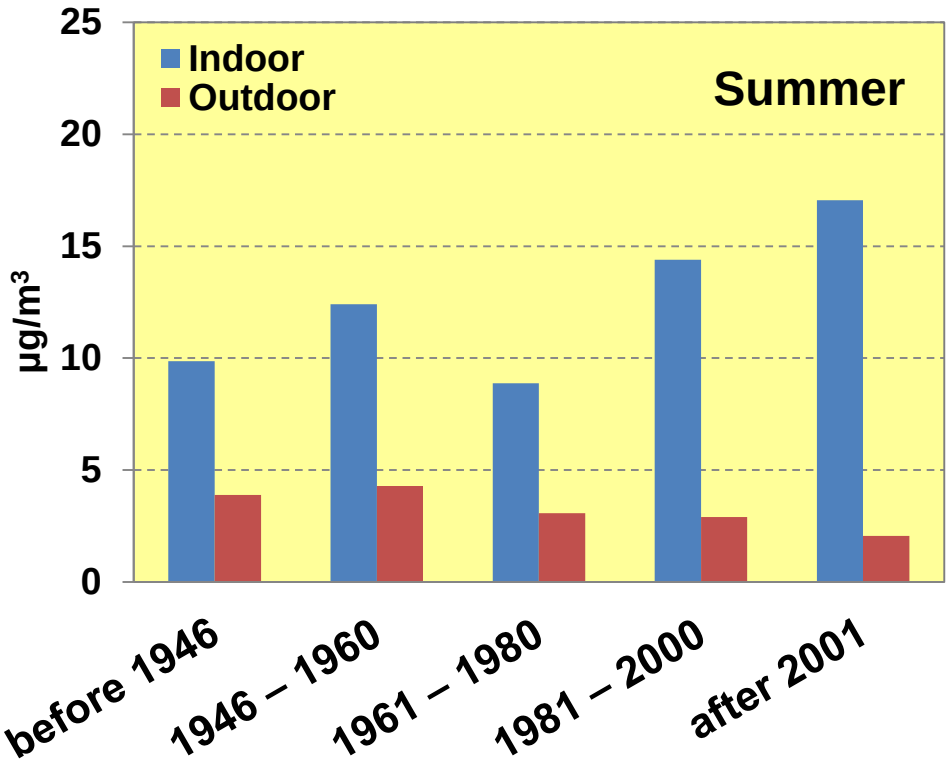


Median BTEX levels in different construction year strata of Edmonton homes



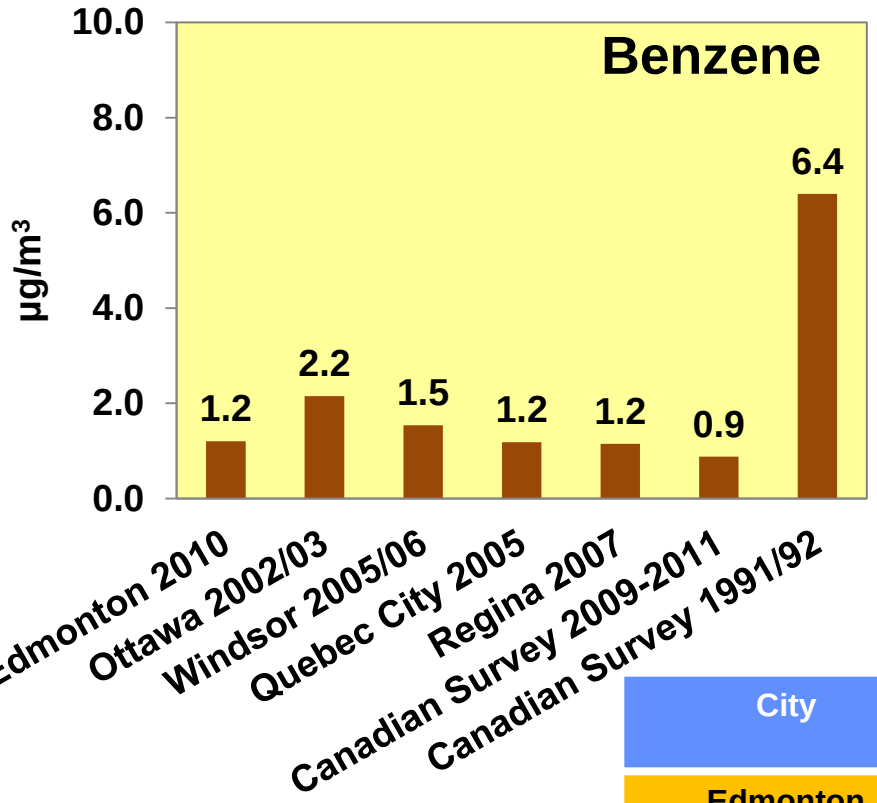
Indoor:
Significant variation (*p*-value: <0.0001)

BTEX



Indoor:
Significant variation (*p*-value: 0.002)

Median winter BTEX levels in Canadian homes (indoors)



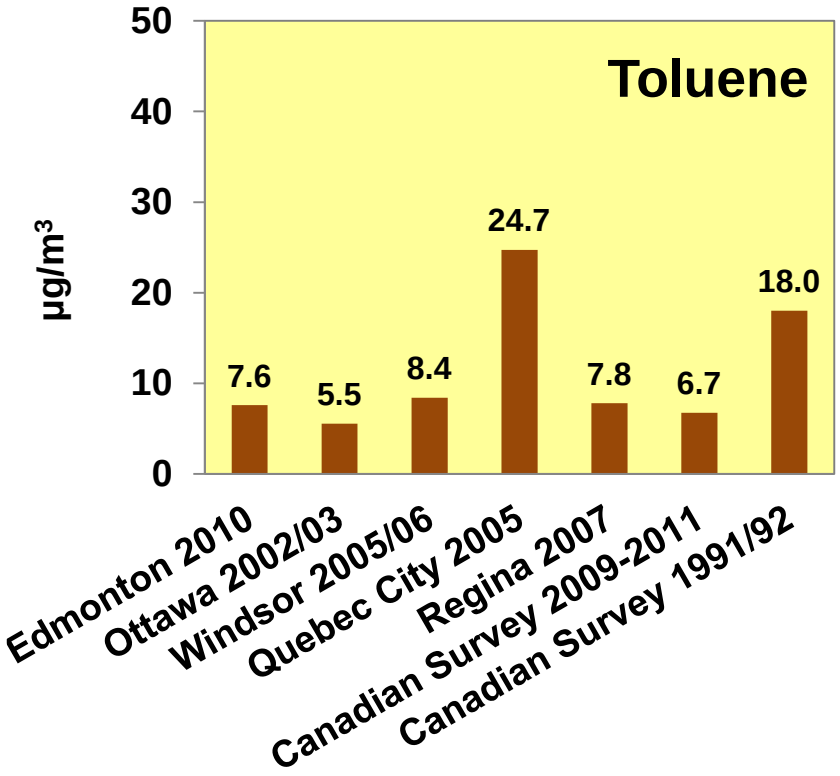
No IAQ guidelines

Median ranged: 0.5 – 2.2 µg/m³

Indoor/outdoor (I/O): 1.5 – 2.4

City	Study period	No. of homes	Reference
Edmonton	2010	74	This study
Ottawa	2002–2003	75	Zhu et al. 2005
Windsor	2005–2006	48	Health Canada 2010
Quebec City	Jan–April 2005	96	Héroux et al. 2008
Regina	2007	146	Health Canada 2010
Canadian Survey	2009–2011	3857	Zhu et al. 2013
Canadian Survey	1991–1992	750	Fellin and Otson 1994

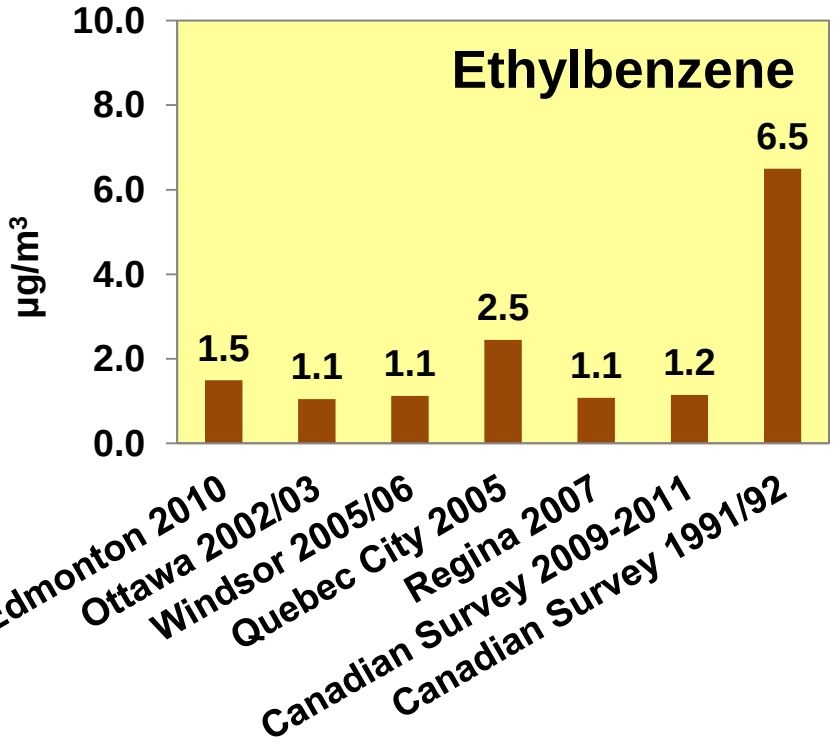
Median winter BTEX levels in Canadian homes (indoors)



Canadian IAQ guideline: 2300 µg/m³

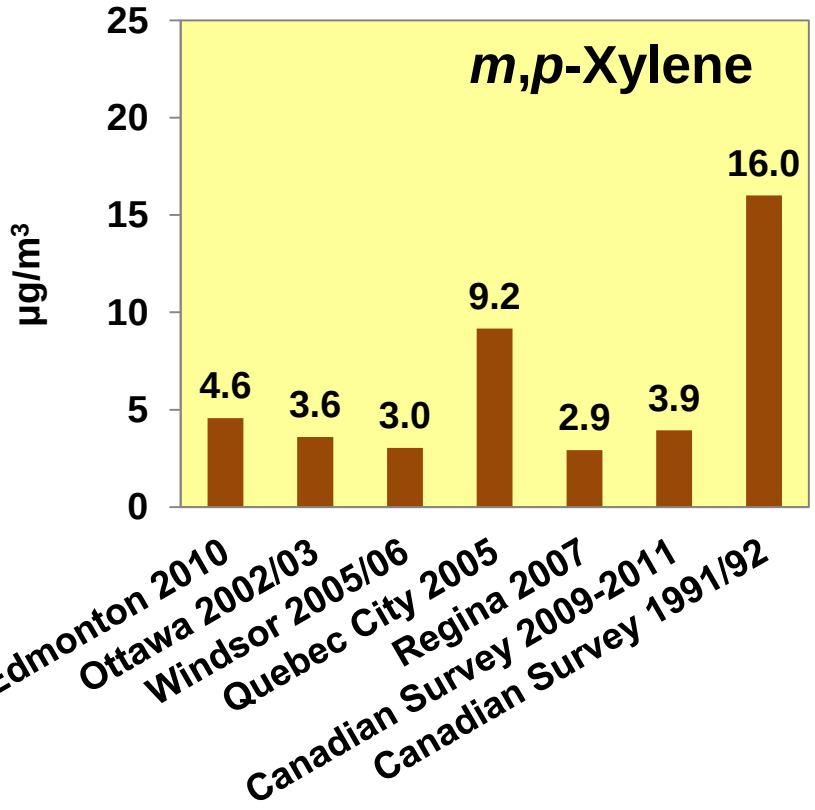
Toluene/Benzene (T/B): 1.5–3.0 (vehicle)

Edmonton outdoors, T/B: 1.7 – 3.5



No Canadian IAQ guidelines

Median winter BTEX levels in Canadian homes



No Canadian IAQ quidelines

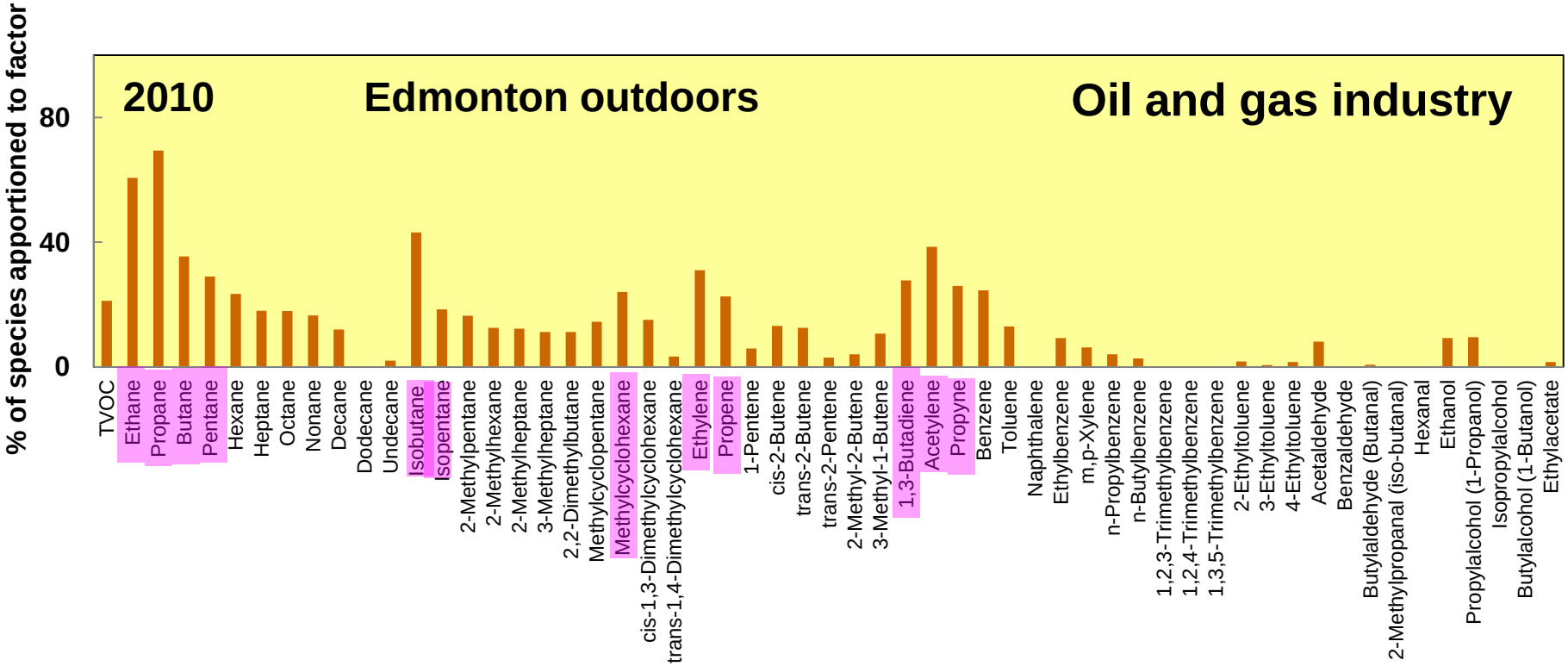
European Commission: 200 µg/m³

I/O ratios of BTEX at Edmonton homes: 2 – 9

Predictors of BTEX:

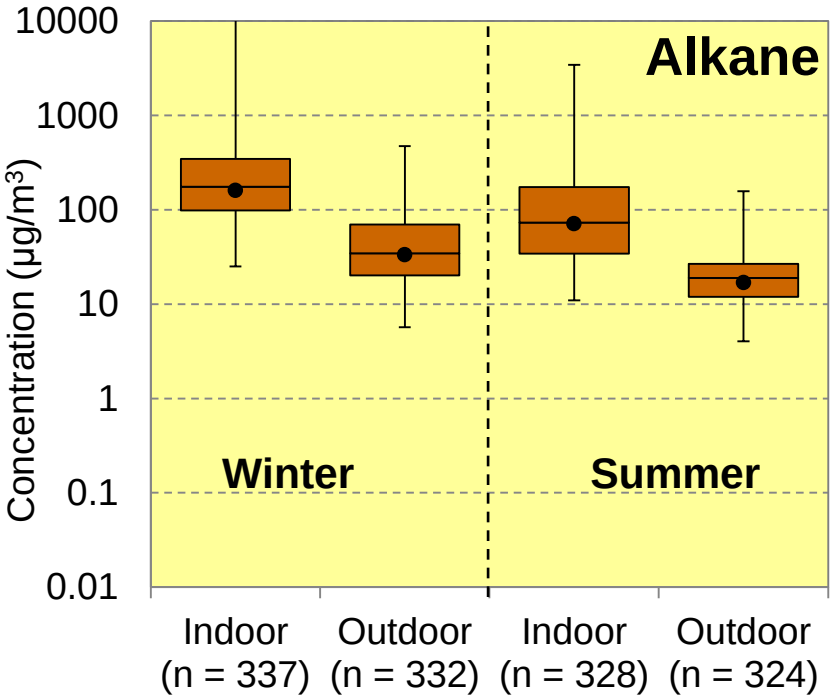
- **product use, paints, building materials**
- **Evaporative emissions from attached garages**
- **Vehicle combustion gases**

Tracers of petroleum-related emissions



Bari et al. 2015. Build. Environ. 90, 114–124

Results – alkane levels at Edmonton homes

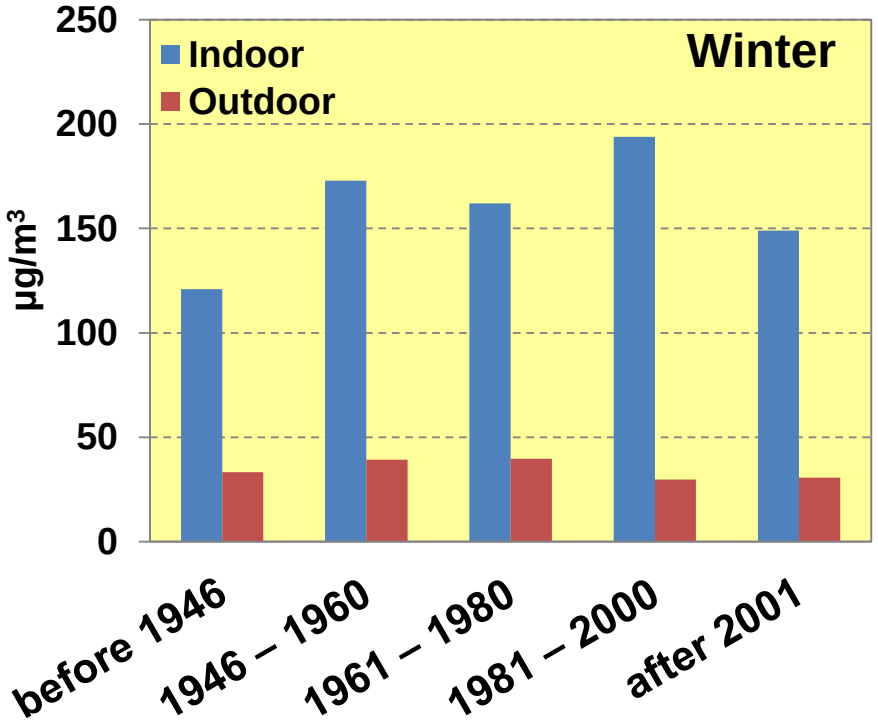


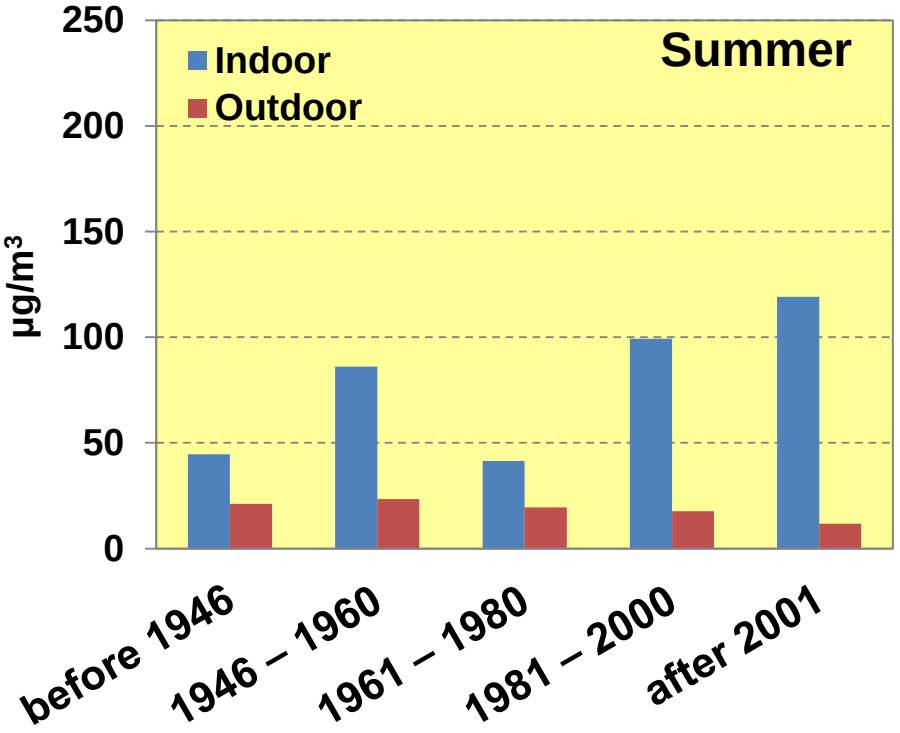
Winter 2010

Alkane	Median µg/m³	Min–Max µg/m³
Ethane	33.8	1.2–1466
Propane	19.6	1.6–383
Butane	12.4	0.2–358
Isobutane	15.2	0.1–1171
Pentane	5.1	0.7–31
Isopentane	10.6	1.4–123

Median alkane levels in different construction year strata

Alkane

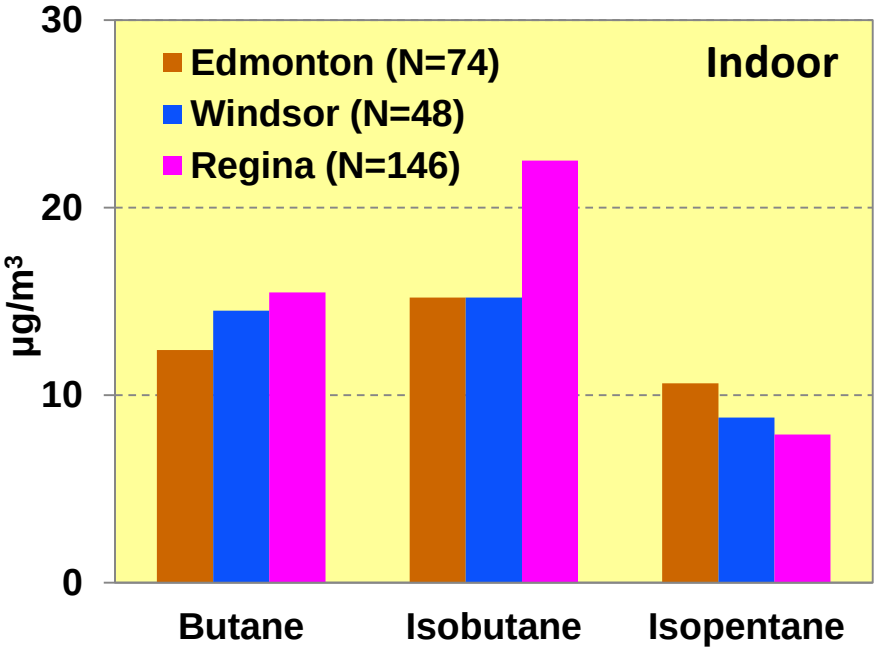


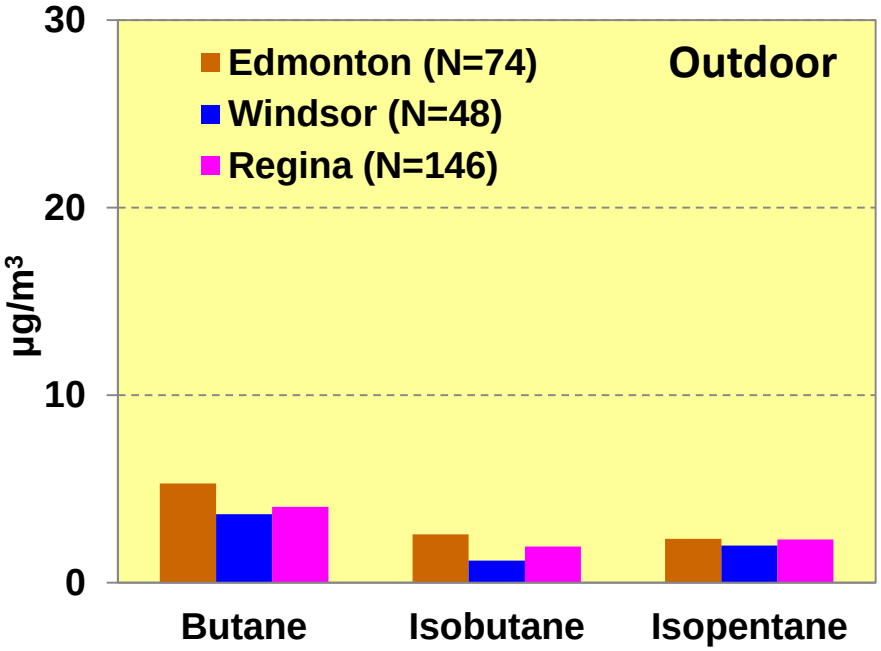


Indoor:
Significant variation (*p*-value: <0.0001)

Indoor:
Not significant (*p*-value: 0.09)

Alkane levels in Canadian homes





Comparison of alkane levels in 2010 Edmonton IAQ study with Edmonton east and central (NAPS)

2010 Median µg/m³	Winter				Summer			
	Edmonton IAQ		Edmonton (NAPS)*		Edmonton IAQ		Edmonton (NAPS)*	
	Indoor	Outdoor	East	Central	Indoor	Outdoor	East	Central
Butane	12.4	5.3	31.6	5.4	6.3	2.7	21.5	3.4
Isobutane	15.2	2.6	15.8	2.6	5.9	1.2	8.9	1.3
Pentane	5.1	1.6	11.5	1.7	3.4	1.2	12.9	1.1
Isopentane	10.6	2.3	15.9	2.6	6.8	1.9	20.6	2.1
Hexane	1.7	0.6	4.5	0.7	0.7	0.4	2.8	0.4
Heptane	1.6	0.3	1.5	0.4	0.7	0.2	0.7	0.3
Octane	0.5	0.1	0.5	0.1	0.3	0.1	0.2	0.1
2-Methylpentane	1.9	0.7	3.9	0.7	0.8	0.5	3.5	0.5
3-Methylpentane	1.2	0.5	2.3	0.5	0.5	0.4	1.9	0.4
2,2-Dimethylbutane	0.2	0.0	0.2	0.1	0.1	0.0	0.2	0.0
Cyclopentane	0.4	0.1	1.2	0.1	0.2	0.1	1.0	0.1
Methylcyclopentane	0.9	0.4	2.1	0.4	0.4	0.3	1.3	0.3
Cyclohexane	0.5	0.2	1.3	0.2	0.2	0.1	0.7	0.1
Methylcyclohexane	0.9	0.3	1.9	0.3	0.3	0.1	0.8	0.1

***NAPS data (Environment Canada, 2010)**

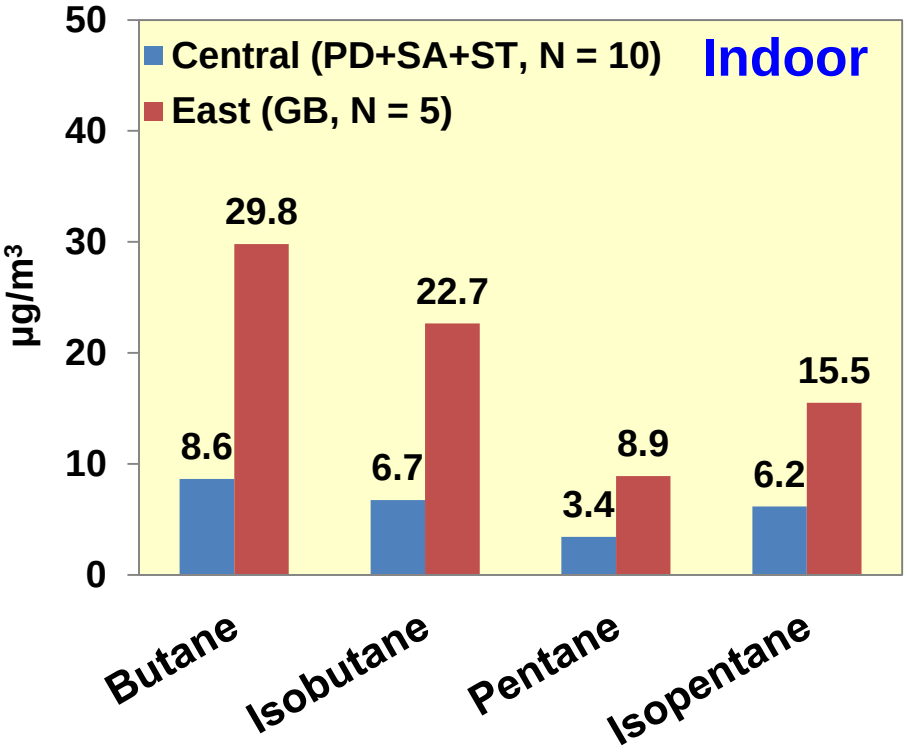
Alkane levels in Edmonton neighborhoods

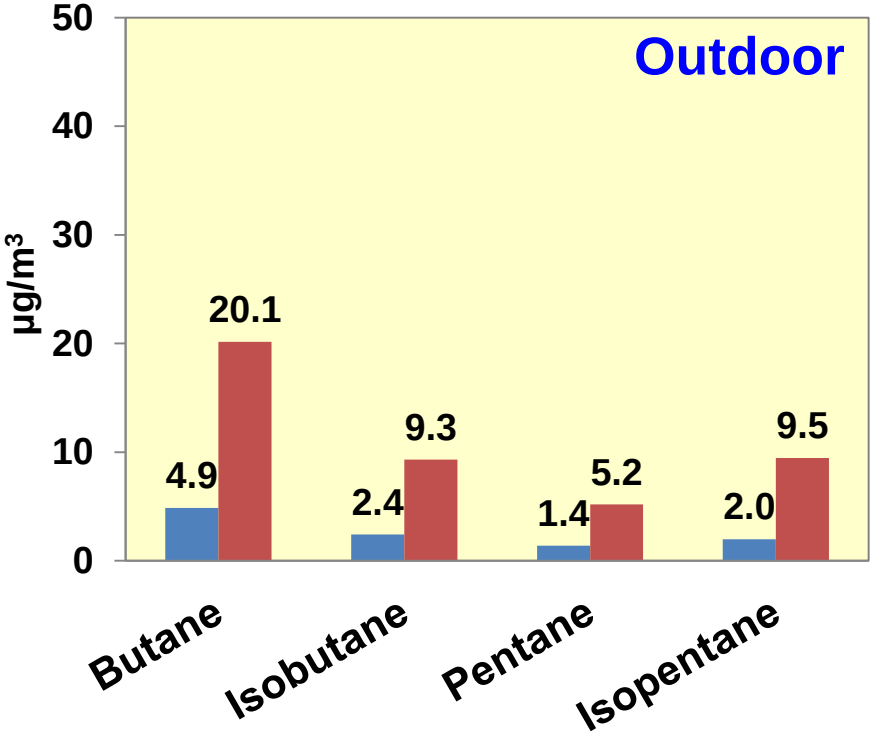
Central (~ 4 km)
PD-Parkdale
SA-Spruce Avenue
ST-Strathearn

East
GB-Gold Bar

Median alkane levels in Edmonton neighborhoods Central vs East

Winter 2010

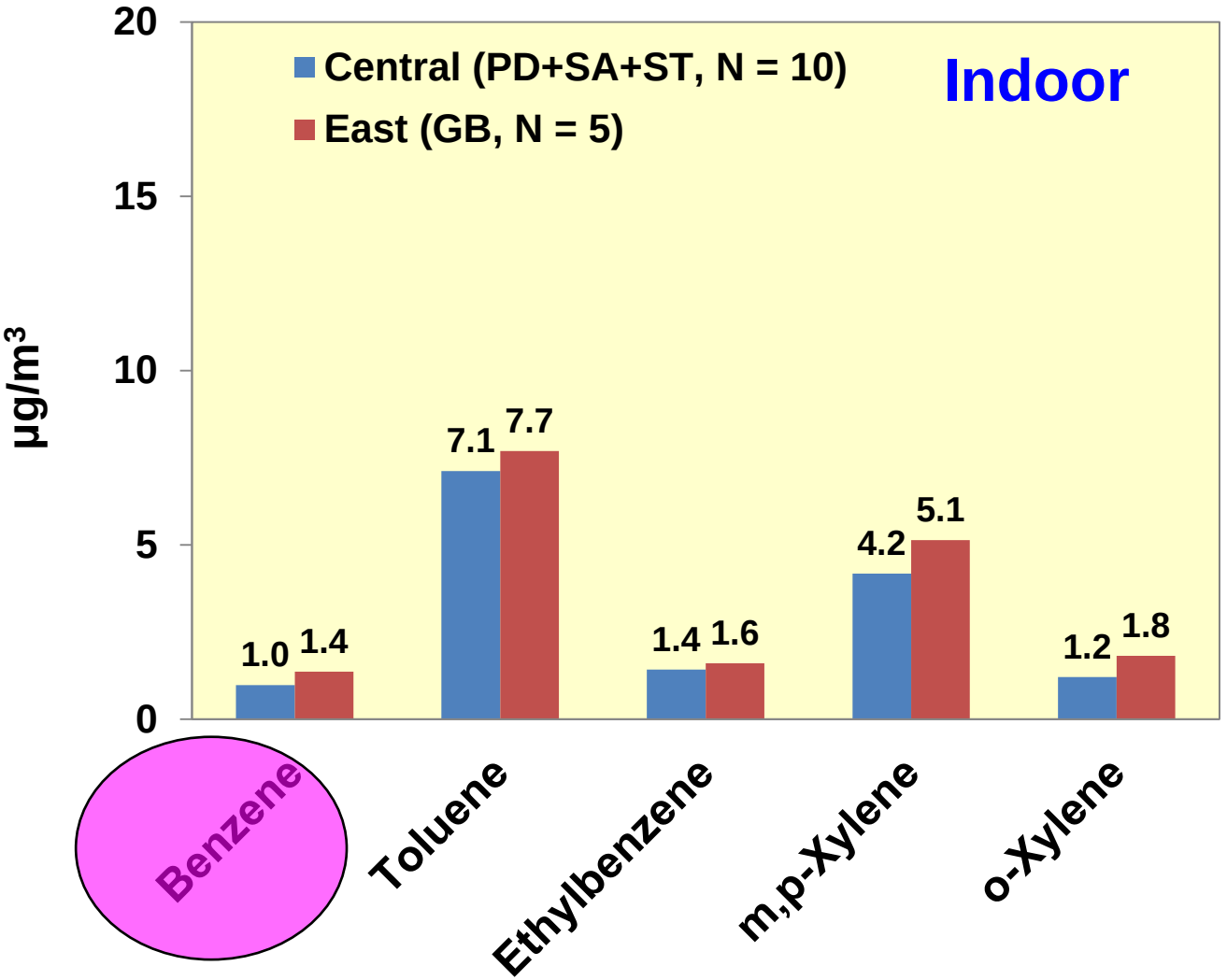




Alkane

Median BTEX levels in Edmonton neighborhoods Central vs East

Winter 2010



BTEX

Summary

- **Indoor BTEX levels 2- to 6-fold higher than outdoors for both seasons.**
- **A significant variation in BTEX levels was found in different strata with higher levels in newer homes.**
- **Alkanes were dominant in Edmonton homes indoors.**
- **More work needed to better understand levels and sources of population exposure to VOCs.**

Acknowledgment

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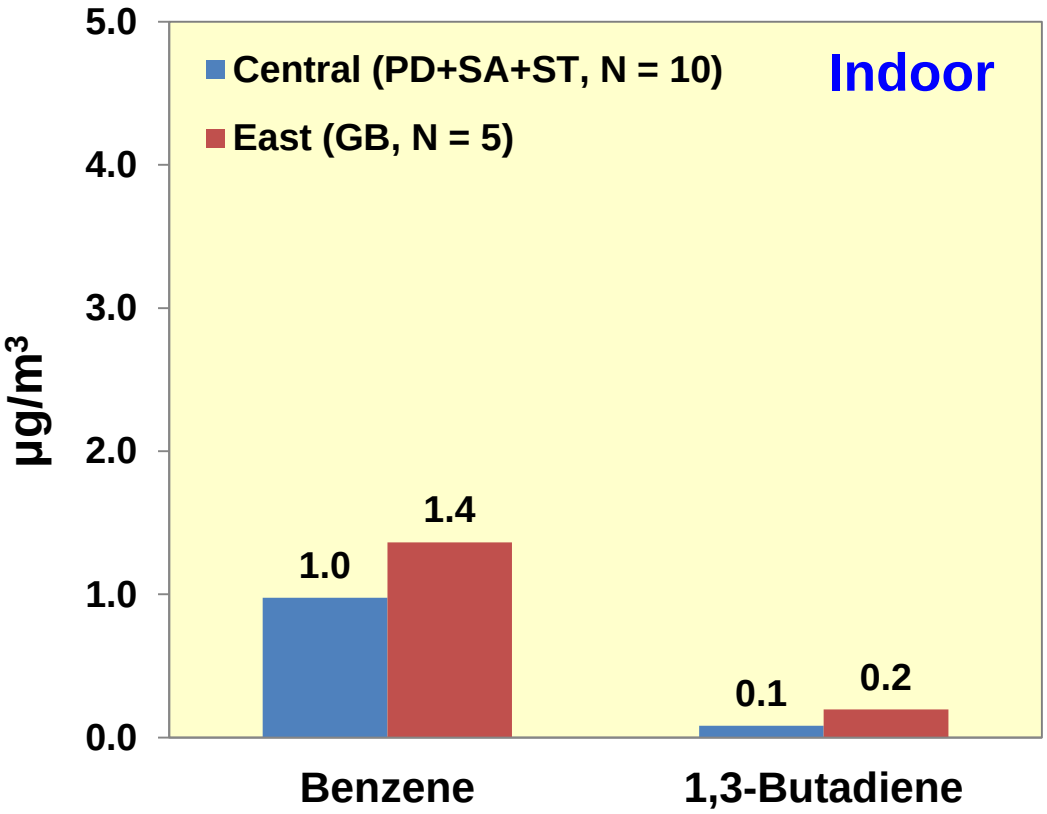
Morgan MacNeill
Ryan Kulka

Thank you very much for your attention!

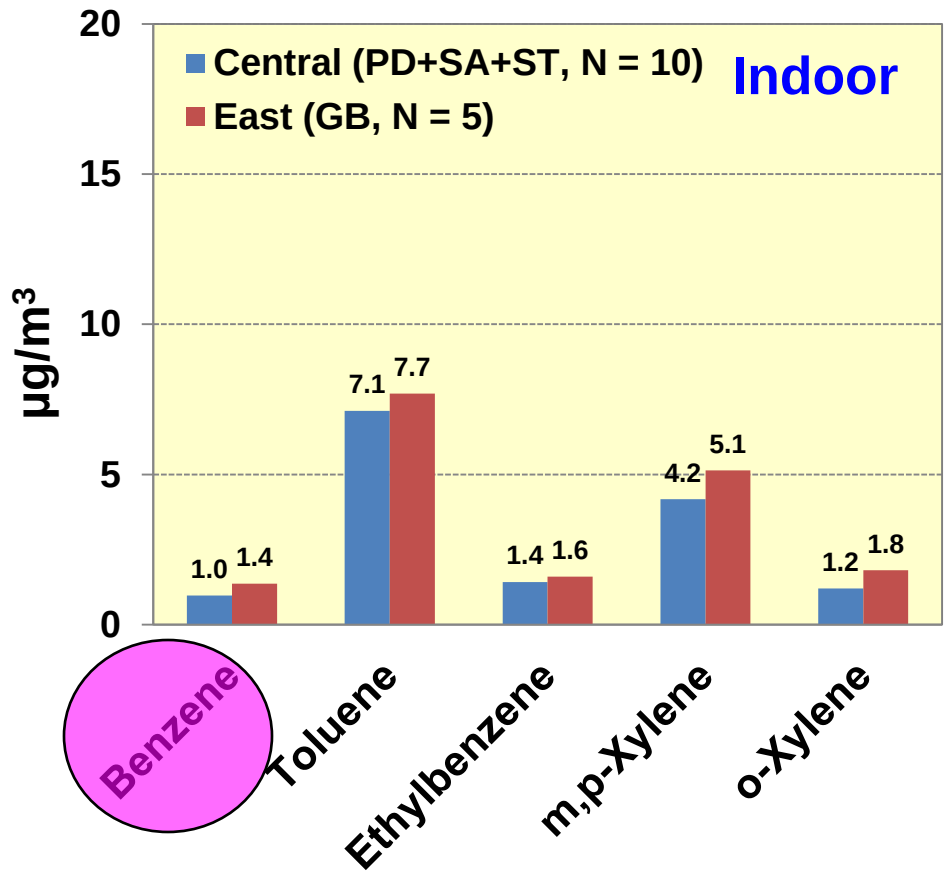
Median levels in Edmonton neighborhoods Central vs East

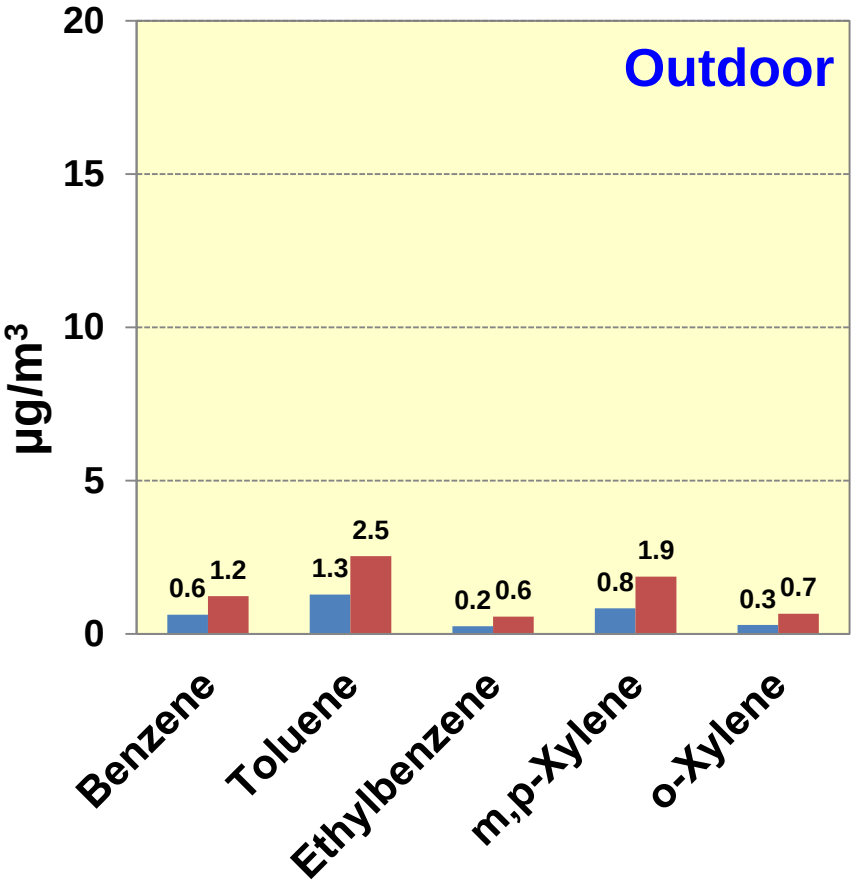
Winter 2010



Median BTEX levels in Edmonton neighborhoods
Central vs East

Winter 2010





BTEX