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Reducing Exposure to Airborne Chemical Toxics (REACT): Community-Scale Air Monitoring in Memphis

Chunrong Jia
School of Public Health
University of Memphis

Jim Holt; Larry Smith
Pollution Control Section
Shelby County Health Dept

Ngee-Sing Chong
Chemistry Dept
MTSU

Outline

- Project overview
- Project objectives
- Methods
  - Study design
  - Field sampling and laboratory analysis
- Results
- Community engagement
- Future work

Overview of the "REACT" Study

- REACT: **Reducing Exposure to Airborne Chemical Toxics**
- Study team
  - Leader: The Shelby County Health Department's Pollution Control Section.
  - Collaborators:
    - University of Memphis SPH
    - Middle Tennessee State University

- Timeline
  - Aug 2011, the proposal was selected
  - Nov 2013, QAPP approved
  - 2014, field monitoring of air toxics in Shelby County
  - Mar 2016, project completed

Objectives of the study

1. To measure ambient concentrations of air toxics in the metropolitan Memphis;
2. To identify common sources of air toxics;
3. To evaluate health risks from exposures to air toxics; and
4. To explore if the spatial distribution of air toxics is associated with socioeconomic status and/or ethnicity.

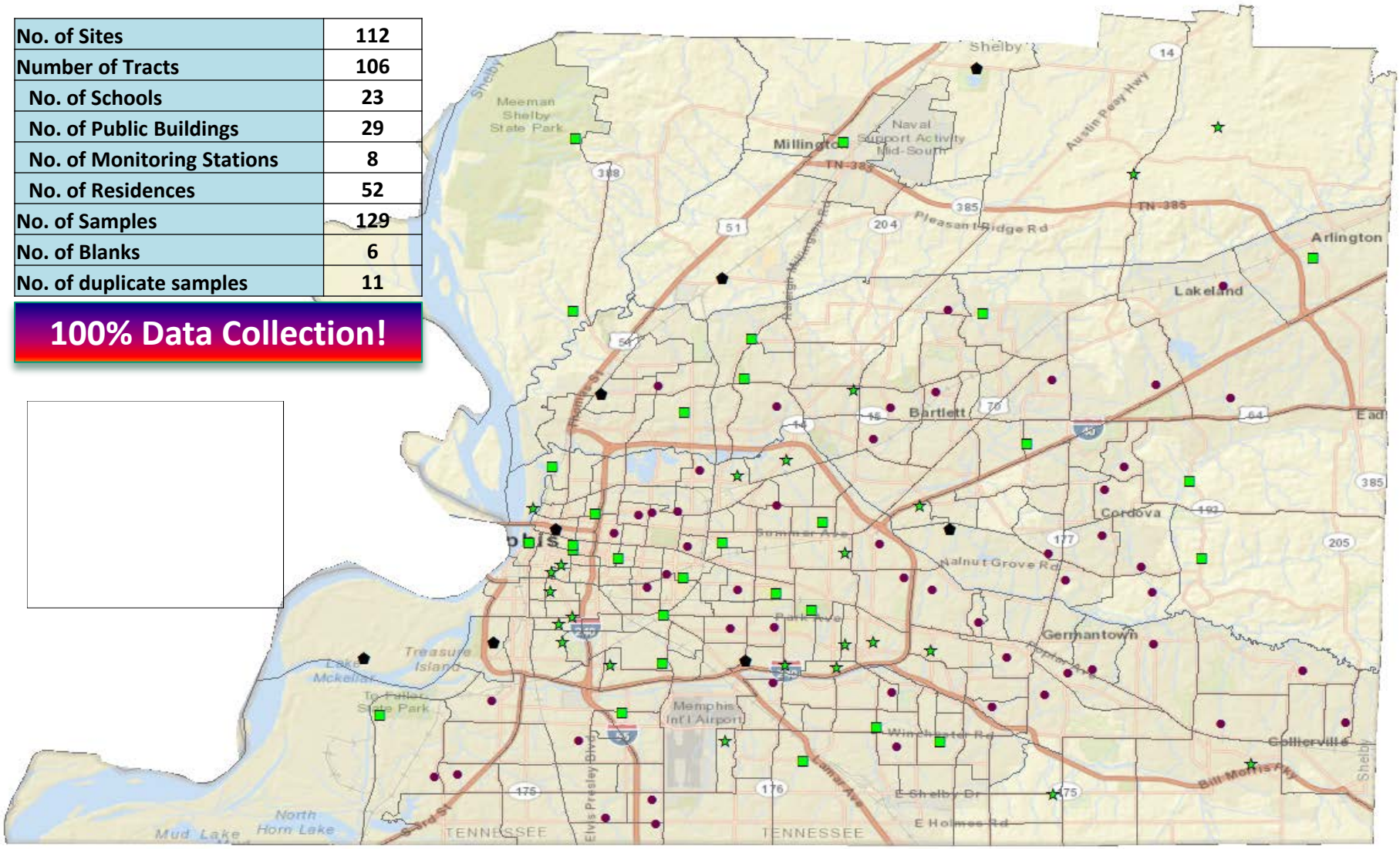
Study design

- Ambient air toxics concentrations were measured at 100 census tracts in Shelby County, TN.
- Monitoring sites in census tracts were selected based upon presence of industries (past and present), proximity to neighborhoods, and accessibility.
- Sampling was conducted in four seasons.
- 24-hour samples were collected in pre-cleaned and pre-evacuated canisters.
- Samples were analyzed for 71 target compounds.
  - They have high toxicity
  - They have been frequently detected in previous studies
  - They are suitable for the canister sampling and GC/MS analysis method.

Sampling sites

No. of Sites	112
Number of Tracts	106
No. of Schools	23
No. of Public Buildings	29
No. of Monitoring Stations	8
No. of Residences	52
No. of Samples	129
No. of Blanks	6
No. of duplicate samples	11

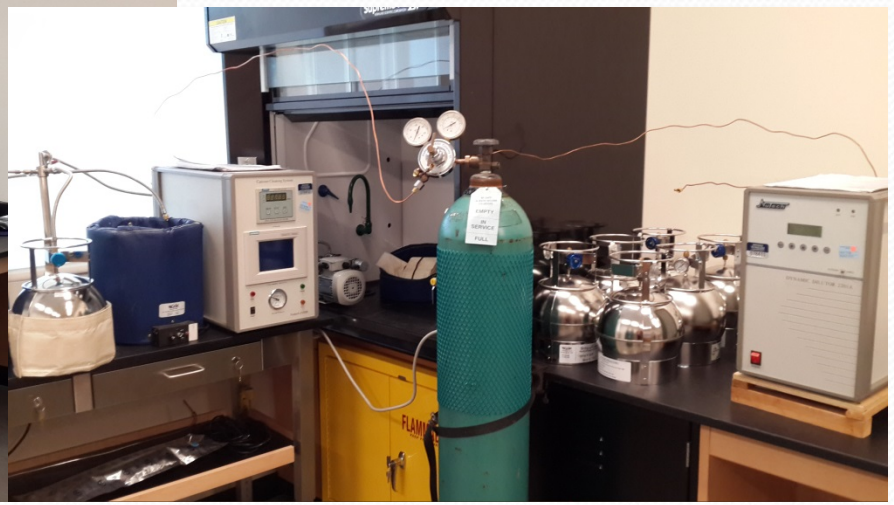
100% Data Collection!



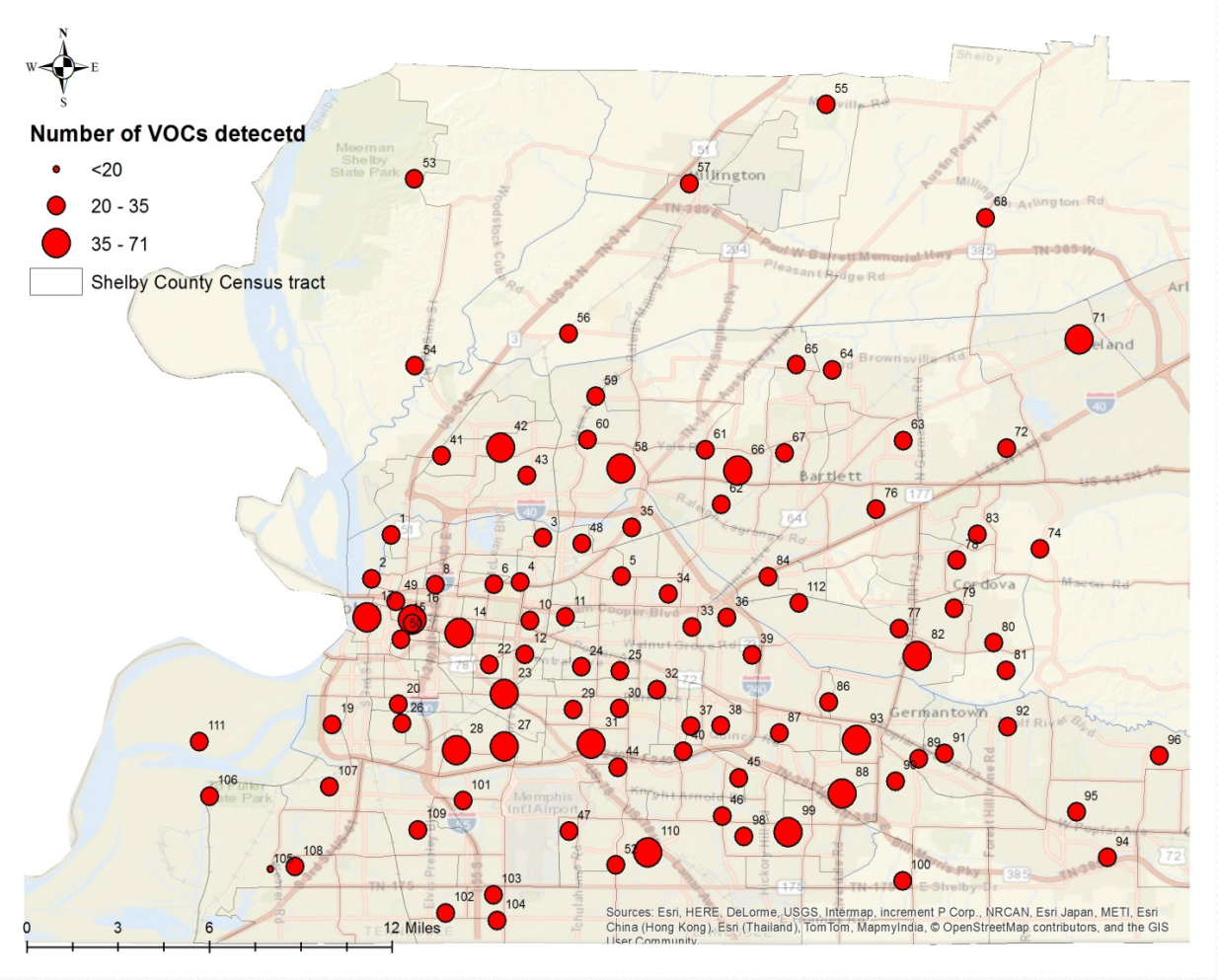
Field sampling, Jan-Dec, 2014

Laboratory analysis

- The analytical methods used for this study is EPA Method TO-15.
- Compounds are concentrated in cryogenic traps and then analyzed on a GC/MS system.
- After analysis, canisters are cleaned and vacuumed for the next use.



Detection frequencies of target VOCs

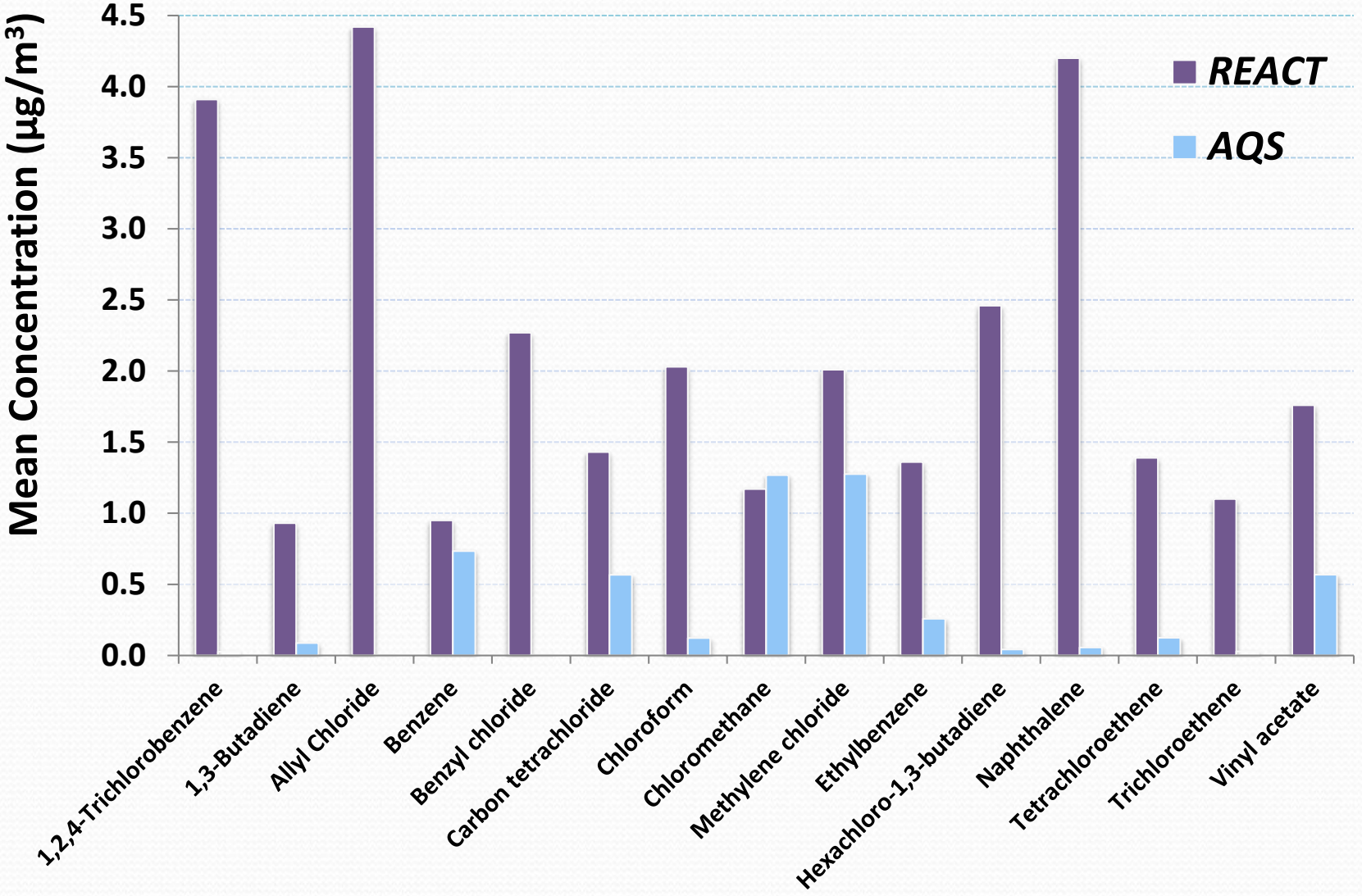


- All of the 71 target VOCs were detected.
- The most frequently detected VOCs in Memphis were acetone, ethanol, Freon 112, and propene

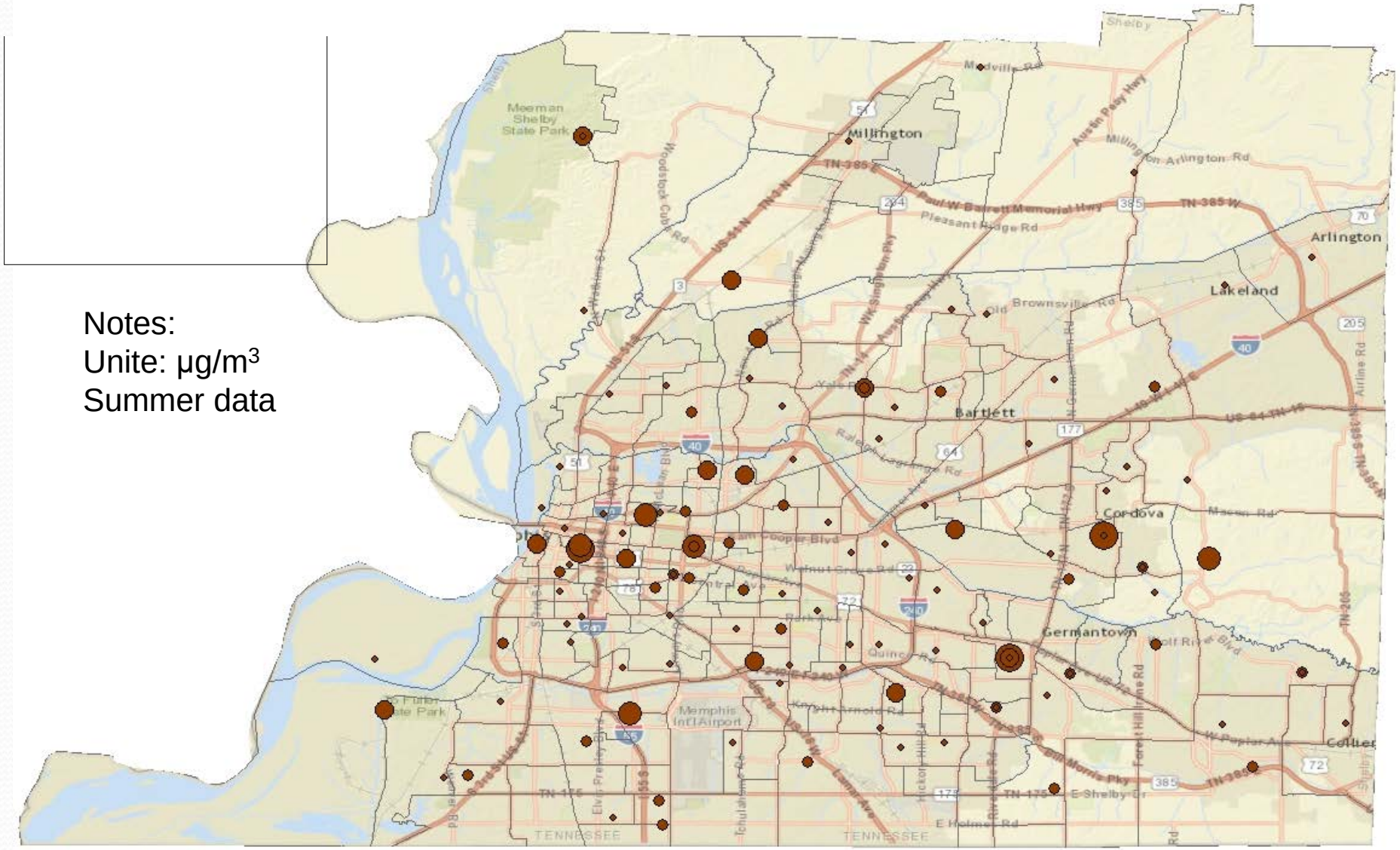
Concentrations of air toxics

VOCs	Mean	SD	Min	Median	Max	RfC	HQ
			($\mu g/m^3$)				
Allyl chloride	4.42	22.39	0.67	1.54	232	1	4.42
Naphthalene	4.20	1.98	3.03	3.36	12.96	3	1.40
Trichloroethene	1.10	0.06	0.68	1.10	1.26	2	0.55
1,3-Butadiene	0.94	0.22	0.48	0.78	1.70	2	0.47
Bromoethene	0.99	0.06	0.63	0.99	0.99	3	0.33
1,2-Dichloropropane	0.96	0.04	0.60	0.96	0.96	4	0.24
Bromomethane	0.90	0.05	0.55	0.90	0.90	5	0.18
trans-1,3-Dichloropropene	1.00	0.00	0.60	1.00	1.00	20	0.05
Tetrachloroethene	1.20	0.00	0.80	1.20	1.60	40	0.03
Benzene	0.90	0.30	0.60	0.90	2.70	30	0.03
Hexachloro-1,3-butadiene	2.70	1.80	1.80	1.80	14.40	90	0.03
Chloroform	1.96	2.94	0.98	0.98	16.66	98	0.02
1,2,4-Trichlorobenzene	4.00	2.00	4.00	4.00	14.00	200	0.02
Carbon tetrachloride	1.00	0.00	1.00	1.00	3.00	100	0.01
Chloromethane	0.90	0.90	0.90	0.90	8.10	90	0.01
Chloroethene	1.00	0.00	1.00	1.00	2.00	100	0.01

Comparison with national levels



Spatial distribution of TVOC



Notes:
Unite: μg/m^3
Summer data

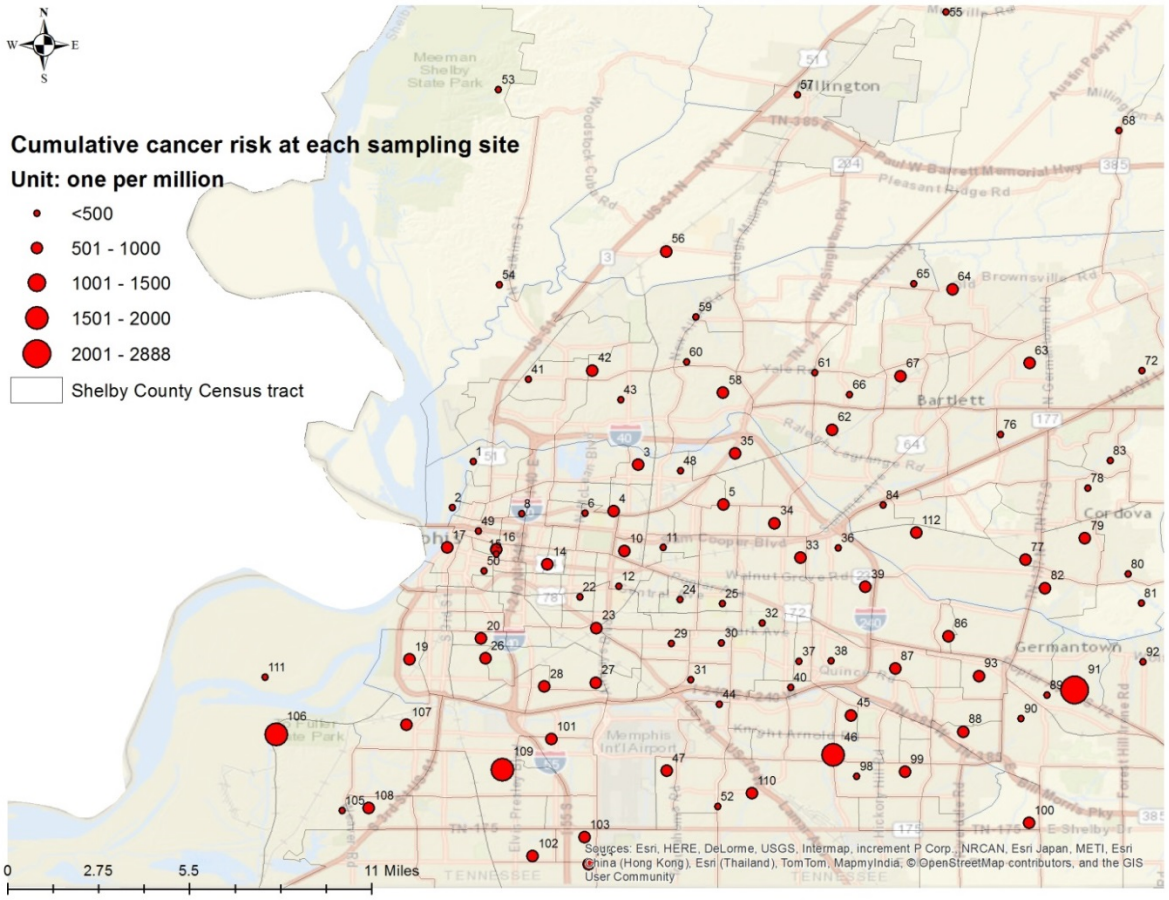
Common sources

VOCs/Factors	F1	F2	F3	F4	F5
Hexachloro-1,3-butadiene	**0.96**	-0.03	-0.04	0.11	-0.01
1,2,4-Trimethylbenzene	**0.95**	-0.02	0.05	0.09	-0.02
n- Butylbenzene	**0.94**	0.04	0.06	-0.03	0.07
Benzyl chloride	**0.94**	-0.05	0.01	0.06	-0.06
Methyl butyl ketone	**0.92**	-0.02	0.07	0.08	0.00
Naphthalene	**0.84**	0.02	0.15	0.06	0.07
Methyl isobutyl ketone	**0.72**	0.08	0.06	0.11	0.39
2,2,4-Trimethylpentane	0.07	**0.80**	0.12	-0.15	0.01
1,3,5-Trimethylbenzene	0.06	**0.67**	0.15	-0.19	0.07
Toulene	0.05	**0.77**	0.20	-0.05	0.34
Benzene	0.05	**0.52**	0.23	0.05	0.31
o-Xylene	0.00	**0.90**	-0.05	0.03	-0.04
m,*p*-Xylene	-0.04	**0.92**	-0.02	0.00	-0.01
Ethylbenzene	-0.16	**0.86**	-0.11	0.11	-0.09
Propene	0.10	0.32	**0.55**	0.41	0.04
Acetone	0.09	-0.03	**0.80**	0.21	0.20
Ethyl Methyl Ketone	0.07	0.02	**0.83**	-0.01	0.23
Vinyl acetate	0.02	0.16	**0.77**	-0.17	-0.06
Chloromethane	0.23	-0.14	0.08	**0.87**	-0.03
Freon 112	0.00	-0.13	0.07	**0.89**	-0.04
Isopropyl alcohol	0.21	-0.02	-0.01	-0.06	**0.74**
Ethanol	0.07	0.03	0.50	0.01	**0.61**
n-Hexane	-0.15	0.18	0.24	0.06	**0.58**
Allyl chloride	0.37	0.13	-0.16	0.44	0.27
Variance explained (%)	26.5	20.6	11.8	7.9	5.1
Cumulative (%)	26.5	47.1	58.9	66.8	71.9

F1: Emissions from organic synthesis processes;
F2: Vehicle exhaust; F3: Industrial solvent and precursors
F4: Ubiquitous rrefrigerants; F5: Gasoline additives

Cancer risks and risk drivers

Carcinogenic VOCs	Mean ($1/10^6$)	Contrib. (%)
Naphthalene	143	24
Benzyl chloride	111	19
1,1,2,2-Tetrachloroethane	55.7	9.5
Chloroform	46.6	7.9
Hexachloro-1,3-butadiene	54.1	9.2
Bromoethene	31.2	5.3
Allyl chloride	26.5	4.5
1,3-Butadiene	28.0	4.8
1,2-Dichloroethane	19.1	3.3
1,1,2-Trichloroethane	17.6	3.0
1,4-Dichlorobenzene	12.3	2.1
Chloroethene	9.74	1.7
Carbon tetrachloride	8.56	1.5
Benzene	7.39	1.3
Cumulative	**587**	**100**

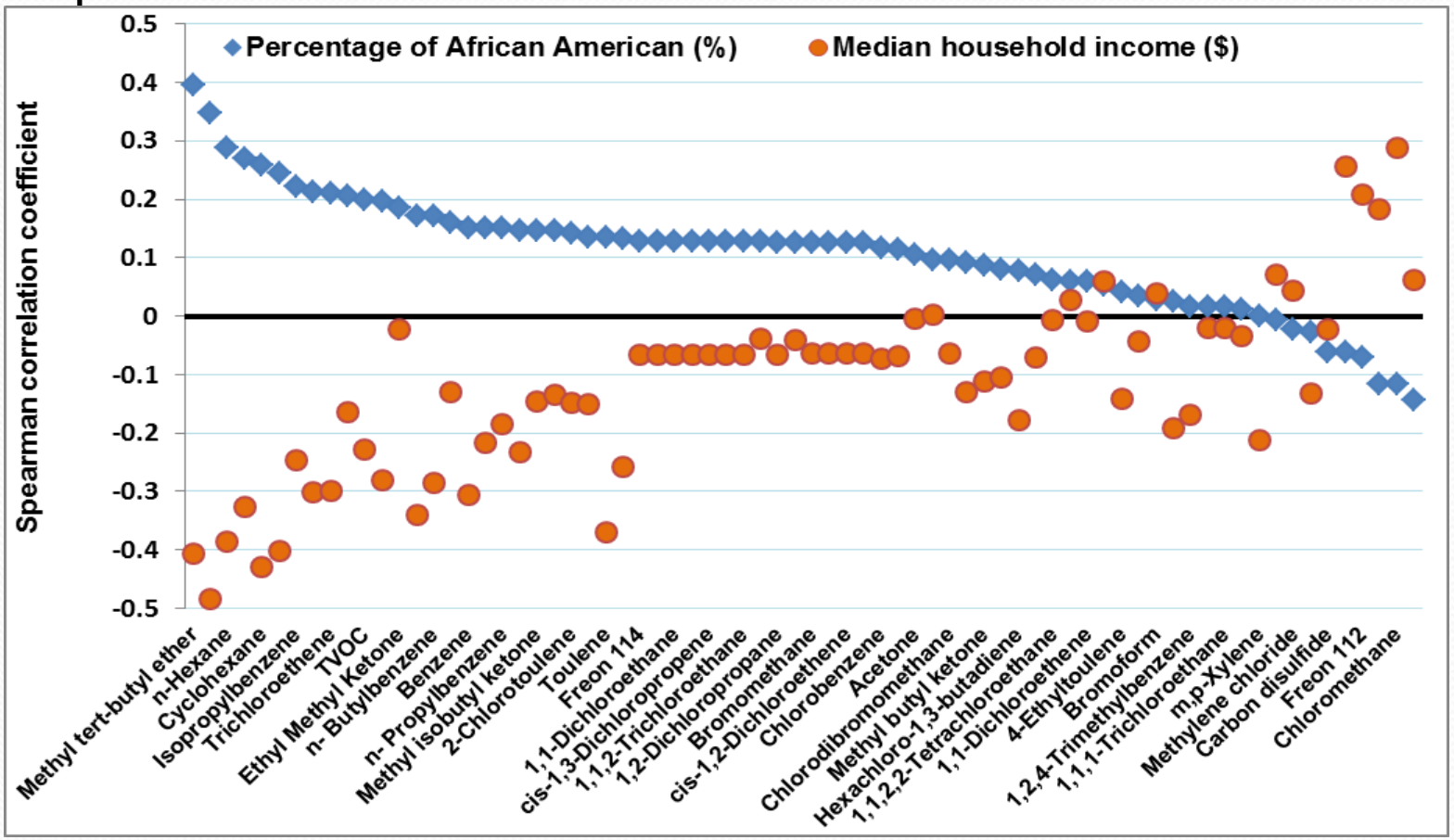


Target organ specific hazard index

Target organs	Mean	VOCs
Neurological	6.71	1,1,1-trichloroethane, toluene, styrene, n-hexane, methylene chloride, 1,1,2-trichloroethane, m,p-xylene, o-xylene, chloromethane, tetrachloroethene, bromomethane, naphthalene, allyl chloride
Respiratory	1.84	toluene, 1,2,4-trichlorobenzenem,p-xylene, o-xylene, trans-1,3-dichloropropene, bromomethane, 1,2-dichloropropane, naphthalene
Reproductive/ Developmental	1.03	chloroethane, methyl isobutyl ketone, ethylbenzene, isopropylbenzene, 1,2,4-trichlorobenzene, trichloroethene, 1,3-butadiene
Ocular	0.61	methyl tert-butyl ether, m,p-xylene, o-xylene, tetrachloroethene, trichloroethene
Immune	0.58	benzene, trichloroethene
Cardiovascular	0.55	methylene chloride, trichloroethene
Liver and Kidney	0.4	1,1,1-trichloroethane, methyl tert-butyl ether, 1,2-dichloroethane, chlorobenzene, 1,4-dichlorobenzene, methyl methacrylate, methylene chloride, 1,1,2-trichloroethane, 1,2,4-trichlorobenzene, 1,1-dichloroethene, carbon tetrachloride, chloroethene, chloroform, bromoethene
Hematologic	0.03	benzene
Total	11.8	

Environmental justice

- At the census tract level, concentrations of the majority of compounds had positive correlations with percent of the black, and negative correlations with median household income.
- The associations are not statistically significant for most compounds.

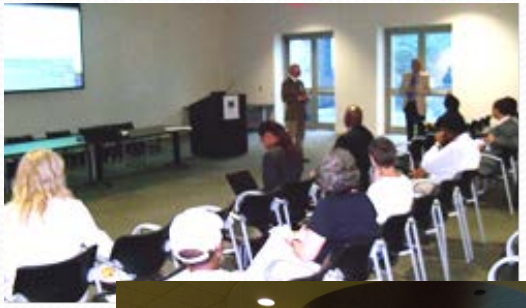


Community Engagement

- Established a community-government-academia partnership:
  - Communities: Sierra Club, Shelby County Schools, Engineers' Club of Memphis, Bridges, etc.
  - Government: EPA Region 4 Office, White House Council on Strong Cities Strong Communities, Memphis Police Department, Memphis Fire Department, Shelby County Sherriff's Department
  - Universities: UM, MTSU, UTHSC, etc.

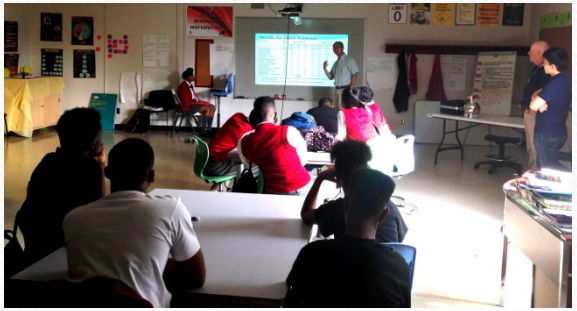
Community engagement outputs 1

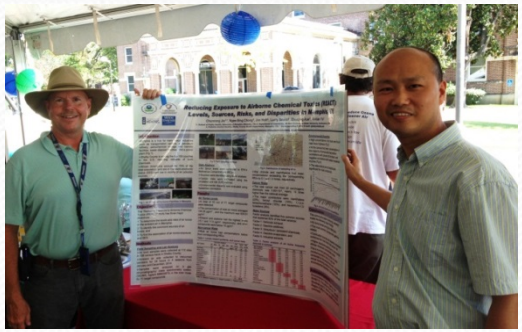
- Educational resources: Project flyers, fact sheets, and letters of findings.
- Public meetings. We held **24** public/stakeholders' meetings during the entire project period.
- Sierra Club Cable TV Interview.



Community engagement outputs 2

- Classroom connections. We established our “classroom connections” engagement with Shelby County Schools.
- Public connections. We presented our study in a number of local events, including Tiger Blue Goes Green, Earth Day, and Sierra Club Annual Environmental Justice Conference.





Community engagement outputs 3

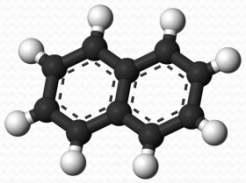
- Presentations in scientific conferences and publications.
- Secured grants.
  - Harvard Environmental Health Fellowship.
  - Next community-scale air toxics monitoring study.
- Support future projects.

Harvard EH Fellowship

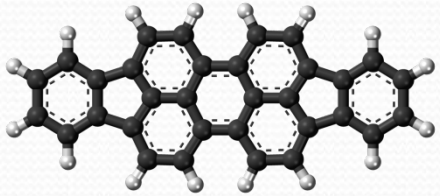
EPA CitySpace Project

Future work

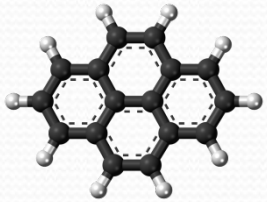
- Memphis PAHs Study
  - PAHs: Polycyclic aromatic hydrocarbons
  - Overall objective:
    - Delineate the concentrations and distributions of PAHs in ambient air in Memphis Tri-state Area
    - Identify major sources and apportion the contributions
    - Characterize near-source PAH profiles, and
    - Assess non-carcinogenic and carcinogenic risks.



Naphthalene



Indeno[1,2,3-c,d] pyrene



Pyrene

Benzo[a]pyrene (BAP)