

Electronic Supplemental Information (ESI) for Environmental Science: Processes and Impacts.
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Supplementary Information
for
Potential for City Parks to Reduce Exposure to BTEX in Air

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Fig. 1S. Picture of deployed passive organic vapor monitor and iButton with plastic housing.

Table 1S. Temperature (mean \pm standard deviation) and precipitation (total sum) data during the sampling campaign from stations in Birmingham (WBAN ID 13876) and Selma, AL (WBAN ID 63897). The weather station in Selma, AL is the closest one to the sampling location in Camden, AL. Data acquired from the National Centers for Environmental Information.¹ The transition between Week 1 and Week 2 took place on July 15, 2017.

Sampling Campaign	Date	Birmingham		Selma	
		Temperature [°C]	Precipitation [mm]	Temperature [°C]	Precipitation [mm]
	July 8, 2017	26 \pm 2.3	TRACE	26 \pm 2.8	15.7
	July 9, 2017	26 \pm 3.7	0	25 \pm 3.7	1.8
	July 10, 2017	27 \pm 5.1	0	26 \pm 3.4	0
Week 1	July 11, 2017	25 \pm 2.8	35.3	26 \pm 3.3	0
	July 12, 2017	27 \pm 3.2	0	26 \pm 2.9	0
	July 13, 2017	28 \pm 2.8	TRACE	27 \pm 3.5	0
	July 14, 2017	26 \pm 2.7	29	27 \pm 3.9	0
-----	July 15, 2017	25 \pm 2.2	3	27 \pm 3.5	0.5
	July 16, 2017	25 \pm 2.7	11.4	25 \pm 2.4	0
	July 17, 2017	27 \pm 3.0	0	26 \pm 2.6	4.3
	July 18, 2017	27 \pm 3.9	0	26 \pm 3.7	0
Week 2	July 19, 2017	29 \pm 3.9	0	27 \pm 4.1	0
	July 20, 2017	29 \pm 3.3	0	28 \pm 4.1	0
	July 21, 2017	30 \pm 3.6	0	26 \pm 3.9	0.8
	July 22, 2017	29 \pm 3.0	0	27 \pm 4.4	0

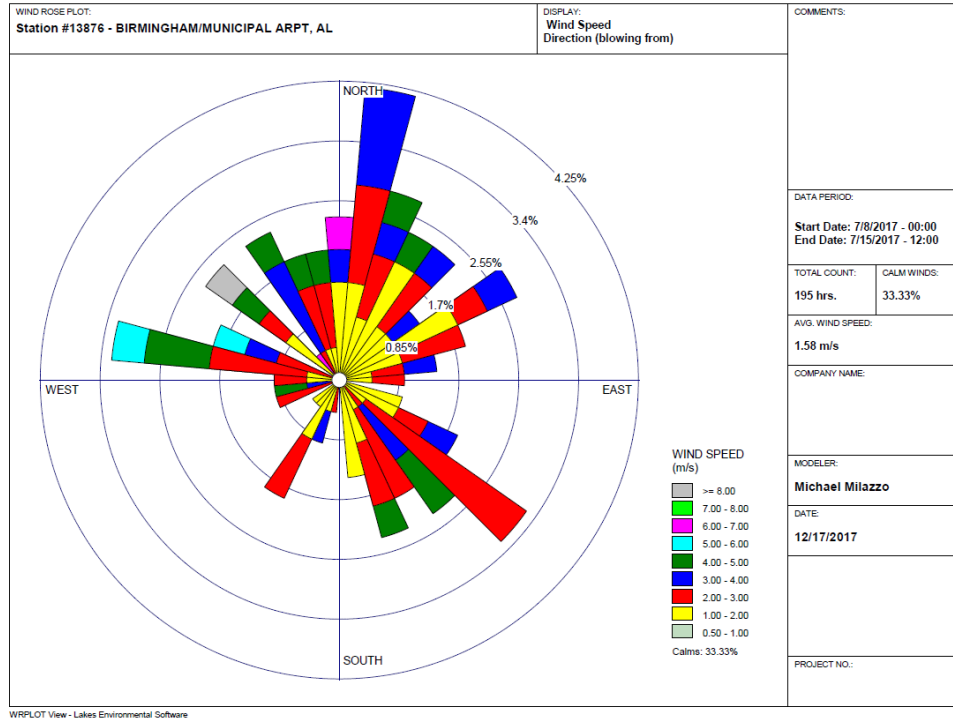


Fig. 2S. Wind rose plot² during Week 1 from station in Birmingham, AL (WBAN ID 13876). Data acquired from the National Centers for Environmental Information.¹

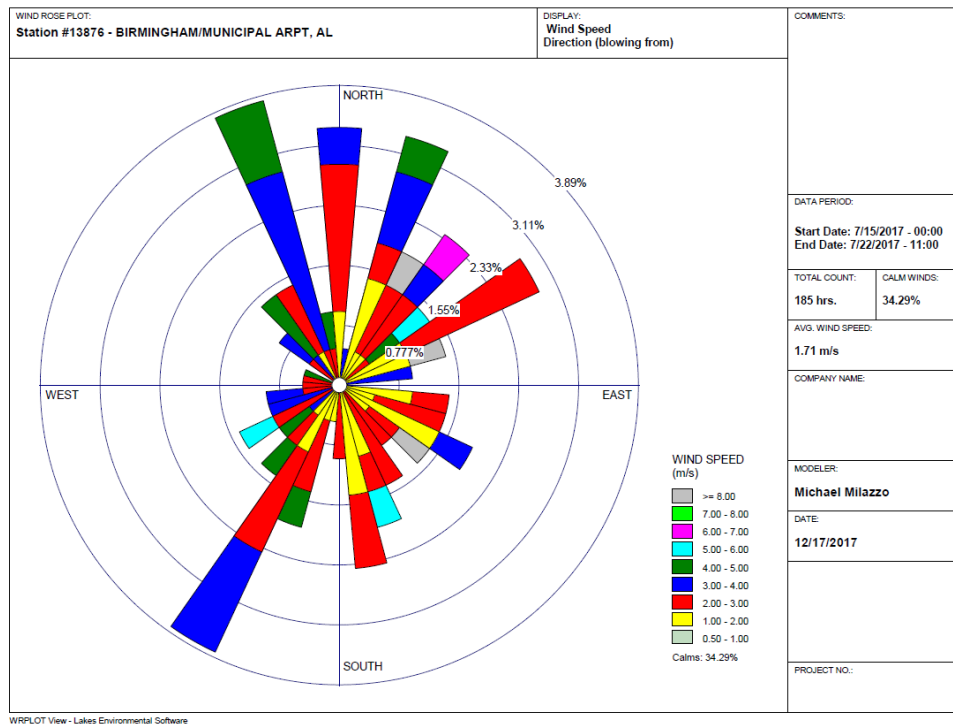


Fig. 3S. Wind rose plot² during Week 2 from station in Birmingham, AL (WBAN ID 13876). Data acquired from the National Centers for Environmental Information.¹

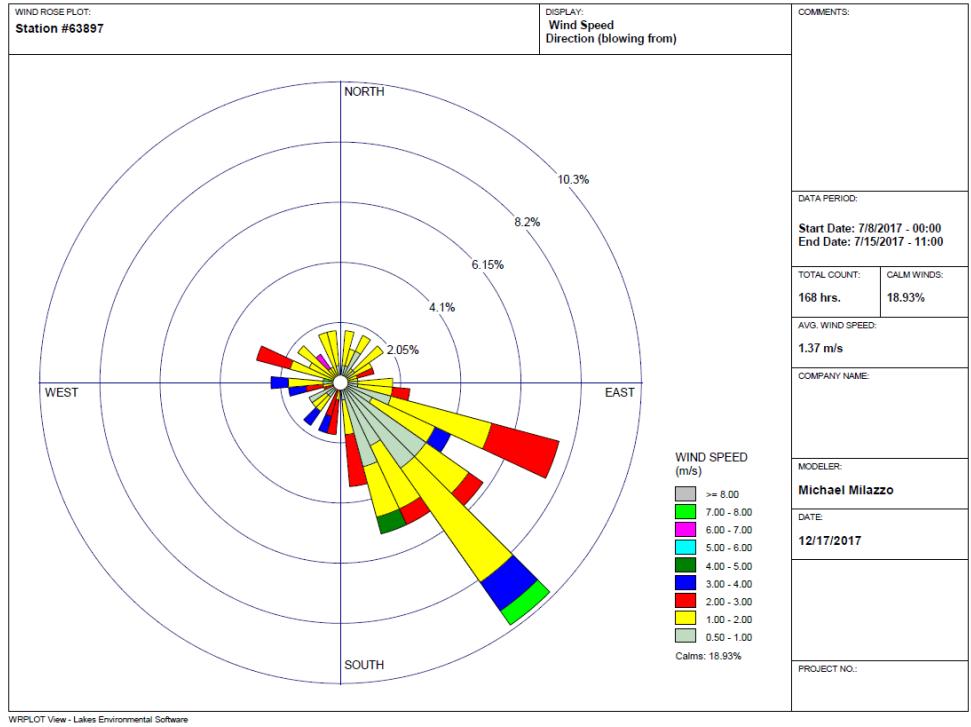


Fig. 4S. Wind rose plot² during Week 1 from station nearest Camden in Selma, AL (WBAN ID 63897). Data acquired from the National Centers for Environmental Information.¹

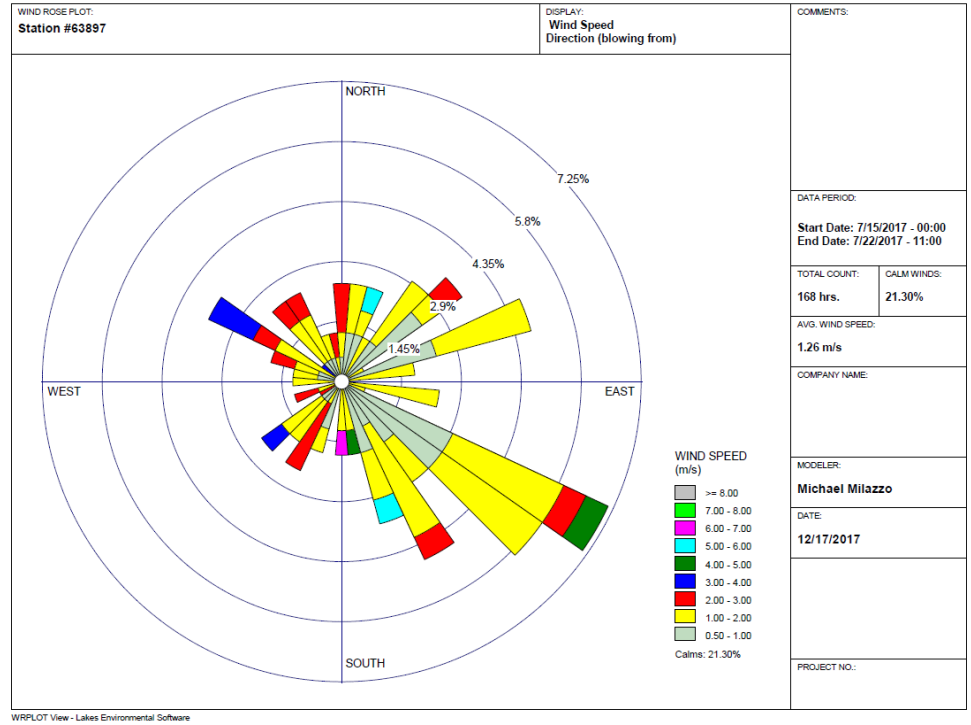


Fig. 5S. Wind rose plot² during Week 2 from station nearest Camden in Selma, AL (WBAN ID 63897). Data acquired from the National Centers for Environmental Information.¹

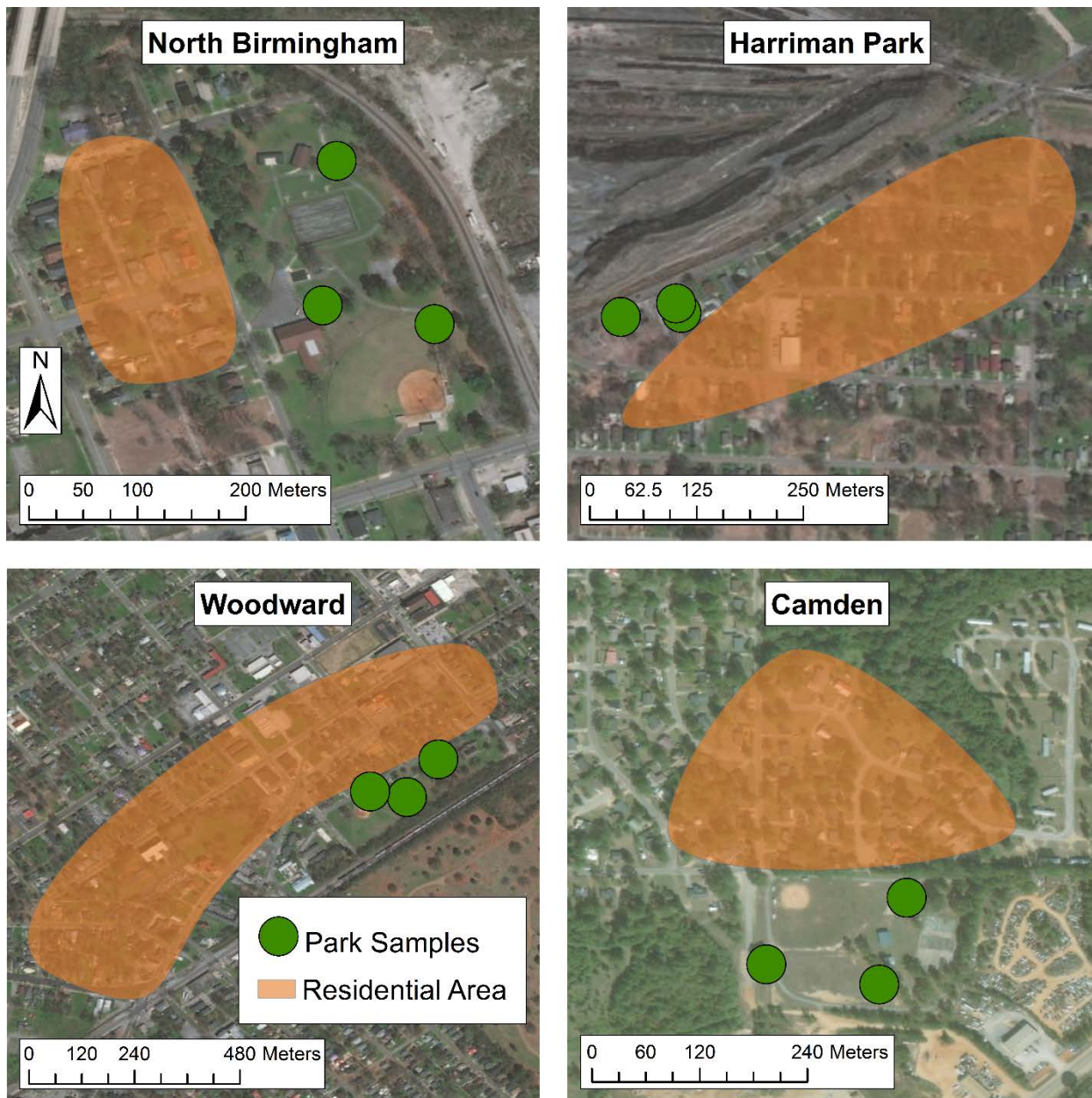


Fig. 6S. Sampling locations in (clockwise from top-left): North Birmingham, Harriman Park, Woodward, and Camden. Specific sample locations in the residential areas are not shown in order to maintain the privacy and confidentiality of the participants.

Table 2S. GC-MS method detection limits for BTEX and surrogate standard, conducted per EPA Method Detection Limit Procedure.³ The equivalent gas-phase concentration, assuming a 7-day sampling period with this type of organic vapor monitor, is also shown.

	Benzene	Toluene	Ethylbenzene	m-,p-Xylene	o-Xylene	p-Bromofluorobenzene
Liquid extract [ng mL ⁻¹]	31.4	23.9	3.80	5.76	5.67	4.15
Gas-phase equivalent [μg m ⁻³]	0.132	0.113	0.0207	0.0314	0.0309	N/A

Table 3S. BTEX and surrogate standard recovery [%] determined by desorption efficiency tests.

Mass Loaded [ng]	Benzene	Toluene	Ethylbenzene	m-,p-Xylene	o-Xylene	p-Bromofluorobenzene
75	92.6	130	73.2	80.6	81.7	57.1
	122	138	83.9	96.0	92.1	70.0
	133	145	88.6	103	102	72.5
150	108	110	79.1	86.4	86.5	64.1
	117	121	89.2	93.5	94.2	70.8
	106	116	84.1	93.6	91.9	65.7
750	102	111	109	112	105	89.6
	96.3	119	114	117	109	78.4
	89.7	109	105	109	102	74.4
1875	88.3	97.2	100	103	98.8	86.5
	99.2	113	117	118	112	76.5
	93.7	108	113	113	106	80.3

Table 4S. Method, trip, and reagent blanks (n=4 each) for BTEX and surrogate standard [ng mL⁻¹]. NF signifies “not found” while * denotes 25% of blanks (1 of 4) were not detected.

Blank type	Benzene	Toluene	Ethylbenzene	m-,p-Xylene	o-Xylene	p-Bromofluorobenzene
Method blanks	NF	25.9 ± 1.6*	NF	NF	NF	56.4 ± 4.1
Trip blanks	NF	29.9 ± 1.3	NF	NF	NF	63.2 ± 2.1
Reagent blanks	NF	NF	NF	NF	NF	NF

Effect of Rain Cover. A separate experiment was conducted to determine whether the rain cover used to protect the passive samplers might have affected the measurements. Four passive samplers, two with rain covers and two without, were deployed for one week (August 13–21, 2018) under an eave at a residence in Blacksburg, VA. These passive samplers, along with one field blank, were analyzed in the laboratory using the same methods described in the paper. The results are presented in Table 5S. According to t-tests, concentrations were not significantly different with and without rain covers, except for m-,p-xylene ($p=0.02$), for which concentrations were 7% higher without the rain covers. Therefore, the rain covers were presumed not to introduce bias to the results.

Table 5S. BTEX concentrations [$\mu\text{g m}^{-3}$] and p-bromofluorobenzene surrogate standard recovery [%] for experiment conducted to assess potential bias of rain cover. Concentrations in field blanks [$\mu\text{g m}^{-3}$], solvent blanks [ng mL^{-1}], and method blanks [ng mL^{-1}] are also provided.

Passive Sampler	Benzene	Toluene	Ethylbenzene	m-,p-Xylene	o-Xylene	p-Bromofluorobenzene
With rain cover	0.382	0.803	0.113	0.190	0.127	76.1
	0.150	0.764	0.106	0.188	0.125	76.4
Without rain cover	0.315	0.781	0.114	0.202	0.127	76.4
	0.261	0.873	0.127	0.205	0.151	86.4
Field blank	NF	0.131 ^a	0.021 ^a	NF	NF	66.7
Solvent blank	NF	NF	NF	NF	NF	NF
	NF	NF	NF	NF	NF	NF
Method blank	NF	26.2	NF	NF	NF	74.8
	NF	26.7	4.81	NF	NF	81.5

^a Calculated assuming a 7-day exposure period. The concentrations in the extract were 30.1 ng mL^{-1} and 4.1 ng mL^{-1} for toluene and ethylbenzene, respectively.

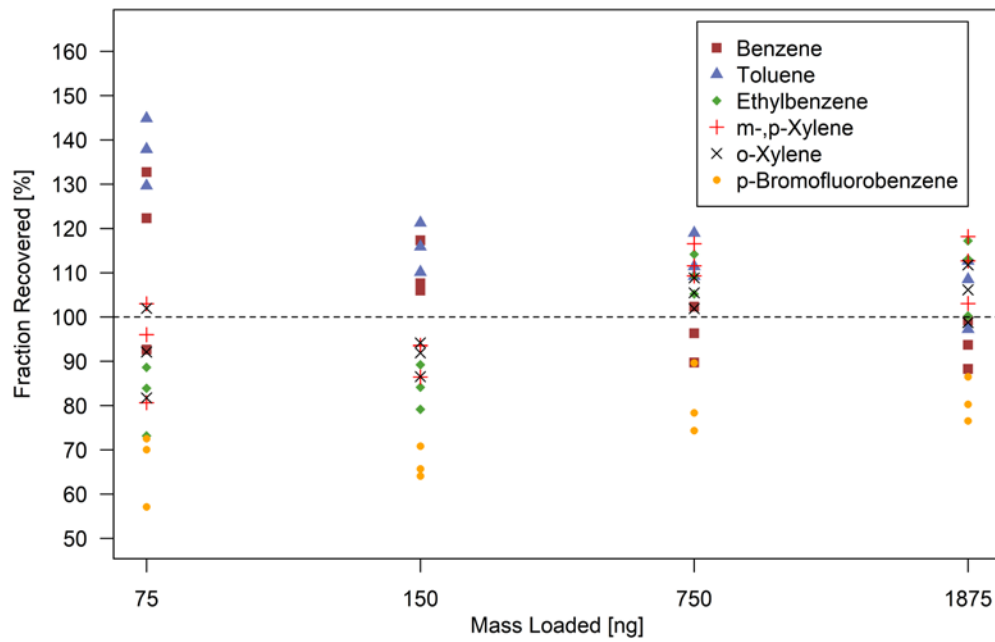


Fig. 7S. BTEX and surrogate standard percent recovery determined by desorption efficiency tests. Dashed line is 100% recovery.

Table 6S. All BTEX concentrations by site and week [$\mu\text{g m}^{-3}$].

Name	Type	Site	Week	Benzene	Toluene	Ethylbenzene	m-,p-Xylene	o-Xylene	Surrogate Recovery Efficiency [%]
North Birmingham	Park	A	1	2.51	1.67	0.291	1.13	0.426	71.1
			2	1.83	1.30	0.256	0.989	0.366	56.4
		B	1	1.70	1.36	0.251	0.936	0.353	72.5
			2	1.92	1.41	0.288	1.10	0.394	66.7
		C	1	1.31	1.02	0.170	0.654	0.247	61.0
			2	1.62	1.32	0.251	0.975	0.350	60.6
	Residential	A	1	1.75	1.51	0.266	1.02	0.392	62.4
			2	1.53	1.44	0.279	1.08	0.385	59.4
		B	1	1.64	1.29	0.224	0.846	0.322	58.5
			2	1.47	1.38	0.264	1.05	0.377	67.2
		C	1	2.01	1.57	0.267	1.03	0.395	58.2
			2	1.75	2.26	0.405	1.57	0.600	63.7
Harriman Park	Park	A	1	1.83	1.77	0.357	1.37	0.515	65.5
			2	1.57	1.94	0.459	1.75	0.675	72.4
		B	1	2.08	1.66	0.312	1.21	0.472	68.5
			2	1.17	1.30	0.289	1.12	0.422	65.6
		C	1	1.66	1.79	0.362	1.39	0.504	62.1
			2	1.30	2.03	0.480	1.86	0.694	63.5
	Residential	A	1	1.63	1.86	0.350	1.37	0.548	61.3
			2	1.44	1.76	0.394	1.54	0.577	67.5
		B	1	1.57	1.55	0.303	1.18	0.448	57.1
			2	1.44	1.84	0.405	1.63	0.592	71.1
		C	1	1.62	2.03	0.431	1.58	0.640	60.4
			2	1.41	2.18	0.463	1.80	0.678	81.7
Woodward	Park	A	1	0.608	2.14	0.303	1.03	0.416	60.5
			2	0.558	2.09	0.305	1.03	0.418	58.3
		B	1	0.805	1.90	0.312	1.07	0.437	58.7
			2	0.667	1.95	0.303	1.03	0.407	56.8
		C	1	0.660	1.74	0.274	0.960	0.390	52.9
			2	0.768	2.21	0.339	1.15	0.471	64.5
	Residential	A	1	0.751	1.87	0.293	1.01	0.410	52.7
			2	0.800	2.11	0.330	1.11	0.445	59.7
		B	1	0.693	1.91	0.319	1.15	0.468	47.1
			2	0.906	2.69	0.458	1.55	0.619	69.0
		C	1	0.769	3.10	0.549	1.95	0.755	55.9
			2	1.13	3.21	0.518	1.76	0.674	61.2
Camden	Park	A	1	0.142	0.542	0.065	0.230	0.084	53.1
			2	0.301	1.06	0.186	0.632	0.242	50.5
		B	1	0.170	0.716	0.085	0.300	0.108	54.9
			2	0.265	1.35	0.225	0.753	0.290	54.8
		C	1	0.169	0.472	0.062	0.191	0.073	54.1
			2	0.325	0.861	0.141	0.473	0.189	46.0
	Residential	A	1	0.291	0.830	0.142	0.522	0.219	59.5
			2	0.306	1.34	0.407	0.844	0.329	54.6
		B	1	0.285	0.707	0.108	0.321	0.115	60.6
			2	0.306	1.12	0.223	0.598	0.230	57.9
		C	1	0.244	0.869	0.125	0.454	0.176	57.7
			2	0.412	1.31	0.241	0.783	0.312	66.2

Table 7S. BTEX concentrations [$\mu\text{g m}^{-3}$] for Week 1, grouped by park name and location type.

Name	Type	Benzene	Toluene	Ethylbenzene	m-,p-Xylene	o-Xylene	Surrogate Recovery Efficiency [%]
North Birmingham	Park	1.84 ± 0.610	1.35 ± 0.325	0.237 ± 0.0614	0.905 ± 0.238	0.342 ± 0.0900	68.2 ± 6.24
	Residential	1.80 ± 0.189	1.46 ± 0.150	0.252 ± 0.0248	0.963 ± 0.102	0.370 ± 0.0415	59.7 ± 2.37
Harriman Park	Park	1.86 ± 0.211	1.74 ± 0.0715	0.344 ± 0.0274	1.32 ± 0.0992	0.497 ± 0.0223	65.4 ± 3.21
	Residential	1.61 ± 0.0310	1.82 ± 0.243	0.362 ± 0.0650	1.38 ± 0.202	0.546 ± 0.0958	59.6 ± 2.22
Woodward	Park	0.691 ± 0.102	1.93 ± 0.204	0.296 ± 0.0201	1.02 ± 0.0566	0.414 ± 0.0235	57.4 ± 3.95
	Residential	0.738 ± 0.0395	2.29 ± 0.701	0.387 ± 0.141	1.37 ± 0.505	0.544 ± 0.185	51.9 ± 4.41
Camden	Park	0.160 ± 0.0161	0.576 ± 0.126	0.0707 ± 0.0124	0.240 ± 0.0556	0.0884 ± 0.0179	54.1 ± 0.905
	Residential	0.273 ± 0.0252	0.802 ± 0.0847	0.125 ± 0.0170	0.432 ± 0.102	0.170 ± 0.0524	59.3 ± 1.46

Table 8S. BTEX concentrations [$\mu\text{g m}^{-3}$] for Week 2, grouped by park name and location type.

Name	Type	Benzene	Toluene	Ethylbenzene	m-,p-Xylene	o-Xylene	Surrogate Recovery Efficiency [%]
North Birmingham	Park	1.79 ± 0.153	1.34 ± 0.0560	0.265 ± 0.0201	1.02 ± 0.0674	0.370 ± 0.0226	61.3 ± 5.16
	Residential	1.58 ± 0.143	1.69 ± 0.492	0.316 ± 0.0776	1.23 ± 0.291	0.454 ± 0.127	63.5 ± 3.92
Harriman Park	Park	1.35 ± 0.206	1.76 ± 0.401	0.409 ± 0.105	1.58 ± 0.400	0.597 ± 0.152	67.2 ± 4.68
	Residential	1.43 ± 0.0199	1.93 ± 0.225	0.420 ± 0.0369	1.66 ± 0.130	0.616 ± 0.0547	73.4 ± 7.34
Woodward	Park	0.665 ± 0.105	2.08 ± 0.130	0.316 ± 0.0201	1.07 ± 0.0737	0.432 ± 0.0342	59.8 ± 4.10
	Residential	0.946 ± 0.170	2.67 ± 0.548	0.436 ± 0.0962	1.48 ± 0.331	0.579 ± 0.119	63.3 ± 5.02
Camden	Park	0.297 ± 0.0304	1.09 ± 0.246	0.184 ± 0.0418	0.620 ± 0.140	0.240 ± 0.0503	50.4 ± 4.39
	Residential	0.341 ± 0.0609	1.26 ± 0.118	0.290 ± 0.102	0.742 ± 0.128	0.290 ± 0.0529	59.6 ± 5.95

Table 9S. Toluene:benzene (T:B) and m-,p-xylene:ethylbenzene (m-p-X:E) mass ratios (mean \pm standard deviation).


Name	Type	Week 1		Week 2	
		T:B	m-,p-X:E	T:B	m-,p-X:E
North Birmingham	Park	0.747 \pm 0.0710	3.81 \pm 0.0719	0.753 \pm 0.0516	3.85 \pm 0.0375
	Residential	0.810 \pm 0.0443	3.82 \pm 0.0367	1.06 \pm 0.206	3.92 \pm 0.0671
Harriman Park	Park	0.946 \pm 0.141	3.84 \pm 0.0179	1.30 \pm 0.235	3.86 \pm 0.0438
	Residential	1.13 \pm 0.133	3.82 \pm 0.140	1.35 \pm 0.178	3.94 \pm 0.0713
Woodward	Park	2.84 \pm 0.606	3.44 \pm 0.0628	3.18 \pm 0.484	3.39 \pm 0.0176
	Residential	3.09 \pm 0.827	3.54 \pm 0.0735	2.82 \pm 0.165	3.39 \pm 0.0132
Camden	Park	3.61 \pm 0.737	3.38 \pm 0.269	3.76 \pm 1.24	3.37 \pm 0.0313
	Residential	2.97 \pm 0.546	3.42 \pm 0.391	3.74 \pm 0.595	2.67 \pm 0.591

Thank you for participating in the ENACT July 2017 air quality measurement campaign!


“BTEX” stands for Benzene, Toluene, Ethylbenzene, and Xylenes, which are 4 pollutants that come from cars or some factories.

While any amount of exposure will have some risk, the BTEX levels measured at your house are low. Our professional opinion is that you have very little risk from exposure to BTEX in your area.

Organic Vapor Monitor



	Your Average Concentrations ($\mu\text{g} / \text{m}^3$)	Average Outdoor Concentrations ($\mu\text{g} / \text{m}^3$)	EPA Safe Level ($\mu\text{g} / \text{m}^3$)
Benzene	1.7	1.5 - 6.95	30
Toluene	1.9	7.17 - 26.9	5,000
Ethylbenzene	0.4	0.59 - 2.06	1,000
Xylenes	2.2	4.01 - 17.46	100



EnactAlabama.org

For more reading on BTEX and their health effects, please see the enclosed pamphlets from the Centers for Disease Control’s Agency for Toxic Substances and Disease Registry.

This information should not be used for any purpose other than to share the results of an academic study with the community members who kindly invited us to their home. If you have any questions, please contact Virginia Tech researchers Dr. Julia Gohlke at (540) 231-7880 or Michael Milazzo at Milazzo@vt.edu

Fig. 8S. Example pamphlet distributed to community members who allowed deployment of passive samplers on their property. “Your Average Concentrations” are the values for the two weeks combined; the example data presented are from Harriman Park, Type Park, Site A. “Average Outdoor Concentrations” are ranges of the studies assessed in Bolden et al. 2015.⁴ “EPA Safe Level” are inhalation Reference Concentrations.⁵⁻⁸

References

- (1) Climate Data OnLine. National Oceanic and Atmospheric Administration, National Centers of Environmental Information: Asheville, North Carolina.
- (2) The, J. L.; The, C. L.; Johnson, M. A.; Shatalov, O. WRPLOT View. Lakes Environmental Software: Waterloo, Ontario 2016.
- (3) *Definition and Procedure for the Determination of the Method Detection Limit, Revision 2*; Environmental Protection Agency Office of Water: Washington, DC, USA, 2016.
- (4) Bolden, A. L.; Kwiatkowski, C. F.; Colborn, T. New Look at BTEX: Are Ambient Levels a Problem? *Environ. Sci. Technol.* **2015**, *49* (9), 5261–5276.
- (5) Chemical Assessment Summary: Benzene. *Integrated Risk Information System*. Environmental Protection Agency, National Center for Environmental Assessment: Washington, D.C., USA 2003, p 43.
- (6) Chemical Assessment Summary: Toluene. *Integrated Risk Information System*. Environmental Protection Agency, National Center for Environmental Assessment: Washington, D.C., USA 2005, p 33.
- (7) Chemical Assessment Summary: Ethylbenzene. *Integrated Risk Information System*. Environmental Protection Agency, National Center for Environmental Assessment: Washington, D.C., USA 1987, p 20.
- (8) Chemical Assessment Summary: Xylenes. *Integrated Risk Information System*. Environmental Protection Agency, National Center for Environmental Assessment: Washington, D.C., USA 2003, p 32.