Comprehensive Air Monitoring Across North Texas from 2014-2015

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INTRODUCTION

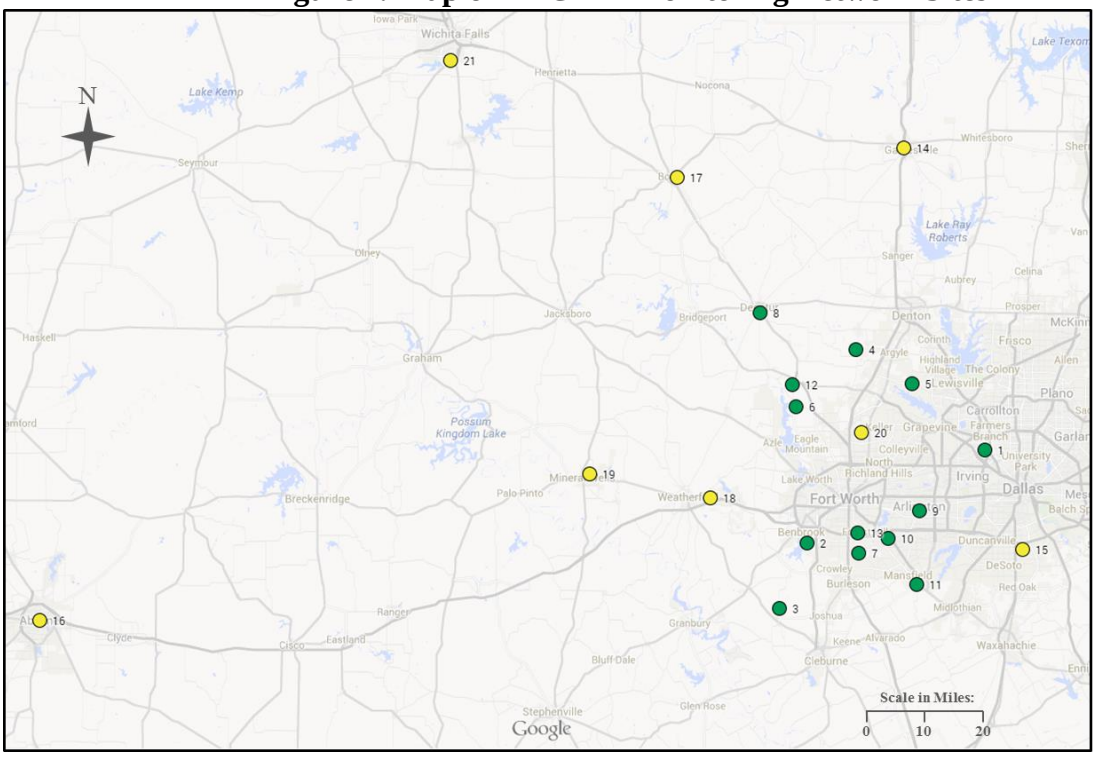
Oil and natural gas production in the Barnett Shale in North Texas has increased twenty-fold since 2000.[1] The increase in activity has led to local concerns about air quality and its impact on human health in the 25 counties potentially affected by production. In response to these concerns, the Texas State Legislature passed Senate Bill 527, which called for the establishment of a regional air toxics monitoring program to generate actionable data useful to improving air quality and public health in the region. The Texas Commission on Environmental Quality (TCEQ) selected the North Texas Commission (NTC), a regional non-profit consortium of local businesses, governments, and higher education institutions, to fulfill the requirements of this bill. NTC subsequently contracted AECOM to install, operate, and report data for the NTC air monitoring network.

The NTC network consists of 21 monitoring sites: eight canister sampling sites and 13 automated gas chromatography (AutoGC) sites. The network encompasses an area of over 11,000 square miles, and the monitoring locations can be seen in Figure 1. Concentrations of dozens of volatile organic compounds (VOCs) and air toxics, including benzene, are measured. These compounds are of importance because they have to potential to affect local air quality and human health in the Barnett Shale region.

A very large data set has been generated since the inception of the NTC network in 2013. A total of approximately 40,000 VOC concentrations are measured at the canister sites each year and approximately 4,000,000 VOC concentrations are measured at the AutoGC sites each year. This data set provides a definitive and long-term examination of the relationship between oil and gas activities and air quality in North Texas.

Previous published studies have examined the link between oil and gas activities and air quality in the North Texas region utilizing air monitoring data that predates the establishment of the NTC network.[2,3] This current study presents a summary of monitoring data collected across North Texas from 2014-2015, including an assessment of potential health risks and an analysis of spatial and temporal monitoring trends.

Figure 1. Map of NTC Air Monitoring Network Sites



Site List

1. Dallas Elm Fork
2. Fort Worth Benbrook Lake
3. Godley FM 2331
4. DISH Airfield
5. Flower Mound Shiloh
6. Eagle Mountain Lake
7. Everman Johnson Park
8. Decatur Thompson
9. Arlington UT Campus
10. Kennedale Treepoint Drive
11. Mansfield Flying L Lane
12. Rhome Seven Hills Road
13. Joe B. Rushing Road
14. Gainesville Doss Street
15. Lancaster Cedardale
16. Abilene North 3rd Street
17. Bowie Patterson Street
18. Weatherford Highway 180
19. Mineral Wells 23rd Street
20. Keller
21. Wichita Falls MWSU

Site Legend

- AutoGC
- Canister

METHODOLOGY

Network monitoring includes both continuous monitoring using on-site instruments and periodic sample collection for analysis in an off-site analytical laboratory. Meteorological parameters are measured at 19 of the sites and include wind speed and gust, wind direction, ambient temperature, and barometric pressure.

The 13 AutoGC (Perkin Elmer Clarus 500 Gas Chromatograph) monitors operate continuously 24-hours a day to determine hourly ambient concentrations of 48 VOCs, including both aliphatic and aromatic petroleum hydrocarbons. VOC analysis using the AutoGC systems follows the procedures established by the United States Environmental Protection Agency (U.S. EPA).[4] The detection limits range from 0.1- 0.3 ppbv depending on the compound.

Canister samples are collected every sixth day from midnight to midnight following the current U.S. EPA sampling schedule. Canister sampling provides a 24-hour integrated concentration for 84 target compounds. These target compounds include many of the same petroleum hydrocarbons as the AutoGC monitors, but additionally include various chlorinated hydrocarbons and freons. Canister samples are sent to GD Air Testing in Richardson, TX for laboratory analysis by GC/MS adhering to the guidance provided in EPA Method TO-15. The limit of quantification is roughly 0.5 ppbv for all target compounds except ethane and ethylene.

Construction of the NTC network occurred throughout 2013, and the network became fully operational in December of 2013. Four additional AutoGC sites were incorporated into the network in April of 2014. Data presented in this paper were collected from January 1, 2014 to June 30, 2015, unless otherwise noted.

RESULTS

Measured VOC concentrations from canister samples collected across the NTC network are summarized in Table 1. Results are shown for any compound detected in 80% or more of the samples and for any compound detected in any sample at concentrations of 1 ppbv or greater. Short straight- and branched-chain alkanes and short alkenes were found at the highest concentrations of any of the VOCs detected.

Table 1. Summary of Canister Site VOC Concentrations for Selected Compounds

Compound	%Det[a]	Max (ppbv)	Avg[b] (ppbv)	Compound	%Det[a]	Max (ppbv)	Avg[b] (ppbv)
n-Butane	100	20.9	2.51	n-Pentane	95.4	57.9	0.81
Isobutane	99.9	7.20	2.71	Styrene	95.0	0.77	0.04
Propane	99.9	30.6	3.91	3-Methylpentane	93.0	0.71	0.16
Freon-12	99.9	0.91	0.44	Ethylbenzene	90.6	0.48	0.03
3-Methylhexane	99.3	1.26	0.31	Methylcyclohexane	89.4	0.41	0.08
Propylene	99.2	1.33	0.30	o-Xylene	88.1	0.48	0.03
Isopentane	98.6	144	2.08	1,2,4-Trimethylbenzene	86.1	0.52	0.04
Toluene	98.6	2.47	0.16	n-Hexane	76.4	1.26	0.15
Chloromethane	98.6	1.05	0.51	Isohexane	61.5	1.13	0.20
m-/p-Xylene	98.5	0.90	0.07	Isoprene	52.7	1.45	0.13
Benzene	98.5	6.44	0.15	1-Pentene	47.3	1.06	0.05
Carbon Tetrachloride	98.3	0.29	0.07	Acetylene	37.4	23.8	0.22
Freon-11	98.3	0.42	0.20	1,3-Butadiene	29.0	1.16	0.05
1-Butene	97.5	2.14	0.44	n-Undecane	21.9	17.8	0.13
Methylene Chloride	97.1	0.86	0.12	Ethane	NC[c]	87.3	NC[c]
Cyclohexane	96.3	0.89	0.26	Ethylene	NC[c]	2.94	NC[c]

a. %Det indicates the percentage of total concentration measurements that were greater than the compound reporting limit.
b. Averages were calculated with a value of one-half the sample-specific reporting limit substituted for non-detect readings.
c. %Det and averages were not calculated due to the high (20 ppbv) quantification limits for these compounds

Method Comparison

When VOC concentrations for the canister and AutoGC sites were compared, good correlation was observed. For example, monthly average benzene concentrations for the AutoGC sites were plotted against monthly average benzene concentrations for the canister sites. Excluding January 2014 when canister benzene concentrations were consistently greater than AutoGC benzene concentrations, the R^2 value was calculated to be 0.75.

Spatial and Temporal Variability

The NTC network spans a large area, and although a small degree of spatial variability is apparent in the VOC concentrations, the concentrations measured throughout the network are relatively homogenous. Overall, low molecular-weight compounds generally have the highest frequencies of detection and the highest maximum concentrations.

Additional insight into spatial variability can be gleaned from examining the highest detected concentrations throughout the network. Ethane and propane are compounds of interest as they are potential indicators of natural gas activity. Benzene and toluene are of interest due to their presence in gasoline and subsequent widespread pervasiveness in ambient air, and because they are reasonably believed to be associated with Barnett Shale oil and gas production.[2]

Relatively high ethane concentrations were measured across the network, and ethane had the highest hourly concentrations of any compound monitored (1054 ppbv at Godley). The highest propane concentrations were seen predominantly at Decatur Thompson (414.9 ppbv) and Godley, and the highest toluene concentrations were at Everman Johnson Park (169.8 ppbv). The largest benzene concentrations measured were scattered across the AutoGC network, which suggests that no single emission source predominates.

Temporal seasonal trends within the data were evaluated with a focus on the compounds that were frequently detected at relatively high concentrations. Analysis of propane and toluene concentrations as a function of time for the canister sites revealed that higher concentrations of propane and toluene are generally seen during the winter months. This is believed to be a function of the more stable atmospheric conditions during winter months, such as occur during temperature inversions or overcast conditions. The stable meteorological conditions minimize the transportation or dispersion of VOCs and results in higher wintertime VOC concentrations.

Human Health Impacts

The Texas Commission on Environmental Quality (TCEQ) has air monitoring comparison values (AMCVs) for a range of VOCs. AMCVs are screening levels used for evaluating measured levels of common air toxics and their potential effects on human health.[5]

The short- and long-term AMCVs for pentane, benzene, toluene, ethyl benzene, and m&p-xylene can be seen in Table 2. There are no short-term or long-term AMCVs for ethane or propane. Comparing the highest hourly and 24-hour concentrations measured at the AutoGC and canister sites to the short-term AMCVs, all high concentrations measured at the NTC network are well below the associated AMCVs. Similarly, the average concentrations of pentane, benzene, toluene, ethyl benzene, and m&p-xylene measured at the canister sites are well below the long-term AMCVs. Throughout the network there have been no exceedances of any AMCVs, and thus VOC concentrations in the NTC network area are not deemed a threat to human health.

SUMMARY

Throughout the NTC network, AutoGC and canister concentrations correlated well between the two sampling methods. Furthermore, VOC concentrations across the network were generally homogenous. Slight seasonal trends were apparent as relatively higher concentrations were observed in the winter months, likely due to the more stable atmospheric conditions during winter months that minimize the transportation or dispersion of VOCs.

When compared to the TCEQ AMCVs, short-term and long-term compound concentrations across the network were well below the associated levels of concern. It can be concluded that compound concentrations are acceptable throughout the NTC network and are not a threat to

Table 2. Summary of VOC Concentrations vs. Short Term and Long Term AMCVs

Compound	Highest AutoGC 1-hr Concentration (ppbv)	Highest Canister 24-hr Concentration (ppbv)[a]	Short Term AMCV (ppbv)	Average Canister 24-hr Concentration (ppbv)	Long Term AMCV (ppbv)
Ethane	1054.4	87.3	--	8.76	--
Propane	414.9	30.6	--	3.91	--
Pentane	122.2	57.9	68,000	0.81	8,000
Benzene	3.5	6.44[b]	180	0.15	1.4
Toluene	169.8	2.47	4,000	0.16	1100
Ethyl benzene	1.6	0.48	20,000	0.03	450
M&p-xylene	7.3	0.9	1,700	0.07	140

a. Short-term data but not directly comparable to the 1-hr AMCVs
b. Atypical benzene values were reported for the Bowie Patterson canister sample on 1/17/14

human health. This finding is consistent with the conclusions of a previous study that analyzed data from six air monitoring sites north of Fort Worth, TX from 2000 to 2011 and found that levels of VOCs did not pose a health concern.[2]

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