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Identification and Characterization of a Potential Crematorium Mercury Emission Source

Katherine McGowan

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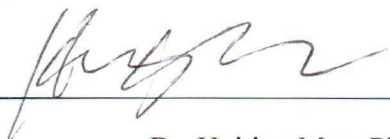
**Identification and Characterization of a Potential Crematorium Mercury Emission
Source**

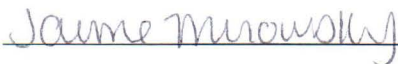
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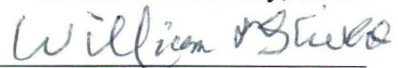
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May 2017

APPROVED

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Abstract

Mercury is a global pollutant with serious harmful impacts on human and ecosystem health. It is emitted into the atmosphere from many sources such as fossil fuel combustion, incineration, and landfill. Some sources/processes are either poorly documented or unknown. Cremation processes are one of these that have not been studied and are currently unaccounted for in the United States Environmental Protection Agency's National Emissions Inventory. The objective of this study was to characterize the temporal variation of total gaseous mercury (TGM) concentrations and identify an unknown, seemingly highly localized source of gaseous mercury causing very high episodic concentrations. TGM measurements were conducted from the State University of New York College of Environmental Science and Forestry (SUNY-ESF) campus in downtown Syracuse, New York during the time period of summer 2013 – fall 2015. A complete annual cycle was observed, with lowest concentrations (1.36 ng m^{-3}) in September, and highest (1.57 ng m^{-3}) in January, with an annual average amplitude of 0.21 ng m^{-3} . Concentrations appeared to be decreasing continuously throughout the study period, with decreases of 0.12 ng m^{-3} and 0.18 ng m^{-3} for summer 2013-2014 and 2014-2015, respectively; 0.14 ng m^{-3} and 0.05 ng m^{-3} for fall 2013-2014 and 2014-2015, respectively; and 0.08 ng m^{-3} for winter 2014-2015. Diurnal cycles were observed with daily maximums at 13:00-16:00 UTC (1.55 ng m^{-3} - 1.65 ng m^{-3}) in winter-spring, 1:00 UTC (1.4 ng m^{-3} - 1.7 ng m^{-3}) and 12:00-16:00 UTC (1.3 ng m^{-3} - 1.52 ng m^{-3}) in summer-fall. The concentrations above the seasonal 99th percentile values under calm ($< 2 \text{ m s}^{-1}$) and southeasterly wind conditions were associated with probable Hg emissions from a nearby crematorium, located approximately 890 meters to the southeast

of the monitoring station. The total emission of mercury from this source was estimated to be 0.51 lbs, 1.64 lbs, and 0.49 lbs for 2013, 2014, and 2015, respectively. These were compared to nearby sources documented in the EPA's National Emissions Inventory 2011, including the Syracuse Steam Station (0.3 lbs), Onondaga County Resource Recovery Facility (7.7 lbs) and Bristol-Myer Squibb Company (9.52E-02 lbs). Further study is warranted to determine the extent of mercury emissions from crematoriums across the United States.

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I would like to thank Ann Moore for always encouraging me to do my best and motivating me to never give up when difficulties arise. The encouragement I received the past four years has been wonderful. I would like to thank Dr. Jaime Mirowsky for being my second reader for this project. I would like to thank Dr. William Shields and the SUNY-ESF Honors Program for their funding throughout my project and for allowing me the opportunity to grow in my independence, working to go above and beyond my curriculum requirements. Thank you to SUNY-ESF for providing an opportunity for undergraduate research which has been an experience I will never forget. Lastly, I would like to thank my family and friends for their continued support throughout my undergraduate college career.

1. Introduction

Sources of total gaseous mercury (TGM) in the atmosphere include fossil fuel combustion, incineration, landfills, mining, and cremation processes (UNEP, 2013). Mercury is well-known toxic metal and can lead to severe nervous system damage (ASTDR, 2015). It is important to identify all potential sources of mercury in the environment, including anthropogenic sources. However, there are large uncertainties in the emission estimates for anthropogenic sources, which can arise from inaccurate measurements and lack of knowledge about different waste types (Pirrone et al., 2010). Pirrone (2010) notes that knowledge of waste types including electronic devices, fluorescent lamps, and cremation processes are scarce and can be greatly affected by such uncertainties.

In countries, such as Japan, Germany, Norway, Switzerland and the United Kingdom, studies have been performed to determine the mercury concentrations as well as other toxic substances emitted from crematoriums (Mari & Domingo, 2009). Past work has demonstrated that silver amalgam dental fillings contain mercury that may volatilize when it reaches the required temperature necessary for cremation. Above 180°F the mercury will volatilize and be released into the atmosphere (Rahill, n. d.). A study performed in Italy estimated that 0.0036 to 2.140 g of mercury may be released with every cremated body that contains amalgam tooth fillings (Santaserio et al., 2006). Another study done in the United States estimated that 0.37 to 0.74 grams of mercury are contained in each tooth filling for an average of 2.9 grams of mercury per body, in agreement with a 2001 UK study which found an average of 2.95 grams (Reindl, 2012). A report in Norway found a higher emission at 4.9 grams per cremation (Reindl, 2012).

Reports on total mercury emissions from crematoriums are quite limited and contain a wide range of estimates from 0.94E-3 grams per cremation to as high as 8.6 grams per cremation. The United Nations Environment Programme (UNEP) (2013) has estimated that 3.6 tons of mercury may be emitted globally into the atmosphere each year by cremation processes. They have stated that little work has been done in the dental filling preparation and removal sector to quantify the mercury that may be released into the environment (UNEP, 2013), highlighting the need for further research.

Current National Emissions Inventories for the United States do not explicitly account for cremation processes in annual mercury totals (US EPA, 2014). In the Federal Register volume 69, the EPA concluded that a human body is not considered solid waste and crematories should be considered under other authorities for regulations (Rahill, n. d.). Therefore, continued research into United States crematories is necessary to gather more information and data specific to US practices. Domingo and Mari (2009) note that scientific literature on the topic and practices is scarce and very few published studies exist, especially regarding United States data. It is necessary to identify and understand all sources in order to regulate emissions in the future (Selin, 2014).

In an urban location in Syracuse, NY, TGM was measured for three years, summer 2013 – fall 2015, on the roof of Jahn Laboratory on the SUNY College of Environmental Science and Forestry campus. It was determined that this site was above the urban canopy and was regionally representative (Hall, 2014). Hall (2014) noted uncharacteristic peaks in the short-term data set indicating an unidentified nearby source. This study is aimed to characterize the temporal variabilities in TGM concentrations and further identify the potential local source using long-term data.

2. Methods

The sampling site for this study is located on the roof of Jahn Laboratory on the SUNY-ESF campus in Syracuse, NY ($42^{\circ}2'3.41''$ N, longitude $76^{\circ}8'13.41''$ W, 25 meters agl). This site is located above the urban canopy and measures regionally representative air masses (Hall, 2014). It is approximately 0.5 km west of Interstate 81, and 2 km north of highway 690. The EPA lists major industrial sources of mercury in the National Emissions Inventory (NEI), including a waste incineration plant 3.6 km to the southeast, a coal fired power plant 6 km to the northwest, and Syracuse University Steam Station 0.8 km to the northwest of the sampling site.

To measure the TGM, a Tekran 2537A mercury vapor analyzer was used. Two cartridges sampled every five minutes per cartridge providing a dataset of continuous five-minute resolution. The instrument was calibrated using internal mercury permeation source set to 60.9 pg or 12.18 ng m⁻³ every 24 hours during the first few months of the sampling period and every 25 hours during for the remainder of the sampling period. To confirm permeation rate of the internal source was within $\pm 5\%$, injection testing was performed approximately every 3 months. Quality control (QC) protocols were based on recommendations in Steffen et al. (2012), and were adjusted for sampling TGM. Data were checked to ensure cartridges A and B were within 5% of one another over the entire sampling interval. When the data contained multiple peaks during desorption, baseline voltage deviations reached >0.1 , baseline voltage shifted greater than 0.01 V, and sampling volume exceeded $\pm 5\%$ from the expected, the data were rejected and not included in the data set.

Carbon monoxide (CO) was measured using a Teledyne-API 300EU gas filter correlation analyzer. Data were collected as one-minute averages. The span calibration point of the instrument was checked once a week using NIST traceable CO gas of ~500 ppbv. If the span gas was outside of 5%, the data would be rejected. If the data were between 2% and 5%, the instrument would be recalibrated. Carbon dioxide (CO₂) was measured using a Li-Cor 7000 differential non-dispersive infrared detector. Lastly, wind speed and wind direction were measured using a Young USA anemometer, model 05305, atop a mast above Jahn Laboratory. More details about the instrumentation used can be found in Hall (2014).

3. Results and Discussion

3.1 General Characteristics

Total gaseous mercury was monitored from June 2013 through November 2015. The 5-minute average TGM data are displayed in Figure 1 and a number of statistics metrics are described in Table 1. TGM had an average five-minute concentration of 1.50 ng m⁻³ (± 0.54 ng m⁻³). The highest recorded concentration was 144.79 ng m⁻³, the lowest concentration was 0.31 ng m⁻³, and the median concentration was 1.47 ng m⁻³. Measurements from Jahn Laboratory were below the 2.1 ng m⁻³ median concentrations at urban sites in Asia, Canada, Europe, and the USA (Mao et al., 2016). This median value data is more consistent with the background concentration ranging from 1.5 to 1.7 ng m⁻³ for the Northern Hemisphere atmospheric TGM (Mao & Talbot, 2012). There is quite a bit of variability within the dataset, which is also consistent with findings in Mao et al. (2016) (references therein), in which there was a higher and larger variability in

continental urban sites compared to rural and remote surface sites and high-elevation sites in the Northern Hemisphere.

The 30-day running average for the raw data is indicated by the black line and the 99th percentile, 2.29 ng m⁻³, is indicated by the red line (Figure 1). The annual cycles are evident, with highs in January (1.57 ng m⁻³) and lows in September (1.36 ng m⁻³), and an annual amplitude of 0.21 ng m⁻³. The seasonal variation was found to vary greatly, and is in agreement with one of the five patterns that were found in Mao et al. (2016) (references therein). Seasonal trends were found to vary from one continental urban site to another leading to the emergence of five seasonal trends, one being the absence of a clear seasonal pattern (Mao et al., 2016; references therein), which is consistent with this study site. The low periods in the annual cycles are more clearly distinguished in the median TGM concentration values plotted for each month found in Figure 2. The lowest values for 2013 and 2015 were in September, 1.43 ng m⁻³ and 1.22 ng m⁻³, respectively. In 2014, the lowest value was in October (1.33 ng m⁻³). Concentrations appeared to be decreasing continuously throughout the study period, with decreases of 0.12 ng m⁻³ for summer 2013-2014, 0.18 ng m⁻³ for summer 2014-2015, 0.14 ng m⁻³ for fall 2013-2014, 0.05 ng m⁻³ for fall 2014-2015, and 0.08 ng m⁻³ for winter 2014-2015. Mao et al. (2016) (references therein) showed similar patterns of decreasing concentrations in multiple rural Canadian sites from 1995 to 2011, as well as an urban site in Windsor, Canada from 2007 to 2009. The decreases from the Jahn site are not consistent with the NEI total emissions for Onondaga County from 2011 to 2014. There was an increase in mercury concentrations recorded in the NEI from 29.54 lbs in 2011 to 51.58 lbs in 2014 (US EPA, 2011; US EPA, 2014). The major causes of this increase were attributed to increases in

fuel combustion sources using oil (US EPA, 2011; US EPA, 2014). Further study is needed to understand the decreases over the three year period.

Following the analysis of the annual cycles, daily diurnal cycles were examined. In Figure 3, the four panels represent diurnal cycles calculated using the median values at each hour. Diurnal cycles were observed with daily maximums at 13:00-16:00 UTC (1.55 ng m^{-3} - 1.65 ng m^{-3}) in winter-spring, 1:00 UTC (1.4 ng m^{-3} - 1.7 ng m^{-3}) and 12:00-16:00 UTC (1.3 ng m^{-3} - 1.52 ng m^{-3}) in summer-fall. All Figures show a decrease in median concentration of TGM with each consecutive year that is consistent with the decrease in concentration seen in the monthly values. Mao et al. (2016) (references therein) found an increase in TGM throughout the night and a maximum in the early morning in urban surface sites. The TGM concentrations identified from the Jahn Laboratory indicate a peak in early to mid-morning rather than early morning for spring and winter. Fall had a peak during mid-morning and summer had a sharp peak in the evening and variable peaks in the morning and afternoon (Figure 3).

3.2 High Concentration Episodes

It was noted that there were many periods of very high concentrations up to 145 ng m^{-3} . During the study period, from time to time, observed concentrations were two orders of magnitude higher than the median concentration, 1.47 ng m^{-3} .

To better separate the highest concentrations of TGM, the 99th percentile was calculated for each of the nine seasons (Table 2). The data that were greater than the 99th percentile were used to construct average diurnal cycles (Figure 4). Spring, summer, and fall indicated spikes of TGM occurring in the morning and afternoon primarily, whereas

winter had high levels in late evening and night (Figure 4). The concentrations of TGM rose very rapidly, peaking within one hour and levels remaining elevated for an average of only 39 minutes, suggesting one acute source.

It is curious what sources and/or processes may have contributed to such rapid increases sustained over a time window of mere 20 – 50 minutes. To understand the sources for the elevated TGM, the concentrations exceeding the 99th percentile were first compared to carbon monoxide (CO) and carbon dioxide (CO₂) measurements (Figure 5), as fossil fuel combustion is the leading source of mercury in Onondaga County (US EPA, 2014), and CO and CO₂ are two environmental tracers for fossil fuel combustion (Lopez et al., 2013). Our analysis suggested no evident correlation between TGM and CO or CO₂, which had an r^2 value of 0.0108 and 0.0213, respectively. This led to a closer look at the highest values that were observed to identify their potential sources that were not related to fuel combustion in the area.

Using the data exceeding the 99th percentile for each season, a windrose was created to map the wind speed and direction with relation to TGM concentration (Figure 6). The orange and red points indicate the highest concentrations of TGM with values of 3.5 – 4.0 ng m⁻³ and greater than 4.0 ng m⁻³, respectively. Each season exhibited elevated concentrations of TGM from all directions. The highest wind speeds ranged from 6.0 m s⁻¹ to 10.0 m s⁻¹. This indicates that very strong sources tens of kilometers upwind or sources in close proximity frequently influenced the TGM concentrations at our sampling site. The spring and summer windrose diagrams showed more occurrences of high concentrations from the south than other directions and the winter and fall windrose diagrams showed more occurrences of high concentrations from the southeast. To

pinpoint specific instances of elevated TGM concentrations, “episodes” were identified when four or more consecutive readings exceeded the 99th percentile. This resulted in a total of 138 episodes.

3.3 Local Sources of Mercury

Multiple sources in the area could contribute to the elevated mercury concentrations that were found. One source includes the Onondaga County Resource Recovery Facility (OCRRA waste-to-energy facility), which is located ~3.5 km to the south and produces 7.7 lbs of mercury annually. Another local source could be the Syracuse University steam, station located 0.8 km to the northwest that produces 0.3 lbs of mercury annually. Additional sources are identified in Figure 7 and Table 3. Some of the elevated concentrations did not correspond to the documented sources in the area listed in the EPA’s NEI, which included the ones under southerly and southeasterly wind directions and low wind speeds ($>2 \text{ m s}^{-1}$) (Figure 6). Further investigation of potential mercury sources in the local area surrounding the SUNY-ESF campus revealed a crematorium. Oakwood Cemetery Crematorium is located only 890 meters southeast of the Jahn monitoring station (Figure 8). Therefore, it is possible that the silver amalgam fillings in the teeth of cremated bodies may be the local source of TGM in this area. This could account for the episodes of elevated concentrations that are occurring with an average duration of ~30 to 45 minutes rather than a constantly elevated mercury level. The Onondaga County Resource Recovery Facility operates daily, running throughout most of the day, and would not be able to account for the short episodes under low wind conditions.

We believe that the influence of a local source, such as a crematorium, could become apparent in measurements at wind speed $< 2 \text{ m s}^{-1}$, while the regional influence of elevated TGM would be dominant at higher wind speeds. The latter is not the focus of this study. To identify the episodes of TGM that may correspond with the crematorium source, the 138 episodes were compared to the windrose diagrams. Any episode that had wind speeds greater than 2 m s^{-1} (with the exception of 3 episodes that had wind speed between 2.0 and 2.15 m s^{-1}) and did not have at least one value over 3.5 ng m^{-3} were eliminated. This resulted in 47 total episodes with high mercury concentrations for the entire study period.

The total amount of mercury that may be emitted from this unknown source was calculated according to the time period of the episode. The episodes were separated into 4 time periods 5:00 -10:59 UTC, 11:00-16:59 UTC, 17:00-22:59 UTC, and 23:00-4:59 UTC. In local time, this corresponded to very early morning, mid-morning/midday, afternoon, and evening. The majority (80%) of the episodes occurred during the mid-morning/midday and afternoon, 19 and 18 episodes, respectively. This was consistent with the diurnal cycles of the TGM concentrations above the 99th percentile shown in Figure 4. Using the specified time periods that were associated with specific planetary boundary layer heights, an estimate of the total emissions was calculated. The time periods, 5:00 -10:59 UTC, 11:00-16:59 UTC, 17:00-22:59 UTC, and 23:00-4:59 UTC corresponded to a boundary layer height of 700 m, 500 m, 1000 m, and 1500 m, respectively (Mao & Talbot, 2004). A radius of 1000 m around the monitoring site was used in combination with the appropriate planetary boundary heights.

The emission from the crematorium during an episode was estimated using the following equation:

$$\text{Total Emission (g)} = [C_1 - C_0] \times A \times PBL$$

where C_1 is the peak concentration during the episode (ng m^{-3}), C_0 the average concentration before episode (ng m^{-3}), A the area of emission influence (m^2), and PBL the planetary boundary layer height (m). The sinks include GEM oxidation and dry deposition. The former is most likely negligible as the time period of interest here is tens of minutes whereas the lifetime of GEM is 6 months to 1 year. Dry deposition of mercury was estimated using:

$$\text{Total Dry Deposition (g)} = C_1 \times V_d \times A \times \Delta t$$

where C_1 is the ambient concentration of TGM (ng m^{-3}), v_d the deposition velocity of GEM (cm s^{-1}), A the area of emission influence (m^2), and Δt the duration of the episode (s).

The dry deposition was calculated to be two orders of magnitude less than the total emission and determined to be negligible. A total emission of TGM of 0.51 lbs, 1.64 lbs, and 0.49 lbs were estimated for 2013, 2014, and 2015 with 15, 13, and 17 episodes, respectively (Table 4).

This was compared to the local sources in the area that were listed in the EPA's NEI. The estimated emissions from the crematorium were between 6.1 and 7.2 lbs less than the Onondaga County Resource Recovery Facility (7.7 lbs). However, the emissions were greater than the other 6 sources that were nearby, including WPS Syracuse Generation LLC (0.45 lbs), Syracuse Energy Corporation (4.33E-02 lbs), Syracuse Steam Station (0.3 lbs), Bristol-Myer Squibb Company (9.52E-02 lbs) Dewitt Rail Yard (0.23

lbs) and L & JG Stickley Inc. (0.2 lbs). This suggests that the TGM emitted from the crematorium could be a major contributor to the TGM concentration in Syracuse, NY.

4. Summary

This study identified diurnal to year-to-year changes in TGM concentrations measured at an urban site in downtown Syracuse, NY during the time period of summer 2013 – fall 2015. TGM at this site showed a median value of 1.47 ng m^{-3} similar to the Northeast U.S. background concentration and a wide range of $0.31 - 145 \text{ ng m}^{-3}$. Annual cycles were observed with lowest concentrations (1.36 ng m^{-3}) in September, and highest (1.57 ng m^{-3}) in January, and concentrations were continuously decreasing by $\sim 10\%$ (relative the median value) per year ($\sim 0.12 \text{ ng m}^{-3}$ and 0.18 ng m^{-3}) in summer and by $\sim 5\%$ (0.08 ng m^{-3}) in winter. Diurnal cycles were observed with daytime maximums and the largest diurnal amplitude of $\sim 0.15 \text{ ng m}^{-3}$ in spring.

A total of 47 episodes of high TGM concentrations ($>99^{\text{th}}$ percentile) were identified under calm to weak wind conditions ($<2 \text{ m s}^{-1}$), with an average duration of 39 minutes over a 27 month long study, which were attributed to the Oakwood Cemetery Crematorium near the SUNY-ESF campus in Syracuse, NY. The estimated total mercury emissions for this potential crematorium site was estimated to range from 0.49 lbs to 1.63 lbs per year, comparable to those of known, documented local sources, and even higher in some instances, such as Syracuse Energy Corporation ($4.33\text{E-}02$ lbs), Syracuse Steam Station (0.3 lbs), and Bristol-Myers Squibb ($9.52\text{E-}02$).

This is a cause for concern because crematoriums are not listed in the EPA's NEI. Mercury from cremation processes is not accounted for in the United States and may lead

to inaccuracies in the global mercury budget. UNEP (2013) estimates 3.6 tons of mercury enter the atmosphere from cremation processes each year; however, there is no uniform data, specifically from the U.S., to determine the reliability of that value. It is imperative to have an accurate estimation of global atmospheric mercury to better understand the extent of future human health implications. Further research into cremation processes in the United States is warranted to obtain a more consistent and reliable value for the amount of mercury entering the atmosphere during cremation.

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Figures and Tables

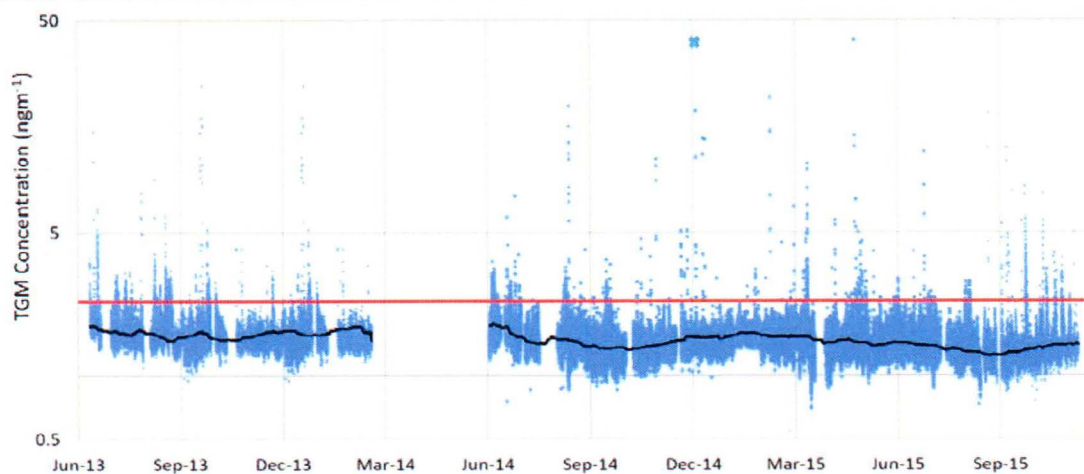


Figure 1. Time series of five-minute averaged TGM (blue) from June 2013 through November 2015 with 30-day running average (black), and 99th percentile value for entire study period (red) (2.29ngm^{-3}).

✖ indicates 3 emitted values above 50ngm^{-3} .

Table 1. General characteristics of the TGM raw data beginning in June 2013 through November 2015.

Season	N	Range	Mean	5th	25th	Median	75th	90th	95th	99th
Summer 2013	14130	1.09-15.23	1.68	1.38	1.49	1.60	1.77	1.98	2.21	2.88
Fall 2013	21502	0.94-25.10	1.53	1.28	1.40	1.49	1.59	1.74	1.87	2.28
Winter 2014	21211	1.09-35.02	1.64	1.43	1.53	1.62	1.71	1.82	1.90	2.09
Summer 2014	13038	0.31-20.05	1.56	1.23	1.36	1.49	1.69	1.92	2.08	2.54
Fall 2014	22485	0.86-11.24	1.39	1.14	1.27	1.37	1.49	1.59	1.67	1.94
Winter 2015	22871	0.97-144.80	1.56	1.31	1.44	1.54	1.63	1.71	1.77	1.92
Spring 2015	22700	0.71-40.25	1.49	1.19	1.34	1.46	1.60	1.72	1.81	2.15
Summer 2015	22780	0.74-12.10	1.38	1.13	1.25	1.35	1.46	1.61	1.72	2.10
Fall 2015	21896	0.76-18.35	1.34	1.08	1.20	1.29	1.39	1.55	1.78	2.46

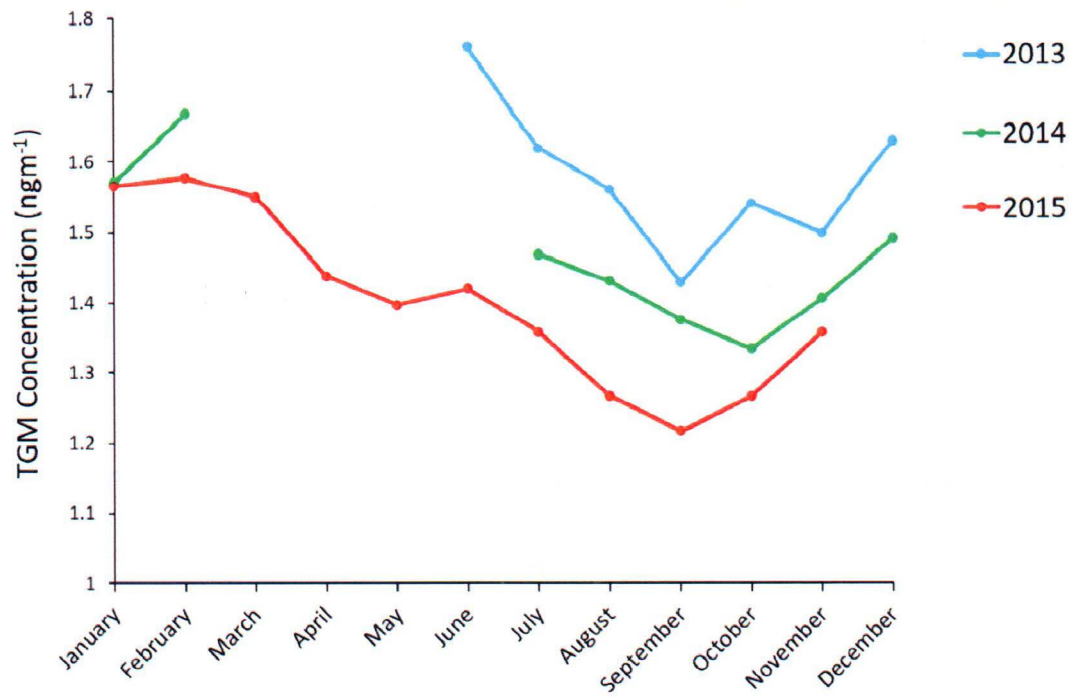


Figure 2. Monthly median TGM values from June 2013 through November 2015.

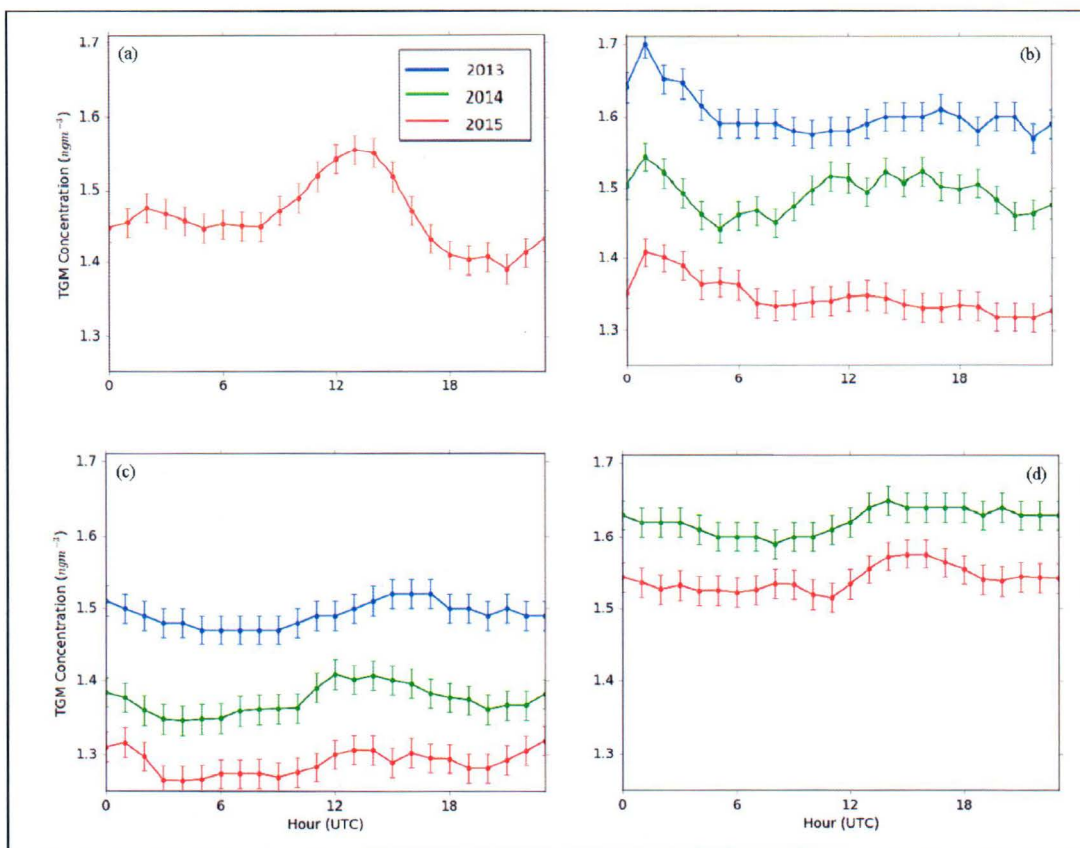


Figure 3. ((a) spring (b) summer (c) fall (d) winter) Median value diurnal cycles of TGM for 2013, 2014, and 2015.

Table 2. The 99th percentile values for each season.

Season	N in 95th	Mean of 95th	N in 99th	Mean of 99th	Number of Episodes
Summer 2013	685	2.75	140	3.94	13
Fall 2013	1075	2.27	215	3.30	17
Winter 2014	1051	1.93	212	3.09	16
Summer 2014	649	2.48	129	3.51	8
Fall 2014	1120	1.88	224	2.36	18
Winter 2015	1143	2.27	228	4.05	16
Spring 2015	1128	2.17	226	3.23	17
Summer 2015	1138	1.99	228	2.54	16
Fall 2015	1094	2.30	219	3.53	17

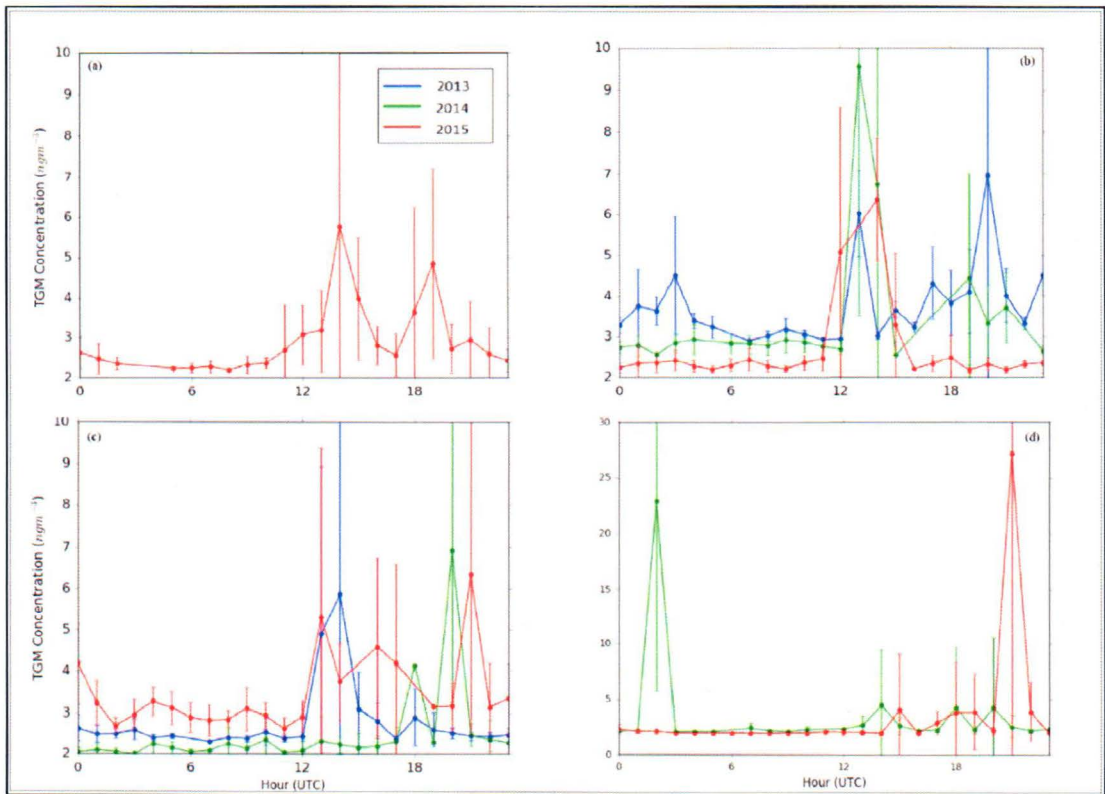


Figure 4. ((a) spring (b) summer (c) fall (d) winter)) Averaged diurnal cycles of TGM above the 99th percentile for each season for 2013, 2014, and 2015.

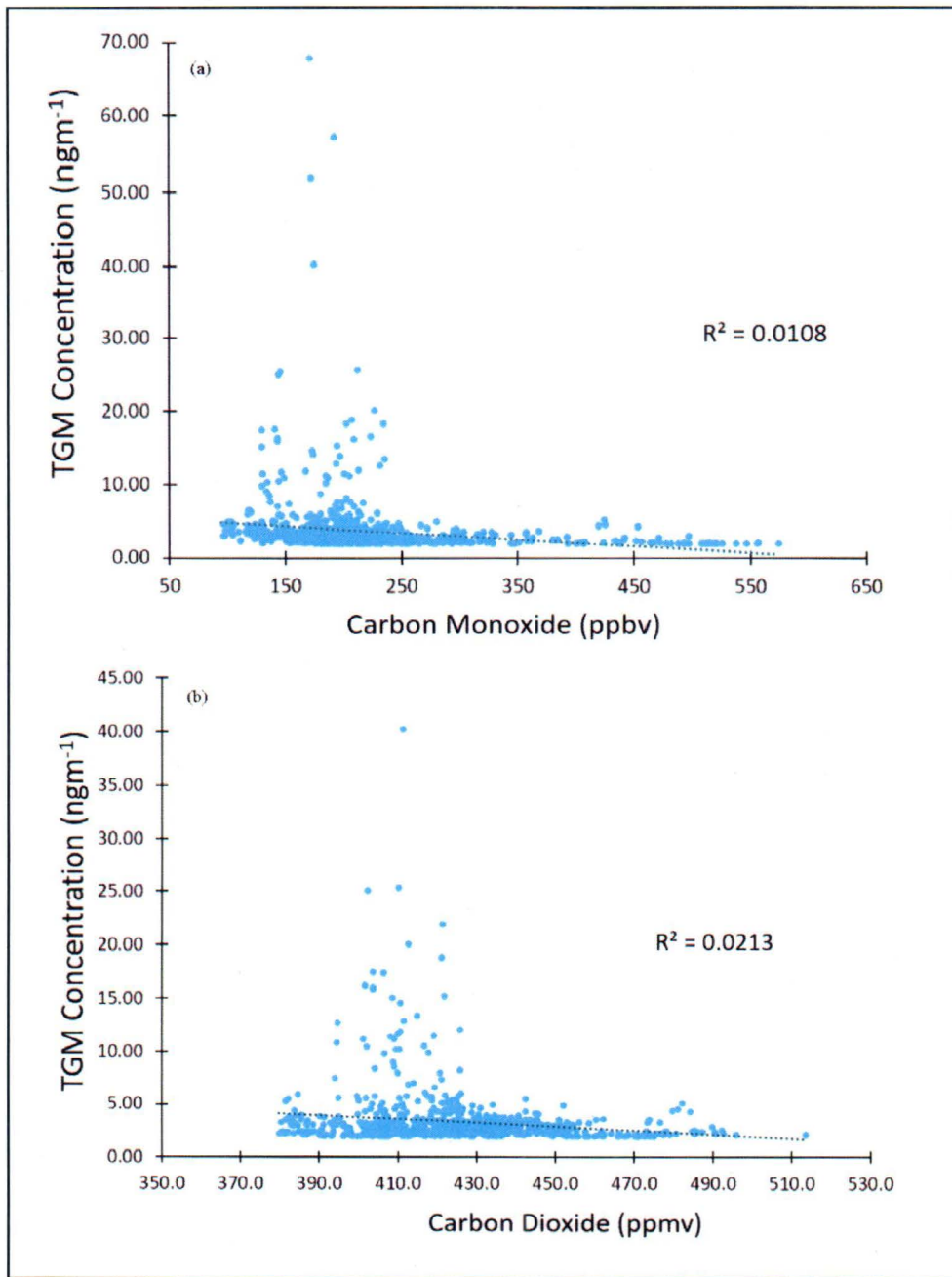


Figure 5. TGM versus (a) carbon monoxide and (b) carbon dioxide for TGM concentration above the 99th percentile for 2013-2015.

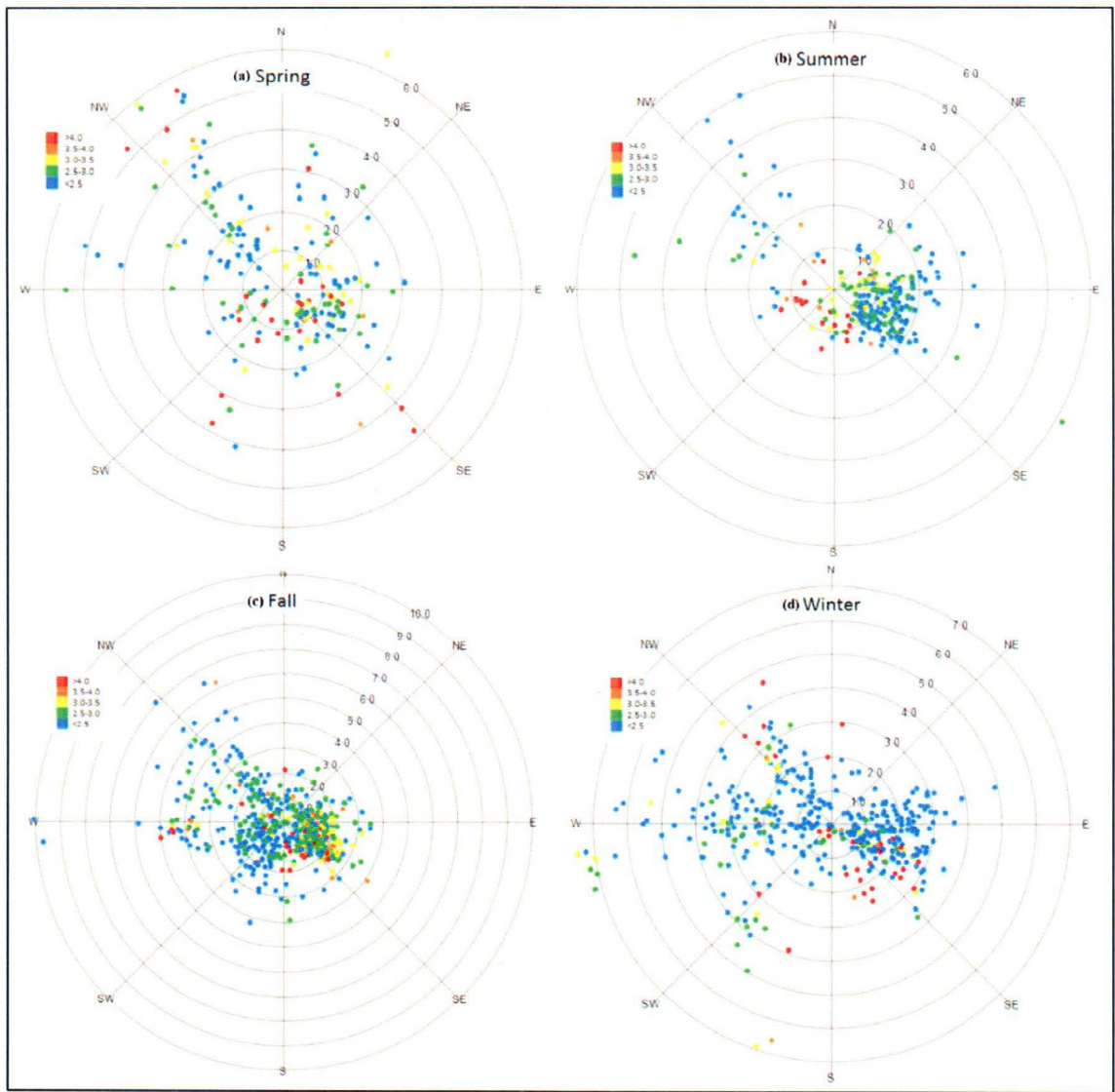


Figure 6. Windrose diagrams ((a) spring (b) summer (c) fall (d) winter)) of the highest concentrations (above 99th percentile) of TGM for each season.

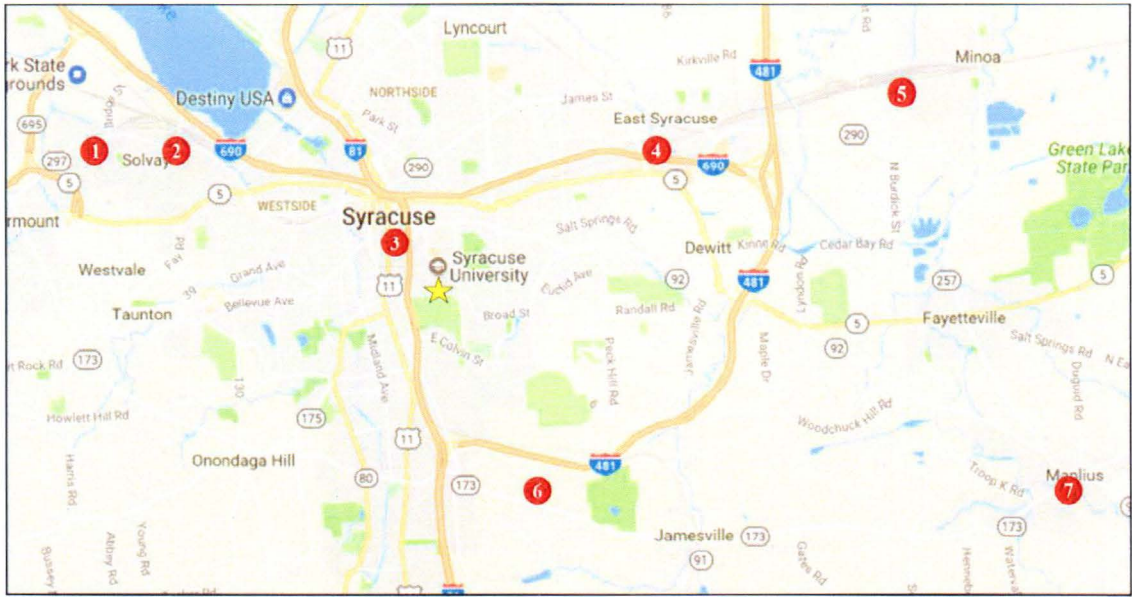


Figure 7. Map of local sources with corresponding annual total emissions in Table 3. Monitoring site indicated by yellow star.

Table 3. Local sources and associated emissions in the area surrounding the monitoring site (NEI, 2011).

Local Source	Emission (lb)
1. WPS Syracuse Generation LLC	0.45
2. Syracuse Energy Corporation	4.33E-02
3. Syracuse Steam Station	0.3
4. Bristol-Myers Squibb Company	9.52E-02
5. Dewitt (Rail Yard)	0.23
6. Onondaga CO Resource Recovery Facility	7.7
7. L & JG Stickley Inc.	0.2



Figure 8. Ariel image of study site (yellow star) in relation to local crematorium (red box).

Table 4. Emission estimates for a 1km radius around the monitoring site.

Year	# of episodes	Average Duration (min)	Sum (g)	Average (g)	Total emissions (lbs)
2013	15	38.67	230.83	15.38	0.50
2014	13	31.15	743.30	57.17	1.63
2015	17	45.88	223.95	13.17	0.49