Quantitative GC-MS Determination of Benzene and Toluene in the Ambient Air of Shelby County, Tennessee

by
Fady Barsoum

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Thesis Committee:

Dr. Ngee Sing Chong, Thesis Director

Dr. Kevin L Bicker, Second Reader

Dr. Katy Hosbein, Third Reader

Dr. Andrienne C. Friedli, Thesis Committee Chair

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APPROVED:

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Dr. Ngee Sing Chong, Thesis Director
Professor, Department of Chemistry

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Dr. Andrienne C. Friedli, Thesis Committee Chair
Professor, Interim Chair, Department of Chemistry

Acknowledgments

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Abstract

Since 1988, the USEPA has enforced the Toxic Substances Control Act (TSCA), which requires industries and factories in the United States to report the amounts of toxicants released annually. The point source and fugitive emissions of volatile organic compounds (VOCs) in the ambient air from industrial and transportation sources are potentially harmful to the public via inhalation exposure. Due to the volatile nature of VOCs, these toxicants can remain in the ambient air for months and spread over large distances, reaching other counties and states. The organic compounds with the highest annual releases based on the Toxic Release Inventory (TRI) data provided by the USEPA are aromatic VOCs. In this research, we use Gas Chromatography-Mass Spectrometry (GC-MS) with the extracted ion chromatogram (EIC) method to analyze and calculate the concentrations of two of the most widely detected aromatic VOCs in the ambient air of Shelby County, benzene and toluene. Most of our samples were taken around the metropolitan areas of Memphis, Tennessee; however, these results can also significantly affect the air quality of nearby cities and counties. Based on the results obtained from the 50 samples taken each season, we concluded that aromatic compound concentrations in the ambient air are much higher in summer than in winter. Furthermore, in the summer, the average concentration of toluene was higher than that of benzene; conversely, in the winter, the average benzene concentration was over four times higher than the average concentration of toluene.

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I. Introduction:

Although air quality significantly impacts human health, the environment, and overall public safety, citizens and companies often overlook how harmful chemicals released from the factories around them may contribute to certain community diseases. These toxic chemicals may contribute to the mortality rates of the affected population if not regulated and can have adverse health effects for children and immuno-compromised individuals. Some of the compounds are deadly, even for those individuals who are very healthy. The United States Environmental Protection Agency (USEPA) regulates many harmful chemicals released by industries, including VOCs, non-volatile organic compounds, and metals. The VOCs have the potential to be released into the air by factories and industries in the gaseous state. They can also spread over long distances, affecting surrounding cities and counties. Almost all VOCs have various effects on human health, many of which are carcinogenic. In addition, VOCs can also affect the central nervous system and may have mutagenic effects.[1] Most of these VOCs can have acute or chronic effects on human health that can lead to the sickness and death of many individuals, considering how close these factories and industries are to residential areas.

The EPA classifies VOCs as compounds with low boiling points of less than 250°C at standard atmospheric pressure (101.3 kPa).[2] VOCs are more dangerous because their volatile nature allows them to stay in the atmosphere for long periods and distances.[3] This can lead to long-term exposure to these compounds simply by inhaling the air in public outdoor areas or even in indoor spaces like homes and offices where indoor air quality can be affected by ambient air.[3] To keep track of these compounds and their effects, the USEPA has been requiring industries to report how much chemicals are released or leaked by the industries in every county every year since 1988. The laws require these factories to report the quantities of chemical releases and follow the guidelines set by the USEPA for providing the chemical release data per the Toxic Substances Control Act. The USEPA splits the data collected into on-site disposal and off-site disposal, where the on-site data refers to the chemicals released on-site and could impact on-site workers' health. In contrast, the off-site data provides information on the amount or proportion of the chemicals released to nearby cities and residential areas.

EIC allows us to analyze the samples for lower concentrations of VOCs as it has a much lower detection level than TIC. The EIC technique may take longer to analyze the data, but it allows us to detect compounds at concentrations as low as 0.01 parts per billion volume (ppbv). VOCs encompass a variety of organic chemical classes, including aldehydes, ketones, alcohols, and most notably, aromatic hydrocarbons such as BTEX (the acronym for benzene, toluene, ethylbenzene, and *o-, m-, p*-xylene).[3]

Based on recent findings, BTEX compounds make up a large percentage of known VOCs in the ambient air. BTEX comprises 60% of VOCs in urban areas.[3] This finding shows that the concentrations of these aromatic compounds in the ambient air are very high in heavily populated urban areas because BTEX are primarily released from transportation sources or the engine emissions of cars, trucks, buses, and aircrafts using hydrocarbon fuels. Studies have found that urban areas are ideal for studying BTEX emissions since the concentration levels of BTEX appear to be higher than in the atmosphere of remote background areas.[6]

Inhalation of aromatic compounds such as benzene and toluene can cause various symptoms and discomfort and may even lead to death at high exposure levels. For example, benzene is classified as a group 1 carcinogen due to evidence showing a high correlation with acute myeloid leukemia, a type of blood cancer.[7] This makes these aromatic compounds even more dangerous since they pose a dire threat to the on-site workers and the entire community due to how easily they can spread with increased vehicles on the road and at gas stations.[7] For this reason, this research focuses on the emission and effects of benzene and toluene in public and residential areas such as schools and hospitals during the winter season in Shelby County, Tennessee.

Aromatic VOCs could be the most dangerous class of VOCs released, considering how widespread they are and how they appear in high concentrations in public locations. In addition, we hypothesize the concentration of benzene and toluene will be much higher in the summer than in the winter due to the high summer temperatures, which allow the compounds to vaporize and enter the ambient air. This research is mainly focused on the spread of benzene and toluene, two of the most abundant aromatic compounds, in the ambient air of public and residential areas of Shelby County, Tennessee, during the winter and summer seasons and how exposure to these compounds can negatively impact the health of workers and residents daily. Samples from 50 different locations are collected during the summer and winter seasons. The research aims to calculate the concentrations of these compounds in ambient air using two different techniques in GC-MS, EIC, and TIC.

II. Materials and Methods:

A. Sample Collection

The samples were collected from Shelby County, Tennessee, during different seasons and locations for this research project. These samples were collected by a previous research group and were used for this research analysis.

B. Standards Analysis

The samples were analyzed using GC-MS along with Target Explorer to pinpoint volatile organic compounds that have high release rates based on the TRI (Toxics Release Inventory) explorer data provided by the USEPA, where industries are required to record the names of the compounds that have high release along with an estimate of the total on-site disposal/release of the compound. The chosen compounds were analyzed in Target-view, and a retention time was identified to determine where the compound is present in the standards prepared in the lab. Based on the retention times, we were able to pinpoint the peaks of the volatile organic compounds in different volumes of the standards at 150 mL, 100 mL, 75 mL, 50 mL, 25 mL, and 5 mL.

C. EIC vs. TIC Methods for Analyzing the Standards

First, we used Extracted Ion Chromatogram (EIC) and set it to a specific mass for each compound. The ion value used for EIC depended on which value provided the clearer and higher curves. Then, we used Total Ion Chromatogram (TIC) to scan for the peaks of each compound based on the retention time. Once we finished collecting the data at these volumes, we calculated an average of the samples. Then, we used the average and the sample volumes to plot a graph using Excel. We also calculated the r^2 value and a y=mx+b equation to ensure that the data is precise and free from any outliers. Finally, the linear regression equation determines the VOC concentration in the collected samples. Again, these calculations were done using MS Excel to ensure accuracy.

D. Analysis of collected samples from Shelby County using EIC

Once all the linear regression equations are recorded for each of the compounds, we used EIC analysis on the samples collected to determine the concentration of each aromatic compound we tested, also known as BTEX (benzene, toluene, ethylbenzene, p-xylene). The concentrations calculated using the linear regression equations are used to convert the values from $\mu g/m^3$ to ppbv of each compound using Eurofins Calculator.[6] The ppbv values are then compared to the USEPA's TRI-Explorer data from 2014.

III. Results and Discussion:

A. Analyzing the Standards (EIC)

(a)

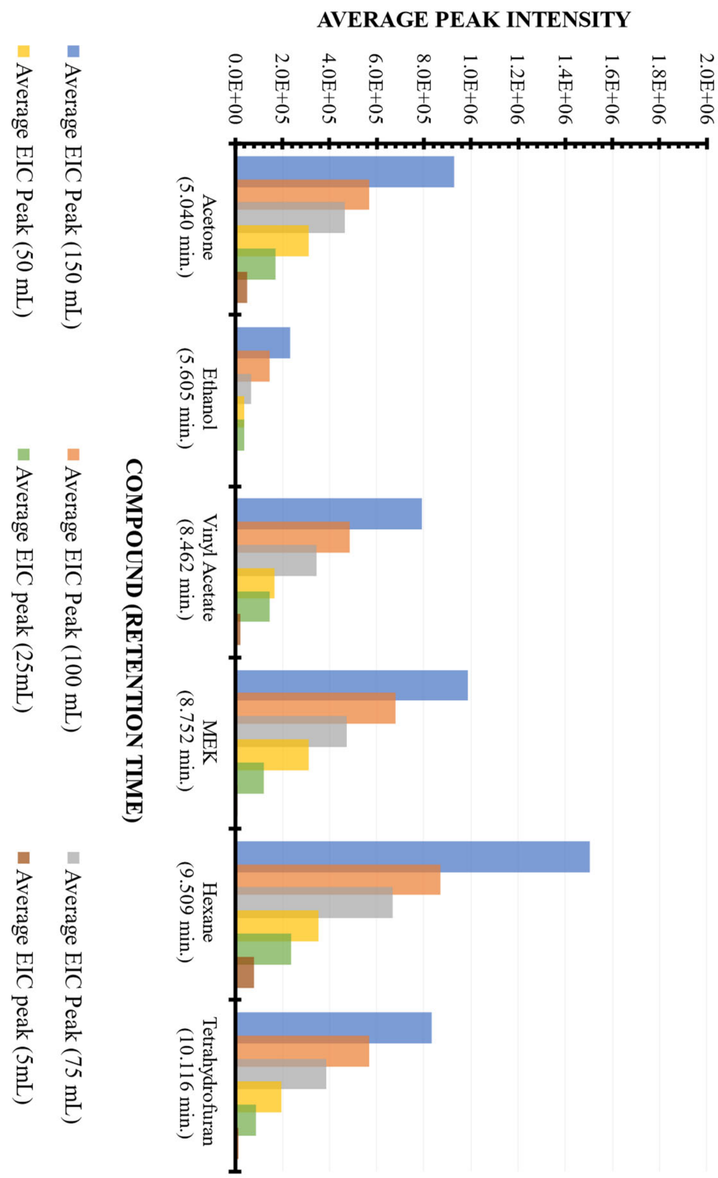

Figure 1a. The concentration of thirteen VOCs at various volumes in standards

(b)

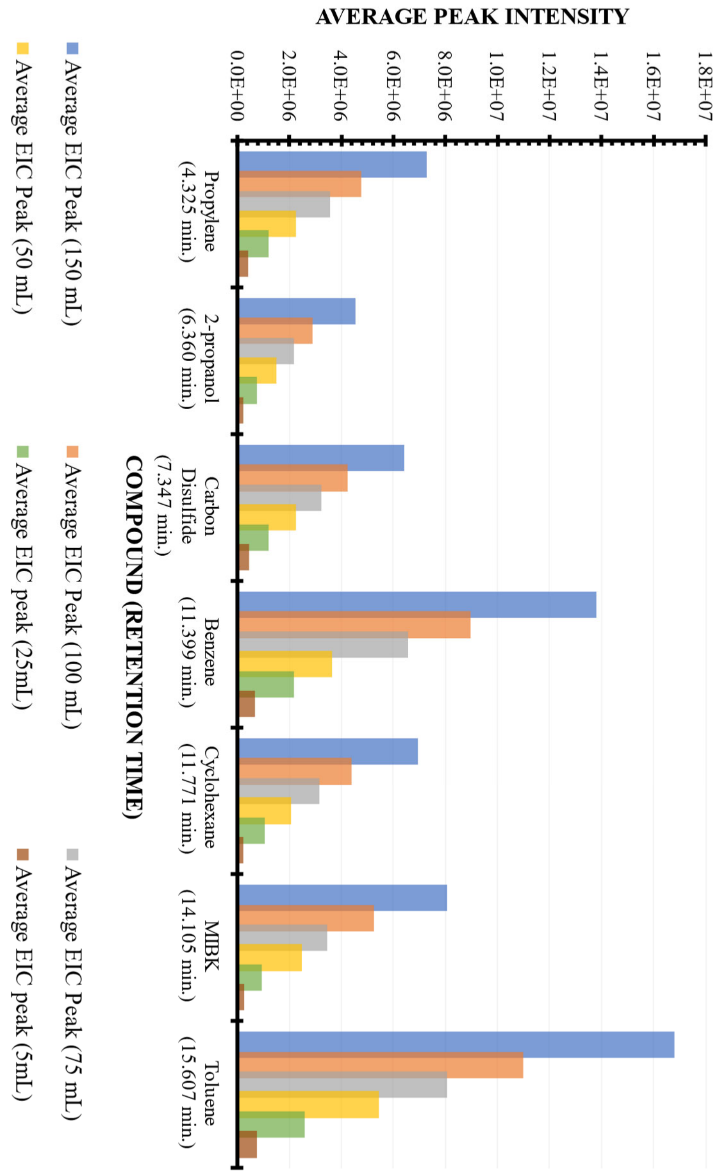

Figure 1a shows the quantitative calibration data of the thirteen standard compounds that were analyzed to determine their retention times and TIC peak areas at different injection volumes of the four ppbv standards. The x-axis of this graph shows the names of the compounds analyzed at different volumes, as indicated in the legends with different color codes. The y-axis is the EIC values of their peak areas for different analyte

levels. The compounds are ordered by retention time from first to last. The average retention time for each compound is provided under the compound's name. **Figure 1a** also shows that the highest volumes showed the highest peak intensity value for every compound. By analyzing the graph, it is clear that benzene and toluene have the highest peak intensities out of the thirteen standards examined in this research.

To calculate the concentration of the benzene and toluene in the samples collected in Shelby County, lab standards were analyzed for both compounds to determine a calibration curve along with a linear regression equation (y=mx+b) that can be used with the peak areas of the analyzed compound to determine its concentration in ppbv in the ambient air of various locations in Shelby County. Outliers were disregarded when plotting the linear regression plot to ensure that the linear regression equation was as accurate to the calibration curve as possible.

a. **Benzene (EIC-78) Standard:**

Table 1. GC-MS Calibration Data of Benzene Standards using EIC at m/z 78

Std. Vol. (ml)	TIC	Mass (ng)
150	4.46E+07	1.92
100	2.89E+07	1.28
75	2.09E+07	0.958
50	1.44E+07	0.639
25	7.30E+06	0.319
5	2.83E+06	0.0639

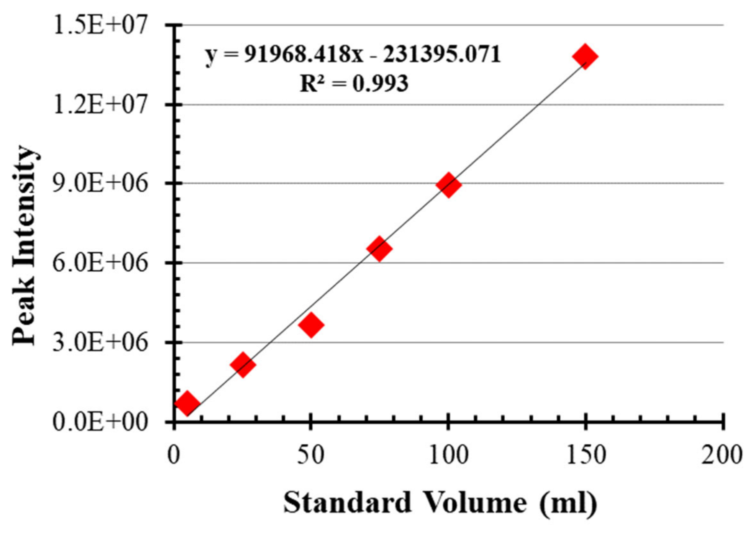

Figure 1. Benzene volume standards using EIC-78

In **Table 1**, lab standards were analyzed to determine a calibration curve and a linear regression equation to calculate benzene concentrations in the samples collected later. The EIC (Extracted Ion Chromatogram) was set at 78 amu, and these were the recorded values for benzene based on the peaks and the retention time obtained from the TargetView. Each of those values is the average of four different values recorded at each volume. The mass is calculated using a 4 ppbv standard of benzene.

In **Figure 1**, the data collected and recorded in **Table 1** is used to plot a graph and write a y=mx+b equation that can be used to determine the concentration of benzene in the samples collected. In this graph, the volumes we used for analysis are shown on the x-axis, while the values for the peak intensities are shown on the y-axis. The chart also shows an r^2 value of 0.993, which indicates that the data is accurate and precise to the linear curve. Generally, the closer the r^2 value is to 1.000, the more precise the data is.

b. Benzene (TIC) Standard:

Table 2. GC-MS Calibration Data of Benzene Standards using TIC

Std. Vol. (ml)	TIC	Mass (ng)
150	4.46E+07	1.92
100	2.89E+07	1.28
75	2.09E+07	0.958
50	1.44E+07	0.639
25	7.30E+06	0.319
5	2.83E+06	0.0639

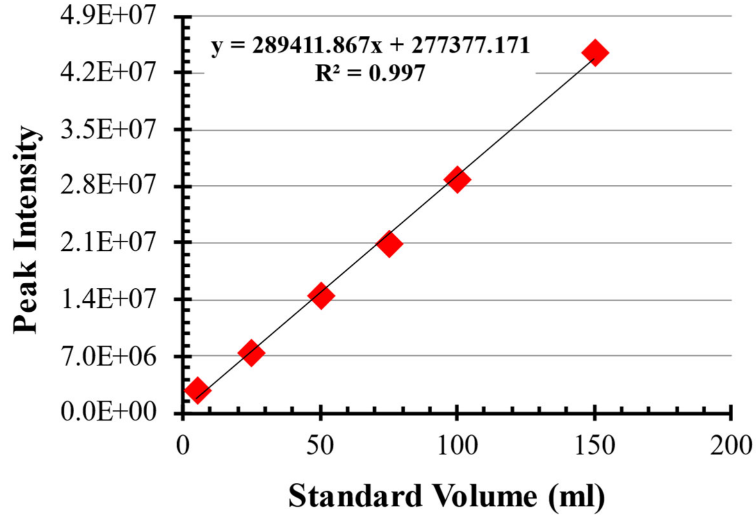

Figure 2. Benzene volume standards using TIC

In **Table 2**, the GC-MS was used for quantitative calibration in the TIC mode (Total Ion Chromatogram), which is not as specific as EIC since it was not set to look for a specific mass. These were the recorded values for benzene based on the peaks and the retention time obtained from the TargetView. Each of those values is the average of four different values recorded at each volume. The mass is calculated using a 4 ppbv standard of benzene.

In **Figure 2**, the data collected and recorded in **Table 4** is used to plot a graph and write a y=mx+b equation. The chart also shows an r^2 value of 0.997, which indicates that the data is accurate and precise to the linear curve. Generally, the closer the r^2 value is to 1.000, the more precise the data is.

c. **Toluene (EIC-91) Standard:**

Table 3. GC-MS Calibration Data of Toluene Standards using EIC at m/z 91

Std. Vol. (ml)	EIC-91	Mass (ng)
150	1.68E+07	2.26
100	1.10E+07	1.51
75	8.08E+06	1.13
50	5.43E+06	0.754
25	2.59E+06	0.377
5	7.72E+05	0.151

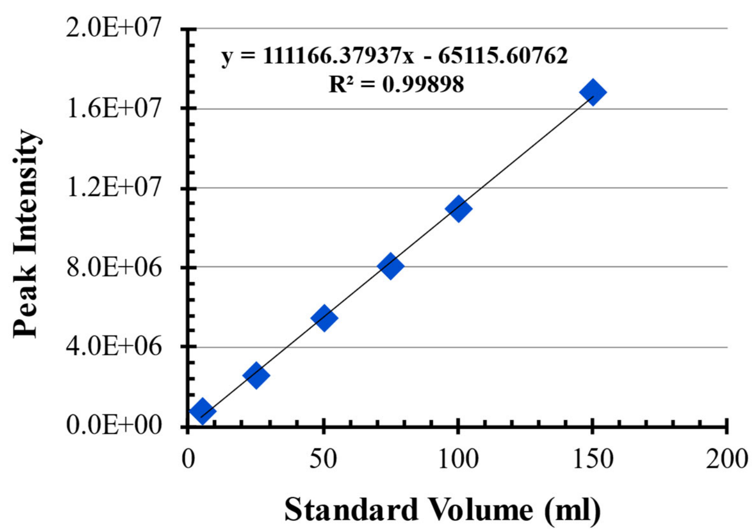

Figure 3. Toluene volume standards using EIC at m/z 91

Similar to benzene, **Table 3** shows the lab standards that were analyzed for toluene to determine a calibration curve along with a linear regression equation to calculate the concentrations of toluene in the samples collected later on the EIC (Extracted Ion Chromatogram) was set at 91 amu. These were the recorded values for toluene based on the peaks and the retention time obtained from the TargetView. The peak values recorded for each volume were obtained by averaging the peak intensity from 4 separate runs at each volume to ensure the most accurate data points. The mass is calculated using a 4 ppbv standard of toluene.

Figure 3 shows the peak areas from **Table 3** for toluene obtained from the lab standards plot against the standard volume on the x-axis. A linear regression curve was determined based on the data, and the r^2 value of 0.9989 indicates that the data is accurate and precise to the linear curve since the r^2 value is very close to 1.000.

d. Toluene (TIC) Standard:

Table 4. GC-MS Calibration Data of Toluene Standards using TIC

Std. Vol. (ml)	TIC	Mass (ng)
150	4.34E+07	2.26
100	2.80E+07	1.51
75	2.06E+07	1.13
50	1.37E+07	0.754
25	6.49E+06	0.377
5	1.98E+06	0.151

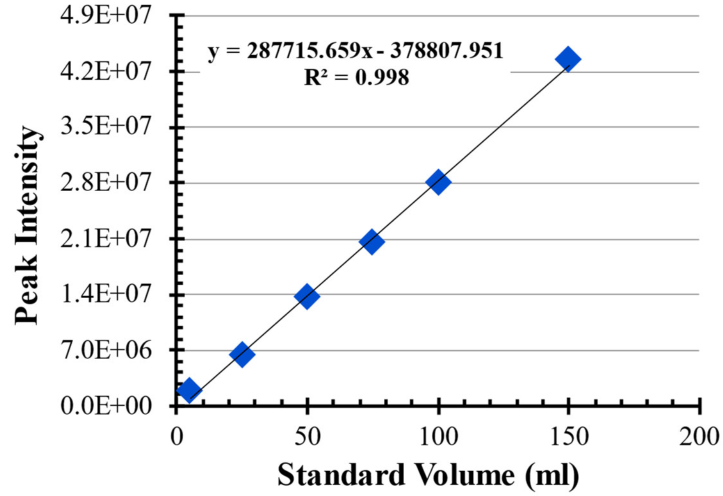

Figure 4. Toluene volume standards using TIC

Again, the GC-MS was set to analyze for TIC, which is not as specific as EIC since it is not set to look for a particular mass. **Table 4** shows the recorded values for toluene based on the peaks and the retention time obtained from the TargetView. Each of those values is the average of four different values recorded at each volume. The mass is calculated using a 4 ppbv standard of toluene.

Figure 4 shows a plot of the peaks on the y-axis versus the standard volumes on the x-axis. A linear regression curve was determined based on the data, and the r^2 value of 0.9989 indicates that the data is accurate and precise to the linear curve since the r^2 value is very close to 1.000. However, the EIC data for toluene seemed to be more specific.

Target View was utilized for the EIC technique by setting it to a specific m/z (mass to charge ratio) peak unique to each compound's molecular mass. For this reason, the results obtained from EIC are more precise and accurate because it extracts the peaks that match the compound using both the retention time and mass. On the other hand, TIC searches for the peaks of each compound using only the retention time obtained from the standards; however, this technique does not account for the uniqueness of each compound as some compounds may show up at similar retention times. Nevertheless, by analyzing the graphs of both the EIC and TIC data, it is clear that the EIC data is very accurate by comparing the r^2 values. Additionally, the EIC technique is more specific for each compound, which will be very important for calculating accurate volumes for each compound. For these reasons, it was agreed upon that the EIC technique provided more accurate linear regression equations and peaks, so we used this technique for the sample data analysis.

B. Sample Data Analysis:

Once all the standards were calculated, we ran the collected sample files through GC-MS and set the EIC to 78 and 91 for benzene and toluene, respectively. Each sample was obtained at a different location in Shelby County. The samples were collected from residential areas, public buildings, schools, hospitals, and healthcare centers that vary in distance from the closest factory to them. The peaks for each sample were analyzed in the GC-MS under similar retention times to the ones we obtained from the standards, which were around 11.67 min. and 15.89 min. for benzene and toluene, respectively. The peaks were analyzed under these conditions and ran through TargetView. Peaks detected by the GC-MS resembling benzene and toluene were recorded. The recorded peaks were used to solve for the x value (volume in ml of the compound) in the EIC linear regression equations obtained from the standards analyzed using the EIC technique.

First, we analyzed the samples collected during the summer season, which fell between July and August. The volumes were calculated in ml using linear regression equations. The volume in ml was then converted to $\mu g/m^{3.}$ Then using the Eurofins calculator, the $\mu g/m^3$ was converted to ppbv (parts per billion volume) to help us compare the presence of each compound in the ambient air of Shelby County.

a. Summer vs. Winter Concentrations

The summer sample values are shown in **Figure 5.1** in ppbv, and the results from the winter are shown in **Figure 6.1** in ppbv. By observing both graphs, it is evident that the presence of both of these aromatic compounds is higher in the summer than in their winter counterparts. For benzene, the compound averaged 0.29 ppbv in the summer with a maximum of 1.06 ppbv. On the other hand, benzene averaged 0.14 ppbv in the winter with a maximum of only 0.32 pbbv. Similarly, toluene had an average of about 0.38 ppbv and a maximum of 2.13 in the summer compared to an average of 0.03 ppbv and a maximum of 0.17 ppbv in the winter. In both the summer and the winter, some locations did not show any concentrations of benzene or toluene, which is likely due to the wind carrying these compounds to other areas in Memphis.

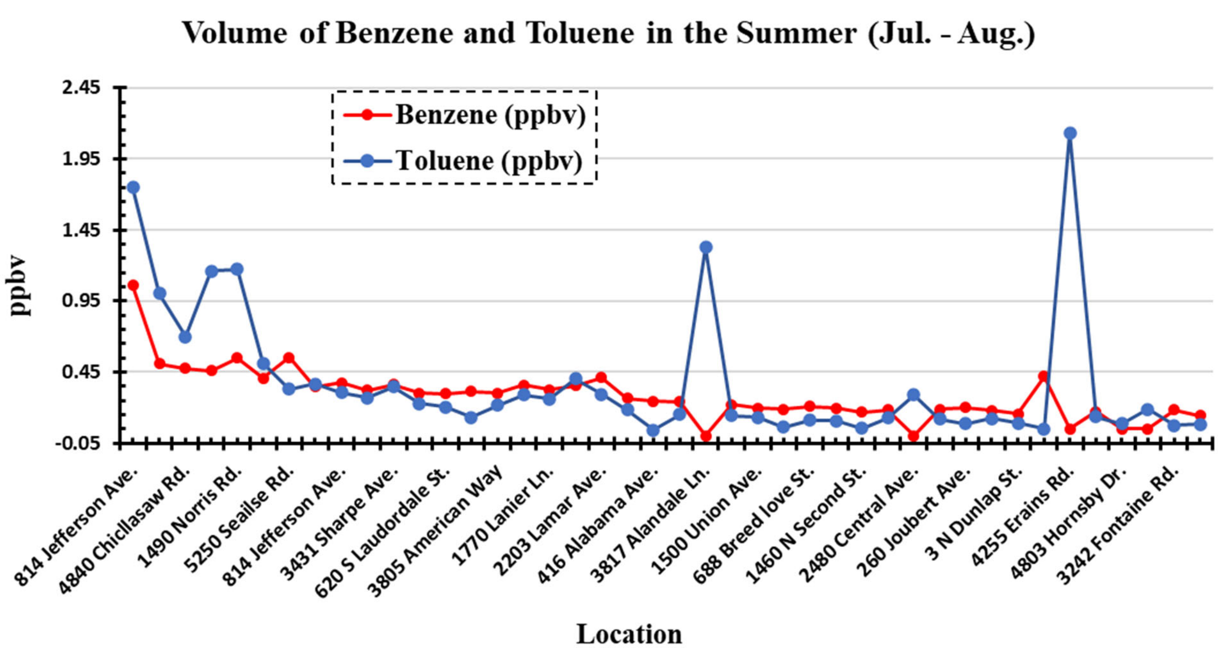

Figure 5a. Concentrations of Benzene and Toluene in the Summer (Jul. – Aug.)

The calculated summer ppbv values are plotted in **Figure 5.1** for benzene and toluene. The ppbv concentrations are on the y-axis, while the x-axis shows the different locations (addresses) where the samples were collected.

As mentioned before, the average ppbv concentration for benzene in the summer was 0.29 ppbv, while the average concentration for toluene was 0.38 ppbv. Therefore, dividing toluene's average by benzene's average can calculate that the concentration of toluene is 1.32 times more than that of benzene. This is also clearly shown in **Figure 5a** and **Figure 9** (MS Excel summer 3D map), where the toluene values are significantly higher than benzene.

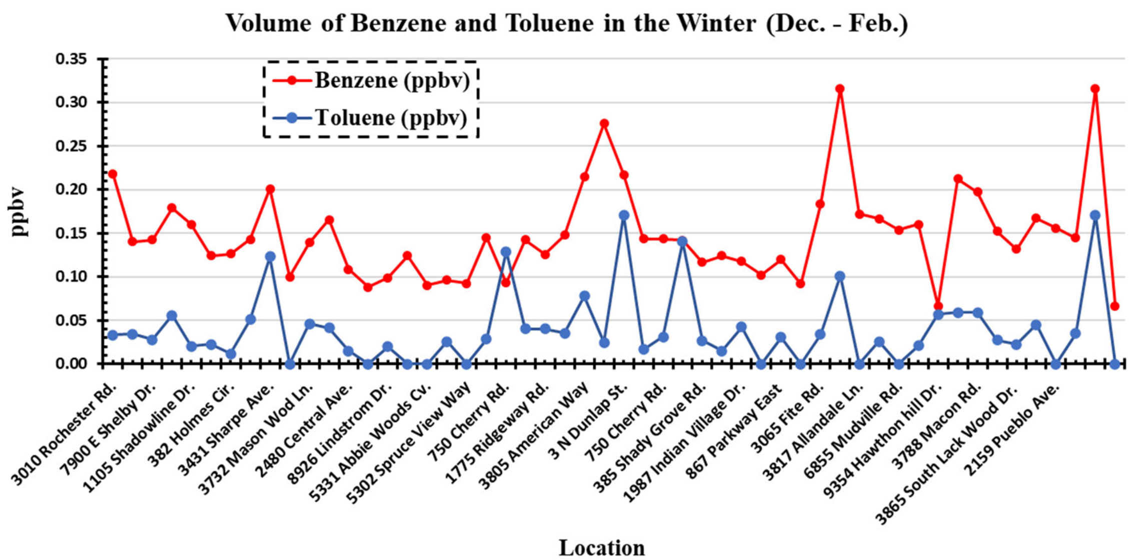

Figure 6a. Concentrations of Benzene and Toluene in the Winter (Dec. – Feb.)

The calculated winter ppbv values are plotted in **Figure 6a** for benzene and toluene. The ppbv concentrations are on the y-axis, while the x-axis shows the different locations (addresses) where the samples were collected.

The results shown in the winter are almost the opposite of summer. The average value of benzene concentration in the winter is about 0.32, which is 4.15 times higher than the average toluene concentration of 0.08. Again, this is shown very clearly in both **Figure 6a** and **Figure 10** (MS Excel winter 3D map), as the benzene data points are significantly higher than the data points for toluene.

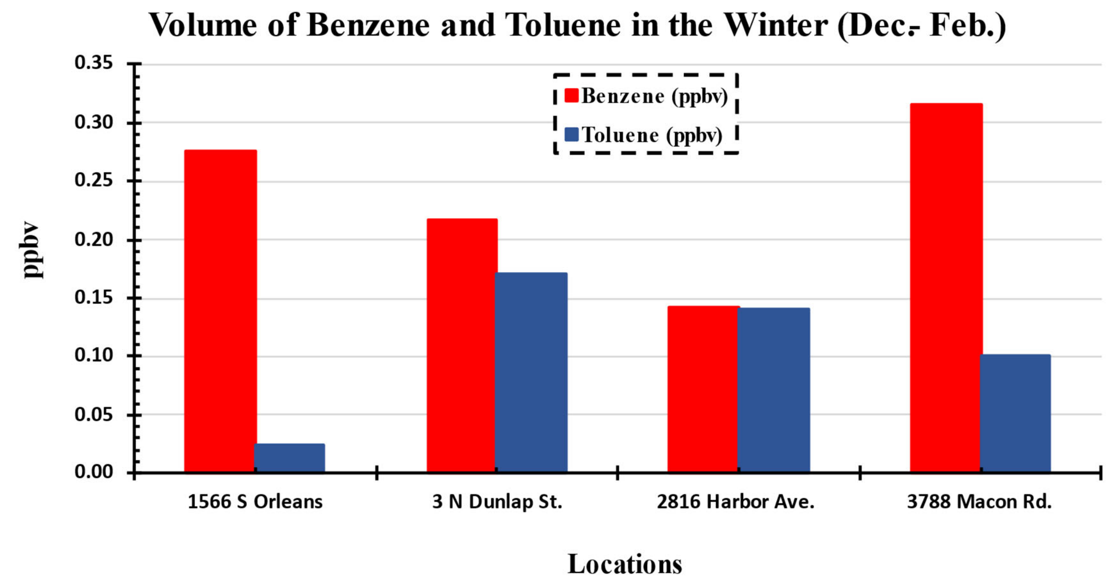

Figure 5b. Closer Look at the Highest Summer Concentrations

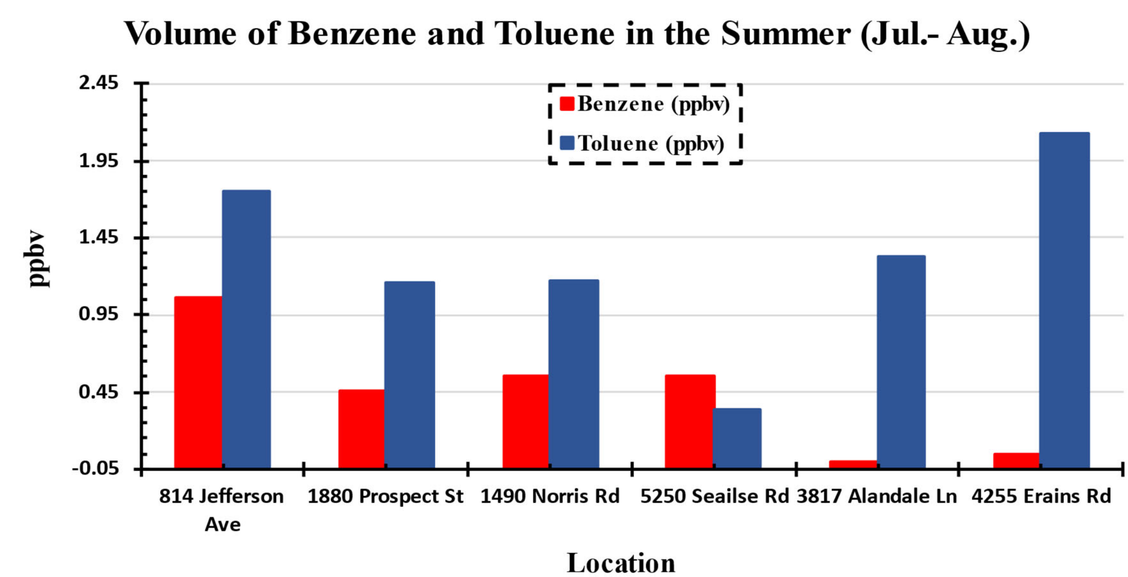

Figure 6b. Closer Look at the Highest Summer Concentrations

Figure 5b provides a closer look at only the highest concentrations of benzene and toluene collected in the summer, where the trend of toluene's higher concentration continues. **Figure 6b** also provides a closer look at only the highest concentrations of benzene and toluene collected in the winter, where benzene's concentration trend continues. This is the same trend observed in **Figure 6a.**

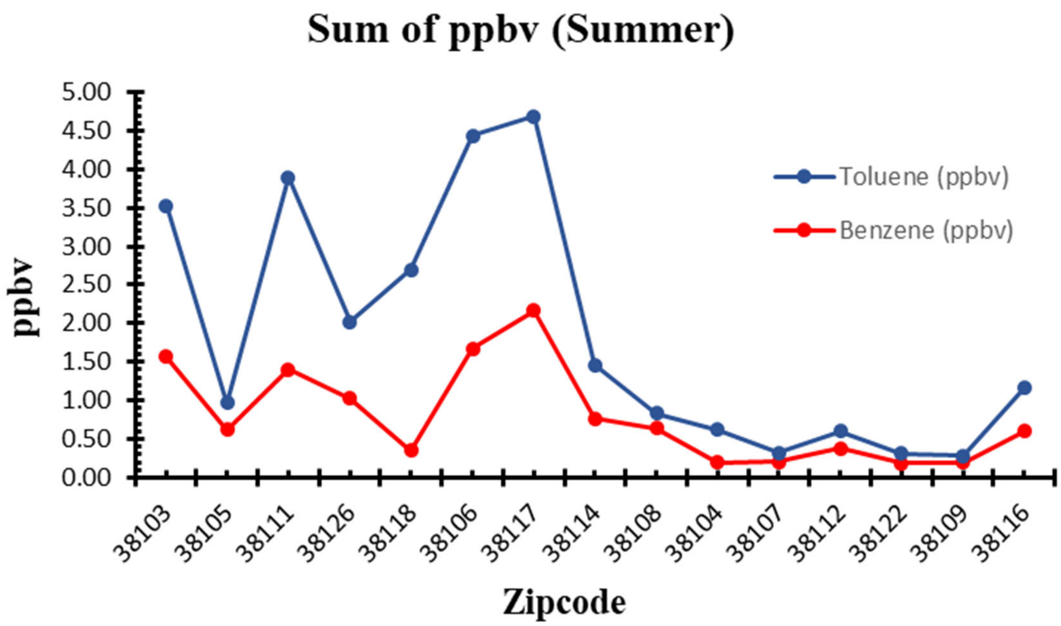

Figure 7a. Sum of ppbv (Summer)

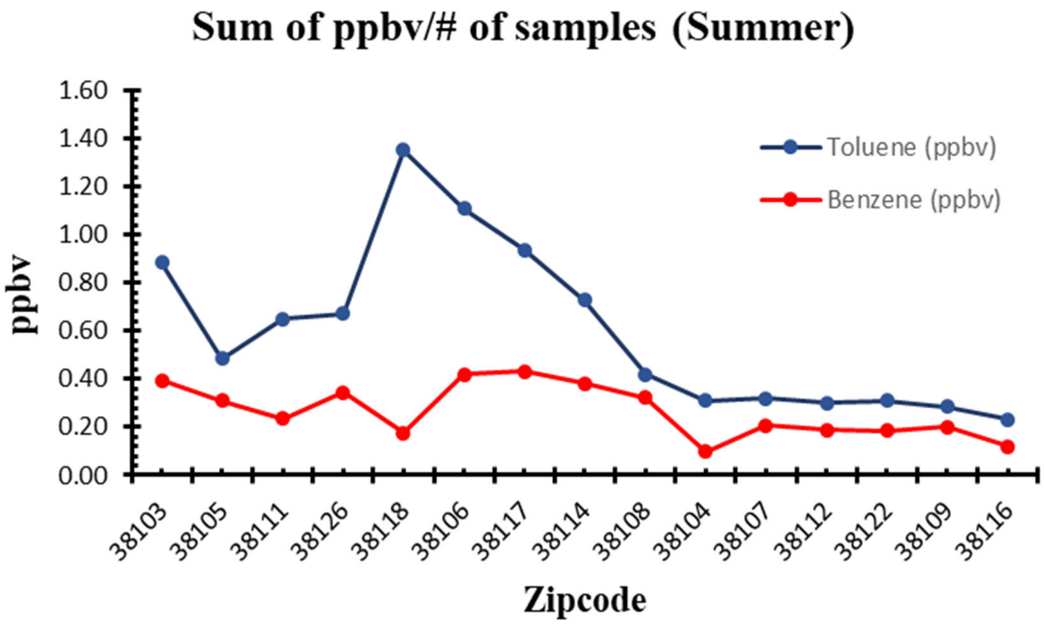

Figure 7b. Sum of ppbv/# of samples (Summer)

Figure 7a and **Figure 7b** show the ppbv values for both compounds plotted against the list of zip codes that the samples were gathered in the summer (July - August).

Figure 7a shows the total ppbv value for each zip code; however, some zip codes had a higher sampling frequency than others, so **Figure 7b** shows the total amount of ppbv per zip code by dividing the total ppbv value for each compound by the number of times the zip code appeared in the sample collecting. This was done to show which areas of Shelby County have a higher volume of these compounds in the ambient air with respect to others.

On the other hand, the concentration of benzene and toluene show a dramatic drop as well as a switch in their trendlines in the winter. As discussed before, benzene concentration is noticeably higher in the winter than toluene. This is shown in **Figure 8a** and **Figure 8b,** where the concentration of benzene spikes up in most areas while the concentration of toluene remains dormant. The concentration ratios of toluene to benzene also provide a greater understanding of their contribution from transportation compared to industrial sources.

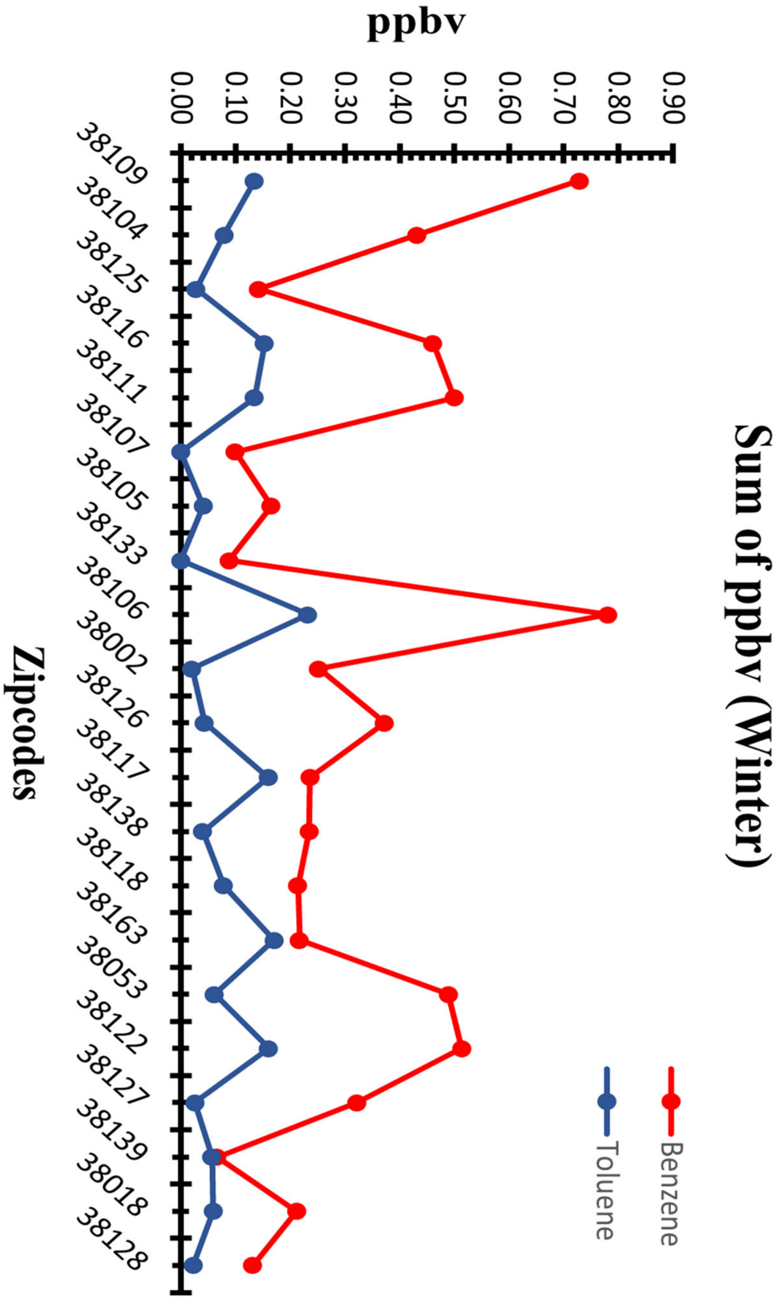

Figure 8a. Sum of ppbv (Winter)

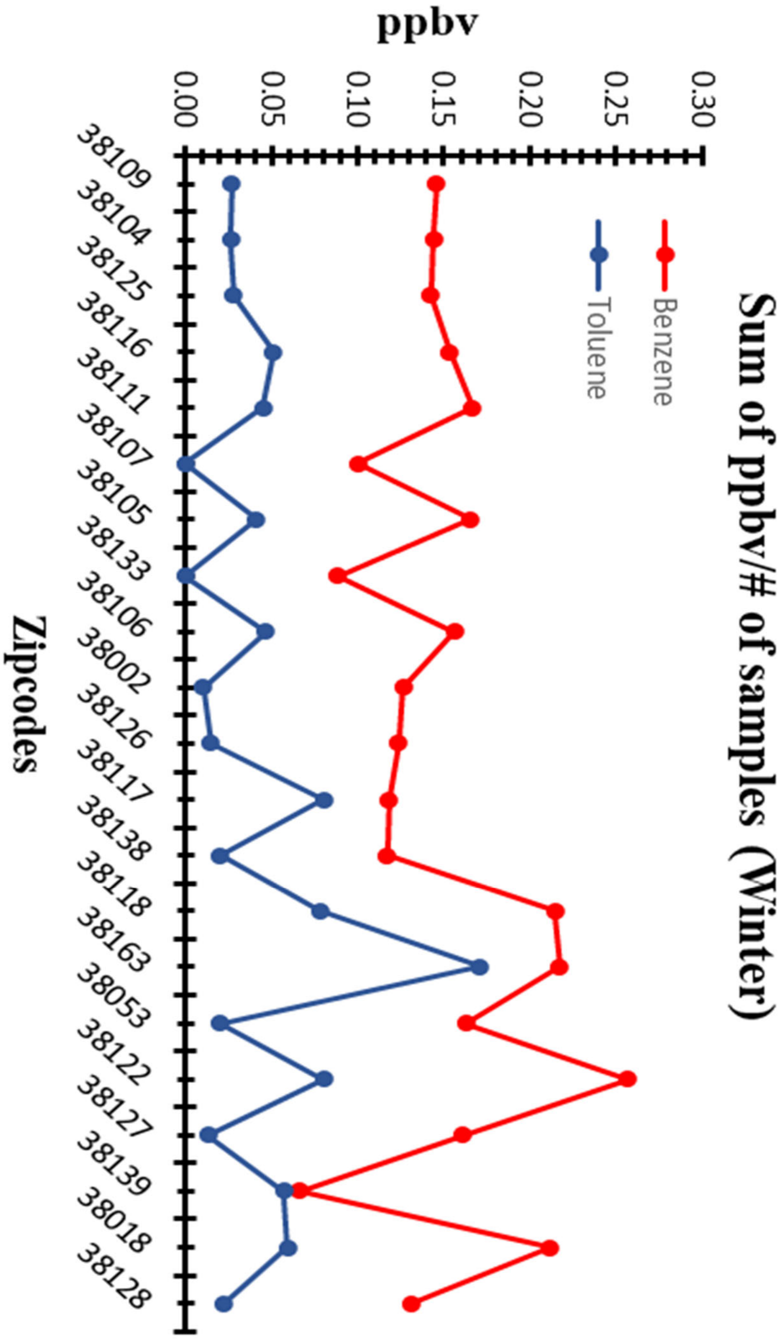

Figure 8b. Sum of ppbv/# of samples (Winter)

Figure 8a and **Figure 8b** show the ppbv values for both compounds plotted against the list of zip codes where the samples were gathered in the winter (December - February). **Figure 8a** shows the total ppbv value for each zip code; however, some zip codes had a higher frequency than others, so **Figure 8b** shows the total amount of ppbv per zip code by dividing the total ppbv value for each compound by the number of times the zip code appeared in the sample collecting. This was done to show which areas of Shelby County have a higher volume of these compounds in the ambient air with respect to others.

In addition to these graphs, we used MS Excel's 3D mapping feature to show the concentrations of benzene and toluene and how they compare across Shelby County. We also mapped nearby factories that reported the release of either benzene, toluene, or both using the addresses and locations provided by the EPA in TRI Explorer.[12] By mapping the nearby factories, we can visualize how these compounds spread from one area to the next.

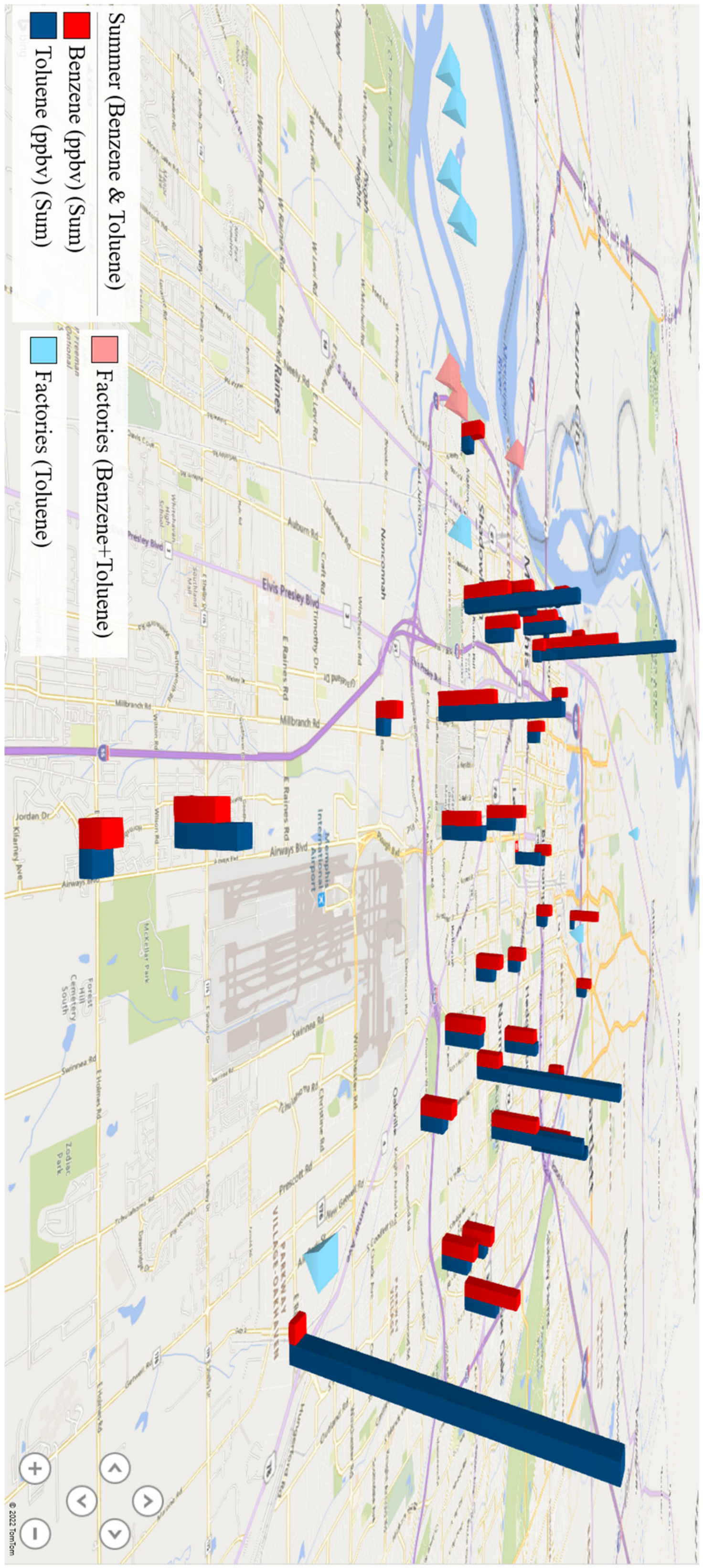

Figure 9. Benzene and toluene concentrations in the Summer (Jul. – Aug.)

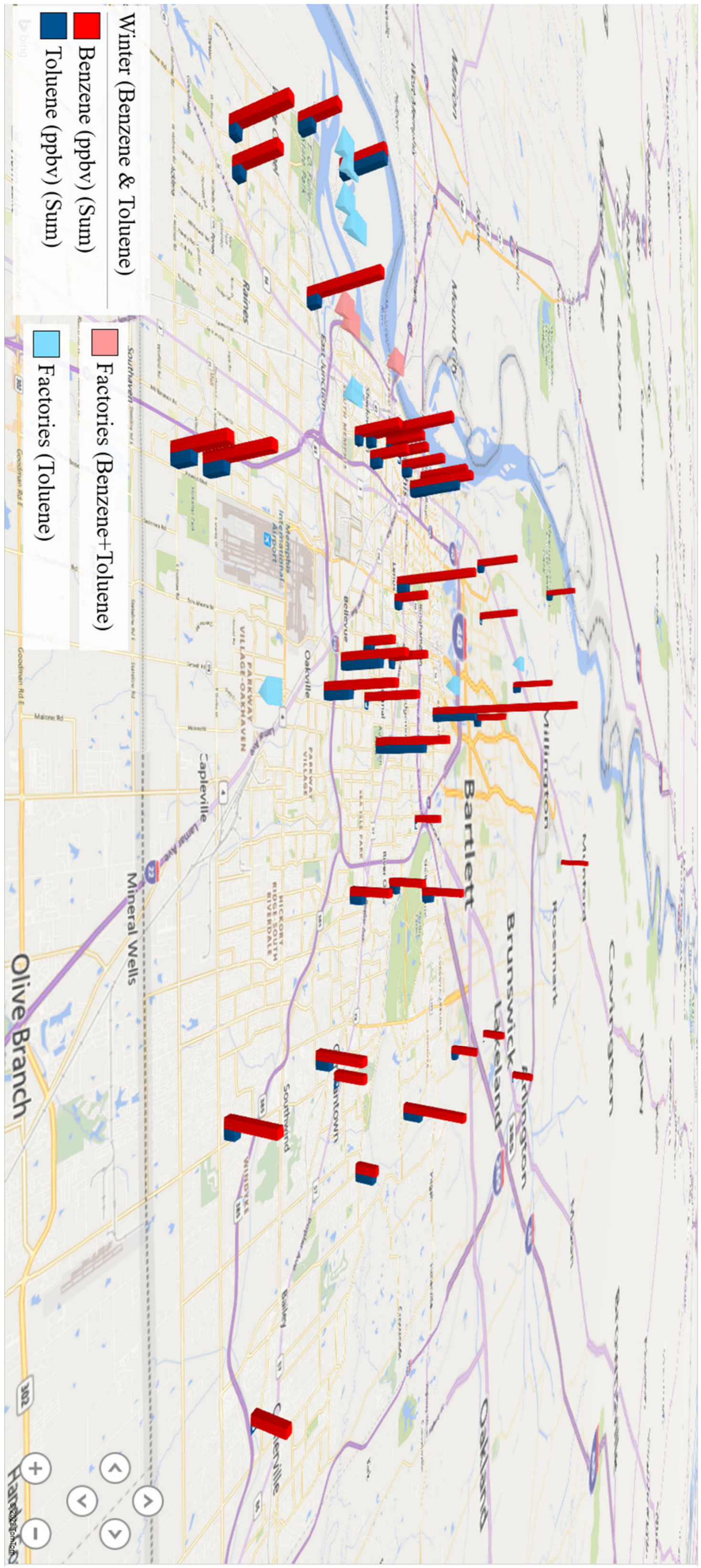

Figure 10. Benzene and toluene concentrations in the Winter (Dec. – Feb.)

By analyzing both **Figure 9** and **Figure 10**, it is clear once again that these VOCs are much higher in the summer than in the winter. Figure 11 shows a direct comparison between summer and winter concentrations. We can see that the concentrations of these aromatic compounds are almost three times higher in the summer than in winter. This confirms our hypothesis that VOCs are present in higher concentrations in the summer, most likely due to the higher temperatures that allow these compounds to break down and evaporate. Once VOCs evaporate and make their way into the ambient air, the compounds can remain in the air for long periods due to their volatility.

Aromatic compounds like benzene and toluene require relatively low energy to vaporize benzene (C6H6); an aromatic compound composed of a ring of six carbons connected by covalent bonds requires 33.9 kJ/mol to vaporize.[13] Similarly, Toluene (C_7H_8) is also composed of a six-membered carbon ring; however, it is substituted with a methyl (CH_3) which raises the energy required to vaporize the compound to 37 kJ/mol.[14] Higher temperatures make these values much easier to reach during the summer. Additionally, in the summer, there is higher vapor pressure since vapor pressure has a direct relationship to temperature. Vapor pressure is also proportional to volatility, allowing VOCs to remain in the ambient air for a long time.

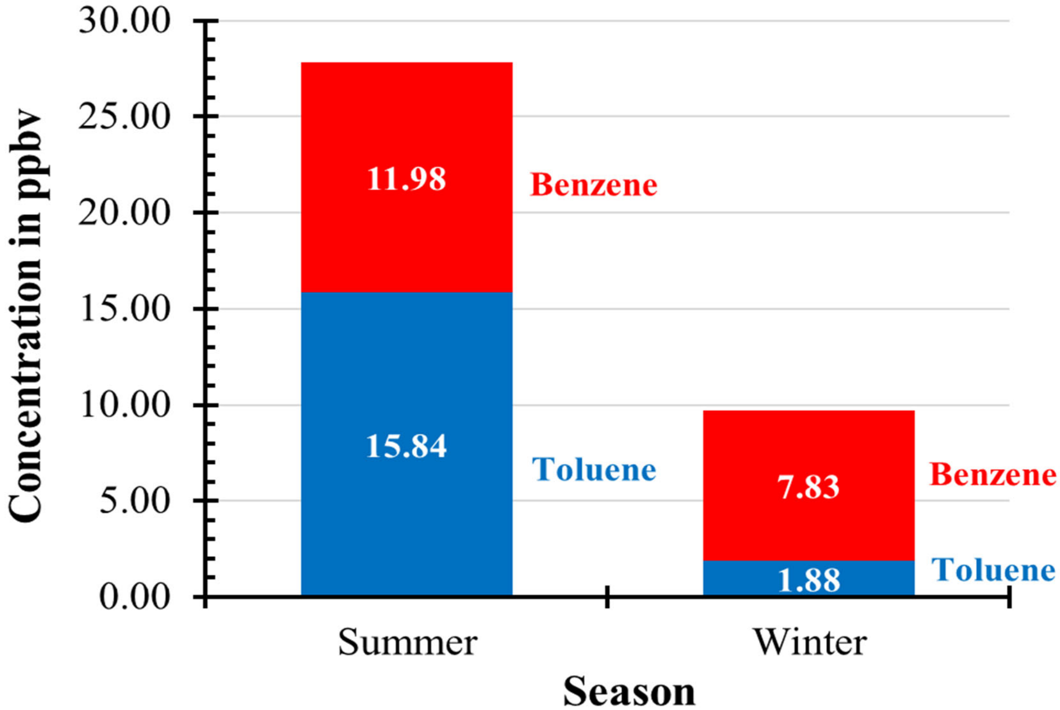

Figure 11. Direct Comparison between Summer and Winter VOCs Concentration

On another note, the concentrations shown on the winter map seem to be dispersed and further away from the factories that reported the release of these compounds. In contrast, the winter concentrations appeared to be higher around the factories. We suspected this could be due to higher wind speeds in the winter, which could have carried these compounds further away from the factories. For this reason, we also recorded the wind speeds of the days when the highest concentrations of toluene and benzene were found both in the summer and the winter. Indeed, the winter season had higher wind speeds ranging from 7-19 mph with an average of 12 mph, while the summer wind speeds ranged from 7-8 mph with an average of 7.7 mph.[15] Therefore, the higher wind speeds in winter must have been a factor in dispersing the concentration of benzene and toluene across the city, leading to greater dispersion to distant locations and higher concentrations overall.

Figure 12 (summer wind speed and direction) and **Figure 13 (winter wind speed and direction)** visually demonstrate the average speed and direction of the wind recorded on those days, along with the locations of the top 5% concentrations of benzene and toluene from the samples collected.

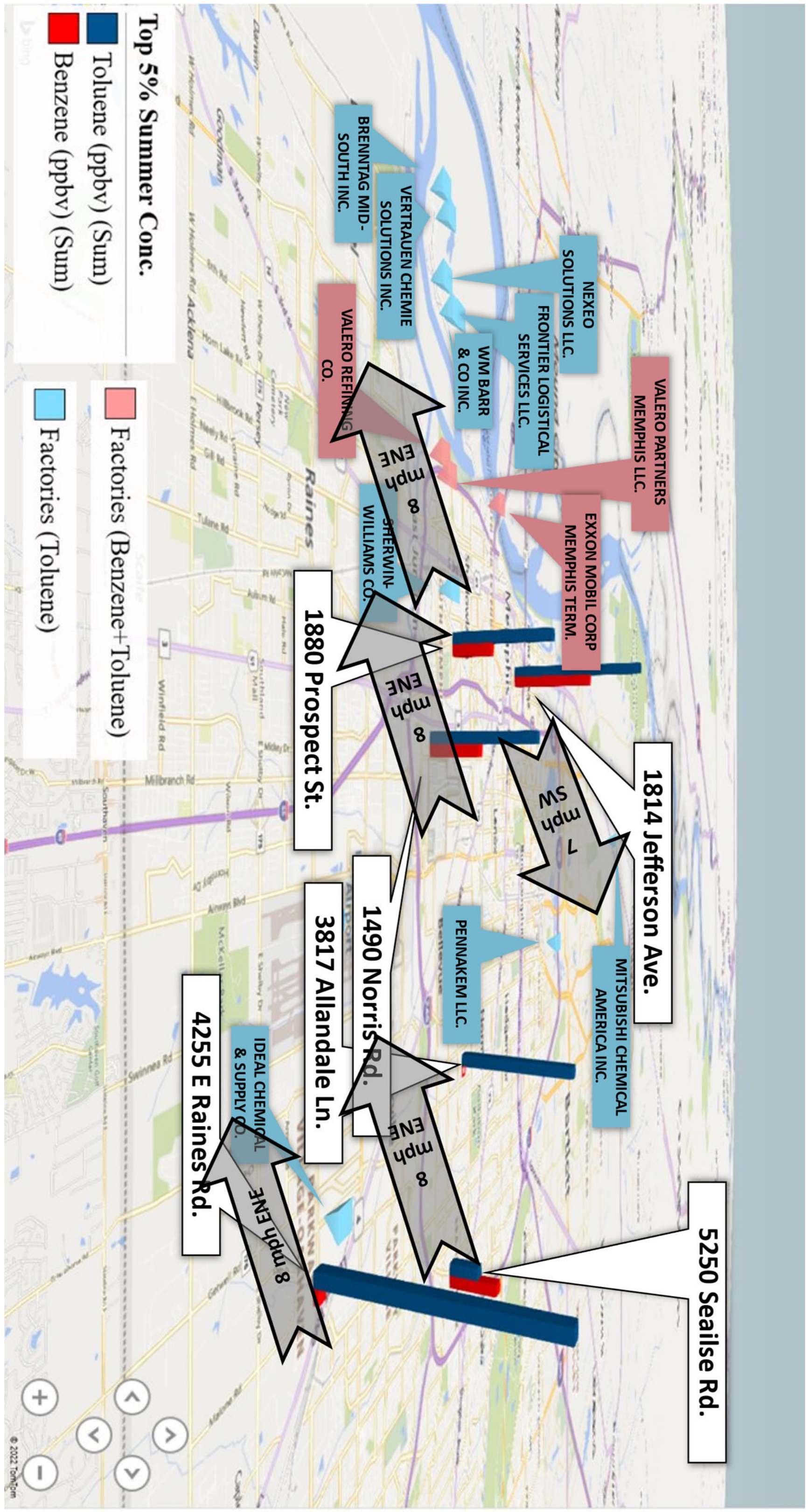

Figure 12. Summer Wind Speed and Direction (July – August)

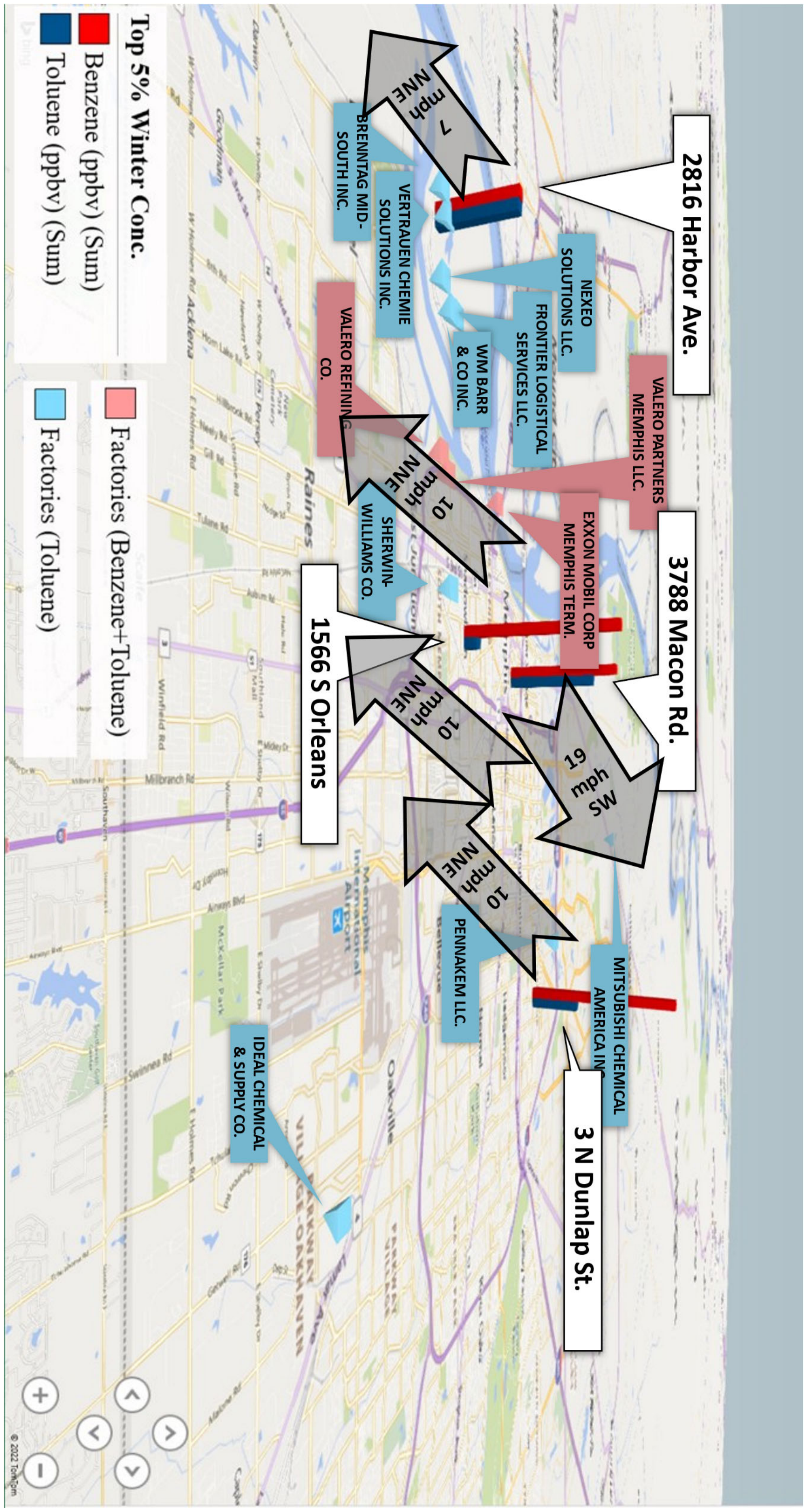

Figure 13. Winter Wind Speed and Direction (December – February)

C. Health Risks of Inhaling Benzene and Toluene

Exposure to most VOCs can harm public health and cause mild to deadly symptoms. For example, exposure to benzene through inhalation can cause neurological symptoms, including drowsiness, dizziness, headaches, and unconsciousness in humans. Increased incidence of leukemia has been observed in humans occupationally exposed to benzene. EPA has classified benzene as a Group A, known human carcinogen.[5] Exposure to benzene in the ambient air can cause many issues and pose a considerable risk to public health. The effects of exposure to benzene can be deadly, and its presence in the air composition makes it even more dangerous. In parallel, toluene affects the immunological and neurological systems.[10] Central nervous system dysfunction and narcosis are among the main symptoms exhibited in individuals exposed to high levels of toluene. Long-term effects of toluene can lead to irritation of the upper respiratory tract and eyes, sore throat, headache, and dizziness.[12]

However, benzene and toluene concentrations found in the analyzed samples are well below the concentrations that would pose a risk to public health. For example, for benzene, an individual would need to inhale at least 700 parts per million (ppm) or 700,000 ppb of benzene for a constant period to begin feeling any adverse effects such as drowsiness, dizziness, headaches, etc. Furthermore, inhaling high levels of benzene in the ambient air, from 10,000 ppm to 20,000 ppm, can result in death.[13] Luckily, based on the concentrations calculated from the samples, it does not seem that there is enough benzene in the ambient air to cause these issues since the highest concentration of benzene between our summer and winter samples was only 1.06 ppb or 0.00106 ppm. Similarly, the exposure limit set by OSHA for toluene is 200-500 ppm, almost 10,000 times the amount found in the samples collected.[14] And so, toluene does not pose a severe risk to public health at the concentrations we found.

However, it is worth noting that wind speeds and temperature could have contributed to those concentrations being dispersed throughout the county. It is also vital to realize that tracking the concentrations of these VOCs is extremely important should their concentrations dramatically increase. The concentrations we found for benzene and toluene align with the values reported in the TRI-Explorer by the EPA. In the TRI, toluene, and benzene are in the top 30 chemicals released in Shelby County, coming in at #17 and #27, respectively, where 24,085 pounds of toluene and 5,055 pounds of benzene were recorded for total on-site releases.[12] The concentrations calculated from the samples collected also showed similar behavior where toluene was higher in most areas. Therefore, it is safe to conclude that both compounds are present in about the same amount between the summer and the winter across the entire county.

IV. Conclusion:

Based on these findings from this research, it is safe to conclude that VOCs (volatile organic compounds) can have long-term effects on public health and can cause many complications to multiple organs in the body by exposure through inhalation of the compound in the ambient air. For this reason, the USEPA has enforced environmental laws to track how much of these compounds are released by industries and factories. In addition, by law, industrial facilities and factories must submit a report of the chemicals released annually to ensure that community residents have access to these data.

In this research, we attempt to use GC-MS as a more efficient means of analyzing the data and pinpointing two aromatic compounds with high concentrations in Shelby County and specifically in the samples collected. Luckily, the toluene and benzene concentrations in the samples we collected were not high enough to pose a risk to public health.

We used the EIC technique to analyze our data as it provided us with more accurate values specific to each compound since it focuses on the specific atomic weight. Generally, the EIC data had higher r^2 values, indicating that EIC data fit the linear curve better than the data provided by the TIC. In some cases, the TIC data showed a slightly higher r^2 value, but the EIC data provided clearer and stronger peaks overall. Therefore, we concluded that EIC data is more beneficial for this research, although it takes longer to complete. The EIC data from the standards were used to analyze the samples collected and calculate the volume in ppbv for benzene and toluene in the summer and winter. The data from this research shows how the concentration of VOCs can change based on temperature, wind speed, and vapor pressure. As shown in the results, the concentrations of both compounds were much higher in the summer, which could be influenced by multiple factors such as wind, temperature, and vapor pressure. These findings are significant as they help data analysts better understand the values based on the location and time of the samples collected, which will lead to faster and more efficient action toward ensuring the safety and health of the public.

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