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Original Paper

Pollution Characteristics and Source Apportionment of Volatile Organic Compounds (VOCs) in the Main Urban Area of Wuxi City, 2025

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Abstract

In To identify pollution sources of volatile organic compounds (VOCs) in Wuxi City, we analyzed their pollution characteristics, ozone formation potential (OFP) and source apportionment using online monitoring data from December 2024 to November 2025. The average VOCs volume fraction was 38.90×10-9, showing a seasonal trend of higher levels in winter/autumn and lower in spring/summer. Alkanes (30.90%) and oxygenated VOCs (OVOCs, 34.71%) were the dominant components, and all chemical species exhibited a "double peaks and one valley" diurnal pattern.Total OFP reached 75.90 μg/m³, with OVOCs (55.87–66.16%) being the primary contributor across seasons. Aromatic hydrocarbons contributed significantly more in winter (15.71%) than in spring, summer and autumn (4.93–8.79%). Acetaldehyde (19.43–32.02%) ranked first in annual OFP contribution, followed by acrolein and vinyl acetate. Positive Matrix Factorization (PMF) identified seven source factors. Motor vehicles (28.6%) and solvent usage (19.9%) were the dominant VOCs sources, followed by plant/biomass combustion (12%), combustion sources (10.7%), industrial emissions (10.6%), LPG (9.9%) and oil/gas volatilization (8.2%). Therefore, priority should be given to controlling these two major sources for effective VOCs abatement in Wuxi.

Keywords

Pollution Characteristics, Volatile Organic Compounds, PMF Source Apportionment, Ozone Formation Potential

1. Introduction

Volatile organic compounds (VOCs) are defined by the World Health Organization (WHO) as various organic compounds with boiling points ranging from 50°C to 260°C at room temperature (HALIOS, LANDEG-COX, LOWTHER et al., 2022; MENEZES, AMORIM, & CARDEAL, 2012). VOCs are characterized by two core properties: volatility and the ability to participate in atmospheric photochemical reactions. They can react with nitrogen oxides (NO_x) to form ozone (O_3), and also react with atmospheric free radicals to generate secondary organic aerosols (SOA), posing severe adverse impacts on both atmospheric environment and human health (KOPPMANN, 2020; PEREIRA, HAMILTON, RICKARD et al., 2012; CHEN, XU, XU et al., 2022).

Since the beginning of the 21st century, China's rapid economic growth has propelled it to become the world's second-largest economy, yet the environmental challenges arising from this development have grown increasingly severe (HAN, HUANG, & LI, 2020). Atmospheric environmental issues such as ozone pollution and haze have become prevalent in key economic development regions including the Beijing-Tianjin-Hebei (BTH) region, Yangtze River Delta (YRD), and Pearl River Delta (PRD) (ZHENG, CAO, ZHAO et al., 2024). Volatile organic compounds (VOCs) are recognized as the most critical precursors for the formation of ozone (O_3) and secondary organic aerosols (SOA) (ZHANG, FAN, SONG et al., 2022; LI, ZHANG, BELL et al., 2024). The coordinated control of particulate matter (PM) and ozone has become a top priority during the 14th Five-Year Plan period and beyond, and clarifying the emission characteristics and source composition of VOCs is the scientific prerequisite for achieving their precision emission reduction.

Located in the hinterland of the Yangtze River Delta (YRD), Wuxi is a typical manufacturing powerhouse and a leading economic city in southern Jiangsu Province. The dense concentration of chemical, electronics, printing and coating industries, persistently high motor vehicle ownership, coupled with significant regional transport impacts, have led to the increasingly prominent ozone pollution problem in the city. At present, considerable observational data on volatile organic compounds (VOCs) have been accumulated for the YRD urban agglomeration. However, studies focusing on Wuxi itself, particularly those investigating high spatiotemporal resolution component characteristics and quantitative source apportionment in combination with its typical industrial structure, remain relatively limited, which fails to provide sufficient scientific support for the precise formulation of localized ozone prevention and control strategies.

Taking Wuxi City as the study area, this study conducted continuous online monitoring of VOCs at the Dongting monitoring station. Based on the analysis of VOCs concentration levels, chemical compositions and diurnal variation patterns in different time periods, the Positive Matrix Factorization (PMF) model was applied to quantitatively apportion the sources and their contribution proportions of VOCs, and identify the key pollutants that contribute significantly to the ozone formation potential (OFP). The research results can provide decision-making references for the precise source tracing of VOCs and the coordinated prevention and control of ozone pollution in Wuxi City.

2. Materials and Methods

2.1 Monitoring Site and Quality Control

The geographical coordinates of the monitoring site are 120.3489°E and 31.5865°N. The monitoring period spanned from December 1, 2024 to November 30, 2025, and the monitoring data were recorded as hourly averages. The monitored pollutants included 30 alkanes, 11 alkenes, 17 aromatic hydrocarbons, 34 halogenated hydrocarbons, 21 oxygenated volatile organic compounds (OVOCs) and 1 alkyne, totaling 114 species. Total volatile organic compounds (TVOC) were defined as the sum of the concentrations of these 114 VOC species.A total of 8760 raw data samples were collected. After removing outliers and missing values during equipment maintenance periods, 8235 valid data samples were obtained, with a valid rate of 94% and sample completeness exceeding 90%. The data quality fully met the requirements for subsequent data analysis, and the impact of data gaps on the overall research results was negligible.

In this study, VOCs components were monitored using the ZKGD-VOCs-1000 online volatile organic compound monitoring system, which is uniformly equipped at all national-controlled ambient air quality automatic monitoring stations in Wuxi City. This instrument operates based on the gas chromatography-flame ionization detector (GC-FID) principle (9 Gas chromatography, 2003) and enables continuous automatic monitoring of 114 VOCs species ranging from C_2 to C_{12}. The system adopts full-line heated sampling at 20°C with a sampling flow rate of 50–100 mL/min and an accuracy of ±2%. Target analytes are enriched via electronic refrigeration at -25°C, followed by rapid thermal desorption at 280°C with a heating rate of no less than 100°C/s. Separation is achieved using DB-1 and DB-624 dual chromatographic columns. The oven temperature programming was set as follows: initial temperature of 40°C held for 5 min, ramped to 150°C at 5°C/min, then further ramped to 220°C at 10°C/min and held for 10 min. The FID detector temperature was set to 250°C, with a hydrogen flow rate of 30 mL/min, air flow rate of 300 mL/min, and makeup gas flow rate of 25 mL/min. The instrument has a detection limit of ≤0.1 ppb and a measurement range of 0.1 ppb to 1000 ppb. The single sample analysis cycle is 60 min, including approximately 50 min for enrichment, 5 min for chromatographic analysis, and 5 min for system backflush and reset. Regular calibrations were performed during daily operation to ensure the accuracy of monitoring data.

2.2 Ozone Formation Potential (OFP) Calculation

Ozone Formation Potential (OFP) is used to quantify the contribution of different VOCs pollutants to ozone (O_3) formation during atmospheric photochemical reactions. Due to their varying chemical reactivities, different VOCs species exhibit distinct OFP values, which are therefore commonly used to characterize the chemical reactivity of VOCs pollutants. Analysis of the OFP of individual VOCs species allows the identification of the dominant contributors to ozone formation among VOCs. In this study, the OFP of VOCs pollutants was calculated using the Maximum Incremental Reactivity (MIR) method. MIR is defined as the ratio of the change in ozone concentration to the incremental amount of VOCs added. Calculating the OFP per unit mass of VOCs emitted from pollution sources to characterize their ozone reactivity can better reflect the inherent ozone formation capacity of a given source independent of its VOCs emission intensity. The calculation formula is as follows (HE, ZOU, LV et al., 2024):

$$OFP=MIR_i\times VOC_i \tag{1}$$

where:OFP_i is the ozone formation potential of the i-th VOC species, with the same unit as the VOCs concentration;MIR_i is the maximum incremental reactivity of the i-th ambient air VOC species;VOC_i is the concentration of the i-th ambient air VOC species.The total OFP is the sum of the OFP values of all 114 VOC species.

2.3 Principles of the PMF Model

In the source apportionment of ambient air VOCs, the Positive Matrix Factorization (PMF) model factorizes the receptor VOCs component concentration matrix X_{nxm} (Equation 2) into two factor matrices: the factor contribution matrix G_{nxp} and the factor profile matrix F_{pxm}, plus a residual matrix E_{nxm}. Under the non-negativity constraint that all elements in matrices G and F are non-negative, an objective Q-value function (Equation 3) is defined, and the optimal solutions for matrices G and F are obtained when the value of the Q-value function is minimized. Based on these results, different source categories are identified using the characteristic chemical composition information or marker species of pollution sources. Multiple linear regression is then performed on matrix G to derive the contributions of different source categories to ambient VOCs samples. The calculation formulas of PMF are as follows:

$$X_{(n\times m)}=G_{(n\times p)}\times F_{(p\times m)}+E_{(n\times m)} \tag{2}$$

where:X_{nxm} is the receptor VOCs component concentration matrix;G_{nxp} is the factor contribution matrix;F_{pxm} is the factor profile matrix;E_{nxm} is the residual matrix;n is the number of samples;m is the number of VOCs components (i.e., number of VOC species);p is the number of resolved factors (i.e., number of pollution sources).

$$Q=\sum_{i=1}^{n}\sum_{j=1}^{m}\left(\frac{E_{ij}}{\sigma_{ij}}\right)^2 \tag{3}$$

where:Q is the objective Q-value function;E_{ij} is the residual of the j-th VOCs component in the i-th sample;σ_{ij} is the uncertainty of the j-th VOCs component in the i-th sample;n is the number of samples;m is the number of VOCs components (i.e., number of VOC species).

3. Results and Analysis

3.1 Analysis of VOCs Pollution Characteristics

The annual average volume fraction of total volatile organic compounds (TVOC) in the main urban area of Wuxi in 2025 was 38.91×10^{-9}. Compared with other cities (WANG, LUN, WANG et al., 2024; QU, HUANG, SHEN et al., 2025; FENG, WANG, HUANG et al., 2018; HADZIHAFIZOVIC, 2024; ALTYNOV, BOGDANOV, LUKYANOV et al., 2023; DING, LU, LIU et al., 2020; ZHANG, WU, FANG et al., 2018; BLAKE, & ROWLAND, 1995), it was higher than that in Dalian (17.52×10^{-9}), Wuzhen (Jiaxing, 30.52×10⁻⁹), Anji (27.48×10⁻⁹), Suzhou (28.87×10⁻⁹), Puyang (32.2×10⁻⁹), Jinzhong (21.193×10⁻⁹) and Hohhot (24.60±17.84 ppb), but lower than that in the main urban area of Lanzhou (64.2±22.1 ppb).

Table 1. Comparison of TVOC Volume Fraction between Wuxi and Other Cities

City	Time Period	Volume Fraction / Concentration
Wuxi	2024.12-2025.11	38.91×10^{-9}
Dalian	2024.01-2024.12	17.52×10^{-9}
Wuzhen	2024.01-2024.12	30.32×10^{-9}
Anji	2020.06-2021.05	37.5×10-9
Suzhou	2023.12-2024.11	28.87×10^{-9}
Puyang	2021.01-2021.12	32.2×10^{-9}
Jinzhong	2024.01-2024.12	21.193×10^{-9}
Hohhot	2020.06-2020.08	24.60±17.84 ppb
Lanzhou	2023.09-2024.08	64.2±22.1 ppb

The seasonal variation of TVOC in Wuxi was significant. TVOC concentrations in winter (43.80×10^{-9}) and autumn (45.17×10^{-9}) were comparable, as were those in spring (32.90×10^{-9}) and summer (33.75×10^{-9}), exhibiting a seasonal trend of "higher in winter and autumn, lower in spring and summer". The volume fractions of different chemical components (alkanes, alkenes, aromatic hydrocarbons, halogenated hydrocarbons, alkynes, oxygenated volatile organic compounds (OVOCs)) showed significant differences. Alkanes (12.02×10^{-9}) and OVOCs (13.51×10^{-9}) had the highest concentrations, accounting for 30.90% and 34.71% of the total TVOC, respectively. This was followed by halogenated hydrocarbons (7.22×10^{-9}, 18.55%) and alkenes (3.52×10^{-9}, 9.05%). Aromatic hydrocarbons (1.88×10^{-9}) and alkynes (0.76×10^{-9}) had the lowest concentrations, contributing 4.83% and 1.94% of the total TVOC, respectively.

During the study period, alkanes and oxygenated volatile organic compounds (OVOCs) had the highest concentration levels and showed a distinct seasonal alternation: their concentrations were comparable in autumn, alkanes were higher than OVOCs in winter, while OVOCs exceeded alkanes in both spring and summer. Halogenated hydrocarbons had the next highest concentrations but were consistently lower than OVOCs. This alternation may be attributed to the dominant unfavorable dispersion conditions and weak atmospheric photochemical oxidation capacity in autumn and winter, which lead to the continuous accumulation of pollutants from primary emissions including solvent usage, industrial processes, motor vehicle exhaust and plant emissions. Chemically stable alkanes have higher accumulation efficiency, resulting in their concentrations being comparable to or exceeding those of OVOCs in these two seasons. In spring and summer, with the deepening of the boundary layer and enhanced photochemical reactions, alkanes are diluted and consumed, while the secondary formation of OVOCs increases significantly, leading to their concentrations being substantially higher than those of alkanes (WANG, LUN, WANG et al., 2024). Among other components, halogenated hydrocarbons and alkenes also exhibited higher concentrations in autumn and winter and lower concentrations in spring and summer. Although aromatic hydrocarbons also showed a winter-high and summer-low trend, their decrease in spring and summer was particularly pronounced. Reactive components such as aromatic hydrocarbons and alkenes are rapidly oxidized and consumed in the warm season, which simultaneously affects the secondary formation of OVOCs and further strengthens the dominance of oxygenated components, reflecting the characteristic of rapid photochemical consumption of reactive pollutants in the warm season. In contrast, the seasonal variation of alkynes was not significant.This seasonal mismatch reveals that local VOCs concentration levels in autumn and winter are mainly dominated by the accumulation of primary emissions represented by alkanes and halogenated hydrocarbons, while in spring and summer, they shift to being dominated by photochemically formed secondary oxygenated components. The oxidative consumption of reactive aromatic hydrocarbons and alkenes provides important precursors for OVOCs. Therefore, ozone pollution prevention and control in the warm season should focus more on the emissions of oxygenated organic compounds and their precursors.

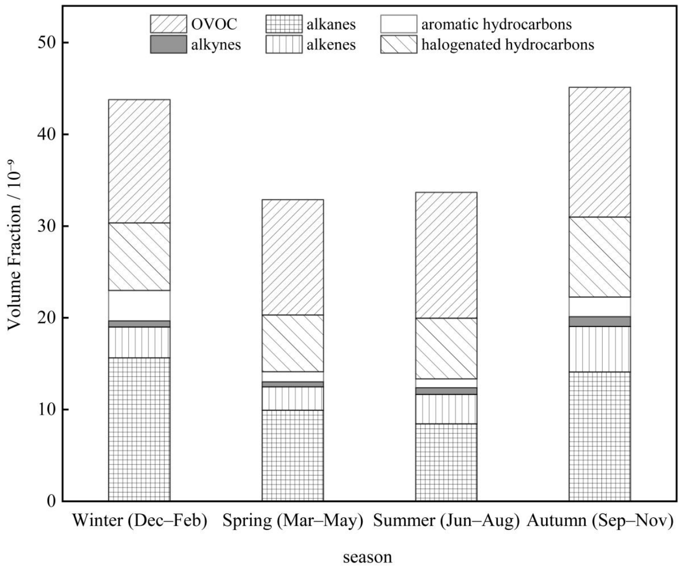

Figure 1. Seasonal Variations in Volume Fraction of Various VOC Components in Wuxi

The diurnal variation trends of each chemical component differed across seasons, as shown in Figure 2. Alkanes, oxygenated volatile organic compounds (OVOCs), halogenated hydrocarbons, alkenes, aromatic hydrocarbons and alkynes all exhibited a "double peaks and one valley" pattern. Peaks occurred at 6:00–9:00 (morning rush hour) and 21:00–23:00 (evening), while the trough appeared at 14:00–15:00. The morning peak was mainly attributed to the significant influence of motor vehicle sources, coupled with the gradual intensification of photochemical reactions and improving dispersion conditions. The evening peak was primarily caused by the weakening of photochemical reactions and dispersion conditions, leading to pollutant accumulation. The trough occurred when photochemical reaction intensity reached its maximum, resulting in the fastest pollutant consumption rate, combined with the deepening of the atmospheric boundary layer and favorable dispersion conditions (ZHANG, XIAO, WANG et al., 2021). The morning peak appeared at 6:00–8:00 in spring and summer, but shifted to 8:00–9:00 in autumn and winter, which may be due to the later onset of intensified photochemical reactions in the latter two seasons. This is consistent with the previous conclusion on "VOCs composition and secondary formation in spring and summer". The photochemical reaction intensity in spring and summer was stronger than that in autumn and winter for almost the entire day, and the morning peak was also affected by the superposition effect of secondary formation.

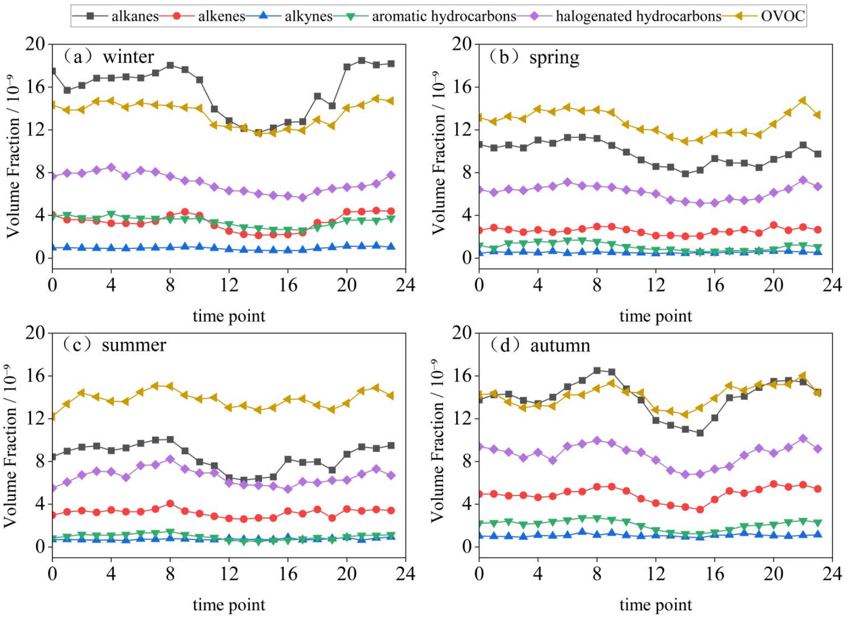

Figure 2. Diurnal Variations of Chemical Components of VOCs in Different Seasons

3.2 OFP Analysis and Identification of Key Components

The total ozone formation potential (OFP) in Wuxi was 74.50 μg/m³, and the contribution proportions of OFP components of VOCs in different seasons are shown in Figure 3. Overall, oxygenated volatile organic compounds (OVOCs) were the dominant contributors to the annual OFP in this region, followed by alkenes, alkanes and aromatic hydrocarbons. Alkynes and halogenated hydrocarbons made negligible contributions to OFP, accounting for less than 1.5% throughout the year, and their impact on regional ozone formation can be ignored. The OFP contributions of each component exhibited significant seasonal variations, reflecting changes in emission source characteristics and atmospheric photochemical processes across different seasons.

The OFP contribution of oxygenated volatile organic compounds (OVOCs) exceeded 55% in all four seasons, with the highest proportion in spring (66.16%), followed by summer (64.56%), and relatively lower proportions in autumn (56.48%) and winter (55.87%). Photochemical oxidation of atmospheric VOCs generates large amounts of secondary OVOCs, and the stronger solar radiation and higher ambient temperatures in spring and summer accelerate the secondary formation process, further enhancing the ozone formation contribution of OVOCs.The OFP contribution of alkenes exhibited a variation trend of autumn > summer > spring > winter, with the highest proportion in autumn (19.51%), followed by summer (18.18%), and the lowest in winter (12.38%). Alkenes possess extremely high atmospheric reactivity and are key precursors for ozone formation. The elevated contribution of alkenes in summer and autumn was mainly attributed to vigorous plant growth, which led to a significant increase in emissions of biogenic alkenes such as isoprene, as well as motor vehicle exhaust and gasoline volatilization emissions under high-temperature conditions.The seasonal variation of alkanes' OFP contribution was relatively mild, with the highest proportion in winter (14.60%) and the lowest in summer (11.05%). The OFP contribution of aromatic hydrocarbons showed a characteristic of being significantly higher in winter (15.71%) than in other seasons, being 2.5 times that in spring (6.29%) and 1.8 times that in autumn (8.79%). Aromatic hydrocarbons are mainly derived from fossil fuel combustion, motor vehicle exhaust and solvent usage. The substantial increase in aromatic hydrocarbons' contribution in winter is a typical characteristic of winter atmospheric pollution in this region, which is also associated with the pollutant accumulation effect under unfavorable meteorological conditions.

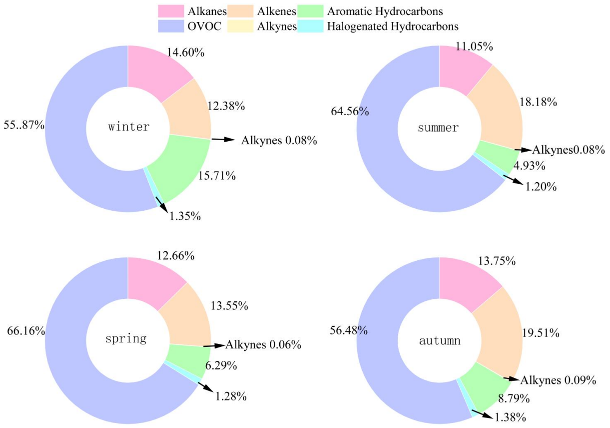

Figure 3. Contribution Proportion of VOCs Chemical Components to OFP in Different Seasons

To further accurately identify the main drivers of ozone formation, the top 15 VOC species ranked by OFP contribution in each season were quantitatively analyzed, as shown in Figure 4. The results showed that a small number of highly reactive pollutants contributed the majority of ozone formation in this region. The cumulative OFP contributions of the top 15 species were 77.4% in winter, 78.9% in spring, 85.1% in summer and 79.6% in autumn, respectively. Among them, the contribution concentration of the top 15 species in summer was the highest, indicating that ozone formation in summer had a stronger dependence on key pollutants, and precision control of highly reactive pollutants can achieve twice the effect with half the effort.

Acetaldehyde was the highest contributor to the annual OFP, ranking first in contribution proportion in all four seasons and exhibiting significant seasonal fluctuations. It had the highest contribution proportion in autumn (32.02%), followed by spring (30.53%), and relatively lower proportions in summer (24.02%) and winter (19.43%).Acetaldehyde is mainly derived from industrial solvent usage, motor vehicle exhaust, biomass burning and other sources. Secondary formation via photochemical oxidation of precursors such as alkenes and alkanes in the atmosphere is also an important source pathway. Higher temperatures and favorable radiation conditions in autumn and spring promoted the progress of photochemical reactions, leading to a significant increase in the secondary formation contribution of acetaldehyde. This is consistent with the previous conclusion that OVOC components accounted for a higher proportion of OFP in spring and autumn.

Acrolein and vinyl acetate were the key OFP contributors second only to acetaldehyde throughout the year, both ranking among the top 5 in all seasons. Their contributions were particularly prominent in winter, with acrolein accounting for 16.16% and vinyl acetate for 9.79%. Together, they contributed 25.95% of the total winter OFP, which was comparable to the contribution proportion of acetaldehyde. Acrolein is mainly derived from motor vehicle exhaust emissions, incomplete combustion of fuels and atmospheric photochemical reactions, and its extremely high reactivity makes it an important precursor for ozone formation (HE, ZOU, LV et al., 2024; ZHANG, XIAO, WANG et al., 2021). Vinyl acetate is an important industrial solvent and chemical raw material. Its high contribution reflects the significant impact of industrial process emissions on ozone formation in the study area, providing a new direction for ozone pollution prevention and control in this region.

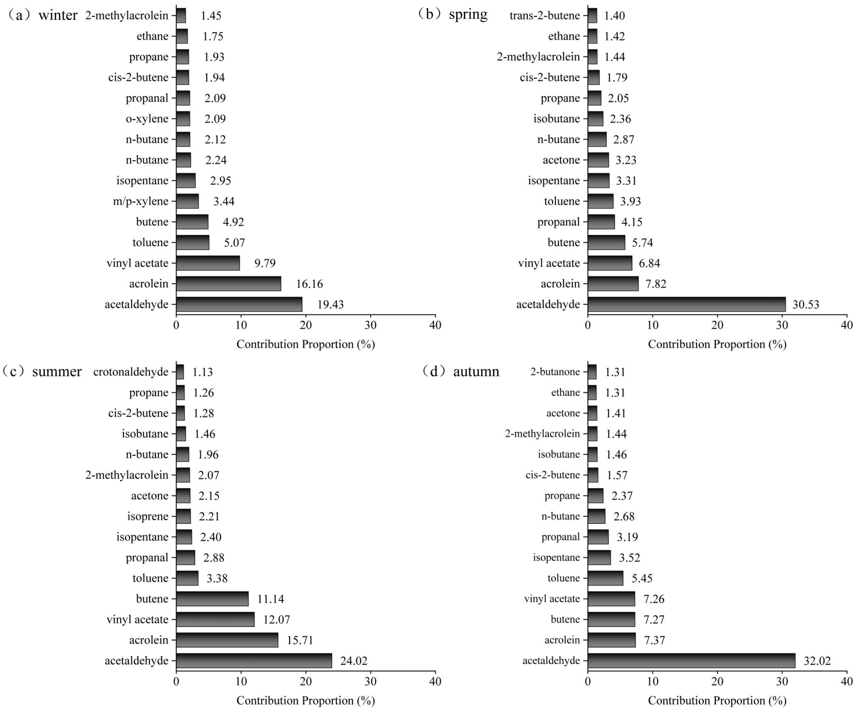

Figure 4. Top 15 Pollutants in Contribution Proportion to Total OFP in Each Season

In winter, in addition to acetaldehyde, acrolein and vinyl acetate, aromatic hydrocarbon pollutants made relatively prominent contributions. m/p-xylene (3.44%), o-xylene (2.09%) and toluene (5.07%) all ranked among the top 10.In spring, ethane, propane, isobutane, n-butane and isopentane all entered the top 15, with a total contribution proportion of 12.82%, reflecting the emission characteristics caused by the full resumption of industrial activities and increased motor vehicle traffic in spring. The pollutant contributions in summer were highly concentrated. The top 4 pollutants (acetaldehyde, acrolein, vinyl acetate and butene) together accounted for 62.94% of the total OFP. Isoprene (2.21%) entered the top 15 for the first time, which is a typical indicator of the significant increase in biogenic emissions caused by vigorous plant growth in summer.In autumn, the contributions of alkene pollutants increased significantly. Butene (7.27%), cis-2-butene (1.57%) and other alkenes all ranked among the top 15, which was mainly affected by the combined effects of motor vehicle exhaust emissions and emissions from plant secondary metabolism in autumn.

2.3 VOCs Source Apportionment

As shown in Figure 5, a total of 7 major factors were identified using the 2025 VOCs concentration data and the PMF source apportionment method.The contribution rates of n-heptane, methylcyclohexane, ethylene, propylene, butene, acetylene and toluene were 40%, 33%, 38%, 32%, 26%, 27% and 32%, respectively. Studies have shown that acetylene is a product of incomplete combustion of hydrocarbon fuels and a tracer for combustion sources. Low-carbon alkenes such as ethylene, propylene and butene are typically products of continuous combustion, accompanied by alkanes and aromatic hydrocarbons (WANG, LUN, WANG et al., 2024; FENG, WANG, HUANG et al., 2018). Factor 1 was therefore identified as combustion sources.The contribution rates of isopentane, n-pentane, 2-methylpentane and 3-methylpentane were 67%, 42%, 46% and 44%, respectively. Isopentane and n-pentane are important components of oil and gas (HADZIHAFIZOVIC, 2024; ALTYNOV, BOGDANOV, LUKYANOV et al., 2023). Factor 2 was identified as oil and gas volatilization sources.The contribution rates of ethane, propane, isobutane, n-butane, ethylene and propylene were 68%, 55%, 30%, 32%, 48% and 42%, respectively. Studies have shown that ethylene, propylene and acetylene are mainly produced by incomplete combustion in motor vehicles, while low-carbon alkanes such as ethane and propane are typically from mixed emissions of motor vehicle fuel volatilization and exhaust (DING, LU, LIU et al., 2020; ZHANG, WU, FANG et al., 2018). Factor 3 was identified as motor vehicle sources. The contribution rates of isobutane and n-butane were 45% and 29%, respectively, with additional contributions from various alkanes and alkenes. Studies have shown that the presence of low-carbon alkanes such as isobutane and n-butane with small amounts of alkenes is a typical characteristic of LPG sources (BLAKE & ROWLAND, 1995). Factor 4 was identified as LPG sources.The contribution rates of dichloromethane, carbon tetrachloride, 1,2-dichloroethane, 1,2-dichloropropane, ethyl acetate, acetaldehyde and acetone all exceeded 30%. Halogenated hydrocarbons are specialized solvents for industrial cleaning, paint stripping and extraction. Ethyl acetate and acetone are universal solvents for paints, inks and adhesives.

Acetaldehyde is emitted as a solvent impurity or along with chemical raw materials (SALTHAMMER, 2023). Factor 5 was identified as solvent usage sources. The contribution rates of isoprene and acetone were 54% and 46%, respectively, with additional contributions from butene and methyl chloride. Studies have shown that isoprene is naturally released by plants under light conditions and is a characteristic tracer for plant sources. Acetone is significantly emitted during biomass burning and straw combustion (SRIKANTH, MAXTON, MASIH et al., 2024). Factor 6 was identified as plant and biomass burning sources. The contribution rates of toluene, ethylbenzene and m/p-xylene were 43%, 74% and 85%, respectively, all of which are important substances used in industrial processes[23]. Factor 7 was identified as industrial process sources.

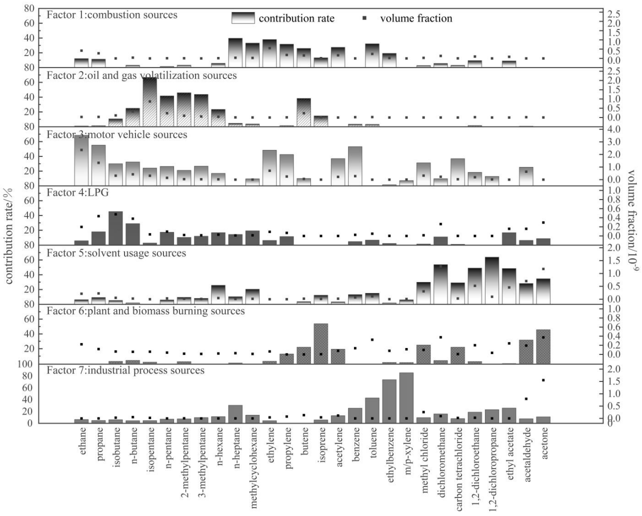

Figure 5. Source Profiles from VOCs Source Apportionment

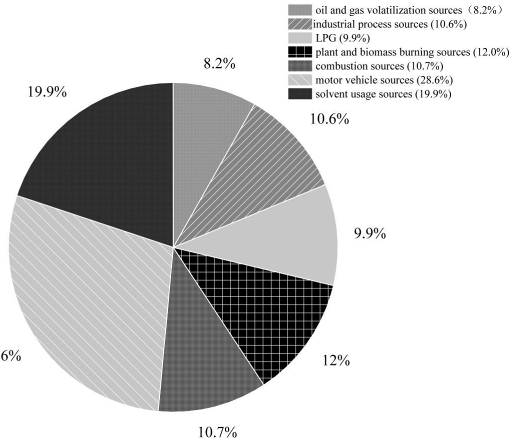

Figure 6. Contribution Proportion of Each Factor from VOCs Source Apportionment

As shown in Figure 6, the contribution proportions of the 7 factors identified by VOCs source apportionment at the Dongting monitoring station in 2025 were as follows: oil and gas volatilization sources (8.2%), industrial process sources (10.6%), LPG sources (9.9%), plant and biomass burning sources (12%), combustion sources (10.7%), motor vehicle sources (28.6%), and solvent usage sources (19.9%).Among them, motor vehicle sources (28.6%) and solvent usage sources (19.9%) were the dominant contributors to VOCs in Wuxi City. The remaining sources, including oil and gas volatilization sources, industrial process sources, combustion sources, LPG sources and plant and biomass burning sources, had comparable contribution proportions.

4. Conclusion

(1) From December 2024 to November 2025, the average volume fraction of total volatile organic compounds (TVOC) in Wuxi City was 38.90×10^{-9}. Alkanes (30.90%) and oxygenated volatile organic compounds (OVOCs) (34.71%) accounted for the largest proportions, followed by halogenated hydrocarbons (18.55%) and alkenes (9.05%), while aromatic hydrocarbons (4.83%) and alkynes (1.94%) had the lowest proportions. The seasonal variation of TVOC was significant, showing a trend of "higher in winter and autumn, lower in spring and summer".

(2) The diurnal variations of alkanes, OVOCs, halogenated hydrocarbons, alkenes, aromatic hydrocarbons and alkynes in all seasons in Wuxi all exhibited a "double peaks and one valley" pattern. Peaks occurred at 6:00–9:00 (morning rush hour) and 21:00–23:00 (evening), while the trough appeared at 14:00–15:00 in the afternoon.

(3) The average total ozone formation potential (OFP) in Wuxi was 75.40 $\mu g/m^3$. The OFP contributions in all seasons were consistently dominated by OVOCs (55.87–66.16%), followed by alkenes (12.38–19.51%) and alkanes (11.05–14.60%). The OFP contribution of aromatic hydrocarbons in winter (15.71%) was significantly higher than that in spring, summer and autumn (4.93–8.79%). Acetaldehyde (19.43–32.02%) was the highest contributor to OFP throughout the year, followed by acrolein (7.37–16.16%) and vinyl acetate (6.84–12.07%).

(4) Seven source factors were identified by the Positive Matrix Factorization (PMF) source apportionment method, including oil and gas volatilization sources (8.2%), industrial process sources (10.6%), LPG sources (9.9%), plant and biomass burning sources (12%), combustion sources (10.7%), motor vehicle sources (28.6%) and solvent usage sources (19.9%). Among them, motor vehicle sources and solvent usage sources were the dominant contributors to VOCs in Wuxi City.

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