Post-print: Atmospheric VOCs Concentration Levels and Species Annual Variation in Kuitun City

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Abstract

To obtain real-time concentration composition and diurnal variation characteristics of atmospheric volatile organic compounds (VOCs), a three-year observation was conducted from 2013 to 2015 using an online gas chromatograph on the rooftop of a building approximately 25 m high in downtown Kuitun City, Xinjiang. The results indicated that the annual average TVOCs concentration in Kuitun City ranged from 66.0 to 80.7 ppbv, with light alkanes, light alkenes, heavy alkanes, aromatic hydrocarbons, and heavy alkenes constituting the five primary VOCs categories, whose combined concentrations accounted for 84.1% of the total TVOCs concentration. The winter VOCs concentration in Kuitun City was 1.5 times the annual average, with an approximately threefold difference between winter and summer concentrations. Compared with other cities, the overall concentration level of atmospheric volatile pollutants was relatively high. Relative to the previous two years, the percentage contents of halogenated hydrocarbons, aromatic hydrocarbons, and oxygenated (nitrogenated) VOCs in the atmosphere in 2015 increased significantly, rising by 15.6 percentage points, 6.5 percentage points, and 5.9 percentage points, respectively, indicating an elevated proportion of toxic and harmful components in atmospheric VOCs. Since halogenated hydrocarbons are more susceptible to photochemical reactions than other organic compounds under identical conditions among various volatile organic compounds, the high summer content of halogenated hydrocarbons suggests that the photochemical reaction capacity in Kuitun City is continuously intensifying during summer.

Full Text

Introduction

Study Area

Kuitun City is located in the northern foothills of the Tianshan Mountains, in the central region of the Northern Xinjiang Economic Belt. As of 2014, the city had a population of 15.34×10 and covered an area of 31.74 km². The urban area comprises several districts: the old city district, the new city district, the industrial park, the railway station area, and the agricultural development zone, with areas of 1,500 km², 2,700 km², 2,100 km², 1,300 km², and 2,170 km² respectively, while the agricultural development zone spans 7,000 km² [FIGURE 1].

Methods

Volatile organic compounds (VOCs) were monitored using an online gas chromatography system (TH-300) deployed on the roof of a building at a height of 20 meters. The observation period covered 2013–2015, with continuous online monitoring of 103 VOC species. The annual average concentration of total VOCs (TVOCs) ranged from 66.0 to 80.7 ppbv. The main VOC classes identified were light alkanes (C -C), light olefins (C -C), heavy alkanes (C -C), aromatic hydrocarbons, and heavy olefins (C -C), which together accounted for 84.1% of TVOCs. The VOC concentration in winter was 1.5 times the annual average and approximately 3 times higher than in summer.

Results

VOC Concentrations and Composition

The five dominant VOC species contributed 84.1% of TVOCs concentration. Table 3 lists the major VOC species and their concentrations in Kuitun. The monitoring data from 2013–2015 reveal significant seasonal and annual variations in VOC levels [TABLE 3].

Seasonal Variations

Monthly distribution patterns show distinct seasonal characteristics [FIGURE 4, FIGURE 5]. Winter VOC concentrations were substantially elevated compared to other seasons, with TVOCs reaching 130.2 ppbv in winter versus annual averages of 66.0–80.7 ppbv. The winter concentration of TVOCs was approximately 3 times higher than summer levels, while spring and autumn showed intermediate values.

Annual Trends and Comparisons

Comparing 2015 data with previous years, the proportions of halohydrocarbons, aromatic hydrocarbons, and oxygenated (nitrogen-containing) VOCs increased by 15.6%, 6.5%, and 5.9% respectively. The photochemical reactivity of halohydrocarbons is notably higher than other organic compounds under the same conditions, suggesting enhanced ozone formation potential during summer months when their concentrations are elevated.

Comparative analysis with other cities indicates that Kuitun' s VOC concentrations are generally higher than those observed in other urban areas [TABLE 4, TABLE 5]. The concentration hierarchy across different urban functional zones followed the pattern: industrial areas > traffic areas > mixed commercial-residential areas > background sites [FIGURE 3].

Key Findings

1. **Concentration Levels**: Annual average TVOCs ranged from 66.0 to 80.7 ppbv, with winter concentrations reaching 1.5 times the annual mean.
2. **Composition**: Light alkanes (C -C) were the most abundant component (34.8%), followed by light olefins (15.3%), heavy alkanes (14.6%), aromatics (11.4%), and heavy olefins (8.0%).
3. **Seasonal Variation**: Winter concentrations were approximately 3 times higher than summer levels across all VOC classes.
4. **Annual Changes**: 2015 showed significant increases in halohydrocarbons (+15.6%), aromatics (+6.5%), and oxygenated VOCs (+5.9%) compared to 2013–2014.
5. **Spatial Distribution**: Industrial and traffic-influenced areas exhibited the highest VOC concentrations, with industrial areas showing concentrations 1.4–1.5 times higher than background sites.

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Abstract: To determine the real-time concentrations and temporal distribution of volatile organic compounds (VOCs) in Kuitun, Xinjiang, China, VOCs were observed using online gas chromatography on the roof of a 20-meter-high building during 2013-2015. The results show that the annual average concentration range of total VOCs (TVOCs) in Kuitun was 64.8–82.8 ppbv, and the main classes of VOCs were light alkanes, light olefins, heavy alkanes, benzene series, and heavy olefins, which accounted for 84.1% of TVOCs. The concentration of VOCs in winter was 1.5 times higher than the annual average and 3 times higher than in summer. Compared with other cities, the concentration level of VOCs in Kuitun is higher overall. Compared with the previous two years, the percentages of halohydrocarbon, benzene series, and oxygen (nitrogen) VOCs in air increased by 15.6%, 6.5%, and 5.9% respectively in 2015, as did the proportion of toxic and harmful compositions of VOCs in air. Due to the easier photochemical reaction of halohydrocarbon than other organic matters under the same conditions, the ability of photochemical reaction has been constantly increasing from the change trend point of view about the high content of halohydrocarbon in summer.

Keywords: VOCs; kinds; concentration level; annual change; characteristic

Note: Figure translations are in progress. See original paper for figures.