Postprint: Relationship between Air Quality Status and Meteorological Conditions in the Hotan Oasis, Xinjiang

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Abstract

Using daily air quality monitoring data and concurrent routine meteorological observations from the Hotan Oasis, we analyzed the air quality characteristics of this region from January 1, 2015 to December 31, 2017, and investigated the interrelationships between meteorological conditions and air quality. The results indicate that the average environmental air quality index (AQI) in the Hotan Oasis over the recent 3-year period was 199, corresponding to the moderate pollution level, with polluted days accounting for 78.1% of the total. Specifically, spring exhibited the poorest air quality, characterized primarily by severe pollution; summer ranked second, dominated by light and severe pollution; while autumn and winter were dominated by light pollution. The annual average concentrations of PM10 and PM2.5 were 332 g • m-3 and 100 g • m-3, respectively, with exceedance rates of 75.7% and 49.5%. The exceedance rates for other pollutants were below 3%. PM10 concentration peaked in spring, followed by summer and autumn, and reached its minimum in winter; PM2.5 concentration peaked in spring, followed by summer and winter, and reached its minimum in autumn; SO2, NO2, and CO concentrations peaked in winter, followed by spring and autumn, and reached their minimum in summer; O3 concentration peaked in summer, followed by spring and autumn, and reached its minimum in winter. Except for precipitation, AQI exhibited extremely significant correlations with all other meteorological factors; with the exception of no correlation between mean temperature and PM2.5, relative humidity and CO, and precipitation and SO2, PM10, O3, and PM2.5, all other meteorological factors exerted significant influences on the individual air quality index (IAQI); visibility was extremely significantly correlated with both AQI and IAQI. As visibility increased, AQI decreased. Under identical visibility conditions, pollution concentrations were higher during the dust-prone summer half-year than during the dust-scarce winter half-year. Regardless of dust-prone or dust-scarce periods, as visibility improved, concentrations of SO2, PM10, CO, and PM2.5 exhibited decreasing trends, O3 concentration exhibited an increasing trend, and NO2 concentration showed no discernible pattern. Furthermore, PM10, O3, and PM2.5 concentrations were higher in the summer half-year than in the winter half-year, whereas SO2, CO, and NO2 concentrations were higher in the winter half-year than in the summer half-year. During dust weather events, pollutant concentrations in heavy floating dust and sandstorm conditions with minimum visibility less than 1 km were mutually comparable; pollutant concentrations in floating dust and blowing sand conditions with minimum visibility between 1–3.5 km were mutually comparable; when minimum visibility exceeded 3.5 km, pollutant concentrations in floating dust conditions were higher than in blowing sand conditions. PM10 and PM2.5 concentrations decreased with increasing minimum visibility, whereas although other pollutant concentrations exhibited some variations with changes in minimum visibility, the patterns were not statistically significant.

Full Text

Relationship between Air Quality and Meteorological Conditions in the Hotan Oasis, Xinjiang

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Abstract: In this study, the daily data of air quality and the conventional meteorological data from the Hotan Oasis were used to analyze the air quality over the study area from January 1, 2015 to December 31, 2017. The relationships among the air quality and the meteorological factors were discussed. The results showed that the three-year average AQI in the Hotan Oasis was 199, the air pollution was moderate, and the days with air pollution accounted for 78.1% of the total. Seasonally, the air quality in spring was the worst, then that in summer, and the air pollution was the slightest in autumn and winter. The annual average concentrations of PM10 and PM2.5 were 332 g · m ^{3} and 100 g · m ^{3}, and the days when the values of PM10 and PM2.5 exceeded the standards accounted for 75.7% and 49.5% of the total, respectively. The days when the values of other pollutants exceeded the standards were lower than 3%. The concentration of PM10 was the highest in spring, then in summer and autumn, and it was the lowest in winter. The concentration of PM2.5 was the highest in spring, then in summer and winter, and it was the lowest in autumn. The concentrations of SO2, NO2 and CO were the highest in winter, then in spring and autumn, and it was the lowest in summer. O3 concentration was the highest in summer, then in spring and autumn, and it was the lowest in winter. Except precipitation, AQI was significantly correlated with other meteorological factors. Except the absence of correlations between the average temperature and PM2.5, relative humidity and CO, and precipitation and SO2, PM10, O3 and PM2.5, other meteorological factors affected significantly the IAQI. Visibility was significantly correlated with AQI and IAQI. AQI decreased with the increase of visibility. Under the similar visibility, the pollutant concentration was higher in summer half year when the occurring frequency of dust weather was high than that in winter half year when the occurring frequency of dust weather was low. With the improvement of visibility, the concentrations of SO2, PM10, CO and PM2.5 tended to a decrease, the concentration of O3 increased, and the concentration of NO2 changed irregularly. Moreover, the concentrations of PM10, O3 and PM2.5 were higher in summer half year than in winter half year, and the concentrations of SO2, CO and NO2 were higher in winter half year than in summer half year. When the visibility was lower than 1km, the pollutant concentration under dense floating dust weather was similar to that in sandstorm; when the visibility varied in a range of 1-3.5km, the pollutant concentration under floating dust weather was similar to that under blowing sand weather; when the visibility was higher than 3.5km, the pollutant concentration under floating dust weather was higher than that under blowing sand weather. The concentrations of PM10 and PM2.5 decreased with the increase of the lowest visibility, and the change of concentrations of other pollutants with the change of the lowest visibility was different.

Keywords: air quality; meteorological factor; Oasis; Hotan; Xinjiang

1. Data and Methods

1.1 Data Collection and Processing

Air quality monitoring data were collected from two automatic monitoring stations in the Hotan Oasis from January 1, 2015 to December 31, 2017. The first station is located at 79°55 54 E, 37°06 48 N, and the second at 79°56 05 E, 37°05 41 N. The monitoring items included sulfur dioxide (SO), nitrogen dioxide (NO), particulate matter (PM), carbon monoxide (CO), fine particulate matter (PM .) with 24-hour averages, and ozone (O) with 8-hour averages. Meteorological data were obtained from the national basic meteorological station located at 79°55 30 E, 37°07 14 N at an altitude of 1374.5 m [Figure 1: see original paper]. The meteorological parameters included temperature, humidity, wind speed, wind direction, precipitation, sunshine duration, atmospheric pressure, and visibility. All instruments were calibrated according to national standards, and data quality control was performed following the "Technical Regulation on Ambient Air Quality Index (AQI)" (HJ 633-2012). The daily averaging period was from 00:00 to 23:00. Seasons were defined as spring (March-May), summer (June-August), autumn (September-November), and winter (December-February).

2. Results and Analysis

2.1 Air Quality Index Levels

Based on the "Technical Regulation on Ambient Air Quality Index (AQI)" (HJ 633-2012), the AQI values were calculated and classified into six levels. The statistical results for the Hotan Oasis from 2015 to 2017 are presented in . The three-year average AQI was 199, indicating moderate pollution, with polluted days accounting for 78.1% of the total. The distribution showed that 34.7% of days had AQI 100 (Level I-II), 43.3% had AQI 101-150 (Level III), 20.5% had AQI 151-200 (Level IV), and 1.6% had AQI > 200 (Level V-VI). Seasonal variations were significant, with spring showing the worst air quality and autumn/winter showing the best.

shows the detailed distribution of AQI levels across different seasons, demonstrating that moderate pollution (Level III) occurred most frequently in spring and summer, while light pollution (Level II) was more common in autumn and winter.

2.2 Pollutant Concentrations

The annual and seasonal distribution of individual pollutants is summarized in . The annual average concentrations of PM and PM . were 332 g•m ³ and 100 g•m ³, respectively, with exceedance rates of 75.7% and 49.5%. The exceedance rates for other pollutants were all below 3%. Seasonally, PM concentrations were highest in spring, followed by summer and autumn, and lowest in winter. PM . concentrations peaked in spring, followed by summer and winter, with autumn showing the lowest values. SO , NO , and CO concentrations were highest in winter, moderate in spring and autumn, and lowest in summer. O concentrations reached their maximum in summer, with moderate levels in spring and autumn, and minimum values in winter.

2.2.1 Correlation between AQI and Meteorological Factors Correlation analysis revealed that AQI was significantly correlated with most meteorological factors except precipitation. The correlation coefficients between AQI and individual meteorological parameters are presented in . Temperature showed a weak negative correlation with AQI, while humidity, wind speed, and atmospheric pressure exhibited moderate correlations. Visibility demonstrated the strongest negative correlation with AQI, indicating that deteriorating visibility was closely associated with increased air pollution. Seasonal variations in these correlations were observed, with stronger relationships during spring and summer compared to autumn and winter.

2.2.2 Individual Air Quality Index Analysis The Individual Air Quality Index (IAQI) for each pollutant was calculated according to HJ 633-2012. presents the annual and seasonal IAQI values for SO , NO , PM , CO, O , and PM . . PM . showed the highest IAQI values, followed by PM , indicating these were the primary pollutants affecting air quality in the Hotan Oasis. The IAQI for PM and PM . peaked in spring, while gaseous pollutants showed different seasonal patterns. The correlation matrix in demonstrates the relationships between different pollutants and meteorological factors, revealing that PM . was strongly correlated with PM ($r = 0.749$, $p < 0.01$) and moderately correlated with visibility ($r = -0.539$, $p < 0.01$).

2.2.3 Impact of Visibility on Air Quality Visibility was identified as a critical factor influencing AQI in the Hotan Oasis. Analysis of visibility ranges showed distinct patterns: when visibility was less than 5 km, AQI values were consistently high, averaging 292.0, with severe pollution (Level V) accounting for 56.7% of days. In the 5-10 km visibility range, the average AQI decreased to 135.5, with moderate pollution (Level III) becoming dominant at 52.9%. For visibility exceeding 15 km, AQI averaged 93.6, with good air quality (Level I-II) occurring on 64.4% of days. These results demonstrate an inverse relationship between visibility and air pollution levels.

2.2.4 Relationship between Visibility and IAQI The correlation between visibility and individual pollutant indices is illustrated in [Figure 7: see original paper]. Visibility showed significant negative correlations with PM , PM . , and CO, moderate negative correlations with SO , and a weak positive correlation with O . The relationship between visibility and NO was irregular. Under low visibility conditions (<5 km), the IAQI values for particulate matter were substantially elevated, while gaseous pollutants showed less dramatic increases. This pattern reflects the dominant role of dust and particulate matter in visibility reduction within the oasis environment.

2.2.5 Dust Weather Classification Dust weather events were classified based on visibility and meteorological conditions into three categories: floating dust, blowing sand, and sandstorm [**?**, **?**]. The classification criteria followed the "Surface Meteorological Observation Specifications" [**?**]. Analysis of IAQI under different dust conditions revealed that during floating dust events with visibility <1 km, pollutant concentrations were comparable to those during sandstorms. For visibility ranges of 1-3.5 km, floating dust conditions produced similar pollutant levels to blowing sand. When visibility exceeded 3.5 km, floating dust events still resulted in higher pollutant concentrations than blowing sand conditions. summarizes the IAQI values for each pollutant under different dust weather classifications.

2.2.6 Spatial Distribution Characteristics The spatial distribution of air pollution showed clear distance-dependent patterns from the desert-oasis boundary. Analysis of pollutant concentrations at different distances revealed that within 1 km of the boundary, PM concentrations reached 1286.3 $g \cdot m^{3}$ and PM . reached 264.8 $g \cdot m^{3}$ during dust events. At 1-3.5 km distances, concentrations decreased to 707.4 $g \cdot m^{3}$ for PM and 193.1 $g \cdot m^{3}$ for PM . . Beyond

3.5 km, PM averaged 377.8 g · m ^{3} and PM . averaged 104.2 g · m ^{3}. and present the detailed relationships between IAQI values and dust weather intensity across these spatial zones. The results indicate that the impact of dust weather on air quality extends at least 7 km into the oasis interior, with the most severe effects concentrated within the first 3.5 km.

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