

Vertical distribution characteristics of outdoor particulate matter concentration in high-rise buildings during working days and non-working days

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Abstract : With the acceleration urbanization in China, it is great significance to understand the distribution characteristics of outdoor particulate matter concentration in high-rise buildings during working days and non-working days. In this paper, a high-rise building of different heights (1, 7, 11, 17, 23, 27) in a university in Xi'an is tested and analyzed. The test times are 8:00, 14:00 and 21:00 respectively. The results showed that the change trend of the particulate matter concentration with the increase of vertical height is the same at all times of the non-working day. While the change trend of particulate matter concentration with the increase of vertical height is basically the same at other times except 8:00 on the working day. In addition, the concentration of particulate matter on working days increased significantly compared to non-working days, with the largest increase at 14:00. On non-working days, $PM_{1.0}/PM_{10}$ and $PM_{2.5}/PM_{10}$ both showed a trend of first increasing, then decreasing, and then increasing in different time periods. On weekdays, $PM_{1.0}/PM_{10}$ and $PM_{2.5}/PM_{10}$ all showed a trend of falling first and then rising in different time periods. This article provides a reference for the development of high-rise buildings and the effective control of particulate matter concentration in high-rise buildings.

Keywords: high-rise building, particulate matters, vertical distribution

1 Introduction

Atmospheric particulate matter is one of the most important pollutants in world, especially for urban populations[1-2]. It not only has a stimulating effect on the human respiratory system, but also can carry bacterial microorganisms, viruses and carcinogens into the human body to cause the health problem[3]. With the development of high-rise buildings, it is more important to understand the vertical concentration distribution characteristics of outdoor atmospheric particulate matters in high-rise buildings for people living on

different floors [4]. The vertical distribution changing characteristics of outdoor atmospheric particulate matter in a high-rise building in Xi'an on working days and non-working days was tested and analyzed in this paper. It provides reference significance for controlling the concentration distribution characteristics of atmospheric particulate matters on different floors of high-rise buildings.

2 Methods

2.1 Test instrument

GRIMM1.109 portable aerosol particle size spectrometer

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was used to measure particulate matter concentration in the atmosphere. The measurement range is $0.1\sim100.000\mu\text{g}/\text{m}^3$. Repeatability is 5%. The indoor temperature and humidity were measured by TSI7525 indoor air quality tester. The measurement range is $0\sim60^\circ\text{C}$. Measuring accuracy $\pm 0.6^\circ\text{C}$. Relative humidity is measured in the range of 5 to 95% RH. The measurement accuracy is $\pm 3\%\text{RH}$. HD37AB1347 indoor air quality monitor was used to measure the flow rate. The measurement range is $0\sim50\text{ m/s}$. The measurement accuracy range is $\pm 3\%$.

2.2 Test content

A high-rise building in a university in Xi'an was used to the test target. The building is 3.3 meters high and has 29 floors. It is about 60m from the main road of the city. The school's basketball court, volleyball court and campus road are directly in front of the building. The tested different floors were included 1st, 7th, 11th, 17th, 23th and 27th floors of the high-rise building. The altitudes are 1.5 m, 23.1 m, 36.3 m, 56.1 m, 75.9 m and 89.1 m, respectively. The test time is 8:00, 14:00 and 21:00 respectively.

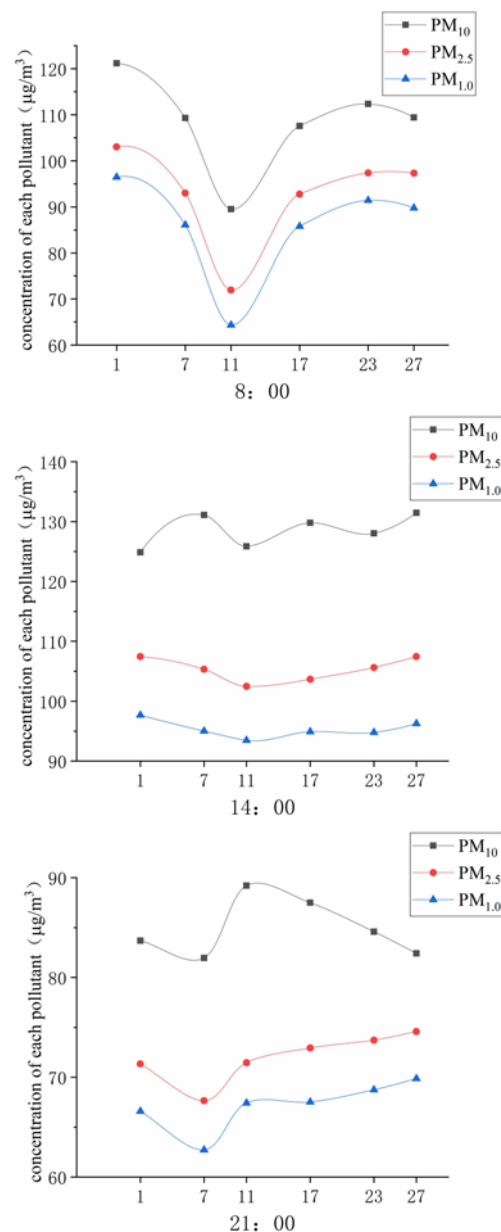
3 Results and Discussion

3.1 Variation characteristics of particulate matter concentration on different floors

Variation characteristics of particulate matter concentration on different floors in non-working days and working days were showed in Figure 1.

It could be seen from Figure 1(a), with the increase of building height, the mass concentrations of PM_{10} , $\text{PM}_{2.5}$ and $\text{PM}_{1.0}$ all showed a trend of first decreasing and then increasing at 8:00. When the time was 14:00, the mass concentration of PM_{10} first increased, then decreased and then increased. While the mass concentrations of $\text{PM}_{2.5}$ and $\text{PM}_{1.0}$ showed a trend of first decreasing and then increasing gradually. At 21:00, with the increase of building height, the mass concentration of PM_{10} first decreased, then increased and then decreased. The mass concentrations of $\text{PM}_{2.5}$ and $\text{PM}_{1.0}$ both showed a trend of first decreasing and then increasing. The change trend of the mass concentration

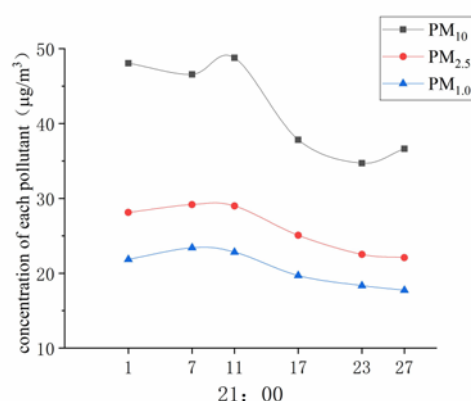
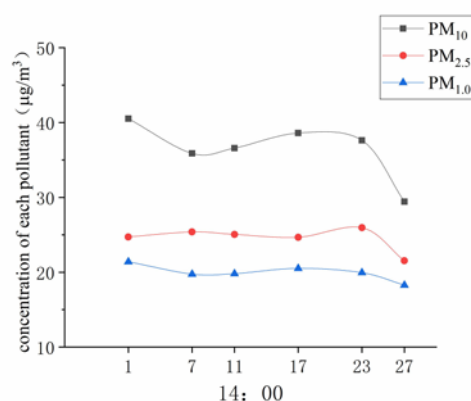
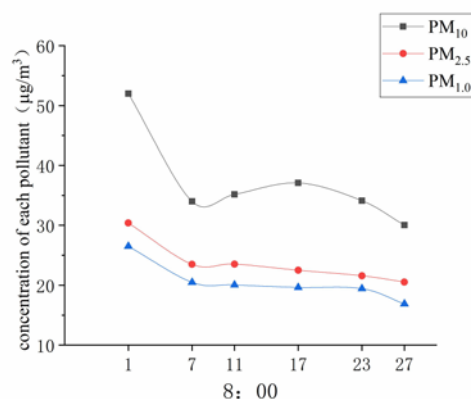
of particles with different heights at 8:00 and 21:00 was roughly the same. The main reason was that the temperature was lower in the morning and evening, and there was an inversion layer [5].



(a) Working days

From Figure 1(b) showed that at 8:00, with the increase of building height, the mass concentration of PM_{10} showed a trend of first decreasing, then increasing and then decreasing. While the mass concentrations of $\text{PM}_{2.5}$ and $\text{PM}_{1.0}$ both showed a decreasing trend. At 14:00, with the building height increased, the mass concentration of PM_{10} showed a trend of first decreasing, then increasing and then decreasing. The mass concentrations of $\text{PM}_{2.5}$ and $\text{PM}_{1.0}$ were relatively stable, with little change. At 21:00, with the increase of building

height, the mass concentration of PM_{10} first decreased, then increased and then decreased. The mass concentrations of $PM_{2.5}$ and $PM_{1.0}$ both increased first and then decreased.



(b) Non-working days

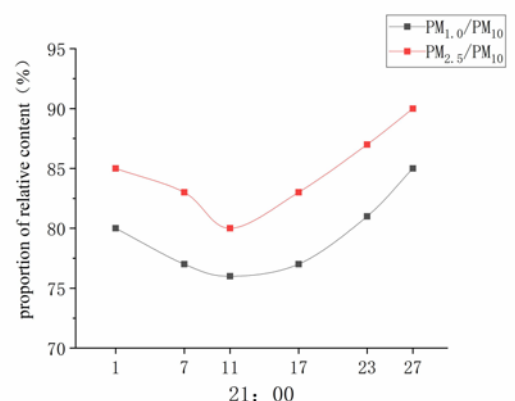
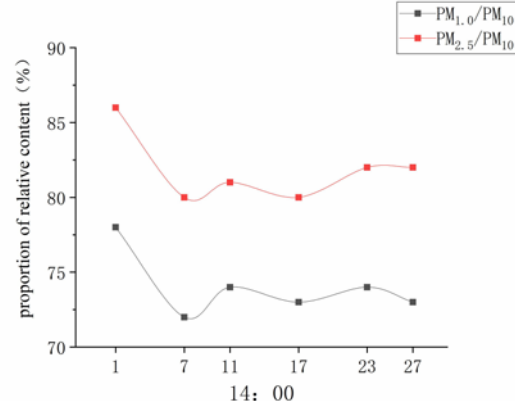
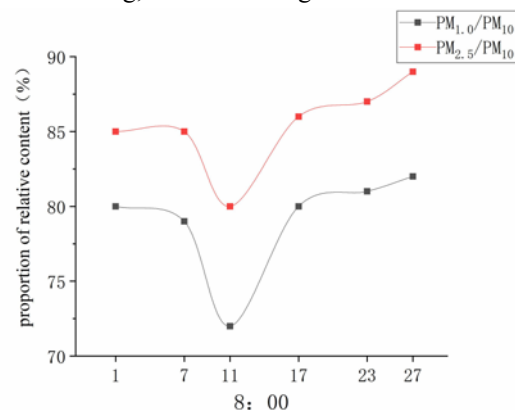
Fig. 1. Variation of particulates at different heights in non-working days and working days

3.2 Change of relative concentration of particulate matters on different floors

Changes in the relative concentration of particulate matter on different floors in working days and non-working days were showed in Figure 2.

It could be seen from Figure 2(a), at 8:00 and 21:00, with the increase of building height, $PM_{2.5}/PM_{10}$ and

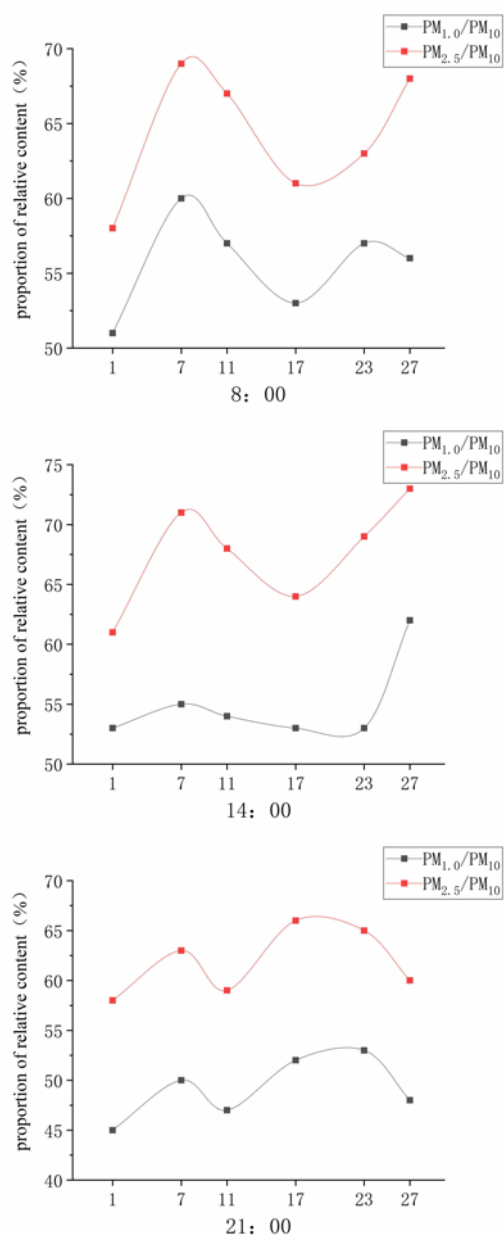
$PM_{1.0}/PM_{10}$ both showed a trend of first decreasing and then increasing. At 14:00, with the increase of building height, $PM_{2.5}/PM_{10}$ and $PM_{1.0}/PM_{10}$ both showed a trend of first decreasing, then increasing and then decreasing.



(a) Working days

From Figure 2(b) showed that at 8:00, 14:00 and 21:00, with the increase of building height, $PM_{2.5}/PM_{10}$ and $PM_{1.0}/PM_{10}$ showed a trend of first increasing, then decreasing and then increasing. The ratio of $PM_{2.5}/PM_{10}$ and $PM_{1.0}/PM_{10}$ was the highest at 14:00. The main reason was that there was sufficient sunshine at this time. With the increase of solar radiation, the ground temperature increased faster, the inversion layer near the ground was destroyed, and atmospheric convection caused the stability of the

atmospheric layer to be destroyed [6]. As a result, the concentration of particles in the upper air increased.



(b)Non-working days

Fig. 2 .Change of relative concentration in non-working days and working days

4 conclusion

A high-rise building of different heights in a university in Xi'an was tested and analyzed in this paper, and the results were showed as follows:

1.The variation trend of particulate matter concentration with the increase of vertical height was the same at all time in non-working days. While the variation trend of particulate matter concentration with

the increase of vertical height was basically the same at all time except 8:00 and 21:00 in working days. And the concentration of particulate matters in working days was significantly higher than that in non-working days.

2.PM_{1.0}/PM₁₀ and PM_{2.5}/PM₁₀ showed a trend of first increasing, then decreasing and then rising in different time periods in non-working days, and the ratio of PM_{2.5}/PM₁₀ and PM_{1.0}/PM₁₀ is the highest at 14:00. PM_{1.0}/PM₁₀ and PM_{2.5}/PM₁₀ showed a trend of first decreasing and then rising at all times in working days.

This paper has reference significance for the development of high-rise buildings and the effective control of the concentration of particulate matters in high-rise buildings.

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