The variation of atmospheric particulate matter concentration in the suburb areas over Fuzhou city

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Abstract. The atmospheric particulate matter concentration (APMC) and meteorological factor were supervised and analyze the variation and characteristics in Fuzhou National Forest Park. The result showed that: 1) the atmospheric particulate matter concentration is generally low in summer and high in winter, while in spring and autumn, the APMC with different diameters changed between summer and winter. 2) The daily variation of APMC in different seasons has different characteristics; 3) maximum wind speed, average wind speed, air pressure, wet bulb index, thermal index, humidity and temperature were the meteorological factors that affect APMC. Improving the site condition play a positive role on reducing the APMC and enhancing environmental functions.

1. Introduction

With the economic developed, life quality of residents has been generally improved. Health promotion has become an important part of tourism and residents when they are tripping. Due to convenient transportation and beautiful environment, suburban recreation areas have gradually become the most popular tourist sites [1-3]. Air quality as one of the criteria to evaluate the quality of recreation, people paid more and more attention on it. Due to atmospheric particulate matters (PMs) are the primary pollutant in city areas over China, the concentration of PMs are the certain standard to determine the level of recreational environment quality.

At present, the studies of PMs in various recreational areas were mainly concentrated in the different subsurface effects on PMs [4], the effect of plant configuration on dust removal effect [5-9] and the distance effect from different sources of pollution [10,11]. Suburban recreation should be plan by what, which season, which period, which type of recreation is the most suitable for visitors is a question worth discussion. Fuzhou is located in the southeast coast, the rapid economic development, industrialization and urbanization caused the increase of the concentration of PMs. Coupled with the basin near the formation of inversion and other special weather conditions, urban air pollution was increased [12]. This study focused on the concentration of PMs in Fuzhou, the diurnal variation of PMs and the meteorological factors were analyzed. The contents of PMs, including total suspended particulate (TSP, d≤100 μm), PM10 (d≤10), PM2.5 (d≤2.5μm) and PM1.0 (d≤1.0μm) were investigated.
Meteorological factors e.g. wind speed, air pressure, wet bulb index, heat index, temperature and humidity were also calculated and to explore the relationship between different types of PMs and meteorological factors to provide basic data for suburban recreational land planning and design, and enrich the relevant background of Fuzhou air quality research For Fuzhou.

2. Materials and methods

2.1. Overview of the study site
The annual temperature is 16 ~ 20 ℃, the average annual sunshine is 1700 ~ 1980h, the annual precipitation is 900 ~ 2100mm, the winter is short, cold and dry while summer is long, warm and humid. The coldest month are January-February with average temperature of 6-10 ℃, the extreme minimum temperature -1.2 ℃, the hottest months are July-August with average temperature of 24-29 ℃, the extreme maximum temperature of 42.3 ℃, relative humidity is around 77%.

2.2. Research methods
Days with typical weather were selected to monitored the data in spring, summer, autumn and winter, during the study period. Observation time are 7: 00, 9:00, 11:00, 13:00, 15:00, 17:00, 19: 00. The monitors were set with the height of 1.2 ~ 1.5 m, and 3 times were repeated at each observation point.

3. Result and analysis

3.1. Variation of seasonal mean value of atmospheric particulate matter concentration
The concentration of atmospheric particulate matter in the recreational area of Fuzhou National Forest Park has obvious seasonal variation, and the atmospheric particulate matter concentration with different particle size shows different variation characteristics. In general, the concentration of TSP in the total suspended particulates in autumn forest park was significantly lower than that in the other three seasons. The concentration of TSP was in the rake of spring, winter, summer, autumn (Figure 4-1). PM$_{2.5}$ and PM$_{1.0}$ showed different seasonal trends, and the order of the large particle size (TSP, PM$_{10}$) showed the same seasonal variation, and the order of the small particle size (PM$_{2.5}$, PM$_{1.0}$) , Spring, autumn, summer (Figure 1).

![Fig. 1 The seasonal variation of concentration of PMs](image)

The seasonal variation of atmospheric particulate matter at different particle sizes was also significantly different. Inhaled particulate matter and other two fine particulate matter concentrations were highest in winter, followed by spring, autumn and summer. PM$_{10}$ concentration was the lowest in autumn, and the lowest concentration of two fine particles (PM$_{2.5}$, PM$_{1.0}$) was spring (Fig. 2), the proportion of particles with smaller particle size is the lowest in spring, the highest in winter, and the difference between summer and autumn (Fig. 2). The main reason for this is that the contribution of spring dust to coarse particles is larger than that of fine particles. The contribution of winter coal to coarse particles is coarse.
3.2. Diurnal variation of atmospheric particulate matter at different seasons

3.2.1 Spring In spring, TSP and PM$_{10}$ diurnal curves were "V" shape, PM$_{2.5}$ and PM$_{1.0}$ diurnal curve was "U" type, the lowest value of the four particle size atmospheric particulate concentration were appears at noon (Fig. 3). From 7:00 am to 13:00 pm, PMs of each particle size were decreasing, and it starts to rise from 15:00 to 19:00 in the afternoon. At 7:00 and 9:00, the concentrations of PMs reached the peak. The concentration of atmospheric particles increases rapidly during 7:00 to 13:00, and the lowest is at 13:00, and then the upward trend is also larger, the whole variations showed "V" type change; and the fine particle is relatively large at 7:00 to 11:00, although it reaches the lowest value at 13:00, but the downward trend from 11:00 to 13:00 was slight, and the rising trend after 13:00 is also less obvious, the overall was oblique "U word" type.

![Fig. 2](image1.png)

**Fig. 2** The seasonal variations of the rate of smaller size PMs in the larger size PMs

![Fig. 3](image2.png)

**Fig. 3** The variations of diurnal concentration of PMs in spring

3.2.2 Summer The concentration of atmospheric particulate matter in summer was as high as that of summer and early afternoon (Fig. 4). The specific trends are: from 7:00 am to 13:00 pm, the atmospheric particulate matter concentration decreases from 15:00 to 19:00 in the afternoon, and the increase rate is small, and the monitoring time 7:00 in the segment is the peak. 7:00 to 13:00 to reach the lowest value, and a larger decline, followed by a slow upward trend.
3.2.3 Autumn In the autumn, the diurnal variation and characteristics of TSP, PM$_{10}$, PM$_{2.5}$ and PM$_{1.0}$ were similar to summer, and the whole curve showed "U" type, and the concentration of atmospheric particles was high at 7:00, and the lowest appeared at 13:00, in the afternoon the concentration of PMs increased slightly (Fig.5). Specific trends are similar to spring.

3.2.4 Winter In winter, the diurnal concentrations of TSP and PM$_{10}$ curves were "V" shape, PM$_{2.5}$ and PM$_{1.0}$ diurnal curve showed "oblique L word" type, the lowest of the four particle size of the atmospheric particulate concentration were appeared at 13:00 and increased in the afternoon (Fig. 6). All the four size of the particular meter showed two peaks, which were between 7:00 and 9:00 in the morning and 19:00 pm, respectively. At 7:00-13:00, the PM$_{2.5}$ and PM$_{1.0}$ were showed a downward trend, while the increase trend in the 13:00-19:00 was less obvious.
3.3. Correlation between meteorological factors and concentration of PMs

The concentrations of the atmospheric particulate matter are affected by the environmental factors such as meteorological factors. We found that the atmospheric particle concentration and meteorological factors (including wind speed, temperature, cold, relative humidity, Dew point temperature, wet bulb temperature) have a correlation. The results show that the environmental factors which affecting the atmospheric particles were wind speed, air pressure, wet bulb index, heat index, humidity and temperature. Among them, the relative humidity, heat index and air pressure have a significant positive correlation with the particles (TSP, PM$_{10}$, PM$_{2.5}$ and PM$_{1.0}$) with different particle sizes in the air, and the influence of the thermodynamic index on the TSP was obviously. The effect of atmospheric pressure on the particle size of each particle size was slight, and the atmospheric particulate matter concentration increases with the increase of air pressure and humidity. Wind speed, wet bulb index, temperature and atmospheric particulate matter were significantly negatively correlated. The wind speed was only related to the concentration of large particle size, while the wet bulb index and temperature were negatively correlated with the atmospheric particle concentration.

| PMs   | correlation | Wind Speed | Air pressure | Wet bulb | Thermal Index | Humidity | Temperature |
|-------|-------------|------------|--------------|----------|---------------|----------|-------------|
| TSP   | Pearson     | -0.19**    | 0.36**       | -0.54**  | 0.40**        | 0.91**   | -0.53**     |
|       | Significance| 0.32       | 0.00         | 0.00     | 0.00          | 0.00     | 0.00        |
| PM$_{10}$ | Pearson  | -0.017     | 0.45**       | -0.53**  | 0.19*         | 0.72**   | -0.87**     |
|       | Significance| 0.27       | 0.00         | 0.00     | 0.09          | 0.00     | 0.00        |
| PM$_{2.5}$ | Pearson | 0.20       | 0.122        | 0.59**   | -0.81**       | -0.13    | 0.58**      |
|       | Significance| 0.83       | 0.26         | 0.00     | 0.00          | 0.14     | 0.00        |
| PM$_{1.0}$ | Pearson  | 0.10       | 0.57**       | -0.81**  | -0.16*        | 0.67**   | -0.75**     |
|       | Significance| 0.11       | 0.00         | 0.00     | 0.03          | 0.00     | 0.00        |

4. Conclusion

The results show that the atmospheric particulate matter concentration was met the national II emission standards by CAAQS, and the air quality was relatively good, by the consistent of the results of previous studies [9-11]. It also showed that, the seasonal variation of air quality was obvious with winter and spring was high while in summer and autumn air quality was better in Fuzhou National Forest Park. Combined with the experimental results with the major cities of atmospheric particulate comparison [6-10], indicating that Fuzhou ecological environment was good, long-term investment in environmental protection has made a significant effect. The construction of the recreational area has improved the living environment of the public. Based on the study of the seasonal variation of atmospheric particulate matter in this study, we will further study the variation and characteristic of atmospheric particulate matter concentration in a wide range of recreational land in Fuzhou, and provide some guidance for improving the landscape planning and construction of Fuzhou air ecology. For relative humidity, heat index and air pressure have significant positive correlations with different particle size in air, the meteorological factors are worth to concern to improve the air quality.

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