Study on the Concentration Level and Influence Factors of the Indoor Particles in the Office Building

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Abstract. In order to understand the indoor and outdoor inhalable particulate matter concentration and its influencing factors in cold areas, two different airtight office buildings in cold area were studied.The concentrations of PM2.5 and PM10 in indoor and outdoor were measured in the winter of 2015, summer in 2016 and winter of 2016..And the indoor and outdoor factors of office buildings PM2.5 and PM10 were analyzed.The results showed that PM2.5 and PM10 concentrations in indoor and outdoor were different in different degrees during the measurement period.Meteorological conditions, the airtightness of the envelope is the main factor affecting the indoor and outdoor relations, PM2.5 and PM10 I / O ratio, indoor respirable particulate matter impact.In addition, the correlation between the I / O ratio of PM2.5 and PM10, and the concentration of indoor and outdoor respirable particulate matter was studied.The results provide a basis for the study of barrier properties of outdoor inhalable particles and the improvement of indoor environmental quality.

Keywords: public buildings, inhalable particulate matter (PM2.5 and PM10), mass concentration, influencing factors.

1 Introduction

People spend more than 85 percent of their time indoors, so indoor environmental quality has a far greater impact on people's quality of life and public health than outdoor environmental quality.According to relevant research, the increase of human mortality and morbidity has a significant relationship with particulate matter exposure [1].Increased incidence of pulmonary disease and cardiovascular disease is associated with the increase of particle concentration, air inhalable particles (PM10) in the average increased by 10%, a 1% drop in lung function, all kinds of respiratory symptoms and diseases such as cough, asthma and a 10% increase in [2].

Shenyang is located in the cold climate area of China's architectural climate zoning, which is a temperate semi-humid continental climate city. Winter for nearly six months and very cold, the annual temperature between -35 ℃ ~ 36 ℃.In order to clarify the influence of the change of concentration of particulate concentration in the buildings in the cold region, this paper selects the typical city of shenyang as the research object.Analysis of two buildings indoor and outdoor PM2.5 and PM10 daily average concentration, the instantaneous concentration and the I/O than change rule, etc., and through the change rule of indoor and outdoor concentrations change correlation, regression and comparison with the values specified in the research, the office building indoor PM10 concentration level and its influencing factors were analyzed.

2 Method

2.1 Test location

The experiment in the January 20, 2009 to January 22, 2016 July 18 to August 03 and 2017 between February 28 to March 13,during the period,Measurement point A and point B and outdoor measurement point C particle mass concentration were measured.As shown in fig.1, the outdoor measuring point C chooses a platform closer to the two measuring points, which can be considered as the same as the atmospheric environmental parameters in the indoor and outdoor measuring points C.There are no obvious outdoor pollution sources such as construction and factory.Measuring point A, measuring point B and measuring point C position shown in Figure 2.

(a) measuring point A (b) measuring point B (c) measuring point C

Fig. 1. Appearance of A, B and C buildings

Fig. 2. Points A, B and outdoor measuring point C position diagram

Both buildings are public office buildings. During the test period, keep the observation points A and B doors and Windows closed, ensure that the ventilation and ventilation equipment is closed and there is no staff activity in the measuring room.Point A window outside air tightness levels to grade 8, point B outside window tightness level to grade 4, the site of the two doors in the building interior, ignore the adjacent room influence on indoor particulate matter concentrations of measuring points.

Table 1. Air tightness performance of exterior doors and Windows

Grade	1	2	3	4	5	6	7	8
Unit seam length grading index value q_1 [$m^3/m \cdot h$]	4.0≥q_1 >3.5	3.5≥q_1 >3.0	3.0≥q_1 $_1$>2.5	2.5≥q_1 >2.0	2.0≥q_1 >1.5	1.5≥q_1 >1.0	1.0≥q_1 >0.5	q_1≤0.5
Unit seam area grading index value q_2 [$m^3/m^3 \cdot h$]	12≥q_2 >10.5	10.5≥ q_2>9.0	9.0≥q_2 >7.5	7.5≥q_2 >6.0	6.0≥q_2 >4.5	4.5≥q_2 >3.0	3.0≥q_2 >1.5	q_2≤1.5

2.2 Measuring methods and instruments

This article according to "Ambient air quality standards" GB3095-2012 [3] measured by weight method. The test sampling time is set between 10:00 and 9:00 for a total of 23 hours per day. The selection of the measuring point position According to the "Ambient air PM2.5 and PM10 measured weight method" HJ618-2011 [4] provides, combined with the actual situation will be placed in the indoor measuring point from the outer window about 1.5m, about 1.2m from the ground position.2030 Laoying intelligent TSP sampler was used to detect PM2.5 and PM10 daily average concentration range, the parameters of the apparatus (60~130) L/min, a resolution of 0.1 L/min, the accuracy is not more than ± 2.5%.The PM2.5 instantaneous concentration was monitored using the atmospheric dust detector (DUST TRAK II 8532) produced by TSI. The instrument was in the range of 0.001 to 400 mg/m3 and the sampling flow was 3.0 L/min with a resolution of ±0.1% reading, 0.001mg/m3. Instantaneous value measured and daily average sampling the same number of days, respectively, the three measured points measured, the test time from 08:00 to 20:00, the time interval of 2 hours. The instantaneous value uses the mean of 1 minute for the time node.

3 Results

Table 2 shows the mean daily concentration of PM2.5 for the three measured periods. Table 3 shows the mean daily concentration of PM10 for three measured periods.From table 2 and table 3, it can be seen that the mass concentration of indoor and outdoor particulates (PM2.5 and PM10) varies greatly in different seasons,the trend of the mass concentration is 2016-01-09 to 2016-01-22 mass concentration > 2017-02-28 to 2017-03-13 mean value of concentration > 2017-02-28 to 2017-03-13 mean value of concentration .

This is because coal is mainly used to supply energy for winter heating in shenyang, 2016-01-2016-01-22 is the peak heating period of shenyang in a year, and 2017-02-28 to 2017-03-13 is the low peak period of the year of heating. The burning process of coal produces a lot of particulate matter which is the main source of haze.The particle mass density contrast of three measuring points, measuring point C > measuring point B > measuring point A, this is because in the process of the measured indoor air pollution, indoor particulate matter contribution comes from outside, and the palisade structure of the measuring point A tightness (grade 8) higher than that of point B(grade 4) it can more effectively stop the outdoor particles through the palisade structure into indoor.

Table 2. Summary of the three measured PM2.5 mass concentration

Testing time	PM2.5 mass concentration mean(μg/m³)		
	Point A	Point B	Point C
2016-01-09 to 2016-01-22	53.74	59.91	91.37
2016-07-18 to 2016-08-03	16.31	21.46	54.53
2017-02-28 to 2017-03-13	24.71	29.27	67.34

Table 3. Summary of the three measured PM10 mass concentration

Testing time	PM10 mass concentration mean(μg/m³)		
	Point A	Point B	Point C
2016-01-09 to 2016-01-22	61.38	68.76	132.22
2016-07-18 to 2016-08-03	21.38	25.15	79.85
2017-02-28 to 2017-03-13	30.43	33.3	94.05

4 Discussion

4.1 Summary of the number of days during the measurement period

Table 4 shows the actual measurement of PM2.5 mass concentration of the number of days, Table 5 shows the actual measured PM10 mass concentration of the number of days.Table 5 in the outdoor test point C in the standard value of 150 μg/m³ selected according to the "ambient air quality standards" GB3095-2012;Table 4 in the indoor measuring point A and measuring point B of the standard value of 75 μg/m³ selected according to the "Building Ventilation Test and Evaluation Criteria"[5] JGJT309-2013,Table 4 in the indoor measuring point A and measuring point B of the standard value of 75 μg/m³ selected according to "Indoor Air Quality Standard"[6] GB / T18883-2002.

Table 4. PM2.5 mass concentration of the number of days

Item	2016.01.09 to 01.23			2016.07.18 to 08.03			2017.02.28 to 03.13		
	C $PM_{2.5}$	A $PM_{2.5}$	B $PM_{2.5}$	C $PM_{2.5}$	A $PM_{2.5}$	B $PM_{2.5}$	C $PM_{2.5}$	A $PM_{2.5}$	B $PM_{2.5}$
Standard value/(μg/m³)	75	75	75	75	75	75	75	75	75
Standard Days	4	14	11	13	17	17	10	14	14
Exceeded days	10	0	3	4	0	0	4	0	0
Standard rate/(%)	28.57	100.00	78.57	76.47	100.00	100.00	71.43	100.00	100.00

Table 5. PM10 mass concentration of the number of days

Item	2016.01.09 to 01.23			2016.07.18 to 08.03			2017.02.28 to 03.13		
	C PM2.5	A PM2.5	B PM2.5	C PM2.5	A PM2.5	B PM2.5	C PM2.5	A PM2.5	B PM2.5
standard value/(μg/m³)	150	150	150	150	150	150	150	150	150
Standard Days	6	14	14	17	17	17	12	14	14
Exceeded days	8	0	0	0	0	0	2	0	0
Standard rate/(%)	42.86	100.00	100.00	100.00	100.00	100.00	85.71	100.00	100.00

4.2 I/ O ratio

I/O ratio refers to the indoor and outdoor inhalable particulate matter ratio, directly reflects the indoor and outdoor particle concentration relationship[7].Table 6 shows the PM2.5 I/O ratio of point A and point B. Table 7 shows the PM10 I/O ratio mean of point A and point B.

Table 6. PM2.5 I/O ratio

Testing time	$PM_{2.5}$ I/O ratio	
	Point A	Point B
2016-01-09 to 2016-01-22	0.60	0.67
2016-07-18 to 2016-08-03	0.32	0.42
2017-02-28 to 2017-03-13	0.38	0.44

From Table 6 and Table 7, the PM2.5 and PM10 I/O ratios of point A are bigger than the PM2.5 and PM10 I/O ratios of point B, which is due to the air tightness of the envelope of point A (grade 8) higher than the measuring point B of the air tightness (grade 4),can block more of the particles into the room;comparison of the I/O ratio in the three actual measurement processes, there were 2016-01-09 to 2016-01-22 I/O ratio Mean> 2017-02-28 to 2017-03-13 I/O ratio Mean> 2017-02-28 to 2017-03-13 I/O ratio Mean,this is due to indoor exposure to high concentrations of outdoor concentrations of outdoor particles in the case of indoor concentration will reach a higher concentration, resulting in I/O than the mean increase.

Table 7. PM10 I/O ratio

Testing time	PM_{10} I/O ratio	
	Point A	Point B
2016-01-09 to 2016-01-22	0.48	0.53
2016-07-18 to 2016-08-03	0.28	0.33
2017-02-28 to 2017-03-13	0.33	0.36

4.3 Indoor concentration varies with outdoor concentration

Fig.3, Fig.5, Fig.7, respectively, from 2016 January 9 to January 22, 2016 July 18 to August 03 and 2017 February 28 to March 13 during the point A and point B PM2.5 concentration with the outdoor changes;Fig.4, Fig.6,Fig.8, respectively, PM10 concentration with the outdoor changes.It can be seen from Fig.3 to Fig. 8 the R value of the measurement point B is greater than the R value of A, which indicates that the indoor PM2.5 and PM10 in the measuring point B are significantly affected by outdoor.

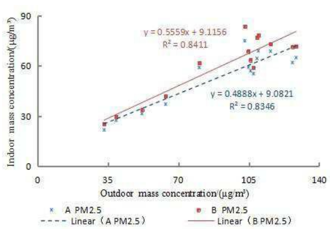

Fig. 3. PM2.5 linear regression

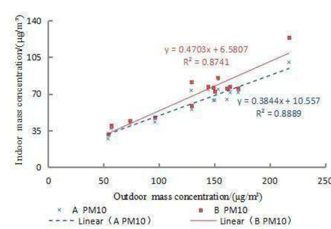

Fig. 4. PM10 linear regression

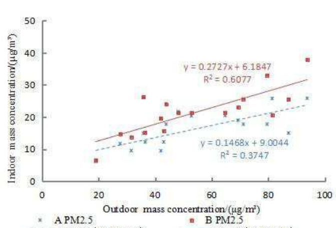

Fig. 5. PM2.5 linear regression

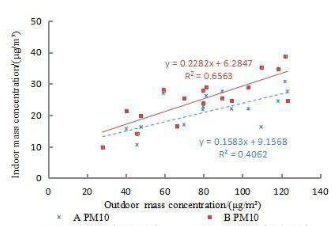

Fig. 6. PM10 linear regression

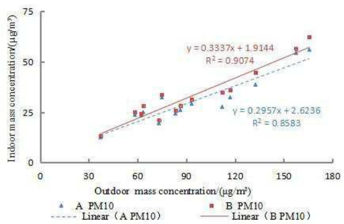

Fig. 7. PM2.5 linear regression

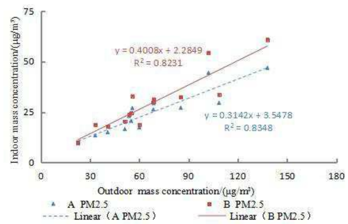

Fig. 8. PM10 linear regression

4.4 Indoor maximum outdoor concentration forecast

The indoor PM2.5 limit 75 μg/m³and the PM10 limit 150 μg/m³are the maximum, which is stipulated in the "Standard for the test and evaluation of building ventilation effect"JGJT309-2013 and the"Indoor Air Quality Standard"GB/T18883-2002, According to the linear relationship of Fig.3 to Fig.8, the maximum outdoor PM2.5 and PM10 mass concentrations that can be tolerated by point A and point B in different time periods can be calculated, as shown in Table 7.

Table 8. Predicts maximum PM2.5 and PM10 maximum concentrations

Testing time	Predicted to withstand the maximum outdoor PM2.5 concentration(μg/m³)		Predicted to withstand the maximum outdoor PM10 concentration(μg/m³)	
	Point A	Point B	Point A	Point B
2016-01-09 to 2016-01-22	134.86	118.52	362.75	304.95
2016-07-18 to 2016-08-03	366.04	262.68	952.27	695.48
2017-02-28 to 2017-03-13	227.41	181.42	498.40	443.77

5 Conclusion

Comparison of PM2.5 and PM10 average concentration range and sample mean value of point A, point B and point C, it can be seen that point A is superior to point B for outdoor inhalable particulate matter, mainly because The air tightness of the envelope of point A is better than that of point B.

Compared with the actual measurement rate of PM2.5 and PM10 in the three actual measurement processes, it can be seen that the outdoor PM2.5 and PM10 compliance rates are low at the peak of heating, which is mainly due to the coal combustion in winter heating and the coal combustion process dust is the main cause of the formation of haze.

The I/O ratio of the measuring point A is smaller than the I/O ratio of the measuring point B. This is because the air tightness (grade 8) of the envelope of the measuring point A is higher than the air tightness of the measuring point B (grade

4)blocking more of the particles into the room;Compared with the PM2.5 and PM10 I/O ratios during the three measurements, it can be seen that the I/O ratio increases when the room is exposed to high concentrations of outdoor particles for a long time.

The maximum concentration of PM2.5 and PM10 can be calculated according to the standard limit value. The results show that the measurement point A with high air tightness (grade 8) can withstand higher outdoor concentration;The higher the mass concentration of outdoor particulate matter (PM2.5 and PM10), the lower the outdoor concentration.

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