Measuring and analyzing environment parameters of Dalian Maple Leaf International School

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Abstract. This paper mainly investigates and analyzes the environment quality of Dalian Maple Leaf International School. Firstly, indoor and outdoor environment parameters are measured, including air quality parameters, noise level parameters, and illuminance parameters. Secondly, by the comparison with environmental quality standards stipulated by China, the environment quality in Dalian Maple Leaf International School is assessed. Finally, some suggestions are given to improve the school environment quality.

1 Introduction

In recent years, the establishment of a green campus environment throughout the country has received much attention. In 2013, the China Urban Science Research Council Green Building and Energy Conservation Professional Committee organized and published the “Green Campus Evaluation Criteria”.^[1] It stipulated that seven categories of indicators would be used to evaluate a campus: planning and sustainable development sites, energy conservation and utilization, water conservation and utilization, material conservation and utilization, indoor environment and pollution control, and operation management. In 2014, Ding Qi and Qian Jia took the University of California at Berkeley as an example to study the overall sustainable development framework of the green campus evaluation system^[2]. In 2015, from the aspect of energy conservation, Dong Jing expounded the issues of site planning, wall insulation design, building ventilation and indoor lighting of green campus^[3]. In 2016, Liao Shoufeng analyzed and compared the mainstream green campus evaluation standards of China, the United States and Britain, and gave suggestions on the development of China's green campus evaluation standards on the basis of summarizing the emphasis and differences between the standards on environmental and health indicators^[4]. In 2017, Han Feng discussed the feasibility of applying existing technical means to improve campus air quality.^[5]

On the basis of continuous monitoring of Dalian Maple Leaf International School indoor and outdoor environmental parameters, combined with the “green campus evaluation criteria,”^[1] “ambient air quality standards”^[6], “environmental electromagnetic health standards”^[7] and other norms of environmental quality, this paper thoroughly examines the environmental quality of Dalian Maple Leaf International School. The environmental parameters involved include: the air

quality parameter, the noise level parameter, and the light parameter.

2 Experimental Process

2.1 Air quality parameter

The monitored air quality parameters include Total Suspended Particle (TSP), Respirable Particulate Matter (PM10), fine particles (PM2.5), Air Quality Index (AQI), the concentration of formaldehyde, and the concentration of oxygen. Among them, TSP, PM10 and PM2.5 refer to particles in the ambient air with aerodynamic equivalent diameters less than or equal to 100 μm, 10 μm and 2.5100 μm respectively.

According to the “Environmental Air Quality Index (AQI) Technical Regulations (Trial)”^[8], AQI is calculated by the following formula

$$AQI = \max \{I_1, I_2, I_3, I_4, I_5, I_6\} \quad (1)$$

Among them, I_k $k = 1, 2 \dots 6$, represents the air quality sub-index of six air pollutants: PM2.5, PM10, ozone (O₃), sulfur dioxide (SO₂), nitrogen dioxide (NO₂) and carbon monoxide (CO), respectively. The air mass sub-index of the kth air pollutant is calculated by

$$I_k = \frac{I_k^H - I_k^L}{C_k^H - C_k^L} \times (C_k - C_k^L) + I_k^L \quad k = 1, 2 \dots 6 \quad (2)$$

C_k is the mass concentration of the kth air pollutant obtained through the process of monitoring. C_k^L and C_k^H are the limit values close to the value of C_k . The

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relationship between C_k , C_k^L , and C_k^H can be determined through the value of C_k . The relationship is

$$C_k \in [C_k^L, C_k^H] \quad (3)$$

That is, C_k^L and C_k^H are the upper and lower limits of the associated interval respectively. I_k^L and I_k^H are the “Air Quality Sub-Index” values, and they correspond to the value of C_k^L and C_k^H .

According to National Standards [8], AQI is divided into six levels: 0-50 (excellent), 51-100 (good), 101-150 (mild pollution), 151-200 (moderate pollution), 201-300 (high pollution), and greater than 300 (severe pollution).

The indoor and outdoor air quality parameters of Dalian Maple Leaf International School were monitored using “Lekong Laser Particle Multi-Function Detector” and “Xima Oxygen Detector”, as shown in Figures 1 to Figures 6. Among them, the abscissa is the number of monitoring, the ordinate is HCHO, oxygen concentration, TSP, PM10, PM2.5 and AQI, and the red solid line is the limit value specified by the National Standard.

Fig. 1. The curve of formaldehyde

According to the “Green Campus Evaluation Criteria” [1] and the “Code for Indoor Environmental Pollution Control of Civil Building Engineering” [9], the formaldehyde concentration limit in the school room is $0.08\text{mg}/\text{m}^3$. Figure 1 shows that the formaldehyde concentrations in classrooms, canteens and playgrounds are less than the national limit, which comply with the standard.

Fig. 2. The curve of oxygen concentration

According to the Safety Regulations for Hazardous Oxygen Operation [10], the oxygen concentration must be greater than 19.5% in the places where the risk of hypoxia operation are high. Figure 2 shows that the oxygen concentrations in classrooms, canteens and playgrounds are about 20.8%, much higher than the limit of 19.5%.

In Figure 3, the black curve is the playground measurement with a peak point on it, which is the result of a sudden change in weather. Figure 3 shows that the TSP matter per unit volume of the canteen is much higher than the classroom and playground values.

Fig. 3. The curve of Total Suspended Particulate (TSP)

Fig. 4. The curve of PM10

Fig. 5. The curve of PM2.5

According to the Ambient Air Quality Standard [6], the 24-hour average concentration limits for PM2.5 and

PM10 are $75\mu\text{g}/\text{m}^3$ and $150\mu\text{g}/\text{m}^3$, respectively.

Figures 4 and 5 show that the concentrations of PM10 and PM2.5 in the classroom and playground are both below the limit, in line with national standards; the concentration of PM10 and PM2.5 in the canteen exceeds the standard.

Fig. 6. The curve of Ambient Air Quality

Figure 6 shows that the AQIs of the classroom and playground are less than 50, which are at excellent levels; the AQI of the canteen is greater than 150, which is moderate pollution.

The curves from Figures 3 to 6 show that the air quality of the canteen is poor. The direct cause is that the ventilation of the canteen is not smooth.

In order to compare with the average air quality of Dalian, Figure 7 exhibits three AQI curves. Among them, the blue line is the average air quality index AQI curve of Dalian city from the Dalian Air Quality Index issued by Dalian Meteorological Bureau from April 01 to April 12, 2018. The green line is Dalian Maple Leaf International School Classroom AQI curve. The black line is the AQI curve of the playground of Dalian Maple Leaf International School.

Fig. 7. Comparison of air quality between classrooms and playgrounds in Dalian city and Dalian Maple Leaf International School

Figure 7 shows that the air quality of the playground of Dalian Maple International School is better than that of the classroom. The air qualities of classrooms and playgrounds are significantly better than that of Dalian. Dalian Maple Leaf International School is closed to the sea, with few residents nearby and no high-pollution enterprises. The natural environment is the direct reason why its air quality is significantly better than the Dalian city average.

2.2 Environmental noise parameter monitoring and analysis

When there are sound waves, the pressure in the air exceeds the static pressure. For normal person, the threshold sound pressure of 1000 Hz is $2 \times 10^{-5} \text{Pa}$,

the pain threshold sound pressure is 20Pa , 10^6 times difference between the two. The sound pressure level SPL is in the unit of decibels (dB) and its definition expression is

$$\text{SPL} = 20 \lg \left(\frac{P}{P_0} \right) \quad (4)$$

Among them, $P_0 = 2 \times 10^{-5} \text{Pa}$ is the reference sound pressure. According to the expression (4), the threshold sound pressure level is 0 dB, and the pain threshold sound pressure level is 120 dB. Through the definition of sound pressure level, the range of sound characteristic parameters is reduced from $[P_0 = 2 \times 10^{-5} \text{Pa}, 20 \text{Pa}]$ to $[0 \text{dB}, 120 \text{dB}]$, which facilitates the analysis and evaluation process of noise.

According to Chinese standards and International standards [11], the Equal Loudness Level curve is a curve of the pure tone, sound pressure level and frequency that the typical listener considers to be the same loudness. The abscissa is the frequency, and the ordinate is the sound pressure level. The sound with the frequency of 1000Hz represents a certain sound pressure level that is used as a reference. The sounds of other frequencies are compared with the reference to find the sound pressure level. When the human ear feels the loudnesses are the same, the points with the same loudness are connected, and an equal loudness curve is drawn. The loudness value of the loudness level curve is defined to be equal to the value of the sound pressure level at a frequency of 1000 Hz on the curve, and the unit of loudness is Phon. When a 40 Phon loudness curve is used, and the measured sound pressure level value is calibrated by interpolation method, the sound pressure level of the A-frequency weighting can be obtained. Similarly, when a 70 Phon or 100 Phon loudness level curve is used to calibrate the measured sound pressure level value, the sound pressure level of the B frequency weighting or the sound pressure level of the C frequency weighting can be obtained.

The “Aihua Brand Sound Pressure Meter” was selected to monitor the indoor environmental noise of Dalian Maple Leaf International School. The sound pressure level curves of classrooms, canteens and bedrooms were plotted, as shown from Figures 8 to Figure 10. In these figures, the abscissa is the number of monitoring, the ordinate is the sound pressure level, and the red line is the A sound pressure level limit specified by the national standard. According to the “Acoustic Environmental Quality Standards” [12] and “Social Living Environment Noise Emission Standards” [13], the daily limit of the sound frequency level of the frequency of the cultural education places is: 45dB in the classroom, 45dB in the canteen, 40dB in the dormitory, respectively.

Fig. 8. The curve sound pressure level in classroom

Fig. 9. The curve of sound pressure level in canteen

Fig. 10. The curve sound pressure level in bedroom

Figure 8 to 10 show that the canteen has the highest sound pressure level, followed by the bedroom, and the classroom is the smallest. The sound pressure levels of three places are higher than the national limit, which is the result of the measurement time limitation. The research team members often chose meal time, class time and self-study bedtime to measure the data, which contains the voice of people.

2.3 Environmental illuminance parameter monitoring and analysis

Illuminance describes the luminous flux per unit area of the surface of the object being detected, and its definition expression is

$$L = \frac{\Phi}{A} \quad (5)$$

where, Φ is the luminous flux received by the surface of the object to be detected, the international unit is lumens

(Lm); A is the surface area of the object to be inspected, and the international unit is square meters; L is the illuminance of the surface of the object to be inspected, and the international unit is Lux (Lx).

The Unicent license meter was used to monitor the indoor illuminance value of Dalian Maple Leaf International School. The illuminance curves of the classroom, canteen and bedroom were plotted, as shown in Figure 11 to Figure 13. In these figures, the abscissa is the number of monitoring, the ordinate is the illuminance, and the red line is the illuminance limit specified by the national standard.

Fig. 11. The curve illumination in classroom

Fig. 12. The curve illumination in canteen

Fig. 13. The curve illumination in bedroom

According to the Architectural Lighting Design Standards [14], the illumination limit of the classroom desk is 300 Lx, the restaurant table illumination limit is 150 Lx, and the bedroom reading area illumination limit is 150 Lx.

Figure 11 to Figure 13 show that the illumination of classrooms and canteens are often lower than the national limit, but the average illumination of the bedroom meet the standard. The reason why the illumination of the classroom does not meet the standard

is that the lighting is not fully illuminated; the reason for the lack of illumination in the dining hall is that the lighting in the dining hall is not good, and the lighting is not fully illuminated.

3 Conclusion

The results of the monitoring and analysis on environmental parameters of Dalian Maple Leaf International School have shown that

(1) The air quality is generally good. The school's location is closed to the sea without polluting factories and much residents nearby, which makes the air quality significantly better than the average air quality of Dalian. However, due to poor ventilation in canteen, the value of TSP in canteen displays that PM10 and PM2.5 exceeds the standard. Therefore, it is recommended to upgrade and renovate the canteen ventilation system.

(2) The indoor sound pressure level is higher than the national limit, which is the result of the measurement time limit. The members of the research team often perform measurement during the meal time, the class time and the self-study bedtime, so the sound pressure level data contains the voice of the person talking and noisy. It is recommended that students in the classroom should not shout loudly to ensure that the classroom is quiet and convenient for others to learn.

(3) The average illuminance of the bedroom is in line with national standards, but the illumination measurements in classrooms and canteens are often below national limits. The reasons why the classroom and canteen illumination is not up to standard are: the lights are not all lit and the lights are not in good conditions. It is recommended to light up all the lights in the classroom to ensure illumination above 300Lx to protect the students' eyes.

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