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Investigation and Measurement Analysis of Campus Noise Pollution Based on a University in Hengyang

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Abstract: In view of the increasingly serious problem of noise pollution in students' life and study in the process of building campus culture, this paper analyzed the acoustic environment and acoustic comfort of a college in Hengyang by means of questionnaires, on-site measurement and mathematical model evaluation. After field measurement, the survey found that students are mainly concentrated in dormitory, teaching building and library. The over-standard rates for each location were 87.5%, 54.2%/50%, and 37.5%, respectively. Then this paper used the mathematical model based on fuzzy matrix method to calculate that the membership degree of college acoustic environmental quality belongs to slight pollution is the largest, which is 0.3775. It is advised that relevant departments should adopt a restriction strategy on the noise source to change the acoustic environment and sound comfort of the school.

1.Introduction

Colleges and universities are good places for teaching, scientific research, life, entertainment, production and other functions[1]. A good sound environment can ensure the physical and mental health of teachers and students, and ensure the high-quality completion of learning, work and other tasks. However, due to the unreasonable campus location, the building structure and decoration, and the campus noise control, which makes colleges and universities face serious noise pollution problems. Kurra et al. validated that living noise was the main indoor noise, followed by mechanical and electrical equipment noise, especially HVAC equipment noise through a series of surveys in Turkey and Brazil [2]. Bridgetshiel et al. surveyed outdoor noise in 142 schools in London, it was also found that the traffic noise is the most serious among the outdoors noises [3], and the noise from the adjacent room was the most serious among the noises heard indoors [4]. Shantou University of China has systematically monitored and analyzed campus noise, it was found that the noise was caused by the traffic both on and off campus, students' daily activities on campus, and business activities around the campus [5]. Lanzhou University, Northwest University for Nationalities and other universities have also carried out the campus acoustic environment monitoring and evaluation work and obtained the solution of noise control [6].

However, due to the differences of regional culture and economic development level, the noise climate of cities in different regions are significantly different, and it is hard to understand the general level of sound environment in Colleges and universities. This paper is based on a college in Hengyang to carry out the acoustic environment measurement and questionnaire survey. To further clarify the campus acoustic environmental pollution level, we also combined the evaluation of mathematical model, which provided reference for the formulation of corresponding noise prevention methods.



2. Correlation analysis of questionnaires

2.1 Determining the location of the noise analysis

This survey collected 503 questionnaires in total, there were 500 valid questionnaires, which from all grades. The survey results showed that 96.12% of the students believed that there was a little noise pollution on campus, which had impact on life and study. This study used the method of surveying the students' concentrated distribution throughout the day. It was found that students mainly concentrated in the teaching building in the morning and afternoon, concentrated in the library at night (night self-study time), and concentrated in the dormitory at night. Then, the field measurement work were carried out at the corresponding time and place. This work monitored the noise of the three locations to determine whether the acoustic environment quality reach the standard.

2.2 Noise measurement and results analysis

Referring to GB3096-2008 [7], the teaching buildings, libraries and dormitories belong to the category 1 of acoustic environment functional areas, the noise can not exceed 55dB during the day and 45dB at night. The measurements started in November 2018 for a total of 7 days. The measuring time was 8:00 to 12:00 a.m., 12:00 to 14:00 noon , 15:00 to 19:00 p. m., and 21:00 p. m. to 01:00.

2.2.1 Test conditions. Referring to reference [7], the survey measured the noise of the NO.1 teaching building twice, they are tested in the morning and in the afternoon. The test height of all measuring points is 1.2 m away from the ground. The test time is 20 min according to the standard requirement, 4 groups per test, and one group of data is measured every 5 min Each group of data has 4 test values (L10, L50, L90, Leq) [8], one test point measures 24 sets of data. The weather was good during the test, the wind speed was below 5m/s [9], and the sampling interval was no more than 1s. The measuring instrument used in the monitoring is AWA6228 Class A sound level meter.

2.2.2 Test results. After investigation, it was found that the noise in the morning and afternoon were mainly concentrated in the teaching building, so we measured separately in the morning and afternoon. In the odd and even areas of the NO.1 teaching building, each area were selected 12 measuring points which were evenly distributed. So we measured separately in the morning and afternoon. In the odd and even areas of the NO.1 teaching building, each area were selected 12 measuring points which were evenly distributed. Each measuring point data was measured during the class time. The following noise distribution results were obtained in Figure 1:

In the morning , 13 of the 24 measuring points exceed the allowable range, the unqualified rate is 54.2%. In the afternoon , half of the data among the 24 measuring points exceed the actual allowable maximum, and the over-standard rate reach 50%, which intuitively reflect that the sound environment of the teaching building is not ideal. It may be related to the movement of students outside the corridor and the voice of the conversation.

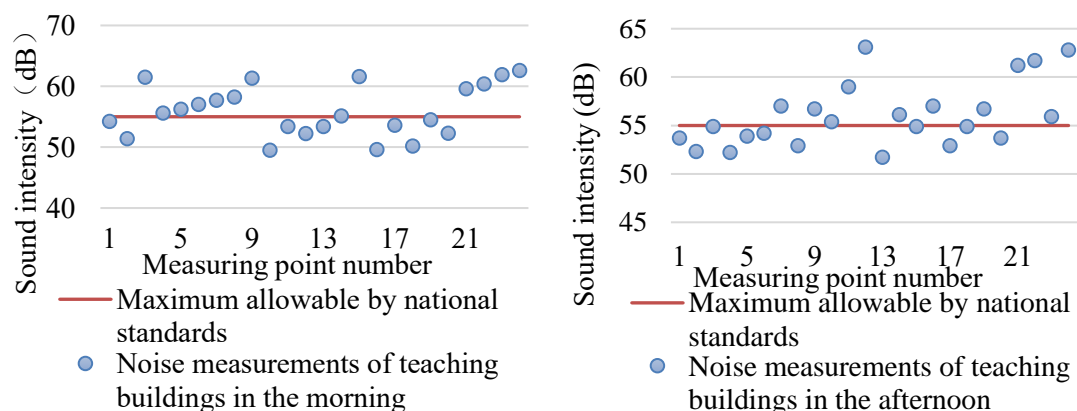


Figure 1. Comparison of morning and afternoon measurement the NO. 1 teaching building

The test methods for the library and the dormitory are the same. The first four floors are arranged with measuring points, and each floor is set up with six measuring points. The following noise distribution results were obtained in Figure 2:

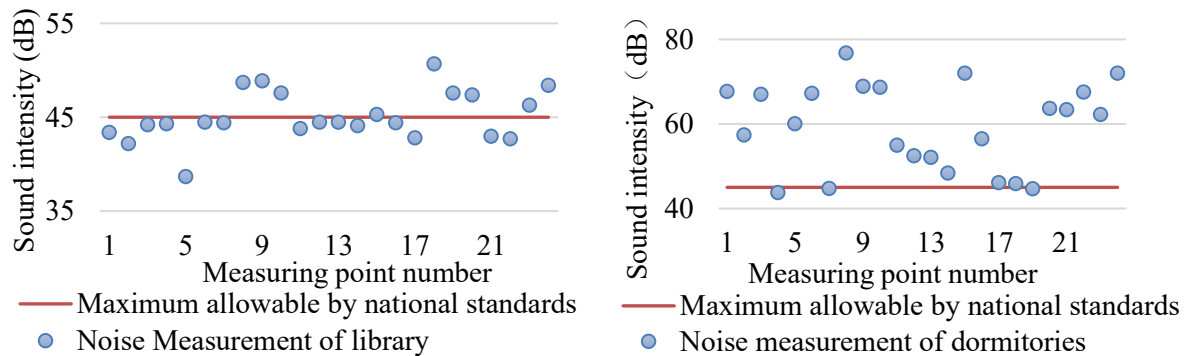


Figure 2. Comparison of the measured values of the library and the dormitory

The library has a better learning environment and less noise interference. There are only 9 super-standard measuring points, accounting for 37.5%. However, the acoustic environment of the dormitory is not optimistic, and the over-standard rate is about 87.5%. It was mainly related to unreasonable daily habits of students, such as the sound of closing the door, the sound of flowing water and the sound of playing games.

3. Comprehensive Evaluation Model of Campus noise

3.1 Fuzzy Comprehensive Evaluation Method

(1) The evaluation object factors U is determined, $U = \{u_1, u_2, u_3, u_4\}$, where u_1, u_2, u_3, u_4 are four environmental noise monitoring values of the evaluation object factors. (2) The evaluation set V is determined, $V = \{v_1, v_2, v_3, v_4, v_5\}$, where v_1, v_2, v_3, v_4, v_5 are the corresponding evaluation grade of the evaluation object factors. (3) The fuzzy relationship between environmental factors and evaluation levels can be represented by the fuzzy matrix R_i for, $R_i: U \cdot V \rightarrow [0,1]$. Fuzzy relation matrix R_i can represent the degree of membership of each factor corresponding to each evaluation object. (4) The weight vector A is determined, $A = \{A_1, A_2, A_3, A_4\}$, where A_1, A_2, A_3, A_4 are the corresponding weight vector coefficient among the factors of each evaluation object. So Fuzzy comprehensive evaluation mathematical model (where B_i is the result of fuzzy comprehensive evaluation):

$$B_i = A \cdot R_i \quad (1)$$

3.2 Determination of evaluation grade criteria

According to Environmental quality standard for noise (GB3096-2008)[7], we can determine evaluation set V is {no effect (V_1), mild (V_2), moderate (V_3), serious (V_4), more serious (V_5)}.

Table 1. Evaluation criteria for equivalent A sound level of campus noise pollution (dB).

Content	No effect	Mild	Moderate	Serious	More serious
Equivalent sound level LAeq,d	55	60	65	70	75
Nighttime equivalent sound level LAeq,n	45	50	55	60	65

3.3 Noise detection results

According to reference [7], from which you can get the university belongs to Category 1 noise standard, that is, the noise control standard should be below 45 dB at night and 55 dB in the daytime. the results of environmental noise monitoring in campus are shown in Table 2.

Table 2. Monitoring results of campus environmental noise

	Serial number	Monitoring points	Average noise value (dB)	Excess value (dB)	Excess rate
Daytime	1	Teaching Building (morning)	59	4	54.20%
	2	Teaching building (afternoon)	57.45	2.45	50%
Nighttime	3	library	44.06	—	37.50%
	4	dormitory	57.86	12.86	87.50%

3.4 Comprehensive Evaluation of Campus noise Environment quality

3.4.1 Determining membership function and establishing Fuzzy Matrix. Referring to the criterion of Table 1, the membership function of U_{ij} and V_1, V_2, V_3, V_4, V_5 are determined. The expression of membership function is shown in (2) ~ (6) [10].

$$u_{i1}(u) \begin{cases} 1 & l_{eq} \leq (55-l) \\ -\frac{1}{5}[L_{eq} - (60-l)] & (55-l) < L_{eq} < (60-l) \\ 0 & l_{eq} \geq (60-l) \end{cases} \quad (2)$$

$$u_{i2}(u) \begin{cases} 0 & l_{eq} \leq (55-l), l_{eq} \geq (65-l) \\ \frac{1}{5}[L_{eq} - (55-l)] & (55-l) < L_{eq} < (60-l) \\ -\frac{1}{5}[L_{eq} - (65-l)] & (60-l) < L_{eq} < (65-l) \end{cases} \quad (3)$$

$$u_{i3}(u) \begin{cases} 0 & l_{eq} \leq (60-l), l_{eq} \geq (70-l) \\ \frac{1}{5}[L_{eq} - (60-l)] & (60-l) < L_{eq} < (65-l) \\ -\frac{1}{5}[L_{eq} - (70-l)] & (65-l) < L_{eq} < (70-l) \end{cases} \quad (4)$$

$$u_{i4}(u) \begin{cases} 0 & l_{eq} \leq (65-l), l_{eq} \geq (75-l) \\ \frac{1}{5}[L_{eq} - (65-l)] & (65-l) < L_{eq} < (70-l) \\ -\frac{1}{5}[L_{eq} - (70-l)] & (70-l) < L_{eq} < (75-l) \end{cases} \quad (5)$$

$$u_{i5}(u) \begin{cases} 0 & l_{eq} \leq (70-l) \\ \frac{1}{5}[L_{eq} - (75-l)] & (70-l) < L_{eq} < (75-l) \\ 1 & l_{eq} \geq (75-l) \end{cases} \quad (6)$$

u_{ij} ($i = 1, 2; j = 1, 2, 3, 4, 5$); the measured values in the daytime are u_{ij} ; the measured values in the night are u_{2j} ; u_{ij} represent the membership degree of four monitoring points, when “ L_{eq} ” represent the values in the daytime, $l = 0$, and when “ L_{eq} ” represent the values at night, $l = 10$.

3.4.2 Determine weight assignment. Frequency statistical analysis method were used to analyze the weight coefficient of four monitoring points. The following weight allocations are obtained (A_1 for daylight and A_2 for night): $A_1 = [0.2 \quad 0.2]$, $A_2 = [0.3 \quad 0.3]$. Therefore, the comprehensive evaluation of the

impact of campus noise (B_1 for the daytime, B_2 for nighttime) is: $B_i = A_i \bullet R_i$; and R_1 、 R_2 stand for day time and nighttime fuzzy matrix.

Considering the same influence degree of campus noise in day and night, therefore, the weight coefficient between day(B_1) and night(B_2) is: $A_0 = (0.50, 0.50)$. Therefore, the fuzzy comprehensive evaluation of the influence of campus noise on teachers and students is as follows:

$$B = A_0 \begin{bmatrix} B_1 \\ B_2 \end{bmatrix} \quad (7)$$

3.4.3 Fuzzy Comprehensive Evaluation of Sound Environment quality in Campus. According to the environmental noise monitoring value in Table 2 and its corresponding membership function V , the fuzzy matrix is obtained. Then, fuzzy relationship B_1 、 B_2 can be obtained:

$$B_1 = A_1 \bullet R_1 = (0.355 \quad 0.645 \quad 0 \quad 0 \quad 0)$$

$$B_2 = A_2 \bullet R_2 = (0.4 \quad 0 \quad 0.2568 \quad 0.3432 \quad 0)$$

The result of fuzzy comprehensive evaluation can be obtained as follow:

$$B = A_0 \begin{bmatrix} B_1 \\ B_2 \end{bmatrix} = (0.3225 \quad 0.3775 \quad 0.1284 \quad 0.1716 \quad 0)$$

The fuzzy comprehensive evaluation results show that slight pollution is the largest, which is 0.3775. The results show that the sound environment in this university is a slight pollution.

4. Conclusion

(1) The environmental noise in the college campus generally exceeds the standard. The noise values in the day are between 50~73dB, and the average rate of exceeding the standard is 52.2%. The noise values at night are between 40 dB and 71 dB, and the monitoring points of dormitory seriously exceed the standard, the average rate of exceeding the standard is 62.5%.

(2) The fuzzy matrix method is used to evaluate the sound environment quality of the campus. The results show that the degree of membership of the campus sound environment can reach 0.3775 which is a slight pollution.

(3) The school can strengthen in-school traffic management, appropriately add campus green zone, and formulate necessary rules and regulations to regulate student activities.

Acknowledgments

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