

Indoor environment quality in the university dormitory*

WU Xiangsheng, YANG Jia, AO Lu, ZHENG Zhiyong

Department of Architecture and Environment, Logistical Engineering University, Chongqing 400041, P.R. China

Abstract: The indoor environment quality(IEQ) in the dormitory of 9 universities has been investigated by the questionnaire for three times. The results indicate that the indoor air quality (IAQ) of the dormitory is very poor and it is far beyond the acceptable standard of the IAQ. The discontentment rate of the IEQ in the dorm is rather high, and the factors affecting the IEQ concentrates on the air pollution, awful smell, thermal comfort, narrow individual space, etc. Also the spot tests were done in a university in Chongqing, and the results indicate that the 6 indexes, such as indoor temperature, humidity, the density of CO₂, SO₂ and dust, the total bacterium, etc, are far beyond the correlative standard.

Key words: indoor environment quality; questionnaire; spot test; dormitory

The indoor air quality is very poor almost in all dormitories in our country, and it is far beyond the standards of the IAQ. The IEQ in the dormitories of 9 universities has been investigated with the questionnaire for three times. The result of the spot test which was done in one university in Chongqing indicates that the 6 indexes, such as indoor temperature, humidity, the density of CO₂, SO₂ and dust, the total bacterium are far beyond the correlative standards. It is in great need to improve the IAQ in the dormitories.

1. Content and method of the investigation

The questionnaires of IEQ were handed out to 9

universities three times: from Sep. 2000 to Oct. 2000, from Dec. 2000 to Jan.2001, and Mar. 2001 to Apr. 2001. The contents of the questionnaire include the setting information of the dorm, the discontentment rate, the main factors affecting IEQ and the infection to health by IEQ. 1410 questionnaires were handed out and 1386 ones reclaimed in all, and 1386 ones were available. The each callback rate is 98.4%, 99.1% and 99.8%. The spots of the investigation, the information of questionnaires providing and callback are illustrated in the Table 1(the universities are substituted by the serial number in the following tables and figures). The investigation was carried out through the internet.

Table 1 The Information of Questionnaires

No.	University	Proportion of Sex		The First Time		The Second Time		The Third Time	
		Male/%	Female/%	Handed out	Callback	Handed out	Callback	Handed out	Callback
1	Harbin University of Science and Technology	70	30	50	50	50	50	50	50
2	Dalian Warship University	100	0	80	80	100	100	50	50
3	Beijing University of the Second Foreign Language	40	60	50	50	40	40	40	40
4	Zhengzhou College of aviation industry management	80	20	50	50	30	30	40	40
5	Logistic engineering university	90	10	100	98	50	50	50	50
6	South-west university of politics and law	60	40	50	42	40	36	30	30
7	Navy engineering University	100	0	60	60	60	60	50	50
8	Hunan Normal School	50	50	50	50	50	50	50	50
9	Guangzhou University of Foreign Language and Trade	45	55	50	50	50	40	40	40
Total				540	530	470	466	400	390

Wu Xiangsheng(吴祥生): Male; born 1955; Prof., Research field: air condition engineering and building energy efficiency.

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2. The investigation results

The even discontentment rate of the 3 investigations relatively is 53.7 %、66.7 % and 44.8 %. In these investigations some factors were chosen which possibly arouse discontentment of the investigated to IEQ such as light(A), noise(B), humidity(C), dryness(D), cigarette smell (E), narrow individual space(F), peculiar smell(G), thermal environment(H), frowziness(I), static(J), fresh air insufficiency(K), dust(L), smell from painted wall and furniture(M). The degree influenced by these factors varies with the spot or time. The top 3 items of the main factors which the investigated of the 9 universities considered are shown in Figs. 1 to 3.

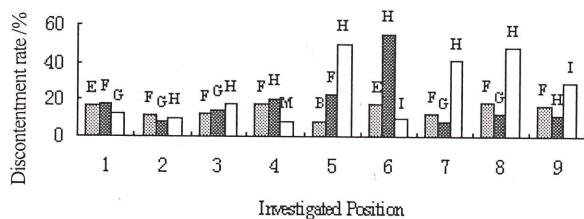


Fig.1 The main factors of discontentment rate(the 1st time)

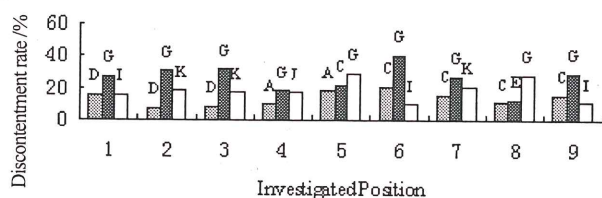


Fig.2 The main factors of discontentment rate(the 2nd time)

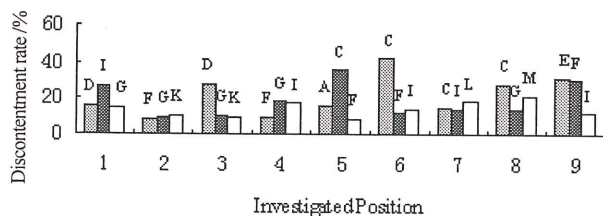


Fig.3 The main factors of discontentment rate(the 3rd time)

3. The analysis of the investigation result

3.1 Air grimeiness or peculiar smell in the apartment

Almost in each investigated spot the condition is air grimeiness or peculiar smell indoor. The peculiar smell is caused by CO_2 from human's body, breath and shoes and socks. CO_2 is an important index of the indoor air pollution. It has been proved by some related experiments that the smell is bad to the sensitivity when the CO_2 concentration reaches 700 $\mu\text{L/L}$, and air quality begins to worsen. When the CO_2 concentration

reaches 1000 $\mu\text{L/L}$, people widely feel uncomfortable.

3.2 Thermal environment

In summer, the thermal environment in door is very poor in Chongqing, Wuhan and Changsha which are in the Changjiang drainage area. The temperature indoor is always higher than 30°C or even 40°C when there are no air conditions. It is poorer with the great humidity indoor. The environment becomes worse in the city of Beijing, Guangzhou with the trend of the globe warming.

3.3 Humidity and dryness

It is necessary to adopt the measure of wetting because the relative humidity indoor is only 15~35 % in the transition seasons in the north. While, the relative humidity in the south is above 80% in spring or summer. The too high humidity resists heat giving out from human's bodies, and makes the people uncomfortable. Besides, microorganism reproduces so fast that may cause the rage of the contagions. So it is necessary that the measures of dehumidify and disinfections in time be adopted and keep the room clean.

3.4 Narrow individual space

The average lodging area of each person is very small because of the tension lodging in the university. So the narrow individual space is a phenomenon at large (5~8 m^3 per person in average), and it worse the IAQ to some extent. It is recommended that 12 m^3 in average are needed to each person [1], but the situation at present is far from it.

3.5 Others

The factors like light, noise, dust, static, frowziness and smell from painted wall and furniture also exist, but they are different from different university. The investigated of the Logistic Engineering University consider it is too obscuration in door, because the air pollution is so severe in Chongqing that TSP density is rather large and the cloud is rather thick. The investigated of the Hunan Normal School consider that the dust indoor is too much because of the outdoor clay brought in. The investigated of the Beijing University of the Second Foreign Language consider that there exists static because of the dryness of the air. The problems of smell from painted walls and furniture lies in some dormitories of well fitted especially the new

apartments.

4. Spot test

4.1 Instruments

The testing instruments include the testing tube, the dust testing instrument, the psychrometer, the ordinarily agaragar culture utensil, the blood culture utensil, the GM12 type CO₂ testing instrument made in Finland, etc.

4.2 The tested room and indexes

After compare, four typical rooms were selected as the testing rooms. Combining with the questionnaire and the fact of the dormitories, the indexes consist of dry-bulb temperature, the relative humidity, CO, CO₂, SO₂, NO_x, dust and total bacterium.

4.3 Time and method

The tests were carried out from the 26th to 28th in Feb. 2001 and twice in each morning, noon and evening separately. The each index may be directly read from instruments except the amount of bacterium. In this method, the ordinarily agaragar culture utensils and the blood culture utensils are placed at a certain place in the

room. After a while, the utensils are covered and set in the culture box for 48 hours maintaining the temperature at 37°C. Then the total amount of the bacterium is accounted. According to the method[2], the amount of bacterium dropping on the utensils within 100cm² in five minutes equals the amount of bacterium in 10 liter air.

5. The result of the test and analysis

The tested value of the dry-bulb temperature, the relative humidity, the concentration of CO, CO₂, SO₂, NO_x, dust and total bacterium were shown in the table 2, from which it can be seen that the thermal environment indoor is rather poor, and the problems of CO₂, SO₂, dust and total bacterium contaminated are rather severe. The air contamination is very severe in Chongqing area and there is few measure of air filtration, disinfections and ventilation in the dormitories so that the outdoor contaminations can be easily brought in and then accumulate to fairly high density in door. This situation exists at large in the universities dormitories around the country. The test results indexes of the CO₂, SO₂, dust and total bacterium are beyond the related standard.

Table 2 Test results of the dormitory air quality

room		dry-bulb temperature /(°C)	Relative Humidity /(%)	CO /(mg/m ³)	CO ₂ /(μL/L)	SO ₂ /(mg/m ³)	NO _x /(mg/m ³)	Dust /(mg/m ³)	Total Bacterium /m ³
I	average	13.2	71	2.94	950	0.25	0.0142	0.33	3500
	range	11.2~15.2	62~80	2.78~4.64	450~1900	0.10~0.30	0.005~0.05	0.1~0.47	1000~7000
II	average	13.4	81.5	1.18	1100	0.16	0.025	0.21	5000
	range	11.8~14.9	68~95	1.06~2.88	440~2600	0.05~0.30	0.005~0.08	0.1~0.59	2000~7500
III	average	13.3	74	2.30	1000	0.25	0.020	0.35	4000
	range	12~14.5	63~85	1.39~2.87	450~2200	0.10~0.45	0.005~0.06	0.1~0.45	2000~8000
IV	average	13	67.5	2.15	700	0.28	0.0185	0.22	7000
	range	11~15	55~80	1.56~3.15	410~1400	0.08~0.50	0.005~0.07	0.1~0.55	1000~10000
Out door	average	10.9	67.5	2.17	400	0.13	0.005	0.21	—
	range	8.7~13.2	55~80	1.78~3.48	380~580	0.05~0.40	0.004~0.005		

SO₂: The results of the test indicate that the concentration of the SO₂ is beyond the standard (0.15 mg/m³) because Chongqing is a traditional industry city, and the air quality is poor. It is stated from some related information that the total exhaust emission

of the industry is 1 833 933 million Nm³ and the emission of SO₂ is 758 800 t. The air contamination affects the IAQ greatly.

Dust: It was stipulated that tiptop sufferance dust density in inhabitancy area is 0.15 mg/m³, but the test

value is from 0.21 mg/m^3 to 0.35 mg/m^3 , which is far beyond the standard. This item cannot be acquired from the investigated because the diameter of the dust is so little that it directly aggrades alveolus by breathing which cannot be aware of.

Total bacterium: It is stipulated of the related standard of the indoor air sanitation that the number of the bacterium is lower than 4500 m^{-3} in clear air in winter, but contaminated air is above 7000 m^{-3} . The bacterium contamination situation of the test position is between the clear air and contaminated air. The test results prove the fact that the dwellers are easy to be suffered from infection.

CO₂: The test result accords with the questionnaire well. The concentration of the indoor CO₂ is much higher than that outdoor, and it varies with the number of the person indoor. The phenomenon is very rife around the country. The average concentration change of the indoor and outdoor is shown in Figs. 4 and 5. The Fig. 6 is the concentration change with the space distributing in the room in the first testing day. From the figure it can be seen that the concentration varies with the height in door, and the reason is that the temperature of CO₂ from human is higher than the indoor air. Besides, the contamination concentration is rather high in the top corner of the room.

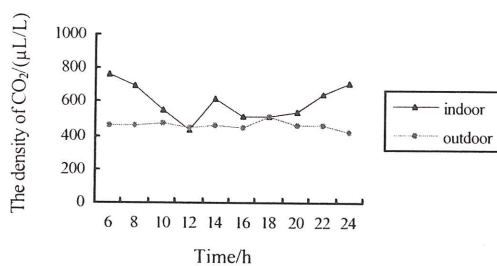


Fig.4 The CO₂ density change(The 1st day)

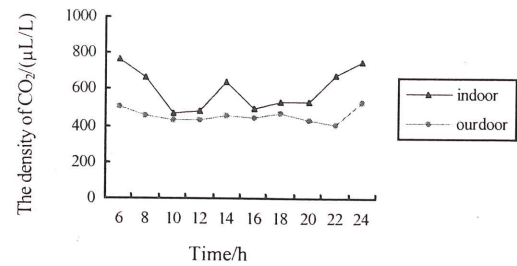


Fig. 5 The CO₂ density change(The 2nd day)

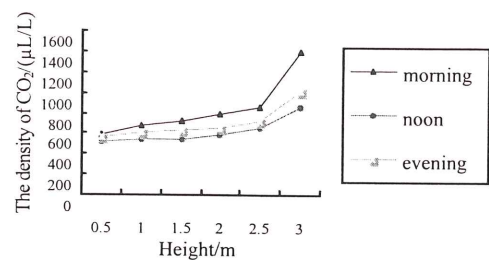


Fig. 6 The CO₂ density space distribution

The indoor air quality of the investigated universities is rather poor from the spot test. The 6 indexes such as temperature, relative humidity, CO₂, SO₂, dust and total bacterium of the 8 indexes almost can't reach the standard, in which the indexes of the temperature, relative humidity and CO₂ explain the problem of high discontentment rate to indoor thermal environment and awful smell, and the overtook total bacterium offers the condition for contagions in dormitory, and the phenomenon of the high density of dust which hasn't been found with the questionnaire is found by the spot test.

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