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Measurement and analysis of indoor carbon dioxide concentration and temperature and humidity

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Abstract
In this paper, the temperature, humidity, carbon dioxide concentration and other indicators were tested and investigated on the spot, representative samples were selected, and the collected samples were analyzed, and the main reasons affecting the air quality were the excessive carbon dioxide concentration, insufficient number of air changes and overstaffing, and proposed solutions. This paper focuses on the process and method of experimental and sample analysis, using data to explain how to improve indoor air quality, and pointing out the ideal state achieved after improvement, so as to provide a good learning environment and ultimately achieve good teaching results.

Keywords: *carbon dioxide concentration, temperature, humidity, air quality, number of air changes*

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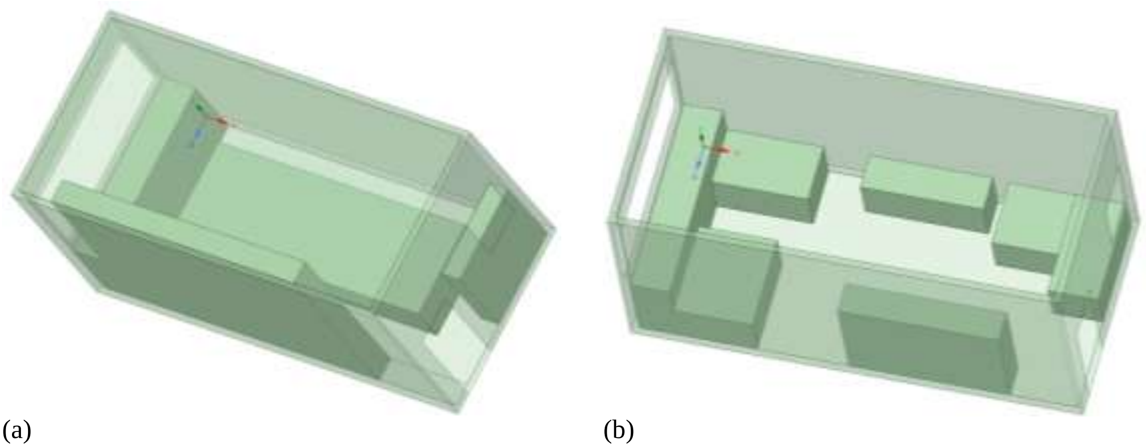
I. INTRODUCTION

The indoor air quality (IAQ) of primary and middle school students ' classrooms has always been concerned. To this end, the state has promulgated the " Hygienic Standard for Ventilating Classrooms in Primary and Secondary Schools " (GB / T17226-1998). The indoor air quality of graduate laboratory is equally important. Graduate students spend a lot of time in the laboratory, but there is no hygienic standard for graduate laboratory. Therefore, the following analysis is based on GB / T17226-1998 and 'Indoor Air Quality Standard 'GB / T 18883-2002. There are two main reasons for the deterioration of indoor air quality : one is the pollutants in the air ; the other is the temperature, humidity and air exchange rate of air. In order to understand the air quality of the graduate laboratory during the experiment, a field test of CO_2 concentration in the air was carried out in the existing laboratory. The physical models of the room are shown in Figure 1.1 (a) and Figure 1.1 (b) respectively :



(a) (b)

Fig. 1 (a) is represented by room 1，(b)is represented by room 2

In addition, no obvious source of pollution was measured near the two rooms; In the past three years, no interior decoration and no tables and chairs have been replaced.

II. Test instruments and test systems

Research data show that there are hundreds of indoor pollutants, some of which are very low in concentration and will not affect human work and learning. For this office, it mainly detects the concentration of carbon dioxide. The equipment used is HUMLOG 20 carbon dioxide online analyzer, as shown in Figure 2.1.

Fig. 2HUMLOG 20 carbon dioxide analyzer

Humlog 20 facilitates accurate and professional recording of climate measurements of humidity, temperature, pressure and CO_2 concentration. Long battery life and large capacity memory allow long continuous recording of data. Using SmartGraph3 software within the scope of supply, the configuration of the data recorder and the evaluation of the measured data are simple and clear. The built-in Ethernet interface makes the Humlog 20 network capable and ensures maximum reliability of data transmission. The Humlog 20 data logger can be used in a wide range of areas such as residential and commercial buildings, museums and exhibition halls, clean spaces, professional storage rooms, EDP computer centers, calibration laboratories, power distribution cabinets, wind turbines, etc.

Table 1: Instrument main technical parameters

	Model			
Measurement Categories	**THI**	**THIP**	**TCO**	**E**
Temperature (air)	√	√	√	
Relative humidity	√	√	√	
Absolute humidity	√	√	√	
Dew point temperature	√	√	√	
Barometric air pressure		√		
Relative air pressure		√		
CO_2 Concentration			√	
Extemal input - digital RH/T-Sensor				√
External input- Pt100, Thermocouple				√
Analogue input voltage 0 - 1 V				√
Analogue input current 0/4 - 20 mA				√
Functions				
Power supply battery	√	√	√	√
Power supply USB	√	√	√	√
Measured data storage	3200000	3200000	3200000	3200000
Battery life, typ	＞1 year	＞1 year	＞4 months	＞5 months
C-display	√	√	√	√

One-button operation	√	√	√	√
1-point calibration by operator	√	√	√	√
CrF switchable	√	√	√	√
Optical / acoustical alarm	√	√	√	√
ate / time	√	√	√	√
Records MIN/MAX/AVG	√	√	√	√
SmartGraph3 evaluation software	√	√	√	√
Functions Software				
Graphical representation	√	√	√	√
Numerical data display	√	√	√	√
Print function	√	√	√	√
Export function (e.g. Excel)	√	√	√	√
Gathered printouts of all measurement sites	√	√	√	√
User administration	√	√	√	√
ninistration of up to 255 data logger	√	√	√	√

According to the ' Indoor Air Quality Standard ' GB / T 18883-2002 : the number of sampling points depends on the size of the indoor area and the situation on site, in order to correctly reflect the level of indoor pollutants. In principle, rooms less than 50 m^2 should have 1 ~ 3 points ; room 22 with 50 ~ 100 m^2 has 3 ~ 5 points. More than 100m^2 set at least 5 points. The measured classroom area is less than 50m2, so two collection points are selected and evenly arranged on the diagonal of the room. The distance from the wall should be greater than 0.5 m. The height of the sampling point is in principle consistent with the height of the human respiratory zone.

III. Test data

Because there is no decoration work in the room within three years, the walls, tables and chairs are old, so a series of chemical pollutants caused by decoration such as formaldehyde is negligible. room1 and room2 Humlog 20 data logger measurement points are arranged as shown in Fig.3 and Fig.4 respectively.

（a） By the window

(b)Indoor

Fig. 3 room1 measurement point arrangement


(a)


(b)

Fig. 4Room2 measurement point arrangement

3.1 Room 1 test monitoring results

3.1.1 Carbon dioxide concentration

Room1 CO_2 monitoring results are shown in Fig.5

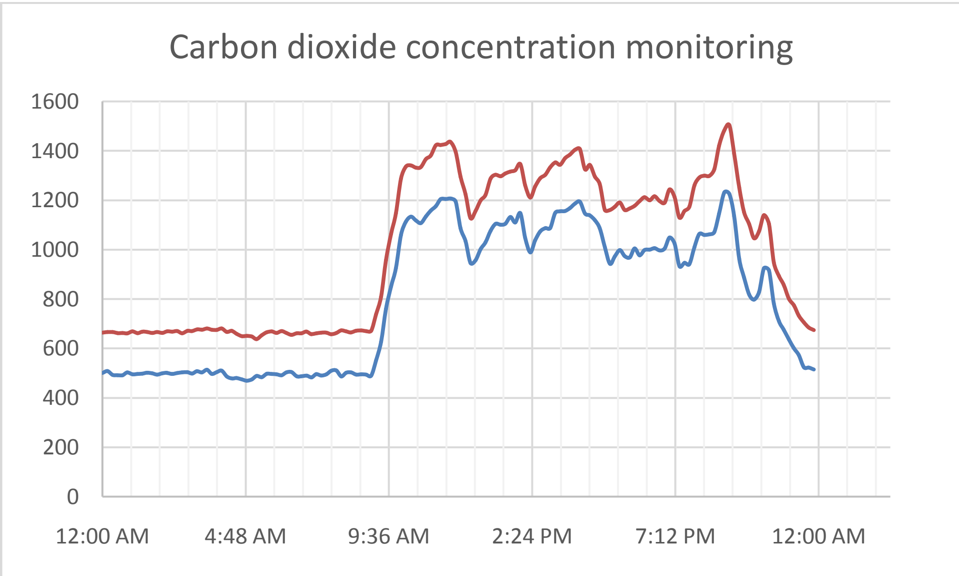


Fig. 5 Room 1 office CO_2 concentration monitoring results

3.1.2 Temperature

Room1 temperature monitoring results are shown in Fig.6

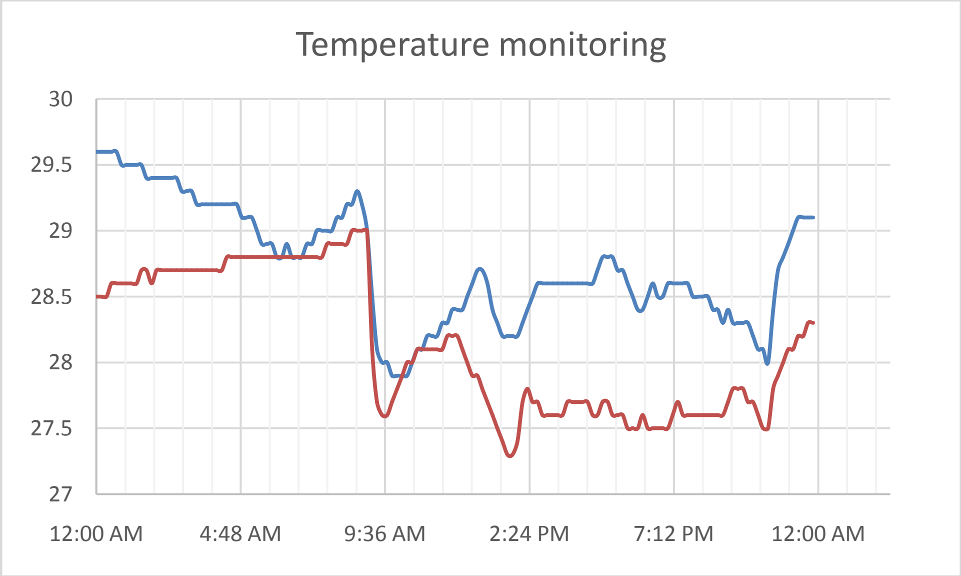


Fig. 6 Room 1 temperature monitoring results

3.1.3 Humidity

Room1 humidity monitoring results are shown in Fig.7

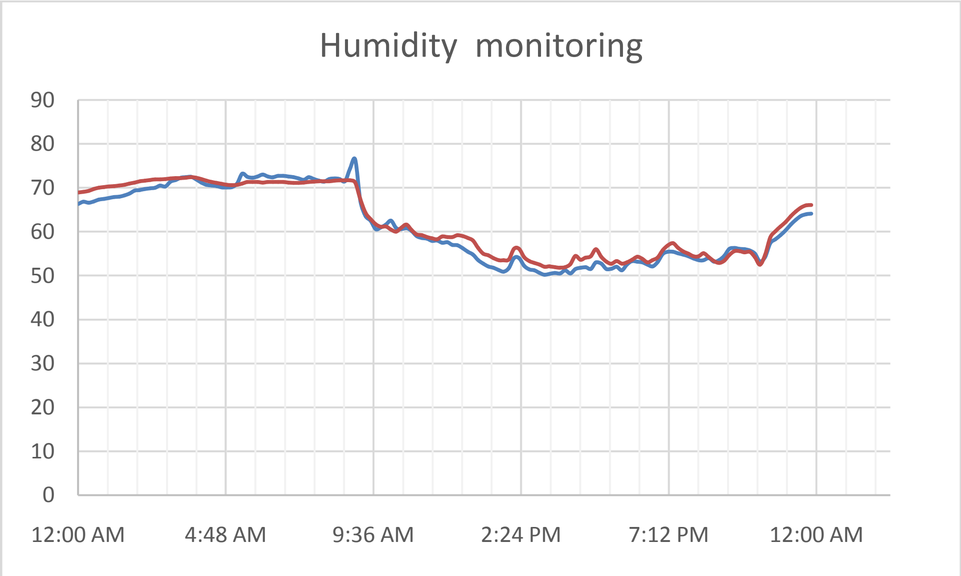


Fig. 7 Room 1 humidity monitoring results

3.2 room2 test results

3.2.1 Carbon dioxide concentration

Room2 CO_2 monitoring results are shown in Fig.8

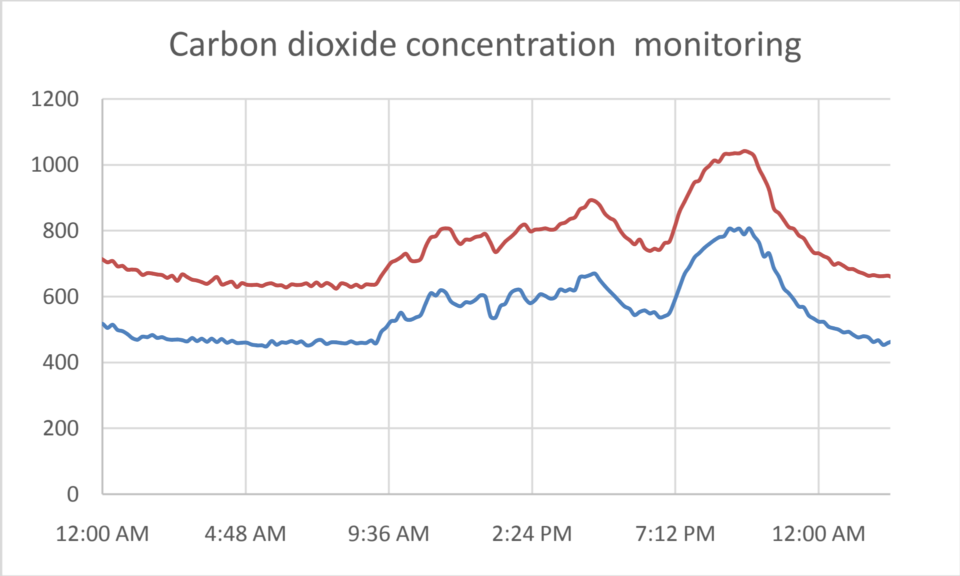


Fig. 8 Room2 CO_2 concentration monitoring results

3.2.2 Temperature

Room2 temperature monitoring results are shown in Figure 3.7

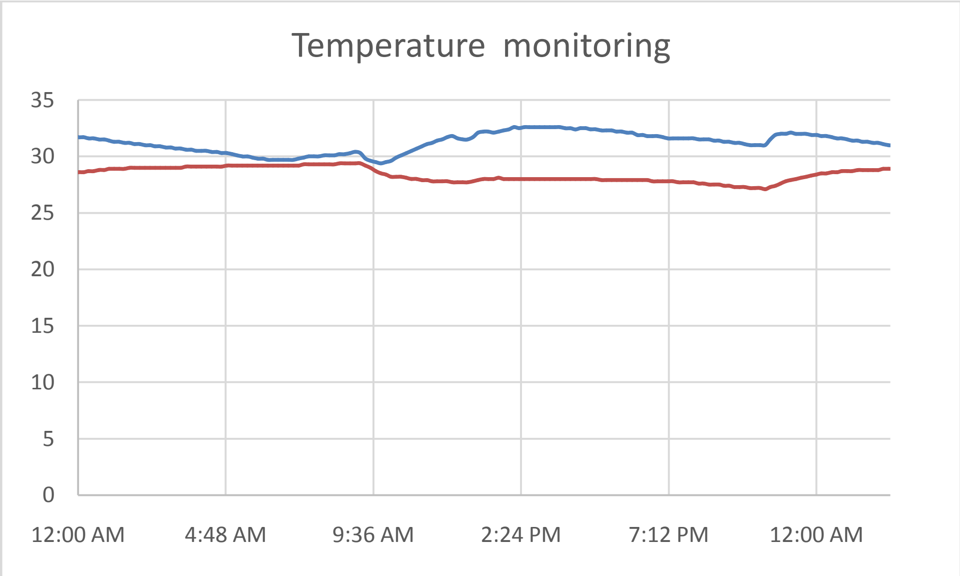


Fig. 9 Room2 temperature monitoring results

3.2.3 Humidity

Room2 humidity monitoring results are shown in Figure 3.8

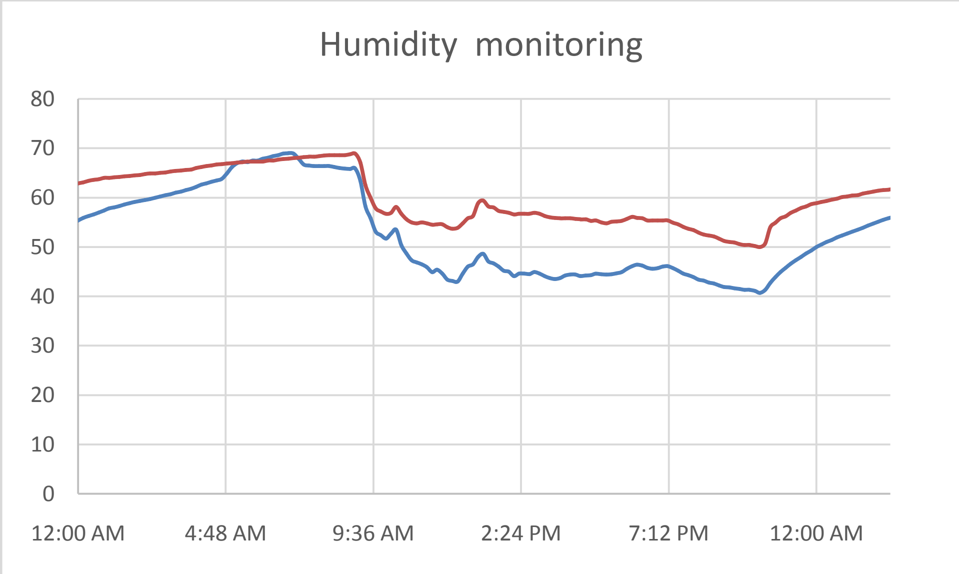


Fig. 10 Room2 humidity monitoring results

IV. Data Analysis

According to the Indoor Air Quality Standard GB/T 18883-2002, the allowable concentration of carbon dioxide in indoor air is 0.10%, i.e. 1000PPM; according to the Health Standard for Ventilation in Primary and Secondary School Classrooms GB/T 17226-1998, the maximum allowable concentration of carbon dioxide in indoor air is 0.15%, i.e. 1500ppm.

4.1 Influence of outdoor environment

Data 1, 2, and 3 exceeded the standard after 9:00, 7:50, and 7:55, respectively, but data 3, which had the highest occupancy rate, was not the earliest one. The reason for this is that when data 3 was measured, it was windy and sandy weather outside, and the outdoor wind caused the window seam penetration to strengthen, which led to the delay of this data exceeding the standard. It can be seen that the indoor CO2 concentration is not only related to the density of indoor people and the opening degree of windows and doors, but also has a great relationship with the outdoor weather conditions, and the outdoor wind speed is one of the main influencing factors. Although the outdoor wind speed was high on that day, it did not fall below the standard at 12:00 a.m. This was due to the high concentration of carbon dioxide caused by too many people.

4.2 Calculation of the number of air changes

The formula for the number of air changes using the gas decay method (Health Standards for Air Changes in Primary and Secondary School Classrooms GB/T 17226-1998) is as follows:

$$E = [2.303 \times Lg(K_1 - K_0) / (K_2 - K_0)] / t \qquad (1)$$

where:E—Number of air changes per hour;

K1—Indoor air CO2 concentration at the beginning of the test;

K2—The test ended with the indoor air CO2 concentration;

K0—Outdoor air CO2 concentration.

The conditions for this formula are: generally in windless weather (outdoor wind speed 0.5m/s or less). At the end of the class, after all students and teachers exit, the use of carbon dioxide gas stored in the classroom or artificial release of carbon dioxide, according to a certain time (15min, 30min, 45min) to determine the concentration of carbon dioxide in the indoor air before and after opening the air windows (or closing the air windows), to calculate the number of classroom ventilation.

Therefore, data 1 and data 2 are selected for the calculation of the number of air changes, and data 1 (closing the front and back doors) and data 2 (opening the front and back doors) in the period from 11:30 to 12:00, we can obtain the number of air changes for the two are: 0.62; 3.45. According to the "Health Standards for Ventilation in Primary and Secondary School Classrooms" GB/T 17226-1998: the number of air changes in secondary school classrooms should not be less than 4 times. Therefore, when the front and rear doors are opened, the number of air changes is not less than 4. Therefore, when the front and rear doors are opened, the number of air changes is very close to the provisions of the Health Standards for Ventilation in Primary and Secondary School Classrooms, so the following conclusion can be drawn: classrooms without or without conditions for installing ventilation systems can basically meet the requirements for air changes if the front and rear doors are kept open.

4.3Full attendance

From the first three sets of data as a whole, the higher the full occupancy rate the higher the state CO_2 concentration is also, rising faster and falling slower. Therefore, the full occupancy rate is also an important factor affecting the CO_2 concentration.

V. Conclusion

High CO_2 concentration is very harmful and can stimulate the respiratory center, causing shortness of breath, and can cause headaches and confusion. Studies on the effect of CO_2 concentration in indoor air on students' brain work ability show that the difference in air cleanliness has a significant effect on students' calculation and completion of homework effects, and as the air CO_2 concentration increases, students' brain work ability decreases significantly. It can be concluded that air dirtiness is a factor that cannot be ignored in causing students' fatigue and reducing their learning efficiency. Therefore, it is crucial to reduce indoor CO_2 concentration. Currently, most classrooms in universities are not equipped with ventilation systems, and the following measures can be taken to reduce the concentration of CO_2 in classrooms:

1. Keep the front and rear doors open, and open the windows between classes to keep the air circulating and rapidly reduce the concentration of carbon dioxide.

2. A certain amount of green plants can be arranged indoors, which is not only beautiful, but also can release oxygen while absorbing carbon dioxide and accelerate the concentration of diluted carbon dioxide.

By meeting the above conditions, the indoor air quality can be greatly improved.

References