



Long-term indoor gas pollutant monitor of new dormitories with natural ventilation



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ABSTRACT

New furniture and wood-based decoration are the major sources of gas pollutant in indoor environments. Ventilation is the most straightforward approach to eliminate the indoor gaseous pollution. There were many studies investigating the VOC emission characteristics of various building materials, but people still can't answer the question that how long should we ventilate for an acceptable indoor concentration level in the real life. This study monitors the long-term gas pollutant concentration of 14 new student dormitory rooms with newly furnished beds, desks and closets. The formaldehyde, TVOC, and ammonia concentrations were measured, the concentration of detected composition of VOCs was listed, and the decay rate under natural ventilation was analyzed. To determine the natural ventilation rate, the traditional tracer gas method and fast VOC decay method were compared, then a quick ventilation rate method was proposed. The VOC emission rate from the furniture was also measured at different times during the whole testing period. As the field measurement has many un-controlled factors, a small single room model was built and furnished with corresponding loading amount of furniture board materials. The influence of furniture density, supplier and room location on VOC emission rates was also analyzed.

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1. Introduction

Gas pollutant significantly affects the indoor air quality level. Volatile organic compounds (VOCs) emitted from building materials and furniture have been recognized as major indoor pollutants [9,10]. It has been identified that such pollution may result in acute health effects, discomfort and reduced productivity among occupants [2,3]. Many organizations, such as World Health Organization, have set standards for indoor gas pollutant including formaldehyde's concentration [21]. However, indoor formaldehyde concentration in 70% of the newly built or remodeled houses exceeded the standard in China [25]. This was much higher than that in developed countries [23]. Compared with organic compounds, studies on indoor ammonia pollution were very rare. Ammonia is a colorless gas with a strong irritating odor, which can cause respiratory discomfort and disease. In newly built rooms, especially those built during cold climate or weather condition, indoor ammonia mainly comes from the antifreeze additives in the concrete, which is widely used in the buildings in China. One recent

study from Japan has shown that ammonia and VOCs can emit from concrete, with the source of ammonia being amine additives [26]. Ventilation is the most straightforward approach to eliminate the indoor gaseous pollution under the situation that the occupants cannot control the source [22,20]. This has been well recognized by most population in China now, and people are opening the window to allow a period, normally several months to 1 year, for strong VOC emission in newly built or decorated rooms [14]. However, people still can't answer the question that how long should we ventilate for an acceptable indoor concentration level before moving into a room with new decoration and new furniture.

Ventilation is effective by decreasing the VOCs emission rate over long-term. There were many studies investigated the gas pollutant emission characteristics of various building materials. However, as the gas pollutant emission is a time dependent process, many of the previous studies were conducted in laboratory. Liang et al. [17] did a two-year study in a full-scale experimental room to capture the formaldehyde concentration profile emitted from fibreboard. The effect of temperature and humidity was well studied. However, as there was no ventilation, the concentration decay cannot represent that in the real application. Chen et al. [6] did a study on air leakage rate for evaluating the impacts of VOC emissions, but the effects of window opening on air change rate were not considered in the analysis.

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Table 1
Basic information and test detail of the test rooms.

Room No.	Symbol	Supplier	V (m ³)	Sets*	Test Date (Test batch)														
					7.29 (batch 1)			8.18 (batch 2)			9.23 (batch 3)			10.4 (batch 4)			10.23 (batch 5)		
					F	A	T	F	A	T	F	A	T	F	A	T	F	A	T
1	□	1	35	2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2	×	1	35	2	✓		✓	✓		✓	✓		✓	✓		✓	✓		✓
3	▲	1	35	2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4	●	2	45	4	✓		✓	✓		✓	✓		✓	✓		✓	✓		✓
5	+	2	45	4		✓			✓			✓		✓			✓		✓
6	—	2	45	4			✓			✓			✓			✓			✓
7	△	3	45	4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
8	○	3	45	4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
9	◆	3	45	4	✓		✓	✓		✓	✓		✓	✓		✓	✓		✓
10	◇	4	35	2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
11	×	4	35	2	✓		✓	✓		✓	✓		✓	✓		✓	✓		✓
12	■	4	35	2			✓			✓			✓			✓			✓
13	—	5	30	1	✓	✓	✓				✓	✓					✓		
14	—	5	30	1	✓	✓	✓												

Note: F – formaldehyde; A – ammonia; T – TVOC; Room 13, 14 were only tested on batch 1 because the initial gas pollutant concentration of them was below the limited value. * Sets means sets of furniture, one set of furniture contains a desk, a wardrobe and a bed.

With the normal ventilation operation of real building, researchers have measured the indoor VOC concentration with new furniture for over years. For such long-term monitor, normally the buildings are monitored with occupants living/working in the building, therefore the furniture or building materials are not only the VOC concentration contributor [27,5]; or the ventilation operation was not regularly recorded [8,16], therefore cannot indicate the VOC emission change under routine ventilation operation. There are many factors influencing the test data in field study, such as uncontrolled test condition; occupants-related emissions; and complexity of indoor emission sources. Few field studies with controlled environmental condition on long term VOC concentration test were found. Besides, few long-term tests in real buildings analysed the concentration decay of each composition of VOCs under the effect of natural ventilation, but paid more attention to the reduction of TVOC concentration, or analysed the seasonal detected composition change without the consideration of ventilation effect [15,18].

Therefore, this study monitored the long-term gas pollutant concentration change during a 3 months period in real un-occupied rooms with recorded or controlled ventilation. These tested rooms are equipped with same new furniture, therefore the furniture and building material, such as concrete and wall paint, are the only sources for gaseous pollutant. The main objective is to answer the question that how long should we ventilate for an acceptable indoor gas pollutant concentration level for newly decorated or furnished rooms.

2. Methods

2.1. Tested rooms

The indoor TVOC(T), formaldehyde(F), and ammonia(A) concentrations were measured for 14 newly built student dormitories on a new campus in Tianjin, China. These dormitories were built during 2014–2015, and are equipped with 4 sets, 2 sets or 1 set furniture of new beds, desk and closets as shown in Fig. 1. Furniture in different room type is made of the same material type, but from different suppliers. The bed boards are made of pinewood, and the major material for desk and closets are particleboard. The area of the dormitory is about 10–18 m², so the pinewood loading ratio was estimated to be 0.320, 0.206 and 0.120 m²/m³ for the three types of rooms, respectively; the particle board loading ratio was estimated to be 0.590, 0.379 and 0.271 m²/m³, respectively. Five batches field test with the details shown in Table 1 were conducted and lasted four months from July to October in 2015. The test went immediately after furniture was introduced, so that can be considered as new furniture. All the tests were conducted at un-occupied condition. The rooms are regularly ventilated, means opening the window at 8nam, and closing at 7 pm after the installation of furniture, except special weather condition, e.g. rain or storm. The door and windows were closed for 12 h before each batch of the test. Closet doors are closed during the whole process.



Fig. 1. Tested student dormitories with 4 sets, 2 sets and 1 set furniture.

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