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Investigation of Microclimate and Air Pollution in the Classrooms of a Primary School in Wuhan

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Abstract

Field campaigns were conducted in autumn and winter of 2013, respectively, to investigate indoor microclimate and air pollution in four naturally ventilated classrooms for the sixth-grade students at a primary school in Wuhan's urban area. The experimental results showed that indoor air temperature was 13-22 °C in autumn and 5-22 °C in winter, while mean RH was around 55% in autumn and 40% in winter respectively. Indoor carbon dioxide (CO_2) level varied in the range from 500 ppm to 11231 ppm during school time. Formaldehyde (HCHO) and total volatile organic compounds (TVOCs) concentrations were low and at acceptable levels, but indoor $PM_{1.0}$, $PM_{2.5}$ and PM_{10} levels were the same as outdoor, up to 325 μg/m^3 332 μg/m^3 and 411 μg/m^3 in autumn, and 899 μg/m^3 927 μg/m^3 and 1090 μg/m^3 in winter, respectively. According to the results, low air temperature and poor ventilation made issues of concern for the students in the classrooms in winter. In addition, indoor air pollution caused by PM was further elevated in winter due to severe ambient air pollution

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Keywords: Schoolchildren; Field investigation; Indoor Air pollution; Indoor microclimate

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1. Introduction

Children are considered to have greater susceptibility to air pollutants than adults, because they breathe higher volumes of air relative to their body weights and their tissues and organs are actively growing [1]. Accordingly, allergic respiratory diseases, such as asthma and rhinitis have been found increased among children [2]; and today, asthma is of great concern in children health, as up to 1/3 of children in some regions have been diagnosed with asthma [3].

Exposures to indoor air pollutants, such as particulate matter (PM), formaldehyde (HCHO), volatile organic compounds (VOCs) have been associated with the children's respiratory health such as asthma, allergy and airway inflammation [4,5,6]. In China, a number of studies have investigated indoor pollution in the classrooms, where children spend most of their daytime [7,8,9]. This paper is an additional contribution focusing on air pollutants in indoor microclimate and air pollution in the classrooms of a primary school in the general urban area.

2. Methods

(a) (b)

Fig. 1. (a) primary school; (b) classroom.

We conducted the field experiments in four classrooms on a four-storeyed teaching building of a primary school as shown in Fig.1: one classroom (S1) around the corner on the second floor and three classrooms (S2, S3 and S4) along the same corridor on the third floor. The building was naturally ventilated with ceiling fans and separated air conditioners installed in each classroom for indoor thermal control. The measurements were done in the autumn and winter of 2013, respectively, to examine the changes in indoor climate and air pollution caused by the seasonal climate variation. The field investigation included three tasks: (1) monitoring of air temperature, relative humidity (RH) and CO_2 level; (2) measurement of PM mass concentration; (3) test of HCHO, acetaldehyde, and VOCs in air. Task (1) lasted for two weeks to characterize the indoor climate in four classrooms in the seasons. Task (2)–(3) were carried out when we visited the primary school to set up the instruments for Task (1) on November 11th and December 19th.

2.1. Monitoring of air temperature, RH and carbon dioxide (CO_2) concentrations

The data loggers with temperature and humidity sensors (T&D TR-71Ui&TR-72Ui; ESPEC Thermal Recorder RS-11) were used to monitor air temperature and RH at an interval of 10 min for 2 weeks. In each classroom, the data loggers were placed at three positions: 0.1 m (H0.1 m) and 1.1 m (H1.1 m) in the front of classrooms, and outdoors in the corridor. CO_2 concentration was monitored at an interval of 5 min for 2 weeks with the data logger (Lutron MCH-383SD) placed on the ground at the corner, to avoid the direct influence of people's exhalation. Outdoor CO_2 concentration was left out because it normally varied at relatively small levels that cannot lead to the high indoor CO_2 levels of concern.

2.2. Measurement of PM mass concentrations