EnvironmentAsia
The international journal published by the Thai Society of Higher Education Institutes on Environment

Available online at www.tshe.org/EA
EnvironmentAsia 3(special issue) (2010) 103-108

Indoor Air Quality in Selected Samples of Primary Schools in Kuala Terengganu, Malaysia

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Abstract

Studies have found out that indoor air quality affects human especially children and the elderly more compared to ambient atmospheric air. This study aims to investigate indoor air pollutants concentration in selected vernacular schools with different surrounding human activities in Kuala Terengganu, the administrative and commercial center of Terengganu state. Failure to identify and establish indoor air pollution status can increase the chance of long-term and short-term health problems for these young students and staff; reduction in productivity of teachers; and degrade the youngsters learning environment and comfort. Indoor air quality (IAQ) parameters in three primary schools were conducted during the monsoon season of November 2008 for the purposes of assessing ventilation rates, levels of particulate matter (PM_{10}) and air quality differences between schools. In each classroom, carbon monoxide (CO), CO_2, air velocity, relative humidity and temperature were performed during school hours, and a complete walkthrough survey was completed. Results show a statistically significant difference for the five IAQ parameters between the three schools at the 95.0% confidence level. We conclude our findings by confirming the important influence of surrounding human activities on indoor concentrations of pollutants in selected vernacular schools in Kuala Terengganu.

Keywords: Indoor air quality (IAQ); Particulate matter (PM_{10}); Carbon monoxide (CO); Carbon dioxide (CO_2); Terengganu

1. Introduction

Indoor air pollution has been identified as one of the most critical global environmental problems (WRI, 1998). In the last several years, Indoor Air Quality (IAQ) in workplace and residential environments caught the attention of scientists and the public redundant. Until the late 1960s, attention to air quality was primarily focused on the outdoors because, by that time, outdoor air pollution was considered responsible for many adverse health effects (Zhang, 2005). People spend most of their time indoors and institutional buildings, such as schools, represent a significant fraction of the day (Yip *et al*., 2004); and since people spend more than 90% of their time indoors, good indoor air quality is very important to us.

Air quality at classrooms is of special concern since children are susceptible to poor air quality, and indoor air problems can be subtle and do not always produce easily recognizable impacts on health and wellbeing (USEPA, 1996). The physical environment of children is different and more vulnerable from those of adults, even when living in the same home. Failure to prevent indoor air pollution can increase the chance of long-term and short-term health problems for students and staff; reduction in productivity of teachers; and degrade the student learning environment and comfort. Particulate air pollution has been found associated with increased respiratory symptoms, school absences and medication use for asthmatic children (Peters *et al.,* 1997). Moreover, the Canadian Lung Association (CLA) 2002 estimates up to 10% of children experience symptoms of asthma, a condition accounting for ¼ of school absenteeism.

The metabolic rate per kilogram of body weight of children is much higher than that of an adult, in part because children are still developing and they are smaller. This means that their respiratory rate, for example, is proportionately greater and they breathe in much more air pollution in relation to their body weight than an adult in similar circumstances (Yassi *et al.,* 2001). Also, their bodies are still developing and the effect of an environmental insult can interfere with that development.

Children and elderly are known as sensitive group to indoor air pollution. Previous studies have found out that indoor air quality affected these sensitive groups more compared to ambient atmospheric air. Due to this fact, an indoor air quality study was carried out in selected vernacular schools in Terengganu state, Malaysia. This study is imperative because children spend half of their day in school buildings. Moreover, no studies have been reported as regards to indoor air pollution status of schools in the East Coast of Malaysia. For that reason, this study is timely and there is a pressing need to determine the actual IAQ status especially in the schools, where our nation's so-called future leaders are trained. Therefore, the aim of this research is to determine the concentrations of selected IAQ parameters in selected schools in Kuala Terengganu; and also to evaluate IAQ trends in the monitored areas and between samples and comparing them with existing IAQ guidelines and standards.

2. Methodology

This study was conducted in schools situated in Kuala Terengganu. Kuala Terengganu is capital city of Terengganu state. It has an approximate area of 605 km^2 (Terengganu Economy Planning Unit, 2008). There are 80 primary schools entire of Kuala Terengganu but only three schools were selected in this study (shown in Fig. 1). The selection of study location is based on its different site of human activities such as commercial area (Sekolah Kebangsaan Sultan Sulaiman 1), sub-urban area (Sekolah Kebangsaan Pasir Panjang) and outskirt-hilly area, Sekolah Kebangsaan Bukit Wan respectively. Table 1 shows the sampling locations and their coordinates.

2.1. School and room selection

As clearly defined in the overall objectives of this research, only classrooms were targeted during this study. It was also mandatory that a space be occupied during sampling as defined by the ASHRAE procedure for ventilation for acceptable indoor air quality (ASHRAE Standard 62-2001, Ventilation for Acceptable Indoor Air Quality). Three classrooms in each school were randomly chosen for sampling because of the following reasons: First, logistics dictated that three as the optimal sample size and second, in the event of instrument failure, sampling could be repeated. Participant recruitment and consent were approved by the Terengganu Education Department (TED).

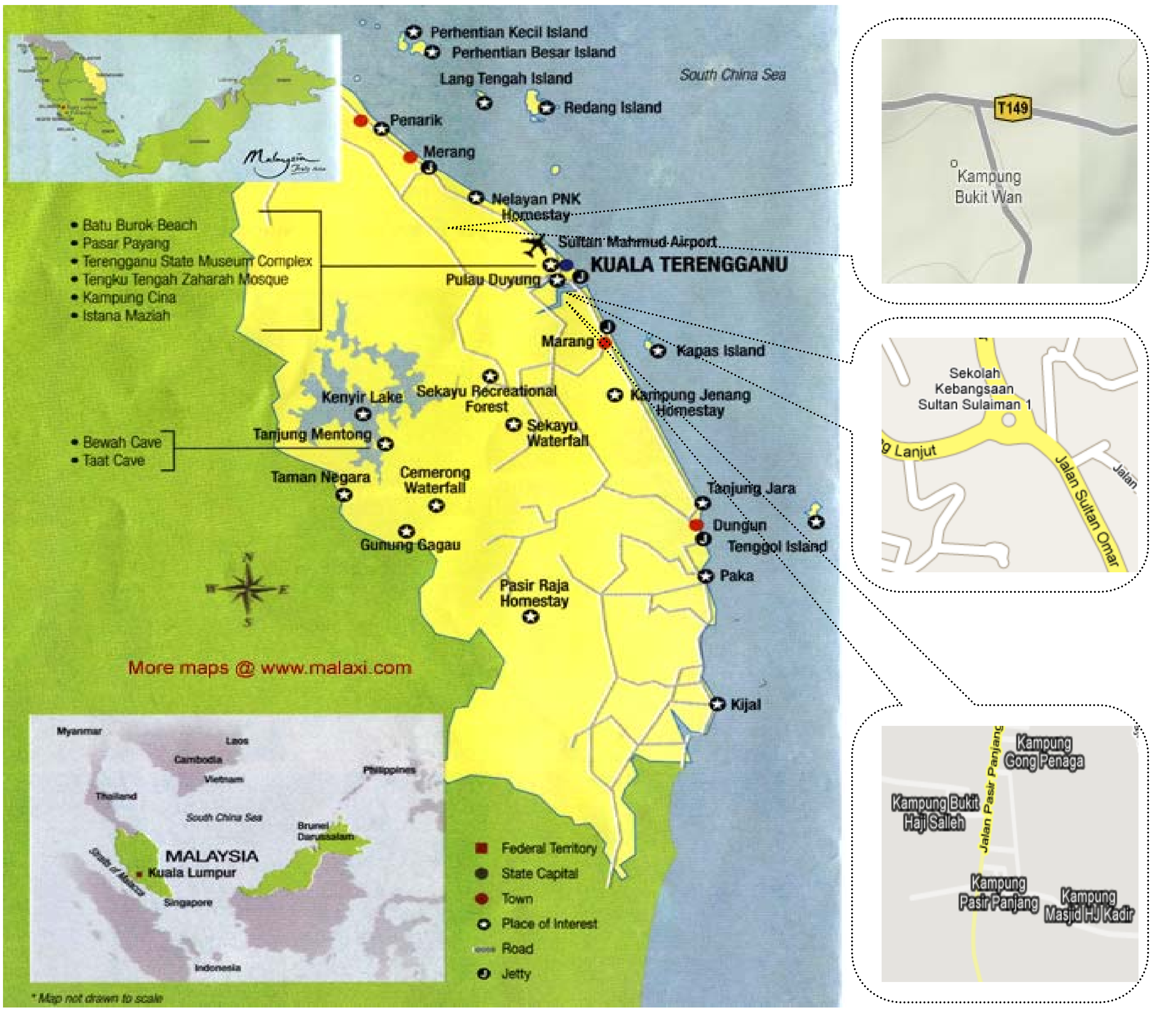

Figure 1. Map of sampling location.

Table 1. Sampling site locations together with their coordinates

Sample	Location	Coordinate	Site Category	Sampling Duration
1	Sekolah Kebangsaan Sultan Sulaiman 1 (SKSS1)	05°19'15"N; 103°08'32"E	Commercial Area	5 hours
2	Sekolah Kebangsaan Pasir Panjang (SKPP)	05°18'9"N; 103°08'17éE	Sub-urbanArea	5 hours
3	Sekolah Kebangsaan Bukit Wan (SKBW)	05°23'48"N; 103°00'55"E	Outskirt-hilly Area	5 hours

2.2. Selection of Monitoring Instruments

Research objectives required collection and analysis of baseline IAQ data from schools. The methodology selected had to support measurement of several environmental parameters including temperature, relative humidity, airflow rates, carbon dioxide (CO_2) and carbon monoxide (CO). Air sampling was conducted indoors while classes were in session. All of the air-monitoring equipments used in this study were supplied by Department of Engineering Science, Universiti Malaysia Terengganu. A Kanomax Climomaster was used to obtain air velocity measurements of indoor air, while Kanomax IAQ Monitor was used for temperature, relative humidity, CO_2 and CO measurements within selected classes/spaces. Casella Microdust Pro was used to detect particulate matter (PM_{10}).

2.3. IAQ Sampling and Data Analysis

The IAQ sampling methodology follows a systematic approach as shown in Fig. 2. Sampling parameters include PM_{10}, CO_2, CO, air velocity, temperature and relative humidity in each room. Monitoring was conducted in occupied rooms over a 3-day period in each school from 8 am to 1.00 pm. The measurement of all schools was conducted in two rounds: in first round, August 13, 2008 until August 28, 2008 and in second round, November 1, 2008 until November 19, 2008. Air velocity, CO and CO_2 were measured every 5 min using Kanomax Climomaster and Kanomax IAQ Monitor. Except for PM_{10}, all the other parameters were sampled utilizing grab sampling technique, whereby the detectors are placed at the back of each classes, at least 0.6 m above the floor and below the ceiling, away from windows, doors, at least 0.5 m

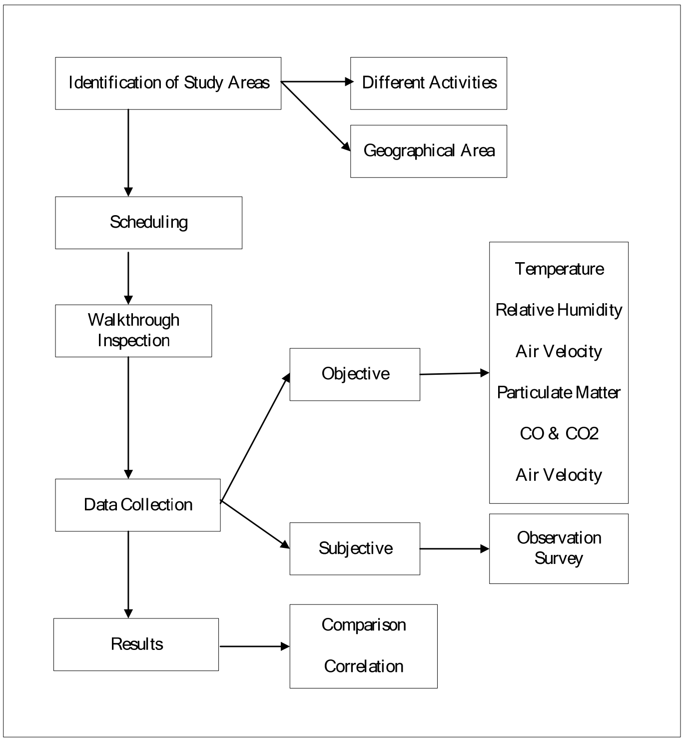

Figure 2. Sampling methodology.

away from bookshelves, and out of reach of children. Outdoor measurements were carried out in school field of each school, usually at an area not frequently visited by the students, for security purposes. For PM_{10}, sampling was conducted over a 5-min period for each occasion to obtain a representative data.

All the collected data were entered into a spreadsheet i.e. MS Excel for analysis. Where normality and homogeneity of variance of the data were confirmed, single classification analysis of variance (ANOVA) F test was performed. Descriptive statistics for the concentrations of the parameters were calculated, including mean; standard deviation; maximum; minimum.

3. Results and Discussion

3.1. Carbon Monoxide

Outdoor combustion generated activities i.e. automobiles exhaust from attached garages, nearby roads, or parking areas and construction are believed to be the sources of CO concentration. There exists a statistically significant difference ($P < 0.05$) between the means of the three schools with SKSS1 recording the highest value while SKPP has the lowest concentration of CO. Fig. 3(a) shows that the measured concentration CO ranged between 2.74 to 4.09 ppm in SKSS1, 0.49 to 2.18 ppm in SKBW and 0.12 to 0.61 ppm in SKPP, respectively. These values are well below the Malaysian Code of Practice (DOSH, 2005) recommended value of 10 ppm for an 8-hour period exposure.

3.2. Carbon Dioxide

The recommended values of exposure for CO_2 exposure should not exceed 1000 ppm for an 8 hour period as indicated by Malaysian Code of Practice (DOSH, 2005) and ASHRAE standards. Fig. 3(b) shows that CO_2 concentrations are almost in the same range for the three schools i.e. 638.27 to 698.90 ppm for SKSS1, 555.50 to 647.60 ppm for SKBW, 545.60 to 675.0 ppm for SKPP, respectively. There is not much difference in CO_2 value between the schools because the number of students in each class is almost the same as recommended by the Malaysian Ministry of Education. In general, during classes in each school, the CO_2 concentration is significantly higher compared to during recess hours (10 am). Outdoor concentration and occupant density (the prime source is human respiration) were found to be the origin of indoor CO_2 concentration in each school.

3.3. Particulate Matter

Age of building, types of flooring, presence of curtains, shelf area, dust from blackboard and fans were found to be the determinants in the PM_{10} classrooms. The recommended threshold level for respirable particulates (for particulate ≤ 10 μm) in the Malaysian Code of Practice (DOSH, 2005) is 150 μg/m^3. Fig. 3(c) shows the concentration of particulate indoor ranged between from 64 to 136 μg/m^3 for SKSS1; from 100 to 188.8 μg/m^3 for SKBW; and from 150 to 284 μg/m^3 for SKPP. Average PM_{10} concentrations for SKSS1 (101.5 μg/m^3) and SKBW (143.3 μg/m^3) is within the recommended value. On the contrary, there is a cause for concern in terms of indoor particulate pollution for SKPP which has an average concentration of 194.3 μg/m^3. The average concentration value for outdoor environment was measured at 31 μg/m^3 and this is well below the recommended outdoor air quality standards of 150 μg/m^3 (DOE, 1988). This suggested that outdoor air being introduced into the classrooms was not a major contributor to the suspended particulate matter.

3.4. Temperature and Relative Humidity

Fig. 3(e) and (f) shows the temperature and RH for the 3 schools i.e., SKBW, SKPP, SKSS1 with mean value of 27.99 °C , 81.78%; 30.61 °C, 71.90%; and 26.47 °C, 88.45%; respectively. The recommended range for acceptable indoor air quality is 23.0 °C to 26.0 °C for temperature and 30% to 65% for RH from American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE, 2007). This is due to the fact that Malaysia is located in the tropical region with a hot and humid climate, which affected the thermal comfort levels of the students. In general, the temperature profile increase slightly from morning to afternoon while for RH, the trend is reversed, with decreasing value as the time pass by.

4. Conclusion

The primary objective of this study was to determine the concentrations of selected IAQ parameters in the schools in Kuala Terengganu. Apart from particulate matter, we conclude our findings by confirming the important influence of surrounding human activities on indoor concentrations of pollutants in selected vernacular schools in Kuala Terengganu.

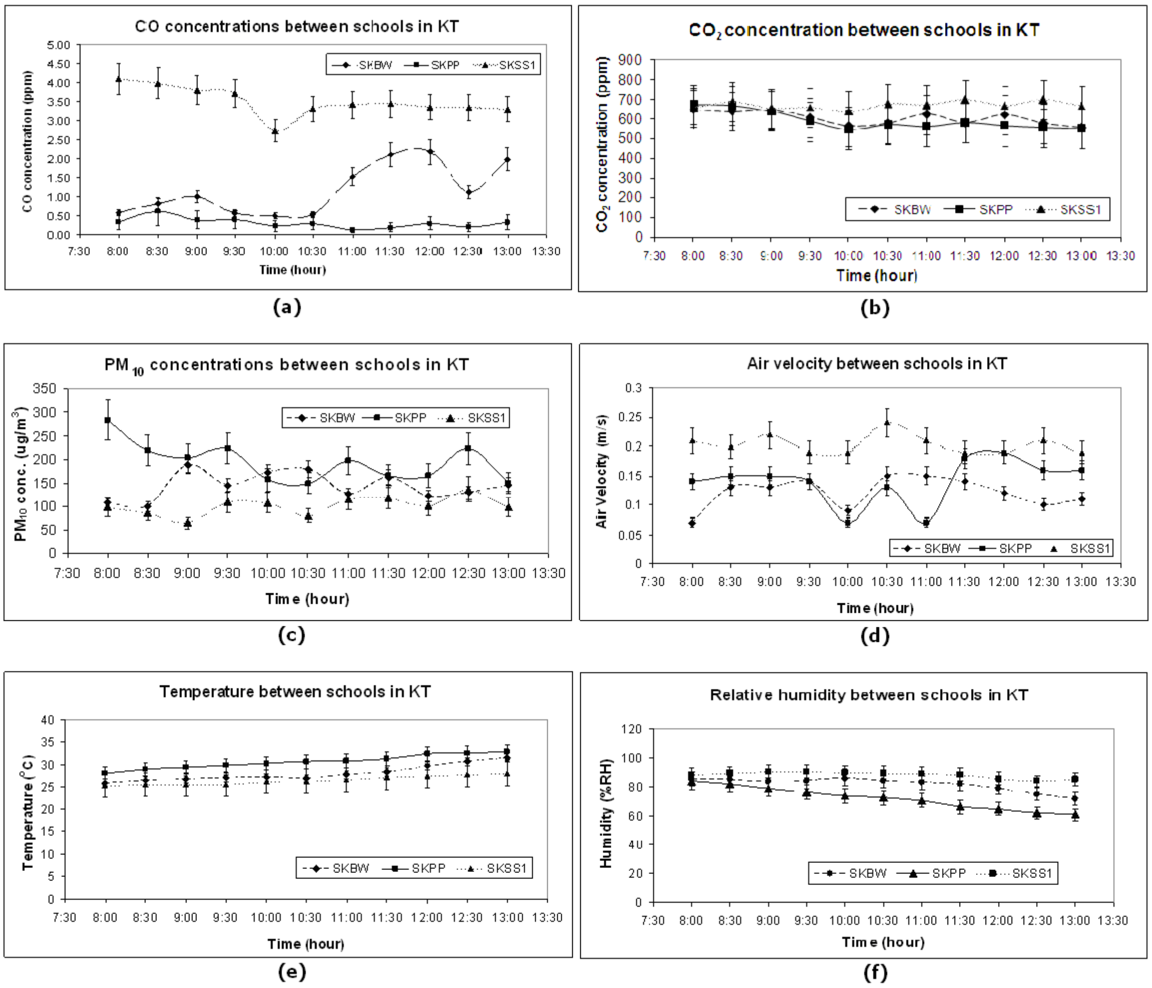

Figure 3. Studied parameters against time between the schools.

Acknowledgements

The authors would like to thank the Terengganu Education Department, (TED) and all staffs and students in Sekolah Kebangsaan Sultan Sulaiman 1, Sekolah Kebangsaan Pasir Panjang and Sekolah Kebangsaan Bukit Wan for their kindness and cooperation during the sampling duration. Special thanks to all of UMT staffs for their cooperation during implementing the sampling and lab work.

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Received 29 September 2009
Accepted 1 December 2009

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