Indoor Air Quality Assessment in Sri Lankan University Dormitories: A Case Study of On-Site Measurements and Inspections at Rajarata University

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1. Introduction

Research has consistently demonstrated that indoor air quality (IAQ) poses significant concerns for human health (Dales et al., 2008), largely because people typically spend between 80% and 90% of their time indoors (Borràs-santos et al., 2013) Prolonged exposure to indoor environments makes individuals vulnerable to various factors influencing IAQ, including physical, chemical, and biological (Dales et al., 2008).

The literature frequently highlights the health risks associated with poor IAQ (World Health Organization, 2018) with particular emphasis on particulate matter exposure (Huang et al., 2016) and the effects of environmental factors like CO_2 levels, temperature, and humidity in residential settings (Sun et al., 2019). Despite substantial research into the harmful effects of indoor pollutants, significant gaps remain, especially in the context of Sri Lanka. The use of modern building materials and chemicals in cleaning products has contributed to rising indoor air pollution. Moreover, contemporary building designs often result in inadequate ventilation, leading to the accumulation of indoor pollutants (Sun et al., 2019), further emphasizing the need for a thorough IAQ assessment and management strategy.

Although many studies have extensively investigated IAQ (Wierzbicka et al., 2018) comprehensive on-site evaluations of indoor air quality in Sri Lankan university dormitories are still scarce. This study aimed to fill that gap by conducting a detailed assessment of IAQ in Sri Lankan university dormitories through systematic on-site measurements and observations.

2. Materials and Methods

Phase I

The Sri Lankan Student Health (SLSH) study was conducted in two phases. Phase I involved a cross-sectional questionnaire study, using multi-stage cluster sampling to collect self-reported data on student health and dormitory conditions. Seven buildings were selected using stratified random sampling from a total of 14, with 502 rooms chosen at random. A total of 2,956 students were invited to participate. The questionnaire, adapted to Sri Lankan socio-economic conditions, and environment. Students had two days to complete and return the forms, and the survey was conducted in May 2020.

Phase II

Phase II of the study was a nested case-control study involving students from the cross-sectional survey. Students with at least two symptoms doctor-diagnosed asthma, current wheeze, or current rhinitis were selected as cases (190 students), while 198 healthy students with no asthma or allergy symptoms were chosen as controls. In total, 245 dormitory rooms were inspected. Inspectors, unaware of the students' health conditions, measured indoor environmental factors like temperature, CO_2, humidity, formaldehyde, $PM_{2.5}$, and PM_{10}. The dormitories, located in rural areas, were naturally ventilated, with louvers on windows, and common kitchen facilities were used by students for cooking.

Measured environmental parameters in the university dormitories.

In August 2020, environmental measurements were conducted in university dormitory rooms, focusing on physical parameters such as temperature, relative humidity (RH), and carbon dioxide (CO_2). These were measured continuously over 24 hours using highly accurate monitors. Additional pollutants, including $PM_{2.5}$, PM_{10}, and formaldehyde, were also recorded. Data collection spanned two seasons. CO_2 sensors were calibrated with a 1-minute sample interval, and monitors were positioned centrally in the rooms. Formaldehyde and particulate matter were measured for 5 minutes using portable instruments, ensuring readings were unaffected by nearby vents or heat sources. The study used the CO_2 tracer gas method to measure the air change rate (ACR) in dormitory rooms. This method has been employed in prior studies for similar analyses (Sun et al., 2024).

3. Results and Discussion

Results

In Phase I of the study, 2,234 students participated, achieving a 76% response rate. Conducted in May 2020, the survey revealed that 71.4% of respondents were female. Around 11% of students reported a family history of allergies, and 60.1% came from families with a monthly income exceeding 14,000 SLR. The findings show that 91.5% of the dormitory buildings were less than 10 years old, and 10% were single-story buildings. Nearly 61% of students used natural ventilation by opening windows.

Sri Lanka, a tropical region, experiences consistent warmth and sunshine, with rainfall being the main climatic variation. Measurements in the dormitories at Rajarata University included temperature, humidity, CO_2 concentration, air change rate (ACR), $PM_{2.5}$, PM_{10}, and formaldehyde. The median indoor temperature was 28.3°C, with 81.2% humidity. Nighttime CO_2 concentration was 1160 ppm, and the ACR was 0.86 h^{-1}. $PM_{2.5}$, PM_{10}, and formaldehyde levels were all within national limits (Table 1).

Table 1: Median distribution of the measured indoor environmental parameters in the dormitory of the Rajarata University of Sri Lanka

Parameters	N	Min.	25th percentile	50th percentile	75th percentile	Max.
Physical environmental parameters						
Temperature for 24 h[a] (°C)	245	25.2	27.6	28.3	28.8	30.7
RH for 24 h[a] (%)	245	68.6	77.7	81.2	85.9	97.2
CO_2 at night time[b] (ppm)	245	521	1047	1160	1360	2283
ACR at night time[b] (h^{-1})	245	0.43	0.70	0.86	1.08	3.20
Chemical, environmental parameter [c]						
$PM_{2.5}$ ($\mu g/m^3$)	245	10	13	15	16	35
PM_{10} ($\mu g/m^3$)	245	13	16	17	20	48
Formaldehyde (mg/m^3)	245	0.01	0.02	0.03	0.06	0.59

[a] 24 hour, [b]Night time 0.00- 07.00, [c]For 5 minutes.

Discussion

The evaluation of indoor air quality (IAQ) in the student dormitories at Rajarata University of Sri Lanka reveals several environmental issues, especially when compared to both national and international standards. The average CO_2 concentration exceeds the recommended thresholds, which typically advise levels below 1000 ppm, suggesting inadequate ventilation and potential overcrowding (Sun et al., 2011). This high concentration indicates a need for better ventilation systems and reduced room occupancy. A study in Tianjin, China, similarly found elevated CO_2 levels (1011-1483 ppm) in dormitories during the heating season with closed windows, which aligns with the results of this study (Sun et al., 2011).

The measured relative humidity (81.3%) also exceeds the upper limit of the Chinese national standard, raising concerns about mold growth and other humidity-related health problems (Sun et al., 2011). While the temperature is within acceptable ranges, the levels of particulate matter ($PM_{2.5}$ and PM_{10}) and formaldehyde are comfortably below the permissible limits, suggesting that the air is relatively free from common pollutants typically linked to respiratory issues. Previous studies conducted in Colombo, Sri Lanka, have reported higher levels of indoor $PM_{2.5}$ concentration than our study (Nandasena, and Wickremasinghe, 2011; Ranasinghe et al., 2015). For example, research in Colombo and Panadura monitored indoor $PM_{2.5}$ in 198 homes and found higher levels, especially in households that used biomass for cooking, with $PM_{2.5}$ concentrations exceeding WHO standards (50 $\mu g/m^3$) (Nandasena, and Wickremasinghe, 2011). Another study found average $PM_{2.5}$ levels of 143.7 $\mu g/m^3$ in the Colombo area (Ranasinghe et al., 2015). Studies conducted across several Asian countries have reported higher indoor $PM_{2.5}$ levels, such as 137 $\mu g/m^3$ in a study across seven region and 61 $\mu g/m^3$ in a study conducted in Shanghai, China (Lee et al., 2010). However, the lower $PM_{2.5}$ levels observed in this study are likely due to the rural setting, fewer industries, low urbanization, and the university policy prohibiting cooking inside the dormitories. Furthermore, cultural factors, such as the low smoking rates among Sri Lankan women and students (7.9%), also contribute to the lower $PM_{2.5}$ concentrations.

4. Conclusion

These results highlight the indoor air quality (IAQ) conditions in the student dormitories at Rajarata University of Sri Lanka. The study revealed that while most IAQ parameters, such as particulate matter ($PM_{2.5}$ and PM_{10}) and formaldehyde, remained within acceptable limits, the average CO_2 concentration significantly exceeded both national and international standards. This indicates an urgent need for targeted interventions to improve ventilation and air exchange rates in the dormitories. The findings underscore the importance of regular IAQ monitoring and the implementation of corrective measures to align with global health and safety standards, ensuring a healthier indoor environment for students.

5. Acknowledgment

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6. Key Words

Carban Dioxide (CO_2), Formaldehyde, Indoor Environment, Temperature.

7. References

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