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## **INDOOR AND OUTDOOR AIR AND LIGHTING QUALITY ASSESSMENT IN HIGH-RISE LOW-COST HOUSING IN PENANG**

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### **Abstract**

Georgetown, the capital of Penang Island, records the second highest density in Malaysia. On the other hand, those with lower economic status mostly live in low-cost, high-density vertical housing with indoor and outdoor environmental quality. Such housing conditions have severe implications on the residents' comfort. Hence, this study adopted the mixed-method approach to assess indoor and outdoor air and lighting quality in high-rise low-cost housing. The qualitative approach was deployed to observe three low-cost high-rise housing in Penang while the second approach was quantitative data collected using a survey questionnaire distributed to households in the case study area. This study aims to identify the current environment indoor and outdoor lighting quality in low-cost high-rise housing. The three low-cost housing areas investigated in this study, namely, Taman Ampang Jaya (TAJ) (Seberang Jaya Utara (SPU) district), Halaman Kenanga (HK) (Daerah Timur Laut (DLT) district), and Idaman Seroja (IS) (Daerah Barat Daya (DBD) district), had more than 200 units. Resultantly, the three-housing had an average air and lighting quality, whereas the corridor indicated poor lighting, as well as foul and unhealthy air. Indoor and outdoor air quality and lighting in high-rise housing are related to the environment surrounding the site.

**Keywords:** High-rise housing, quality of housing, air quality, lighting quality

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## **INTRODUCTION**

Low-cost housing attracts a high-density population, where people live in crowded spaces with limited facilities. Such housing conditions are associated with poor housing quality as the residents are faced with high-level air and noise pollution with heavy traffic congestion (Bakhtyar et al., 2013). Meanwhile, high-rise housing residents are becoming wary of sustainable development and smart cities.

Results from an (OCDE, 2011) study conducted on international housing showed that people living in good-quality homes with good indoor air quality enjoyed good mental health and prosperous lives. High-rise building design and construction features can contribute significantly to a sustainable environment in Malaysia (Zainon et al., 2016). Specifically, high-rise low-cost housing with high density is developed in Malaysia so that people can live in a building with shared facilities. According to (Husin et al., 2021), population density has a significant impact on the development of high-rise buildings in Malaysia. However, low-cost house dwellers residing in crowded units with fewer openings have a designed layout. A study revealed that low-cost housing with small overall floor areas of 650 sq ft and 700 sq ft, which come within a low budget, can lead to poor indoor environmental quality if the layout is poorly designed (Mohamed et al., 2014). Muhammad et al. (2015) reported that the housing quality is based on building design, wall and roofing material, building condition, building age, and lighting in the high and medium density areas. Architects need to design better low-cost houses to provide a better living environment for the occupants to achieve satisfaction and wellness in low-cost housing (Ismail et al., 2017). Additionally, architects must apply sustainable design principles to understand the laws and regulations related to the environment as referred by local authorities (Mohd Nawayai et al., 2020).

### **Indoor and Outdoor Air Environment**

Indoor environment quality (IEQ) is critical in low-cost housing units, especially in narrow inter-building areas and high-density housing. However, other factors contribute to indoor discomfort and poor air quality, such as the release of energy from household activities and appliances (Sahabuddin & Bin, 2019). In Malaysia, high-rise low-cost housing layout floor plans have a combination of 12 units or 16 units for the one-floor plan. The indoor ventilation needs more IEQ when the floor plan is crowded. According to (Fantozzi & Rocca, 2020), occupants' health is related to indoor environmental quality. For instance, different apartments in Korea can evaluate the indoor environment to consider the noise and air condition to maintain a healthy home environment and lighting condition in old apartments (Cho & Lee, 2011).

The corridor and staircase make up the outdoor parts of a high-rise building. Outdoor is a social recreation area for individuals to interact with neighbours and visitors. Meanwhile, a high-rise housing corridor is a walkway that serves as a link to the lift lobby or the staircase. Outdoor space facilitates social interaction and affects residents in high-rise housing (Huang, 2006). Outdoor ventilation needs good air quality for residents to be healthy and comfortable at the corridor and staircase. The wind flow for high-rise buildings has different heights to ensure the efficient use of outdoor ventilation (Lee et al., 2013).

### **Indoor and Outdoor Lighting Environment**

Lighting is important for both indoor and outdoor environments since it is the most frequently used element in a building. People tend to live in unhealthy environments when their homes lack natural lighting. The provision of daylight in the interior aspect of a house depends on the efficient design of the aperture, or in this case, the window. According to Kranti Kumar and Kranthi (2019), efficient daylight design must choose daylight methods aligning with passive techniques for building design.

The building design is essential to identify the housing quality and residents' quality of life in high-density housing. In order to measure residents' satisfaction towards the building quality, natural lighting is among the design quality and relevant indicators to be adopted in the Malaysian construction industry (Suratkon & Jusoh, 2015). Lighting is one of the building elements that the residents directly perceive and should be in good condition (Adeleye et al., 2014). Daylighting benefits the occupants of high-rise buildings to dry clothes and save indoor energy environment. Meanwhile, natural lighting is crucial to ensure comfort, healthy human body temperature, and a better interior environment. The outdoor area in a high-rise building needs good lighting, especially at the corridor and staircase, so that people can walk and perform outdoor activities comfortably.

### **RESEARCH BACKGROUND**

Three high-rise low-cost housing areas, namely, Taman Ampang Jajar (TAJ), Halaman Kenanga (HK), and Idaman Seroja (IS), were selected to evaluate indoor and outdoor air environmental quality. The first case study, Taman Ampang Jajar (TAJ), is located in Seberang Perai Utara (SPU) district; while the second case study, Halaman Kenanga (HK), is situated in Daerah Timur Laut (DTL) district. The third case study is Idaman Seroja (IS), which is located in Daerah Barat Daya (DBD) district.

A 5-point Likert scale ranging from 1 = very poor, 2 = poor, 3 = simple, 4 = good, and 5 = very good was used in this study. Previous studies have shown

that this measuring scale assists in assessing the level of housing quality problem (David, 2010; Lestan et al., 2014). The assessment of housing quality depends on the housing condition (i.e., good or poor). The use of respondents' quality value level is easy to understand, thus allowing the house interior quality to be assessed. The objective of this study was to assess the quality of air and light indoor and outdoor at the selected high-rise low-cost housing areas.

## **METHODOLOGY**

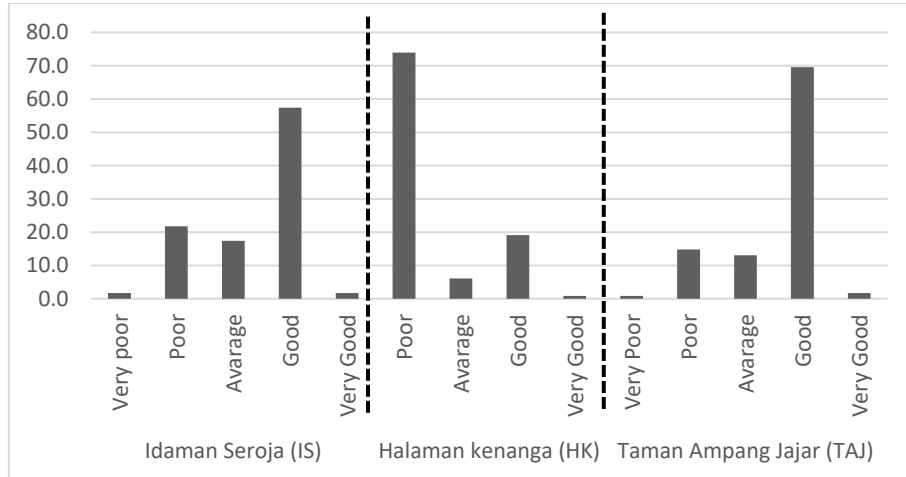
A mixed-method approach was employed in this study. Data were collected using a closed-ended survey questionnaire, whereas three low-cost high-rise housing in Penang were assessed in the case study. Stratified random sampling was used to select 115 households according to each case study area and low-cost high-rise housing chosen in the district at Penang.

A total of 345 households were involved in this study. Observation data were collected by capturing photos around the case study areas and inside the housing units with permission from the residents. Secondary data collection included population density, housing type, and housing location obtained from the Seberang Perai Municipal Council (MPSP) and the Department of Survey and Mapping Malaysia. The air and lighting quality values were measured based on on-site observation and experience. Observations of the images (photo taken) and data analysis revealed that level 7 corresponds to poor air and lighting quality levels.

## **RESULTS AND DISCUSSION**

The present results focused on four specific variables to assess occupants' satisfaction with high-rise building housing: air quality, light quality, indoor and outdoor areas, and noise pollution. From the air and lighting assessment in the housing units (see Figure 1), HK had poor air and lighting quality (73.9%) while 57.4% and 69.9% of respondents in IS and TAJ respectively stated that their housing units had good air quality and lighting.

Photo 1 illustrates the indoor lighting condition in one of the housing units in HK at level 7. Despite receiving natural light through the windows, the interior was still dark and the residents had to turn on the lights even during the day. HK housing had 22 floors in one building; the housing units on floors one to seven received inadequate sunlight from daylight. Referring to the guideline from Uniform Building by Law (UUBL), ventilation and lighting need 15% opening for a room. The developer needs to follow the guidelines and implement new low-cost housing designs ((Amir et al., n.d.).



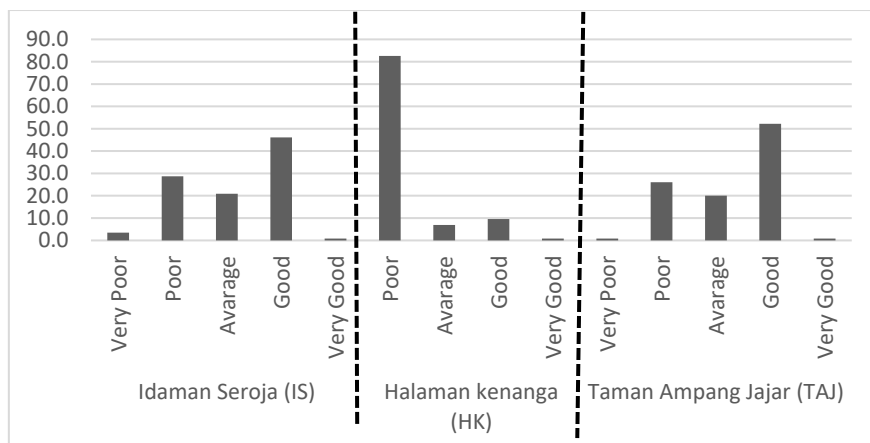
**Figure 1:** Air and light quality for indoor unit houses



**Photo 1:** Air and lighting quality of the indoor unit house in HK level 7

*Source: Wan (2019)*

Figure 2 shows that 52.2% of TAJ housing residents stated that the building had good air quality and lighting, followed by IS housing by 46.1% of the residents. However, 82.6% of respondents from HK stated that the air quality and lighting in the building was poor due to narrow corridors and high unit density. At times, foul odour reeked when it rained.



**Figure 2:** Criteria of air and lighting at the corridor

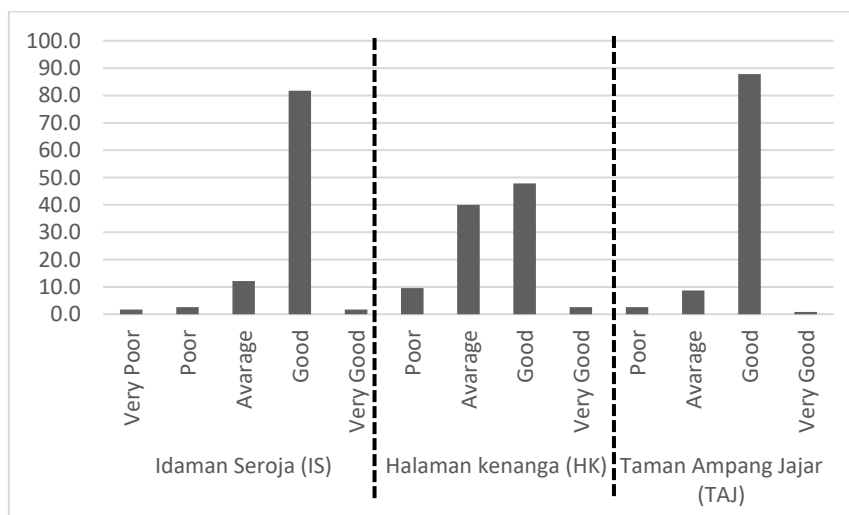


**Photo 2:** Air and lighting quality of HK housing corridor Level 7  
 Source: Wan (2019)

Photo 2 displays that HK housing level 7 required additional lighting during the day. The residents may improve the lighting in the corridor by installing lights in front of their houses. This is crucial for the residents' safety and comfort when walking down the corridor to the elevator or stairs. In this 22-block building, the size of the air voids was small and caused the units on the lower floors to suffer from poor air quality and lighting. In contrast, both IS and TAJ residential building designs had a wider opening in the lobby area. The IS housing had two separate blocks, in which one building block had only 16 units

with stairs that had an opening. This design ensured better air quality and lighting in the corridors of this building than that in the HK housing area. Meanwhile, the TAJ housing only had one L-shape block with an opening in the middle and the stairs were located at both ends of the open building.

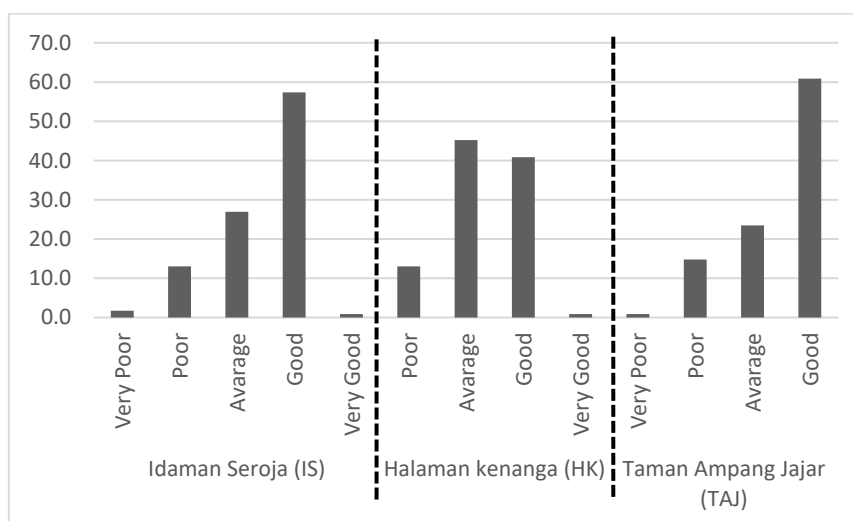
Good air quality and lighting in the staircase area is essential for residents' and occupants' safety when using stairs. Figure 3 shows that 81.7% of respondents in IS housing stated that the air and lighting condition at the stairs was in good condition. Similarly, 87.8% of TAJ respondents were satisfied with the air condition and lighting of the staircase area in the building. Observations on IS and TAJ housing areas showed that the open stairs were located on both sides of the building without any stumbling block around the area; signifying good lighting and air at the staircase area.



**Figure 3:** Criteria of air and lighting at the staircase area

Regarding the noise pollution assessment (see Figure 4), 45.2% of HK residents were awarded a simple score, 40.9% stated that the sound quality in the housing environment was of good quality, and 13.0% claimed that the noise quality was in poor condition. The HK residential building had two blocks and each consisted of 22 floors with a total of 357 units per block. The total number of housing units in this building was 714 units – indicating a high number of occupants. The noise was heard occasionally in the morning when the residents were getting ready to go to work and upon returning home in the afternoon. Additionally, children played in the playground that was located close to the site. Apart from the occupants, the source of noise pollution was from the main road that was close to the building (see Photo 3). Nevertheless, 57% of IS housing

respondents were satisfied with the minimal noise pollution in the morning and evening while 60.9% of TAJ housing respondents had no complaint about the noisy condition. This is because the TAJ housing is surrounded by landed housing, rice fields, and factories that did not contribute significantly to the generated noise.



**Figure 4:** Criteria of noise pollution in the housing areas



**Photo 3:** Low-cost Halaman Kenanga (HK) in front main road and playground inside site housing  
 Source: Wan (2019)

## CONCLUSION AND RECOMMENDATION

In conclusion, air quality and indoor lighting in high-rise low-cost residential buildings demand efficient ventilation. The shape and orientation of the building that is in line with the direction of the sun and wide openings with the appropriate



distance between buildings are crucial to improving air quality and lighting. Window size is also important in increasing natural airflow and lighting into the building. Good air and lighting offer comfort and safety to the residents when walking along the corridor. An architect needs to consider the outdoor environment quality in building design for the occupants to live comfortably in high-rise buildings. Good air and lighting are pertinent for occupants' safety, especially at the staircase for fire escape. This study assessed the air and lighting quality in indoor and outdoor of low-cost high-rise housing areas located in Penang. Future studies may determine indoor and outdoor daylight quality of low-cost high-rise housing in Malaysia. This study highlights the need to improve the environment and design to ensure more comfortable indoor and outdoor lighting quality. This could be achieved by ensuring that a unit house has a gap opening, a maximum of 16 floors, and the presence of a side opening staircase. Future research might consider different study methods or designs and target groups, such as high income and residents in the city.

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