



# The Perception of the Indoor Environment Quality (IEQ) of Private Hostels in Ifite-Awka, Nigeria

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## **Authors' contributions**

*This work was carried out in collaboration among all authors. Author CAO designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author FOE supervised every stage of the work. Author CBNBO managed the analyses of the study. Author NBI managed the literature searches. All authors read and approved the final manuscript.*

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## **ABSTRACT**

This study aimed at evaluating the indoor environment conditions of the private hostels in Ifite Awka Anambra state with a view to establishing its quality and impacts on students dwelling on these hostels in the study area. Being a survey research, the study was affected by the use of questionnaire, literature searches and direct observations. Accordingly, a total of 311 questionnaires were administered while 258 questionnaires which represent 83% were returned and found useful. The study found that IEQ parameters of hostels in study area are: Indoor air quality was poor due to inadequate ventilation of rooms; thermal comfort of rooms was found to be warm; indoor light quality was found good and the acoustics comfort and noise slightly good and to some extent poor. Therefore, the study recommended that during the design and construction of buildings, IEQ parameters should be considered, so as to obtain a quality indoor environment.

*Keywords: Indoor environment quality; indoor air quality; indoor light quality; acoustic comfort and noise.*

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## 1. INTRODUCTION

The common endeavour of humans across the globe and through the timeline of human existence is to create a comfortable indoor environment at any circumstance to satisfy people. The quality of the indoor environment constantly plays a critical and major role for humans not only in term of comfort but also has major influence on human life [1]. Technical flaws or weakness into the building system regarding the environmental condition can bring about negative effects on human health and comfort. Exposure to poor environmental conditions has been associated with deterioration of the physical health, mental and cognitive performance [2]. Long time exposure to a poor indoor environment can create a fatal effect on the human's health therefore it is important that standards are created for designers to improve the indoor environment quality. [3] guideline, indicated that people spend about 80-90% of their time indoors and many studies highlighted the fact that characteristics of building as regards its indoor environment has effect on human health, comfort, satisfaction and wellbeing [4,5]. Building performance has a critical role for human behaviour and has become a vast area of research focus for researchers globally [6].

Indoor environment quality is the quality or the level of excellence of the environment encompassing any building. [7] posits indoor environment quality to represent a domain that encompasses diverse sub- domains that affect the human life inside a building. They include indoor air quality, lighting, thermal comfort, acoustics, drinking water, ergonomics, electromagnetic radiation, damp, odor and many more. Indoor environment quality is the standard condition of the inside of a building which affects the behaviour and development of its occupiers. Indoor generally is defined as inside of a building. Environment' as the condition that affects the behaviour and development of somebody or something and 'Quality' as the standard of something when it compared to other things like it, fitness for purpose and fulfillment of requirements [8].

Indoor environment quality generally is concerned with the condition of the internal of a building and its relationship to the comfort of the building occupants, building function and its economic value. This condition affect energy condition /consumption of buildings. In view of these definitions above it is obvious that there is

no clear definition for indoor environment quality, it was basically expressed in terms of occupant's health determined by environmental aspects like indoor air quality, thermal comfort, lighting quality and others [9,10]. Therefore, indoor environment quality addresses the condition of the inside of a building, its quality and the factors responsible to keep it in its optimal standard, ensuring the comfort of the building users is achieved. Thus, it's important to note that the performance of a building occupant depends mainly on his/her indoor environment quality and other factors. On this note, this study aimed at evaluating the indoor environment conditions of the private hostels in Ifite Awka Anambra state with a view to establishing its quality and impacts on students dwelling on these hostels in the study area.

### 1.1 Indoor Environment Quality Parameters

The indoor environment quality parameters are those variables used to determine the condition or quality of the indoor environment. According to [11] these parameters may include:

- i. Indoor air quality
- ii. Thermal comfort
- iii. Indoor light quality
- iv. Acoustics comfort and noise.

### 1.2 Indoor Air Quality

According to [12] indoor air quality is a subsection and a substantial determinant of indoor environment quality and includes temperature and humidity. [12] carried an experiment to ascertain the indoor air quality using two molds growing on the ceiling to determine the indoor air variables where two molds were used. Both molds equal rate and neither was prevented after being washed by cleaning agents and repainting. He found that mold one releases no gas and its spores have no effect on occupants but just an eyesore. Mold two produced obnoxious odour and its spores caused several health problems to the occupants. The second mold is considered to be an indoor air quality variable as it has adverse effect on occupants when it mixes with the air of the room and the first mold is not an indoor air quality variable as it had no effect on occupant but just an eyesore. The molds grew in the environment as a result of the temperature and humidity of the internal environment, therefore they (temperature and humidity) are considered a subset of indoor air quality.

The research by [11] titled 'investigating the indoor environment quality parameters and their relationship with occupant's satisfaction in office buildings' opined that comfort is not commonly used in relation to indoor air quality but it is mainly linked with lack of discomfort due to odour and sensory irritation. They stated that poor indoor air quality is widely regarded as a significant health, environmental and economic problem. Whereas acceptable air quality is that in which there is no known contaminant at harmful concentrations and the people exposed to the air do not express dissatisfaction. The reason for dissatisfaction found to originate from construction details which include paint materials used and roof covering. [11] further stated that heating, cooking, and other indoor activities can as well influence indoor air quality.

Also, [13] in the research titled 'indoor air quality levels of some criteria pollutants in university hostels in Nigeria. Looked at the hostels in Federal University of Technology Owerri and the major air pollutants discovered are: Sulphur dioxide, carbon monoxide and particulate matters. They found that human exposure to these pollutants affect the health, wellbeing and productivity of building students (occupants) and also that indoor air quality level may be 2-5 times and occasionally more hundreds of times higher than the outdoor levels. Activities of people within the building such as the use of kerosene and gas stove, fuel combustion, tobacco smoking etc. is the main factors that cause the presence of air pollutants which result to poor indoor environment quality.

In-addition, [14] investigated the indoor air quality in primary school classrooms. The research indicated there is much concern in the air quality of classrooms. Ventilation rates, carbon dioxide and particulate matters were measured and analysed, and found that ventilation rate in the naturally ventilated classroom with windows and doors closed are less and carbon dioxide concentration during class hours can increase and also closing windows and doors can only partly prevent particulate matters from entering into the indoor air. The research indicated also that to ensure a good indoor air quality, mechanical ventilation system must be installed in the classrooms.

Furthermore, [15] in the study titled 'indoor air quality investigation according to the age of school buildings. The research revealed that the construction materials and furnishing have

negative effects on the indoor air quality. School buildings that are old tend to emit chemical that mix with the indoor air. It was found that school buildings that are young significantly have better indoor air standard. Therefore, increasing the ventilation rate by means of a mechanical system and the use of low emission furnishing can play key roles in improving the indoor air quality within schools.

### 1.3 Thermal Comfort

Thermal comfort is an essential factor of the indoor environment quality and it plays important role in the satisfaction and comfort of occupants. [16] defined thermal comfort as that condition of mind which expresses satisfaction with the thermal environment, influenced by environmental factors such as air temperature, radiant temperature, relative humidity, air velocity and personal factor such as metabolic heat activity level of human body and clothing. Also, [11] defined thermal comfort as that condition of mind that expresses satisfaction with thermal environment and is assessed by subjective evaluation.

Thermal comfort is characterised by two factors: environmental parameters and personal factors. Environmental parameters consist of air velocity, air temperature, air relative humidity and personal factors consist of human body insulation through clothing and their metabolic rates.

Thermal standard may be difficult to create as there is variation to individual's thermal adaptation which is correlated to characteristics such as race, culture, gender, time of year, age, body and geographical location and climate. Varied variables of thermal comfort make it more complicated to prepare a comfortable condition regarding thermal comfort for occupants as a result, despite all the professional endeavour to craft benchmark for thermal comfort, it is still one of the most dissatisfying sources in the buildings. Masoud et al. [11] found that by applying natural ventilation and courtyard it is possible to reduce the energy consumption of a building.

Furthermore, in the [17] researched on thermal comfort and described it as a "state of mind which expresses satisfaction with the thermal environment". It is a subjective state which varies from person to person. The judgment of comfort is a cognitive process involving inputs influenced by physical, physiological and psychological

factors. Comfort is dependent on highly independent and dynamic factors such as clothing, altering activity, changing posture, window location and mood. Achieving overall thermal comfort in a building is a complex task, as thermal comfort is an outcome of different physical parameters, creating a thermal state and understanding a collection of subjective human responses to that thermal state. Thermal comfort varies individually and geographically due to a broad range of factors such as age, sex, metabolism rate, time of the year, among many others. Thermal comfort in an office is measured by analysing the number of discomfort complaints. Complaint analysis is a reactive method.

Likewise, [18] researched on developing a thermal comfort model for sleeping environment in the subtropics and found that clothing (acceptable formal dress) also influence the occupant (employee) comfort. The formal dress code varies from culture to culture across the globe. This presents an opportunity to map a comparison amongst various countries and their attire in line with acceptable comfortable temperature. Temperature and productivity indicate that different functions have different optimum temperatures of productivity. Optimal thermal comfort and optimum performance may not coincide with the particular type of tasks.

Similarly, [14] on the research titled the effect of vegetation on the indoor and outdoor thermal comfort conditions, from a micro-scale study of two similar urban buildings in Akure, Nigeria. Used the thermal conditions of two buildings, one of the building had shaded trees and the other had unshaded trees. The research showed that the building with shaded trees became less comfortable thermally during the dry season before the noon. Also, the outdoor area around the tree-shaded building is more thermally comfortable than around the unshaded tree irrespective of the season. Trees as a form of vegetation, foster microclimatic control and thermal comfort. [19] deduced that tree shading reduces the duration of thermal dissatisfaction by over half and limits the severity of heat from solar radiation.

Also, [20] on the research titled 'numerical simulation of the different vegetation patterns' effects on outdoor pedestrian thermal comfort' compared the microclimatic control pattern between trees, grasses and shrubs. They found that trees may not always improve pedestrian

thermal comfort in all directions around buildings because to a certain extent they obstruct and block the wind flow. [21] on the research titled assessment of thermal performance of residential buildings in Ibadan, Nigeria, found that the thermal performance and efficiency of buildings are measured through climate responsive design. The use of site and climate for design with regard to thermal efficiency has further potential for reducing active energy which is the operational energy of the building. Lawal (2008) stressed that due to the increased concern about passive energy utilization in buildings for provision of thermal comfort, in saving energy life cycle costing can be used in computing the capital cost of constructing and operating the building over its projected life.

#### 1.4 Indoor Light Quality

According to [11], Light is one of the essential elements needed for human populations and it is known to correlate in affecting their physical and psychological behaviours. A good lighting is not only able to provide a basic required level for visual performance, but it also determines spatial appearance, provides safety and indirectly contributes to occupant's well-being. [11] aimed to find a correlation between the quality of indoor environment light and human performance. The result of this study on the indoor environment parameters and their relationship with occupants' satisfaction in the office buildings carried out by [11] indicated that being exposed to insufficient or inappropriate light has the ability to disrupt human standard rhythms, therefore it might have adverse results for human performance, safety and health.

Lighting environment can influence an occupant's safety, the level of fatigue, comfort, as well as work efficiency and accuracy. Providing a high quality lighting system is an essential factor in the buildings to ensure the visibility of the objects, occupants' health, and comfort; however, the quality of the light significantly depends on several aspects of the lighting system as luminance, illuminance (intensity of light that impinges upon a surface), avoiding the glare, uniformity, distribution, and colour contrast. Regarding illuminance the recommended range significantly depends on the need for visual activity and the age of the user, whereas for the maximum luminance ratio guidelines come with some recommendation, i.e., the range of luminance in the visual field [22].

The indoor day lighting is affected by two major factors: characteristics of the building and the total natural light from the sky. Building characters include windows, building shading, indoor partitions, and direction of the building, atrium, and skylights. The amount and direction of natural light are varied due to movement of the sun and the condition of the sky. Regarding the artificial light, the indoor light quality relies on the several aspects of lighting function as a number of luminaries, locations, and light source type as well as the specifics of the indoor surfaces' materials like their colour and spectral reflectivity. Moreover, the details of controlling the indoor lighting system as a, no control over lights, manual control of overhead, automatic dimming of artificial light, and task lighting has a strong potential to influence lighting quality.

The research by [23] titled 'Economic analysis of the daylight-linked lighting control system in office buildings. Found that daylight influences our day-to-day tasks throughout the year. Daylight controls our biological clock/internal clock which have been set for millions of years according to the rising of the sun and the darkness of night. Daylight is considered to be the best source of light with excellent colour rendering that offers the best light for human visual comfort. It provides a sense of cheeriness and brightness and has a positive impact on people [24,25]. Buildings worldwide contributed to roughly 40% of the world's annual energy consumption [26]. Lighting has the highest share (33%) in the calculation of average electricity consumption in the buildings, they account for one-third of the nation's primary energy consumption. Artificial lighting utilizes 25-40% of the total commercial buildings' energy consumption [27]. The research indicated that artificial lighting is a major contributor to carbon dioxide emissions and global warming as it utilises one-third of the electricity bill. Efficient day lighting measures and intelligent lighting systems can help reduce the artificial energy load and thus the carbon footprint of a building. Organisations that pay attention to the importance of day lighting achieve higher occupant productivity in their workplaces. Building occupants prefer natural light/sunlight over artificial light [28].

A building therefore should be designed according to local climate, building's orientation, solar altitude, and immediate surroundings, nature of the space, and layout of the building alongside and day lighting availability. A day

lighting design can be any method by which natural light is brought into a room to provide adequate lighting conditions. It involves analyses of daylight availability which is dependent on the light available from the sun and the sky at a certain locations, times and weather conditions [29]. Daylight analysis lays the path to the day lighting strategies of side-lighting (windows) and top-lighting (skylights, roof monitors) [30].

Illuminance from natural sources is determined by the Daylight Factor (DF). The Daylight Factor is the percentage of outdoor light under overcast skies available indoors. It takes three components into account; the sky component (SC), the light from external surfaces/externally reflected component (ERC) and the light reflected from surfaces within the room/internally reflected component (IRC) [31]. The recommended level of Daylight Factor (DF) for different buildings depends on the type of task the building is used for. Excess of direct sunlight and artificial light can result in a glare that results in visual discomfort. A low level of lighting can lead to ocular discomfort and improper lighting design leads to worker dissatisfaction. The Illuminating Engineering Society of North America (IESNA) describes the density of luminous flux on a surface, which represents flux per unit area of distribution. A high level of illuminance from daylight may cause glare inside a building, called Daylight Glare (Rea, 2000). Daylight glare has the measurement metric known as Daylight Glare Index (DGI). Glare can be caused by combination of daylight and artificial lighting.

### 1.5 Acoustics Comfort and Noise

Acoustic comfort as defined by [32] is a state of contentment with acoustic conditions". Therefore, any sound could be considered as noise by occupants when it starts to push the human toleration. In other words, inappropriate acoustic inside the building could cause occupants to lose their concentration and comfort. Moreover, the quality of the sound environment has some parameters as physical properties of a room and physical properties of sound itself. The sound has two characters as sound pressure level (Short-term and long-term period) and sound frequency. The acoustic quality is affected by reverberation time, absorption, sound insulation and physical room properties [33]. In relation to sound pressure level, [34] claimed that the neutral sound pressure level for occupants to feel comfortable in a typical air-conditioned room

should have mean of 57.5 dB (decibels), minimum of 45 dB and the maximum of 70 dB. Another study found that occupants had a satisfaction with sound pressure level when the noise level was below 49.6 dB, and when the noise level passed this threshold the subjects had started to feel unsatisfactory [35]. Another major parameter is reverberation, it is a phenomenon that happens when the reflection of all the surfaces inside a room combine to each other. It can influence and reduce the speech intelligibility and increase the sound level in a room, one way to reduce or eliminate the reverberation is to absorb the unwanted reflection off surfaces [36]. Echoes elimination is also possible by absorption. For instance, the rear wall of the auditorium is one the prime candidates for implementing the absorptive material, since the rear walls have great potential to create the echoes and cause the ultimate dissatisfaction or discomfort for the audiences. Therefore, the users' discomfort has a relation to sufficient acoustic quality in the indoor environment, the sources of discomfort should be eliminated to prevent the discomfort and prepare a comfortable environment regarding noise. Privacy and distractions are the main characters of the acoustic discomfort in buildings [37].

Huang et al. [35] claimed that the productivity of occupants in an office has a direct relation with privacy and distraction. The spaces which the speech causes a prevailing source of the noise, a concern regarding privacy might occur. [38] claimed that the privacy issue is more severe and dissatisfied in the open plan office with a high number of users than the cellular and individual offices. Noise in the building is created by various inside and outside sources like peoples talking, mechanical, electrical, and outside sounds. The most common noise sources in buildings, other than the inhabitants, are related to heating, ventilating, air conditioning (HVAC) systems, plumbing systems, and electrical systems [39]. The acoustic environment is influenced by such physical room properties as sound insulation, absorption and reverberation time [39]. Considering the acoustic quality in buildings is an unavoidable fact for increasing comfort and performance. Therefore, buildings should be designed in the way that totally satisfied occupants in the related of acoustic quality. Acoustic comfort can also be achieved using sound absorbing materials in the room. Acoustic quality of a room is described by the reverberation time and the sound absorption of a room. It is related to the absorption

characteristics of the room surfaces and the volume of space [40].

## 2. METHODOLOGY

This study adopted survey research design. The population of the study includes students and hostel warders in Ifite. The number of registered private hostels in Ifite from the records available in the university is 1,400. The sample size for the categories of the study population was calculated using the Taro Yamane formula. From the calculation the sample size for is 311 respectively. The population of the private hostels for the study was drawn using cluster sampling technique. This involves breaking down the population into sub-groups and sample was drawn from only one part of the groups at a time. Then the respondents in each of the hostels were drawn using purposive sampling method by selecting a student from the chosen hostel.

Data for this study were collection using a well-structured questionnaire. The questionnaires centre on the four parameters of the indoor environment qualities (i.e. indoor air qualities, indoor light qualities, thermal comfort, acoustic comfort and noise). The questionnaires were measured with the using 5-scale Likert scale. The data obtained with the use of questionnaires were analysed and presented using table of frequency, percentages and bar charts.

## 3. RESULTS

From Table 1, a total of 311 questionnaires were administered to respondents while 258 questionnaires which represent 83% were returned and found useful. However, 53 questionnaires representing 17% were not returned. According to Fincham (2019) who stated that the acceptable response rate of a survey questionnaire should be greater than or equal to 80. This indicates there was a high response rate which is found adequate for the study.

Figs. 1 – 4 solicit the reactions of the respondents towards their indoor environment qualities considering its 4 – parameters

## 4. DISCUSSION

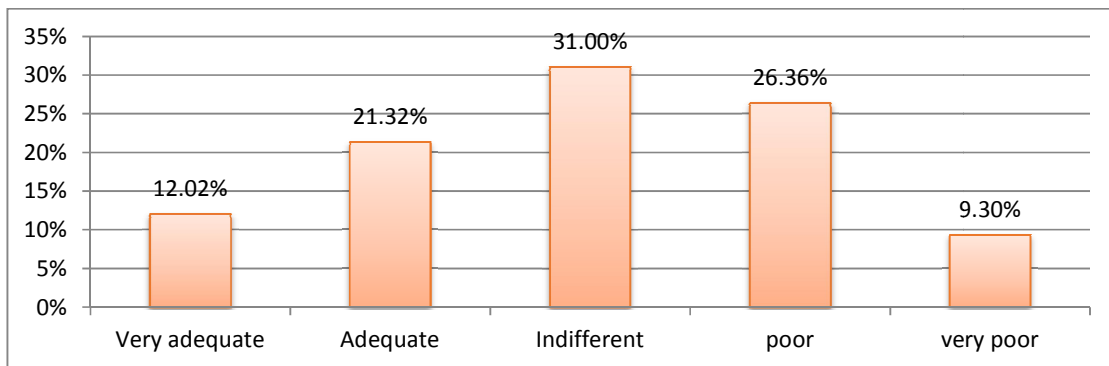
Fig. 1 shows the respondents perception with the quality of the indoor air in rooms. This data is gotten using students who live in private hostels in Ifite. The result in Fig. 1 shows that 12.02% and 21.32% of the respondents believes that the

indoor air quality of their hostels is very adequate and adequate respectively. Whereas 26.36% and 9.30% opted for poor and very poor respectively meanwhile 31% were indifferent. Based on this,

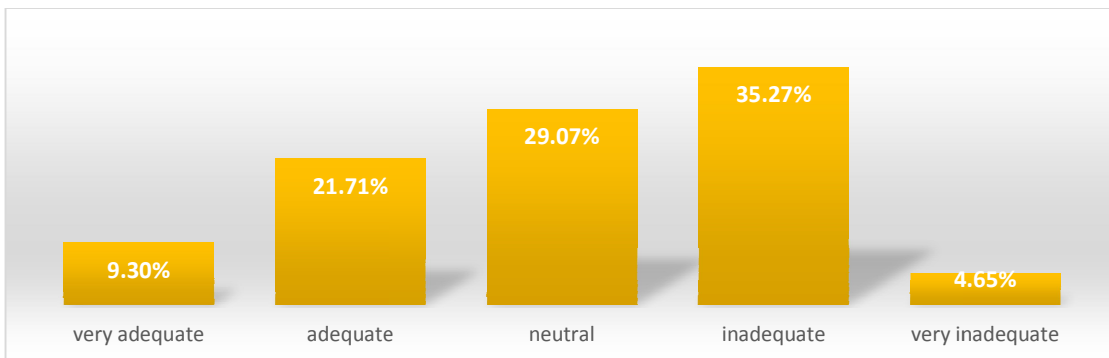
33.34% of the respondents are satisfied with their indoor air quality with 35.66% not satisfied. Therefore, the indoor air quantities in these hostels can be drawn to be poor.

**Table 1. Questionnaire distributions and response rate**

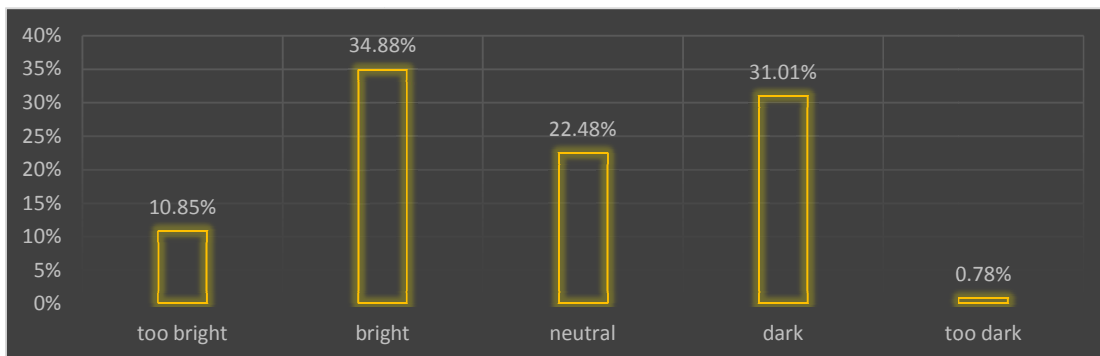
Questionnaire	Frequency	Percentage (%)
Number of questionnaires shared	311	100
Number of questionnaires returned	258	83
Number of useful questionnaires	258	83



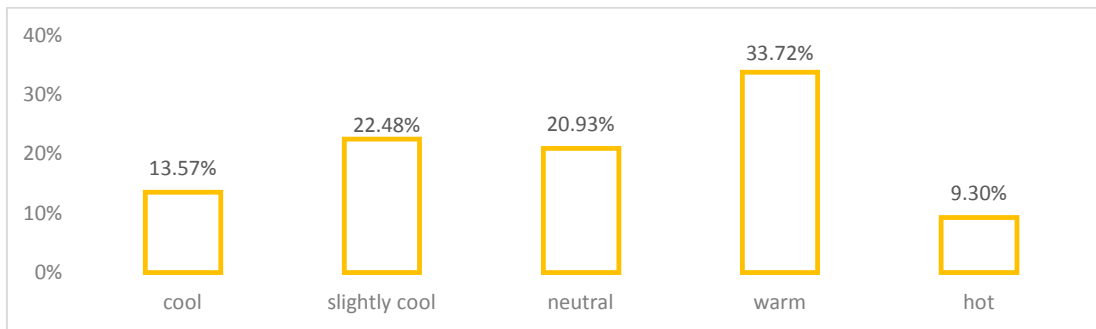
**Fig. 1. Indoor air quality of hostels in the study area**



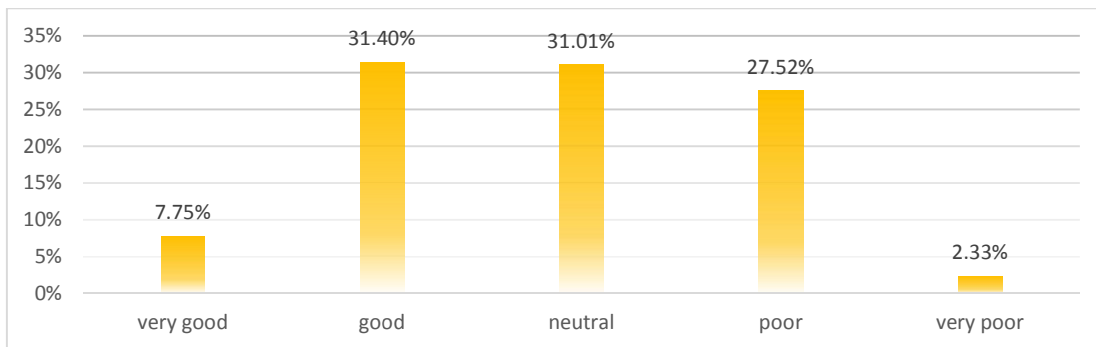
**Fig. 2. Natural ventilation received in the indoor environment of the hostel**



**Fig. 3. Indoor light quality in the study area**



**Fig. 4. Thermal comfort**



**Fig. 5. Acoustics comfort and noise**

The result in Fig. 2 revealed that 9.30% and 21.71% of the respondents agreed that amount of natural ventilation they received in their hostels are very adequate and adequate respectively. 35.27% and 4.65% of the respondents were of the opinion that amount of natural ventilation they receive is inadequate and very inadequate respectively. Also, the result in Fig. 2 revealed that 29.07% of the respondents are indifferent as regard the amount of natural ventilation they received in their hostels. From this, 31.01% and 39.92% were satisfied and not satisfied with the amount of the natural ventilation they received in their hostel. This supports the findings in Fig. 1 and amount of natural ventilation received in these hostels would be termed inadequate.

The result in Fig. 3 reveals that 10.85% and 34.88% of respondents were of opinion that indoor light qualities in their rooms were too bright and bright respectively. Also, 31.01% and 0.78% of the respondents went for dark and too dark respectively (see Fig 3). Accordingly, 45.73%, 22.48% and 31.79% of the respondents are satisfied with the amount of light received, neutral and not satisfied respectively. Thus, difference between those satisfied with their

indoor light quality to those not satisfied is 13.94%.

The results in Fig. 4 revealed that 13.57% and 22.48% were of opinion that thermal comfort of their rooms is cool and slightly cool. However, 33.72% and 9.30% were warm and hot respectively with 20.93% neutral (see Fig. 4). The rating of thermal comfort in Fig. 4 indicates 36.05% and 43.02% were either cool or slightly cool and warm or hot respectively. Accordingly, the thermal comfort would be rated hot or warm in the study area. The perception of the respondents as regard acoustic comfort and noise in Fig. 5 shows 7.75%, 31.40%, 31.01%, 27.52% and 2.33% went for very good, good, neutral, poor and very poor respectively. Thus, the proportion of acoustic comfort and noise rated good to poor stood at 39.15% and 29.85%.

## 5. CONCLUSION

Indoor environment quality is an important concern in the design and construction of buildings, therefore the design and construction of buildings should be in a way that the required standard for an indoor environment is met, since people spend most of their time indoors. This



study concluded that indoor air quality is significantly poor due to inadequate ventilation into the rooms, the thermal comfort of rooms was found to be warm, indoor light quality was found good and the acoustics comfort and noise slightly good and to some extent poor which defined the quality of indoor environment. Therefore, the study concluded by recommending that in the design and construction of buildings, indoor environment quality parameters should be considered, so as to obtain a quality indoor environment and every room should have a minimum of two windows of adequate sizes for cross-ventilation sake.

### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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