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# Implications of Indoor Air Pollution in Business Buildings in Nigeria

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**Abstract.** Globally, the majority of individuals spend 90 percent of their daily routine time indoors. Outside air pollution adds to the toxins created in interior spaces owing to heating and cooling, which has a substantial impact on person healthiness (illness that results in mortality and morbidity) and productiveness. This study investigates the implications of air pollution on interior air quality in commercial buildings such as event centres in Kogi State, Nigeria. Descriptive research approach was used with a questionnaire administered to 120 participants chosen through a random sampling procedure in business buildings. Findings indicated that inadequate window and tiny door size, including absence of mechanical cooling devices linked favourably with higher temperature in the interior but negatively with its moistness. The results show that indoor air quality has negatively impacted on the workforce performance and productivity of the customers, and also on the efficiency of their activities in the event centres. Implication for practice is that designs of apertures should be large enough to allow for cross ventilation while mechanical cooling systems should be included in the design for optimal interior air quality. The study recommends synergistic interventions from academics, policymakers, and occupational practitioners to improve national standard and its implementation for the management and regulation of indoor air quality in inside settings in Nigeria

**Keywords:**air, buildings, human health, pollution

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## 1 Introduction

Indoor air attribute describe the ambiance attributes in and about buildings plus formations since it associates to the physical condition and contentment of building residents. Yahaya, Hagos and Basrawi [1]. Research have shown that indoor air quality (IAQ) is key in the design of residential, commercial and school buildings as users of these buildings such as the managers, occupants and workers spend more than 90% of their daily living activities indoors [2]. According to Burroughs and Hansen [3] IAQ can have impact on the building's inhabitants'

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health, comfort, well-being and productivity. Hence, it is a basic indicator of health quality, comfort and productivity of occupants. Yadav [4], identified that interaction between the construction site, building design, construction techniques, contaminants sources and respondents' activities are among the major factors which influence indoor air quality.

Balmes [5], asserted that Environmental Protection Agency (EPA) ranked IAQ among the top five most significant environmental risks to human health. Kelly and Fussell [6], affirmed that because IAQ occupy a restricted space and the dynamic combination of physical, biological, and chemical factors it can lead to poor IAQ which affect the occupants' health and physical reactions. Other numerous factors that can contribute to poor quality of indoor air as identified by Ahmed [7] are ecological factors, interior and exterior space activities, overcrowding, layout of spaces, and types of materials used in construction and furnishing. The pollutant levels in indoor surroundings might be greater than outside environments.

Furthermore, evidence suggests that volatile organic chemicals commonly present in office indoor air may trigger sick building syndrome symptoms [8].

Study on air attribute has been concentrated on the outside and interior air quality (IAQ) with its consequences receiving significantly less attention until the last decade (Sundell, 2004). Studies have revealed that inside air is further polluted than outside air, which made experts and the general public have focused on the concerns connected with inside ambient attribute [9]. Perpetual alterations in living mode and the supplies utilised in inside surroundings result in considerable changes in the character and intricate formations of inside air contaminants allowing for more extensive analysis [9]. As such, the study seeks to examine the health impact of these contaminants.

Event centres attract large population of users that stay for long hours at a stretch for purposes of social gatherings, meetings, and conferences, including the workers. This huge population needs to inhale and exhale good quality air for reasons of health and comfort of the users. While architectural design makes provision for adequate ventilation either through natural and/or mechanical means, most time the effect of this is negated by the offshoot of users estimated population. This in most instances is exceeded by the attendees causing overcrowding and poor indoor air quality [10]. In addition, the presence of tobacco smoke within the environment, radon, nitrogen oxide ($No_2$), and aldehyde also contaminate the indoor air [11]. Consequently, these cause health symptoms such as headache, fatigue, breathing difficulty (asthma) and irritated skin, and low work/users' productivity which has become a serious concern in the last three decades [12].

In Nigeria, the majority of commercial buildings, particularly, event centers utilise motorized airing schemes as airing and air-conditioning to sustain the building inside cooling because of the hot weather. While mechanical systems provide fresh air in good condition, however, when faulty, they convey polluted air to indoor environment [8]. Consequently, the contaminated air by the mechanical systems affects workers' health and psychology due to the poor IAQ that causes illness to the building users and invariably, limit their productivity [13]. Besides, polluted ambience does not allow indoor air temperature to be controlled, either too hot or too cold, which makes the occupants of the buildings uncomfortable [14].

This research seeks to explore the effects of air pollution on the indoor air quality in commercial buildings such as event centres in Kogi State, Nigeria. It is anticipated that government could formulate policies for improving indoor air quality performance in commercial building designs, resulting in a comfortable experience for users and workers' productivity.

## 2 Pollutants and Health Impacts

Manisalidis, Stavropoulou, Stavropoulos and Bezirtzoglou [15] explained pollution as the release of toxic compounds into the environment which endangers humans and other living beings. The compounds could be toxic solids, liquids, or gases created in greater quantities than ordinary attention that degrade the attribute of the human environment and are discharged in huge amounts into the air making it dangerous to human health [16]. Anthropogenic air contamination is one of the utmost grave civic fitness risks worldwide, responsible for about 9 million deaths annually [17]. Through the advancement of livelihood ideals, extra man-made supplies and chemicals are being employed in manufacturing. Insect killer, clean-up chemicals, air fresheners, and culinary gases are further contributors of inside air contamination [18].

Building materials and furnishings frequently release dangerous air pollutants, such as various forms of Volatile Organic Compounds (VOCs), which have serious consequences for human health. Human lifestyle and everyday activities (such as cooking, washing, and cleaning) are the primary causes of an increase in pollution levels within a structure [19]. Indoor pollution is most influenced in buildings with insufficient ventilation, a need of air cooling schemes, individual behaviours, and a diversity of materials, chemicals, and gases [20]. Giani, Castruccio, Anav, Howard, Hu and Crippa [21] espoused that inside air contamination begot over 1.5 million deaths in the year 2000. Table 1 lists several contaminants found in indoor environments as well as their health consequences. The critical elements that influence the variety and composition of indoor air pollutants, as well as human health, are poorly known [2].

**Table 1** Classification of Pollutants and Health impacts

| Pollutants | Contaminant Sources | Health effects |
|---|---|---|
| Allergens | Furry pets, dust mites | Asthma |
| Endotoxins | Attendance of domestic animals, impure vapouriser, food waste storage space, lesser airing speed, huge deep-rooted settled dirt | Asthma, reduced lung function |
| Dampness and mold | Unattended plumbing leaks in building fabric, hidden food spills | Top wheezing signs, cold, gasp, and gasping |
| smoke | Tobacco smoke | Untimely death, lung tumor, children flu and gasp, respiratory sickness, baby mortality |
| Coal & biomass fuels burning product | Cooking and heating | burning of hard fuels, cycloalkane hydrocarbons, which boosts danger of lung cancer, childhood asthma |
| Carbon Monoxide (CO) | Fumes from vehicle, kiln, wood stoves, hearths & Tobacco fumes | Headache, nausea, fatigue, dizziness, and at very high-level death. Elderly people, pregnant women, young children |
| Nitrogen dioxide ($NO_2$) | burning of remnant petroleum e.g., grease oven and heater | Increased risk of respiratory symptoms and lung diseases, kids and populace with wheezing are mainly perceptive to Nitrogen dioxide. |
| Pesticides | contaminated soil, stored pesticide containers | Causes nuisance to eye, nose, and throat & injury to central nervous system |
| Formaldehyde (HCHO) | Planks items amassed by urea-formaldehyde resins, Tobacco fumes, pigments, glazes, hardboard, balsa atom floorboard,; floor materials; bonding agents and epoxy resin; floor finishes. | Eye, nose, throat irritation, asthma, bronchitis, and is considered a potential human carcinogen. |
| Plastic Compounds | Polyvinylchloride for flooring, plastic wall materials | Bronchial obstruction, asthma, wheeze, cough, and phlegm |
| Volatile Organic Compound (VOC) | Tobacco fumes, lately launder-valet clothes space deodorisers, carpets, pigment compounds (paints), cleaning compounds, dried out floor drains, cosmetics, photocopiers. swill | Asthma, bronchial hyper-reactivity |
| Radon | Natural decay of uranium, Ground water buildings, building materials, and ground water. | Lung cancer, Leukemia |
| Pulverised atoms | cuisine, burning behaviour | Grave impacts on some human organs. |

Source: [2, 22]

Wolkoff [23] affirmed that how buildings are designed affects its indoor surroundings and consequently affects building users' health. Hence, poor indoor air quality can result a variety of health problems, including headaches, dizziness, and nausea, as well as asthma, cardiovascular disease, cancer, and mortality [22] . The harshness of a contaminant's influence on human fitness is resolved on its concentration and length of exposure [24]. Furthermore, the impurity's influence is also affected by the age and gender of those inhabiting a location [25, 26].

Air pollution causes a range of adverse physical condition. Even when there is little ambiance pollution, the fitness of susceptible and perceptive persons might be debilitated [27]. Interim exposure to air contamination has been linked toward Chronic Obstructive Pulmonary Illness (COPI)), cold, asthmatic, panting, respiratory illness, including a high risk of hospitalization (a measurement of morbidity), according to [28]. Grave asthma, pneumonic deficiency, and coronary disease, including its death are entirely lasting effects of ambiance contamination. In addition, air contamination seems to contain a variety of adverse fitness effects in untimely person existence, plus pulmonary, cardiac arrest, mental, including postnatal matters [29]. These effects can lead to baby fatality or grave illness in maturity age [30]. According to WHO national reports, there is an elevated risk of morbidity and death [24, 31].

Work Exposure Limits (WELs) may apply to healthy working-age adults (20–59) who are directly exposed to pollutants as part of their job [15, 32]. However, provision room is often made for lower exposure limits [3]. These lower limits should be implemented if a person is exposed to pollutants for a period of time that exceeds 8 hours or if their occupational activity does not directly involve the pollutants [33]. To understand the complexities of the challenges, it is necessary to investigate the building bio-network which integrates building design, indoor pollutants, and human health. Previous research by Aye [34] demonstrated that poor indoor air quality in business buildings has an effect on human well-being and working effectiveness. However, the critical factors responsible for the poor indoor air quality in buildings are limited in knowledge.

Yahaya, Hagos and Basrawi [1], research on indoor air quality in commercial buildings in Kautan unveiled that while some buildings have acceptable interior air quality, others have limited air movement, a lot of dust, and high temperatures. Abdullah [11], further the understanding on indoor air quality in Malaysian office buildings and analyzed public health issues about job performance and productivity. The study found that the building's indoor air quality was adequate and suitable for habitation despite the presence of countable symptoms of sick building syndrome (SBS) among its residents. Yet, little is known on the implications of IAQ in commercial buildings on its users. Hence, more study is required on IAQ in impoverished nations such as Nigeria with particular attention to elucidate building users on the acceptable exposure to pollutant levels and its implications to their health. As such, there is the need for research to examine the IAQ in business buildings for public health purposes because of its association to workers and customers' performance and productivity.

The study by Yadav [4] highlighted that building systems (i.e. location, design, construction, operation, and maintenance) have an influence on interior physical qualities (i.e. air quality, lighting, and noise level) as well as indoor contaminants ($CO_2$, dust, radon, and VOCs), which have a negative impact on health. Meanwhile, studies conducted by Che, Tso, Sun, Ip, Lee,

Chao and Lau [33] had earlier expressed that among the characteristics that promote interior environmental quality and occupant comfort in buildings, indoor air quality has attracted the greatest attention in research. Whilst it could be argued that poor indoor air quality is caused by dust particles on or after carpets; Megahed and Ghoneim [17] indicated that volatile compounds such as formaldehyde and glue are emitted by construction materials. Meanwhile, studies by Chan & Liu (2018) observed that air pollutants from office equipment such as photocopiers and printers are caused by mould spores that grow in HVAC systems due to moisture or filth. Other polluting elements include interior furnishings and building activities such as cleaning and equipment use [35]. Hence, both indoor pollutant exposures and indoor physical features are influenced by building factors with consequential impact on public health. As a result, health outcomes can have an impact on productivity and employee performance [36].

Schieweck, Uhde, Salthammer, Salthammer, Morawska, Mazaheri and Kumar [37] established that people spend around 80% of their time indoors (or 90% in trade countries, thus, the increasing prevalence of building-related diseases (BRI) and sick building syndromes (SBS) has been attributed to poor indoor air quality [22]. The health, reaction, and workability of users are affected by indoor environmental factors, particularly temperature and air quality. According to Rowan [38] the efficiency of air movement, the labour circumstances of places, and the building appearance and silhouette all have an impact on indoor air quality. The sources of contaminants in indoor and outdoor areas are important to investigate since they are all relevant to the monitoring of indoor air impurities.

The coronavirus, known as the COVID-19 pandemic, which produces negative health effects, is aided greatly by poor air quality produced by ineffective aeration [39]. As a result, indoor air quality remains a critical issue, affecting occupiers' health, pleasure, and production. As a result, the attribute of inside air have been a critical factor in assessing the performance of different buildings, and it may be measured by the assimilation of several air impurities in the inside environment [40]. Air attribute is harmed by inappropriate ventilation, insufficient filtering, and diffusion of air in small areas, although it can be improved by regulating the source, constructing correct air movement schemes, and using air cleansing [35].

Indoor air quality has an impact on people's morale, which can lead to users’ complaints and decreased productivity among employees and workers. The productivity of the building is vital to the completion of its tasks and responsibilities (function). According to Burroughs and Hansen [3], because people expend a lot time inside buildings, the attribute of inside air and thermal coziness have turn into exceedingly important to investigate. For instance, if the use of an event center decreases due to poor interior air quality, it will not serve its full role, resulting in low productivity. According to Domínguez-Amarillo, Fernández-Agüera, Cesteros-García and González-Lezcano [30], indoor environments contain a significant influence on person

fitness, comprising allergic reactions, flu, respiratory illness, migraines, and productivity. Indoor air pollution, due to dangerous chemicals and other harmful compounds, has a decuple detrimental consequence on person life attribute when contrasted to contaminated air exterior [1]. All of these health consequences of poor indoor air quality demand the necessity for this study with the goal for professionals to address the issues by design.

## 3 Methodology

The study employed descriptive research design using a quantitative research approach. A survey questionnaire was employed as a research instrument in the collection of quantitative data. A purposive sampling technique was employed to select two locations that include the Mission event center, and a conference and event center named Location A and Location B in Kabba and Lokoja, respectively, in Kogi the State of Nigeria. The selected sites were chosen for a variety of reasons, including high traffic density routes, high commercial activity such as event centers, and proximity to the state capital. A random sampling method was utilised to choose 120 respondents from two locations as the sample size for the data collection. In addition, ethical consideration in the form of clued-up assent approval was acquired from the responders prior to the administration of the questionnaire. The variables used in the instrument were adapted from previous studies to ascertain the perception and experiences of the users [2, 15, 41]. The respondents were asked questions about the incidence of attending social events, what creates the inside air to be unbearable and the causative components to the attribute of inside air. Furthermore, the questionnaire was administered on the spot, face to-face, using three research assistants, which lasted for five working days and a weekend (Monday to Saturdays). The choice of the administration of the questionnaire was made to improve the response rate and to coincide with event days when most respondents would be available. Data collected was examined with descriptive and inferential statistics by the help of the Statistical Package for Social Sciences (SPSS) version 22. To obtain the prevalence including the percentages of the opinion poll, the inquiries were assessed using a 5-point Likert scale (1 = Not Comfortable to 5 = Very Comfortable). Also, the respondents' profiles such as age and gender, and the contributing factors to poor indoor air quality were obtained. The results were interpreted and discussed in the succeeding section.

## 4 Results and Discussion

Table 2 shows the participants' response rates. It revealed that 120 surveys were disseminated to 103 participants that were concluded and the feedback was analysed. The received survey signified 85.8% (i.e., 103 respondents) of the reply value and was reasoned sufficient for the inquiry to be assessed as espoused by Morse [42].

**Table 2** Respondents' response survey

| Site | Number Allotted | Number Returned | Received % | Response |
|---|---|---|---|---|
| **Location A** | 60 | 55 | 53.9% | |
| **Location B** | 60 | 47 | 46.1% | |
| **Total** | 120 | 103 | 85.8% | |

Source: Author's Field work, 2021

A reliability test to determine the interior trustworthiness of participants through the components on a multiple-item measure was employed for this study as opined by [43]. The result obtained indicated that the results were suitable by a trustworthiness of 0.616 that suggests the responses are dependable and satisfactory (see Table 3).

**Table 3** Reliability Statistics

| Cronbach's Alpha | Cronbach's Alpha Based on Standardized Items | Items |
|---|---|---|
| **.616** | .615 | 11 |

Source: Author's Field work, 2021

Table 4 reveals the participants demographics profile that comprise sex and age range, of the participants in the research. It reveals that there are 40 male participants (38.8%) and 63 female participants (61.2%). This indicates that male turnout at occasion buildings is small when contrasted to female turnout. This corroborate with the study of Wang [44] which found that females are more in hospitals and event centers than males. This suggests that there is the need to ensure good quality indoor air in event centers as females are more susceptible to air bone infection than males.

**Table 4** Demographic characteristics of respondents

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| | | | **Gender** | | |
| Valid | Male | 40 | 38.8 | 38.8 | 38.8 |
| | Female | 63 | 61.2 | 61.2 | 61.2 |
| | Total | 103 | 100.0 | 100.0 | 100.0 |
| | | | **Age Group** | | |
| | 0-14 yrs | | 9.3 | | |
| | 15-29 yrs | | 69.6 | | |
| | 30-44 yrs | | 15.2 | | |
| | 45-59 yrs | | 5.9 | | |

The results revealed that the majority (69.6%) of the respondents in the two buildings are in the age range of 15–29 years old, while the lowest (5.9%) age ranges from 45–59 years. This insinuates that youths was graded the foremost in event attending as adults' turnout is really small. This suggests that youth (age spectrum) are the active majority and are appropriate age for labour and social activities. Although the number of older people is little, it is significant to

be careful of the inside ambiance attribute of the structure as the opposition echelon of the older people is higher than that of the younger people.

The respondents were asked about their experiences with indoor air quality in the event centers. This assessment ranges from very comfortable (5) to not comfortable (1). The outcome of the analysis is revealed in table 5.

**Table 5** Knowledge of participants about inside air attribute

| | Incidence | Proportion (%) | Cumulative Proportion (%) |
|---|---|---|---|
| Very Comfortable | 14 | 14.6 | 14.6 |
| Comfortable | 44 | 42.7 | 57.3 |
| Neutral | 1 | 0.97 | 100.0 |
| Fairly Comfortable | 36 | 35 | 91.2 |
| Not Comfortable | 8 | 7.8 | 99.0 |
| Total | 103 | 100.0 | |

Source: Author's Field work, 2021

The findings shows that 57.3% are in the comfy precinct, 35% are moderately cozy, and 7.8% are uncomfortable with the occasion centers studied. This indicates that the generality of the participants have a good echelon of contentment with being comfortable with the indoor air quality at the selected event centers.

Questions were asked about what makes the indoor air quality uncomfortable for the users relative to its contributing factors shows that small window size, small door size, and absence of air conditioners (AC) were causative factors as they were found to positively correlate to the high temperature in the indoor but negatively correlate to its being moist (see Table 6).

**Table 6** Correlations between users' opinion for uncomfortable IAQ* and causative features

| | | | It is hot | It is moist | Odour | Small window size | Small door size | Absence of AC | Space relative to number of | Unpleasant odour |
|---|---|---|---|---|---|---|---|---|---|---|
| Kendall's tau_b | View on what creates the inside ambiance troubled - It is hot | Correlation Coefficient | 1.000 | -.518** | -.401** | .285** | .027 | .217* | -.019 | -.269** |
| | | Sig. (2-tailed) | | .000 | .000 | .004 | .783 | .029 | .847 | .007 |
| | | N | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 |
| | View on what makes the indoor air uncomfortable – It is damp | Relationship Coefficient | -.518** | 1.000 | -.046 | -.093 | -.036 | -.113 | .162 | -.015 |
| | | Sig. (2-tailed) | .000 | | .647 | .349 | .720 | .257 | .103 | .877 |
| | | N | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 |
| | View on what makes the indoor air uncomfortable – Odour | Relationship Coefficient | -.402** | -.047 | 1.000 | -.083 | .102 | .075 | .229* | .537** |
| | | Sig. (2-tailed) | .001 | .648 | | .408 | .311 | .459 | .023 | .001 |
| | | N | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Causative factors – Small window size | Alikeness Coeval | .286** | -.093 | -.083 | 1.001 | .196 | -.076 | -.109 | .164 |
| | Sig. (2-tailed) | .005 | .350 | .408 | | .051 | .454 | .279 | .103 |
| | N | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 |
| Causative factors – Small door size | Comparability Coeval | .028 | -.037 | .102 | .196 | 1.001 | .088 | -.095 | .131 |
| | Sig. (2-tailed) | .784 | .721 | .311 | .051 | | .380 | .347 | .193 |
| | N | 103 | 102 | 102 | 102 | 102 | 102 | 102 | 102 |
| Causative factors – Absence of AC | Correlation Coefficient | .217* | -.113 | .074 | -.075 | .087 | 1.000 | -.143 | .049 |
| | Sig. (2-tailed) | .029 | .257 | .458 | .453 | .379 | | .151 | .622 |
| | N | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 |
| causative factors – Small space relative to number of users | Correlation Coefficient | -.019 | .162 | .228* | -.108 | -.094 | -.143 | 1.000 | .051 |
| | Sig. (2-tailed) | .847 | .103 | .022 | .278 | .346 | .151 | | .608 |
| | N | 102 | 102 | 102 | 102 | 102 | 102 | 102 | 102 |
| Causative factors – Unpleasant odour | Correlation Coefficient | -.269** | -.015 | .536** | .163 | .130 | .049 | .051 | 1.000 |
| | Sig. (2-tailed) | .008 | .878 | .001 | .103 | .193 | .623 | .609 | |
| | N | 103 | 103 | 103 | 103 | 103 | 103 | 103 | 103 |

** Correlation is significant at the 0.01 level (2-tailed);
*Correlation is significant at the 0.05 level (2-tailed)
Source: Author's Field work, 2021

Though, it was a small space in relation to the amount of customers, and the unlikable smell was unhelpfully linked with the fact that it was hot. This connotes that the majority of the participants articulated that the main elements begetting uneasiness to users due to the poor quality of indoor air at the event centres are the hotness of the air and having small window sizes, small door sizes, and the absence of air conditioners as its causative factor to design. This finding corroborates the result of the study by Yahaya, Hagos and Basrawi [1] that high temperatures lead to very hot environments, which can cause discomfort to building occupants such as headaches, dizziness, and fatigue. To prevent high temperatures, there should be adequate fenestrations and/or working air conditioning system in the building.

Also, the findings from this study show that sufficient quantity of entrances, number of ambiance conditioners plus room magnitude comparative to the number of customers all contribute significantly to the elements influencing good inside air attribute. This suggests that sufficient openings, suitable air conditioners, and a large crowd relative to space size affect the quality of indoor air quality in event centers. This result substantiates the findings of Rosbach [45] and Sekhar [46] that thermal comfort is related to ventilation adequacy and thermal comfort is crowdedness in indoor environments such as schools and event centers. Consequently, sufficient ventilation is required to reinstate musty indoor air with fresher air.

Table 7 shows that the majority (75.5%) of the responders robustly agrees that the frame of mind of business center clients is effected via the attribute of the inside ambiance, though,

11.7% differed. This implies that the mental state of the people using the building affects the indoor air quality.

**Table 7** Influences on Indoor Air Quality (IAQ) on the users

| | *Questions relative to influences on Indoor Air Quality (IAQ)* | Strongly disagree (1) | | Disagree (2) | | Neutral (3) | | Agree (4) | | Strongly agree (5) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Freq | Perc% | Freq | Perc % | Freq | Perc % | Freq | Perc % | Freq | Perc % |
| 1 | IAQ influences the mood of event centre users | 4 | 3.9 | 8 | 7.8 | 13 | 12.7 | 19 | 18.6 | 58 | 56.9 |
| 2 | IAQ influences the attention span of event centre users | 8 | 7.8 | 6 | 5.9 | 20 | 19.6 | 36 | 35.3 | 32 | 31.4 |
| 3 | IAQ influences the interest of event centre users | 4 | 3.9 | 9 | 8.8 | 18 | 17.6 | 23 | 22.5 | 48 | 47.1 |

*Source: Author's Field work, 2021*

Also, the majority (66.7%) of the participants agreed that the attention span of occasion center customers is clouted via the attribute of the inside ambiance, although, 13.7% dissented. This implies that the customers' concentration duration in the business centre depends on the quality of the inside air. Furthermore, the majority (69.6%) of the participants concurred that the interests of commercial center customers are affected through the quality of inside air, while 12.7% differed. This suggests that indoor air quality affects workplace performance and productivity based on the mood, concentration, and interest of the users. Further findings indicated that majority of the respondents strongly agreed that the fitness of the customers' in the business center is impaired by inside ambiance attribute. However, 20% were neutral that the health of event center users was affected by indoor air quality. This result corroborates the findings of Toyinbo et al. (2019) that occupants' vulnerability to contaminants could contain diverse affect on their fitness, prospectively catalyzing infirmity, nonattendance, and reduced production. Accordingly, 69% of the participants robustly agreed that inside ambiance attribute is a significant element of occasion undertakings while 18% disagreed. This suggests that the majority (87%) of the participants concurred that inside ambiance attribute is an important factor that influences the efficiency of the activities of the users in the event centers. This corroborates the previous findings by Abdullah [11] that indoor ambiance attribute impacts on the workplace effecting and productivity of commercial buildings.

## 5 Conclusions

This study examines the implications of air pollution on the inside ambiance attribute in business buildings such as event centers in Kogi State, Nigeria. Findings in this study

demonstrate that sufficient quantity of entrance, suitable air conditioners including sufficient room volume comparative to the number of customers contribute to an enormous degree of the components poignant to the good inside ambiance attribute in event centers. Workforce performance and productivity were negatively affected based on the mood, concentration, and interest of the users. This affects the efficiency of users' activities at the event centers. As a result, event centers should be designed with enough openings in terms of size and number for optimum ventilation. In order to provide thermal comfort in event centers, there is need to integrate passive and mechanical cooling within the scheme. Furthermore, to evade overcrowding, business buildings should be designed with room size proportional to the projected number of users. Toxic materials should be avoided in the building, and air conditioners should be constantly maintained as the need arises on a regular basis.

## REFERENCE


1 Yahaya, N.H., Hagos, F.Y., and Basrawi, M.F.: ' Indoor air quality evaluation of commercial buildings in Kauntan ', in Editor (Ed.)^(Eds.): 'Book Indoor air quality evaluation of commercial buildings in Kauntan ' (2018, edn.), pp. 1-10

2 Mannan, M., and Al-Ghamdi, S.G.: 'Indoor air quality in buildings: a comprehensive review on the factors influencing air pollution in residential and commercial structure', International Journal of Environmental Research and Public Health, 2021, 18, (6), pp. 3276

3 Burroughs, H., and Hansen, S.J.: 'Managing indoor air quality' (River Publishers, 2020. 2020)

4 Yadav, A.K.G., C.; & Banerjee, B. D.: 'A review of indoor air pollution and associated health impacts with special reference to building designs', International Research Journal of Environmental Sciences, 2019, 8 (4), pp. 1-11

5 Balmes, J.R.: 'Household air pollution from domestic combustion of solid fuels and health', Journal of Allergy and Clinical Immunology, 2019, 143, (6), pp. 1979-1987

6 Kelly, F.J., and Fussell, J.C.: 'Improving indoor air quality, health and performance within environments where people live, travel, learn and work', Atmospheric Environment, 2019, 200, pp. 90-109

7 Ahmed, F.H., S. Hossain, S. Fakhruddin, A. N. M. Abdullah, A. T. M. Chowdhury, M. A. Z. & Gan, S. H. : 'Impact of household air pollution on human health: Source identification and systematic management approach', SN Applied Sciences, 2019, 1, (418), pp. 1-19.

8 Kamaruzzaman, S., and Sabrani, N.: 'The effect of indoor air quality (IAQ) towards occupants' psychological performance in office buildings', Journal Design+ Built, 2011, 4, (1), pp. 49-61

9 Ramya, A., Nivetha, A., and Dhevagi, P.: 'Overview of Indoor Air Pollution: A Human Health Perspective': 'Spatial Modeling and Assessment of Environmental Contaminants' (Springer, 2021), pp. 495-514

10 Toyinbo, O.P., W. MS, Shaughnessy, R. & Shaughnessy, U. H. : 'Building and indoor environmental quality assessment of Nigerian Primary schools: A pilot study', Indoor Air,, 2019, 29 (3), pp. 510-520

11 Abdullah, A.H.L., Y. Y.; Eeydzah, A.; Lee, Y. H. : 'Indoor air quality assessment for a multi-storey University office building in Malaysia', Journal of Green Bulding, 2021, 14 (4), pp. 93-109

12 Han, C., Xu, R., Zhang, Y., Yu, W., Zhang, Z., Morawska, L., Heyworth, J., Jalaludin, B., Morgan, G., and Marks, G.: 'Air pollution control efficacy and health impacts: A global observational study from 2000 to 2016', Environmental Pollution, 2021, 287, pp. 117211

13 Baloch, R.M., Maesano, C.N., Christoffersen, J., Banerjee, S., Gabriel, M., Csobod, É., de Oliveira Fernandes, E., Annesi-Maesano, I., Szuppinger, P., and Prokai, R.: 'Indoor air

pollution, physical and comfort parameters related to schoolchildren's health: Data from the European SINPHONIE study', Science of the Total Environment, 2020, 739, pp. 139870
14 Freda, D.C., P. Gaudio, M. & Lenzumi, P. : 'A unified method to compute limits of acceptability for thermal comfort and indoor air quality at the workplace. ', Indoor and Built Environment, 2017, 26 (2 ), pp. 199-207
15 Manisalidis, I., Stavropoulou, E., Stavropoulos, A., and Bezirtzoglou, E.: 'Environmental and health impacts of air pollution: a review', Frontiers in public health, 2020, pp. 14
16 Mannucci, P.M., and Franchini, M.: 'Health effects of ambient air pollution in developing countries', International journal of environmental research and public health, 2017, 14, (9), pp. 1048
17 Megahed, N.A., and Ghoneim, E.M.: 'Indoor Air Quality: Rethinking rules of building design strategies in post-pandemic architecture', Environmental Research, 2021, 193, pp. 110471
18 Gonzalez-Martin, J., Kraakman, N.J.R., Perez, C., Lebrero, R., and Munoz, R.: 'A state–of–the-art review on indoor air pollution and strategies for indoor air pollution control', Chemosphere, 2021, 262, pp. 128376
19 Sekhar, S.C.: 'Thermal comfort in air-conditioned buildings in hot and humid climates-why are we not getting it right?', Indoor Air, 2016, 26 (1), pp. 138-152
20 Ezezue, M.A., Diogu, J. O. . . . . 'Investigation of indoor air quality of residential buildings in Enugu, Nigeria', Journal of Architectural Technology, 2017, 6 (206), pp. 1-4
21 Giani, P., Castruccio, S., Anav, A., Howard, D., Hu, W., and Crippa, P.: 'Short-term and long-term health impacts of air pollution reductions from COVID-19 lockdowns in China and Europe: a modelling study', The Lancet Planetary Health, 2020, 4, (10), pp. e474-e482
22 Dionova, B.W.M., M. N.; Al-Zubaidi, S.; Yusuf, E.: 'Environment indoor air quality assessment using fuzzy inference system', Ict Express, 2020, 6, (3), pp. 185-194
23 Wolkoff, P.: 'Indoor air humidity, air quality, and health–An overview', International journal of hygiene and environmental health, 2018, 221, (3), pp. 376-390
24 Atarodi, Z., Karimyan, K., Gupta, V.K., Abbasi, M., and Moradi, M.: 'Evaluation of indoor air quality and its symptoms in office building–A case study of Mashhad, Iran', Data in brief, 2018, 20, pp. 74-79
25 Jacobson, T.A., Kler, J.S., Hernke, M.T., Braun, R.K., Meyer, K.C., and Funk, W.E.: 'Direct human health risks of increased atmospheric carbon dioxide', Nature Sustainability, 2019, 2, (8), pp. 691-701
26 Allen, J.G., and Ibrahim, A.M.: 'Indoor air changes and potential implications for SARS-CoV-2 transmission', Jama, 2021, 325, (20), pp. 2112-2113
27 Dutheil, F., Baker, J.S., and Navel, V.: 'COVID-19 as a factor influencing air pollution?', Environmental pollution, 2020, 263, pp. 114466
28 Coker, E., and Kizito, S.: 'A narrative review on the human health effects of ambient air pollution in Sub-Saharan Africa: an urgent need for health effects studies', International journal of environmental research and public health, 2018, 15, (3), pp. 427
29 Marlon, J.R., Bloodhart, B., Ballew, M.T., Rolfe-Redding, J., Roser-Renouf, C., Leiserowitz, A., and Maibach, E.: 'How hope and doubt affect climate change mobilization', Frontiers in Communication, 2019, pp. 20
30 Domínguez-Amarillo, S., Fernández-Agüera, J., Cesteros-García, S., and González-Lezcano, R.A.: 'Bad air can also kill: residential indoor air quality and pollutant exposure risk during the COVID-19 crisis', International Journal of Environmental Research and Public Health, 2020, 17, (19), pp. 7183
31 Organization, W.H.: 'World health statistics overview 2019: monitoring health for the SDGs, sustainable development goals', in Editor (Ed.)^(Eds.): 'Book World health statistics overview 2019: monitoring health for the SDGs, sustainable development goals' (World Health Organization, 2019, edn.), pp.
32 Agarwal, N., Meena, C.S., Raj, B.P., Saini, L., Kumar, A., Gopalakrishnan, N., Kumar, A., Balam, N.B., Alam, T., and Kapoor, N.R.: 'Indoor air quality improvement in COVID-19 pandemic', Sustainable Cities and Society, 2021, 70, pp. 102942
33 Che, W.W., Tso, C.Y., Sun, L., Ip, D.Y., Lee, H., Chao, C.Y., and Lau, A.K.: 'Energy consumption, indoor thermal comfort and air quality in a commercial office with retrofitted

heat, ventilation and air conditioning (HVAC) system', Energy and Buildings, 2019, 201, pp. 202-215
34 Yuan, J., Chen, Z., Zhong, L., and Wang, B.: 'Indoor air quality management based on fuzzy risk assessment and its case study', Sustainable Cities and Society, 2019, 50, pp. 101654
35 Hess-Kosa, K.: 'Indoor air quality: the latest sampling and analytical methods' (CRC press, 2018. 2018)
36 Rowan, N.J.L., J. G. : 'Unlocking the surge in demand for personal and protective equipment (PPE) and improvised face coverings arising from coronavirus disease (COVID-19) pandemic: implications for efficacy, re-use and sustainable waste management', Science Total Environ 2020, 752, (142259)
37 Hansell, A.L., and Villeneuve, P.J.: 'Invited perspective: ambient air pollution and SARS-CoV-2: research challenges and public health implications', Environmental Health Perspectives, 2021, 129, (11), pp. 111303
38 Sloan Brittain, O., Wood, H., and Kumar, P.: 'Prioritising indoor air quality in building design can mitigate future airborne viral outbreaks', Cities & health, 2021, 5, (sup1), pp. S162-S165
39 Ruan, T., and Rim, D.: 'Indoor air pollution in office buildings in mega-cities: Effects of filtration efficiency and outdoor air ventilation rates', Sustainable Cities and Society, 2019, 49, pp. 101609
40 Morse, J.M.: ' Determining sample size. Qualitative ', Health Research Journal, 2000, 10, (1), pp. 3-5
41 Price, P.C., Jhangiani, R.S., and Chiang, I.-C.A.: 'Reliability and validity of measurement', Research methods in psychology, 2015
42 Wang, S.K.C., S. P.; Jusoh, M. T.; Khairunissa, A.; LEONG, K. Y.; & Azid, A. A. : 'WST based indoor air quality monitoring in classrooms', in Editor (Ed.)^(Eds.): 'Book WST based indoor air quality monitoring in classrooms' (2017, edn.), pp.
43 Rosbach, J.T.M.V., M.; Duijm, F.; VanGinkel, J. T.; Gehring, U.; Brunnckreef, B. : 'A ventilation intervention study in classrooms to improve indoor air quality: the FRESH study', Environmental Health, , 2013, 12 (1), pp. 110
44 Sekhar, S.C.: 'Thermal comfort in air-conditioned buildings in hot and humid climates-why are we not getting it right?', Indoor Air, 2016, 26 (1), pp. 138 -152