Scientific Foundation SPIROSKI, Skopje, Republic of Macedonia
Open Access Macedonian Journal of Medical Sciences. 2020 Apr 25; 8(E):395-404.
https://doi.org/10.3889/oamjms.2020.3785
eISSN: 1857-9655
Category: *E - Public Health*
Section: *Public Health Disease Control*

Empirical Study on Sick Building Syndrome from Indoor Pollution in Nigeria

Adedeji O. Afolabi*, Akpa Arome, Faith T. Akinbo

Department of Building Technology, Covenant University, Nigeria

Edited by: Sinisa Stojanoski
Citation: Afolabi AO, Arome A, Akinbo TF. Empirical Study on Sick Building Syndrome from Indoor Pollution in Nigeria. Open Access Maced J Med Sci. 2020 Apr 25; 8(E):395-404. https://doi.org/10.3889/oamjms.2020.3785
Keywords: Air pollution; Indoor air quality; Sick building syndrome; Pollution; Maintenance
***Correspondence:** Afolabi A.O, Department of Building Technology, Covenant University, Nigeria. Tel: 234-8034169272. E-mail: adedeji.afolabi@covenantuniversity.edu.ng
Received: 26-Sep-2019
Revised: 04-Mar-2020
Accepted: 06-Mar-2020

Funding: The authors hereby acknowledge the financial contribution in paying for the Open Access fee by Covenant University Centre for Research, Innovation and Discovery, Nigeria.
Competing Interests: The authors have declared that no competing interests exist

Abstract

There are rising cases of building occupants with health-related challenges such as irritation, asthma, lung infections, headaches, and other allergies. These health conditions sometimes disappear once the occupants live such buildings which are referred to as sick building syndrome (SBS). With the high fatality rate associated with air pollution and Nigeria ranking 4th in the poorest air quality globally, the study assessed SBS from indoor pollution in residential and office spaces. The study utilized a cross-sectional survey research design and employed the use of an air quality detector to measure a 24-h mean measurement of air conditions within the study area. The study was carried out in Zaria, Kaduna State. Statistical tools such as graphs, mean score, analysis of variance (ANOVA), and correlation matrix were used to analyze the dataset. The study showed that the major symptoms associated with SBS from indoor pollution. The indoor conditions that may contribute to SBS in the residential and office spaces were mainly lighting conditions, headroom in the building, and position of windows. While the study reported that the presence of SBS from indoor pollution can lead to increased maintenance, dizziness, and depression/breakdown. The measurement of the indoor pollutants contributing to the SBS among residential and office space occupants showed that $PM_{2.5}$ and PM_{10} were mostly above the average 24-h mean standard. The study suggested recommendations to improve indoor air quality and reduce syndromes associated with sick buildings.

Introduction

In Maslow's hierarchy of man's needs proposed by Abraham Maslow in 1943, shelter is listed under the physiological need of man as the first out of five other needs of man [1]. Shelter serves as a place of rest and safety for people which should be carefully designed for their comfort. To achieve rest and safety, people spend about 90% of their time in buildings [2]. Several factors are usually considered in the design and construction of buildings to achieve maximum comfort and safety of the occupants such as ventilation, choice of materials, and the likes. When these factors which demand cognizance are not held in consideration during the production of buildings, they can be hazardous to the environment and the users in diverse ways. It has been witnessed, either through primary or secondary participation, the various negative effects buildings which were not properly designed and constructed have had on both the environment and their users. Instances such as building collapses, poor building materials in buildings have affected the health of the users and other related occurrences [3], [4]. It can be boldly stated, in light with popular perspectives, that buildings must be designed and constructed with an uncompromising consideration of the safety and well-being of the users in terms of the choice of materials (how the users will react to the materials health wise) and other constructional processes.

A significant percentage of workers in the private or public sector execute work in formidable office spaces (buildings), of which in most cases would have a central cooling and heating system, and windows that are seldom opened [5]. In these office spaces, several materials are used in the formation of working units in the likes of wallpapers and carpets, including equipment such as printers, computer screens, and photocopiers. The lighting system is usually not good because flickering neon lights are used. Furthermore, several chemical products are used for the maintenance and cleanness of the offices. All these compounds form the conditions that degrade the quality of the internal environment, and more generally, the internal climate of the buildings, with overt and important repercussions on both the mental and physical state of workers. Similar problems as these also arise in homes as well. In homes, the conditions for which cooking was carried out is very relevant. Some building occupants use coal and kerosene while some use gas. The fumes that are generated in the process if they are not well channeled outdoor or with proper ventilation systems can harm the occupants of the building. One of the formally-identified health effect which results from being exposed to indoor air contaminants is sick building syndrome (SBS). A myriad of symptoms signified the effects or presence of the SBS in occupants or users of buildings as well as the buildings themselves. The more the users or occupants of these buildings stay indoors, the more the symptoms persist [6]. However, when they exit the building for a while, these symptoms either subside or cease completely.

There are rising cases of building occupants with health-related challenges such as irritation, asthma, lung infections, headaches, and other allergies [7]. From the study by Iyagba [7], it was shown that some of these health-related challenges are interconnected with attributes of the building they reside or work in. This may be aggravated with the presence of insects, rats, and other microbial organisms, indoor air pollution, as well as poor sanitary environments. A critical look at indoor air quality shows that Nigeria has been burdened with high fatalities (150 deaths per 100,000) attributed to air pollution based on the annual state of the Health Effects Institute [8]. Nigeria ranked 4th globally among countries with the poorest air quality. The air quality can be attributed to both indoor and outdoor quality of building occupants. On the other hand, indoor air quality is negatively affected by the building fabrics, lack of ventilation, fumes from vehicles and generator fumes, indiscriminate burning, and cooking fumes. The unhealthy air quality has been attributed to the rising health challenges experienced in the eyes, lungs, and heart conditions of building occupants, including cancer. Therefore, this study was aimed at assessing SBS from indoor pollution in residential and office spaces with a view of highlighting probable solutions to reduce the effect of SBS on the occupants. The following objectives would guide this study, which are to;

- Examine the symptoms associated with the SBS from indoor pollution in residential and office spaces
- Examine the indoor conditions that may be contributing to SBS in the residential and office spaces
- Evaluate the implication of SBS from indoor pollution on residential and office space occupants
- Measure the indoor pollutants contributing to the SBS among residential and office space occupants.

Review of Related Literature

According to Fotoula [9], the phenomenon "SBS" is a phrase which was first formed in the 1970s which is to delineate a state in when the occupants of a building suffer intense health challenges or a wide span of descriptions that include a collection of symptoms which surface when persons stay within certain buildings over a period of time. The World Health Organization [10] described SBS as a health situation in which persons in a building experience symptoms of sickness or feel temporarily ill with no clear cause. SBS ism a condition whereby building occupants suffer severe health issues and discomfort that are most probably influenced by the length of time spent within a building [11]. The study in Sarafisa *et al*. [6] explained SBS as the range of symptoms on the well-being of a person that is identified with his/her stay in a building, which has a faulty interior condition quality. Subsequently, the term SBS is ordinarily utilized, so as to portray every one of those circumstances where the individual feels different symptoms or general bigotry and malaise and has no solid and distinguished disease that depicts these side effects. Some of these symptoms are itchy eyes, skin rashes, headache, dizziness, throat irritation, nausea, dry or itching skin, hoarseness of voice rashes, dry cough, allergy symptoms, and asthma attacks [7]. There are less obvious symptoms such as difficulty in concentration, fatigue, aches and pains, personality changes, and being sensitive to odors. The specified symptoms usually reduce or total seize after leaving the building, but the symptoms related to the skin and the skin being dry may take several days to fade out. When about 20% of individuals that work in a particular building have these symptoms and they vanish or decline significantly when employees leave the building, this can be a sign of SBS [12]. Most of the instances of SBS appears to be in buildings that run on automated heating systems, air-conditioning, and system ventilation, even though it can as well arise in commercial buildings such as Hospitals, Education institutes, and Schools an apartment building [9]. According to Zamani *et al*. [13], one of the popularly known health impacts resulting from the introduction of indoor air pollutants is SBS. SBS is a noteworthy concern as a significant number of people is possibly in danger. As characterized by the WHO (2010), it results into work-related disturbances of the mucous membranes and the skin and several possible symptoms such as headaches, fatigue, and difficulty with concentrating. The World Health Organization [14] evaluated that up to 30% of newly constructed and redesigned structures around the world might be identified with SBS. Complete investigation carried out in the UK on about 4373 office specialists in 42 open structures uncovered 29% of those considered experienced at least five of the trademark symptoms associated with SBS [15]. An examination of 600 office laborers in the USA inferred that 20% of the workers were experiencing SBS symptoms and this affected the work productivity of a large portion of them [5]. Moreover, an investigation on 1390 laborers in five open structures in Quebec, Canada, demonstrated that 50% of specialists experienced SBS symptoms [16]. In more recent times, SBS has turned into an issue of elevated concern in China, as large-scale construction of high-rise structures in metropolitan territories has prompted an unintended increase in building snugness. In an office high-rise, which was recently constructed in downtown Beijing, a dominant part of occupants lodged complaints relating to discomforts every day without clear causes. SBS was viewed as a feasible reason for this situation [17].

Research Methods

This section enumerates the research methods by which the study was carried out this study. It presents the step by step procedures through which data were collected and analyzed. In addition, it gives a brief geographical and historical background study of the study area so as to create a better understands of the topic. Cross-sectional survey research and experimental research design were used during the research to gather information. This was achieved through the distribution of questionnaires that were carefully constructed to ascertain the conditions prevalent in the population size. A consent form was distributed alongside the questionnaire due to the nature of the research. While the experimental research survey design was executed through the use of a gadget called an air quality detector (produced by Ou Chuang Rui Technology), as shown in Figure 1. To carry out the experimental procedure in this research, the air quality detector was taken to locations within the area of study for on-ground measurement of the indoor air quality.

Figure 1: Air quality detector (produced by Ou Chuang Rui technology)

It is important to identify the actual population for the study. All buildings and office spaces within Nigeria form the population of the study. However, for the time frame of the study, buildings and offices within Kaduna State were chosen by the researchers. It includes house owners and tenants for residential and office users for the office environment. It is predominantly constituted of middle-class and more of lower-class citizens. The characteristics of the building owners and office space occupiers are people in different professions within the study area. Kaduna State is one of the 36 states in Nigeria that is located in Northern Nigeria. According to Health Effects Institute [8], Kaduna is listed amongst the top 10 most polluted places in Nigeria in terms of air pollution resulting from poor waste disposal and drain blockages. One of its local government, Zaria, was selected because it has a balanced mixture of urban and rural settlements. The area of study was scaled down to Samaru and the staff quarters in Ahmadu Bello University, both in Zaria, for houses while the Faculty of Agriculture in the same university was the study area for offices. From the population of residential and office spaces, the population was streamlined to an adequate sample size using the quota-purposive sampling technique and simple random sampling method. The quota-purposive sampling technique was used because there is no comprehensive data on the number of buildings in Kaduna at the time of this research. Therefore, a total of 60 residential buildings in the outskirt of the office spaces were selected. The formula used to obtain the sample size for the number of office spaces to be surveyed (using the air detector monitor) was a simple random sampling formula of;

$$n = \frac{N}{1+\alpha^2 N} \quad (1)$$

Where; α, confidence level = 0.05

N, total number of office spaces = 60

$$n = \frac{60}{1+(0.05)^2 60} = 52$$

There are presently 60 offices in the faculty of Agriculture, Ahmadu Bello University, which was ascertained through manual counting as the study area for offices. The sample size of 52 office spaces was calculated for the study, whereas only 51 office space users participated in this study. From the 60 residential buildings surveyed, only 49 occupants participated in the study.

This informed a balanced data collection from both residential and office buildings. The primary data in this study were obtained using a questionnaire instrument. It had four sections that were all aimed at assessing the buildings and perception of users in the buildings. Section A of the questionnaire contains background information of the respondent. Section B is concerned with the symptoms experienced by the respondent while within the building. Section C examined the indoor conditions available in the residential/office spaces. While Section D evaluated the implication of SPS from indoor pollution on the occupants. Furthermore, an air quality detector manufactured by Ou Chuang Rui technology was used in measuring the air quality in the residential and office spaces. Figure 2 showed a screenshot of a recording on the air quality detector device. In Figure 2, readings for HCHO (formaldehyde), $PM_{2.5}$ (particle matter), PM_{10} (particle matter) total volatile organic compound (TVOC), temperature, and relative humidity were obtained.

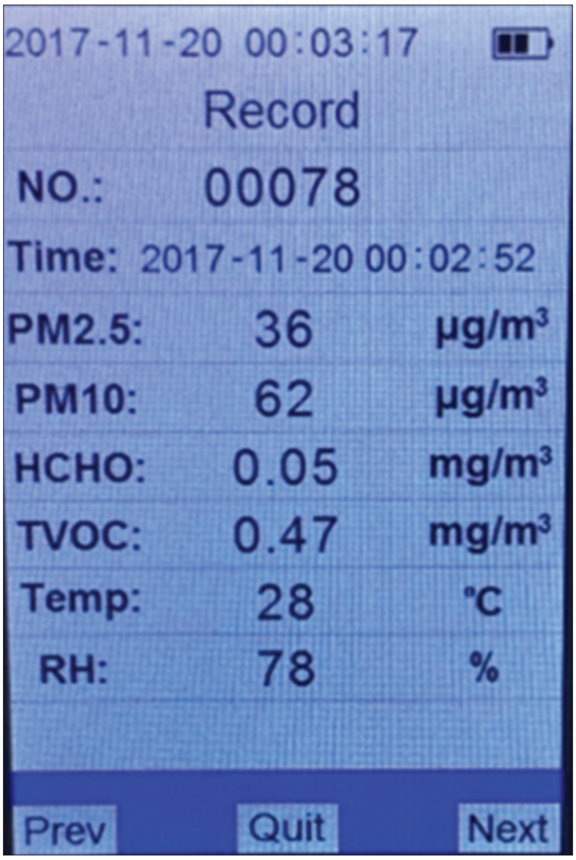

Figure 2: Screenshot of a recording on the air quality detector device

Results and Discussion of Findings

This section delineates the data analysis carried out on the data collected through the questionnaire survey and the readings from the indoor air quality detector. The questionnaires were given and collected from office and residential space users. The chapter shows a breakdown of the symptoms associated with SBS, the effects it has on the users of such buildings, and the probable factors that contribute it. The data collected were presented using percentages, pie chart, frequencies, bar chart, mean score, cross-tabulation, and ranking index.

Background information

In the course of this research, the respondents were selected randomly to participate in the survey. Table 1 showed a summary of the background information of the respondents in the study. The background information sought through the study includes the highest academic qualification, number of occupants in the buildings, gender, marital status, and duration of staying within the building. Table 1 showed that in the office space, under the highest qualifications, 1 (1.96%) of respondents just had senior secondary certificate examinations (SSCE), 8 (15.69%) were OND/HND holders, 20 (39.73%) were B.Sc./B.Tech/B. Eng holders, 8 (15.69%) were M.Sc./MBA/MPM/M. Tech holders, and 14 (27.45%) were Ph.D. holders. While in residential spaces 15 (30.61%) had just SSCE, 3 (15.69%) were OND/HND holders, 18 (36.73%) were B.Sc./B.Tech/B.Eng holders, 7 (14.29%) were M.Sc./MBA/MPM/M.Tech holders, and 6 (12.14%) were Ph.D. holders. These results presented showed that the respondents were literate enough to have participated in the study. Table 1 also revealed that in the offices' spaces, 18 (35.29%) of the offices were occupied by only one person, 20 (39.22%) were occupied by two people, 4 (7.84%) were occupied by three people, 3 (5.88%) were occupied by four people, and 6 (11.76%) were occupied above four people, while in residential spaces, 3 (6.12%) were occupied by one person, 1 (2.04%) were occupied by two people, 4 (8.16%) were occupied by three people, 8 (16.33%) were occupied by four people, and 33 (67.65%) were occupied by above four people. Among the respondents in the office space, 34 (66.6%) were males and 17 (33.3%) were females whine in residential spaces, 25 (51.0%) were male and 24 (48.97%) were female. In the office spaces, 8 (15.69%) had spent 1 year in that space, 9 (17.65%) had spent 2 years, 5 (9.80%) had spent 3 years, 1 (1.96%) had spent 4 years, 2 (3.91%) had spent 5 years, and 26 (50.98%) had spent about 5 years, while in residential spaces, 8 (16.33%) had spent 1 year in that space, 2 (4.08%) had spent 2 years, 5 (10.20%) had spent 3 years, 6 (12.24%) had spent 4 years, 2 (4.08%) had spent 5 years, and 26 (50.98%) had spent above 5 years.

Table 1: Summary of background information

Background information	Type of building (%)		Total (%)
	Office space	Residential spaces	
Highest academic qualification attained			
SSCE	1 (1.96)	15 (30.61)	16 (0.16)
OND/HND	8 (15.69)	3 (56.12)	11 (0.11)
B.Sc./B.Tech/B.Eng	20 (39.21)	18 (36.73)	38 (0.38)
M.Sc./MBA/MPM/M.Tech	8 (15.60)	7 (14.29)	15 (0.15)
Ph.D.	14 (27.45)	6 (12.14)	20 (0.20)
Number of occupants			
One	18 (35.29)	3 (6.12)	21 (0.21)
Two	20 (39.22)	1 (2.04)	21 (0.21)
Three	4 (7.84)	4 (8.16)	8 (0.08)
Four	3 (5.88)	8 (16.33)	11 (0.11)
Above four	6 (11.76)	33 (67.65)	39 (0.39)
Gender of respondent			
Male	34 (66.6)	25 (51.0)	59 (0.59)
Female	17 (33.3)	24 (48.97)	41 (0.41)
Marital status			
Married	40 (78.43)	19 (38.78)	59 (0.59)
Single	11 (21.57)	30 (61.22)	41 (0.41)
Period of stay in the building (year)			
1	8 (15.69)	8 (16.33)	16 (0.16)
2	9 (17.65)	2 (4.08)	11 (0.11)
3	5 (9.80)	5 (10.20)	10 (0.10)
4	1 (1.96)	6 (12.24)	7 (0.07)
5	2 (3.91)	2 (4.08)	4 (0.04)
Above 5	26 (50.98)	26 (50.98)	52 (0.52)

Symptoms associated with SBS

This section highlighted the symptoms that occupants experience or suffer when using specific buildings under investigation. Table 2 showed the symptoms associated with SBS either for residential and office space users. The presence or absence of the 22 highlighted symptoms was indicated by the respondents and analyzed using a 4-point Likert scale with “Always = 4”, “Sometimes = 3,” “Rarely = 2,” and “Never = 1.” The symptoms associated with SBS were identified from previous studies in Atarodi *et al*. [18].

Table 2: Symptoms associated with sick building syndrome

Symptoms	Residential apartment		Office spaces		Overall MS	Overall RI
	MS	RI	MS	RI		
Symptoms of cold or flu	2.22	5th	2.43	1st	2.32	1st
Weakness	2.35	1st	2.14	3rd	2.24	2nd
Burning or nasal itching	2.22	5th	2.10	4th	2.16	3rd
Muscle pain in arm or hand	2.31	2nd	2.02	9th	2.16	3rd
Feeling cold in the hands or feet	2.31	2nd	2.00	11th	2.15	5th
Feeling heavy air	2.24	4th	2.04	7th	2.14	6th
Chest pain or chest tightness	2.22	5th	2.06	6th	2.14	6th
Back pain	2.12	8th	2.16	2nd	2.14	6th
Itching the eyes	2.12	8th	2.10	4th	2.11	9th
Fatigue	2.04	12th	2.04	7th	2.04	10th
Respiratory problems	2.08	11th	1.96	12th	2.02	11th
Nervousness	2.00	13th	2.02	9th	2.00	12th
Itching, swelling, or dry skin	1.98	15th	1.96	12th	1.97	13th
Burning or sore throat	1.98	15th	1.94	14th	1.96	14th
Depression	1.92	19th	1.92	15th	1.92	15th
Neck pain	2.10	10th	1.73	21st	1.91	16th
Dizziness	2.00	13th	1.80	18th	1.90	17th
Drowsiness	1.96	17th	1.82	16th	1.89	18th
Problem with vision/ blurred vision	1.86	21st	1.82	16th	1.84	19th
Nausea	1.94	18th	1.75	20th	1.84	19th
Headache	1.88	20th	1.76	19th	1.82	21st
Fever	1.69	22nd	1.67	22nd	1.68	22nd

MS: Mean score, RI: Ranking index.

In Table 2, the study showed that among residential occupants, the main symptoms associated with SBS were major signs of weakness, muscle pain in arm or hand, feeling cold in the hands or feet, and feeling heavy air. Among office space users, the main symptoms include cold or flu, back pain, and weakness. The overall mean score showed that the building occupants mostly felt symptoms of cold or flu, weakness, burning or nasal itching, and muscle pain in the arm or hand. Therefore, the study showed that cold or flu, weakness, burning or nasal itching, and muscle pain in arm or hand are symptoms of SBS that both residential and office space users mostly experience. Even though the symptoms ranked between “sometimes” and “rarely,” they are still significant in that occupants have in one time or the other felt SBS, which inhabiting their residential or workspace. This study is corroborated by findings from Atarodi *et al*. [18]. In that, most of the symptoms identified in this study are similar to the findings in their study. Most of the respondents faced symptoms associated with discomfort reported in Iyagba [7] as mucus membrane irritation which affects the nose and other respiratory parts. The study by Gomzi and Bobic [12] reported that over 40% of the persons surveyed reported having headaches, stuffy nose, and fatigue in relation to SBS.

Indoor conditions of the building spaces

This section evaluated the indoor conditions of residential and office spaces with respect to several necessary features and functions that should be available. Table 3 revealed the indoor conditions of the residential and office spaces that were surveyed during this study. The conditions were indicated by the respondents and analyzed using a 5-point Likert scale with “Very Convenient = 5,” “Appropriate = 4,” “Normal = 3,” “Inappropriate = 2,” and “Very Inappropriate = 1.”

Table 3: Indoor conditions of residential and office spaces

Indoor condition	Residential apartment		Office space		Overall	Overall
	MS	RI	MS	RI	MS	RI
Lighting conditions	3.57	6th	4.12	1st	3.85	1st
Headroom in the building	3.67	2nd	3.96	2nd	3.82	2nd
Position of the windows	3.78	1st	3.84	7th	3.81	3rd
Size of the windows	3.67	3rd	3.88	4th	3.78	4th
Ventilation	3.67	3rd	3.86	6th	3.77	5th
Size of the doors	3.67	3rd	3.76	11th	3.72	6th
Color of walls	3.57	6th	3.82	8th	3.70	7th
Size of the room spaces	3.39	9th	3.90	3rd	3.65	8th
Noise level	3.53	8th	3.63	15th	3.58	9th
Curtains	3.33	10th	3.75	12th	3.54	10th
Maintenance of facilities	3.20	11th	3.82	8th	3.52	11th
Odor	3.04	15th	3.88	5th	3.47	12th
Air conditioning system	3.14	13th	3.75	12th	3.45	13th
Smoke	3.02	16th	3.78	10th	3.41	14th
Congestion/overcrowding	3.18	12th	3.55	16th	3.37	15th
The heat	2.96	17th	3.67	14th	3.32	16th
The cold	3.06	14th	3.47	17th	3.27	17th

*MS: Mean score, *RI: Ranking index.

From Table 3, most of the indoor conditions within the buildings were normal. In the residential spaces, the indoor conditions occupants were most comfortable with was the position of the windows, the headroom in the building, the size of the windows, ventilation, and the size of the doors. In the office spaces, occupants were most comfortable with the lighting conditions, headroom in the building, and the size of the windows. Overall, occupants were comfortable with lighting conditions, headroom in the building, and the position of the windows. The findings from this study showed that the visual and working environment is mostly affected by the indoor conditions prevalent within the buildings studied. Iyagba [7] noted that once lighting, headroom, and windows are poor within a living or working space, it forces a strain on the eye which can lead to headaches and other SBS. Furthermore, the study posits that some indoor conditions could spur SBSs. The hypothesis was put forward for testing that;

H_{01} – There is no relationship between specific indoor conditions and identified SBSs.

H_1 – There is a relationship between specific indoor conditions and identified SBSs.

The study used a spearman rho’s correlation matrix to understand the relationship between specific indoor conditions and SBSs. Table 4 showed the correlation matrix between indoor conditions within the offices and residential spaces and the SBSs identified in the study. Using the significant value of 0.05 p-value, Table 4 showed relationships that exist between indoor conditions and SBS within the surveyed area. In Table 4, there was a significant relationship between occupants’ having headaches and fever with indoor conditions such as the use of air conditioning systems and increased noise level. This corroborated in the study by Fotoula [9], where it was affirmed that there is a need to provide a protective measure toward reducing noise pollution and a review of cleaning practices in homes and offices. This can be achieved through concerted efforts in educating occupants and active legislation to tackle these pollutants. Furthermore, there was a significant relationship between drowsiness and lighting conditions and weakness and size of the room spaces. Gomzi and Bobic [12] referred to the issues of lighting conditions affecting an occupant's health as a building factor because individuals may have limited control over the lighting conditions within a building.

Implications of SBS

This section was concerned about the implications of SBS on the health of the residential and office space users. Table 5 presented the implications of SBS experienced by the respondents. The implications were analyzed using the respondents and analyzed using a 5-point Likert scale with "Very High = 5," "High = 4," "Moderate = 3," "Low = 2," and "Nil = 1."

From Table 5, among the residential occupants, SBS can lead to a need to change residential/office space, fatigue, and high irritation. While, among office space users, the major consequences of SBS were mostly increased maintenance needs, dizziness, and depression/breakdown. The overall mean score among the residential and office space users showed that SBS can lead to increased maintenance needs, dizziness, and depression/breakdown. A further inferential statistical test was carried out to ascertain if there were significant implications as a result of SBS on occupants in the buildings surveyed. The hypothesis put forward tested that;

H_{02} – There is no difference in the implication of SBS on both office space users and residential apartment occupants.

H_2 – There is a difference in the implication of SBS on both office space users and residential apartment occupants.

The study tested hypothesis two using analysis of variance (ANOVA) to measure the significant difference that exists in the implication of SBS. Table 6 showed the ANOVA test on the implications of SBS on office and residential occupants. Using the type of occupants as the factor and the implication of SBS as the dependent list, the ANOVA test was conducted. The decision rule of when $p < 0.05$, the alternate hypothesis is accepted and the null hypothesis is rejected and this applies vice-versa. Therefore, in Table 6, the significant implications of SBS are that SBS can lead to stress, can reduce productivity, can affect concentration, can lead

Table 4: Correlation matrix on indoor conditions and SBSs

Indoor conditions / Sick building syndrome	Lighting conditions	Ventilation	Size of the room spaces	Air conditioning system	Noise level
Headache	−0.159	−0.090	−0.162	−0.240*	−0.283**
Fever	−0.059	−0.004	−0.109	−0.237*	−0.241*
Dizziness	0.038	−0.042	−0.128	−0.066	−0.071
Fatigue	0.118	0.076	−0.096	−0.092	0.003
Drowsiness	0.201*	0.176	0.002	0.106	0.141
Weakness	−0.027	−0.127	−0.273**	−0.038	−0.117
Nausea	−0.017	−0.080	−0.041	−0.159	0.049
Respiratory problems	−0.027	−0.019	−0.096	−0.049	0.035
Muscle pain, arm, or hand	−0.132	−0.068	−0.151	−0.076	−0.016
Chest pain or chest tightness	0.037	−0.029	−0.093	−0.034	−0.009
Back pain	−0.069	−0.027	−0.152	0.057	−0.069
Itching the eyes	0.147	0.190	−0.085	0.052	0.076
Neck pain	−0.084	−0.043	−0.038	0.012	−0.029
Problem with vision/blurred vision	0.058	0.006	−0.024	0.011	−0.089
Burning or sore throat	0.187	0.138	0.139	0.060	0.078
Burning or nasal itching	0.067	−0.003	0.001	−0.077	0.016
Symptoms of cold or flu	0.039	−0.042	0.006	−0.075	−0.110
Depression	0.029	−0.021	−0.114	−0.064	−0.009
Nervousness	0.025	−0.061	0.000	−0.073	−0.063
Itching, swelling or dry skin	−0.022	−0.019	−0.126	−0.168	−0.049
Feeling cold in hand or feet	−0.025	0.081	−0.083	−0.143	−0.017
Feeling heavy air	0.108	0.055	−0.193	−0.051	0.037

**Correlation is significant at the 0.01 level (2-tailed), *Correlation is significant at the 0.05 level (2-tailed).

Table 5: Implications of sick building syndrome

Implications	Residential apartment		Office space		Overall MS	Overall RI
	MS	RI	MS	RI		
Increased maintenance needs	2.39	11th	2.47	1st	2.70	1st
Dizziness	2.51	6th	2.33	2nd	2.42	2nd
Depression/breakdown	2.55	4th	2.25	3rd	2.40	3rd
Need to change residential/office space	2.73	1st	2.02	7th	2.37	4th
High irritation	2.57	3rd	2.12	5th	2.34	5th
Poor breathing	2.39	11th	2.25	3rd	2.32	6th
Reduced commitment	2.53	5th	2.10	6th	2.31	7th
Fatigue	2.58	2nd	2.02	7th	2.29	8th
Loss of appetite	2.47	8th	1.98	10th	2.22	9th
Can lead to stress	2.49	7th	1.92	12th	2.20	10th
Frequent illness (headache, etc.)	2.35	13th	2.02	7th	2.18	11th
Reduced productivity	2.45	10th	1.90	13th	2.17	12th
Loss of sleep	2.35	14th	1.96	11th	2.15	13th
Loss of concentration	2.41	9th	1.80	15th	2.10	14th
Health challenges	2.29	15th	1.84	14th	2.06	15th

*MS: Mean score, *RI: Ranking index.

to the need to change residential/office space, reduced commitment, and increased need for maintenance works. These findings are supported by Joshi [11] in that SBS affects the productivity of workers and would increase absenteeism amongst workers.

Table 6: ANOVA test on the implications of sick building syndrome

Implications	Sum of squares	df	Mean square	F	Sig.
Can lead to stress					
Between groups	8.069	1	8.069	4.944	0.028
Within groups	159.931	98	1.632		
Total	168.000	99			
Reduced productivity					
Between groups	7.478	1	7.478	5.138	0.026
Within groups	142.632	98	1.455		
Total	150.110	99			
Health challenges					
Between groups	4.895	1	4.895	3.845	0.053
Within groups	124.745	98	1.273		
Total	129.640	99			
Loss of concentration					
Between groups	9.124	1	9.124	8.777	0.004
Within groups	101.876	98	1.040		
Total	111.000	99			
Fatigue					
Between groups	7.858	1	7.858	8.409	0.005
Within groups	90.647	97	0.935		
Total	98.505	98			
Frequent illness (headaches etc.)					
Between groups	2.678	1	2.678	2.260	0.136
Within groups	116.082	98	1.185		
Total	118.760	99			
Need to change residential/office space					
Between groups	12.779	1	12.779	8.431	0.005
Within groups	148.531	98	1.516		
Total	161.310	99			
Reduced commitment					
Between groups	4.676	1	4.676	4.550	0.035
Within groups	100.714	98	1.028		
Total	105.390	99			
Loss of sleep					
Between groups	3.726	1	3.726	3.121	0.080
Within groups	117.024	98	1.194		
Total	120.750	99			
High irritation					
Between groups	5.146	1	5.146	3.841	0.053
Within groups	131.294	98	1.340		
Total	136.440	99			
Poor breathing					
Between groups	0.441	1	0.441	0.286	0.594
Within groups	151.319	98	1.544		
Total	151.760	99			
Increased maintenance needs					
Between groups	5.478	1	5.478	3.961	0.049
Within groups	135.522	98	1.383		
Total	141.000	99			
Depression/breakdown					
Between groups	2.191	1	2.191	1.654	0.201
Within groups	129.809	98	1.325		
Total	132.000	99			
Dizziness					
Between groups	0.782	1	0.782	0.582	0.447
Within groups	131.578	98	1.343		
Total	132.360	99			
Loss of appetite					
Between groups	5.976	1	5.976	3.633	0.060
Within groups	161.184	98	1.645		
Total	167.160	99			

Indoor pollutants contributing to the SBS

The air quality monitor was used to obtain the readings of certain air particles that can lead to SBS. The particles that the air quality monitor read were $P.M_{2.5}$, $P.M_{10}$, and formaldehyde (HCHO). The readings for the temperature and relative humidity of the office and residential spaces visited during this survey were taken. According to the World Health Organization [19], the 24-h mean standard for $PM_{2.5}$ is 25 $\mu g/m^3$. $PM_{2.5}$ is a fine particulate matter usually referred to as air pollutants due to the fact that they have been found to have a close link with heart and lung diseases such as asthma, bronchitis, and other respiratory problems. Figure 3 showed a chart generated from the readings of particles, $PM_{2.5}$ obtained from thirty-five (35) offices space, and thirty-five (35) residential spaces in comparison to the standard reading from the World Health Organization (WHO).

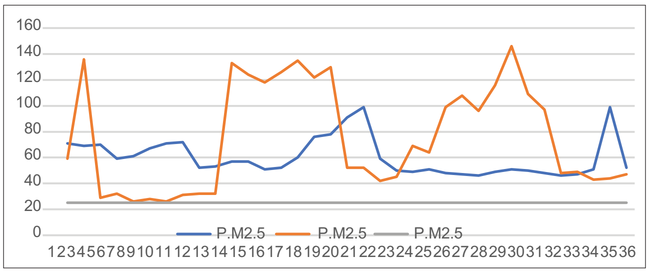

Figure 3: Measurement of particles, $P.M_{2.5}$

The 24-h mean for $PM_{2.5}$ was 75.57 $\mu g/m^3$ and 60.26 $\mu g/m^3$ for the residential spaces and office spaces, respectively. From Figure 3, only two residential spaces came close to the WHO standard for 24-h mean standard for $PM_{2.5}$ while the other spaces for both the office and residential spaces were clearly above the standard for $PM_{2.5}$. Therefore, it can be concluded from the results in the chart that $PM_{2.5}$ was unhealthy in most of the offices and residential spaces. Whereas, PM_{10} is a more coarse particle with 10 μm. They are regarded as air pollutants from combustion activities such as motor vehicles and industrial processes. According to the World Health Organization [19], the 24-h mean standard for PM_{10} is 50 $\mu g/m^3$. Figure 4 showed the chart generated from the readings of PM_{10} obtained from the survey compared with the WHO standard for PM_{10}.

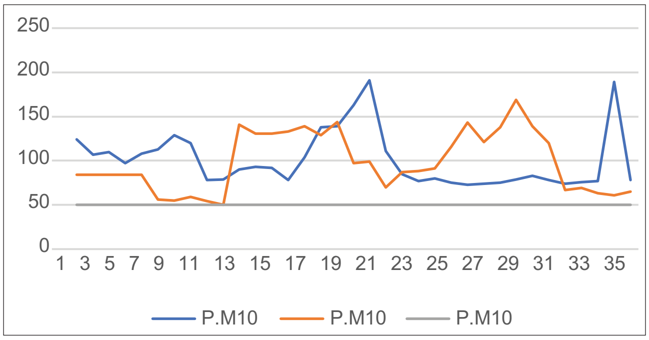

Figure 4: Measurement of particles, PM_{10}

The 24-h mean for PM_{10} was 98.43 $\mu g/m^3$ and 101.06 $\mu g/m^3$ for the residential spaces and office spaces, respectively. In Figure 4, only two residential spaces were the closest to the standard, while the rest for both the office and residential spaces are clearly above the WHO standard for the 24-h mean standard for PM_{10}. The findings of the high presence of $PM_{2.5}$ and PM_{10} are replicated in other studies [13]. Whereas, Riediker *et al*. [20] reported that exposure to high levels of $PM_{2.5}$ and PM_{10} can induce heavy breathing and result in cardiovascular problems, mainly among young office workers.

The air quality measuring device was used to measure the TVOC present in the air in the buildings surveyed. TVOC or TVOCs is a term used to describe a group of compounds that are present in emissions or ambient air. The chemical properties of TVOCs vary widely. They are essentially a complex mixture of potentially hundreds of low-level VOCs. They impact the air quality of places such as hospitals, office buildings, and schools. TVOCs can exist indoor as a result of fabrics, paints, glues, varnishes, disinfectants, smoke, floor wax, and soaps. Figure 5 showed the 24-h measurement of the TVOC, TVOC for the residential and office spaces. The 24-h mean for the TVOC was 0.26 ppm and 0.29 ppm for the residential spaces and office spaces, respectively. This is lower than the maximum limit of 3 ppm for TVOC.

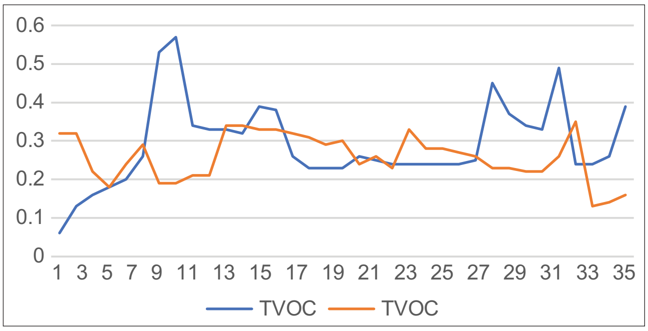

Figure 5: Measurement of total volatile organic compounds (TVOC), TVOC

The standard for formaldehyde (HCHO) in the work place is 0.75 parts formaldehyde per million parts of air (0.75 ppm) over 8-h [21]. The readings for formaldehyde (HCHO) were given by the air quality monitor in *mg/m*^{3}, so the formula was used to convert the readings to the unit *ppm,* which is shown in Equation 2.

$$X_{ppm} = \frac{Ymg/m^3 \times 24.25}{30.031g/mol} \quad (2)$$

After the readings for formaldehyde in both offices and residential spaces were converted, a chart was derived, as shown in Figure 6.

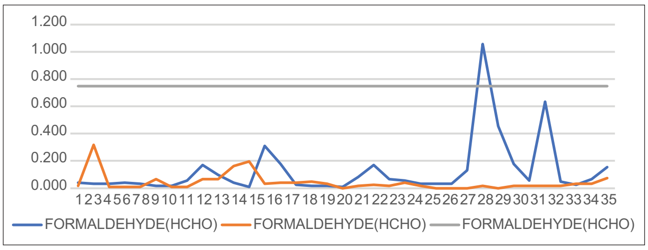

Figure 6: Measurement for formaldehyde (HCHO)

The 24-h mean for the HCHO was 0.16 ppm and 0.05 ppm for the residential spaces and office spaces, respectively. This is lower than the maximum limit of 0.75 ppm for TVOC. The chart in Figure 6 showed that the formaldehyde (HCHO) in about the 27th office space was above the standard and that of the 31st office space was close to exceeding the standard. However, the other readings for both the residential and office spaces were below the standard which is safe. The temperature readings for both the residential and office spaces were taken as well during the survey with the same Air Quality Monitor. It is expected that the average room temperature of every space should be 23°C. The 24-h mean for the room temperature was 25.41°C and 24.06°C for the residential spaces and office spaces, respectively. This is higher than the average room temperature of 23°C.

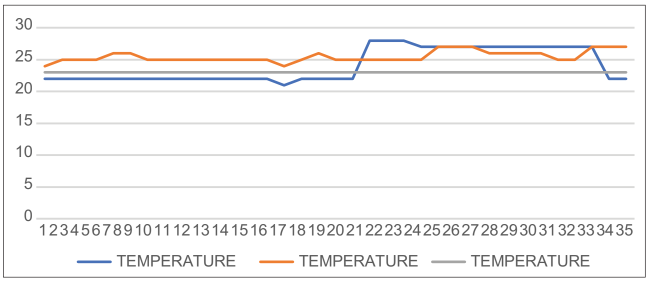

Figure 7: Measurement of temperature (23°C) in the building spaces

In Figure 7, the office spaces, the 1st to 19th office had room temperature below 23°C while the other readings both for the residential and office spaces exceeded the average temperature. For the spaces below the room temperature, there may be an indirect adverse implication on the health of the occupants, especially those with cardiorespiratory diseases. With lower temperature, there is more probability of having wet elements which can result into molds which can affect the health of the occupants. In addition, for those spaces, the huge cost is been accrued on energy utilization. With other spaces in residential and office spaces having their room temperature higher than the ideal room temperature standard of 23°C, they may find it hard to concentrate due to the high temperature considering the high temperate region of Northern Nigeria. While discussing the ideal room temperature, humidity plays an important role in the thermal comfort of occupants. For the office and residential spaces that were surveyed, the readings for relative humidity were obtained. It is expected that the indoor relative humidity should be at 50%. On this basis, the chart in Figure 8 was formed using the readings of the relative humidity obtained from the residential and office spaces surveyed.

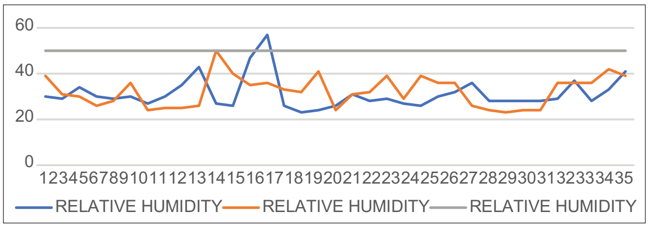

Figure 8: Measurement for relative humidity in the building spaces

From Figure 8, most of the building spaces in residential and office spaces had low humidity below the standard of 50%. The 24-h mean for the relative humidity was 32.37% and 31.20% for the residential and office spaces. With low humidity, this means that it would result in high temperatures within the building spaces. The low humidity can cause discomfort among occupants and make them susceptible to cold/flu and other respiratory problems due to the dryness that occurs in the mucous membrane in their nose and throat. The presence of dry air from the low humidity can also affect the eyes, the skin, and create an environment that is virus-friendly.

Conclusion and Recommendations

The study assessed SBS due to indoor pollution in residential and office buildings. The study showed that the symptoms associated with the SBS from indoor pollution were mainly cold or flu, burning or nasal itching, and muscle pain in arm or hand. The indoor conditions that may contribute to SBS in the residential and office spaces were mainly lighting conditions, headroom in the building, and position of windows. Further analysis showed that there was a significant relationship between occupants' having headaches, fever, and dizziness with indoor conditions such as the use of air conditioning systems and increased noise level. Moreover, there was a significant relationship between drowsiness and lighting conditions and nausea and size of the room spaces. In addition, the implication of SBS from indoor pollution on residential and office space occupants was manly increased maintenance, dizziness, and depression/breakdown. The study showed that there were significant implications of SBS which leads to stress, can reduce productivity, can affect concentration, can lead to the need to change residential/office space, reduced commitment, and increase the need for maintenance works. The measurement of the indoor pollutants contributing to the SBS among residential and office space occupants showed that PM2.5 and PM10 were above the average mean standard, while the TVOC and HCHO were within the average standard recommended by the WHO. The study recommended that;

- Air cleaning through the use of mechanical filters or electronic air cleaners can be a helpful solution in capturing and control of small particles. Alternatively, high-performance filters can be installed to capture smaller particles as well as respirable particles but are expensive to install and operate
- Building owners/developers can focus on smart buildings that integrate air quality detectors in web-based systems that can alert occupants on the air pollution levels and ways to minimize the source of air pollution
- The filters in air conditioning systems should be consistently cleaned to allow good airflow indoors
- There is a need to keep air pollution such as burning of wood, smoking, or other combustion to a minimum indoors to avoid issues of SBS
- In light of the major symptoms associated with SBS, attention should be duly given to the working environment by employers by providing proper ventilation, both natural and artificial, in the right proportions. Building occupants should practice airing of spaces by opening the windows periodically to air out the homes and office spaces to improve air quality
- There is a need for increased awareness of SBS through seminars and public lectures that pertain to information about SBS, prevention and the associated effects on individuals

Subsequently, further research in this line can be carried out using qualitative analysis which will involve engaging the respondents orally to obtain primary data. Industrial areas and factories can also be considered as the study area. This study focused on the 24-h mean of measuring the air pollutants, future studies can be focused on measuring a year mean and compared with the international standards. The scope on the study area can also be increased from Kaduna State to other states that have high air pollution such as Lagos and Rivers State.

References

1. Jerome N. Application of Maslow's hierarchy of need theory; impacts and implications on organizational culture, human resource and employee's performance. Int J Bus Manage Invent. 2013;2(3):39-45. Available from: https://www.pdfs.semanticscholar.org/b0bc/c8ca45193eaf700350a8ac2ddfc09a093be8.pdf. [Last accessed on 2019 Sep 21].
2. Evans GW, McCoy JM. When buildings don't work: The role of architecture in human health. J Environ Psychol. 1998;18:85-94.
3. Afolabi A, Tunji-Olayeni P, Oyeyipo O, Ojelabi R. The socio-economics of women inclusion in green construction. Constr Econ Build. 2017;17:70-89. Available from: https://www.epress.lib.uts.edu.au/journals/index.php/ajceb/article/view/5344/5858. [Last accessed on 2019 Sep 21]. https://doi.org/10.5130/ajceb.v17i1.5344
4. Tunji-Olayeni P, Afolabi A, Okpalamoka O. Survey dataset on occupational hazards on construction sites. Data Brief. 2018;18:1365-71. Available from: https://www.sciencedirect.com/science/article/pii/S2352340918303792. [Last accessed on 2019 Sep 21]. https://doi.org/10.1016/j.dib.2018.04.028
5. Kukec A, Dovjak M. Prevention and control of sick building syndrome (SBS). Part 1: Identification of risk factors. Int J Sanit Eng Res. 2014;8:16-40. Available from: https://www.journal.institut-isi.si/prevention-and-control-of-sick-building-syndrome-sbs-part-1-identification-of-risk-factors/?download=15467. [Last accessed on 2019 Sep 21]. https://doi.org/10.1007/978-3-642-17919-8_30
6. Sarafisa P, Sotiriadou K, Dallas D, Stavrakakis P, Chalaris M. Sick-building syndrome. J Environ Prot Ecol. 2010;11:515-22. Available from: https://www.researchgate.net/publication/262728404_sick-building_syndrome. [Last

accessed on 2019 Sep 21].

7. Iyagba RA. The Menace of Sick Buildings: A challenge to all for its prevention and treatment. Akoka, Nigeria: University of Lagos Press; 2005. Available from: http://www.196.45.48.50/opendoc.php?sno=9130&doctype=pdf&docname=the-menace-of-sick-buildings:-a-challenge-to-all-for-its-prevention-and-treatment. [Last accessed on 2019 Sep 21].
8. Health Effects Institute. State of Global Air 2018. Special Report. Boston, MA: Health Effects Institute; 2018. Available from: https://www.stateofglobalair.org/sites/default/files/soga-2018-report.pdf. [Last accessed on 2019 Sep 21].
9. Fotoula PB. The sick building syndrome (SBS). Health Sci J. 2011;5(2):72-3.
10. World Health Organization. WHO Guidelines for Indoor Air Quality: Selected Pollutants. Geneva: World Health Organization; 2010. Available from: http://www.euro.who.int/__data/assets/pdf_file/0009/128169/e94535.pdf. [Last accessed on 2019 Sep 21].
11. Joshi SM. The sick building syndrome. Indian J Occup Environ Med. 2008;12(6):1-4. Available from: http://www.ijoem.com/article.asp?issn=0019-5278;year=2008;volume=12;issue=2;spage=61;epage=64;aulast=joshi. [Last accessed on 2019 Sep 21]. https://doi.org/10.4103/0019-5278.43262
12. Gomzi M, Bobic J. Sick building syndrome: Do we live and work in unhealthy environment? Period Biol. 2009;111(1):79-84. Available from: https://www.hrcak.srce.hr/file/56816. [Last accessed on 2019 Sep 21].
13. Zamani M, Jalaludin J, Shaharom N. Indoor air quality and prevalence of sick building syndrome among office workers in two different offices in Selangor. Am J Appl Sci. 2013;10(10):1040-7. Available from: https://www.pdfs.semanticscholar.org/3304/34a5ad02f6ec7d060203c51c0ab439036b35.pdf. [Last accessed on 2019 Sep 21]. https://doi.org/10.3844/ajassp.2013.1140.1147
14. World Health Organization. Indoor Air Pollutants: Exposure and Health Effects. EURO Reports and Studies. Geneva: World Health Organization; 1983.
15. Burge S, Hedge A, Wilson S, Bass JH, Robertson A. Sick building syndrome: A study of 4373 office workers. Ann Occup Hyg. 1987;31(4A):493-504.
PMid:3439759
16. Bourbeau J, Brisson C, Allaire S. Prevalence of the sick building syndrome symptoms in office workers before and six months and three years after being exposed to a building with an improved ventilation system. Occup Environ Med. 1997;54(1):49-53. https://doi.org/10.1136/oem.54.1.49
PMid:9072034
17. Wang J, Li J, Zhao C. A Case of Sick Building Syndrome Caused by Incorrect Ventilation Design of the Tight Building. Proceedings of Indoor Air, 490-493; 2002. Available from: http://www.irbnet.de/daten/iconda/cib7170.pdf. [Last accessed on 2019 Sep 21].
18. Atarodi Z, Karimyan K, Gupta VK, Abbasi M, Moradi M. Evaluation of indoor air quality and its symptoms in office building-a case study of Mashhad, Iran. Data Brief. 2018;20:74-9. https://doi.org/10.1016/j.dib.2018.07.051
PMid:30105278
19. World Health Organization. WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide. Global Update 2005. Summary of Risk Assessment; 2006. Available from: https://www.apps.who.int/iris/bitstream/10665/69477/1/who_sde_phe_oeh_06.02_eng.pdf. [Last accessed on 2019 Sep 21].
20. Riediker M, Cascio WE, Griggs TR, Herbst MC, Bromberg PA. Particulate matter exposure in cars is associated with cardiovascular effects in healthy young men. Am J Respir Crit Care Med. 2004;169(8):934-40. https://doi.org/10.1164/rccm.200310-1463oc
PMid:14962820
21. Occupational Safety and Health Administration. Indoor Air Quality in Commercial and Institutional Buildings. Occupational Safety and Health Administration U.S. Department of Labor; 2011. Available from: https://www.osha.gov/publications/3430indoor-air-quality-sm.pdf. [Last accessed on 2019 Sep 21]. https://doi.org/10.1201/9781315269603-43