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Indoor Air Quality and Prevalence of Sick Building Syndrome Among Office Workers in Umm Al-Qura University in Kingdom of Saudi Arabia

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Abstract

In the Kingdom of Saudi Arabia due to the harsh climatic conditions, especially high temperature and seasonal dusty storm, office building have extensively evolved to become tightly constructed and sealed with controlled environments. Therefore, office workers may be particularly at risk due to accumulation of indoor air pollutants. This study aimed to investigate the indoor air quality (IAQ) in offices and prevalence of sick building syndrome (SBS) symptoms among office workers in the deanship of faculty members and employees affairs of Umm Al- Qura University. Furthermore, a comparison with an established benchmark was conducted to identify rooms for improvement.

The result shows that the measured levels of carbon dioxide (CO_2) in offices of all sections were well within the limits described by the ASHRAE except in salaries section. Total volatile organic compounds (VOCs) in all sections exceeded Mølhave recommended value (200 µg/m^3). Temperature levels were not within the threshold values specified by ASHRAE. However, relative humidity (RH) levels were well within the limits described by the ASHRAE in all sections. Particulate matter concentrations (PM2.5 and PM10) in offices of most sections exceeded both the maximum 24-h and annual mean limits provided by WHO and EPA. Growth of fungal and bacterial species was observed with variable counts in offices of all sections.

The SBS symptoms were assessed by using questionnaires. 93(92%) office workers responded to the questionnaire and the findings showed that running nose (41%) red eyes (19%), eye irritation (21%), fatigability (36%) headache (41%) and itch skin (15%) were the most prevalent SBS symptoms.

Key words: Indoor Air Quality (IAQ), Sick Building Syndrome (SBS), Carbon Dioxide (CO_2), Volatile Organic Compounds (VOCS), Particulate Matter, Biological Contaminants.

INTRODUCTION

Worldwide, there is growing attention on the occupational risks associated with office's indoor air quality (IAQ) due to the increasing number of cases reported on health problems involving workers in indoor facilities, since most of them are spending 90% of their works time in indoors environment (Jones, 1999; Lee and Chang, 2000). Pollutants accumulated inside indoor facilities are 100 times more than that exist in outdoors (Ingrosso, 2002; Yang *et al.*, 2004). Thus, indoor air pollution may adversely affect the health of office workers more than outdoor pollution (EPA Indoor air quality, 2013).

In the Kingdom of Saudi Arabia due to the harsh climatic conditions, especially high temperature and seasonal dusty storm, office building have extensively evolved to become tightly constructed, sealed and controlled environments with ventilating and air-conditioning systems to reduce natural air infiltration and exfiltration, which, in turn, builds up of indoor high levels of toxic contaminants. Moreover, using of the modern office devises (e.g. computers photocopiers and printers etc.), building material and measures for energy conservation also increases indoor air contaminants and threatens to the health of office workers and consequently reduce their performance (Wyon, 2004). Annually, indoor air pollution cause more than 1.6 million annual deaths and 2.7 % of the global burden of disease (WHO program on IAQ, 2010).

Office common indoor air pollutants sources include biological contaminants (fungi and bacteria), particulate matters (PM) and chemical contaminant like total volatile organic compounds (TVOC) and carbon dioxide (CO_2) which its concentrations are often used as an indicator for the rate of outside air supply per occupant. Moreover, physical factors such as air temperature and humidity, affect general comfort and influence office's air quality thus, traditionally used to express thermal comfort (Seppänen *et al.*, 2003). For instance, if the air is become dry, then the static electricity will build up and increase particles suspension in the air which can be inhaled or cause skin rashes.

Exposure of office workers to indoor pollutants is potentially associated with sick building syndrome (SBS) and this becomes obvious when occupants of office building experience health problems of unknown causes (Mendell1993). World Health Organization (WHO) defined SBS as an excess of work-related medical symptoms like skin irritation, headache, fatigue, red eyes and running nose, reported by employees in modern office buildings (Zamani *et al.*, 2013). Moreover, in previous study Seppänen and Fisk (2006) reported that increased severity of SBS symptoms may shows negative effect on the performance of the affected workers.

Usually, office indoor air quality investigate by measuring the concentrations of PM, CO_2, VOCs, biological contaminants in buildings and prevalence of SBS among occupants; therefore, this study was carried out to assess the status of indoor air pollutants and prevalence of sick building syndrome among the office workers in five sections of deanship of faculty members and employees affairs of Umm AL-Qura University, Makkah, Saudi Arabia.

MATERIALS AND METHODS

Site Description and Study Population

Samples were collected between 8.00 am to 3.00 pm, from Sunday to Thursday, in the main building of the Deanship of faculty members and employees affairs of Umm Al- Qura University, where most administrative activities and tasks are performed. The main offices of five sections namely, travelling section, faculty members section, Saudi faculty members section, salaries section and administrative, health and technical staff section were selected as sampling points for measuring IAQ parameters and prevalence of SBS among office workers.

Indoor Air Quality Measurements

Assessment of IAQ in offices was conducted by dividing each office to five sampling points and the measurements were repeated three times. The average data were calculated and recorded.

CO_2, Temperature and Relative Humidity

Assessment of Indoor CO_2, temperature and relative humidity in offices was conducted by means of environmental monitoring equipment. Amprobe CO_2-100 Hand-held Carbon Dioxide Meter was used to measure levels of CO_2, temperature and relative humidity. The portable CO_2 meter uses NDIR (Non-Dispersive Infrared) technology to ensure the reliability of the results.

Total Volatile Organic Compounds (TVOCs)

TVOCs were measured in all offices by using Data logging VOC METER (Model VOC08). The VOC08 is an easy-to-use handheld instrument for making ballpark measurements of mixed-gas volatile organic compound (VOC)

Particulate Matters

Sampling of particulate matters of different sizes was performed using a nephelometer (DustTrak ™ II Aerosol Monitor Model 8530, TSI Inc., SHOREVIE, MN, USA). With this equipment, two different particle sizes (PM2.5 and PM10) were measured in the air by using size respective impactors. The impactor assembly is attached to the instrument in place of the inlet cap. Air was sampled at the rate of 3L/min as the factory default settings. The instrument was calibrated by Zero Cal run prior to every use in different locations to maintain accuracy. Each office was divided into five sampling points. Duration of each sampling point was 30 min to represent the selected area and it was repeated three times during working hours.

The evaluation of IAQ in the office buildings was carried out by comparing the measured levels of chemical pollutants, factors of thermal comfort and particulate matter with that of international standards such as the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE,2007; 2013) World Health Organization (WHO, 2000; 2006; 2010), Environmental Protection Agency (EPA, 2013) as well as previous studies such as those by (Mølhave, 1991).

Measurements of biological air pollutants

Samples of microbial air pollutants were collected from the selected offices for ten days, using R-300 vacuum pump device, on filter paper (size 3 cm diameter). By the end of the sampling period, the filter papers were collected and put aseptically in sterilized plastic bags, then returned to the lab. Each filter paper was put aseptically on Petri dishes contain either malt extract agar for fungi or nutrient agar for bacteria. Three Petri dishes were prepared for each experiment. The dishes were incubated at 30 ^{0}C and for 48 hrs. for bacteria and at 25^{0}C and for 5-7 days for fungi. The recovered colonies for bacteria and fungi were counted and identified using Murray (Murray, *et al*., 1995) and Alexopoulos (Alexopoulos, *et al.*,1996) methods, respectively.

Socio-demographic Information, Health Status and Prevalence of Sick Building Syndrome

A self-administered questionnaire was designed to obtain all information from the respondents regarding the occurrence of SBS symptoms such as dry and itchy eyes, cough, chest tightness, runny nose, headache and shortness of breath. The questionnaires were distributed randomly to 101 occupants. The questionnaire was also used to collect background information related to the research. Recorded SBS symptoms were checked on same day of IAQ assessment. Office workers will be defined as having SBS if at least one symptom appeared when entered their office and disappeared when they left and appeared at least once in a week.

RESULTS AND DISCUSSION

Evaluation of IAQ for an Average 30-min Period

Table (1) shows a summary of the highest 30-min average levels of on-site measured parameters of IAQ along with the relevant standards/guidelines at the selected office buildings in five different sections.

Relative Humidity (RH)

The average result showed that the measured levels of relative humidity (RH) in the five sectors were in the range between 38.7 to 55.5 well within the limits described by the (ASHRAE, 2007) which is between 30 to 60; hence, RH considered not contributing to the deterioration of IAQ in the offices.

Temperature

The measured values of temperature inside the office buildings were in the range of 22.2-24.7 °C. Except for travelling section (22.2 °C) all office in four sections were higher than the ranges specified by ASHRAE’s standard (20.0 - 23.5°C), (Table 1). The adverse effect of temperature on health and prevalence of SBS symptoms among building occupants was already reported despite the physical factors being within the comfort range (Mendell and Mirer, 2009).

Carbon Monoxide (CO_2)

As illustrated in Table (1) the measured concentrations of CO_2 in all selected offices were lower than the ASHRAE (2007) standards limit except for the Salaries section which recorded 786 ppm compared to700ppm of the ASHRAE standard. The CO_2 measurement trends at this section indicated that the peak concentrations of CO_2 exceeded the standard values during the working time which is a clear sign of poor dilution and dispersion of human- and building-generated pollutants. Since CO2 is a by-product of human respiration, this elevated level may be due to the higher occupancy of employees also the number of visitors for the offices space is higher than other offices space. This also may be due to poor ventilation where the circulation of fresh air not only plays a vital role in the dispersion and dilution of the indoor pollutants but also is a prime indicator of ventilation adequacy in a building. These elevated levels of indoor CO_2 reflect the fact that ventilation is very low in the salaries section. In previous study Sulaiman, and Mohamed, (2011) reported that elevated levels of CO_2 are associated

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with discomfort, insufficient ventilation, appearance of SBS symptoms and reduction of worker's productivity due to the buildup of human-and building-generated pollutants.

Total Volatile Organic Compounds (TVOCs)

Four exposure ranges proposed by Mølhave (1991) are used in the present study to define acceptable levels of TVOCs: comfort range (< 200 µg m-3), multifactorial range (200-3,000 µg m-3), discomfort range (3,000-25,000 µg m-3), and toxic range (> 25,000 µg m-3). Table (1) shows that workers in all offices were exposed to TVOCs at the multifactorial level. The highest concentrations of TVOCs were observed in salaries section (615µg m-3) followed by travelling Section (558µg m^{-3}) and Saudi Faculty Staff section (528µg m-3). TVOC concentrations > 500 µg m^{-3} are considered indicative of the presence of complicated VOC mixtures which may result in irritation of the eyes, nasal membranes, throat, and respiratory tract, and in general discomfort. High indoor levels of TVOCs may be caused by the emission of pollutants by new furniture or carpets, aerosol sprays, cleaning agents, or paints. Also possible are outdoor sources of TVOCs which become indoor air pollutants. Similar result was reported by Abdul-Wahab *et al.*, (2015)

Table (1): Average levels of IAQ parameters in selected offices of different sections

Parameter	location	Peak level/range	Standard/Guideline
Carbon Dioxide (ppm)	Travelling section	544	700 (continuous exposure) ASHRAE
	Faculty members section	560	
	Saudi faculty members section	603	
	Salaries section	786	
	Administrative health and technical staff section	641	
TVOC (µg m-3)	Travelling section	558	< 200 µg/m^3 (comfort range) Mølhave
	Faculty members section	491	
	Saudi faculty members section	528	
	Salaries section	615	
	Administrative health and technical staff section	279	
Temperature (°C)	Travelling section	22.2	20.0-23.5 (Winter) ASHRAE
	Faculty members section	23.9	
	Saudi faculty members section	27.2	
	Salaries section	24.7	
	Administrative health and technical staff section	23.6	
Relative Humidity (%)	Travelling section	52.4	30-60 ASHRAE
	Faculty members section	46.3	
	Saudi faculty members section	38.7	
	Salaries section	47.6	
	Administrative health and technical staff section	55.5	

Particulate matter (PM)

Data on PM were not recorded for a full 24-h, instead DustTrak ™ II Aerosol Monitor was used for a duration of 30 minutes for each sampling point (five sampling point for each office) and repeated three times during working time. Although a comparison of short-term on-site measurements is not possible due to the lack of any standards or guidelines for this average period, here in this study to get some idea about the PM levels in the building during working times we compared it with EPA revised level of the 24-hour PM2.5 and PM10 standards and **WHO Air quality guidelines for particulate matter.**

Two measuring probes were used in this study. Measured concentrations of PM with a diameter < 10 µm (PM10) and diameter < 2.5µm (PM2.5) for a 30-min average period were represented in figures (1and 2). For PM2.5 as illustrated in figure 1 the PM concentrations in offices of all sections exceeded both the guideline of WHO and standard of EPA with the highest concentration (119 µg/m^3) shown in salaries section. These PM levels indicate the presence of internal and external sources of PM in the building, which can affect the health of occupants. For PM10 the average measured values inside the office buildings were in the range of 41 µg/m^3 to 98 µg/m^3 which were exceeded the WHO 24-hour mean which is 50 µg/m^3 except for the Saudi faculty member section level which was 41 µg/m^3. However, when compared with EPA (150 µg/m^3) the PM concentrations in all offices were lower than EPA standard except for secretary section and s2alaries section with magnitudes of 185µg/m^3 and 161 µg/m^3 respectively. These results indicate lower air-circulation at offices which may lead to PM accumulation. Also, offices were located aside a busy road in central Makkah and surrounded with cars parking, which may have contributed to higher concentration of PM2.5 and PM10 in almost all offices. Particulate matters considered as one of the most important indoor contaminants and associated with wide range of SBS symptoms and adverse health problems include respiratory and cardiovascular diseases as well as diabetes (Franck *et al.*, 2011; Estokova *et al.*, 2010; Tippayawong, *et al.*, 2009; and Puett, *et al.*, 2011).

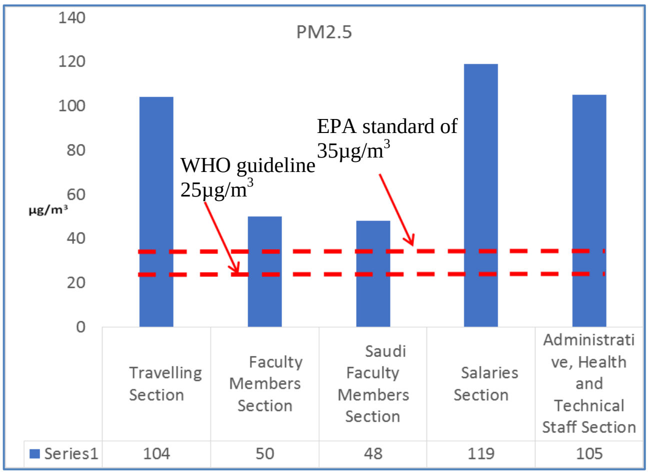

Fig.1 Concentrations and the limit value of PM2.5 in the office buildings of five sections compared to EPA particulate matter national ambient air quality standard and WHO guidelines.

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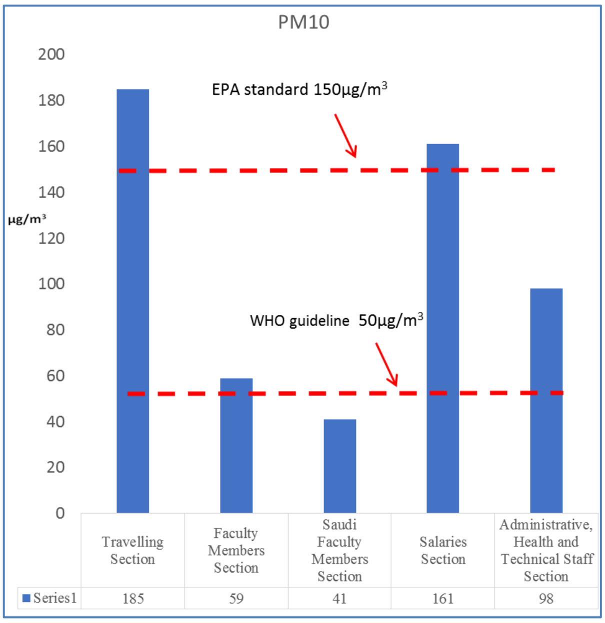

Fig.2 Concentrations and the limit value of PM10 in the office buildings of five sections compared to EPA particulate matter national ambient air quality standard and WHO guidelines

Biological Contaminants

Fungal growth was observed in offices of all sections with variable counts as showed in table (2). *A. flavipes* was the most common fungal species comprised ($12x10^3$) in faculty members section followed by travelling section which accounted ($10x10^3$). *A. flavus* appeared in high occurrence in all sites except administrative, health and technical staff section in which it occurred in moderate occurrence. *A. parasitic*us and *A. niger* appeared in moderate occurrence in most sites. *Trichderma* sp appeared only in travelling section in low occurrence. *A. ochraceus* isolated in low occurrence in most sections (Table,2). Richard and Elizabeth (2000), declared that if the indoor fungal level is more than 1000 CFU/m^3 and the outdoor count is more 2500 CFU/m^3 is represent an area of low air quality. Also, Ekhaiseet and Ogbogohodo (2011) reported that *Aspergillus niger* and *A. flavus* were the most frequently isolated fungi from two major hospitals in Benin city in Nigeria**.**

Data in table (3) showed that all bacterial species recorded in moderate occurrence except *S. aureus* appeared in high records ($6.4x10^2$) in offices of faculty members section. *Serratai* sp. appeared only in offices of travelling section in moderate count. *Klebssiella* sp. Appeared in all sites of investigation but absent in offices of administrative, health and technical staff section. Ekhaise *et al.*, (2010) reported, that the most prevalent isolate includes *S. aureus*, *S. epidermidis*, *Esherichia coli, Bacillus sp. Proteus sp., and Streptococcus sp.*, with *S, aureus*. In previous study by Lateef (2003) it was found that S. *aureus* was responsible for the infections of the skin, deeper tissue and organs. These microorganisms are known primary agents of nosocomial infection in hospitals.

Table 2: Fungal species count (colonies), calculated by colony forming unit CFU/m^3, which isolated from sites of investigation

Place / Fungal species	Travelling Section		Faculty Members Section		Saudi Faculty Members Section		Salaries Section		Administrative, Health and Technical Staff Section	
	TC	Q.R.	TC	O.R.	TC	O.R.	TC	O.R.	TC	O.R.
A. flavus	$4x10^3$	H	$4x10^3$	H	$3x10^3$	M	$4x10^3$	H	$2x10^3$	M
A. niger	$4.5x10^3$	H	$3x10^3$	M	00	00	$2x10^3$	M	$3x10^3$	M
A. parasitic	$3x10^3$	M	00	00	$2x10^3$	M	$5x10^3$	H	$2x10^3$	M
A. flavipes	$10x10^3$	VH	$12x10^3$	VH	00	00	$4x10^3$	H	$3x10^3$	M
Trichoderma spp.	$1x10^3$	L	00	00	00	00	00	00	00	00
A. ochraceus	$1x10^3$	L	$1x10^3$	L	$1x10^3$	L	00	00	$2x10^3$	M
Total gross	$24.5X10^3$		$20x10^3$		$6x10^3$		$15x10^3$		$12x10^3$	

- Very High (VH) => $5x10^3$ CFU/m^3
- High(H) =$3\text{-}4x10^3$
- Medium (M)= $2\text{-}3x10^3$
- Low (L)= $1\text{-}2x10^3$
- No Concern (N.C.) = 100- 1000 cfu/m^3
- O.R. Occurrence Remark
- TC Total count

Table (3): Average numbers of bacterial species recorded in sites of study

Site and Bacteria species	Travelling Section	Faculty Members Section	Saudi Faculty Members Section	Salaries Section	Administrative, Health and Technical Staff Section	Maximum Levels (CFU/m3)
	TC&OR	TC&OR	TC&OR	TC&OR	TC&OR	< 50 very small 50-100 small 100-500 medium 500-2000 high >2000very high (CEC,1993)
Bacillus cereus	$3x10^2$ medium	$5X10^2$ medium	$3.3x10^2$ medium	$1,9x10^2$ medium	$3.9x10^2$ medium	
Micrococcus loteus	$2.2x10^2$ medium	$1.3X10^2$ medium	$2x10^2$ medium	$0.9x10^2$	$1x10^2$ medium	
Staphylococcus aureus	$3.5x10^2$ medium	$6.4X10^2$ high	$4.4x10^2$ medium	$4.5x10^2$ medium	$3.5x10^2$ medium	
Serratiasp	$1.2x10^2$	00	00	00	00	

	medium					
Klebsiellasp	$2x10^2$ medium	$1.4x10^2$ medium	$2x10^2$ medium	$1x10^2$ medium	00	

Prevalence of Sick Building Syndrome (SBS)

Based on IAQ result, salaries section was used to investigate the prevalence of SBS among office workers. In this study, 92% of office workers in salaries section were responded. The high percentage of responses received in this assessment indicates most of these respondents often felt disturbed or affected with the SBS symptoms in the workplace. The SBS symptoms that were asked in the SBS symptoms questionnaires were headache, fatigue and lethargy, irritated and study nose, hoarse and dry throat, eye irritation and as well as skin rashes and itchiness. Table 4 shows the SBS symptoms level that have been obtained in this study. The results showed that headache (41%), running nose (41%), fatigue (39%), red eyes (19%), eye irritation (28%) and itchy skin (14%) were the most common general symptoms of SBS.

The prevalence of the SBS symptoms by respondents in the offices of salaries section's building are in line with the IAQ level that has been obtained in this study. Most of IAQ physical parameter and IAQ contaminants exceed the IAQ standard that has been set up by ASHRAE, (2007;2013), WHO (2000, 2006, 2010), EPA, (2013) as well as TVOC comfort range (< 200 µg m-3) proposed by Mølhave, 1991). Thus, it is not surprising if most of them were distracted by the SBS symptoms. Similarly, Saraga *et al.,* (2011) reported that eye and skin irritation are among the SBS symptoms resulted from exposure to poor IAQ.

Accordingly, this result is consistent with the prevalence of SBS that was appeared in a review reported by Seppänen, *et al*., 1999, about one-half of 22 studies of SBS symptoms in offices showed that high concentrations of indoor CO_2 and TVOC levels were positively associated with a high prevalence of SBS symptoms.

In general, factors such as inadequate ventilation per office worker and elevated indoor chemical pollutants concentrations like TVOC and CO2, fungi and Bacteria are important indoor air factors that can influence the prevalence of SBS (Apte *et al*., 2000). Moreover, in previous study, Sulaiman and Mohamed (2011) reported similar results and declared that there were significant associations between SBS and indoor air parameters namely CO_2, temperature, bacteria, fungus and TVOC.

Table 4: Prevalence of Common Sick Building Syndrome Symptoms among office workers in salary section

Symptom	Frequency (N=93)	Percentage (%)
Running nose	38	41
Red eyes	19	20
Eye irritation	28	30
Fatigue	36	39
Headache	38	41
Itchy skin	14	15

CONCLUSIONS

The results of this study showed that the office buildings in the deanship of faculty members and employees affairs of Umm Al- Qura University are suffering from indoor pollutants that encourages SBS. It is apparent from the findings of the present study that the office workers were affected because of exposure to chemical contaminants along with particulate matters, uncomfortable thermal levels and biological contaminants. The elevated levels of CO_2 and PM were indicative of insufficient building ventilation. The observed concentrations of TVOCs, PM2.5 and PM_{10} indicated the presence of strong indoor and outdoor contaminant sources. The physical environment of the offices was also not appropriate for the occupants due to high temperature. The elevated levels of each of these parameters were possibly worsening the IAQ. Pathological symptoms such as headaches, eye irritation, skin, fatigue, dizziness, stuffiness, etc. may have been due to the manifestation of elevated IAQ levels.

To prevent SBS and offer a healthy environment for building occupants, the levels of indoor air pollutants should be kept under permitted values and ventilation should be adjusted as needed to maintain workers' health.

The result of this research declares the need for comprehensive study on air-circulation inside the air-conditioned buildings and its effects on indoor air pollution. However, a year-long study on IAQ inside offices is greatly needed.

Finally, this study has been carried out with the hopes of raising the awareness and can be used as a reference in improving the IAQ in indoor environments at the workplace, particularly in universities or other similar institutions for the benefits and health being of the office workers.

Conflict of interest statement

We declare that we have no conflict of interest.

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REFERENCES

Abdul-Wahab, S., N. Salem, S. Ali, 2015. Investigation of the Environmental Indicators at the Main Library of Sultan Qaboos University (SQU) in the Sultanate of Oman. Sustainable Environment Research, 25(3):131-139.

Alexopoulos, C., C. Mims, and M. Blackwell. 1996. Introductory Mycology. Wiley & Sons, Inc. New

Apte, M.G., W.J. Fisk, J.M. Daisey, 2000. Associations between indoor (CO_2) concentrations and sick building syndrome symptoms in US Office Buildings: an analysis of the 1994–1996 BASE Study Data (LBNL 44385), Indoor Air, **10**, 246–257.

ASHRAE, 2013. Standard 55-2013. Thermal environmental conditions for human occupancy. ASHRAE. Atlanta, USA. Assessed on 31st of May 2015 - https://www.ashrae.org/resources--publications/bookstore/standard-55.

ASHRAE, 2007. Standard 62.1 - Ventilation for Acceptable Indoor Air Quality. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Atlanta, GA. *Ekhaise* F. O., B. L. *Ogboghodo,* 2011. Microbiological Indoor and Outdoor Air Quality of Two Major Hospitals in Benin City, Nigeria. Sierra Leone Journal of Biomedical Research, 3(3):169-174

Ekhaise F.O., E.E., O. Isitor, Idehen, A.O. Emoghene, 2010. Airborne Microflora in the Atmosphere of a Hospital Environment of University of Benin Teaching Hospital (UBTH), Benin City, Nigeria. World J Agric. Sci. 6(2):166-170

EPA Indoor air quality, 2013. http://www.eea.europa.eu/signals/signals-2013/articles Accessed on April 2016.

Estokova, A., Stevulova, N. and Kubincova, L. (2010) Particulate matter investigation in indoor environment. Global Nest Journal, 12 (1), 20-26.

Franck, U., Herbarth, O., Roder, S., Schlink, U., Borte, M., Diez, U., Kramer, U., G. I. Lehmann, I. 2011. Respiratory effects of indoor particles in young children are size dependent. Science of the Total Environment, 409(9):1621-1631.

Ingrosso, 2002. Free radical chemistry and its concern with indoor air quality: an open problem." Microchemical Journal, 73(1-2), 221-236.

Jones, A. P., 1999. Indoor Air Quality and Health. Atmospheric Environment, 33(28), 4535-4564.

Lateef A. 2003. The Microbiology of a Pharmaceutical Effluent and its Public Health Implications. Res J Microbiol. 8(3): 212-218

Lee, S. C., M. Chang, 2000. Indoor and Outdoor Air Quality Investigation at Schools in Hong Kong. Chemosphere, 41,109-113.

Mendell, M.J. 1993. Non-specific symptoms in office workers: A review and summary of the epidemiologic literature. Indoor Air 3, 227–236.

Mendell, M. J., A. G. Mirer, 2009. Indoor thermal factors and symptoms in office workers: findings from the US EPA BASE study. Indoor Air, 19(4), 365-368.

Mølhave, L. 1991. Indoor climate, air pollution, and human comfort. J. Expo. Anal. Environ. Epidemiol., 1(1), 63-81.

Murray PR, Baron EJ, Pfaller MA, Tenover FC, Yolken RH (eds), 1995. Manual of Clinical Microbiology 6th Ed. ASM Press, Washington, D.C.

Puett, R.C., Hart, J.E., Schwartz, J., Hu, F.B., Liese, A.D. and Laden, F. 2011. Are particulate matter exposures associated with risk of type 2 diabetes? Environ. Health Perspect., 119, 384-389.

Richard C. *F.*, A. *Elizabeth, 2000. Gilman Biological Contamination* of the *Building Environment*: *Sampling* and *Analysis* of JABSA 5, (1*)*, 19–29

Saraga, D., S. Pateraki, A. Papadopoulus,, C. Vasilakos, Maggos. 2011. Studying the Indoor Air Quality in Three Non-Residential Environments of Different Use: A Museum, a Printer Industry and an Office. *Building and Environment.* 46, 2333-2341.

Seppänen, O., W. J. Fisk, 2006. Some quantitative relations between indoor environmental quality and work performance or health. International Journal of HVACR Research, 12(4), 957-973.

Seppänen, O., W.J. Fisk, D. Faulkner, 2003. Cost benefit analysis of the night-time ventilation cooling. Proceedings of the Healthy Buildings Conference, 3, 394-399.

Seppänen, O.A., Fisk, W.J., M.J. Mendell, 1999. "Association of ventilation rates and CO2 concentrations with health and other responses in commercial and institutional buildings," Indoor Air 9:226-252

Sulaiman, Z. and M. Mohamed, 2011. Indoor air quality and sick building syndrome study at two selected libraries in Johor Bahru, Malaysia. Environment Asia, 4(1):67-74.

Tippayawong, N., Khuntong, P., Nitatwichit, C., Khunatorn, Y., C. Tantakitti, 2009. Indoor/outdoor relationships of size-resolved particle concentrations in naturally ventilated school environments. Building and Environment, 44:188-197.

WHO, 2010. Guidelines for Indoor Air Quality: Selected Pollutants. World Health Organization, Copenhagen, Denmark.

WHO, 2006. Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide. World Health Organization, Geneva, Switzerland. WHO.

WHO, 2000. Air Quality Guidelines for Europe. 2nd Ed., World Health Organization, Copenhagen, Denmark.

Wyon D.P. 2004. The effects of indoor air quality on performance and productivity. Indoor Air [Online]. Wiley Online Library, [Viewed 11 Dec 13]. Available from: DOI: 10.1111/j.1600-0668.2004.00278.

Yang, X., J. Srebric, X. Li, G. He, 2004. Performance of three air distribution systems in VOC removal from an area source. Building Environ. 39, 1289- 1299.

Zamani, M. E., J. Jalaludin, N. Shaharom, 2013. Indoor air quality and prevalence of sick building syndrome among office workers in two different offices in Selangor. American Journal of Applied Sciences, 10(10):1140–1147.