IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Conference on Advances in Civil Engineering 2018 (CACE-2018)

Thakur College of Engineering and Technology, Thakur

Vol. 5, Special Issue 3, February 2018

Indoor Air Quality (IAQ) in Educational Canters and Office Buildings: A Review

Khalid Sayed[1], Bharat Shinde[2], Manasi Rane [3], Rohit Parkar[4], Milan Gada[5], Rupali Baranwal[6]

Assistant Professor, Dept. of Civil Engineering, Thakur College of Engineering and Technology, Mumbai, India[1]

Assistant Professor, Dept. of Civil Engineering, Thakur College of Engineering and Technology, Mumbai, India[2]

Dept. of Civil Engineering, Thakur College of Engineering and Technology, Mumbai, India[3]

Dept. of Civil Engineering, Thakur College of Engineering and Technology, Mumbai, India[4]

Dept. of Civil Engineering, Thakur College of Engineering and Technology, Mumbai, India[5]

Dept. of Civil Engineering, Thakur College of Engineering and Technology, Mumbai, India[6]

Abstract: Air standards have surpassed the prescribed limits around the world and violations are the worst in urban areas. Most of the people living and working in urban areas lives unhealthy glamorous life neglecting their health. Substantial population mainly in urban centres are affected by air pollution related diseases. Air comprises of oxygen, which is vital for survival of human beings. The oxygen less air circulating in poorly air conditioned buildings with indoor pollutants is causing serious health problems. The physical conditions are having effect on teaching and learning process in education centres. Similarly, the physical conditions are having effect on work rate of the workers in offices. In the recent decade various researchers all around the world have monitored the indoor pollutant levels and their effects on the inmates in educational centres and offices showing indoor pollutants as silent invisible killer. In education centres and offices, indoor air pollutants have crossed the prescribed limit due to use of new emerging materials in decorating the interiors of these campuses. The indoor air pollutants should be within prescribed limit being more susceptible to its pollution impacts on inmates. In this review study, impacts of various indoor pollutants on inmates of education centres and offices are distinguished, and inmates in these environments is concentrated on and expressed. The review paper suggests the urge of controlling the increasing indoor pollution in the education centres and offices for a healthy environment.

Keywords: Indoor Air Quality, Educational Centre, Office building, ASHRAE.

I. INTRODUCTION

In present decade, environmental awareness has made human beings aware of the various pollutions and their possible health effects. Air comprise of few gases. There are some fix percentages of gases present in the air. Anything in air other than the natural composition of air is a pollutant. Approximately 21% of oxygen gas is naturally present in the air. Oxygen is vital for respiration process and considered as life on earth. However, some air conditioned buildings are not equipped with mechanical ventilation systems, and thus natural ventilation and air infiltration are fresh air supplies. [1,2]. There is an increase in the ratio of buildings that do not confirm to the standards of relative humidity, room temperature and carbon dioxide (CO_2) concentration in the last decade.[14]. Oxygen less environment has an adverse effect on the health of human being. The health problems due to indoor air pollution and oxygen less environment are not known ordinarily to the exposed population and usually neglected as the effects on health are assumed to be not instantaneous in some cases.In recent time, there is more existence of volatile organic compounds (VOCs) all over in the environment. The development and urbanization all over the globe has caused building related symptoms (BRSs),called the sick building syndrome, has come up as an occupational and environmental health affair, since the early 1970s [13]. Since there are many sources (e.g., traffic and industrial ejections as outdoor sources, building and furnishing materials, arts and crafts materials, cleaning agents, and personal care commodities as indoor sources) [3,4]. High rate of VOC concentrations were measured more in indoor than outdoor.[12]. Other factors that control indoor air quality are: Schools generally have high students density, poor ventilation, lack of maintenance, and not good enough cleaning [5,6].

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
Conference on Advances in Civil Engineering 2018 (CACE-2018)
Thakur College of Engineering and Technology, Thakur
Vol. 5, Special Issue 3, February 2018

LITERATURE REVIEW

Temperature, humidity, air exchange rate, air movement, ventilation, particle pollutants, biological pollutants, and gaseous pollutants are the factors which largely affect indoor environment [19]. The causes responsible for health problems in educational centres and offices are oxygen less environment and indoor air pollutants. In recent years few studies were carried out across the world to monitor the current status of indoor pollutants in educational canters & offices.

Source	VOCs
Adhesives/sealants	Formaldehyde,butylether,vinyl cyclohexane,2-propenoicacid,propylene glycol
Carpet	4-Phenylcyclohexene,vinylacetate, styrene,dodecanol,acetaldehyde
Cleaningchemicals	Limonene,isopentane,isopropanol,butoxyethanol,1,4dichlorobenzene
Linoleum	Aceticacid,hexanal,hexanoicacid,pentanoicacid,decane
Millwork	formaldehyde,2-pentylfuran, benzaldehyde,hexanal,pentanal
Office furniture	formaldehyde,acetaldehyde, butylacetate,hexanal,cyclohexanone
Building occupants	Benzenefromtobaccosmoke(ETS)and attachedgarages,limonene(aterpene)and varioussiloxanecompounds(eg, decamethylcyclopen-tasiloxane)from personalcareproductsincluding antiperspirantsanddeodorants, tetrachloroethylenefromdry-cleaned clothing,andC12toC16alkanesfrom handandbodylotion,moisturizingsoaps, andcosmetics
Paints	Toluene,propyleneglycol,ethyleneglycol,butylpropionate,methylpropanol
Printers/copiers	Styrene,ethylbenzene,xylenes,benzene,2- ethyl-1-hexanol
Resilient/rubber flooring	Styrene,dodecane,benzothiazole,vinyl acetate,cyclohexane
Textiles	Formaldehyde,acrylonitrile,acetaldehyde, decane,tetradecane
Wallcovering	Naphthalene,methylpyrrolidinone, styrene,phenol,ethylhexanoicacid
Windowshades	Ethylhexanoicacid,decanol,dodecene, ethylhexanol,naphthalene

Table 1. Vocs and their sources [39]

A. Educational Centres

Location of the building and environmental quality, and various building-related factors, such as the condition, maintenance, and cleaning of the school are responsible for influencing Indoor Environmental Quality of school building [27]. The ASHRAE Standard 62-1999 (A SHRA E, 1999) suggests a minimum ventilation rate of 8 l/s-person (15cfm/person) for classrooms. Given usual occupant density of 33 per 90 m^2 (1000 ft^2) and a ceiling height of 3 m (10 ft), the current ASHRA E standard suggests an air exchange rate of about 3 air changes per hour (ACH) for a classroom. Indoor CO_2 concentrations more than 1000 ppm indicates the ventilation rates that are objectionable with respect to body odours. Concentrations of CO_2 below 1000 ppm do not forever guarantee that the ventilation rate is sufficient for removal of air pollutants from other indoor sources[40]. High concentrations of indoor gaseous pollutants as Volatile Organic Compounds (VOCs) and radon have been measured in classrooms across the world, these pollutants worsened the indoor air quality in schools.[45]. Because of the higher breathing rate comparative to the body size, and ongoing growth school children's are more susceptible to indoor air pollutants than adults [7], this exposes into higher health risk levels. Moreover, according to researchers, there are studies relating poor indoor environmental quality (IEQ) in schools to the performance of students [8], and poor ventilation to health symptoms [5]. IEQ is also affected by pollutants that are generated indoors.

B. Office Building

Health problems and non-specific symptom complaints apparently related to buildings or indoor air, sometimes referred to as "sick building syndrome" or "tight building syndrome," have been recognized for over 15 years[23]. Most people understand that good air conditioning is just the control of temperature or ventilation which gives up comfort but there are many other people in such environment who suffer for nose irritations, stuffed

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
Conference on Advances in Civil Engineering 2018 (CACE-2018)
Thakur College of Engineering and Technology, Thakur
Vol. 5, Special Issue 3, February 2018

nose, rainy nose, eye irritations, cough, tightness in the chest, fatigue, headache, rash and a lot more symptoms [32]. Indoor air quality (IAQ) may significantly affect human health and comfort because people spend around 90% of their time indoors in offices, shops, public premises and homes. In this circumstance, offices are of concern, as they represent the majority occupational environment in developed countries. IAQ has been identified as a major concern in terms of its potential impact on human health[15]. Office buildings have widely evolved to become controlled environments with refined ventilating and air- conditioning systems. However, little is known about IAQ in these premises. Office buildings have not been broadly studied compared to other indoor environments in terms of time spent by the inhabitants, such as schools and dwellings According to [World Health Organization [WHO], 2010], the indoor environmental quality in offices may affect cognitive performance and even subclinical disturbances may lead to losses in work productivity due to indoor air pollutants [25]. Symptom increases found to be associated with air- conditioned buildings may more appropriately be considered as associated with air-conditioned, sealed buildings. The prevalence of some work-related symptoms was strikingly high in several studies even in the least problematic office buildings [36]. The researchers reported that higher overall symptom prevalence was associated with air-conditioned buildings, independently of associations also found between symptom prevalence and various individual, psychological, occupational, and architectural factors [36,37].

II. HARMFUL EFFECTS OF INDOOR AIR POLLUTANTS

The quality of indoor air was recognized as amongst the most influencing concerns in context of health effect. In fact, people were normally exposed to high concentrations of pollutants indoors, which resulted in large dosage received with considerable health related effects [30].Scientific literature paid great attention on the micro environments where more pollutants were emitted typically located within offices (e.g. Printers, scanners and other workplace environments (e.g. industrial activity, schools. However, a crucial dose (and then a considerable health risk) can be also received during long exposures in non-occupational indoor microenvironments such as schools [31].

A. Educational Centers

A number of serious health effects [4,9] and symptoms such as asthma and allergic reactions are linked with some of the VOCs. It has been reported that there were 6.8 million children with asthma [10] in the US, which was the major cause of school absenteeism accounting for 20% of lost school days in elementary and high schools [11]. Building Related Symptoms are related with poor quality of indoor air and may have other causes, particularly psycho-social stress. They consist of general, mucosal, and skin infection that some individuals experience when spending time in certain buildings [13]. In class rooms with low ventilation there is a particular concern for potential increased risks of contracting certain communicable respiratory illness, such as influenza and common colds [41].The formaldehyde (HCHO), Total volatile organic compounds (TVOC), and biological contaminants were the majority pollutants commonly measured in schools. The SBS is suspected to be caused by VOCs. TVOC concentrations, which are above 1 – 2 mg/m^3, indicate that strong VOC sources and/or low ventilation are present [42]. The California Air Resources Board states that HCHO concentrations should be as low as possible as a caution for the possible cancer risk from repeated exposures [43]. A statistically significant partial correlation between symptoms of headaches, dizziness, heavy headed, tiredness, difficulties concentrating, unpleasant odor, and high CO_2 concentrations (1500 – 4000 ppm compared with concentrations below 1500 ppm) was found out by investigators [44]. Discussing about the classroom conditions, the factors causing daily nuisance in classrooms were noise and poor quality of indoor air [47].

B. Office Buildings

Office Buildings various symptoms and diseases have been increasingly attributed to non-industrial indoor environments during the past few decades. The term sick-building syndrome (SBS) means the non-specific complaints, including upper- respiratory irritation symptoms, rash, fatigue and headaches which are commonly related with a particular building by their secular pattern of occurrence and grouping among inhabitants or colleagues. It is reported that the frequency of SBS has increased since the 1970s, as older naturally ventilated buildings have been replaced by new energy- efficient buildings[22].A mong the various categories of compounds found in indoor environments, volatile organic compounds (VOCs) and aldehydes are found to repeatedly reach higher indoor concentrations as compared to the subsequent outdoor values. In this circumstance, probable health effects arising from indoor exposure to VOCs have been acknowledged recently [16]. Since, the environment inside the poorly air conditioned buildings becomes dry. The dry

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
Conference on Advances in Civil Engineering 2018 (CACE-2018)
Thakur College of Engineering and Technology, Thakur
Vol. 5, Special Issue 3, February 2018

eye-like symptoms is developed due to visually demanding tasks and relatively low humidity at workplaces [17, 18]. Case studies on epidemiology suggests that there is a direct effect of relative humidity on cell membrane which is in connection with respiration, contraction, nose tissue inflammations or influenza and fever [33]. The spreading rate of influenza virus increases considerably in environment where the relative humidity is less than 50% [34]. Researchers analyzed resent studies and found that there was an increase in the sick building syndrome (SBS) between 30% and 200% in the buildings with air-conditioning systems as compared to natural ventilation systems. A serious warning for indoor environment problems related to air conditioned systems is being given from the above events. It is not wrong to say that indoor environment problems still exist in today's mechanically conditioned buildings, even though present standards are met [20]. The combined effect of low ventilation rates and the presence of numerous synthetic chemicals results in elevated concentrations concentrations of indoor particle pollutants and volatile organic compounds (VOCs) (e.g. benzene, toluene, and formaldehyde). This is considered to be a major contributing factor to compound hypersensitiveness [21]. In urban areas with hot and humid climate the artificial air-conditioning is a issue of concern for respiratory symptoms. Researchers documented this study and evaluated the relationship of respiratory symptoms of full-time workers from buildings with air-conditioning without humidification systems in comparison with naturally ventilated buildings in a city with hot and humid climate [26].]. Sealed buildings with air- conditioning are related with a higher chances of work-related upper respiratory symptoms as compared to buildings with natural ventilation, irrespective of being a tropical country with high relative and absolute humidity rates all around the year [38].

III. STANDA RD LIMITS OF INDOOR AIRPOLLUTANTS

The design and installation of air conditioning system to control thermal environment to achieve human thermal comfort and health inside a buildings should comply with the ashra e standard which is the most appropriate [35].

Table2. ASHRAE Ventilation Standard, for Acceptable Indoor Air Quality

Contaminant	**Long Term**		**Short Term**	
	Level	**Time**	**Level**	**Time**
Carbon Monoxide			40mg/m^3	1hr
			10mg/m^3	8hr
Lead	1.5 µg/m^3	3 Months		
Nitrogen dioxide	100 µg/m^3	Yr		
Oxidants (Ozone)			235 µg/m^3	1hr
Particulates	75 µg/m^3	Yr	260 µg/m^3	24hr
Sulfur dioxide	80 µg/m^3	Yr	365 µg/m^3	24hr

Table3. ASHRAE, Additional Ambient Air Quality Guidelines

Contaminant	**Long Term**		**Short Term**	
	Level	**Time**	**Level**	**Time**
Acetone - O	7mg/m^3	24hrs	24 mg/m^3	30min
Acrolein – O			25 µg/m^3	C***
Ammonia – O	0.5 mg/m^3	Yr	7 mg/m^3	C
Beryllium	0.01µg/m^3	30 Day		
Cadmium	2.0 µg/m^3	24 Hrs		
Calcium Oxide (Lime)			20-30 µg/m^3	C
Carbon Disulfide- O	0.15 mg/m^3	24 hrs	0.45 mg/m^3	30min
Chlorine – O	0.1 mg/m^3	24 hrs	0.3 mg/m^3	30min
Chomium	1.5 µg/m^3	24 hrs		
Cresol-O	0.1 mg/m^3	24 hrs		
Dicholoroethane-O	2.0 mg/m^3	24 hrs	6.0 mg/m^3	30min
Ethyl acetate –O	14 mg/m^3	24 hrs	42 mg/m^3	30min

IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Conference on Advances in Civil Engineering 2018 (CACE-2018)

Thakur College of Engineering and Technology, Thakur

Vol. 5, Special Issue 3, February 2018

Formaldehyde-O			120 µg/m^3	C
Hydrochloric acid-O	0.4 mg/m^3	24 hrs	3 mg/m^3	30min
Hydrogen sulphide-O	40.50 µg/m^3	24 hrs	42 µg/m^3	1 hr
Mercaptans-O			20 µg/m^3	1hr
Mercury	2 µg/m^3	24 hrs		
Methyl alcohol-O	1.5 mg/m^3	24 hrs	4.5 mg/m^3	30min
Methylene	20 mg/m^3	Yr	150 mg/m^3	30min
Chloride-O	50 mg/m^3	24 hrs		
Nickel	2 µg/m^3	24 hrs		
Nitrogen monoxide	0.5 mg/m^3	24 hrs	1 mg/m^3	30min
Phenol-O	0.1 mg/m^3	24 hrs		
Sulfates	4 µg/m^3	Yr		
	12 µg/m^3	24 hrs		
Sulfuric acid-O	50 µg/m^3	Yr	200 µg/m^3	30min
	100 µg/m^3	24 hrs		
Trichloroethylene-O	2 mg/m^3	Yr	16 mg/m^3	30min
	5 mg/m^3	24 hrs		
Vanadium	2 µg/m^3	24 hrs		
Zinc	50 µg/m^3	Yr		
	100 µg/m^3	24 hrs		

Note :

* unless otherwise specified ,all air quality measurements should be corrected to standard conditions of 25^{O}C (77^{O}F) temperature and 760 mm. of mercury pressure.

** These materials marked “O” have odours at concentrations sometimes found in outdoor air. The tabulated concentration levels do not necessarily result in odourless condition.

*** Ceiling ,or maximum allowable concentrations

IV. CONCLUSION

The studies reflect that indoor air pollutants persist in the education centers and office buildings. The oxygen less environment and exposure to higher levels of indoor pollutants with certain exposure time can have serious health impacts on the inmates. Indoor Air Quality should be monitored frequently to check the pollutant levels and take necessary safety measures for a superior domain.

REFERENCES

[1] AASHRAE Handbook Fundamentals: Ventilation and Infiltration, American Society of Heating, Refrigerating and Air Conditioning Engineers, 2009.

[2]] Z. Peng, W. Deng, R. Tenorio, “Investigation of indoor air quality and the identification of influential factors at primary schools in the north of China”, Sustainability 9 (7) , pp 1180,2017.

[3] Sexton, K., Mongin, S.J., Adgate, J.L., Pratt, G.C., Ramachandran, G., Stock, T.H., Morandi, M.T., “Estimating volatile organic compound concentrations in selected microenvironments using time-activity and personal exposure data”, J. Toxicol. Environ. Health A 70, pp 465 – 476,2007.

[4] Shendell, D.G., Winer, A.M., Stock, T.H., Zhang, L., Zhang, J., Maberti, S., Colome, S.D.,” Air concentrations of VOCs in portable and traditional classrooms: results of a pilot study in Los Angeles County”, J. Expo. Anal. Environ. Epidemiol, 14, pp 44 – 59,2004.

[5] Daisey, J.M., Angell, W.J., Apte, M.G.,” Indoor air quality,ventilation and health symptoms in schools: an analysis of existing information”, Indoor Air 13, pp 53 – 64,2003.

[6] Smedje, G., Norback, D., Edling, C.,” Subjective indoor air quality in schools in relation to exposure”, Indoor Air 7, pp 143 – 150, 1997.

[7] Faustman, E.M., Silbernagel, S.M., Fenske, R.A., Burbacher,T.M., Ponce, R.A.,” Mechanisms underlying childrens susceptibility to environmental toxicants”, Environ. Health Perspect. 108 (S1),pp 13 – 21,2000.

[8] Mendell, M.J., Heath, G.A.,” Do indoor pollutants and thermal conditions in schools influence student performance? A critical review of the literature”, Indoor Air 15,pp 27 – 52,2005.

[9] Sax, S.N., Bennett, D.H., Chillrud, S.N., Ross, J., Kinney, P.L., Spengler, J.D.,” A cancer risk assessment of inner- city teenagers living in New York City and Los Angeles”, Environ. Health Perspect, 114,pp 1558 – 1566,2006.

[10] ALA (American Lung Association), Diseases – Asthma & Children Fact ,2007. Sheet.,http://www.lungusa.com.

[11] Bayer, C.W., Crow, S.A., Fischer, J.,” Causes of Indoor Air Quality Problems in Schools: Summary of Scientific Research, A Report to Department of Energy”, Energy Division, Oak Ridge National Laboratory, Oak Ridge, TN,2000. [12] Sait C.

[12] Sofuoglu, Guler Aslan, Fikret Inal , Aysun Sofuoglu, “An assessment of indoor air concentrations and health risks of volatile organic compounds in three primary schools”, International Journal of Hygiene and Environmental Health 214,pp 36 – 46,2011.

[13] Redlich, C.A., Sparer, J., Cullen, M.R.," Sick-building syndrome", Lancet 349,pp 1013 – 1016,1997. Azuma, K., Ikeda, K., Osawa, H., Kagi, N., Yanagi, U., Saito, H., Kamakura, R.," Actual status of environmental sanitation and building maintenance in Japan", Trans. Soc. Heat. Air Cond. San. Eng. Jpn. 179, pp 19 – 26,2012.

[14] World Health Organization, Selected pollutants, WHO Indoor Air Quality Guidelines; WHO Regional Office for Europe: Copenhagen, 2010.

[15] Wolkoff, P.," Indoor air pollutants in office environments: assessment of comfort, health, and performance", Int. J. Hyg. Envir. Heal. 216(4): pp 371-394,2013.

[16] Wolkoff, ., Hhyeyin - like environments. Environ, Int. 34,pp 1204 – 1214.

[17] Wolkoff, P.," External eye symptoms in indoor environments", Indoor Air 27, pp 246 – 260, 2017.

[18] Graudenz, G.S., Oliveira, C.H., Tribess, A., Mendes, C., Latorre, M. R.D.O., Kalil, J.," Association of air- conditioning with respiratory symptoms in office workers in tropical climate", Indoor Air 15, pp 62 – 66,2005.

[19] Seppanen, O., Fisk, W.J.," Association of ventilation system type with SBS symptoms in office workers", Ind or Air12,pp 98 – 112,2002.

[20] Wang, Z., Bai, Z., Yu, H., Zhang, J., Zhu, T.," Regulatory standards related to building energy conservation and indoor- air-quality during rapid urbanization in China", Energy Build.36, pp 1299 – 1308,2004.

[21] Carrie A Redlich, Judy Sparer, Mark R Cullen," Sick-building syndrome", Lancet , 349:pp 1013 – 16,1997.

[22] Mark J. Mendell, MPH, Allan H. Smith," Consistent Pattern of Elevated Symptoms in Air-conditioned Office Buildings: A Reanalysis of Epidemiologic Studies", AJPH , Vol. 80, No. 10, October 1990.

[23] Kwok Wai Tham," Indoor air quality and its effects on humans — A review of challenges and developments in the last 30 years", Energy and Buildings 130,pp 637-650, 2016.

[24] Corinne Mandin, Marilena Trantallidi, Andrea Cattaneo, Nuno Canha, Victor G. Mihucz, Tamás Szigeti, Rosanna Mabilia, Erica Perreca, Andrea Spinazzè, Serena Fossati, Yvonne De Kluizenaar, Eric Cornelissen, Ioannis Sakellaris, Dikaia Saraga, Otto Hänninen, Eduardo De Oliveira Fernandes, Gabriela Ventura, Peder Wolkoff, Paolo Carrer, John Bartzis," Assessment of indoor air quality in office buildings across Europe – The OFFICAIR study", Science of the Total Environment xxx (2016) xxx – xxx. ht tp ://dx.doi.or g/10.1016 /j.scit ot env.2016.10.238.

[25] G. S. Graudenz, C. H. Oliveira, A. Tribess, C. Mendes, Jr, M. R. D. O. Latorre, J. Kalil," Association of air-conditioning with respiratory symptoms in office workers in tropical climate", Indoor Air ; 15, pp 62 – 66,2005.

[26] Luca abile,MDola, ldo sAgearia Massimo, Giorgio Buonanno," The effect of natural ventilation strategy on indoor air quality in schools", Science of Total Environment 595, 894-902, 2017.

[27] Buonanno, G., Giovinco, G.,Morawska, L., Stabile, L., "Tracheobronchial and alveolar dose of submicrometer particles for different population age groups in Italy", Atmos.Environ. 45, pp 6216 – 6224,2011.

[28] Stabile, L., Dell'Isola, M., Frattolillo, A., Massimo, A., Russi, A.," Effect of natural ventilation and manual airing on indoor air quality in naturally ventilated Italian classrooms", Build. Environ. 98, pp 180 – 189, 2016.

[29] A.V. Arundel, E.M. Sterling, J.H. Biggin, T.D. Sterling, "Indirect health effects of relative humidity indoor environments",Environmental Health Perspectives 65, pp 351 – 361,1986.

[30] A.V. Baughman, E.A. Arens, "Indoor humidity and human health — part I: literature review of health effects of humidity-influenced indoor pollutants",ASHRAE Transactions 102,pp 193 – 211,1996. J.H. Hemmers, K.C. Winkler, S.M. Kool, "Virus survival as a seasonal factor in influenza and poliomyelitis", Nature 188 (4748) ,pp 430 – 431,1960.

[31] ANSI/ASHRAE 55-2004, Thermal environmental conditions for human occupancy, American Society of Heating Refrigerating and Air-conditioning Engineers Inc., Atlanta, USA, 2004.

[32] Mark J. Mendell, MPH, And Allan H. Smith," Consistent Pattern of Elevated Symptoms in Air-conditioned Office Buildings: A Reanalysis of Epidemiologic Studies", AJPH, Vol. 80, No.10, October 1990.

[33] Hedge A, Burge PS, Robertson AS, Wilson S, Harris-Bass J," Work-related illness in offices: a proposed model of the "sick building syndrome", Environ Intl, 15, pp 143-158,1989. G. S. Graudenz, C. H. Oliveira, A. Tribess, C.Mendes, Jr, M. R. D. O. Latorre, J. Kalil," Association of air-conditioning with respiratory symptoms in office workers intropical climate", Indoor Air, 15,pp 62 – 66,2005.

[34] Jonathan A. Bernstein, Neil Alexis, Hyacinth Bacchus, I.Leonard Bernstein, Pat Fritz, BS,Elliot Horner, Ning ,Stephany Mason, Andre Nel, John Oullette, Kari Reijula, Tina Reponen, James Seltzer, Alisa Smith, and Susan M. Tarlo, "The health effects of nonindustrial indoor air pollution", J ALLERGY CLIN IMMUNOL, VOLUME 121, NUMBER 3, MARCH 2008.

[35]Apte, M.G., Fisk, W.J. and Daisey, J.M.," Associations between indoor (CO2) concentrations and sickbuilding syndrome symptoms in US Office Buildings: an analysis of the 1994 – 1996 BASE Study Data (LBNL 44385)", Indoor Air, 10, pp 246 – 257,2000.

[36] Fisk, W.J., "Estimates of potential nationwide productivity and health benefits from better indoor environments: an update",In: Spengler, J., Samet, J.M. and McCarthy, J.F. (eds) Indoor Air Quality Handbook, New York, McGraw Hill, pp 1 – 36,2001