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RESEARCH ARTICLE

INDOOR AIR VENTILATION IN PRIMARY SCHOOLS IN EASTERN PROVINCE, SAUDI ARABIA

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ABSTRACT

The provision of good indoor air quality (IAQ) in schools is essential for students' health as well as for their academic achievement. The purpose of the present study was to assess the ventilation rates in a representative sample of (N= 36) primary schools in Eastern Province by using CO_2 as an indicator of ventilation. The results revealed that only four schools (10%) of the total primary schools selected in this study have adequate ventilation. The average mean CO_2 rates were 1333.9± 475.4 ppm and 1198.5± 303.6 ppm at 9:00 AM in rented and governmental schools building, respectively. On the other hand, at 12:00 PM the mean CO_2 rates were 1780.4± 636.5 ppm and 1563.3± 595.7 ppm in rented and governmental schools buildings, respectively. Interestingly, the average mean of CO_2 rates in rented schools were significantly higher at 9:00 AM and 12:00 PM (p= 0.020) and (p= 0.028), respectively. In conclusion, the ventilation rate is relatively poor since mean CO_2 rates in schools exceeded the recommended guideline (1000 ppm) in the majority of schools. Raising awareness of schools and communities regarding the importance of ensuring good ventilation in classroom is highly required. Policy makers should work hard in parallel with community to ensure better healthy and safe schools environment. Emphasis should be given to the research conducted in different schools regarding broader aspects of school environment and their potential hazards.

INTRODUCTION

Air in the atmosphere is considered to be one of the essential elements required for existence of the human being on earth. The adverse effect of poor indoor air quality (IAQ) on building occupants is well known. The establishment of good IAQ is important for both health and productivity of schools occupants. Furthermore, poor IAQ can be particularly detrimental to children in schools who spend approximately 30% of their time inside school buildings, which is more than in any other building type other than their homes (Bakó-Biró *et al.*, 2011).

The Ottawa Charter for Health Promotion stated that "health is created and lived by people within the settings of their everyday life; where they learn, work, play and live" (WHO, 1987). Indeed, proper schools provide a social and physical environment that facilitates learning and fosters appropriate behavior. So, in line with that, the American Academy of Pediatrics defines a "healthful school environment" as "one that protects students and staff against immediate injury or disease and promotes prevention activities and attitudes against known risk factors that might lead to future disease or disability" (American Academy of Pediatrics, 1993).

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Furthermore, WHO defines a health-promoting school as "one that constantly strengthens its capacity as a healthy setting for living, learning and working" (WHO, 2014). Therefore, the school environment encompasses the social, physical and biological factors. However, students' perception of the school environment, either indoors or outdoors, is directly related to their satisfaction with those environments, and student satisfaction promotes more active behavior (Fjortoft and Sageie, 2000; Herrington and Studtmann, 1998). Mendell and Heath (2005) noted that there is potential for children to sustain long lasting damage because their tissue and organs are still growing (Mendell and Heath, 2005). Poor ventilation rates can lead to high CO_2 levels, which have been shown to have an effect on the health and performance of occupants (Coley *et al.*, 2007, Bakó-Biró *et al.*, 2011). Previous meta-analysis studies have reported that low ventilation rates are common in schools and are linked to adverse health effects in children and adults (Wargocki *et al.*, 2002; Mendell and Heath, 2005; Daisey *et al.*, 2003). It is likely that poor ventilation can contribute to absenteeism and poor student performance. Studies have found that an increase in CO_2 concentrations by 1000 ppm is associated with an increase by 10-20% of absenteeism (Shendell *et al.*, 2004). Moreover, reduced ventilation rates might be linked to reduced academic performance in a school (Wargocki *et al.*, 2002, Seppanen, 2006). A recent study in a controlled environment on healthy adults indicated that CO_2 concentrations commonly encountered in school classrooms directly impaired decision making (Satish *et al.*, 2012).

Low ventilation rates were associated with inflammatory biomarker response of the nasal mucosa (Walinder *et al*., 1998) and asthmatic symptoms in children (Mi, 2006; Smedje and Norbäck, 2000). Moreover, poor indoor air quality may increase rates of asthma, allergies, and infectious and respiratory diseases, and affect student performance of mental tasks involving concentration, calculations, and memory (EPA, 2000).Ventilation is usually achieved through 'natural' ventilation (the opening of windows and doors) or 'mechanical' ventilation (using various forms of air conditioning), or of course by combination of both. CO_2 is about the only parameter that can actually measure the amount of fresh air that is being delivered to a space based on its occupancy. Smedje and Norback (2000) recorded that Swedish standards require an internal CO_2 concentration below 1000 ppm. Regarding CO_2 concentrations, the recommended ventilation performance standard can be summarized as follows (ASHRE):

- The average concentration of CO_2 should not exceed 1500 ppm during occupied hours.
- The maximum concentration of CO_2 should not exceed 5000 ppm during the teaching day.
- At any occupied time the occupants should be able to reduce the concentration of CO_2 to 1000 ppm.

However, the official spokesman of the Ministry of Education recorded the number of students for the year 2012-2013 at 2,513,815 children in primarily schools, 1,198,414 students in intermediate schools and 1,125,602 students in the secondary level. (ARAB NEWS, 2012). Surprisingly, given the magnitude of the school population, information on indoor air quality in schools in Saudi Arabia is very limited. This study is considered one of first to highlight the IAQ among representative samples in Eastern Provence in Saudi Arabia. Therefore, the purpose of this study was to fill the gap and to assess the ventilation rates in primary schools and to establish the baseline for future research and action. Special emphasis was given to compare indoor ventilation in rented and governmental schools at different time intervals (at 9:00 AM and 12:00 PM).

MATERIALS AND METHOS

In this study, assessment of ventilation levels in representative sample of primary schools in Eastern Province, Saudi Arabia, was carried out. Large schools numbers were chosen for this investigation. Stratified sampling technique was used classifying schools into two main categories namely; governmental building (built by government to be schools) and rental buildings (Buildings –usually houses- rented by government to be schools). A proportionate samples method was used selecting 26 governmental schools and 10 rented schools, allowing for 36 primary schools out of the total of 70 primary schools in Eastern province (Dammam and Khobar cities), which were randomly selected. Data were collected during normal teaching day activities in the selected classrooms in primary schools. Four classes in each school were randomly selected for the measurements of CO_2 rates (n= 144 classrooms). Sampling of CO_2 rate was conducted at two time intervals (9:00 AM and 12:00 PM); in each classroom CO_2 rate was measured five times in five different points, then the mean of CO_2 rates was calculated.

Because of the usual atmosphere (e.g. humidity and heat) all of the classrooms visited contain supplementary mechanical supply and all the buildings of the visited schools were built before 2008 and are located in urban areas in the eastern province of Saudi Arabia. Interestingly, all classrooms examined here have a single wall and more than one window and all windows can be opened manually. Allmeasurements were undertaken in occupied classrooms during normal occupied hours and throughout summer. However, the CO_2 measurements must be undertaken during normal occupied hours and, so, it cannot say if the windows were open or shut during each monitored period. The collected data were subjected to statistical analysis and presented graphically using SPSS. Descriptive statistics and student t- test analysis were performed comparing the mean level of CO_2 rate between the different types of schools (Rented building Schools vs. Governmental Building Schools). The differences were considered significant at $p < 0.05$.

RESULTS

Table (1) shows the distribution pattern of mean CO_2 rates at 9:00 AM and 12:00 PM at selected schools in both of governmental and rented schools. Only four schools (S9, S10, S15 and S32) have average CO_2 rate at acceptable limit of 1000 ppm by ASHRE, however, the rest of schools shows high levels of average mean of CO_2 and exceeding the standard. Figure 1, represents variation levels of CO_2 in governmental primary schools. Where, the total studied governmental schools varied in the levels of CO_2 measured in 9:00 AM and 12:00 PM respectively. Mean CO_2 rate at 12:00 PM always higher than the mean CO_2 rate at 9:00 AM almost in all schools except slightly lower CO_2 rates at 12:00 PM in three schools (S8, S10, S18).

Also, Figure 2 shows that in the rented schools the rate of CO_2 measured at 12:00 PM always higher than mean CO_2 rate at 9:00 PM almost in all schools more than the limits except (S6 and S9). In rented schools, the highest level of CO_2 rate was reported in S10 at 9:00 AM (mean CO_2 = 2950 ppm) and 12:00 PM (mean CO_2= 3020 ppm). Figure (3) represents the average mean levels of CO_2 rates in all selected governmental and rented primary schools. The average mean CO_2 rates exceeded the ASHRE recommended rate in both type of schools and through the figure the average mean CO_2rates in rented schools was higher than in the governmental schools. Table (2) represents the difference in the mean levels of CO_2at different periods of time in the selected primary schools. In the governmental schools, there was no significant difference (p=0.204), between the average mean CO_2rate measured at 9:00 AM and 12:00 PM (1198.5± 303.6 ppm) and (1333.9± 475.4 ppm) respectively. Similarly, in rented schools the average mean CO_2 rate measured at different periods was not significantly different (p=0.440). Table 3, shows the comparison of schools type with regard to their average mean CO_2 rate at the same period. It indicates that there is a significant difference in the average mean CO_2 rate at 9:00 AM between governmental and rented schools. On the other hand, the average mean CO_2 rate in rented schools was significantly higher than the average mean CO_2 rate in governmental schools (p=0.020), at 9:00 AM. Also, at 12:00 PM the average mean CO_2 rate was found to be significantly higher in rented schools (p=0.028) with compare to governmental schools.

Table 1. Distribution of mean CO_2 rates at 9:00 AM and12:00 PM in governmental and rented schools

Type of Schools	Mean CO_2 Rate at 9:00 AM	Mean CO_2 Rate at 12:00 PM	Average Mean CO_2 Rates
Governmental Schools			
S1	1164	1306	1235
S2	1131	1442	1286.5
S3	1260	1361	1310.5
S4	800	1230	1015
S5	1000	1113	1056.5
S6	1019	1020	1019.5
S7	1120	1131	1125.5
S8	1501	1140	1320.5
S9	900	1030	965
S10	1001	950	975.5
S11	1010	1120	1065
S12	1343	1515	1429
S13	1240	1415	1327.5
S14	1050	1200	1125
S15	960	980	970
S16	1180	1200	1190
S17	1250	1340	1295
S18	1220	1201	1210.5
S19	1120	1300	1210
S20	1150	1250	1200
S21	1020	1100	1060
S22	1110	1250	1180
S23	2010	2200	2105
S24	1020	1115	1067.5
S25	2150	3339	2744.5
S26	1434	1434	1434
Rented Schools			
S27	1720	1815	1767.5
S28	1343	1434	1388.5
S29	1715	1720	1717.5
S30	1750	2212	1981
S31	1906	2200	2053
S32	995	1010	1002
S33	1110	1248	1179
S34	1119	2150	1634.5
S35	1020	1000	1010
S36	2950	3020	2985

Table 2. Comparison of average mean CO_2 rates at different 9:00 AM and 12:00 PM among the same type of schools

Type of Schools	(CO_2 level ppm) 9:00 AM Mean ± SD	(CO_2 level ppm) 12:00 AM Mean ± SD	P-Value
Governmental Schools	1198.5± 303.6	1333.9± 475.4	*0.204*
Rented Schools	1563.3± 595.7	1780.4± 636.5	*0.440*

Table 3. Comparison of mean CO_2 rates between the different types of primary schools at the same period

Average CO_2 rates	Governmental Mean ± SD	Rental Mean ± SD	P-Value
At 9:00 AM	1198.5± 303.6	1563.3± 595.7	*0.020*
At 12:00 AM	1333.9± 475.4	1780.4± 636.5	*0.028*

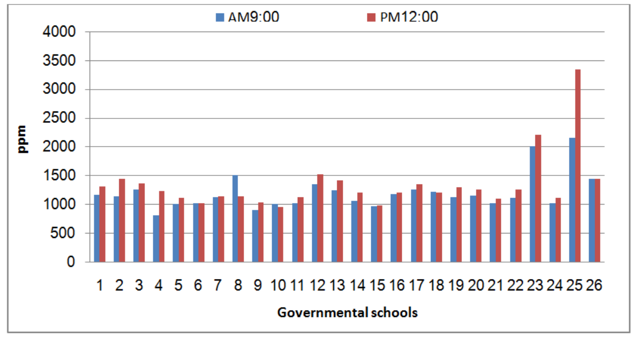

Figure 1. Mean indoor CO_2rates at 9:00 AM and 12:00 PM in governmental schools

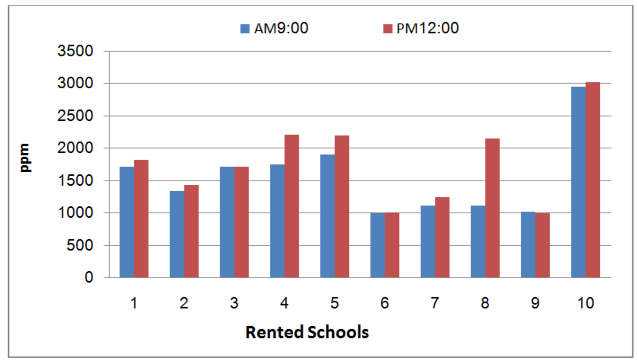

Figure 2. Mean indoor CO_2rates at 9:00 AM and 12:00 PM in rented schools

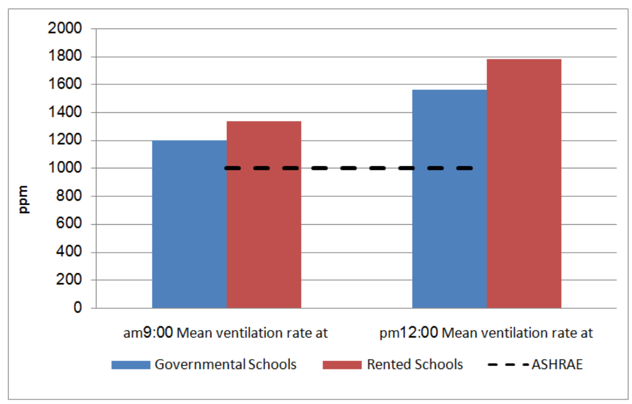

Figure 3. Total mean CO_2rates in the rented and governmental primary school buildings at 9:00 AM and 12:00 PM

DISCUSSION

Carbon dioxide (CO_2) levels are used as an indicator of adequate ventilation in a room. In the majority of the international standards, CO_2 is used as a key indicator of ventilation performance. As presented in (Table 1), the data shows that the mean indoor CO_2 rates exceeded the 1000ppm the recommended guideline by ASHRE, in the majority of governmental and rented school buildings. Only four schools (10%) (S9, S10, S15 and S32) have CO_2 levels at adequate limit of 1000 ppm by ASHRE (Table 1). Concentrations of CO_2 below 1000 ppm do not always guarantee that the ventilation rate is adequate for removal of air pollutants from other indoor sources (Seppänen *et al*., 1999; Apte *et al*., 2000). However, it has been found that inadequate ventilation in classrooms; increase the risk for asthma and other health-related symptoms among school children (Daisey *et al*., 2003, Mendell and Heath 2005). High levels of CO_2 have been shown to cause a negative influence on students learning ability. Interestingly, Coley and Greeves (2004) in their research investigated the effect of low ventilation rates on the cognitive function of a primary school class. Children spend much of their time in schools; it is the indoor environment where they spend most of their time besides in their home. It is therefore important that schools have a good indoor air quality (IAQ). Classroom ventilation was already acknowledged as an important factor of indoor air quality. The recent review of Sundell *et al*. (2011) looked into the available literature until 2005 and discussed five articles that have studied the school environment. They concluded from the reviewed studies that low ventilation rates are associated with increased absenteeism and more respiratory symptoms in school children (Sundell *et al*., 2011).

In general, the data from this study indicates that mean CO_2 rates increased at 12:00 PM with compare to CO_2 at 9:00 AM in both governmental and rented schools (Figure 1, Figure 2). Generally, however, rented schools buildings showed high average mean CO_2 rate (Figure 3). However, it has been found that increased levels of CO_2 led to a decrement in 'Power of Attention' of approximately 5% (Coley and Greeves, 2004). Moreover, study by Wargocki and Wyon demonstrated that air quality and temperatures in classrooms are important factors in the learning process and improving them should be given as much priority as improving (Wargocki and Wyon, 2006). More recently, Bako-Biro *et al*. concluded in their experimental study that elevated level of indoor air pollutants including CO_2 due to inadequate ventilation encountered in classrooms can affect learning performance (Bako-Biro *et al*., 2012). The increasing and decreasing of CO_2 concentration is dependent on multiple factors such the climate temperature and its humidity and what is the surrounding area and the type of building and the end what is the case of the conditioned air inside the building. Faulty heating, ventilation, and air conditioning systems can exacerbate air quality problems. In this presented study, the level of CO_2 exceeds the standard value of 1000 ppm in governmental schools and rental school which represent the classrooms with highest CO_2 rates of the difference between governmental and rented school as 258.67 ppm, 388.58 ppm at 9:00 AM and 12:00 PM, respectively. Consequently, in rental schools pupils might exposed to high level of levels of CO_2 with bad ventilation which in turn can affect the learning performance. In contrast to rented schools, governmental schools are bigger and may have better ventilation because the classrooms have more than one large window. Study investigating noise levels at primary schools in Eastern Province, Saudi Arabia was performed and published (Alsubaie, 2014).

Alsubaie study revealed that indoor noise levels in primary schools in Eastern Province were found to be significantly pollutant since it exceeded the WHO guideline (35 dB). In line with that, a recent study conducted by El-Sharkawy and Alsubaie in high education institute complex in the Eastern Province in Saudi Arabia revealed that both levels of environmental indoor and outdoor noise pollution were significantly higher than the guideline values (El-Sharkawy and Alsubaie, 2014). These environmental air quality parameters require more concern and effective environmental control strategies in education settings. The Ottawa Charter for Health Promotion stated that "health is created and lived by people within the settings of their everyday life; where they learn, work, play and live" (WHO, 1987). Indeed, suitable schools provide a social and physical environment that fosters appropriate behavior and facilitate learning. The American Academy of Pediatrics defines a "healthful school environment" as "one that protects students and staff against immediate injury or disease and promotes prevention activities and attitudes against known risk factors that might lead to future disease or disability" (American Academy of Pediatrics, 1993). WHO defines a health-promoting school as "one that constantly strengthens its capacity as a healthy setting for living, learning and working" (WHO, 2014). Therefore, the school environment encompasses the social, physical and biological factors. Moreover, students' perception of the school environment, either indoors or outdoors, is directly related to their satisfaction with those environments, and student satisfaction promotes more active behavior (Fjortoft and Sageie, 2000; Herrington and Studtmann, 1998).

Considering the average values of CO_2rates in the classrooms, only few schools show adequate ventilation in average. The majority of classrooms were shown to have low ventilation to satisfy the occupants and exceeding the recommended standard. There should be more practical guidance regarding provision of fresh air ventilation for schools. At least one classroom should have a CO_2 sensor for continuous monitoring and recording (Griffiths and Eftekhari, 2008). Also, this study revealed that the mean CO_2 rates were higher at rented schools with compare to governmental schools (Figure 3, Table 2). That might be explained by the small size of classes of rented schools, the quality and type of ventilation system, as well as the number of students in classes. However, schools in Saudi Arabia seem to face a lot of challenge, and schools buildings are on the top. Moreover, rented schools lack major safety measures and important elements needed for a good education. Education Minister has reaffirmed his ministry's determination to cut down the number of rented school buildings. "We have already brought down the number of rented buildings from 41 to 22 percent," he said (ARAB NEWS, 2012). Moreover, unfortunately, In Saudi Arabia school health is not a central part of the fundamental mission of schools nor has it been well integrated or organized into the broader national strategy.

Conclusion

The present study provides strong evidence that the ventilation rates in primary schools are inadequate in both type of schools buildings. In conclusion, although more studies are needed to determine the extent of IAQ problems in schools, evidence shows that ventilation rates in rented schools buildings is lower than governmental schools buildings and both not meeting the recommended standard. Therefore, schools should be designed, built, and maintained in ways to minimize and control sources of pollution, provide adequate exhaust and outdoor air ventilation by natural and mechanical means, maintain proper temperature and humidity conditions, and be responsive to students and staff with particular sensitivities such as allergies or asthma (EPA, 2003). Ministry of Education and policy makers in Saudi Arabia should be informed regarding the IAQ in schools and the potential hazards and effect that students and staff in schools may get. On the other hand, both the school and the community can benefit from working together to create a safe physical environment at schools. For example, school can use the services of a local company to improve its ventilation system. Also, school can help to educate parents about potential environmental health threats in the home. Furthermore, more research studies are needed investigating IAQ in female schools where they are presumed to be relatively in poorer condition and left behind because of cultural issues and less attention they receive in usual. This study provides a scientific sound basis for setting standards and programs for healthier ventilation in classrooms and schools for students and staff. It is clear that monitoring programs should be put in place to ensure that all schools provide necessary ventilation for children students in Saudi Arabia. It is hoped that this study can open the floor for more extensive research regarding schools environmental health in future. Quantifying air pollution parameters can be an important guide to educationists, health professionals, and community, as well as for policy makers (Alsubaie, 2014).

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REFERENCES

Alsubaie, A.S.R., 2014. Indoor Noise Pollution in Elementary Schools of Eastern Province, Saudi Arabia. *Journal of Research in Environmental Science and Toxicology* 3(1):25-29.

American Academy of Pediatrics., 1993. Committee on School Health, School Health Policy and Practice, Fifth Edition.

Apte, M.G., Fisk, W.J., Daisey, J.M., 2000. Associations Between Indoor CO2 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.

ARAB NEWS, Published -Friday 31 August 2012. Available at: http://www.arabnews.com/rented-school-buildings-reduced-41-22 (Accessed on 16 January 2014).

ASHRAE 62.07., 2010.Ventilation for acceptable indoor air quality. ASHRAE Standard 62-2010. American Society for Heating, Refrigerating and Air Conditioning Engineers. Atlanta, GA.

ASHRAE., 1999.Ventilation for Acceptable Indoor Air Quality. Standard 62-1999. American Society for Heating, Refrigerating and Air Conditioning Engineers. Atlanta, GA.

Available at: http://www.who.int/ceh/publications/cehphysical/en/ (Accessed on 15 January 2014].

Bakó-Birób, Z., Clements-Croomea, D.J., Kochhara, N., Awbia, H.B., Williams, M.J., 2012. Ventilation rates in schools and pupils' performance. Building and Environment 48, 215–223

Coley, D.A. Greeves R., 2004.The effect of low ventilation rates on the cognitive function of a primary school class, Report R102.for DfES, Exeter University,

Daisey, J.M., Angell, W. J., Apte, M.G., 2003. Indoor air quality, ventilation and health symptoms: An analysis of existing information. Indoor Air 13, 53-64.

DfES., 2006. Building bulletin 101 - ventilation of school buildings.

ElSharkawy, M., Alsubaie, A.S.R., 2014. Study of Environmental Noise Pollution in the University of Dammam. Saudi Journal of Medicine and Medical Scinces. (Accepted May, 2014).

Fjörtoft, I., Sageie, J., 2000. The natural environment as a playground for children: Landscape description and analyses of a natural landscape. Landscape and Urban Planning 48, 83–97.

Griffiths, M., Eftekhari, M., 2008.Control of CO_2 in a naturally ventilated classroom. Energy and Buildings 40, 556–560.

Herrington, S., Studtmann, K., 1998. Landscape interventions. New directions for the design of children's outdoor play environments. Landscape and Urban Planning 42, 191-205.

Many of the references need to be adjusted by adding Space between the Years of publication and the Title of Paper.

Mendell, M.J., Eliseeva, E.A., Davies, M.M., Spears, M., Lobscheid, A., Fisk, W.J., Apte, M.G., 2013. Association of classroom ventilation with reduced illness absence. A prospective study in California elementary schools. *Indoor Air* 23, 515-528.

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

Myhrvold, A.N., Olsen, E., Lauridsen. O., 1996.Indoor environments in schools—pupils health and performance in regard to CO_2 concentrations. Proceedings of the 7th International Conference on IAQ and Climate—Indoor Air 4, 369–374.

Satish,U., Mendell, M.J., Shekhar, K., Hotchi, T., Sullivan, D., Streufert, S., Fisk, W.J., 2012. Is CO_2 an Indoor Pollutant? Direct Effects of Low-to-Moderate CO_2 Concentrations on Human Decision-Making Performance. Environmental Health Perspectives. Availabla at: http://ehp.niehs.nih.gov/wp-content/uploads/2012/09/ehp. 1104789.pdf (Accessed 15 January 2014])

Seppanen, O., Fisk, W.J., Lei, Q.H., 2006. Ventilation and performance in office work, Indoor Air 16, 28-36.

Shendell, D.G., Prill, R., Fisk, W.J., Apte, M.G., Blake, D., Faulkner, D., 2004. Associations between classroom CO_2 concentrations and student attendance in Washington and Idaho. Indoor Air 14, 333-341.

Simons, E., Hwang, S., Fitzgerald, EF., Kielb, C., Lin S 2010. The impact of school building conditions on student absenteeism in upstate New York. *Am J Public Health* 100, 1679-1686.

Smedje, G., Norbäck D., 2000.New ventilation systems at select schools in Sweden.Effects on asthma and exposure. *Archives of Environmental Health* 55, 8-25.

Smedje,G., Norback, D., Edlin,.C., 1996.Mental performance by secondary school pupils in relation to the quality of indoor air. Proceedings of the 7th International Conference on IAQ and Climate—Indoor Air 413–419.

Sundell, J., Levin, H., Nazaroff, W.W., Cain, WS., Fisk WJ., Grimsrud, DT., Gyntelberg F., Li Y, Persily AK, Pickering AC, Samet JM., Spengler JD., Taylor ST, Weschler CJ., 2011Ventilation rates and health: multidisciplinary review of the scientific literature. *Indoor Air* 21, 191-204.

Walinder, R., Norbäck, D., Wieslander, G., Smedje, G., Erwall, C., Venge, P., 1998. Nasal patency and biomarkers in nasal lavage: The significance of air exchange rate and type of ventilation in schools. *International Archives of Occupational and Environmental Health* 71, 479-486.

Wargocki, J., Sundell, W., Bischof, G., Brundrett, P.O., Fanger, F., Gyntelberg, S.O., Hanssen, P., Harrison, A., Pickering, O., Seppanen, P., Wouters, P., 2002. Ventilation and health in non-industrial indoor environments: report from a European Multidisciplinary Scientific Consensus Meeting (EUROVEN), Indoor Air, 12, 113-128.

Wargocki, J., Wyon, D., 2006. Research report on effects of HVAC on student performance.American Society of Heating P., Refrigerating and Air-Conditioning Engineers (ASHRAE) Journal 48.

WHO., 2004. Information Series in School Health: The Physical School Environment - An Essential Component of a Health-Promoting School. *World Health Organisation*.

WHO., 2014. School and Youth Health, What is a health promoting school?. Available at: http://www.who.int/school_youth_health/gshi/hps/en/(Accessed on 8 January 2014).

WHO.,1987. The Ottawa Charter for health promotion. Health Promotion International. Available at: http://www.who.int/healthpromotion/conferences/previous/ottawa/en/ (Accessed on 15 January 2014).

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