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Study the indoor air quality level inside governmental elementary schools of Dammam City in Saudi Arabia

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ABSTRACT

Aims: The aim was to study the indoor air quality (IAQ) levels inside the governmental elementary schools of Dammam City in Kingdom of Saudi Arabia (KSA) and study factors affecting these levels.
Materials and Methods: Sixteen schools were selected for this study; 12 of them were representing governmental constructed buildings, while the other 4 schools were representing rental buildings. Levels of dust or total suspended particulates (TSP), carbon monoxide (CO), carbon dioxide (CO_2), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and benzene; in addition to temperature degree and relative humidity percent were measured during this study at four selected locations inside each school and one location outside it.
Results: The highest levels of all pollutants were found inside classrooms that were located directly on the moderate traffic streets compared with low or very low traffic activity ones. Levels of most air pollutants inside the governmental constructed buildings were higher than those inside the rental type of schools.
Conclusion: The average levels of TSP, NO_2 and CO inside all selected schools were lower than the air quality guidelines (AQGs). In contrary, all mean levels of CO_2 and nearly 50% of SO_2 and benzene levels were higher than their AQGs. Increasing the efficiency of the mechanical and air condition systems inside classrooms is important for appropriate ventilation and improving IAQ level.

Key words: Adverse effects, air quality guidelines, elementary schools, indoor air quality, school environment

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INTRODUCTION

Indoor air quality (IAQ) has increasingly been attracting attention worldwide.[1-3] Good IAQ in schools, universities and other educational areas is an important component of a healthy indoor environment. It contributes to a favorable learning environment for students, productivity for teachers and staff, and a sense of comfort, health, and well-being.[4,5] School IAQ, particularly in elementary schools, has become a global concern as children spend the second highest percentage of their time in schools and are especially susceptible to air pollution.[6] Children may be more likely than adults to be adversely affected by indoor air pollution because they breathe a greater volume of air relative to their body weight and this may lead to a greater burden of pollutants on their bodies.[7] They are also susceptible to health problems from indoor pollutants because their organs are developing.[8] The indoor environment in any building

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is a result of the interaction between the site, climate, building system (original design and later modifications in the structure and mechanical systems), construction techniques, contaminant sources (building materials and furnishings, moisture, processes and activities within the building, and outdoor sources), and building occupants.[9] Whether a source of air pollutants causes an IAQ problem or not depends on the type of air pollutant, the amount and rate at which it is released from its source and the degree of ventilation available to remove it from indoors.[10]

Indoor air pollution may have many sources in schools, and accordingly, IAQ can vary widely. Schools have diverse activities and a wide range of potential air pollutant sources. These sources include: Cafeterias; art, science, and other classrooms; vocational education areas; pools; restrooms; and locker rooms. The quality of indoor air is influenced both by the quality of outdoor air and by the emission characteristics of indoor sources.[9] A range of health consequences are associated with indoor biological and chemical pollutants and with building conditions such as poor ventilation and dampness. These include upper and lower respiratory diseases and symptoms, headaches, skin problems and fatigue, all of which can compromise learning. Air in most indoor environments contains a variety of particles and gaseous contaminants. These contaminants are commonly referred to as indoor air pollutants. From the health point of view, the most important indoor air pollutants are dust (or particulate matter), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and volatile organic compounds. The carbon dioxide (CO_2) concentrations generally encountered in buildings have no adverse health effects. Its concentrations is related to the ventilation rate relative to the number of occupants and building volume.[11-15]

Several previous studies and researches concerning the assessment of IAQ in schools have been conducted in different areas in the world.[16-19] In the Kingdom of Saudi Arabia (KSA), few researches have been conducted concerning the assessment of IAQ inside Saudi schools.[20] This study was aiming to assess levels of IAQ inside the governmental elementary schools in Dammam City, which is considered one of the main cities in the Eastern Province of KSA, and compare these levels with the national and international air quality guidelines (AQGs).

MATERIALS AND METHODS

Selection of schools and sampling locations inside them

From a total of 49 governmental elementary schools in Dammam City, 16 schools were selected for this study by the simple statistical random method, 12 of them were representing governmental constructed buildings, and the other 4 schools were representing rental buildings. The selected number of each type was based on an equal percent (33%) from the total number of each type of schools. Inside each school, four different classrooms were selected as sampling points for measuring air pollutants, representing most locations inside the school. In addition, a fifth sampling point was selected at the school playground outside all classrooms, representing the outdoor atmosphere.

Indoor air quality measurements

Inside each selected location, levels of dust or total suspended particulates (TSP), CO, CO_2, NO_2, SO_2, and benzene were measured simultaneously with the temperature degree and relative humidity percent.

Except for TSP, the other gaseous pollutants were measured during two periods of the school day; from 8 to 9 am and from 10 to 11 am. During the first period, most of the students are present inside their classrooms, while the second period usually comes directly after the student break, which is characterized by very high students' activity. As for TSP, only one continuous period was selected for sampling process from 8.0 to 10.0 am due to the nature of technique and instruments that are used for collecting such type of air pollutants. Levels of TSP were determined gravimetrically[21] in milligram of dust per cubic meter of air (mg/m^3) by the Staplex® PST-2X Personal Air Sampler (The Staplex® Company, New York, USA). This sampler is used for collecting different type of particulate matter for full-day worker 8 h at maximum flow rate from the internal battery pack. Samples can be collected at flow rates from 0.5 to 2 liter per minute (LPM) using 0.8 μ filter cassettes. The built-in flow meter is calibrated every 0.2 LPM and has a recessed electronic flow control to adjust the flow rate. Each sample of dust was collected on a membrane filter carried in a filter holder assembly. Three dust samples were collected from each selected site inside the same school, and a total of 240 dust samples were collected from all schools during this study.

Except for NO_2 gas, the calibrated MIRAN 205B Series SapphIRe-XL Portable Ambient Air Analyzer (The Thermo Scientific Company, USA) was used during this study for assessment levels of the other selected gaseous air pollutants (CO, CO_2, SO_2, and benzene) from the environment of the selected locations. This analyzer has the ability to measure any compound having an absorbance in the wavelength region from 7.7 to 14.1 μ, display and log compensated concentration for up to five gases. In addition, its user library can be programmed to store up to 120 single gases. Levels of NO_2, temperature and relative humidity were measured simultaneously and directly by using the Aeroqual 305 Monitor (The Aeroqual Limited Company, Auckland, New Zealand). This monitor has been specifically designed to incorporate Aeroqual's in-depth knowledge of accurate ambient gas measurement, in which, different sensor heads are used for specific gases or depending upon whether high or low concentrations are to be measured. At each measuring point, a reading per 15-30 min was recorded for each gaseous air pollutant in parts per million (ppm). A total of 700-800 readings were recorded for each gaseous pollutant inside all selected schools during this study.

RESULTS

Effect of outside traffic activity

The traffic activity outside schools was classified into three categories according to the average number of cars that were moving outside each school per hour. The first category was the very low traffic activity in which the number of cars was <100 cars/h. The second category was the low traffic activity in which the number of cars ranged from 100 cars to <200 cars/h, while the third category was the moderate traffic activity in which the number of cars ranged between 200 and 500 cars/h that were moving outside the school.

Figure 1 represents the relation between average levels of air pollutants inside the selected schools and the degree of traffic activity outside these schools. The highest levels (mean ± standard deviation) of TSP (4.0 ± 1.0 mg/m^3), CO (3.2 ± 0.92 ppm), NO_2 (0.02 ± 0.006 ppm), SO_2 (0.06 ± 0.011 ppm), and benzene (0.4 ± 0.12 ppm) were found inside schools that are surrounded by streets with moderate activity. On the other hand, the highest mean level of CO_2 (1600 ± 268.7 ppm) was obtained inside schools that are surrounded by streets with low activity.

To study the significance of this factor, the *t*-test was applied for the data as presented in Table 1, which indicates that there was a very strong significant difference for CO and SO_2 gas ($P \leq 0.005$), a slight significant difference for benzene ($P = 0.05$) and there was no any statistical differences for the other air pollutants ($P > 0.05$).

To confirm the above results, a relation between the overall outdoor mean levels of air pollutants and their overall mean levels inside schools were studied during the present study and presented in Figure 2. The mean levels of all pollutants outside schools, except CO_2, were slightly higher than those indoor. In contrary, the mean level of CO_2 inside schools (1510 ± 226.9 ppm) was much higher than its outdoor level (410 ± 35.8 ppm). Statistically, except for CO_2, there were no significant differences for the other pollutants as shown in Table 1.

Type of the school building

As mentioned before, two types of school buildings were selected: Governmental constructed buildings and governmental rental buildings. The average levels of air pollutants inside each type were calculated and illustrated in Figure 3. It is clear that levels of all measured six air pollutants inside the governmental constructed buildings (TSP [2.9 ± 0.84 mg/m^3], CO [2.4 ± 0.89 ppm], NO_2 [0.019 ± 0.005 ppm], SO_2 [0.046 ± 0.01 ppm], CO_2 [1597 ± 245.5 ppm] and benzene [0.3 ± 0.11 ppm]), were higher than those inside the rental type (1.4 ± 0.13 mg/m^3, 1.3 ± 0.27, 0.01 ± 0.003, 0.029 ± 0.004, 1363 ± 292 and 0.14 ± 0.03 ppm respectively). The independent *t*-test values [Table 1] indicate that there

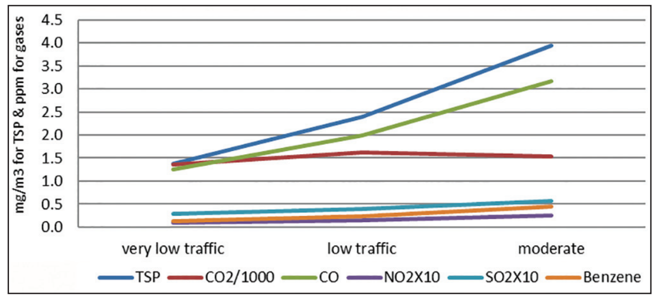

Figure 1: Mean levels of air pollutants inside schools and traffic activity in the surrounding areas

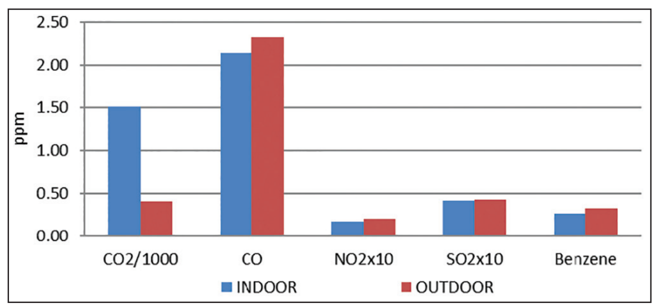

Figure 2: Mean levels of air pollutants inside and outside studied schools

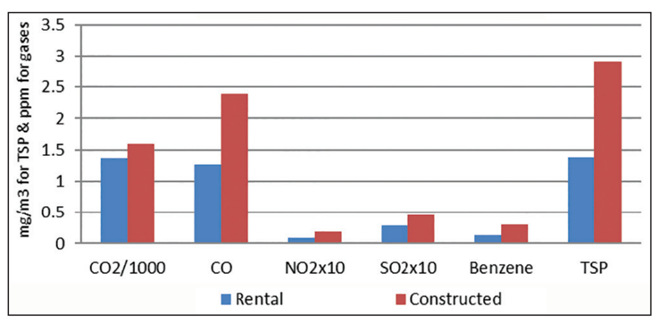

Figure 3: Mean levels of gaseous air pollutants inside schools and type of school building

Table 1: *t*-test values for the relation between mean air pollutants levels and different affecting factors

Type of relation	CO_2	CO	NO_2	SO_2	Benzene	TSP
Mean air pollutants levels inside schools and traffic activity outside	0.641	0.001	0.458	0.005	0.05	0.949
Mean air pollutants levels inside and outside schools	0.000	0.891	0.354	0.839	0.920	0.445
Mean air pollutants levels in the governmental constructed and rental school buildings	0.262	0.014	0.049	0.473	0.426	0.018
Mean air pollutants levels inside classrooms located at different school floors	0.579	0.249	0.019	0.400	0.383	0.172

CO_2: Carbon dioxide, CO: Carbon monoxide, NO_2: Nitrogen dioxide, SO_2: Sulfur dioxide, TSP: Total suspended particulates was a statistical significant difference for CO, NO_2, and TSP levels ($P < 0.05$) between the governmental constructed and rental school buildings.

Location of classrooms

Location of the classroom inside any school has an important role in the IAQ level inside it. During this study, two factors engaged with the classroom location were studied. The first was the floor number in which the classroom was located, while the second was the outside area which surrounds the classroom.

Some of the studied classrooms were located at the ground level (first floor), while the others were located at the second floor. The average level of each air pollutant inside all classrooms of the same floor was calculated and presented in Figure 4. The average levels of all pollutants inside the classrooms of the first floor were higher than those of the second one. Except for NO_2 gas, there was no any significant difference for the other pollutants as shown in the independent *t*-test [Table 1].

To study the effect of the outside area on the classroom air quality level, all the studied classrooms were divided into three categories; those that are located directly on the playgrounds, those that are located on branched streets and those that are located on main streets. Figure 5 shows the average levels of air pollutants inside classrooms of each type of the three categories. The highest levels of all gaseous pollutants were found inside classrooms that are located directly on the main street for the same reasons that mentioned before. Using the one-way ANOVA test for comparison between the three outside sites, it was found that there were no any significant differences for all studied air pollutants between the three sites as shown in Table 2.

Ventilation rate inside classrooms

Figure 6 represents the total volume of all windows inside each classroom in square meter in relation to level of CO_2 inside this classroom as an indicator for ventilation efficiency. It is evident that there was no any correlation between the two factors and there was also no significant correlation ($P > 0.05$). On the other hand, the relation between the total volume of the classroom (length × width × height) in a cubic meter and levels of all air pollutants levels inside each classroom was statistically studied using ANOVA and Pearson Correlation tests as shown in Table 3. There were negative very weak correlations between the total volume of classrooms and levels of air pollutants inside them. In addition, there were no any significant statistical differences for all pollutants.

A correlation between the number of students and mean level of CO_2 was also studied inside each classroom because the human body is considered a source of this gas in the closed areas. The average number of students inside all studied classrooms ranged between 15 and 34 students. Levels of CO_2 during this study ranged between 1987.5 ± 298.3 ppm inside classroom, which was occupied with 24 students, and 1244.6 ± 244.9 ppm inside classroom which was occupied

Table 2: One-way ANOVA test for the relation between air pollutants levels inside classrooms and the direct outside areas

Multiple comparisons				
Dependent variable	(I) outside area for class	(J) outside area for class	Standard error	Significant
CO_2 (ppm)	Play ground	Branch street	174.326	0.777
	Play ground	Main street	697.303	0.740
	Branch street	Main street	696.600	0.836
CO (ppm)	Play ground	Branch street	1.5203	0.356
	Play ground	Main street	6.0812	0.187
	Branch street	Main street	6.0751	0.093
NO_2 (ppm)	Play ground	Branch street	0.000900	0.027
	Play ground	Main street	0.003585	0.273
	Branch street	Main street	0.003584	0.647
SO_2 (ppm)	Play ground	Branch street	3.59393	0.825
	Play ground	Main street	14.37572	0.482
	Branch street	Main street	14.36122	0.396
Benzene (ppm)	Play ground	Branch street	5.77983	0.788
	Play ground	Main street	23.11933	0.340
	Branch street	Main street	23.09601	0.261
TSP (mg/m^3)	Play ground	Branch street	332.478335	0.475
	Play ground	Main street	1340.426653	0.781
	Branch street	Main street	1339.771988	0.604

CO_2: Carbon dioxide, CO: Carbon monoxide, NO_2: Nitrogen dioxide, SO_2: Sulfur dioxide, TSP: Total suspended particulates

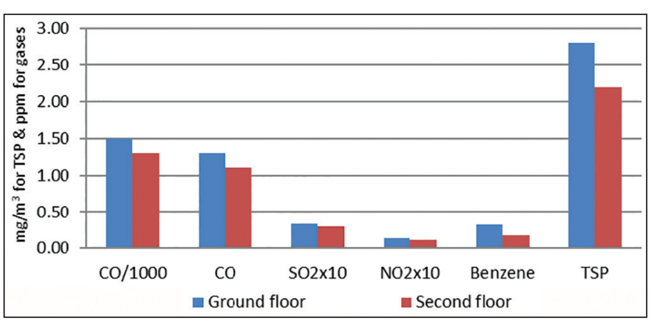

Figure 4: Mean levels of air pollutants inside classrooms located at different floors

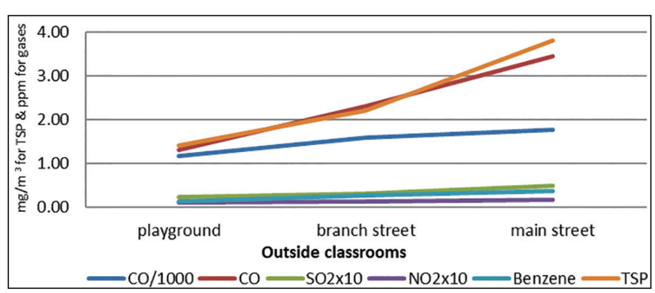

Figure 5: Effect of the outside area in air pollutant levels inside school classrooms

with 28 students. Unexpectedly, no correlation was found between these two variables as shown in Figure 7.

Inside classrooms, the temperature degree is affected by several factors such as the outside temperature degree, the efficiency of mechanical ventilation system inside the classroom and time of the school academic day. To study the relation between temperature degree and levels of air pollution inside the classrooms, two different times were selected during the day for conducting the air quality measurements; from 8 to 9 am and from 10 to 11 am. Figure 8 illustrates results of this relation, in which, levels of all gaseous pollutants inside classrooms were increasing with the progress of time. The Pearson Correlation test for this factor indicated that there is a positive very weak correlation between the degree of temperature inside classrooms and levels of CO, SO_2, and benzene, while there was a negative very weak correlation for CO_2 and TSP. In addition, there were very strong significant differences for CO, SO_2, and benzene as shown in Table 4.

Air quality guidelines

Standards for air pollution or AQGs are concentrations over a given time period that are considered to be acceptable in the light of what is known about the effects of each pollutant on health and on the environment. They can also be used as a benchmark to see if air pollution is getting better or worse.[22]

Table 5 represents the AQGs as suggested by different international scientific agencies. These agencies include; the U.S. Environmental Protection Agency, the World Health Organization (WHO), the National Institute for Occupational Safety and Health, the Occupational Health and Safety Administration, and the American Conference of Governmental Industrial Hygienists.[23] In this table, unless otherwise specified, values are given in ppm. Number in brackets refers to either a ceiling or to averaging times of less than or greater than 8 h (min = minutes; hr = hours; yr = year; C = ceiling; L = long term). Where no time is specified, the averaging time is 8 h.

The average level of each air pollutant inside the 16 schools that were studied during the present study was compared with its IAQ. The average levels of TSP, NO_2, and CO inside all selected schools were lower than the AQGs of all agencies of the world. In contrary, all mean levels of CO_2 were higher than the AQG value, which is recommended by the WHO and in Europe. Nearly 50% of the studied schools have mean

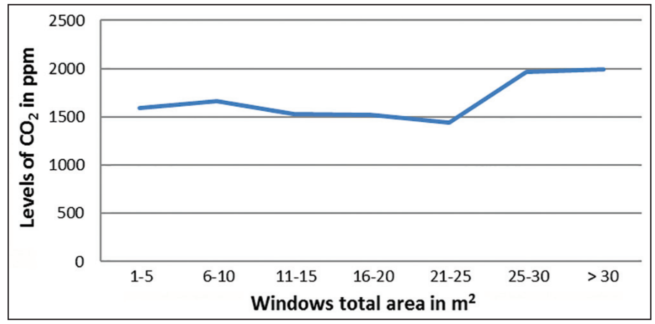

Figure 6: Mean levels of carbon dioxide and total windows area inside classrooms

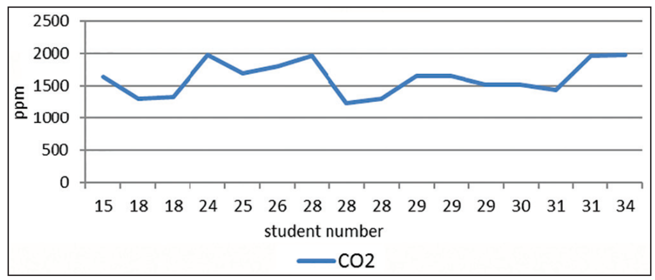

Figure 7: Mean levels of carbon dioxide gas and number of students inside classrooms

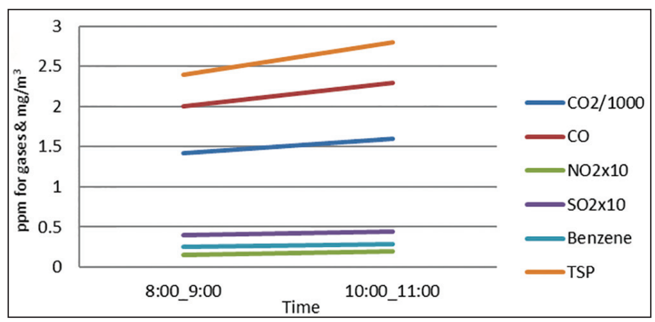

Figure 8: Mean levels of air pollutants inside classrooms at different times of measurement

Table 3: Pearson correlation test values for the relation between air pollutants levels and total volume of classrooms

Studied Factor	Type of correlation	CO_2	CO	NO_2	SO_2	Benzene	TSP
Total volume of classrooms (m^3)	Pearson correlation	−0.047	−0.115	−0.082	−0.059	−0.084	−0.014
	Significant (2-tailed)	0.602	0.201	0.366	0.511	0.350	0.872

CO_2: Carbon dioxide, CO: Carbon monoxide, NO_2: Nitrogen dioxide, SO_2: Sulfur dioxide, TSP: Total suspended particulates

Table 4: Pearson correlation test values for the relation between air pollutants levels and degree of temperature inside classrooms

Studied Factor	Type of correlation	CO_2	CO	NO_2	SO_2	Benzene	Dust
Temperature degrees inside classrooms	Pearson correlation	−0.117	0.268	0.009	0.332	0.314	−0.094
	Significant (2-tailed)	0.148	0.001	0.911	0.000	0.000	0.298

CO_2: Carbon dioxide, CO: Carbon monoxide, NO_2: Nitrogen dioxide, SO_2: Sulfur dioxide, TSP: Total suspended particulates

Table 5: Standards and guidelines for common indoor contaminants

Pollutant	NAAQS/EPA	OSHA	WHO/Europe	NIOSH	ACGIH
CO_2		5000	1000	5000	5000
CO	9 35 (1 h)	50	25 (1 h) 10 (8 h)	35 200 (C)	25
NO_2	0.05 (1 year)	5 (C)	0.1 (1 h) 0.004 (1 year)	1.0 (15 min)	3 5 (15 min)
TSP		5 mg/m^3			10 mg/m^3
SO_2	0.03 (1 year) 0.14 (24 h)	5	0.048 (24 h) 0.012 (1 year)	2 5 (15 min)	2 5 (15 min)
Benzene			0.24 (3 h)		

WHO: World health organization, NIOSH: National institute for occupational safety and health, ACGIH: American conference of governmental industrial hygienists, OSHA: Occupational health and safety administration, EPA: Environmental protection agency, NAAQS: National ambient air quality standards, CO_2: Carbon dioxide, CO: Carbon monoxide, NO_2: Nitrogen dioxide, SO_2: Sulfur dioxide, TSP: Total suspended particulates

levels of SO_2 and benzene higher than the AQG value that were recommended by the WHO and in Europe.

DISCUSSION

Air pollutants that originate in the outdoor atmosphere from automobile and factory emissions and other combustion processes are likely to be present indoors. In the absence of indoor sources of these pollutants, concentrations indoors will be close to or lower than those outdoors.[24] Except for CO_2 gas, levels of the other pollutants inside schools that are surrounded by streets with moderate activity were higher than those surrounded by streets with low or very low traffic activity. It is also evident from results that levels of all air pollutants, except CO_2, in the outdoor air were slightly higher than those inside the school environment. In addition, the highest levels of all gaseous pollutants were found inside classrooms that are located directly on the main street compared with other classrooms that are located on branched street or the school playground. All of these data indicate that outdoor sources of air pollution has the principle effect in decline the air quality inside the school because of absence of such pollutants' sources inside schools, and hence, IAQ inside schools and their classrooms are adversely affected, depending on their locations relative to the outdoor sources of air pollution, particularly traffic activity. In contrary, the CO_2 levels inside schools were much higher than the outdoor levels because human activity is considered a main source of this gas in the atmosphere, which was confirmed by the very strong statistical difference between the indoor and outdoor sources of CO_2.

Levels of all measured air pollutants inside the governmental constructed buildings were higher than those inside the rental type of school buildings. This may be related to the clear difference in the design of the two building types. School sizes, number of classrooms and number of occupants in the governmental constructed buildings are usually higher than the rental type. In addition, most of the governmental constructed buildings are located at or near from traffic roads contrary to the rental buildings that are usually located inside residential areas. For these reasons, levels of air pollution inside the governmental constructed buildings were logically higher than the rental buildings.

It is obvious that the average levels of all pollutants inside the classrooms of the first floor were higher than those of the second one, which confirms the previous conclusion of the direct effect of the outside traffic activity on the IAQ inside schools and their classrooms. Due to the dispersion process, concentration of air pollutants decreases with increasing the horizontal and vertical distances, and for this reason, levels of pollutants in the second floor were the lowest.

Because the human body is considered a source of CO_2 in the atmosphere as the result of expiration process, a correlation between numbers of students and levels of this gas was studied inside each classroom. Unexpectedly, no correlation was found between these two variables as shown in Figure 7. This may be related to the ventilation rate and air condition system, which was applied inside each classroom. This factor is considered one of the most important control techniques that are used for improving the IAQ inside any closed room or building. In addition, CO_2 is considered as an important indicator for appropriate or deficient ventilation rate,[25] and hence, decreasing of CO_2 level with the high number of students in some classrooms can be explained by the good ventilation system and rate inside these classrooms.

Natural ventilation is the intentional flow of outdoor air through an enclosure under the influence of wind and thermal pressures through controllable openings. Natural ventilation is driven by pressure differences across the openings caused by ambient pressure and temperature differences between different openings within a unit.[26] On the other hand, the mechanical ventilation systems circulate fresh air using ducts and fans, rather than relying on airflow through small holes or cracks in a home's walls, roof, or windows. In many cases, the mechanical ventilation is very important to provide fresh air and prevent or reduce levels of moisture, odors, and other pollutants that can build up inside a home.[25] Unlike other Arab countries such as Egypt, most of buildings inside the KSA are completely dependent on the mechanical ventilation system or air condition system, in spite of the presence of windows and other openings inside these buildings. The main cause for this phenomenon is the climatic characteristic and the presence of high levels of dust in the environment of most KSA cities. For this reason, most of windows inside Saudi's schools and classrooms are completely closed and they are used only for transmitting the sun light, but not for natural ventilation. It is clear from the result of this study that there was no any correlation between number or volume of windows and level of CO_2 gas inside the studied classrooms, which indicates that levels of air pollutants inside the classroom depends mainly on the efficiency of mechanical, not natural, ventilation systems.

To study the relation between temperature degree and levels of air pollution inside the classrooms, two different times were selected during the day for conducting the air quality measurements; from 8 to 9 am and from 10 to 11 am. Levels of all gaseous pollutants inside classrooms were increasing with the progress of time. The factors that may be responsible for this result include increasing of traffic activity outside schools, increasing of students activities after the school day break, and/or increasing the temperature degree with the progress of time. The first two factors have been already studied as previously discussed in this work. The temperature was ranged between 26°C and 26.5°C during the first period (8-9 am), while it raised to 27-27.4°C during the second one (10-11). Temperature is one of the basic IAQ measurements that has a direct impact on perceived comfort and in turn, concentration and productivity. According to the American Society of Heating, Refrigerating and Air Conditioning Engineers Standard 55, the recommended temperature ranges perceived as "comfortable" are 73-79°F (22.8-26.1°C) in the summer and 68-74.5°F (20.0-23.6°C) in the winter.[27] If the air temperature is too hot or too cold, this will make the occupants uncomfortable, and it would probably make them use only half of their mind and effort in concentrating on their job while the other half is concentrating on the uncomfortable air quality.[28] During this study, the temperature degrees were higher than the recommended values, which makes students are more susceptible to the bad effects of indoor air pollutants. Thus, controlling of temperature degree inside classrooms has a considerable role in improving levels of IAQ and enhancing the thermal comfort, which is essential for learning and teaching process.

All mean levels of CO_2 inside all studied schools were higher than its AQG value which is recommended by the WHO and in Europe. Nearly 50% of the studied schools have mean levels of SO_2 and benzene higher than their AQG values that were recommended by the WHO and in Europe. The average levels of TSP, NO_2 and CO inside all selected schools were lower than their AQGs. These results reflect the relative bad indoor air quality in the schools of Dammam City, which is considered as an important and a representative city for the eastern province of KSA, due to the inefficient rate of ventilation and absence of environmental awareness.

CONCLUSIONS AND RECOMMENDATION

Except for CO_2 gas, levels of the other pollutants inside schools that were surrounded by streets with relative high traffic activity were higher than those surrounded by streets with low traffic activity, which reflects the importance of outside sources of pollution in decline the IAQ level. Levels of CO_2 were greatly affected by the indoor human activity, rather than the outdoor sources. The mean levels of some air pollutants inside schools were higher than their AQG, which refers to a relative bad IAQ inside schools of Dammam City. Increasing the efficiency of mechanical ventilation inside classrooms and selection of locations for construction of school buildings far from traffic activity are effective procedures for improving IAQ level.

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