International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

# Assessment of Ambient Air Quality in Primary Schools in Various Areas of Lahore

**Hajira Tahir[1], Muhammad Abdullah Ahsan Shah[2]**

[1,2]Department of Environmental Sciences, University of Veterinary and Animal Sciences Lahore

**ABSTRACT**

Indoor air pollutants assessment in 54 primary schools of both government and private sectors in 9 different towns of Lahore were carried out for the purpose of measuring concentration of Particulate matter ($PM_{2.5}$, $PM_{10}$), Carbon monoxide(CO), Carbon dioxide ($CO_2$),Nitric oxide(NO), Nitrogen dioxide ($NO_2$),Nitrous Oxide ($NO_x$),Sulphur dioxide ($SO_2$), Hydrogen sulphide ($H_2S$), Ground level Ozone ($O_3$)and Volatile Organic Compounds (VOCs). After analysisthe level of $CO_2$ is lower in both schools. The government schools has more concentration than private schools. After analysis the level of COis lower in both schools. The government schools has more concentration than private schools. The level of $O_3$ is lower in both schools. Both government and private schools has almost same concentration. The concenteration of NOis higher in both schools as compared to standard. The private schools has more concentration than government schools. The level of $NO_2$ is higher in both schools as compared to standard. The private schools has more concentration than government schools. The concenteration of $SO_2$ is so much higher in both schools as compared to standard value. The government schools has more concentration than private schools. The concenteration of $H_2S$is higher in both schools as compared to reference value. The government schools has more concentration than private schools. The concenteration of VOC'sis low in both schools as compared to standard value. Both schools have almost the same concentration.The concenteration of $PM_{10}$ is so much higher in both schools as compared to reference value. The government schools has more concentration than private schools. The concenteration of $PM_{2.5}$ is so much higher in both schools as compared to standard value. The government schools has more concentration than private schools.The standard value of the pollutants are $CO_2$ (1000ppm), CO (10mg/$m^3$), $O_3$ (130µg/$m^3$), NO (40µg/$m^3$), $NO_2$ (80µg/$m^3$), $SO_2$ (120µg/$m^3$), $H_2S$ (0.47ppb), VOC's (25ppb), $PM_{10}$ (150µg/$m^3$), $PM_{2.5}$ (15µg/$m^3$).

**Keywords**: Ambient air Quality, Pollutant, Government and Private schools

## Introduction

Air pollution is becoming a serious issue about public health worldwide. It is creating long term and worse impacts on human's health, plants, equipment, ecosystem and short term effect on visibility (Fenger, 1999; Riga-Karandinos, 2005). Air quality has become a challenge in big cities because people are exposed to high risk by pollutants. In developed countries, 75% population resides in urban areas whereas the urban ratio in developing countries is more than 35% causing negative impacts on air quality (Wolf, 2002; Agrawal et al. 2003; Vargas, 2003; Brajer et al.2006; Oudient et al. 2006). Air pollution in cities has become more overwhelming due to increasing population. An abandoned increase in population direct

towards the industrialization without taking natural strategies about topography and meteorological conditions. The population has become double today as compare to past some decades (Baldasano et al. 2003). Population increase is directly proportional to: increase variety of mobile facilities for transportation of products, increase needs of space, material, energy, food and comfort. These demands lead towards the utilization of natural resources by deforestation. A number of mobile sources like road automobile and stationary sources like mining, power plant, industry, commercial activities, trade centers and space heating etc are responsible for the maximum level of pollutants in ambient air of cities. It is a difficult task to meet the international standards of pollutant and control their emissions in developing countries because they have low economies (Ozden et al. 2008).

A number of pollutants are responsible for pollution in air that alter the composition of air and damaged the living population. Atmosphere has the ability to absorb the pollutant emitted from the different source of origin but the concentration of these pollutants is depending upon the emission source. The air pollution is not fixed in ratio but change its concentration temporarily or spatially. This change occurs due to meteorological conditions and topography of an area. Air pollutants such as CO, NO, $NO_2$, $SO_2$, $H_2S$, $NH_3$, ground level ozone ($O_3$), Volatile organic compounds ($VOC_S$), polycyclic aromatic hydrocarbons ($PAH_S$) has toxic effects on health of humans (Brunekreef and Holgate, 2002). As pollutants emit from their sources, they dispersed, transport from source and are combine to form variety of secondary pollutants. This phenomenon occurs in atmosphere. Ground level ozone forms when Oxides of nitrogen combines with the $VOC_S$ in atmosphere (Fenger, 1999). The combination of primary or secondary pollutant with oxides of sulphur leads to formation of secondary particulate matter (Atkinson, 2000). The oxidation of $NO_2$ forms $HNO_3$ and then changed into $NO_3^-$. These secondary pollutants are the main cause of reduced visibility, acidification and has deleterious impacts on humans (Riga-Karandinos and Saitanis, 2005). WHO (World Health Organization), EPA (Environment Protection Agency), World Bank and European Union Air Quality Framework set up the standards of these pollutants for the safety measurements (Lim et al. 2005). WHO air quality guideline provides guidance about threshold level of air pollutants. Values for particulate matter in air are: annual mean of $PM_{2.5}$ is 10µg/$m^3$& 24-hour mean of $PM_{2.5}$ is 25µg/$m^3$ and annual mean of $PM_{10}$ is 20µg/$m^3$ & 24-hour mean of $PM_{10}$is 50µg/$m^3$. Value for 8-hour mean of $O_3$ is 100µg/$m^3$. A value for annual mean of NO2 is40µg/$m^3$ and 1-hour mean of $NO_2$ is 200µg/$m^3$. A value for 24-hour mean of SO2 is 20µg/$m^3$ and 10 minutes mean of $SO_2$ is 500µg/$m^3$(WHO, 2005).According to EEA study, it was expected that the urban cities of Europe will face elevated amount of air pollutants in 2010 (EEA, 2003). The concentration of CO, $NO_x$ and $NO_2$ above permissible limit in ambient air can cause heart coronary diseases (Anne, 2006).

Particulate matter has negative effects on health like cardiovascular, lung diseases and premature death in children (Pope et al. 2002; NARSTO, 2004; Silva et al. 2013).Volatile organic compounds are ubiquitous and are the major air pollutant of indoor ambient air (Wolkoff and Nielsen, 2001). It has been found that very trace amount of VOC's even than the standard concentrations are responsible for odor (Peng et al. 2009) and affect the human sensory system due to which people feels annoyance and creates health problems (Nicell, 2009). Pakistan is becoming an urbanized country with total 180 million populations (Government of Pakistan, 2012). Air pollution is increasing continuously by rising vehicle emissions, power

plants, and industrial activities due to industrialization which produces variety of pollutants in atmosphere causing pollution in Pakistan. As compare to United States, the emissions from Pakistani automobiles contains 3.5 times more $SO_2$ levels and 20 times higher $CO_2$ and CO levels (Barber, 2008). Transport sector is mainly dependent on diesel fuel which is the root cause of $PM_{2.5}$ concentration in air (Shyamsundar et al. 2001). According to an estimation, in Pakistan, particulate matter pollution impacts on health costs 65 billion with 700 deaths of children and 22000 among adults (World Bank, 2006). Pakistan EPA and World Bank estimate the total value of health impact caused by ambient air pollution in Pakistan. The health impacts measured in Pakistan due to ambient air pollution with their annual costs are: Premature Mortality rate is 21,791 and annual cost ranges 58-61 in billion rupees. There are 658 cases reported of mortality in children with annual 0.83 billion costs. Chronic bronchitis caused 7,825 cases with 0.06 billion cost annually. Respiratory symptoms leads to Lower respiratory illness have been seen in 706,808,732 and 4,924,148 cases with total cost of 0.84 billion respectively (EPA and World Bank, 2006).

Pakistan Environmental Protection Agency has drafted the National Environmental Quality Standards for Ambient Air. In pursuance of the statutory requirements under clause (e) of Sub-section (1) of section (6) of the Pakistan Environmental Protection Act 1997, the drafted standards are being published. National Ambient Air Quality Standards of Pakistan (NAAQS) are 35µg/$m^3$, 80µg/$m^3$, 40µg/m3, 120µg/$m^3$, 5µg/$m^3$ and 130µg/$m^3$ for $PM_{2.5}$, $NO_2$, NO, $SO_2$, CO and $O_3$ respectively. Pakistan EPA and JICA 2001, investigates the average pollutants level in ambient air of Lahore. The pollutant concentration of $PM_{2.5,}$ $SO_{2,}$ $NO_{x,}$ CO and $O_3$ was found to be so high as 895.0µg/$m^3$, 44.60ppb, 156.60ppb, 2.82ppm and 8.50ppb respectively as compare to permissible limits of WHO guidelines.Primary school going children are more susceptible to the pollutant exposure because they inhale an air loaded with pollutant is larger than their body weight. Children are growing; their respiratory airways are weak and tiny in size for hazardous pollutants to pass through, so their respiratory system damaged earlier than adults (Aziz et al. 2014).

## Materials and Methods

The research work was conducted in the Department of Environmental Sciences, University of Veterinary and Animal Sciences Lahore (UVAS). In the current study, an assessment was carried out for 11 air pollutants in the government and private schools in 9 towns of Lahore. The main objective of this study was to assess the ambient air quality in private as well as public primary schools in all the 9 towns of Lahore.

### Sample Collection

The data was collected from 6 schools in each town (3 Private and 3 Government) and 54 in total. One point was taken inside and one outside of each school. The 3 Government schools were categorize as (A, B & C) while the 3 Private schools were categorized as (D, E & F). The nine towns are:

1. Data Gang Baksh Town
2. Ravi Town
3. Samnabad Town
4. Shalimar Town

5. Wagha Town
6. Iqbal Town
7. Gulberg Town
8. Aziz Bhatti Town
9. Nishtar Town

**Analysis of Ambient Air**

Ambient air pollutants ($PM_{2.5}$, $PM_{10}$, CO, $CO_2$, NO, $NO_2$, $SO_2$, $H_2S$, NOx, $O_3$ and VOCs) were analyzed by using HAZ-SCANNER Model HIM-6000 Ambient Air Quality Monitoring System. The air monitoring was done by this system from February to March.

**Statistical Analysis**

T-test was applied to detect if different groups of government and private schools produced statistically significant difference to permissible values for air pollutants.

**Results**

Outcomes of this research provided mean concentration of pollutants found in ambient air of schools in Lahore. It shows comparison of ten pollutants concentration ($PM_{2.5}$(µg/$m^3$), $PM_{10}$ (µg/$m^3$), CO (ppm), $CO_2$(ppm), NO (ppb), $NO_2$(ppb), $SO_2$ (ppb), $H_2S$ (ppb), $O_3$(ppb)and VOCs (ppb)) between government and private school groups of nine towns of Lahore and also compared them with standards.

**$C0_2$**

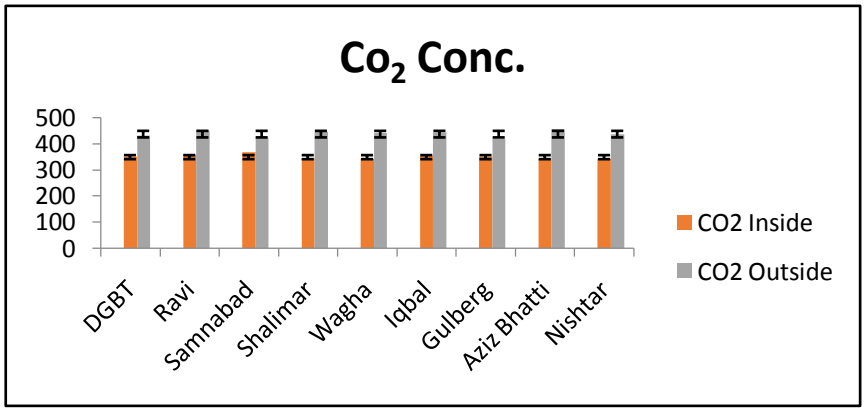


**Figure No 1:**Concentration of $CO_2$

Figure 1 shows a comparison of $CO_2$ concentration between school groups of different towns. Results were compared inside and outside of the schools. Results shows that $CO_2$ concentration was high in Samnabad town and low in Iqbal Town inside the school. $CO_2$ concentration was high in Shalimar Town and low in Gulberg outside the schools.Every town has an increasing trend of $CO_2$ but still it value was under the set standards. The set value of $CO_2$ is 1000 ppm.

**CO**

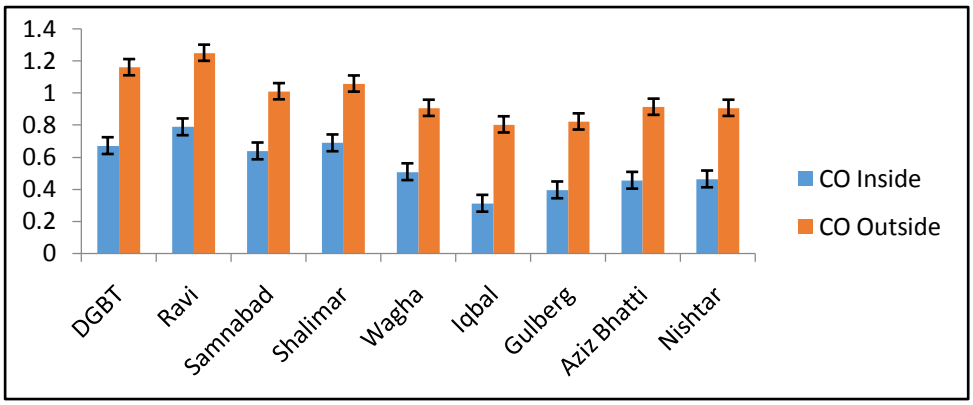


**Figure No 2 Concentration of CO**

Figure 2 shows a comparison of COconcentration between school groups of different towns. Results were compared inside and outside of the schools. Results show that CO concentration was high in Ravi town and low in Iqbal Town inside the school. CO concentration was high in Data Gang Baksh Town and low in Iqbal Town outside the schools.CO concentration is under the set standards of NEQS. Set value is 10mg/$m^3$.

**H2S**

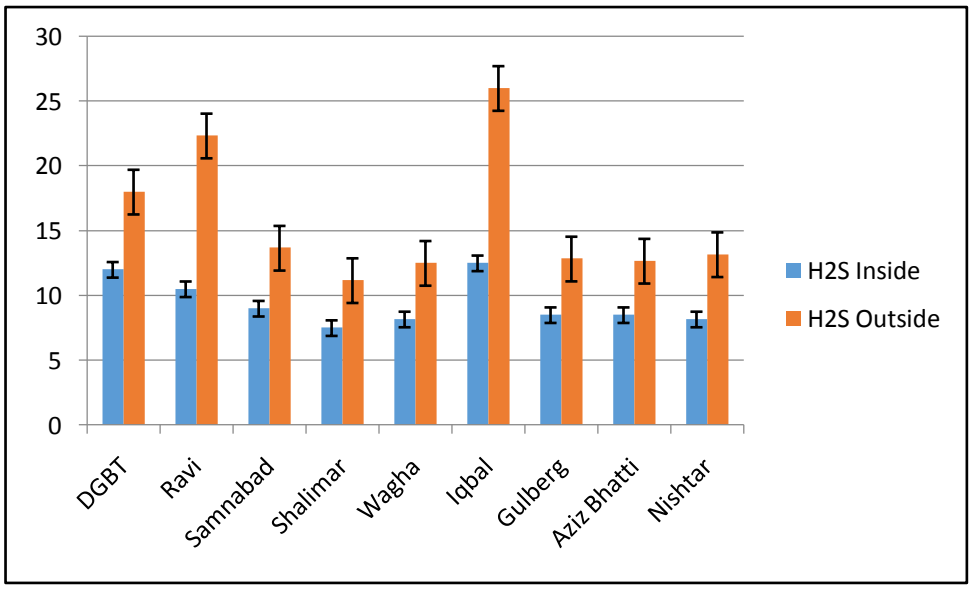


**Figure No 3 Concentration of H2S**

Figure 3 shows a comparison of H2S concentration between school groups of different towns. Results were compared inside and outside of the schools. Results show that H2S concentration was high in Iqbal Town and low in Shalimar Town inside the school. H2S concentration was high in Ravi Town and low in Wagha outside the schools.

**NO**

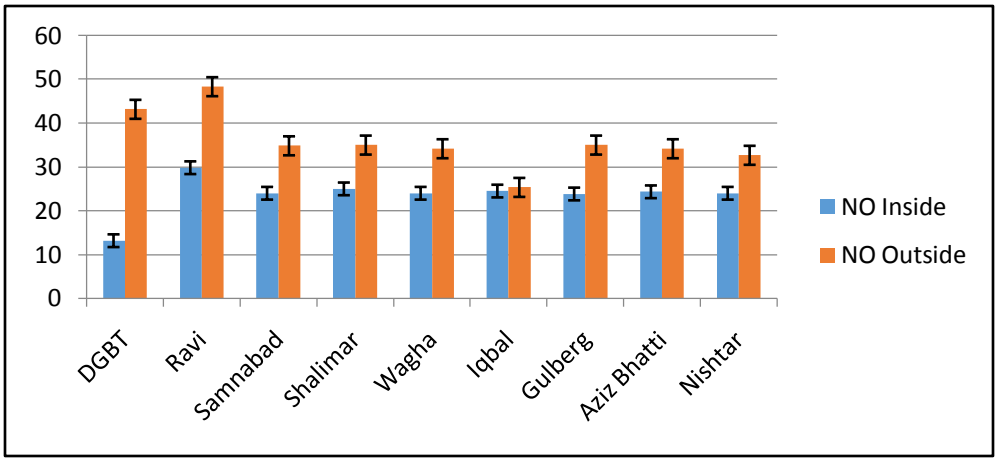


**Figure No 4 Concentration of NO**

Figure 4 shows a comparison of NO concentration between school groups of different towns. Results were compared inside and outside of the schools. Results show that NO concentration was high in Shalimar Town and low in Data Gang Baksh Town inside the school. NO concentration was high in Ravi Town and low in Iqbal Town outside the schools. NO values are very high than standards. Standard value for NO is 40µg/$m^{3.}$

**$NO_2$**

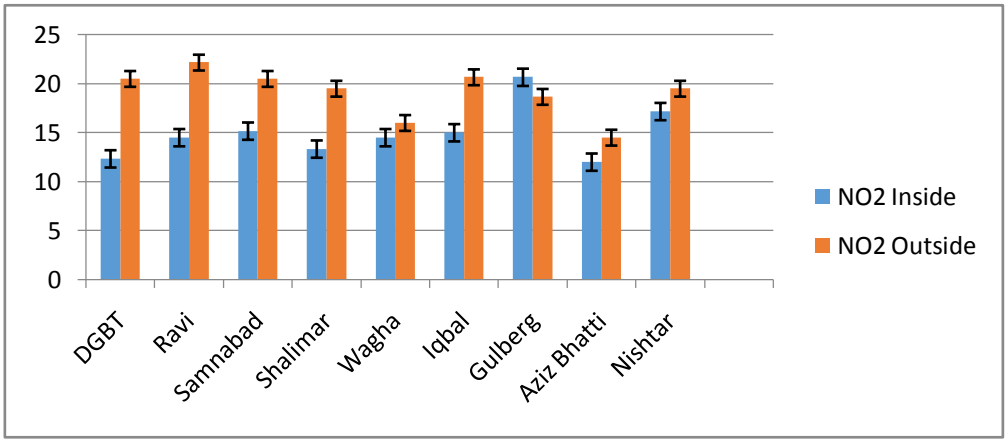


**Figure No 5 Concentration of $NO_2$**

Figure 5 shows a comparison of $NO_2$ concentration between school groups of different towns. Results were compared inside and outside of the schools. Results show that $NO_2$ concentration was high in Gulberg and low in Data Gang Baksh Town inside the school. $NO_2$ concentration was high in Ravi Town and low in Aziz Bhatti Town outside the schools.

**NOx**

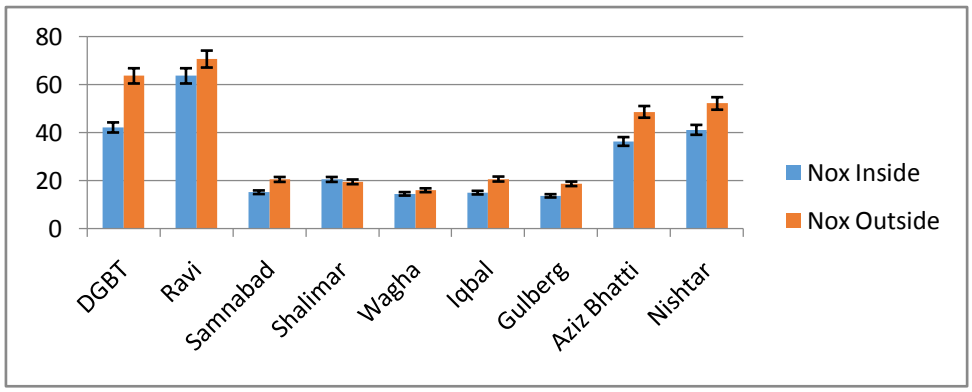


**Figure No 6 Concentration of $NO_x$**

Figure 6 shows a comparison of $NO_x$ concentration between school groups of different towns. Results were compared inside and outside of the schools. Results show that $NO_x$ concentration was high in Data Gang Baksh Town and Wagha inside the school. $NO_x$ concentration was high in Ravi Town and low in Wagha outside the schools.

**$O_3$**

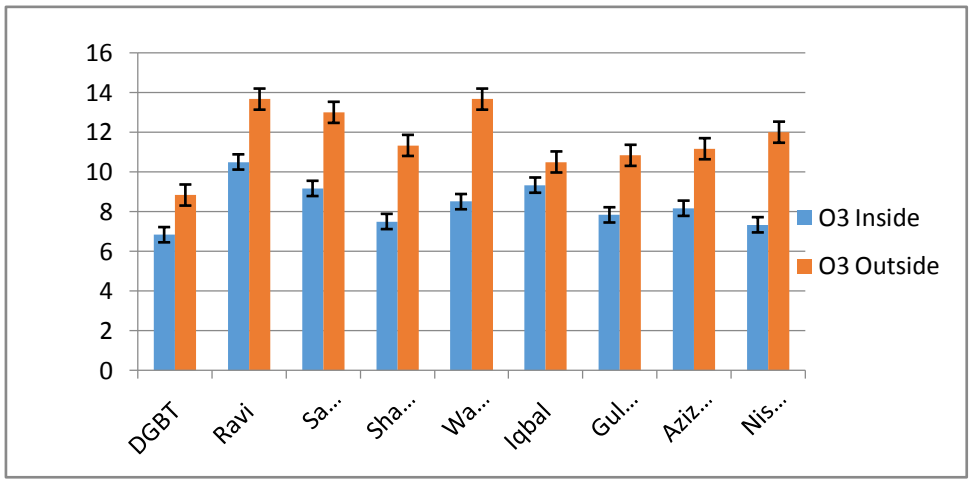


**Figure No 7 Concentration of $O_3$**

Figure 7 shows a comparison of $O_3$ concentration between school groups of different towns. Results were compared inside and outside of the schools. Results show that $O_3$ concentration was high in RaviTown and low in Data Gang Baksh Town inside the school. $O_3$ concentration was high in Ravi Town and low in Data Gang Baksh Town outside the schools. Ozone concentration is under the permissible values. Standard value is 130µg/$m^3$.

**$PM_{10}$**

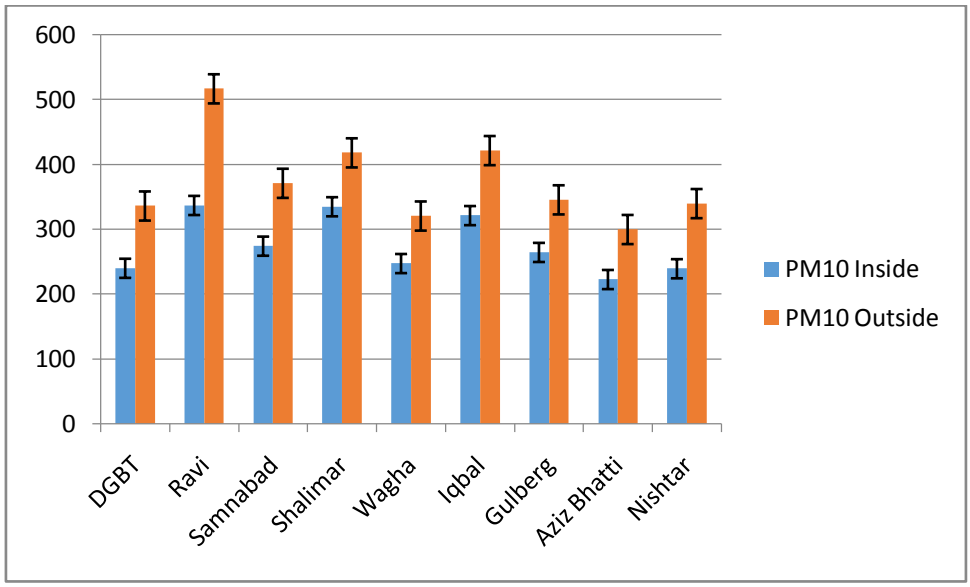


**Figure No 8 Concentration of $PM_{10}$**

Figure 8 shows a comparison of $PM_{10}$ concentration between school groups of different towns. Results were compared inside and outside of the schools. Results show that $PM_{10}$ concentration was high in Ravi Town and low in Aziz Bhatti Town inside the school. $PM_{10}$ concentration was high in Ravi Town and low in Aziz Bhatti Town outside the school. The value of $PM_{10}$ is higher than the standards. The set value of $PM_{10}$ is 150 µg/$m^3$. Each town is significantly high value of this particulate matter.

**$PM_{2.5}$**

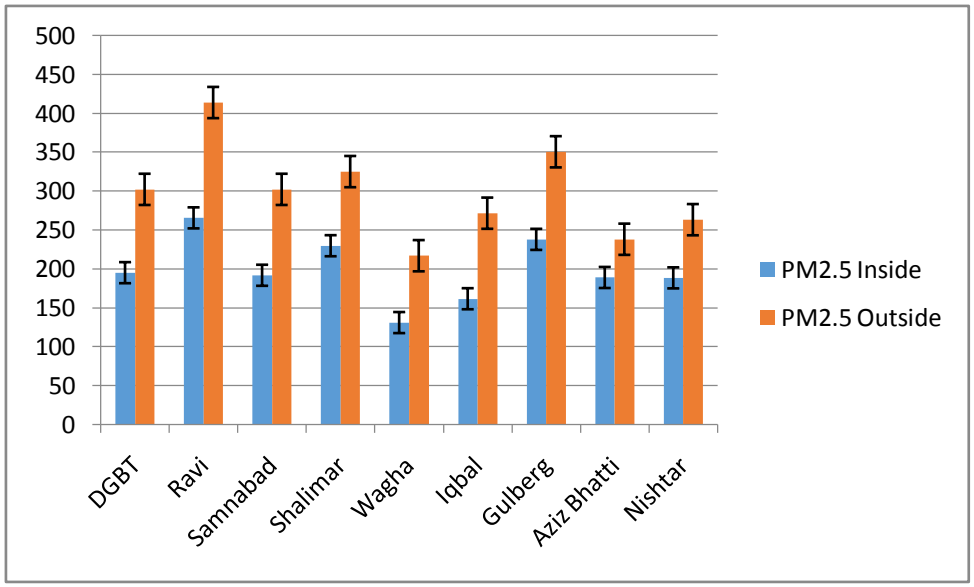


**Figure No 9 Concentration of $PM_{2.5}$**

Figure 9 shows a comparison of $PM_{2.5}$ concentration between school groups of different towns. Results were compared inside and outside of the schools. Results show that $PM_{2.5}$ concentration was high in Ravi Town and low in Wagha inside the school. $PM_{2.5}$ concentration was high in Ravi Town and low in Wagha outside the schools. The converted value of $P.M_{2.5}$ was very much high than the standards set by NEQS. The standard value is 15µg/$m^3$ but the data collected from towns elaborates its very much high value.

**$SO_2$**

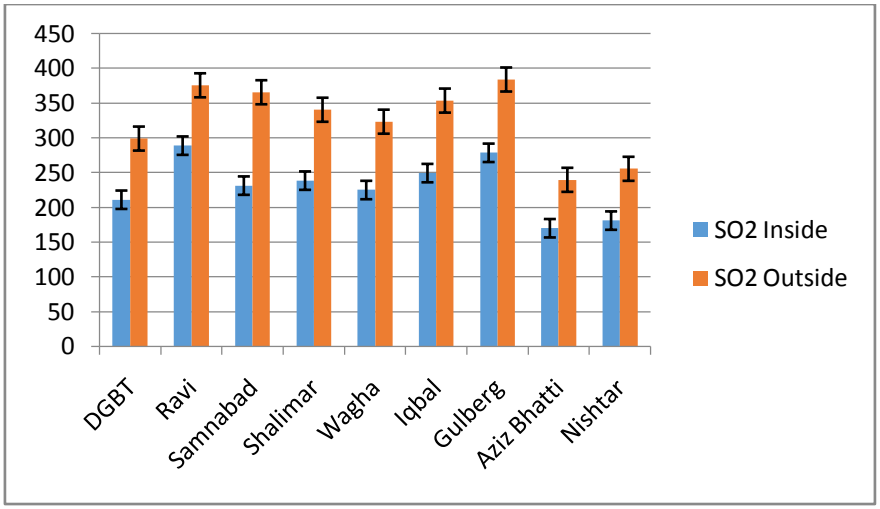


**Figure No 10 Concentration of $SO_2$**

Figure 10 shows a comparison of $SO_2$ concentration between school groups of different towns. Results were compared inside and outside of the schools. Results show that $SO_2$ concentration was high in Ravi Town and low in Aziz Bhatti inside the school. $SO_2$ concentration was high in Ravi Town and low in Aziz Bhatti outside the schools.

**VOCs**

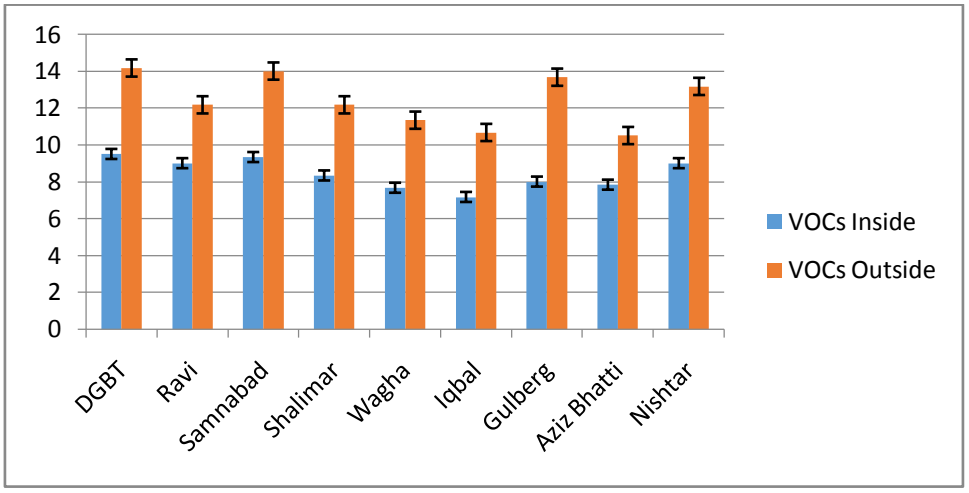


**Figure No 11 Concentration of VOCS**

Figure 11 shows a comparison of VOCs concentration between school groups of different towns. Results were compared inside and outside of the schools. Results show that VOCs concentration was high in Data Gang Baksh Town and low in Iqbal Town inside the school. VOCs concentration was high in Data Gang Baksh Town and low in Aziz Bhatti outside the schools.

**Mean Pollutants Value**

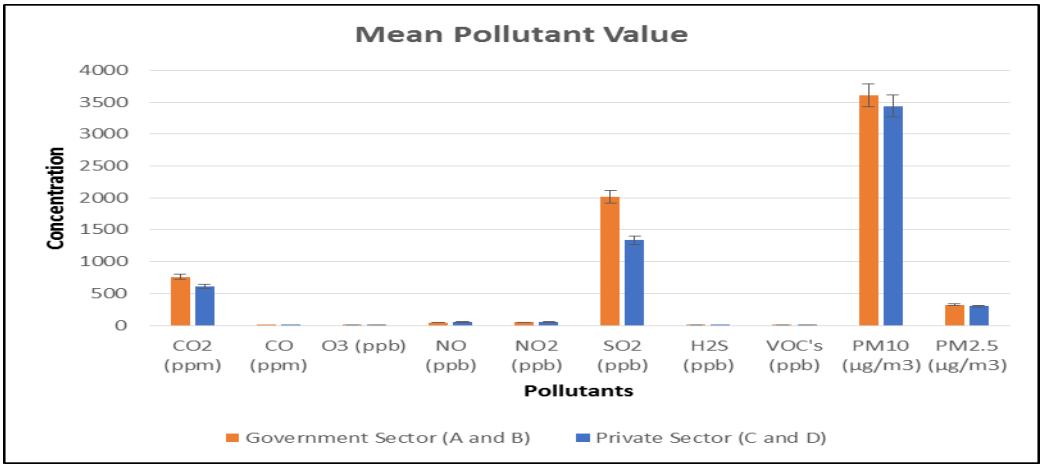


**Figure No 12 Mean Concentrations of Pollutants in School**

Pollutants $PM_{2.5}$, $PM_{10}$, CO, $CO_2$, NO, $NO_2$, $SO_2$, $H_2S$, $O_3$ and VOCs found in air through many sources. The concentration of these pollutants measured in volumetric units in air have been converted to compare them with standard values of these pollutants given by National Environmental Quality Standards (NEQS). The standard value of the pollutants are $CO_2$ (1000ppm), CO (10mg/$m^3$), $O_3$ (130µg/$m^3$), NO (40µg/$m^3$), $NO_2$ (80µg/$m^3$), $SO_2$ (120µg/$m^3$), $H_2S$ (0.47ppb), VOC's (25ppb), $PM_{10}$ (150µg/$m^3$), $PM_{2.5}$ (15µg/$m^3$). Values are converted by this formula:

$$\mu g/m^3 = \frac{ppm \times Molecular\ Weight \times 1000}{22.4}$$

**Discussion**

Air pollution is becoming a sensitive issue about public health worldwide. It is creating acute, chronic and worse impacts on human's health, plants, equipment, ecosystem and short term effect on visibility (Fenger, 1999; Riga-Karandinos, 2005). Air quality has become a challenge in big cities because people are exposed to high risk by pollutants. In developed countries, 75% population resides in urban areas whereas the urban ratio in developing countries is more than 35% causing negative impacts on air quality (Wolf, 2002; Agrawal *et al.* 2003; Vargas, 2003; Brajer *et al.* 2006; Oudient *et al.* 2006).

Air pollution in cities has become more overwhelming due to increasing population. An abandoned increase in population direct towards the industrialization without taking natural strategies about topography and meteorological conditions. The population has become double today as compare to past some decades (Baldasano *et al.* 2003). Population increase is directly proportional to: increase variety of mobile facilities for transportation of products, increase needs of space, material, energy, food and comfort. These demands

lead towards the utilization of natural resources by deforestation. A number of mobile sources like road automobile and stationary sources like mining, power plant, industry, commercial activities, trade centers and space heating etc are responsible for the maximum level of pollutants in ambient air of cities. It is a difficult task to meet the international standards of pollutant and control their emissions in developing countries because they have low economies (Ozden *et al.* 2008).

A number of pollutants are responsible for pollution in air that alter the composition of air and damaged the living population. Atmosphere has the ability to absorb the pollutant emitted from the different source of origin but the concentration of these pollutants is depending upon the emission source. The air pollution is not fixed in ratio but change its concentration temporarily or spatially. This change occurs due to meteorological conditions and topography of an area. Air pollutants such as Carbon-mono-oxide (CO), Nitrous oxides (NO, $NO_2$), Sulfur oxides($SO_2$), Hydrogen Sulfide ($H_2S$), Ammonia( $NH_3$), ground level ozone ($O_3$), Volatile organic compounds ($VOC_S$), polycyclic aromatic hydrocarbons ($PAH_S$) has harmful effects on health of humans (Brunekreef and Holgate, 2002). As pollutants emit from their sources, they dispersed, transport from source and are combine to form variety of secondary pollutants. This phenomenon occurs in atmosphere. Ground level ozone forms when Oxides of nitrogen combines with the $VOC_S$ in atmosphere (Fenger, 1999). The combination of primary or secondary pollutant with oxides of sulphur leads to creation of secondary particulate matter (Atkinson, 2000). The oxidation of $NO_2$ forms $HNO_3$ and then changed into $NO_3^-$. These secondary pollutants are the main cause of reduced visibility, acidification and has deleterious impacts on humans (Riga-Karandinos and Saitanis, 2005)

Air pollution has become an alarming situation in Pakistan. The pollutants in air such as $PM_{2.5}$, $PM_{10}$, CO, $CO_2$, NO, $NO_2$, $SO_2$, $H_2S$, $O_3$ and VOCs have been reached to their maximum level in metropolitan cities. The maximum concentration of these pollutants is found about 200m near to the roadways and heavy loaded roads (Brugge *et al.* 2007). Thus, the schools and buildings in this vicinity has more exposure to pollutants.

This study was conducted to estimate the concentration of air pollutants in public and private schools of Lahore. It was found that the level of $CO_2$ was increased as compare to standard value 1000ppm. The value of $CO_2$ was higher in government school as compare to the private schools. Inadequate ventilation system is the cause of high concentration of $CO_2$ in classrooms. Through opening and closing of windows repeatedly, an inadequate air passage was occur caused high $CO_2$ value. The other factor is no of pupils present in the classrooms. (Pegas et al 2011) was found that the high concentration of $CO_2$ is responsible for high concentration of other indoor air pollutants in classrooms. The mean concentration of $CO_2$ in government schools is 438.31 and in private schools are 349.80. The significance value in case of $CO_2$ is less than 0.05 which means the null hypothesis is rejected. The concentration is higher in government school than private school.The mean concentration of $NO_2$ in government schools is 19.11 and in private schools are 17.11. The significance value in case of $NO_2$ is less than 0.05 which means the null hypothesis is rejected. The mean concentration of $SO_2$ in government schools is 326.33 and in private schools are 278.36. The significance value in case of $SO_2$ is less than 0.05 which means the null hypothesis is rejected.The mean concentration of COin government schools is 0.98 and in private schools are 0.76. The significance value in case of CO is less than 0.05 which means the null hypothesis is rejected. The mean concentration of $H_2S$in government schools is 15.81 and in private schools are 12.6. The significance value in case of $H_2S$ is less than 0.05

which means the null hypothesis is rejected. The mean concentration of NOin government schools is 35.85 and in private schools are 29.70. The significance value in case of NO is less than 0.05 which means the null hypothesis is rejected.The mean concentration of $NO_x$ in government schools is 36.29 and in private schools are 32.92. The significance value in case of $NO_x$ is less than 0.05 which means the null hypothesis is rejected.The mean concentration of $O_3$ in government schools is 12.6 and in private schools are 8.5. The significance value in case of $O_3$ is less than 0.05 which means the null hypothesis is rejected.The mean concentration of $PM_{10}$ in government schools is 374.21 and in private schools are 275.40. The significance value in case of $PM_{10}$ is less than 0.05 which means the null hypothesis is rejected.The mean concentration of $PM_{2.5}$ in government schools is 298.12 and in private schools are 198.79. The significance value in case of $PM_{2.5}$ is less than 0.05 which means the null hypothesis is rejected. The mean concentration of VOCsin government schools is 19.10 and in private schools are 8.4. The significance value in case of VOCs is less than 0.05 which means the null hypothesis is rejected.

## Conclusion

The air quality condition of government school is dangerous as compared to private school. The mean concentrations of all the parameters were above the permissible values (PEQS) in both the private and government schools. There should be proper check and balance and rules and regulations as these conditions are severe, not healthy for the children studying there.

**Acknowledgement:** The authors thank to University of Veterinary and Animal Sciences Lahore, Pakistan for financial assistance for this study.

## References

Abrar A, Sundas W, Perveen F, Habib M. 2014. Air Quality Monitoring of some Gaseous Pollutants at selected points in Gullberg II, Lahore, Pakistan. Int Res J Environ Sci. 3(6): 38-47.

Agrawal M, Singh B, Rajput M, Marshall F, Bell JNB. 2003. Effect of air pollution on peri-urban agriculture: a case study. Environ Pollut. 126: 323–9.

Air quality guidelines.Global update 2005.Particulate matter, ozone, nitrogen dioxide and sulfur dioxide. Copenhagen, WHO Regional Office for Europe, 2006.

Anne M, Vincent B, Laurent H, Phiippe S, Reges GD. 2006. Impact of Urban atmosphere pollution on coronary disease. Europ Heart J. 27: 2275-2284.

Ayuni NA, Juliana J, Ibrahim MA. 2014. "Exposure to PM10 and NO2 and association with respiratory health among primary school children living near petrochemical industry area at Kertih, Terengganu," J Medical and Bioengine. 3(4): 282-7.

Aziz A, Jalaludin J, Bakar SA. 2014. Indoor air pollutants exposure and the respiratory inflammation (feno) among preschool children in Hulu Langat, Selangor. Adv Environ Bio. 8(15): 164-70.

Aziz K, Ali Z, Nasir ZA, Colbeck I. 2015.Assessment of airborne particulate matter (pm2.5) in university classrooms of varrying occupancy. J Anim Plant Sci. 25(3): 649-655.

Baldasano JM, Valera E, Jimenez P. 2003. Air quality data from large cities.Sci Total Environ. 307: 141–65.

Barber N. 2008. World in Focus-Focus on Pakistan, World Almanac Library, Stamford.

Brajer V, Mead RW, Xiao F. 2006. Valuing the health impacts of air pollution in Hong Kong.J Asian Econ. 17: 85–102.

Branis M, Rezacova P, Domasova M. 2005. The effect of outdoor air and indoor human activity on mass concentrations of PM10, PM2.5, and PM1 in a classroom. Environ Res. 99: 143-149.

Brunekreef B. Holtage ST. 2002. Air pollution and health. The Lancet.360: 1233.

Carrier M, Apparicio P, Se´guin AM, Crouse D. 2014. Ambient air pollution concentration in Montreal and environmentalequity: Are children at risk at school? Case Studies on Transport Policy. 2: 61–69.

Choo CP, Jalaludin J, Hamedon TR, Adam NM. 2015. Preschools' indoor air quality and respiratory health symptoms among preschoolers in Selangor. Procedia Environ Sci. 30: 303-308.

Daisey JM, Angell WJ. 1999. Indoor air quality, ventilation and health sympto schools: an analysis of existing information. Proceedings of the 8th In Conference on Indoor Air Quality and Climate – Indoor Air. 99: 1-6.

EEA, 2003. Exposure of population to exceedances of EU air quality standards.

Fenger J. 1999. Urban air quality. Atmos Environ. 33: 4877–4900.

Fromme H, Heitmann D, Dietrich S, Schierl R, Körner W, Kiranoglu M, Zapf A, Twardella D. 2008. Air quality in schools - classroom levels of carbon dioxide (CO2), volatile organic compounds (VOC), aldehydes, endotoxins and cat allergen. Gesundheitswesen.Article in German. 70(2): 88-97.

General Accounting Office. 1995. School facilities: condition of America's schools, U.S. GAO Washington, D.C., GAO/HEHS-95-61.

Hashmi DR, Shaikh GH, Usmani TH. 2005. Measurement of Major Ambient Air Pollutants at Urban Background Site of Karachi. J chem soci Pak.27(4).

Hou Y, Liu J, Li J. 2015. Investigation of Indoor Air Quality in Primary School Classrooms. Procedia Engineering. 121: 830 – 837.

Jones AP. 1999. Indoor air quality and health.Atmos Environ. 33: 4535–4564.

Kalimeri KK, Saraga DE, Lazaridis VD, Legkas NA, Missia DA, Tolis EI, Bartzis JG. 2016. Indoor air quality investigation of the school environment and estimated health risks: Two-season measurements in primary schools in Kozani, Greece. Atmos Pollution Res.7(6):1128-1142.

Khan A, Al-Salem S. 2007. Primary and secondary pollutants monitoring around an urban area in the state of Kuwait: A three years study. Res J Chem Environ. 11: 77.

Madureira J,Paciência I,Rufo J, Ramos E, Barros H, Teixeira JP,Fernandes EO. 2015. Indoor air quality in schools and its relationship with children's respiratory symptoms. Atmos Environ. 118: 145-156.

McConnell R, Islam T, Shankardass K, Jerrett M, Lurmann F, Gilliland F, Gauderman J, Avol E, Künzli N, Yao L, Peters J, Berhane K. 2010. Childhood Incident Asthma and Traffic-Related Air Pollution at Home and School. Environ Health Perspect. 118: 1021–1026.

NARSTO. 2004. Particulate Matter Science for Policy Makers: A NARSTO Assessment. McMurry M, Shephard M, Vickery J. (Eds.), Cambridge University Press, Cambridge, England.

Nicell JA. 2005. Assessment and regulation of odour impacts. Atmos Environ. 43: 196–206.

Oudinet J-P, Méline J, ChelmickiW, Sanak M, Magdalena D-W, Besancenot J-P. 2006. Towards a multidisciplinary and integrated strategy in the assessment of adverse health effects related to air pollution: the case study of Cracow (Poland) and asthma. Environ Pollut. 143: 278–84.

Pegas PN, Alves CA, Evtyugina MG, Nunes T, Cerqueira M, Franchi M, et al. Seasonal evaluation of outdoor/indoor air quality in primary schools in Lisbon. J Environ Monit. 13(3): 657-67.

Pakistan EPA/ World Bank. 2006. Strategic Country Environmental Assessment: Rising to the Challenges. Draft May 2006.

Pakistan EPA/JICA. 2001. Three Cities Investigation of Air and Water Quality with Analytical Comments (Lahore, Rawalpindi, and Islamabad). Pakistan Environmental Protection Agency and Japan International Cooperation Agency. June 2001.

Peng CY, Lan CH, Wu T J. 2009. Investigation of indoor chemical pollutants and perceived odor in an area with complaints of unpleasant odors. Built Environ. 44: 2106–2113.

Pope CA, Burnett RT, Thun MJ, Calle, EE, Krewski D, Ito K, Thurston GD. 2002. Lung Cancer, Cardiopulmonary Mortality, and Long-term Exposure to Fine Particulate Air Pollution. J Am Med Assoc. 9: 1132–1141.

Rasheed A, Viney P, Aneja VP, Aiyyer A, Rafique U. 2015.Measurement and Analysis of Fine Particulate Matter (PM2.5) in Urban Areas of Pakistan. Aerosol Air Qual Res. 15: 426–439.

Riga-Karandinos AN, Saitanis C. 2005.Comparative assessment of ambient air quality in two typical Mediterranean coastal cities in Greece.Chemosphere. 59: 1125–36.

Rufo JC, Madureira J, Paciência I, Aguiar L, Teixeira JP, Moreira A, Fernandes EO. 2016.Indoor air quality and atopic sensitization in primary schools: A follow-up study.Porto Biomed. J. 1(4):142–146.

Shiva SM, Nagendra, Harika PS. 2010. Indoor air quality assessment in a school building in Chennai City, India.WIT Trans Ecol Environ. 136(12): 275-286.

Shyamsundar P, Hamilton K, Segnestam L, Sarraf M, Fankhauser S.2001.Country assistance strategies and the environment, Environmental Economics Series Paper No. 81, World Bank, Washington, D.C. 66.

Silva RA, West JJ, Zhang Y, Anenberg SC, Lamarque JF, Shindell DT, Collins WJ, Dalsoren S, Faluvegi G, Folberth G, Horowitz LW, Nagashima T, Naik V, Rumbold S, Skeie R, Sudo K, Takemura T, Bergmann D, Cameron-Smith P, Cionni I, Doherty RM, Eyring V, Josse B, MacKenzie IA, Plummer D, Righi M, Stevenson DS, Strode S, Szop S, Zeng G. 2013. Global Premature Mortality Due to Anthropogenic Outdoor Air Pollution and the Contribution of Past Climate Change. Environ. Res. Lett. 8: 1–11.

Sunyer J, Esnaola M, Alvarez-Pedrerol M, Forns J, Rivas I, López-Vicente M, Suades-González E, Foraster M, Garcia-Esteban R, Basagaña X, Viana M, Cirach M, Moreno T, Alastuey A, Sebastian-Galles N, Nieuwenhuijsen M, Querol X. 2015. Association between Traffic-Related Air Pollution in Schools and Cognitive Development in Primary School Children: A Prospective Cohort Study. PLoS Med 12(3): e1001792.

Syafiqah AK, Jalaludin J, PohChoo C. 2015. Indoor Air Quality and Its Association with Respiratory Health among Malay Preschool Children in Shah Alam and Hulu Langat, Selangor. Adv. Environ. Biol. 9(9): 17-26.

Wang J,Smedje G,Nordquist T,Norbäck D. 2015. Personal and demographic factors and change of subjective indoor air quality reported by school children in relation to exposure at Swedish schools: A 2-year longitudinal study. Sci Total Environ.508: 288-296.

Wangchuk T, He C, Dudzinska MR, Morawska L. 2015.Seasonal variations of outdoor air pollution and factors driving them in the school environment in rural Bhutan.Atmos Environ. 113: 151-158.

Wolf C. 2002. Urban air pollution and health: an ecological study of chronic rhinosinusitis in Cologne, Germany. Health Place. 8: 129–39.

Wolkoff P, Nielsen GD.2001. Organic compounds in indoor air—Their relevance for perceived indoor air quality. Atmos Environ. 35: 4407–4417.

World Bank. 2006. Pakistan Strategic Country Environmental Assessment, The World Bank, South Asia Environment and Social Development Unit, Washington D.C.

Yang J,Nam I,Yun H,Kim J,Oh HJ,Lee D,Jeon SM,Yoo SH,Sohn JR.2015. Characteristics of indoor air quality at urban elementary schools in Seoul, Korea: Assessment of effect of surrounding environments. Atmos Pollution Res. 6(6). 1113-1122.