Air quality in the vicinity of a governmental school in Kuwait

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Abstract

There is a growing concern in Kuwait for the air quality in the vicinity of schools. The problem exacerbates due to the peak time congestions, which adversely affect the traffic flow, and air quality. Several exceedances of certain primary pollutants have been observed during the peak periods in the country.

Air quality in the vicinity of a governmental school was assessed in March 2006 for a period of two weeks using air pollution monitoring station which recorded continuously various pollutants' concentrations and meteorological variables in five minute intervals. The results show that during the weekdays, the measured pollutants emitted from the road traffic next to the selected school, such as carbon monoxide (CO) and nitrogen dioxide (NO_2), were always under the allowable limits for Kuwaiti air quality standards except for a single exceedance of NO_2 concentration at morning hours. On the other hand, the values of non-methane hydrocarbon pollutants were found to be several times above the Kuwaiti air quality standards throughout the investigated period. The suspended particulates (PM_{10}) concentrations have exceeded twice the limits of Kuwaiti air quality standards. A traffic counter was used to record the number of cars in the main road next to the school in fifteen minute intervals for ten days during the monitoring period for air quality. Statistical analysis was used in order to test whether there is any correlation between variations in the CO concentrations and the traffic frequency during working days' morning and afternoon periods. A relation was developed for predicting the necessary reduction in traffic based on the necessary reduction in CO concentrations.
Keywords: air pollution, Kuwait, schools, statistical analysis.

WIT Transactions on Ecology and the Environment, Vol 116, © 2008 WIT Press
www.witpress.com, ISSN 1743-3541 (on-line)
doi:10.2495/AIR080251

1 Introduction

In Kuwait, the urban population is growing at about 3.4% per year (Institute of Banking Studies, 2004). This increase in population in addition to the development of urban areas has in turn resulted in massive increase in the demand for transport. Motor vehicles and buses are the only means of road transportation in Kuwait. Road vehicles have increased as shown in Figure 1 with an average growth of 3.0% annually. The number of buses has not increased from year 1993 till year 2002 (Ministry of Planning, 2003), and its annual growth rate is negligible. Presently, there are 377.2 vehicles for every 1000 persons, which indicates that there are 2.65 persons per car (Institute of Banking Studies. 2004). Motor vehicles and buses cause environmental pollution due to exhaust emissions and tyres abrasion which depend on driving cycles, engine design and condition, fuel composition and air to fuel ratio. The vehicular emissions constitute harmful pollutants that affect the health adversely such as carbon monoxide, particulate matter, nitrogen oxides, and lead. A large proportion of urban pollution is mainly due to road traffic.

According to the Ministry of Education (MOE) in Kuwait statistical data and Ministry of Planning statistics, the school buses are serving approximately 17 to 18% of students in the governmental schools. Based on 2003/2004 statistics, there are 23,302 students using buses out of 131,597 total students. The rest of students mostly depend on private transportation.

According to various reports (The Ashdon Trust, 1994), it was proved medically that the vehicle air pollutants such as nitrogen dioxide (NO2), carbon monoxide (CO) and particulates (PM10) have pronounced effect on human health as shown in Table1.

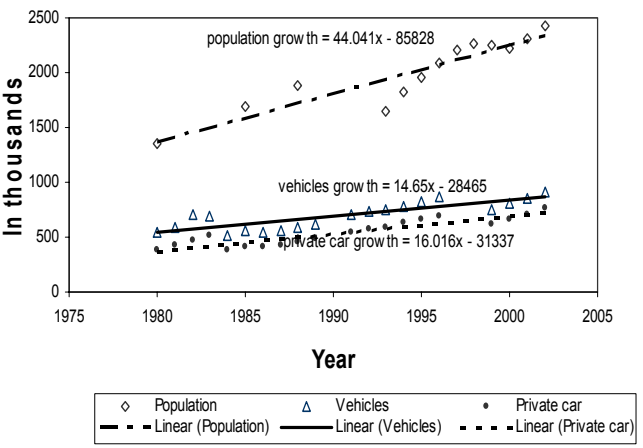

Figure 1: Vehicles in use and the growth of population (after Institute of Banking Studies, 2004).

Table 1: Health effects of vehicle air pollution.

Pollutant	Source	Health Effects
Nitrogen dioxide (NO2)	One of the nitrogen oxides emitted in vehicle exhaust	May exacerbate asthma and possibly increase susceptibility to infections
Particulates PM10, Total Suspended Particulates, Black smoke	Includes a wide range of solid and liquid particles in air. Those less than 10μm in diameter (PM10) penetrate the lung fairly efficiently and are most hazardous to health. Diesel vehicles produce proportionally more particulates than petrol vehicles	Associated with a wide range of respiratory symptoms. Long-term exposure is associated with an increased risk of death from heart and lung disease. Particulates can carry carcinogenic materials into the lungs
Carbon monoxide (CO)	It is mainly produced from petrol car exhausts	Lethal at high doses. At low doses can impair concentration and neuro-behavioral function. Increases the likelihood of exercise related heart pain in people with coronary heart disease. May present a risk to the fetus.
Ozone (O3)	Secondary pollutant produced from nitrogen dioxides and volatile organic compounds in the air	Irritates the eyes and air passages. Increases the sensitivity of the airways
Volatile organic compounds (VOCs)	A group of chemicals emitted from the evaporation of solvents and distribution of petrol fuel. Also present in vehicle exhaust	Benzene has given most cause for concern in this group of chemicals. It is a cancer causing agent which can cause leukemia at higher doses than are present in the normal environment

[Reproduced from "How Vehicle Pollution Affects Our Health" © The Ashden Trust 1994, p2.]

1.1 Study area

The governmental school which was selected for the study is located at the Mishref area in flat and homogeneous terrain region without any major local air pollution sources. This school is surrounded by Road 57 from north as shown in Figure 2 (www.municipality) which is considered a main street and from the east there is another school under construction. From west and south there are minor streets. The school is surrounded by residential houses and other governmental schools. The schools are adjacent to each other in one lane and there are no school buses at morning or afternoon for students.

The school area is 18,000 m² and has a parking in the front of the school entrance gate. About 985 students attended this school for year 2005/2006 during the time of monitoring the air quality.

Figure 2: Location of the governmental school at the Mishref area.

2 Methodology

Air quality and weather data were recorded at sampling intervals of 5 minutes by Kuwait Institute for Scientific Research (KISR) air monitoring station as shown in Figure 3 for two weeks. The measured data included the concentration of different pollutants such as carbon monoxide (CO), carbon dioxide (CO_2), methane (CH_4) and non-methane hydrocarbons, nitrogen oxides (NO_x), nitrogen dioxide NO_2, and suspended particulates (PM_{10}). In addition, the measured data included wind speed, wind direction, solar radiation and ambient temperature. The monitoring station was parked in Mishref area next to the governmental school entrance. A traffic counter was used to record the number of cars in the roads as shown in Figure 4 next to the selected school for every 15 minutes

throughout the study period. The measurements were taken in March 2006 including weekdays and weekend holidays. Statistical analysis of the recorded data was performed to establish whether there is any correlation between working days' variations in the levels of CO and the traffic frequency in the vicinity of the governmental school.

3 Discussion and results

3.1 Traffic

The hourly average weekday and weekend traffic flow profile is shown in Figure 5. The profile of the traffic indicates two peaks during the working days which are related to the opening time of the school and start of working hours in the morning and closing time in the afternoon and end of working hours. At weekends there are no sharp peaks and traffic flow gradually increases followed by slight decrease at afternoon time then minor increase in the evening.

Figure 3: Air monitoring station next to school.

Figure 4: Cars counters on the selected road.

3.2 Air quality

All the measured pollutants' concentrations in the vicinity of the selected school for a period of two weeks were compared with the allowable levels according to Kuwait's air quality standards. The Air Quality Standards (A.A.Q) in the residential areas for Kuwait, Federal US and California states are presented in Table 2. The mean concentration and the maximum and minimum level of CO, NO_2, and PM_{10} pollutants are shown in Figures 6 to 8. The CO concentrations are always under the allowable limits. The average non-CH_4 concentrations are always above the specified limits as shown in Figure 9. NO_2 concentration had exceeded the allowable limits 15 times (do you mean on fifteen occassions?) during the study period. The NO_2 exceedances are mainly due to road traffic since these values were associated with the increase of CO levels. Regarding PM_{10} levels it has exceeded the limits of A.A.Q (on two occassions) during the time of recording.

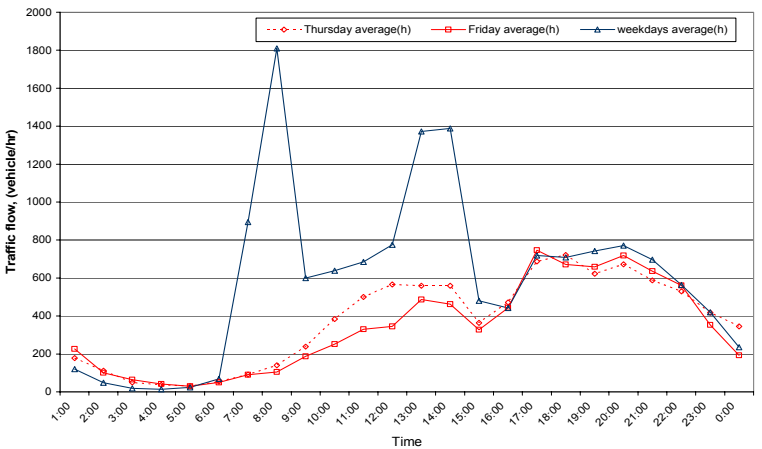

Figure 5: Hourly traffic flow for weekdays and weekend days at the site.

Table 2: The hourly air quality standards for Kuwait, Federal US and California State.

Pollutant	Kuwaiti Standard*	Federal Standard	California State standard
Ozone µg/m^3	157	235	180
CO (ppm)	30	35	20
NO2 (ppm)	0.1	-	0.25
PM10 µg/m^3	350 (24 hours)	150 (24 hours)	50 (24 hours)
Non methane HC	0.24 ppm for a period of 3 hours (6-9 AM)	-	-

*Al-Kuwait Al-Youm. 2001

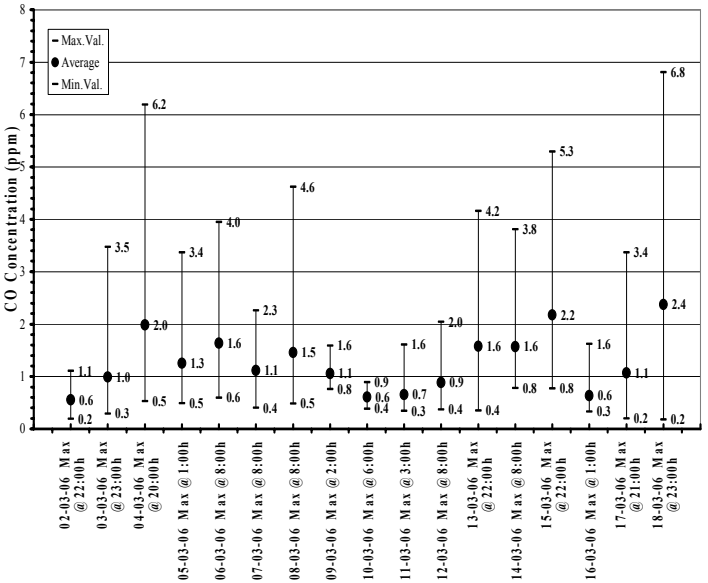

Figure 6: Mean, maximum, and minimum level of CO concentrations.

3.3 Statistical analysis

The recorded data for CO concentration and cars counts on every 15 minutes during the study period were analyzed taking into consideration the morning hours from 5:00hr -10:00hr and afternoon hours from 11:00hr -16:00hr. This strategy was adopted in order to decrease the influence of traffic in the surrounding area and to focus mainly on the traffic in the vicinity of the school, which is the main objective of this research. For the selected time periods, the measured CO concentrations are plotted against car counts for the 15 minutes intervals. A strong correlation is found in mornings showing 4.4 ppb car while in the afternoon the CO emissions were 1.3 ppb car depending on the traffic flow as shown in Figure 10. The dispersion of pollutants is slower in morning times than afternoon due to prevailing meteorological conditions, temperature, wind, and inversion layer. The equation, which was obtained from the morning trend of cars versus CO concentration, was used to predict the effect of reducing the number of cars according to the desired level of CO concentrations. Figure 11 presents the dependency of CO concentration reduction as a function decrease in number of cars on the road in the vicinity of the school. This correlation is very important and can be used to regulate the traffic according to desired reduction in air pollution. In this case 40% reduction in traffic leads to 32% reduction in CO concentration.

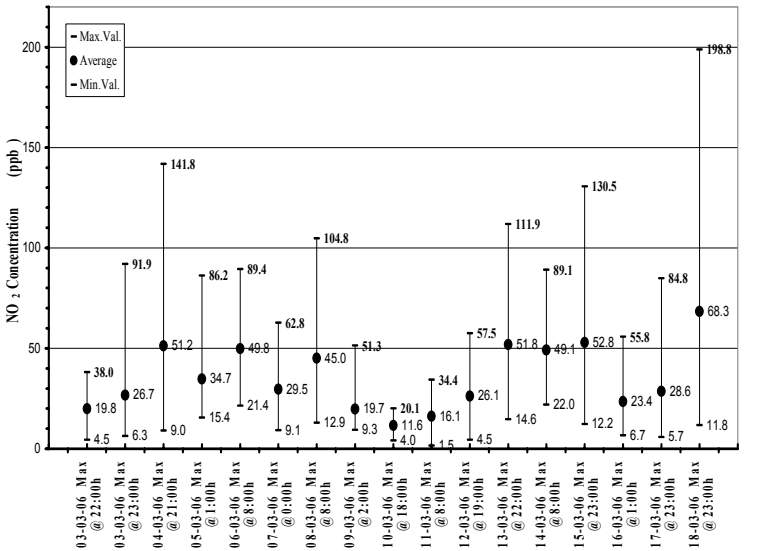

Figure 7: Mean, maximum, and minimum level of NO_2 concentrations.

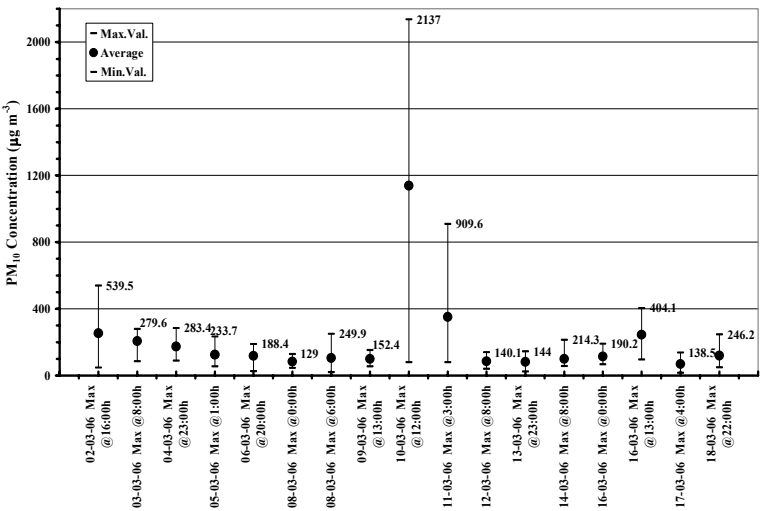

Figure 8: Mean, maximum, and minimum level of PM_{10} concentrations.

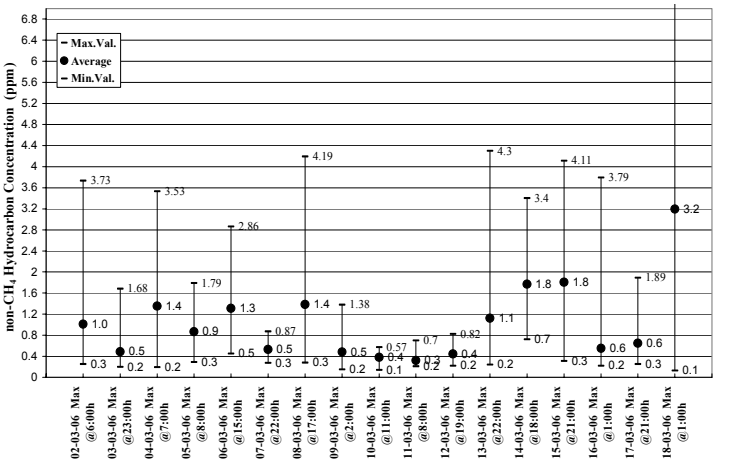

Figure 9: Mean, maximum, and minimum level of non-CH4 Hydrocarbon concentrations.

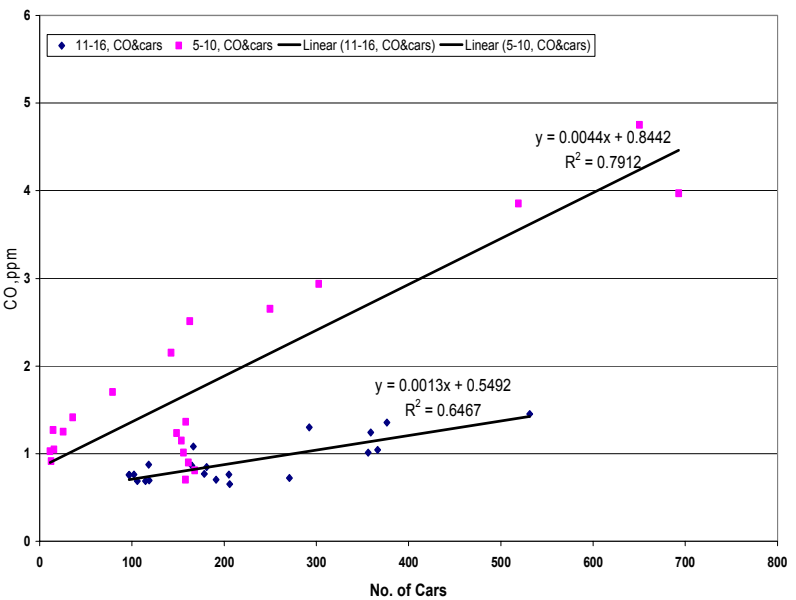

Figure 10: The correlation between CO pollutant and the number of cars (5 – 10 = morning hours; 11 – 16 = afternoon hours).

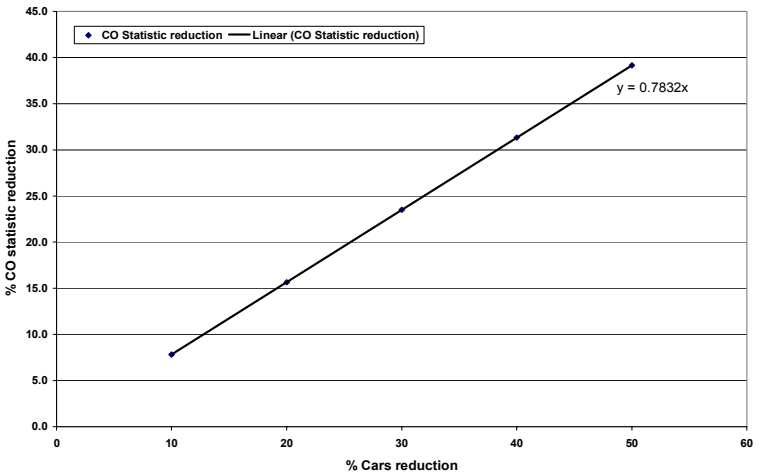

Figure 11: The predicted effect of decreasing the number of cars on CO concentration.

4 Conclusion and recommendation

It is important to maintain high standards of air quality around the schools in order to reduce the effect of traffic pollutants on health of children and their performance. High levels of pollution and traffic conjunctions are recognized as health risk.

Kuwait government should consider public transportation for the governmental schools students to abate traffic conjunction and associated air pollution problems in the country.

Protective measures such as introduction of school buses using superior quality fuel to combat high pollutants emissions are required to achieve good ambient air quality in the country.

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