Air pollution and road traffic in Kuwait

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Abstract

Kuwait having one of the highest GDP and the least fuel price provides an ideal opportunity for ownership of motorized vehicles. Weather has also a major role in this issue where in long summer (lasting about nine months), temperature sores to nearly 50 ºC very often and in short winter, and it drops to single digit value in early mornings and nights. The road transport is vital for the local inhabitants as the sole means of transport (commuting and transporting goods).

In the last decade, the motorized road vehicle fleet has grown significantly bringing unprecedented mobility to the burgeoning population. With the growth of vehicles, the fuel consumption has also increased. Motor vehicles are a critical source of urban air pollution (PM_{10}, CO, CO_2, NOx, O_3, SO_2 and VOC's). Air pollution is a serious health problem and accounts for hundred of millions of dollars for health care and welfare cost.

This paper focuses on the environmental impact of urban growth that has resulted into an unabated increase in the light vehicles fleet. Two case studies for Ambient Air Quality (A.A.Q) are presented and discussed in detail. The Environmental Protection Authority (EPA) in Kuwait is mitigating to reduce the increasing levels of air pollutants discharged regularly from motor vehicles and to take necessary measures for the implementation of severe checks to maintain strict compliance with air quality standard.
Keywords: Kuwait, road transport, fuel consumption, air pollution, urban growth, ambient air quality.

1 Introduction

Kuwait is situated on the north-western coast of Arabian Gulf. It borders Iraq, Saudi Arabia and Arabian Gulf (Fig.1). The total area of Kuwait is about 17,820 km² and is mainly arid land while urban development is on the coastline

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of the gulf. Kuwait is modern well developed and planned emerging economic country having 4450 km of total road network (3587 km paved) according to the statistical data for year 1999 [1].

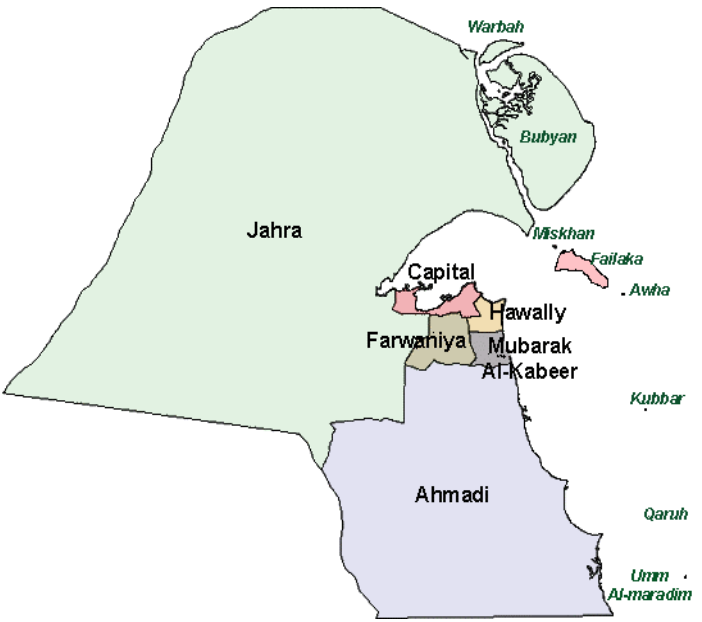

Figure 1: A detailed map of the state of Kuwait.

Crude oil is the only energy viable source and the major generating commodity in Kuwait. It accounts for nearly half of Gross Domestic Product (GDP), 95% of export revenues and 80% of government income [1]. The GDP per capita in Kuwait was around $16,000 in year 1999 which is considered high to some countries.

Transportation in Kuwait is a necessity and is essential for comfortable living as summer is extremely hot and humid at times. Summer season extends over seven months, from April to October and the temperatures reaches 50 ºC in July and August. For most of summer months, the difference between dry bulb temperature (DBT) and wet bulb temperature (WBT) is high, which reflects the dry and hot nature of Kuwaiti weather and very strong need for transportation.

2 Transportation in Kuwait

Transport sector is considered to be a huge consumer of energy in Kuwait. It was accounted for more than 24% of oil products consumption in year 1995 which is considered high compared to some GCC countries as shown in Table 1 [2].

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Motor vehicles and buses are the only means of transportation in Kuwait. Road vehicles represent 80% of the total transport fuel consumption. With increasing population in the country, road vehicles have increased from 543 thousands in 1980 to 912.8 thousands in 2002 with an average growth of 3.0 % annually [3] as presented in Fig 2. Such a rapid growth is directly the result of fast urbanization and affluence.

Today, there are 377.2 vehicles for every 1000 person which is considered high compared to OECD countries, excluding the United States where there are 366 cars per 1000 person [4]. The vehicle density is 51.3 vehicles per square kilometre of total area. Consequently, harmful exhaust emissions such as carbon monoxide and hydrocarbons are also expected to have increased which consequently contributes to local ozone, regional (acid rain) and global (CO_2) pollution [5].

2.1 Emissions regulations and inspection

An experimental test study was conducted by Kuwait Institute for Scientific Research (KISR) on vehicle exhaust emission [6]. This study examined 270 different types of gasoline motor vehicles (leaded fuel type) to measure the total percentage of concentrations of HC, CO, and NOx. Two types of tests were applied; first type when the motor vehicle is in state of idle, and the second type when the motor vehicle is in the state of accelerating. The results show that the emission rate of the vehicle is relatively higher than the vehicle emission in the United States of America, mainly because there were no emission legislations in Kuwait by that time. Vehicles were not tuned during maintenance to reduce pollutant emission.

A further study was also conducted by KISR with the cooperation of Public Traffic Department (DPT) and Environment Protection Council (EPC), to assess the pollutant levels of CO and HC, and PM_{10} which are emitted from the exhaust of 2324 gasoline motor vehicles (leaded type fuel) in Kuwait based on make and engine cylinders [7]. The results of this study show that 47% and 33% of vehicles would be over the maximum permissible levels of concentration for both CO and HC respectively.

Table 1: Gasoline consumption and percentage share of gasoline in total oil consumption in GCC countries.

Country	Gasoline Consumption (1000 Barrels/Day)			Percent of Gasoline of Total of Oil		
	1999	2000	2001	1999	2000	2001
United Arab Emirates	34.3	32.6	32.7	11.9	11.1	11.0
Bahrain	7.8	8.4	8.8	39.0	38.2	38.3
Saudi Arabia	219.6	223.7	224.3	20.1	19.2	19.1
Qatar	10.3	10.9	10.8	46.8	47.4	47.0
Kuwait	39.4	39.3	39.3	24.0	24.3	24.1

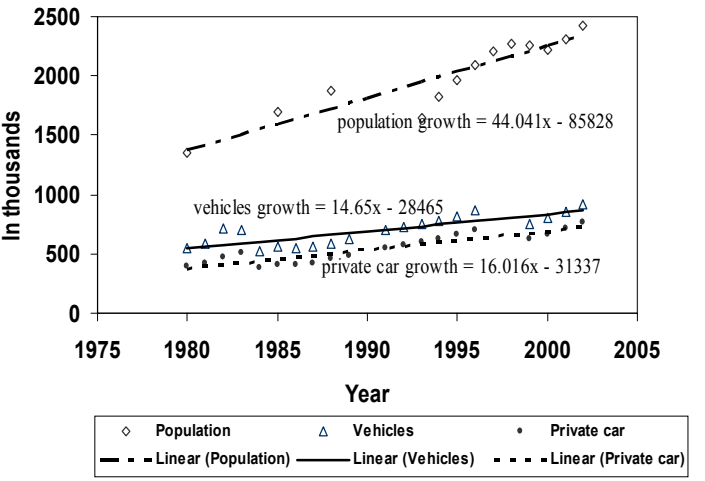

Figure 2: Population growth and increase in vehicles in use as a function of time [3].

The Arabian Gulf Cooperation Council (GCC) with the contribution of Kuwait issued many procedural details in 1984 explaining the method of testing gasoline car air pollution (CO, HC, and NOx) and published the allowed limits of exhaust air pollution for different car weights [8] as illustrated in Table 2.

EPC presented a report regarding the methods of reducing the pollution from the exhaust of motor vehicles [9]. The recommendations put forward in their study were, the usage of unleaded gasoline and a restricted Kuwaiti standard specification for the allowed pollution emitted from the exhaust of motor vehicles.

Kuwait is obliged to introduce new policies to abate gases emissions since offering its signature to the United Nations Framework Convection on Climate change. Kuwait has introduced a new policy to fuel composition to control emissions as the case in reducing the lead content of leaded where the lead is considered a pernicious component of particulate matter and creates a severe neurological health hazard especially for children living near high traffic streets. Kuwait has practiced the price policy to encourage the citizens to use unleaded fuel where the price cost of unleaded gasoline is less than the price cost of lead gasoline. In addition, the numbers of leaded gasoline filling stations are very few to eliminate the use of leaded in fuel near future. It was found that the unleaded gasoline lowers exhaust HC emissions due to changes in the characteristics of combustion chamber deposits [10].

Table 2: The weight of car and the maximum limit air pollution emitted from the exhaust.

Car Weight (kg)	CO (g)		HC (g)		NOx (g)	
	Model Test	Accep-tance Test	Model Test	Accep-tance Test	Model Test	Accep-tance Test
Less than 750	65	78	6	7.8	8.5	10.2
750-850	71	85	6.3	8.2	8.5	10.2
850-1020	76	91	6.5	8.5	8.5	10.2
1020-1250	87	104	7.1	9.2	10.2	12.2
1250-1470	99	119	7.6	9.9	11.9	14.3
1470-1700	110	132	8.1	10.5	12.3	14.8
1700-1930	121	145	8.6	11.2	12.8	15.4
1930-2150	132	158	9.1	11.8	13.2	15.8
2150-3500	143	172	9.6	12.5	13.6	16.3

3 Results and discussions

Kuwait EPA publishes the pollution levels within Kuwait every year in the annual report. The annual report [11] is based on the data collected in year 1998 consisting of various pollutants including PM_{10}. It is noticed that concentration of PM_{10} is the highest in summer months and reduces to almost 50% in winter months. This is not only due to traffic but meteorological weather conditions, dusty weather in summer and rainy in winter. Heavy vehicles, buses, trucks contribute a lot to the PM_{10} concentrations.

Urban areas concentrations of PM_{10} for 1997, 1998 and 1999 are listed in Table 3. The concentration of PM_{10} in 1997 was very high and decreased significantly in 1998 but increased again in 1999. The peak value of PM_{10} concentrations always existed in the summer months. It is obvious that PM_{10} concentrations are the highest in Shuwaikh and Mansoria areas. The analysis of the PM_{10} samples revealed that other than calcium and sodium metals, iron and lead are substantially high which is strongly related to road traffic. The concentration of metallic lead is low in summer months due to increase in sample size caused by dust storms. In winter months, the concentration of lead is almost tripled indicating the true levels of pollutants.

The annual average concentrations of main air pollutants for 1998 were measured from fixed air monitoring stations for the entire state of Kuwait (Table 4). It is clear that the concentrations of NOx, CO, SO_2 and HC are much higher in commercial and urban areas reflecting the traffic activity while non-urban areas such as Al-Jahra, Um-AlHaiman, and Um-Alaish have very low recorded values.

An extensive research activity has been initiated by KISR to assess the condition of light vehicle fleet in the state of Kuwait based on fuel consumption

and exhaust emissions. To combat this problem a broad monitoring program for fuel consumption and exhaust emissions for light vehicles will be commenced and inspection/maintenance strategy will be adopted.

3.1 Case study Jabria

Jabria is considered a very crowded area. It has a lot of building complexes, hospitals, schools, commercial buildings in addition to residential houses,. Air quality assessment study at Jabria residential area was done by Environmental Protection Authority in 1999. The purpose of this study was to measure different air pollutants concentrations for this area which has very high traffic density in its main streets and entrances.

A mobile lab was moved to a location next to Hadi Hospital [12] as shown in Fig 3 to measure the different pollutants during the period from Sept. 21 to the 30th of Oct. 1999. The mean concentration and the maximum and minimum level of pollutants concentrations were registered as shown in Table 5. The data in this table illustrates the concentration levels which are varying and most of the time it is under the allowable limits [13] and some times it is exceeding limits of Air Quality Standards (A.A.Q) as indicated in Table 6. The pollutants that are exceeding the levels are mainly NO_2 and non-CH_4. Both of these pollutants are mainly due to heavy traffic on main highway (Fahaheel Road) that passes near the selected site (about 50 m) where the mobile lab was parked. There is high activity in the morning and afternoon due to location of many schools and main hospital in this area.

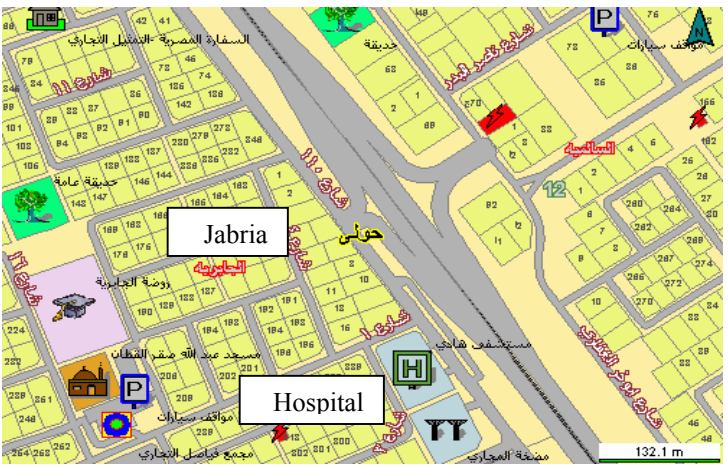

Figure 3: The location of the mobile lab next to hospital at Jabria area.

Table 3: Monthly average of the mean conc. Of S.P.M. collected during 1997,1998, and 1999.

Month	Districts								
	Shuwaikh			Mansoria			Kuwait city		
	1997	1998	1999	1997	1998	1999	1997	1998	1999
Jan.	67.38	71.6	79.4	55.12	65.1	63.5	55.12	65.3	72.8
Feb.	100.31	77.6	84.35	96.19	68.7	66.46	96.19	70.1	42.44
Mar.	66.89	91.1	252.5	90.38	88.5	114.2	90.38	86.8	327.0
Apr.	199.82	111.6	116.6	139.29	99.5	107.4	139.29	73	140.5
May	112.80	116.5	258.2	106.54	107	260.8	106.54	110.5	290.3
Jun.	132.31	181.4	215.3	148.78	123.3	188.9	148.78	144	187.7
Jul.	502.4	181	280.3	312.92	203.4	254.4	312.92	130.7	293.8
Aug.	581.52	144.1	216.8	803.43	133.9	171.3	803.43	153.9	190.3
Sep.	141.23	149.8	181.5	151.92	134.3	150.2	151.92	128.1	130.6
Oct.	105.07	178.9	188.9	90.67	154.4	158.3	90.67	132.9	131.9
Nov.	76.96	154.8	121.0	59.96	123.8	100.6	59.96	110	97.3
Dec.	55.04	137.0	101.5	43.31	103.6	77.4	43.31	99.1	73.6

Table 4: Annual mean concentration of different pollutants during 1998.

Pollutants	Mansoria	Rabia	Rigga	Al-Jahra	Um-AlHaiman	Um-Alaish
TS ppb	22.1	17.07	22.7	-	-	-
THC ppm	2.61	2.07	2.9	-	-	-
non-CH_4 ppm	0.62	0.28	0.75	0.28	0.31	0.29
CH_4 ppm	2.03	1.8	2.26	2.08	2.13	1.55
NOx ppb	112	42.99	113.45	27.76	31.3	8.67
NO_2 ppb	52.9	20.1	35.0	13.7	19.7	5.9
CO ppm	1.92	1.15	1.3	1.36	0.16	0.4
O_3 ppb	21.7	16.7	23.0	31.8	35.8	35.8
NH_3 ppm	-	-	0.14	-	-	-

Table 5: Mean concentration of different pollutants at Jabria Area.

Pollutants	Conc. (ppb)				Conc. (ppm)
	CO	n-CH_4	CH_4	O_3	NO_2
Mean Std. Dev.	2.1±1.9	0.94±0.6	2.05±0.25	11.0± 10.0	133.0±76.0
Max. reading	16.6	4.17	3.32	131	544
Min. reading	0.1	0	1.7	0	0
Ex. limit% per hour	1.5	9.8	-	0.2	88.7

Table 6: The air quality standards in residential areas.

Pollutant	Hourly (ppb)	8 Hours (ppb)	Daily (ppb)	Annually (ppb)
NO2	100	-	50	30
CO	30000	10000	8000	-
SO2	170	-	60	30

3.2 Case study: Mansoria

Mansoria area is considered part from the capital city. It is mainly residential area surrounded by main roads, Cairo Street, Maghreb highway, Ist ring road, and IInd ring roads; containing many schools, banks and a big super-market as shown in Fig. 4. Mostly the pollution in this area is representing motor road pollutants.

A fixed station was installed in this area to monitor and measure hourly the concentration of different pollutants among these pollutants total hydrocarbons, methane CH_4, non-methane hydrocarbons, nitrogen oxide, NOx, carbon monoxide, CO, and ozone. Annual concentration measurements of different

pollutants during year 1998 are presented in Table 7. The measured values of NO_2 concentrations are above the standard levels published by Kuwait EPA. The main cause for these high levels is excessive motor vehicles that use the surrounding freeways linking downtown with other residential areas in the State of Kuwait.

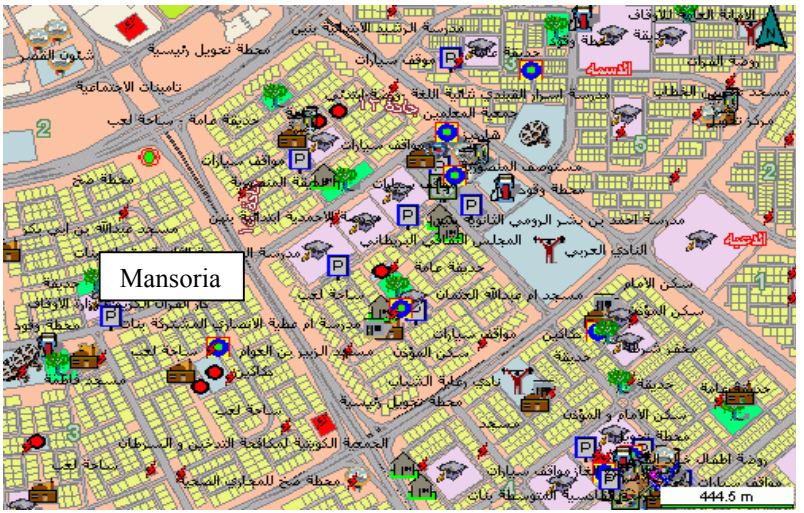

Figure 4: Mansoria residential area map in Kuwait Governate.

Table 7: Annual Mean Concentration, Monthly Maximum Mean, and % of Hourly Reading Exceeds the A.A.Q. Stds. reading of different pollutants.

Pollutants	Mansoria		
	Mean	Max.	% Exc. Limits
THC (ppm)	2.61	3.09	-
non-CH_4 (ppm)	0.62	1.23	-
CH_4 (ppm)	2.03	2.91	-
NOx (ppb)	112	196.1	-
NO_2 (ppb)	52.9	100	0.4
CO (ppm)	1.92	4.58	0.0
O_3 (ppb)	21.7	60.0	-
NH_3 (ppm)	-	-	-

4 Recommendation

Kuwait government has addressed to the problem of high lead concentrations and forced the population to adopt non-leaded fuel for their vehicles. Number of

fuel filling stations with leaded fuel has been decreased to be minimal to implement vehemently non-leaded fuel policy.

There is a need to conduct a comprehensive study to assess the current status of energy consumption and environmental pollution caused by motor vehicles in transportation sector in Kuwait. Protective measures to combat superfluous consumption of energy and high pollutants emissions are required to achieve ambient air quality in the country.

Kuwait government has a long term plan to build new residential colonies with school, banks, hospitals and commercial centre to abate traffic conjunction and associated air pollution problems in capital city.

The quality of the fuel has been improved by adding oxygenated hydrocarbons to reduce carbon monoxide emissions from light vehicles.

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