Mapping and Validation of Noise Level in Kuwait City

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ABSTRACT: Noise Pollution Modeling Software "CUSTIC 2.0" has been used to assess the noise level due to traffic flow in Kuwait City during weekdays and weekends at three different time slots. Geographical Information System (GIS) was used to generate, store and retrieve the spatial data and map the sound levels using an interpolation technique. In general as the traffic flow increases the noise pollution levels tend to increase in their magnitude. During the weekdays, the traffic noise is generally higher in the morning period than in the afternoon time due to higher car numbers, while in the weekends, the traffic noise is higher in the afternoon than in morning time due to increase of traffic movement for shopping purposes. In general, the maximum noise level was measured between March 2011 and February 2012 was 83 dBA and 82 dBA for weekdays and weekends respectively. The predicted levels of noise have been calculated as 80 and 70.5 dBA for weekdays and weekends. The two predicted and measured noise levels were compared with the noise level measurements at 25 different locations in Kuwait City. A good agreement between the measured and predicted results was found.

KEYWORDS: Traffic noise; Noise model; Traffic flow; Noise measure; Noise prediction

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INTRODUCTION

Noise pollution of the vehicular traffic has undesirable impact not only on the human health but also on the quality of life, thus it becomes one of the serious factors in urban development planning (Lipfert *et al.*, 2006; Belojevic *et al.*, 2008). There are various factors that contribute to increase of noise levels. One of main factors is increasing urban population, which contributes to higher traffic volume and intensity (Al-Awadhi, 2014). Due to cost and time restrictions, the modeling of noise is often preferred to its measurement in most cities (Abo-Qudais & Alhiary, 2007) and such modeling takes into account various traffic parameters.

Noise dispersion modeling can be helpful in decision making processes for reducing the noise pollution in the capital cities (Gündoğdua *et al.*, 2005). The influence of excess noise on human body can be due to direct effects upon the auditory system, non-auditory physiological processes and on purely psychological mechanisms (Tonin, 2000). The level of noise pollution in Kuwait's urban areas is high enough to adversely affect the human health and well-being of the residents (Al-Mutairi *et al.*, 2011). Also, due to the exponential growth of the population in Kuwait, the number of private vehicles owned by individual citizens has increased and hence this adds up to the noise pollution in the roads. With the rapid expansion of the infrastructures in metropolitan Kuwait, it is virtually definite that traffic noise will shortly assume a dangerous dimension, and will be a ground of escalating fear for both the public and liable policy makers. Accordingly, this paper aims to provide a widespread picture on the current status of traffic noise levels in one of rapidly growing city in the Arab Gulf countries, using a simple, low cost software solution "CUSTIC 2.0". This study aimed at: quantifying temporal and spatial dynamics of urban traffic-induced noise pollution in Kuwait city; assessing noise levels based on national noise standards; evaluating the results of the model with the noise level measurements.

METHODOLOGY

The CUSTIC 2.0 Noise Pollution Modeling Software was used to assess the noise level due to traffic flow in Kuwait city. The model calculates attenuation due to noise source enclosures and other noise control measures, the distance from the source to the receiver, the noise source size, type and directivity, barriers and natural topographical features and sound absorption in the air. Figure 1 illustrates the input data including sources (traffic roads presents line source), ambient (climate) data, grid size and scale. Based on data entered the software calculates noise levels and presents those levels in form of iso-lines, numerical grid or color gradient.

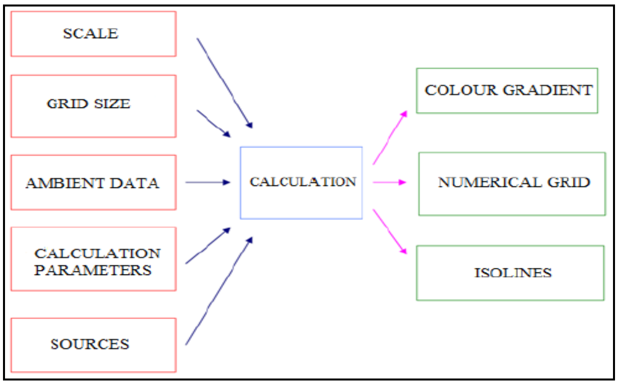


Figure 1. Input and output data of the software

In the calculation of CUSTIC 2.0, a road traffic noise level is estimated through average vehicle velocity and vehicles number data. Automatic traffic counts were carried out by the Ministry of Interior- Traffic Department for one week at thirty roadway intersections in Kuwait city (Fig. 2).The volume counts included all vehicle-size categories. The locations of traffic survey were spread over the network of main roadways in Kuwait city. Table 1 presents the average hourly number of vehicles running on the main roads in Kuwait city; it ranges from 611 to 2792 vehicles/hr. Traffic volumes were considerably heavier during the afternoon (peak hours). The maximum speed of traffic assigned in the city road ranged between 60 to 80 Km / hr (Table 2).

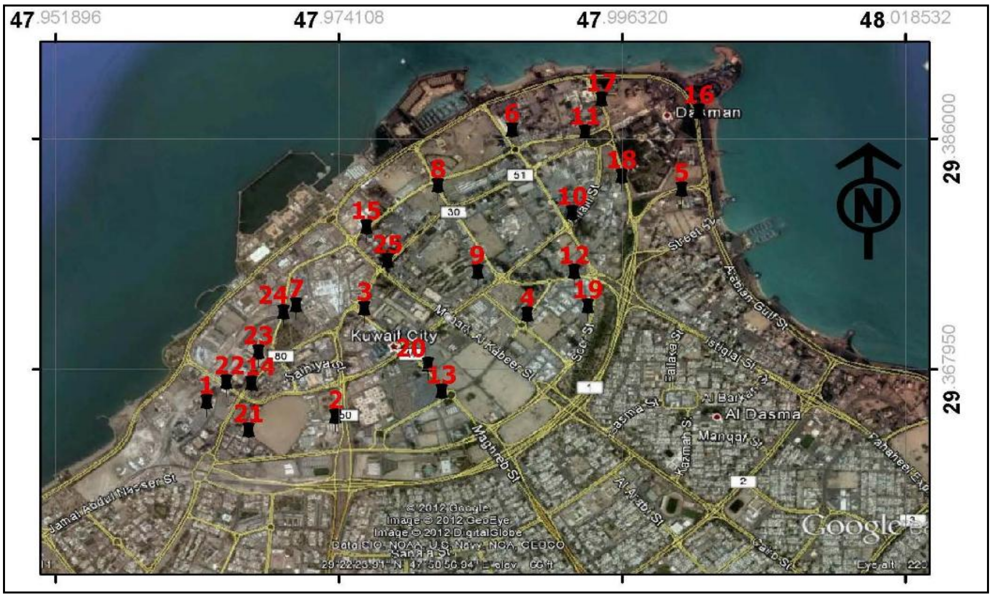


Figure 2. Selected intersections for traffic survey

Table 1. Traffic survey counts

Location		Working days			Weekend		
		7-14	14-22	22-7	7-14	14-22	22-7
1-1	A	3262	2432	445	1617	2323	635
	C	2022	1322	169	712	1318	178
1-2	A	2600	2084	403	1437	2108	493
	B	1569	1205	154	892	1150	160
1-3	A	3074	2203	384	1258	2104	612
	B	316	170	22	93	41	17
1-4	A	3014	2072	383	1092	2013	642
	D	347	420	98	281	480	193
1-5	B	2289	1148	287	654	1370	448
1-7	A	1776	1652	214	712	1462	381
	C	2549	1270	332	691	1644	521
3-1	A	1068	855	94	490	702	83
	B	1444	1236	194	901	1140	171
3-2	A	1746	1541	236	1016	1348	232
3-3	A	2039	1562	243	959	1278	225
3-5	A	1628	1117	181	739	822	152
	D	1646	1235	155	749	1014	148
3-8	A	1344	1084	179	652	823	154
	D	887	562	102	339	386	144
3-9	D	1163	866	145	514	781	151
4-1	A	1861	1704	217	1985	1879	232
	B	1610	1313	187	1501	1347	181
	D	825	671	85	927	782	82
4-2	A	1583	1111	120	585	845	130
	B	1594	1075	145	749	914	119
4-3	A	1514	1381	172	860	1209	159
	B	1348	1069	104	783	1060	143
4-4	A	1735	1282	165	728	1058	131
	B	926	950	172	755	637	150
	D	1174	1125	116	660	939	106
4-5	A	1970	1502	190	820	1185	187
	D	1839	1604	212	993	1354	213
4-7	A	1066	945	110	490	754	108
	D	1769	1431	217	795	1023	190
4-8	A	763	565	99	441	596	130
	D	953	845	125	478	695	136
4-9	A	1128	859	176	480	819	248
	D	1705	1411	213	695	1031	185
	E	785	574	110	364	397	100
5-2	A	3125	2584	362	1895	2400	400
	B	744	428	88	328	355	94
5-3	A	1453	942	99	503	727	70
	D	1442	1030	123	475	780	128

TRANSACTIONS ON SCIENCE AND TECHNOLOGY

Location		Working days			Weekend		
		7-14	14-22	22-7	7-14	14-22	22-7
5-4	A	747	567	39	271	396	41
	D	2033	1562	164	854	1231	154
5-5	A	1699	1526	228	820	1215	243
	D	2053	1981	303	1266	1649	282
6-1	A	2537	2451	336	2557	2209	316
	B	1217	1009	95	811	928	80
	C	1284	941	235	994	798	186
	D	1484	1451	283	866	1186	218
	F	145	140	16	120	117	15
6-2	A	3170	2751	427	2089	2201	440
	B	1654	1172	147	801	819	113
	C	3252	2081	363	1260	1703	205
6-3	A	1626	1499	260	698	1158	200
	B	2845	1702	439	1634	1778	337
	D	3842	2465	370	1552	2049	267
6-4	A	1192	1029	150	510	1053	149
	B	1334	783	109	433	605	83
	D	1951	1574	153	892	1220	142
6-5	A	2422	2027	404	1121	1931	345
	B	3333	2598	638	1949	2811	543
	D	3285	3268	491	1972	3017	509
6-6	A	2984	2725	526	1420	2118	456
	B	401	412	79	170	453	120
	D	87	96	14	47	75	17

Table 2. Vehicle Velocity (Km/h) for main streets

Location	**Vehicle Velocity (Km/h)**	**Location**	**Vehicle Velocity (Km/h)**
Fahad Al-Salem St.	60	East Maqwa Rd.	60
Soor St.	80	Mobarak Al Kabeer St.	60
Jahra Rd.	80	Khalid Ibn Al Waleed St.	60
Riyath St.	100	Ali Al Salem St.	60
First Ring Road	100	Ahmad Al Jaber St.	60
Maghreb Expy.	120	Gulf St.	80
Cairo St.	80	Sharq Market	60
Istiqlal St.	100	Jaber Al Mobarak St.	60

RESULT AND DISCUSSION

Ambient data used in the current study are 25ºC for temperature and 40% relative humidity. This data is used as an input to describe the change of sound levels as one move toward or away from a sound source; i.e., attenuation coefficient related with temperature and relative humidity, describes the reduction of sound per unit distance.

The following assumptions of input data were taken into consideration to generate noise mapping model:

• Assumption for building data:

• All the buildings have same type of construction material.

• The built-up area will be assumed acoustically hard because it is easy to check in the field.

• There is no occurrence of noise due to façade effect from the wall of the buildings.

• Assumption for traffic data:

• The road traffic includes all types of vehicles such as light vehicles, small vehicles, heavy vehicles and light trucks.

• The noise is emitted from the centerline of roads.

• The type of road surface is same in the entire study area and it is assumed to be asphaltic concrete.

• The road surface of study area is flat without any undulations in ground surface.

• Assumption for noise absorbing area like open ground:

• The noise absorbing areas such as road material, trees and water is not considered in the noise calculation model.

• In the noise calculation, only the noise from road traffic is considered not the background noise.

• During noise calculation it is assumed that there is no noise barriers located in the noise map.

GIS has been used to map noise pollution by displaying spatial variations of pollution is via a contour map. Accordingly, the software generated noise levels model, for three periods of time during working days as well as weekend, and presented in form of iso-lines, numerical grid. For the purpose of model calibration, a Sound Level Meter, Casella CEL-490, was utilized to measure the noise level at 25 different locations in Kuwait city (Fig. 3). The Sound Level Meter (SLM) used for noise assessment, consists of microphone, amplifier, electronic filter and digital readout. SLM shows the Sound Pressure Level (SPL),measured in decibel (dB), instant-by-instant using standard specified time constant responses designated 'Fast' and 'Slow'. Sound Level Meter was calibrated before and after each measurement. The microphone was set-up on tripods at a height of approximately 1.5m above the grounds and included full environmental protection against adverse weather conditions. All noise sources (e.g., traffic, human voices, pumps and other machinery, wind) were included in the analysis and a distance of at least five meters was maintained from traffic noise sources during the measurements.

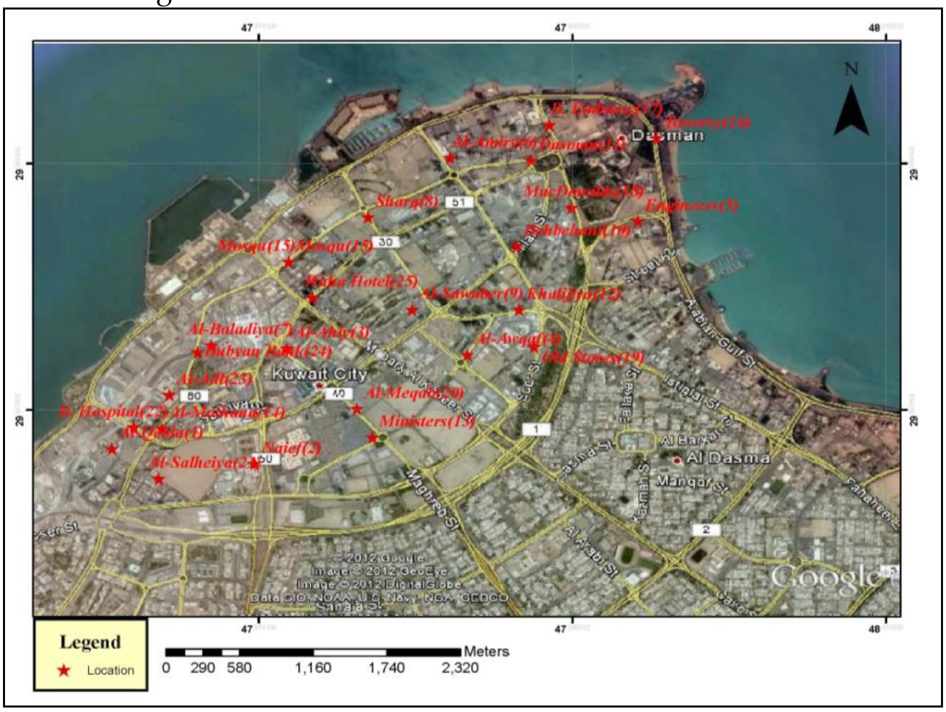


Figure 3. Noise Measurement locations in Kuwait City

Table 3. Traffic noise level (dBA) during different periods of time

Period	Working Days			Weekend		
	Layer	Area (km)	Percentage	Layer	Area (km)	Percentage
7-14	55-60	1.14	12.21	55-60	3.9	41.65
	60-65	4.83	51.61	60-65	3.36	38.84
	65-70	2.75	29.46	65-70	1.64	17.54
	>70	0.63	6.73	>70	0.18	1.97
14-22	55-60	2.06	22.06	55-60	2.7	28.89
	60-65	4.55	48.57	60-65	4.32	46.19
	65-70	2.35	25.15	65-70	2.04	21.79
	>70	0.39	4.22	>70	0.29	3.14
22-7	50-55	0.86	9.16	45-50	0.76	8.09
	50-55	4.47	47.76	50-55	4.34	46.44
	55-60	2.73	29.27	55-60	2.91	31.13
	60-65	1.23	13.21	>60	1.34	14.34
	>65	0.06	0.59			

Spatial Noise Level

The spatial noise pollution level (Leq) resulting contour maps for Kuwait city during working days and weekends, and during day and evening times are illustrated in Figures 4 and 5.

(A) (B) (C)

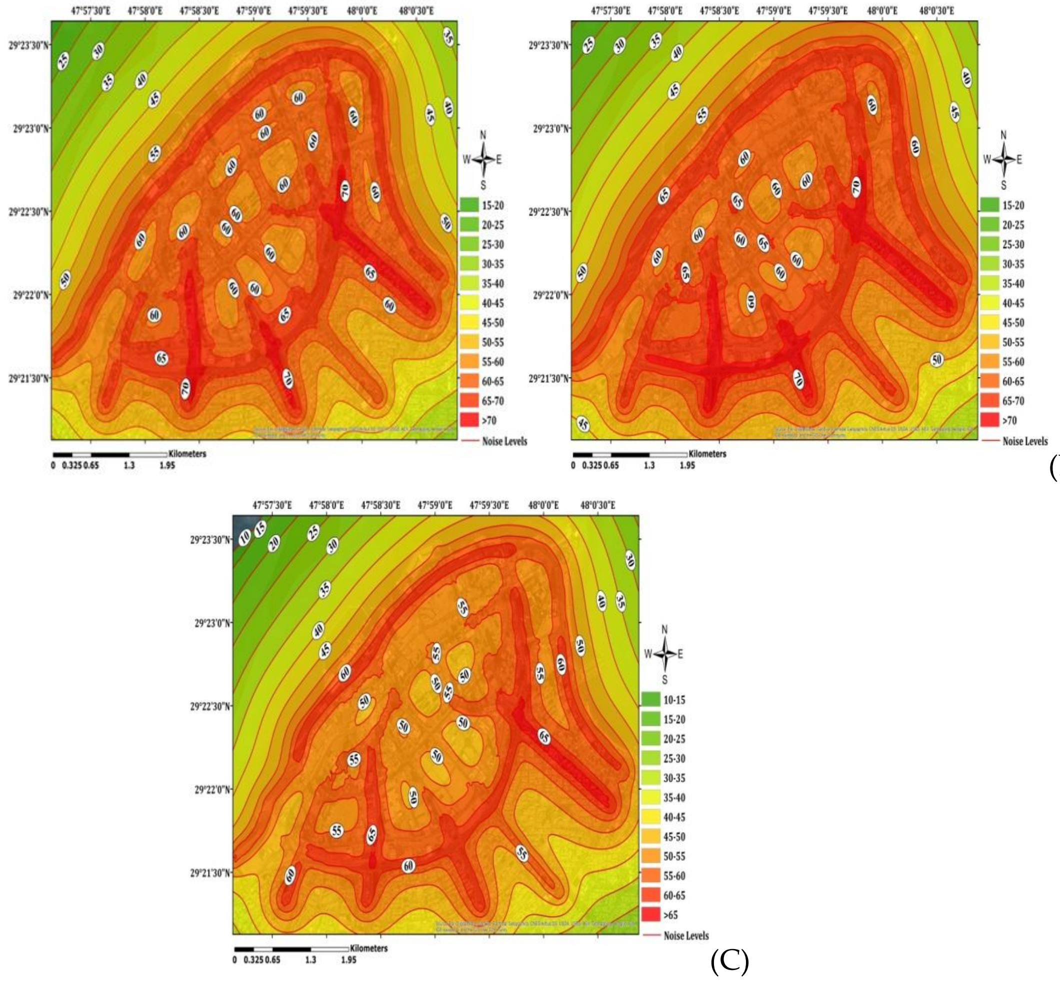


Figure 4. Contour plots for noise dispersion modeling for morning (period 7-14h), afternoon (period 14-22h) and evening (period 22-7h) during working days

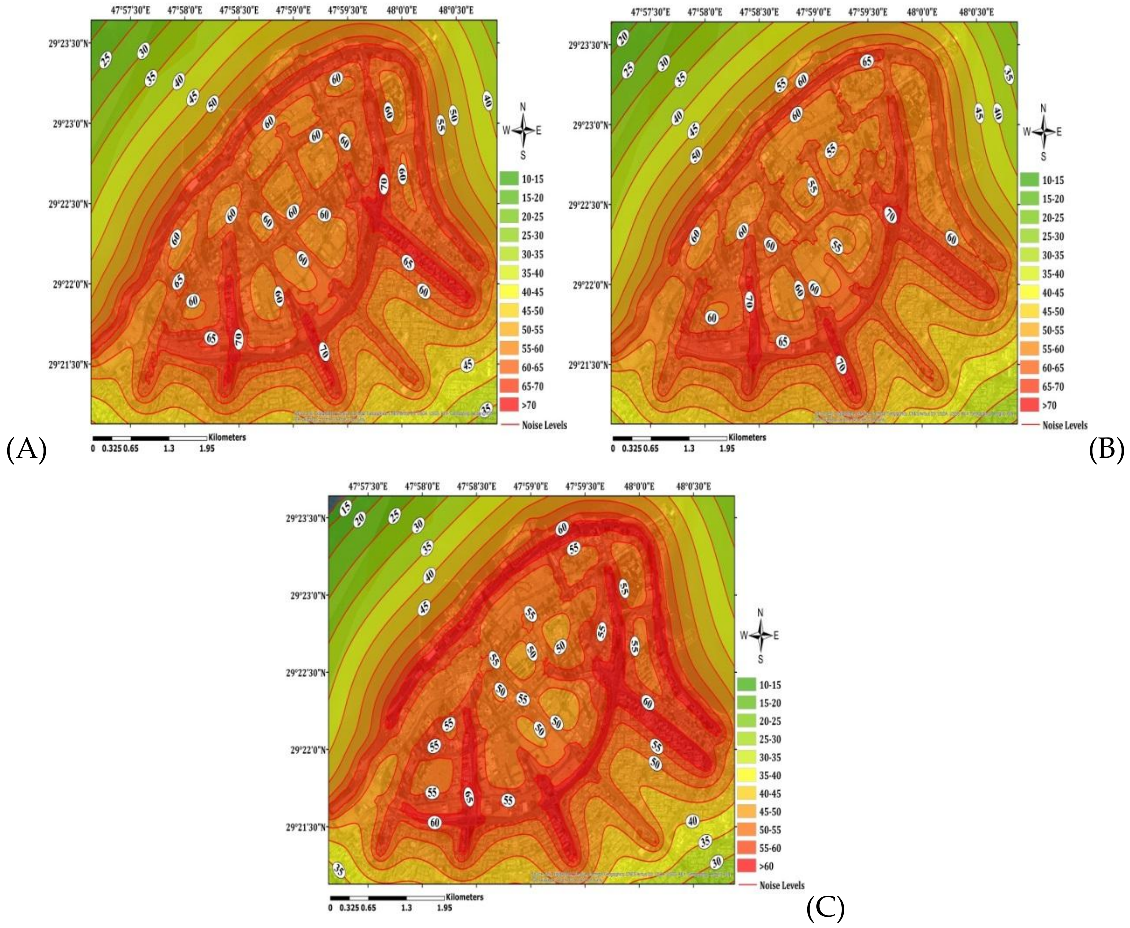


Figure 5. Contour plots for noise dispersion modeling for morning (period 7-14h), afternoon (period 14 22h) and evening (period 22-7h) during working days

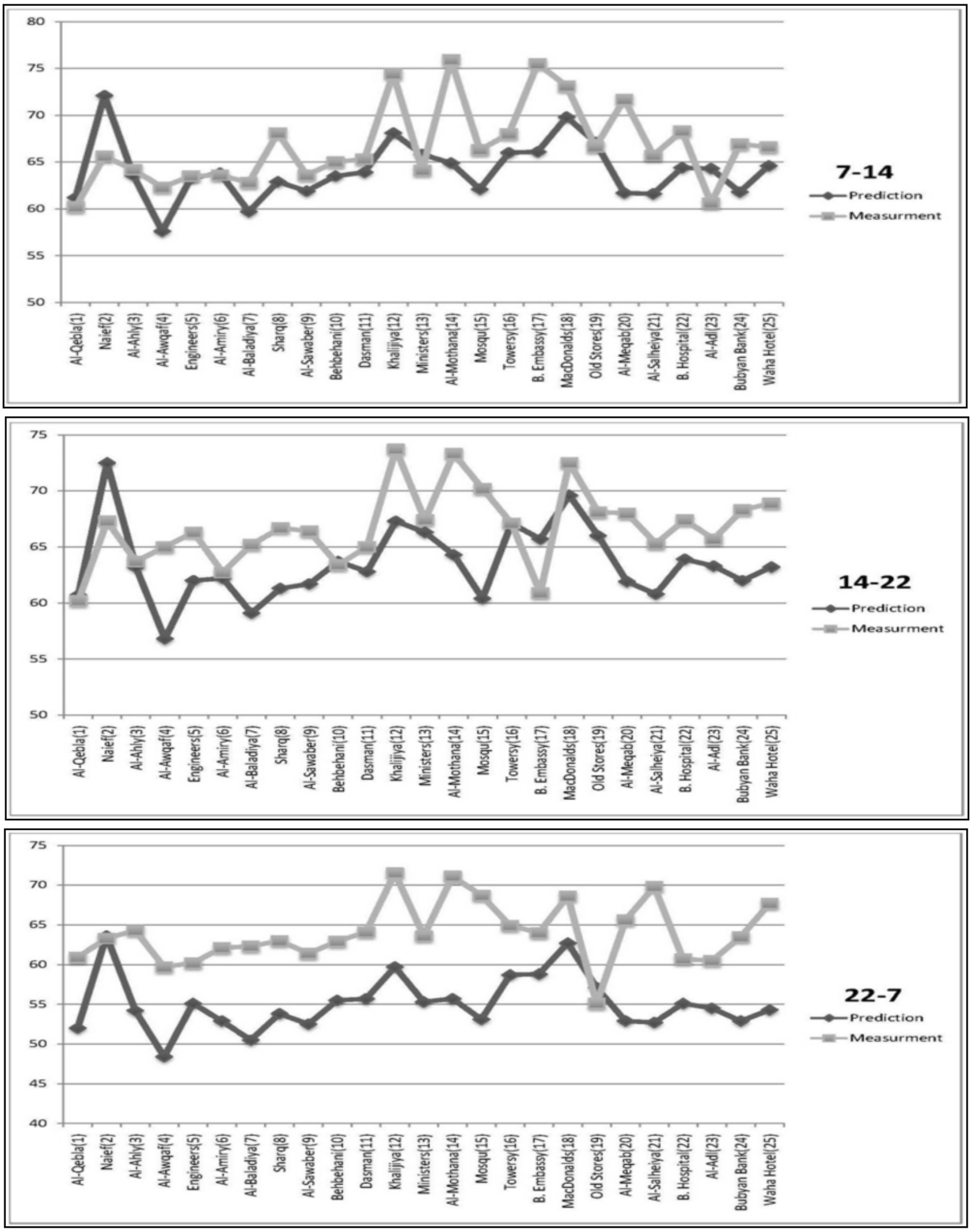
The distribution patterns of noise levels in morning and evening periods are generally similar during weekends, with elevated noise level during evening time. This may confirm that a significant portion of the noise is generated from vehicles in the city, mostly due to increase of traffic movement for shopping purposes in the weekend's evenings. However, distribution patterns of noise levels in morning and evening period differ during working days; with obvious elevated noise level during the morning time in the downtown area where many governmental offices, headquarters of most Kuwaiti corporations and banks are located, while the distribution patterns of noise levels in the vicinity of the area covering the southwestern entrance to the city remain similar. Table 4 shows the maximum noise levels predicted by the model during morning, afternoon and evening periods at working and weekend days.

Table 4. Maximum sound level predicted by the model

Date	Longitude (UTM-38z)	Latitude (UTM-38z)	Noise Level
Working Days	7-14		
	790801.15	3253164.22	74.99
	14-22		
	790754.57	3253257.38	74.22
	22-7		
	790940.89	3253071.06	67.04
Weekend	7-14		
	788798.24	3251533.95	72.5
	14-22		
	790847.73	3253024.48	73.36
	22-7		
	790801.15	3253210.80	66.13

Model calibration

For the purpose of model calibration the measured noise levels at 25 locations in the study area have been compared with noise levels predicted at the same locations at three time periods during working and weekend days. The comparison is illustrated in Figures 6 and 7. It appears that there is a good agreement between the measured and predicted values of the noise level. The predicted noise levels at most of the locations are lower than noise level values measured with an average percentage of 8.2%. This might be due to the effect of other noise sources in the vicinity of the surrounding area beside the traffic noise. Also it may be attributed to the limitations of the acoustic modeling with respect to ground absorption and meteorological conditions. Nevertheless, noise attenuates quickly with distance, generally within the range of six dB(A) for every doubling of the distance between the noise source and the receptor.

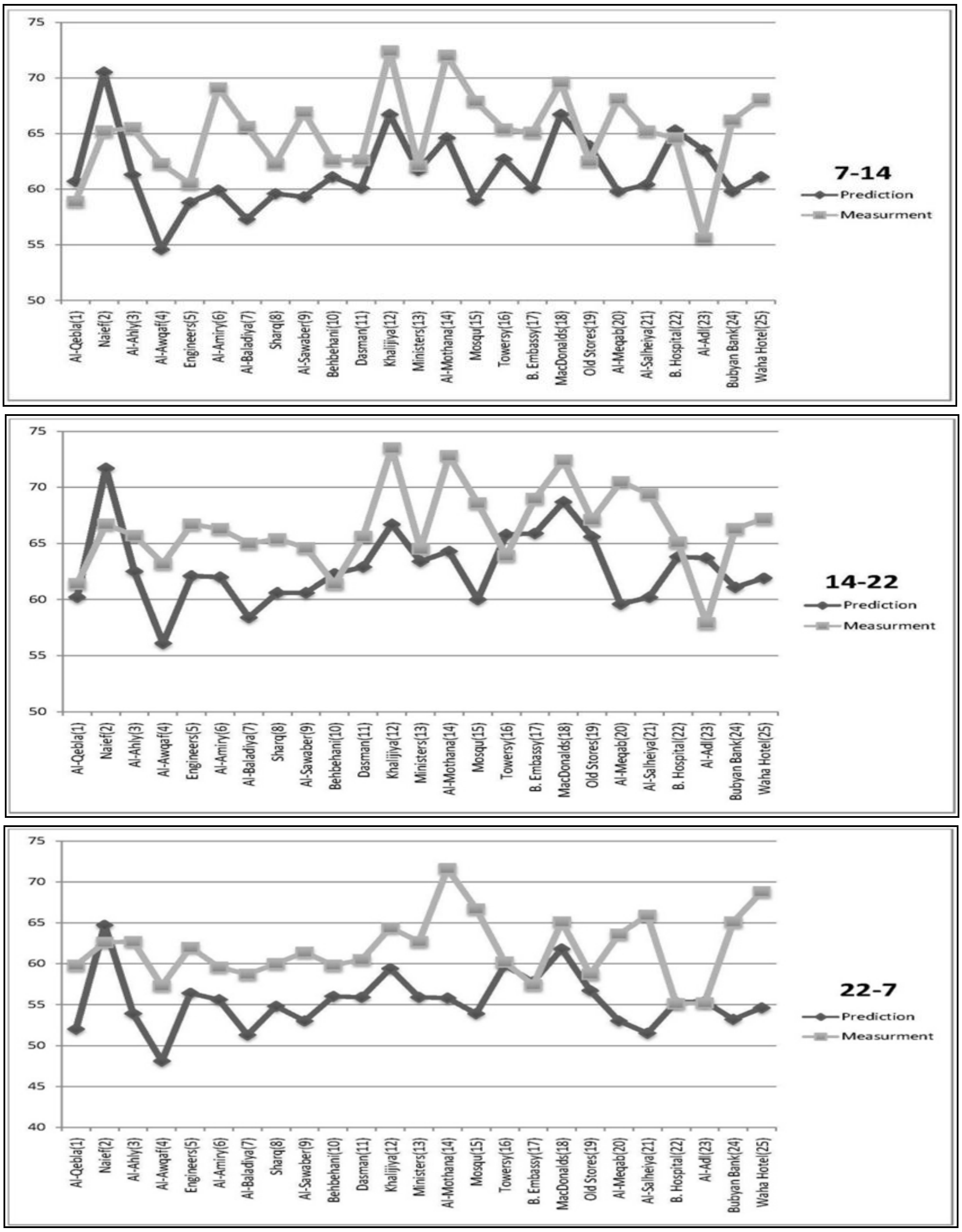


(A)

(B)

(C)

Figure 6. Comparison between measured and modeled values of L_{eq} during working days, (A) period 7-14h, (B) period 14-22h and (C) period 22-7h.



(A)
(B)
(C)

Figure 7. Comparison between measured and modeled values of L_{eq} during weekend days. (A) period 7-14h, (B) period 14-22h and (C) period 22-7h.

CONCLUSION

In summary, the following conclusions can be drawn from the current study:

(1) The results demonstrate that the levels of noise in the study area are greater than the national standard for urban areas (60dBA).

(2) Predicted Equivalent Average Sound Levels were mainly determined by traffic volume.

(3) The adopted model can be used to successfully predict noise pollution and could be useful in assessing the efficiency of any abatement techniques.

In order to achieve a sustainable transport, a fleet composition change is required. However, during recent years, number of cars has been increased. As a consequence raising awareness on the environmental benefits of non-motorized vehicles can encourage people to reduce noise pollution as well. This is especially practicable as the city is flat and with no considerable gradient.

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