International Journal of Applied Engineering and Technology ISSN: 2277-212X (Online)
An Open Access, Online International Journal Available at http://www.cibtech.org/jet.htm
2014 Vol. 4 (4) October-December, pp.36-42/Ali
Research Article

TRAFFIC NOISE LEVELS AND RESTRICTIONS IN ALEXANDRIA CITY, EGYPT

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ABSTRACT
This study concerns road traffic noise in Alexandria, the second biggest city in Egypt. Goals of this study are to carry out measurements to evaluate road traffic noise levels, whether these levels exceeded permissible noise levels set by Egyptian noise standard and policy to protect public health, to carry out restrictions to reduce noise levels for improving environmental conditions. Measurements taken for traffic noise levels, indicates that noise levels are higher than those set by Egyptian noise standards. L_{dn} = 80 dB and higher were recorded, while maximum permissible level is 60 dB. L_{dn} are calculated for 22 locations spread over different urban zones of city. It was found out that 95.5 % out of locations display L_{dn} are over 65 dB. 86.4 % out of total number of locations their L_{dn} are over 70 dB. Results of restrictions found that (i) in absence of horns, L_{dn} decreased at all sites reduction was 11.2 dB occurred in downtown area. (ii) In absence of horns, trucks and buses reductions in L_{dn} range between 6.2 to 14.3 dB. This shows that town planner can use various strategies to change traffic composition in order to achieve quieter city environments.

Keywords: *Traffic Noise, Measurements, Restrictions, Alexandria, Egypt*

INTRODUCTION
It is obvious clear that road traffic noise in Alexandria city causes much nuisance to the residences. They cannot relax, try to sleep, or concentrate in their activities and so on (Yoshida and Kawaguchi, 1997; Job, 1988; Seiichiro *et al*., 1996; Saadu and Ogisi, 1996; Onuu, 2000). Road traffic noise problems arose in Alexandria in 1980's due to population increase stemming from accelerated growth, internal immigration, the larger number of vehicles, motor vehicles which are poured and added into the already overcrowded streets. Alexandria (2006) was estimated to have populations of 7 million. Approximately half a million populations swell daily as workers flow into the city from surrounding area, clogging roads and rail lines every morning and evening. So there are traffic jam and traffic noise problems. In the last period the urban blocks of city adherence together and became one block. Many areas contain dense pattern of constant activity as commercial, administrative, tourist center, cultural institutions, business establishments, governmental offices, universities, and hotels, which together create a dense pattern of constant activity. So its roads are too crowded and there are traffic jams everywhere. Road traffic noise disturbs many activities and it is an urgent problem in Alexandria city. The purpose of this study are to carry out measurements to evaluate road noise levels, are these levels exceeded the permissible levels set by Egyptian noise standard and policy to protect public health and welfare, and carry out restrictions to reduce noise levels for improving environmental conditions.

Field Measurements
The purpose of road traffic noise monitoring was to obtain noise-level information which was representative for each site. This was obtained for 22 sites represent different kinds of roads as highways (road No.1), arterial (road No.2), collector (road No.3), and local roads (road No.4), located in different zones in the city. Zones are educational, residential, tourism, downtown, and industrial areas. Table 1 illustrates sites of measurements in Alexandria. The data were obtained at the noisiest point near the facades of a particular building facing the road. The sound level meter was portable and stood 1.2 m. A microphone was placed 1.0 m away from the facades of buildings and any reflective surface. The Sound exposure level was measured automatically by a precision integration sound level meter Bruel & Kjaer type 2230. All measurements were carried out during working days; the duration of each measurement in

each site was during 7:00 – 22:00 (day time) then from 22.00 – 7.00 (night time). Relative humidity and temperature of sites varied from 50 to 60 % and 20° to 30° C at the time of measurements. Restrictions were introduced to improve environmental conditions as: absence of horns, absence of horns and trucks, and absence of horns, trucks and buses. L_{dn} was measured before and after restrictions.

Table 1: Sites of measurements in Alexandria city

Zone	Road No.1	Road No.2	Road No.3	Road No.4
	Al Sahilly	El-gaish st.	El Isawy st.	El Nahass st.
Residential area	Dawlley rd.	Gamal Nasir st.	----	----
(Moustafa Kamel)	Cairo-Alexandria agriculture rd.	Salam Aref st.	----	----
Tourism area	Alexandria-	Al bitash st.	Blbays Shahr Al	Ballw Shatea
(Al bitash)	Matroh rd.		Asal st.	Gharam st.
Educational area	---	Al Askander	Suez canal st.	Moshrafah st.
(El Shatbey)		Al Aakbar st.		
Industrial area	Cairo-Alexandria	Al Sad Al Aali st.	Ome Zeghbour st.	Ahmed Al
(Al maxs)	desert rd	Al Kornish st.		Sabagh st.
Downtown area	---	26 July st.	Sidi Metwally st.	Anis Fekry st.
(El Raml)				

Results and Discussion of Measurements

Measurements were carried out for 24 hours. L_{Aeq} 7-22 was calculated for 22 different roads by using the following equations: -

$$L_{Aeq} = 10 \log_{10} 1/n \left(\sum_{i=1}^{n} 10^{LAeqi/10} \right) \text{ (Schultz, 1982)} \quad (1)$$

Where, n; number of measurements from 7:00–22:00 measured every 10 minutes.

The Day-Night Average Sound Level (L_{dn}) is the average noise level over a 24 hour period. The noise between the hours of 10 pm and 7 am is artificially increased by 10 dB. This noise is weighted to take into account the decrease in community background noise of 10 dB during this period.

Day – night road traffic noise levels L_{dn} have been calculated for all the sites from the formula: -

Day –night road traffic noise levels L_{dn}

$$L_{dn} = 10 \log_{10} 1/24 \left(15 \left(10^{Ld/10}\right) + 9 \left(10^{(Ln+10)/10}\right)\right) \text{ (Schultz, 1982)} \quad (2)$$

Where L_d and L_n represent the daytime and night – time average sound levels, respectively. The results are shown in table 2.

Table 2: Road traffic noise levels L_{dn} [dB] in 22 sites in Alexandria city

Zone	Road No.1	Road No.2	Road No.3	Road No.4	Mean value of zones
	85.3	83.1	71.6	64.1	79.18
Residential	86.2	82.5	----	----	
	----	81.4	----	----	
Tourism	83.1	82.6	72.0.	65.8	75.8
Educational	---	85.8	78.2	68.5	77.5
Industrial	86.7	85.2	79.4	71.7	81.46
	----	84.3	----	----	
Downtown	---	85.7	79.7	75.0	80.14
Mean value of roads	85.32	83.79	76.18	69.02	

Results of measurements for types of roads in different land uses are shown in table 2.
Road No. 1 with width 30 - 40 m, 6 lanes or more, more than 10,000 vehicles at rush hours, speed 80 km / h or more. Road No. 2 with width 24 - 30 m, 4 - 6 lanes, more than 5,000 vehicles at rush hours, speed 60 km / h. Road No. 3 with width 20 - 24 m, 4 lanes, more than 3,000 vehicles at rush hours, speed 45 km / h. Road No. 4 with width 12 - 16 m, 2 lanes, more than 1,000 vehicles at rush hours, speed 30 km / h.
Table 2 shows mean L_{dn} values in different types of roads as: in highways (road No. 1) were 85.32 dB, L_{dn} in arterial roads (road No. 2) were 83.79 dB, L_{dn} in collector roads (road No. 3) were 76.18 dB, and L_{dn} in local roads (road No. 4) were 69.02 dB. So major roads (highways and arterial roads) were the noisiest roads in the city, and L_{dn} in all kinds of roads in Alexandria were higher than 60 dB, considering by preventive medicine as the limit value one can be exposed to.

Table 3: Distribution of measured L_{dn} values per zone (land uses)

L_{Aeq} [dB]	**Educational**	**Tourism**	**Residential**	**Downtown**	**Industrial**	**No. of location (%)**
Local legislation [dB]	**50**	**55**	**60**	**65**	**70**	
$50 < L_{Aeq} \leq 55$	---	---	---	---	---	---
$55 < L_{Aeq} \leq 60$	---	---	---	---	---	---
$60 < L_{Aeq} \leq 65$	---	---	64.1	---	---	1 (4.5 %)
$65 < L_{Aeq} \leq 70$	68.5	65.8	---	---	---	2 (9.1 %)
$70 < L_{Aeq} \leq 75$	---	72.0	71.6	75.0	71.7	4 (18.2 %)
$75 < L_{Aeq} \leq 80$	78.2	---	---	79.7	79.4	3 (13.6 %)
$80 < L_{Aeq} \leq 85$	---	82.6 83.1 ---	81.4 82.5 83.1	---	84.3	6 (27.3 %)
$85 < L_{Aeq} \leq 90$	85.8 ---	---	85.3 86.2	85.7 ---	85.2 86.7	6 (27.3 %)
Location per zone	3	4	7	3	5	22

Table 3 illustrates distribution of measured L_{dn} values per zone (land uses). 95.5 % out of the locations display L_{dn} were over 65 dB. Over eighty five percent (86.4 %) of the locations measured show L_{dn} were over 70 dB. But Egyptian environmental law [8] mentioned that the sound level category of 66 – 70 dB is to be regarded as the threshold of health impairments. According to this, from the point of view of preventive medicine, L_{dn} of 60 dB should be maintained as the limiting value of exposure to noise during the day. 68.2 % out of the total number of locations measured display extremely high values of L_{dn} were over 75 dB, i.e. 68.2 % of the population is exposed to noise greater than 75 dB, considered as the threshold of health impairments. So there are no sites have measurements in accordance with the local legislation.

Egyptian Noise Standard and Policy

Ministry of Environment instituted Egyptian environmental law Number 4 of year 1994 and its executive regulation. It determined the maximum permissible limit for noise intensity in different areas as shown in table 4 [8].

Table 4: Egyptian noise standards and policy about maximum permissible limit for L_{dn} [dB] in different land use

Type of area	Permissible limit for L_{dn} in dB					
	Day		Evening		Night	
	From	To	From	To	From	To
Commercial, administrative and downtown areas	55	65	50	60	45	55
Residential areas with some workshops or commercial establishments or located on a main road	50	60	45	55	40	50
Residential areas in the city	45	55	40	50	35	45
Residential suburbs with low traffic	40	50	35	45	30	40
Residential rural areas, hospitals and gardens	35	45	30	40	25	35
Industrial areas (heavy industries)	60	70	55	65	50	60

Day from 7 a.m to 6 p.m,
Evening from 6 p.m to 10 p.m,
Night from 10 p.m to 7 a.m

The Egyptian Ministry of Housing and Urban Development classified the following noise levels that measured outdoors in residential areas as: -

$L_{dn} \leq 50$ dB clearly acceptable
$50 < Ldn \leq 60$ dB normally acceptable
$60 < Ldn \leq 75$ dB normally unacceptable
$L_{dn} > 75$ dB clearly unacceptable

By considering the above criteria, all locations in residential area classified as normally unacceptable and clearly unacceptable.

By comparing road traffic noise levels in Alexandria shown in tables 2 and 3 with Egyptian statutory standards regulations shown in table 5 we find that road traffic noise level in Alexandria are higher than those set by Egyptian environmental law to protect public health and welfare in residential areas. L_{dn} = 80 dB and higher were recorded, while maximum permissible level is 60 dB.

Road traffic noise levels in Alexandria are too high due to abuse of horn, passing of busses and trucks in residential area. To know the effect of that factor, restriction experiments were carried out in absence of horn, busses and trucks to reduce noise levels for improving environmental conditions.

Restriction Experiments

By studying characteristics of traffic in Alexandria, we assumed that road traffic noise levels in Alexandria were too high due to many reasons as: (i) using horns without reason, (ii) using horns and trucks, (iii) using horns, trucks and buses.

Restrictions were carried out in selected sites. The aims of this experiment are to investigate the effect of these reasons on road traffic noise level. To evaluate how many are the reduction of road traffic noise level when carrying out every type of restriction. This experiment was carried out restriction to decrease road traffic noise levels. How the town planner can use various strategies to change traffic composition in order to achieve quieter city environments.

L_{dn} was measured without restrictions and repeated next day with restrictions. Descriptions of carrying out restrictions were as follows:

- To study effect in the absence of horns. First day we carried out measurements without any restrictions. Next day at the same time, same place, approximately same composition of traffic, we demand from drivers not using horns by putting many obvious big signs in place of measurement, and we carry out measurements for case in the absence of horns.
- To study effect in the absence of horns and trucks. First day we carried out measurements without any restrictions. Next day at the same time, same place, trucks were forbidden to pass in this road by help of traffic administration, we demand from drivers not using horns by putting many obvious big signs in place of measurement, and we carry out measurements for case in the absence of horns and trucks.

• To study effect in the absence of horns, trucks and buses. First day we carried out measurements without any restrictions. Next day at the same time, same place, trucks and buses were forbidden to pass in this road by help of traffic administration, we demand from drivers not using horns by putting many obvious big signs in place of measurement, and we carry out measurements for case in the absence of horns, trucks and buses.

This experiment was carried out in five sites represent different land uses as follows:

5.1. Site Description

Various types of site were selected as: a residential area, a tourism area, an educational area, a downtown area, and an industrial area. A brief description of each site is given below.

5.1.1. Residential Area

The site chosen to represent residential land use is Moustafa Kamel area. The location for field measurement was along Gamal Nasir street, a main arterial street, two-ways, 50 m wide, separated by green island with wide 10 m, every way with wide 15 m, pedestrians movement served by two sidewalk on either side of the road, each 5m wide. The traffic flowing along the road is mixture of private cars, taxis, minibuses, buses and a few trucks, accommodating 1,200 vehicles an hour on the inside lane during the peak traffic hour.

5.1.2. Tourism Area

The site chosen to represent the tourism land use is Al bitash area in the west of Alexandria city. The location for field measurement was along Al Bitash Street, Arterial Street, two-ways, 40 m wide. The traffic flowing along the road is mixture of private cars, taxis, minibuses, buses and trucks, accommodating 800 vehicles an hour on the inside lane during the peak traffic hour.

5.1.3 Educational Area

The site chosen to represent educational land use is El Shatbey area. The location for field measurement was along Al Askander Al Aakbar Street, Arterial Street, two-ways, 40 m wide. Pedestrian movement served by two sidewalks on either of the road, each 5 m wide. The traffic flowing along the road is a mixture of taxis, privates cars, bikes, minibuses, and buses, accommodating 900 vehicles an hour on the inside lane during the peak traffic hour.

5.1.4. Downtown Area

The site chosen to represent downtown land use is El Raml area. The location for field measurement was along 26 July Street, Arterial Street, two-ways, 50 m wide. It is a main shopping street with heavy pedestrian movement served by two sidewalks on either of the road, each 5 m wide. The traffic flowing along the road is mixture of taxis, privates cars, bikes, minibuses, and buses, accommodating 1,200 vehicles on the inside lane during the peak traffic hour.

5.1.5. Industrial Area

The site chosen to represent the industrial land use is located in Maxs a major industrial suburb to the west of Alexandria. The location for field measurement was along Al Sad Al Aali Street, arterial street, two-ways, 55m wide, accommodating 900 vehicles an hour on the inside lane during the peak traffic hour.

Table 5: L_{dn} [dB] before and after restrictions in Alexandria city

Case study	Residential Gamal N. Street	Tourism Al bitash Street	Educational Askander Aakbar st.	Downtown 26 July Street	Industrial Al Sad Al Aali Street
Without restrictions	84.5	84.6	87.8	87.7	87.2
In the absence of horns	80.6	82.1	79.2	76.5	83.7
In the absence of horns and trucks	79.8	75.9	----	76.2	----
In the absence of horns, trucks and buses	78.2	----	----	73.4	----

5.2. Results of Restrictions

Restrictions were introduced to improve environmental conditions as: (i) absence of horns, (ii) absence of horns and trucks, (iii) absence of horns, trucks and buses. L_{dn} before and after restrictions were measured. Table 4 shows L_{dn} [dB] before and after restrictions in Alexandria, Egypt.

As shown in Table 5: -

- In the absence of horns, L_{dn} decreased at all sites. The maximum reduction was 11.2 dB occurred in the downtown area.
- In the absence of horns and trucks L_{dn} decreased between 4.7 to 11.5 dB respectively.
- In the absence of horns, trucks and buses, L_{dn} decreased 14.3 dB at downtown area.
- So restrictions as: absence of horns, trucks, and buses can decrease road traffic noise level in the city.

Conclusion and Remarks

Measurements taken for road traffic noise levels in Alexandria, indicates that noise levels in the city were higher than those set by Egyptian noise standards and policy to protect public health and welfare.

About 95.5 % of the locations measured in this study show L_{dn} were over 65 dB, the limit for preventive medicine. Over eighty five percent (86.4 %) of locations measured show L_{dn} were over 70 dB. (68.2 %) of locations measured show high values of L_{dn} were over 75 dB. A widely accepted scientific fact is that living in ‘‘black acoustics zones,’’ where L_{dn} were higher than 60 dB, put an urban population in a high risk category for numerous noise subjective effects, including psychological, sleep, and behavioral disorders.

Mean L_{dn} value per zone were: L_{dn} in educational area was 77.5 dB, In tourism area was 75.8 dB, in residential area was 79.18 dB, in downtown area was 80.14 dB, in industrial area was 81.46 dB. This means industrial area was the noisiest area. Traffic noise levels in all different land uses areas were higher than the permissible levels.

Mean L_{dn} in highways (road No. 1) were 85.32 dB, in arterial roads (road No. 2) were 83.79 dB, collector roads (road No. 3) were 76.18 dB, and in local roads (road No. 4) were 69.02 dB. This means L_{dn} in all kinds of roads in Alexandria were higher than the permissible levels.

Restrictions were introduced to improve environmental conditions as: (i) absence of horns, (ii) absence of horns and trucks, (iii) absence of horns, trucks and noisy buses. L_{dn} before and after restrictions was measured. Results of this study showed that:-

- In the absence of horns, maximum reduction of noise was 11.2 dB occurred in downtown area.
- In the absence of horns and trucks L_{dn} decreased between 4.7 to 11.5 dB respectively.
- In the absence of horns, trucks and buses, maximum reduction of noise was 14.3 dB at downtown area.
- So restrictions (as: (i) absence of horns, (ii) absence of horns and trucks, (iii) absence of horns, trucks and noisy buses) can decrease road traffic noise levels in the city. This shows that town planner can use various strategies to change traffic composition in order to achieve quieter city environments.

ACKNOWLEDGEMENT

The authors are grateful to traffic administration of Alexandria city for helping us to carry out restrictions. This study was financially supported by The Egyptian Ministry of Higher Education.

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