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ASSESSMENT OF ROAD TRAFFIC NOISE POLLUTION AT TAIZ CITY, YEMEN.

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ABSTRACT

The present study provides an evaluation of road traffic noise pollution in the city of Taiz. Statistical noise index L10 (18 hour) was calculated at 55 streets throughout the city of Taiz. The British Calculation of Road Traffic Noise (CRTN) method was used to calculate the noise level throughout the city for the year 2015. Corrections for mean traffic speed, gradients, percent of heavy vehicles, road surface types are determined using appropriate expressions. The results showed that Taiz is environmentally noise polluted at all the studied locations ,except at two locations, with noise levels ranging between 60.1 and 73.7 dB(A); thereby exceeding the maximum allowable limit of 60 dB(A). Actual noise measurement carried out using sound level meter at 10 locations and it has been found that the difference between measured and calculated noise using CRTN method was within the limit ± 3.0 dB(A).

The CRTN method was also employed to predict future noise levels throughout the city for the year 2020 which were found to be higher than the current predicted noise levels.

INTRODUCTION

Noise in unwanted sound. The increasing urbanization in cities and the growth of activities therein have contributed to the mounting volume of noise, intruding upon the quiet life and privacy of the urban dwellers. The annoyance and discomfort caused by noise can at times assume serious proportions meriting urgent attention. Noise in cities is the result of a number of activities such as road traffic, aircraft, railways and industrial and constructional works. The traffic engineer is concerned with the abatement source of annoyance (1).

Generation of noise by road traffic

The generation of noise caused by road traffic can be considered under the following categories (2).

1- **Noise generated by various parts of the vehicle;**
   - **Engine (Power Unit), especially during acceleration;**
   - **Aerodynamic friction;**
   - **Exhaust system;**
   - **Sounds of cooling fans, gearboxes and brakes;**
   - **Horns;**
2- **Noise contributed by the interaction between the vehicle and the road surface.**
3- **Noise dependent on the speed, flow and density of traffic.**

Noise sources associated with transportation include passenger vehicles, medium trucks, heavy trucks and buses. Each of these vehicles produces noise, however, the source and the magnitude of the noise can vary greatly depending on the vehicle type, while the noise from passenger vehicles occurs mainly from the tire-roadway interface and is therefore located at ground level, it was found that noise from heavy trucks is produced by a combination of noise from the tires, the engine, and the exhaust, resulting in a noise source that is approximately 2 m, above the ground (3). Table (1) shows the maximum limit or the acceptable limits allowed according to the Yemeni legislation noise control regulation for environment protection (4).

Table (1): Yemeni Ambient Noise Standards.

LAND USE	Limits - Leq Decibel (A)		
	Day 07:00 - 18:00	Evening 18:00-23:00	Night [1] 23:00-07:00
Rural Residences and Picnic Places	45	40	35
Residential Areas in suburbs	50	45	40
Urban Residential Areas	55	50	45
Urban Residential Areas with Workshops and City Centers	60	55	50
Industrial and Commercial Areas	70	70	60

1. Also applies to holidays.
Source: Implementation List of the Environmental Protection Law, Yemen, 2005

Developed countries in the world have put some norms on the noise levels. For example in Sweden, the guidelines for indoor noise levels are 45 dB and for outdoor are 65 dB (5). If these limit values is exceeded, the noise can be deemed to be a potential sanitary nuisance.

STUDY AREA PROFILE

Large cities like Taiz face growing problems with noise pollution, which is a significant environmental problem in many developing areas. Fig. (1) shows the number of vehicles registered in Taiz city during 1996- 2008, from this figure, it can be seen that the high percentage of vehicles, the continuously increasing rate of growth in vehicle ownership due to fast development, the expansion of the economy and fast growth of the industrial and commercial sectors all contribute to noise pollution. In addition to the relatively large population growth of approximately 2.65 million in year 2008, the city has been expanding continuously in all directions during the past two decades. This high percentage of vehicles, along with the continuously increasing rate of growth in vehicle ownership, contributed to the high noise level recorded in this city. Predictions and measurements of road traffic noise levels are essential for roadway planning and noise control (6).

The number of registered vehicles in the city has increased from 9508 in 1996 to 67989 in 2008 recording an average annual growth rate of 16.3% during 1996-2008 (7).

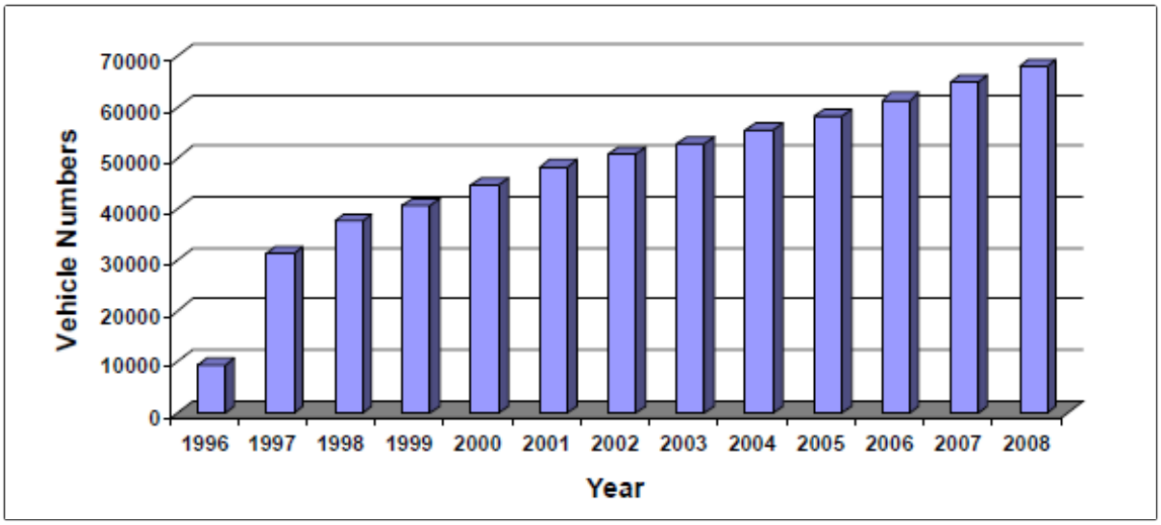


Figure (1): Growth of Vehicles in Taiz.

EARLIER STUDIES

Data on noise pollution in Yemen is scarce and not enough studies are available to present the effects of traffic noise pollution. However, noise measurement carried out in year 2006 in the capital city of Sana'a as a part of Comprehensive Traffic Management study for Sana'a (Environment and Social Assessment)(8). In this study 16 major intersection in the city were selected for the noise pollution study. The study showed that the equivalent noise level dB (A) at these sites varies from 72 to 77 dB(A) there by exceeding the permissible values given by the Yemeni Environmental Protection Agency, as shown in figure (2) below.

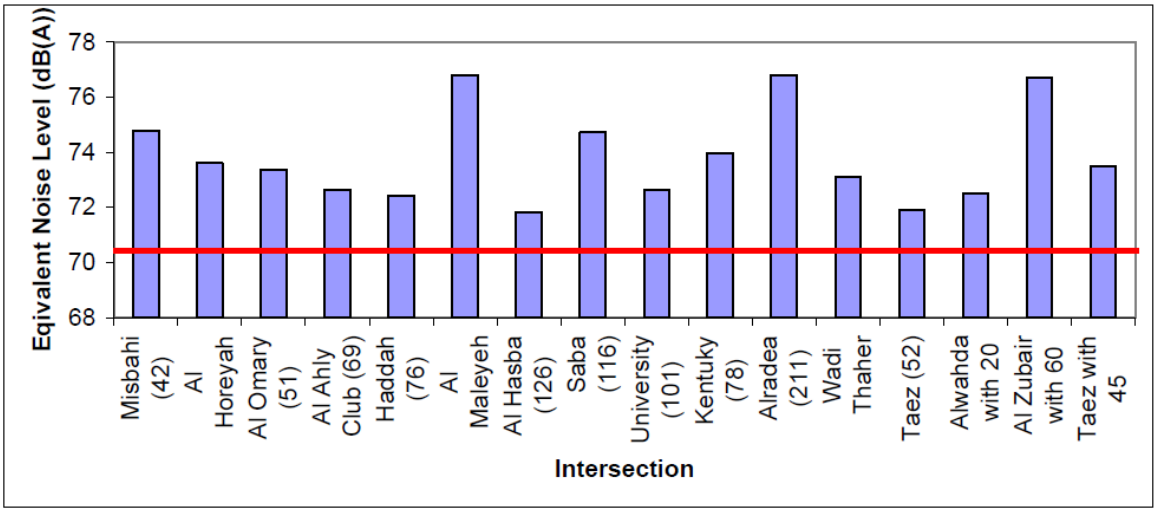


Figure (2): Noise measurements at sixteen different crossings in Sana'a city.

2. MATERIALS AND METHODS

The adopted data collection procedure is designed in such a way to collect as much data in an accurate and practical manner. The noise measurement are taking place simultaneously along with the traffic count. The criteria for selection the measurement location is:

1. **Class of the road (i.e. arterial, collector, or local);**
2. **Traffic volume and composition;**
3. **Land use within the road vicinity.**

Specially designed forms were prepared to record and document all the collected data. The temperature and wind speed were recorded during the measurements, while the humidity data obtained from the Civil Aviation and Metrology Authority.

The noise is measured using a sound level meter. During the measurement, the sound level meter is located at a distance of about 10.0 m from the existing road level about 1.5 m above the road surface. For each measurement, two replicates were taken.

Traffic volumes and composition is counted and recorded manually by a team of surveyors during the measurement of noise emissions. Each individual is assigned for counting specific vehicle category. The traffic fleet was divided into light traffic and heavy traffic.

The data collection process took place in February 2015 in Taiz city at 55 streets throughout the city (figure 3). Classified traffic count carried out for the 18 hours between 06:00 to 24:00, as well as traffic speed, gradients, percent of heavy vehicles and road surface types are recorded.

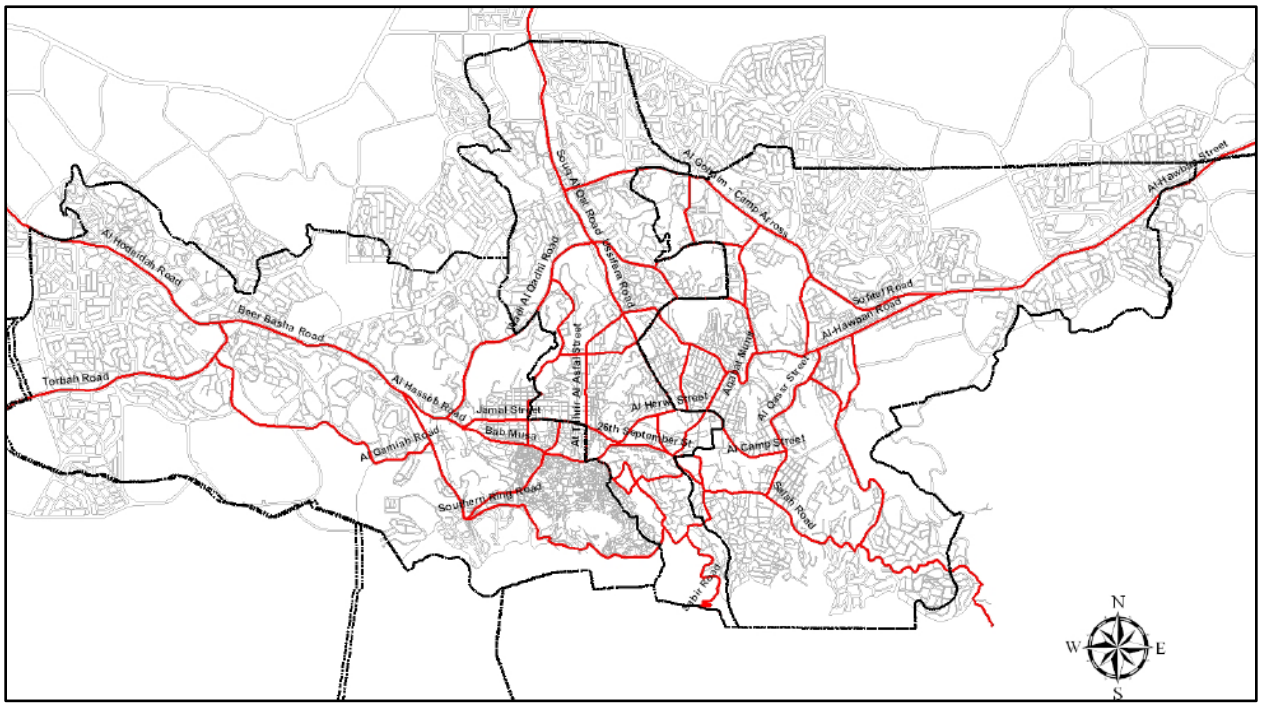


Figure (3): Taiz City Road Network.

In this study, the levels of noise emitted by traffic are measured or predicted using the standard UK method for the Calculation of Road Traffic Noise (CRTN) (9). All predicted or measured noise levels are expressed in terms of the index L10 hourly or L10 (18-hour) dB (A). The value of L10 hourly dB(A) is the noise level exceeded for just 10% of the time over a period of one hour. The L10 (18-hour) dB(A) is the arithmetic average of the values of L10 hourly dB(A) for each of the eighteen one-hour periods between 06:00 to 24:00 hours.

The basic noise level hourly is predicted at 10 meters away from the nearside carriageway according to the following equation:

$$L_{10} \text{ (hourly)} = 42.2 + 10 \log_{10} q, \text{ dBA} \longrightarrow (1)$$

And the basic noise level in terms of total 18-hour flow is

$$L_{10} \text{ (18-hour)} = 29.1 + 10 \log_{10} Q, \text{ dBA} \longrightarrow (2)$$

Where q and Q are the hourly traffic flow (vehicles/hour) and 18-hour flow (vehicles/hour), respectively. Correction for mean traffic speed, percentage of heavy vehicles, gradient, road surface and distance were carried out as per standard UK method.

Correction for mean traffic speed, percentage of heavy vehicles, surface types and gradient are carried out as per CRTN manual (9).

The correction for percentage of heavy vehicles and traffic speed are determined using the following expressions

$$\Delta_{pV} = 33\log_{10}\left(V + 40 + \frac{500}{V}\right) + 10\log_{10}\left(1 + \frac{5p}{V}\right) - 68.8 \text{ , dB(A).} \quad (3)$$

In this expression the percentage of heavy vehicles is given by

$$p = \frac{100f}{q} = \frac{100F}{Q} \quad (4)$$

Where

f and F are the hourly and 18-hour flows of heavy vehicles, respectively.

Equation (3) is applied to the basic hourly or 18-hour levels. The value of V to be used in equation (3) depends upon whether the road is level or on a gradient.

Once the speed of traffic is known them the adjustment for the extra noise from traffic on a gradient is calculated from

$$\Delta_G = 0.3G \text{ , dBA} \longrightarrow (5)$$

4. ROAD SURFACE

The noise level depends upon the amount of texture on the road surface. For roads which are impervious to surface water and where the traffic speed used in expression (3) is V ≥ 75 km/h a correction to the basic noise level is applied. The correction for concrete surfaces is given by

$$\Delta_{TD} = 10\log_{10}(90TD + 30) - 20 \text{ , dBA} \longrightarrow (6)$$

for bituminous surfaces

$$\Delta_{TD} = 10\log_{10}(20TD + 60) - 20 \text{ , dBA} \longrightarrow (7)$$

where TD is the texture depth measured by the sand-patch test.

If $V < 75$ km/h :
- for impervious bituminous road surfaces$\Delta TD = -1$ dBA
- for pervious road surfaces $\Delta TD = -3.5$.

FUTURE NOISE LEVELS

The future noise levels at all sites were predicted using the CRTN method. The year 2020 was selected for the future prediction (n=5 years). The input data needed for predicting future noise levels were assumed to be the same as for the current year 2015. The future traffic flow used in the CRTN method was obtained by applying the following relationship using an annual growth rate of r%. This rate is based on the average growth rate of vehicles in Taiz city.

$$F = P(1+i)^n \longrightarrow (8)$$

where,

F = Future predicted traffic volume

P = Present traffic volume

I = Rate of growth of vehicles

n = Number of years

Table (2) Show the 18 hourly traffic volumes, percentage of heavy vehicles and the calculated link wise noise pollution for the years 2015 and 2020 respectively. It is clear from Table (2) that the noise level at almost all the links for base year as well as future year exceeded the Yemeni ambient noise level.

Table (2): Calculated Link wise noise pollution for the years 2015 and 2020 in Taiz City.

Sl.No	Road Name	Stretch Name	LINKWISE NOISE POLLUTION L10(18-hour) dB(A)					
			2015			2020		
			Traffic volume (18-hour)	% Heavy vehicles	Noise pollution	Traffic volume (18- hour)	% Heavy vehicles	Noise pollution
1	Jamal Street	Bab Musa/Jamal Street to Mohammed Ali Othaman	28055	0.61	68.6	33928	0.61	69.4
2		Mohammed Ali Othaman to Al Awedhi	29184	0.36	70.5	35302	0.36	71.3
3		Al Awedhi to Al Tehrir	25867	0.35	69.9	31275	0.35	70.8
4		Al Tehrir to Al Muwasalat	32158	0.38	68.7	38892	0.38	69.5
5	Al Herwi Street	Muwasalat to Al Howd	42368	0.46	69.8	51247	0.46	70.6
6		Al Howd to Al Camp	18474	1.04	68.1	22340	1.04	68.9
7	A Qassar Street	Al Kindi Jn to Al Qassar Jn	15401	3.25	68.6	18622	3.25	69.4
8	AL Askari Street	AL Askari Street	14123	0.86	65.5	17085	0.86	66.3

9	Sala Road	Sala Road	6629	0.58	61.7	8021	0.58	62.5
10	New Ring Road	New Ring Road	3501	2.34	61.4	4234	2.34	62.3
11	Saber Road	Saber Road	4727	0.22	60.9	5720	0.22	61.8
12	Al Kahira Castle	Al Kahira Castle	8142	0.18	63.1	9849	0.18	63.9
13	Southern Ring Road	Southern Ring Road	19758	0.52	66.4	23899	0.52	67.2
14	Al Gamian Road	Al Gamian Road *	12808	2.83	66.1	15487	2.83	66.9
15	Bab Musa - Sina Road	Bab Musa - Sina Road	9917	1.25	64.0	11995	1.25	64.8
16	26th September	Bab Al Kabeer Jn to 26th September	12565	0.42	64.3	15205	0.42	65.1
17	Bab Musa	Bab Musa	12510	1.56	66.6	15129	1.56	67.4
18	Aqabat Mufera	Aqabat Mufera *	13396	1.14	66.4	16215	1.14	67.2
19	Wadi Al Qadi	Wadi Al Qadi *	11040	12.31	71.7	13330	12.31	72.5
20	Third Ring Road	Third Ring Road *	13590	9.40	70.0	16414	9.40	70.9
21	Al Qat Road	Al Qat Road *	9689	6.56	66.7	11707	6.56	67.5
22	To Sofitel	Al Rawdha Jn to Sofitel	2899	4.02	60.1	3504	4.02	60.9
23		Al Rawdha Jn to Poweplant Jn	6440	6.52	68.0	7783	6.52	68.8
24	Ussefera	Sinan Jn to Safer Jn	11182	1.31	65.2	13526	1.31	66.0
25		Powerplant Jn to Sinan Jn	18878	2.18	67.3	22828	2.18	68.1
26	Al Tehrir Al Asfal Street	Al Tehrir Al Asfal Street	14466	1.04	65.5	17497	1.04	66.3
27		Al Markazi Jn to Al Asfal St	6126	0.24	61.5	7406	0.24	62.3
28	Mohammed Ali Ottoman	Mohammed Ali Ottoman	10000	0.52	63.5	12097	0.52	64.3
29	Al Awedhi Street	Al Awedhi to Jamal Street	15299	1.21	67.2	18503	1.21	68.1
30	Al Tehrir Up	Al Tehrir up to Jamal Street	5618	1.41	62.8	6796	1.41	63.6
31		Al Nokta Al Raba Jn to Public Park	18567	0.71	66.4	22465	0.71	67.2
32	Soug Assimil	Soug Assimil to Al Howd Jn	2951	0.85	58.4	3570	0.85	59.2
33		Soug Assimil to Al Nokta Al Raba Jn	5001	0.08	60.1	6054	0.08	60.8
34	Aqabat Munif	Aqabat Munif Jn to Al Howd Jn	26851	1.17	71.3	32470	1.17	72.1
35	Al Hawaban	Aqabat Munif Jn to Farzat Sana'a Jn	24265	1.81	68.3	29338	1.81	69.2
36	Al Shab Jn	Al Shab Jn to Al Nokta Al Raba Jn	18206	0.45	70.8	22029	0.45	71.6

37	Ath Thwarah street	Al Kharabah Jn to Aqabat Munif Jn	17734	1.01	66.6	21451	1.01	67.4
38	Ash Shamsi Street	Ath Thawrah Jn to Al Ashbat Jn	18210	0.98	66.4	22023	0.98	67.2
39	Gawlat Senan Al Baath	Sinan Jn to Al Kharaba Jn	9893	1.21	63.9	11961	1.21	64.7
40		Kharabah Jn to Safer Jn	18003	2.11	67.1	21771	2.11	67.9
41	Al Horaish Street	Safer Jn to Al Horaish Jn	17384	0.88	66.8	21021	0.88	67.6
42	Second Ring Road	Kalabah Jn to 2nd Ring Road	14065	1.41	65.6	17009	1.41	66.4
43	Kalabah Bridge Road	Kalabah Jn to Petrol Pump	8435	6.15	67.0	10187	6.15	67.8
44	Sofitel Road	Petrol Pump to Jumla Market Jn	14397	10.02	73.7	17380	10.02	74.5
45	Soug Al Gomlah Road	Jumla Market Jn to Al Gomlah Jn	14307	6.05	67.9	17294	6.05	68.7
46	Farzat Sanaa Road	Al Qassar Jn to Farzat Sana Jn	38124	3.62	71.1	46086	3.62	71.9
47		Farzat Sana Jn to Kalabah Jn	17907	1.60	66.7	21652	1.60	67.6
48	Al Hawaban Road	Sofitel Jn to Al Qassar Jn	32396	3.85	71.7	39155	3.85	72.5
49	Sofitel Road	Sofitel Jn to Jumla Market Jn	10341	13.51	69.2	12478	13.51	70.1
50	Al Goham Al Qamariyah Road	Al Rawdha Hospital Jn to Kalabah Road	12245	1.52	66.2	14812	1.52	67.0
51	Al Haseeb Road	Saba Phone office to Al Haseeb Road *	38400	3.74	71.5	46413	3.74	72.4
52	26 th September	Al Nokta Al Raba Jn to Tehrir Up	6628	0.90	61.9	8020	0.90	62.7
53	Safer Al Tahrir Al Asfal	Safer Jn to Al Tahrir	11794	0.49	64.3	14261	0.49	65.1
54	Al Masbah Wadi Al Qadi	Wadi Al Qadi to Al Masbah	3265	1.01	59.5	3952	1.01	60.4
55		Mohammed Ali Ottoman Down to Al Masbah	14602	1.19	66.0	17681	1.19	66.9

Figures (4) and (5) show the link wise noise pollution in d(B)A for the years 2015 and 2020. It is clear from figures that the actual noise level exceeded the Yemeni ambient noise standards.

Fig. (4): Link wise NoisePollution for the year 2015

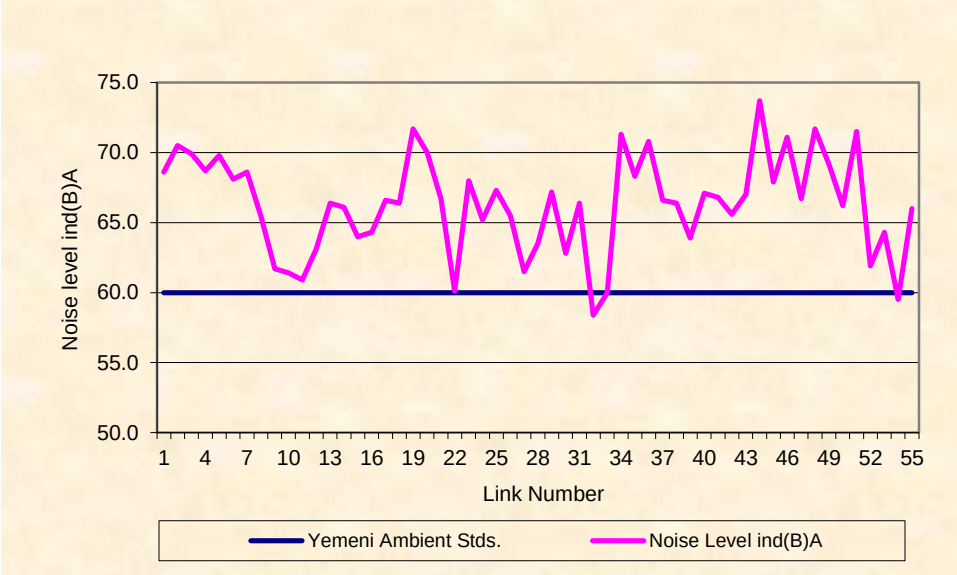
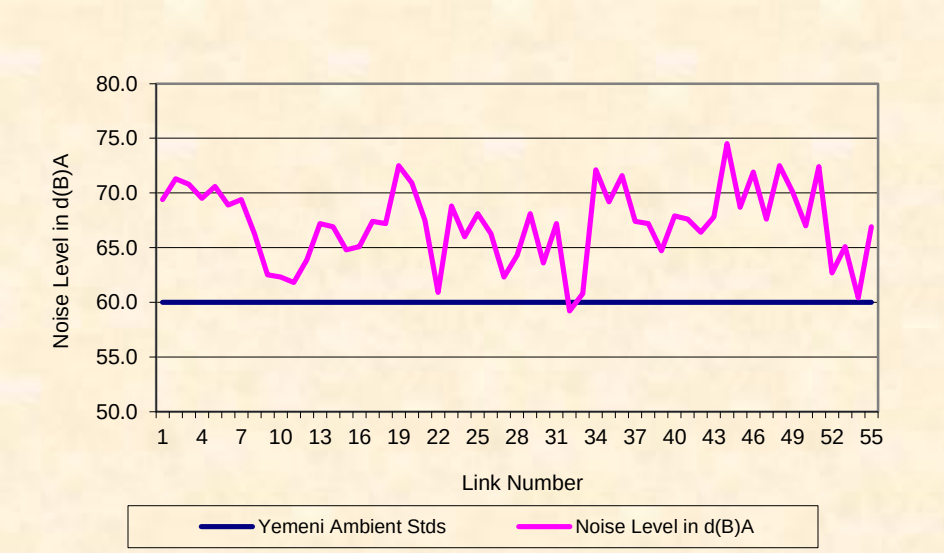


Fig. (5): Link wise Noise level for the Year 2020



RESULTS AND DISCUSSION:

Noise pollution is defined as the generation of unwelcome and displeasing sound in the environment. Among the various sources of noise pollution, automobiles and other transport systems contribute the maximum sound production. Because of the other important noise pollutants industrial production systems are negligible in the city, so it is possible to say that the root cause of noise pollution is transportation machines- traffic vehicles in Taiz city. The results showed that Taiz is environmentally noise polluted at all the studied locations ,except at two locations, with noise levels ranging between 60.1 and 73.7 dB(A); thereby exceeding the maximum allowable limit of 60 dB(A).

To test the accuracy of CRTN method in Yemen environment, actual noise measurement carried out using sound level meter at 10 locations, the measurement procedure carried out as mentioned above, and it has been found that the difference between measured and calculated noise using CRTN method was within the limit ± 3.0 dB(A). Hence CRTN methodology can be used for predicting traffic noise level in Yemen.

The CRTN method was also employed to predict future noise levels throughout the city for the year 2020 which were found to be higher than the current predicted noise levels as shown in table (2) above. The results clearly show that the noise levels for the year 2020 found to be higher than the current predicted noise levels.

ADVERSE HEALTH EFFECTS OF NOISE POLLUTION

The World Health Organization (WHO) has documented seven categories of adverse health effects of noise pollution on humans (10):

1- **Hearing impairment**
2- **Interference with spoken communication**
3- **Sleep disturbances**
4- **Cardiovascular disturbances**
5- **Disturbances in mental health**
6- **Impaired task performance**
7- **Negative social behavior and annoyance reactions**

CONTROL OF TRAFFIC NOISE

Techniques available for control of traffic noise can be considered under the following headings (2):

1- **Changes in design of vehicles**
2- **Changes in tyres and road surfaces;**
3- **Elimination of nosier vehicles;**
4- **Modifications in traffic operation;**
5- **Designing streets, buildings and areas for produces less noise.**

CONCLUSION

Regarding the data achieved during noise measurement and the high equivalent noise level in all the streets in the city, implementing strategies to control the noise in Taiz city necessary. The results proved that noise pollution must be devoted more attention and reached serious levels and it has become one of the major environmental problems. Therefore, protections related to planning, technical, legislative and educational issues should be taken in order to avoid negative effects of noise pollution on the environment and human beings. In addition, the awareness of the population about the risk of noise pollution.

REFERENCES

1) **London Noise Survey, H.M.S.O., London, U.K. 1968.**
2) **Kadiyali, L.R., Traffic Engineering and Transport Planning, Khanna Publisher, 2000.**
3) **POWH (OHS) Unit: Noise Management Handbook, 2010.**
4) **Implementation List of the Environmental Protection Law, Yemen. 2005.**
5) **Pettersson, B.: Indoor noise and high sound levels- a transcription of the Swedish national board of health and welfare's guidelines. J. of Sound and Vibration, 205 (4), pp.475-480, 1997.**
6) **Khan, M.M., Memon, M.A. and Khan, M.N., Traffic noise pollution in Karachi, Pakistan, JLUMHS, volume 9, pp.114-120, 2010.**
7) **Central Statistical Organization. Statistical year book. Sana'a, Republic of Yemen: Ministry of Planning and International Cooperation, (1996-2008).**

8) **Comprehensive Traffic Management study for Sana'a (Environment and Social Assessment), volume 2, Team International, 2007.**
9) **Department of Transport and Welsh Office. Calculation of Road Traffic Noise. HMSO, London, 1988.**
10) **Berglund B, Lindvall T. (Eds.) Community Noise. *Archives of the Center for Sensory Research.* 1995; 2: 1-195. This document is an updated version of the document published by the World Health Organization in 1995. Available at: http://www.who.int/docstore/peh/noise/guidelines2.html. Accessed January 6, 2007.**

تقييم التلوث الضوضائي للطرق المرورية بمدينة تعز-اليمن

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الملخص:

تقدم الدراسة الحالية تقييما للتلوث الضوضائي الناتج لحركة مرور المركبات في مدينة تعز. تم حساب مؤشر الضوضاء الإحصائية L10 (18 hour) في ٥٥ شارع في مدينة تعز. تم استخدام طريقة حساب حركة المرور على الطريقه البريطانية (CRTN) لحساب مستوى الضوضاء في جميع أنحاء المدينة لعام ٢٠١٥. و تم عمل التصحيحات لمتوسط سرعة حركة المرور، ميول الطرقات، النسبة المئوية للمركبات الثقيلة، وأنواع سطح الطريق باستخدام المعادلات المناسبة بما يتناسب مع ظروف مدينة تعز. وأظهرت النتائج أن مستوى الضوشاء في مدينة تعز في جميع الشوارع المدروسة، باستثناء شارعين، تتراوح ما بين ٦٠.١ و ٧٣.٧ ديسيبل (A)؛ وبذلك تتجاوز الحد الأقصى المسموح به وهو ديسيبل ٦٠ (A).

تم قياس الضوضاء الفعلي في عشرة شوارع في مدينة تعز باستخدام مقياس مستوى الصوت وتبين أن الفرق بين الضوضاء المقيسة والمحسوبة باستخدام طريقة (CRTN) كان في حدود ± ديسيبل ٣.٠ (A).

واستخدمت الطريقة (CRTN) أيضا للتنبؤ بمستويات الضوضاء في المستقبل في جميع أنحاء المدينة لعام ٢٠٢٠ التي تبين أنها أعلى من مستويات الضوضاء الحالية المتوقعة.