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Traffic Noise Predection Model For Mohammed Al-Qassim Freeway In Baghdad Environment

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Abstract:

Noise is one of the environmental pollutants that is encountered in daily life. While rapid increasing of number of vehicles in Iraq, the noise and air pollution rate are increased. In present study a freeway traffic noise prediction model for Mohammad AlQassim Freeway in Baghdad city condition is developed using multiple regression analysis technique. Traffic volume, percent of heavy vehicle along freeway measured manually and average sound level (L_{eq}) dBA, were measured using (Victor 824 A Digital Sound Level Meter) instrument. The collected data had been analyzed, the model was developed considering satisfactory as it gives accepted results, with R^2 value of (0.762). The coefficient of correlation R^2 value for observation and estimated noise level by RNM is (0.777).

Key words: Traffic noise model, Traffic noise, Traffic volume, % H.V.

موديل تنبؤ بالضوضاء المرورية لطريق محمد القاسم السريع في بيئة مدينة بغداد

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الخلاصة:

الضوضاء هي إحدى الملوثات البيئية التي نصادفها في الحياة اليومية. نتيجة الزيادة المفرطة في إعداد المركبات ، ازدادت نسبة تلوث الهواء والضوضاء. في هذه الدراسة نحاول إيجاد نموذج للتنبؤ بالضوضاء المرورية لطريق محمد القاسم السريع في ظروف مدينة بغداد باستخدام تقنية الانحدار الخطي المتعدد. الحجم المروري، نسبة المركبات الثقيلة، تم قياسها يدويا، ومتوسط مستوى الضوضاء بالديسبل تم قياسه باستخدام (Victor 824 A Digital Sound Level Meter) بعد ان تم جمع المعلومات حللت البيانات لايجا نموذج التنبؤ، التحليلات الإحصائية بينت إن الموديل مقنع وأعطى قيمة جيدة لمعامل الارتباط بلغت (0.762). معامل الارتباط بين القيم ألمقاسه المستنبطة من RNM بلغت (0.777).

Introduction:

Traffic volume composite from passenger cars and heavy vehicles like buses, trucks,….ect. The heavy vehicle plays an important role over road traffic noise emission. With the raising of traffic volume through the last years in Iraq the percent of noise and air pollution are raised.

A massive public opinion survey in America taken in early 1970's revealed that the public ranked noise pollution as a serious problem [1].

Investigation in Several countries in the last decades considered that noise has adverse suriom effect on human health living in close proximity to congested road highways ranging from annoyance to insanity and death [2].

The noise can be defined as excessive or unwanted sound. Noise characterized by sound level frequency spectrum and variation over time. Noise level measured in (dB) (decibel), which is logarithmic measure range from zero to (140 dB) which yield point or harm level.

The level of highway noise depends mainly on [1]:

- Traffic volume
- Number of heavy vehicle in the flow of traffic.
- Speed of the traffic.

Methodology for Data Collection:

Mohammed Al-Qassim freeway has been selected as the study area. The studied section for long about (2650) m, which is illustrated in **Figure (1).** The studied route divided into two sections. 70 percent of the measured data used for model construction while 30 percent is used for validation stage of the model. Data collections process start at 4/11/2012 and continued for one month. The methodology of data collection containing measured of noise level, traffic volume and percent of heavy vehicle.

- **Noise Level:** measured using digital sound level meter (Victor 824 A), **Figure (2)** represents photo to the instrument.

  Traffic noise measurements through a whole month, during the days of the weak (Sunday, Monday, Tuesday, Wednesday, and Thursday). Noise meter was placed about (2 m) from pavement edge and about (1.2 m) above ground level, this limitation used in the study according to (Aziz et al., 2012) [3].

  Noise level and traffic volume measured start at 7 A.M to 6 P.M to find the peak hour which find that A.M peak period is (7:30 to 9:30) and P.M peak period is (1:30 to 3:30).

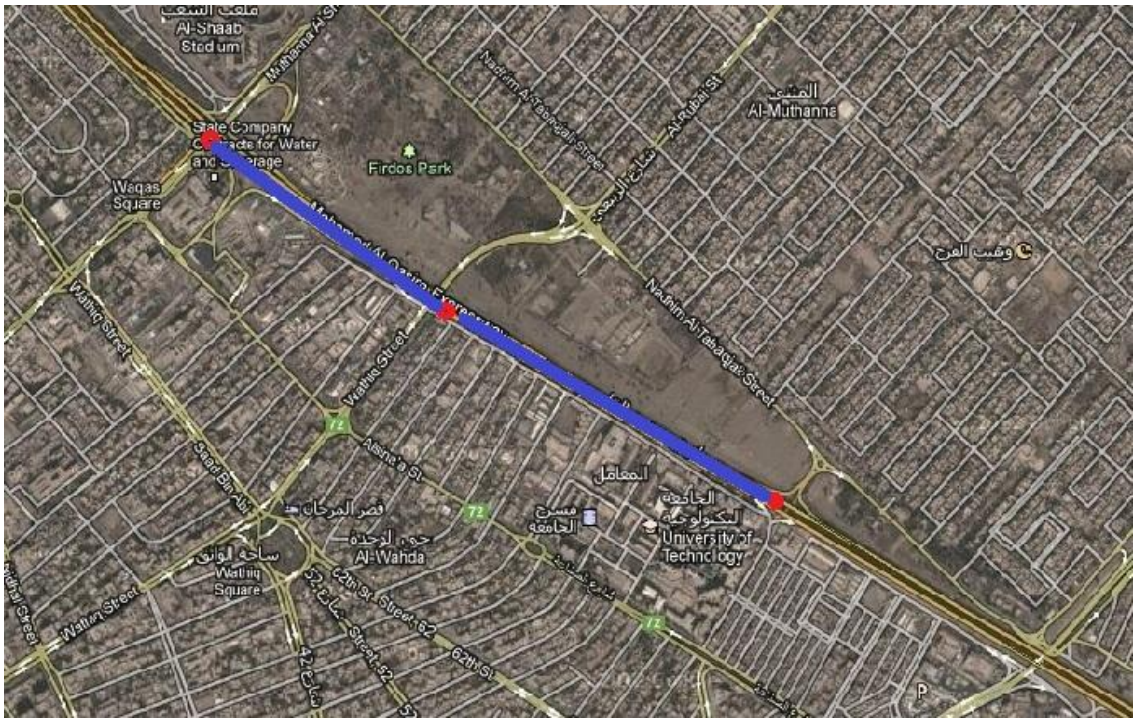

Fig.(1) study area

Fig. (2) Digital Sound Level Meter (Victor 824 A)

- **Traffic Volume:** counted at the same duration of noise measurement. All small vehicles (kia, peak up) counted as passenger car, while trucks with three or more axles and buses were counted as heavy vehicles. The traffic volume counted on the peak hour for two duration A.M and P.M period at the same time with noise level measures

  Most countries keeping in view the alarming increase in environmental noise pollution have given the permissible noise level standards [4], unfortunately in Iraq there are no

such considerations and standards. Table (1) gives ambient noise level standards being followed in India for different type of area. [4].

Table (1) Noise Level Standards in India

S.N	Area	L_{eq} dBA	
		Day Time	Night Time
1	Industrial Area	75	70
2	Commercial Area	65	55
3	Residential Area	55	45
4	Silence Zone	50	40

The methodology followed for the data collection of the field data is illustrated in the following steps:

1- The measured field data used to developed road noise model (RNM) by using multiple regressions technique, using software program SPSS version 18.
2- 30 percent of the measured data are used to validate the (RNM) road noise model.
3- Compare the generated model with Calixto and CEE models.

Mathematical Model Background:

The most of mathematical models determine equivalent noise level, L_{eq}, as the most representative physical variable quantifying noise emissions. The equivalent noise level corresponds to the sound pressure of a fictions stationary noise source emitting the same acoustic energy as the actual nonstationary source. The equivalent continuous noise level in A-weighted decibels (dBA) is a widely recognized as a stable descriptor of motor vehicle noise levels. It is recommended by many national and international regulatory agencies as a suitable index for use in motor vehicle noise assessments [5].

L_{eq} is known to correlate well with known effects of the noise environment on the individual and the public. The physical parameters to which L_{eq} is correlated are, among others, traffic intensity, type of road surface, type of urban area, height of buildings, width of road, etc.

Mathematical models for prediction the traffic noise usually extract the functional relationship between the parameter of noise emission, L_{eq}, and measurable parameters of traffic and roads. The classical functional relationships available in the literature are based on the data measured through semi-empirical models, typically regression analysis. All the mathematical models available in literature, the ones which present this feature are those proposed by Calixto, Burgess , Josse [5] , Fagoti, [6] , CEE , NAISS [5]. These functional

relationships are essentially based on statistical analysis (i.e. regression techniques) and are reported below:

$L_{eq} = 10 \log [Q (1+10VP/100)]$ *(Calixto)* *(1)*

$L_{eq} = 55.5 + 10.2 \log Q + 0.3 p - 19.3 \log (L / 2)$ *(Burgess)* *(2)*

$L_{eq} = 38.8 +15 \log Q - 10 \log L$ *(Josse)* *(3)*

$L_{eq} = 10 \log (N_c + N_m + 8N_{hv} + 88 N_b) + 33.5$ *(Fagoti)* *(4)*

$L_{eq} = 10 \log (N_c) + p$ *(CEE)* *(5)*

$L_{eq} = 10 \log (N_c + 3.7N_{hv} + 1.9 N_b) + 38.2$ 55 $dBA < L_{eq} < 65dBA$ NAISS (6)

$L_{eq} = 10 \log (N_c + 11.7N_{hv} + 3.1 N_b) + 44.3$ 65 $dBA < L_{eq} < 75dBA$ NAISS (7)

were *p and VP* is the percentage of heavy vehicles, *L* is the road width, *Q* is the total number of vehicles per hour, N_c is the number of light vehicles per hour, N_m is the number of motorcycles per hour, N_{hv} is the number of heavy vehicles per hour, N_b is the number of buses per hour.

Although these correlations are nonlinear they do not provide very accurate approximation of the trend followed by sound pressure level according to a certain number of physical parameters because any models itself includes the flow and composition of the road traffic which may be different than examined urban areas. The prediction model of traffic noise for the flow and traffic composition of the road traffic in Baghdad city is presented in this study.

The traffic noise on observed measurement points are mainly caused by the motor vehicles, especially the heavy vehicles for their slow characteristics and heavy engine.

Road Noise Model (RNM) Development:

Equivalent noise level (L_{eq}) in units of (dB) on a weighted scale (dBA) is used as dependent variable. Equivalent noise level is defined as the constant noise level consist the same quantity of acoustical energy as the real fluctuating of interest over the same period of time. [8]

Traffic volume with its composition use as the dependent variables to developed the model. Each type of vehicle passenger car, light and heavy vehicle produces noise level differently depends on their size and engine size. These variables are employed to develop linear multiple regression models using the statistical software of SPSS version 18.

Approximately 70 % of the sample size used to build the model, which is equal to (62) points, while the remaining 30 % of sample size, which is equal to (18) points is used for the validation stage of the model. All data were recorded in statistical sheet of Excel and SPSS software. The plot of data between L_{eq} and vehicle flow showed a logarithmic variations for obtaining convenient liner regression fit, while the plot of data between L_{eq} and % H.V showed linear relationship. **Figure (3)** and **(4)** shows scatter plot for total volume and % H.V vs. Noise Level respectively.

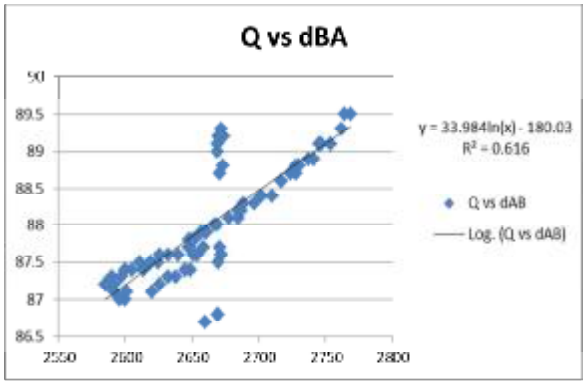

Fig.(3) Scatter Plot for Total Volume vs. Noise Level

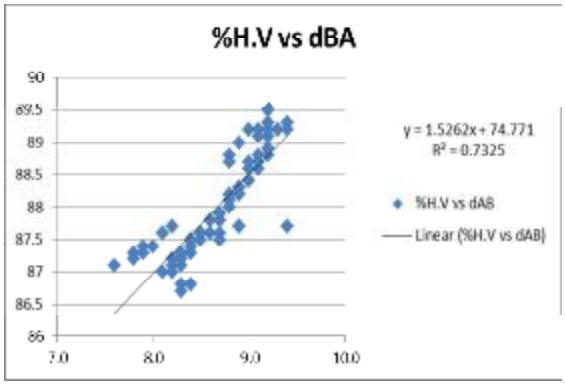

Fig.(4) Scatter Plot for % H.V vs. Noise Level

The developed model is:

$$L_{eq} = 1.779 + 22.124 \log Q + 1.203\ \%\ H.V \qquad (8)$$

Were:

L_{eq} = Noise Level in (dBA).

Q = Total Traffic Volume (veh./hr.)

% H.V = Percent Heavy Vehicle.

Coefficient of determination (R^2) for the regression model is (0.762) with standard error of (0.378).

Model Limitation:

The estimated models work significantly within the data rang used in regression analysis. Table (2) illustrates the original data rang for each variable.

Table (2) Models Limitations

Variables	Symbols	Upper Limits	Lower Limits
Noise levels	**L_{eq}**	89.5	86.7
Hourly volume	**Q**	2769	2585
% Heavy vehicle	**% H.V**	9.4	7.6

The estimated model had been checked for workability with the above limitations.

Correlation Matrix:

Table (3) illustrates correlation matrix between variables for the RNM model. This value represents coefficient of correlation R.

Table (3) Correlation Matrix for the Variables.

Variables Symbols	L_{eq}	Log Q	% H.V
L_{eq}	1.000	0.760	0.858
Log Q	0.760	1.000	0.744
% H.V	0.858	0.744	1.000
N	62	62	62

Model Validation:

For the validity of new developed model, model used to calculate a (L_{eq}) noise level for a new data not included in the data used to build the model, the estimated noise level value were compared with the actual measured value to check the reliability and level of accuracy of the developed model in explaining the actual data. **Figure (3)** presents the observed versus estimate noise level value.

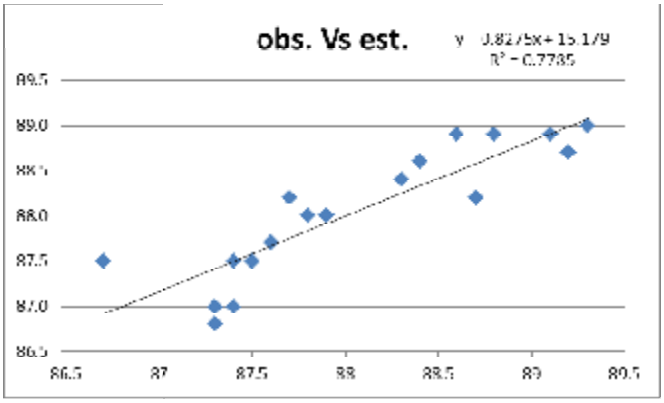

Fig. (3) Observed Vs. Estimated Noise Levels

Coefficient of determination (R^2) is 0.777. R^2 value of 1.0 is considered best fit, where any value above 0.7 is considered good [7].

The average difference between mean of the measured (observed) noise level and the mean of estimated noise level is (0.023). Concerned have been given to compare means of samples for the purpose of determining the observed difference is significant or not, and hence consider the models unvalid. This comparison of mean is carried-out by hypothesis testing. The null hypothesis was examined by the t-test; t calculated is (0.928).

$t._{tabulated}$ @ 1 % level of confidence and 34 degree of freedom is 2.732

$t._{tabulated}$ @ 5 % level of confidence and 34 degree of freedom is 2.034

The t test calculated is less than tabulated , this indicate there is no significant difference between observed and estimated noise level mean value for the RNM at 1 % and % 5 % level of confidence, therefore the model is valid and the difference is reasonable. Table (4) presents summary calculation for performing t –test.

Table (4) Calculation for Performing t -Test

	Observes Noise Level dBA	**Estimate Noise Level dBA**	**Observe – Estimate**
Sample Size	18	18	18
Mean Value	88.056	88.033	0.023
Std. Dev.	0.766	0.705	0.061
Cal. paired t-test			0.928
Tab. Paired t-test @ 1% level of significant			2.732
Tab. Paired t-test @ 5% level of significant			2.034
significance			No Sig. Diff.

The chi square to test goodness of fit, this is mean the null hypothesis states that there is no significant different between the observed and estimated distribution. To test the significant of discrepancy between observed and estimated noise level χ^2 test of goodness of fit has been applied. $\chi^2_{calculated}$ is (0.025).

$\chi^2_{tabulated}$ @ 1 % level of significance and 17 degree of freedom = 24.769

$\chi^2_{tabulated}$ @ 5 % level of significance and 17 degree of freedom = 27.587

$\chi^2_{tabulated}$ @ 95 % level of significance and 17 degree of freedom = 8.672

Since $\chi^2_{calculated}$ value is too small to $\chi^2_{tabulated}$ value, therefore noise level calculated and observed value are in good agreement at 17 degree of freedom at 1%, 5 % and 95 % significance level.

Comparison between Noise Level Predicted by RNM, Calixto and CEE Models:

The Calixto model is basically a statistical technique which is used for carrying out the generation of noise by considering the various road traffic factors and provides us with the levels of noise corresponding to that road traffic conditions. This models takes percentage of heavy vehicles and volume of vehicles i.e number of vehicles passing through the highway at a certain time period as input and provide us with the levels of noise been generated by the vehicles [8]. The calixto model is also based on the fact that heavy vehicles are responsible for greater production of noise in comparison to the lighter vehicles. The CEE and RNM tack into consideration the same fact.

Two models Calixto and CEE model are used to predict noise level for the highway studied and compared these values with measured and predicted noise level value from RNM model, the measured noise level did not used in model build. Noise level measured ranged between (89.3) dBA and (86.7) dBA, while the noise level predicted by Calixto model ranged between (54.1) dBA and (53.2) dBA, where the noise level predicted by RNM ranged between (89.0)dBA and (86.8)dBA, the noise level predicted by CEE model ranged between (43.2) dBA and (41.7) dBA, **Figure (4)** shows the comparison between measured, RNM, Calixto and CEE models. **Table (5)** presents these ranges.

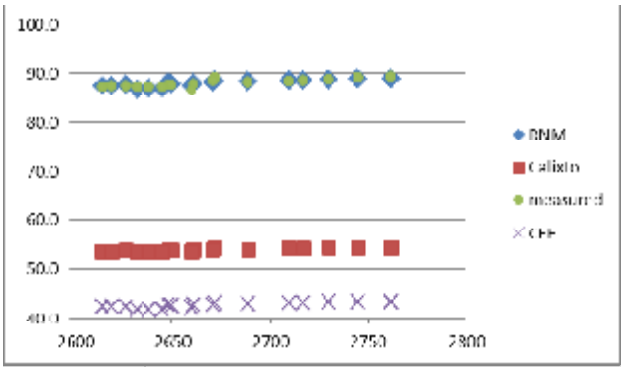

Fig. (4) Comparison between Measured, RNM, Calixto and CEE Models

Table (5) Range of Measured Noise Level and Estimated Noise Level by RNM,Calixto and CEE Models

	Upper Limit In dBA	Lower Limit In dBA
Measured	89.3	86.7
Est. RNM	89.0	86.8
Est. Calixto	54.1	53.2
Est. CEE	43.2	42.0

To compare the difference in meaning sample between the measured noise level value and noise level predicted by the RNM , Calaxito and CEE models, by performing t-test to determine the observed difference is significant or not to reveal which model among the three models is more suitable in presenting the Iraqi freeway environment. **Table (6)** shows the necessary calculations for the paired t-test.

Table (6) Summary Calculation for t - Test to Perform Comparison among RNM, Calixto and CEE

	Observes Noise Level dBA	Estimate Noise Level RNM dBA	Observe – Estimate	Estimate Noise Level Calxito dBA	Observe – Estimate By Calxito	Estimate Noise Level CEE dBA	Observe – Estimate by CEE
Sample Size	18	18	18	18	18	18	18
Mean Value	88.056	88.033	0.023	53.7	34.356	42.9	45.156
Std. Dev.	0.766	0.705	0.061	0.07	0.696	0.535	0.231
Cal. paired t-test			0.928		4.736		3.678
Tab. Paired t-test @ 1% level of significant			2.732		2.732		2.732
Tab. Paired t-test @ 5% level of significant			2.034		2.034		2.034
significance			**No Sig. Dif.**		**Sig. Dif.**		**Sig. Dif.**

The result shows a difference between mean of observed and Calixto model of (34.356) which is significant difference at 1% and 5% level of significant and 34 degree of freedom. While the difference between mean of observed and CEE model of (45.156) which is significant difference at 1% and 5% level of significant and 34 degree of freedom.

Since the difference between observed and estimated noise level produced by RNM (0.023) is not significant difference, therefore the RNM is the most suitable model in presenting noise level in Baghdad freeway environment.

Conclusions:

A multiple regression model was developed to investigate traffic noise in freeway of Baghdad environments. Two significant variables investigated traffic volume and percent of heavy vehicle in traffic flow, the following points can be concluding:

1- The RNM model has a good coefficient of correlation R^2 value of (0.762).
2- The coefficient of correlation R^2 value for observation and estimated noise level by RNM is (0.777).
3- RNM has been checked for validation by chi square of goodness of fit, which indicate a valid model at 1%, 5% and 95% level of confidence.
4- The difference in noise level (L_{eq}) mean between observed and estimated value tested by t-test, which indicates that there is no significant different between means at 1 % and 5% level of confidence.
5- A comparison between RNM, Calixto and CEE models indicates that among these different models the RNM model is more accurate in predicting noise level for Baghdad freeway environment.

Finally the study suggested that:

1- Noise level can be reduce by limiting the number of vehicles by encourage the public transport and restrict the passage of trucks and large vehicles at certain times of the day so as not to affect the traffic flow.
2- Future study is required to include some other factor such interaction between tyres and road surface, pavement condition, car horn, etc.
3- Preparing educated program for public concerning the effect of traffic noise on human health.
4- Imposing financial penalties for each kind of noise and air pollutants similar to the fines for traffic violations.

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