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Traffic Parameters and Noise Pollution of Highway

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ABSTRACT

The noise pollution and its harmful effects on public health has become a major problem of the largest metropolises around the world and attracted academic interest. In this study, one of the most crowded areas of the Tehran metropolitan was selected. In this case study, the traffic statistics and sound levels measurements of the area were received, and the noise levels generated in the area in a 7.5-meter distance from the highway was calculated. This distance is the standard calculation value for noise pollution and is commonly used in noise calculations. To validate the model, the received statistical data were examined, and a model was developed accordingly, and the data were verified. The correlation of the linear model was equal to 0.871.
KEYWORDS: Noise, Pollution, Traffic, Health, Statistics.

INTRODUCTION

Noise emission in environment or in another word noise pollution, become one of the most important issues in cities with high population. Noise pollution issue will be more important when health of its citizens reach in hazard zone. Deceases like hearing problems, neurological and psychiatric disorders, tiredness and impatience, insomnia and its side effects become more due to noise pollution in residential zones. With population growth in crowded cities and crossing highways along residential areas, noise pollution level rises dramatically. Thus, authorities describe standard levels in different areas to prevent noise pollution side effects for citizens. Many researchers conducted studies to understand noise behavior and its relation to traffic characteristics and there are many mathematical models to calculate noise with traffic parameters like average velocity of vehicles and highway capacity.

The more average velocity of vehicles (because of decreasing motor sound), the less is noise level. In another hand, increase of vehicle counts in region will increase the number of sound sources, so noise pollution will be risen.

Different models are presented for noise pollution calculation. Each of these models evaluated and are precise. Their differences are their parameters that they use for their calculations. There is one standard method that is used by United States and many countries use this method as their standard model. It is called FHWA and it is become popular among other standard models. Jaoet al (2012) presented a model for non-straight roads. They modified FWA model and change some of its parameters to predict sound level in non-straight roads **[12]**. Some researchers, related pavement conditions to noise pollution and made a model to determine sound level of the area **[1]**.Also, role of porous asphalt in noise emission is considered **[3]**. Watts et al (1999) conducted a comparison between sound barriers and porous asphalt effects in noise level of the area and applied a correction parameter to mathematical models of noise calculations **[10]**.

To calculate noise pollution level of the area with use of physic and wave relations, complex equations are resulted. Therefore, possibility of error is higher and measuring of wave parameters (like wavelength) are more difficult. For better results, equations have been made to calculate noise pollution level with use of traffic parameters. These equations are easier to conduct and are shown better results. Different models are defined in each country. These differences are due to various factors that have unique effect in each region.

Some models can calculate equivalent noise level base on flow-speed diagram **[5]**. This diagram has many applications in noise emission models such as annual noise level calculation in urban areas **[4]**. Another model presented by Ramirez (2013) is based on random road traffic for calculating noise level **[8]**. There are some other models using genetic algorithm for calculating noise level**[7]**. Neural system models also has been applied to calculate noise level in some areas**[2]**.

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In conclusion, there are numerous models to calculate noise level base on various traffic parameters. Most studies shows that these models are applicable with insignificance difference between the results if model assumptions are applied correctly**[6]**.

2.METHODOLOGY

2.1. Case-Study

The Azadegan Highway was selected for this study from the highways located in Tehran City. The reason was that this highway hosts the traffic of different types of vehicles (e.g. trailers and trucks) and thus it demonstrates a higher level of noise pollution. This highway is connected to the Tehran-Karaj intercity corridor from the northwest and thus it accommodates a high level of intercity traffic of vehicles. Moreover, noise pollution is an issue in the West of Tehran Azadi Square due to the presence of residential units and the necessity of ensuring the convenience of citizens.

Azadegan Highway is a highway in Tehran City. It stretches from the northwest to the southeast of this city. This highway starts from the Tehran-Karaj freeway in the northwest and ends to SerahAfsarieh (Basij) in the southeast. Following its intersection with Tehran-Karaj freeway this highway meets the following highways along the southeast lane: ShahidLashghari Highway, Fath Highway, Tehran-Saveh Freeway, Ayatulla Saeed Highway (Saveh Road), Khalij-e Fars Freeway (Tehran-Qom) in Jihad Square, BeheshteZahran Highway, ShahidRajai Highway, Dowlat Abad Highway (underconstruction), and Serah-e Afsarieh (Basij). Therefore, this highway is linked to Shahr-e Rey through the ShahidRajai Highway. Azadegan Highway is located in the north-west zone of the city and stretches from northwest to southeast. It also ends to Tehran-Karaj freeway in the northwest and ends to Serah-e Afsarieh (Basij) in the southeast. Azadegan Highway crosses Tehran-Karaj Freeway in its path. It also crosses the following highways and freeways along its south-east lane: ShahidLashgari, Fath, Tehran-Saveh, AyatullahSaeedi (Saveh Road), Khalij Fars (Tehran-Qom) in Jihad Square, Behesht-e Zahra, Rajai, Dowlat Abad and Serah-e Afsarieh (Basij). In traffic terms, this highway is known as a superhighway. It is also considered among the inlets and outlets of the capital (Tehran). Azadegan Highway is connected to Shahr-e Rey through Rajai Highway. It is, therefore, a substantial route for passengers aiming to travel beyond Tehran and its boundaries. The main traffic load of this highway occurs in vacations and weekends).

2.2. Noise level measurement in the area

The street was in fact a bridge on Azadegan highway with an island separating the two sides of the street. It had a width of 16 meters with two lanes in each direction.

The noise level was measured in the sides of street in 5-min intervals. In other words, first, measurements were conducted by a device in one side of the street for 5 minutes. Then, the same device was used for the 5-min measurements in the other side. This was because in one side, new asphalt had been distributed, and there were new materials, while in the other side, there was an old asphalt. This made it possible to make a general comparison between noise propagation in new and old asphalts. A boulevard was also located in the middle of the street which somewhat helped distinguish the sound propagation.

The data collection was performed in 11:00 am in June 29, 2014 in Sanaye-e Havaii Street in 5-min intervals. The collected data were then compared, and the effect of pavement type on the noise propagation and the mathematical model used in the study was investigated.

According to the results, which will be described in the following sections, a coefficient was considered for pavement in the mathematical model which gives the modified noise according to the measurements**[6]**.

2.3. Traffic Statistics of the Area

To calculate the noise in the area, it was necessary to collect traffic data including the average speed of the passing vehicles and the volume of passing traffic by each type of vehicles. Accordingly, the data was received from the Traffic and Transportation Organization of Iran and was used as the input in the calculations. Table (1) shows the traffic data for one month in the studies area.

Table 1. Number of vehicles crossing the study area in three classifications

Date	Evening			Day			Night		
	Heavy	Medium	Light	Heavy	Medium	Light	Heavy	Medium	Light
23-Jul	1778	6449	25218	1201	4213	19901	585	1538	9518
24-Jul	1500	6146	25275	1141	3913	19232	602	2136	10675
25-Jul	808	3388	18917	679	2446	14233	568	2513	12391
26-Jul	1699	5884	24408	1162	4173	19985	668	2252	11099
27-Jul	1974	6789	25446	1338	4573	20996	612	1842	9847
28-Jul	1982	7641	24344	1643	5844	22537	869	2944	14039
29-Jul	777	4090	18872	1141	4863	18841	1496	6862	21174

Figure (1) shows the number of passing vehicle in a week in the area by light, medium, and heavy vehicle. Light vehicles had the heaviest traffic, thus, the light vehicle traffic parameters in terms of passing speed and number had a greater weight in the model.

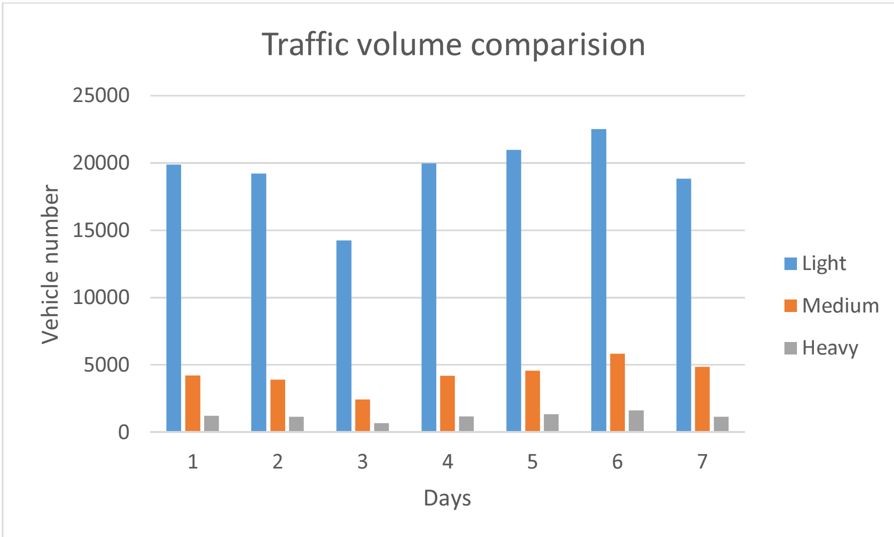

Figure 1. Traffic volume comparison for each vehicle classification in one week

Table (2) shows the primary input for the mathematical model developed in the program. The other input of the mathematical model was the average speed of the vehicle by weight which is shown in Table (3) for July-August 2014.

Table 2. Average speed of vehicles in three weight classifications

Date	Heavy			Medium			Light		
	Evening	Day	Night	Evening	Day	Night	Evening	Day	Night
23-Jul	103	106	103	97	99	99	103	105	105
24-Jul	104	106	97	98	101	100	104	106	105
25-Jul	108	99	96	102	104	99	108	108	105
26-Jul	104	106	97	98	100	99	104	106	105
27-Jul	103	105	91	96	100	100	102	105	105
28-Jul	97	103	96	91	97	96	98	103	103
29-Jul	104	95	93	96	89	85	102	94	91

The primary inputs could be entered in the program according to the Tables (2) and (3). Another parameter in the model was the correction of the effects of the pavement condition on the noise propagation.

Table 3. Linear regression analysis results of the model

R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
			R Square Change	F Change	df1	df2	Sig. F Change
.872	.871	.54504	.872	715.386	3	315	.000

2.5. Sample Validation

To ensure the model validation, various statistical tests were performed on the model output and its independent variables. Different models were applied in statistical series, and the best models were selected.

Table (3) shows the results of the linear regression analysis of the model. The R value for the model was obtained as 0.871 by the mean sum of squares. This value was used for the model accuracy in the statistical analyses. This value was higher than the acceptable level, 0.5. The mean sum of squares can be calculated by the following equation:

$$R^2 = 1 - \frac{\sum_i (y_i - f_i)^2}{\sum_i (y_i - \bar{y})^2} \quad (1)$$

The degree of freedom, df, represents the normal distribution of the employed variables, which was not used in the model utilized in the present study. Also, the Sig. F value, which is the sum of the mean differences, was zero in the above table which verified the validity of the problem assumptions.

Normal distribution of depend value (Equivalent noise level) is shown in figure (2). Residual of normal distribution value is in zero area and this result shows that model assumption and independent values are chosen correctly.

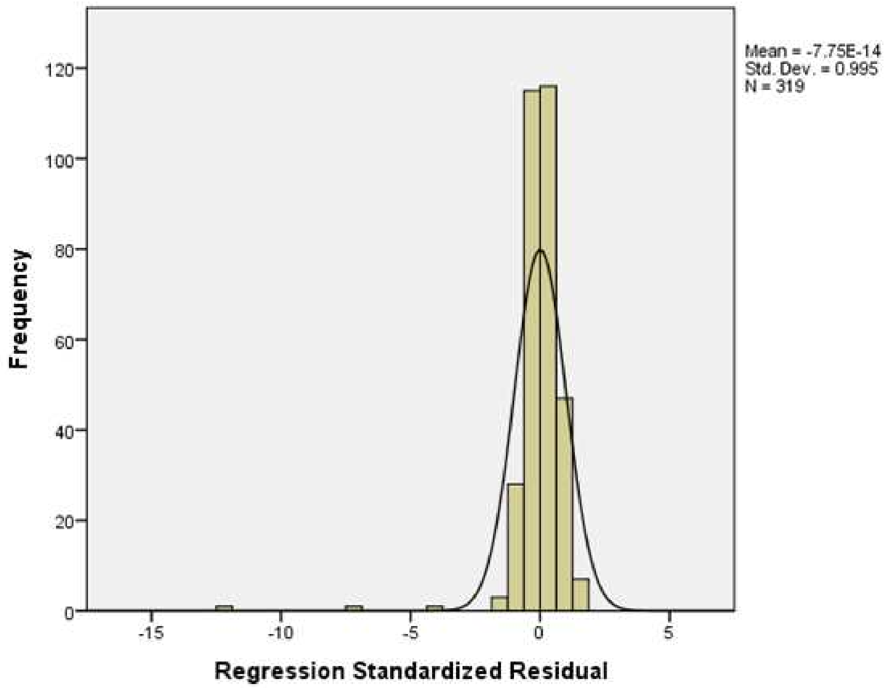

Figure 2. Regression standardized residual for 319 data

In table 4, coefficient factors of independent values are related to dependent value (Equivalent noise level) is illustrated. These values concluded from statistical tests. As shown in table, the dependence of dependent value to velocity of vehicles is more than other values. Therefore, the change rate of speed of vehicles is more important.

Table 4. *Results of coefficient analysis of independent values*

Parameters	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	79.586	.706		112.673	.000
Ql	.000072	.000	.782	37.079	.000
Qh	.000241	.000	.295	13.770	.000
V	.094	.008	.244	11.879	.000

According to table 4, linear equation can be result as below.

$$L_{eq} = 0.72Ql \times 10^{-4} + 0.241Qh \times 10^{-3} + 0.094V + 79.59 \quad (2)$$

This equation shows that all parameters (Ql for light vehicles and Qh for heavy vehicles) are directly related to noise emission. In another words, by increasing the value of each value in equation, sound level of area will be increased.

Estimated relation between traffic volume and noise pollution is shown in Table 5.

Table 5. Relation between traffic volume decreasing and noise decreasing[9]

Volume decreasing (Percent)	Noise decreasing (dB)
10	0.5
20	1.0
30	1.6
40	2.2
50	3.0
75	6.0

For example for velocity and volume of vehicles, table 1, 2 can be used in the equation and the equivalent noise level will be obtained. As shown in the equation the direct relationship is between the volume of traffic and increasing the noise levels. Also in table 5 is a studied work that is done for noise levels and decreasing of traffic percentage**[9].**

Statistical result and data received from various analysis tests on model shows precision of this model for study area is reliable and linear, cubic and logarithmic models have closer results to observed equivalent noise level. Since the presented model is a logarithmic model, the statistical results show that the model is accurate and reliable to perform the calculations.

3.CONCLUSION

Finally, based on the inputs and measurements carried out, for one year, the amount of noise generated by vehicle traffic on highways is obtained. Table 6, defined standard for urban areas is provided.

Table 6. The EPA standard for the maximum level of noise in urban areas in terms of dB

Area	*Day (7.00 to 22.00)*	*Night (22.00 to 7.00)*
Residential	55	45
Residential-Commercial	60	55
Commercial	65	50
Residential-Industrial	70	60
Industrial	75	65

In conclusion, most days of the year in Azadegan highway, noise level of area is too high. This level can harm citizen's health if they stay for long term. Two towns are in effect of this highway, Icbatan town and Darya town. These to town linger in close range of highway axis and noise produced by this highway affect thses areas. Therfore, authorities should conduct some sollutions for decreasing sound level in the area. Two general sollution could be performed in area. First is sound barriers in highway shoulders and second is use of porous asphalt. Both of this sollution are worked in some cities and the results shows that this sollutions decrease the sound level of the area dramatically. These sollution could be performed for increasing citizen's comfort.

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