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Prediction of Highway Noise Pollution Level by Model FHWA -TNM (Case Study: Vakilabad Highway in Mashhad-Iran)

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ABSTRACT

This study aimed to model the noise pollution level in 9th and 11th districts of Mashhad municipality (Vakilabad highway) by using Traffic Noise Model (TNM 2.5). To this end, the equivalent sound level measurement of the 25 high-traffic stations selected along the Vakilabad highway in Mashhad was carried out by the TES-1358 sound level meter, for 6 months and each month for 1 working day in the year's 2017. Traffic volume data was also measured to level the day by the wood line method and then the total data was introduced to model the traffic noise volume in the area. The assessment of the traffic noise of the study area in the model showed that the average equivalent sound level calculated by the model for the stations measured at Vakilabad highway is 6.51 dB less than the recorded values by the sound meter in the real environment by the average of 78 dB. In addition, the results of this study indicated that the TNM could provide a reasonable prediction of traffic volume and its distribution on the Vakilabad highway in Mashhad, due to providing a similar ranking of areas with low or high noise pollution and also displaying acceptable values of Leq calculated as compared to recorded sound values in the real environment.

Key words: Equivalent Sound Level; Highway; Urban Traffic Noise; Sound Level; Traffic Noise Model (TNM)

INTRODUCTION

Environmental pollution has attracted Global attention more than ever in the recent three decades. Meanwhile, the issue of Noise pollution in cities is considered a widespread problem in many countries, all over the World [1,2,3]. Noise, like all pollutants, reduces the quality of life and results in significant health risks, and the physiological and psychological effects of noise pollution on humans usually appear gradually [4,5]. Therefore, it seems that in today's world, Noise pollution is considered as one of the urban problems of citizens; however, despite its expansion in large cities of Iran, unfortunately, the importance and place of noise pollution in the country are not clear and obvious, like most types of pollution. Hence, in macro planning of development in the Environmental sector, it is necessary to take into account the issue of controlling and reducing the sources of pollutants.

The assessment of traffic noise can be considered as one of the appropriate strategies to predict the conditions for reducing pollution in urban environments [6,7,8]. One of the most common methods for predicting traffic noise volume and assessing its effects is the development of statistical models that can provide the necessary management measures to control traffic and reduce traffic noise [9,10,11,12,13]. The purpose of this modelling is to apply the traffic flow characteristics, such as volume, vehicle classification and travel speed along existing highways. Thus, with the rapid development of road transport tools, the effect of traffic flow structure on the traffic noise level has become one of the main research areas. It is possible to monitor the basic parameters of the traffic flow and their procedures to predict and monitor the noise generated in a particular section of the transportation network. In this way, different modes of traffic management can be applied to provide noise reduction effects that are absolutely important for human health and environment improvement. Modelling noise pollution is done through the use of the standard sound propagation model. Such models are used based on the classification of studied regions and passing vehicles, as well as the determination of sound absorption coefficients at different levels and conditions. In this regard, several standard models have already been introduced to assess urban traffic volume, including CORTN in the UK, Traffic Noise Model (TNM) in the United States, RLS90 in Germany, CNR in Italy, NMPB model in France, ASJ model in Japan, SPREAD-GIS System for the Prediction of AcousticDetectability-Geographic Information System in the United States and Sound Plan Model in Germany and, the researchers' efforts have focused to optimize these standard models [14]. However, unfortunately up to now, numerous studies in the field of noise pollution modelling have failed to provide a model that is proportional to climatic characteristics, sound power and noise propagation factors of Iranian cars. So mostly activities are performed based on models from other countries using the relevant software or a model of the aforementioned models is calibrated for the studied area [14,15,6]. However, it seems that the TNM is more suitable for assessing traffic noise pollution, especially in the urban highways of Iran, in comparison with other existing software, which is often expensive or designed for specific purposes [16,17,6]. Some advantages of this model include its high ability to estimate the sound intensity values at any height and any desired point and with regard to the presence of obstacles and sound equipment while ensuring the effectiveness of noise barrier (height and length), reduce the number of samplings and consequently cost reduction, the ability to estimate the sound parameters in different management modes and different working and environment conditions, as well as the lack of sensitivity of modelling to background noise (in actual measurements, unlike modelling, if the background noise is high, it is impossible to determine the sound intensity caused by sources). Therefore, due to the effective role of traffic on the noise pollution of cities in Iran, as well as the lack of comprehensive studies in this area in Mashhad, and separation of the municipality areas of this metropolis, there is a need for research in this regard. Hence, this study was conducted with the aim of modelling the noise pollution level in 9th and 11th districts of Mashhad municipality (Vakilabad Highway) using the TNM.

MATERIALS AND METHODS

In this research, Vakilabad highway in Mashhad City was selected as the main roadway connecting different areas of Mashhad to summer resorts of Torqabeh and Shandiz with high vehicle traffic volume as well as the focus of administrative, educational, residential and commercial centres as a case study. Vakilabad Highway includes parts of two municipality districts of nine and eleven, which have had a high urban expansion over the past decade, due to its high rate of development compared with other areas of Mashhad [18].

Data Collection

Firstly, in this research, after collecting and extensively studying the available scientific sources, conducting field visits as well as interviewing people and authorities, sources of noise pollution in Vakilabad highway area of Mashhad were identified. They were selected mainly around and as far as possible to overlook sensitive areas. Then, 25 stations were determined based on the intersections and density of the sensitive points using the route map [19]. The geographic location of these stations is shown in Table 1. Measurement of the equivalent sound level at the mentioned stations was carried out for 6 months and 1 working day in each month in 2017 at traffic peak hours, from 7:30, AM to 8:30 PM. The duration of the measurement for noise pollution level in each station was considered to be one hour.

In this research, the Sound Analyzer 1358 (TES-1358) was used to measure the equivalent sound level. The apparatus was set up on the A-frequency weighing network, fast speed and the 130-30 dB spectrum and calibrated using the Sound Level Calibrator (TES-1356). According to World Health Organization (WHO) standards, sound measurements were performed on a base with a height of 1 m from the ground surface and at a distance of 0.5 m from the curb and 3.5 m from the wall and a foam windscreen were employed on the apparatus's sensor to minimize the effect of air currents on the data [20]. It should be noted that traffic volume data was also measured through the wood line method from 7:30 AM to 8:30 PM. The duration of the survey in each station was considered one hour.

Traffic Noise Evaluation Using the TNM Model

In this research, TNM2.5 interpolation system model was used to predict traffic noise volume in the study area. TNM was produced by the Federal Highway Administration (FHWA) and T. M. Barry & J. A. Reagan, between 1995 and 1993. Moreover, the TNM2.5 was released in 2004 and the new version, TNM 3.0, was released to the market in 2015. In this model, there are five types of vehicles, including car, medium truck, heavy truck, bus and motorcycle. The TNM uses a computational algorithm formula according to Equation (1) for estimating the equivalent noise level of one hour (LAeq 1h) for each vehicle. In this Equation, EL_i values represent the total noise emission level from the total vehicle by type of vehicles, $A_{traffic(i)}$ is the adjustment for traffic flow, A_d is the adjustment for sound intensity for distance from the road and the road length, and A_s is the adjustment for noise intensity for barriers, ground and trees. In the following, it is mentioned that how to calculate each of the mentioned cases [21,22,23].

$$L_{Aeq\ 1\ h} = EL_i + A_{traffic(i)} + A_d + A_s \qquad (1)$$

The adjustment for traffic flow ($A_{traffic\ (i)}$) is calculated by the Equation (2) in the TNM, where V_i represents the vehicle flow per time unit (h) and S_i

represents the vehicle speed in km/h [21,22,23]. It should be noted that in this study, the average speed of the highway was assumed for all vehicles with no traffic equal to 80 km/h.

$$A_{traffic(i)} = 10\ \text{Log}10\left(\frac{V_i}{S_i}\right) - 13/2\ \text{dB} \quad (2)$$

Table 1: Geographical Location of Noise Measurement Stations at Vakilabad Highway in Mashhad

#Station	Station's Location	X Coordinates	Y Coordinates
1	Park Square	728007.668	4021983.494
2	Beginning of Azadi Terminal	727687.612	4022092.783
3	End of Azadi Terminal	727395.720	4022190.604
4	Jalal Al-e Ahmad	726668.440	4022445.822
5	Sayed Razi	725923.858	4022711.736
6	Danesh Amooz	725291.837	4022935.123
7	Daneshjoo	724478.540	4023221.600
8	Vakilabad 43-41 (Sadaf)	723901.878	4023426.520
9	Vakilabad 53-51 (Shahid Ghane)	723192.834	4023680.277
10	Vakilabad 63 (Valiasr Boarding Clinic)	722761.952	4024017.822
11	Vakilabad 77 (Fareqotahsilan Blvd)	721627.283	4024234.111
12	West Terminal	719059.922	4025059.275
13	Vakilabad 70 (Shahid Bronsi Blvd)	720788.033	4024456.957
14	Vakilabad 64-62 (Center for Elderly people health)	721551.973	4024193.326
15	Vakilabad 60 (Iqbal Lahouri Blvd)	720315.136	4024049.679
16	Vakilabad 54 (Ladan Blvd)	722292.936	4023916.953
17	Vakilabad 50-52	722634.219	4023814.693
18	Vakilabad 42-40 (Sayyad Shirazi Blvd)	723210.991	4023603.022
19	Vakilabad 36 -34	723598.074	4023467.530
20	Vakilabad 30 (Hafez Blvd)	723859.462	4023364.361
21	Vakilabad 24-22 (Sohravardi Boarding Clinic)	724600.150	4023104.826
22	Vakilabad 20-18	725151.397	4022911.508
23	Vakilabad 14-16 (building of medical complex)	725321.486	4022846.861
24	Vakilabad 4 (Farabi Hospital)	726508.994	4022427.233
25	Bahonar Blvd (Faculty of Dentistry)	727513.245	4022060.437

As previously mentioned, the TNM transversely modifies the noise intensity based on the distance between the road and receiver, which is calculated by Equation 8. (Fig.1) [21,22,23].

$$A_d = 10 \times log_{10}\left[\left(\frac{15}{d}\right)\left(\frac{a}{180}\right)\right] dB \quad (3)$$

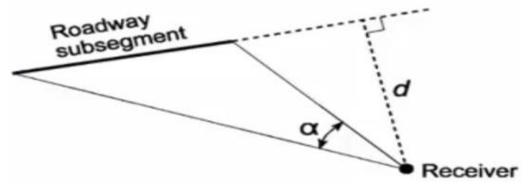

Fig. 1: The angle of the crossing line with the vertical distance between the road and the receiver [23]

As already mentioned, the TNM considers and modifies the effects of the ground and the existing barriers between the receiver and the source of sound production on the traffic noise reduction by A_s. So that the sound released from the source is affected by various factors such as trees and plants, barriers and sound walls, buildings, ground, asphalt, and weather condition. In the model used, the number of each of the abovementioned factors is calculated individually as a correction coefficient. It should be noted that in the TNM, atmospheric effects such as wind speed and temperature gradients have not been calculated. Furthermore, the TNM considers buildings as a barrier, with the exception that for considering the possibility of passing sound from buildings once the model is created and averaged with the assumption of complete barrier and once without the building. If there is not enough space between the buildings, it is considered as a complete barrier. The model considers only one row of buildings and takes into account 1.5 dB as the sound intensity reduction for each row of additional buildings. The minimum sound reduction is 10 dB due to the presence of buildings, so that the sound effect is also different on the surface of the ground, such that hard grounds cannot absorb the sound, but reflects the sound and increases the sound intensity. Soft grounds reduce sound intensity and cause sound absorption and energy. The sound intensity reduction or its increment should be expressed separately for each frequency because the reduction of sound intensity is different for each frequency. It should be noted that in this study, road surfaces were considered as ordinary asphalt and hard ground. Rainfall, especially in the form of snow, also has a great impact on the results because it increases the absorption of sound energy by the ground. Snow also creates positive temperature profile around the ground surface, which will increase the sound on the ground surfaces [21,22,23]

RESULTS AND DISCUSSION

In this section, Fig. 2, shows the location of sound measurement and its analytical parameters on the Vakilabad highway in Mashhad.

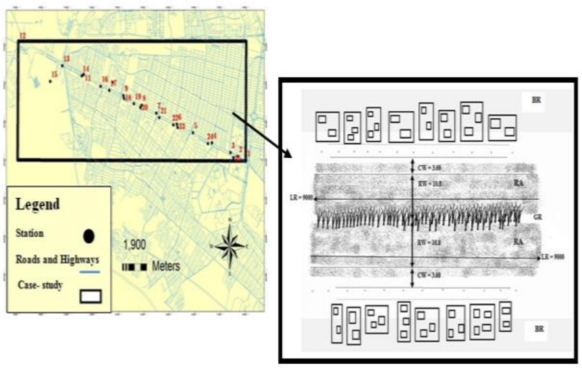

Fig.2.: Location of sound measurement and its analytical parameters in Vakilabad highway in Mashhad (◦: measured stations, measured unit in meters, BR: building row as a sound receiver, CW: highway bypass, RW: highway route width, LR: highway route length, GR: Greenspace and highway centre, RA: road asphalt)

The basic information required for the implementation of the model was entered into the model, according to Table 2 for all 25 stations studied. This information includes various data such as the station location (latitude and longitude), the elevation of the sea level of the study area (1050 meters), street width (eight lines and the distance of each line with the next line 3.60 meters in a reciprocating way), road slope (2-3%), building rows, green space that is continuously in the middle of the highway, the traffic volume (the passing volume of different vehicles from the roadway and vehicle's speed), and the measured values of equivalent sound level (Leq).

Table 2:TNM input data to predict road traffic noise

Station	**X coordinates**	**Y coordinates**	**Building Row based on building density**	**Traffic volume (vehicle per hour)**					**Vehicle speed**	**Ambient equivalent sound level Leq (dB)**
				Car	Bus	Motorcycle	Medium truck	Heavy truck		
1	728007.668	4021983.494	0	1696	71	30	57	6	80	74/9
2	727687.612	4022092.783	0	2143	41	33	63	6	80	79/43
3	727395.72	4022190.604	2	2077	65	42	66	9	80	77/8
4	726668.44	4022445.822	2	2083	59	15	75	9	80	78/85
5	725923.858	4022711.736	2	1741	38	24	69	9	80	76/87
6	725291.837	4022935.123	3	1684	38	39	69	6	80	80/3
7	724478.54	4023221.6	3	1552	53	36	69	6	80	79/39
8	723901.878	4023426.52	3	1561	35	33	72	12	80	78/28
9	723192.834	4023680.277	2	1633	38	24	63	9	80	78/07
10	722761.952	4024017.822	2	1588	32	21	57	6	80	78/39
11	721627.283	4024234.111	2	1678	38	27	66	9	80	77/72
12	719059.922	4025059.275	2	1750	59	18	63	21	80	77/36
13	720788.033	4024456.957	3	1687	50	33	90	9	80	76/57
14	721551.973	4024193.326	3	1600	35	18	84	6	80	76/9
15	720315.136	4024049.679	3	1564	35	21	69	6	80	76/39
16	722292.936	4023916.953	3	1711	38	33	63	6	80	76/56
17	722634.219	4023814.693	2	1750	29	33	72	6	80	79/73
18	723210.991	4023603.022	2	2047	29	27	84	6	80	80/67
19	723598.074	4023467.53	2	1738	32	24	75	12	80	80/34
20	723859.462	4023364.361	2	1699	38	24	75	6	80	85/63
21	724600.15	4023104.826	2	1726	38	36	60	6	80	75/26
22	725151.397	4022911.508	2	1816	38	15	72	6	80	79/31
23	725321.486	4022846.861	2	1855	38	18	54	6	80	77/45
24	726508.994	4022427.233	2	2422	53	39	72	12	80	77/32
25	727513.245	4022060.437	2	2506	56	48	93	9	80	76/53

Then, at the final stage, considering the noise barriers at each station for each vehicle, the average equivalent sound level was determined based on the raw input data and information to the TNM2.5 whose results are shown in Table 3.

In examining the results, it was found that the maximum equivalent sound level (Leq) calculated by the TNM is related to station 20 located at Vakilabad 30 (Hafez Blvd) which is equal to 79.50 dB, and the most important type of vehicle affecting the rate of equivalent sound level at this station is related to cars and motorcycles, which is equal to 74.4 and 66.5 dB, respectively (Table 3).

According to the sound standards level in ambient air in Iran, it can be stated that the average equivalent sound level at station 20 has been 19.50 dB in the weighted network (A) more than the allowable limit for commercial-residential districts. The effective factors in increasing the equivalent sound level at station 20 include traffic volume, traffic speed, horn usage, number of lines and their width, road slope and highway pavement installation, which indicate a significant relationship between noise caused by street traffic and daily pollution. The increase in the number of cars on Vakilabad highway in Mashhad and the lack of wide roads and streets, especially in the highway, have caused an increase in traffic congestion in the secondary streets and main sections of this highway during the hours of the day, which might increase the equivalent sound level or the environmental noise in the area. Moreover, the results of Table 3 show that the lowest equivalent sound level (Leq) calculated by the TNM is equal to 66.7 dB, which is related to the station 1 in Mellat park square and, the most important type of vehicle affecting the equivalent sound level at this station is related to cars and motorcycles, which is equal to 65.7 and 57.5 dB, respectively. The equivalent sound level at station 1 is 6.80 dB higher than the allowable limit for commercial-residential areas compared to sound standards level in ambient air in Iran. The existence of a relatively fluid traffic load, as well as the presence of traffic police officers and traffic lights, can be the main reasons for recording the lowest level of noise pollution at the station 1.

Table 3: The average equivalent sound level (Leq) calculated by the TNM for all types of vehicles at each station of Vakilabad Highway in Mashhad

Station	User area	Leq (dB)					
		Vehicle type					
		Station	Car	Bus	Motorcycle	Medium truck	Heavy truck
1	Commercial- administrative	66/8	65/7	51	57/8	53/8	50/7
2	Commercial- administrative	71/7	68/6	54	60/7	56/7	53/6
3	Commercial- administrative	70/8	44/1	37/6	48/2	37/6	41/2
4	Residential-commercial	72/3	48/1	40	50/1	40/2	44/2
5	Residential-commercial	68/2	67/1	52/4	59/2	55/1	52/2
6	Residential-commercial	76	65/9	51/1	58	53/9	51
7	Residential-commercial	73/2	67/1	52/4	59/2	55/2	52/2
8	Commercial- administrative	71/7	46	39/7	50	39/6	44/1
9	Residential-commercial	75/52	45/9	39/7	50	39/6	44/1
10	Residential-commercial	70/8	49/7	43/3	52/8	43/2	47/9
11	Residential	69/8	68/6	54	60/7	56/7	53/7
12	Commercial- administrative	69/8	68/6	54	60/7	56/7	53/7
13	Commercial- administrative	71/7	49/4	43/1	52/7	43	47/8
14	Residential	68	66/9	52/2	59	54/9	52
15	Commercial- administrative	68/2	67/1	52/4	59/2	55/2	52/2
16	Residential-commercial	73/9	50	42/1	49/4	42/4	44/1
17	Residential-commercial	73/7	36/9	29/7	38/1	30/6	31/4
18	Commercial- administrative	74/4	53/2	45/6	52/8	45/8	49
19	Residential-commercial	75/6	74/4	60	66/5	62/8	59/6
20	Residential-commercial	79/5	74/4	59/9	66/5	62/8	59/6
21	Residential-commercial	68/9	55	48/2	55/5	48/3	52/5
22	Residential-commercial	72/2	55/4	48/5	55/6	48/6	52/7
23	Residential-commercial	69/3	53/1	45/5	52/7	45/7	48/9
24	Commercial- administrative	70/2	67/1	52/4	59/2	55/1	52/2
25	Commercial- administrative	71/2	64/1	49/3	56/2	52/1	49/2

Fig. 3 demonstrates the comparison between the equivalent sound level in two modes of the real environment and the TNM with the ambient-air sound standards of Iran. Comparing the values of the equivalent sound level (Leq) by the sound meter in the real environment and also the modelled values of the equivalent sound level (Leq) by the TNM shows that the maximum Leq recorded in the real environment and the TNM model is related to the station 20 (Vakilabad 30, Hafez Blvd) which is 85.63 and 79.5 dB, respectively (Fig. 3). According to the sound level standards in ambient air in Iran, it can be stated that the average equivalent sound level recorded in two modes of the real environment and the TNM in the weighted network (A) has been more than the permissible limit for commercial-residential areas. Furthermore, the lowest Leq measured in the real environment and its predicted values by the model is related to station 1 located at Mellat Park Square, which is 74/97 and 66/87 dB, respectively. In general, it can be seen from Fig. 3 that the TNM shows the same ranking for areas with low or high noise pollution compared to its measured values in the real environment, which can indicate the suitability of the mentioned model for evaluating the highway traffic noise.

Also, the results of this study indicate that the average equivalent sound level calculated by the TNM for the stations measured at Vakilabad highway is 6/51 dB lower than the values recorded by the sound meter in the real environment with an average of 78/24 dB (Fig. 3). This could be due to the consideration of buildings as noise barriers in the mentioned model, as well as the lack of consideration of factors such as the actual slope of the road, the role of the ground surface in the sound reflection in the region, the role of the type of materials used in the building facade, road kind, different types of sidewalks and surface texture in the sound reflection and the friction role of vehicle tires with the road surface in the mentioned model.

Also, since in linear sound-producing sources such as highways, the reduction of the equivalent sound level by doubling the receiver distance from the sound-producing source is 3 dB, near-highway areas and other sound-producing sources can affect the equivalent sound level measured in the area. In most cases, most of the sound measurements in this study took place in the distance of 0.5m from the main road, although the traffic on the opposite and adjacent streets of highway may affect the measured sound level due to the above. Therefore, it seems that the role of sound reflection by urban streets can be studied through the use of more advanced 3D models such as the Sound Plan [24,25,26,27]. Bypassing a vehicle from a point, noise pollution is received from all points of the road or from any point where the vehicle is present, and the level of noise decreases with increasing distance from the source. Any changes in the volume of sounds and their decrease in the source, the propagation route or in the receiver, can affect the incoming waves of the human ear. Thus, the traffic caused by medium trucks may also increase the amount of recorded sound in urban environments. The size and range of noise caused by the tire of a car (automobile) or heavy vehicles with the sidewalk are different depending on the speed of the vehicle. In this way, the noise generated by this collision in trucks with speeds greater than 30 miles per hour is considered as the dominant sound-producing source and by doubling the speed of the vehicle increases the equivalent sound level by 10 to 12 dB. Though, road surface tire collision is considered to be the dominant source of noise for cars (automobile), the noise intensity generated by the tire increases proportionally with the speed, while the engine propulsion system (engine, exhaust, cooling system, and other auxiliary components in the engine compartment) is the dominant sound-producing source for heavy vehicles at relatively low speeds. In the study area, heavy vehicles drive at relatively low speeds; therefore, the noise generated from the vehicle propulsion system is of great importance in producing environmental noise [24]. In fact, by the increase of every five kilometres per hour that the speed of the vehicle is increased, the intensity of the sound produced by the tire is increased by 1 dB [14,5]. Hence, the sound produced by this system in models such as TNM that are designed for high speeds of the vehicle on highways is not entirely considered, which itself results in less estimation of the equivalent sound level in this model compared to the real environment.

Moreover, various climatic factors such as temperature, inversion phenomenon, etc., which are not considered in this study, can affect the sound level of the region and sometimes increase it. Therefore, since the permissible limit of difference between the values measured in the real environment and the values calculated by the TNM is 1 to 7 dB, it seems that the mentioned model can provide a reasonable prediction of the volume of traffic noise and, consequently, noise pollution of Vakilabad Highway in Mashhad [28].

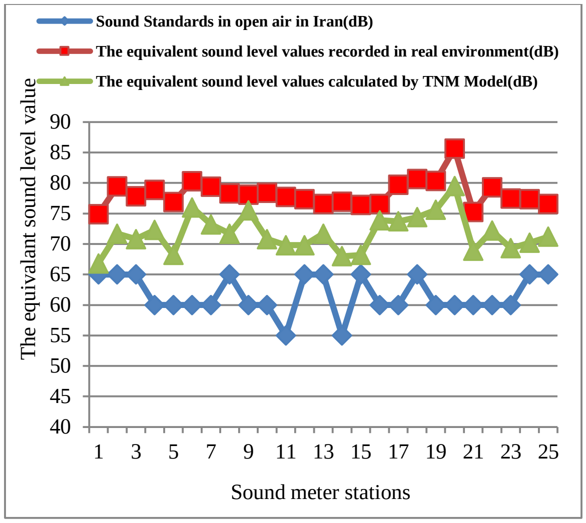

Fig. 3: Comparison of equivalent sound level values in two modes of the real environment and the TNM model with the Sound Standards in the open air in Iran

In a study by Nirjar *et al.*, researchers found that among the various models, CORTN and TNM models could be a satisfactory answer to assess the degree of noise pollution in Delhi, India. In this study, the allowable limit of difference between measured values in the real environment with the values calculated by TNM and CORTN models was expressed 1 to 7 dB and 1 to 4 dB, respectively [29]. The results of Huang *et al.*'s research in 2013 in Beijing also showed that there is a relatively high correlation between the measured values of sound in the real environment and the values calculated by the TNM in the short term. In addition, an assessment of the relationship between traffic and noise level in the three US cities showed that there is a high correlation between total vehicle traffic and noise level in Atlanta (78%), Los Angeles (58%) and New York City (62%). In addition, in this study, the noise level predicted by the TNM was related to the noise level measured in the real environment, though it showed lower values from the real environment [30]. Hassani *et al.* evaluated traffic noise pollution in the grand bazaar of Tehran with TNM. They also displayed that although the TNM has a relative advantage, especially in estimating the equivalent sound level compared to other models, the breadth of its use in implementation has limitations such as the reflection in the model, being multiline or two-way of streets and also their slope that is effective in the accuracy of the model studied [6]

CONCLUSION

This study was carried out with the purpose of modelling the noise pollution level of Vakilabad highway in Mashhad using TNM. The results of this study indicated that the TNM shows the same ranking for areas with low and or high noise pollution compared to its measured values in the real environment, which can display the suitability of the mentioned model for assessing the traffic sound in the case study. Furthermore, according to the results, the average equivalent sound level calculated by the TNM for the stations is 6.51 dB lower than the values recorded by the sound meter in the real environment with an average of 78.24 dB. Therefore, since the allowable limit of difference between the values measured in the real environment and the values calculated by the TNM model is 1 to 7 dB, it seems that the mentioned model can provide a reasonable prediction of traffic volume and consequently the situation of distribution and noise pollution of the study site. The TNM can be considered as an important component of designing in the stage of urban designing or urban development, and, with applying proper urban management, provide comfort and health for residents and employees. However, studies on the noise emission levels of Iranian cars, which represent the cumulative noise exposure over a multi-year career, are suggested at different speeds and conditions for better sound modelling.

ETHICAL ISSUES

All the unique sentences, no theft is plagiarism.

COMPETING OF INTEREST

Authors have no conflict of interests.

AUTHORS' CONTRIBUTIONS

All authors equally helped to write this manuscript.

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