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Modeling Traffic and Noise Pollution for Metropolitan Highways (Case Study of Ahvaz City)

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Abstract

Background and Objective:

Noise pollution is one of the major environmental problems in cities which has been a growing concern in the last few years. One of the important factor in urban construction designs is noise prevention. According to a study in 2020_2021 in Ahwaz, a suggested is presented for traffic noise compatible to conditions in Ahwaz.

Research Method:

Data was colleted to design a model from totally 113 measuring stations, 4 weekdays and 2 intervals an rush hours, yielding to a total number of 1344 traffic noise measurements (L_{eq}) and the influencial factors from traffic load, speed of vehicles, environmental and dimensional factors of roads. In the next step, all field data was put to Excel and SPSS, two soft wares for process. Then based on desired overall structure, using analytical and experimental modeling strategies, several Regression multi- variables were tested on data in order to design a model.

Results

Au recordings collected from 112 measuring stations inchcded 28224 records, a number which is considered a strength point for the present study. The model designed for Ahwaz consists of q inputs with high clarification coefficient (R^2=0.92) and correlation coefficient (R= 0.95). The number of inputs allows the model to record important features of traffic to yield more accurate estimations.

Conclusion

Due to precision and minutness of designing as well as the the number of inputs, the model can be a suitable one to define half – hair equal level for traffic noise and estimation of noise pollution in Ahwaz. The model can be developed by defining variables such as wind speed and gradient, estimation of absorption and reflection by construction materials estimation of absorption by plant species, etc.

Keywords: noise, pollution, statistical modeling, traffic, Ahwaz.

1. Introduction

Environmental pollution has been a growing global concern in the last three decades. Noise pollution among all other types, is a widespread issue concerning all the world (1 and 2).

Traffic and transportation of vehicles are two of the main causes. (3,4,5) Since transportation of vehicles an streets, roads, and highways directly affects the lives of people living near there, an evaluation of traffic noise and predictions for decreasing environmental pollutions is getting a more and more important issue in urban areas. (6, 7). An appropriate model for environmental noise caused by traffic can portray a clear picture of distribution and quality of noise pollution in an urban area, so that the application of such a model and city management can provide a healthful and peacful living condition to the inhabitants. If the model is able to estimate and predict traffic noise, too, it can be one of the main components of urban designing and civil development (8). In many developed countries, there are comprehensive, elaborated national models designed for this. Rahmani et al. 1390, reported two statistical models for road traffic noise in mashad, by applying analytic algorithm and considering parameters of traffic load, vehicles combination and speed, in order to calculate L_{eq}. (9)

Banerjee et al. 2008, studied effective factors on L_{eq} and developed models for industrial city, Asansol, India. (10). Gundogdu.o et al. 2005. Presented a model for Erzurum, western Turkey by applying a genetic algorithm model. They classified vehicles in 3 groups, and passage slope, vehicles combination, maximum distribution level of cars were there variables (11). Pamanikaboud and Viuitajinda, Thailand, 2002, presented a separate model for seven groups of vehicles (12). Seung eho, and Mun depicted a model for highway traffic noise in order to evaluate in 2008 in Northern korea. (B).

Abu-Qudais and Alhiary developed 3 models for L_{max}, L_{eq}, L_{min} based on analyses an 14235 records in Jordan. (14). Ahwaz, the center of Khouzestan Province, of 220 m^2 area and a population of over 1405939 (15) is amongst important cities due to its geographical and industrial status.

Drastiz expansion in urban areas, universities and industries, in the last few years in Ahwaz, has increased transportations through city roads and routs so that total number of vehicles including bicycles, motorcycles, cars, taxies, van, long vehicles, etc.) are over 336710. (15), a fact which has caused various types of pollution, especially noise pollution. The present study, there fore, was an attempt to measure traffic noise and its causes based on appropriate strategies and data transferred by modeling techniques and databases to a calculating software in order to designs a model. Advanced statistical techniques and multi- variable Regression Aralyser in SPSS were both applied to reate a comprehensive model for research on highways in Ahwaz.

2. Materials and Research method

Data was collected form 1344 measurments of traffic noise (L_{eq}) along with effective parameters including traffic load, speed, environmental features, road sizes and climate conditions in 112 stations an 7 main roads of the city. (Pasdaran Highway, Ayatollah Behbahani H.W. Enqhelab Bolivar. Sh. Chamran B.L.V. Gohestan Blv. Dr. Shariati St. Azadegan st.) Measurments were perforwed on 4 days a week (sat. Tue. Thur. Fr.) which represented week. Days and weelcend. ۱۰, there fore, were at three rush hours (7-8 A.M. 12-13 P.M. 8-9 P.M.) squares, intersections, areas between the selected spots were considered as stations. (17, 18, 19). All measurements were recorded by advanced phonometer CEL-450. The device is so accurate and in accordance with international standards. The above mentioned system has various models and applications able to measure various noise pollution variables. (20). The phonometer was calibrated daily and before measuring when the device was stoped and in order to eliminate wind effect, a sponge protector was used on microphone (6,24). The device was mounted at 1.6m from the ground (9, 12, 14, 25). Noise recording was done based on the standard distance from roadway. (3moters) (8, 26, 27, 28(and in frequency distribution network A (2, 14, 28) and each, sampling lasted for 30 minutes. (8, 29, 30). All measurements were dore on two sides of the road. (8, 28, 29, 31, 32, 33).

As mentioned above, the best multivariable Regression line model was required, according to the research objective, to be based on relations between independent variables effective on traffic noise and dependent variable (L_{eq}). Regarding designed models in various countries (8, 9, 11, 17, 25, 26, 28, 33) it was hypothesized that dependent variable (L_{eq}) was to be a function of 15 dependent variables. Fifteen dependent variables with hair indexes followings:

L: The length of the path (m).

W: Overall width of the road m).

H: Height of the surrounding buildings (m).

S: Slope of the path. (%) percent

F: The orea planted on the path (m^2)

N1: Number of passing vehicles including cars, vans, per hour. (with maximum weight of 4500 kg).

N2: Number of passing long vehicles including trucks, minibuses per hour. (with overall weight between 4500-12000 kg).

N3: Number of passing vehicles including trucks, buses, per hour with overall weights over 12000 kg).

N4: Number of passing motorcycles and tricycles per hour.

V1: Average speed of passing cars and vans (km/h)

V2: Average speed of passing trucks and minibuses (km/h)

V3: Average speed of passing trucks and buses (km/h)

V4: Dry weather temperature (ċ)

RH: Relative humidity (%)

If is wroth mentioning (cars, semi – long, long vehicles, motor- cycles) were was done at the some time of noise measuring. In order to calculate average speeds, the time of passage of each type of vehicle passing through two spots was recorded by a chronometer, and then it was calculated by given distances and speed formula. The climate conditions effective on sound such as dry temperature and relative humidity as well as dimension features of roads (Planted areas sizes, surrounding buildings, heights) were recorded while measuring. After recording all required samples in order to design the model, collected data was transferred to Excel and SPSS. In the next step requiered calculations were per formed on traffic docta to prepare the model.

To study relations between each of the 15 independent variables and dependent variable (L_{eq}) Stepwise was applied on SPSS. This is the best method for statistical modeling (28). Modeling was done in several steps by multivariable Regression Analysis a technique able to relate independent variables to a dependent one.

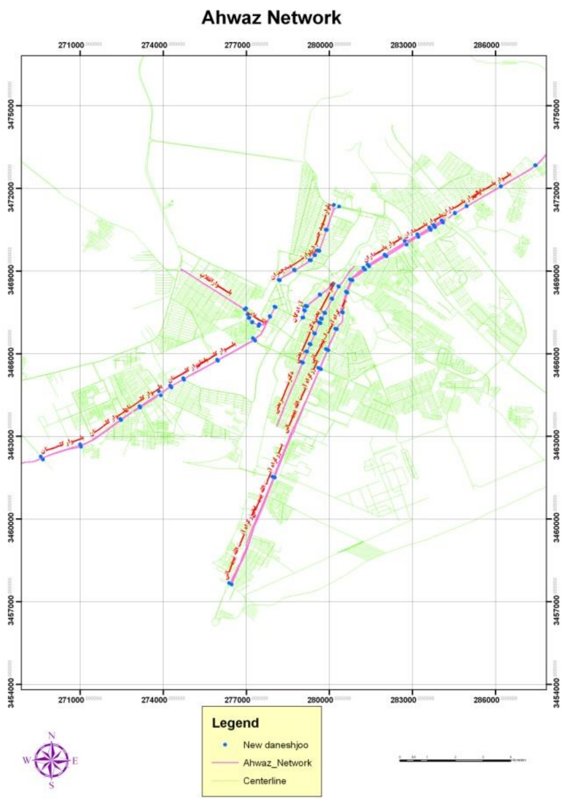

Figure1. Mapping of Ahwaz with location of measuring stations

3- Results. The results showed average L_{eq} at all stations as 72.62 ± 2.53. dBA and on all studied roads, days and in all periods, noise level was above standard. Max- Min L_{eq} ranges were 83.44 ± 3.8 and 65.37 ± 3.36 respectively. Statistical analysis showed that among all traffic parameters, passing cars sand vans were more than other vehicles in number per hour. (2304.34) and their average speed was also more than other vehicles, per hour. (34.30 km/h). Trucks and buses were of the fewest passage (35.11) with lower average speed per hour compared to other vehicles (25.40 km/h). Among dimension and environmental parameters, the length of the studied area of roads was of highest average (1654.65 cm) and slope was of the lowest average. (0.2 %). Results of Pearson correlation Test, quantitative traffic data and dimension and environmental data showed that L_{eq} showed that L_{eq} was directly related to all three variables. The highest correlation coefficient among the given variables was for cars, and vans passing per hour. (r=1).

1-3 Designing a Traffic Noise Prediction Model for Field Study Data

According to Regression Analysis Primary results, clarification coefficient between independent variables and L_{eq} was (R^2 = 0.7) which showed scattered data of high effect. In order to achieve a better clarification coefficient, therefore, data was standardized and refined (From total 1344 measured reassured records, 1135 were selected). In the next steps, analysis was done on the selected records.

1-1-3. Linear Regression Analysis Results

In order to study effects of each independent variable on L_{eq}, Linger Regression Analysis was applied and results are as Follows.

2-1-3. Final Model for Traffic Noise Prediction

After data refining range defined, and scattered data eliminated Regression Analysis was performed in several steps regarding clarification coefficient and modeling rules, and the best result was selected to write the best multivariable Regression line equation. It was found that a independent variables out of 15 had a meaningful effect on L_{eq}. The best Regression model, therefore, suggested is a follows:

Where L_{eq} 30 min is predicted for 3 meter distance from roadway. Other variables were introduced previously.

2-3. Matching the Designed Model with FHWA- STAMINA

One of the most complete models is a model by federal Highway Administration Model called FHWA designed by Body Vrigon. Being under development and expansion, it resulted from National cooperative Highway Program NCHRP. It was later completed and released under the name STAMINA (34). Including experimental and analytical contents, the model has been used for all main roads with interrupted traffic, though introduced as Highway Model. It represents traffic flow features as well as environmental and surrounding features of roads and bumps (34, 35, 36, 37). In environmental modeling it was praised as the selected model, being relatively advantageous in L_{eq} estimation for including numerous incomes compared to other models. (34). In order to match suggested model with FHWA, STAMINA, 7 correctional records were required to be calculated and included in L_{eq} (ref). Since these 7 factors have no effects on the on the current study in Ahwaz, and considering the fact that formulas and equations based on them did not result from field study in Ahwaz and are actually derived from models and studies in other countries (34, 35, 38) the seven calculation steps are not included. The steps are listed as follows:

1. The effect of distance and earth material shown as Δdistance This effect is considered on a condition where L_{eq} is required to be defined from a distance longer than standard (3m). Since the distance was considered as standard (3m). the present study did not need to calculate this value.

2. Relative humidity and temperature effects shown as Δair. This factor is calculated from a specific table. Since in the present study the above factors were calculated by regression Analysis and the mentioned table was not used, this factor was eliminated.

3. Trees and long Grass Effects. Shown by Δg. Because there was no such planted areas surrounding the studied sections, this factor was not requied to be calculated.

4. Building Block Effect, shown as Δ housing Since noise level model is true from standard distance (3m) this factor was ignored by avoiding entering building blocks.

5) Short sound barrier effect: Δ_1 barrier

6) Log and thin sound barrier; Δ_2 barrier

7) Thick or long and wide barriers effect; Δ_3 barrier.

Regarding the fact that there were no sound barriers in the city, steps 6/7 were ignored.

3-2- checking validity of the Model

To ensure accuracy and ability of the model, field study data was reentered to the model to define correlation between results of suggested model and field study results. This was necessary as modeling was done according to the given clarification coefficient and scattered data refinement (135 records). Hence the model required to be performed to total 1344 records in order to be able to define difference between predicted values by the model and measured L_{eq} of the field study. In this step the model was per formed once without refining data and once without it. Distribution and correlation coefficient values were checked. For 1344 recordings entered to distribution diagram and correlation coefficient was 0.7 and for 1135 recordings it mounted to 0.9. Diagrams 1 and 2 show the results.

3-4. Comparison of the Model Results with those of Similar Models for Research Data

Correlation values of measured L_{eq} were next compared with estimations of models FHWA- TNM (34,37). FHWA-STAMINA (37) India Model (36) china Model (33). Turkey Model (11), Hong kong Model (39), Iran Passage Model ITNR (8). The results of Pearson correlation Test results showed that except for Turkey and India models others reported a relatively acceptable L_{eq} for field study data. The lowest correlation coefficients between measured L_{eq} and estimated L_{eq} among all were (r=0.304) and (r=0.306) respectively for India and Turkey models, and the highest values were for r=0.788 and 0.722 respectively for ITNP and FHWA , STAMIAA models. Correlation values for FHWA, TNM model was (r=0.592) and Hong kong (r=0.462) and china (r=0.552). Estimated L_{eq} values for the designed model of the present study (before standardization) had correlation coefficient value of (r=0.702) which mounted to r=0.95 after standardization. The results showed that estimated L_{eq} values by the designed model represented an acceptable difference with those of other models. This finding in fact, revealed the necessity of designing anew and comprehensive model for research in the city. Diagrams 3-9 show the distribution of measured and estimated L_{eq}s from different models.

Also the difference between average estimated L_{eq} values of the model and those of above models were measured and it showed this difference for the designed model – 1.5 dB to be a desired value, compared to other models including Turkey (with average difference of – 6.4). India (with average difference of – 8.2), FHWA – STAMINA (with average difference of +2.08) , ITNP (with average difference of -2.38) Hong kong (with average difference of +5.2) china (with average difference of -3.8).

4- Discussion and Final conclusions

The present field study is based on data colleted from 1344 traffic noise and its effective factors measurements in Ahwaz. Sampling included measuring 6 traffic factors at each station at a time, 8 records of traffic load and speed, 2 records of climate, 3 records of dimensions, 2 records of environment. Overall number of records for 112 stations at the end was 28224. This was a strength point for the current stud. Multi – variable Regression Analysis method was applied in order to design the model and SPSS was wed to select the effective parameters on traffic noise in several steps. The model was eventually designed with a inputs of high clarification coefficient (R^2=0.920 and correlation coefficient of R=0.95 for the city. The number of inputs allows important traffic features to be put to predict the most real value possible. In the models studied by steel (2001) the highest input number was for FHWA which considers dimension, except for distance from mid line on passage (37). The present model, however, considers surrounding buildings, heights as an effective factor to be a complementory factor additional to the above parameters. The study of difference between average values of L_{eq} estimated by different models with measured values of field study showed average difference for ITNP and FHWA- STAMINA, -2.38 and +2.08 respectively and for all other models except for Turkey and India, the average difference was 5.20 – 3.97. This difference of the estimation from various models with that of the present model, considering various modeling strategies, traffic condition, distribution level, passage features etc. showed the above models valid only to their own conditions and not suitable for a field study like the present one. The results also showed preference of FHWA- STAMINA and ITNP to other models for the present field study. Aside from these differences, the difference between average measured values and estimated values by the designed model, was- 1.5 which showed the priority of results from the designed model to other models.

5. Conclusion

The accuracy and precision in designing the model and considering effective environmental factors, as well as the large number of inputs incision of main parameters of traffic demension environment of roads under study and its expandability the present model could be an appropriate one to predict L_{eq} 30 minutes in Ahwaz, Practical for estimation of traffic noise pollution of the city. The model can be developed by defining variable such as wind speed and gradient effect , calculation of absorption and reflection, level by construction materials, absorption level by plant species, etc. (3 meters from road way), defining a variable named (distance from roadway), a model based on results from field studies performed in four seasons of the year, as well as on all days of the weak, and in two day period (DL) and night period (NL) are suggetable.

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