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Regression modelling of Traffic Noise Pollution at various crossings in Jammu City (J&K)

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Abstract

The present study has been carried out to assess the traffic noise levels and prepare a mathematical model for prediction of traffic noise at various crossings of Jammu city during the rainy, winter and summer seasons. The study area was divided into three Zones: Zone I (Crossings on NH1A Highway), Zone II (Crossings on the main roads connecting the Highway) and Zone III (Crossings within old Jammu city with light vehicular traffic). Regression equation was developed using SPSS software. The validity of the prepared model was assessed by comparing calculated noise levels and observed noise levels during different seasons of two-year study period. Further the goodness of fit of the model was tested using chi square test which revealed insignificant difference ($p>0.05$) between the observed and calculated values of L_{eq}.

Keywords: Regression modeling | Noise pollution | Jammu

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Modern day life is facing huge problems and one of such issues is that of noise. Noise is actually unnecessary sound that is dumped into the environment from various sources. The term ‘Noise’ is derived from Latin word “nausea” which means unwanted sound or sound that is loud, unpleasant or unexpected. EU Directive 49/EC (2002) defined Environmental noise as “an unwanted or harmful outdoor sound created by human activities including noise emitted by means of transport, road traffic, rail traffic, air traffic and from sites of industrial activity, to which humans are exposed in particular in built-up areas, in public parks or other quiet areas in an agglomeration, in quiet areas in open country, near schools, hospitals, and other noise sensitive buildings and areas”. Road vehicles form an important part of our urban environment and constitute about 55% of total urban noise (Banerjee *et al.* 2008).

Various noise surveys conducted by workers (Robinson, 1971; Roy *et al*., 1984; Ravindranath *et al*., 1989; Thakur, 2006) at different sites considered road traffic as the dominant source of annoyance. Prabat and

Nagarnaik (2007) reported that the Indian cities face road transport crisis characterized by ill-planning, noise pollution, improper traffic facilities, injuries, congestion and inequality as compared to contemporary cities in most of Europe and North America. Bhattacharya *et al*. (2001) also supported to the similar view stating that Indian cities have heterogeneous vehicular traffic flow on the same right-of-way with interrupted traffic flow conditions.

Noise is considered a serious threat to the environmental health having adverse effects (O¨hrstro¨m, 1993; Stansfeld *et al.* 1985 and Bluhm *et al*., 2007). Noise interferes with speech. The learning of children is also affected by noise (Evans, 1990; Hygge, 1993). It leads to emotional and behavioural stress and a person feels disturbed and annoyed in the presence of loud noise. Noise may permanently damage hearing. Noise increases the chances of occurrence of diseases such as headache, blood pressure, heart failure, etc. It affects the sleeping there by inducing the people to become restless (Nagai *et al.* 1989) and lose concentration and presence of mind during their activities.

Noise being one of the pollutants of the environment needs to be controlled so some measures need to be suggested to overcome this problem. Traffic noise prediction models are one of such measures to curb the ever increasing effects of noise pollution. These models help in predicting sound pressure levels, specified in terms of Leq, L_{10}, etc. They are useful for designing of road structures, predicting effects of various traffic light cycles, traffic routings, pedestrian crossing locations and other controls and preparing the acoustic section of Environmental Impact Statements (Steele 2001).

The present study was made to prepare a traffic noise model for various crossings of Jammu city. Jammu district is located between 74º 24″ and 75º 18″ longitude and 32º 50″ and 33 º 30″ North latitude and has a population of 15.264 lacs as per 2011 census. The study was conducted on the different sites including crossings located on NH1A highway passing through the Jammu city (from Satwari chowk to Amphalla chowk) and the major roads connecting to it. The traffic noise prediction was prepared taking into account various physical parameters like atmospheric temperature, surface temperature, relative humidity and Leq at the sampling sites as well as speed of the vehicles and vehicle count at the sampling time.

Material and methods

To develop mathematical model for predicting traffic noise, the study area was categorised into three zones:

Zone I. Crossings on NH1A Highway viz.

- Site I. Satwari chowk
- Site II. Vikram chowk
- Site III. Jewel chowk
- Site IV. Rehari chowk
- Site V. Amphalla chowk

Zone II. Crossings on the main roads connecting the Highway viz.

- Site VI. Panama chowk
- Site VII. Canal Road chowk
- Site VIII. Patta Bohri chowk
- Site IX. Shakti Nagar chowk
- Site X. Maheshpura chowk
- Site XI. Kachi chawni chowk
- Site XII. Gole market
- Site XIII. Zorawar singh chowk

- Site XIV. Bantalab chowk
- Site XV. Shalamar chowk
- Site XVI. Indira chowk
- Site XVII. Panjtirthi chowk
- Site XVIII. Paloura chowk
- Site XIX. Kunjwani chowk
- Site XX. Janipur chowk
- Site XXI. Narwal Byepass chowk

Zone III. Crossings within old Jammu city with light vehicular traffic viz.

- Site XXII. Gujjar Nagar chowk
- Site XXIII. Chowk chabutra
- Site XXIV. City chowk
- Site XXV. Shaheedi chowk

Atmospheric data like air temperature, surface temperature, and relative humidity were measured thrice i.e. Morning period (0800-1000hrs.), Noon Period (1200-1400hrs.) and Evening period (1800-2000hrs.) a day at the selected sites using handheld Thermometer, Soil Thermometer and Psychrometer respectively. The numbers of vehicles (to and fro) per ten-minute passing through the different crossings were counted manually thrice i.e. Morning period (0800-1000hrs.), Noon Period (1200-1400hrs.) and Evening period (1800-2000hrs.) a day at the selected sites. The speed of the vehicle (Km/hr) passing through the roads were determined using handheld speed radar gun (Model M10P) thrice for the above said time periods and the noise levels were also recorded using Digital Sound level meter (Data Logger Model: 407764A) at the selected sites. L_{eq} was calculated as:

$$L_{eq..}=10\log\left(\sum_{i=1}^{n} fi10^{Li/10}\right)\text{dB(A)}$$

Where Li = sound intensity

fi = fraction of time for which sound pressure level persists

i = time interval

n = number of observations

The data was compiled for three seasons of two years and Traffic noise equation for noise prediction was developed by calculating the constants for Total vehicle count in both directions, Average speed of vehicles in kmph, Average atmospheric temperature in ^{0}c, Average surface temperature in ^{0}c, Relative humidity in %, by taking these as independent variables and L_{eq} as dependable variable by regression method using SPSS software (version 24) to obtain best form of following regression equation.

$$L_{eq} = X + aT_a + bT_s + cR.H + dV.C + eV.S \quad (R^2 = Y)$$

Where,

T_a = Average atmospheric temperature in ^{0}c,

T_s = Average surface temperature in ^{0}c,

R. H = Relative humidity in %,

V.C = Total vehicle count in both directions,

V.S = Speed of vehicles in Km/hr

R^2 = Coefficient of correlation.

X, Y, a, b, c, d and e are constants which vary for different road conditions.

Coefficient of Correlation (R^2) existing among the variables was also determined. This equation can be used for predicting Traffic Noise in Jammu city. Further the validity of the prepared model was determined by comparing calculated noise levels and observed noise levels during different seasons of two year study period and the goodness of fit of the model was tested using chi square test.

Observations and Discussion

The analysis of the compiled data for two years revealed that during rainy season of first year study period average Observed L_{eq} ranged from 74.7 dB at Zone III (Site XXII-XXV) to 88.7 dB at Zone I (Site I-V) with average value of 80.9 dB at study area and it varied from 77.2 dB at Zone III (Site XXII-XXV) to 89.4 dB at Zone I (Site I-V) with average value of 81.8 dB at study area during second year study period. The analysis of data of observed L_{eq} revealed that it varied from 74.0 dB at Zone III (Site XXII-XXV) to 78.6 dB at Zone I (Site I-V) with average value of 76.0 dB at study area during winter season of first year study period and 74.6 dB at Zone III (Site XXII-XXV) to 81.4 dB at Zone I (Site I-V) with average value of 77.0 dB at study area during winter season of second year study period. Further the L_{eq} ranged from 75.7 dB at Zone III (Site XXII-XXV) to 83.1 dB at Zone I (Site I-V) with average value of 78.5 dB at study area during first year study period of Summer season and from 75.9 dB at Zone III (Site XXII-XXV) to 84.1 dB at Zone I (Site I-V) with average value of 78.9 dB at study area during second year study period of summer season. (Table I)

Overall survey of data revealed that Zone I (Site I-V) exhibited maximum observed L_{eq} during all the seasons of two-year study period. The observed L_{eq} in rainy, winter and summer season of second year study period exhibited higher values as compared to that of rainy season of first year except for Zone II (Site VI- XXI) in rainy and winter season.

Traffic Noise equation (**L_{eq}=52.89+0.244T_a-0.102T_s+ 0.182R.H+0.03V.C-.043V.S**) for noise prediction was developed by calculating the constants for Total vehicle count in both directions, Average speed of vehicles in kmph, Average atmospheric temperature in ºC, Average surface temperature in ºC, Average relative humidity in %, by taking these as independent variables and L_{eq} as dependable variable by regression method using SPSS software (Version 24). Coefficient of correlation for the model prepared was observed to be 0.56. The calculated L_{eq} using the above equation was observed to be:

The calculated L_{eq} varied from 75.7 dB(A) at Zone III (Site XXII-XXV) to 86.8 dB(A) at Zone I (Site I- V) with average value of 80.3 dB(A) at study area during rainy season of first year study period and 78.5 dB (A) at Zone III (Site XXII-XXV) to 87.4 dB(A) at Zone I (Site I-V) with average value of 81.9 dB(A) at study area during rainy season of second year study period. During winter season of first year study period average calculated L_{eq} ranged from 72.3 dB(A) at Zone III (Site XXII-XXV) to 82.5 dB(A) at Zone I (Site I-V) with average value of 76.6 dB(A) at study area and it varied from 72.7 dB(A) at Zone III (Site XXII-XXV) to 83.6 dB(A) at Zone I (Site I-V) with average value of 77.1 dB(A) at study area during second year. The study further revealed that the average calculated L_{eq} ranged from 77.4 dB(A) at Zone II (Site VI-XXI) to 81.4 dB(A) at Zone I (Site I-V) with average value of 78.8 dB(A) at study area during first year study period of Summer season and from 76.3 dB(A) at Zone III (Site XXII-XXV) to 80.7 dB(A) at Zone I (Site I-V) with average value of 77.8 dB(A) at study area during second year study period of summer season. (Table II).

Overall survey of data revealed that Zone I (Site I-V) exhibited maximum calculated L_{eq} during all the seasons of two-year study period. The calculated L_{eq} in rainy, season of both the years of study period exhibited higher values as compared to that of winter and summer seasons (except for Zone III in first year).

Further the analysis of data of both the years of study period showed the observed L_{eq} ranging from 76.0 dB to 89.1 dB with an average of 81.3 dB for the study area and the calculated L_{eq} ranging from 77.1 dB to 87.1 dB with an average of 81.1 dB for the study area during rainy season. During winter season the observed L_{eq} varied from 74.3 dB to 80.0 dB with an average of 76.5 dB for the study area and the calculated L_{eq} varied from 72.5 dB to 83.0 dB with an average of 76.8 dB for the study area and for summer season the values varied from 75.8 dB to 83.6 dB with an average of 78.7 dB for the study area for observed L_{eq} and from 76.9 dB to 81.1 dB with an average of 78.3 dB for the study area for calculated L_{eq}. Overall analysis of data showed that Zone I exhibited maximum L_{eq} for all the seasons of two-year study period. On compilation of the data the study revealed chi sq. p-value ranging from 0.99 to 1 signifying insignificant difference ($p>0.05$) between observed and calculated L_{eq} for all the Zones and the study area. (Table III).

Subramani *et al.* (2012) constructed a similar mathematical model for traffic noise of Coimbatore city (Tamilnadu) by using the parameters like traffic flow rate, speed of vehicle, atmospheric temperature, surface temperature, and relative humidity. R^2 value for the developed model was 0.523. The Federal Highway Administration (FHWA) model used by Govind and Soni (2012) considering traffic volume and speed data proved to be a successful tool for predicting the noise levels along National Highway near Gorakhpur city. Suksaard (1999) noise prediction model for EIA in Thailand was accurate with ±3 dB when predicted noise levels were compared with that of measured traffic noise levels.

Average Observed Leq (dB A)						
Zone	**Ist year**			**2nd Year**		
	Rainy	**Winter**	**Summer**	**Rainy**	**Winter**	**Summer**
I	88.7	78.6	83.1	89.4	81.4	84.1
II	79.2	75.2	76.6	78.8	75.0	76.7
III	74.7	74.0	75.7	77.2	74.6	75.9
Study area	80.9	76.0	78.5	81.8	77.0	78.9

Zone I: Site I- V
Zone II: Site VI- XXI
Zone III: Site XXII-XXV

Table I: Zone wise average Observed Leq during Rainy, winter and summer season in two year study period

Average Calculated L_{eq} (dB)						
Zone	**Ist year**			**2nd Year**		
	Rainy	**Winter**	**Summer**	**Rainy**	**Winter**	**Summer**
I	86.8	82.5	81.4	87.4	83.6	80.7
II	78.3	74.9	77.4	79.8	75.0	76.5
III	75.7	72.3	77.6	78.5	72.7	76.3
Study area	80.3	76.6	78.8	81.9	77.1	77.8

Zone I: Site I- V
Zone II: Site VI- XXI
Zone III: Site XXII-XXV

Table II: Zone wise average Calculated L_{eq} during Rainy, winter and summer season in two year study period

Observed Vs Calculated Leq (dB)							
Zone	Rainy		Winter		Summer		Chi sq. (p-value)
	Observed	Calculated	Observed	Calculated	Observed	Calculated	
I	89.1	87.1	80.0	83.0	83.6	81.1	0.999983
II	79.0	79.1	75.1	75.0	76.7	76.9	1
III	76.0	77.1	74.3	72.5	75.8	76.9	0.999977
Study area	81.3	81.1	76.5	76.8	78.7	78.3	1.0

Zone I: Site I- V
Zone II: Site VI- XXI
Zone III: Site XXII-XXV

Table III: Observed Vs Calculated Leq of Zones during Rainy, winter and summer season in two year study period

Conclusion

The collected data of various parameters like Atmospheric temperature (Ta), Surface temperature (Ts), Relative humidity (R.H), vehicle count (V.C.) and vehicular speed (V.S.) was used to determine the calculated noise level with the help of regression analysis. The comparison test was made in order to examine the goodness of fit, between the observed and calculated noise level from the collected data. From the present study it was concluded that there was insignificant difference between the observed and calculated noise levels and R^2 value for the equation was found to be 0.56.

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