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A Review on Road Traffic Noise Pollution and Modeling using Multiple Linear Regression

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Abstract —*Technological process has brought many conveniences, but it has also resulted in many hazards. Noise pollution is one of the types of it. Noise is one of the most undesirable products of a modern and mechanized way of life. Higher exposures to high noise levels may cause variety of biological reflexes and responses. Different types of mathematical models are available for noise modeling like ANN (Artificial Neural Network), ASJ (Acoustical Society of Japan), MLR (Multiple Linear Regressions).*

Keywords-*Road Traffic Noise, Noise Levels dB(A), Traffic Volume, Multiple Linear Regression Analysis, Traffic volume count, Temperature (°C), Humidity (%)*

I. INTRODUCTION

"Noise is derived from the Latin word "nausea" implying 'unwanted sound' or 'sound that is loud, unpleasant or unexpected. Noise pollution has become a serious concern globally."
Every country is worried about the health effects of the noise emitted by vehicles traveling on more and more roads. Traffic noise is one of the main sources of noise pollution in metropolitan areas that cause different health hazards.
"To prevent and control the sources of the noise, the Government of India has published the rules known as Noise Pollution (Prevention & Control) Rules, 2000. According to that, the noise standards for ambient air and for automobiles, domestic appliances and construction equipments are as under: (CPCB, 2000)."

Table 1: Guidelines on noise pollution by CPCB [13]

Sr.No	Category	Standards	
		Day Time	Night Time
1.	Industrial zone	75	70
2.	Commercial zone	65	55
3.	Residential zone	55	45
4.	Silence zone	50	40

Note:

1. Day time starts from 6:00 a.m. to 22:00 p.m.
2. Night time starts from 22:00 p.m. to 6:00 a.m.
3. The Silent Area is defined as an area of no less than 100 meters around hospitals, schools and courts. Silent area declared by the competent authority.
4. Areas of a mixed category may be declared by the competent authority as one of the above four categories.
5. * dB (A) Leq is the weighted average sound level of the "A", sound level associated with human hearing.
6. "Decibel" is the noise measurement unit.
7. "A" Leq in dB (A) is the frequency of the noise measurement and corresponds to the human ear frequency response characteristic.
8. Leq: This is the energy average of the noise level over a certain period of time.

A. Sources of noise pollution

The sources of traffic noise are as follows:

- Vehicle engines
- Exhaust systems
- Tire-pavement interaction

- Horns
- Aerodynamic friction and by the interaction between vehicles
- Sounds of cooling fans, gearboxes and brakes.

B. Harmful effects of noise on human beings

Noise is usually harmful and poses a serious risk to health. It has a wide range of consequences and has many physical, physiological and psychological effects on human beings.

1 Physical Effects:

- Hearing impairment (i.e., total deafness).
- Noise can ultimately damage the hearing. Sudden loud noise can cause serious damage to the eardrum.

2 Physiological Effects:

There are several physiological signs of noise pollution as follows:

- Headache by expanding blood vessels in the brain.
- Increase heart rate.
- Arterial narrowing.
- Change your arterial blood pressure by increasing blood cholesterol levels.
- Reduce heart output.
- Heart Pain.
- Digestive cramps through nervousness and enlargement of the pupil of the eye, thus causing eye strain
- Night vision disorders.
- Color perception rate has dropped.
- Reduce the concentration and memory impact.
- Muscular tension and nervous disorder.

II. Multiple Linear Regression Analysis:

Linear regression is a concept to model the relationship between scalar dependent Y and one or more than one independent variable X.

$$Y= B_0 + x_1b_1 + x_2b_2+ x_3b_3+\ldots.+ x_nb_n + E$$

Where, Y = Noise level

Bo = Constant of regression

x_1, x_2 and x_3 = independent variables

b_1 to b_n = coefficient relating n independent variable.

E = Standard error

Multiple Linear Regression (MLR) method is a statistical technique which can be used to find the relationship between a dependent variable based on two or more independent variables connected to dependent variables. Multiple linear regression analysis observes to assess the independency of dependent variable to independent variables, mean values.

The applications of noise regression sample which is necessary to apply on the data separated out of the model for testing purposes and for future prediction of noise in particular locations.

A. Materials and Methods:

Required data collection:

For generating linear regression, the following data are required:

1. Noise data
2. Traffic volume data
3. Meteorological parameters (Temperature, Humidity)

III. Literature review

The review of literature is divided into two parts:

1. Noise monitoring
2. Noise modeling using linear regression

A. Noise Monitoring:

In their study, traffic noise in Tirupur City was already in peak hours at high traffic areas. Noise levels vary with the atmospheric conditions and temperature and humidity in all regions are also recorded. The level of noise also varies

depending on the number of vehicles passing, so the total vehicle is also recorded during the study period. The results show that compared with the morning, the whole city is greatly affected by noise pollution in the evening, and the prevalence of noise in more than 90% areas exceeds the ambient noise level. It has been found that in many areas, the noise level is generally around 90% of the urban busy spots with an average of 85 dB. Most of the noise is generated only by speakers in vehicles such as rickshaws, buses, trucks and trucks. [5]
It conducts a one week-long monitoring between 2012 and 2014.The measurement is done for day, night and evening. It concluded that optimizing the measurement techniques for the overall noise from urban traffic and facilitating measurement tasks at specific Valencia locations. [6]
In this study four weeks of noise measurements were conducted on 22 sampling points in four different areas of Surat city residential, commercial, silent and industrial areas. Timing selected for survey is in morning hours 5 am to 6 amand 9 am to 10 am and for night time 6 pm to 7 pm and 11 pm to 12 pm. Noise measurements are made using the minimum, maximum, and average of all stations. It can be concluded the noise levels in most of the area of Surat city of all four zones are above the standard limits, mainly due to the high traffic density. [7]

It is held in the city of Kolhapur during the winter season (from December to February). For this study, five sampling sites were selected. Noise pollution indicators are calculated as L_{10}, L_{50}, L_{90}, Noise Climate (NC), Leq, Noise Level (Lnp), and Noise Exposure Index (NEI) for all areas. Leq is above the normative constraints while for other areas it is slightly lower. The study clearly revealed the alarming state of the noise pollution in Kolhapur. Some of the preventive measures are being implemented to control the noise pollution in the city of Kolhapur. [8]

B. Noise modeling using linear regression

In their study, 6 sites were identified to collect data on noise levels at highways. Noise samples, classified volume of traffic and vehicle speeds were collected at each site. The continuous recording of noise shall be carried out for one hour at each sampling point. Traffic video was also recorded using the Sony Handy camera, and the speed of the cars was detected using a Falcon HR radar gun. Multiple linear regression analysis is performed. It was concluded that the Chi-square test was appropriate. It was also concluded that the negative effects of vehicular noise was considered. It was found that the contribution of three wheels and heavy vehicles was more than that of four wheels and two wheels. [1]

The purpose of this study is to introduce a compact model of road traffic noise for traffic variables in traffic conditions. They collected noise generation parameters such as the speed of the vehicle, the type of vehicle, the number of fixings and so on. Two sets of Leq noise levels are recorded at selected intersection points near State Road 4, at 97.9 dB(A) and 98.9 dB(A), respectively, and on the other nearby roads Avadi was 56 dB(A) and 57.8 dB(A). The first set of data used to predict the noise level shows a ± 1.18% dB(A) change to the developed Leq model. The second set of data was used to validate the model, which showed about 95% applicability in predicting the noise level. [2]

In its study, measures the volume of traffic and noise during peak traffic in selected areas of the city of Tirupati. Traffic volume surveys, including vehicle types, are measured three times a day at different intersections. The analysis of the data was carried out with the help of SLM. In the morning (8:00 am - 10:00 am), the peak hourly clock (from 2:00 am to 3:00 pm) and the evening peak hour (5:00 am - 19:00 pm). The model used to validate the development used linear regression analysis and artificial neural networks to predict the noise level on the road. It is observed that the R^2 value between the measured and predicted values at all four intersections is greater than 0.9. The regression (R^2) values of the developed mathematical equations and artificial neural networks are 0.982 and 0.970. The mathematical equations developed give accurate predictive noise levels between the two models (ie developed math and artificial neural networks). It can be concluded that the two proposed models predict the traffic noise in Tirupati town. [3]

It implements noise prediction models in Surat city and analyze various parameters that affect road traffic noise. The noise level is measured during peak hours (5 pm to 8 pm). A linear regression model to predict urban traffic noise is established. Studies show that the current noise levels of the three main roads exceed the CPCB limits. The noise prediction (regression) model was examined in one of the corridors and a 7.53% error was observed. [7]

In this study, a mathematical model was developed in the city of Coimbatore (Tamil Nadu) for Dindigul-Bangalore (NH-209). A mathematical model for predicting the L10 or Leq level has been developed, taking into account these parameters such as vehicle volume per hour, average vehicle speed (km / h), atmospheric temperature (° C), surface temperature (° C), relative humidity (%, noise levels of L10 or Leq were used in the prediction regression analysis.) It was concluded that the R^2 ranges value from 0.7 to 1.0. [10]

In his study, evaluates the heavy traffic that links the countries of Tamil Nadu and Kerala. Data was collected in 4 locations. In its study, the parameters of traffic noise, such as traffic flow, instantaneous speed of each vehicle category, atmospheric temperature, surface temperature, relative humidity, are measured. A model for multiple linear regressions is developed to predict traffic noise. The value R^2 is 0.809. The value R^2 can be improved by including variants, i.e. taking multiple sets of data at different locations and at different time intervals. [11]

He studies the level of noise pollution in the town of Sylhet. Noise was measured at 37 seats from 7:00 to 23:00. of working days at four time intervals, i. 7:00 - 11:00, From 11:00 to 15:00, 15:00 - 19:00, 19:00 - 23:00 from 2003 to 2004. It defines L10, L90, Lmax, Le and Laeq. Daily traffic volume and traffic noise index data are also calculated. The noise level on major roads near residential, hospital and educational areas is above the recommended level (65dBA). Multiple regression analysis is performed for traffic. It was found that the forecast equations are in 60-70% correlated with the measured noise level. [4]

IV. Concluding Remarks

Public health of noise is a matter of great concern to all of us that noise control is needed. The noise pollution can be controlled at the source generation itself by reducing the noise level from domestic sectors, maintenance of automobiles, low voice speaking, prohibition of honking and prohibitions of loud speakers.

According to a study of the reports, noise pollution is one of the most serious problems in industrial zones as well as in commercial areas. In the future, participation of the public, the government and NGOs can play a significant role in controlling noise pollution.

Noise traffic predicting models have been built and developed using various approaches. The method linear regression modeling is widely adopted. Most of the noise predicting models in India and worldwide have been builtusing regression modeling. From this literatures regression modeling method is very reliable and satisfactory method to generate noise predicting model.

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