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INFLUENCE OF REGRESSION EQUATION IN TRAFFIC NOISE POLLUTION PREDICTION MODEL – A CASE STUDY

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ABSTRACT

Noise pollution is the excessive sound that can have adverse effects on human health, animals and environmental quality. Traffic noise is the combined sound energy originating from motor vehicle. It consists chiefly of road surface, engine/transmission, tire, aerodynamic and braking elements. India is the developing nation where transportation sector is growing rapidly at over 7.50% per annum and level of pollution by vehicles on Indian roads is growing at a very fast rate. Country having a population of 1.3 billion which let to overcrowded roads and increase in traffic noise level. The aim of this study is to build a traffic noise prediction model for the areas to predict noise levels due to road traffic. The prediction model is prepared by conducting a survey on volume count, noise levels and spot speed in the study area for achieving the objective of study. As observed when the noise generated the vehicle are normally in linear form along the roads. Hence roads were taken for the study purpose. The study data are collected by fixing three study locations. Prediction model is developed for each road stretch separately. The study shows noise level between 60dB to 85 dB along the road side and level of sound in that specific area has good range until noise level goes above 80dB is heard. The significant steps should be taken to overcome the growing traffic noise pollution

KEY WORDS: Noise pollution, Traffic noise, Prediction model, Regression equation

INTRODUCTION

Noise pollution is generally known as environmental noise or sound pollution, is propagation of noise that may lead to adverse effects on the activity of human being, animal life and environment. Noise pollution is commonly generated inside many industrial facilities and workplaces but it also comes from highway, railway and airplane traffic and from outdoor construction activities. Environmental noise pollution is a serious threat to health and welfare of human or animal inhabitants. It is growing more rapidly and extensive than ever before, it will continue to increase in magnitude and severity because of population growth, urbanization and the associated growth in the useof progressively powerful, varied, and highly mobile source of noise.

Vehicular noise problem is contributed by various kinds of vehicles like heavy, medium trucks/buses, automobiles and two wheelers.

The word "noise" descends from latin word "nausea", meaning seasickness, or, more generally, any similar sensation of disgust, annoyance, or discomfort. The World Health Organization (WHO) considered Noise as the third most hazardous type of pollution right after Air and Water pollution (WHO 2017). According to WHO, sound levels less than 70 dB are not damaging to living organisms, regardless of how long or consistent the exposure is. Exposure for more than 8 hours to constant noise beyond 85 dB may be hazardous. Research regarding urban noise pollution and its consequences for the community has been studied by several countries. Adverse effects due to exposure to noise may include interference with

speech communication and decreasing children's learning skills.

A study on Analysis of day time traffic Noise level by Anirban Kundu Chowdhury *et al.,* (Chowdhury *et al.,* 2012) for Kolkata city at 26 locations was monitored. Correlation analysis among equivalent continuous sound pressure level for one hour duration revealed that Leq (1hr)), noise levels exceeded for 10, 50 and 90% of the time of the measured duration (L10, L50 and L90). L10, the peak noise level, generally resulted from honking of horns by car drivers. Another model was developed by Kalaiselvi and Ramachandraiah (Kalaiselvi and Ramachandraiah, 2010) for traffic noise prediction in heterogeneous traffic conditions. In this study noise mapping parameters such as Ld, LN, Lden have been arrived at by taking into consideration the geometrical features of the roads and varying heights of the buildings.

The traffic noise problem is not properly recognized despite the fact that it is steadily growing in developing countries. The permissible noise levels specified by Tamil Nadu Pollution Control Board (TNPCB) are given in Table 1.

OBJECTIVE AND STUDY AREA

The objective of this work is to develop a road traffic noise prediction model for the three location of straight stretch road. The model consists of traffic noise generated from highways. Traffic flow data will be used for constructing this model consisting of vehicle noise, vehicle volume and vehicle spot speed.

Chennai, the capital of Tamil Nadu forms one of the developed urban centres of India with a population of 4.68 million as per 2011 census. It is located towards South East along the coastal Plains of India. It is one amongst the four metropolitan cities of India. The vehicle population in Chennai as of 2012 is 3,760,000 vehicles. The total length of road network in Chennai is 2780 Km, the city is continuously growing in terms of population in geometric progression. The city being a hub of commercial and business activities is facing ever-increasing vehicular traffic. This has resulted in multifaceted traffic problems such as accidents, peak hour congestion etc. The road network of Chennai city is of Radial Pattern having major highways to the North, West and Southwest. The other major roads are the arterial road along the coast and the road parallel to NH4. However, the existing road network in the city is unable. State Highway 49A also identified as Rajiv Gandhi Salai is a major road linking Chennai, Tamil Nadu with Mahabalipuram in Kanchipuram district, Tamil Nadu. It is 45 km long and was previously known as the Old Mahabalipuram Road (OMR). The road twitches from Madhya Kailash Temple on Sardar Patel Road in South-East Chennai and dismisses on East Coast Road near Mahabalipuram. The esteemed TIDEL Park, home to a number of BPO and IT/ITES companies and numerous other major IT/ITES Companies in the country are situated along the Rajiv Gandhi Salai. Prominent technical and educational Institutions, national research laboratories are also sited sideways of the Corridor. Besides, State Industries Promotion Corporation of Tamil Nadu Ltd (SIPCOT) has developed a Cyber City, supper over 2000 acres in Siruseri, neighbouring the IT Corridor. Many IT/ITES Companies have customary up their amenities in the Cyber City Zone-1 is from Madhya Kailash to Sholinganallur and Zone-2 is from Sholinganallur to Kelambakkam. To develop the traffic noise prediction model, the first task was site selection. So according to different surveys and noise problem, a 6 lane straight patch road where continuous flow of vehicle occurs, without any obstruction like traffic signals etc., was selected at OMR road (SH 49A) of three different location (Figure 2) they are:

S.R.P

2. Perungundi

3. Metukuppam

Table 1. Noise Levels

Types of areas	TNPCB (Day time)	TNPCB (Night time)	CPCB (Day time)	CPCB (Night time)	FHWA	AASHTO
Industrial areas	75dB	70dB	75dB	70dB	75dB	75dB
Commercial areas	65dB	55dB	65dB	55dB	75dB	75dB
Residential areas	55dB	45dB	55dB	45dB	70dB (Interior Max 55dB)	70dB (Ext.) 55 dB(Int.)
Silence zone	50dB	40dB	50dB	40dB	60dB	55-60dB

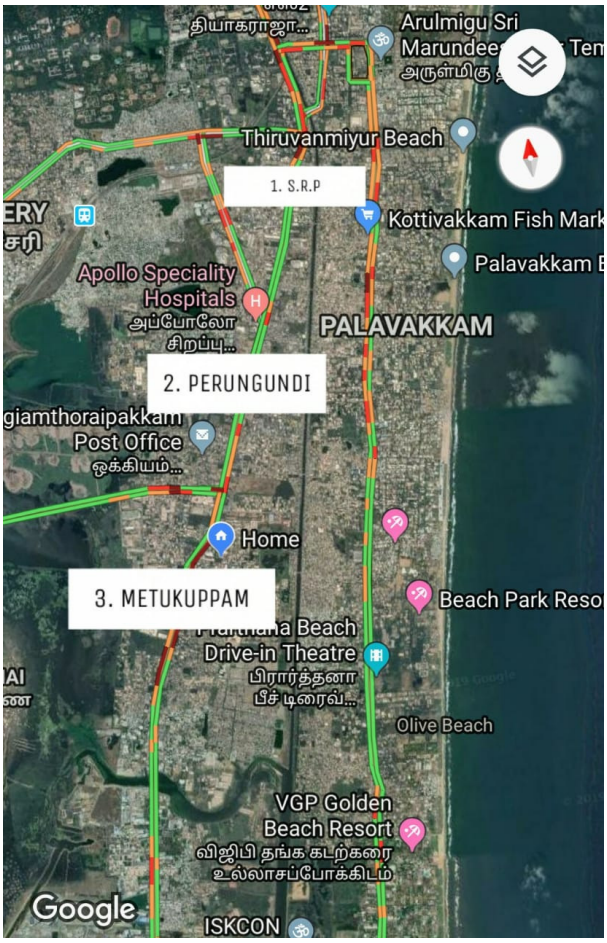

Fig. 1. Arial view of study location

DATA COLLECTION AND ANALYSIS

Three busy commercial corridors of OMR Road were selected for the present study. These corridor is one which is having traffic volume higher at all times of the day. The study road extends from S.R.P (O.M.R Road) to Metukuppam (O.M.R Road). This corridor is busy corridor in OMR Road as the IT Companies and Colleges is located near to this corridor and traffic volume is more throughout the day. Each site has its unique characteristics, i.e., having typical road width, roadside housing pattern, traffic flow pattern. At each of these locations, measurements were made when there was a reasonable traffic activity (in general from 8 a.m. to 11 a.m. and 6 p.m. to 9 p.m.). Sound Level Meter (Figure 3) having digital display was used to record the equivalent noise level at different selected locations. Noise levels were recorded at these locations and simultaneously the volume and speed of traffic streams were also monitored.

Noise levels were recorded at these locations and simultaneously the volume and speed of traffic streams were also monitored. Noise level is gradually increasing from morning 8:00am to 9:00am and then reaching morning peak from 10:00 am to 11:00 am. It is observed that the noise level is maximum during evening peak hours between 6:00pm and 9:00pm. It is also observed that the noise level is decreasing with increasing speed. Similarly for the other two locations, noise, traffic volume and speed data were collected and analysed.

Then is Speed, it is the one of the most important characteristics of traffic and its measurement is a frequent necessity in traffic engineering studies. Speed is the rate of movement of traffic of specified components of traffic and is expressed in metric units in kilometre per hour (K. P. H). Spot speed is the immediate speed of a vehicle at a quantified location. Spot speed data is collected using direct timing procedure method. This method base length is important. The base length of the section is decided using IRC guidelines. The data pertaining to three locations are presented in table 1. The table contains the total vehicle volume in PCU per hour, spot speed in km/h and noise level measurements. The following graph is data collected for prediction model.

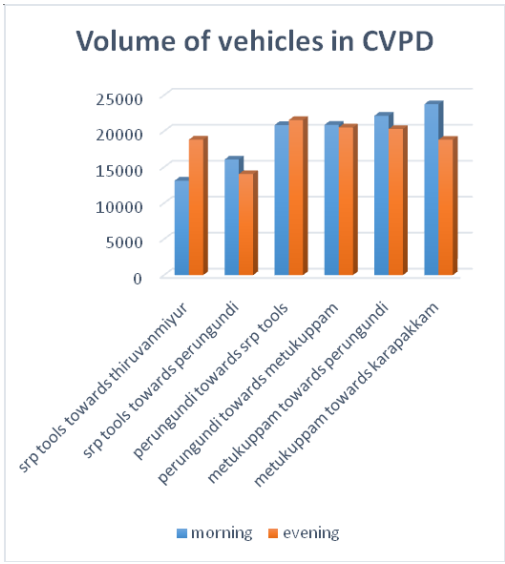

Fig. 2. Data pertaining of total vehicle of each location

Development of Regression Model

Prediction is a very important part of noise impact assessment. The basic prediction procedure involves consideration of the nature and noise level of the sources, propagation along the paths between

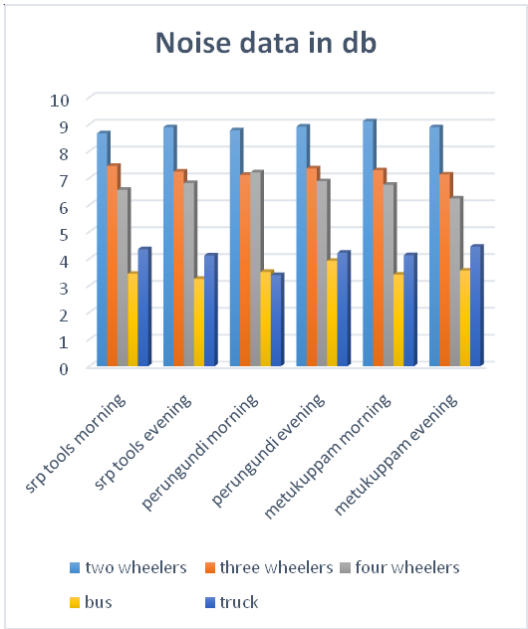

Fig. 3. Data pertaining of noise level of each location

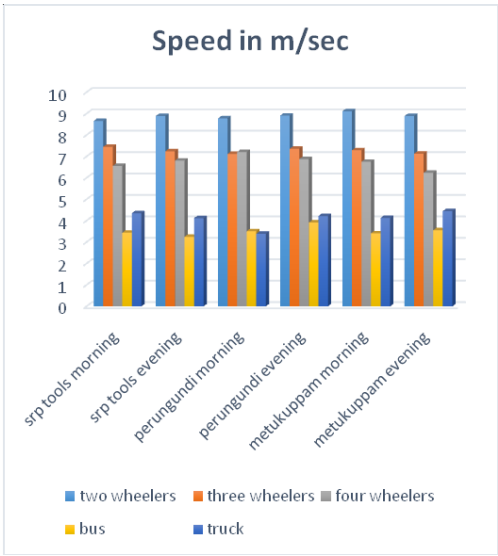

Fig. 4. Data pertaining of spot speed of each location

sources and receivers and the location of the receivers. Each vehicle in the stream having mixed traffic system has different noise generation characteristics and this fact makes the road traffic noise problem little complex (Gupta *et al.*, 2017). In order to understand the behaviour of road traffic noise or to understand the various relationships, it is necessary to convert all vehicles into some equivalence based on their noise generation characteristics. The Passenger Car Noise Equivalence (PCNE) of particular vehicles represents that, how many times the vehicle is noisier than car. PCNE values can be used to quantify noise produced by different types of vehicles into a common unit and is used in modelling process.

Mathematical models for prediction of traffic noise usually extract the functional relationship between the parameter of noise emission, Leq, and measurable parameters of traffic and roads. The classical functional relationships available in literature have been stated based on data measured through semi-empirical models, typically regression analysis (Jain *et al.*, 2018). In practice the relationship is found to exist between two or more variables. In the present study, the important parameters that affect traffic noise like hourly traffic volume, speed (kmph), distance of observer from edge of pavement (meters) in both directions are taken as independent variables.

A Multiple Linear Regression Model is developed. Though there are a number of independent variables which may affect traffic noise, in this study, the important parameters like traffic volume, spot speed and noise were taken as independent variables. Since heavy vehicle is responsible for stronger noise than a light vehicle, a factor has been taken into account for such vehicles. As the percentage of heavy vehicles and as weighting factor, is given by following equation

$$Qeq = Q(1 + n \times VP/100) \quad (1)$$

and the term 10log(Qeq) will be transformed into

$$10\log[Q(1 + 10 \times VP/100] \quad (2)$$

Weighting factor is calculated by using largest correlation coefficient between observed Leq values given in Table 2 and the factor given by equation (2) and found n=10

$$Leq = 10 \log[Q(1 + 10 \times VP/100)] \quad (3)$$

Using the observed data, a new model with weighting factor n = 10 has been developed by calibrating Calixto model. Microsoft excel spread sheet has been used for estimating the values using equation (3). The estimated Leq values were then compared with observed Leq values to get the regression equation as follows

$$Leq = 19.92224 \log [Q(1 + 0.1 \times VP)] + 12.597 \quad (4)$$

Speed varies from location to location due to volume of traffic and road width. Noise levels are taken near the junction where the speeds change

drastically depending upon the signal phases. The noise level will be higher at lower stream speeds and higher stream speeds but at medium stream speed the noise level will be lower. Lower the speed, higher is the noise level since the driver decelerates the vehicles during red signal and accelerates during starting of green signal timings. The noise level is also higher during higher speed after green signal timings. Hence this speed on the near side and for side has positive impact on the noise. It is observed that the value of R2 in most cases lies between 0.2 and 0.5.

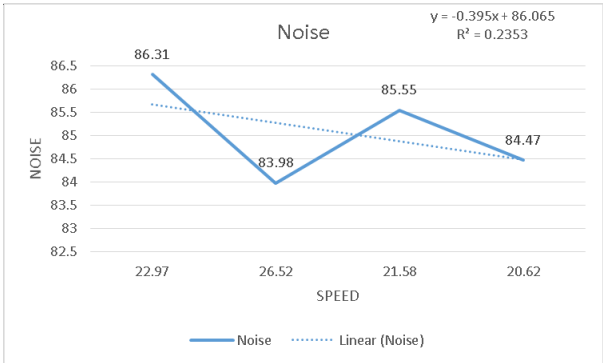

Fig. 5. Metupukkam Noise vs Speed

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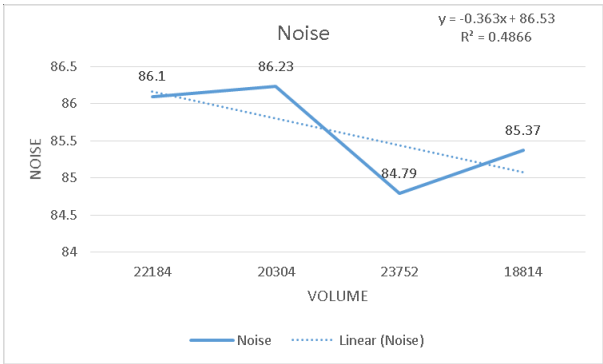

Fig. 6. Metupukkam Noise vs Volume

The following equation for Noise vs Speed is

$Y = 0.395 x + 86.065$ .. (1)

Where $R^2 = 0.2353$ for Noise vs Volume

$Y = 0.363 x + 86.53$ .. (2)

Where = 0.4866

CONCLUSION

Thelinear regression equation for predicting the equivalent noise level (Leq) was established using the following parameters: Noise level, Traffic, Vehicle speed.The value for Noise vs Speed equation was found to be 0.2353 and for Noise vs Volume is 0.4866. It can be concluded that the model gives significantly higher correlation coefficient values and can be applied to the calculation of road traffic noise under interrupted traffic flow conditions in urban areas of Indian cities. It was found that the equivalent noise levels at all selected sites were found to be higher than that prescribed by the CPCB. The noise levels are observed in the range of 65-86 dB (A) during peak and non-peak hours. These noise levels are inexcess of the prescribed limits given in Table 1. The following are the future scope of the study.

- The effects of a range of bituminous road surfaces on road traffic noiseneeds to be expanded. These surfaces include:
- Dense grade asphaltic concrete for a range of formulation types
- Open graded porous asphalts especially speciality 'low noise 'formulations.
- Cement concrete roads

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