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TRAFFIC NOISE ANALYSIS USING RLS-90 MODEL IN URBAN CITY

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ABSTRACT

Traffic noise is considered as one of the important source of noise pollution and its contribution is approximately 75% of the total noise pollution in urban areas. Delhi is considered as second noisiest city in the world. Ten locations have been selected in Delhi on the basis of their land use pattern, to monitor the ambient noise level. The monitoring has been conducted during morning peak hours, off peak hours and evening peak hours. Sound level meter has been used to monitor the ambient noise level at the selected locations. During this study, RLS-90 Model has been used to predict the noise level at all the selected location. After data analysis, it was observed that the measured ambient noise level at all the locations were violating the permissible limits prescribed by CPCB. During monitoring, highest traffic noise level was observed at Ashram Chowk. This may be due to higher traffic volume as well as high traffic congestion at the particular location. The percentage error between monitored traffic noise level and predicted traffic noise level was found within the range of 0.5 % to 5.75%, which indicates the suitability and applicability of the model in a city like Delhi.

1. INTRODUCTION

Today all the developing as well as developed country are facing threat due to noise pollution after air and water pollution. Developing countries like India, migration of people from rural to urban areas expansion of cities, infrastructure development, population growth and urbanization are important factors resulting in motorization and consequent increase in levels of various urban pollution (Banerjee, et al 2008). The population of Delhi is approximately 11 million, which is the second highest population in India and this number will be expected to expand by 40% in year 2021 (Census of India 2011). The vehicular population in the Delhi, jumped by 135.59 % from 1999-2000 to 2011-12 and vehicle population became 7.4 million in year 2011, amid a similar period the quantity of vehicles per thousand population expanded from 253 to 436. Likewise, it is noticed that the road network system of the capital has expanded from 28,508 km (year 2001) to 32,663 km (year 2011) (Economic survey of Delhi report 2012-2013), which is not even sufficient to accommodate the entire vehicle fleet. As a result of increasing traffic volume, congestion and poor traffic management in urban area, the traffic noise level has become so high that it exceeded the prescribed limit of CPCB. Traffic is one of the primary source of noise pollution in city like Delhi. A study conducted in Central London to observe that different types of vehicles contribute different level of noise pollution and also revealed that buses and trucks are more responsible in contributing to high traffic noise levels (Stephenson and Vulkan,1968). The noise level was found higher along all the busiest roads in all over Delhi (Akhter et al., 2012). Noise pollution can affect both health and behavior of all living beings. It can also damage physiological and psychological health. It can cause annoyance and aggression, high stress levels, hypertension, hearing loss, sleep disturbances and other harmful effects (Mishra et al 2010). The high noise level can also affect physiological and psychological health. It can contribute to cardiovascular effects and exposure to moderately high levels during a single eight-hour period causes a statistical rise in blood pressure of five to ten points and an increase in stress (NANMN report conducted by CPCB-2015-16). A social survey indicated that 73.8% of respondent residents were highly or moderately irritated by road traffic noise (Ali and Tamura, 2002)

To study the effect and to control the noise, different type of models like Federal highway administration (FHWA) model in USA, Calculation of road traffic noise (CORTN) model in UK, Stop and Go model in Bangkok and Richtlinien für den Lärmschutz an Straben (RLS-90) model in Germany, are used in different countries. These models are used to predict the noise level and help in the designing of noise barrier. In the present study, traffic noise level has been monitored at selected locations in Delhi. The road traffic noise prediction model i.e. RLS-90 has also been used to predict the noise level at all the selected locations. RLS90 model is based on the point source method with spreading ground attenuation, screening and reflection (Akhter et al., 2012). The forecasting of the traffic noise level at different year assumes that the only traffic volume is variable and another factor like road width, gradient, road surface, speed and traffic flow are constant.

2. METHODOLOGY

The noise monitoring procedure includes identification and selection of sampling locations, time duration for monitoring as well as the type of instrument used. The future traffic is predicted on the basis on observed traffic and expected annual growth rate of vehicles.

2.1 Site Selection

Total ten locations are selected in Delhi on the basis of their land use pattern. During site selection some of the locations are found under residential or commercial and silence zone. Land use pattern like locations having high rise building on one side or both sides and locations under the flyover bridge is the most affecting factor for variation in the noise level at different locations. Selected sites with their characteristics are presented in Table 1.

Table 1: List of selected noise monitoring sites in Delhi

Serial No.	Location	Area	One side	Other side
1.	Ashram Chowk	Mixed	Building	Building
2.	Lodhi road near Sai temple	Silence zone	Building	Open
3.	K.G& Tolstoy Marg	Silence zone	Building	Open
4.	Nirman Vihar	Commercial	Building	Building
5.	Pahrganj near police station	Commercial	Building	Building
6.	Peeragarhi Chowk	Commercial	Building	Open
7.	Patel Nagar Chowk	Mixed	Building	Open
8.	Shakti Nagar Chowk	Residential	Building	Building
9.	Kingsway Camp	Residential	Building	Building
10.	Badli mod near passport office	Mixed	Building	Open

2.2 Monitoring of Traffic Noise

The traffic noise level was monitored with the help of CESVA SC 260 sound level meter at the distance of 1m away from the edge of the road and the height of the sound level meter was taken as 1.5 m from the ground. This sound level meter is based on integrating averaging sound level meter and 1:1 and 1:3 octave band spectrum analyzers. It's monitored all frequencies (A- weight, C –weight and Z-weight) sound. Sound level meter calibrated before starting measuring of the traffic noise level.

2.3 RLS-90 model

RLS -90 model is used in the German for the prediction of the noise pollution level in highway and parking place. RLS- 90 is two parts:

(I). Sources level emission model (II). Propagation model

(I). **Sources level emission model**

In this model characteristic of the traffic flow, speed of the vehicles, type of the vehicles, according to its weight and texture of the road surface all these responsible factors of the L m E. Sources level emission calculated by the following formula:

$L_M E = (Lm\ 25\ basic) + C_{speed} + C_{gradient} + C_{road\ surface} + C_{reflection}$

Where,

$Lm = 37.3 + 10*\log\{m*(1+.082p)\}$

M=Mean hourly traffic volume

P =% truck exceeding 2.8 tones

- **Speed correction**

$C_{speed} = L_{car} - 37.3 + 10*\log[100 + \{(10^{.1*c})*p / (100+8.23*P)\}]$

$L_{car} = 27.8 + 10*\log\{1 + (.002*V_{car})^3\}$

$L_{truck} = 23.1 + 12.5\log*(V_{car})$

$c = L_{truck} - L_{car}$

Where,

V_{car} = Speed of the car

V_{truck} = Speed of the truck

(II). Propagation model

In this model noise level measured at the observation point noise is propagated energetic addition to the all contribution of the producing sources. Lengthy road and other meteorological factor affecting the noise level. Inverse relation between distance and sound, so that of the width of the road play important role.

$Lm = Lm\ E + C_{section} + C_{spreading} + C_{ground\ absorbent} + C_{screening} + C_{met}$

Where,

$C_{spreading}$ =spreading correction factor

$C_{ground\ absorbent}$ = Absorbent correction factor

$C_{screening}$ = Screening correction factor

C_{met} = Meteorological correction factor

3. RESULTS AND DISCUSSION

On the basis of collected data related to traffic noise study like traffic volume, average speed of vehicles, traffic noise data, the predicted value of noise level has been calculated at all the selected locations during peak and off-peak hours. The following sections discuss about the variation of monitored as well as predicted value of noise level during peak and off-peak hours.

3.1 Comparison between measured and predicted noise level during peak & off peak hours at Ashram Chowk

At Ashram Chowk, average noise level varied from 76.6 dB (A) to 80.1 dB (A) and 78.3 to 84.4 dB (A) during morning and evening peak hours respectively, whereas during off peak hours it was found as 77.3 dB(A). The variation of the noise level with respect to traffic volume is shown in Fig.1. In residential area average traffic noise level is quite higher than the standard noise level (55 dB (A)) because of the heavy traffic flow condition and due to the high rising building on both sides of the road. At the evening peak hour traffic noise level is maximum due to high traffic density or jam condition and honking effects. The percentage difference between observed average traffic noise level and predicted traffic noise level during morning peak hours, off peak hour and evening peak hours was found as 2.1%, 2.1% and 4.3% respectively, which indicates the applicability of the model.

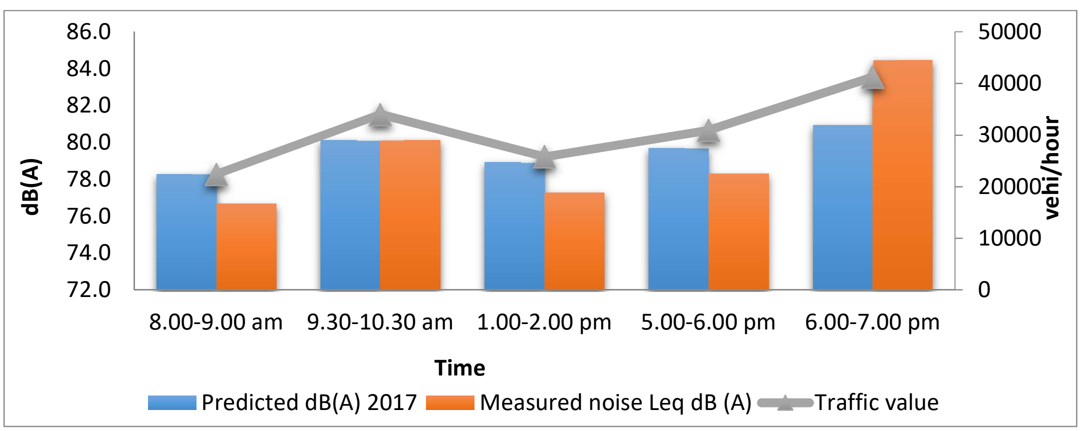

Fig 1. Variation of noise level during peak & off-peak hours at Ashram Chowk

3.2 Comparison between measured and predicted noise level during peak & off peak hours at Lodhi road

At this location, during peak hours the traffic volume was found between 6300 to 7340 vehicles per hour, whereas noise level varied from 70.2 to 74.8 dB (A). The Average noise level at Lodhi road varied from 74.3 to 74.8 dB (A) in morning peak hour. On the other hand, the evening peak hours showed a variation in noise level i.e. 73.7 to 74.7 dB (A) (Fig.2). The average traffic noise level was found quite higher than the standard noise because of the heavy traffic flow condition and probably due to the irregular movement of vehicles. At this location, the percentage error was also calculated and found as 3.30, 1.38 and 3.12 respectively.

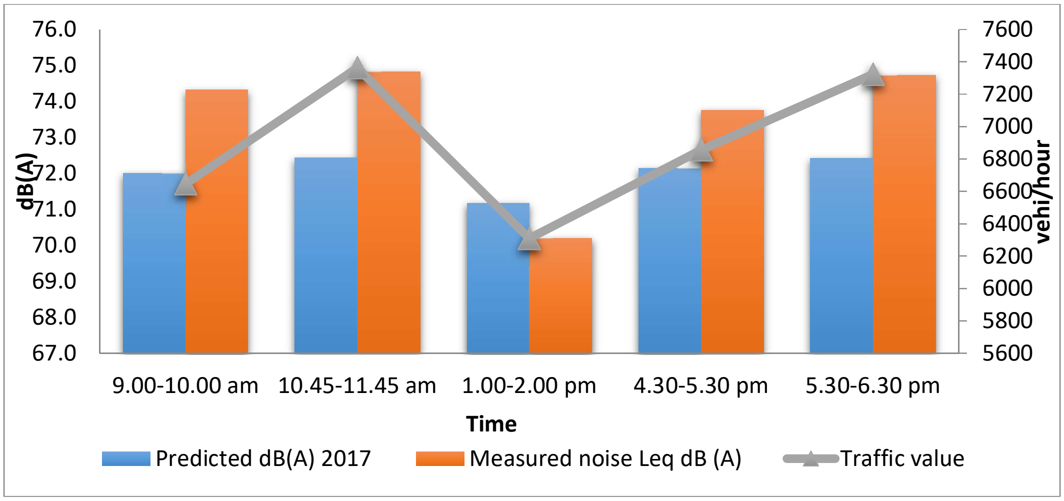

Fig 2. Temporal variation of traffic noise level at Lodhi road

3.3 Comparison between measured and predicted noise level during peak & off peak hours at K.G &Tolstoy Marg

It is depicted from figure 3 that the noise level at this location was found quite high as compared the Indian ambient standards. The morning peak hours showed a variation in noise level i.e. 72.8 to 74.7 dB (A), whereas 71.9 to 73.7 dB (A) during evening peak hours. The lowest noise level was found as 70.56 dB (A) during off-peak hours. The average traffic noise level at K.G & Tolstoy Marg was found high than the standard noise level i.e. 50 dB (A).

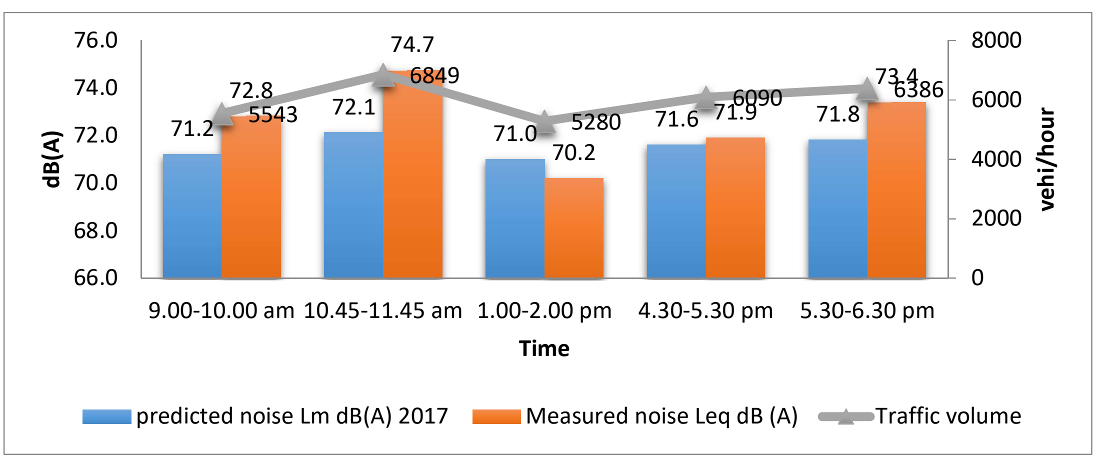

Fig 3. Temporal variation of traffic noise level at K.G & Tolstoy Marg

3.4 Comparison between measured and predicted noise level during peak & off peak hours at Nirman Vihar

The highest traffic noise was monitored during evening peak hour i.e. 6:00 to 7:00 pm, whereas minimum was also seen during morning peak hour i.e. 8:30 to 9:30 am (Fig. 4). From the analysis, it was concluded that the noise level found even during off-peak hour was higher than the ambient standards. The average traffic noise level at Nirman Vihar (commercial area) was also found higher than the prescribed standard i.e. 65 dB (A). It may be due to unavailability of parking facility at this location which may lead to higher traffic congestion and noise. The percentage error between predicted and measured traffic noise level was calculated during morning, off and evening peak hours and found as 3, 2.5 and 0.5 % respectively.

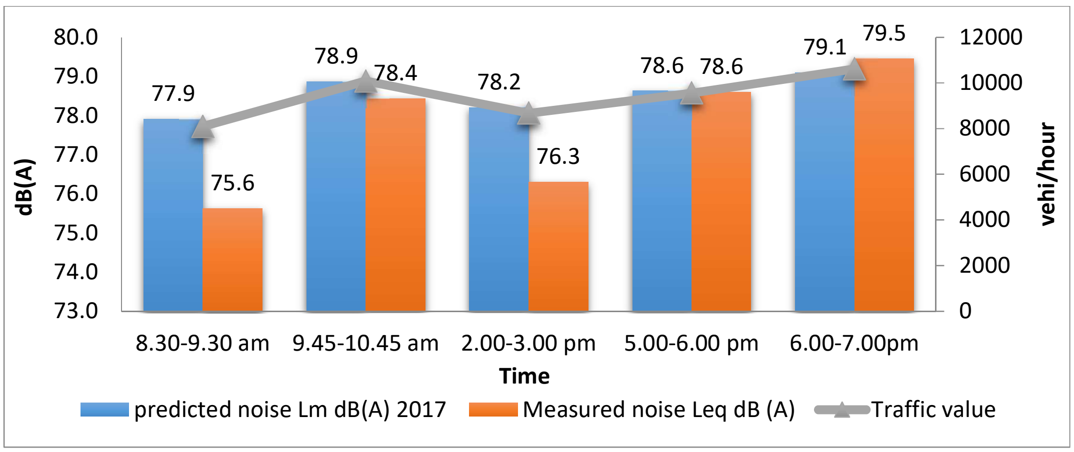

Fig 4. Traffic noise level variation during peak & off peak hours at Nirman Vihar

3.5 Comparison between measured and predicted noise level during peak & off peak hours at Paharganj

This location was categorized under commercial zone (Fig. 5). At this location, the average noise level was observed varying from 75.6 to 77.2 dB(A) in the morning peak hours and from 78.4 to 80.5 dB(A) during evening peak hours. The average traffic noise level at Paharganj (commercial area) was found quite higher than the standard noise level (65 dB(A)) because of the heavy traffic flow condition and high rising building on both sides of the road.

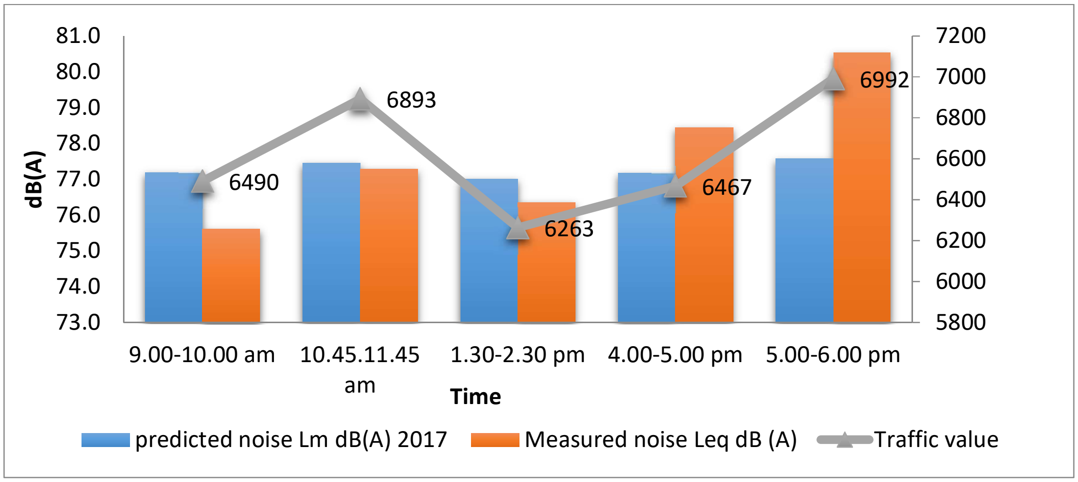

Fig 5. Temporal variation of traffic noise level at Paharganj Chowk

3.6 Comparison between measured and predicted noise level during peak & off peak hours at Peeragarhi Chowk

This location showed its highest noise level during 11:00 to 12:00 am. Average noise level at Peeragarhi vary from 75.1 to 80.7 dB (A) in the morning peak hours, in the evening peak hours vary from 77.6 to 79.1 dB (A), and during off peak hours noise level is 75.6 dB (A). The average traffic noise level at Peeragarhi Chowk (commercial area) is higher than the standard noise level (65 dB (A)) because of the area under the flyover bridge and heavy traffic flow condition. The percentage difference between modeled and observed noise level in the morning peak, off peak and even peak hours was obtained as 5.52, 3.87 and 1.84% respectively as shown in Fig. 6.

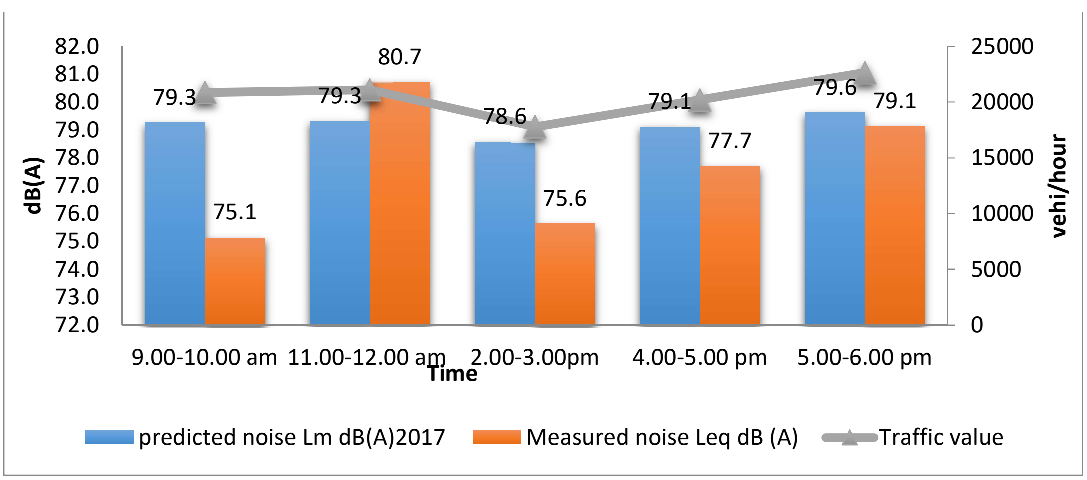

Fig 6. Variation of the traffic noise level during peak & off peak hours at Peeragarhi

3.7 Comparison between measured and predicted noise level during peak & off peak hours at Patel Nagar Chowk

At Patel Nagar Chowk, the highest traffic volume was observed during evening peak hours i.e. 6:00 to 7:00 pm, while the highest average noise level was also found during the same hour i.e. 76 dB (A). On the other hand, the predicted value during the same hours was 75.1 dB (A). At this site, the lowest noise level was found even high as compared to permissible limit. The average traffic noise level at Patel Nagar Chowk (residential area) was also found quite high than the standard noise level (55 dB (A)) due to heavy traffic flow and interrupted traffic conditions during evening time (Fig.7).

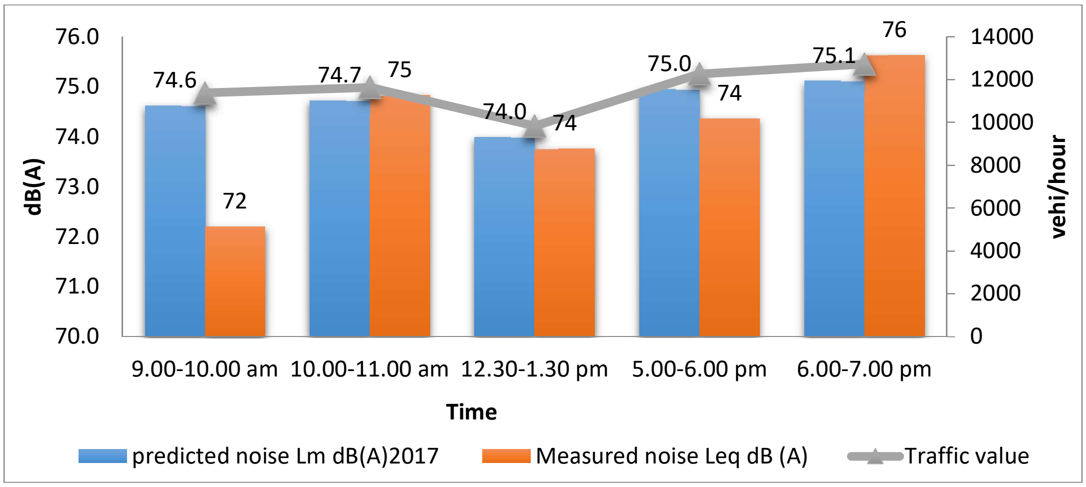

Fig 7. Variation of the traffic noise level during peak & off peak hours at Patel Nagar

3.8 Comparison between observed and predicted noise level at Shakti Nagar Chowk

This location was found under the category of residential land use pattern. At this location, very small difference of predicted noise level was found between peak and off-peak hours. Approximately similar kind of noisy condition was found during all time measurement of noise level at this location. With reference to traffic volume at this location, the hour 6:00 to 7:00 pm showed highest traffic i.e. 7749 vehicles/hour, whereas the observed traffic noise level was 79.5 dB(a), the highest one during all time scheduled measurement (Fig. 8). To check the suitability of the model, the percentage error of the predicted and monitored noise level was calculated and found as 5.3, 5.57 and 1% respectively during morning, off and evening peak hours.

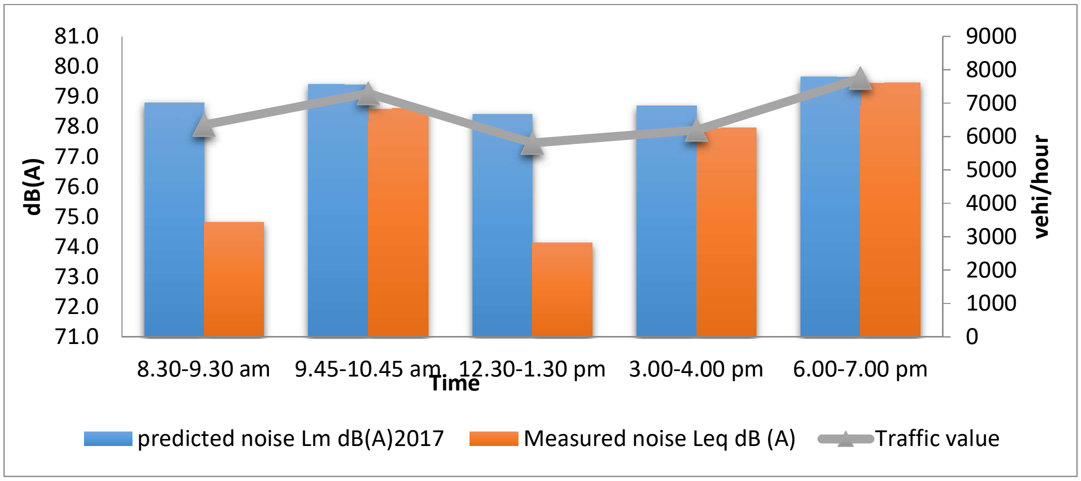

Fig 8. Traffic noise level during peak & off peak hours at Shakti Nagar Chowk

3.9 Comparison between measured and predicted noise level at Kingsway Camp

During traffic noise monitoring at this location, the maximum noise level was found as 75.1 dB (A) followed by 73.7 dB (A) during 11:00 to 12:00 pm and 6:30 to 7:30 pm respectively, whereas this hour also represented the highest traffic volume (Fig.9). The difference of noise level during morning peak hours, off peak hours and even peak hours was found as 1.26, 0.83 and 0.20 dB(A) respectively, and the percentage error was obtained as 1.75, 1.14 and 0.54 % respectively, which indicates the applicability and suitability of the model in city like Delhi.

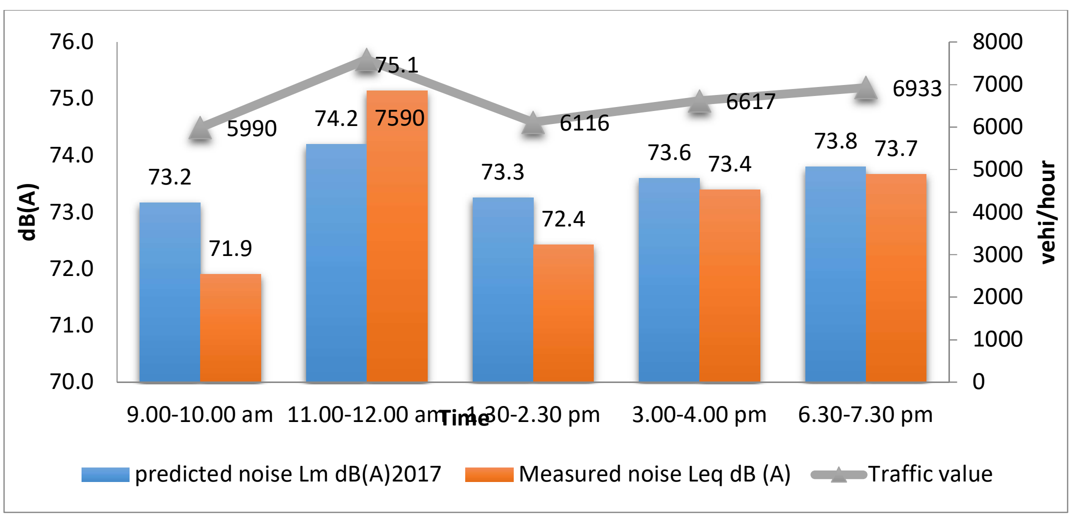

Fig 9. Variation of noise level at Kingsway Camp

3.10 Comparison between monitored and estimated noise level at Badli Mor

This location represents mix kind of land use pattern. The traffic volume was also found quite high during evening peak hour. The evening peak hour i.e. 6:30 to 7:30 pm showed a very high traffic noise i.e. 78.5 dB 78.5 dB (A), while the lowest was as 74.3 dB (a) during off-peak hour. A direct association was observed between noise and traffic volume at this location (Fig. 10). The monitored data of this location was also used to calculate percentage error during morning peak hour, off-peak hour and evening peak hour and attained as 1.47, 1.38 and 2.35% respectively. This small percentage error indicates the applicability of RLS-90 model for this study.

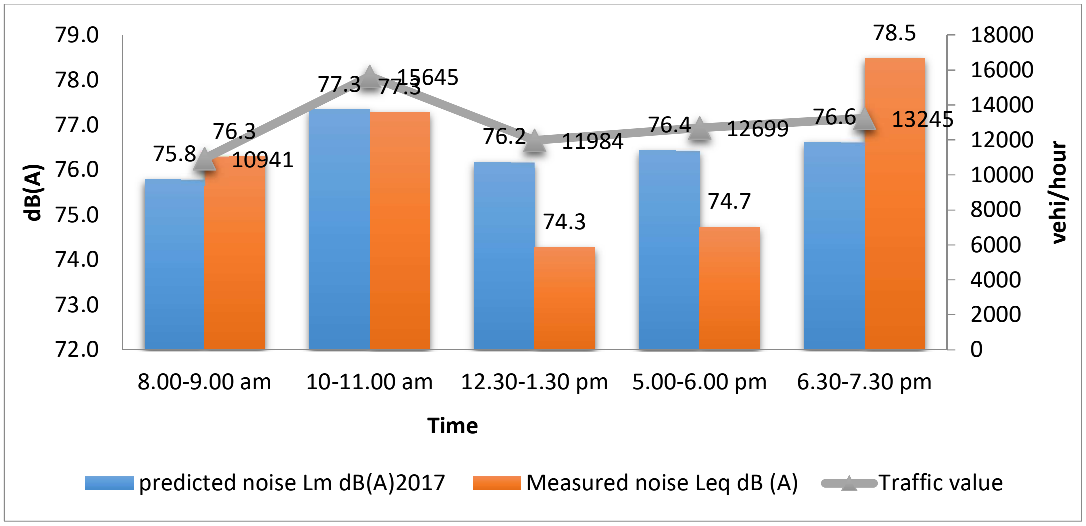

Fig 10. Temporal variation of traffic noise level at Badli Mor

On the basis of the comparative analysis between monitored and modeled traffic noise, at some locations, the measured noise level was found a little bit higher than the predicted one, whereas at some locations the predicted noise level was found a little bit more than the monitored noise level. At each location the percentage error has also been calculated and overall range of the percentage difference was found between the range of 0.5 to 5.75 %, which indicates the best suitability and applicability of this model in city like Delhi.

4. Forecasting of traffic noise level

Prediction of road traffic noise level by using RLS -90 model is found best suitable model in Indian heterogeneous traffic conditions. The same model has been used to forecast the traffic noise level for the year 2022, 2027 and 2032 (Table 2).

Table 2: Forecasting of traffic noise level for different years

Year / locations	Predicted noise level in 2017 dB(A)	Predicted noise level in 2022 dB(A)	Predicted noise level in 2027 dB(A)	Predicted noise level in 2032 dB(A)
Ashram Chowk	81.0	81.6	82.0	82.5
Lodhi Road near Sai temple	72.4	73.0	73.6	74.0

K.G & Tolstoy Marg	71.8	72.4	73.0	73.4
Nirman Vihar	79.1	79.7	80.2	80.7
Paharganj	77.6	78.1	78.7	79.1
Peeragarhi Chowk	79.6	80.2	80.8	81.2
Patel Nagar Chowk	75.11	75.71	76.25	76.72
Shakti Nagar Chowk	79.7	80.3	80.8	81.3
Kingsway Camp	73.8	74.4	75.0	75.4
Badli Mor	76.6	77.2	77.8	78.2

During this forecasting average annual vehicle growth rate is taken as 3% and other input parameters of the model assuming constant. Taking 2017 as a base year, road traffic noise has been predicted for different years i.e. 2022, 2027 and 2032. The forecasting of the traffic noise level at Ashram Chowk varied from 81 dB (A) to 82.5 dB(A) in 2017 to 2032 year, predicted traffic noise level much above the prescribed level due to heavy traffic flow and covered by high rise building on both sides of roads. Prediction of the traffic noise level at Lodhi road and K.G & Tolstoy Marg are varying from 72.4 to 74 and 71.8 to 73.4 dB (A) respectively, both locations consider as silence zone by CPCB. At Nirman Vihar traffic noise level predicted 79.1 to 80.7 dB(A) in 2017 to 2032 year. Paharganj Chowk which is near the New Delhi railway station, the traffic noise level has been predicted 77.6 to 79.1 dB (A).

5. CONCLUSION

After the analysis of the collected data, it is revealed that at each monitoring location, the traffic noise level was found more than the standard noise level as prescribed by CPCB. At Ashram Chowk, Nirman Vihar, Shakti Nagar and Peeragarhi Chowk the traffic noise level was observed much more during the evening time as compared to morning time. The reason behind this may be high traffic congestion and traffic volume during the evening period. It was observed that the locations covered by both sides high rising buildings and under the flyover bridge, having higher traffic noise level than the open or plain area. At silence zone area (Lodhi road and K.G. Marg), it was observed that the traffic noise level is more than prescribed standard noise level and sometime its was found equivalent to residential and commercial noise level. The developed model, i.e. RLS-90 gave very close results to the measured values. Percentage difference between predicted noise level and monitored noise level was found between 0.5 to 5.75%, which indicates the best suitability and applicability of this model in city like Delhi, whereas heterogeneous kind of traffic is found. The forecasted noise level at all the locations were found much more than the permissible noise level, which indicates the mitigatory measure like noise barriers would be required at all the locations to curb the noise pollution and its associated adverse health problems.

6. REFERENCES

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