Indian Journal of Pure & Applied Physics
Vol. 55, September 2017, pp. 687-692

Effect of odd-even vehicular restrictions on ambient noise levels at ten sites in Delhi city

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Received 16 August 2016; accepted 13 May 2017

The paper describes the ambient noise data acquired in Delhi city under diversified National Ambient Noise Monitoring Network (NANMN) set up across seven major cities of India and covering 70 stations for continuous noise monitoring throughout the year. The annual average L_{day} (06:00-22:00 h) and L_{night} (22:00-06:00 h) values observed in year 2016 in month of January and April for the 10 locations in Delhi city have been described to analyze the effect of odd-even restrictions on the ambient noise levels. The study shows that ambient noise levels have marginally decreased at some sites. The study discusses the noise levels acquired under the NANMN project only for the ten sites and thus shouldn't be interpreted as generic scenario for Delhi city. Also, the present study may not be misinterpreted with the success or failure of odd-even restrictions implemented for reducing pollution in Delhi city of India.

Keywords: National Ambient Noise Monitoring Network, Day equivalent sound level, Night equivalent sound level, Day-night average sound level, Equivalent continuous sound pressure level

1 Introduction

The vehicular population on the roads is one of the major environmental issues faced by every country in the world as it creates air and noise pollution, which is harmful to the community. In Indian scenario, every metropolitan city has been facing this problem since last two decades. The capital city of India, Delhi has 451 vehicles per 1000 population and 5588 vehicles per sq. km. Two wheelers and cars have grown exponentially in years on Delhi roads. Vehicles are the major source in contribution of total air pollution in metropolitan cites. In 2000-01 about 35 lakhs registered vehicles[1] exist in Delhi, but in 2008-09 this number is 60 lakhs more than 25 lakhs from 2000-01. Thus, it is very important to focus on the suitable effective measures to control the vehicular density and arrest the increasing air and noise pollution levels in these cities. The government of Delhi decided to implement odd-even vehicular restriction for the month of January starting from January 1st to January 15th, 2016 so as to control the increasing air pollution in the city. According to the rule, cars with even numbered registration plates will ply on even dates, while those with odd numbers will ply on the odd dates between 08:00 and 20:00 h. This rule doesn't apply on Saturdays and Sundays and all taxis, passenger cars operating on CNG and electric power cars with only women passengers and all motorized two wheelers. Two wheelers, cars driven by women, cars with differently-abled persons and those of VIP, VVIP such as Prime Minister, President, Chief Justice and Chief Ministers of states and Union territories were exempted by the rule. Overall, the rule was a great step is reducing the traffic congestion on the roads, but there has been no definitive answer whether the pollution levels have come down during the period or not. Additional transport arrangements were made by Delhi government such as running of 9000 buses (4500 DTC; 1500 cluster and 3000 private); 82,000 autos; 79,600 taxis and also the carrying capacity of Delhi Metro trains was enhanced from 26 lakhs to 32 lakhs across all the lines[2]. The IInd phase of odd-even restrictions was started in April, 2016 implemented from 15th April to 30th April, 2016 again with an objective of reducing the air pollution levels in the Delhi city. The present study is focussed on the ambient noise levels during the implementation of odd-even restrictions in the city for January and April, 2016 at ten sites in the city. Although, the major thrust behind the implementation of odd-even scheme was to control the air pollution, yet the present study only focuses on noise pollution as noise pollution is also one of the important concerns

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apart from air pollution for the metropolitan cities like Delhi especially when the annual growth of vehicles in Delhi city increased from 4.72% in 1999-2000 to 6.89% in[3] 2014-15. Lowering of pollution levels has been reported in different cities of world like in Paris, Beijing etc. due to imposition of odd-even rule[4].

2 Methodology

The ambient noise levels discussed in the present study corresponds to the ten sites wherein continuous noise monitoring system for 24×365 days is established by Central Pollution Control Board (CPCB), India. CPCB initiated a pilot project on development of a National Ambient Noise Monitoring Network (NANMN) project established at 35 sites in the country covering seven cities of India[5]. The details of the NANMN project, methodology, instrumentation used and data analyzed has been elaborately discussed in reference[6]. Since years 2014, a diversification of NANMN project was done covering 70 stations in seven major cities of the country namely, Bengaluru, Chennai, Delhi, Hyderabad, Kolkata, Lucknow and Mumbai. The Delhi city has now ten noise monitoring station established at ten sites which comprises of 4 sites lying in commercial zone; 2 in residential and 4 in silence zone. The present study thus analyzes the ambient noise levels data acquired under the NANMN project at these ten sites in month of January and April, 2016 with an objective of ascertaining the difference in average levels during the normal days and days when odd-even restrictions were imposed. The day equivalent sound level (L_{day}) and night equivalent sound level (L_{night}) is calculated from the 24 h noise data for each day of the year. The day-time is from 6.00 a.m. to 10.00 p.m., while the night time is considered from[5-7] 10.00 p.m. to 6.00 a.m.

The average value of L_{day} (06:00-22:00 h) and L_{night} (22:00-06:00 h) for n day's sound level data is calculated as:

$$L_{\text{day},n} = 10\ log\left[\frac{1}{n}\sum_{i=1}^{n} 10^{0.1(L_{day,i})}\right] \quad \text{... (1)}$$

$$L_{\text{night},n} = 10\ log\left[\frac{1}{n}\sum_{i=1}^{n} 10^{0.1(L_{night,i})}\right] \quad \text{... (2)}$$

where n is the number of days or nights; n=31 for January and n=30 for April, 2016 and $L_{day,i}$ and $L_{night,i}$ are the i^{th} corresponding A-weighted equivalent level for the considered period.

The 24 h equivalent sound pressure levels, $L_{\text{Aeq,24h}}$ was calculated from the 24 h sound pressure level data acquired from these sites. It may be noted that the study discusses the noise levels acquired under the NANMN project only for the ten sites and thus shouldn't be interpreted as generic scenario for Delhi city. Also, the present study may not be misinterpreted with the success or failure of odd-even restrictions implemented for reducing pollution in Delhi city of India. The ambient noise levels at the ten sites are compared with the recommended ambient noise standards[7] in respect of noise (Table 1) so as to ascertain the compliance of these sites with ambient standards especially during the imposition of odd-even rule in Delhi.

3 Analysis of Ambient Noise Levels

The monthly average equivalent day levels and night levels, L_{day} and L_{night} and 24 h equivalent sound pressure levels, $L_{\text{Aeq,24h}}$ at the ten sites in Delhi city in month of January and April, 2016 is reported in Table 2. The comparison of these levels with ambient noise standards reveals that only the CPCB site marginally meets the ambient standards in January, 2016. There is no other site out of the ten sites under consideration that meets the ambient noise standards. The ITO commercial site experiences high ambient noise level which necessitates the implementation of suitable noise abatement plans so as to bring these levels below the ambient noise standards. Figure 1 shows the average equivalent day levels and night levels, L_{day} and L_{night} and 24 h equivalent sound pressure levels, $L_{\text{Aeq,24h}}$ separately for the normal day and odd-even restrictions day at these ten sites in Delhi city in month of January, 2016. It can be observed that even for the days wherein odd-even restrictions are imposed; the CPCB site only marginally meets the ambient noise standards. No other site meets the ambient noise standards amongst all the ten sites in the

Table 1 – Ambient air quality standards[7] in respect of noise in India

Area code	Category of area/zone	Limits in dB(A) L_{eq}*	
		Day time	Night time
A	Industrial area	75	70
B	Commercial area	65	55
C	Residential area	55	45
D	Silence zone	50	40

* L_{eq} denotes the time weighted average of the sound level in decibels in A-weighting

Table 2 – Monthly average ambient levels, L_{day}; L_{night} and $L_{Aeq,24h}$ for ten noise monitoring stations installed in Delhi city under NANMN pilot poject

Name of location	Area characteristics	Ambient noise levels in dB(A)					
		January, 2016			April, 2016		
		L_{day}	L_{night}	$L_{Aeq,24h}$	L_{day}	L_{night}	$L_{Aeq,24h}$
Civil Lines	Commercial	61.3 ± 0.5	59.6 ± 0.6	60.7 ± 0.5	61.3± 0.9	60.1± 0.5	60.9± 0.6
R K Puram	Residential	58.8± 2.1	52.9± 3.1	56.6± 2.1	60.5± 1.7	52.5± 1.1	57.8± 1.3
Anand Vihar	Commercial	67.4± 0.5	62.1± 0.7	65.6± 0.5	67.8± 0.5	63.3± 0.6	66.3± 0.4
Mandir Marg	Silence	52.1± 2.0	44.8± 2.7	49.5± 1.9	56.4± 2.7	48.6± 2.7	53.7± 2.5
Punjabi Bagh	Residential	57.1± 1.0	50.2± 1.9	54.7± 1.1	59.7± 1.9	51.8± 1.7	57.0± 1.6
Dilshad Garden	Silence	51.4± 0.8	45.8 ± 2.5	49.4± 1.3	51.4± 1.0	50.5± 2.6	50.8± 1.0
CPCB HQ	Commercial	65.7± 1.2	54.3± 1.4	61.9± 0.9	65.5*	56.0*	62.3*
DTU, Bawana	Silence	50.7± 2.4	45.9± 2.3	49.0± 2.2	54.5± 1.2	49.4± 1.7	52.6± 1.0
ITO	Commercial	73.8± 1.2	68.0± 1.2	71.8± 1.1	70.9± 4.3	66.1± 3.0	69.3± 3.8
NSIT, Dwarka	Silence	56.5± 1.0	52.4± 1.7	55.1± 1.1	57.2± 0.8	55.9± 3.2	56.2± 1.1

*Standard deviation is not available due to maintenance work

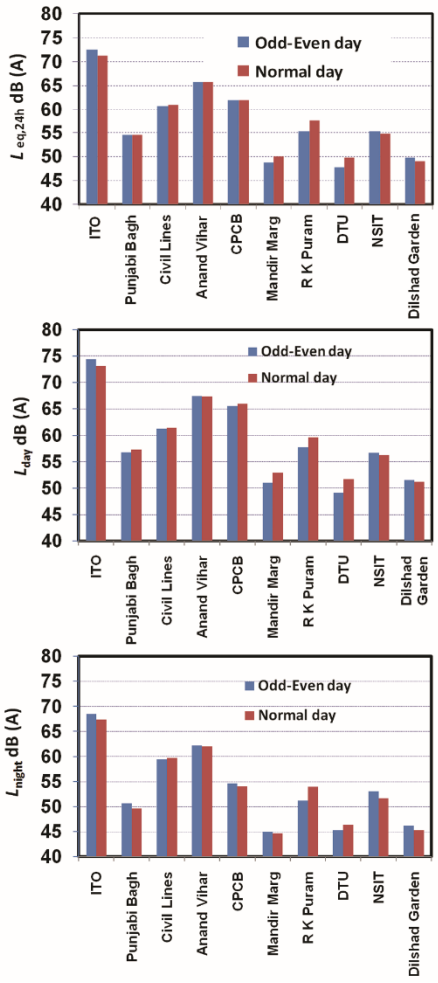

Fig. 1 – Average equivalent day levels and night levels, L_{day} and L_{night} and 24 h equivalent sound pressure levels, $L_{Aeq,24\,h}$ separately for the normal days and odd-even restriction days at ten sites in Delhi city in month of January, 2016.

city. Also, the analysis of L_{day} and L_{night} levels reveals that the difference of less than 2 dB(A) between L_{day} and L_{night} levels is observed for Civil lines and Dilshad Garden site in months of January and April, 2016, which suggests that suitable noise control measures should be implemented to bring the night levels in compliance with the ambient noise standards for sleep disturbance protection and increased sensitivity of community to noise at night. The US Department of Housing and Urban Development (HUD) recommends the $L_{Aeq} \leq 49$ dB(A) as clearly acceptable; $49 < L_{Aeq} \leq 62$ dB(A) as normally acceptable, $62 < L_{Aeq} \leq 76$ dB(A) as normally unacceptable and $L_{Aeq} > 76$ dB(A) as clearly unacceptable[8]. Interestingly, in accordance with these criteria, 8 sites out of 10 sites under consideration meet these criteria for both the months. Two sites namely, Anand Vihar and ITO don't meet the recommended HUD criteria which suggests that these sites should be give utmost priority for controlling the ambient levels out of all the sites under consideration. A consideration of interim target of 55 dB L_{night} recommended[9] shows that 7 sites meet these criteria. The night levels at Civil lines, Anand Vihar and ITO areas are above the target of 55 dB $L_{night.}$

Figure 2 shows the average equivalent day levels and night levels, L_{day} and L_{night} and 24 h equivalent sound pressure levels, $L_{Aeq,24\,h}$ separately for the normal day and odd-even restrictions day at these ten sites in Delhi city in month of April, 2016. It can be observed that no site meets the ambient noise standards amongst all the ten sites in the city under consideration. Table 3 shows the difference in average ambient levels between odd-even day in 1st phase and normal day

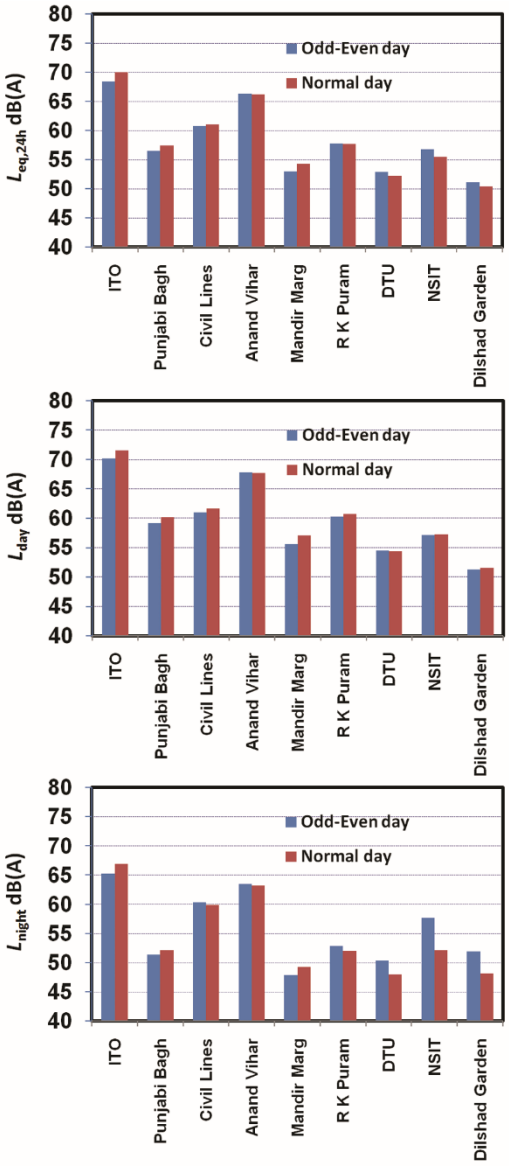

Fig. 2 – Average equivalent day levels and night levels, L_{day} and L_{night} and 24 h equivalent sound pressure levels, $L_{Aeq,24\ h}$ separately for the normal days and odd-even restriction (II[nd] phase) days at ten sites in Delhi city in month of April, 2016.

for L_{day}; L_{night} and $L_{Aeq,24\ h}$ parameters for ten noise monitoring stations installed in Delhi city under *NANMN* pilot poject. It can be thus observed that for only three sites namely, R K Puram; Mandir Marg and ambient DTU, Bawana; there is reduction of noise levels by 1.8 dB, 1.9 dB and 2.6 dB, respectively. namely The other sites namely Anand Vihar; Dilshad Garden; ITO; and NSIT Dwarka registed an increase in day ambient noise levels during the odd-even restrictions. However, this increase is not at all associated with the odd-even restrictions which is confirmed by the fact that even the night levels for these sites are higher for the days wherein odd-even restrictions are imposed in comparison to the normal days.

Table 4 shows the difference in average ambient levels between odd-even day in II[nd] phase and normal day for L_{day}; L_{night} and $L_{Aeq,24h}$ parameters for ten noise monitoring stations installed in Delhi city under NANMN pilot poject. The data for CPCB site was however not available for few days only due to some maintenance work. It can be observed that for three sites namely, Mandir Marg, Punjabi bagh and ITO, there is a decrese in day equivalent sound levels. The analysis of vehicular population at some sites during the days of odd-even restrictions were imposed by Goel *et al.*[10] which shows that during the odd-even experiment, car flow rates per hour on different roads decreased by 9% to 17% in some area[10] in parallel with approximately similar increases in bus flow and auto rickshaw rates and significant increases in motorized two wheeler flow rates. The study also reveals that increase in flow of vehicles other than cars will offset the decrease in the emissions from cars. Also, another reason may be attributed to the increase in number of cars converted to CNG as from September to December, 2015; 5463 vehicles have been converted to CNG; while from January to April 14, 2016; 12,126 cars have been converted to CNG[11]. These studies in conjunction with the ambient noise levels analysis show that for the ten sites under consideration; there is a marginal decrease in the ambient noise levels. However, exact counting of the vehicles moving on the Delhi roads during the odd-even days and normal days shall supplement the present study and shall present a better correlation of the decrease in ambient noise levels with decrease in the number of vehicles. The marginal decrease in the ambient noise levels is consistent with observations reported by CPCB pertaining to air pollution levels stating that some reduction in air pollution is likely to happen due to odd-even scheme. However, a single factor or action can't substantially reduce pollution levels in Delhi and thus integrated measures are required for bring the pollution levels below the recommended standards[12]. It is also observed that almost all sites have ambient noise levels higher than the recommended ambient noise standards which also suggest the need of suitable noise abatement actions plans[13-16] for controlling the ambient noise levels for bringing them below the recommended standards.

Table 3 – Difference in average ambient levels between odd-even day in 1st phase and normal day for L_{day}; L_{night} and $L_{Aeq,24h}$ parameters for ten noise monitoring stations installed in Delhi city under NANMN pilot poject

Name of location	Area characteristics	Ambient noise levels in dB(A) January, 2016		
		L_{day}	L_{night}	$L_{Aeq,24h}$
Civil Lines	Commercial	-0.2	-0.3	-0.2
R K Puram	Residential	-1.8	-2.8	-2.0
Anand Vihar	Commercial	0.2	0.2	0.2
Mandir Marg	Silence	-1.9	0.4	-1.0
Punjabi Bagh	Residential	-0.4	1.0	0.0
Dilshad Garden	Silence	0.3	0.9	0.6
CPCB HQ	Commercial	-0.4	0.5	-0.2
DTU, Bawana	Silence	-2.6	-1.1	-2.1
ITO	Commercial	1.3	1.1	1.2
NSIT, Dwarka	Silence	0.4	1.3	0.7

Table 4 – Difference in average ambient levels between odd-even day in IInd phase and normal day for L_{day}; L_{night} and $L_{Aeq,24\,h}$ parameters for ten noise monitoring stations installed in Delhi city under NANMN pilot poject

Name of Location		Ambient noise levels in dB(A) April, 2016		
		L_{day}	L_{night}	$L_{Aeq,24h}$
Civil Lines	Commercial	-0.6	0.4	-0.2
R K Puram	Residential	-0.4	0.8	0.1
Anand Vihar	Commercial	0.1	0.2	0.1
Mandir Marg	Silence	-1.4	-1.3	-1.3
Punjabi Bagh	Residential	-1.0	-0.8	-0.9
Dilshad Garden	Silence	-0.3	3.8	0.7
DTU, Bawana	Silence	0.1	2.4	0.7
ITO	Commercial	-1.4	-1.7	-1.5
NSIT, Dwarka	Silence	-0.1	5.5	1.3

These noise abatement measures are essentially required as the growth rate of vehicles has been observed[3] to be 6.89% in 2014-15.

4 Conclusions and Recommendations

The paper presents the ambient noise scenario at the ten sites in Delhi city in month of January and April, 2016 while the odd-even restrictions were imposed. The study reveals that the ambient noise levels were marginally decreased at some sites. Some sites like ITO commercial area showed an increase in ambient levels by 1.3 dB(A) in month of January, but analyzing the night levels confirms that this increment is not due to the odd-even restrictions. The study also shows that out of the ten sites under consideration, no site meets the ambient noise standards. Thus, the present study suggests the need of suitable and effective implementation of noise abatement plans so as to control the ambient noise levels at these sites. It may be noted that the study discusses the noise levels acquired under the NANMN project only for the ten sites and thus shouldn't be interpreted as generic scenario for Delhi city. Also, the present study may not be misinterpreted with the success or failure of odd-even restrictions implemented for reducing pollution in Delhi city of India. However, it is recommended that future studies should focus on analyzing the ambient noise levels at various sites in Delhi during the imposition of odd-even rule in conjunction with measuring the change in traffic flow which shall be indispensable in ascertaining the effect of odd-even restrictions on ambient noise scenario in Delhi city of India. It is also recommended that suitable effective measures such as erection of noise barriers especially for areas under the silence zone like hospitals, schools and colleges etc.; provision of green buffer zones; restrictions on honking behaviour; exercising noise limits especially on heavy vehicles, restrictions on movement of heavy vehicles in residential areas, timing traffic lights, etc. could also be some important administrative steps that may be considered for reducing noise pollution levels especially in residential and silence zones. Apart from the administrative rule enforced by the government of India and Delhi region, awareness and cooperation of general masses in maintaining a "noiseless community" is must for controlling the noise pollution levels in Delhi city.

Acknowledgement

The authors are very thankful to the CPCB authorities for their permission to publish the present

work. Authors also express there gratitude towards Director, CSIR-National Physical Laboratory, India and Head, Physico–Mechanical Metrology Division for their constant encouragement and support for the research work and allowing to publish the study.

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