

Impact of Traffic Noise on the Teaching and Learning Process of School Environment



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Abstract Long-term exposure to noise causes various health problems, including hypertension, depression, distressed cognition, and hearing impairment. The existing literature indicates rapid industrialization, population, and uncontrolled growth in vehicular traffic as the main causes of outdoor noise generation. In this study, measurements were conducted by monitoring the noise levels outside/inside of two school campuses, named A and B. Class-2 precision sound level meter was used to find out the exposure of students to noise inside classrooms in both prevailing (PC) and silence (SC) condition. Noise maps developed from these measurements reflect an alarming situation for both schools with high noise exposure. Furthermore, there is an average noise level reduction of 6.15 and 6.72 dB(A) in school A & B respectively, when situation changed from prevailing to silence. Results also indicate that the measured noise levels (L_{Aeq}) were nearly twice as high as the recommended limit set by World Health Organization (WHO) for classrooms occupied with students. The z-test indicates a significant difference in noise levels for PC and SC. The questionnaire survey investigates the perception and awareness of the students towards the health consequences of high noise exposure. Results indicate higher distraction in the classroom due to road traffic noise. Around 67% of students experienced difficulty in speech intelligibility and 78% found it difficult to concentrate in classrooms. The study has shown a significant impact of traffic noise on the school environment which leads to detrimental effects on the academic performance and well-being of school children. Hence, it is strongly recommended to mitigate road traffic noise generated outside these schools in the form of thick vegetation/noise barriers, thereby ensuring healthy learning conditions inside the classrooms.

Keywords Noise pollution · Road traffic noise · School children · Health consequences · Noise maps

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1 Introduction

Over the years, rapid industrialization has grown, which had led to polluting the ambient atmosphere [1]. Urban noise is one of the main sources that makes life hard to sustain in metro cities [2]. It is the unwanted sound that may be acceptable to an individual but not to others [3–5]. Most of the research used to be done on water and air pollution because noise is invisible [6], and the type of pollution that cannot be seen is thought to be less dangerous [4] than the pollution that can be seen. But in the last few years, noise has also come to be seen as a major problem. Most of this noise comes from unbalanced growth and a sudden rise in traffic [7]. In recent years, most of the studies have focused to look at how traffic noise affects roadside shopkeepers, traffic police, and roadside vendors. Most of these studies found a positive correlation between noise exposure and physical and mental distress [8]. It is also clear that loud noise can cause psychological trauma [9], sleep problems, cardiovascular diseases, and high blood pressure (BP), including a wide range of other health problems that can last for a long period of time. Hearing impairment, mental health issues, heart disease, and coronary illness have all increased in the past five years [10–12]. This reflects the severe nature of traffic-related noise pollution in the surrounding environment. Limited studies were observed on school environment and children’s exposure to noise [13]. However, most of the children under the age of 12 were not able to realize the damaging impact of noise pollution on their ability to learn, concentrate, perform, and react until it’s too late [14–16]. According to federal regulations, schools and hospitals must be situated in a noise-free environment [17–19], but it is still a challenging situation in urban areas. The WHO permissible limit for noise in school playground is 55 dB(A), while it is 35 dB(A) for classrooms [20] (Table 1).

Considered literature indicate that the measured noise levels in schools were typically neither below the permissible value nor even close to that number [5, 12, 16, 21, 22]. A detailed questionnaire survey was conducted to determine the student’s perception of noise and its impact on their health [23]. The CPCB noise guidelines [24] were shown in Table 2.

Table 1 World health organization-recommended decibel levels for classrooms [20]

Certain situation	L_{Aeq} dB(A)	Health impact (s)
Indoors, in preschool and elementary school classrooms	35 (during class)	Problems in understanding speech, interpreting meaning, and conveying messages
Outdoors, school, and playground	55 (during play)	Annoyance (external source)

Table 2 Ambient noise standards (CPCB) [24]

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

2 Study Area

Surat, with an approximate area of 474.2 km², is one of Gujarat's most developed cities in India. According to the census 2011, the city has a population of around 4,645,384 people and a population density of 10,052 people/Km². In addition to this, it is widely recognized as the commercial capital of the diamond and textile industries. The city is situated in western Gujarat on the Tapi River at 21° 12' 00.00" North and 72° 52' 00.00" East.

The study was conducted in two secondary schools, which is shown in Fig. 1. School A is located across the six-lane arterial road which is possessing heavy traffic due to a large number of commercial vehicular transportation as compared to school B. Since the school is located in a fast-developing commercial zone of the city, its topographical area is smaller than School B. The school operates in two shifts and offers English and Gujarati as a medium of study for standard 1–12. Small food courts, walkways, city transportation, commercial cars, and personal vehicles near the school area are all sources of noise pollution from outside school A. School B is a three-storied building located across the arterial and sub-arterial road, it is well-developed with a spacious playground and parking area. It consists of students from grade 1–12. The medium of instruction is in English. The school was at a significant distance from arterial road, but adjacent to the sub-arterial road which was the main source of traffic noise. The small food court vendors and pedestrians were the other sources of noise.

3 Methodology

The detailed methodology is shown in Fig. 2. It includes taking permission from the principal of schools to conduct the experiments in the school premises. The schools are so selected that the location of schools should be near to a street of any urban/main road, i.e., only schools which are highly prone to traffic noise. Children of these schools (located along moderate to high-traffic roads in a busy commercial locality) were likely to be in a critical stage of noise exposure. Students in grades 7, 8, 9, and 11 were considered due to the fact that lower-grade students may not provide answers with logical thinking. For measurement of road traffic noise, two Sound

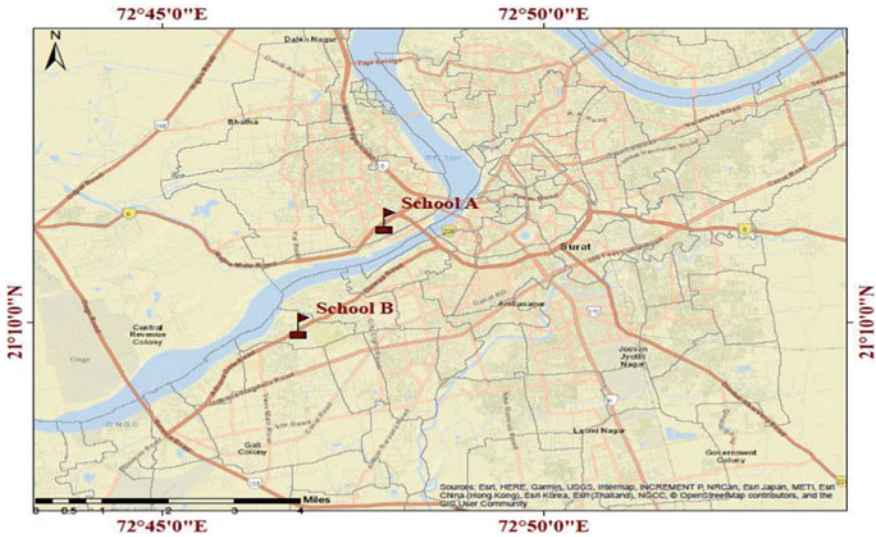


Fig. 1 Location map of the study area

level meters—class-2 precision (Kimo-dB300) were used, one sound level meter was placed outside of the school boundary facing towards the road traffic with a minimum distance of 1.2–1.5 m from the boundary wall and another sound level meter was placed inside the classroom which was mounted over the tripod at the height of 1.5 m (Fig. 3) and with the minimum distance of 1.5 m from the wall. Measurement of sound was performed simultaneously from both sound level meters and further extracted by the computer software of Kimo-dB300. The classroom noise levels were measured at two different noise conditions, i.e., in prevailing condition (when the study was done with all doors, windows open and noisy electrical equipment was operating, it was referred as prevailing condition (PC)) and in silence condition (when the study was done with all doors, windows closed with closing noisy electrical equipment it was referred as silence condition (SC)).

It was observed that school A was having high road traffic noise due to nearby vehicle stopping zone (traffic light) causing horn honking, acceleration–deceleration vehicular engine noise, and tire-pavement noise generated by vehicles on the main arterial road and flyover. School B is having moderate noise exposure due to the lesser number of vehicles on the sub-arterial road as compared to the main arterial road.

The average classroom size was 7 m × 11 m, well equipped with wooden benches with a maximum of two occupancies per bench, half-glazed windows of size 1.8 m × 1 m, wooden blackboard, six fans, speakers, wooden platform of size 1.8 m × 1.2 m × 0.5 m near to the writing board, teacher's table, and chair was present in the classroom. The responses to the questionnaire were analyzed through IBM-SPSS (Statistical Package of Social Science). The school's location and noise maps were prepared through ArcGIS 10.8 and Google Earth Professional. The questionnaire

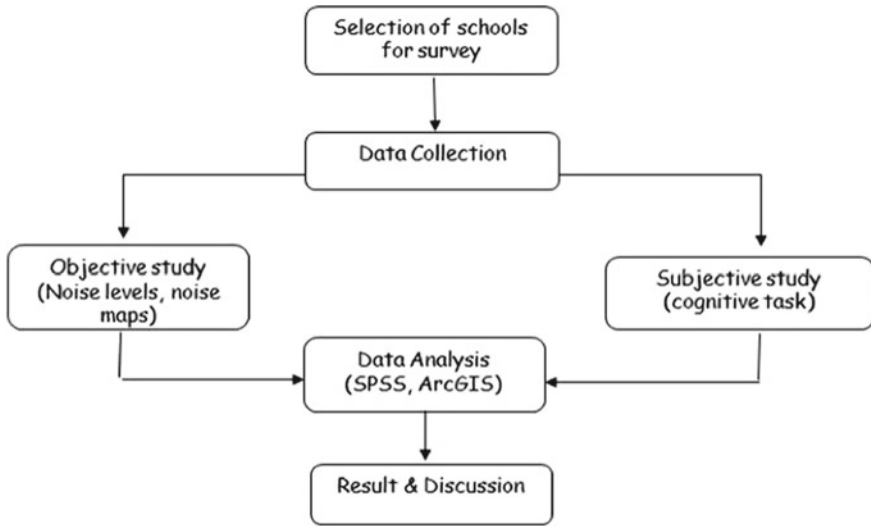


Fig. 2 Methodological framework



Fig. 3 Class-2 precision sound level meter

consists of ten questions, which are based on major factors of learning directly/indirectly affected by ambient noise.

The sound level measurement inside the classroom was taken for 15 min for the prevailing condition, 15 min for the silence condition, and 10 min have been given for the questionnaire survey. Figure 4 shows the photographs of data collection in classrooms and roadside of schools for traffic noise.



(a)



(b)

Fig. 4 Data collection through class-2 precision sound level meters, **a** inside classroom, **b** roadside

4 Noise Measurement Results

The result of noise inside a classroom with the prevailing condition and silence condition and road traffic noise was shown in Table 3. The measured noise levels in all observed classes were much beyond the WHO recommended guidelines (35 dB during ongoing class). RT refers to the decibel level of noise generated by vehicles on the road.

The noise levels in the classrooms were observed to decrease by an average value of 6.15 dB(A) and 6.72 dB(A) in schools A and B respectively, when all doors and windows were closed and noisy electrical equipments were turned off (SC). This

Table 3 Measurements of ambient noise dB(A)

Parameters	Class 7			Class 8			Class 9			Class 11		
	PC	SC	RT	PC	SC	RT	PC	SC	RT	PC	SC	RT
<i>School A</i>												
L _{Aeq}	77.0	72.8	79.8	74.2	68.2	78.3	74.9	67.3	77.8	76.4	69.6	78.5
L _{Amax}	87.2	76.3	84.2	89.1	76.9	86.8	82.1	82.8	82.6	82.5	73.8	91.1
L _{Amin}	65.3	62.7	64.3	66.7	62.0	65.6	58.9	53.4	65.1	54.2	56.1	68.4
L ₉₅	67.6	63.4	68.7	61.4	64.3	65.6	64.2	58.9	63.6	61.4	58.2	59.8
<i>School B</i>												
L _{Aeq}	62.3	56.2	65.8	67.2	58.2	65.7	71.2	65.1	64.2	62.2	56.5	68.2
L _{Amax}	73.4	62.4	82.8	74.9	61.8	82.2	84.0	71.2	78.1	74.8	66.4	81.4
L _{Amin}	44.5	48.4	56.8	57.2	43.4	57.4	58.2	48.4	52.4	47.2	41.2	62.4
L ₉₅	48.2	44.5	47.8	58.7	44.4	52.4	64.2	48.6	51.4	52.8	42.4	50.2

* PC: Prevailing condition, SC: Silence condition, RT: Road traffic noise levels

Table 4 Z-test results of measured noise levels in prevailing and silence conditions

Parameter	Class 7th	Class 8th	Class 9th	Class 11th
<i>School A</i>				
Z-value (P-value)	8.71(0.00)	10.1(0.00)	7.24(0.00)	-0.63(0.52)
Variance PC (SC)	26.1(14.6)	17.7(30.0)	28.0(37.9)	14.6(31.0)
Mean PC (SC)	74.5(72.2)	74.2(71.3)	70.4(67.6)	68.8(69.0)
<i>School B</i>				
Z-value (P-value)	49.8(0.00)	32.4(0.00)	61.4(0.00)	48.6(0.00)
Variance PC (SC)	35.0(15.3)	37.7(15.0)	39.5(15.3)	33.9(18.8)
Mean PC (SC)	64.7(53.1)	63.7(56.0)	68.0(53.1)	64.8(53.1)

Note Bold features indicate the statistical difference between the samples

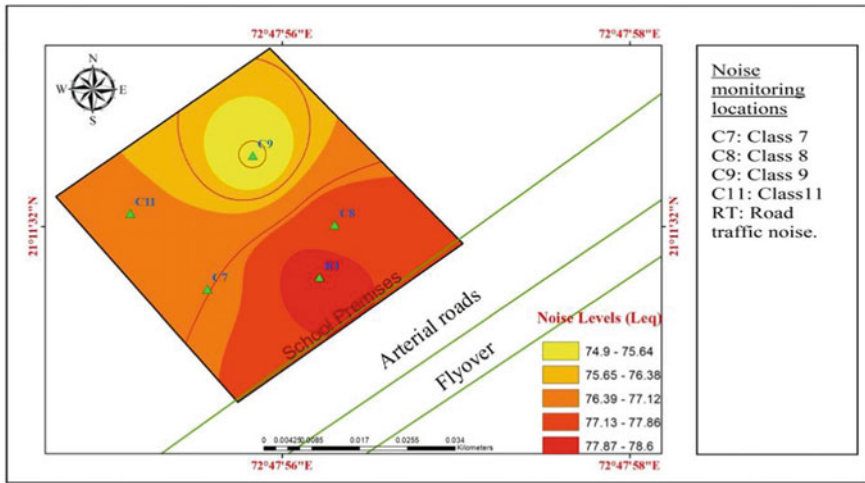
indicates that maintaining acoustic conditions within the classroom have resulted in a significant reduction in noise levels.

The z-test was performed on measured noise levels in prevailing and silence conditions inside the classrooms and the results were shown in Table 4. In almost all considered classes, a significant statistical difference was found.

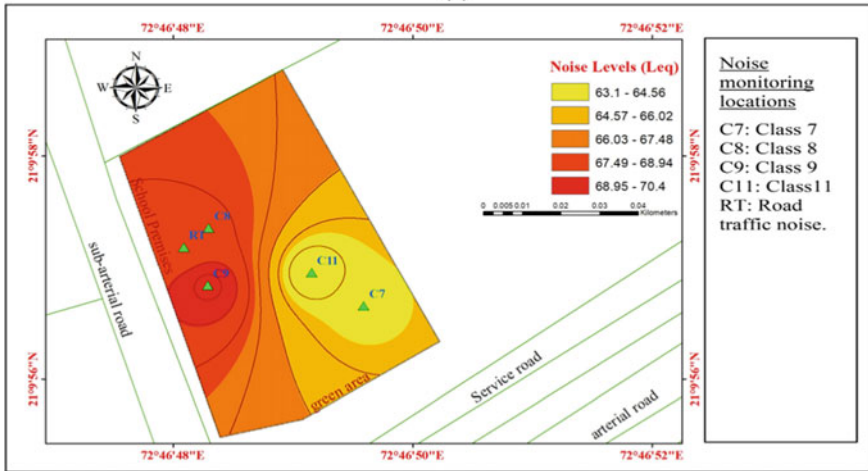
5 Noise Maps of School Premises

Based on the measurements, the noise maps were developed through Google Earth Professional and ArcGIS to represent the exposure of road traffic noise to the ongoing classrooms inside the schools. It was found that classes near to roadside, i.e., class

7 and class 8 of school A and class 8 and class 9 of school B are more influenced as compared to the classes far from the road. This indicates that the impact of noise reduces as it propagates away from roadside traffic. Figures 5a, b shows the developed noise maps for School A and school B, respectively, where the boundary of the map is the school premises.



(a)



(b)

Fig. 5 Noise map for a School A. b School B

6 Assessment Through Questionnaire Survey

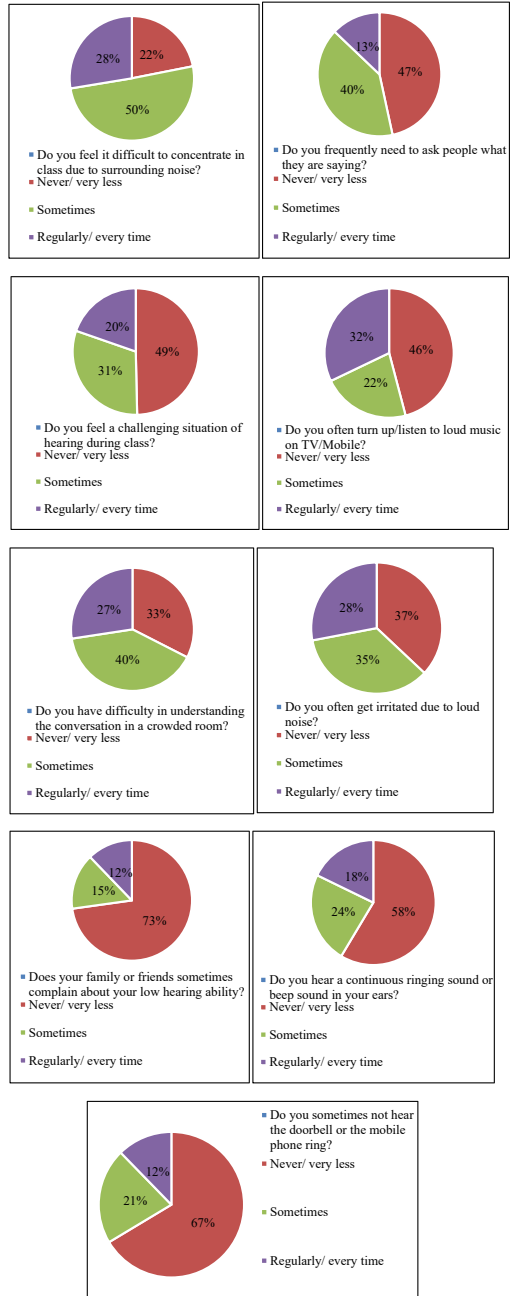
As per the responses to the questionnaire survey, the road traffic noise shows a higher level of disturbance which becomes a cause of loss of concentration and distraction, and sometimes leads to hearing loss. It was found that 50.1% ($n = 105$) of the students thought the classroom atmosphere was sometimes loud, while 28.2% ($n = 59$) said it was always noisy and difficult to concentrate in the classroom owing to noise. Similarly, 40.2% ($n = 83$) of students found it difficult to understand conversation in a full classroom, which increases the level of interior noise, although only 27.2% ($n = 58$) of students encountered this on a regular basis. Excessive conversational noise may also hinder speech comprehension and create disruptions. Due to the presence of ambient noise, 35.2% ($n = 75$) of students found it difficult to comprehend the discussion on the cell phone. However, just 20.6 percent ($n = 43$) of students thought this happened on a regular basis. This might be because school students are not permitted to carry or often use cell phones (Fig. 6).

It can be inferred that 34.2% ($n = 72$) of students occasionally found hearing impairment or less hearing, whereas 12.2% ($n = 24$) of students found this every time or on a regular basis by combining two questions—"do you frequently need to ask people what they are saying" and "do your family or friends occasionally complain about your low hearing ability." More than half of the students ($n = 106$) were affected by noise in the classroom, with 37.4% ($n = 63$) reporting issues sometimes and 19.3% ($n = 42$) suffering problems on a regular basis.

7 Conclusion

This study tries to determine how road traffic noise affects the academic performance of schoolchildren. Using noise level measurements, maps, and questionnaire responses from students, the impact of ambient (traffic) noise on the teaching and learning process in the classroom was measured. The major source of noise in schools is road traffic noise, which includes engine, tire-pavement interaction, and horn honking. However, teachers have confirmed that it is not the only source of disturbance in the regulation of proper classes; other sources such as disturbance from another class, students running in corridors, dusters hitting a table, ill-maintained electric fans, furniture shifting, and playground noise were also sources of indoor noise. The results reveal that more than fifty percent of students experienced hearing difficulties throughout class and that more than forty percent of students found it tough to converse in a noisy classroom. Both the teaching and learning processes need heightened focus; also, questionnaire data indicates a positive association between increasing noise levels and students' declining performance. The measured noise levels outside the school building facades were much higher than the WHO limits (55 dB(A)) for noise-sensitive areas. The average reduction in noise levels is 6.15 and 6.725 dB(A) in schools A and B when the situation changed from prevailing to

Fig. 6 Results of questionnaire analysis



silence indicating a substantial difference in noise exposure settings (PC and SC). The z-test indicates a significant difference in noise levels for PC and SC. In addition, the results show that school A needs immediate noise reduction in the form of a noise barrier or a class relocation away from the road, as increased noise levels in the classrooms impede student learning. This study concludes that if rigorous noise pollution reduction approaches and scrupulous legislative measures are applied, there is a greater chance that student performance will improve. The use of noise barriers, noise-absorbing materials, double-glazed glass windows, and soundproof doors could also help to limit roadside noise penetration into classrooms, whereas the government authorities should conduct public awareness programs to encourage the use of public transportation, which reduces the number of personnel vehicles, and consequently, road traffic noise.

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