original article

Vulnerability of school children exposed to traffic noise

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ABSTRACT

Aims: The aim of this study was to find out the vulnerability of school children affected by roadside vehicle noise.

Materials and Methods: The noise levels were measured in three time zones: 10.45 and 11.45 am, 12 and 1 pm, and 2 and 3 pm. A self-made interview schedule was constructed for getting feedback from the teachers and students about the problems associated with the teaching — learning process. The different percentile values $L_{10,}$ L_{50}, L_{90} were used for the evaluation of noise climate (NC), equivalent noise level (Leq), transport noise index, and noise pollution level (L_{NP}).

Results: The results revealed that the average distance of the roadside school situated in urban area (9.4 feet) was much less than in rural area (14.4 feet). The average number of vehicles in rural areas was much less than in urban areas. The study also demonstrated that out of five varieties of vehicles, only heavy vehicles like bus and trucks produce intense noise (85-90 dB). Although air siren of train has a very high noise, which range from 90 to 115 dB, other varieties of light vehicles also produced noise ranges from 76 to 90 dB. The average noise meter reading clearly indicates that lesser the distance from the roadside, higher is the noise intensity.

Conclusion: Results revealed that not all schools, particularly those schools that are very close to the roadside, are intensely affected by such high pitch noise and subsequently teaching — learning process were also greatly affected by such activities. Therefore, it is highly recommended that village committee and municipality authority should coordinate with the school authority for taking measures for such irreversible damaged.

Key words: Heavy vehicles, light vehicles, noise, road side school, school children

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Access this article online

Quick Response Code:

Website: www.ijehe.org

DOI: 10.4103/2277-9183.139739

INTRODUCTION

Education of every citizen is essential to all modern societies.[1] In our education system, formal education takes place in schools through interactive verbal communication between students and teachers. In the past, classrooms were silent and pleasant.[1] But today they are relatively noisy. Now-a-days noise pollution has been increasing not only in urban centers but also in rural centers. The noise problem of the modern societies is seen incomparable to the past given the

This article may be cited as:
Mondal NK, Ghatak B. Vulnerability of school children exposed to traffic noise. Int J Env Health Eng 2014;3:24.

larger sources of noise now, present outdoors and indoors. Traffic noise is one of the main causes of environmental noise exposure in urban areas.[2] Noise pollution is a disturbance to the human environment, which is escalating at such a high rate that it will become a major threat to the quality of human life. It also reduces environmental quality, and might affect health and cognition.[3] It is well documented that chronic noise exposure would impair concentration, general cognitive functioning, and particularly reading skills.[4-10]

School is an important micro environment in our country, like home, office, etc. Proper physical learning environment of schools helps the cognitive, creative, social, physical, and intellectual development of children. Moreover, attention, memory power, reading ability, and intelligence are all involved in cognitive development at an early school age (5-11 years).[11] Children can gather information by various processes like rehearsal, organization, and elaboration.[12] Bryant and Bradley demonstrated in their paper that children's reading ability highly depends on perception and memory, but at an early stage, awareness of speech sounds could be distorted by ambient noise.[13] Children are intensely affected by the noise because of its detrimental effects on learning at a critical developmental stage and due to their less capacity to anticipate, understand, and cope with stress than adults.[14] Cohen *et al*. found that children's reading ability was strongly affected by nearby traffic noise.[15] Moreover, Wachs and Gruen demonstrated that indoor noise impaired children's cognitive and language development.[16] A recent study indicated that external noise can intensely have an effect on health,[17] happiness as well as on learning, and academic achievement.[18] Noise intensities above 75 dB are high enough to cause annoyance, aggressive behavior, and sleep disturbance.[19,20] Routine exposure to 65 dB can result in hypertension and noise above 75 dB can lead to increased stress levels, heart rates, and potential hearing loss.[21] Traffic noise is indicated to be the main source of annoyance and many other symptoms due to other sources, such as industrial activities, aircraft, and community noise.[22]

Noise pollution depends on time of exposure, noise intensity, and individual sensitivity. It is measured in decibels (dB). According to the World Health Organization (WHO) (2000), the permissible noise level in school environments should not exceed 35 dB.[20] There have been some studies on the detrimental influence of chronic external noise upon the community. But limited study has been done on the academic performance and attainments of school children. Keeping the above problem in mind, the present study has been conducted to find out the status of noise levels of rural and urban roadside schools of Burdwan town and its adjoining villages.

MATERIALS AND METHODS

The entire study has been performed by considering it as a cross sectional method, involving field measurement of environmental noise levels at specific geographic coordinates of urban and rural areas of Burdwan town and its adjoining villages. The schools of the mentioned areas are situated near the roadside and are exposed to different types of vehicle noise. This paper has focused on selected noise pollution, which causes health hazard and associated it with learning and teaching process. The noise levels were measured using sound level meter (SL-4001, Taiwan) set at the medium response mode. The noise levels were measured in three time zones: 10.45 and 11.45 am, 12 and 1 pm, and 2 and 3 pm. The noise meter reading was recorded inside the classroom during class hours.

The measurements covered 10 schools representing the age group of 13-15 years of both boys and girls. The equivalent sound levels LAeq were measured with an integrating sound level meter SL-4001, Taiwan. The meter was placed at a position in the middle of the group corresponding to the ear height of the students. Sound level measurements were made for 25 min in the middle of a lesson for each class. The first and last 10 min of the lesson were excluded because of the beginning and ending procedure of the lesson. While measuring the sound level measurements, students were seated in a class room where mathematics and English subjects were being taught. Immediately after the sound level measurements, students filled in a questionnaire (attached as Supplementary file). A total of 300 students aged between 13 and 15 years took part in this study.

Traffic density or the manual count of the number of vehicles, automobiles like motor van, taxi, or jeep (light vehicles), trucks, buses, and trains (heavy vehicles) around the school with the highest noise level was also measured during the study period. The geographic ordinates of the school location were measured by GPS (GPS-12, Germin).

A self-made interview schedule (format attached in Supplementary File) was constructed for getting feedback from the teachers and students about the problems associated with the teaching — learning process. The instrument was calibrated internally by the internal sound level calibrator before making measurements. The desired response of the sound was set to A-weighting and "slow." The different percentile values L_{10}, L_{50}, L_{90} were used for the evaluation of noise climate (NC), equivalent noise level (Leq), transport noise index, and noise pollution level (L_{NP}). According to O'cinneide[23,24] L_{10} is an indication that the upper end of the level range, while L_{90} constitutes the background level in the absence of nearby noise sources.[25-28] In contrast, L_{eq} is defined as the total energy response by the human ear and hence an indicator of physiological disturbance to the hearing mechanism. Prabat and Nagarnaik studied that L_{NP} gives vibration in sound signal with a fluctuating noise.[29] Saadu *et al*.[30] explained in detail about the traffic noise index (TNI) in their paper.

$$Leq = 10\log\left[\sum_{i=1}^{N}(anti\log LA_i/10)n_i\right]$$

$$L_{NP} = L_{Aeq} + (L_{90} - L_{10})$$

$$TNI = (L_{90} - L_{10})\ (L_{90} - 30)$$

Noise descriptors such as L_{10}, L_{90} and L_{eq} were recorded. Baseline sound levels were monitored for two different periods of the day, namely: Day-time, afternoon-time, and evening-time. Definition for the noise descriptors are given as follows:

L_{10}: A specified dBA level, which exceeds 10% of the time during the whole period of measurement.

L_{90}: A specified dBA level, which exceeds 90% of the time during the whole period of measurement.

Leq: The equivalent continuous dBA level, which has the same energy as the original fluctuating noise for the same given period of time.

Statistical calculation

SPSS 17.0, 233 South Wacker Drive, Chicago Software was used for the statistical analysis. Basic statistics including paired *t*-test and chi-square has been done to calculate the significant difference. Computer software Origin 6.1 was used for construction of all figures, and for mathematical formulas, MATLAB software was used.

RESULTS

From the results of the study, it has been found that the studied schools in rural areas are situated between 7 and 10 feet from the main road where vehicles continuously pass with high frequencies of noise [Table 1]. Whereas in urban areas studied, the school was situated between 7 and 22 feet from the main road [Table 2]. The average distance in rural and urban areas between the school and main road is 13.4 and 11.4 feet, respectively. Therefore, the students from the urban area schools are more intensely affected by the high frequency noise than in rural areas. This phenomenon is clear from the noise meter reading (NMR), which indicated that the maximum noise was from trains (120 dB), minimum from motor cycles (85 dB) and intermediate noise from four wheelers [Figure 1].

The vehicle densities in rural areas vary from 35 to 108 dB during 10.45-11.45 am. As the rural area schools are not exposed by train noise, therefore it can be seen that total noise input during the first phase of experiment is less in Palashan High School. But vehicle density reduced from the noon to afternoon period [Figure 2]. The other schools in the rural areas like Kuchut and Raipur Girls were exposed by the average

Table 1: Geographical location, classroom distance from main road and number of vehicles in three time interval (in rural areas)

Name of school (rural)	Logitu./latu.	Distance (main gate) from road (feet)	No. of vehicles between 10.45 and 11.45 am	No. of vehicles between 12 and 1 pm	No. of vehicles between 2 and 3 pm
Palashan	23°.14′.58″N 87°.50′.36″E	8	35	28	23
Kuchut	23°.14′.17″N 87°.52′.36″E	18	108	97	90
Adarsha balika	23°.14′.17″N 87°.50′.36″E	10	64	51	48
Raipur boys'	23°.14′.17″N 87°.52′.36″E	17	98	97	93
Raipur girls'	23°.14′.17″N 87°.52′.36″E	14	102	100	92

Table 2: Geographical location, classroom distance from main road and no. of vehicles in three time interval (in urban area)

Name of school (urban)	Logitu./latu.	Distance (main gate) from road (feet)	No. of vehicles between 10.45 and 11.45 am	No. of vehicles between 12 and 1 pm	No. of vehicles between 2 and 3 pm
CMS	23°.14′.58″N 87°.50′.36″E	8	120	125	100
CMS-Baburbag	23°.14′.17″N 87°.52′.36″E	22	108	97	90
Harishava	23°.14′.17″N 87°.50′.36″E	7	110	111	100
Municipal	23°.14′.17″N 87°.52′.36″E	10	230	180	150
Banipith	23°.14′.17″N 87°.52′.36″E	10	102	100	92

108 and 102 vehicles, respectively, during the first phase of the experimental period. But two other schools in the rural areas, Adarsha Balika Vidyalaya and Raipur Boys, were exposed moderately by 64 and 98 vehicles, respectively [Table 1]. In contrast, in urban areas, Municipal Boys School, Harishava and CMS B.C. Road, are situated near the B.C road, and the average vehicle passing during the three experimental time periods is 230, 110, and 120, respectively. In the second phase of the study, urban areas showed a little higher vehicle density than in the first phase followed by much lesser vehicle density in the third phase of experiment [Table 2]. Therefore, it has been found that the average number of vehicles in the rural areas is much less than in the urban areas [Figure 2] in the three experimental study time periods. But both the study areas showed that the number of vehicles decreased from the 10.45 am to 3.00 pm time period and as the density of vehicles decreased from the 10.45 am to 3.00 pm, the overall noise was definitely reduced. Equivalent noise level (Leq) was much higher in the urban areas compared with that of the rural areas and it is significantly different from one another ($P < 0.002$). Similar significant results were recorded for L_{10}, L_{50}, and L_{90} [Table 3]. However, total noise index (TNI) and NC in the different studied areas does not show any significant variation. In contrast, the studied results also indicate that the overall noise pollution level (L_{NP}) are significantly different between rural and urban area ($P < 0.000$).

Table 3: Noise level status between rural and urban schools

Parameters (dBA)	Rural school	Urban school	*t* value	*P* value
L_{eq}	93.37	109.9	9.73	<0.002
L_{10}	99.2	146.7	10.62	<0.002
L_{50}	89.32	104.6	5.68	<0.011
L_{90}	35.6	89.7	10.96	<0.002
TNI	260	287.7	1.33	<0.275
L_{NP}	164.08	251.34	42.67	<0.000
NC	63.6	57.0	3.55	<0.038

dBA: decibels, A-weighted scale

The present investigation demonstrated that out of the five varieties of vehicles, only bus and truck produced a strong intense noise (range from 85 to 110 dB), which is a danger for the auditory system. Although, train has a much more intense noise range (90-115 dB), which is very much detrimental for mankind. But in this present study, only one school was exposed to the noise from train. The other sources are motor cycle, motor van and taxi, jeep, etc., having noise ranges 76-84, 77-88, and 80-90 dB, respectively. Results also revealed that in the rural areas, especially Kuchut school, was exposed strongly by the intense noise during the 10.45 am to 4.15 pm time period followed by Raipur Boys' and girls' schools and lowest in Adarsha Balika and Palashan [Table 4], in contrast, during the 12-1 pm time period, all schools had less noise levels compared with the 10.45-11.45 am time period. This is probably due to the fact that less number of vehicle pass during the school hours. Again in the 2-3 pm time period, the vehicle density increased a little except for Palashan and Adarsha Balika School. The vehicle density status in urban areas is very alarming for all the studied areas.

Table 4: Teachers' feedback regarding interference of traffic noise during class time

Parameters	Rural	Urban	X^2	Significant level
How do you feel when vehicles are passing with intense horn during your teaching time?	50	50	12.878	*P*<0.01
Do you feel any problem with intense vehicle noise during imparting any critical matter?	50	50	28.131	*P*<0.01
What type of physical or mental problems you have been suffering from such intense noise?	50	50	1.465	NS
In which time maximum noise disturb in your class?	50	50	16.714	*P*<0.01
Which is most disturbing class in your school?	50	50	10.705	*P*<0.01
What is experience regarding the problem associated with vehicle among students?	50	50	2.389	NS

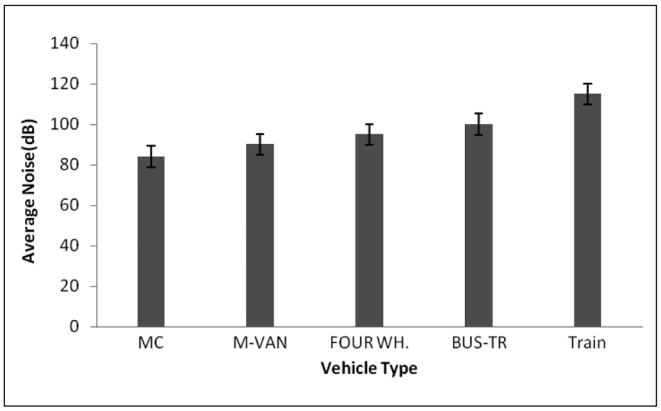

Figure 1: Maximum noise level from different vehicles

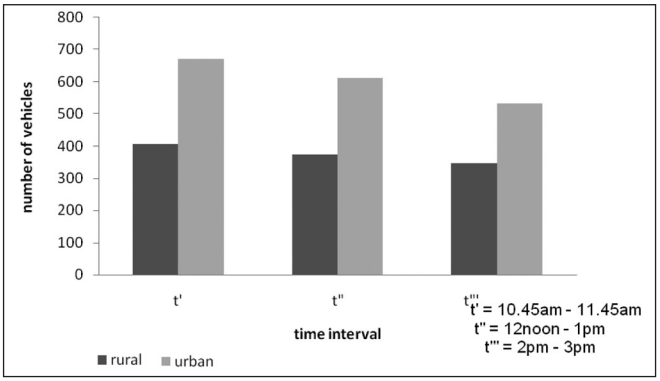

Figure 2: Average vehicles density over three phases of experimental time period

The average noise meter reading (ANMR) clearly indicates that lesser the distance from the roadside higher is the ANMR, which was highest in Kuchut school and lowest in Palashan school [Figure 3] in rural areas, but in urban areas, the highest and lowest ANMR was Municipal boys and Banipith, respectively. From Figures 4, 5 and 6, it is clear that in both the rural and urban area schools were exposed by intense noise due to their location from the roadside. It is quite possible because the short distance from the road means noise directly goes inside the classroom. One such urban school is Harishava Girls school, which has many windows toward the roadside. Therefore, it is speculated that the students of Harisava school are affected by the noise and this definitely hampered the performance level of these students. The results also demonstrated that about 73% of the class teachers and 63% of the students responded that they were highly annoyed due to such high noise [Tables 4 and 5]. Moreover, from Tables 4 and 5 it is clear that the rural and urban teachers have significant different ($P < 0.01$) views of noise interference in teaching — learning processes. About 82% and 52% of the rural teachers said that they feel strongly irritating and communication problems due to intense vehicle noise, respectively [Table 4]. However, 88.6% rural students informed that they have intense nonauditory effect and it is statistically significant with the urban students [Table 5]. In contrast, a correlation study revealed that vehicle noise in urban areas and both the teachers' and students' annoyance is highly positive nonsignificant relationship [Table 6]. However, vehicle noise in rural areas and both the teachers' and students' annoyance showed much weak positive

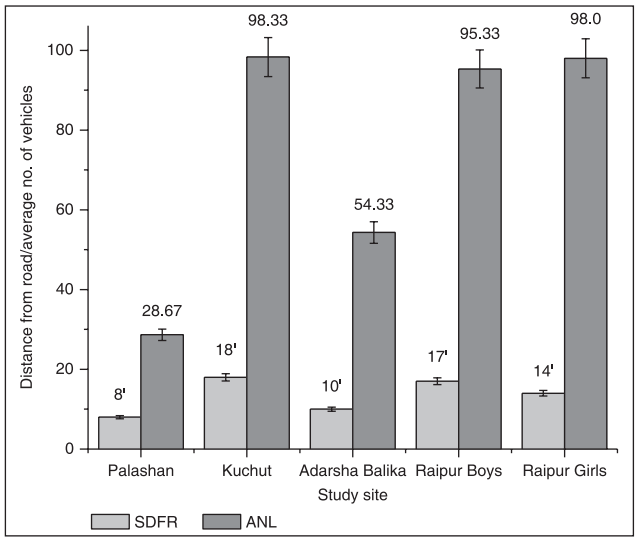

Figure 3: School distance from the main road and average noise meter reading of rural area. SDFR: School distance from road and ANL: Average noise level

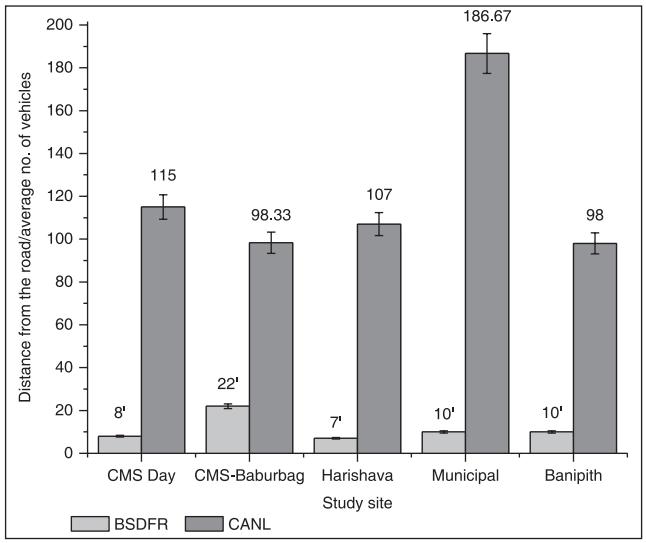

Figure 4: School distance from the main road and average noise meter reading of urban area. SDFR: School distance from road and ANL: Average noise level

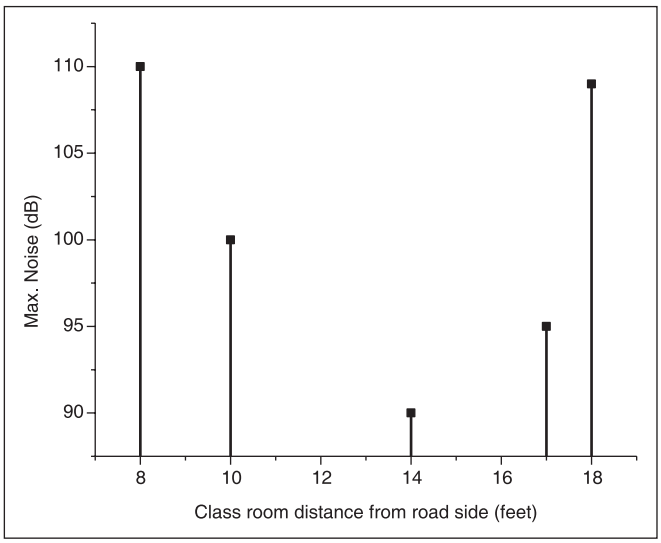

Figure 5: Vertical drop line graph indicates classroom distance from the main road and maximum noise recorded inside the classroom in rural area

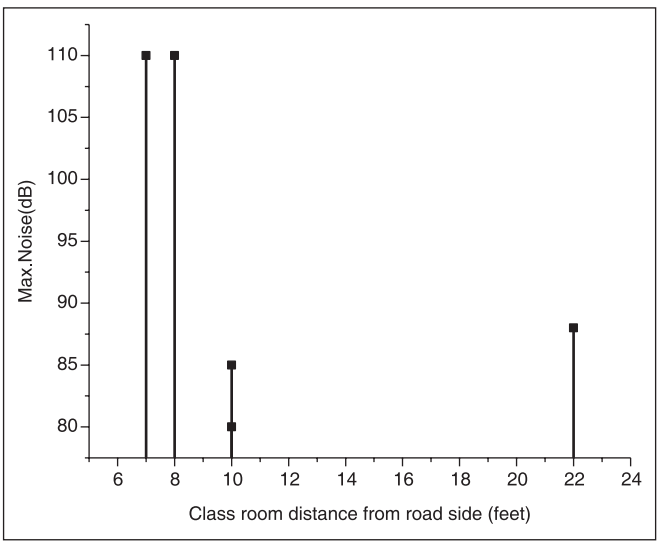

Figure 6: Vertical drop line graph indicates classroom distance from the main road and maximum noise recorded inside the classroom in urban area

relationship [Table 7]. The classroom communication problem between student and teacher showed a high positive relationship with students' and teachers' annoyance [Tables 6 and 7]. Literature also revealed that annoyance is one of the most commonly studied effects of environmental noise.[31] Many meta-analyses of exposure — response data measured by various questionnaires in different countries showed that annoyance in relation to environmental noise generally increases with exposure.[32,33]

DISCUSSION

Higher level of noise inside the classroom is due to the huge number of buses and trucks that pass near the school, consequently school children and other members of that particular school will be affected. The same was endorsed by Pujol *et al*.[34] But these two schools do not support the ANMR with distance from the roadside. This is probably due to the types and frequency of vehicles and the absence of windows in the classroom toward the roadside. But in Kuchut school, the classroom distance from the roadside was a little shorter but, ANMR was very high. This is also due to the types and frequency of vehicles that pass during the school hours and also infrastructural drawbacks. However, all environmental noise may not directly link with the student's academic achievement levels.[35] Although, the same group of authors suggested that, roadside schools were normally disturbed with respect to academic and health. But in urban areas, such irregular results were not recorded. The highest ANMR was recorded in Municipal boys school (186.67 dB) and lowest in Banipith school (98 dB). This variation is also due to the variety and frequency of vehicles. Such high noise level inside the classroom may cause detrimental effect to both teachers and students.[36,37] As all the studied schools showed much higher level of noise as recommended by WHO, therefore undoubtedly, it can be speculated that every member of the studied schools will face health-related problems. There is an increasing evidence that in (assumed) steady state conditions, environmental noise exposure is associated with various adverse physiological and psychological health end points.[38] Results also demonstrated that both teachers and students are highly annoyed and felt communication problem due to such high noise in the school. The same observation was reported by Seep *et al*. and Ali.[39,40] Moreover, they stated that the best way to solve acoustic problems is to

Table 5: Students' feedback regarding interference of traffic noise during class time

Parameters	Rural	Urban	X^2	Significant level
Do you feel any problem from vehicle noise during your class time?	150	150	33.346	$P<0.01$
Do you feel vehicle noise disturb your concentration?	150	150	15.014	$P<0.01$
Is there any problem for recalling of memory during school hour?	150	150	6.929	NS
Do you feel any problem in hearing?	150	50	16.144	$P<0.01$
Do you have any non-auditory effect?	150	150	19.892	$P<0.01$
During classroom transaction, traffic noise intensely effects on communication	150	150	12.653	$P<0.01$
Is there any irritation during intense noise?	150	150	31.94	$P<0.01$

Table 6: Correlation between noise level in Urban area and teachers' and students' annoyance, communication problem, hearing problem of student and headache

Variables	UVN	TA	SA	Communication problem	SHP	Headache
UVN	1					
TA	0.690	1				
SA	0.794	−0.229	1			
Communication problem	0.447	0.410	0.054	1		
SHP	0.271	0.340	−0.067	0.668	1	
Headache	0.134	−0.181	−0.158	0.431	0.139	1
NAP	0.006					
	0.309	−0.539	0.501	−0.236	−0.139	

UVN: Urban vehicle noise, TA: Teacher annoyance, SA: Student annoyance, SHP: Students hearing problem, NAP: Non-auditory problem

Table 7: Correlation between noise level in Urban area and teachers' and students annoyance, communication problem, hearing problem of student and headache

Variables	RVN	TA	SA	Communication problem	SHP	Headache
RVN	1					
TA	0.436	1				
SA	0.337	−0.289	1			
Communication problem	0.221	0.341	0.611	1		
SHP	0.436	0.354	−0.001	0.122	1	
Headache	−0.212	0.091	−0.158	0.011	0.032	1
NAP	−0.324	0.117	−0.539	0.043	−0.055	−0.139

RVN: Rural vehicle noise, TA: Teacher annoyance, SA: Student annoyance, SHP: Students hearing problem, NAP: Non-auditory problem

avoid them in the design phase. In another study, Mondal and Das pointed out that the teachers' community should be aware about the negative impact of noise on the student's academic performance.

In summary, it appears that especially those studying near the roadside schools are more or less exposed under intense noise and definitely this particular event has an effect on their performance level.

CONCLUSION

From the present study it was found that not all schools, particularly those schools that are very close to the roadside, are intensely affected by such high pitch noise and subsequently teaching — learning process were also greatly affected by such activities. The school environment should promote an atmosphere that induces everyone's interest in listening and being involved in communication. Therefore it is highly recommended that village committee and municipality should coordinate with the school authority for taking measures for such irreversible damage.

ACKNOWLEDGEMENT

Authors greatly acknowledge to Dr. J. K. Datta, Professor, department of Environmental Science, the University of Burdwan, for his constant encouragement and moral support.

CONFLICT OF INTEREST

Authors have no conflicts of interest.

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Source of Support: University of Burdwan, **Conflict of Interest:** None declared.