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ORIGINAL ARTICLE

Investigating the Role of Educational Centers as a Constant Source of Noise Pollution in Urban Areas - A Case Study of Schools in Tehran Metropolitan City

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ABSTRACT

Undoubtedly, one of the main sources of noise pollution in cities is educational centers. The subject of discussion in related studies has always been the effects of noise pollution on educational centers, but almost none of them have ever looked at the subject from the perspective that these centers can also be an important source of noise pollution in urban areas. Therefore, this research, with a different approach, was addressed the effect of educational centers as an important source of noise pollution in urban areas. For this purpose, a total number of 32 state and nonprofit schools were selected randomly from north, south, east, and west of Tehran City. Then, after identifying different sources of noise in the schools, their sound level was measured by TES sound level meter (model, 1358), at distances of 10, 20, and 30 m from the centers. The measurement parameters included 10-minute equivalent sound pressure meter (Leq_{10min}), maximum sound level (L_{max}), and minimum sound level (L_{min}). Daily average sound level (Ld) was another parameter calculated for a period of 15 hours (from 7 am to 22 pm). According to the results, at the nearest distance to the schools (10 m), the highest average L_{max} was 69 dB (A), measured at the time of students' departure. Its lowest was 64.7 dB (A) measured at the time the students had physical education class. The highest and average Ld levels at the distance of 10 m from the schools were 65.2 dB (A) and 59.2 dB (A), respectively, in state male primary schools and nonprofit female high schools. The average outdoor Leq and Ld level in the areas surrounding the target schools was about 5.5 dB (A) higher than the ambient noise. According to the results of the study, noises from schools may be considered as a disruptive factor in urban environments which has to be paid more attention.

KEYWORDS: *noise pollution, equivalent sound pressure level, daily average sound level, educational centers, school*

INTRODUCTION

Nowadays, noise pollution is one of the most important environmental problems in big cities. Irregular population growth, industrial development, and technological progress during recent years have caused an increase in noise pollution in cities and in exposure level of citizens to this kind of pollution.

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Results from researches showed that peoples' exposure to noise can create hearing problems, hypertension, anxiety and stress, dizziness, headache, mood disorders, heart diseases, and sleep disorder [1-3]. In most of the studies already conducted, industrial and commercial activities, flight of airplanes, road traffic, building construction, and trains were introduced as the main sources of sound diffusion in

urban environments; through evaluation of the noise produced by them share of each of these sources in pollution has been determined. For example, Mehdi et al. (2011) reported the mean value of noise resulted from road traffic in Karachi (Pakistan) on working days of a week in the morning (79dBA), at noon (73dBA), and in the evening (80dBA) [4]. In a study conducted by Ozkurt et al. (2014), about 4% of the people residing around Ataturk airport in Istanbul (Turkey) were reported to be exposed to 55dBA noise or more, during a day [5]. In a study performed by Monazzam et al. (2014), noise exposure level of people residing around two railroads in Tehran was measured to be 71.21 and 74.38dBA [6]. In an evaluation performed by Hunashal and Patil (2012), highest level of residents' exposure to noise in industrial parts of Kolhapur City and in commercial parts were reported to be 72.25dBA and 64.47dBA, respectively [7].

However, educational centers as one of the permanent sources of noise pollution in most of societies have been mostly ignored and not seriously taken into consideration. They play an important role in noise diffusion to the surrounding environment and their inappropriate location in residential areas can exert negative effects on physical and psychological health of school and university students and teachers, in addition to their neighbors. During recent years, due to the importance of the role of noise in creation of physical and psychological disorders in people, especially sensitive groups of society such as students, many studies were performed in relation to measurement of noise level in educational centers, specifically in schools [8-10]. Also, related values obtained were compared to international standards. For example, Sarantopoulos et al. (2014) evaluated noise level in indoor environment of 15 schools in Greek. Their results showed that noise level in indoor environment of the schools was 14dBA higher than the recommended level by the World Health Organization (WHO) [11].

Standard noise for residential and educational areas during the day was specified to be 55dbA by the World Health Organization (WHO) [12-13]. Also, in their study, Equivalent Continuous *Sound Pressure Level* (Leq-5min) and mean SNR (signal to noise ration) were reported to be 69dBA and 12dBA, respectively [11]. In a study performed by Ai Ali in Egypt (2013), L_{Aeq} measured in schools of Assuit City was higher than the standard set by WHO, ranging from 61.3dBA to 73.2dBA [14]. Golmohammadi et al. (2010) measured noise level in the indoor space of 244 classes in primary, middle, and high schools of Tehran. In their study, mean Leq in classes, corridors, and school yards during the class time were 72, 65.8, and 64.1dBA, respectively. Also, there was a significant difference between mean Leq in boys' classes (75.7dBA), and girls' ones (68.7dBA) ($p=0.0001$). Mean Leq in primary, middle, and high schools were reported to be 72.3, 70.7, and 73dBA, respectively; their differences were significant ($p=0.0001$). Also, according to the findings of a study conducted by Golmohammadi et al. (2010), noise levels in internal environment of Tehran schools were higher than the authorized specified level of 55dBA [15].

As it is observed, in most of the researches performed, high noise levels in indoor environment of schools were proved. However, to date no formulated study was conducted to evaluate the noise pollution level caused by various educational environments and its effect on people residing outside these places. In fact, the sound of the cry, hubbub and fuss of school or university students, noise resulted from loudspeakers, noise resulted from transportation services, etc. are inseparable parts of each educational environment which could be annoying and unbearable for those people residing around these places.

Considering the large number of schools as the most important educational centers in municipal districts, in the present research, as the first formulated one, share of these important educational centers in producing the noise diffused in various districts of Tehran metropolitan city was evaluated. In addition, the role of gender, grade (primary and high schools), and type of schools (public and non-profit) was carefully examined.

METHODOLOGY

In this study, 32 schools from four regions of north, south, east and west of Tehran were selected as the study area. The presence of residential buildings in the vicinity of the schools was the main criterion for selecting them and their inclusion in the study. Also, sample selection in each region, it was tried to keep the balance concerning the ratios of "gender" and

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"educational level". Thus, in each of the four geographic regions, eight male and female schools were selected from both primary and high schools which were run both in state and nonprofit forms. The location of the target schools in Tehran is shown in Figure 1.

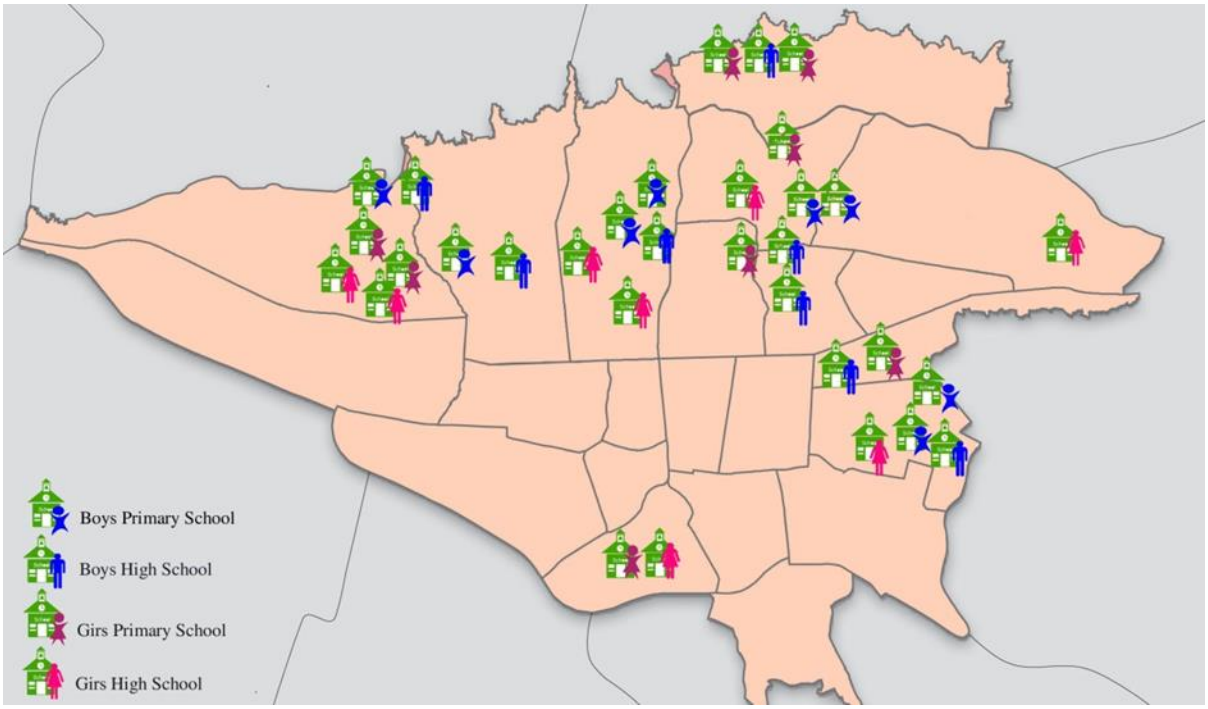

Fig. 1. location of the target schools in Tehran City

In order to determine the share of schools in the amount of noise pollution in Tehran, first, different sources of sound caused by these educational centers were identified. Then, the level of noise from each of these sources was measured at distances of 10, 20, and 30 m outside the schools to determine the contribution of each source to the amount of noise released to the environment throughout the day. Distance from the main door of the schools was measured with a laser meter. TES sound level meter, model 1358, was used to measure the noise level which works according to the IEC6056 standard. The sound level meter was calibrated prior being used in this study. In all measurements, the operator kept it at a height of 1.5 m above the ground (hearing height). All the measurements were conducted from 6.30 to 15.30 on working days of the week (during the week other than holidays) and during winter season. The noise measuring parameters were equivalent sound level (Leq_{10min}), maximum sound level (L_{max}), and minimum sound level (L_{min}). Distance from the noise source, educational level, type of school, gender of the students, and geographical area were other variables studied in this research.

In addition, in order to calculate the daily average sound level (Ld), the sound level was also measured at school closing time. In this study, the Ld was calculated for a period of 15 hours (from 7 am to 10 pm) according to the following formula [16-17]:

$$Ld = 10 \log [1/15 \sum (t_i \times 10^{Li/10})] \qquad (1)$$

Where;

L_i is the mean equivalent sound level measured from each source and t_i is the duration of exposure to the sound emitted from each source. Finally, the obtained results were compared via SPSS software, version 18, using parametric tests, ANOVA, and the least significant difference (LSD). Kolmogorov-Smirnov test was used to check the normality of data.

RESULT

Based on field studies, the sound of the fuss of the students when entering school, morning routine, morning exercise, break time, physical education time,

and school departure time were recognized as the main sources of noise from these educational centers. The average Leq_{10min}, L_{max}, and L_{min} levels from each of these sources at three distances of 10, 20, and 30 m from the schools showed in Table 1.

According to the results, the highest Leq_{10min} level at the distance of 10 m from the schools was 69.0±3.7, recorded at the time the students left schools. The mean value of Leq_{10min} was measured to be 64.7 ± 3.3 dB (A), using the data obtained from the students' physical education class time. At the same distance, the mean value of L_{max} fell within the range of 72.9 ± 5.8 dB (A) to 76.9 ± 7.6 dB (A). The mean L_{min} at this distance also varied from 55.8 ± 5.1 dB (A) to 61.9 ± 4.2 dB (A). The highest and lowest average L_{max} and L_{min} at the distance of 10 m were recorded at the time of students' departure and physical education, respectively. Based on the statistical test results, there was a significant difference between the Leq_{10min} levels at students' arrival and departure time and between break and physical education time at the distance of 10 m (P-value<0.05). However, the difference between the time of departure and that of morning routine was not significant (P-value=0.61). At the distance of 10 m, a significant difference was found between the L_{max} levels at the time of departure and that of entrance, as well as between physical education and break time (P-value<0.05). The difference between L_{max} levels at the times of departure and morning routine was not significant (P-value=0.16). The results of comparing the values of the mean L_{min} at different times were quite similar to those of the comparison of the mean Leq and L_{max} values. There was also found a significant difference between the mean value of L_{min} at departure and entrance times, and between the physical education and break times at the distance of 10 m from the schools (P-value <0.05). No significant difference was observed between the L_{min} values, considering morning routine and at routine time (P-value=0.59).

At the distance of 20 m, the mean value of Leq_{10min} was 67.6 ± 3.3 dB (A) and its lowest was was 64.1 ± 3.8 dB (A). Similar to the measurement results at the distance of 10 m, the highest and lowest average Leq_{10min} values, at the distance of 20 m, belonged to the times of students' exit and physical education. At this distance, the average value of L_{max} fell within the range of 76.3 ± 8.6 dB(A) to 70.5±6.7 dB(A) and its average in the range of 61.3 ± 4.2 dB(A) to 55.7 ± 6.7 dB(A). The maximum and minimum mean values of L_{max} and L_{min}, at the distance of 20 m, were measured at the times of students' exit and physical education, respectively. Statistical comparison of the results showed that there was no significant difference between the mean value of Leq_{10min} in the time of departure and the time of morning routine (P-value = 0.16). However, the difference between the Leq_{10min} data of other times was significant (P-value <0.05). The results of the comparison of L_{max} and L_{min} recorded in different time intervals at the distance of 20 m were quite similar to that at the distance of 10 m. There was also no significant difference between departure time and that of morning routine (P-value = 0.24).

At a distance of 30 m, the maximum and minimum mean values of Leq_{10min} were recorded to be 66.8 ± 4.4 dB (A) and 63.3 ± 4.8 dB (A), at the time of students' departure and that of their physical education, respectively. At this distance, the mean value of L_{max} was 74.4 ± 5.9 dB(A) to 70.9 ± 7.4 dB(A) and the mean value of L_{min} 59.8 ± 4.9 dB(A) to 55.0 ± 5.7 dB(A). The maximum mean values of L_{max} and L_{min} at the distance of 30 m were observed at the time of students' departure and the minimum at the time of physical education. The Leq_{10min} value of departure time showed no significant difference with none of the time intervals, except for physical education (P-value>0.05). At the same distance, the mean L_{max} value of the departure time had no significant difference with none of the time intervals (P-value> 0.05). The reason for the inconsistency of the results were obtained at a distance of 30 m with those at other distances is the close proximity of the measurement points at this distance to the main streets.

Comparing the measurement values of the parameters at different distances showed the more distance from the schools, the more the level of the noise caused by these centers. Based on ANOVA, this trend is not significant (P-value> 0.05). In this study, the signal-to-noise ratio (SNR) from each noise source was also calculated by subtracting the minimum values of recorded sound levels (L_{max}-L_{min}). At the distance of 10 m, the maximum SNR was estimated to be 17.0 dB (A), which was related to the students' physical education time. While the minimum SNR was obtained as 12.6 dB (A), which belonged to the time of morning routine in the schools. The maximum and minimum values of this parameter at the distance of 20

m were 15.1 dB (A) and 13.1 dB (A), respectively. The maximum amount of SNR at the 20-meter distance was related to the students' arrival time and its minimum value was obtained from the data of morning routine. At a distance of 30 m, the maximum SNR value was estimated to be 16.0 dB(A), which was similar to those obtained concerning the distance of 10 m, and belonged to the student's exercise time. The minimum amount of SNR at this distance, like the other two distances (10 m and 20 m), was 13.3 dB (A) at the time of morning routine. The overall results of SNR calculations at different times and locations from the schools were presented in Table 2.

The results of ANOVA test indicated that there was no significant difference between the SNR values of different time intervals (P-value> 0.05). As mentioned earlier, in this research, the amount of Ld Table 3 shows the calculated values of Ld. According to the table, the highest mean Ld was 65.2% dB(A), which belongs to state male primary schools, while its lowest was 59.2 dB(A) related to the nonprofit female high schools.

Based on ANOVA test, it was revealed that there was a significant difference between the calculated Ld values of some schools (p = 0.002). Therefore, for significant difference between the groups in the same column of Table 4, however, the groups of two different columns in the table were significantly different from each other.

Table 1. Average Leq_{10min}, L_{max}, and L_{min} levels from each of pollution sources at three distances of 10, 20, and 30 m from the schools

Occasion	Distance from schools (m)	Leq_{10min} (dB(A))	L_{max} (dB(A))	L_{min}(dB(A))
Entrance time	10	65.5±3.8	73.1±6.9	59.1±4.7
	20	64.3±4.7	73.0±7.3	57.8±5.3
	30	65.3±4.6	72.7±8.9	57.5±5.2
Morning routine time	10	68.1±4.1	73.7±6.5	61.1±4.1
	20	65.6±3.5	73.5±7.6	60.4±4.1
	30	65.0±4.3	72.3±9.0	59.0±5.1
Physical education time	10	64.7±3.3	72.9±5.8	55.8±5.1
	20	64.1±3.8	70.5±6.7	55.7±6.7
	30	63.3±4.8	71.0±7.4	55.0±5.7
Break time	10	66.9±3.7	73.3±6.1	59.4±4.8
	20	65.0±4.3	72.0±5.6	58.7±5.0
	30	65.4±3.4	71.7±6.2	58.2±4.4
Departure time	10	69.0±3.7	76.9±7.6	61.9±4.2
	20	67.6±3.3	76.3±8.6	61.3±4.2
	30	66.8±4.4	74.4±5.9	59.8±4.9

Table 2. SRN values at different times and locations from school

Occasion	Mean Values of SNR(dB)		
	10 m	20 m	30 m
Students' arrival time	14.0±7.3	15.1±8.3	15.2±10.2
Morning routine time	12.6±8.1	13.1±8.3	13.3±9.5
Physical education time	17.0±9.1	14.8±8.8	16.0±10.1
Break time	13.9±7.7	13.3±7/.3	13.5±7.6
Students' departure time	15.0±8.5	15.0±9.0	14.6±8.5

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Table 3. The mean Ld values at the target schools

Type of School	Gender/Educational level	Mean Ld (dBA)
State	Male/primary	65.2 (±1.9)
	Male/high school	64.8 (± 5.5)
Nonprofit	Male/primary	65.0 (±2.2)
	Male/high school	63.3 (±4.5)
State	Female/primary	62.0 (±2.9)
	Female/high school	61.5 (± 2.8)
Nonprofit	Female/primary	61.7 (±5.8)
	Female/high school	59.2 (± 3.2)

Table 4. Comparing the Ld values of different schools using Duncan's post-test

School type	Subset for alpha = 0.05		
	1	2	3
Nonprofit female high school	59.2	-	-
State female high school	61.5	61.5	-
Nonprofit female primary school	61.7	61.7	61.7
State female primary school	62.0	62.0	62.0
Nonprofit male high school	-	63.3	63.3
State male high school	-	64.8	64.8
Nonprofit male primary school	-	65.0	65.0
State male primary school	-	-	65.2
Sig.	.113	.053	.054

The mean Ld values of primary and secondary schools were calculated to be 63.5 dB (A) and 62.2 dB (A), respectively. Statistical comparison of the results showed that there was no significant difference between mean Ld values of these two educational levels (P-value> 0.05). There was found no significant difference between the mean Ld values of public and non-profit schools (P-value> 0.05). The mean Ld value was 63.4 dB (A) in state schools and 62.3 dB (A) in nonprofit schools. However, the difference between the mean Ld values of female and male schools was significant (P-value <0.05). The mean value of Ld in male schools was calculated 64.6 dB (A), which was 3.5 dB (A) higher than that of female schools. According to the mean Ld values of the schools in four parts of Tehran, this variable was the highest (65.0 ± 4.6 dB (A)) in the southern part. Its lowest (61.0 ± 2.7 dB (A)) was related to the western part. Mean Ld values in the north and east of Tehran were reported to be 62.68 ± 3.69 dB (A) and 63.1 ± 4.7 dB (A), respectively. The results of the LSD post hoc test showed a significant difference between mean values of Ld in the northern and southern regions of Tehran (P-value <0.05), but the difference between the other regions was not significant (P-value> 0.05).

DISCUSSION

The results of the present study showed that noise from schools can be considered as a disturbing factor in urban environments. The results from measurement of Leq obtained from various sources of noise in these important educational centers indicated that the highest share of noise pollution produced by schools was related to students' departure time from school with mean Leq of 68.8dBA, and the lowest

share (55dBA) was related to their physical education classes.

In general, it can be said that students' departure time had the largest share in the production of noise pollution at schools, and the smallest share belonged to students' physical education time. The main causes of the high value of this parameter at the time of departure can be the students' excitement noise at school closure time, as well as the simultaneous presence of transportation services and parents for the transfer of students to home. The less attendance of students in school yard at physical education time, compared to other times, and the use of gyms can be the main reason for the low levels of noise at this time interval.

The Ld values showed that the highest value of this parameter, i.e. 65.2 dB (A), was related to state male primary schools. The lowest was 59.2 dB (A) belonging to nonprofit female high schools. The higher level of noise in male schools compared to that in the female schools depends on the social and individual differences between the two sexes. Boys are more active than girls, so they generate a higher noise level outdoors. The population of students in public schools is higher than that in nonprofit schools, which is the reason for higher level of noise in public schools compared to nonprofit schools. According to the data obtained from different regions of Tehran, it was observed that the mean value of Ld in the southern regions of this city (65.0 dB (A)) was higher than that of other areas. The high level of noise levels in the southern regions of Tehran could be due to the larger population and the lower economic levels of people living in this region, compared to other areas.

In general, Leq and mean noise level during the day in all the places around the schools under the study was higher than the standard value set for residential areas during the day (55dBA). So, schools could be considered as one of the most important sources of noise pollution in cities. The subject has been less taken into consideration seriously. Noise pollution levels in educational centers were discussed in a large number of studies in various parts of the world. Unfortunately, no single study similar to the present one has been conducted in relation to evaluation of noise pollution resulted from these important educational centers in cities. For example, noise level was measured by Hunashal and Patil (2012) in educational areas of Kolhapur City in India; and, it was higher (63.7dBA) than standard level [7]. In study performed by Banerjee et al. (2008) also, Leq and mean noise level during the day in sensitive areas of industrial Asansol City, including educational centers, courts, health and religious centers, have been higher than standard level, being variable between 60.8 to 85.6dBA and between 67.6 to 81.3dBA [18]. In a study performed by Tsai et al. (2009) also, mean noise levels in educational areas in Tainan City in Taiwan during winter and summer was reported to be 63.7dBA and 71dBA, respectively [19].

The effect of noise pollution in occurrence of numerous physical and psychological diseases among citizens were demonstrated by various researches [20-22]; high level of noise at schools can be considered as a serious threat for people residing around these places, producing an irreversible damage to their health. Considering the proved negative effects of environmental noise on individuals present in indoor space of schools, it could be expressed that existence of these important centers in residential areas can be annoying both for those people present inside schools (students and teachers) and those outside the schools (people residing around schools). Environmental noise level in indoor space of schools have been evaluated in numerous studies all over the world [23 & 24] as well as the effects of noise pollution on health of students and teachers [25-27]. However, as mentioned before, unfortunately no study similar to the present one has been performed in respect of evaluating noise pollution produced in these important educational centers in cities, and its effects on citizens' health. So, considering the results obtained from the present study and the presence of high level of noise in areas adjacent to schools, more comprehensive studies have to be performed in this respect.

CONCLUSION

In the study, schools have been recognized as one of fixed sources of noise pollution in cities. So, considering negative effects of noise pollutions on citizens, these pollution-producing centers have to be taken into consideration and controlling methods of pollutions produced in these places have to be studied precisely. Acoustic amendment in schools, acoustic-oriented site selection and design of newly-constructed schools, gradual and planned entry and exit of

students, lowering the sound level of speakers and bells, and tree-planting and development of green spaces in schools are among suggested strategies to control and reduce noise level of schools and consequently, enhancement of mental and physical health of nearby residents.

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CONFLICTS OF INTEREST

The authors have no conflict of interests to declare.

REFRENCES

1. Khaiwal R, Singh T, Tripathy JP, Mor S, Munjal S, Patro B, Panda N, Assessment of noise pollution in and around a sensitive zone in North India and its non-auditory impacts. *Sci Total Environ*. 2016; 566-567: 981-987.
2. Basner M, Babisch W, Davis A, Brink M, Clark C, Janssen S, Stansfeld S, Auditory and non-auditory effects of noise on health. *Lancet (London, England)* 2013; 383(9925): 1325-1332.
3. Münzel T, Gori T, Babisch W, Basner M, Cardiovascular effects of environmental noise exposure. *Eur Heart J* 2014; 35(13): 829-836.
4. Mehdi MR, Kim M, Seong JC, Arsalan MH, Spatio-temporal patterns of road traffic noise pollution in Karachi, Pakistan. *Environ Int* 2011; 37(1): 97-104.
5. Ozkurt N, Sari D, Akdag A, Kutukoglu M, Gurarslan A, Modeling of noise pollution and estimated human exposure around İstanbul Atatürk Airport in Turkey. *Sci Total Environ* 2014; 482-483: 486-492.
6. Monazzam MR, Nasserpour M, Naderzadeh M, Pouragha HR, Meshkani M, Developing a Train Noise Index for Noise Pollution Assessment of Inter-Urban Trains. *Fluct Noise Lett* 2014; 13(03):1450014. DOI: 10.1142/S021947751450014X.
7. Hunashal RB, Patil YB, Assessment of Noise Pollution Indices in the City of Kolhapur, India. *Procd Soc Behv* 2012; 37: 448-57.
8. Yassin MF, Almutairi H, Alhajeri N, Al-Fadhli F, Al Rashidi MS, Shatti T, Assessment of noise exposure and associated health risk in school environment. *Int J Environ Sci Te* 2016; 13(8): 2011-2024.
9. Dreger S, Meyer N, Fromme H, Bolte G, Environmental noise and incident mental health problems: A prospective cohort study among school children in Germany. *Environ Res* 2015;143 (Pt A): 49-54.
10. Sala E, Rantala L, Acoustics and activity noise in school classrooms in Finland. *Appl Acoust* 2016; 114: 252–259.
11. Sarantopoulos G, Lykoudis S, Kassomenos P, Noise levels in primary schools of medium sized city in Greece. *Sci Total Environ* 2014; 482–483: 493-500.
12. Zannin PHT, Sant'Ana DQ, Noise mapping at different stages of a freeway redevelopment project – A case study in Brazil. *Appl Acoust* 2011; 72: 479–486.
13. WHO, World Health Organization. Résumé D'orientation Des Directives De I'oms Relatives Au Bruit DansI' environmental, 2003.
14. Ai Ali SA, Study effects of school noise on learning achievement and annoyance in Assiut city, Egypt. *Appl Acoust* 2013; 74(4), 602–606.
15. Golmohammadi R, Ghorbani F, Mahjub H, Daneshmehr Z, Study of School Noise in the Capital City of Tehrain-Iran. *J Environ Health Sci* 2010; 7(4): 365-370.
16. Makarewicz R, The annual average sound level of road traffic noise estimated from the speed-flow diagram. *Appl Acoust* 2013; 74(5): 669–674.
17. Makarewicz R, Gołębiewski R, Estimation of the long term average sound level from hourly average sound levels. *Appl Acoust* 2016; 111: 116-120.
18. Tsaj KT, Lin MD, Chen YH, Noise mapping in urban environments: A Taiwan study. *Appl Acoust* 2009; 70(7): 964-972.
19. Banerjee D, Chakraborty SK, Bhattacharyya S, Gangopadhyay A, Evaluation and analysis of road traffic noise in Asansol: an industrial town of eastern India. *Int J Environ Res Pub He* 2008; 5(3): 165-171.
20. Ongel A, Sezgin F, Assessing the effects of noise abatement measures on health risks: A case study

in Istanbul. *Environ Impact Asses* 2016; 56: 180–187.
21. Baliatsas C, van Kamp I, van Poll R, Yzermans J, Health effects from low-frequency noise and infrasound in the general population: Is it time to listen? A systematic review of observational studies. *Sci Total Environ* 2016; 557-558: 163-169.
22. Christensen JS, Raaschou-Nielsen O, Tjønneland A, Nordsborg RB, Jensen SS, Sørensen TI, Sørensen M, Long-term exposure to residential traffic noise and changes in body weight and waist circumference: A cohort study. *Environ Res* 2015; 143(Pt A): 154-161.
23. Augustyńska D, Kaczmarska A, Mikulski W, Radosz J, Assessment of Teachers' Exposure to Noise in Selected Primary Schools. *Arch Acoust* 2010; 35(4), 521–542.
24. Silva LT, Oliveira IS, Silva JF, The impact of urban noise on primary schools. Perceptive evaluation and objective assessment. *Appl Acoust* 2016; 106, 2–9
25. Connolly DM, Dockrell JE, Shield BM, Conetta R, Cox TJ, Students' Perceptions of School Acoustics and the Impact of Noise on Teaching and Learning in Secondary Schools: Findings of a Questionnaire Survey. *Energy Proced* 2015; 78, 3114-3119.
26. Paunovic K, Belojevic G, Jakovljevic B, Blood pressure of urban school children in relation to road-traffic noise, traffic density and presence of public transport. *Noise Health* 2013; 15(65): 253-260.
27. Pujol S, Levain JP, Houot H, Petit R, Berthillier M, Defrance J, Lardies J, Masselot C, Mauny F, Association between ambient noise exposure and school performance of children living in an urban area: a cross-sectional population-based study. *J Urban Health* 2014; 91(2): 256-271.

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