World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(Review Article)

Check for updates

Assessment of noise pollution and specific mitigation measures to reduce it in educational settings and its impact on students' academic performance: A review

AZZA MOHAMED AL-ASMAR [1, 2, *]

[1] *Department of Environmental Sciences, Faculty of Science, Damietta University, New Damietta 34517, Egypt.*
[2] *Department of Biology, AL-Baha University, Kingdom of Saudi Arabia, AL-Baha, P.O.Box (1988).*

World Journal of Advanced Research and Reviews, 2025, 25(01), 273-286

Publication history: Received on 22 November 2024; revised on 01 January 2025; accepted on 03 January 2025

Article DOI: https://doi.org/10.30574/wjarr.2025.25.1.0008

Abstract

Noise pollution causes many problems in the educational process and adversely affects the performance of educators and students. This study reviewed the research, studies, surveys, and questionnaires on the subject and examined the effects of noise pollution on the academic performance of students and certain mitigating measures to control it. This document provided a comprehensive overview of noise measurements, comparison with guidelines/standards, factors affecting noise in college and university campuses, external and internal noise sources in the educational environment, effects of noise on health and student performance, sound quality of classrooms, and noise reduction. The results of the review revealed that most academic students are exposed to noisy environments, which have significant physiological and psychological effects on health. The review recommended certain noise control and management measures that include the use of noise barriers, construction of green spaces, design of noise reduction infrastructure, implementation of awareness programs, strict enforcement of laws and noise regulations, the development of advanced noise control technologies, integrated strategies, and sustainable environmental planning to reduce the menace of noise pollution.

Keywords: Noise Pollution; Educational Environments; Noise Sources; Noise Impacts; Noise Mitigation Measures; Review

1. Introduction

Pedagogical and educational psychology experts believe that the appropriateness of the physical and social environment of the classroom, the motivation of teachers and students for teaching and learning, the cognitive, emotional, and motor readiness of students, classroom management by teachers, and their experiences in the subject area are important for effective education. In order to stop the development of behavioral and disruptive elements, the teacher works to create the ideal learning environment [1]. The learning environment has a significant impact on student learning outcomes. Factors that can make students to be distracted in the classroom include noise, inadequate temperature, inadequate lighting, crowded classrooms, poorly placed blackboards, and inappropriate classroom layout [2]. Noise, along with air pollution, is an important risk factor affecting overall health integrity [3, 4, 5]. Noise pollution causes many problems in the education process and negatively affects the performance of both educators and students [6].

Noise is generally defined as unwanted sound with high-energy waves that has significant effects on humans and is characterized by the frequency, periodicity, intensity, and duration of the sound [7, 8]. Noise levels are measured in decibels (dB); the unit of sound pressure level (SPL), and not all sounds are considered noise pollution [9]. Noise levels are usually converted to a single number called Leq (A). The Leq indicator (A) is the average acoustic intensity over time [10]. The A-weighted decibel scale starts at zero. This represents the weakest sound that people with perfect hearing can hear. The loudness of sounds (how loud they seem to people) varies from person to person, so there is no exact

* Corresponding author: AZZA MOHAMED AL-ASMAR

definition of loudness. However, according to extensive tests conducted on a large number of people, a sound level of 70 sounds twice as loud to the listener as a sound level of 60 [11]. MahiPal and Prasad [12] stated that there are two types of noise: impulsive and continuous. Noise that occurs over a short period of time is called impulsive noise. It is more dangerous than continuous noise because our ears are not used to this type of noise, and it severely affects the diaphragm of the inner ear. Impulsive noise has been reported to have a 10 dB greater impact than chronic continuous noise (induced noise that triggers hearing).

Lawrence *et.al.* [13] held that "depending on how it changes over time, noise can be divided into steady and non-steady. Steady noise is noise in which there is negligible fluctuation in the sound pressure level during the observation period; it is a constant continuous noise, such as that from a pump or electric motor. If the sound pressure level changes during the observation, the noise is said to be non-steady. This type of noise can be divided into intermittent and fluctuating noise. Intermittent noise is a continuous but intermittent sound, such as that of an air compressor or an automatic machine. However, fluctuating noise is characterized by one or two discrete frequencies. Fluctuating noise may consist of: *Periodically fluctuating pulses, ex: surface grinding; *Nonperiodically repeated impulses, ex: manual work; *Single impulses, ex: hammer blow; and *Repeated impulses, like automatic press. The non-steady noise is much more annoying than broadband noise characterized by energy at many different frequencies, and of the same sound pressure level as the tonal noise "(pp.443-444).

Due to the development of modern technologies, industrialization, urbanization and urban traffic, noise has become a major environmental problem at the global level, especially in rapidly urbanizing regions [14, 15, 16, 17]. The World Health Organization (WHO) estimates that "430 million people, that is, more than 5% of the world's population, suffer from hearing loss that causes disability and that by 2050, 700 million people, or one in ten, will suffer from it [18]". Also, according to the Central Pollution Control Board [19], noise interferes with work, rest, entertainment, sleep, etc. It causes negative physiological and psychological effects in people by interfering with social activities.

The documented negative effects are due to constant exposure to noise pollution. The effects of noise pollution can be classified as auditory or non-auditory. One type of hearing impairment is the physical or auditory effects of the condition [20]. It is the most common cause of hearing loss and patients may not realize that their condition has become so severe that there is no chance of recovery [21]. Negative effects on work performance, including decreased productivity and misinterpretation of what is heard, have been associated with non-auditory effects. According to Münzel [22], noise pollution increases children's stress levels, resting blood pressure, and learning difficulties. Furthermore, prolonged exposure to high levels of noise can cause permanent or temporary damage to a person's physical and mental health. In addition, long-term exposure to noise can temporarily or permanently affect the functions of the human body [23, 24, 25, 26, 27]. This is a serious problem worldwide, especially in schools and educational institutions in developing countries [28, 29, 30, 31].

With the exception of sleep disorders, the above-mentioned conditions can have a negative impact on university teaching and research [32]. Because the masking effect of oral communication makes it difficult to speak in a noisy environment, students may perform better in quiet environments than in noisy environments [33, 34]. Poor mental performance, educational level, and noise levels are closely related, especially in jobs that require mental effort, communication, and thinking [35]. Exposure to noise for one second significantly affects people’s cognitive abilities by impairing concentration for thirty seconds [36].

Some studies have shown that noise has a detrimental effect on language and reading development [37, 38, 39, 40, 1]. It also causes problems with motivation, memory, and concentration [41]. Teachers often have to speak loudly to compensate for the noise level in the classroom. Teachers who use this speaking style are at risk of developing speech problems [42]. Background noise in classrooms must be reduced so that teachers and students can learn and work in a healthy environment. Noise pollution in academic environments leads to disruptions in the teaching-learning process, lack of speech intelligibility (hearing and understanding), difficulties in classroom discussions, disruptions in language, homework performance, concentration in reading, problem-solving, memory, increased absenteeism, health problems and psychological stress [43, 6, 44, 45, 46]. According to the World Health Organization (WHO), the background sound pressure level during a teaching session should not exceed 35 dB "equivalent" sound level (Leq) and 55 dB Leq inside the building but outside the classroom (e.g. in corridors). The sound pressure level of external noise should not exceed 60 dB Leq in outdoor playgrounds along a major road and 40 dB Leq in a residential area during the day [36, 8].

Numerous studies have been conducted to identify internal and external noise sources and their impact on students in colleges and universities (campuses, classrooms, and teaching laboratories) across the world. These studies have revealed many differences and similarities among the noise sources. The quality of education is directly affected by noise. Debnath *et al.* [6] found that noise levels in eight schools and institutes in Nagaon, Assam, India ranged from 54 to 80 dB(A), which is above the standard limit. Obot and Ibanga [44] observed a trend of increasing noise levels in the Uyo City University campus to a maximum of 89.5 dB(A) during the daytime, which gradually decreased during the night hours. Ozer *et al.* [47] found that the noise level in the Ataturk University campus, Erzurum was above 55 dB (range 62-70 dB). Mamun *et al.* [48] found that 60% of teachers and students in educational institutions close to transportation hubs in the city of Chittagong experienced disruptions in the teaching-learning process, 25% had difficulty participating in class discussions, and 25% experienced health problems. Hussein and Al-Sulttani [35] reported that the noise level in the study area of Kufa University in Najaf, Iraq, reached a maximum of more than 90 dB (minimum 60 dB) in the afternoon, and the spatial distribution of the equivalent noise level in the corridor of the class building at noon exceeded 75 dB. The noise level at BRD Medical College and MMM University of Technology in Gorakhpur, India, exceeded acceptable limits at all locations on their respective campuses [49].

Herzog *et al.* [50] found that daily noise levels in a technical secondary school in Ravna, Slovenia were 74 dB(A) in classrooms and 84 to 91 dB(A) in laboratories. To easily and quickly identify noise hotspots in each area, recent noise studies have also used GIS geostatistical techniques to represent noise measurement values using isopleth noise maps [51, 52]. However, according to Kallankandy and Deswal [53], the noise levels in classrooms, laboratories, workshops, corridors, and open areas in the designated area of NIT Kurukshetra academic area are higher than what is permissible for educational institutions in India and by WHO. Where, the mean Leq values for the academic area were weekday (65.88 dB), weekday-night (47.70 dB), weekday-night (57.73 dB), and weekday-night (45.77 dB), 31.77%, 19.24. %, 15.45% and 14.43% above the recommended standards for academic institutions respectively.

Smaldino *et al.* [54], however, found that there are several potential sources of background noise in a classroom, including student activities in the academic area (especially movement in the hallways), loud talking, inadequate isolation from the classroom, activities outside the academic area (traffic on the northern highway surrounding the academic area) (e.g., neighborhood noise and loud music during extracurricular activities), lack of public awareness, and failure to comply with legal requirements are the main causes of noise pollution.

Due to the increasing acoustic pollution in educational environments and its negative impacts, it has become necessary to study acoustic pollution in the academic contexts of educational institutions or universities. Therefore, the purpose of this study is to examine the existing noise levels in educational institutes, compare these levels with the permissible limits, identify the main sources of acoustic pollution, determine the main effects of noise on health and academic performance of students, and suggest specific corrective measures to reduce acoustic pollution in educational institutes.

2. Levels, standards, and sources of noise pollution in academic environments

Noise pollution research shows that noise has negative effects on areas such as communication and concentration, especially in academic settings such as schools, teaching laboratories, and universities (i.e., colleges and universities). Kinsler *et al.* [55] reported that "multiple sources of noise affect the acoustics of a room; these are: (a) external noise; road, rail, and air transportation; (b) mechanical engineering services; basic plant and power systems for ventilation, air conditioning, and sanitation; (c) electrical services; lighting, and elevators; and (d) people; crosstalk, motion, and noise from operating machinery". There are two types of noise sources in the classroom: internal and external. External noise comes from diesel-electric generators, vehicle horns, traffic, parking, construction activities in and around the campus, and the voices of students in other classrooms, laboratories, or campus activities, while internal noise comes from the classroom itself and the air-conditioning equipment (ventilation system) [56, 57, 58, 59].

However, the equipment in teaching laboratories is the main source of noise, and noise intensity varies depending on the type of laboratory, the number and type of noisy equipment, and the type of noise generated by this equipment (continuous, intermittent, and bursty noise). For example, fume hoods, compressors, centrifuges, stirrer motors, and refrigerators in chemistry, biology, and biochemistry laboratories may generate different types of noise with different decibel levels than workshops with welding, lathe, and construction machines [60, 61]. Other factors also affect noise levels, such as the background noise level, the acoustic performance of a building, and the interior design of the laboratory, which must provide a pleasant acoustic environment for researchers, students, and teachers [62, 60].

In a study conducted at the Faculty of Engineering at King Abdulaziz University in Jeddah, Saudi Arabia, Balila and Siddiqi [63] concluded that air conditioning and controls in the faculty buildings were responsible for increasing the already poor noise pollution. On the other hand, noise on the campus may also arise from street traffic and parking lots, especially during rush hour, when traffic is congested due to honking horns of vehicles. The noise level exceeds the 55 dBA permissible limits for educational environments according to the World Health Organization guidelines and the global limits approved by the United States Environmental Protection Agency [64]. "This phenomenon has been observed in the campuses of the Faculty of Engineering, Kingdom of Saudi Arabia (KSA); University of Guwahati, India;

Federal University of Paraná, Brazil; Ataturk University, Turkey; University of Dammam, KSA; Faculty of Engineering and University of Technology, Iraq; and Al Nahrain University, Iraq" [63, 65, 66, 47, 67, 68, 69, 70].

The other major sources of noise on campus are power generators, especially in countries that experience frequent power cuts and rely on diesel generators on weekdays. Obot and Ibanga [44] found that the maximum noise level at the University of Uyo in Nigeria was 95.2 dB(A) and reported that the major sources of noise pollution were power generators at 42%, followed by students at 37%. Additionally, Olaosun and Ogundiran [71], Ibrahim [68]; Ibrahim [69], and Hassan and Ibrahim [70] found that noise near power generators reaches levels of up to 110 dBA. Machines such as milling, grinding, bar cutting, disc cutting, power drilling, welding, lathing, electrical sieving, concrete mixing, and strength testing machines have also been found to generate noise at a level of 110 dBA in technical and engineering colleges. It has been observed that teaching laboratories and workshops are responsible for increasing noise levels on campus when doors and windows are opened on work and study days, contributing to an increase in noise levels beyond permissible limits [72, 71, 68, 69].

Students who gather in campus gardens and squares for lectures and recreational activities also constitute another source of noise [73, 68, 69]. Basheer *et al.* [74] conducted a study in all buildings of the Faculty of Science, Zakho University, and found that "the noise levels were highest on the ground floor of building one at (11:00 AM-12:00 PM) and (12:00-1:00 PM), respectively, changing from 60.6 to 73.7 dB at (11:00 AM-12:00 PM) and 63.3-73.8 dB at (12:00-1:00 PM) (12-1:00 PM) ". They attributed their findings to students taking lunch breaks in the afternoon and frequent visits to the canteen in this area and concluded that the high indoor sound pressure levels observed in their study were due to hundreds of students moving around the buildings every day. There were also students chatting in the corridors, especially on the ground floor. The findings of the studies reviewed above show that the average noise levels in all educational institutions are above the stringent WHO requirements of 50 dB during the day and 40 dB at night [75].

3. Acoustic quality of classrooms

Radosz [76] stated that classroom acoustic quality is a term proposed to describe the acoustic characteristics that contribute to the subjective impression received by a person, such as speech intelligibility, external noise, or vocal effort. It is necessary in classrooms where adequate conditions must be provided for the transmission of verbal content to students, taking into account their age. The main concern in university classrooms is that inadequate acoustic conditions can lead to poor verbal communication, which can lead to reduced learning efficiency. In addition, these conditions can cause fatigue, stress, and health problems (headaches, sore throats) for teachers who have to compensate for poor acoustic conditions by raising their voices [77]. Poor acoustic quality, which can be defined by excessive reverberation time, for example, disrupts verbal communication, causes increased noise levels in teaching and learning rooms and interferes with the reception of messages, especially those conveyed through modern warning signs [78, 79].

However, the acoustic conditions in a classroom depend on three main factors: the geometry of the room (size and shape), the sound-absorbing properties of the interior surfaces of the room, and the number of students in the classroom [80]. All these factors influence the levels of background noise and speech as well as the reverberation time [77]. Background noise is the ambient noise at a specific place and time. Its level is measured in empty rooms when certain noises are suppressed [81]. Reverberation time (RT) is the time it takes for a loud sound to decay to an inaudible level after its source is stopped. It can also be defined as "the difference between the sound and inaudible levels of -60 dBA. Typically, it is normally evaluated for the sound reduction from -5 and -35 dBA (RT60) and multiplied by a factor of 2 to ensure RT60 compliance". Standards such as American National Standard, ANSI S12 and DIN4109 specify that the loudest ambient noise should not exceed 35 dBA and that the reverberation time for classrooms should be between 0.4 and 0.6 s [82, 42]. If the measurement results do not comply with the standards, there may be discontinuities between the teacher and the students, because if the reflection of the sound takes a long time, the penultimate sounds become blurred and the clarity and quality of the speech decreases. If the reflection of the sound does not take a long time, the speech loses its characteristic and its quality decreases. These conditions lead to poor learning outcomes [83]. By improving the acoustic quality of teaching and learning spaces, it is possible to reduce noise in classrooms and improve the conditions for educational activities. In addition, environmental noise, sound insulation, reverberation time, speech intelligibility, audibility, and acoustic materials are the main factors to be considered in creating a good acoustic environment in the classroom [77, 84, 85, 76, 86, 87, 88, 89, 90].

4. Impacts of noise pollution on student health and academic success

Over the past century, since noise was identified as an environmental pollutant, WHO publications have continued to explain and describe the effects of noise pollution on human health and have issued recommendations on how to reduce these effects and set limits for acceptable noise levels indoor and outdoor [36, 91, 92, 3]. These publications have been accompanied by other publications from organizations such as the National Institute for Occupational Safety and Health [93] and the Canadian Centre for Occupational Safety and Health [94].

According to the World Health Organization [3], noise is the greatest environmental stressor on overall health [24]. Stansfeld and Matheson [95] divided the effects of noise pollution into auditory and non-auditory effects. While the auditory half relates to the inner ear and hearing loss, the non-auditory effects of noise exposure include stress and behavioral changes. Noise exposure could increase blood pressure and trigger the production of endocrine hormones such as cortisol, norepinephrine, and adrenaline, all of which can lead to cardiovascular disease [96]. Long-term effects can also include respiratory, gastrointestinal, and cardiovascular problems. Fatigue, low self-esteem, reduced work capacity, interpersonal dysfunctions and some of these effects can lead to more accidents and worsening of classroom communication and academic performance [97]. Other researchers describe these effects (hearing loss, sleep disturbances, tinnitus, stress, malaise, ischemic heart disease, effects on balance, and, in some cases, reduced immunity to diseases) [98, 95, 99, 100]. These effects depend not only on the physical properties of the noise but also on the parameters associated with each person and each environment [101, 102, 103].

Many studies have examined the effects of noise on the teaching-learning process and the relationship between noise exposure of students of different educational levels and their performance in various cognitive tasks and revealed the impact of noise on various aspects of students such as their educational level, concentration, learning ability, communication, and continuity with teachers [77, 104, 105, 106]. Some studies show that students exposed to noise pollution during class experience higher levels of stress and have delays in reading. According to other studies, noise pollution can affect students' ability to concentrate on class, interrupt conversations, distract students from the classroom, and even lower their grades, especially in arithmetic [6, 107, 108].

In a noisy environment, Chiang and Lai [109] observed the following side effects: headache, tinnitus, pallor, increased heart rate, dyspepsia, loss of appetite, insomnia, and rapid fatigue that reduces productivity. However, according to various studies, noise pollution is the main cause of discomfort among teachers and students, manifesting itself in pain, impatience, irritability, headache, fatigue, drowsiness, depression, and inability to concentrate. According to the World Health Organization publications, background noise levels around 45-55 dBA cause communication disruption and relaxation while speaking. When the noise level reaches 65 dBA, the speaker must make an effort to vocalize in order to be understood. Most of the studies mentioned in this review found background noise levels above 55 dBA for college and university campuses and classrooms; therefore, the effects of communication disorders can be clearly observed.

The discomfort caused by noise can be defined as noise annoyance and can be used as an indicator of noise-related stress as it reflects the individual perception of sound level and discomfort. Basheer *et al.* [74] stated that the most common direct effect of noise on students was malaise, which affected 23%, followed by headaches at 18%. They also showed that noise has little psychological impact on students, such as anxiety (6%) and sleep problems (4%); finally, the proportion of students affected by memory loss (2%) and fatigue (3%) was lower than other effects, but 22% of students were not affected by noise. Some studies and surveys have highlighted students' difficulty concentrating, discomfort, and headaches due to noise. Researchers such as Engel *et al.* [110] found that 43%, 25%, and 12% of students in their survey sample had difficulty concentrating, felt sad, and experienced headaches, respectively, which resulted in decreased productivity in academic settings. Emilse and Marina [56] and Ibrahim [58] found that 50% and 30% of students in their survey sample suffered from the above-mentioned effects, respectively.

5. Noise reduction measures in academic environments

One of the purposes of this paper is to review the remedial measures suggested by researchers to control noise pollution in academic environments. Since noise pollution has many harmful effects on human beings, both mentally and physically [95], noise pollution management and reduction should be the most efficient method of noise reduction and should be selected from the existing methods [111]. Noise abatement is a set of strategies aimed at reducing noise pollution. Therefore, noise reduction measures should be adapted to the location and conditions, where the control measures may vary from region to region. Many studies suggest that a mix of active and passive or source and receiver interventions could provide synergistic effects towards overall noise reduction [112]. Some important mitigation measures are described below, where its individual or combined application can lead to a quieter and more pleasant acoustic environment.

The noise problem is usually associated with three interrelated elements (source, receiver, and transmission path). This transmission path is usually the atmosphere through which the sound travels, but it can also include the building materials of the building where the receiver is located. Therefore, it is necessary to clarify the interrelationship between these elements in order to adopt the most appropriate procedural measures to control noise pollution. Federal Railroad Administration [113] held that "each transit source generates close-by noise levels which depend upon the type of source and its operating characteristics. Then, along the propagation path between all sources and receivers, noise levels are reduced (attenuated) by distance, intervening obstacles, and other factors. And finally, at each receiver, noise combines from all sources to interfere, perhaps, with receiver activities"(pp.2-1). The technique or combination of techniques to be used to control noise will therefore depend on the level of noise reduction required, the type of equipment used, and the economics of the available techniques. The techniques employed for noise control can be broadly classified as: control at source, control in the transmission path, and use of protective devices [114, 115, 116, 117].

Controlling noise pollution at its source can be achieved by using various techniques, such as controlling material vibrations by using adequate foundations, rubber pads, etc. to reduce the noise level caused by vibrations; speaking softly so that communication reduces excessive noise levels; prohibiting the use of loudspeakers in occupied areas except for large meetings or events; and selecting machines, tools or equipment as appropriate to reduce excessive noise levels. For example, choosing chairs or certain machines/equipment that produce less noise (sound) due to their superior technology is also an important factor in the noise reduction strategy.

However, by changing the transmission path, the wave propagation length is extended and is absorbed/refracted/spread into the environment. Installing barriers between the noise source and the receiver can reduce noise levels. For a barrier to be effective, its side width must extend beyond the line of sight as much as its height. The barrier can be placed close to the source or receiver to increase the passage length of the sound wave. It is also worth noting that the presence of the barrier can reflect sound back to the source. At very large distances, the effectiveness of the barrier is reduced due to possible refraction and atmospheric effects.

Building design, on the other hand, involves the use of appropriate sound-absorbing materials that reduce noise levels in walls, doors, windows, and ceilings, such as fiberglass; acoustillite, available in the form of tiles, composed of wood fibers and compressed wood pulp; an acoustic blanket made of fiberglass or mineral wool; fur felt, made of coarse cotton and wool fibers; cork carpet, a type of flooring made of split cork coated with linseed oil; and/or acoustic plaster, consisting predominantly of gypsum. Additionally, an audio source may be enclosed in a panel structure, such as a room, to reduce noise levels at the receiver. The actual difference between sound pressure levels inside and outside an enclosure depends not only on the transmission loss of the enclosure panels but also on the sound absorption within the enclosure and the details of the penetrations (openings) of the panels, which may include windows or doors. The product of the frequency of interest and the surface weight of the absorbent material is the key parameter for reducing noise through transmission losses. With traditional designs, the high-frequency transmission loss of a panel is limited to about 40 dB because the sound is transmitted through secondary paths other than the panel itself. Examples of such sites are structural connections or channels connecting two cavities on either side of the plate of interest [114].

In addition, the use of protective devices is a last resort in sound insulation technology after the reduction, redirection of the source, or technical control of the sound transmission path. Assessing the severity of the problem, identifying the person, and determining his exposure to noise are the first steps of protective equipment engineering. Noise-cancelling headphones, earplugs and similar devices are often used to protect hearing. Noise-cancelling headphones vary greatly in size, shape, sealing material and other attenuation features. According to literature review, noise-cancelling headphones can reduce noise levels by up to 32 dB on average [118]. However, the use of earplugs or earmuffs to protect the receiver is ineffective due to the speech and hearing demands of the educational process; therefore, alternative methods must be used.

Noise control can also be achieved through legislation by creating quiet zones around schools and hospitals and by educating the public that noise is pollution and not a necessary part of daily life. Safeguarding the exposed person can be achieved by creating vegetation, where plants act as a buffer zone by absorbing and dissipating sound energy. Trees should be planted in schools, roadsides, and other places. In addition, developing green belts can reduce sound levels. The degree of reduction varies depending on the type of green belt (shrubs and trees). Legislation instructs industry to create a green belt four times the size of the built-up area to reduce various air pollutants, including noise.

In order for our specific study to take the most appropriate measures to reduce noise in the academic environment, noise control methods should be selected based on the source of noise pollution and whether it is propagated from outside or inside the campus. For example, Al Mamun *et al.* [119] recommended considering a large buffer zone when building educational institutions adjacent to busy roads. The buffer space can be equipped with functional noise barriers by placing multi-storey commercial buildings, high walls or trees with a dense canopy. These can significantly reduce noise in the schoolyard and also in classrooms. Different widths of tree belts and their influence on sound insulation have been examined in various studies. Martenes [120] found that forest masses and tree belts of at least 12 meters in length can be used effectively as noise barriers in urban areas. In another study, Watts *et al.* [121] studied the influence of vegetation cover on noise reduction using natural and artificial noise sources with a certain frequency and concluded that a 30 m wide tree belt planted at the side of the road can increase the noise by about 6 dB more than a green space at the side of the road.

Ozer *et al.* [122] suggested planting 100 m wide tree belts, considering appropriate planting techniques and tree species in terms of beautification and ecological conditions. They also explained the reason for the different effects of using pure acacia trees and mixed stands in reducing noise pollution in the green season (5.01 and 6.05 dB, respectively) by the reflection, refraction, scattering, and barrier function of carob branches and leaves that absorb sound waves. These components reduce noise during the green season when trees have more branches and leaves. This problem has been revealed in various studies by many researchers. For example, the influence of leaf size and branch shape of deciduous trees on the distribution and attenuation of acoustic energy has been confirmed by Aylor [123] and Cook and Hoverbeke [124].

Finke [125] reported that open green areas and/or flower beds should be 10 to 15 m wide and planted with an appropriate mix of coniferous and deciduous tree species. If these mitigation measures are taken, noise levels can be reduced by 10 to 15 dB(A), which can significantly reduce noise pollution. Sound-absorbing plants such as *Pinus sylvestris* L. and *Picea abies* L., suitable for urban areas, can be planted to reduce noise. *Acer pseudoplatanus*, a deciduous tree, is known to attenuate noise the most (10-12 dB(A)) and is comparable to *Quercus robur* (6-8 dB(A)) and *Acer negundo* (4-6 dB(A)). Shrubs such as *Betula pendula* (4-6 dB(A)) and *Ribes diricatum* (6-8 dB(A)), *Syringa vulgaris* (6-8 dB(A)), *Forsythia intermedia* (4-6 dB(A)) and *Sambucus nigra* [126] are also planted. In addition, the plant material used in the planting design should have branches at ground level, have a dense leaf area, and be planted so that the leaves face the noise sources.

However, Price [127] stated that the best supports as acoustic barriers are mixed stands of several species of trees with multiple leaves. Furthermore, Aparicio *et al.* [128] stated that plant leaves absorb acoustic energy by transferring the kinetic energy of the vibrating air to the vibration pattern of the leaves. Thus, the vibration energy is removed from the acoustic field and some of this energy is lost as heat when leaf friction occurs on a vibrating plant. Furthermore, Ozer *et al.* [122] concluded that pines perform more efficiently than firs in reducing noise. This difference was measured to be approximately 6.3 dB(A) at a distance of 25 meters from the noise source. They stated that the reason for this is that pine needles are denser than fir needles. However, when choosing plants to use as noise barriers, it is important to choose long-lasting, evergreen species (native plants are preferred) that require little maintenance [129]. However, planting trees as noise barriers within the campus and near fences is an effective strategy to reduce noise pollution, reduce stress, produce oxygen, and increase visual comfort.

On the other hand, Ozer *et al.* [47] stated that the noise on the Ataturk University campus could be caused by high traffic density, including a large number of buses. They suggested limiting the number and type of vehicles allowed. These vehicles could be replaced by electric vehicles that could reduce noise levels. In addition, vehicles entering the area should be directed to large parking lots and should not be parked near educational institutions. They also recommended that the areas where there are barriers restricting traffic be rearranged and new ones be added if necessary. These devices can prevent excessive noise by reducing the speed of vehicles. In this respect, the barriers that are currently inadequate should be carefully examined and the necessary measures should be taken. After the driver passes the barrier, their speed increases, which increases noise pollution. Therefore, the barriers should be placed at least 100 m away from the buildings. In addition, the main access roads to the university should be changed to avoid educational facilities. In cases where this is not possible, buffer zones with appropriate noise-reducing types should be created between the educational buildings and the main road arteries [130, 122].

Furthermore, Başar [131] reported that in cities like Erzurum, where winters are extremely cold, building insulation is essential to save heat. This type of insulation not only reduces heat loss but can also reduce noise pollution in residential areas. He added that since the university was founded in 1957, noise pollution has continuously become a new and serious environmental problem on campus. In this regard, it has been proposed to limit the number of vehicles on campus by more effectively controlling vehicles entering the area and carefully adjusting the location and number of barriers to calm traffic. One of the most effective measures to reduce noise levels is the effective construction of buffer zones for main axes, which cover the pedestrian paths of major road arteries [132, 122]. Regarding specific mitigation measures in educational institutions, Debnath [6] suggests that educational institutes should be located away from major arteries, congested roads and other noise sources; should have structures with high concrete wall enclosures and soundproofing systems; should plant trees and vegetation buffer zones; teachers, students and the public should help reduce noise levels in educational institutions; should implement strict laws to combat noise pollution; should limit traffic in or near educational institutions; and should set speed limits for cars in their areas.

According to an assessment of noise pollution conducted at the University of Uyo in Nigeria, Obot and Ibanga [44] recommended increasing public awareness of the risks, dangers and health disasters associated with noise pollution through education, conferences, and workshops; Using insulation and soundproofing materials in doors, walls, and floors; planting vegetation that absorbs and blocks noise pollution; zoning of urban areas to separate quiet and excessively noisy areas; adopting specific laws to launch permitted noise levels and control noise pollution; establishing a regulatory authority to help mediate, monitor and enforce the law to record the desired objectives; and recommending that most noisy devices be subject to technical controls that combat noise at its origin or transmission route with sound-absorbing material; using silencers or mufflers; creating barriers or noise abatement panels and isolating them.

Basheer *et al.* [74] concluded that students should be warned about the dangers of noise pollution. The high levels of indoor sound pressure observed in their study were due to hundreds of students moving around the university buildings on a daily basis, as well as students chatting in the corridors and especially on the ground floor. Based on the findings of their study in the academic sector of NIT Kurukshetra, Kallankandy and Deswal [53] also suggest setting up special rooms where students can wait during free time; changing class schedules to minimize student movement in corridors; using natural barriers and sound absorbers (e.g., layered plantings) in open spaces in and around academic areas; using sound absorbers (e.g., panels, curtains, etc.) in classrooms, laboratories, and workshops; using double-glazed windows and repairing damaged windows to make them airtight. Regular maintenance of machines or devices as well as heavy machinery casings, especially in workshops; use covering hallways with thick flooring to muffle noise from pedestrians in the hallway next to classrooms and increase awareness among students and staff.

In addition, general measures that can be taken during the design phase to reduce noise in educational institutes are also suggested, such as considering the design of classrooms and related structures during design; building sufficient open space between the academic area and roads/noise sources to provide noise protection to academic institutions during planning; implementing traffic restrictions in and around academic areas; and making use of noise masking techniques by adding natural sounds (e.g. water fountains) or artificial sounds to mask the effects of unwanted noise. By implementing appropriate planning measures, noise pollution can be effectively mitigated [133]. Therefore, each place has its own control measures that must be followed to achieve a satisfactory level of noise control.

Recommendations

For future research in this area, it is recommended to conduct noise assessment for the entire university/institute campuses including multiple measurement points for greater granularity, real-time monitoring and further detailed subjective analysis of noise pollution. While designing new college campuses, noise pollution should be one of the planning factors. Care must be taken to establish campuses in areas away from urban centers and noise sources to achieve low noise levels on campus. Planting trees on campus premises and beside fences as noise barriers is an effective strategy to curb noise pollution, reduce stress, generate oxygen, and improve visual comfort. Awareness programs on the negative effects of noise pollution should be conducted using multimedia approaches, especially in urban areas. This can be reinforced by city-wide noise mitigation plans focusing on specific hotspots and noise sources. Laws and regulations must be properly implemented to prevent noise pollution.

6. Conclusion

The results of this study showed that the average noise level in all educational institutes was above the strict WHO guidelines of 50 dB during the day and 40 dB at night. The loudest sources were streets, car parks, power generators, and student gatherings in schoolyards, where there was a high level of background noise that could disturb students and teachers during lessons. Environmental noise can have a negative impact on people's health by interfering with basic activities such as sleeping, resting, learning, and communicating. In addition, chronic exposure to noise can lead to the prolonged activation of several predictable physiological responses, such as increased heart rate, blood pressure, and endocrine release. These effects depend not only on the physical properties of the noise itself but also on parameters associated with each person and each environment. Therefore, it is important to study noise pollution both quantitatively and in terms of the discomfort it causes to the population. Achieving optimal acoustic conditions is essential when designing classroom activities, especially those that require high-quality sound: attention and participation. Based on the research findings, this study proposes some methods for noise control and management, including the use of noise barriers, the construction of green areas, the design of infrastructure to reduce noise, the implementation of noise reduction programs, rigorous implementation of noise control laws and regulations. Acting together, we can create a more peaceful and harmonious living environment for ourselves and future generations.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Sapna Ch, Sianna A, Victoria C, Andrew N. Designing classrooms to maximize student achievement. Policy Insights from the Behavioral and Brain Sciences. 2014; 1(1): 4-12.

[2] Gaines KS, Curry ZD. The inclusive classroom: The effects of color on learning and behavior. Journal of Family and Consumer Sciences Education. 2011; 29(1): 46-57.

[3] World Health Organization (WHO). Burden of disease from environmental noise, Quantification of healthy life years lost in Europe; 2011.

[4] Djercan B, Bubalo-Zivkovic M, Lukic T, Pantelic M, Markovic S. Road traffic noise exposure in the city of Novi Sad: trend analysis and possible solutions. Pol. J. Environ. Stud. 2015; 24(3): 977-986. DOI:10.15244/pjoes/31226

[5] Harari Y, Bechar A, Raschke U, Riemer R. Automated simulation-based workplace design that considers ergonomics and productivity. Int. J. Simul. Model. 2017; 16(1): 5-18. doi: 10.2507/IJSIMM16(1).355.

[6] Debnath D, Nath SK, Barthakur NK. Environmental noise pollution in educational institutes of Nagaon town, Assam, India. Global Journal of Science Frontier Research Environment and Earth Sciences. 2012; 12(1): 1-5.https://globaljournals.org/GJSFR_Volume12/1-Environmental-Noise-Pollution-in-Edu.pdf.

[7] Jakovljevic B, Pavnovic K, Belojevic G. Road-traffic noise and factors influencing noise annoyance in an urban population, Environment International. 2009; 35: 552-556. http://dx.doi.org/10.1016/j.envint.2008.10.001

[8] Qzar IA, Azeez NM, Al-Kinany SM. The impact of noise pollution on schools' students of Basra city, Iraq: A Health study. Eurasia J Biosci. 2020; 14: 5197-5201.

[9] Caddick ZA, Gregory K, Arsintescu L, Flynn-Evans EE. A review of the environmental parameters necessary for an optimal sleep environment. Building and Environment. 2018;132: 11–20.

[10] Kamil MY. Ambient air quality monitoring during Nawruz festival in Duhok city, Iraq. International Journal Of Current Research. 2016; 8(5):31040-31046.

[11] Muralikrishna IV, Manickam V. Noise Pollution and Its Control. In: Environmental Management- Science and Engineering for Industry. BSP Books Pvt Ltd; Elsevier Inc.; 2017. p.399-429. http://dx.doi.org/10.1016/B978-0-12-811989-1.00015-4.

[12] MahiPal, Prasad B. Noise pollution and control. Jr. of Industrial Pollution Control. 2004; 20 (1):149 -158.

[13] Lawrence K, Wang and Norman C, Pereira and Yung-Tse Hung. Advanced Air and Noise Pollution Control. New Jersey USA: Humana Press; 2005.p.443-444.

[14] Brainard JS, Jones AP, Bateman IJ, Lovett AA. Exposure to environmental urban noise pollution in Birmingham, UK. Urban Studies. 2004; 41(13): 2581-2600. doi:10.1080/0042098042000294574

[15] Mansouri N, Pourmahabadian M, Ghasemkhani M. Road traffic noise in downtown area of Tehran. Iran J. Environ. Health. Sci. Eng. 2006; 3(4): 267-272. https://applications.emro.who.int/imemrf/Iran_J_Environ_Health_Sci_Eng/Iran_J_Environ_Health_Sci_Eng_2006_3_4_267_272.pdf

[16] Oyedepo OS, Saadu AA. A comparative study of noise pollution levels in some selected areas in Ilorin Metropolis, Nigeria. Environ. Monit. Assess. 2009; 158:155-167. doi: 10.1007/s10661-008-0570-5.

[17] Ausejo M, Recuero M, Asensio C, Pavón I, López JM. Study of precision, deviations, and uncertainty in the design of the strategic noise map of the macrocenter of the city of Buenos Aires, Argentina. Environ.Model. Assess. 2010; 15:125-135. doi: 10.1007/s10666-009-9191-9.

[18] World Health Organization (WHO, n. d.), Deafness and hearing loss. https://www.who.int/news-room/factsheets/detail/deafness-and-hearing-loss.

[19] Central Pollution Control Board (CPCB). Status of ambient noise level in India 2017, New Delhi; 2017. https://cpcb.nic.in/noise_data/Noise_Report_2017.pdf (accessed 06 July 2023).

[20] Basner M, Babisch W, Davis A, Brink M, Clark C, Janssen S, Stansfeld S. Auditory and non-auditory effects of noise on health. The lancet. 2014; 383(9925): 1325-1332.

[21] Basner M, Brink M, Bristow A, De Kluizenaar Y, Finegold L, Hong J, Sörqvist P. ICBEN review of research on the biological effects of noise 2011-2014. Noise and health. 2015; 17(75): 57.

[22] Münzel T, Sørensen M, Schmidt F, Schmidt E, Steven S, Kröller-Schön S, Daiber A. The adverse effects of environmental noise exposure on oxidative stress and cardiovascular risk, Antioxidants and redox signaling. 2018; 28(9): 873-908.

[23] Atkinson R. Ecology of sound: the sonic order of urban space. Urban Studies. 2007; 44(10): 1905-1917. doi:10.1080/00420980701471901.

[24] 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. Science of the Total Environment. 2016; 557:163-9. doi:10.1016/j.scitotenv.2016.03.065.

[25] Ersoy S, Ertuğrul I, Aygül E. Measurement of noise level in the fair area. Applied Technologies and Innovations. 2017; 13(1): 21-25. DOI: doi:10.15208/ati.2017.03.

[26] Maqsood N, Younes I, Nasar-u-Minallah M. Industrial noise pollution and its impact on the hearing capacity of workers: a case study of Gujranwala city, Pakistan. International Journal of Economic and Environmental Geology. 2019; 10(2): 45-49. doi:10.46660/ijeeg.Vol10.Iss2.2019.261.

[27] Kallankandy S, Deswal S. A comprehensive review of noise measurement, standards, assessment, geospatial mapping, and public health. Ecological Questions. 2023; 34(3):1-26. doi:10.12775/EQ.2023.035.

[28] Sadick AM, Issa MH. Occupants' indoor environmental quality satisfaction factors as measures of school teachers' well-being. Build. Environ. 2017; 119: 99-109. doi: 10.1016/j.buildenv.2017.03.045.

[29] Thattai D, Sudarsan JS, Sathyanathan R, Ramasamy V. Analysis of noise pollution level in a university campus in South India, in: IOP Conference Series: Earth and Environmental Science, IOP Publishing, 80,012053;2017. doi: 10.1088/1755-1315/80/1/012053.

[30] Vilcekova S, Meciarova L, Burdova EK, Katunska J, Kosicanova D, Doroudiani S. Indoor environmental quality of classrooms and occupants' comfort in a special education school in Slovak Republic. Build. Environ. 2017; 120: 29-40. doi: 10.1016/j.buildenv.2017.05.001.

[31] Sajin S, Chin CS, Neo J. Acoustics vs. psychoacoustics: an objective and subjective analysis of classroom acoustics in Singapore. Noise Control Eng. J. 2019; 67(2): 80-97. https://www.researchgate.net/publication/335990272_Saju_Sajin_Acoustics_vs_Psychoacoustics_An_Objective_and_Subjective_Analysis_of_Classroom_Acoustics_in_Singapore.

[32] Schlarb AA, Friedrich A, Claßen M. Sleep problems in university students–an intervention. Neuropsychiatric disease and treatment, 2017; 13: 1989.

[33] Slater BR. Effects of noise on pupil performance. J. Educ. Psychol. 1968; 59(4): 239-43. doi: 10.1037/h0026025.

[34] Massonnié J, Rogers CJ, Mareschal D, Kirkham NZ. Is classroom noise always bad for children? The contribution of age and selective attention to creative performance in noise. Front. Psychol. 2019; 10: 381. doi:10.3389/fpsyg.2019.00381.

[35] Hussein RN, Al-Sulttani AH. Spatial analysis of noise in Kufa University (Kufa River Campus) using GIS. Journal of Geoinformatics and Environmental Research. 2021; 1(01): 38-45. doi:10.38094/jgier1114.

[36] Berglund B, Lindvall T, Schwela DH. Guidelines for community noise. World Health Organization; 1999. https://apps.who.int/iris/handle/10665/66217.

[37] Picard M, Bradley JS. Revisiting speech interference in classrooms. Audiology. 2001; 40:22144.

[38] Shield BM, Dockrell JE. The effects of environmental and classroom noise on the academic attainments of primary school children. J Acoust Soc Am. 2008; 123:13344.

[39] Shield B, Greenland E, Dockrell J. Noise in open plan classrooms in primary schools: A review. Noise Health. 2010; 12:22534.

[40] Woolner P, Hall E. Noise in schools: A holistic approach to the issue. Int J Environ Res Public Health. 2010; 7:325569.

[41] Hygge S. Summary of the nonauditory effects of noise on children's health, In: Bistrup ML, Keiding L, editors. Children and Noise: Prevention of Adverse Effects. Copenhagen: National Institute of Public Health; 2002. p.1628:1628.

[42] American National Standards Institute. American National Standard Acoustical Performance Criteria, Design, Requirements, and Guidelines for Schools Accredited Standards Committee S12, Noise (United States: Acoustical Society of America), (ANSI S12.60-2002), New York; 2002.

[43] Bridget MSh, Dockrel JE. The Effects of Noise on Children at School: A Review. J. Building Acoustics. 2003;10(2): 97-106.

[44] Obot OW, Ibanga SM. Investigation of noise pollution in the university. International Journal of Engineering Research and Technology. 2013; 2(8): 1375-1385. https://www.academia.edu/54736329/Investigation_Of_Noise_Pollution_In_The_University

[45] Lee J, Francis JM, Wang LM. How tonality and loudness of noise relate to annoyance and task performance. Noise Control Eng. J. 2017; 65(2): 71-82. doi:10.3397/1/376427.

[46] Farooqi ZUR, Sabir M, Latif J, Aslam Z, Ahmad HR, Ahmad I, Imaran M, Ilic P. Assessment of noise pollution and its effects on human health in industrial hub of Pakistan. Environmental Science and Pollution Research. 2020; 27(3): 2819-2828. doi:10.1007/s11356-019-07105-7.

[47] Ozer S, Zengin M, Yilmaz H. Determination of the noise pollution on university (education) campuses: a case study of Ataturk University. Ekoloji. 2014; 23(90): 49-54. doi:10.5053/ekoloji.2014.906.

[48] Mamun M, Shil A, Paul A, Paul P. Analysis of noise pollution impacting educational institutes near busy traffic nodes in Chittagong city, in: Proceedings of 1st International Conference on green architecture, ICGrA; 2017. p. 127-133. https://www.researchgate.net/publication/319879633

[49] Yadav M., Patel R. K., Yadav A., Sharma G., Pandey G. Assessment of noise pollution at various locations of Gorakhpur. International Journal of Engineering, Science and Technology. 2021; 13(1): 131-137. doi:10.4314/ijest.v13i1.20S.

[50] Herzog NV, Buchmeister B, Spindler L. Assessment of school and industrial noise: measurements vs personal perceptions. DAAAM International Scientific Book; 2020. p. 33-48. DOI:10.2507/daaam.scibook.2020.03.

[51] Banerjee D, Chakraborty SK, Bhattacharyya S, Gangopadhyay A. Attitudinal response towards road traffic noise in the industrial town of Asansol, India. Environ. Monit. Assess. 2009; 151(1-4): 37-44. doi:10.1007/s10661-008-0247-0.

[52] King G, Roland-Mieszkowski M, Jason T, Rainham DG. Noise levels associated with urban land use. Journal of Urban Health. 2012; 89(6): 1017-1030. doi: 10.1007/s11524-012-9721-7.

[53] Kallankandy S, Deswal S. Assessment of noise pollution levels in an academic area of an engineering institute in India. Journal of Engineering, Management and Information Technology. 2024; 02(03):147-160, doi: 10.61552/JEMIT.2024.03.006.

[54] Smaldino JJ, Crandell CC, Kreisman BM, John AB, Kreisman NV. Room acoustics for listeners with normal hearing and hearing impairment. In: Valente M, Hosford Dunn H, Roesner R, editors. Audiology Treatment. 2nd ed. New York: Thieme; 2008.

[55] Kinsler L, Frey A, Coppens A Sanders J. Fundamentals of Acoustics. Canada: John Wiley and Sons;1982.

[56] Emilse AM, Marina AD. College students' perception of classroom noise and its consequences on learning quality. Audiol Commun Res. 2014; 19 (2):138-44.

[57] Muhammad SK, Mohanad F, Hadi A. A Study of some noise pollution variables in sports halls and classrooms for college of sport education-Tikrit University-Iraq. International Journal of Advanced Sport Sciences Research. (2014); 2(4): 417-428.

[58] Ibrahim Sh Aj. Study noise effects on the students of the Faculty of Engineering /Mustansiriyah University. Al-Nahrain Journal for Engineering Sciences. 2018; 20 (2):178-186.

[59] Mahmoud RM, Abbas HA, Yaseen RH. Assessment of Noise Pollution and Architectural Solutions for The Colleges and Universities. REVISTA AUS. (2019); 26:445-453.

[60] Froehlich P. Noise Pollution in the Laboratory. Parker Hannifin Corporation; 2013.

[61] Onyango DO, Kinyua R, Mayaka AN, Kanali Ch. Noise-induced hearing loss in workshops and laboratories in Kenyan Universities. Journal of Environment Pollution and Human Health. 2020; 8(2):79-87.

[62] Asselineau M. Noise control of laboratories: case studies, Acoustics'08 Paris conference, June 29- July 4. 2008.

[63] Balila YA, Siddiqi AA. Critical evaluation of the noise environment with respect to academic activities: A case study of some buildings in the Faculty of Engineering at King Abdulaziz University. Journal of King Abdulaziz University: Engineering Sciences.1999; 2(1):193-210.

[64] Environment Protection Agency (EPA, 2008).

[65] Phukan B, Kalita K. An experimental study of noise pollution in Guwahati, Assam, India. International Journal of Environmental Sciences. (2013); 3:5.

[66] Zannin PH, Gama VL, Cunha ML, Damiani EF, Benetti M, Bianchi H. Noise mapping of an educational environment. Canadian Acoustics. 2013; 40(1):27-34.

[67] El-Sharkawy MF, Alsubaie AS. Study of environmental noise pollution in the University of Dammam Campus. Saudi Journal of Medicine and Medical Sciences. 2014; 2(3):178-184.

[68] Ibrahim Sh Aj. Noise mapping of the campus of the College of Engineering/The University of Al-Mustansiriyah. Journal of Environmental and Earth Science. 2015; 5(4):108-115.

[69] Ibrahim Sh. Aj. Noise mapping of the University of Technology. Journal of Engineering and Sustainable Development. 2016; 20 (6):115-123.

[70] Hassan S H, Ibrahim Sh Aj. The effect of parking lots distribution arrangements on environmental noise level for the universities campuses, IOP: Conference Series: Material Sciences and Engineering; 2020. p.881.

[71] Olaosun AO, Ogundiran O. Noise levels in a Nigerian Tertiary Institution. International Journal of Recent Scientific Research. 2014; 5(4): 720-723.

[72] Ibrahim Sh. Aj. Determining noise zones in the laboratories of the College of Engineering at the University of Al-Mustansiriyah. International Journal of emerging science and engineering (IJESE). 2014; 2(9): 1- 6.

[73] Jaff PM, Hosseini H. Study of noise pollution at the campus of University of Sulaimani. Journal of Kirkuk University – Scientific Studies. 2012; 7(1): 98-109.

[74] Basheer T E, Omar OS, Hashim SK. Effects of noise pollution on Zakho University students at two Faculty of Science buildings. Science Journal of University of Zakho. 2022; 10(2): 35–38. https://doi.org/10.25271/sjuoz.2022.10.2.892

[75] Papageorgiou G, Stravokostas A, Alamanis N, Xafoulis N, Paschalis E. Urban road noise analysis: study on two major roads in the city of Larissa, Greece. Journal of Engineering and Applied Science. 2020; 67(7):1821-1839.

[76] Radosz J. Global index of the acoustic quality of classrooms. Archives of Acoustics. 2013; 38(2): 159–168.

[77] Hodgson M. UBC-Classroom acoustical survey. Canadian Acoustics.1994; 22(4):3-10.

[78] Sato H, Bradley JS. Evaluation of acoustical conditions for speech communication in working elementary school classrooms. Journal of the Acoustical Society of America. 2008; 123(4): 2064–2077.

[79] Radosz J. Methodology issues of ultrasonic noise exposure assessment. Noise Control Engineering Journal. 2012; 60:645-654. 10.3397/1.3701038.

[80] Mikulski W, Radosz J. Effect of volume and equipment on the acoustic performance of classrooms, Proceedings of the Noise Control, Ksiaz; 2010.

[81] Peters R, Smith B, Hollins M. Acoustics and Noise Control, 3rd edition, Pearson Education Limited; 2011.

[82] DIN4109:1989-11 Schallschutz im Hochbau Anforderungen und Nachweise, Sound Insulation in Buildings Requirements and Testing (Germany: DIN).

[83] Williams Sh. What are Room Modes; 2009. (www.gikacoustics.com/what-are-room-modes)

[84] Zannin PHT, Zwirtes DPZ. Evaluation of the acoustic performance of classrooms in public schools. Appl. Acoust. 2009; 70: 625-35.

[85] Rasmussen B, Brunskog J, Hoffmeyer D. Reverberation time in classrooms – Comparison of regulations and classification criteria in the Nordic countries, Proceedings of Joint Baltic-Nordic Acoustics Meeting, June 18th-20th, Denmark; 2012.

[86] Toyinbo O, Matilainen M, Turunen M, Putus T, Shaughnessy R, Haverinen-Shaughnessy U. Modeling associations between principals reported indoor environmental quality and students' self-reported respiratory health outcomes using GLMM and ZIP Models. Int. J. Environ. Res. Public Health. 2016;13(385).

[87] Montiel I, Mayoral AM, Pedreño JN, Maiques S. Acoustic comfort in learning spaces: moving towards sustainable development goals. Sustainability. 2019; 11: 3573. www.mdpi.com/journal/sustainability,

[88] Connolly D, Dockrell J, Shield B, Conetta RA, Mydlarz CA, Cox TJ. The effects of classroom noise on the reading comprehension of adolescents. The Journal of the Acoustical Society of America .2019; 145 (1): 372. http://usir.salford.ac.uk/id/eprint/49931/

[89] Bakare SY, Alibaba HZ. The construct of comfort: A case study of environmental comfort of university classrooms. United International Journal for Research and Technology.2020; 1(6):19-23.

[90] Ibrahim Sh Aj. Room mode analysis for classrooms: a case study in the College of Engineering, IOP Conference Series: Materials Science and Engineering, 870; 2020.

[91] World Health Organization (WHO). Noise, Environmental Health Criteria 12; 1980.

[92] World Health Organization (WHO). Occupational noise, Environmental Burden of Disease Series, No. 9; 2004.

[93] National Institute for Occupational Safety and Health (NIOSH). Criteria for a Recommended Standard, Occupational Noise Exposure, NIOSH Publication No.98:126;1998

[94] Canadian Centre for Occupational Health and Safety (CCOHS). Noise-Auditory Effects. 2011.

[95] Stansfeld SA, Matheson MP. Noise pollution: non-auditory effects on health. British Medical Bulletin. 2003; 68(1):243-57. PMID: 14757721

[96] Auger N, Duplaix M, Bilodeau-Bertrand M, Lo E, Smargiassi A. Environmental noise pollution and risk of preeclampsia. Environ. Pollut. 2018; 239:599-606. PMID: 29704672

[97] Goines L, Hagler L. Noise pollution: a modern plague. South Med J. 2007; 100(3):287-94. PMID: 17396733

[98] Passchier-Vermeer W, Passchier WF. Noise exposure and public health. Environmental Health Perspectives.2000; 108(1):123-131.

[99] Clausen Th, Christensen K, Lund Th, Kristiansen J. Self-reported noise exposure as a risk factor for long-term sickness absence. Journal of Noise and Health. 2009; 11(43): 93-97.

[100] Hammersen F, Niemann H, Hoebel J. Environmental noise annoyance and mental health in adults: Findings from the cross-sectional German health update (GEDA) study 2012. Int. J. Environ. Res. Public Health. 2016; 13: 954.

[101] EnHealth Council. The health effects of environmental noise - other than hearing loss. Australia: Commonwealth of Australia, Department of Health and Ageing, Publication No. 3311 (JN 7845); 2004.

[102] Martín MA, Tarrero A, González J, Machimbarrena M. Exposure effect relationships between road traffic noise annoyance and noise cost valuations in Valladolid, Spain. Appl. Acous. 2006; 67:945-58.

[103] Clark C, Stansfeld SA. The effect of transportation noise on health and cognitive development: a review of recent evidence. Int J Comp Psychol. 2007; 20:145-58.

[104] Acoustical Society of America. Classroom Acoustics. 2003. (asa.aip.org).

[105] Rabelo N, Oliveria C, Magalhaes M. Effect of classroom acoustics on the speech intelligibility of students. Jornal da Sociedade Brasileira de Fonoaudiologia (CoDAS). 2014; 26 (Brazilian Society of Speech Therapy).

[106] Sarlati S, Haron Z, Yaha K. The importance of acoustic quality in classroom. Journal Teknologi, (Universiti Teknologi Malaysia). 2014; 70.

[107] Nermin B. Noise pollution in Turkish elementary schools: evaluation of noise pollution awareness and sensitivity training. Int J of Environ and Sci Edu. 2014; 9: 215-234.

[108] Gilavand A, Jamshidnezhad A. The effect of noise in educational institutions on learning and academic achievement of elementary students in Ahvaz, South West of Iran. Int J Pediatr. 2016; 4(3): 1453-63.

[109] Chiang C, Lai C. Acoustical environment valuation of joint classrooms for primary schools in Taiwan. Build. Environ. 2008; 43(4):1619–32.

[110] Engel MS, Ferraz FH, Zannin PHT. Characterization of environmental noise on a university campus based on noise measurements and interviews, DAGA 2012 – Darmstadt; 2012. p.117-118.

[111] Sutton P. Process plant noise: Evaluation and control. Applied Acoustics. 2003; 9: 17-33.

[112] Ramussen RO, Bernhard RJ, Sandberg U, Mun EP. The little book of quieter pavements. Security; 2007. p.1–33.

[113] Federal Railroad Administration (FRA). High-Speed Ground Transportation Noise and Vibration Impact Assessment manual; 2012. p.2-1.

[114] Franken AP. Community Noise Pollution, Industrial Pollution. 1974 ed. New York: Van Noistrand Reinhold Company; 1974.

[115] Muralikrishna KVSG. Air Pollution and Control. 1995 ed. Kakinada, AP: Kaushal and Co.; 1995.

[116] Rao PR. Noise Pollution and Control, Encyclopedia of Environmental Pollution and Control. 1995 ed, Vol.:2. India: Environmedia Publications; 1995.

[117] Environmental Protection Department. Guidelines on Design of Noise Barriers, Government of the Hong Kong SAR Second Issue; 2003. Available from: http://www.epd.gov.hk/epd/english/ environmentinhk/noise/guide_ref/files/barrier_leafl et.pdf.

[118] Mathur JSB. Noise Control: Legislation, Planning and Design, Industrial Effluent Treatment.1981 ed., Vol.:2. London: Applied Science Publishers Ltd.; 1981.

[119] Al Mamun Md, Mustiafiz, Shil A, Paul A, Paul P. Analysis of noise pollution impacting educational institutes near busy traffic nodes in Chittagong City,1st International Conference on Green Architecture (ICGrA 2017) Prospects and Challenges of Going Green 4-5 August 2017, Dhaka, Bangladesh; 2017.

[120] Martenes MJM. Noise abatement in plant monoculture and plant communities. J. Applied Acoustics.1981; 14: 167–189.

[121] Watts GR, Chinn L, Godfrey N. The effect of vegetation on the perception of traffic noise. Applied Acoustic.1999; 56: 39-56.

[122] Ozer S, Akif Irmak M, Yilmaz H. Determination of roadside noise reduction effectiveness of Pinus sylvestris L. and Populus nigra L.in Erzurum, Turkey. Environ. Monitoring and Assessment. 2007; 1: 11-18.

[123] Aylor DE. Noise reduction by vegetation and ground. J. Acoust. Soc. Am.1972; 51: 197–205.

[124] Cook DI, Haverbeke DFV. Trees and shrubs for noise abatement. University of Nebraska College of Agriculture Experiments Bulletin, RB-246: 218;1974.

[125] Finke L. Abilities of green spaces to improve urban climate and air in the respect of urban planning. İstanbul University Faculty of Forestry Journal.1980; 30(2): 225-255.

[126] Bernatzky A. Tree ecology and preservation. Amsterdam - Oxford - New York: Elsevier Scientific Publishing Company; 1978.

[127] Price MA. Sound attenuation through trees: Measurement and models. J. Acoust. Soc. Am. 1988; 84: 1836-1844.

[128] Aparicio-Ramon, DV, Surez M. Subjective annoyance caused by environmental noise. J.Environ. Pathol. Toxicol. Oncol. 1993; 12: 237-243.

[129] Khan Sh A, Kainat F, Saddam Hussain, Muhammad Minhal Ali, Abdul Mannan, Nasim Iqbal Butt. Mitigation of noise pollution in urban areas by strategically planting trees and shrubs. Journal CleanWas. 2023; 7(1): 41-47.

[130] Erdoğan E, Yazgan ME. Landscape architecture works in the reduction of noise problem in cities: the sample of Ankara. Journal of Tekirdag Agricultural Faculty. 2007; 4(2): 201-210.

[131] Başar H. Class Management. Ankara: Pegem Publications; 2000.

[132] Demirel Ö. Noise problem in Trabzon and solution approach with green texture. Noise Pollution. No:1998/1. Trabzon: TMMOB Chamber of Mechanical Engineers Trabzon Branch Publication;1998.

[133] Güler Ç, Çobanoğlu Z. Noise. Ankara: Environmental Health Basic Resource Series No: 19; 1994.