Analysis and Assessment of Noise Pollution in University Campus and Human Health

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Abstract— Noise is a pollutant. In contrast to other environmental problems, noise pollution continues to grow, and it has a short decay time. In this paper, seven reference libraries which situated in different locations inside university campus were assessed. At each location, noise levels were measured continuously every 30 seconds for at least 3 hours. Maximum sudden noise levels were also recorded every five minutes during this assessment. The average sound pressure level, (Lp), equivalent continues equal energy level, (Leq), sound exposure level (SEL), in addition to statistical measures (L10), (L50), and (L90) were also calculated during this work. The results of assessment show that most of these locations are suffering from high noise pollution. The average noise levels, (Lp) at the library of colleges of Arts, education, administration and economic, mathematics and computer science, and dentistry were 61.7, 57.7, 52.3, 58.5, and 57.3 dBA respectively. All these levels are surpassed the level recommended by criteria which equals to 40 dBA. In the halls of central library these levels were equal to 40.3, and 39.0 dBA. The values of (Leq) were also considerably above the recommended levels in all locations. Worst condition was noted in the college of Art which had (Leq) value of 62.4 dBA followed by the colleges of education, mathematics and computer science and, dentistry which had values equal to 58.4, 59.4, 57.8 dBA respectively. The effect of neighbouring corridors noise was very distinguished in the colleges of Arts, education, mathematics and computer science, and dentistry. At college of administration and economic this effect was less important. The bad selection of the finishing materials plays a rule in increasing the noise pollution inside the libraries.
From this standpoint the halls of the central library possessed the best handling whereas; the worst treatment is noted in the college of Education. The most polluted site by the sudden impact noise is the college of Arts. Most of this noise is coming from external sources. The central library has the most quite location. The disarray actions inside the halls have also a role in increasing the maximum sudden noise levels. From this viewpoint the college of education has the worst condition followed by the college of economic.

Keywords: Noise Pollution, Human Health

I. INTRODUCTION

Noise, commonly defined as unwanted sound, is an environmental phenomenon to which humans are exposed before birth and throughout life. Whether a sound is unwanted depends on when and where it occurs, what the listener is doing when it occurs, characteristics of the sound (loudness, pitch and duration, speech or music content, irregularity), and how intrusive it is above background sound levels. Noise can also be considered an environmental pollutant, a waste product generated in conjunction with various human activities. Under the letter definition, noise is any sound that can produce an undesired effect in an individual, and that may interfere with social ends of an individual or group. These social ends include all activities such as communication, work, rest, sleep and others. As waste, the humans produce two general types of pollutants.

The general public has become well aware of the first type – the mass residuals associated with air and water pollution – that remains in the environment for extended period of time. However, only recently has attention been focused on the second general type of pollution, the energy residuals such as the waste heat from manufacturing processes that creates thermal pollution of streams. Energy in the form of sound waves constitutes yet another kind of energy residual, but, fortunately, one that does not remain in the environment for extended periods of time.

Noise has a short decay time and thus does not remain in the environment for extended periods, as do air and water pollution. Noise has a significant impact on the quality of life and is a health problem in accordance with the World Health Organization's (WHO) definition of health. Excessive noise has been blamed not only for hearing damage and community annoyance but also for hypertension, fatigue, and heart trouble. In general, a pattern of exposure to any source of sound that produces high enough levels can result in temporary hearing losses. If the exposure persists over a period of time, this could lead to permanent hearing impairment.

In addition, noise can interfere with the teaching and learning process, disrupt the performance of certain tasks, and increase the incidence of antisocial behaviour. Much work has been done in an effort to understand the effect of noise on human beings and to establish suitable criteria for relating the unfavourable effects to specific measurements of sound field. These criteria are then used to develop standards which describe noise environments considered acceptable in a given situation(11). These standards then form the basis for regulations which are adopted by communications to prescribe acceptable noise environments in the community and workplaces. The level of sound is a measure of its intensity, expressed in decibels (dB).

Most of the sounds hear in the environment are a combination of many frequencies at many levels. Common terms and measures for noise and sound are: dBA: Sound is measured on a logarithmic decibel (dB) scale. A more common measure of sound, dBA is based on this scale but is weighted to account for frequency and pitch, which affect human perceptions of sound. It is important to note that 3 dBA is considered the minimum perceptible change in noise level and that a 10 dBA sound increase is perceived as a doubling of loudness. Therefore, changes in noise levels of 3 dBA may be considered a minor impact.

A. Research Objectives

This research aims to achieve the following objectives-

1) To assess the conditions of noise pollution inside the libraries.
2) To analyse the characteristics of noise pollution inside the selected locations.
3) To evaluate factors those are affecting on the noise levels in these locations.

B. Theoretical Calculations of Sound Level Metrics

1) The LN Concept

The parameter LN is a statistical measure that indicates how frequently a particular sound level is exceeded (19). If for example, we write L40 equal a specific value than we know that this level was exceeded for 40 % of the measuring time. A plot of LN against N where N = 1 %, 2 %, 3 % and so forth, would look like cumulative curve. Allied to the cumulative distribution curve is the probability distribution curve. A plot of this will show how often the noise levels fall into certain class intervals. The relationship between this curve and that for LN can be done by adding the %ages in given successive class interval from right to left.

2) The Leq Concept

The equivalent continues equal energy level; (Leq) can be applied to any flocculating noise level (20, 21). It is that constant noise level that, over a given time, expands the same amount of energy as the flocculating level over the same time period. It is expressed as follows:

$$L_{eq} = 10 \cdot \log \cdot \left[\frac{1}{t} \cdot \int_0^t 10^{\frac{L_i}{10}} \cdot dt \right]$$

Where:
t = the time over which Leq is determined
L(t) = the time varying noise level in dBA
Generally, there is no well-defined relationship between L(t) and time, so a series of discrete samples of L(t) have to be taken. This modifies the expression to:

$$L_{eq} = 10 \cdot \log \left(\frac{1}{t} \cdot \sum_{i=1}^{i=n} 10^{\frac{L_i}{10}} \cdot t_i \right)$$

Where:
n = the total number of samples taken
Li = the noise level in dBA of the jth sample
ti = fraction of total sample time.

3) Maximum Sound pressure Level (Lmax)

The highest sound level measured during a single event in which the sound level changes value as time goes on is called the maximum sound level. It is usually abbreviated by Lmax. Two different time periods may be used to determine Lmax: 0.125s (fast response) or 1.0 s (slow response). The “A” frequency weighting typically is used with Lmax and is identified as LAmax.

4) Sound Exposure Level (SEL)

Individual time-varying noise events have two main characteristics: a sound level which changes throughout the event and a period of time during which the event is heard. Although the maximum sound level, described above, provides some measure of the intrusiveness of the event, it alone does not completely describe the total event. The period of time during which the sound is heard is also significant: The longer the event, the more intrusive it will be. The Sound Exposure Level (abbreviated SEL) combines both of these characteristics into a single metric. It has the physical units of pressure-squared multiplied by duration (time). Sound Exposure Levels are usually A-weighted (ASEL).

Note that sound exposure level is a composite metric that represents both the intensity of a sound and its duration. It does not directly represent the sound level heard at any given time, but rather provides a measure of the net impact of the entire acoustic event. It has been well established in the scientific community that Sound Exposure Level measures this impact much more reliably than just the maximum sound level.

Because the Sound Exposure Level and the maximum sound level are both expressed in decibels, there is sometimes confusion between the two, so the specific metric used should be clearly stated. The following equation can be used to calculate the sound exposure level:

$$L_{AE} = 10 \cdot \log \cdot \left[\frac{1}{t_0} \cdot \int_0^t 10^{\frac{L_i}{10}} \cdot dt \right]$$

$$L_{AE} = 10 \cdot \log \left(\frac{1}{t_0} \cdot \sum_{i=1}^{i=n} 10^{\frac{L_i}{10}} \cdot t_i \right)$$

Where:t0 = the reference duration (1 second)

II. MEASUREMENT PROCEDURES

The experimental procedure was designed to calculate the sound pressure level inside the references libraries. Digital professional sound level meter type (EXTTECH 407727) with a resolution of 0.1dB and selectable weighting (A or C) and response time (fast or slow), was used in this evaluation. Seven libraries which located in different locations inside the university were selected for this study. All tests have been done according to methodology suggested by the Executive Director of the Pollution Control Agency and the American National Standards Institute (ANSI) S1.4-1983 (1, 23) for the measurement of non-impulsive noise.

In all measurements, the sound measuring device was adjusted to be on "A" weighting and SLOW response characteristics; and it was putted at the point of human activity nearest the noise source at least one meter off the ground or surface and away from natural or artificial structures which would prevent an accurate measurement (barriers, houses).

The measurement procedure was divided into eight groups; each one represents one of the selected libraries. In each group three to four runs were conducted. Each run represents the readings for one day measurement. In each day, the noise meter readings were recorded every 30 seconds continuously for at least three hours. During the measurement the noise level readings were varied within a range between 36 to 84 dBA, see figure (1). Each 10 of noise meter readings which correspond to a period of time equal to 5 minutes were combined and averaged using equations so; one middling reading for each five minutes was obtained.

For each library, one average value for the collection of sound pressure measurements was calculated using equation (3). The equivalent continues equal noise levels, (Leq) were estimated using equation (5). Sound exposure levels with a referencing time interval of one second were also determined at each group using equation(7).

The maximum sound pressure levels (Lmax) were recorded continuously every five minutes during each run of measurements using a period time of one second (slow response) and "A" frequency weighting as recommended by(2, 4). The average noise pressure levels of the maximum measurements for each library were calculated using equation (3).

III. HUMAN HEALTH EFFECTS

The WHO has documented seven categories of adverse health effects of noise pollution on humans. Much of the following comes from the WHO Guideline on Community Noise and follows its format. The guideline provides an excellent, reasonably up-to-date, and comprehensive overview of noise-related issues, as do the other recent reviews on this subject;

A. Hearing Impairment

Hearing is essential for well-being and safety. Hearing impairment is typically defined as an increase in the threshold of hearing as clinically assessed by audiometry. Impaired hearing may come from the workplace, from the community, and from a variety of other causes (eg, trauma, ototoxic drugs, infection, and heredity). There is general agreement that exposure to sound levels less than 70 dB does not produce hearing damage, regardless of the duration of exposure.

There is also general agreement that exposure for more than 8 hours to sound levels in excess of 85 dB is potentially hazardous; to place this in context, 85 dB is roughly equivalent to the noise of heavy truck traffic on a busy road. With sound levels above 85 dB, damage is related to sound pressure (measured in dB) and to time of exposure. The major cause of hearing loss is occupational exposure, although other sources of noise, particularly recreational noise, may produce significant deficits. Studies suggest that children seem to be more vulnerable than adults to noise induced hearing impairment.

Noise induced hearing impairment may be accompanied by abnormal loudness perception (loudness recruitment), distortion (paracusis), and tinnitus. Tinnitus may be temporary or may become permanent after prolonged exposure. The eventual results of hearing losses are loneliness, depression, impaired speech discrimination, impaired school and job performance, limited job opportunities, and a sense of isolation.

B. Negative Social Behaviour and Annoyance

Annoyance is defined as a feeling of displeasure associated with any agent or condition believed by an individual to adversely affect him or her. Perhaps a better description of this response would be aversion or distress. Noise has been used as a noxious stimulus in a variety of studies because it produces the same kinds of effects as other stressors. Annoyance increases significantly when noise is accompanied by vibration or by low frequency components. The term annoyance does not begin to cover the wide range of negative reactions associated with noise pollution; these include anger, disappointment, dissatisfaction, withdrawal, helplessness, depression, anxiety, distraction, agitation, or exhaustion. Lack of perceived control over the noise intensifies these effects.

Social and behavioural effects of noise exposure are complex, subtle, and indirect. These effects include changes in everyday behaviour (eg, closing windows and doors to eliminate outside noises; avoiding the use of balconies, patios and yards; and turning up the volume of radios and television sets); changes in social behaviour (eg, aggressiveness, unfriendliness, nonparticipation, or disengagement); and changes in social indicators (eg, residential mobility, hospital admissions, drug consumption, and accident rates); and changes in mood (increased reports of depression).

Noise exposure per se is not believed to produce aggressive behaviour. However, in combination with provocation, pre-existing anger or hostility, alcohol or other psychoactive agents, noise may trigger aggressive behaviour.

The results of annoyance are privately felt dissatisfaction, publicly expressed complaints to authorities (although underreporting is probably significant), and the adverse health effects already noted. Given that annoyance can connote more than slight irritation, it describes a significant degradation in the quality of life, which corresponds to degradation in health and wellbeing. In this regard, it is important to note that annoyance does not abate over time despite continuing exposure to noise.

C. Interference with Spoken Communication

Noise pollution interferes with the ability to comprehend normal speech and may lead to a number of personal disabilities, handicaps, and behavioural changes [1]. These include problems with concentration, fatigue, uncertainty, lack of self-confidence, irritation, misunderstandings, decreased working capacity, disturbed interpersonal relationships, and stress reactions. Some of these effects may lead to increased accidents, disruption of communication in the classroom, and impaired academic performance. Particularly vulnerable groups include children, the elderly, and those not familiar with the spoken language.

D. Sleep Disturbances

Uninterrupted sleep is known to be a prerequisite for good physiologic and mental functioning in healthy individuals. Environmental noise is one of the major causes of disturbed sleep. When sleep disruption becomes chronic, the results are mood changes, decrements in performance, and other long-term effects on health and well-being. Much recent research has focused on noise from aircraft, roadways, and trains. It is known, for example, that continuous noise in excess of 30 dB disturbs sleep. For intermittent noise, the probability of being awakened increases with the number of noise events per night.

The primary sleep disturbances are difficulty falling asleep, frequent awakenings, waking too early, and alterations in sleep stages and depth, especially a reduction in REM sleep. Apart from various effects on sleep itself, noise during sleep causes increased blood pressure, increased heart rate, increased pulse amplitude, vasoconstriction, changes in respiration, cardiac arrhythmias, and increased body movement. For each of these, the threshold and response relationships may be different. Some of these effects (waking, for example) diminish with repeated exposure; others, particularly cardiovascular responses, do not. Secondary effects (so-called after effects) measured the following day include fatigue, depressed mood and well-being, and decreased performance. Decreased alertness leading to accidents, injuries, and death has also been attributed to lack of sleep and disrupted circadian rhythms.

Long-term psychosocial effects have been related to nocturnal noise. Noise annoyance during the night increases total noise annoyance for the following 24 hours. Particularly sensitive groups include the elderly, shift workers, persons vulnerable to physical or mental disorders, and those with sleep disorders.

E. Cardiovascular Disturbances

A growing body of evidence confirms that noise pollution has both temporary and permanent effects on humans (and other mammals) by way of the endocrine and autonomic nervous systems. It has been postulated that noise acts as a nonspecific biologic stressor eliciting reactions that prepare the body for a fight or flight response. For this reason, noise can trigger both endocrine and autonomic nervous system responses that affect the cardiovascular system and thus may be a risk factor for cardiovascular disease. These effects begin to be seen with long-term daily exposure to noise levels above 65 dB or with acute exposure to noise levels above 80 to 85 dB. Acute exposure to noise activates nervous and hormonal responses, leading to temporary increases in blood pressure, heart rate, and vasoconstriction. Studies of individuals exposed to occupational or environmental noise show that exposure of sufficient intensity and duration increases heart rate and peripheral resistance, increases blood pressure, increases blood viscosity and levels of blood lipids, causes shifts in electrolytes, and increases levels of epinephrine, norepinephrine, and cortisol. Sudden unexpected noise evokes reflex responses as well.

Cardiovascular disturbances are independent of sleep disturbances; noise that does not interfere with the sleep of subjects may still provoke autonomic responses and secretion of epinephrine, norepinephrine, and cortisol. These responses suggest that one can never completely get used to night-time noise.

Temporary noise exposure produces readily reversible physiologic changes. However, noise exposure of sufficient intensity, duration, and unpredictability provokes changes that may not be so readily reversible. The studies that have been done on the effects of environmental noise have shown an association between noise exposure and subsequent cardiovascular disease. Even though the increased risk for noise-induced cardiovascular disease may be small, it assumes public health importance because both the number of people at risk and the noise to which they are exposed continue to increase.

Children are at risk as well. Children who live in noisy environments have been shown to have elevated blood pressures and elevated levels of stress-induced hormones.

F. Disturbances in Mental Health

Noise pollution is not believed to be a cause of mental illness, but it is assumed to accelerate and intensify the development of latent mental disorders. Noise pollution may cause or contribute to the following adverse effects: anxiety, stress, nervousness, nausea, headache, emotional instability, argumentativeness, sexual impotence, changes in mood, increase in social conflicts, neurosis, hysteria, and psychosis [2]. Population studies have suggested associations between noise and mental-health indicators, such as rating of well-being, symptom profiles, the use of psychoactive drugs and sleeping pills, and mental hospital admission rates. Children, the elderly, and those with underlying depression may be particularly vulnerable to these effects because they may lack adequate coping mechanisms. Children in noisy environments find the noise annoying and report a diminished quality of life.

Noise levels above 80 dB are associated with both an increase in aggressive behaviour and a decrease in behaviour helpful to others. The news media regularly report violent behaviour arising out of disputes over noise; in many cases these disputes ended in injury or death. The aforementioned effects of noise may help explain some of the dehumanization seen in the modern, congested, and noisy urban environment.

IV. RESULTS AND DISCUSSION

The probability distribution curves of noise levels at each of the colleges of Arts, Education, Administration and Economic, Mathematics and Computer Science, Dentistry, , first floor reference hall at the Central library, and second floor reference hall the at central library respectively. In table (2), the calculations of the noise level metrics at these locations are represented. Although the average sound pressure level (Lp) and the noise equivalent levels (Leq) are the preferred noise indexes, %ile levels L10 and L50 are also measured. Normally, L10 represents the value near to the average of the noise peaks, L50 is near to the mean level for the readings and L90 may be considered as background noise level.

As noted in the table, the average sound pressure levels for five of measured locations were significantly above the recommended level suggested by the criteria which equal to 40 dBA(11). The average levels at the central library were better than the other five locations. At the first floor the average value of reference hall was nearby to the recommended value and it was equal 41.23 dBA, whereas the average sound pressure level in the reference hall which located at the second floor was appropriate since it less than the recommended value by the criteria.

In order to assess the impact of noise on the people inside the libraries, the noise equivalent levels (Leq) were also measured at these locations. For most of these areas, the levels of noise exceed the standards recommended inside the halls of reference libraries(11). These values also varied from one location to other. Worst value was calculated in the library of the college of Arts which was equal to 62.4 dBA. As well understand this value is too high and extremely increase the recommended value.

The energy of the maximum isolated noise event which happened during the test and lasted for one second is measured in the parameter of the sound exposure level (SEL). As in the other factors, the college of Arts had the highest value. Each of external and internal sources is responsible for this result. The effect of random noise that coming from the neighbouring corridor was very distinguished in this library in addition to the unsuccessful selection of the finishing materials inside the library plays a great rule in this failure.

Percentage of readings had maximum noise level between 80 and 82 dBA. The majority of maximum noise level readings in each of college of education and administration and economic ranged between 82 to 85 and 77 to 80 respectively. In the colleges of Mathematics and Dentistry the mass part of maximum readings had noise values ranging between 77 to 79 and 82 to 85 dBA respectively. About 28 % of readings recorded in the 1st floor hall of the central library had noise levels ranging between 49 and 51 dBA whereas 23 % of readings recorded in the 2nd floor had values ranging between 44 and 46 dBA.

The probability distribution curves for the maximum noise levels at each library are represented. In table (3), the calculation of maximum noise level metrics recorded during the work are reviewed. Basically, maximum sound pressure level represents the sudden impact noise coming from either external or internal source. In our work this factor was measured continuously each five minutes.

The effect of external sources can generally reflect by the (L90) factor(19, 2, 4) whereas, the effect of noise that coming from disarray sudden action inside the hall, such as chair trail, scream or any other action is usually appeared by the difference between (L90) and (Lp). From this standpoint, the library of the college of Arts is the most polluted location by noise; most of this noise is coming from external sources. The central library has most quite location; the 2nd floor hall is better than one in the first floor. The library of the college of education has the most disarray noise levels followed by the library of the college of administration and economic. The maximum noise level readings at these locations were classified in individual groups.

One more additional note is that the noise pressure levels tend to distribute normally. In figures (14 and 15) the cumulative distribution curves for the halls of the central library are represented. As shown, 54 and 76 % of noise level readings recorded in these locations were ranging between 36 to 40 dBA. The shape of noise levels distribution in these locations has other types of distribution.

This is due to better isolation of the external corridor noise. The effect of good handling of these halls plays also a rule in this arrangement. However, if the effect of external noise is omitted from noise distribution curves of these locations a type of normal distribution can be noted.

V. CONCLUSIONS

The assessment of noise level pressure at seven reference libraries shows that most of these locations are suffering from high noise pollution. The average sound pressure levels, (Lp) at the library of the college Arts, education, administration and economic, mathematics and computer science, and dentistry were 61.737, 57.743, 52.309, 58.526, and 57.276 dBA respectively. All these levels extremely above the level recommended by criteria which equal to 40 dBA. The average sound levels (Lp) in the reading halls at the 1st and 2nd floors of central library were less than that for other locations and equal to 40.228, and 38.969 dBA respectively.

To assess the impact of noise on the people inside the libraries, equivalent continues energy level, (Leq) is calculated. In all locations this level was above the recommended value. Worst condition was noted in the college of Art which had (Leq) value of 62.4 dBA. These values were slightly lower in the college of education, mathematics and computer science and dentistry which were equal to 58.37, 59.367, 57.826 dBA respectively. In The reading halls of the 1st and 2nd floors of the central library the equivalent continues energy level, (Leq) were equal to 42.6, and 40.208 dBA respectively.

The majority of noise pollution occurred in the college of Arts is coming from non-internal sources. However, the effect of neighbouring corridors noise was very distinguished in the colleges of education, mathematics and computer science and dentistry. At college of administration and economic this effect was lesser. In the reading halls of 1st and 2nd floors of the central library the impact of this factor was less important.

The bad selection of ground and roof finishing materials in addition to the unsuitable arrangement of the tables and bookshelves inside halls play a role in increasing the noise pollution in these libraries. From this standpoint the hall of the central library which located on the second floor has the best handling whereas; the worst treatment is noted in the library of the college of administration and economic.

More than 23% of recorded noise levels in the college of Arts had values between 61 and 63 dBA. About 22% of readings in the college of education had levels ranging between 56 and 58 dBA. In the college of Administration and economic, more than 32% of readings had noise level varied between 53 and 57 dBA, whereas 18 % of levels in the college of mathematics and programming science had noise pressure between 57 to 59 dBA. In the college of Dentistry more than 26 % of readings possess noise pressure level ranging between 55 to 57dBA.The ultimate goal should be to identify ways to improve the acoustic environment, but generally only rudimentary measures (dBA) have been reported. These acoustic metrics may be overly simplistic for hospital environments [5]. Additionally, a number of “mechanism” studies evaluating changes in the acoustic environment are needed in order to optimize the effectiveness of acoustic or behavioural alterations [7]. We should prevent exposure of noise in working environment to save our precious life.

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