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Noise Mapping of the Campus of the College of Engineering /The University of Al-Mustansiriyah

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Abstract
Noise mapping gives factual information on outdoor noise level propagation by describing real situations. This approach helps to assess the noise levels to which people are exposed and monitor the impact of noise. This paper focuses on campus noise mapping, where there are various noise sources such as electrical diesel generators, parking lots, industrial buildings, road traffic and students gathering in small gardens and squares, which generate high noise levels with adverse effects on students' concentration, communications, mental activities, and learning ability, causing annoyance and hearing impairments. Noise maps drawn by the SoundPlan software involve determining and inserting all noise source requirements followed by comparison with real measurements by using a SVAN957 Type 1 sound and vibration meter with analyzer. Based on two noise mappings, one with generators turned off and another with generators turned on, the dominant noise levels on the campus exceed the permissible limit of 55 dB(A) by WHO. The danger is located in and around areas in which students gather (small gardens and squares) where they take breaks near the generators and other noise sources without awareness of the noise levels to which they are exposed.
Keywords: equivalent continuous A-weighted sound pressure level, noise mapping, noise sources, SoundPlan software.

1. Introduction

Since the 1970s, organizations and agencies, such as the World Health Organization (WHO), National Institute for Occupational Safety and Health (NIOSH), and Occupational Safety and Health Administration (OSHA), have comprehended the dangers of noise on individuals themselves and their life, noted the adverse effects of noise (for example, annoyance, affects the learning and memory of students, sleep disturbance, physiological stress reactions and cardiovascular diseases, in addition to acoustic trauma, tinnitus, and temporary and permanent hearing loss) and raised the alarm regarding noise pollution (NIOSH,1998; Birglund *et al*, 1999; OSHA). According to WHO, noise can be observed everywhere, indoors and outdoors, from road traffic, railways, aircraft, industries, construction and public work; accordingly, countries have been encouraged to assess and determine noise pollution in their territories by drawing noise maps (NIOSH,1998; Birglund *et al*, 1999; OSHA; Stansfeld &Matheson,2003; CCOHS,2011; Hellmuth *et al*, 2012).

In general, noise pollution research indicates the adverse effects of noise on activities such as communication and concentration, particularly, in educational institutions (schools, educational laboratories, colleges and universities); the campus is a place where many noise sources can be found, such as noise generated by leisure activities as well as noise emissions from laboratories, electrical generators, nearby road, rail and air traffic, and industry sites. Some of the researchers studying noise levels on different campuses have found the main noise sources to be road traffic. For example, Balila and Siddiqi (1999) found the noise levels in the campus of Faculty of Engineering, KSA, to be higher than the preferred noise criteria curves (PNC 55) due to the main roads around the campus.

On the campus of Guhati University, India, the traffic noise generated from the national highway that passes through it was mostly responsible for noise nuisances. The noise levels measured in the morning, midday and evening are found to be between 10 to 11.2 dB(A) above the prescribed noise limits for the silence area category for which given by Central Pollution Control Board (Phukan & Kalita,2013).

Traffic noise was also the main noise source on the campus of Atatürk University, Turkey. At the entrance of the campus, the rates of flow were 971 vehicle/hr, so the noise levels measured at various locations were above the permitted value of 55 dB(A) according to the Turkish Environmental Determinants (Ozer *et al*,2014). This noise source was also found on the Campus of the University of Dammam, KSA, where the researcher concluded that the noise levels generated from the traffic flow inside the campus exceeded the WHO guidelines, 55 dB(A) (Al-Sharkawy&Alsubaie, 2014).

Other researchers, such as Olaosun and Ogundiran (2014), found different noise sources on the campus, such as electrical generators, pumps, vehicles horns, welding and lathe machines at the general workshop and ambient noise from bus stops. They measured the noise levels on the campus (at noisy outdoor locations near the main noise sources) of the University of Ibadan, Nigeria, and they found that noise levels exceeded 85 dB in most of these locations, especially near the electrical generator, where the highest levels reached 112 dB.

Noise mapping is the best way to determine how outdoor noise levels differ with location (Peters *et al*, 2011). Noise mapping depends basically on the determination and description of the area under study, including noise sources (road, rail, and air traffic, industrial and construction activities), the number of people exposed (receivers), topography, and meteorological conditions, measuring the equivalent continuous A-weighted sound pressure level and sound power level in dB(A) (ISO-2,1996; DIN45682,2002; WG-AEN,2007). Noise mapping addresses large agglomeration areas such as countries, cities, and industrial plants. For this research, the goal is to draw a noise map for a small agglomeration area (college campus) where the number of people (staff and students) is approximately three thousand, by determining the noise sources and measuring and estimating the outdoor noise levels, to find the noise levels to which people are exposed during the working day. In addition, through noise mapping, the worst noise sources on the campus can be identified.

2. Description of College Site

The site of the college is bounded to the north by existing miscellaneous (residential, commercial and industrial) properties, to the southeast by a side street with bookshops and hawkers, and to the west by the Bab Al-Moatham main road, the Physical Education College and the College of Nursing. The total area is approximately 46700 m^2. Fig. 1 shows a satellite image of the college site.

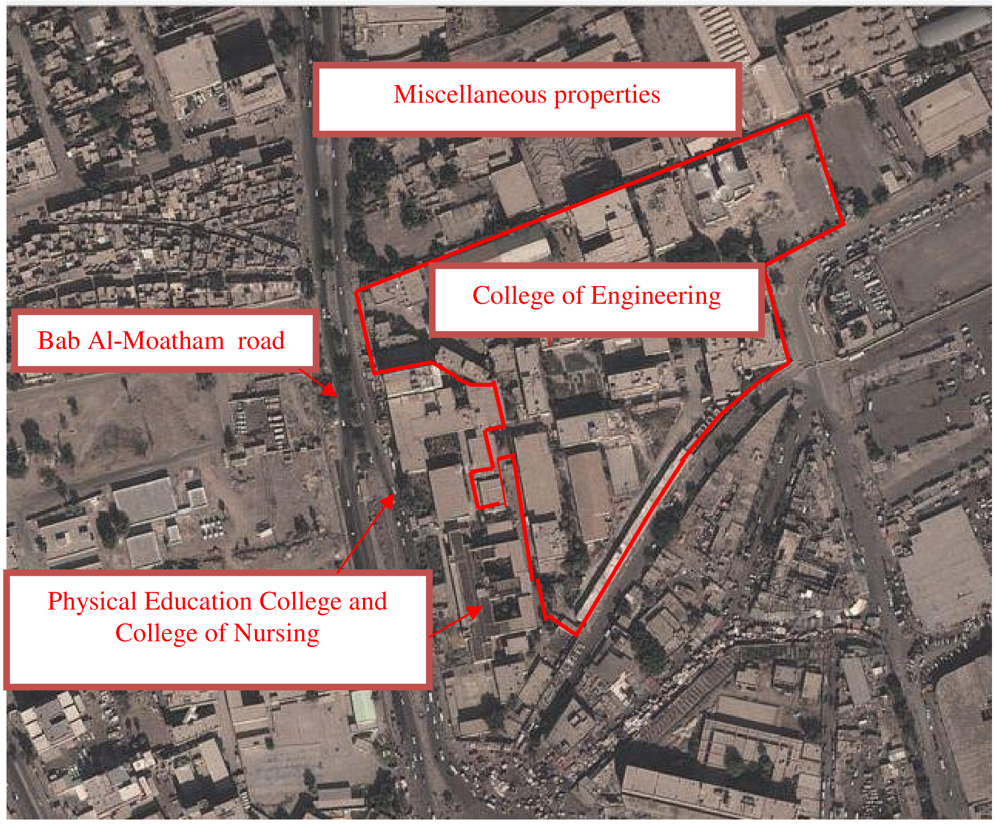

Figure. 1 Satellite image of the College of Engineering site in Bab Al-Moatham district-Baghdad

3. Noise Sources

Various noise sources were found on the campus. The main source is five 500 kVA electrical diesel generators, which operate when the main electric power of the district is shut down. There is no specific time schedule for generator operation because it depends on the hours of shutdown.

The second source is the parking lot for the visitors and staff, representing 4% of the total college area, with a capacity of 100 vehicles.

The third source is the workshop and structure labs, which contain machines and instruments that generate a noisy environment affecting the students and staff who spend time in and around it.

The Bab Al-Moatham main road represents the fourth noise source, bounding the back of the college for 42 m. This road is two way with a lane width of 7.5m and a central reservation width of 2 m, and the traffic flow is described as a pulsed continuous flow (EEA,2003).

The fifth source is the sound generated by the students (speaking, laughing, eating, taking pictures and walking) when they gather in small gardens and squares. The number of students ranges from ten to a few tens per site. Fig. 2 shows the distribution of the electrical generators (represented by black rectangles), the parking lot, Bab Al-Moatham road and student gatherings in green spaces (small gardens and squares).

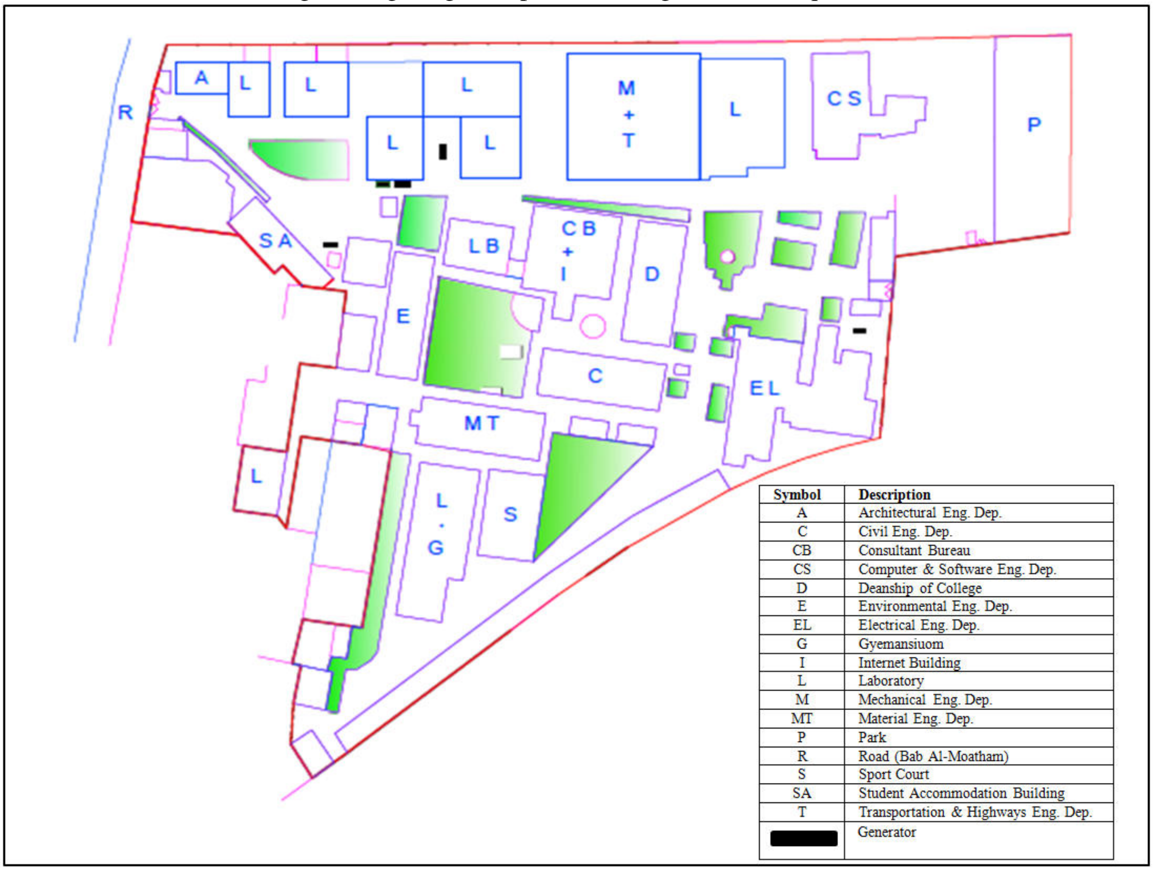

Figure. 2 Noise sources in the campus of the College of Engineering

4. Measurement Methodology

Noise mapping can be performed based on real measurements and/or on relevant data (such as the number of floors in each building in the campus for computing reflections, or the flow rate of vehicles, vehicle speed, and road width for traffic noise) and the assumptions built into the software. Therefore, to obtain the best information and compare the real measurements with assumptions, in this research, two methods were used. On the campus map, noise levels were determined at measurement positions as shown in Fig.3. The measurement points were taken in and around the outdoor noise sources, at least 1 m from the façade and 1.5 above the ground. ([ISO-1,2 , 1996). All measurements were taken during working hours from 8:00 am to 2:30 pm, when the generators were turned on and when they were turned off. The noise measurements were based on the equivalent continuous A-weighted sound pressure level in decibels, measured for 5 minutes in each position. The instrument used for measurement was a SVAN957 Type 1 sound and vibration meter with analyzer.

Figure. 3 Measurements points (small red circles) in the campus of the College of Engineering

The SoundPlan Acoustics software was used to draw noise maps of the campus of College of Engineering based on the input of real data, assumptions and readings in the standards (RLS-90, DIN ISO9613-2) (Braunstein &Berndt, 2012). Fig. 4 shows the interface of the SoundPlan software.

Figure. 4 The interface of SoundPlan software

To compute the sound pressure level in the noise mapping, the basic acoustic formulas are as follows:

$$L_{Aeq,T} = 10 \log \left[\frac{1}{t_2 - t_1} \int_{t_1}^{t_2} \frac{p_A^2(t)}{p_0^2} dt \right] \quad (1)$$

where $L_{Aeq,T}$ is the equivalent continuous A-weighted sound pressure level, in dB, determined over a time interval T starting at t_1 and ending at t_2; p_o is the reference sound pressure (20 μPa); and $p_A(t)$ is the instantaneous weighted sound pressure of the sound signal.

$$L_p = L_w - 20\log(r) - 8 \quad (2)$$

where L_p is the sound pressure level in dB(A), L_w is the sound power level of the source in dB(A), and r is the distance of noise propagation from a point source over a flat terrain. The sound power level can be entered directly or indirectly by using the software library.

According to the SoundPlan software, all the parameters in the map should be defined and described. The buildings are classified as main and industrial buildings. The main buildings include all the buildings on the campus except two laboratories (workshop and structure) that are treated as industrial buildings because of the high noise levels generated in and around them: the noise levels inside the labs reach 105 dB(A) (Ibrahim, 2014), and thus, high noise levels were observed outside the labs when the machines were on and the doors were open. All building descriptions were input including height and number of floors, ranging from 3.3 m with one floor to 12.2 m with three floors.

The generators, gardens and squares represent area sources, and the input data depend on the area dimensions and the description of the source plus the sound power level. The power of the diesel generators is 500 kVA. From the software library, the choice of diesel generators with a sound power level of 111 dB(A)/m^2 corresponds to the real measurements. According to the software library, the sound power level for a human voice level (loud) is 83 dB(A)/m^2, which is similar to the noise generated by students gathering in the gardens and squares (European Commission DG Environment, 2003).

The input data for parking lots include parking type, capacity (number of vehicles), and surface type. The parking lot is designated for staff and visitors with a capacity of 100 vehicles and a road surface covered by asphalt.

To compute the traffic noise generated from the Bab Al-Moatham main road (two ways), the lane width, vehicle flow rate, vehicle speed and type of vehicles are input. The width of each lane is 7.5 m, and the central reservation width is 2 m. The flow rate measurements were taken according to traffic engineering requirements (Roess *et al*, 2004). The hourly average flow rate was 2274 vehicle/hr, 95% of which represents light vehicles (motor cars, motor cycles, vans and minibuses) with weights less than 3500 kg, while the remaining percentage represents heavy vehicles (such as trucks) with weights more than 3500 kg. During the working days, the maximum speed of light vehicles is 55km/hr, 50 km/hr for heavy vehicles.

5. Results and Discussion

To obtain the best information about the noise source effects on the noise mapping of campus of the College of Engineering, two noise maps were drawn. The first was drawn with the generators off, as shown in Fig.5. The second noise map, supposes that all generators are on at the same time, as shown in Fig. 6.

When comparing the two noise maps, the following observations were made:

The number of noise zones changed: the first map distinguishes nine noise zones, starting from a noise level less than or equal to 50 dB(A) and ending with a noise level less than 90 dB(A). The second includes ten noise zones, starting from a noise level less than or equal to 50 dB(A) and ending with a noise level greater than 90 dB(A), clearly apparent around the generators.

The areas of noise zones remain steady in and around the parking lot but with small changes in noise levels of 5 dB(A) around the industrial buildings and Bab Al-Moatham road, and the noise levels generated from these sources affect the neighboring main buildings.

The student gathering areas are affected by the generators: the noise levels rose from 55 dB(A) to more than 90 dB(A), especially in the area beside the generators. In areas distant from the generators, the noise levels rose from 55 dB(A) to 70 dB(A).

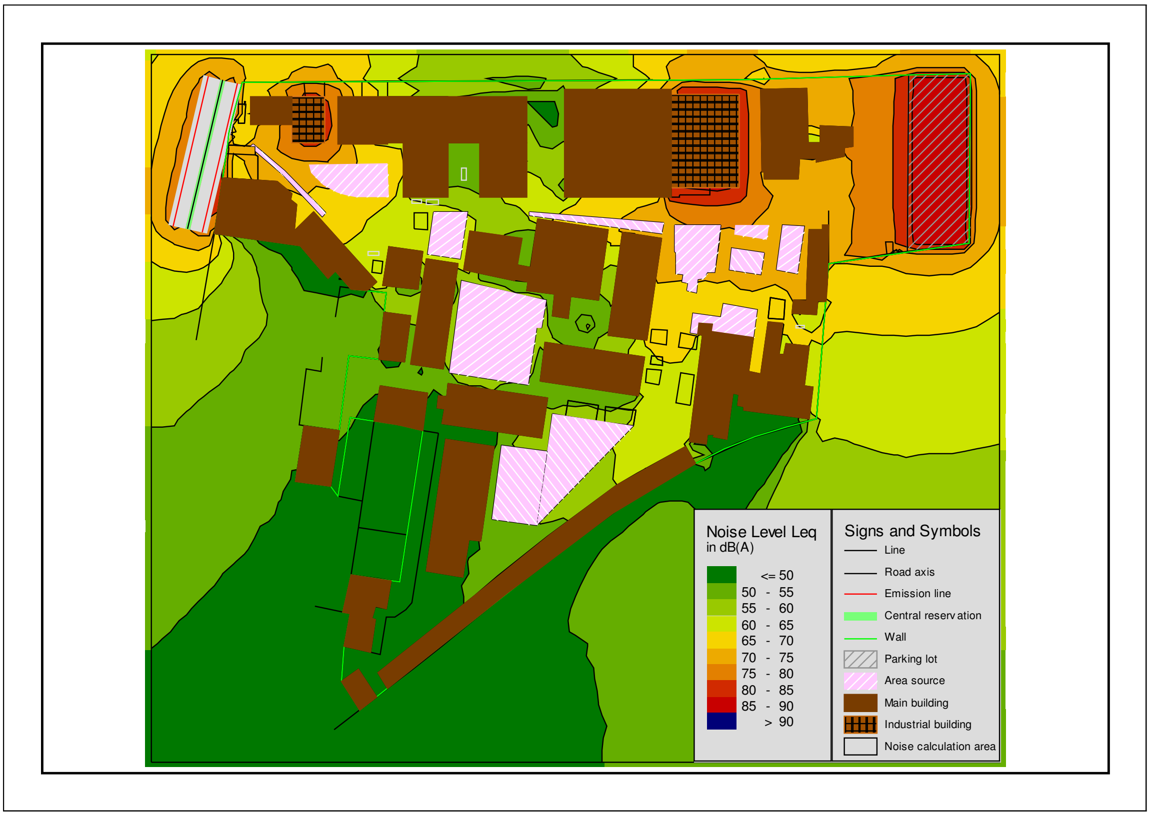

Figure. 5 Noise mapping of the campus of the College of Engineering (generators off)

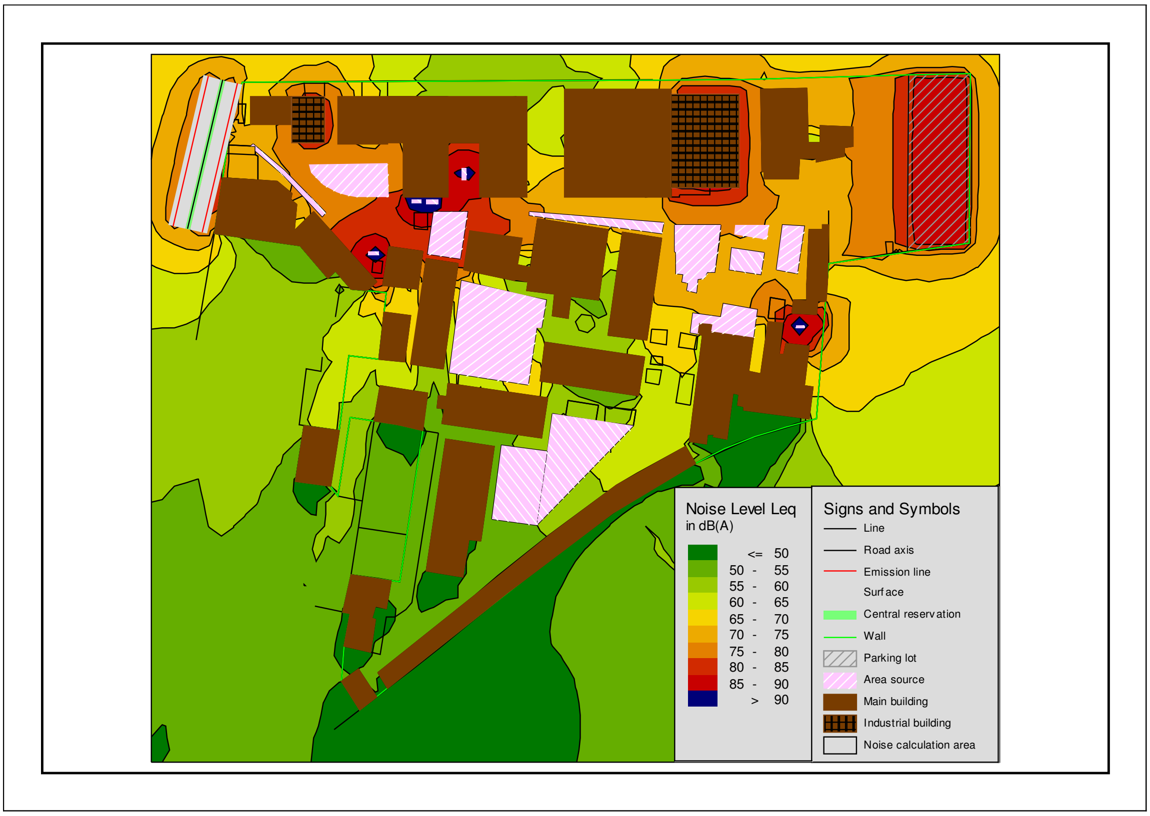

Figure. 6 Noise mapping of the campus of the College of Engineering (generators on)

Analysis results according to the noise sources:

a. Electrical Generators

Although all generators are equipped with sound attenuated enclosures, these enclosures are not appropriate for the generators to operate for long periods of time in the Baghdad meteorological conditions; therefore, the doors of the enclosures are opened during working hours to prevent the generators from shutting down due to high temperature inside the enclosures.

Thus, high noise levels greater than 90 dB(A) were recorded, which decreased with distance to 80 dB(A). The noise levels generated by the five electrical diesel generators are clearly shown in Fig. 6.

These generators have both direct and indirect negative effects. The direct effects are exerted on the students because near these generators, the students gather in small squares and gardens to take breaks (drinking, eating, walking, and talking) during their schedule; thus, they are exposed to high noise doses for extended times depending on the working hours for the generators. The indirect effects take the form of high background noise inside the buildings near these generators, such as laboratories, the Environmental Eng. Department and the library, especially in the spring and summer seasons when the windows are open.

b. Parking Lots

The noise level in parking lots range from 85 to 90 dB(A), and decrease to range from 75 to 80 dB(A). This noise level reaches to the side façade of the Computer & Software Engineering Department.

Figures 5 and 6 reveal that the noise levels around the parking lot are unaffected by the generator noise level because the lot is far away from the generators.

c. Industrial Buildings

The noise levels around the industrial buildings (workshop and structure labs) reach 90 dB (A). Those labs contain machines such as cutting, milling, and grinding machines for the workshop lab, an electric sieve, a crane, a concrete compressive strength testing machine and a concrete mixer in the structure lab, and the noise level generated from these machines reaches 105dB(A) inside the buildings (Ibrahim.2014). During the working day, the doors always open, and there are no sound insulators in these labs. Therefore, the effects of the noise levels reach to the nearby main buildings and gathering students.

d. Bab Al-Moatham Road

The Bab Al-Moatham district is described as crowded. It includes government departments, colleges, schools, shops, carpentry workshops and residential neighborhoods. Thus, this road is considered the main road for the Bab Al-Moatham district. In fact, there has been a bridge under construction, for three years as of the preparation of this study, at the south end of the road, and these construction works limit the speed of vehicles to 55 km/hr.

From Fig. 5, the road noise level does not exceed 70 to 75 dB(A), and it interacts with the same noise levels generated from the industrial buildings (structure lab). The noise area for this level became smaller when the generators turned on, and the area of the noise level of 75 to 80 dB(A) is dominant, as shown in Fig. 6

e. Students gathering in Gardens and Small Squares

The noise levels in and around areas where students gather ranged from 55 to 60 dB(A) where these areas are distant from other noise sources, but these levels increased to 75 dB(A) for the areas near the parking lots, industrial buildings and the Bab Al-Moatham road with the generators turned off, as shown in Fig. 5. When the generators are turned on, the noise levels near them reach up to 90 dB(A), and noise levels range from 60 to 75 dB(A) in areas far away from the generators, as shown in Fig. 6. Therefore, the noise levels generated from the gathering students interact with other sources.

From all of the above, the noise levels exceed the permissible noise limits outdoors 55 dB(A) according to WHO guidelines (Birglund *et al*, 1999). The main noise source with the most adverse effects is the electrical diesel generators, affecting the students gathering outdoors and students and staff inside buildings constructed without sound insulation material, followed by noise generated from industrial buildings (workshop and structure labs). The next sources are the parking lots and Bab Al-Moatham road. The dominant noise levels in this situation range from 75 to greater than 90 dB(A) close to the generators.

The real measurements were identical to the readings of the SoundPlan software, and the above two noise mappings represent the true situation of noise level propagation outdoors.

6. Conclusions

Based on noise mapping, noise levels greater than 90 dB(A) are clearly shown when the generators are turned on, and the lowest levels overlap with noise levels generated by the industry buildings, Bab Al-Moatham road and parking lots. When the generators are turned off, the noise levels greater than 80 dB(A) occur around the industrial buildings and parking lots, while the dominant noise levels ranging from 55 dB(A) to 80 dB(A) are observed in and around student gathering areas. Unfortunately, most of the gathering students are close to noise sources when they take breaks during their schedule and are thus exposed to high noise levels with adverse effects on hearing, concentration and learning without knowing or caring.

To reduce the dominant noise levels to the permissible limits (55 dB(A) or below), there are some recommendations: the location of the electrical diesel generators should be changed if there is free space available, or they should be provided with sound attenuated enclosures appropriate to the operating conditions; a wall should be built parallel to the boundary of the parking lots, and the machines that generate high noise levels should be replaced with quieter ones.

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