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Determining Noise Zones in the Laboratories of the College of Engineering at the University of Al-Mustansiriyah

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Abstract- The aim of this work was to determine the noise zones in twelve main labs of the College of Engineering at the University of Al-Mustansiriyah and to identify risk zones for users of the labs (students, staff and researchers) to prevent or reduce exposure. The background noise was measured in all labs and was found to range from 50 to 65 dBA. Eight labs (computer skills, computer and logic, computer, polymers and chemical, soil mechanics, structure material, metal inspection and air conditioner & refrigeration) had noise levels that were considered acceptable (less than or equal to 80 dBA), two labs (sanitary and hydraulic) would need to implement a hearing conservation program because the noise level was 85 dBA, and two labs (structure and workshop) exceeded the permissible limit, reaching values of 110 dBA; these labs require strong rehabilitation such as replacement of noisy old machines by quieter new machines, redistribution of equipment, reduction of ceiling height and addition of sound insulation material for the walls and ceiling.

Index Terms— background noise, laboratories, noise sources, noise zone.

I. INTRODUCTION

Laboratories are defined as places equipped for experimental studies or for testing and analysis of various types, including educational, research, or medical, which produces different levels of noise that may exceed 120 dB(A). According to the World Health Organization (WHO), noise is a dangerous pollutant that causes chronic health problems [1]. The effects of noise on human health can be divided into auditory and non-auditory effects. Auditory effects include acoustic trauma, tinnitus and temporary and permanent hearing loss, whereas non-auditory effects include diseases such as hypertension, defective hormonal response and cardiovascular effects. Noise also negatively affects work performance and speech intelligibility [1]-[4]. Noise in laboratories is mainly produced by equipment, which depends on the type of laboratory; for example, chemical and biological laboratories may contain hoods, compressors, centrifuges, stirrer motors, and refrigerators that may generate different types of noise such as steady or periodic noise [5]. The maximum noise levels in biochemistry laboratories are produced by centrifuge devices and reach 92 dB, whereas the minimum noise level near urine analyzers is 55 dB. Gültekin, Yener, Develioğlu , Köleli,and Külekci [6] found that noise affects the relationship between care providers and patients. The measured noise levels in a dental laboratory were higher than 85 dB; thus, Singh, Gambhir, Sharma, and Kaur [7]. Suggested that workers in these laboratories were at risk of developing noise-induced hearing loss. Griffiths, Kell, and Taylor [8] evaluated the noise levels in clinical chemistry laboratories and found that they did not exceed 85 dB (A); they suggested that noise problems could be solved by enhanced communication between laboratory architects and laboratory equipment designers. The average noise levels in a welding class laboratory were measured by Reynolds [9] for five days a week and found to range from 55.1 to 78.2 dB (A); these results were acceptable according to OSHA[10]. The noise levels in laboratories depend on factors such as the background noise levels at the site, the acoustical performance of the building, the type of laboratory, and the type and number of devices that produce noise. The interior design of the laboratory must provide an acoustically comfortable environment to the teaching staff, researchers and students [5],[11]. To meet the minimum health and safety requirements regarding the exposure of workers to the risks arising from the noise in the workplace, appropriate devices and optimum work procedures and methods should be selected to generate low noise levels to diminish the risks at the source and ensure that noise levels remain within permissible limits. Additionally, employers should stay updated regarding technical progress and scientific knowledge concerning the dangers of exposure to noise and utilize the necessary methods and precautions to protect the health of workers [12], 13].

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II. DESCRIPTION OF THE LABORATORIES AND THEIR NOISE SOURCES

There are twelve main laboratories distributed over seven departments (Civil, Environmental, Transportation and Highway, Material, Computer and Software , Electrical and Mechanical Engineering), and most of them are shared between two or three departments. The laboratories are used by undergraduate and graduate students and researchers. These laboratories are located in separate buildings or in the main buildings. All of the buildings were constructed using traditional methods and materials (cement, brake, gypsum, concrete and steel with wood doors and single glass windows without insulation) and have square or rectangular shapes with ceiling heights ranging from 3 m to 7 m. In these laboratories, there are many types of noise sources depending the purposes of the laboratory; for example, the workshop lab has two main chambers: one contains cutting, milling, grinding and lething machines and the other is for welding. The hydraulic lab contains a large hydraulic system consisting of a huge channel and pump in addition to four small-scale hydraulic systems. The structural lab contains an electric sieve, a crane, a

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concrete compressive strength testing machine and a concrete mixer. The sanitary lab contains two hoods and centrifuge. The computer lab contains computers with accessories. The other labs contain small machines, instruments and accessories such as different sizes of manual sieves, balances, hoods, fans and pumps.

III. MEASUREMENT METHODOLOGY

The measurement points were defined according to ISO 1996-1[14], i.e., at least 1 m from the walls or other major reflecting surfaces, 1.2 to 1.5 m above the floor and approximately 1.5 from the windows. All of the measurements are taken during working hours from 8:00 am to 2:30 pm, and the background noise was also measured. The noise measurements were based on the equivalent continuous A-weighted sound pressure level in decibels, measured for 5 minutes in each position. It is given by the formula

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

Where LAeq, T is the equivalent continuous A-weighted sound pressure level, in dB, determined over a time interval T starting at t1 and ending at t2; po is reference sound pressure (20 µPa); pA (t) is the instantaneous weighted sound pressure of the sound signal. The instrument used for measurement was a SVAN957 Type 1 sound and vibration meter with analyzer. Fig 1 shows the SVAN957. Each laboratory had different noise zones, which were classified by color, and the boundaries between the zones were established according to multiples of 5 dB, according to ISO 1996-2 [15].

Fig. 1 SVAN957 Sound and Vibration Analyzer

The undergraduate students working and studying in these labs spend a maximum of two hours weekly in each lab, and their laboratory hours are not to exceed 4 hours per day. The laboratory is available to graduate students five days per week, and the technicians and teaching staff are present all week. The labs were classified according to noise zones into three groups: under the limits (<70 dBA), within the limits (60–85 dBA), and above the limits (>85 dBA).

1- In the group under the limits, the noise zones were classified into three levels: 55–60 dBA, 60–65 dBA, and 65–70 dBA. Figures 2–7 show the noise zones for six labs (computer skills, computer and logic, computer, polymers and chemical, soil mechanics and structure material labs). The dominant level in this group was 60–65 dBA, and this level was observed over a broad space. The main noise sources were the voices and movements of the students and teaching staff because the students worked together in groups and noise was generated from small devices such manual sieves, balances, hoods, fans, small pumps and special test instruments, and also to some extent from computers. The background noise in these labs ranged from 50 to 60 dBA, and the labs were constructed in the ground floor and first floor of the main buildings without any sound insulation. The structure material lab had an engineering room with a noise level ranging from 60 to 65 dBA.

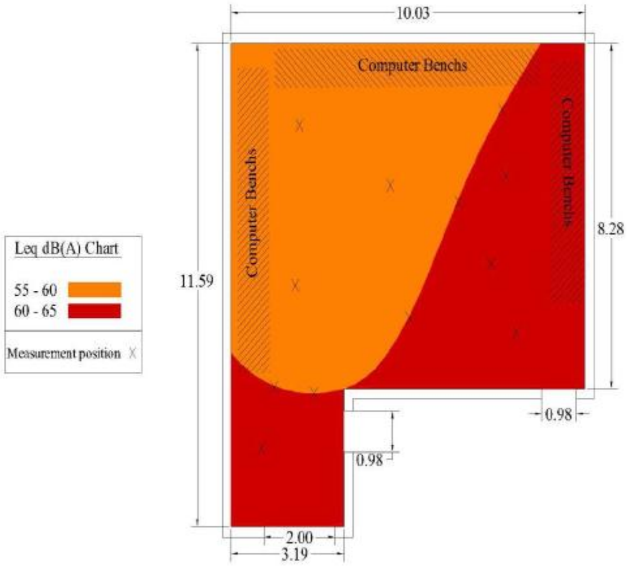

Fig. 2 Computer Skills Lab Map with Two Noise Zones

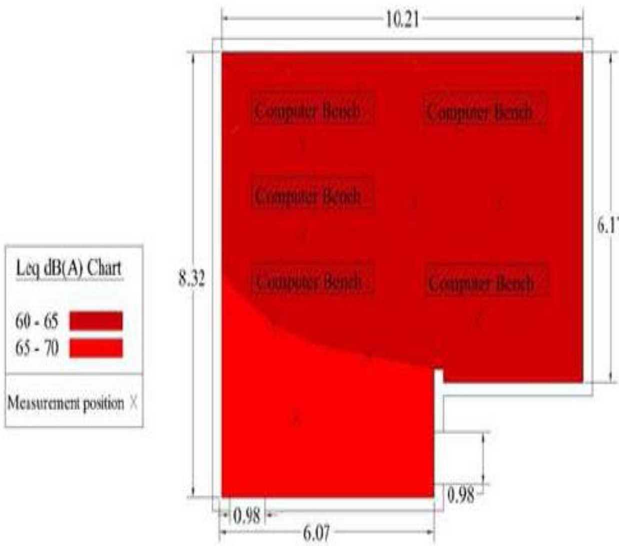

Fig. 3 Computer and Logic Lab Map with Two Noise Zones

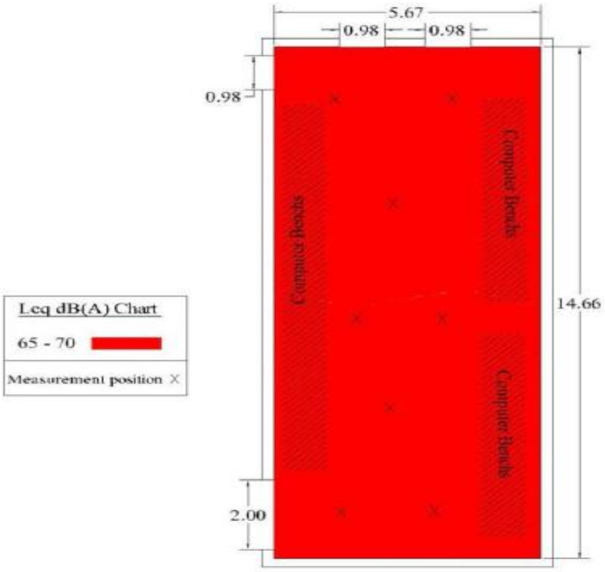

Fig. 4 Computer Lab Map with One Noise Zone

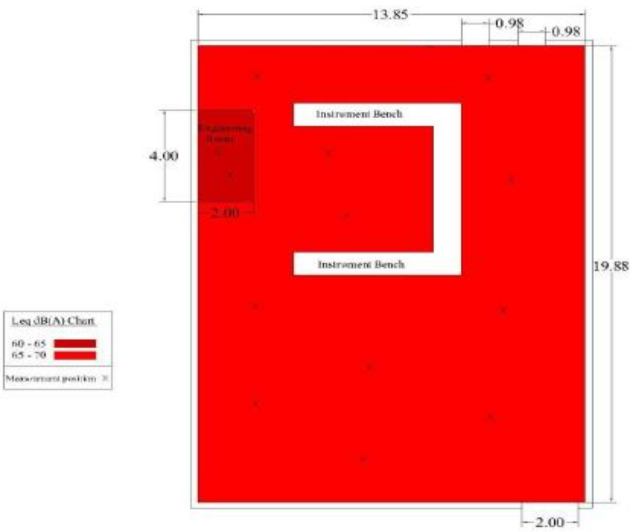

Fig. 5 Polymers and Chemical Lab Map with One Noise Zone

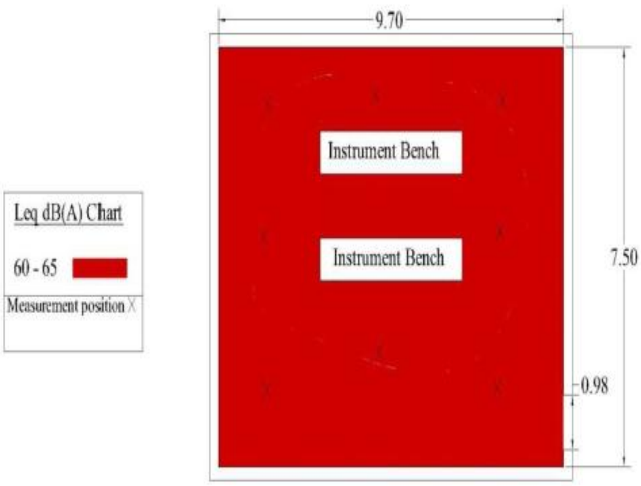

Fig. 6 Structure Material Lab Map with Two Noise Zones

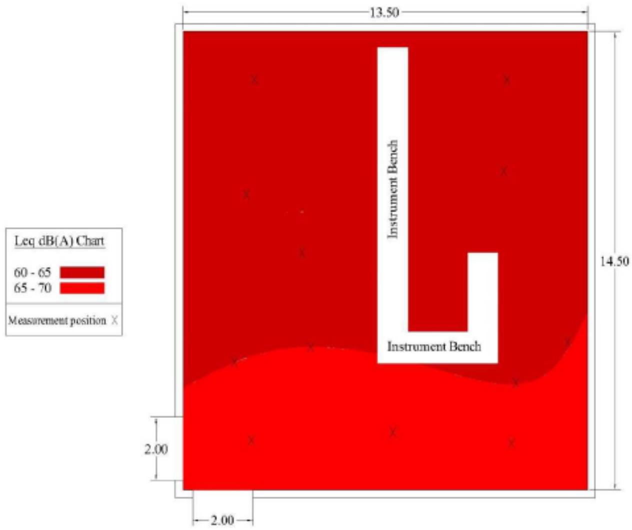

Fig. 7 Soil Mechanics Lab Map with Two Noise Zones

2- In the group within the limits, the noise zones were distributed in five levels: 60–65 dBA, 65–70 dBA, 70–75 dBA, 75–80 dBA and 80–85 dBA. Figures 8–11, show the noise zones for three labs (metal inspection, air conditioner and refrigeration, sanitary and hydraulic labs). Some of the labs contained an engineering room for engineers to perform office work; the noise level of the engineering room was 60–65 dBA in the metal inspection and hydraulic labs and 70–75 dBA in the air conditioner and refrigeration lab. The main noise sources in these labs were devices such as hoods, centrifuges, shakers, test metal instruments, pumps, cooling units and portable hydraulic units. The background noise for the metal inspection and air conditioner and refrigeration labs ranged from 50 to 60 dBA. The labs were constructed in the ground floor in the main buildings. The background noise level was 60–65 dBA in the sanitary and hydraulic labs, which were constructed in separate buildings with ceiling heights of 5 m and 7 m, respectively. A high level of background noise was observed for the sanitary lab because it was adjacent to the playing field for sports, and a high level was observed for the hydraulic lab because it is next to the main square of the college, which is always noisy because it is the gathering place for students.

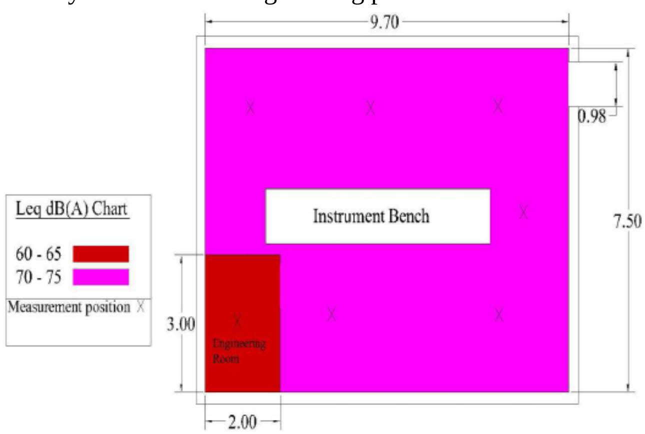

Fig. 8 Metal Inspection Lab Map with Two Noise Zones

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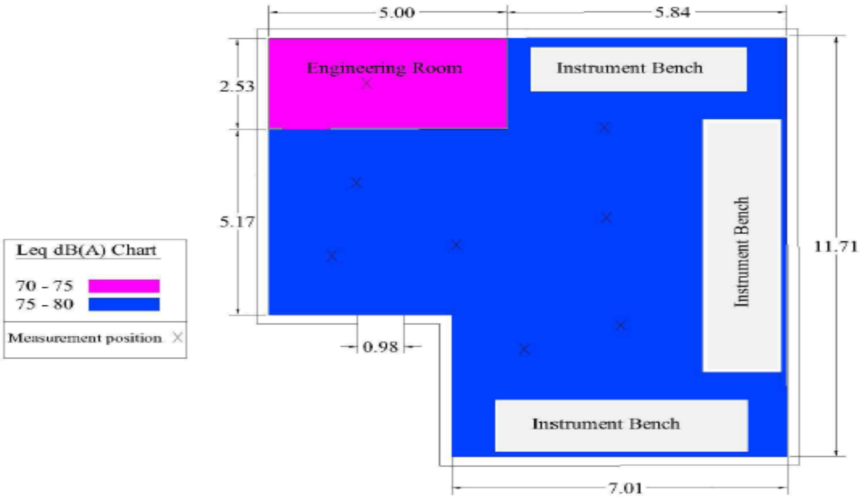

Fig. 9 Air Conditioner and Refrigeration Lab Map with Two Noise Zones

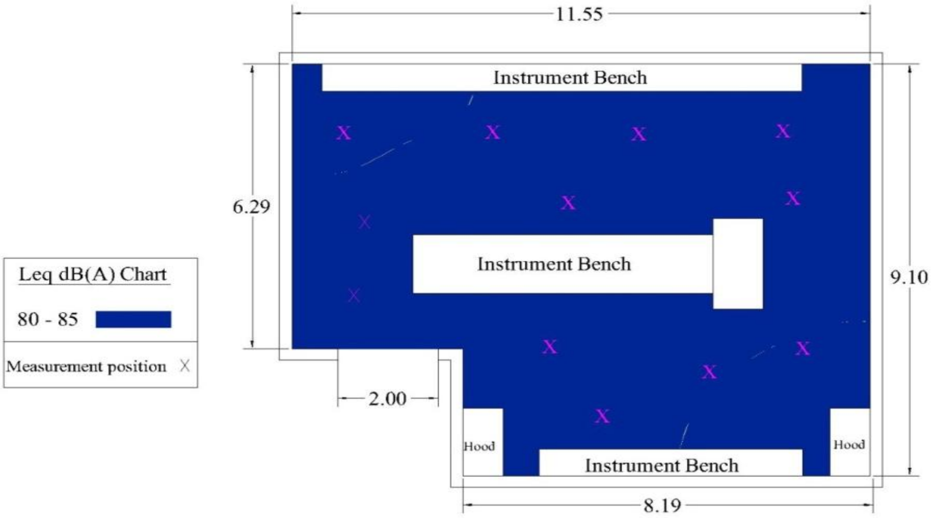

Fig. 10 Sanitary Lab Map with One Noise Zone

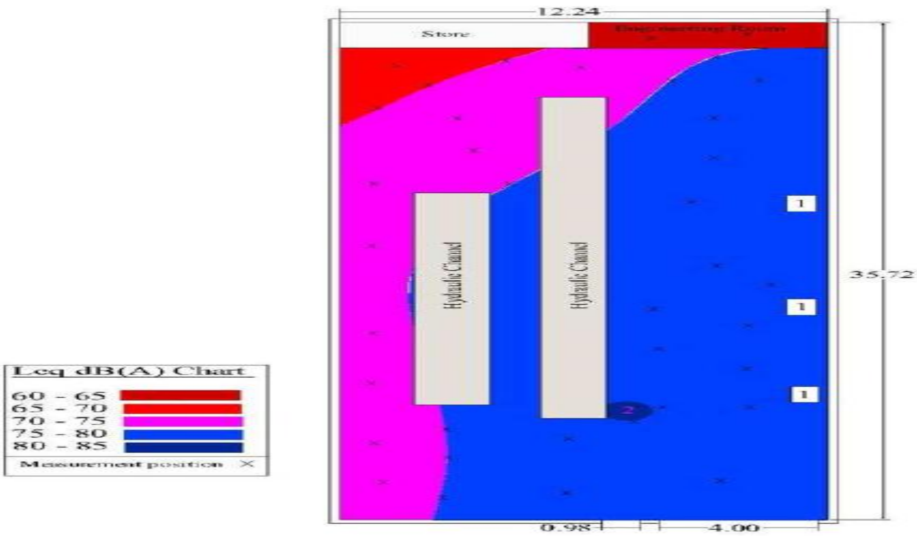

Fig. 11 Hydraulic Lab Map with Four Noise Zones

[1]Portable Hydraulic Unit, [2]Pump

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In the group above the limits, the noise zones were classified into seven levels: 75–80 dBA, 80–85 dBA, 85–90 dBA, 90–95 dBA, 95–100 dBA, 100–105 dBA and 105–110 dBA. Figures 12–13 show the structure and workshop labs with noise zones. The noise level in the engineering room ranged from 75 to 90 dBA. The main noise sources in the structure lab were the electric sieve, crane, concrete compressive strength testing machine and concrete mixer, whereas in the workshop, the main noise sources were the grinding machine, the bar cutting machine, the disc cutting machine, the milling machine, the electric drill and the lething machine. The background noise level ranged from 60 to 65dBA in the structure and workshop labs, which were constructed in separate buildings with a ceiling height of 7 m. A high level of background noise was observed in the structure lab because it is adjacent to the main road outside the campus, and a high level was observed for the workshop lab because it is behind the hydraulic lab and next to the main square of the college.

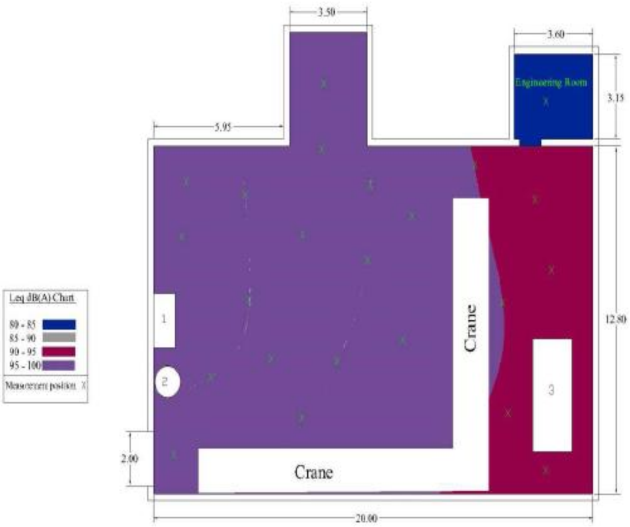

Fig. 12 Structure Lab Map with Three Noise Zones [1]Electric Sieve, [2]Concrete Mixer, [3]Concrete Compressive Strength Testing Machine

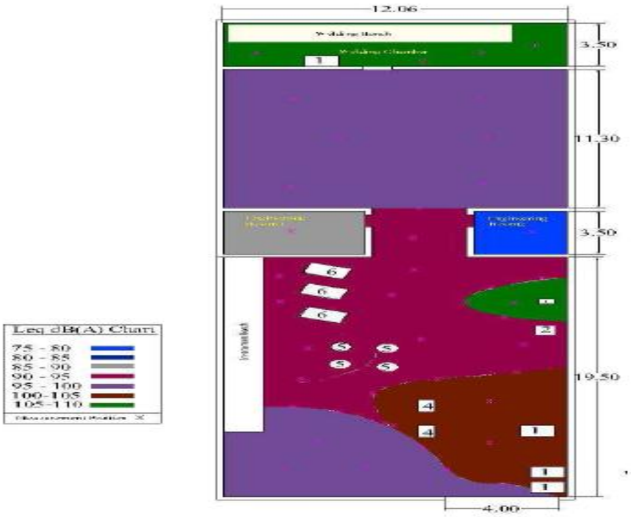

Fig. 13 Workshop Lab Map with Six Noise Zones 1grinding Machine, 2 Bar Cutting Machine, 3 Disc Cutting Machine, 4 Milling Machine, 5 Electric Drill, 6 Lething Machine

IV. DISCUSSION

For all labs, the experiments performed by undergraduates were distributed over 20 weeks, and some of experiments were performed in less than one hour. During the working day, the students and teaching staff did not show any signs of annoyance or discomfort in the first group because noise levels under 70 dBA have not adverse effects on human health; in contrast, students, researchers, and technicians in the second group felt annoyance, disturbance and discomfort because the noise level reached 85 dBA [1],[2],[10]. The third group contained the structure and workshop labs, which shared certain characteristics: first, the machines and equipment used were outdated, thus generating loud noise; second, the ceiling height was 7 m, and the walls and ceiling were not insulating, resulting in a buildup of sound; third, there were no warning signs for noise; and finally, the technicians, students and teaching staff did not all wear the ear protectors. Most of them felt very uncomfortable and experienced discomfort during the working day; the technicians may also be at risk for temporary and permanent hearing loss, tinnitus and acoustic trauma in addition to non-auditory effects such as hypertension and cardiovascular effects[1],[2],[10]. The machines used are often not working in synchrony with each other; rather, they operate separately according to the course schedule and subjects. Simultaneous operation occurs when groups of multiple graduate students and researchers are working on projects at the same time for a period of time exceeding the permitted limits; in this situation, the groups are unable to easily engage in face-to-face conservation without shouting at distances up to 60 cm [2], [16]. The noise levels measured at laboratory benches when no devices were working ranged from 55 to 75 dBA, and these limits not compatible with the laboratory safety design guide, which states that the noise level at laboratory benches should not exceed 55 dBA [17],[18]. These levels may cause students to not respond well to instructions or conduct experiments as required. The noise level in the engineering rooms ranged from 60 to 90 dBA; at this level, the technicians could not take a real break during the working day, which may cause them to experience auditory and non-auditory health effects over time. Thus, for all of the workers in the labs, a hearing loss prevention program must be engaged to preserve their health [19]. The design for the labs did not take into account the sound insulation standards, the purposes of the lab, the health surveillance for workers, and the noise control procedures; therefore, it was not compatible with standards such as OSHA or the Norsok standard[10],[20].

V. CONCLUSION

The determination of noise zones in labs gives an indicator to employers regarding the exposure of employees, students and especially technicians to noise risks that may result in auditory and non-auditory effects on health. The labs were classified by noise levels to three groups; the first group contained labs with a noise level lower than 70 dBA, and these labs were the computer skills, computer and logic, computer, polymers and chemical, soil mechanics and structure material labs.

The second group contained the metal inspection, air conditioner and refrigeration, sanitary and hydraulic labs, which had levels less than or equal to 85 dBA. The noise levels in the third group, which contained the structure and workshop labs, reached 110 dBA. The main noise sources in labs in the first group were the voices and movements of the students in addition to the noise generated by small devices. In the second group, devices such as hoods, centrifuges, shakers, metal testing instruments, pumps, cooling units and portable hydraulic units generated noise. Machines such as those used for grinding, bar cutting, disc cutting, milling, lething and concrete compressive strength testing in addition to cranes, electric drills and sieves were the main noise sources in the third group. Several factors influenced the build-up of sound in these labs, including the absence of an absorbing material, high ceilings, random equipment distribution, and the interior design of the labs, which was not consistent with the guidance for lab design. The noise level in the engineering rooms ranged from 60 to 90 dBA, and at this level, the technicians could not take a real break during the working day, which may result in auditory and non-auditory health effects over time.

VI. RECOMMENDATION

To protect the workers (students, researchers and technicians) in the labs from hearing loss and other adverse effects on health caused by noise, the old equipment generating loud noises should be replaced by new, quieter equipment, and engineering noise control and education programs regarding noise risks should be enforced. The employer must account for occupational safety and health by providing ear protectors, placing warning signs in zones with high noise levels, and providing training programs for all users regarding noise risks and the reduction of noise levels to safe levels. The noise exposure to workers during the working day must be measured in future studies.

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