Investigation of Noise Pollution in an Educational Building –
Case Study of Babylon University in Iraq

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Abstract. Acoustic conditions, considered an indicator of the level of comfort, are a major concern in educational facilities since they are linked to students' well-being and learning capacity. In this study, measurements of the acoustical comfort conditions were performed using portable IEQ meter have been assessed in four selected areas of environmental engineering department building (The classroom for fourth year, student's corridor, teacher's corridor and reception area) in the University of Babylon in Hillah City. This was done by analyzing the data measured for 13 months from August (2020) to August (2021). Statistical analysis by using the linear regression test was performed to determine the relationship between the selected areas. Noise is the major parameter for the educational areas that can interfere with the students’ activities and eventually, this will have a detrimental effect on the students' physical and psychological health. The acquired results were compared to the reference values specified in the handbook to international standards for noise compliance in academic educational facilities. The results show that all the studied areas in the Environmental Engineering Department had back-ground noise levels out of the recommended threshold limit values (>50 dB) revealed that the indoor environment of these areas was of poor quality, indicating the require for interventions. This study can be considered a pilot study for future comparable research on Iraqi universities.

Keywords: Indoor environmental quality; acoustic comfort; regression test; noise levels; environmental pollution

1. Introduction
At the moment, comfort standards are higher than in past eras when, as a result of the explosion of industrial technology development, the prospect of creating significantly enhanced living conditions became apparent [1]. It is observed that indoor acoustic quality is a critical indicator for architects and engineers during the design and renovation of structures [2]. Indoor acoustic quality enables us to evaluate a building's energy efficiency by analyzing its energy usage in relation to the indoor environment quality that can be achieved indoors [3]. Educational areas are those in which much time is spent reading, writing, examining maps, or focusing attention on monitors. To enable these activities, it is critical that the indoor atmosphere meets the required level of comfort [4]. The acoustic environment within a building is one of the most challenging components to design, control, and optimize. The properties of the physical sound field create an acoustic environment that has a direct effect on the structural integrity of buildings, as well as on people's health, safety, comfort,
capacity to communicate, productivity, efficiency, and enjoyment [5]. The background noise level, reverberation duration, noise isolation, and speech intelligibility and privacy are all physical elements that affect the acoustical environment [6]. Noise is quantified using A-weighted sound levels and is Sound pressure levels are measured in decibels, which are named after Alexander Graham Bell (dB). The human ear can perceive the different levels of noise levels, ranging from a very low to high levels of noise pollution [7]. Table 1 shows the classification of noise levels according to the types of sound sources [8].

| Table 1. Noise levels according to the different sound sources. |
|---------------------------------------------------------------|
| source of sound | Noise level (dB) |
|-----------------|-----------------|
| Hearing threshold | 0               |
| Whisper         | 30              |
| General office environment | 60              |
| Normal speaking | 70              |
| Loud speaking   | 90              |
| Truck horn      | 110             |
| Symphony orchestra | 130           |
| Four–jet–engine plant | 167           |

Academic areas are at the primary motivations for building universities establishments [9]. Various studies from a variety of sources are conducted in educational buildings, to obtain the best possible results, provide standard indoor conditions. The quality of the educational building’s indoor environment As a result, it's crucial. The learning ability of users of any academic facility may be considerably influenced by good and acceptable indoor environmental quality (IEQ) [10]. Proper IEQ settings, for example, can boost the efficacy of absorption and assimilation, skill improvement, and the quality of activities like reading [10–13]. Through this concept, to be considered sustainable, a building must achieve high levels of sustainability in three key areas throughout its life cycle: enhancing the local and global environment, increasing internal comfort, and attaining cost-effectiveness and flexibility [14]. Among them, enhancing interior comfort received significant emphasis, since it corresponds to the educational background and interests of the participants. Indoor acoustics, for example, is an important but frequently overlooked part of indoor environmental quality [15]. Indoor acoustical characteristics in academic buildings on campus cannot be overlooked, yet they are difficult to establish. Whether the interior atmosphere is excessively loud or too quiet, it causes disruptions and diversions for students, academic staff, and researchers, as well as having a significant impact on teaching and laboratory operations [1,16]. The main aim of this study is to investigate the current environmental noise pollution of the Department of Environmental Engineering inside Babylon University building in Hilla City and find the interaction between the noise pollution and the selected study areas by performing a statistical analysis using the linear regression test.

2. Materials and methods

2.1. The study area
The Environmental Engineering Department was founded in 2007 and it had thirty eight students. Environmental engineering education offers a good basis for addressing the world's most pressing environmental concerns. It prepares students for a variety of occupations, including engineering design, teaching, law, medicine, and public health, as well as additional education. The number of student entrants rose over the whole ten-year period, with much of the increase in 2020–2021. Inside the department, there are several classrooms for the educational, social, and administrative services, consists more than 40 staff and 300 students capacity. The department is operated by academics with considerable teaching, business, and industry expertises were sought. They offer a wealth of information from their various professions' research and professional activity to the classroom,
providing students with a fascinating, multi-dimensional academic atmosphere. Due to the small size of the classes, lecturers are able to respond to individual learning demands.

![Environmental Engineering Department /College of engineering/ University of Babylon](image1)

**Figure 1.** Environmental Engineering Department /College of engineering/ University of Babylon.

### 2.2. Measurement of noise

Digital Multi – function environment meter was utilized to determine sound level, humidity, and temperature with measuring range 30 dB to 130 dB, accuracy ± 1.5 dB. For analyzing and recording temperature, a temperature meter with a measurement range of -20°C to 50°C was used. The decibel level of noise was measured using a digital sound level meter held at a height of 2 meters from several rooms. From 9.00 a.m. to 5.00 p.m., measurements were obtained seven times in each room at varied intervals of time.

![Digital Multi-function environment meter](image2)
2.3. Data analysis
The average values of continuously measured noise levels for the four selected areas (The classroom for fourth year, student's corridor, teacher's corridor and reception area) in the University of Babylon in Hillah City were taken into statistical analyses. The measured data of noise and temperature was processed and analyzed with Microsoft Excel 2016 V16.0 (Microsoft Headquarters One Microsoft Way Redmond, WA 98052, Washington, USA). The average value of all observed minimum data was used to derive the minimum value of each department. Following the same technique as before, the highest value of each department was computed.

3. Results and discussion

3.1. Acoustic measurements analysis
The results of noise measurements in different areas of the environmental engineering department are shown in the Figure (3). In general, all the selected study areas exceed the internationally recognized threshold value of noise levels (50 dB) [17]. The findings show that the student’s corridor (B) had the highest noise level highlighting the large number of students compared to the small size of the students’ corridor.

![Figure 3](image)

**Figure 3.** The level of noise in various functioning spaces of environmental engineering department. A: the classroom for fourth year, B: student's corridor, C: teacher's corridor and D: reception area.

Figures (4) and (5) show the results of Temperature (T) and relative humidity (RH) measurements in different areas of the environmental engineering department respectively. Generally, classroom temperature should not exceed the permissible standard levels (24 °C) [17]. In general, all the selected study areas were within the internationally recognized threshold value that is suitable for study environment. Moreover, the findings also show that the relative humidity is within the standards levels reflecting that the building maintained comfortable indoor thermal conditions in most spaces during the period of study.
3.2. Regression model analysis

The average values of continuously measured noise levels for the four selected areas of environmental engineering department building (The classroom for fourth year, student's corridor, teacher's corridor and reception area) in the University of Babylon in Hillah City were analyzed for thirteen months from August (2020) to August (2021). The measured data were taken into statistical analysis. Distributions of measured average total, indoor noise levels with temperature in the four areas were analyzed using the linear regression test to examine the significant relationship between the IEQ parameters.

Table (2) shows the summary output of the regression analysis of IEQ for the four selected areas of environmental engineering department building (The classroom for fourth year, student's corridor, teacher's corridor and reception area) respectively. According to the statistical analysis results, there is a statistically significant correlation between temperature with noise and light levels in the classroom for fourth year (Significance F=0.006, $R^2=0.99$), the student's corridor area (Significance F=0.022, $R^2=0.96$) and the teacher's corridor area (Significance F=0.017, $R^2=0.95$). The findings confirm a high
and strong linear relation of noise and light level values with temperature reflecting the accuracy of the linear regression model for describing the university acoustic and visual levels with thermal conditions in the studied context, which is in good agreement with the literature [18–20]. However, the statistical analysis results for the Reception area showed a non-statistically significant relation between the IEQ parameters as the performance of this regression model is quite low (Significance F = 0.842, R² = 0.59). This might be explained by the fact that this building is exposed to irregular numbers of people including: students, staff and unexpected visitors, resulting in high variation of data measurements.

Table 2: Overall regression statistics output showing the relationship between the indoor environmental quality (IEQ) parameter measurements (noise, temperature and relative humidity) in all four selected areas for the period (August 2020-August 2021).

| Building name | (A) | (B) | (C) | (D) |
|---------------|-----|-----|-----|-----|
| Correlation coefficient<sup>e</sup> | 0.911 | 0.921 | 0.975 | 0.74 |
| Coefficient of determination<sup> (adjusted)<sup>f</sup> | 0.99 | 0.96 | 0.95 | 0.59 |
| Observations points<sup>g</sup> | 13 | 13 | 13 | 13 |
| F statistic<sup>i</sup> | 13.462 | 27.211 | 23.721 | 3.761 |
| Significance F<sup>i</sup> | 0.006 | 0.022 | 0.017 | 0.842 |

<sup>a</sup> The classroom for fourth year;  
<sup>b</sup> Student's corridor;  
<sup>c</sup> Teacher's corridor;  
<sup>d</sup> Reception area;  
<sup>e</sup> Multiple R, degree of association between temperature and relative humidity (independent variables) variables and the noise (dependent variable). It is measured on a scale that varies from +1 through 0 to –1, The IEQ data is more "linear" if its value is close to 1. There is no linear connection between IEQ variables if this value is close to 0;  
<sup>f</sup> Adjusted R², percentage of variation in the IEQ parameter response that is explained by the test. It is value between 0% and 100%, higher the adjusted R² value, the better the regression line fits IEQ data;  
<sup>g</sup> Number of measurements for each IEQ parameters used in the regression analysis test;  
<sup>h</sup> Overall mean regression ratio a sum of squares with the mean error a sum of squares with the mean error a sum of squares with the mean error;  
<sup>i</sup> Test the significance of entire regression coefficients to determine whether the sample correlation represents a real relationship or not. If the significance F is less than 0.05, the set of independent variables are reliable (statistically significant). If this value is greater than 0.05, it's best not to use this collection of independent variables any more.

4. Conclusions and recommendations

This study was conducted to assess the indoor noise quality of the four selected areas of environmental engineering department building (The classroom for fourth year, student's corridor, teacher's corridor and reception area) inside the University of Babylon in Hillah City for the period between August 2020 and August 2021. The results show that all the studied spaces in the Environmental Engineering Department had background noise levels out of the recommended threshold limit values. The results from this present study demonstrated that the quality of these locations' interior environment was low, indicating the need for improvement. Excessive noise levels are also obvious in this research as a primary concern impacting IEQ in the analyzed university building. However, the average indoor temperature and relative humidity of the four selected areas assessed in this study were generally within the threshold limit recommended values reflecting the suitable thermal comfort environment in the whole spaces of environmental engineering department. Additional research is warranted to measure and analyze other indoor environmental quality parameters. Further research is useful to study the associations between indoor environmental quality in university buildings and students' learning outcomes.
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