NOISE LEVEL ASSESSMENT IN ENGINEERING CAMPUS OF UNIVERSITI SAINS MALAYSIA: A COMPARISON BEFORE AND DURING COVID-19 PANDEMIC

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ABSTRAK

Pencemaran bunyi adalah pencemaran yang sering diabaikan. Ia tidak dapat dilihat dengan mata kasar. Ia juga boleh digambarkan sebagai bunyi yang tidak diingini atau tidak menyenangkan yang memberi kesan kepada kesihatan dan kesejahteraan manusia dan juga spesies lain. Industri pembuatan, pembangunan, pengangkutan, aktiviti komuniti dan aktiviti di rumah semuanya menghasilkan pelbagai jenis kebisingan dalam kehidupan moden. Kajian ini dijalankan untuk mengkaji tahap kebisingan dan sumber kebisingan di Kampus Kejuruteraan USM. Selain itu, kajian ini dijalankan untuk membandingkan perubahan tahap kebisingan yang disebabkan oleh pandemik Covid-19. Meter pengukur tahap bunyi, kiraan trafik secara manual, dan pengukuran kelajuan kenderaan digunakan untuk mengukur kebisingan dan lalu lintas. Pemetaan paras bunyi dianalisis menggunakan ArcMap 10.3. Data menunjukkan, beberapa tahap kebisingan setara di Kampus Kejuruteraan USM melebihi tahap kebisingan yang dibenarkan oleh Jabatan Alam Sekitar (JAS) untuk kedua-dua keadaan; sebelum dan semasa Pandemik Covid-19. Walau bagaimanapun, Pertubuhan Kesihatan Sedunia (WHO) menghadkan (55dB(A)) sebagai limit akhir tahap kebisingan, didapati bahawa tahap kebisingan di kampus sebelum pandemik Covid-19 lebih tinggi daripada tahap kebisingan semasa Pandemik. Selain daripada itu, dinyatakan bahawa tahap kebisingan pada Tahap Kebisingan Setara dengan Wajaran-A, L_{Aeq} mempunyai pengurangan purata 6dB(A) semasa Pandemik Covid-19. Akhir sekali, dengan menghasilkan pemetaan bunyi, dapat meningkatkan pemahaman mengenai persekitaran akustik dan masalah persekitaran pencemaran bunyi

ABSTRACT

Noise pollution is a dangerous hazard that is often overlooked. It is invisible to the naked eye, although it exists on land and beneath the water. It may also be described as any undesirable or distressing sound that has an impact on human and other species' health and well-being. Manufacturing, development, transportation, and community and home activities have all produced many types of noise in modern life. This research was conducted to investigate the noise level and sources of noise in the USM Engineering Campus. Besides, this study was carried out to compare the changes of noise level due to the Covid-19 Pandemic. The sound level meter, manual traffic count, and laser speed gun were used to measure noise and traffic. The mapping was analysed using ArcMap 10.3. From the results, from both situations; before and during the Covid-19 Pandemic some of the equivalent noise levels on the campus exceeded the permissible noise levels allowed by Department of Environment (DOE). However, the World Health Organization (WHO) limits (55dB(A)), it is found that noise levels before the Covid-19 Pandemic exceeded higher than during the Pandemic. Apart from that, from the research, it is revealed that noise level of A-weighted Equivalent Noise Level, L_{Aeq} having an average reduction of positive 6dB(A). Last but not least, producing noise mapping, can aids in the development of a better knowledge of acoustic settings and the problem of noise pollution in the environment.

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LIST OF SYMBOLS

dB	Decibel
dB(A)	A-Weighted Decibel
L_{eq}	Equivalent Sound Level
L_{max}	Maximum Sound Level
L_{min}	Minimum Sound Level
L_{10}	Noise level just exceeded 10% of the measurement period
L_{50}	Noise level just exceeded 50% of the measurement period
L_{90}	Noise level just exceeded 90% of the measurement period
L_{Aeq}	A-weighted, Equivalent Sound Level
LAF_{max}	A-Weighted, Fast Response, Maximum Sound Level
km/h	Kilometer per hour
M	Meter
Hr	Hour

LIST OF ABBREVIATIONS

WHO	World Health Organization
DOE	Department of Environment
USM	Universiti Sains Malaysia
UTM	Universiti Teknologi Malaysia
PCU	Passenger Car Unit
REDAC	River Engineering and Urban Drainage Research Centre
PPKT	Pusat Pengetahuan, Komunikasi dan Teknologi
DSG	Dewan Serbaguna
GPA	Grade Point Average
UAE	United Arab Emirates
IEC	International Electrotechnical Commission
APAIE	Asia-Pacific Association for International Education
IDW	Inverse Distance Weighted
CHS	College Health and Science
NYC	New York City

CHAPTER 1

INTRODUCTION

1.1 Background of Research

Noise is described as an unexpected or disruptive sound in a specific location. On the other hand, noise emission happens when the noise level exceeds the acceptable maximum for a given area. Noise acts as an environmental stressor, affecting people's health and interfering with their everyday lives and interactions (Khasawneh et al., 2020). The human that is exposed to noise pollution makes their mind and body less productive, regard to the duration of exposure which causes temporary or permanent harm to the human (Pagès et al., 2018).

According to Harthy and Omar (2019), environmental noise pollution has recently been identified as one of the key environmental issues affecting the quality of life in all nations globally, particularly in metropolitan areas. WHO stated that environmental noise is produced from all the activities in the community except for industrial sectors. It includes road, rail and air traffic, educational, construction, recreational and neighborhood. Sulaiman et al. (2018) stated that traffic is the primary noise source in either rural or urban areas. In Europe, an estimated 125 million individuals are impacted by noise levels of more than 55 dB(A), accounting for around 40% of the population (Segaran et al., 2020). Hence, the adverse effects of noise from transportation will result in students' concentration, learning process and communications (Ibrahim, 2018).

1.2 Problem Statement

Noise pollution has been noted as an urban environmental hazard on university campuses. Excessive noise in areas where educational activities take place might result in poor performance by lecturers, students, and staff. In its blueprint, Transforming Higher Education for a Sustainable Tomorrow, Universiti Sains Malaysia (USM) has set aims to become a world-renowned university for its commitment to sustainability and to be a sustainability-led university. In order to achieve sustainable growth, various environmental factors, including the acoustic environment, must be considered. The first step towards creating a sustainable university is to assess the current state of environmental factors including noise levels on campus before developing sustainability strategies and action plans. According to the World Health Organization (WHO), universities, schools, libraries, and hospitals are among the sensitive sectors that require a calm environment with strict control over noise pollution sources. The outdoor noise level L_{Aeq} for sensitive zones such as universities should not exceed 55 dB(A), whereas the indoor noise level (L_{Aeq}) during class should not exceed 35 dB(A) (Wen et al., 2019). Prior to the onset of Pandemic Covid-19, a research was carried out to measure noise levels on the Engineering Campus at USM. However, no research has been conducted on the noise levels on the campus during the Covid-19 Pandemic. The noise measurement during Covid-19 can serve as a useful reference for moments of low activity, i.e., when there are no students, and the acoustic environment is quieter. During this time, the institution shifted to online classes, although several important functions, such as administrative and maintenance services, remained operational. As a result, this study is conducted to compare noise levels on campus prior to and during Covid-19 in order to become a sustainable university.

1.3 Objectives

The objectives of this project are:

a) To assess the noise level by using Sound Level Meter and source of noise in the USM Engineering Campus.

b) To determine the changes in noise level before and during the Covid-19 Pandemic.

c) To establish noise maps that visualize the noise distributions in USM Engineering Campus.

1.4 Scope of Work

The research was conducted on USM Engineering Campus located at Nibong Tebal, Pulau Pinang. The study areas were determined based on preliminary site assessment to determine the suitable point in each location and related to the study. The selection of location mainly focuses on the main activities of students and staff. For example, the school of each department, student gathering places, office, hostels, field and other facilities.

Field measurement of noise and traffic monitoring was conducted at the campus area. According to the Arahan Teknik Jalan (8/86) and A Guide on Geometric Design of Roads, the traffic composition data were attained based on the vehicle types. It consists of the motorcycle, passenger car and vans, medium lorries and heavy lorries that were manually monitored simultaneously with the noise monitoring at each study site to observe the sources contributing to noise pollution. This study was done only

on working hours due to equipment limitations, workforce and duration of time for monitoring.

1.5 Justification of Research

The main objective of the research is to obtain the level of noise at the engineering campus of Universiti Sains Malaysia (USM), located at Nibong Tebal, Pulau Pinang. Students' focus will be disrupted by noise pollution. As a result, they take a longer time to complete the task than in a calm environment. In addition, students will be tired in the noisy area as they need more concentration to focus. This research would aid in the improvement of rules and legislation to determine the optimal noise level in the study area and immediate and long-term solutions to the noise issue. In certain situations, national norms impose legislation to maintain acoustic efficiency in specific areas such as parks, hospitals, and schools. Apart from that, to limit people's noise exposure, recommending the use of noise indicators and establishing compliance levels.

The analysis generates and evaluates descriptive statistics of noise level for each monitoring session, including noise descriptors, range of noise level recorded, mean and standard deviation of the noise level. Furthermore, the temporal variation in noise level was investigated at each study site to see whether the mean samples collected during the measurement session differed from one another.

1.6 Dissertation Outline

This dissertation consists of five main chapters that explain in detail the research project that has been conducted.

Chapter 1: Introduction - General overview of the research consisting of the problem statement, objectives to achieve and scope of work to be carried out.

Chapter 2: Literature Review – The content of this chapter explain about the past research that related to the sources of noise, regulations of noise control, campus noise, noise mapping, effects of noise pollution, Covid-19 Pandemic impact and mitigation measure to reduce noise.

Chapter 3: Methodology - Explaining the information of field study, data monitoring and analysis that include the flow chart and method need to be use in this study.

Chapter 4: Results and Discussion - The study results are discussed in this chapter, including the assessment level of noise measured at the engineering campus. Apart from that, comparison of the data with secondary data.

Chapter 5: Conclusion and Recommendation - This chapter summarizes the findings of the project and makes recommendations for dealing with the environmental noise issue on the campus.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, the literature review explains the past research related to noise pollution sources, noise control regulations, campus noise, noise mapping, health effects on noise pollution, Covid-19 Pandemic effects and mitigation measures to reduce noise.

2.2 Noise Pollution

Noise pollution has been officially recognised as a genuine challenge to public health and quality of life. Noise can be classified as a pollutant of the environment in the same way as particulate or gaseous pollutants. Noise has been shown to reduce productivity, harm well-being, and raise injury rates. Noise levels that surpass 55 dB(A) during the day and 45 dB(A) at night, as recommended by the World Health Organization (WHO), are considered extremely high (Halim et al., 2019). Continuous noise exposure of 85-90 dB(A) will cause hearing loss and threshold sensitivities to shift.

2.3 Sources of Noise

According to World Health Organization (WHO), noise is the second major pollutant after air, with dangerous effects on humans' health and activities (Ibrahim, 2018). Human beings are irritated by noise pollution. The noise is usually machine-generated sound that disrupts human action or equilibrium. It is a rising environmental

issue that is rapidly becoming an all-pervasive but underestimated source of contamination in both developed and developing countries (Jariwala et al., 2017).

Sources of noise are one of the most critical metrics to determine whether a noise problem will occur on-site is the noise source so that the authority will easily cope with it. According to Adepoju (2010), the primary sources of noise are divided into two major aspects: external and internal sources.

External sources are the primary sources of environmental noise, the noisiest from sources that difficult to control (Adepoju, 2010). Noise pollution is divided into two categories: natural (bugs, weather, birds) and human-made sources (industrial and non-industrial noise, which are related to traffic noise).

Internal noise sources are mainly related to human activities within the building, technology and any equipment can contribute to the noise. This include door slams, footfall (especially in multi-story buildings), dialogue, radio, fans, air conditioners and motorised appliances such as power generation sets (Adepoju, 2010). This kind of noise can contribute to the sources of vibration which intervene with the resident's daily activities and comfort. Figure 2.1 shows the decibel scale depicts the relative amounts of noise generated by various sources.

Apart from that, the major contribution to noise pollution is the noise from road transportation. Recently, several studies have been conducted that highway or road traffic has become the main reason for noise pollution and produced many adverse health effects on humans (Dasgupta, 2019). Commercial trucks and buses produced 10 dB higher than other vehicles. The noise level will rise as the vehicle size increase (Li, 2018).

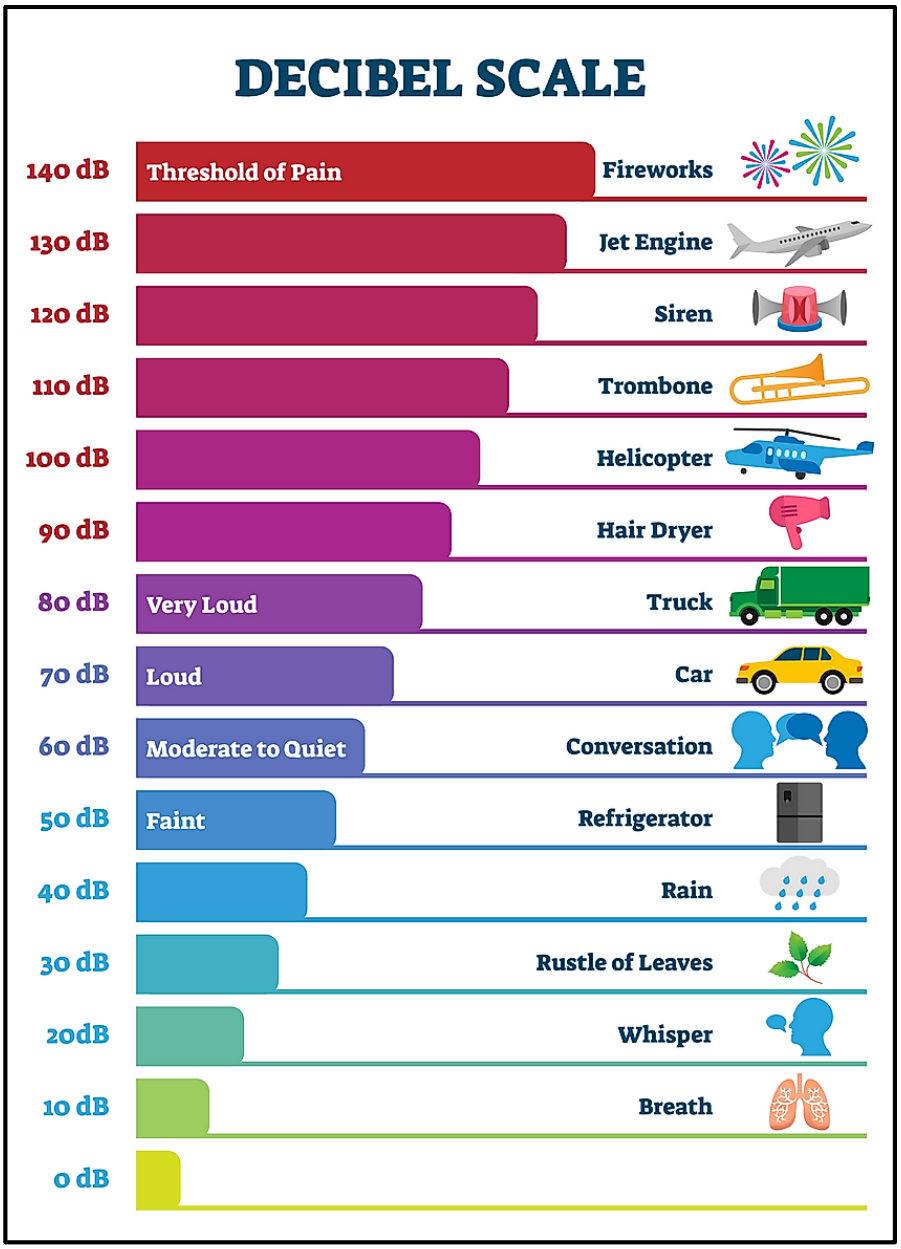

Figure 2.1: Noise level produced by various sources (WorldAtlas, 2021)

2.4 Regulation in Noise Exposure Limit

In order to overcome the excessive noise problem, many countries have outlined guidelines and regulations to ensure the entities in charge of the development sector would adhere to the maximum permissible limits. This effort had been seen as one of the critical factors to control the high level of noise exposure to the receiver.

2.4.1 Regulations in Malaysia

In Malaysia, the guidelines have been set by the Department of Environment (DOE). The guidelines have been outlined in order to prevent any serious health hazards and major impacts on the noise emissions to the receiver. As for that, the recommended sound level limits (L_{Aeq}) by receiving land use for existing built-up areas are shown in Table 2.1.

Table 2.1: Recommended permissible sound level (L_{Aeq}) by receiving land use for existing built-up areas (Department of Environment Malaysia, 2019)

Receiving Land Use Category	**Day Time (7.00 am to 10.00pm)**	**Night Time (10.00 pm to 7.00am)**
Low density residential, noise sensitive receptors, institutional (school, hospital, worship)	60 dB(A)	55 dB(A)
Suburban and urban residential, mixed development	65 dB(A)	60 dB(A)
Commercial business zones	70 dB(A)	65 dB(A)
Industrial zones	75 dB(A)	75 dB(A)

Construction noise has an intrusive temporal nature, and acceptable sound levels (statistical centile L_{90}, L_{10}, and maximum instantaneous sound pressure level) for construction and maintenance and demolition should be observed. The maximum permissible limit for daytime (7.00 a.m. until 7.00 p.m.) sound levels for residential and sensitive areas are 75dB(A) for L_{10} and 90 dB(A) for L_{max}. The maximum permissible limit for commercial and mixed development is 80 dB(A) for L_{10} and L_{10} of 80 dB(A) for industrial areas are recommended (Department of Environmental Malaysia (DOE), 2019).

According to Planning Guidelines for Environmental Noise Limits and Control Department of Environmental Malaysia (DOE), (2019), a recommended permissible sound level (L_{Aeq}) is prescribed in First Schedule for receiving land use for new development. The guideline could use the provided limits for new industrial, commercial, or residential areas that impact those aforementioned areas to protect public health and provide sufficient protection. The table of maximum noise limits of sensitive areas is given in Table 2.2.

Table 2.2: Recommended Permissible Sound Level (L_{Aeq}) by receiving land use for new development (Department of Environment Malaysia, 2019)

Receiving Land Use Category	**L_{Aeq} Day (7.00 am to 10.00 pm)**	**L_{Aeq} Night (10.00 pm to 7.00 am)**
Low-Density Residential, Noise Sensitive Receptors, Institutional (School, Hospital, Worship)	55 dB(A)	50 dB(A)
Suburban Residential (Medium Density), Recreational	60 dB(A)	55 dB(A)
Urban Residential (High Density), Mixed Development	65 dB(A)	60 dB(A)
Commercial Business Zones	65 dB(A)	60 dB(A)
Industrial Zones	70 dB(A)	65 dB(A)

2.4.2 Regulations by World Health Organization

The specific recommendation outlined by WHO were formulated into few categories namely road traffic noise, railway noise, aircraft noise, wind turbine noise and leisure noise; loud sound encountered during everyday leisure activities. The details of the categories are summarized in Table 2.3.

Table 2.3: Type of noise and exposure limit in Europe Region (WHO, 2018)

Type of Noise	Day time Limit dB(A)	Night time Limit dB(A)
Road Traffic	53	45
Railway	54	44
Aircraft	45	40
Wind Turbine	45	-
Leisure	70 (yearly)	70 (yearly)

Several guiding principles were elaborated to provide support for the implementation of the guideline limits. One of the ideals of mitigating noise intrusion and promoting strategies is reducing exposure to noise and conserving safe spaces to promote well-being. Aside from that, coordinating approaches to reduce noise sources and other health threats in the environment.

2.4.3 Regulations in the United Arab Emirates (UAE)

The noise limit guideline of UAE is summarized into Table 2.4 according to different areas as stated in Local Order 6 of 1991 extracted from Environmental Protection Regulation in the Emirate of Dubai.

Table 2.4: The allowable limit for different areas in UAE (Middle East Acoustic Society, 1991).

Area Description	Day time dB(A)	Night time dB(A)
Residential – Light Traffic	50	40
Residential Downtown	55	45
Mixed Residential and Commercial	60	50
Commercial	65	55
Industrial	70	60

2.5 Campus Noise

Souza et al. (2020) conducted a study on evaluating noise pollution related to human perceptions in universities in Brazil. The noise measurement was performed in the Faculties of Engineering, Arts and Design, Architecture and Urbanism region, which covers around 137,000 m^2, or about 10% of the overall area. It includes 32 outdoor and 11 indoor spots. A Portable Digital Thermo-Anemometer (TAD-800 – INSTRUTHERM) and a Portable Digital Sonometer (DEC-5030 1/1 and 1/3 Octave Band Time Analyzer) were used to monitor the noise levels. Apart from that, questionnaires were distributed to 140 volunteers in total, including students and staff.

The results show that 28 of the 32 measured outdoor locations surpassed the NBR 10.151 limits during the daylight period, while 17 of them were above the WHO standards, with a peak value of 12 dB(A) above the limits. Meanwhile, indoor locations recorded that all 11 locations were greater than 35 dB(A), indicating a campus deficiency in delivering acceptable acoustic conditions. Lastly, based on distributed questionnaires, it was found that only 55% of volunteers said they were affected by noise and only half of those who were bothered tried to solve it while studying or working.