Nat. Volatiles & Essent. Oils, 2021; 8(4): 13560-13571

An Essential Plant-Based Noise Absorption Measurement Concept For Machine Learning Data Pre-Processing In Environmental Studies

Jamaludin S M[1] , Hashim W[2] , M A Raj Mohamed R[3] , Nazeri S[4] , Sahwee Z[5] , Omar R[6]

[1]College of Computing and Informatics Universiti Tenaga Nasional Kajang, Malaysia

[2]College of Computing and Informatics Universiti Tenaga Nasional Kajang, Malaysia

[3]College of Computing and Informatics Universiti Tenaga Nasional Kajang, Malaysia

[4]College of Computing and Informatics Universiti Tenaga Nasional Kajang, Malaysia

[5]Engineering and Technology Universiti Kuala Lumpur (MIAT) Dengkil, Malaysia

[6]College of Computing and Informatics Universiti Tenaga Nasional Kajang, Malaysia

Abstract

The noise level in Peninsular Malaysia has constantly remained within the range of 70 dBA to 71 dBA which is above the recommended range by WHO (50dBA - 55dBA). To control the noise intensity level, planting trees has been seen as the most sustainable method to implement. However, the absorption properties of the trees to absorb noise are different from one another. Three measurement methods of determining absorption coefficient such as Adrienne method, impedance tube and reverberation chamberarediscussed and highlighted in this paper with associated analysis. The analysis such as common elements approach and complexity analysis are adopted and modified. The objectives of thesestudyare todesign and develop a measurement concept which can form basic guidance for researchers, communities, town developers as well as landscapers. The proposed concept is based on system organization theory which is modified to suit the aim of the studies. The concept foundation lays important component structures which are further evaluated by adding more elements in parallel to the advancement of information technology.

Keywords: noise attenuation, vegetation, impedance tube, Adrienne method, system theories, common element, geographical mapping, plant, noise absorption

1. Introduction

World Health Organization (WHO) recognises noise as one of the major pollutants influencing the environmental living and health. It was reported that more than 1 million lives are lost every year in Western Europe due to the noise exposure [1]. Noise pollution has turned into a serious concern in the current world and many researchers are actively performing research to find ways of reducing the noise to a tolerable level. In Peninsular Malaysia, it was recorded that the average transportation noise level is71.6dBA during daytime and 70.4dBA during the nighttime[2]. Unfortunately, noise level above 55dBA is already counted as noise pollution[3].

A more conventional mitigation method to reduce the noise is to plant more trees. Treesor vegetationcan reduce noise pollution through a phenomenon called sound attenuation, which is the reduction of sound intensity [4]. Vegetation hastens the normal attenuation mechanisms of absorption, deflection, refraction, and masking.The measurement of noise attenuation for vegetation species can be quite a challenging process to conduct [5]. This involves determination of the sound power level of the source and estimation of the attenuation of noise between the source and the point where noise level is to be controlled. Moreover, in-situ measurementsare not simple to conduct due to unfavourable measurement conditions, but this cannot be avoided if the subjectto be measured is already built-in within the environment.Another challenging step is to identify the suitable methods of noise reduction based on certain absorption properties and to select the best by cost-benefit analysis.A computer program withOut-of-Core Matrices Analyzer (OCMA) system specification in [5] was the beginning of modelling the noise attenuation pattern for predictive analysis purposes. As the modelling technique becoming more advanced, a further accurate predictive modelling can be produced, and such outcomes are the emerging capability of machine learning and data processing.

In this paper, several existing concepts of noise attenuation measurement are discussed and analysed. Among the methods listed are Adrienne method, impedance tubeand the reverberation chamber method.The analysisis categorised into fundamental technique, measurement complexity, applied technology and cost benefit analysis. The outcome of this evaluation exercise is utilized as input in designing our preliminary plant-based noise attenuation measurement concept. A simplified framework is proposed out of this analysis.

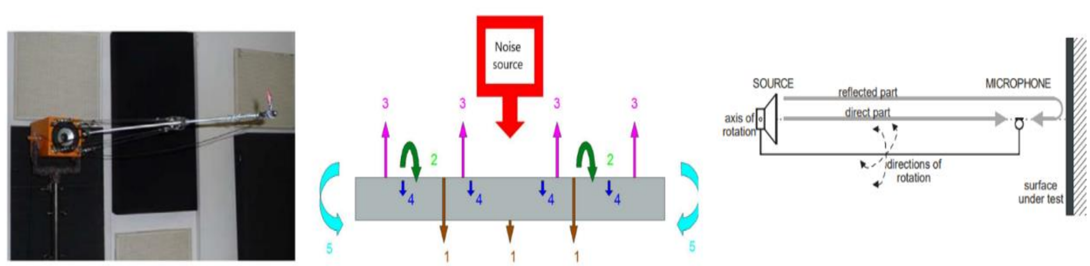
This paper will be organised as follows;a brief description of each measurement method is described in Section 2. Section 3 elaborates on the measurement method analysis and the proposed conceptis discussed in Section 4. Then, Section 5highlights the conclusion of thispreliminary research on the plant-based noise absorption measurement concept.

2. Noise Attenuation Measurement Methods

Prior to designing the preliminary measurement concept, this section reviews and analysethe above-mentioned measurement techniques. The mechanism of each technique is explained and discussed.

2.1. Adrienne Method

The Adrienne method is one of the methods that can be used to measure in-situ sound reflection, diffraction and airborne sound insulation as shown in Figure 1 (a). The measurement principle for the Adrienne method is as follows [6] [7], the sound fromthe source propagates in the form of sound waves, which are partly reflected, bent over and partly bent from thebarrier through the barrier material, as illustrated in Figure 1(b) and (c). The measurement is conducted to determine the noise barrier absorption coefficient(α). The sound absorption coefficient of a material is a dimensionless number valued between zero and one, over a range of frequencies, that represents a percentage of sound energy absorbed based on a unit area exposed to the sound [8].The absorption coefficient can be calculated from the ratio of the maximum and minimum sound pressure of the standing wave for discrete frequencies, or from a transfer function between two fixed points inside the tube where the pressure is measured using equalized microphones.



(a) (b) (c)

Figure 1: (a) Adrienne method setup (b) Adrienne measurement principle (c) Adrienne schematic diagram [6],[7].

2.2. Impedance tube Method

The traditional methods of measuring sound absorption coefficient and sound transmission loss of acoustic materials are usually time-consuming and expensive. To overcome this limitation, normal incidence sound absorption and transmission loss measurement technique using an impedance tube was developed. Unfortunately, this equipment is equally expensive [8]. A schematic diagram of an impedance tube is shown in Figure 2 [9]. The impedance tube (also known as Kundt Tube) obtains the normal incidence absorption coefficient of a small sample with a small diameter (usually less than 10 cm).In addition, it is also commonly used to measure sound transmission losses and acoustic properties of acoustic materials in normal incidence conditions.The impedance tube works on a principle of standing waves in a tube [10]. The sound is generated by a loudspeaker at one end of the tube and the sample is placed and sealed at the other end of the tube. The coefficient describes the ability of the material to absorb sound in a given frequency band.

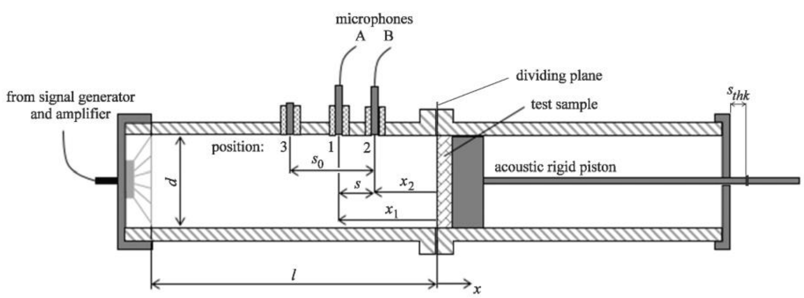


Figure 2: Impedance tube schematic diagram and design parameters [9]

2.3. Reverberation chamber method

Reverberation chamber works on the principle of reverberation time. It consists of a chamber with highly reflective walls, ceiling, and floor. The reverberation time of such a room is very long, and the longer it is, the more accurate the measurement. A standard sample of the material to be tested is laid on the floor and the reverberation time is measured. Comparing this time with the known reverberation time of the empty room yields the impedance of the sample material [10]. Figure 3 depicts a picture of reverberation chamber and its schematic diagram.Reverberation rooms are useful for measuring the sound power of machines that operate in long cycles [11]. However, in [12] the reverberation chamber was used for measuring the diffused field absorption coefficient of larger plant samples.The acoustic set-up consisted of calibrated microphones, amplifier, omnidirectional source, data recording and processing system as well as a thermohygrometer.

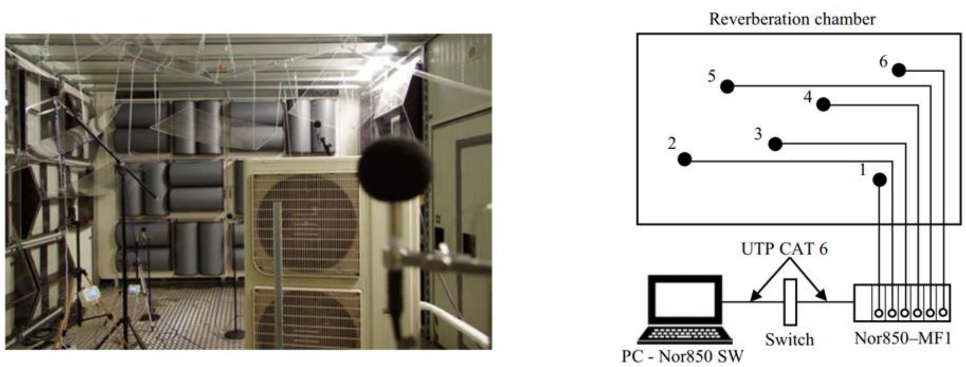


Figure 3: Reverberation chamber example and the schematic diagram [11]

3. Analysing Noise Absorption Concepts

In the previous section, three measurement concepts are briefly explained to highlight the empirical methods involved in determining the noise or sound absorption coefficient of a material. In this paper, the focused material is intended to be only the vegetation category, which are local in the surrounding environment of Peninsular Malaysia. Each of the methods in Section 2 will be further analysed into four categories in order to investigate important elements needed in designing the proposed concept.

3.1. Common element approach analysis for fundamental techniques

The first categorization is to determine the common fundamental elements in these three measurements techniques: Adrienne method, impedance tube and reverberation chamber. A similarity theory based on common element approach [13] is adapted in this analysis. Similarity can be calculated by counting numbers of common elements relative to other elements and/or by summing their values. A slight modification is altered in this theory to suit our intended analysis by removing the value summations. Commonality categories are based on type of inputs, value parameters, processing mechanism, system structure and elements of outputs. Figure 4 shows the analysis outcome onelements of common with respect to theproposed similarity categories on this study. Based on this outcome, it can be observed that the fundamental elements required in designing a measurement noise absorption concept must have criteria listed as X.

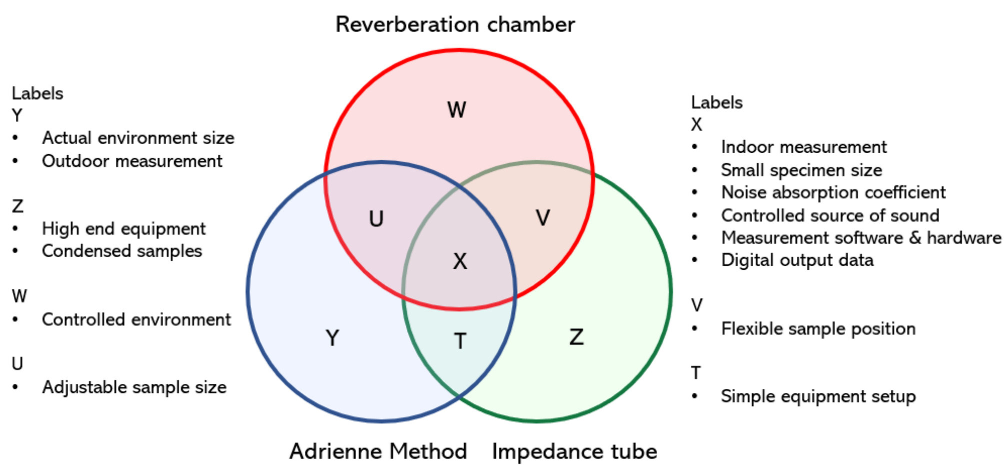
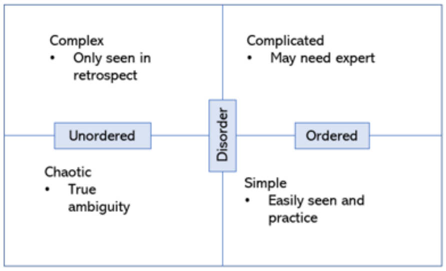


Figure 4: Analysis outcome based on the applied elements of common theory in this study.

3.2. Measurement setup complexity analysis

The second categorization is to figure out the complexity of measurement setup for each of the three methods described in Section 2. Complexity isanalysed following the theory discussed in [14]. Referring to the article'scomplexity and sense making theory, we have reviewed and modified the complexity visual representation on different states which canbe interpreted in different ways, depending on the context and suitability of our study. Figure 5 depicts the analysed measurement complexity and sense making for all methods previously shown. Classification is listed as portability of shifting the setup, level of expertise to configure the setup system, required apparatus necessity for the measurement and lastly the plant sampling preparation from the raw source. The states (complicated, complex, simple, and chaotic) are given based on some common senses. From the figure, it can be observed that, the impedance tube is perceived as easier to setup with scoring of 3/4 simple states.



Classification	Adrienne Method	Impedance Tube	Reverberation Chamber
Portability	Complicated	Simple	Complex
Expertise	Complicated	Simple	Chaotic
Apparatus	Complicated	Simple	Complex
Plant sampling	Complicated	Complicated	Simple

Figure 5: Modified complexity theory visualization states and measurement setup classification table

3.3. Applied technology analysis

In this analysis, the identified technologies applied in those three measurement techniques are arranged before a score of 0 to 5 is examined for each method. The score of 0 represents the least required and 5 for the most required. From Figure 6, it is obvious that each method has its requirement of technology. Reverberation chamber scores most of the chart element except for plant processor and cloud server. This is due to the nature of such method whereby, it can take samples of fresh plants with less limitation on the size and the closed measuring environment that perhaps block certain signals to enter the chamber.

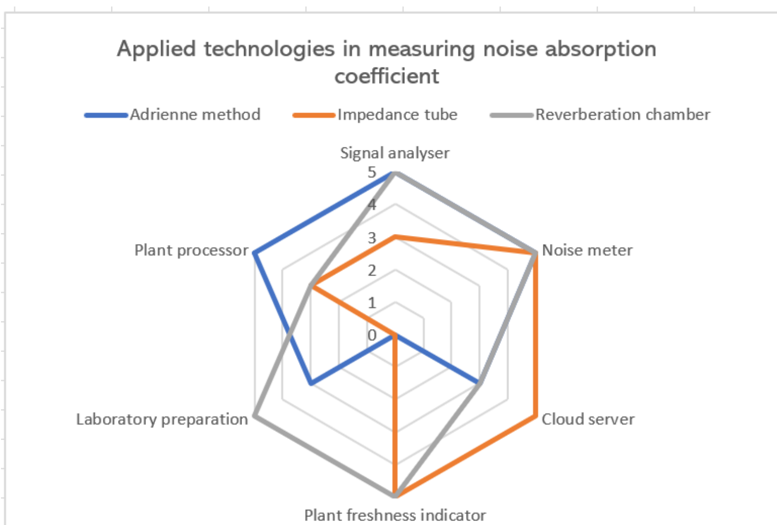


Figure 6: The analysis chart for the applied technologies in each method described in Section 2

3.4. Cost benefit analysis

The last analysis is the cost benefit analysis. Based on the common practise of using cost benefit assessment, Figure 7 is a simple table that listed all the possible costs that need to be considered for each measurement method. Though there is no information about the actual price for each setup, the analyses are based on generic evaluations from reviewing related publications. It is interesting to note that each measurement setup has its own strengths and weaknesses. This is important when a decision needs to be made.

Measurement method	Cost	Benefit
Adrienne method	• Laboratory setup • Devices and apparatus • Processed sample of materials • Industrial use	• Conventional • Affordable • Accurate measurement • Industrial quality
Impedance tube	• In house-built or manufacturer • No laboratory required • Raw materials • Minimum external apparatus • Education and industry	• Easy to build • No limitations of place • Samples can be obtained most places • Sharing of results among students • Acceptable accuracy • Less complex to operate
Reverberation chamber	• Special room is a must • Raw materials with bigger size • Many apparatus and devices • Research and industries	• Dedicated measurement location • Accurate measurement • Experts available to assist • Can analyse many samples

Figure 7: Simplified cost benefit analysis for each method described in Section 2

4. Proposed Measurement Concept

Based on the above analyses, Figure 8 illustrates the proposed preliminary plant-based noise absorption measurement concept for machine learning pre-processing data. Associated analyses form the basis of the proposed concept structure. Enhancement components are added into the fundamental structure to increase the functionality of this concept and keep abreast with the advancement of data processing. The main motivation for such proposed concept is to guide researchers in the same area in visualizing on what need to be considered when adopting such measurement technique. In designing the proposed concept, we have applied organizational system theory model described in [15], where we can identify the input, process and system as well as theexpected output. The enhanced components are related to the element of Internet of Things (IoT), machine learning, predictive analytics and some real time data representation which leads to a geographical mapping of the pollution intensity.

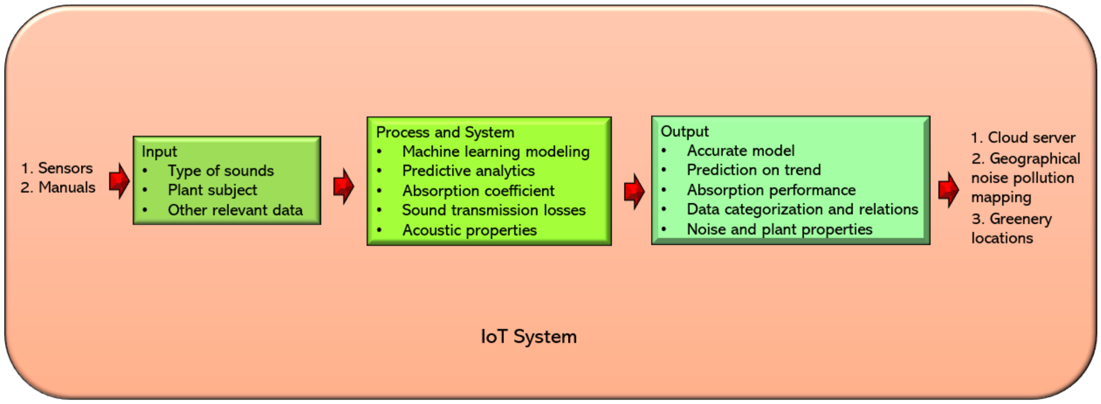


Figure 8: Proposed preliminary plant-based noise absorption measurement concept for machine learning data pre-processing.

5. Conclusion

In this paper we have discussed three main measurement methods that forms the basis to our proposed measurement concept. Analyses are conducted based on specific and relevant theories. Following these analyses, we have designed and proposed our preliminary measurement framework. The basic components consist of system inputs, processing, and system outputs. We have added additional block which is relevant to the current advancement of information technology. The framework can be applied to researcher of similar study areas, the community, town planners as well as residential developers. The noise absorption data based on plant sampling can assist these users in decision making not only to beautify the environment but also to control the noise pollution.

6. Acknowledgements

This research was supported by Fundamental Research Grant Scheme (FRGS) Project code 20190107FRGS and Ministry of Education Reference code FRGS/1/2019/WAB05/UNITEN/02/1 for financial support.

7. References

[1] Babisch W., Backman A. and Basner M., Burden of disease from environmental noise. Bonn: WHO European Centre for Environment and Health. **(2011).**

[2] Shahidan, S., Hannan, N. I. R. R., Maarof, M. Z. M., Leman, A. S., & Senin, M. S., A comprehensive review on the effectiveness of existing noise barriers commonly used in the railway industry. In MATEC Web of Conferences (Vol. 87, p. 01007). EDP Sciences. **(2017).**

[3] N. Ozkurt, D. Sari, A. Akdag, M. Kutukoglu, and A.Gurarslan., “Modeling of noise pollution and estimated human exposure around Istanbul Atatürk Airport in Turkey,” Sci. Total Environ., vol. 482–483, no. 1, pp. 486–492. **(2014).**

[4] Trees energy conservation, How does vegetation help reduce noise pollution in urban ecosystems?, https://trees-energy-conservation.extension.org/. Sept 10 2019. **(2019).**

[5] Peter Sutton, Process plant noise: Evaluation and control, Applied Acoustics

Volume 9, Issue 1, January, Pages 17-33 **(1976).**

[6] Pultznerová, Alžbeta, Ján Šimo, and Juraj Grenčík. "Possibilities of Evaluating the Effectiveness of Noise Barriers in Slovakia." Applied Sciences 11, no. 21: 10206. **(2021).**

[7] Suhanek, Mia, Kristian Jambrošić, and Dražen Miličević. "A comparison of two procedures for in-situ measurements of sound absorption coefficient." In 2009 International Symposium ELMAR, pp. 213-216. IEEE, **(2009).**

[8] Deshpande, Satyajeet P., and Mohan D. Rao. "Development of a low-cost impedance tube to measure acoustic absorption and transmission loss of materials." In 2014 ASEE Annual Conference & Exposition, pp. 24-417. **(2014).**

[9] Ďuriš ,R. and Labašová,E. “The design of an impedance tube and testing of soundabsorption coefficient of selected materials”, IOP Conf. Series: Materials Science and Engineering, September **(2020).**

[10] Hiremath, Nandeesh, Vaibhav Kumar, Nicholas Motahari, and Dhwanil Shukla. "An Overview of Acoustic Impedance Measurement Techniques and Future Prospects." Metrology 1, no. 1: 17-38. **(2021).**

[11] Drabek, Pavel, and Martin Zálešák. "Reverberation chamber and its verification for acoustic measurements." In MATEC Web of Conferences 20th International Conference on Circuits, Systems, Communications and Computers (CSCC 2016). EDP Sciences, **(2016).**

[12] Asdrubali, Francesco, Francesco D'Alessandro, Nicholas Mencarelli, and Kirill V. Horoshenkov. "Sound absorption properties of tropical plants for indoor applications." In Proceedings of the 21st International Congress on Sound and Vibration, China. **(2014).**

[13] Singley, M. K., and Anderson, J. R. "The transfer of text-editing skill."Journal of Man-Machine Interaction, 22, 403-423.**(1985)**.

[14] Turner, John R. and Baker, Rose M., "Complexity Theory: An Overview with PotentialApplications for the Social Sciences. "MDPI Systems, 1 – 23. **(2019)**.

[15]Esu, Bassey Benjamin. and Ufot, Juliet Alfred. "Operational Factors Affecting Service Delivery in Margaret Ekpo International Airport, Calabar, Cross River State, Nigeria."Australian Academy of Business and Economics Review (AABER), Vol. 3, Issue 3. 156-165, **(2017)**.

Authors

Siti Mastura Jamaludin

Siti Mastura is a potential researcher from Petaling Jaya, Selangor. She graduated with a Bachelor of Science degree in Marine Sciencefrom Universiti Malaysia Terengganu (UMT) in 2019. Mastura has a passion in environmental studies especially in areas of reducing air and noise pollution. She has authored a publication on the topic of plants and their noise absorption with data analysis. Mastura is currentlypursuing her study in Master by research in Information Technology at Universiti Tenaga Nasional (UNITEN) since February 2020.

Wahidah Hashim

Wahidah Hashim has been with the College of Computing and Informatics UNITEN, as an Associate Professor, since 2015. Apart from her active research in wireless systems, she has involved in the development of Malaysian technical specification, standard and guidelines of wireless devices. Her projects are related to the measuring and assessing signal quality, Unmanned Aerial System (UAS) as well as vegetation analysis for the electricity transmission corridor. She has published nearly 120 publications and filed several patents.

Rajina M A Raj Mohamed

Rajina received her BSc. in computer science and MSc. in distributed computing from University of Putra (UPM), Malaysia. She is currently a lecturer at UNITEN, Malaysia. She has involved and lead in several series of research projects from the domain of computer networking, data communication, machine learning and data mining. She won several awards at local and international exhibitions. Her research focuses are in the area of artificial intelligence, IoT and sensor-based application. She has published several publications and filed several patents on her research.