FOUR DIMENSIONAL STANDARDS OF TRAFFIC NOISES IN DHAKA CITY

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Abstract

The standard level of traffic noise has already been measured before, as an essential task to define noise pollution in Dhaka City. But, to determine the multi-dimensional standard of traffic noise for the Dhaka City, a sophisticated system of measurement and evaluation can be hereby prescribed. The prescribed system is based on the "new system for the measurement and evaluation of environmental noise" was proposed in 1999 at the "international conference on the measurement and evaluation of regional environmental noise" Kobe, Japan. The system is mathematically designed on the basis of autocorrelation function (ACF) of the sound signal. The four independent factors extracted from the ACF of the traffic noise can be recognized as the four fundamental dimensions of the single noise signal. The factors are: the time delay of the first peak ($\tau 1$), the amplitude of the first peak ($\phi 1$), the effective duration of the envelope at the ten percentile delay (τe), and the energy represented at the origin ($\Phi(0)$) in the normalized ACF. The above four factors of ACF are found so far, to be significantly responsible for the psychophysical correlates. Regarding this, a new concept in which, four different dimensions of standard for each traffic-noise signal can be developed to define noise pollution on the basis of those four factors of ACF. The system is more precise than that of the system available, based on the sound pressure level (SPL) only. The factors, however, extracted from the IACC (Interaural Cross Correlation) can also be used to localize the noise source.

INTRODUCTION

The City of Dhaka is one of the most polluted one in the recent world. Now-a days, there are many growing up activities observed on this regard. But unfortunately, the mass concern about the pollution of traffic noise is not significantly observed like air pollution, water pollution and so on.

The acoustic world around us continuously stimulates the active auditory systems of humans. But the brain selects only relevant signals from the acoustic input, whereas the ear and the lower auditory systems are continuously receiving external stimulation. This is a normal process and does not necessarily imply

disturbing and harmful effects. But the quantitative excessiveness of the effective qualities of the auditory stimuli may be the caused of hyperactivity of the psychophysical processes (Lundberg & Frankenhaeuser, 1978). Such of hyperactivity can, annoyance, and with other psychophysical disabilities (Glorig, et al, 1958; Berglund, et al, 1981). The components of traffic noise are responsible for any harmfulness or any degradation of psychophysical health can be identified as polluted elements.

Since many years, all types of noises have been evaluated in terms of the statistical sound pressure level (SPL), only, represented as *Lx* or *Leq*, and its, power spectrum is being measured by a monaural sound level meter (MSLM) around us. The sound pressure level (SPL) and power spectrum alone, however, do not provide a description that matches subjective evaluations of traffic noises. Thus, the higher values of SPLs of the noise signals are provisionally, considered to be defined as noise pollution. However, that should not be the whole story of defining noise pollution. As because of only the values of SPL are unable to explain sufficiently, the correlates between the properties of noise signals and the psychological as well as physiological effects. In this connection, a new method can be examined whether or not the four independent factors of autocorrelation function (ACF) of sound signal are related to that of the psychophysical affects. The present paper is going to propose such of new method which, can measure and evaluate the standards the traffic-noise pollution with four dimensions in relation to those of the psychophysical effects.

TRAFFIC NOISE

In the physical point of view, there is no difference between the concepts sound and noise, although it is an important distinction for the human listener. The noise is a special type of sounds that are considered as unwanted to the human. In some situations, but not always, noise may adversely affect the health and wellbeing of individuals or populations. Since long agreed among experts, it is not possible to define noise exclusively on the basis of physical parameters of sound. But obviously it can be said that the acoustical energy in noise should be randomly distributed. Instead, it is common practice to define noise operationally as audible acoustic energy that adversely affect, the physiological and psychological wellbeing of people. However, the whole features of noises produced from the different sources around the traffic channels in the City are called traffic noise. Such traffic noises travel from sources to receivers, through a variety of complex media and concerned it-self with the status of psychophysical health of inhabitants.

AUTOCORRELATION FUNCTION

The autocorrelation function (ACF) is going to be the determinant of analyzing the sound signals. It is well known that one of the most promising signal

processes in the active auditory system is that of the ACF, which can be mathematically defined by

$$\Phi(\tau) = \frac{1}{2T}\int_{-T}^{+T} p(t)p(t+\tau)dt, \qquad (1)$$

where, $p(t)$ is the sound signal at the entrances of the ears, τ is the delay time, and $2T$ is the integration interval. However, if the ACF is normalized in the distribution then, $\phi(\tau)$ can be defined by

$$\phi(\tau) = \frac{\Phi(\tau)}{\Phi(0)}, \qquad (2)$$

where, $\Phi(0)$ is the energy at the beginning ($\tau = 0$) of the ACF within each integration interval ($2T$).

It is also known that the ACF and the power density spectrum mathematically, contain the same information (Ando, 1998) as signal processors. In such of ACF analysis, there are four significant parameters, namely,

(1) the energy represented at the origin of the time delay, $\Phi(0)$;
(2) the effective duration of the envelope of the normalized ACF, τe, which is defined by the ten-percentile delay or at which, the envelope of the ACF becomes –10 dB, representing a kind of repetitive feature or reverberation contained within the source signal itself;
(3) the fine structure, including the amplitude, ϕ1, between the first peak and the zero crossing number; and
(4) the fine structure, including the time delay of first peak, τ1;.

Note, that the characteristics of the envelope of the normalized ACF, is also related to important subjective attributes. Thus the signal duration corresponding to the psychological presents, as suggested by Fraisse (1982), is 2T = 0.5 - 5.0 sec. The psychological present defined here as a short, time duration of stimuli needed for subjective responses.

AUDITORY SENSATION AND 'ACF'

A functional model of "auditory-brain system" is existing (Ando, 1998) and working well to describe fundamental psychological attributes for any types of sound fields. It describes the fundamental psychological attributes in respect of autocorrelation function (ACF) and interaural crosscorrelation mechanisms (IACC) of the signals. The temporal and spatial factors, respectively, extracted from the ACF and IACC are individually responsible to that of the characteristics of different sensations. However, another "theory of primary sensation" corresponding, to that of the "auditory-brain system" was proposed by Ando (2001), and Ando et al (2002). The theory in which, four fundamental-auditory perception -loudness, pitch, timbre, and duration- are independently identified (Saifuddin 2001; Saifuddin et al, 2001a, 2001b, and 2001c) in relation

to those of the factors extracted from the ACF and IACC. Thus the primary auditory sensations respectively concern with the above four perceptions can be described well by the four orthogonal factors extracted from the ACF of traffic-noise signals. So, if primary-auditory sensations and their respective four-fundamental perceptions are concerned with the factors of ACF, the traffic-noise pollution can be measured by analyzing ACF on the basis of psychophysical health degradation.

STANDARD OF TRAFFIC NOISE – AVAILABLE CONCEPT

The traditional concept of standardizing noise pollution is popularly based on the level of energy of sound signal. So, all of the noises do not mean noise pollution. But in modern concept, that should not be the whole story of defining noise pollution. Because of the concepts of noise pollution are obviously concerned with the qualitative identification and quantitative level of the sound signals. So the standard of noise pollution should not only be one measure but also the numbers of the fundamental factors extracted from the ACF. In order to that, to define and determine the modern standards of noise pollution, scientific investigations are necessary. However, the actual "critical limits" of the pollution cannot be found objectively by conducting research. Standards are set by society as the out come of a normative efforts, rather than emerging from an objective "scientific result" (Rohrmann, 1993). Regarding this five questions need to be clarified when setting noise standards (Rohrmann, 1993):

(a) Which effects occur ?
(b) Are these caused by the noise emission ?
(c) Which kinds or degrees of effects are unacceptable ?
(d) What exposure levels are they likely or certain to occur ?
(e) Which type of standard would be most protective ?

To make appropriate answers of the above questions a new method of measuring traffic-noise pollution can be applied using the measurement system of the four orthogonal factors of ACF.

Standards Available for Dhaka City

The standards of the traffic noises in the Dhaka City have been measured recently (Alam M.J.B. et al., 2000 and Bangladesh Gazette, 1997). Although the measurement procedure was conducted on the basis of the concept, sound pressure level (SPL) of the noise signals. However, the five different levels of standards were measured as defining as the acceptable levels of noise depending on the different situation in Dhaka City. The measured standards are: 75dB for the industrial area, 70dB for the commercial area, 60dB for the mixed are, 50dB for the residential area, and 45dB for the so-called sensitive areas (park, school, hospital, mosque).

But most of the recent studies (Ando, 1998) have shown that only the sound pressure levels of the noise signals are unable to describe the human annoyance and psychophysical correlates. So that the traditional concepts of standard (SPL)

is needed to be reconsidered. Because, the four factors ($\tau 1$, $\phi 1$, τe and $\Phi(0)$) including SPL ($\Phi(0)$) extracted from the ACF of the noise signal are independent to make effects on the psychophysical health. Even under the standard level of signal energy ($\Phi(0)$) other factors ($\tau 1$, $\phi 1$ and τe) still can be found active to make harmful psychophysical effects. The values of the factors can be measured by analyzing the ACF of the signal, and similarly the source characteristics can be identified in location by analyzing the IACC. Then the noise-control engineering will be able to adopt the system in which, above standards components to be eliminated by changing the noise-source characteristics.

STANDARD OF TRAFFIC NOISE – A MODRN CONCEPT

A newly computational software system is developed (Sakurai et al, 2001) for the evaluation and measurement of sound signals according to the signal processor of autocorrelation function (ACF). The system is based on a model of the human auditory-brain system and the functional specialization of the cerebral hemispheres (Ando, 1998) of human brain. If the quantitative levels of the components of sound signals are concern with the term "pollution" the computational software system can be recognized as an electronic device of signal measurement. The electronic device consists of two microphones arranged as a binaural pair, a laptop computer, and software (Real time analyzer) that extracts the factors of ACF and IACC (Interaural Cross Correlation) from the real-time noise data. The system is able to measure traffic noises automatically and simultaneously calculates the factors of ACF for the two signals and the IACC of the dual signals.

The computational-software system can be used to measure the four-dimensional standard of pollution of traffic noise by means of four factors of ACF. Each standard for each dimension out of four should be measured individually considering the respective levels of psychophysical health. The on going system is very newly introducing in Japan to identify the components as to be defined as polluted one.

FOUR STANDARDS

The new system for the evaluation and measurement of the four standards of traffic-noise pollution can be named as: ***Noise Standard Measurement Device***.

The four standards of traffic-noise pollution which, can be measured by the "Noise Standard Measurement Device" are namely as follows:

1) Standard for energy level = SE-$\Phi(0)$,
2) Standard for frequency level = SF-$\tau 1$
3) Standard for first energy in the ACF = SFE-$\phi 1$
4) Standard for first-time delay in the ACF = SFT-τe

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