Environmental Pollution 239 (2018) 741–750

Contents lists available at ScienceDirect

Environmental Pollution

journal homepage: www.elsevier.com/locate/envpol

Evaluation of an urban traffic Noise–Exposed population based on points of interest and noise maps: The case of Guangzhou☆

Haibo Wang [a, b, c], Hanjie Chen [b, c], Ming Cai [b, c, *]

[a] School of Civil and Transportation Engineering, Guangdong University of Technology, Guangzhou, China
[b] School of Engineering, Sun Yat-sen University, Guangzhou, China
[c] Guangdong Provincial Key Laboratory of Intelligent Transportation System, Guangzhou, China

ARTICLE INFO

Article history:
Received 31 July 2017
Received in revised form
8 November 2017
Accepted 8 November 2017

Keywords:
Point of interest
Environmental noise functional region
Population density
Noise exposure
Noise map

ABSTRACT

The primary objective of this study was to develop an evaluation method for assessing an urban traffic noise–exposed population and apply it in the main urban area of Guangzhou. The method based on points of interest (POIs) and noise map is realized in several steps. First, after regionalizing based on road networks and executing a cluster analysis for regions according to the properties of POIs, the environmental noise functional regions (NFRs) of the urban area are presented. Then, surrounding POIs are used to infer the type of buildings, and according to the attraction of different building types and the whole population of the region, the population distribution at the building level is calculated. Finally, with the help of a noise map, an evaluation method for assessing an urban traffic noise–exposed population is proposed. The method is applied in the main urban area of Guangzhou, and the results reveal the followings. 1) At daytime and nighttime, 23.63% and 30.53% of the population, respectively, experience noise levels that exceed the noise standards. The per capita noise exposure value at daytime and nighttime is 0.9 dB and 2.0 dB, respectively. 2) The percentages of the exposed population of Yuexiu District were 28.89% at daytime and 35.65% at nighttime, which are the largest, followed by the exposed population percentages of Liwan, Haizhu, and Tianhe Districts. 3) From the view of different classes of NFRs, the percentages of the exposed population of Class 1 and Class 4 are larger than the percentages of the exposed population from the other classes, especially at nighttime (48.24% of Class 1 and 40.79% of Class 4). 4) Although there are masses of people affected by traffic noise, a large percentage of them (85%) experience not more than 5 dB of traffic noise superscale.

1. Introduction

Traffic noise has become a significant issue with the rapid growth of motor vehicle use. Statistics from France (Morel et al., 2012), India (Shukla et al., 2012), and Iran (Dehrashid and Nassiri, 2015) shows quite severe sound environments, especially in urban areas. With the high density of road networks and population, noise pollution in urban areas is even more serious, which has had serious effects on people's daily lives (Weyde et al., 2017), physiological health (Roswall et al., 2017), and psychological health (Oiamo et al., 2015). Presently, vehicle designs (Zhang et al., 2017a(1); Zhang et al., 2017b(2)) also consider noise control. Hence, it is essential to evaluate the noise-exposed population in urban areas and provide the basic data for noise abatement.

Urban environmental noise quality evaluation has been an area of increasing interest in environmental acoustics in recent years (Korafli, 2003; Ambrosio et al., 2014; Lam, 2007), which has usually presented the noise distribution and considered the A-weighted sound pressure level (L_A). Furthermore, some scholars performed more detailed studies on noise evaluation with the help of population distribution and sound requirements. For example, Popa et al. (2015) presented an analysis of road traffic noise in Alba Iulia, which considered population, and Piccolo et al. (2005) completed a noise evaluation in Messina with a regionalism of six classes of noise functions. Another study (Gulliver et al., 2015) developed an open-source road traffic noise model for exposure assessment, which has been applied in London. In addition, different models of spatial analysis for noise modeling are developed worldwide (Bilaşco et al., 2017; Kosała and Stępień, 2016; Haq

☆ This paper has been recommended for acceptance by Dr. Hageman Kimberly Jill.

* Corresponding author. Room A408, Building of School of Engineering, Sun Yat-sen University, Guangzhou Higher Education Mega Center, 510006, China.
E-mail address: caiming@mail.sysu.edu.cn (M. Cai).

https://doi.org/10.1016/j.envpol.2017.11.036
0269-7491/

et al., 2012; Sheng and Tang, 2011; Garg and Maji, 2014). However, there are two problems in the evaluation of road traffic noise–exposed populations in urban areas. First, as the requirements of the sound environment are different, the environmental noise functional regions (NFRs) should be regionalized. Most of the regionalism in urban areas are coarse and outdated. Second, the dimension of population density limits the evaluations, and more micromesh evaluations cannot be realized.

Fortunately, the mass of points of interest (POIs) of web maps make the above problems more solvable. With the development of web technology, POIs have been widely used in webGIS, webmap, and navigation (Mckenzie et al., 2015). The scale of information of POIs, which includes positions, properties, etc., is adequate for clustering analysis (Rodrigues, 2010). Some studies employed POI clustering for regionalism with different attributes (Yuan et al., 2012), meticulous population evaluation (Bakillah et al., 2014; Li et al., 2013), and urban planning (Long and Shen, 2015).

In this paper, an evaluation method based on POIs and noise maps for assessing an urban traffic noise–exposed population is introduced. Depending on the information of the road network, data on POIs and buildings, the regionalism of NFRs, and the population distribution at the building level of the urban area are presented. Then, using the noise map, evaluation an urban traffic noise–exposed population is proposed. The method is applied in the main urban area of Guangzhou.

2. Basic description

2.1. POIs

POIs are kinds of places or things that point to the destination or places of activity such as hotels, schools, or hospitals. POIs are used to infer the NFR and population distribution in this study, as the types and density of POIs can reflect the functional property of an area.

2.2. NFR classes

Different functional areas have different ambient sound quality requirements. For example, compared to industrial areas, sound quality requirements in schools or homes are higher. Hence, the evaluation must be based on NFRs. According to the standard of China (GB/T15190–2014) (China's State Environmental Protection Administration, 2014), the noise limits based on L_A of each NFR class are listed as follows.

a) Class 1 includes residential, educational, health caring, and official areas, where the noise limits at daytime and nighttime are 55 dB and 45 dB, respectively.
b) Class 2 includes mixed areas of commercial, industrial, and residential, where the noise limits at daytime and nighttime are 60 dB and 50 dB, respectively.
c) Class 3 includes industrial areas, where the noise limits at daytime and nighttime are 65 dB and 55 dB, respectively.
d) Class 4 includes both sides of road traffic and inland waterway areas, where the noise limits at daytime and nighttime are 70 dB and 55 dB, respectively.

2.3. The study area

Guangzhou is located in southern China. The main urban area of Guangzhou (see Fig. 2a) was chosen as the study area in the present study and includes four districts (Haizhu, Tianhe, Yuexiu, and Liwan). The total area is more than 280 km^2, with a population of approximately 5.14 million in 2010 (National Bureau of Statistics of the People's Republic of China, 2010). The commonly used NFR of this area was completed in 1992 by the local government (Guangzhou Municipal People's Government, 1992), which is coarse and quite outdated. Geographic information of this area, such as data on POIs, buildings, and road network, is acquired, and a new regionalism of the NFR and a more micromesh population distribution are obtained. The evaluation of urban traffic noise–exposed population of this area is presented in combination with a road traffic noise map of Guangzhou.

2.4. Overview of the methodology

The purpose of this paper is to develop an evaluation method for assessing urban traffic noise–exposed population and apply it in the main urban area of Guangzhou. The detailed process is shown in Fig. 1. First, automatic query arithmetic is used to acquire the geographic information from web map, which includes data on POIs, road network, and buildings. Then, the regionalism based on the road network is completed. For every region, a cluster analysis based on types and density of POIs is used to infer the NFR class of that region. Additionally, information from POIs reveals the functional properties of buildings. By setting different attractive coefficients of buildings and resolving the demographic data, the population distribution at the building level is acquired. Finally, the evaluation of the urban traffic noise–exposed population is presented in combination with a road traffic noise map.

3. Regionalism of NFR based on POIs

Considering the uniqueness of the Class 4 region, the clustering method of POIs is used to determine the Class 1–3 regions first. Then, the Class 4 region is acquired by buffering the traffic line according to the Chinese standard GB15190-2014.

The regionalism of NFR based on POIs can be divided into four steps. a) Divide the urban area into multiple regions based on road networks. b) Set description parameters for each region based on types and density of POIs. c) Complete the cluster of POIs according

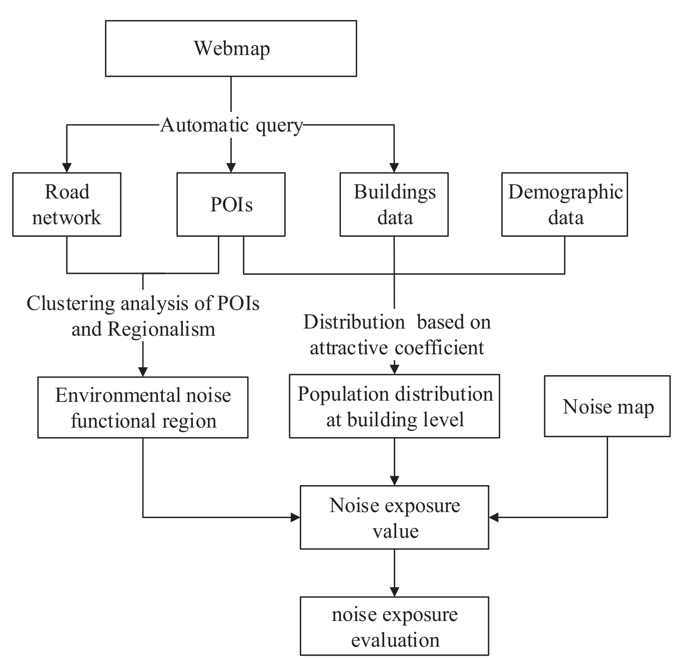

Fig. 1. Overview of the noise exposure evaluation method.