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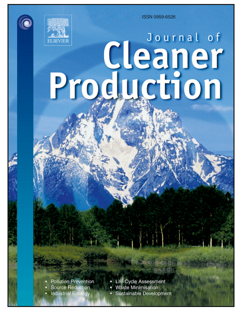

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Emission pattern mining based on taxi trajectory data in Beijing

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Abstract

Traffic-related air pollution has been one of the major environmental problems in China, which hinders the economic development. It is urgent to explore the urban traffic emission patterns so as to support the low-carbon urban planning and traffic management. With this purpose, this paper proposes a new urban traffic emission analysis model. Taking the traffic analysis zones (TAZs) as the analysis unit, this paper studies the dynamic emission patterns spatially and temporally based on taxi GPS data in Beijing. The whole urban area of Beijing is divided into 33 TAZs depending on the feature of road network. And the trip patterns of TAZs are extracted. The instantaneous emissions of CO_2, NOx, VOC and PM within and between TAZs are estimated. The relationships between emissions and road densities are studied. The results demonstrated that (1) the highest taxi trips during the day occur at 10:00, 16:00 and 20:00. (2) The variations of the 4 pollutants within and between TAZs are similar. The emissions of TAZs with business centers, entertainment centers and transportation hubs are obviously higher than others. For TAZs within the 5th Ring Road, the northern emissions are stronger than the southern. Emission patterns can be divided into 3 types, corresponding to the time periods of 0:00-3:00, 3:00-6:00 and 6:00-24:00. (3) There is a positive relationship between emissions within and between TAZs and road densities. And when the road densities of TAZs are bigger than 0.6, emissions within TAZs will rise up obviously with the increasing road densities. The policy implications of results include the region function planning, traffic planning, the public transport improvement, optimal design of charging stations and new energy vehicles promotion.

Keywords: Data mining; Traffic analysis zone; Emission pattern; Beijing

1. Introduction

With the rapid urbanization process, urban traffic demand is increasing quickly in China, leading to traffic problems. The distinctly growing greenhouse gas (GHG) emissions and air pollution generated from road traffic based on fossil fuel have received more and more attention. It has become an imperative task to conduct energy-saving and emission reduction work. The central and local municipal governments in China have paid much attention to emission mitigation (Wu et al., 2017). In the aspect of vehicles, there are efforts about the development of China 1-6 emission standards (MEE and SAMR, 2001, 2005b, c, 2013, 2016), enhanced I/M programs for in-use vehicles (Wu et al., 2011), yellow-labeled vehicles classification and regulations (State Council P.R. China, 2013), improvement on vehicle engines (Huo et al., 2012a) and motorcycles and heavy-duty truck restrictions (MEE and SAMR, 2005a). In the aspect of fuel, the main efforts contain the fuel quality improvement (Yue et al., 2015) and new energy vehicle promotions (State Council P. R. China, 2012). In the aspect of traffic management, there are policies about public traffic infrastructure enhancement, public transport subsidy (MOHURD. P. R. China, 2016), bus lanes (Yu et al., 2015), bus rapid transit system (Liu and Teng, 2014), new energy buses (Lin and Tan, 2017) and taxis, odd and even number restrictions (Wu et al., 2017) and old vehicles regulations (Zhang, 2014). As for economic measures, there are car purchase restrictions (Diao et al., 2016), increased parking fees, new energy vehicle subsidies (Helveston et al., 2015; Ma et al., 2017; Xu et al., 2017) and tax reduction. Besides, the policy about the congestion fee is being considered.

The advanced information and communication technologies promote the development of smart city. At the same time, various traffic detection data is applied into the broader research field. The diversified traffic detection data can be divided into 3 classes. The first one is the individual travel data, containing the smart card records of buses and subway (Huang, Zhengfeng et al., 2017), bike-sharing data (Zhang et al., 2015), car-sharing data (He et al., 2014; Yu et al., 2017), cellphone signaling data (Mao et al., 2016), cellphone navigation data and other application data of cellphone. The second one is the regulation data of enterprises, such as logistic data of commercial vehicle (Joubert and Meintjes, 2015). The third one is the road detection data, including GPS trajectory data (Hsueh and Chen, 2018; Li et al., 2015), electronic toll data based on RFID (Tseng et al., 2014), vehicle detection data of inductive loop detectors, microwave detectors, infrared detectors, laser radar detectors, ultrasonic detectors and closed-circuit television cameras (Seo et al., 2017). The appearance of big data mining techniques makes it possible to explore the patterns of large-scale urban traffic and air pollution. Compared with the social media data, road detection data and mobile communication network data, taxi GPS trajectory data has advantages of wide coverage, high spatial resolution and low installation and maintenance cost. Based on GPS records, related studies have been conducted, e.g. traffic congestion and incident detection (D'Andrea and Marcelloni, 2017; Munoz-Organero et al., 2018), traffic state estimation (Hsueh and Chen, 2018; Zhan et al., 2017) and route choice (Ciscal-Terry et al., 2016) which can provide appropriate suggestions for urban traffic management and control.

In addition, energy-saving and emission-reduction work has become a global issue, leading to some research on traffic

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