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Study on Diurnal and Weekly Vehicle Transportation CO_2 Emission of Typical Urban Road in Beijing

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Abstract. In this paper, the variation characteristics of diurnal and weekly transportation CO_2 emissions at intersection of the Datun and Beichen West Road are studied from the urban road scale. The double-peak and double-trough pattern of diurnal transportation CO_2 emissions at the intersection of Datun Beichen West Road is very obvious. The weekly transportation CO_2 emissions order is: Monday (the first workday of a week) > weekend > Wednesday (an ordinary workday of a week). Based on this, transportation carbon emission reduction is proposed in this paper.

1. Introduction

Urban area is the main area of global carbon emissions. The process of urbanization is bound to have a profound impact on the global carbon cycle and climate change (Nancy B. G, et al., 2008). With the rapid improvement of China's urban motorization, the urban transportation carbon emissions have become increasingly serious (Felix C, ET al., 2009). The Control of urban transportation carbon emissions becomes a focus and one of the key areas for emission reduction in all countries. The spatial scale of the study has been deepened from the urban scale (Andres Schmidt, et al., 2014) to the microscopic urban blocks scale (E. Velasco, et al., 2014) and the bottom-up approach has been relatively widely used in the field of transportation CO_2 emissions (Christian B, et al., 2013; Yu Li, et al.,2017). Selecting the "bottom-up" approach, this study integrates field monitoring of vehicle flow in the study area with MOVES 2014a model (Hatem Abou-Senna, et al, 2013) of U.S. Environmental Protection Agency (EPA), and analyzes the dynamic variation characteristics of transportation CO_2 emissions in the case area, thus providing reference for the study of urban transportation CO_2 emissions.

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2. Data sources and research methods

2.1. Study area

Across the urban arterial road of the Olympic Park section, Bejing Datun Road is from the Beishatan Bridge crossing above the Beijing-Tibet Expressway to connect with the Tsinghua East Road in the west to the Bayan Road in the east, a total length of 4.0 kilometers. There is a two-way six-lane underground tunnel and a two-way four-lane ground road. Beichen West Road starts from Metro Line 10 in the south to the west gate of Olympic Forest Park in Kehui Road in the north, a total length of 3.7 kilometers. There is a two-way eight-lane ground road.

2.2. Vehicle classification method

In this paper, based on the old standard of the Terms and Definitions of the vehicles and trailers (GB/T3037.1-1988) promulgated by the General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) and the Annual Report of China's Pollution Prevention and Control of Motor Vehicle (2013) issued by the Ministry of Environmental Protection, this study draws on the experience of other domestic and foreign vehicle classification methods that were used in estimating the transportation CO_2 emissions. In the case area, the passenger cars are divided into three subcategories: large passenger cars, medium-sized passenger cars and small passenger cars, and the small passenger cars are classified into subcompact cars, SUVs and taxies; the trucks are divided into three subcategories: heavy-duty trucks medium-duty trucks and light-duty trucks; the buses are divided into three subcategories: ordinary buses, extended buses and double-decker buses.

2.3. Video capture of the field traffic flow under the traffic node

Based on the "bottom-up" estimation method of the transportation CO_2 emissions, field manual monitoring of traffic flow in the Olympic center area was conducted. The main monitoring equipment was a camera (SONY, HDR-CX510E) with a 7-meter high pan and tilt. According to the vehicle classification system of transportation CO_2 emissions, the traffic flow monitoring video of the roads and tunnels at the intersection of Datun and Beichen West Road was interpreted, thus obtaining the traffic flow statistics for each vehicle type per 30 minutes of each monitoring point.

2.4. Estimating transportation CO_2 emissions with localized MOVES model

Based on the modification of the parameters of the MOVES 2014a model, such as the monthly, weekly, diurnal time scales, micrometeorological condition, vehicle types, driving speed and vehicle condition, the CO_2 emissions per 30 minutes of the study area were estimated. The data of the transportation CO_2 emissions from 6:00 to 1:00 the next day (a total of 19 hours) of Monday (the first workday of a week) and Wednesday (an ordinary workday of a week) when the traffic restriction was imposed and non-restricted Saturday (non-working day) were observed from September to November in 2014. Among them, the data from 1:00 to 6:00 could be approximately replaced with the data from 24:00 to1:00.

3. Result and discussion

3.1. Characteristics of transportation CO_2 emissions on weekdays

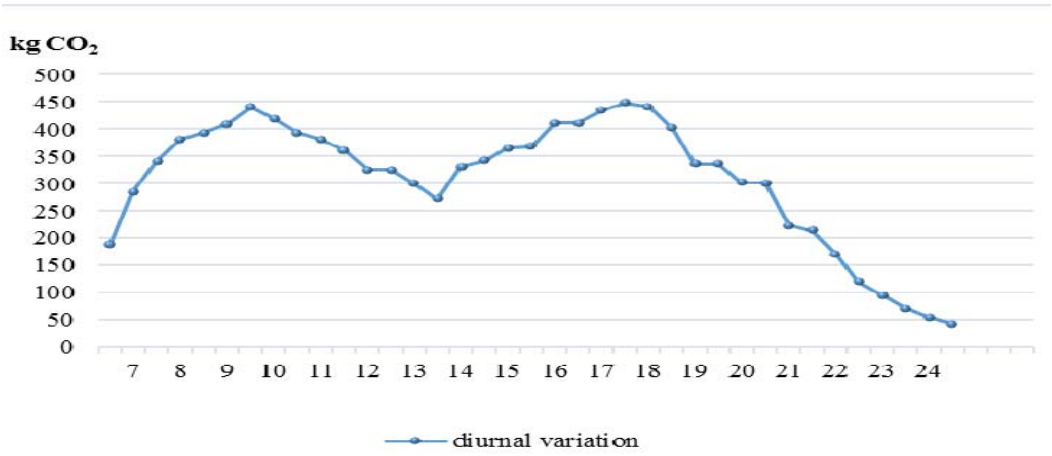

Figure 1. The Average diurnal transportation CO_2 emissions at the intersection of the Datun Road and Beichen West Road in September, October and November of 2014

3.1.1. Diurnal variation characteristics. From September to November in 2014, a total of 1,030.16 tons of transportation CO_2 was emitted at the intersection of Datun and Beichen West Road, with an average of 11,446.215 kg CO_2 per day on weekdays.

From the view of diurnal scale, the "double-peak and double-trough pattern" of transportation CO_2 emissions of the study area at the intersection of Datun and Beichen West Road was very obvious. As can be seen clearly in the Fig.1., the CO_2 emissions increased from 6:00 to 10:30, with the first peak of 440.18kg appearing between 9:30 and 10:00; then it started to decrease and reached a small trough of 272.23 kg; then they increased again and reached the second peak of 448.55 kg between 17:30 and 18:00; then they decreased again and finally reached a large trough of 43.31 kg after 0:00, with occasional slowdown or stagnation in this process.

3.1.2. Weekly variation characteristics. During the period of July 13, 2014 to October 11, 2014, Beijing imposed the traffic restriction on the tail number of the license plates of motor vehicles. It stimulated that the motor vehicles whose tail numbers are 4 or 9 would be restricted on Monday, 5 or 0 on Tuesday, 1 or 6 on Wednesday, 2 or 7 on Tuesday and 3 or 8 on Friday. The vehicles with provisional license plate numbers also were included. The tail number that is English letter was regarded as zero, and all motor vehicles were not restricted in statutory holidays and public holidays. In this study, the variation characteristics of transportation CO_2 emissions were compared and analyzed under the restricted and non-restricted days.

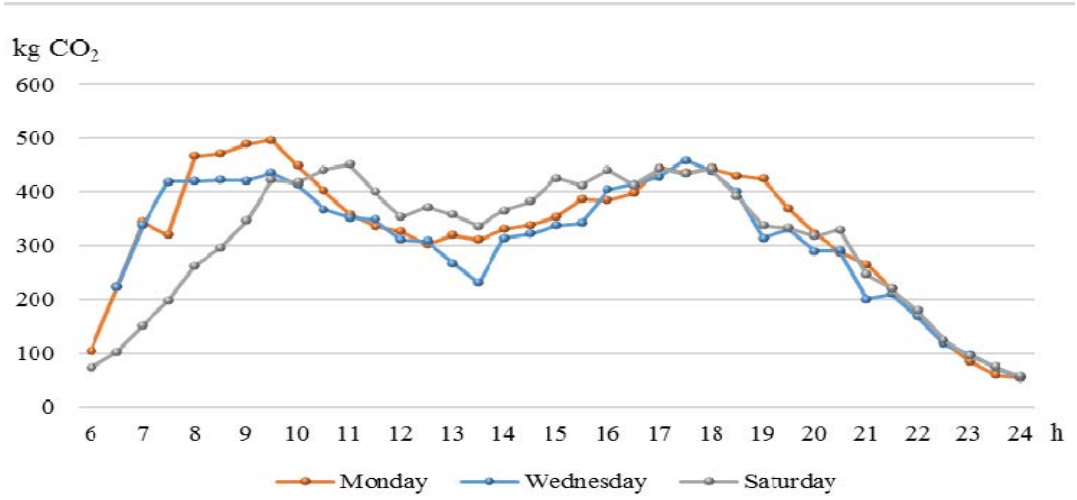

Figure 2. Variation of transportation CO_2 emissions under different traffic restriction days in October, November, and October in Datun

(1) On average, 12,086.678 kg CO_2 were emitted on Monday, 11,321.652 kg CO_2 on Wednesday and an 11.499.571 kg CO_2 on Saturday. The CO_2 emissions On Mondays (the first workday) were the most, and the CO_2 emissions on non-restricted Saturday (weekend) were slightly higher than Wednesday (an ordinary workday of a week).

(2) Under the restricted days, the transportation CO_2 emissions on Monday peaked between 8:30 and 10:30 with a peak of 497.26 kg CO_2 and reached a trough of 308.35 kg CO_2 between 13:00 and 13:30. They reached an evening peak of 443.10 kg CO_2 between 18:30 and 19:00. The transportation CO_2 emissions on Wednesday (an ordinary workday of a week) peaked between 8:00 and 10:30 with a peak of 435.19 kg CO_2 and reached a trough of 230.54 kg CO_2 between 14:00 and 14:30. They reached an evening peak of 459.33 kg CO_2 between 18:00 and 18:30 and then gradually decreased.

Under the non-restricted days, the transportation CO_2 emissions on weekend peaked between 10:00 and 12:00 with a peak of 451.15 kg CO_2 and then reached a small peak of near 443 kg CO_2 between 17:00 and 19:00. Between 11:00 and 17:30, the transportation carbon emissions on Saturday were higher than that on workdays.

4. Conclusion and suggestions

4.1. Conclusion

(1) In the study area at the intersection of Datun and Beichen West Road, the “double-peak and double-trough pattern” of transportation CO_2 emissions within a day is very obvious. The peaks respectively are from 9:30 to10:00 and from17:30 to18:00. Such pattern also presents within a day during the golden week, but the morning peak is delayed by one and a half hours compared with weekdays, with a peak of 519 kg CO_2 that is much higher than the peak of 440 kg CO_2 on weekdays. During the golden week, 11,811.579kg CO_2 are emitted within a day, higher than the 11,446.215kg CO_2 on weekdays. The transportation CO_2 emissions before 10:00during the golden week are lower than that on weekdays while they are higher after 10:00.

(2) In the study area at the intersection of Datun and Beichen West Road, the CO_2 emissions on Mondays(the first workday) are the most, and the emissions on non-restricted Saturday (non-working day) are slightly higher than Wednesday (an ordinary workday of a week) within a week. The transportation CO_2 emissions on the non-restricted weekend peaks between 10:00 and 12:00, with a peak of 451.15kg CO_2, but the peak is delayed by one hour compared with the workdays.

4.2. Suggestions

(1) Carry out UBI insurance (Usage Based Insurance, a new type of insurance for big data) for motor vehicles and establish a mechanism that is actively involved by vehicle drivers through marketization for transportation CO_2 emissions reduction.

(2) Legalize of new and convenient travel modes such as Didi Taxi and Uber, reducing the vacancy rate of private cars and slowing down the total purchases of motor vehicles.

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