

Study on Structure of Traffic CO₂ Emissions on Typical Urban Roads in Beijing

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Abstract. In this paper, the comparison of transportation CO₂ characteristics and vehicle emission structure of two typical urban roads in Beijing are studied from the urban road scale. We found that traffic CO₂ emissions from the North Fifth Ring Expressway is much higher than the Datun and Beichen West urban main road. In both of the two typical urban roads, private vehicles such as ordinary passenger cars and SUV constitute the main part of transport CO₂ emissions. The percentage of CO₂ emitted by trucks in the North Fifth Ring is higher than that in the main urban area while the percentage of CO₂ emitted by public transport is lower than that in the main urban area. Based on this, some recommendations on transportation carbon emission reduction is proposed in this paper.

1. Introduction

Since 2014, China has become the world's largest emitter of carbon emissions (Xinhua News Agency, 2014), and 35 major cities such as Beijing have contributed 40% of the country's CO₂ emissions (Shobhakar D., 2009). Cities are the main carrier of carbon emission reduction in China. According to statistics, the CO₂ emissions of the transport sector is only lower than that of the power and heating sector, accounting for 23% of the world's total CO₂ emissions (International Energy Agency, 2014).

China's automobile production capacity has rapidly increased these years. As of the end of March 2016, the number of motor vehicles in China has reached 283 million vehicles (Ministry of Public Security Administration of Communications, 2016), and the number of motor vehicles in Beijing has reached 5.61 million (China News, 2016). Beijing has an urban design with a high density and a large commuting volume, which depends a lot on auto traffic. The government implemented policies such as license plate restrictions and truck bans. Since 2007, Beijing has adopted several restrictions on major movements such as 2008 Beijing Olympic Games, APEC meeting in November 2014, and the military parade that won the victory of the Anti-Japanese War on September 3, 2015. The evaluation found that the restrictions on motor vehicles have a significant effect on emission reductions, with a contribution of up to 40% (Xinhua, 2016). Studies in Florence, Italy show that age, fuel type, and vehicle speed all affect CO₂ emissions from the transport sector (Gioli, Toscano et al., 2012). Research in Basel, Switzerland, Northern Europe shows that CO₂ level gets peak at around 8 am and 5 pm in the



day (Lietzke, Vogt et al., 2013). Studies in Melbourne, Australia, Oceania found that CO₂ flux diurnal patterns are largely influenced by traffic volume (Coutts, Beringer et al., 2007). Beijing's research suggests that the total amount of cars is the most important factor in controlling the inter-annual changes in Fc in this urban area (Liu and Feng, 2012).

This article selects the Datun and Beichen West Road and the North Fifth Ring Expressway these two typical urban roads in Beijing to study CO₂ emission characteristics. 30-minute transportation CO₂ emissions for 13 types of vehicles are estimated by MOVES model. It is conducive to establish an urban traffic CO₂ emission analysis framework suitable for Beijing conditions to explore CO₂ emission characteristics of traffic in typical urban road sections actively. The transportation CO₂ emission characteristics has great theoretical significance for accurately and efficiently guiding carbon emissions reduction in Beijing.

2. Methods

2.1. Establishing a vehicle classification system

Based on the classification of "Terms and definitions of automobile and trailer types" of the old standard(GB/T3037.1-1988) promulgated by the General Administration of Quality Supervision, Inspection and Quarantine, and the "Annual Report of China's Motor Vehicle Pollution Prevention and Control" issued by the Ministry of Environmental Protection (2013), it draws on domestic and foreign vehicle classification method. It classifies passing vehicles according to the interpretation of the traffic flow combines with monitoring video in the study area. The vehicles are divided into four categories: passenger cars, trucks, buses, and others. On this basis, passenger cars are further divided into three sub-cars: large passenger cars, medium-sized passenger cars, and small passenger cars. Class and subdivided small passenger cars into four subcategories such as ordinary cars, SUVs, taxis and others. We classify trucks into three subcategories: heavy-duty trucks, medium-sized trucks and light-duty trucks. And the buses are further divided into 3 sub-categories, namely general buses, extended buses and double-decker buses, for a total of thirteen categories.

2.2. Measurement of traffic CO₂ emission

2.2.1. Study area. The central area of the Beijing Olympic Park is northern temperate monsoon climate. It is located at the north end of the central axis of Beijing City and is an important support for the construction of a low-carbon city in Beijing.

Datun Road is the main urban road. There are underground tunnels across the Olympic Park. The tunnel is two-way six-lane and the ground road is two-way four-lane. The intersection of Datun Road and Beichen West Road is near National Convention Center Hotel, Fenglin Oasis Residential Building, and research institutes. While the North Fifth Ring is Beijing's first round-the-city expressway and it's 12 kilometers away from the city center. Its designed speed is 100 kilometers per hour, and its two-way 6-lane plus continuous parking zone.

In this paper, we selected the intersections of Datun-Beichen West Road and the North Fifth Ring to make a comparison of the vehicle CO₂ emission structure at these two typical urban road sections.

2.2.2. Recording video and Traffic counts. Sony cameras, a tripod and a 9-meter high pan-tilt head are used to monitor traffic flow at three fixed monitoring points at Datun Road-Beichen West Road intersection, Datun Road Tunnel, and North Fifth Ring. They will be equipped with a rain cover or heavy objects to reduce the impact of precipitation, high winds on monitoring equipment or data quality. The basic conditions such as the location of the monitoring point, the monitoring date, and the weather will be recorded.

According to the classification system for traffic CO₂ emission vehicles constructed in the front, the traffic monitoring videos of the roads and tunnels at the intersection of Datun-Beichen West Road, and the North Fifth Ring are interpreted every 30 minutes in 13 types of vehicles. Corresponding road

section, monitoring date, traffic statistics data of 13 types of vehicles every 30 minutes under the weather are obtained, and other types of vehicles appearing will be marked.

2.2.3. Estimates Transportation CO₂ Emissions with Localized MOVES Model. Using road traffic sub-model of MOVES 2014a model, we define the time span, such as the year, month, and day, the meteorological parameters such as atmospheric pressure, and relative humidity, and the road length, vehicle type. And then we create a localized input database and generate data sheet templates through the Project Data Manager (PDM) of the MOVES model. Finally we estimate and obtain the traffic CO₂ emissions every 30 minutes of these 3 intersections of Datun-Beichen West Road intersection, Datun Road Tunnel, and North Fifth Ring. We monitor the traffic flow from 6:00 am to 1:00 am of the next day for a total of 19 hours, September-November 2014. On this basis, the data of 1:00 to 6:00 is approximately replaced by 24:00-1:00.

3. Data Analyze and Disussion

3.1. Comparison of Total CO₂ emissions and diurnal variations of traffic emission in two typical urban roads

The government issued regulations of "Law of the People's Republic of China on Prevention and Control of Atmospheric Pollution", "Road Traffic Safety Law of the People's Republic of China" and "Prevention and Control of Atmospheric Pollution of Beijing". To improve the quality of the air environment in the capital and effectively reduce the emission of pollutants from motor vehicles, roads within the Fifth Ring Road (excluding) are prohibited from passing by trucks with the consent of the municipal government. The main road of the Fifth Ring Road is forbidden to carry more than 8 tons (including) of cargo. The regulations were imposed daily from 6 a.m. to 23:00 a.m. from April 11th, 2014 (Beijing Traffic Management Bureau, 2014).

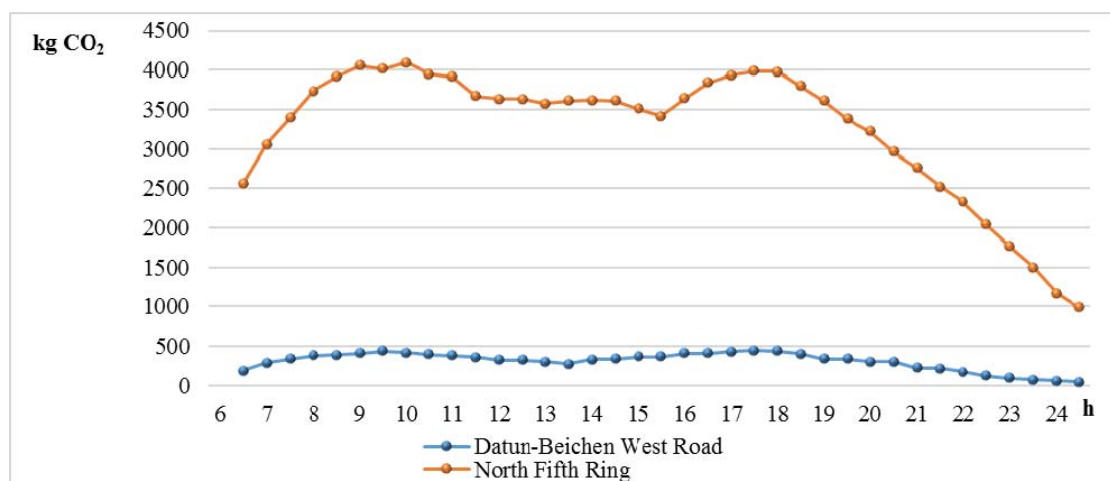


Figure 1. CO₂ emissions from underlying surface of two typical cities

(1) In the fall of 2014, a total of 1030.16t of CO₂ was emitted from the intersection of Datun-Beichen West Road while the North Fifth Ring Road discharged a total of 11020.57 tons of CO₂. The CO₂ emissions from the North Fifth Ring Road are much higher than the intersection of Datun-Beichen West Road, which is 10.7 times that of the intersection of Datun-Beichen West Road.

(2) On a day, the CO₂ emissions from transportation in the study area of the North Fifth Ring have a “trough – peak – sub trough - peak - trough” changing trend from 6:00 am to 1:00 am the next day, and Datun-Beichen West intersection is the same. The peak discharge time of two roads is consistent with the time of work commuting. The peak emissions of the North Fifth Ring Road in one day appear

at 10:00-10:30 and 17:30-18:00, which are 4.09 tCO₂/30min and 3.98 t CO₂/ respectively in 30 minutes. The morning peak was later than Datun and the late peak was roughly the same.

3.2. Analysis and Comparison of CO₂ Emission Structures in Different Grades of Urban Road Traffic

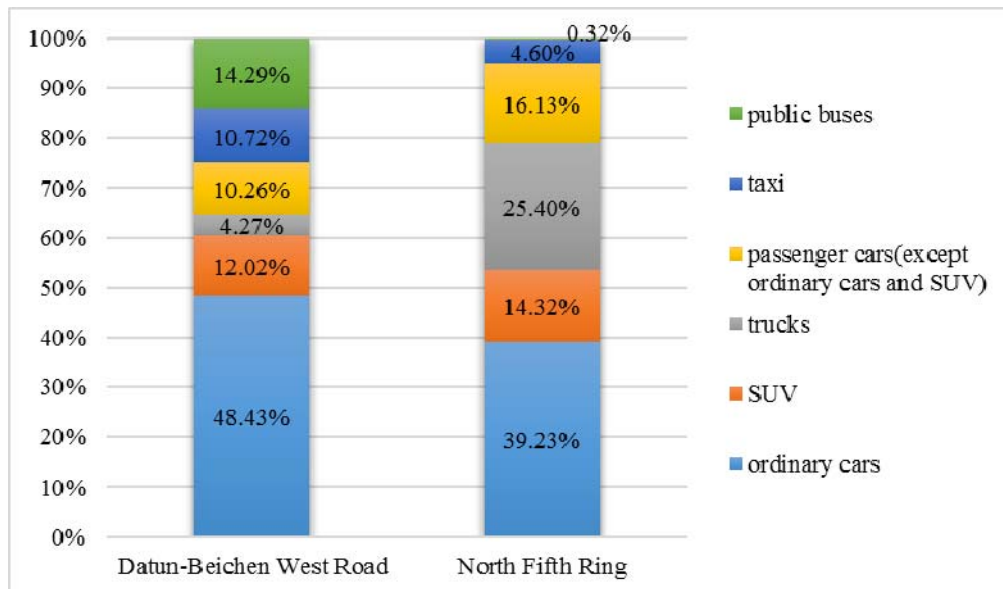


Figure 2. Comparison of CO₂ Emission Structures in Different Grades of Urban Roads

(1) It takes passenger car CO₂ emissions as the main in the Datun-Beichen West Road intersection and North Fifth Ring Research Area. At the intersection of Datun-Beichen West Road, CO₂ emissions from passenger cars accounted for 70.72% of total CO₂ emissions, and CO₂ emissions from passenger cars in the North Fifth Ring accounted for 69.68% of total CO₂ emissions. The percentage of CO₂ emissions from passenger cars to total transportation CO₂ emissions in the Datun-Beichen West Road was 1.04% higher than that of the North Fifth Ring.

(2) Among the passenger cars, the percentage of ordinary cars' CO₂ emission of the intersection of Datun-Beichen West Road and the North Fifth Ring Road both accounted for the largest proportion of total CO₂ emissions, which were 48.43% and 39.23%, respectively. The percentage of ordinary cars' CO₂ emission of Datun-Beichen West Road intersection was 9.2% higher than that of the North Fifth Ring.

(3) CO₂ emissions from trucks accounted for 4.27% of total transportation CO₂ emissions at intersections of Datun-Beichen West Road. And CO₂ emissions from trucks accounted for 25.40% in the North Fifth Ring, which was 21.13% higher compared to Datun-Beichen West Road intersection.

(4) The proportion of CO₂ emissions from public buses at the intersection of Datun-Beichen West Road is 14.29%, and the proportion of CO₂ emissions from the North Fifth Ring Truck to total transportation CO₂ emissions is close to zero. The percentage of CO₂ emissions from buses at Datun-Beichen West Road intersection is 13.97% higher than that of the North Fifth Ring.

4. Conclusion

This article compares the traffic CO₂ emission structure of Datun-Beichen West Road intersection in the urban road built-up areas of modern service industry and the city ring expressway of North Fifth Ring. The main achievements are as follows:

Improving the structure of travel is the key to slowing CO₂ emissions from traffic. There is a clear difference in the CO₂ emission structure between urban trunk roads and the North Fifth Ring Road. The CO₂ emissions situation in the Datun-Beichen West Road intersection are as follows: passenger

cars (70.72%) > public transportation (25.01%) > trucks (4.27%). And the CO₂ emissions from the North Fifth Ring Research Area are as follows: passenger loading Automobiles (69.68%) > Trucks (25.40%) > Public transport (0.32%). Private cars account for a high proportion of CO₂ emissions from transportation in both road sections.

5. Suggestions

Based on the characteristics of the time variation and the results of the vehicle structure of CO₂ emissions in the two typical urban road sections of the intersection of Datun-Beichen West Road and the North Fifth Ring in the Beijing Olympic Central District, the following suggestions are proposed for low-carbon transportation policies:

(1) Adjust the structure of road vehicles and fuel structure, further strengthen the promotion of clean new energy vehicles, and promote the transformation of traditional vehicles to new energy vehicles. By subsidizing the purchase of clean new energy vehicles and strengthening the construction of supporting infrastructure such as charging piles, Beijing has further strengthened the use of clean new energy vehicles and promoted the transformation of traditional vehicles to new energy vehicles.

(2) Formulate green driving behavior evaluation standards and norms, scientifically regulate and guide green driving behavior by drawing lessons from countries such as the United States, Switzerland, Germany, Australia, Japan, and South Korea. For example, Germany regards green driving as the content of training courses for driving schools, and uses green driving knowledge as the content of theoretical examinations or road test subjects. And Japan rewards green driving behavior by establishing green driving subsidies.

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