

Correlation Analysis between Motor Vehicle Types and Air Pollution in Shijiazhuang City

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Abstract. Air pollution is more serious than before in Shijiazhuang in recent years, motor vehicle exhaust emissions is one of the major causes of air pollution. The economy is developing rapidly in Shijiazhuang, the motor vehicles increase at a rate of 20% per year. In August 2017, the number of motor vehicles exceeded 2.6 million in Shijiazhuang. In order to explore the relationship between the types of motor vehicles and air pollution in Shijiazhuang. This paper chose the traffic information of the typical roads which are Heping East Road and Yuhua East Road, and determined emission factors, such as CO, HC, NO_x, PM₁₀ and so on. The EDMS model was used to calculate the air pollutant discharge emissions inventory and compared with the traffic information. The conclusion is that small cars account for 85% of the total traffic volume, the vehicle exhaust account for 68% of CO, 74% of HC, 77% of NO_x and 77% of PM₁₀. Air pollution and the number of small cars have a great correlation. The pollutants contributed by motor vehicles mainly for the small car discharge, in order to reduce the air pollution, relevant departments can take effective measures which include road pricing and limit the number of motor vehicle.

1. Introduction

Shijiazhuang is one of the most serious air pollution city in our country. According to the data published by the Ministry of Environmental Protection, from January to October in 2016, among 74 cities in China, the air quality in Shijiazhuang is the worst. In December 2016, the severe haze covered almost the whole of North China, among which PM_{2.5} in Shijiazhuang city exceeded 1,000 ^[1].

Shijiazhuang, as the capital city of Hebei Province, not only develops rapidly, but also causes serious environmental problems. Among them, motor vehicle exhaust is one of the main factors that cause air pollution in Shijiazhuang. In Shijiazhuang motor vehicle population exceeded 2.6 million in August 2017, of which urban motor vehicles is more than 200 million. According to the statistical data published by the statistical department, at present, every 100 households have about 20 motor vehicles in Shijiazhuang ^[2]. In the urban area, the number of motor vehicles is more than 620,000, if including the number of transit vehicles, the total number of motor vehicles is about 800,000. If large vehicles are converted into small motor vehicles, the number of motor vehicles traveling in the urban areas should be at least 1 million vehicles per day ^[3]. With the rapid economic development, the number of motor vehicles increase year by year and has large quantity in Shijiazhuang. However, The problem of



urban air pollution has become increasingly prominent, so scholars and the public should increase attention given to motor vehicle exhaust of air pollution.

Exhaust gas emitted by vehicles is a kind of scattered mobile source of pollution. Scientific analysis shows that the automobile exhaust contains more than one hundred kinds of different compounds, among which the main pollutants are CO, HC, SO₂, NO_x, PM₁₀ and PM_{2.5} and so on^[4].

At present, the evaluation models of motor vehicle exhaust mainly include MOBILE^[5], COPERT^[6], EMFAC^[7], CMEM^[8], IVE^[9], ONROAD and MOVES developed by the European Commission^[10-11]. Among them, CMEM and ONROAD models belong to micro-scale exhaust evaluation, which is suitable for vehicle exhaust evaluation in small range and narrow sections. The COPERT model deals with excessive emission factors and incomplete fleet information. The MOVES focuses on the problem of vehicle emissions in United States. IVE model is complex for vehicle classification, difficult to obtain data, and lack the effective data in China. The above models are not suitable for the evaluation of vehicle exhaust in road and traffic condition in China^[12]. Therefore, in this research, EDMS is used as the prediction model.

The Emissions and Dispersion Modeling System(EDMS) model was developed by the Federal Aviation Administration (FAA) in cooperation with the U.S. Air Force (USAF) and includes emission models and diffusion models. It is mainly used to establish a list of air pollutant emissions at civilian airports and to calculate the concentration of pollutant emissions^[13]. After continuous perfection and improvement, EDMS model can calculate the emission concentration of air pollutants from ground vehicle, and low requirement for meteorological factors. At present, there are few studies on the use of EDMS models in our country. The EDMS was selected for this project because of its specialization in pollutant emission estimation. In this study, EDMS were used to study the relationship between vehicle types and their pollutant emission.

2. Vehicle exhaust emission factors

2.1. Selection of typical roads

This research chooses 5 main roads and 5 secondary roads as the research objects in Shijiazhuang city. The main roads include: Heping East Road, Yuhua Road, Zhongshan East Road, Jianshe North Street and Sports North Street. Secondary roads include: Fanxi Road, Tanbei Road, Guanghua Road, Yuejin Road, Harvest Road. Figure 1. shows the 5 main roads and 5 secondary roads.

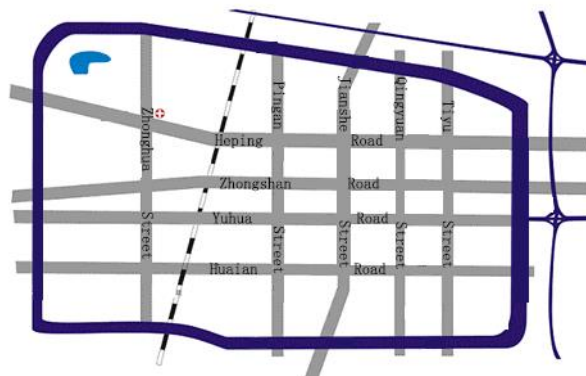


Figure 1. Road distribution in Shijiazhuang

2.2. Vehicle classification

According to 《Specifications for Environmental Impact Assessment of Highways》 (JTJ005-06), this study reclassify the motor vehicle which are divided into three types: small cars, medium-sized vehicles and trucks. Small cars include jubilee truck, cars, vens (below 7 seats) and so on. Medium-Sized Vehicles include medium truck, medium bus(7-40 seats), tricycle for agriculture uses; Trucks

include container cars, Semi-Trailer, engineering vehicle, large bus(over 40 seats), large freight cars and so on.

Table 1. Vehicle classification.

Vehicle Type	The Weight of Vehicle
Small Cars	<3.5t
Medium-Sized Vehicles	3.5t~12t
Trucks	≥12t

2.3. Traffic flow statistics

In this study, the on-the-spot counting method was used to count the traffic volume of 5 main roads and 5 secondary roads. Owing to a great difference between the traffic volume on the roads on holidays and working days, this paper counted the vehicle flow on holidays and work days. According to the difference of people's working hours, travel time and the number of vehicle flow. Therefore, all day is divided into peak period, flat peak period, declining period. (Table 2)

Table 2. The division of traffic time.

Time segment	Peak Period	Flat peak period	Declining Period
Working Day	7:00~9:00	6:00~7:00	
	17:00~19:00	9:00~17:00	23:00~6:00
	0	19:00~23:00	
Holiday	9:00~12:00	6:00~9:00	
	17:00~20:00	12:00~17:00	00:00~6:00
		20:00~00:00	

2.4. Parameters selection

Considering the road traffic and running state of the vehicle, this paper tested the running speed of typical road. (Table 3)

Table 3. Driving speed on typical road.

Road type	Traffic Intervals	Running Speed (km/h)	Value in this paper (km/h)	Value in this paper (mph)
Main Road	declining period	50	50	31
	flat peak period	25~50	45	28
	peak period	5~25	18	11
Secondary Roads	declining period	40	40	25
	flat peak period	20~40	36	23
	peak period	4~20	14	9

3. Results and discussions

3.1. The result of vehicle flow

Figure 2. shows the number of traffic on weekdays, and the vehicle flow on holidays is basically the same as that of working days. The information in the picture shows that small cars on weekdays and holidays account for 85% of the total vehicle flow, medium-sized cars account for 11% of the total, and large-sized cars account for 4% of the total. Thus, small cars occupied the biggest percentage in vehicle flow. With the change of traffic time, the distribution of traffic flow in urban roads shows a

clear trend of double-peak and double-valley. Peak period appear at the peak of work hours, in the morning from 7:00-9:00 am, another peak in the afternoon from 5:00-8:00 pm, and the traffic volume is relatively small in other periods.

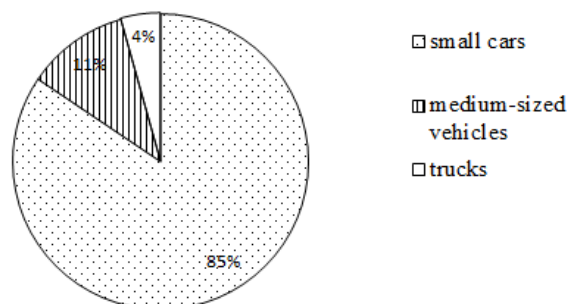


Figure 2. The point is the proportion of small cars in the total vehicle flow, vertical stripe is the proportion of the medium-sized vehicle in the total vehicle flow, the blank is the proportion of trucks in the total vehicle flow.

3.2. Analysis the emission of the motor vehicle exhaust

From the analysis results, see Figure 3. Small cars emit most air pollutants on weekdays, followed by trucks, medium-sized vehicles emit the least pollutants. On holidays, the contribution rate of small cars was the greatest for the motor vehicle exhaust, followed by medium-sized vehicles, the largest ones emit the least pollutants. From the data of the average annual emissions of pollutants, the contribution rate of small cars was the greatest, trucks and medium-sized vehicles emissions are similar. Among them, the emission of pollutants by small cars is 68% of the total amount of CO, 74% of HC, 77% of NO_x and 77% of PM₁₀; the emission of pollutants by middle-sized vehicles is CO account for 16% of the total number of cars, HC accounts for 15%, NO_x accounts for 11% and PM₁₀ accounts for 14%. As for large-scale vehicles emit pollutants, CO accounting for 16%, HC accounts for 11%, NO_x accounts for 12% and PM₁₀ accounts for 9%.

The difference in the vehicle flow cause difference in main roads and secondary roads. On weekdays, the motor vehicle exhaust is 203.18 t/a on the main road, 157.35 t/a on secondary roads. On holidays, the motor vehicle exhaust is 104.08 t/a on the main road, 77.93 t/a on secondary roads. The results showed that the motor vehicle exhaust on the main road was obviously higher than that of pollution on secondary roads.

For CO, the emission intensity of peak period is the highest of all time quantum, mainly caused by the vehicle flow. For HC, the emission intensity is similar to that of CO in different kinds of roads, the results show that different roads have the same running conditions. For NO_x, there is great difference among main road at different times, but there is no obvious difference in emission between flat peak period and peak period of secondary roads, which is due to the fact that vehicle flow has a little change in secondary roads. For the particulate matter, due to the fact that most of the vehicle flow in urban roads is made up of small and medium-sized vehicles composition, so PM₁₀ has low emissions.

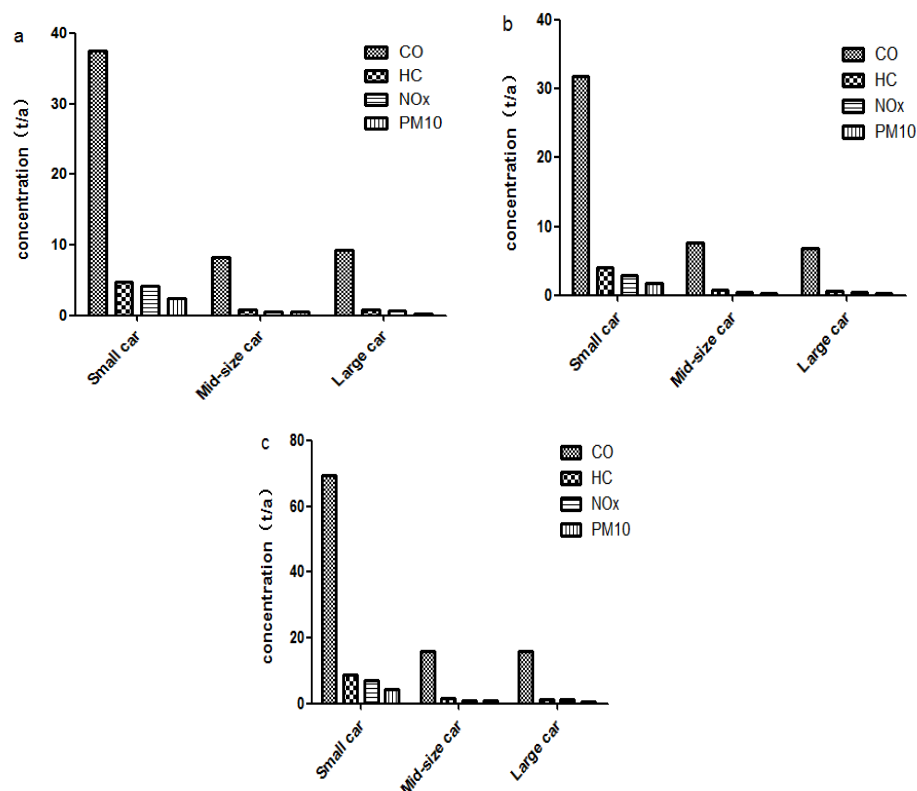


Figure 3. a: the pollutant emissions from different types of vehicles on weekdays. b: the pollutant emissions from different types of vehicles on holiday. c: average annual emissions of pollutants from different types of vehicles.

4. Conclusions

The motor vehicle exhaust is the part cause of air pollution in Shijiazhuang, Air pollution and the number of small cars have a great correlation. The pollutants contributed by motor vehicles mainly for the small car discharge. the contribution rate of small cars was the greatest(85%), which is due to the fact that small cars occupied the biggest percentage in vehicle flow, the sum of middle-sized vehicle and truck is only 15%. the emission of pollutants by small cars is 68% of the total amount of CO, 74% of HC, 77% of NOx and 77% of PM₁₀.

Acknowledgments

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