Journal of Computational Science & Engineering
Available at http://www.asocse.org ISSN 1710-4068 57(2022) 1-5

Research and trend analysis of vehicle exhaust emission inventory in Binzhou city

Jian Guo[1*], Meng meng Hao[2], Chun peng Wang[1], Chao hu Xi[1]
[1]School of electromechanical engineering, Binzhou Polytechnic, Binzhou 256603, China
[2]Public Utilities Service Center, Binzhou 256603, China

Abstract: Binzhou city motor vehicle ownership increases year by year, the serious influence produced by the exhaust air quality, this article through the establishment of exhaust emission list, calculation of binzhou city 2016-2020 motor vehicle exhaust pollutant CO, HC and NOX emissions, PM2.5 and PM10, analyses the points in the region nearly five years car motor vehicle exhaust emission situation and trends, It provides numerical basis for controlling local motor vehicle emissions.

Keywords: Motor vehicle; Emission inventory; Pollution factors; Public service

*Corresponding author. Email: 232463158@qq.com

Received 01 August 2022, Revised 11 August 2022, Accepted 20August 2022

1.Introduction

In 2020, the motor vehicle PARC of Binzhou city is 1,126,000, including 972,700 cars and 630,400 cars. According to the vehicle PARC of binzhou Statistics Bureau in the statistical yearbook of 2015-2020, the number increased from 604,683 to 974,576, an increase of 369,893 in 5 years. By the end of 2021, the number of cars will exceed 1 million, which will bring enormous pressure to urban traffic and the atmosphere. As a variety of pollution sources, the combined air pollution caused by motor vehicle exhaust becomes more and more serious to urban air quality and public health.

The emission inventory of air pollutants from road motor vehicles was issued by the Ministry of Environmental Protection in 2014, which is a compilation guide to solve the motor vehicle emissions and their temporal and spatial distribution and changes in a certain region in a certain period of time. Its significance is to support the simulation study of motor vehicle pollutant concentration and the decision-making of motor vehicle emission control [2]. At present, the research work of vehicle emission inventory has been carried out nationwide [3]-[7]. This paper takes Binzhou City as the research area, and according to the methods in a series of guiding documents such as Technical Guide for Compilation of Road Vehicle Emission Inventory (Trial), The emission list of CO, NOX, HC, PM10, PM2.5, NH3 and other air pollutants from vehicles in Binzhou region from 2015 to 2020 was established, and the contribution rate of vehicle types, emission standards and fuel types in Binzhou were analyzed, in order to provide decision-making basis and reference for the prevention and control of vehicle pollution and comprehensive environmental treatment in Binzhou city.

2. Technical process and method

Technical Guide for compilation of Emission Inventory of Air Pollutants from Road Vehicles established a set of technical methods for emission inventory of air pollutants from road vehicles, and provided part of corresponding parameters[8]-[11] .

2.1 Vehicle ownership and structure

The ownership of non-operational small passenger vehicles, operational small passenger vehicles, micro passenger vehicles and light trucks during 2016-2020 obtained from Binzhou Municipal Bureau of Statistics is shown in Table 1. Motor vehicle emission stage Is determined according to the implementation progress of national motor vehicle emission standards and mainly according to the registration age of vehicles. At present, China implements the classification policy of micro passenger carrier and small passenger carrier. Light trucks will implement the National FIFTH standard after 2018 and the National fourth standard from 2011 to 2017.

2.2 Vehicle exhaust emission coefficient is obtained

Road emission (E) of motor vehicles consists of exhaust emission (E1) and HC evaporation emission (E2), and its calculation formula is as follows:

$$E = E_1 + E_2 \qquad (1)$$

2022@ The American Computational Science Society. All rights reserved.

Table 1 Vehicle ownership in Binzhou City from 2016 to 2020 (vehicles)

year	Non-operating small passenger carrier	Operating small passenger carrier	mini passenger carrier	light truck
2016	543234	3513	12610	49803
2017	624088	3617	10572	55347
2018	692606	3694	9789	60841
2019	755863	3605	9741	68074
2020	822383	3389	9563	76429

The calculation formula of road motor vehicle exhaust emissions is as follows:

$$E_1 = \sum_i P_i \times \mathrm{EF}_i \times \mathrm{VKT}_i \times 10^{-6} \quad (2)$$

where, E_1 is the annual emissions of pollutants from motor vehicles, in metric tons; E_i is the amount of pollutants discharged by exhaust gas per driving distance, and the unit isg/km; P_i is the number of motor vehicles, and the unit is one; VKT_i is the average annual mileage of type I motor vehicles, in km/vehicle.

The calculation formula of vehicle exhaust emission coefficient is as follows:

$$E_{i,j} = \mathrm{BEF}_i \times \varphi_j \times \tilde{a}_j \times \ddot{e}_i \times \grave{e}_i \quad (3)$$

where, $E_{i,j}$ is the emission coefficient of Class I vehicles in area J, BEF_i is the comprehensive benchmark emission coefficient of Class I vehicles, φ_j is the environmental correction factor of region J, $\tilde{a}_j$ is the average speed correction factor of region J, $\ddot{e}_i$ is the deterioration correction factor of Class I vehicles, $\grave{e}_i$ is the correction factor for other service conditions of class I vehicles.

Based on the average cumulative mileage, typical urban driving conditions, meteorological conditions (annual average 13.9℃, relative humidity 66%) and fuel quality (sulfur content of gasoline 10ppm) of all types of vehicles in Binzhou city.Therefore, the comprehensive benchmark emission coefficient of each type of motor vehicle can be determined

Environmental correction factor consists of temperature correction factor, humidity correction factor and altitude correction factor. The formula is as follows:

$$\varphi_j = \varphi_{\mathrm{Temp}} \times \varphi_{\mathrm{RH}} \times \varphi_{\mathrm{Height}} \quad (4)$$

Where, φ_{Temp} is the temperature correction factor, φ_{RH} is the humidity correction factor, and $\varphi_{\mathrm{Height}}$ is the altitude correction factor.

Value based on Binzhou physical geographical environment.According to the road traffic situation in Binzhou, the speed range is 40-80km/h, and the road traffic correction factors include CO 0.39, HC 0.32, $\mathrm{NO_X}$ 0.86, PM2.5 and PM10 0.32.

The deterioration correction factor is based on the deterioration correction issued by the Ministry of Environmental Protection in 2014 for all types of vehicles from 2015 to 2018, where CO values are 1.01-1.62, HC values are 1.01-1.52, NOX values are 1.00-1.67, and the specific values are revised according to different models.

The modification of other conditions of use mainly considers the sulfur content of the actual oil. Currently, the gasoline grades implemented in China are mainly 92# and 95#, so the PPM value is 10.

The value $\grave{e}_i$ is 0.90 in CO, 0.96 in HC and 0.95 in NOX.

HC emission from evaporation is also one of the main pollutants during motor vehicle running and idling, and its calculation formula is as follows:

$$E_2 = (EF_1 \times \frac{VKT}{V} + EF_2 \times \mathbf{365}) \times P \times \mathbf{10}^{-6} \quad (5)$$

At present, the development of automotive engine electronic control technology has developed the on-board refueling oil and gas recovery (ORVR) system and fuel evaporation emission control (EVAP) system for fuel evaporation and other technologies. Therefore, the HC emission coefficient of driving process is 0.2g/h, and the HC

2022@ The American Computational Science Society. All rights reserved.

emission coefficient of idling process is 0.5g/d.

2. Analysis of vehicle exhaust emission source

2.1 Pollutant emission of motor vehicles

Substituting equations (2), (3), (4) and (5) into Equation (1),

So generation into data ,As table 2 (6)

$$E = (\sum_i P_i \times BEF_i \times \varphi_{Temp} \times \varphi_{RH} \times \varphi_{Height} \times \gamma_j \times \lambda_i \times \theta_i \times VKT_i \times 10^{-6}) + [(EF_1 \times \frac{VKT}{V} + EF_2 \times 365) \times P \times 10^{-6}]$$

Table 2 Binzhou city motor vehicle emissions in 2016-2020

year	Vehicle type	Pollutant Discharge (t)				
		CO	HC	NOX	PM2.5	PM10
2016	Non-operating small passenger carrier	2292.272	385.479	146.206	7.823	7.823
	Operating small passenger carrier	717.325	82.918	18.261	0.405	0.405
	mini passenger carrier	72.774	10.222	6.497	0.218	0.218
	light truck	2165.485	162.882	361.120	2.869	3.347
2017	Non-operating small passenger carrier	2633.449	424.340	167.967	8.987	8.987
	Operating small passenger carrier	738.560	85.373	18.802	0.417	0.417
	mini passenger carrier	61.012	9.036	5.447	0.183	0.183
	light truck	2406.544	178.965	401.319	3.188	3.719
2018	Non-operating small passenger carrier	2922.573	457.273	186.409	9.974	9.974
	Operating small passenger carrier	754.283	87.190	19.202	0.426	0.426
	mini passenger carrier	56.494	8.580	5.043	0.169	0.169
	light truck	2645.428	194.903	441.156	3.504	4.089
2019	Non-operating small passenger carrier	3189.497	487.677	203.433	10.884	10.884
	Operating small passenger carrier	736.110	85.089	18.739	0.415	0.415
	mini passenger carrier	56.217	8.552	5.019	0.168	0.168
	light truck	2959.926	215.886	493.602	3.921	4.575
2020	Non-operating small passenger carrier	3470.190	519.649	221.337	11.842	11.842
	Operating small passenger carrier	692.005	79.991	17.617	0.390	0.390
	mini passenger carrier	55.189	8.448	4.927	0.165	0.165
	light truck	3323.210	240.124	554.184	4.402	5.136

2022@ The American Computational Science Society. All rights reserved.

As can be seen from the above table, the emission of pollutants from road vehicles in Binzhou city from 2016 to 2020, in which CO emission increases from 5,247.8 tons in 2016 to 7,540.5 tons in 2020, with an average annual growth rate of 5.1%. HC emissions increased from 641.5 tons in 2016 to 848.2 tons in 2020, with an average annual growth rate of 3.0%. NOX emissions increased from 532.1 tons in 2016 to 798.1 tons in 2020, with an average annual growth rate of 6.1%. PM2.5 emissions increased from 11.3 tons in 2016 to 16.8 tons in 2020, with an average annual growth rate of 6.2 percent. PM10 emissions increased from 11.8 tons in 2016 to 17.5 tons in 2020, with an average annual growth rate of 6.3 percent.

2.2 Contribution rate of vehicle emission

Compare and add other models to calculate, the contribution levels of different models to CO, HC, NOX, PM2.5 and PM10 emissions are significantly different. For CO, the main emission models are heavy trucks, light trucks and private cars, among which private cars and light trucks are the main sources of atmospheric CO pollution in urban streets. For HC, the main emission vehicles are low-speed cars, private cars and motorcycles. Private cars are the main pollution source of urban street HC, and the main reason is that road congestion in urban areas leads to a long idle time and low speed of cars. For the main NOX emission models are heavy trucks, heavy trucks account for more than 60% of the contribution rate, so the state requires the implementation of national five emission standards for heavy trucks, while most of the heavy trucks with urea tanks to reduce NOX emissions, is also the main basis for heavy trucks are not allowed to enter the city; For PM2.5 and PM10, the main emission models are heavy trucks, low-speed trucks and three-wheeled vehicles, mainly because these three vehicles mainly carry goods and burn diesel fuel, resulting in inadequate fuel combustion.

Further analysis shows that there is also a certain relationship between the contribution rate of emissions and fuel. Gasoline fueled vehicles contribute more to CO and HC, while diesel fueled vehicles contribute more to NOX, PM2.5 and PM10. Vehicles perform different emission standards for pollutants discharge has also a certain difference, the contribution rate of The Three Kingdoms 4 standard contribution significantly greater than the five standard contribution, especially motorcycle, because mainly exist in the city suburbs and towns and other regions, emission control level is not high, the implementation of the standard is too low, the engine technology is not high, cause the CO and HC pollutants is higher, The country will implement the national Iv standard and require that the engine must be electronic injection, which will help reduce the emission of motorcycles that do not meet the standard, and accelerate the elimination of yellow cars is also conducive to regional air environment governance.

3 Conclusion

(1) From 2016 to 2020, the emission of pollutants from road vehicles in Binzhou city increased year by year, and the average annual growth rate of CO emission was 5.1%; The average annual growth rate of HC emissions was 3.0%. The annual average growth rate of NOX emissions was 6.1%; The annual average growth rate of PM2.5 emissions was 6.2%; The annual average growth rate of PM10 emissions was 6.3%.

(2) From 2016 to 2020, the annual growth rate of pollutant emissions from road vehicles in Binzhou city showed a downward trend.

(3) From 2016 to 2020, the emission of non-operational small passenger vehicles and light trucks increased significantly, and it is predicted that the emission will continue to increase in 2021; The operation of minivans and minivans is on the decline.

References

[1]Ground-level ozone in the Pearl River Delta and the roles of VOC and NOx in its production[J] . Min Shao,Yuanhang Zhang,Limin Zeng,Xiaoyan Tang,Jing Zhang,Liuju Zhong,Boguang Wang.Journal of Environmental Management . 2007 (1) 512-518.

[2]TVOC and Health in Non‐industrial Indoor Environments[J] . Indoor Air . 2004 (2) 78-91.

[3]The characteristics and origins of carbonaceous aerosol at a rural site of PRD in summer of 2006[J] . Hu W. W.,Hu M.,Deng Z. Q.,Xiao R.,Kondo Y.,Takegawa N.,Zhao Y. J.,Guo S.,Zhang Y. H..Atmospheric Chemistry and Physics . 2012 (261) 1811-1822.

[4]Secondary organic aerosol formation from m -xylene, toluene, and benzene[J] . Ng N. L.,Kroll J. H,Chan A. W. H.,Chhabra P. S.,Flagan R. C.,Seinfeld J. H.Atmospheric Chemistry and Physics . 2007 (98) 3909-3922.

[5]Advances in the science and technology of paints, inks and related coatings[J] . I Holme.Surface Coatings International Part B: Coatings Transactions . 2004 (4) 441-454.

[6]Study on emission characteristics of volatile organic compounds in the exhaust of different types of vehicles.

2022@ The American Computational Science Society. All rights reserved.

LIANG Bao-sheng,et al (College of Environmental Sciences,Peking University,Beijing 100871,China). Environmental Monitoring In China . 2005 211-222.

[7]Hydrocarbon Source Apportionment for the 1996 Paso del Norte Ozone study. Fujita E M. Science of the Total Environment . 2001 171-184.

[8]Study on benzene,toluene,xylenepollution resulted fromvehicle emission. Xu D Q,Liu C M,Li Z. Journal of Environmentand Health . 2004 516-524.

[9]Volatile hydrocarbon emissions from vehicles and vertical ventilations in the Hsuehshan traffic tunnel, Taiwan[J] . Chia-Hsiang Lai,Yen-Ping Peng. Environmental Monitoring and Assessment . 2012 (7) 102-109.

[10]Emission characteristics of nonmethane hydrocarbons from private cars and taxis at different driving speeds in Hong Kong[J] . H. Guo,S.C. Zou,W.Y. Tsai,L.Y. Chan,D.R. Blake.Atmospheric Environment . 2011 (16) 2711-2721.

2022@ The American Computational Science Society. All rights reserved.