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A SHORT COMMUNICATION ON ESTIMATION OF THE AIR-BORNE POLLUTANTS EMISSIONS FROM CONSUMPTION OF GASOLINE AND DIESEL FUEL IN ISFAHAN

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ABSTRACT:

Introduction: The main objective of this study was to determine total carbon monoxide, sulfur oxides, nitrogen oxides, volatile organic compounds (VOCs), PM_{10} and $PM_{2.5}$ emitted to air by burning gasoline and diesel fuel in the city of Isfahan.

Materials and methods: In this study it is assumed that all distributed fuel in Isfahan (including gasoline and diesel fuel) is consumed by diesel and gasoline engines and other their usages are negligible. Then, with the help of emission factors provided by the relevant international organizations such as European Environmental Agency, the total amounts of pollutants were calculated.

Results: The results of this study showed that from 20 March 2016 to 20 March 2017 about 987 million liters of diesel fuel and 1052 million liters of gasoline were distributed in the city of Isfahan by the Oil Refining & Distribution Company of Isfahan, which produced 433115537 and 497070000 million BTU of energy from these fuels, respectively. The results of this study are not limited to fuels that used in vehicle engines in the city of Isfahan and also covers other fuel uses. Also, the results show that nitrogen oxides and carbon monoxide released by diesel engines were 865248 and 186391 tons, respectively. Also, nitrogen oxides and carbon monoxide released by gasoline engines, were as much as 367032 and 222921 tons, respectively.

Conclusions: Nearly 87 and 54 % of VOCs and carbon monoxide in Isfahan are emitted by gasoline engines, respectively. The share of diesel fuel engines in emission of nitrogen oxides, sulfur oxides and PM are estimated equal of 73, 76 and 73%, respectively.

INTRODUCTION

Air pollution means mixing air with various gases or particles that reduce air quality [1]. Air pollution is one of the biggest dangers in metropolises, which worsens over time [2]. Hundreds of pollutants are annually produced by the urban transportation system and released in the atmosphere [3]. Air pollutants are categorized in a fundamental division into fixed resources and moving resources [4]. In cities, cars, buses, trains, airplanes, etc., which are known as moving airborne

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sources, can cause air pollution. Moving sources of air pollution are divided into two categories of mobile road transport resources (such as cars, buses, etc.) and non- road moving vehicles (such as trains, planes, road machinery, agricultural machinery, etc.) [1]. The production of pollutants by moving resources can lead to health problems for urban residents [5]. Heart and respiratory diseases, decrease of health index and harmful economic effects are some consequences of air pollution in large cities such as Isfahan [6]. Therefore, considering the adverse environmental and health effects of air pollutants, it is necessary to study air pollution and efforts to find the best possible solution to increase air quality. Nitrogen oxides (NO_x), sulfur oxides (SO_x), and carbon monoxide (CO) are particulate matters (PM), carbon dioxide (CO_2) and volatile organic compounds (VOCs) are some of the most important air pollutants [4]. Greenhouse effect, ozone depletion and acid rain are the most important atmospheric effects of these air pollutants [7]. The presence of carbon monoxide in the air can endanger the lives of patients with cardiovascular and pulmonary disease [8]. This gas can also lead to headaches, dizziness, high fatigue, and nervous nerves even in healthy people [9]. Nitrogen oxides stimulate the eyes and the deep parts of the lungs and cause excessive fatigue [10]. In addition to the plants, nitrogen oxides also cause a lot of damage [11]. Sulfur oxides stimulate the respiratory tract, especially the throat, nose and larynx, and cause chronic bronchitis, asthma and emphysema [10]. Sulfur dioxide can be converted into acid when it is combined with steam in the air, and its precipitation in the form of acid rain causes corrosion of metals, stones and textiles [1]. Sulfur dioxides like nitrogen dioxides, affects plants and causes them to be extinct [12]. Some vapors of hydrocarbons in the atmosphere have a potential role in damaging the health of humans [13]. Benzene, as one of the most important VOCs, prevents the formation of red blood cells in the bone marrow. The main source of benzene production is gasoline used in automobiles.

The city of Isfahan is one of the great cities of Iran with a high population and a large number of private and public cars, where air pollution has become one of the major dilemmas [14]. Therefore, managing air pollution in Isfahan city is very necessary. The first step in the management of air pollution in each city is to identify sources of contamination and pollutant emissions by each of these resources [15] The determining emission rate of pollutants for each pollutant sources is called the emission inventory [3]. Without the preparation of pollutants emission inventory, any action taken to manage air pollution in cities will be blind and unhelpful.

The main objective of this study is to determine the total carbon monoxide, sulfur oxides, nitrogen oxides, VOCs, PM_{10} and $PM_{2.5}$ released into the air by burning gasoline and gas in the city of Isfahan. The most of the diesel and gasoline are consumed by diesel and gasoline engines. Therefore, in this study it is assumed that all distributed fuel in Isfahan (including gasoline and diesel fuel) is consumed by diesel and gasoline engines. Then, with the help of emission factors provided by the relevant international organizations such as European Environmental Agency (EEA), the total amount of pollutants was calculated.

MATERIALS AND METHODS

In the first step of this study, the amounts fuel consumption of gasoline and diesel fuel in the city of Isfahan were inquired from the Oil Refining & Distribution Company of Isfahan. The pollutants emission inventory was prepared for carbon monoxide, nitrogen oxides, sulfur oxides, VOCs, PM_{10} and $PM_{2.5}$ with the help of the emission factors provided by the US Environmental Protection Agency (EPA). In the table below, the emission factors for burning of diesel and gasoline in engines used in this study are shown. In this table, the amounts of emission factor for different pollutants specifically carbon monoxide, nitrogen oxides, sulfur oxides, VOCs, PM_{10} and $PM_{2.5}$ in terms of the amount of thermal energy consumed are presented. In the estimates, the energy value of 1 L of gasoline was considered to be 0.472 million BTU. Also, the amount of energy in 1 L of diesel fuel was considered equal to 0.11609 million BTU. It was also assumed in this study that all diesel engines in the Isfahan

had a power output of less than 600 hp. The most majority of diesel vehicle engines used for transportation in Isfahan are in this range (less than 600 hp).

In the first step of this study, the thermal energy from diesel fuel distributed in Isfahan (in 2015) was calculated by multiplying its value at 0.11609 in terms of million BTU. In the next step, the amount of gasoline distributed in 2015 in the city was also calculated by multiplying its value by 0.472 in terms of million BTU. Then, by multiplying the thermal energy of gasoline and diesel fuel in the respective emission factor shown in Table 1, the emission rate of each of the pollutants was determined. Finally, the share of the emitted pollutants by burning diesel fuel and gasoline in vehicle engines was determined with the help of Eq. 1.

Where, *S* is the share of pollutant production in percentage, is the amount of emission of pollutants in gasoline or diesel engines in ton, and is the total amount of pollutants produced by gasoline and diesel vehicle engines in terms of tons.

RESULTS AND DISCUSSION

The results of this study showed that from 20 March 2016 to 20 March 2017, about 987 million L of diesel fuel and 1052 million L of gasoline were distributed in the city of Isfahan by the Oil Refining & Distribution Company of Isfahan, which is likely to be consumed by gasoline and diesel engines. However, diesel and gasoline can be used as a propulsion for a variety of other tools, such as compressors, generators, agricultural machinery, road construction machinery, and even the use of fuel as solvent and liquid washing. Therefore, the results of this study are not only related to the engines used in automobiles in Isfahan and also covers other fuel consumption. The calculations also showed that diesel fuel and gasoline consumed in Isfahan in 2015 were equivalent to 433115537 and 497070000 MBTU of energy respectively. This information is shown in Table 2.

Fig. 1 shows the amount of carbon monoxide produced, VOCs, nitrogen oxides, sulfur oxides, total suspended particles and PM_{10}, due to fuel consumption by engines for gasoline and diesel engines. As shown in this figure, the most pollutant released by diesel engines is nitrogen oxides, and the next rank is carbon monoxide. Most pollutants produced by gasoline engines were VOCs, and the next were nitrogen oxides. The results indicated that pollution of diesel engines, except for carbon monoxide and VOCs, was higher than that of gasoline engines. To determine the share of diesel and gasoline engines in Isfahan air pollution, several calculations were carried out. The results of these calculations are shown in Fig. 2.

The contribution of diesel and gasoline engines to emit PM_{10} and total PM are shown in Figs. 1 (a) and (b), respectively. As can be seen 27 % of the particulate matters from fuel combustion in the city of Isfahan belongs to gasoline engines and 73 % of it belongs to diesel engines. Results revealed that approximately, 27 and 73 % of nitrogen oxides are emitted from diesel and gasoline engines, respectively. It was reported that a

Table 1. Emission factors of various pollutants for burning diesel fuel and gasoline in vehicle engines

Engine Type	EF Units	EF Source	PM	PM_{10}	SO_2	NO_X	VOC	CO
Small Diesel	lb/mmbtu	AP-42, Table 3.3-1	0.31	0.31	0.29	4.41	0.35	0.95
Gasoline	lb/mmbtu [d]	AP-42, Table 3.3-1	0.10	0.10	0.08	1.63	2.10	0.99

Table 2. Diesel fuel and gasoline consumption in Isfahan in 2015 and total energy potential of each fuel type

Consumed diesel fuel (L)	Equivalent consumed energy (BTU)
987,000,000	433,115,537,400,000
Consumed gasoline (L)	**Equivalent consumed energy (BTU)**
1,052,000,000	497,070,000,000,000

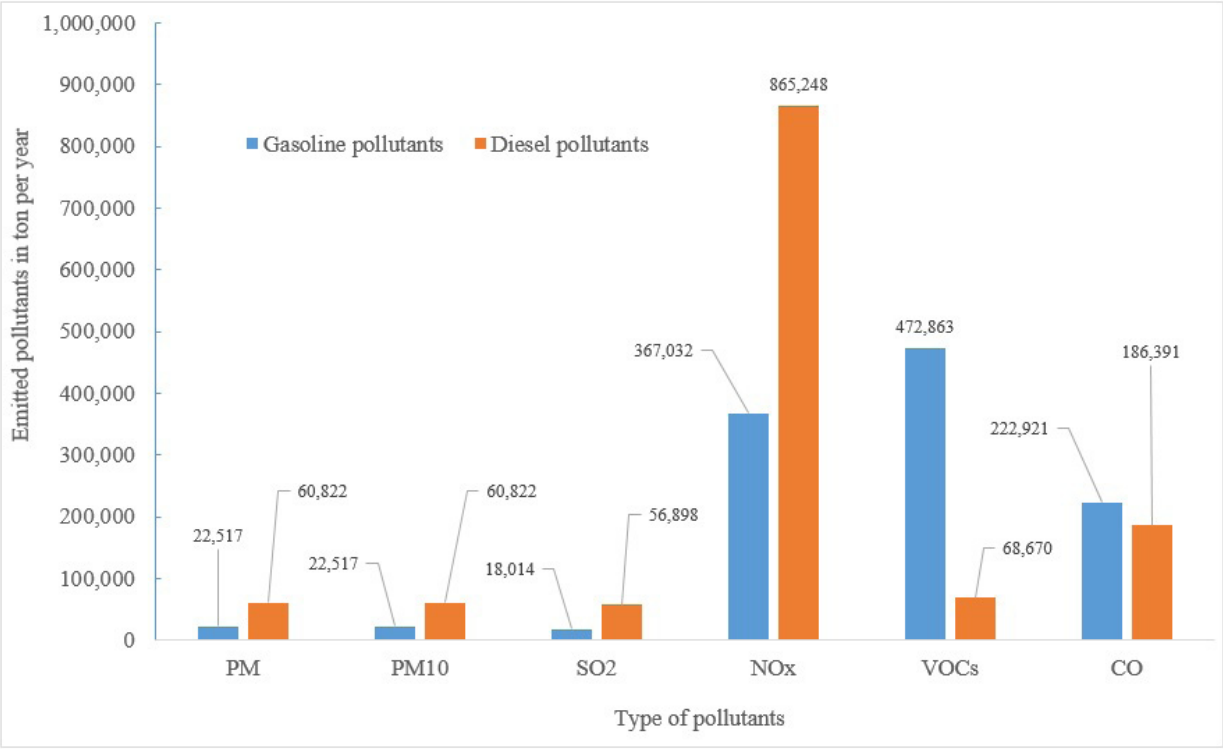

Fig. 1. The amount of different pollutants emitted by gasoline and diesel engines in the city of Isfahan from 20 March 2016 to 20 March 2017

big part of air pollutants in cities are emitted from vehicles [16]. Therefore, it is clear that the main source of nitrogen oxides in Isfahan is emitted by diesel engines. The best strategy to reduce nitrogen oxides in Isfahan air is replacing old diesel vehicle fleet by new vehicles with better systems of pollutants control. Fig. 1(d) shows that nearly 24 and 76 % of sulfur oxides are emitted by gasoline and diesel engines, respectively. The amount of sulfur in diesel fuel is more than gasoline; therefore, it is natural that diesel engines produce more sulfur oxides [17]. The best strategy to reduce sulfur oxides in Isfahan air is enhancement of fuel production systems in the oil refinery to produce fuels with lower amount of sulfur. Based on Fig. 1(e) gasoline engines with 54 % contribution in emission of carbon monoxide into the atmosphere are the main responsible source of this contaminant in Isfahan. The major source of VOCs emission in Isfahan with contribution of 78% is gasoline engines (Fig. 1(f)). VOCs is a mixture of hundreds of compounds that several of them are toxic or carcinogenic.

CONCLUSIONS

The results of this study showed that from 20 March 2016 to 20 March 2017, about 987 million L of diesel fuel and 1052 million L of gasoline were distributed in the city of Isfahan by the Isfahan by the Oil Refining & Distribution Company of Isfahan, which produced 433115537 and 497070000 MBTU of energy, respectively. The results of this study are not limited to engines used in the city of Isfahan and also covers other fuel uses. The results show that nitrogen oxides and carbon monoxide released by diesel engines are as much as 865248 and 186391 tons in 2015. The amount of emitted nitrogen oxides and carbon monoxide by gasoline engines are equal of 367032 and 222921 tons, respectively. The most important pollutant emitted by diesel engines is nitrogen oxides and in the next rank carbon monoxide. The results showed that 87 and 54 % of VOCs and carbon monoxide in Isfahan are emitted by gasoline engines, respectively. The share of diesel fuel engines in emission of nitrogen oxides, sulfur oxides and PM are estimated equal of 73, 76 and 73 %, respectively.

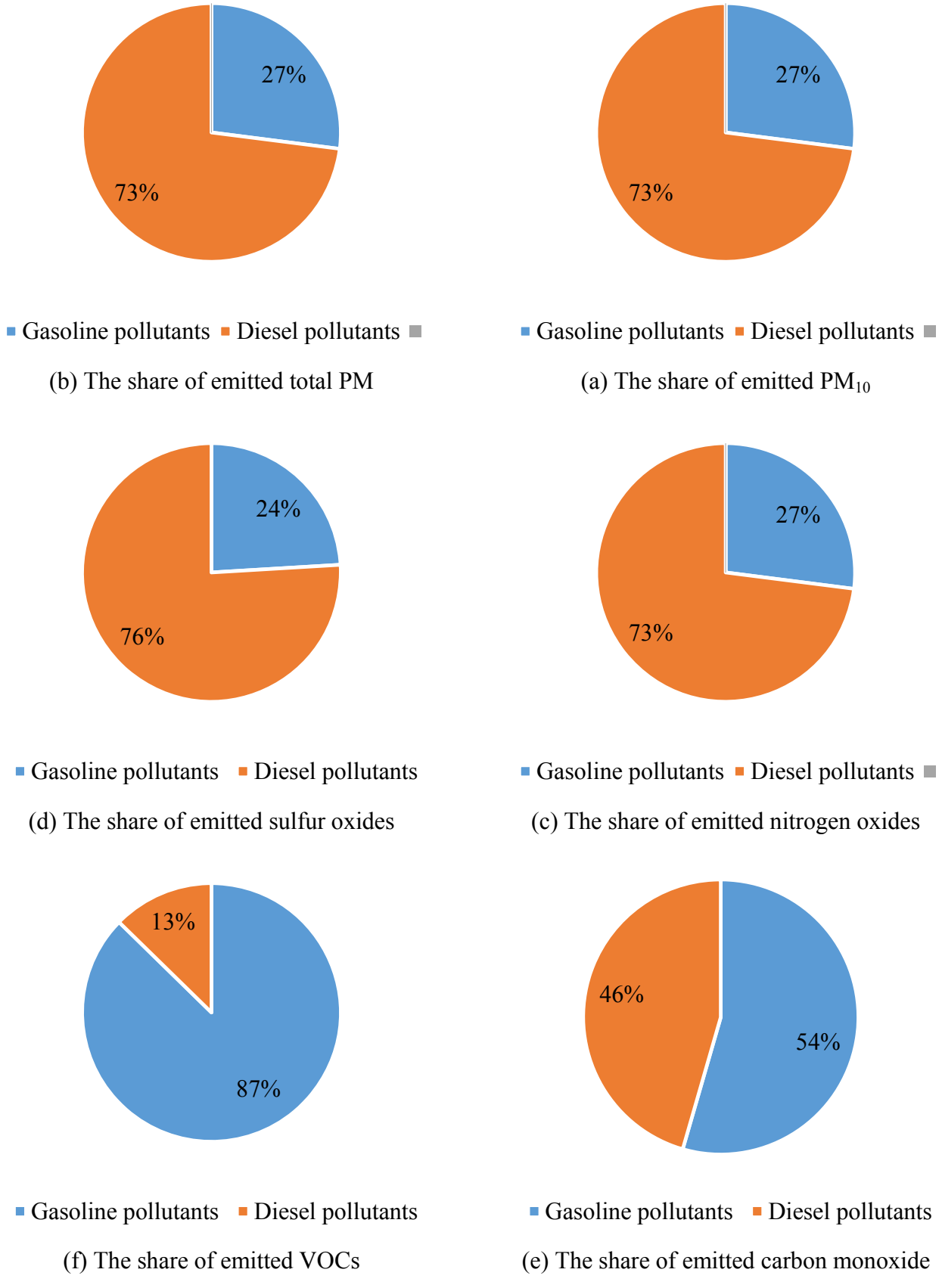

Fig. 2. The share of different pollutants emitted by gasoline and diesel engines in Isfahan from 20 March 2016 to 20 March 2017

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COMPETING INTERESTS

The authors declare that there is no conflict of interest that would prejudice the impartiality of this scientific work.

AUTHOR'S CONTRIBUTIONS

It is certified that all of the authors have made the same contribution in the experiments and manuscript writing.

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ETHICAL CONSIDERATIONS

Authors are aware of, and have complied with, best practices in ethics, specifically with regard to authorship (avoidance of guest authorship), dual submission, manipulation of figures, competing interests and compliance with policies on research ethics. Authors adhere to publication requirements that the submitted work is original and has not been published elsewhere in any language.

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