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Review Article

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Study of the effect of fuel consumption and geographic conditions on Tehran's air pollution

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ABSTRACT:

Studies show that Tehran is one of the most polluted cities in the world. This pollution is more due to the traffic of cars. According to statistics, Tehran only had 3 days of clean air in 2012 and 2013. The consumption of low-grade petroleum products by non-standard vehicles manufactured with old technology has caused air pollution to the city in the absence of an efficient public transport system as well as inefficient management. The results suggest that transition from this dilemma is possible through efficient laws, proper management, the use of world-wide knowledge and culture and general education from the basic levels. Obviously, solving this problem will directly affect the quality of life of citizens, and its effects can be seen in the economic, health, environmental and social spheres. The indirect effects of the crisis can be predicted in economic growth and development, and even in the promotion of national security (at a high level).

Review

Since man has always been a social being and instrumental, he has influenced on nature by his work. Four elements of water, soil, air and fire are four elements that ancient Greeks saw as the constituent elements of the world. Without air, there will be no life on earth, because all living things need air to survive. Air pollution in this age is one of the problems of urbanization around the world, which has harmful effects on humans, organisms and the environment, and one of its consequences is the development of diseases that sometimes lead to death.

Air pollution has caused disastrous events throughout history. Air pollution caused by the air inversion phenomenon in London from 5 to 9 December 1952 [1], and also in January 1956 or December 1962, or the disaster 3th December 1984 in Bhopal, India [2]. All these and many others while the environmental protection is a part of the duties of individuals or legal entities, or of any government, and is one of the rights of every human being.

Efforts have been made to protect the environ-

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ment in many respects, including the Kyoto Protocol [3], the Vienna Convention on the Protection of the Ozone Layer [4], and the Rio Declaration on Environment and Development [5]. In the fifth principle of the Iranian Constitution, it is explicitly stated: "in the Islamic Republic, the protection of the environment that the present generation and subsequent generations must have in this social life is considered as a public duty. Therefore, economic and non-economic activities that are associated with pollution or degradation of the environment are prohibited [6]".

Research history

Pollutants are considered because they have negative effects on the lives of humans and animals. Therefore, the subject of air pollution in the city of Tehran's 8 million people has attracted many researchers [7]. An investigation has been carried out on Tehran's air pollution effects on health costs, frameworks and solutions to address this crisis [8] and researchers have been warning the direct impact of pollutants on the health of citizens [9]. Researchers believe that the use of fossil fuels is one of the most important causes of air pollution in Tehran, and limited financial resources and inconsistencies among the departments as important obstacles to overcoming this crisis [10].

Air pollution

In general, the change (negative changes) in air features is considered to be air pollution. In other words, air pollution is the presence of any substance in the air that can be harmful to humans or the environment (living organisms, etc.) [11]. However, living in cities and the growing urbanization and as a result of population congestion, along with industrialization and the introduction of machinery into human life have contributed to an increase in air pollution [12]. This pollution has two natural origins (such as atmospheric changes, climate, urban geographic location, etc.) and abnormal/human origin (including: motor vehicle traffic, factories and workshops, home use, industrial affairs, etc.). These pollutants number over 180 types. For example, solid particles in sizes less than PM_{10} and particles less than $PM_{2.5}$ are much more dangerous and gases such as tropospheric ozone, CO, nitrogen oxides including NO_2, NO_3, NO_4, NO_5, NO_6, sulfur oxides, especially SO_2, hydrocarbons and organic matter among the aromatic compounds, such as C_6H_6, $C_6H_5CH_3$, fine particulate matter and air-suspended liquid (except pure water), etc., are among these pollutants [13].

According to the "World Health Organization (WHO)" report, Geneva, September 27, 2016, 92% of the world's population live in areas where the air quality level is below the WHO standard (In terms of less than 2.5 microns particles) [14]. According to another WHO report on May 17, 2014, 1600 cities around the world were involved with air pollution, an increase of more than 500 cities as of 2011 [15]. According to the World Health Organization's 2014 report, about 7 million people have died due to air pollution in 2012. More than 3.7 million people died of air pollution in open air and outdoors, with 90% of them in developed countries. In addition, the "International Agency for Research on Cancer (IARC)", under the WHO, on October 17, 2013, declared air pollution in open and public spaces in the first group of cancer-causing agents [16]. Of course, the effects of air pollution do not end there. For example, acid rain, due to changes in PH of soil

and water, in addition to damages to structures and fields, also causes harmful ecological damage, and this also affects human health.

Beijing, Shanghai, Delhi, Paris, London and many other cities in the corner of the world have been involved with the air pollution problem [17] and have plans to control and control this problem[18-20]. Tehran, like many other metropolitan cities, faces an air pollution crisis, and according to the materials mentioned, it is important to consider the issue for a city like Tehran with 8.8 million inhabitants and about 13 million people non-resident [21].

The climate of Tehran

Tehran is surrounded by a geographical location from the north with the Alborz Mountains and from the east and south east with the elevations of Qasr_Firoozeh and Bibi_Shahrbanoo. The atmospheric conditions in Tehran are affected by the local downslope and upslope currents and the western winds from the province of Alborz. These local currents (anabatic wind - katabatic wind) have been decreasing over the past decades [22], and winds from the province of Alborz are largely deviated due to Shahriar heights, and Tehran will only be affected during high winds [23] which builds In recent years, in Tehran's 22nd district, it has been blocking the only entrance port of this small amount of western winds [24].

The air stagnation in the city on the one hand and the continuation of human activities on the other hand, exacerbate air pollution in most days of the year. The rainfall in Tehran is not so high that it eliminates pollution. It should be considered that wind blowing or raining will not eliminate air pollution and will only move it and remove it from the city or transfer it to water and soil.

Tehran's Air Quality Index

Tehran's air quality has been a concern for citizens over the years and was established in 1993 by Tehran air quality control company. The company uses 21 pollutants to measure a range of 4 types of CO, O_3, SO_2, and NO_x pollutants and two types of particulate $PM_{2.5}$ and PM_{10} pollutants. The "Low Emission Zone (LEZ)" has been implemented under various headings as one of the solutions implemented by many European countries [25], which is now being implemented by the organization to control the air pollution of the capital [26]. The project has been implemented in many EU cities as one of the ways to manage and reduce air pollution and its impressive results have been very impressive [27-30].

Many researchers have evaluated Tehran's air quality index over different periods of time, and most of all, they have introduced airborne contaminating sources (cars) as the main cause of this situation. In the research process, data has also been collected for this article.

In the period of research, from 2010 to 2013, simultaneously with the supply of petrochemical's gasoline, changes in indicators and the upward trend of air pollution indicate this. In 2011, the particle concentration of less than 2.5 microns exceeded the limit of 218 days and this was the highest during the 10-year study period. The graphs show the downward trend in urban air quality during this period.

Transportation

Transportation in a city such as Tehran is a matter of great importance to the extent that the share of transportation in the air pollution of the capital is more than 80% [39].

More than 8.5 million inhabitants of this me-

Table 1. Condition of air pollution in terms of pollutants [31-38]

Year	CO	O_3	NO_2	SO_2	PM_{10}	$PM_{2.5}$	AQI	Clean	Healthy	Unhealthy for sensitive group	Unhealthy	Very unhealthy	Dangerous
2007-2008	7	0	0	0	10	0	15	22	324	14	0	0	0
2008-2009	7	14	0	0	43	0	60	13	293	57	2	1	0
2009-2010	4	17	0	0	22	0	42	32	291	36	4	1	1
2010-2011	4	8	15	0	20	83	102	14	249	77	24	1	0
2011-2012	0	0	0	0	12	218	218	8	139	208	7	3	0
2012-2013	0	0	0	0	10	147	147	3	215	134	12	1	0
2013-2014	0	0	0	0	10	160	160	3	202	148	12	0	0
2014-2015	0	0	0	0	9	116	116	16	233	112	4	0	0
2015-2016	0	0	0	0	11	111	111	21	233	105	5	1	0
2016-2017	0	1	3	0	6	88	89	16	260	80	9	0	0
2017-2018	0	7	3	0	7	101	108	14	243	100	8	0	0

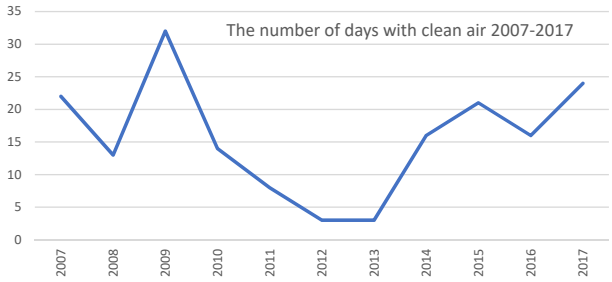

Fig. 1. Number of days with healthy air

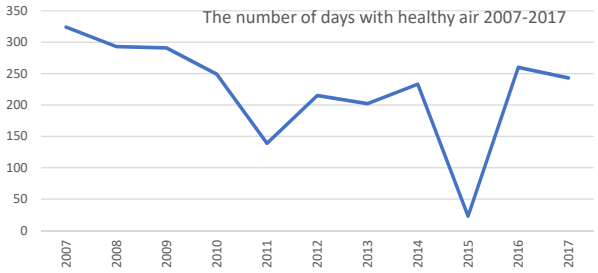

Fig. 2. Number of days with clean air

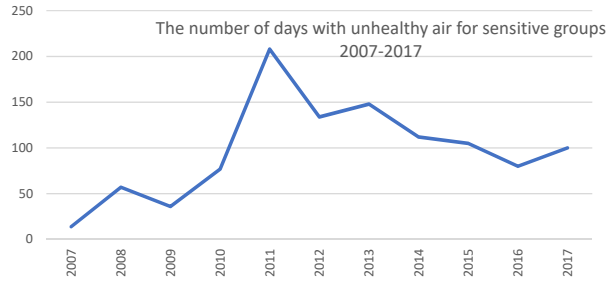

Fig. 3. Number of days with unhealthy air for sensitive groups

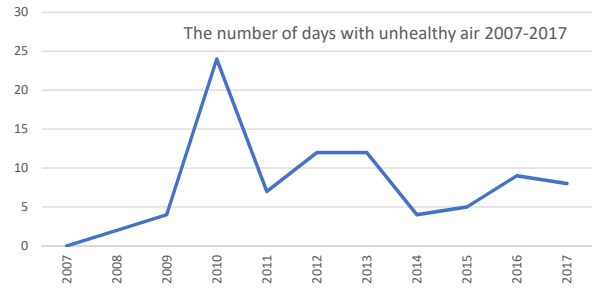

Fig. 4. Number of days with unhealthy air

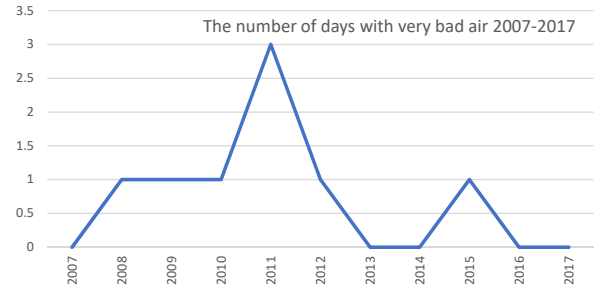

Fig. 5. Number of days with very bad air

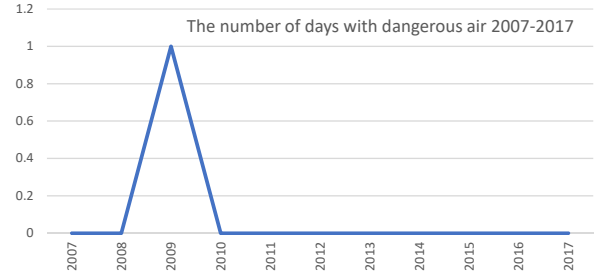

Fig. 6. Number of days with dangerous air

tropolis have access to facilities such as public transport. Tehran metro transports 9% of the city's daily average or more than 3 million people, and saving 0.65 L of gasoline per trip, And in terms of transport management, urbanization, environmental and social justice, it is worth paying particular attention [40- 42]. Buses also carry 13.6% of the daily commute, and around1.8 million passengers traveling only using the Tehran Bus Rapid Transit system (BRT) [43]. It is worth noting that the cost of construction of bus lines is less than 10% of the cost of construction of metro lines [44, 45]. Except for metro and bus, there are other options like mini bus, taxi [46] and etc. [47]. But given the level of income of different sections of society and the cost-effectiveness of intra-city trips, the first two options (metro and bus) they are all considered because they are more environmentally friendly in terms of economic efficiency for citizens [48-51].

According to researches, firstly, the lack of timely construction and operation of subway lines, as well as the shortage of wagons in urban trains due to the lack of equipping the railway fleet and the lack of access to the metro network in some places due to inaccurate location of stations, and, secondly, improper implementation of the privatization law in the company the bus in Tehran and, consequently, the removal of some of the bus lines and the lack of proper location of the bus lines and stations has led to the collapse of the public transport lines and the increasing turning of Tehran's citizens into private vehicles [52]. Personal vehicles are plentiful, and improper use of them is a matter of contributing to air pollution. The number of vehicles in the capital was announced by the authorities of Tehran's municipality 4.6 million units, that 3.5 million of which are gasoline-powered vehicles, and 1 million of which are gasoline motorcycles, and 100 thousand of which are diesel vehicles [53]. On the other hand, the member of the Tehran City Council Environment Committee reports that the number of vehicles numbered in the whole of Iran is 20 million units, of which only 4 million vehicles are in the city of Tehran, and the number of motorcycles is over 3 million [54]. The reason for this statistical heterogeneity is the inconsistency between the police and the municipality of Tehran in relation to the provision of statistics. It should also be noted that personal vehicles that have grown to use do not have much standard production and performance [55] because the optimal lifetime of a new car catalysts, with its exhaust gases, is up to 2 years, while cars under the age of 4 years are exempted from these periodic examinations or vehicles that are certified, in the second six months of the credit check period their technical, 14.5% carbon monoxide and 14.1% hydrocarbons produce more than the first six months of the same year [56] but only 1.2 million units out of a total of about 4 million cars in the capital have annual check-ups for conducting technical inspections [57].

Do not forget the worn out vehicles with 2 times more fuel than new ones [58]. The criterion be counted old for any riding cars, over 20 years, van and bus and minibus, over 15 years of age and trucks, is over 25 years old [59]. These categories of pollutants are far from the Euro4 and Euro5 standards, and often their fuel system is carburetor and does not have catalyst. The obsolete technology used in the production of this category of vehicles, along with the lack of a catalyst for their exhaust gas system, makes the gases from incomplete fuel combustion directly

out of the exhaust system. The number of worn out vehicles is estimated to be 1.35 million units that with a twofold increase in fuel consumption from Than new vehicles, the importance of paying attention to this issue. It is clear to everyone that the removal of worn out vehicles will reduce the air pollution caused by their traffic [60], but over the past years, the number of cleared worn cars has been much lower than the number of new cars [61], while, as we said a little earlier, new and newly developed cars have not matched the standards of the day [62].

By searching for the articles and interviews of officials, it is revealed that 1 million or in other words 3 million motorcycle in Tehran have any production standard and lacked minimum periodic technical examinations, and 95% of them have carburetor and at best, each which of them is 5 to 8 times more polluting than an vehicles whit injector with a Euro2 standard [63, 64]. But the point to be considered here is that each motorcycle is traverse 10 times more than an ordinary car which means fuel consumption more and more. In other words, because of the more activity, motorcycles consume more fuel, which generates 5 to 8 times more pollutants per liter of fuel. According to statistics, about one-fifth or 21% of Tehran's air pollution is borne by motorcycles [65, 66].

Fuel consumption

Consumption of oil products is one of the most important factors in air pollution in Tehran. According to the BP, in the period of 10 years from 2005 to 2015, the consumption of oil and its products in Iran averaged 0.9% annually, but in 2016 this consumption decreased by 0.1% compared to 2015. The average of natural gas consumption increased by 6.4% between 2005 and 2015, and only in 2016, it experienced 4% growth compared to 2015 [67] which this growth was due to the increase in consumption of household and industrial units by the different seasons of the year [68].

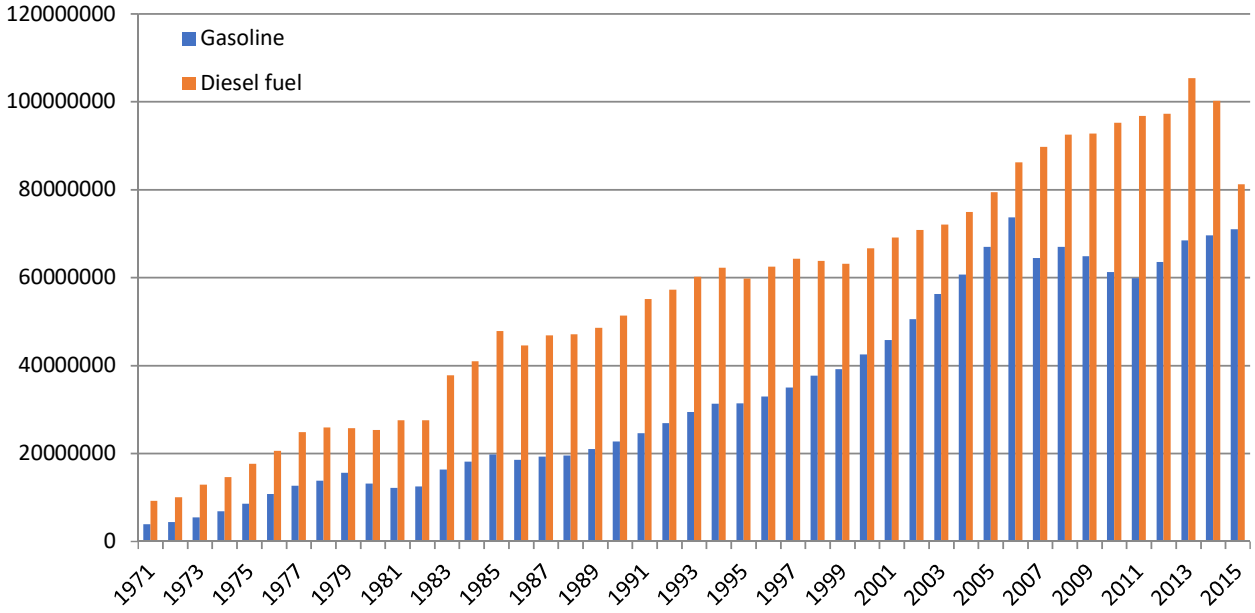

Fig. 7. History of gasoline and diesel fuel consumption in Iran during the 1971-2015 in liters [69]

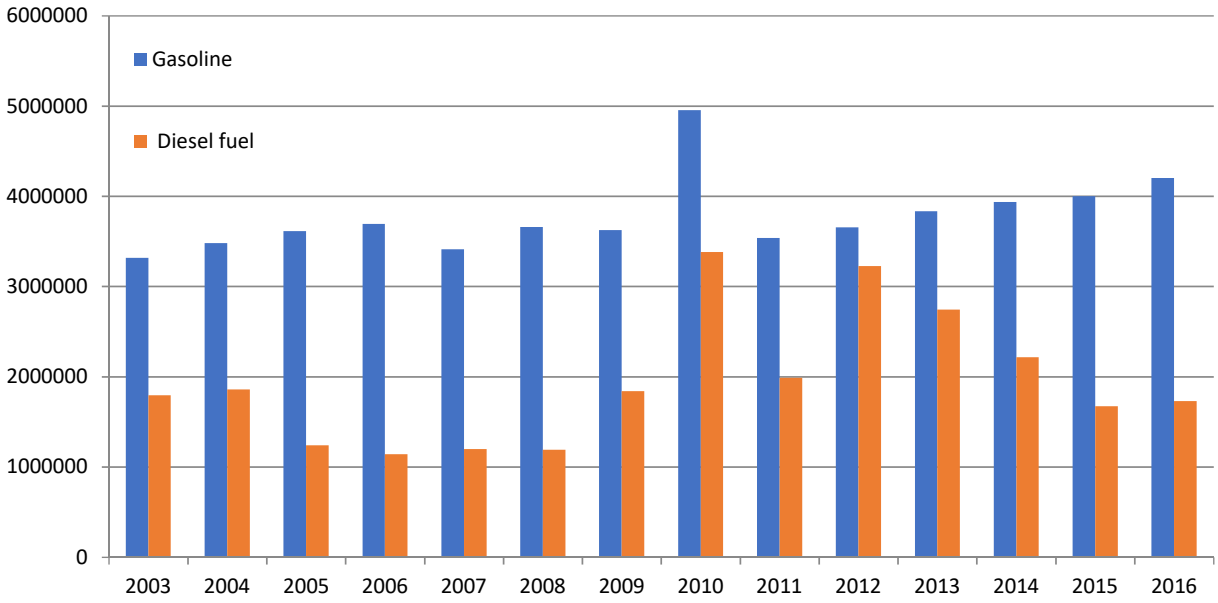

Fig. 8. daily fuel consumption in Tehran during 2003-2016 in liters [70]

The most important petroleum products consumed in the transportation sector are gasoline and diesel fuel. The following chart shows the daily consumption of gasoline and diesel fuel in Tehran.

Part of the cost of each household is related to transportation. According to a survey conducted on the share of transportation for each household [71], the total cost of transporting a city family decreased from 9.6% to 6.7% between 2004 and 2013. But with a little attention and carefulness to the details of that study, it can be seen that this reduction was due to a reduction in the cost of buying a car resulting from the provision of various facilities and loans. Thus, the cost of buying a car in 2004 was 50.55% of the expenses of the Iranian urban population, which dropped to 23.28% in 2013. While fuel cost in 2004 was 12.26%, it increased to 24.85% in 2013. In this way, citizens were encouraged to buy personal cars [72], and consequently the use of private cars and fossil fuel consumption increased. Thus, the growing trend in gasoline consumption increased and its share of the household income basket reached from 0.65% in 2004, reaching 20.55% in 2013.

Over the past decades, fuel types have been used. "Compressed Natural Gas (CNG)" has been considered for low emissions [73], and more safety [74], more biologically friendly, less depreciation of parts, cost-effective versus gasoline and diesel [75, 76], the absence of a significant difference in the true thermal value between CNG with "Liquefied Natural Gas (LNG)" and gasoline and diesel fuel, the octane number is above 130, available CNG resources, align with national security policy, relationship with economic growth and development [77], the possibility of using CNG combined with other types of fuel to reduce emissions and reduce consumption fuel [78], and many other reasons.

The number of vehicles using CNG in other countries, such as Pakistan is 2.79 million, Argentina

2.28 million, Brazil 1.75 million, India 1.58 million, China 1.50 million, Italy 0.82 million, Colombia 0.46 million, Uzbekistan 0.45 million, and Thailand 0.42 million. The United States, Canada, Australia, New Zealand and etc. have also adapted part of their fleet to use CNG fuel instead of gasoline and diesel [79]. In Iran, 3.5 million vehicles are equipped with a CNG fuel system, but for some reason, such as a shortage of gas supplies, inappropriate pricing, long ranks against a few existing positions, lack of culture, etc. many owners of this type of vehicles are reluctant to use it.

Petroleum-derived fuels have been used for many years and research on their optimal use has been made to protect the environment and reduce the pollution of these fuels [80] however, with the advancement of science, more biological friendly fuel have also been introduced. By fermented food and agricultural waste and genetic engineering, and some other actions, green fuels are obtained, which, after combustion, will leave nothing other than CO_2 and H_2O. These types of fuels can be considered important from a national security perspective because of their ability to be renewed, and while economically justified, they will not be harmless to the environment [81-84].

The quality of petroleum products

Fuel quality is another issue that we need to address. Oil and its products are pollutant after burning, so the production of quality oil products is so important that they can't be ignored. The gasoline and diesel are the most of fuel-consuming fuels, and strict standards are required for them. The EURO emission standard has been set up for this purpose, ranging from 1 to 6, and focuses on fuel quality. The emissions of nitrogen oxides for personal gasoline-powered cars in the Euro3 standard in 2000 were 0.15g/kg, which was corrected in 2005 with the Euro4 standard to 0.08 g/kg and the octane number was upgraded to 91 to 95. In 2009, with the launch of the Euro5 standard, the maximum permitted nitrogen oxide release was 0.06 g/kg. Eventually, in 2014, the Euro6 standard stabilized emissions by 0.06 g/kg.

One of the criteria for monitoring fuel quality is the octane number, the higher the number, the higher the fuel quality and the less polluting it [85-87]. Petrol in Iran before January 2011, with the Euro2 and octane 87 standards, and the plan was that after this date use petrol with the standard Euro4 and octane 90, and 60% of the diesel consumption of the country with Euro4 standard and low sulfur content. but this plan was not implemented at all until mid-2013.

Following the implementation of the subsidy targeting plan by the tenth government, the situation was such that Iran was subject to international sanctions [88]. Before this time, Iran had imported about 20 million L of petrol per day for domestic consumption. With the imposition of sanctions, the tenth government demanded petrol from petrochemical units to compensate for the incident. Gasoline imports from the 21 million liters in 2009 reached less than 2 million L in 2012. The petrol produced in petrochemicals, compensated this gap of 18 million L. The gasoline produced in petrochemicals was in fact the same Reformate that contained more than 2% to 10% benzene and 33% to 55% aromatic compounds that threatened the health of citizens [89-93], and diesel did not get better. These events led to the loss of air quality in the cities between 2009 and

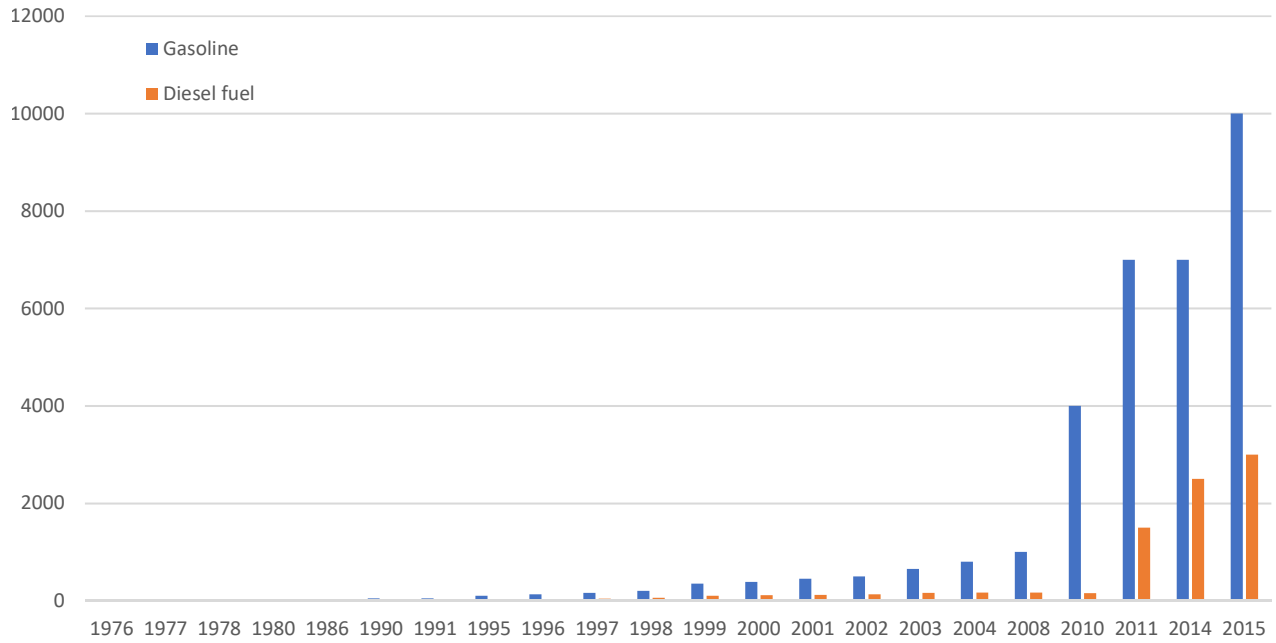

Fig. 9. Chart of growth of oil products prices in Iran per Rials

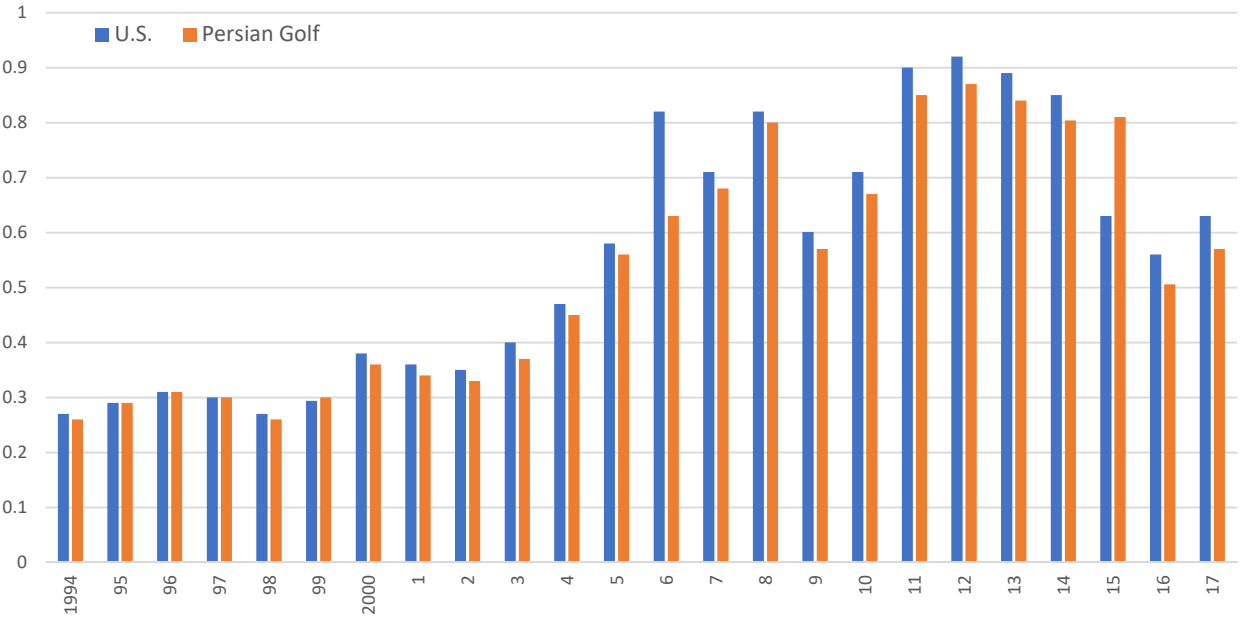

Fig. 10. Gasoline prices 1994-2017 (L/dollars) [95]

2013, which is reflected in the charts included in the Tehran air quality survey.

Fuel price

Although the price of fuel in Iran has grown considerably over the past years but its distance with world prices is still high which makes it economical to use private car. From 1976 to 2015, the price of gasoline increased from 6 Rials per L to 10,000 Rials and diesel from 2,4 Rials to 3,000 Rials. However, these prices are still far away from other countries.

According to officials, the price of gasoline for the government is higher than the current supply. According to them, the production or import of 1 L of gasoline for the government will cost more than 27,000 Rials, which will be paid to the citizens by paying more than 17,000 Rials from the government for the amount of 10,000 Rials [94]. The global gasoline prices are far from the gasoline prices in Iran. The following table shows the price per liter of gasoline on the gulf and the United States.

Capacity of Tehran city

Suitable infrastructure and standard passageways for the transport of vehicles are a requirement of a city. Tehran's roads are 2911 km, which according to the statistics of the municipality of Tehran is 6 times and according to the statistics provided by the Tehran city council 8 times the capacity of the road, the car travels in this city. This means turning the Tehran metropolis into a large parking [96], and the cars that standing at the red lights or in traffic jams, burn their fuel and cause air pollution, while not moved. This is the product of the lack of management of the supply and demand of the car on the one hand and the lack of understanding of the capacity of the city on the other [97, 98], which this important issue was mentioned earlier in the transportation sector and the reasons for the citizens desire to use private cars were raised.

Green space

Talk about air pollution, reminds you the importance of green space and plants [99]. The plants act as natural filters and, with this function, purify pollutants in the air [100, 101]. In other words, they are the lungs of the city. Formaldehyde, benzene, asbestos, insecticides, carbon oxides, sulfur oxides, nitrogen oxides, detergent's vapors, solvents and cleaning liquids, fungi, bacteria, smoke's tobacco, dust and other substances in the air, is part of the air pollutant that plants can absorb them and separate from the composition of the air and thus provides the healthy and habitable environment for humans [102-104]. It should be noted that according to the results of researches, trees and plants can only absorb 7% of PM_{10} particles, and they should not rely on them only for reducing air pollution, and take all of the responsibility to them and as part of the effort to reduce air pollution, while increasing the vegetation of cities, it should reduce pollutant emissions and improve urban management processes [105]. Researchers in Taipei have studied the effects of climate change on air pollution over the years 1995 to 2007, and due to the increasing density of urban space during the research period, especially in the city center, despite the exploitation of grasslands, wetlands, agricultural land and etc. have found that 1.19% decrease in vegetation has occurred, and the set of these changes affected air temperature, air pollution and rainfall [106].

The phenomenon of urban thermal islands is one of the characteristics of metropolises, which is

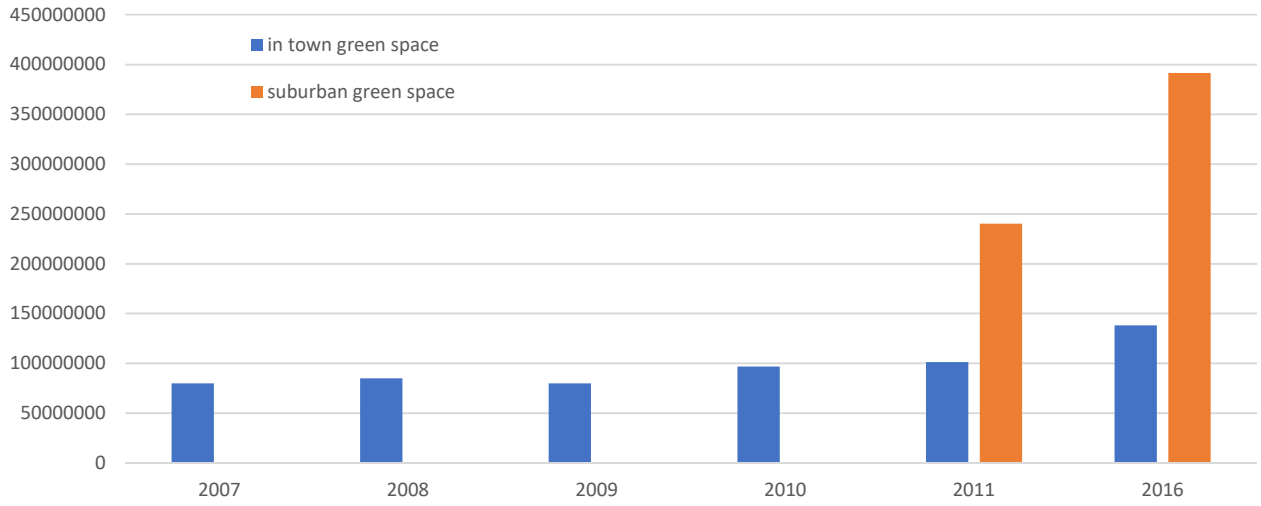

Fig. 11. The area of in town green space and suburban green space in Tehran 2007-2016 (m^2)

due to changes in the structure of the land and the reduction of vegetation and the use of heavy building materials, and its effect on ambient temperature varies from 2˚ to 15˚ celsius. Research has shown that increasing vegetation cover and developing internal green spaces and suburbs will help reduce this effect and improve environmental conditions [107-110].

The role of the plants does not end only on purifying and styling the air. Urban green space, in addition to affecting the physical, mental and health of citizens, also have a serious impact on the provision of cultural and social services [111-113]. Urban green space's capita is recognized as one of the indicators for promoting social justice. In 2011, only 10% of the total area of Tehran was allocated to green space. According to the urban population and the standard of green space's capita, the each citizen's share of urban green space was 9.2 m^2 [114-116].

Plants are also alive and have tolerance thresholds. These beneficial creatures, although they play a significant role in the purification and purity of urban air, are themselves sacrificed and damaged in the face of excessive contamination. deaths of cells and leaves nnecrosis, chlorosis, and discoloration, abnormal growth, or growth retardation include the effects of contamination on plants. Ozone, which on earth is one of the most important pollutants for all living organisms, especially plants, reduces photosynthesis in plants. Nitrogen oxides (NO_x), which produce nitrogen dioxide (NO_2) in the presence of ozone, are another cause of damage to the plant's body. Research has shown that sulfur dioxide (SO_2) disrupts and blocks the stomatal action mechanism and, by entering mesophilic cells in the presence of H_2O, by forming sulfuric acid, inhibits photosynthesis in chloroplast [117-120].

Temperature inversion

Air inversion is a phenomenon in which the air temperature rises as air temperature increases. This phenomenon, which occurs more often in

the cold seasons, makes the underlying layers of the air, which are colder, to be compressed and closer to the surface of the earth, and when this phenomenon becomes a serious problem that occurs in large cities because of its effect, the gases pollutants from human and sometimes inhumane activities are agglomerated at an altitude lower than the surface of the earth and further reduce air quality. The air inversion in the city of London, as mentioned in the introduction, had irreparable damage to human health. Over the years 2011-2015, the research on the capital of Vietnam country ,Hanoi, focused on the health effects of the air pollution from the effects of the air inversion on the health of citizens, with the result that the number of visitors to hospitals on the days when the air inversion was greater and At a closer look, the statistics of people with chronic diseases and cancer patients are on the rise [121]. Of course, research has been carried out to study the simultaneous effect of thermal islands and temperature inversions on air quality and have concluded that these two phenomena can cause urban air conditioning as a point [122, 123].

Citizen lifestyle

Failure to achieve the goals of the fourth development plan and the fifth development plan in the area of public transport fleet expansion, especially the completion of metro lines, led citizens to use personal vehicles. The desire to use personal cars and pay car loans to citizens has changed the supply and demand system [124, 125], and led to an increase in automobile production, and regardless of the capacity of urban roads, increased number of the cars in the road and the number of cars with a passenger was increasing day by day. The entry of gasoline produced by petrochemicals into the market, due to the lack of gasoline resulting from the implementation of international sanctions, has exacerbated the pollution of air in Tehran and many other cities in Iran. For this reason, was considered the reduced fuel consumption and reduced emissions, as well as the use of hybrid and electric vehicles.

For a while, hybrid and electric cars [126, 127] have been commercially marketed and have been considered for low consumption or non-consumption of petroleum products. Governments have also accelerated the process by encouraging citizens to use these types of vehicles in a variety of ways (including tax breaks for these vehicles). But in Iran, the imposition of customs tariffs and the creation of a non-competitive market (market monopoly) has made it difficult for the car to enter the market and has virtually eliminated the best option for replacing worn out vehicles [128, 129].

Conclusion

Large cities with a far greater population than Tehran have been able to overcome their own problems by employing smart and intelligent solutions and prospective management and paying attention to the development of public transport [130, 131]. The Japanese capital is exemplary in public transport. Tokyo, with the planning and harmonization of various types of public transport, has been able to manage the daily needs of its citizens to make the best possible trips within the city [132].

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Competing interest

It is very important to note that there are no conflicts of interest in this article. This article written by one person only that has been introduced on the front page. This research does not have the material and moral support of any governmental or non-governmental organization and is not ordered by any organization. Therefore, all of the material in this research was the results of the researcher's efforts and their authenticity is confirmed by the researcher. Obviously, all rights reserved for the author of this article, and the right to publish this material is prohibited without citing the source.

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Ethical considerations

This article refers to the books, articles and materials of other researchers. Each of them is named in accordance with the ethical standards of the Helsinki Declaration in the Resource Sector.

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