Environmental Sciences Vol.17 / No.1 / Spring 2019

239-252

Assessing the effectiveness of air pollution control programs in Tehran using air quality trend analysis

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Received: 2018.01.14 Accepted: 2018.08.20

Khorasanian, Z., Mobarghaee Dinan, N., Soufizadeh, S. and Rasoolzadeh, R., 2019. Assessing the effectiveness of air pollution control programs in Tehran using air quality trend analysis. Environmental Sciences. 17(1):239-252.

Introduction: Population growth, traffic jam, and industrial development generate air pollution in metropolises such as Tehran. Regarding the fact that air pollution can cause serious damage to the health of citizens, various studies have been conducted at the national and international levels. Undoubtedly, one of the most important ways to reduce environmental pollution is the use of control programs and measures. Therefore, this study aims to evaluate the effectiveness of some plans and programs to reduce the air pollution of Tehran capital city.

Material and methods: To determine the annual fluctuations in air pollutants (Carbon Monoxide (CO), Particulate Matter of 10 microns in diameter or smaller (PM_{10}), Ozone (O_3), Sulfur Dioxides (SO_2), Nitrogen Dioxide (NO_2), and Nitrogen Monoxide (NO), the concentration of these parameters was investigated in Tehran from 2005 to 2012. Pearson correlation analysis and stepwise regression (SAS software) were used to evaluate the relationships between air pollution, number of vehicles and fuel consumption in Tehran.

Results and discussion: From 2005 to 2012, the trend of annual changes in CO concentration was decreased. The highest concentration of this pollutant (2006) was 5 mg/l and the lowest concentration (2011) was about 2 mg/l. During the same period, the annual trend of PM_{10} increased from 100 to140 µg/m^3. In these years, the annual trend of ozone decreased from 0.03 mg/l to 0.02 mg/l. Meanwhile, the annual concentration of sulfur

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dioxide decreased from 0.055 to 0.03 mg/l. Changes in annual NO_2 and NO concentration decreased during the mentioned years from l0.07 to 0.2 mg/l and from 0.05 to 0.010 mg/l, respectively.

Conclusion: Results show that the trend of annual change in the concentration of pollutants was decreasing for all pollutants (except for suspended particles) from 2005 to 2012. Eliminating eroded cars, and using hybrid and gas-fueled vehicles played an important role in reducing air pollution in Tehran. Also, due to the results of the correlation analysis and the significance of the effect of eroded cars on atmospheric pollutants, the impact of this policy on reducing emissions was significant. The results of stepwise regression analysis from 2005 to 2012 showed that eliminating the eroded cars and replacing them with dual-fuel ones had the most significant effect on reducing carbon monoxide emissions in Tehran.

Keywords: Air pollution, Trend analysis, Air pollution control, Pearson correlation, Stepwise regression.

Introduction

Nowadays, air pollution is one of the main environmental and economic problems, which causes acute clinical problems (i.e., respiratory and skin diseases, birth defects, and physical weakness) and the high cost of reducing these pollutants. Therefore, in different countries, various laws and regulations have been established to determine the safe limits of air pollutants (Tern, 1982). Technological and industrial developments, urban expansion, population growth, an increasing number of motor vehicles, the amount of petroleum products consumption, and in some cases geographical specific conditions have resulted in air pollution in Tehran (Canepa *et al*., 2000).

In addition to understanding the pollutants, comprehension of environmental standards and risk assessment are the most important goals of environmental pollution control where laws and regulations have been enacted to control and mitigate the effects of air pollution. Therefore, several studies have been conducted on national and international levels. Beer (1995) mentioned that the performance of pollutant's emission control devices in Melbourne (Australia) depends on the concentration of the emissions of carbon monoxide, nitrogen oxides, and hydrocarbons from vehicles. Additionally, he proposed that appropriate solutions for the reduction of vehicles' emission are strict regulations, appropriate design of vehicles and public transportation development. Asari *et al*. (2006) investigated the effect of meteorological parameters such as wind speed, relative humidity, temperature, dew point, wind, and rain on the concentration of pollutants and stated that the highest concentration of SO_2 in the air of Tehran is emitted from Tehran Oil Refinery and diesel vehicles. Haji Yahya (2007) investigated the management of air pollution in southeastern Asia and suggested policies and strategies to control and manage air pollution in Indonesia. He mostly emphasized on green strategies including education, public awareness, proper management, efficient consumption of biofuels, and prevention and control of air pollution using policies such as quality improvement of fuels, standardization of vehicles, promoting the use of clean and renewable fuels, and implementation of policies to prevent diesel trucks and bus traffic in the city. Moreover, he expressed that the most effective policies to control air pollution in Malaysia for diesel and gas vehicles are applying Euro 2 and Euro 3 standards, respectively (Haji Yahya, 2007). Takeuchi *et al.* (2007) investigated the impacts of control policies on the air pollutants emissions from motor vehicles in Mumbai (India). He expressed that the most effective means and policies to reduce the gas emitted by buses, cars, and motorcycles are conversions of diesel cars into CNG ones, increasing the gasoline price and imposing a heavy tax on the car ownership (Takeuchi *et al.*, 2007). Shaw (2007) investigated the air quality strategies in England, Scotland, Wales and Northern Ireland and listed some factors such as traffic management, use of clean fuel, and promotion of cycling culture as the main reasons for the improvement of air quality in the mentioned areas. Faridi (2011) studied Tehran's air quality management system and stated that its shortcomings are due to the lack of an effective management system, implementation, and enforcement of legislation and standards, fund insufficiency to replace old cars with new ones, and the absence of appropriate programs and public awareness. Finally, he listed effective methods to control air pollution in Tehran and other major cities including changing the fossil fuels of buses and mini-buses into CNG, use of smart traffic systems (ITS), and pollution control through public awareness (Faridi, 2011). Fisher *et al.* (2011) explicated particulate matters and photochemical pollutants as the most toxic matters and major causes of death, and also the most important pollutants emitted by diesel vehicles (Fischer *et al.*, 2011). Boogarde *et al.* (2012) investigated the impact of local traffic policies on the air pollution concentrations and showed that the implementation of traffic policies and controlling the diesel vehicle's traffic decreased the $PM_{2.5}$ and SO_2 concentrations by 30% and 50%, respectively. Finally, they concluded that heavy traffics caused an increase in the concentration of pollutants which were reduced due to traffic control policies (Boogarde *et al.*, 2012). Byers and Matlock (2012) studied EPA rules to reduce the air pollution derived from the oil and natural gas industry. They used stepwise regression analysis to find the relationship between the variables and showed that full implementation of these legislations resulted in a 95% reduction in particulate matters emission (Byers and Matlock, 2012). Vicente *et al.* (2012) investigated PM_{10} emissions from ceramic and tile industry in Spain and mentioned that the most effective ways to mitigate air pollution are avoiding fossil fuel overuse, developing renewable energies, providing appropriate mitigating protocols for industries, and establishing industrial areas far from urban boundaries. Correlations and multiple linear regression showed that the PM_{10} concentrations during the years 2004-2001 had a gradual decrease and experienced a rising trend in 2005 (Vicente *et al.*, 2012). Recently, two studies investigated the effect of air pollution on human (Yang and Zhang, 2018), and air pollution models (Loizeau et al., 2018). Engelbercht and Jayanty (2013) used the coefficient of correlation, principal component analysis (PCA) and matrix analysis and found five main sources of particulate matters and aerosols emissions, four of which were related to geological sources, and one was related to leaded gas. They also concluded that leaded gas was the main resource of particulate matters emission (Engelbercht and Jayanty, 2013). Afandizadeh and Rahimi (2005) investigated the role of culture in the reduction of air pollution. They argued that the improvement of the public transport system (buses, minibusses, and taxis) is a side effect of traffic reduction and also traffic cultural tools and educational planning are the most effective strategies to reduce private car usage and hence a decrease in fuel consumption (Afandizadeh and Rahimi, 2005). Azhdarpoor and Asilian (2006) concluded that carbon monoxide and particulate matters are two main air pollutants in Tehran. Ejtehadi (2007) evaluated the urban air pollution from the transportation system with an emphasis on aerosols and expressed that particulate matters are the most important urban pollutants. He suggested that elimination of eroded cars from the public transport system and the use of public transportation are the best ways to improve Tehran's air quality (Ejtehadi, 2007). Damankeshide *et al*. (2012) measured four types of pollutants in seven urban areas to estimate the equations of factors affecting air pollution in Tehran. Using panel data econometrics, they showed that gas consumption by eroded cars has a positive and significant correlation with concentrations of air pollutants in Tehran (95% confidence limit). However, gas consumption by new vehicles had a significant negative correlation with air pollutants concentration in the same city (Daman Keshideh et al., 2012). Therefore, this study aimed to evaluate the effectiveness of different programs and actions on the reduction of Tehran's air pollution. Annual changes of air pollutants (Carbon Monoxide (CO), Particulate Matter of 10 microns in diameter or smaller (PM_{10}), Ozone (O_3), Sulfur Dioxides (SO_2), Nitrogen Dioxide (NO_2), and Nitrogen Monoxide (NO)) have been studied from 2005 to 2012 in Tehran.

Material and methods

First, we gathered the required data (from 2005 to 2012) such as air pollutant concentrations from the Iranian Department of Environment and the air quality control company, and also the number of cars from Tehran Traffic Police. We used Microsoft Excel, SAS Institute V.9.1.3 (SAS Institute, 2001), and Sigma Plot software to plot the curves and analyze the correlations between parameters. In the present study, CO, SO_2, and NO were considered as the dependent variables and eroded cars, hybrid cars, and diesel trucks were selected as independent variables. Pearson correlation analysis, stepwise regression, and SAS software were used to assess the relationship between air pollution, number of vehicles and fuel consumption in Tehran (SAS Institute, 2001).

Results and discussion

The annual pattern of CO during 2005-2012 showed a declining trend (Fig. 1A). The highest CO concentration was 5 mg/l in 2005 and the lowest was 2 mg/l in 2012. The overall trend of particulate matters during the studied period was steady (Fig. 1B). As observed, the highest concentration of suspended particles was 3140 μg/m^3 in 2011 and the lowest was 3100 μg/m^3 in 2005 and 2006.

Ozone annual changes show a downward trend during 2005-2012 (Fig. 1C). It can be observed that the highest and lowest concentration of O_3 were 0.03 mg/l and 0.02 mg/l, respectively.

The annual trend of SO_2 concentration during 2005-2012 was downward (Fig. 1D). As illustrated in Fig. 1D, the highest (0.055 mg/l) and lowest (0.03 mg/l) concentration of SO_2 were observed in 2005 and 2012, respectively. The trend of the concentration of this pollutant fluctuated during the studied time period and it was significant at a confidence level of 1%, which indicates a significant reduction in the concentration of SO_2 in the years 2005 to 2012.

As Fig. 1E depicts, the annual changes in NO_2 concentration during 2005-2012 was descending. The maximum concentration of NO_2 was observed in 2005 with a concentration of 0.07 mg/l, and its minimum concentration was 0.02 mg/l in 2012. The trend of NO_2 concentration during the studied period was significant at a confidence level of 1%, which indicates a significant decrease in the concentration of this pollutant from 2005 to 2012. In general, the annual standard limit of NO_2 is 0.021 mg/l, and accordingly, the concentration of this pollutant was close to the standard limit.

The annual changes of NO concentration have been declining over the years 2005-2012 (Fig. 1F). As Fig.1F presents, the highest concentration of nitrogen monoxide was in 2005 (0.05 mg/l) and the lowest level in 2012 (0.03 mg/l). The trend of NO concentration changed during the studied period and was significant at a confidence level of 1%, which indicates a significant decrease in the concentration of this pollutant in the studying years.

The results of correlation analysis between the number of cars and atmospheric pollutants during this seven-year period (Table 1) showed a significant and negative correlation (-0.71) between CO and eliminating eroded cars at 1% confidence level, and a significant and positive correlation (0.60) between CO and increasing number of gas taxi at 5% confidence level.

On the other hand, the increasing number of hybrid cars and SO_2 had a significant and negative correlation (-0.71) at 1% level confidence. A significant and positive correlation (0.77) has also been observed between SO_2 and diesel trucks at 1% level confidence.

The correlation between NO_2 and the number of hybrid cars was negative and significant (-0.62) at 5% level confidence. Also, a significant negative correlation was observed between NO_2 and elimination of eroded cars (-0.62).

Fig. 1- Annual changes of atmospheric pollutants in Tehran (2005–2012)

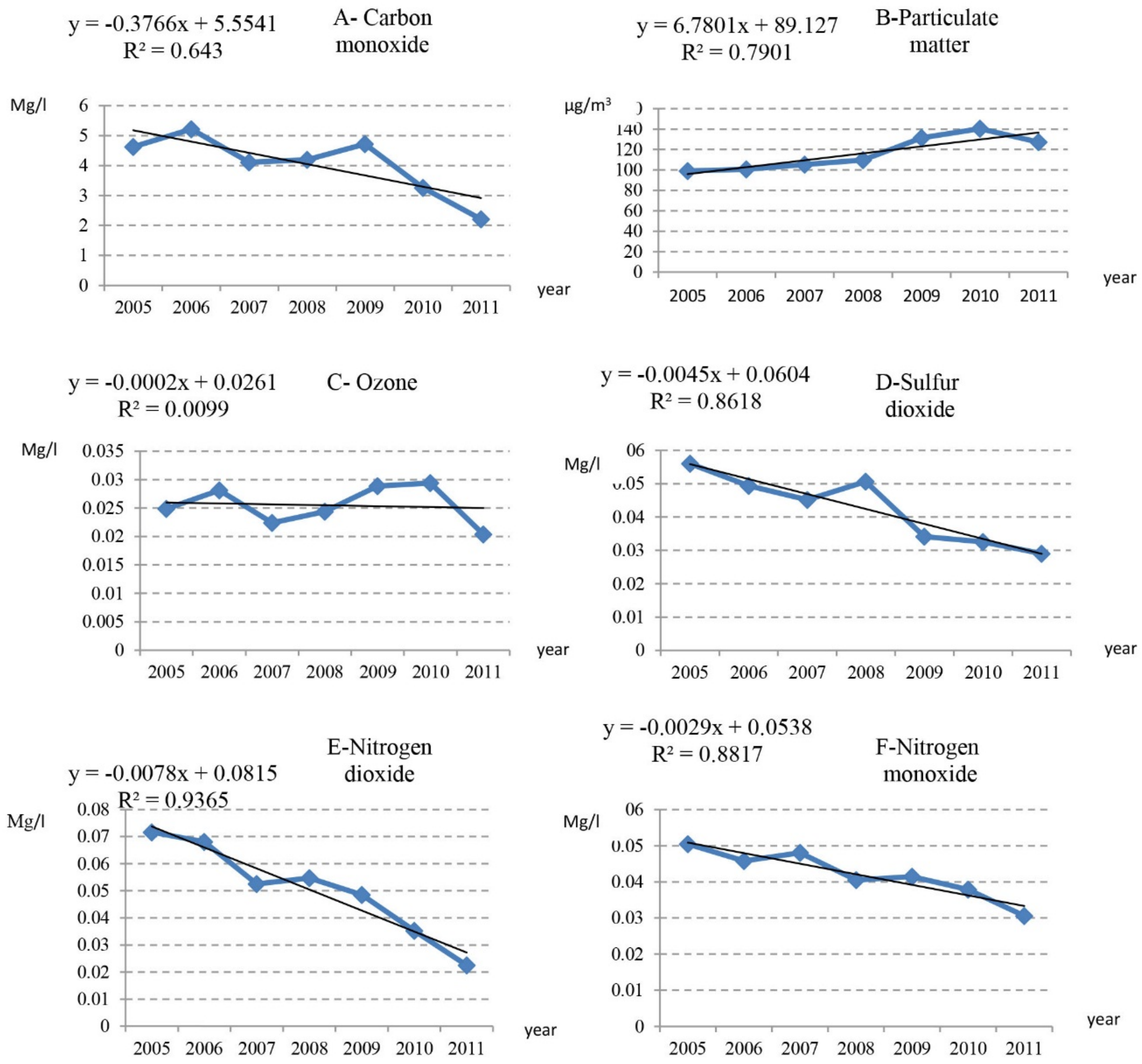

Table 1. Correlations between the number of different types of cars and atmospheric pollutants in Tehran (2005-2012)

Variables	Diesel pickup	Diesel truck	Hybrid cars	Gas taxi	Eliminating eroded cars
CO	0.59*	0.50 ns	-0.61*	0.60*	-0.71**
PM_{10}	0.15 ns	-0.19 ns	0.39 ns	-0.19 ns	-0.41 ns
O_3	0.14 ns	-0.23 ns	-0.28 ns	-0.23 ns	-0.42 ns
SO_2	0.77**	0.69**	-0.71**	-0.13 ns	-0.11 ns
NO_2	0.57*	0.46 ns	-0.62 *	-0.48 ns	-0.50 ns
NO	0.49 ns	0.48 ns	-0.59*	-0.43 ns	-0.62*

*Statistically significant at 5% level of confidence, **statistically significant at 1% level of confidence, ns no significant difference

Table 2. Analysis of the relationship between the number of different types of cars and atmospheric pollutants using stepwise regression (2005-2012)

Pollutant	Step	Type	Correlation	R^2	Standardized β coefficient
CO	1	elimination of eroded cars	61.47	0.6147	-1.56
CO	2	Hybrid cars	18.65	0.1865	-0.75
SO_2	1	Diesel Pickups	65.45	0.6545	2.70
NO_2	1	Hybrid vehicles	62.23	0.6223	-1.78

Stepwise regression analysis form 2005 to 2012 (Table 2) showed that the elimination of eroded cars and the number of hybrid cars are the most effective parameters on the reduction of CO emissions in Tehran. Therefore, 61.47% of changes in Tehran's air pollution were related to the elimination of eroded cars, and 18.65% of CO changes were related to the number of hybrid ones. The results of this analysis showed that 64.45% of changes in sulfur dioxide concentration were due to the increasing numbers of diesel pickups. Moreover, 62.23% of the changes in NO_2 concentration were due to hybrid cars. Similar results were obtained from the annual correlation analysis.

As Table 3 represents, PCA results suggested that the first and second components justify 78.99% of the variations in total, which is statistically significant. The most effective variables on the first component are the elimination of eroded cars, the number of diesel trucks and diesel pickups, and the concentration of CO and sulfur dioxide. Elimination of eroded cars reduced the concentration of carbon monoxide. It was also observed that diesel trucks and pickups increased sulfur dioxide concentration. On the other hand, the most influencing factors on the second component were the number of hybrid cars and the concentration of particulate matters and nitrogen dioxide. Therefore, increasing the numbers of hybrid vehicles resulted in the reduction of particulate matter and sulfur dioxide concentrations. Similar results obtained from stepwise regression (2005-2012).

As presented in Table 4, there are significant and positive correlations between CO and gas consumption (0.71), particulate matter and furnace fuel oil (0.78), SO_2 and furnace fuel oil (0.71) and SO_2 and gas-oil (0.89) at 1% level of confidence. Also, in the case of NO_2, a significant and positive correlation with gas-oil (0.71) and a significant negative correlation with the increase of natural gas consumption (-0.62) were observed.

Table 3. PCA results of the number of cars and atmospheric pollutants in Tehran, 2005-2012

Fuel PC	Total Var.	Var.	Eigenvalue	NO	NO2	SO2	O3	PM10	CO	Diesel pickups	Diesel trucks	Hybrid cars	Gas taxi	elimination of eroded cars
First component	0.2108	0.5791	5.34	0.25	0.36	0.26	0.11	0.13	-0.34	0.33	0.35	0.24	0.29	0.35
Second component	0.7899	0.5791	2.01	-0.24	-0.22	0.42	0.24	-0.40	0.18	0.09	0.24	0.45	-0.01	0.26

Table 4. The correlation between annually fuel consumption and atmospheric pollutants in Tehran

Variables	Natural gas	Gas-oil	Furnace fuel oil	Gas
CO	-0.61^{*}	0.43^{ns}	0.62^{*}	0.71^{**}
PM_{10}	0.15^{ns}	0.61*	0.78^{**}	0.49^{ns}
O_3	0.12^{ns}	0.23^{ns}	0.12^{ns}	0.05^{ns}
SO_2	-0.171^{**}	0.89^{**}	0.71^{**}	0.11^{ns}
NO_2	-0.62^{*}	0.71^{**}	0.15^{ns}	0.25^{ns}
NO	-0.10^{ns}	0.41^{ns}	0.65^{*}	0.13^{ns}

*Statistically significant at 5% level of confidence, **Statistically significant at 1% level of confidence, ^{ns} no significant difference

Table 5. Stepwise regression analysis between fuel consumption and emissions of pollutants into Tehran's atmosphere (2005-2012)

Pollutant	Step	Fuel	Correlation	R2	Standardized β coefficient
CO	1	Gas	63.54	0.6354	1.50
CO	2	Furnace fuel oil	16.23	0.1623	0.32
O3	1	Furnace fuel oil	65.89	0.6589	1.01
SO2	1	Natural Gas	58.59	0.5859	-2.28
SO2	2	Gas-oil	17.24	0.1724	1.12
PM10	1	Gas-oil	56.12	0.5612	0.15

The results of the stepwise regression analysis between the fuel consumption and atmospheric pollutants during 2005-2012 (Table 5) showed that the consumption of gas and furnace fuel oil had the most impact on the CO emission in Tehran's air. In this regard, 63.54% of CO changes in Tehran atmosphere were related to gas consumption, and 65.89% of these variations were because of furnace fuel oil consumption.

Additionally, 58.59% and 17.24 % of SO_2 changes were due to the consumption of natural gas and oil-gas, respectively. Moreover, 62.23% of NO_2 changes were related to hybrid cars. Gas-oil consumption was responsible for 56.12% of changes in PM_{10}.

In fact, in this analysis, CO, O_3, SO_2, and particulate matters were considered as the dependent variables and the consumption of gas, furnace fuel oil, gas-oil, and natural gas were selected as the independent ones. Similar results were obtained by the correlation analysis during 2005-2012.

The PCA results of fuel consumption and atmospheric pollutants showed that the first and second components justify 76.80% of the variations, which is statistically significant (Table 6). The most important variables involved in the first component are gas, furnace fuel oil, gas-oil, carbon monoxide, nitrogen dioxide, and nitrogen monoxide. The increase in gas consumption resulted in more concentration of carbon monoxide, and more consumption of furnace fuel oil and gas-oil increased the concentration of SO_2 and NO. On the other hand, the most affecting factors on the second component were the increase in natural gas consumption and SO_2, since the increase in natural gas consumption reduced the emission of SO_2. Similar results were obtained by the annual stepwise regression.

Table 6. The PCA results of fuel consumption and atmospheric pollutants, 2005-2012

Fuel PC	Oil	Furnace fuel oil	Gas-oil	Natural gas	NO	NO_2	SO_2	O_3	PM_{10}	CO	Eigenvalue	Var.	Total var.
First component	0.37	0.42	0.32	-0.26	0.39	0.54	0.13	-0.07	-0.05	0.37	4.52	0.6525	0.1551
Second component	0.21	-0.24	-0.21	0.42	-0.10	-0.15	0.43	0.27	0.16	0.12	1.55	0.6525	0.8076

According to the results, the average concentration of pollutants (2005 to 2012) except for the Particulate Matters (PM_{10}) showed downward trends. Therefore, Eliminating eroded cars, and using hybrid and gas-fueled vehicles played an important role in reducing air pollution in Tehran. The correlation analysis showed that the elimination of eroded cars had a significant relation with carbon monoxide reduction at 1% level of confidence. Moreover, the results of the stepwise regression analysis (Table 2) indicated that the elimination of eroded cars was a significant factor in reducing carbon monoxide. Regarding the PCA (Table 3), elimination of eroded cars and carbon monoxide are the most influencing variables on the first component. Thus, due to the relationship between air pollutants, particularly carbon monoxide and elimination of old cars, and also imposing the old cars exchange program from 2005 to 2012, the concentration of carbon monoxide has been decreasing. The correlation analysis (Table 1) showed that the program of converting gas cars to CNG-NGV ones has the greatest effect on reducing carbon monoxide, particulate matter, sulfur dioxide, and nitrogen monoxide at 1% level of confidence. Also, PCA results showed that hybrid cars, particulate matters, and sulfur dioxide were the most influencing variables on the second component.

The use of natural gas instead of fossil fuels had the greatest impact on the reduction of carbon monoxide, sulfur dioxide, and nitrogen oxide concentrations. The results of the correlation analysis (Table 4), stepwise regression (Table 5) and PCA (Table 6) indicated that the relationship between using natural gas and carbon monoxide concentration was significant and negative and there was a significant and positive relationship between the number of diesel vehicles and sulfur dioxide concentration.

Statistical analyses showed that the relation between old cars and carbon monoxide and nitrogen monoxide was significant and negative at 1% and 5% confidence levels, respectively. Also, the stepwise regression analysis proved that 61.47% of carbon monoxide changes were related to the elimination of old cars. These results are consistent with the findings of Davis (2008), Azhdarpoor and Asilian (2005), Ejtehadi (2006), Daman Kesheideh *et al.* (2012). Thus, due to the relation between the decreases in atmospheric pollutants, particularly carbon monoxide, and elimination of old cars and also because of imposing old cars exchange program from 2005 to 2012, the concentration of carbon monoxide has been decreasing. So, it can be concluded that the project was effective in reducing the concentration of that pollutant.

According to our findings, CNG-NGV cars had negative correlations with sulfur dioxide at the confidence level of 1%, and carbon monoxide and nitrogen monoxide at 5% level of confidence. It should be noted that these results matched the findings of Takeuchi *et al.* (2007) and Pachon *et al.* (2007). In fact, the results of correlation and stepwise regression indicated that there is a negative and significant relationship between the increasing number of hybrid cars and atmospheric pollutants, which means that the implementation of replacing cars with CNG-NGV ones led to a reduction in the concentration of pollutants. Diesel vehicles had significant and positive relations with sulfur dioxide at the confidence level of 1% and with nitrogen dioxide and nitrogen monoxide at 5% level of confidence. Stepwise regression analysis also showed that 65.45% of sulfur dioxide changes were related to the number of diesel vehicles. Findings of Haji Yahya (2007), Asadollah-Fardi, 2008 and Fischer *et al*. (2011), and Boogaard *et al*. (2012) confirmed these results.

Fuel consumption had significant and negative effects on SO_2 at the confidence level of 1% and CO and NO_2 at a 5% level of confidence. Therefore, it can be concluded that increased consumption of natural gas, unlike fossil fuels, has a positive effect on reducing the concentration of atmospheric pollutants, particularly carbon monoxide, sulfur dioxide, and nitrogen oxides.

In addition, the implementation of a traffic ban on diesel cars and increasing the consumption of natural gas rather than fossil fuels in different sections are other reasons for the reduction of sulfur dioxide. According to statistical analyses and reduction of sulfur dioxide, the execution of the project had a positive effect on reducing SO_2 concentration. According to examinations of the pollutants, average trend of concentration changes and analysis of the policies and strategies about the air pollution in Tehran, it was concluded that, at the present time, the main problem of Tehran’s air pollution comes from an increase in the concentration of particulate matters. Effective factors on the increase of particulate matters are disperse of particulate matters from Iraq, construction activities in Tehran, and increasing traffic jam. According to the results of this study, eliminating the eroded vehicles and other policies did not have a significant impact on the reduction of these pollutants. On the other hand, the reduction of carbon monoxide was due to the elimination of old cars and the scrapping of these vehicles. Moreover, converting taxies to hybrid ones since 2007 and gas base ones since 2008 were considered as other factors for carbon monoxide, sulfur dioxide, and nitrogen oxides reduction. In addition, implementation of a traffic ban on diesel vehicles such as minibusses and buses since 2004 caused a reduction in sulfur dioxide concentration over the studied period. Based on the Council of Minister's directive (2008.10.03), the decision was made in terms of producing diesel vehicles according to EURO I standard since 2005. Using natural gas instead of other fossil fuels in industries is the main action for the reduction of SO_2 emission to the standard limit.

An effective policy on reducing the concentration of NO_2 (besides the elimination of eroded vehicle from the public transport system) was converting the gas base vehicles to the CNG ones. Therefore, traffic management, controlling vehicles speed, fuel quality improvement based on international standards and the implementation of EURO II standard in domestic cars, industrial site selection according to the prevailing wind direction and the distance from residential areas, transferring industries and factories out of Tehran, and converting industries into green ones are considered as operational policies affecting the reduction of atmospheric pollutants concentrations.

Conclusion

Statistical analysis illustrated that the average concentration of pollutants (2005 to 2012) except for the PM_{10} showed downward trends. The correlation between eroded cars and CO and NO was significant and negative at 1% and 5% confidence level, respectively. Therefore, eliminating eroded cars, and using hybrid and gas-fueled vehicles played an important role in reducing air pollution in Tehran

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فصلنامه علوم محیطی، دوره هفدهم، شماره ۱، بهار ۱۳۹۸

۲۳۹-۲۵۲

ارزیابی اثربخشی برنامه های کنترل آلودگی هوا در تهران با استفاده از تجزیه و تحلیل روند کیفیت هوا

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تاریخ دریافت: ۱۳۹۶/۱۰/۲۴ تاریخ پذیرش: ۱۳۹۷/۰۵/۲۹

خراسانیان، ز.، ن. مبرقعی دینان، س. صوفی زاده و ر. رسول‌زاده. ۱۳۹۸. ارزیابی اثربخشی برنامه های کنترل آلودگی هوا در تهران با استفاده از تجزیه و تحلیل روند کیفیت هوا. فصلنامه علوم محیطی. ۱۷(۱): ۲۳۹-۲۵۲

سابقه و هدف: رشد جمعیت، ترافیک و گسترش صنعتی سبب ایجاد آلودگی هوا در کلانشهرها مانند تهران شده است. با توجه به این واقعیت که آلودگی هوا می تواند صدمه جدی به سلامت شهروندان وارد آورد، مطالعات مختلفی در سطوح ملی و بین المللی انجام گرفته است. بدون شک یکی از مهمترین راه های کاهش آلودگی محیطی، استفاده از برنامه های کنترلی و اقدام‌های کاهشی است. لذا این تحقیق با هدف بررسی اثربخشی برخی طرح ها و برنامه های کاهش آلودگی هوا در کلان شهر تهران انجام شده است.

مواد و روش ها: به منظور بررسی تغییرپذیری‌های سالانه آلاینده های هوا (NO ،NO_2 ،SO_X ،O_3 ،PM_{10} ،CO) ، غلظت این پارامترها از سال ۲۰۰۵ تا ۲۰۱۲ در تهران مورد بررسی قرار گرفت و از تجزیه و تحلیل همبستگی پیرسون، رگرسیون گام به گام (نرم افزار SAS) برای ارزیابی رابطه بین آلودگی هوا، تعداد وسیله‌های نقلیه و مصرف سوخت در تهران استفاده شد.

نتایج و بحث: از سال ۲۰۰۵ تا ۲۰۱۲، غلظت سالانه منوکسید کربن کاهش یافته است. بیشترین غلظت این آلاینده در سال ۲۰۰۶ در حدود ۵ میلی گرم بر لیتر و کمترین مقدار آن در سال ۲۰۱۱ در حدود ۲ میلی گرم بر لیتر بود. در طول همان دوره، روند سالانه ذرات معلق از ۱۰۰ تا ۱۴۰ میکروگرم بر متر مکعب افزایش و در این سالها، روند سالانه تغییر غلظت ازن از ۰/۰۳ میلی گرم در لیتر به ۰/۰۲ میلی گرم در لیتر کاهش یافت. در همین زمان غلظت سالانه دی اکسید گوگرد از ۰/۰۵۵ به ۰/۰۳ میلی گرم در لیتر کاهش و روند نیتروژن دی اکسید نیتروژن و غلظت منوکسید نیتروژن در طول سالهای ۱۳۹۰-۱۳۸۴ از ۱۰/۰۷ به ۰/۲ میلی گرم در لیتر و از ۰/۰۵. به ۰/۰۱۰ میلی گرم در لیتر کاهش یافت.

نتیجه‌گیری: نتایج نشان می دهد که روند تغییر غلظت سالانه آلاینده‌ها در سال‌های ۱۳۹۰-۱۳۸۴ برای همه‌ی آلاینده‌ها به غیر از ذرات

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معلق کاهشی است و حذف وسیله‌های نقلیه فرسوده، استفاده از وسیله‌های نقلیه هیبریدی و افزایش مصرف خودروهای گاز سوز نقش مهمی در کاهش آلودگی هوای تهران دارد. همچنین با توجه به نتایج تجزیه همبستگی و معنی‌دار بودن اثر خروج خودروهای فرسوده بر آلاینده‌های اتمسفری، تاثیر اجرای این سیاست در کاهش آلاینده‌ها موثر بوده است. نتایج تجزیه رگرسیون گام به گام در طول سال‌های ۱۳۹۰-۱۳۸۴ نشان می‌دهد که خروج خودروهای فرسوده و جایگزینی با سواری دوگانه سوز بیشترین اثر را در کاهش انتشار گاز منوکسید کربن در سطح شهر تهران داشته است.

واژه‌های کلیدی: آلودگی هوا، تحلیل روند، کنترل آلودگی هوا، همبستگی پیرسون، رگرسیون گام به گام.