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ORIGINAL ARTICLE

A Study on the variation of Nitrogen dioxide concentration in the city of Shiraz between the years 2010 and 2012

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ABSTRACT
An oxidant Nitrogen oxide gas, which is one of the most important air pollutants in many cities, industrial places and indoor air in homes, have artificial and natural sources and produced during fuel combustion in a high temperature combustion chamber. Almost all of the nitrogen oxides produced in the air is formed as Nitrogen monoxide and with the existing concentrations in the air; there do not haveany harmful effects. However oxidizing into Nitrogen dioxide and combining with hydrocarbons along with the sunlight leads to generating photochemical smog.The high concentrations of NO_2 have been investigated to cause serious problems to human being health and also to the environment especially when producing more ozone at ground-level. Accordingly, the managing strategies would be required to recover theNO_2 value at the minimum level. This study investigated the high air pollutant's concentrations recorded between the years 2010 and 2012 by the measurement stations were collected primarily. Afterwards, by using applications such as SPSS and Excel and considering the clean air standard tables, we used Maximum One-Hour concentration. Comparing the standardized concentrations with the standards given by IEPO and EPA, the cases incompatible with the standards were identified and evaluated. Eventually the trend of changes of NO2 concentrations between the years 2010 and 2012 was determined.
Keywords: *NO_2, Pollutant*

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INTRODUCTION

Nowadays many major cities in the world are confronted with environmental issues, which air quality's undesirable situation is on top of that [1, 2]. As a result, citizens being exposed to polluted air are inevitable. The information available shows that in many major cities, especially metropolises, air quality is very much below the regulations set by WHO. Considering the population growth rate in such cities, and lack of the knowledge necessary for air pollution control, chances of worsening in quality of the air and lives being at risk are becoming large [3].

Shiraz is one of the eight polluted cities in Iran and with a population of 1750900 people; it includes 2/5% of Iran's population and is ranked as the sixth crowded city in Iran [4].Approximately 360000 to 400000 of vehicles move around the city. At the year 2008 nearly 60 percent of these vehicles were rusty. Motorcycle vehicles and cars are responsible for more than 70% of the air pollution [5]. Many reasons such as geographical position, city's topography, rusty vehicles, industrial zones near the city, industries such as cement factory and vegetable oil mill located inside city, low amount of precipitation in recent years, temperature inversion and unsuitable winds results in intensive air pollution. Although, loss of vision and harm to objects are important to consider, yet contaminant condensing in the citizens respiratory levels especially along with atmospheric steady states in cold seasons increased cases of death caused by air pollution could alarm about the dangerous situation [6].

Nitrogen oxides, which are one of the most important air pollutants, have artificial and natural sources. They are produced during fuel combustion in a high temperature combustion chamber. At this stage, usually, 95 percent of this admixture is formed as NO which later oxidizes to NO_2.researches show that 70

percent of NO_2 is produced and released by human activities, in other words, human produces NO_2 twice the amount earth releases [7].

The most important nitrogen oxides producers are engine based vehicles and fuel combustion in fixed sources. Therefore, pollutions generated by human activities cause increase in contaminant concentration in urban areas and they are the reason to be warned [4,8].

Low concentrations of nitrogen oxides produced in the upper areas of the atmosphere find their way to below levels after being radiated by the sunlight. Low amounts of nitrogen oxides are generated after forest fires. Bacterial degradation of organic materials are another tiny source of nitrogen oxides in the atmosphere [4]. Almost all of the nitrogen oxides produced in the air are formed as Nitrogen monoxide and with the existing concentrations in the air, there are no harmful effects known. However oxidizing into Nitrogen dioxide and combining with hydrocarbons along with the sunlight leads to generating photochemical smog [9,10]. Anyway, with low concentrations of NO_2 it is only potentially irritating and related to Chronic Obstructive Pulmonary Disease [11]. NO_2 as an air pollutant has so many effects and roles which in most cases separating them are very difficult and sometimes impossible [12]:

1- Experimental studies which were done on humans and animals indicate that concentrations of NO2 more than 200 $\mu g/m^3$ in short term are toxic with considerable effects. Toxicology studies on animals show that long term contact with NO2 with concentrations more than the current amount has undesirable effects.

2- In many epidemiology studies, NO_2 is used as an indicator of the mixture of pollutants related to combustion, especially pollutants which are released in road transportation or indoor environments. In this kind of studies, any health related effects could be linked to other combustion products such as ultrafine, nitrogen oxides, aerosols and benzene. Although, some various studies indoor and outdoor environments sought to focus on NO_2 health risks, it is extremely difficult to dismiss the correlation between the pollutants and health effects.

3- Most of the atmospheric NO_2 generated is formed as nitrogen oxide, which is oxidized to NO_2 rapidly by ozone. NO_2 in the presence of hydrocarbons and ultraviolet waves is the generation source of troposphere ozone and nitrate aerosols, which constitutes a significant part of air masses $PM_{2.5}$. At the moment, safe concentrations of NO_2 for public health established by WHO are 40 $\mu g/m^3$ (annul average) and 200 $\mu g/m^3$ (hourly average) [12].

MATERIALS AND METHOD

In this cross-sectional study, first by visiting the Air Pollution Control Organization of Shiraz, the data recorded by Imam Hussein and Darvazeh Kazeroon station between the years 2010 and 2012 were collected. Afterwards, by using applications such as SPSS and Excel and considering the clean air standard tables, we used Maximum One-Hour Concentration [13]. Comparing the standardized concentrations with the standards given by IEPO and EPA the cases incompatible with the standards were identified and evaluated. Eventually the trend of changes of NO_2 concentrations between the years 2010 and 2012 were determined.

RESULTS

Tables (1) and (2) show the sample volume and average and maximum concentrations, percentage cases more than Iran and EPA's regulations related to NO_2 in Shiraz and maximum concentrations measured in each station between the years 2008 and 2010. As seen in table (1) the most and the least annual average concentrations in these years are respectively 46 ppb and 27 ppb. Also, the utmost daily maximum concentration was 51 ppb which occurred in 2009 and the least daily maximum concentration was 27 ppb in the year 2008.

Table (1) shows a mild gradient increase of pollutants in Shiraz which this trend was intensified during the year 2012. The maximum seasonal concentration was determined in summer, as illustrated in table (1). At the end of summer it decreased slightly and again it started ascending in winter and then descending in spring (Zigzag pattern - Chapter4). The maximum content measured during the study was 82 ppb in Imam Hussein station.

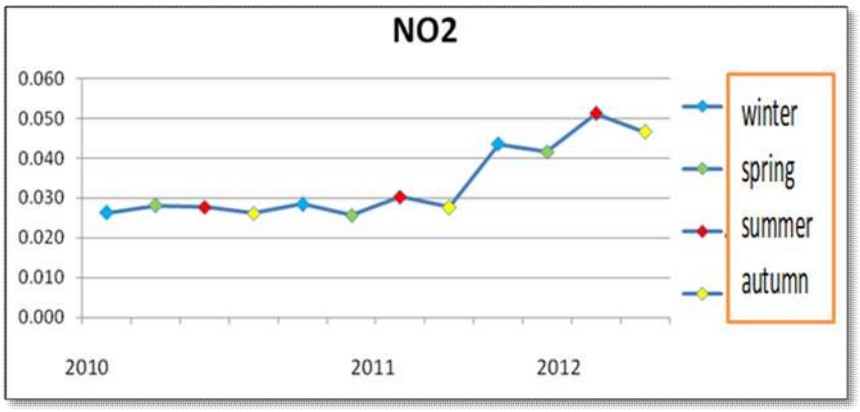
Cases of daily maximum content occurred in both stations. According to table (2), not a single case trespassed the regulations in these stations by the year 2010, and only one case in 2011. However, in 2012 it reached 183 cases, which this increase could be seen in table(2).

Table(1): seasonal content of NO_2 in all the stations between the years 2010 and 2012 in Shiraz

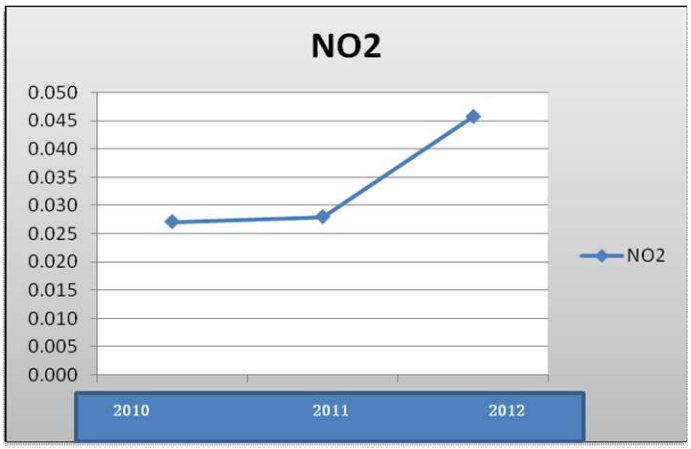
Percent above the standard	Number of cases above the standard	Maximum total stations in Shiraz (ppm)	Peak in station of Imam Hussain (ppm)	Peak in station of darvaze Kazeron (ppm)	Average (ppm)	Sample size (day station(	season	year
0.00	0	0.047	0.023	0.047	0.026	149	Winter	**2010**
0.00	0	0.039	0.030	0.039	0.028	165	spring	
0.00	0	0.043	0.031	0.043	0.028	186	summer	
0.00	0	0.048	0.028	0.048	0.026	169	autumn	
0.56	1	0.051	0.034	0.051	0.028	177	Winter	**2011**
0.00	0	0.039	0.039	0.035	0.026	185	spring	
0.00	0	0.040	0.040	0.039	0.030	186	summer	
0.00	0	0.039	0.038	0.039	0.028	180	autumn	
15.66	26	0.057	0.057	0.053	0.044	166	Winter	**2012**
12.14	21	0.066	0.066	0.055	0.042	173	spring	
43.78	81	0.082	0.082	0.065	0.051	185	summer	
30.56	55	0.081	0.081	0.056	0.047	180	autumn	

Table(2): annual content of NO_2 in all the stations between the years 2010 and 2012 in Shiraz

Number of cases above the standard	Maximum total stations in Shiraz (ppm)	Peak in station of Imam Hussain (ppm)	Peak in station of darvaze Kazeron (ppm)	Average(ppm)	Sample size (day station(	season	year
0.00	0	0.031	0.048	0.240	0.026	669	**2010**
0.14	1	0.040	0.051	0.510	0.028	728	**2011**
25.99	183	0.082	0.082	0.082	0.046	704	**2012**



Figure(1): Average seasonal concentration variation trend of NO_2 in all the stations located in Shiraz between the years 2010 and 2012



Figure(2): Average annual concentration variation trend of NO_2 in all the stations located in Shiraz between the years 2010 and 2012

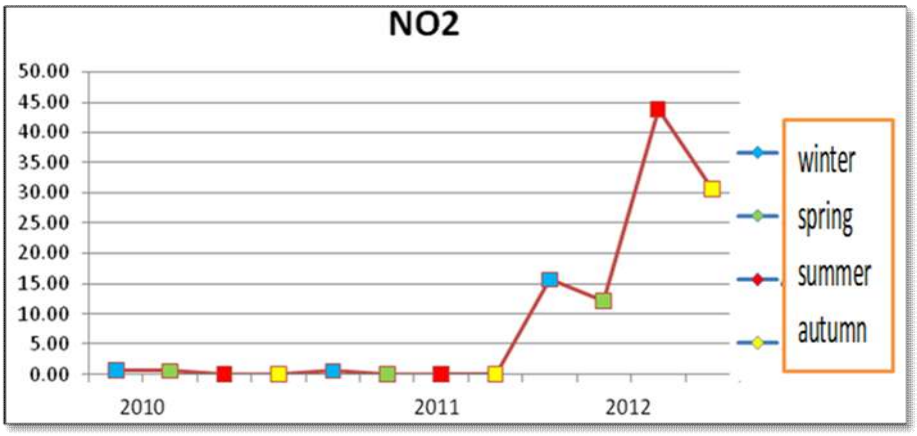


Figure (3): percentage of cases in all of the stations in Shiraz trespassing Iran and EPA's regulations between the years 2010 and 2012.

RESULTS AND DISCUSSION

As shown in table (1), concentrations of NO_2 in the whole city of Shiraz are slightly increasing, and this gradient looks more ascending in the final years of the study.

Chart (2) and table (2) also illustrate trespassing Iran and EPA's regulation during the study period, in a way that all the cases measured in the primary steps of the study matched the standards, then in the second year a single case trespassed the regulations and in the final year of the study, 183 cases are recorded as nonstandard. Table (1) also indicates that in the year 2012 many cases of NO_2 determination trespassed the regulations, so that in summer 43/78 percent of the cases were above standards.

According to table (2), in the year 2010, out of 704 cases measured, 183 cases did not match the regulations, despite the fact that in the beginning of the study, out of 669 cases there was not a single nonstandard case. the reason could be the number of vehicles increased, but it does not singly explain the steep slope in table (2).Another reason explaining the increase is people's desire to use CNG vehicles and to make their vehicles gas based, as a result of rising in the fuel price and limited stock. Also, in this year, many diesel buses in Shiraz were phased out and substituted with CNG busses. Considering that CNG demands more heat for combustion, it produces more NO_2. The increase of pollutants in the summer shown in table (1) is related to more usage of cars and vehicle's increased speed in this season.In autumn, because of the rainfalls, roads being slippery and decrease in people's activities, there is a decrease in vehicle usage and their speed. So that in summer, cars move around the streets and highways until late and in cold seasons, especially in autumn, there is a decrease in traffic at early nights.

All of the above justifies the increase in the pollutant's concentration in summer.A study on the pollutants concentration variation trend during these three years shows that in the future, the air quality of Shiraz indicates that secondary pollutants such as photochemical smog will increase. At the moment, the concentration of NO_2 has passed the warning extent and frequently shows contents more than the regulations. According to the discussed issues above, these considerations should be taken into account to have a significant impact on improving the air quality of Shiraz:

- Necessity of more research about the reasons NO_2 increases and efforts to offer appropriate pattern to reduce pollutants.
- Upgrading vehicles technology in order to reduce pollutant emission and also in CNG cars.
- Using an appropriate and update public transportation in order to reduce private vehicles.
- Using urban electrical or solar or diesel busses with European standards certificates.
- Accelerating the construction of subway transportation in Shiraz which after 20 years is still under construction.

CONCLUSION

Analyze of the results indicates that air quality of Shiraz has improved during the study period. The NO_2 and O_3 pollutants has additional roles in being responsible pollutants besides their increase of concentration, which considering their harmful effects, they should be noticed. Studying the trend of variation of the Nitrogen Dioxides pollutants during the three year study shows that the future of air quality in Shiraz will face concerning increase of secondary pollutants such as ozone and photochemical smog. Although, the concentration of NO_2 has trespassed the regulations and shows contents more than limitations frequently. Also, considering low distance in measurement stations and both stations being located in high traffic areas, results are close and it could not express the status of air quality in whole

part of Shiraz. Studying pollutants seasonal changes shows that effects of changing seasons in every pollutants.

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