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RESEARCH ARTICLE OPEN ACCESS

Photochemical reactions and surface ozone measurements in Tehran city center

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Abstract. Efforts have been made for surface ozone concentration measurements considering secondary reactions via actinometry. Pyro heliometry, pyranometry and spectrophotometry, idometry in Amir Abad station of Tehran city center in parallel. In actinometry method consideration were made to show solar radiation in all different filters of green, yellow, red and dark red by means of 525 nm, 630 nm, 695 nm and 721 nm in parallel by the same time during 1991–1992. Resulted as solar radiation reduction in all filters and concluded for secondary reactions at Amirabad station for the first time in Iran. Measurements were made daily and seasonally at midday in Amirabad station. Where in idometry and spectrophotometry method consideration were made in certain wavelengths of 276.5 nm and 301 nm, for surface ozone measurements during autumn winter considering, October, November, December 1991–1992 and 1999–2001, using rain samples. Which has shown a concentration range of 30–60 (ppb) and 80–115 (ppb), respectively. The concentration measurements of surface ozone were made as a function of photochemical reactions of NO_2. NO and photon rays in agreement with the results of spectrometry method by the same time due to F.M. Shahrtash for the first time in Iran. This study was in agreements with the works in Montreal, Ca (1992). Other consideration was made for surface ozone data collection analysis of (MOI) from Mehrabad station of Tehran city center via Dobson method during summer–autumn 2015. Which has shown a range of concentration of 80–92 (ppb), in comparison with the measurements of Amirabad station. Besides consideration was made for recent research work in China, which has detected the surface ozone concentration of 70–100 ppb during 2013–2018, mainly in North China and Yangtze river plain" by means of "photochemical reactions and surface ozone" in agreement with this study as a whole.

Keywords: Secondary Reactions / Air Pollutants / photon rays / photochemical reactions / Ozone Concentration / Spectrometry / Actinometry methods

1 Introduction

In the preset days focusing on the chemistry of air including the relationship between atmospheric ozone and certain contamination due to the steady increase of air pollution are concerned as tropospheric ozone which if it becomes too concentrated locally is regarded as air pollutants. The markedly more significant process of ozone formation is played by photochemical reactions [1,2] in large air space by means of the reactions of NO_2, NO, NO_x and hydrocarbon with photon rays [3,4]. Ozone is a secondary photochemical pollutant produced from a variety of natural and anthropogenic precursor that include industrial and vehicular emission of (VOC) and (NO_x) Which in elevated concentration it has detriment effects on vegetation, human health and various natural materials [5–7].

There have been very few measurements of surface ozone in Tehran city center as a literature survey by the author. Therefore, several other works of surface ozone measurements in Montreal, Canada and India [1,7,8] have been regarded as a reference for this study. Which has shown the variation concentration of NO_x, SO_2 and O_3 in consequence. By means of increasing surface ozone at Max concentration in reaction of NO_2 and photon rays is corresponding to the decreasing of NO_2 concentration at the Min by the same time. Surface ozone concentration measurements were made via, idometry and spectrophotometry in this study in parallel with optometry analysis, in agreement of one another, discussed by the author for the first time in Tehran city center of Iran and has shown a concentration range of 50–60 (ppb) and 80–115 (ppb) during 1991–92 and 1999–2001 respectively. The way of experiments and the consequence of NO_2, NO and surface ozone concentration were made in the photochemical reactions of NO_2 and photon rays [1,9]. Besides we could

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distinguish the certain days 287th, 323th, and 341th of the solar year by means of 3–5 October, 26 November and 2 December (1991), in Tehran city center as a result of optical method concluding for secondary reactions or smog, because of photochemical reactions [10,11] and a new achievement on actinometry device. Following with chemical method of Spectrometry in certain wavelengths of 274.6 and 301 (nm) and in agreement with the optical method by the same time, regarding, the range of concentration of 30–50 (ppb) and 80–115 (ppb) respectively. Regarding the supervision of F.M. Shahrtash, Prof. S. Mostafa Shahrtash and Prof. F. Moattar. Other concentration were made for data analysis of (MOI) via Dobson method in Mehrabad station of Tehran, during 2015, concluding for the range of concentration of 70–90 ppb in comparison with the results of Amirabad station. This work has been considered as an essential research work by means of "Greenhouse effects and surface ozone in Tehran City Center" [12,13] in agreement with the works in Montreal, Ca. Besides the more recent research work in China, which has detected the surface ozone concentration of 70–100 ppb during 2013–2018, mainly in North China and Yangtze river plain" by means of "photochemical reactions and surface ozone" in agreement with this study so while due to the author.

2 Method of chemical analysis

2.1 Idometry

Idometry is a chemical method of oxidation-reduction reactions of O_3 and I K. Which should avoid the inter effect of other parameters, but doesn't need the calibration and measure O_3 in gas or aliquot phase [14,15]. The reactions are as follows:

$$O_3 + 2I + G_2O \rightarrow I_2 + O_2 + 2OH^-. \quad (1)$$

In neutral conditions, but we add H_2SO_4 to change to acidic condition. After the reactions where it acts in aliquot condition, because of the presence of OH^- as follows:

$$3O_3 + I \rightarrow 3O_2 + IO_3^-. \quad (2)$$

After turning to acidic condition the reactions are as follows:

$$IO_3^- + 6H + 5I^- \rightarrow 3I_2 + 3(H_2O). \quad (3)$$

With the equilibrium of one mole of Iodine to one mole of O_3 according to Bayer and Saltzman, 1987 and the changes of KI [16,17]. Then we add IK for titration before acidic conditions, so the PH of 9 is necessary. The release of I2 in the reaction in high concentration will act in titration method using $S_2O_3Na_2$ and starch as indicator. The reactions are as follows:

$$2(S_2O_3)^- + I_2 \rightarrow 2I^- + S_4O_6^- \quad (4)$$

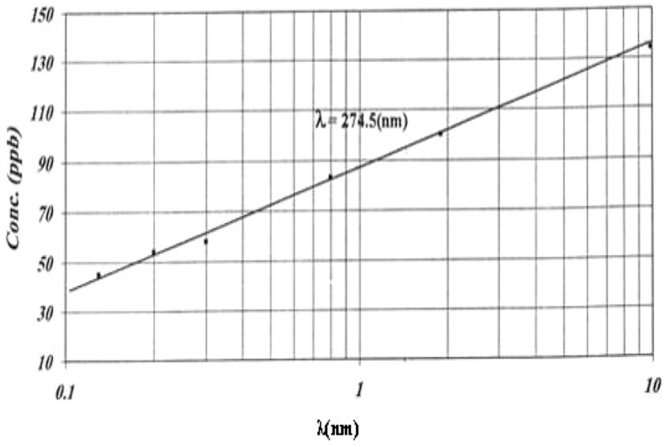

Fig. 1. Calibration for spectrophotometry method in wavelengths of 274.5 (nm).

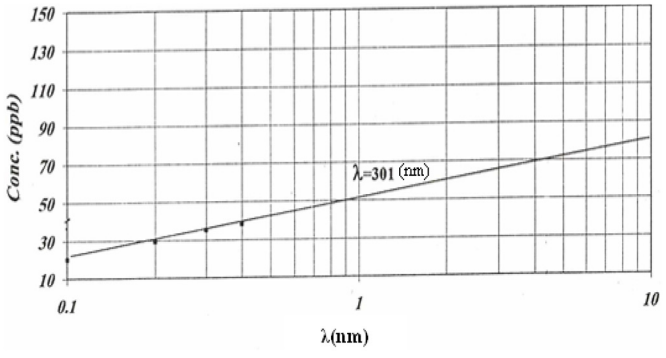

Fig. 2. Calibration via spectrophotometry method in wavelengths of 301 (nm).

which can measure ozone concentration in P.P.M. (according to Bayer and Saltzman 1982.

2.2 Spectrophotometry method

To avoid long term use of chemical calibration in photochemical measurements we used the rate coefficient of Iodide (KI solution 1%). Measurements were made in the wavelength of 274.6 nm and 301 nm using a cuvette of 2 cm filling with distilled water into the reference cuvette. In chemical method of analysis by means of idometry. Calibration were made with the use of aliquot of 0.005 mol/dm^3 in various proportion with reagents and measured by spectrophotometry device. In which Calibration were made on the basis of equilibrium of 0.005 mol/dm^3, (3I2) and 250 g of O_3, a neutral solution is used by means of IK (1%) with aliquot Na_2HPO_4, KH_2PO_4 (0.1 mol/mol/dm^3, for calibration [15,17]. Figures 1 and 2 (1991–1992) followed by spectrometry method measurements concerning two different wavelengths of 276.4 and 301 (nm) in parallel.

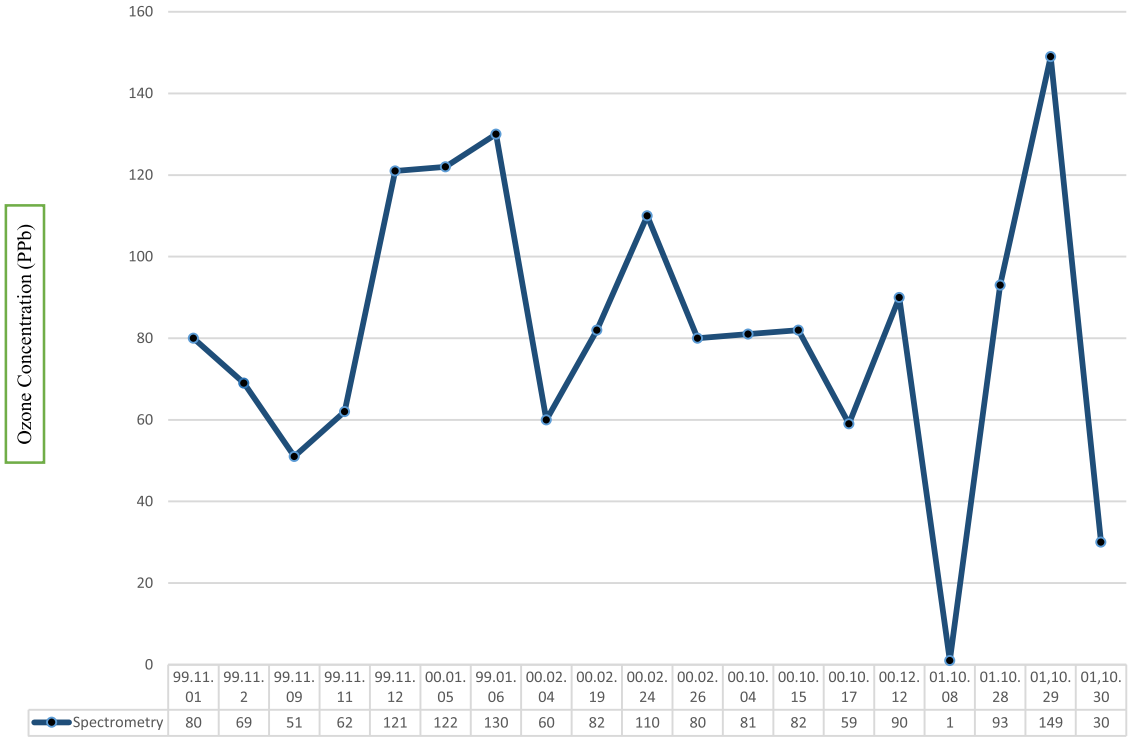

Fig. 3. Surface ozone measurement by spectrometry method (1999–2001).

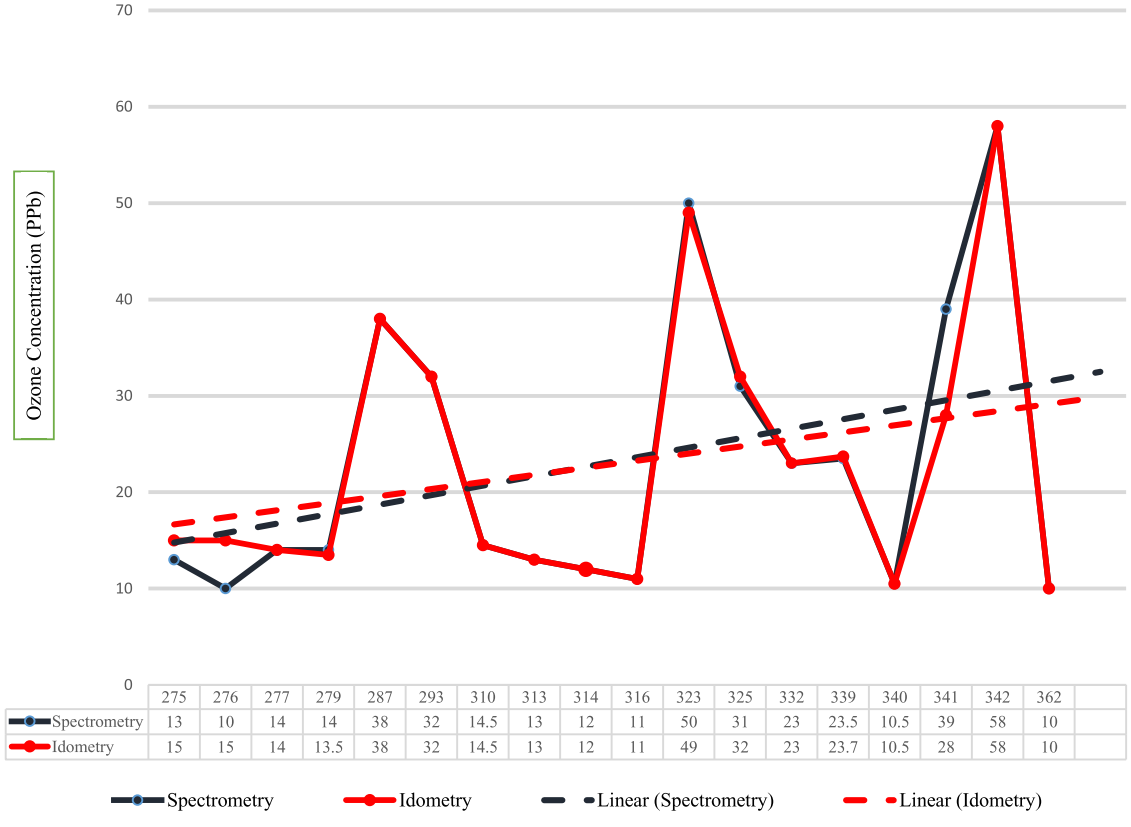

Fig. 4. Surface Ozone measurement by idometry and spectrometry method (1991–1992).

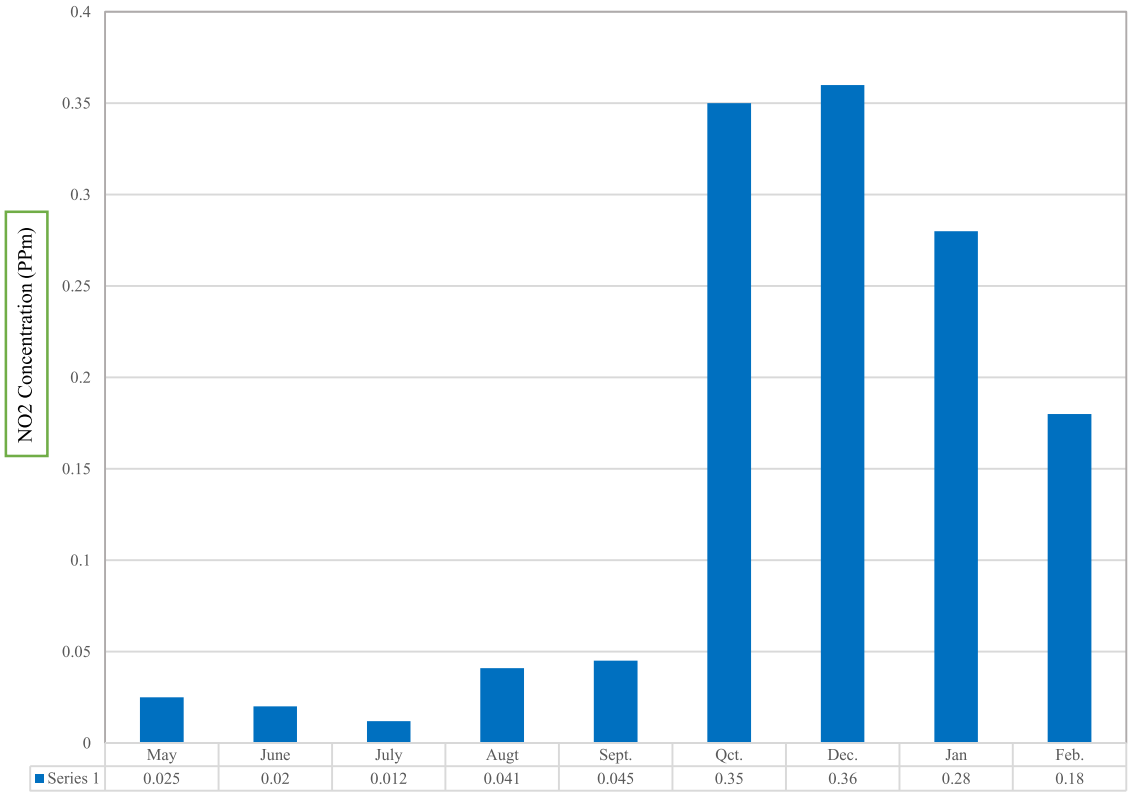

Fig. 5. Data analysis of NO_2 concentration ppm/ months (1991–1992).

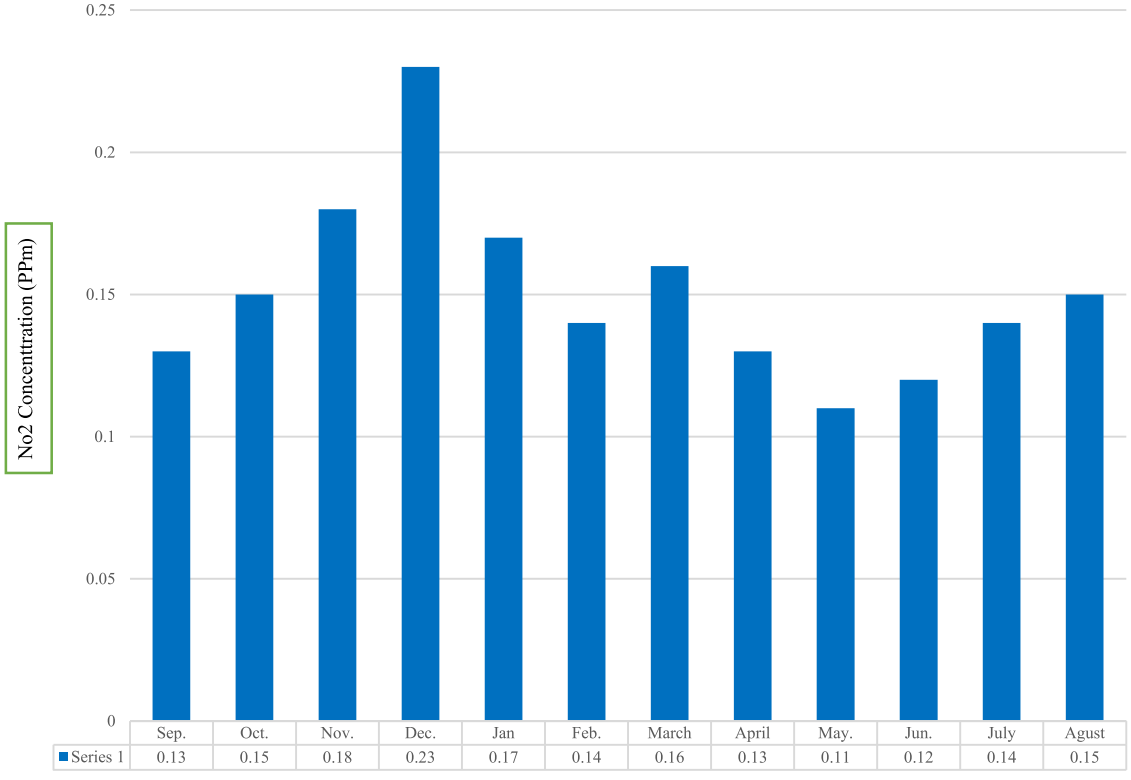

Fig. 6. Data analysis of NO_2 concentration ppm/ months (1999–2001).

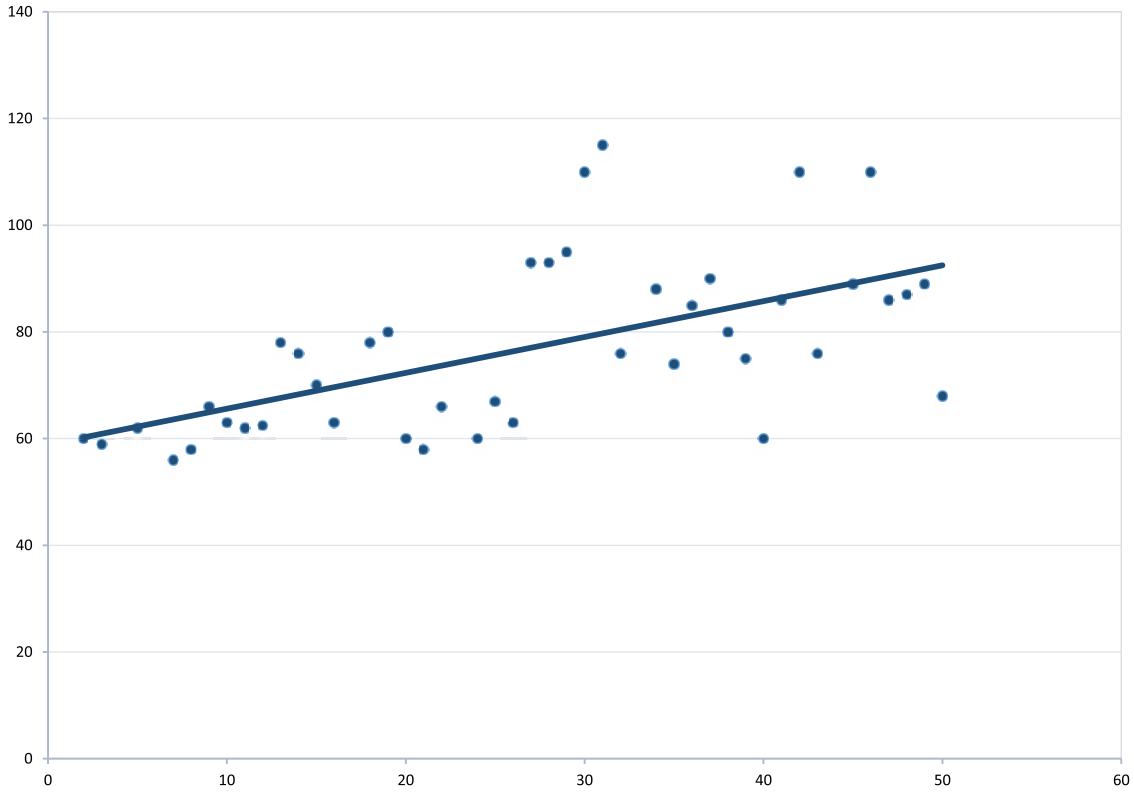

Fig. 7. Surface ozone concentration over time by Dobson ppb/day 2015.

3 Discussion and results

The variation concentration ranges of 50–60 ppb and 80–115 ppb of surface ozone has been carried out as a result of this study in 1991–1992 and 1999–2001, respectively (Figs. 3 and 4).

Data analysis of air pollutants of NO_2, NO, SO_2 in Tehran were made with the help of Environmental Protection Institute of Iran (EPI). Which were concerned as the factors involved in photochemical reactions (Figs. 5 and 6). Therefore, were considered with the variation of surface ozone concentration, and NO, NO_2 concentration in photochemical reactions as a consequence [16,17]. Besides we could achieve findings of solar radiation reduction in certain days of 287th, 323th and 341th over the solar year. Concluding for "secondary reactions", via actinometry devices as a result of this study. In coincident with the spectrometry analysis in agreement, concluding FOR Photochemical reactions and surface ozone production as a phenomenon occurrence and the result of this study. Dealing with further following studies [18], the air pollutants cause the greenhouse effect in a long chain reaction as follows.

$$NO_2 + h\upsilon \rightarrow NO^* + O \quad (5)$$

$$2NO^* \rightarrow N_2O + O \quad (6)$$

$$O_2 + O + M \rightarrow O_3^* + M \quad (7)$$

$$O_3 + NO \rightarrow NO_2 + O_2. \quad (8)$$

Surface ozone is produced in the photochemical reaction of NO_2 and photon rays, where ozone concentration rises up to Max., the NO_2 decrease to Min. concentration. The way of alternative changes of these two trace gases in photochemical reactions were in agreements with those of Montreal measurements in 1992 by means of sequences of NO_2, NO and O_3 concentrations in different seasons (Figs. 3 and 4) in agreement with this study. All studies are concerned a more natural phenomenon that can provide an opportunity to investigate how the photochemical processes of trace gases in the lower troposphere react to the comparatively fast solar radiation changes.

4 Conclusion

This study has been made for surface ozone consideration measurements by means of secondary and reactions via actinometry, besides idometry and spectrometry methods in parallel and in agreement one to another. Actinometry measurements were made in midday, seasonally during the October, November, December (1991–92) in which we could achieve "secondary reactions" as a result. By means of solar radiation reduction in all different solar filters of green, yellow, red and dark red by means of 525 nm, 630 nm, 695 nm and 721 nm (1991–1992). Where we could achieve solar radiation reduction in all wavelengths regarding certain days of 287th, 323th and 341th solar Iranian year corresponding to 3 October, 28 November, and 2 December (1991–92) by means of secondary reactions or smog occurrence as the first result of this study, via

actinometry in optical method, under the supervision of Prof. S. Mostafa Shahrtash and F.M. Shahrtash. Following by chemical methods of idometry and spectrophotometry methods, spectrometry method was made in certain wavelengths of 276.5 nm and 301 nm, at Amir Abad station during October, November, December (1999–2001) respectively. Surface ozone measurements were considered as a function of photochemical reactions of NO_2 and photon rays. Regarding concentration range of and 30–50 (ppb) and 80–115 (ppb) of surface Ozone (1991–92) and (1999–2001). Concluded for an over standard pollution in Tehran city center [16,17]. Surface ozone which if it rises up could cause certain damage to flora, fauna and human health is limited to 30–50 ppb. By means of 20 ppb in the earth surface and could rise up due to air pollutants up to concentration of 30–50 ppb in urban atmosphere. Besides could cause human hazards of coughing and allergies after 2 h of exposure. And if continues it could cause head-ache and serious damages. The threshold limit of surface ozone for worker is predicted to 0.1–1 (ppm). But it differs in different areas and different countries by definitions. The standard limit in USA is defined as 0.2 ppm for 8 h per day [18,19].

5 Implication and influences

Global warming is a phrase that refers to the effect of the climate change and human activities dealing with the consumption of fossil fuels by means of coal, oil and gases [16]. Which cause emission of a large amount of greenhouse gases specially NO_x, NO_2, SO_2. Which with photon rays will act in photochemical reactions to result surface ozone [19] and is known as smog phenomenon. This study is considered with the reaction of NO_2, NO, with photon rays in certain conditions of photochemical reactions. Dealing with the fact of standards and the effect of surface ozone on flora, fauna and human health according to WHO.

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