Assessment of Concentration Changes and Temperature Effect on Total Volatile Organic Compound in the Air of Yasuj City in Iran

Sedighe Porkavosh (1)
Hossein Marioryad (2)
Arsalan Jamshidi (3)
Seyed Abdolmohammad Sadat (3)
Mohammad Mehdi Baneshi (3)
Ali Mousavizadeh (4)

(1) Student Research Committee, Yasuj University of Medical Sciences, Yasuj, Iran.
(2) Social Determinants of Health Research Center, Yasuj University of Medical Sciences, Yasuj, Iran.
(3) Social Determinants of Health Research Center, Yasuj University of Medical Sciences, Yasuj, Iran.
(4) Social Determinants of Health Research Center, Yasuj University of Medical Sciences, Yasuj, Iran.

Corresponding Author:
Hossein Marioryad
Social Determinants of Health Research Center, Department of Occupational Health,
Yasuj University of Medical Sciences,
Yasuj, Iran.
Email: oryadhsn@gmail.com

Abstract

Background and objectives: Volatile organic compounds (VOCs) are among major pollutants in urban air, which can be associated with known effects and complications. Therefore, the aim of this study was to assess concentration changes of total volatile organic compounds (TVOC) and the temperature effect on the concentration of pollutants in the air of Yasuj city.

Materials and methods: In this cross-sectional descriptive and analytical study, the samples were collected from the main squares of the city of Yasuj during two cold and warm seasons at the traffic peak hours of vehicles (7-22) in accordance with full factorial design. This study was carried out in several stages. Firstly, direct-reading device (First Check) was used to measure the concentration of total volatile organic compounds. At this step, the digital device (Model HD50, made in France) measured the temperature simultaneously. In the next step to determine the type of VOCs, environmental sampling pump and activated- charcoal sorbent tubes were used to collect some air samples. After sample preparation, the pollutants were extracted using carbon disulfide. Analysis of the samples was performed by GC-MS device. Data were analyzed using SPSS version 16 software.

Results: Based on the results, the mean TVOCs concentration in the air of Yasuj city was 1058ppb. The concentration of these compounds showed the highest value in the warm season and in the afternoon hours within the midweek days. Concerning the effect of temperature on TVOCs concentration, it can be said that the concentration of these compounds was enhanced with increasing temperature over 10ºC.

Conclusion: With regard to the adverse effects of VOCs on human and environmental health as well as the role of these pollutants in the formation of photochemical oxidants, appropriate actions related to monitoring and controlling these compounds should be considered in urban air.

Key words: Volatile Organic Compounds; Air Pollution; Outdoor Air; Yasuj

Please cite this article as: Marioryad H. et al. Assessment of Concentration Changes and Temperature Effect on Total Volatile Organic Compound in the Air of Yasuj City in Iran World Family Medicine. 2018;16(1):254-259
DOI: 10.5742/MEWFM.2018.93229

Introduction

Air pollution is one of the most important human problems, which is resulting from the release of various pollutants into the atmosphere. The volatile organic compounds (VOCs) are of the major pollutants in the air.

The VOCs are a large group of gaseous hydrocarbons that evaporate at extremely high speed. These compounds are emitted from a variety of sources, including power stations, gas stations, industries, gasoline and diesel vehicles, processes of using dyes etc. The diversity of these gases in different environments depends on the spatial and temporal changes in the sources of emissions, meteorological parameters and other factors. The EPA has listed a wide variety of these compounds as hazardous air pollutants (1-3).

Some of the VOCs cause adverse effects on human and environmental health. For example, exposure to benzene can lead to several types of diseases, such as leukemia, immune system abnormalities, neurological disorders, cardiovascular diseases, respiratory illnesses, etc. (4, 5). Some of the VOCs harmful effects on the environment include participation in the formation of photochemical smog and bad ozone in the lower layer of the atmosphere (6). If there is a release of the VOCs, the concentration of these compounds, similar to other pollutants in atmospheric air, will be influenced by several factors, including meteorological factors (temperature and relative air humidity), the topographical features of the earth's surface and so on. Therefore, it is essential to be aware of the meteorological parameters in which the dispersion process affects the air pollution and causes the decrease or increase in the concentration of air pollutants (7, 8).

Given the importance of the VOCs concentrations in the atmosphere in terms of health and the environment, as well as understanding the situation and changes in air quality levels, this study was conducted to evaluate the changes in TVOCs concentration in the air of Yasuj city and the influence of temperature on the concentration of pollutants in the air of the city.

Materials and methods

The city of Yasuj in southwestern Iran is the capital of Kohgiluyeh and Boyer-Ahmad Province. The total population of the city consists of approximately 120 thousand in 2016 and its area is over 24 km2. Since it is a non-industrial city and motor vehicles are likely to play a major role in air pollution, hence, the crowded areas and main squares were selected as sampling sites in this cross-sectional descriptive analytical study.

Totally, 1,500 samples were collected from ten main squares of the city of Yasuj during two cold and warm seasons (winter and spring) at the traffic peak hours of vehicles (7-22) in accordance with full factorial design.

In order to facilitate statistical analysis, sampling times were classified into three periods, before noon, afternoon and night. In addition, the days of sampling were also divided into the early days of the week, midweek days and the late days of the week.

This study was carried out in three stages. Firstly, direct-reading device (First Check, made in England) with photoionization detector was used to measure the concentration of total volatile organic compounds. The device equipped with a 0.45-micron filter sucked the air with flow of 250 ml per minute and determined the concentration of total volatile organic compounds (TVOCs) by ultraviolet light detector. At this step, the digital device (Model HD50, made in Kimo Co., France) measured the temperature simultaneously. In the next step to determine the type of VOCs, environmental sampling pump (Model HFS-513A, made in America) and activated-charcoal sorbent tubes were employed to collect some air samples from places with significant concentration of the VOCs. In the third step, carbon disulfide was used to extract pollutants from activated-charcoal sorbent tubes. Then, the samples were injected into the gas chromatography–mass spectrometry (GC-MS) according to NIOSH 2549 (model YI6100, made in Korea). Finally, the chromatogram output from the GC-MS detected the most abundant of the VOCs in the urban air.

In this study, SPSS version 16 software was used to analyze the results and to draw the charts. Part of the results have been reported as descriptive statistics (mean, standard deviation). The graph of the regression was constructed to determine association between variables.

Results

In this study, the minimum and maximum TVOCs concentrations were measured as 230 ppb and 1650 ppb in the cold season, as well as 160 ppb and 2200 ppb in the warm season. According to the results presented in Table 1 (next page), the TVOCs concentration was higher in the warm season than in the cold season.

The most TVOCs concentration in the warm season was observed in the afternoon hours and in midweek days and the lowest concentration was found before noon and late days of the week (Figure 1). In the cold season, the highest concentrations of these compounds was found at nighttime and in the late days of the week and the lowest concentration was also observed before noon and in midweek days.

Concerning the type of the VOCs, based on the peaks of air sample injection to GC-MS device, the most abundant of the VOCs in the air of Yasuj city accounted for aromatic compounds such as 2-ethyl-1,3 (2H) -Dithion-1H-Isoindol, 1,3Bis (trimethylsilyl) benzene, 2,4 - Di-tert-butilphenol, dibenzosuberane and N-Butyl-benzene sulfonamide (Figure 2).

Table 1: Summary of statistics related to samples taken during the study

	TVOC samples in cold season (ppb)	TVOC samples in warm season (ppb)	Total TVOC samples (ppb)
Number of samples	750	750	1500
Mean	808	1309	1058
Standard deviation	0.251	0.262	0.3586
Minimum	230	160	160
Maximum	1650	2200	2200

Figure 1- Temporal variations of the volatile organic compound concentration

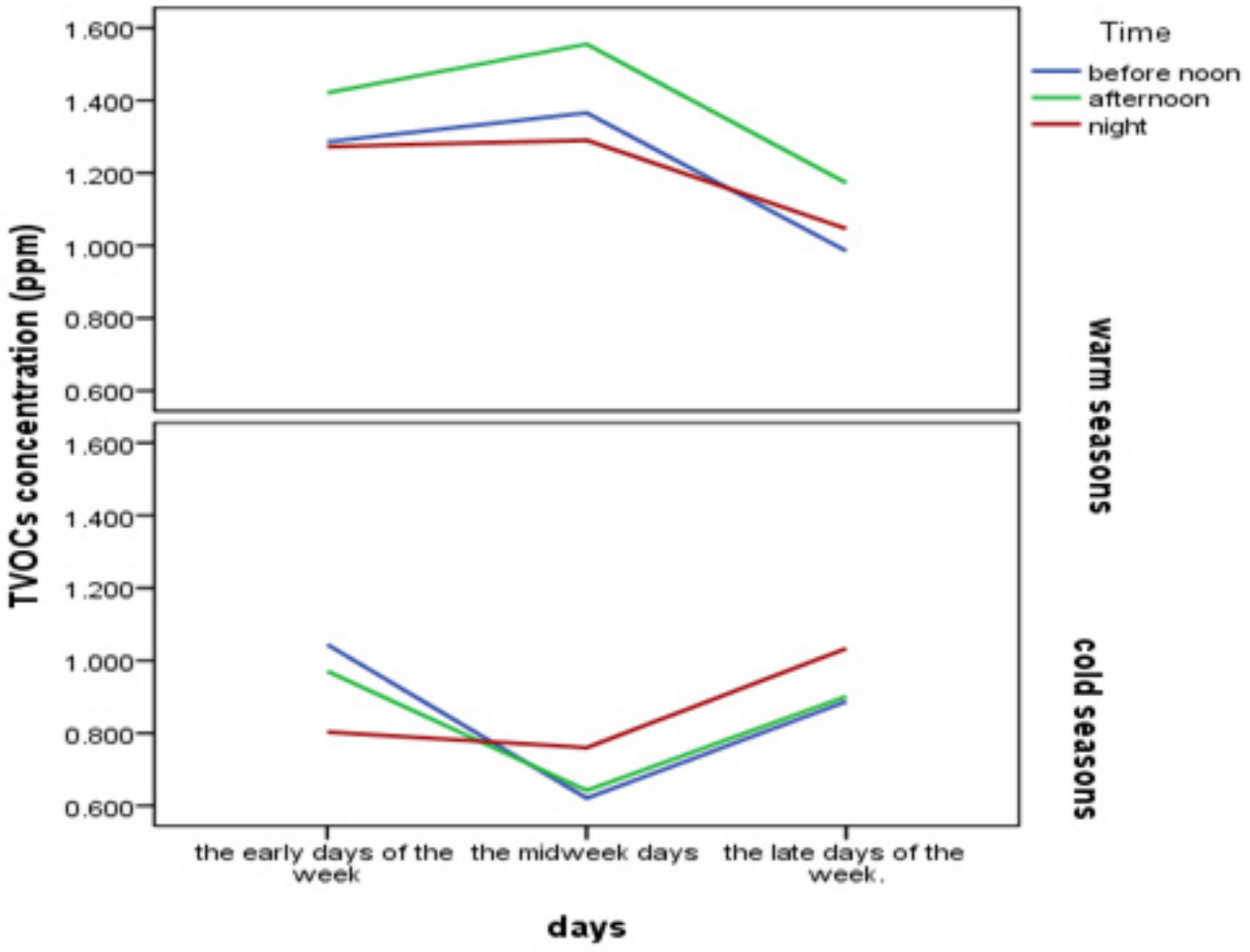


Figure 2: An example of chromatogram obtained from injection of air sample of Yasuj city to GC-MS devices

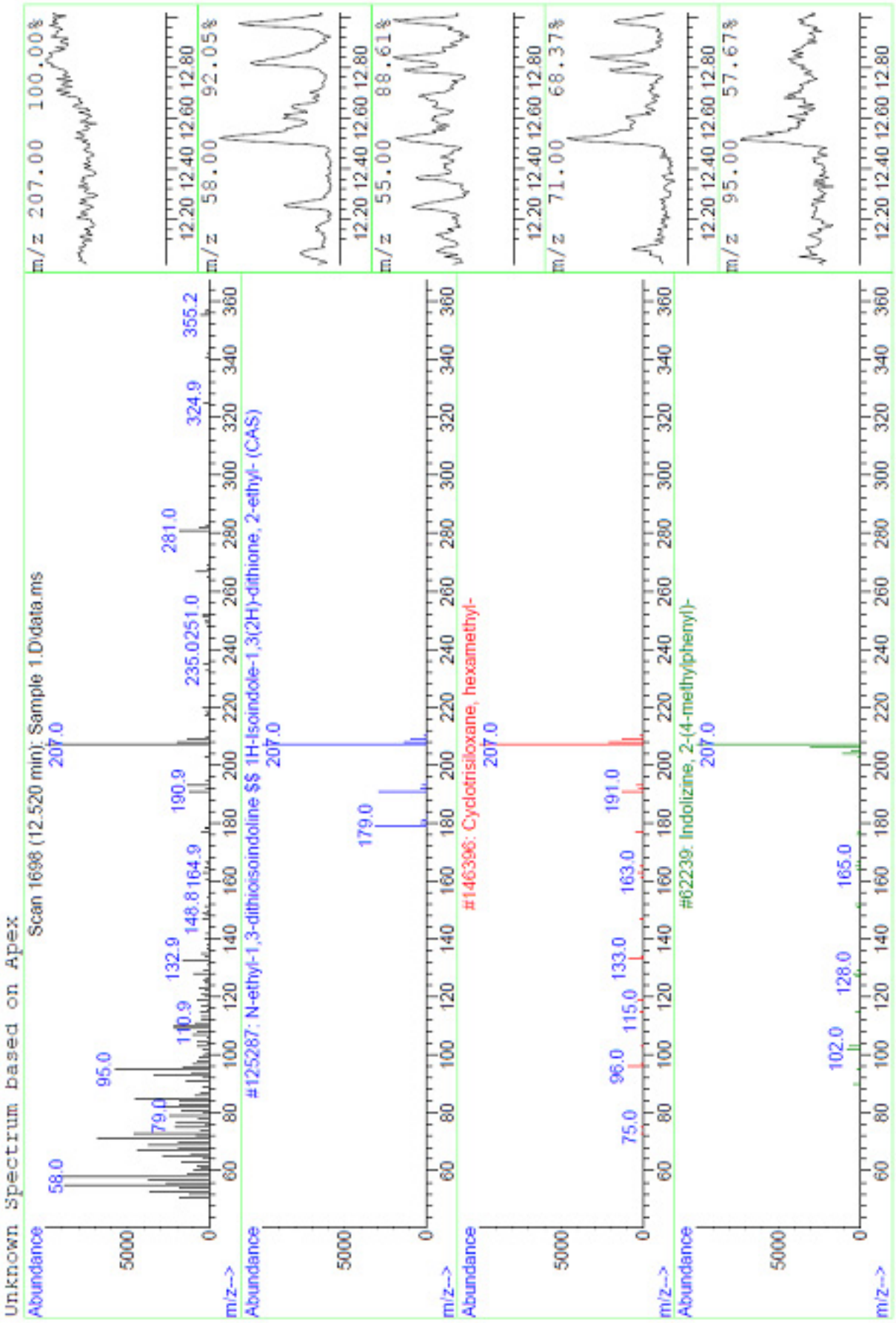
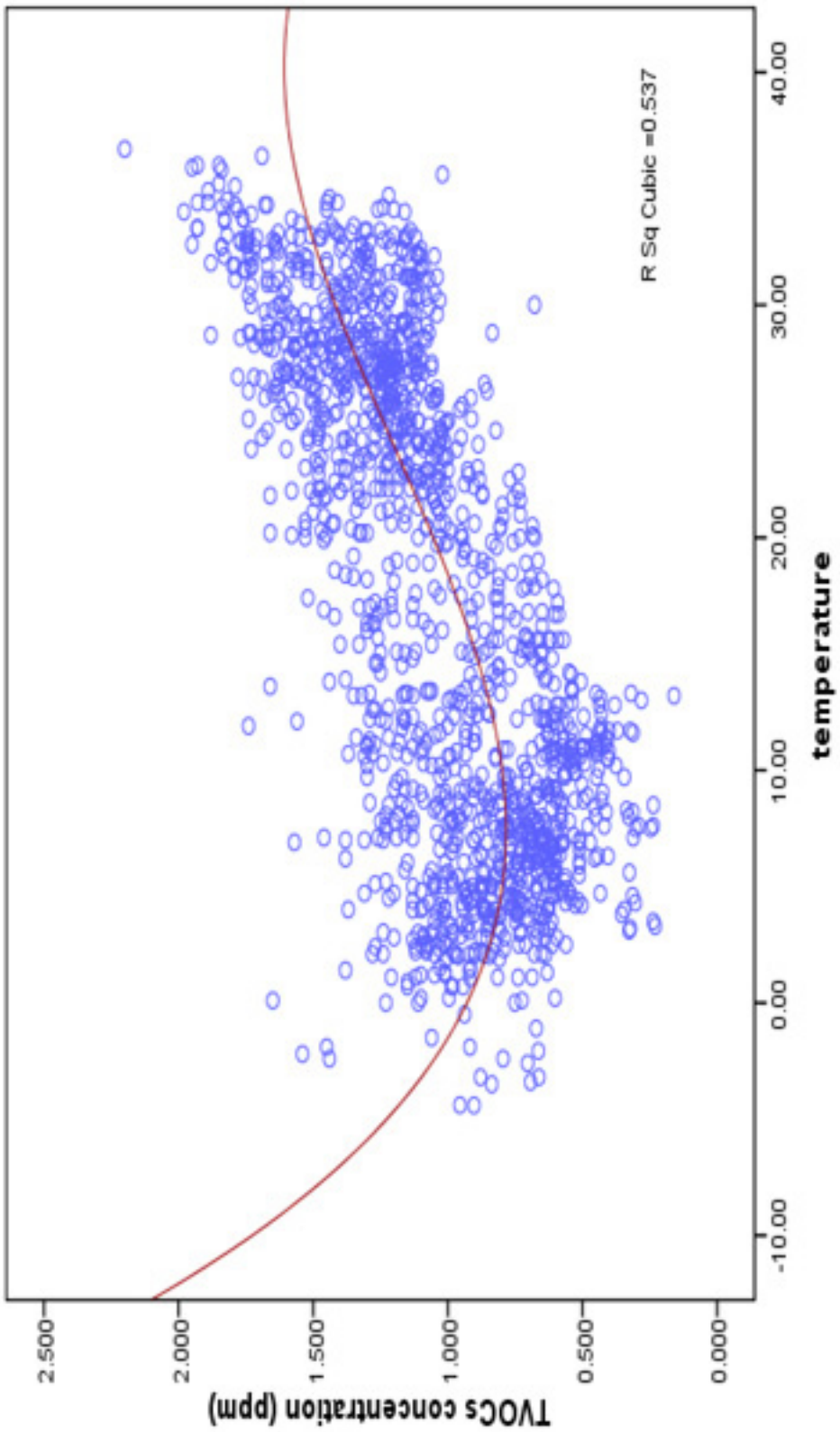


Figure 3 depicts the effect of air temperature on the TVOCs concentration in the air of Yasuj city. Based on this figure, the TVOCs concentration was enhanced with increasing temperature over 10ºC.

Figure 3: Effect of air temperature on the concentration of total volatile organic compounds



Discussion

According to the results of this study, the maximum TVOCs concentration was observed in the afternoon hours of midweek days. The findings from this study are consistent with research of Sarkhosh et al. in Tehran, Iran, and Na et al. in Seoul, South Korea, based on the high VOCs concentration in the afternoon (2, 9).

The results of this study show that the TVOCs concentration was higher in the warm season compared to the cold season. Nguyen et al. during a study in Korea measured 56 kinds of VOCs in the air. Based on these results, the highest VOCs concentration (aromatics except for benzene) was found in summer (10). One reason for the increased VOCs concentration in the mentioned periods has been the temperature increases. As the results this study showed, the TVOCs concentration was elevated with increasing temperature. The reason for this can be attributed to increased evaporative emissions from vehicles and other sources of these compounds due to temperature rise. However, other factors can also be involved in this regard, such as frequent daily travels, increasing the likelihood of temperature inversion, reduced precipitation and pollutants washing in the warm seasons.

In this study, the type of the VOCs in the air of Yasuj city was evaluated as well. Based on the results, the most abundant of the VOCs in the air of the city are composed of aromatic hydrocarbons. The studies Sarkhosh et al. in Tehran, Iran, and Nguyen et al. in Korea, also showed that the highest VOCs concentration in the air of these cities was related to aromatic compounds (2, 10).

According to Geng et al. in Shanghai, China, and Tie et al. in Mexico City, aromatic compounds were the major causes of ozone formation in these two cities (11, 12). Among the factors affecting the increase in the concentration of these compounds in the air, it can be pointed to human activities such as vehicles fuel, residential heating demand, cooking in homes, industrial and production activities.

Conclusion

With regard to the adverse effects of volatile organic compounds on human and environmental health as well as the role of these pollutants in the formation of photochemical oxidants, appropriate actions should be considered to reduce air pollution in the cities; for example, the use of natural gas instead of petrol, vehicle exchange program, regulations of vehicle control like vehicle technical examination, the expansion of green spaces around the squares and streets of the city and so on.

Acknowledgment
The authors would like to thank and appreciate all those who have cooperated in implementing the project, especially Research Deputy of Faculty of Health at Yasuj University of Medical Sciences for providing financial support and required equipment.

References

1. Jia C, A. Batterman S, E. Relyea G. Variability of indoor and outdoor VOC measurements: An analysis using variance components. Environ Pollut. 2012;169:152-9.
2. Sarkhosh M, Mahvi AH, Mohseni M, Shiry L, Alavi J. Assessment of daily variations of volatile organic compound in Tehran in 2010-2011. International Journal of Environmental Health Engineering. 2014;3(3):1-4.
3. Wu XM, Fan ZT, Zhu X, Jung KH, Ohman-Strickland P, P. Weisel C, et al. Exposures to volatile organic compounds (VOCs) and associated health risks of socio-economically disadvantaged population in a “hot spot” in Camden, New Jersey. Atmos Environ (1994). 2012;57:72-9.
4. Bahadar H, Mostafalou S, Abdollahi M. Current understandings and perspectives on non-cancer health effects of benzene: A global concern. Toxicology and Applied Pharmacology. 2014;276(2014):83-94.
5. Zhang L, M. McHale C, Rothman N, Li G, Ji Z, Vermeulen R, et al. Systems biology of human benzene exposure. Chemico-Biological Interactions. 2009;184(2010):86-93.
6. Chan LY, Lau WL, Wang XM, Tang JH. Preliminary measurements of aromatic VOCs in public transportation modes in Guangzhou, China. Environment International. 2003;29(2003):429– 35.
7. M. HABEEBULLAH T. AN INVESTIGATION OF THE EFFECTS OF METEOROLOGY ON AIR POLLUTION IN MAKKAH. Ass Univ Bull Environ Res. 2013;16(1):63-85.
8. Ocak S, Turalioglu FS. Effect of Meteorology on the Atmospheric Concentrations of Traffic-Related Pollutants in Erzurum, Turkey. J Int Environmental Application & Science. 2008;3(5):325-35.
9. Na K, Pyo Kim Y, Moon KC. Diurnal characteristics of volatile organic compounds in the Seoul atmosphere. Atmospheric Environment. 2003;37(2003):733-4
10. Nguyen HT, Kim K-H, Kim M-Y. Volatile organic compounds at an urban monitoring station in Korea. Journal of Hazardous Materials 2008;161(2009):163-74.
11. Geng F, Zhao C, Tang X, Lu G, Tie X. Analysis of ozone and VOCs measured in Shanghai: A case study. Atmospheric Environment. 2006;41(2007):989-1001.
12. Tie X, Madronich S, Li G, Ying Z, Zhang R, R. Garcia A, et al. Characterizations of chemical oxidants in Mexico City: A regional chemical dynamical model (WRF-Chem) study. Atmospheric Environment. 2006;41(2007):1989-2008.