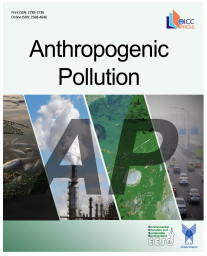

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Assessment of BTX concentrations along Hakim Expressway: A case study from Milad Tower to Resalat Tunnel

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Abstract:
This research aims to assess the concentrations of benzene, toluene, and ethylbenzene along the Hakim Expressway, from Milad Tower to Resalat Tunnel, in order to investigate the impact of traffic, a major contributor to air pollution in Tehran, and the release of volatile organic compounds (VOCs) resulting from fossil fuel burning. Conducted in the fall of 2020, the study reveals that heavy-traffic regions exhibit higher VOC levels. The accumulation of VOCs in the examined areas is influenced by wind direction and time of day. Measurements were taken during both morning and evening periods. The amount of benzene in the morning at Geisha Station is 39.1 ppb and the lowest amount at Azadegan Blvd about 21.22 ppb. The amount of toluene in the morning at Chamran Station is 461.1 ppb and the lowest amount is 359.1 ppb at Azadegan Blvd. The amount of Ethylbenzene in the morning at Chamran Station is 2.86 ppb. These stations showed the highest values in the morning. In the evening, the highest values observed in the Gisha Station, 38.2 ppb the lowest amount at Azadegan Blvd 21.42 ppb. Highest amount of toluene at night were seen at Gisha Station 489 ppb the lowest amount at Azadegan Blvd about 231 ppb. The highest amount of Ethylbenzene was seen at Resalat Tunnel 1.4 ppb and lowest amount at Chamran. Benzene and toluene concentrations remained consistent between morning and night, while ethylbenzene concentrations varied. The traffic load in the sampled areas exhibited a direct effect on BTX (benzene, toluene, and ethylbenzene) concentrations.

Keywords: Tehran; BTX; Air pollution; Traffic; Health; Ambient

1. Introduction

Metropolises worldwide face numerous challenges resulting from population growth in various regions. One significant problem is air pollution caused by heavy traffic on expressways. Clean air is necessary for marinating the living on the earth (Makkiabadi et al. 2022). Tehran, as a metropolis, experiences high levels of air pollution due to population growth, urbanization trends, and geographical factors, leading to a substantial annual mortality rate (Rezayi et al. 2007). Investigations have identified contributing factors such as west and east winds, as well as temperature inversion during cold periods, exacerbating air pollution in Tehran (Sajjadian 2015). Air pollutants in metropolises like Tehran, primarily originating from car fuels, consist of compounds known as volatile organic compounds (VOCs), including benzene, toluene, and xylene (BTX). These compounds are extensively used in various industries, such as paint production and automobile manufacturing (Sahranavard et al. 2015). BTX is a mixture of volatile aromatic hydrocarbons (VAHs), specifically benzene, toluene, and xylene isomers. These carcinogenic compounds pose significant risks to both human health and the environment (Dehghani et al. 2018; Fataei 2020). Leak of petroleum in the soil could cause the entering BTX to the environment (Muhibbu-din and Ayodele 2021).

Benzene finds industrial applications as a solvent for waxes, resins, rubbers, and more (Mostofie et al. 2014). It is characterized as an aromatic, colorless, and volatile substance that burns with a yellow flame and produces soot. Benzene is known to be carcinogenic, and exposure to it can have

Table 1. Geographical coordinates of sampling points.

No	Station	Geographical Location ^{o}	
1	Hakim Expressway & Gisha	51.374848	35.740937
2	Hakim Expressway & Chamran	51.38216	35.742644
3	Hakim Expressway & Resalat Highway	51.24'21.8	35.44'38.3
4	Hakim Expressway & Azadegan Blvd	51.397081	35.741076

adverse effects on bone marrow cells, leading to reduced hematopoiesis, a weakened immune system, blood cancer (leukemia), respiratory diseases, infertility, and lymphoma (Hashemi and Sanayi 2004). In comparison, toluene is considered less hazardous than benzene, although it still poses risks. It directly affects the nervous system and can cause anorexia, fatigue, weakness, insomnia, visual impairment, hearing loss, and even endocrine disorders at low concentrations (Khani et al. 2019).

Dimethyl benzene, also known as xylene, is an organic, volatile, aromatic, and flammable compound with three isomers: para-xylene, ortho-xylene, and meta-xylene, distinguished by the varying positions of methyl groups. This compound is commonly used in gasoline for airplanes and cars, entering the environment through gasoline usage. Xylene poisoning can occur through inhalation, ingestion, or dermal exposure. Adverse health effects of xylene exposure include rhinitis, headaches, kidney and liver problems, skin allergies, blisters, and uveitis (Sadigh et al. 2021).

Investigations have revealed that benzene reaches its highest levels in the ambient air of Tehran during the early morning and late evening, which coincide with peak traffic hours (BaniNaeemeh et al. 2017). Urban air hydrocarbons are introduced into the environment through car exhaust systems (Löfgren 1992). Expressways in metropolises experience significant pollution due to heavy traffic. The combination of heavy traffic and high fuel consumption on expressways leads to the emission of pollutants in the surrounding areas. The Hakim Expressway, a major Expressway in Tehran that spans from east to west, carries a substantial portion of car traffic. This research aims to assess the concentration of BTX along a specific section of the Hakim Expressway, specifically from Milad Tower to Resalat Tunnel.

Therefore, the group of volatile organic compounds (VOCs) known as BTX is recognized as a significant contributor to air pollution in urban ecosystems. Moreover, due to their association with specific activities and conditions related to fossil fuels (such as storage, transportation, distribution, and purification), BTX poses potential occupational safety and health risks. Consequently, assessing BTX levels is of utmost importance from a health, safety, and environment (HSE) management perspective. When BTX concentrations exceed the permissible threshold limit value or when adverse effects are observed among employees and workers in these environments and settings, various control measures can be implemented. These measures include preventing vapor emissions from facilities and equipment through technical adjustments or design modifications. Additionally, reducing workers' exposure to respiratory gases is crucial and, if necessary, providing appropriate personal protective equipment, such as face masks, is crucial. These solutions are applicable to individuals working as gas station attendants, fuel loading ramp operators, and refinery operators.

2. Materials and methods

The selection of BTX assessment points was based on the volume of traffic and proximity to areas with heavy traffic. Sampling was conducted during peak hours in Tehran, specifically from 6 to 8 a.m. and from 4 to 6 p.m., with each period lasting two hours. This sampling was done in the winter of 2021. 4 points were selected for sampling. The concentration of BTEX was measured using the National Institute for Occupational Safety and Health's 1501 method (NIOSH 1501), which used SKC activated charcoal sorbent tubes to sample. In order to collect the air samples, vertical installed carbon tubes have been applied. A total of 150 mg of coconut wood charcoal, divided into two parts of 100 and 50 mg, was contained in the collection tubes. These parts are made from glass wool and urethane foam, the larger is used to collect volatile gases while the smaller one is used when a bigger part can't capture all of them. The study was conducted using a portable air sampling pump model 224-44EX, SKC with the flow rate of 100 mL per minute fitted to charcoal tubes. The samples were analyzed through an Agilent 6890N gas chromatograph. Arc-map software version 10.6 was used to create the GIS map. Table 1 shown the geographical location of sampling points.

3. Results

Table 2 shown BTX concentrations in the morning samples. Highest amount of benzene and toluene were seen

Table 2. BTX concentrations in the morning samples.

No	Location / Parameter	Benzene (ppb)	Ethylbenzene(ppb)	Toluene(ppb)
1	Hakim Expressway & Gisha	39.1	0.0	488
2	Hakim Expressway & Chamran	37.12	2.86	461.1
3	Hakim Expressway & Resalat Highway	35.3	1.1	359.1
4	Hakim Expressway & Azadegan Blvd	21.22	0.1	231.1

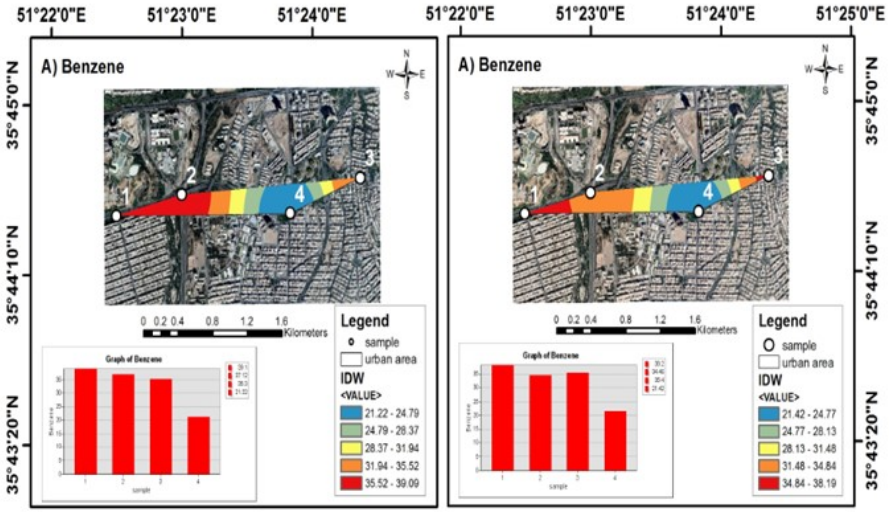

Figure 1. Comparison of benzene concentrations in the morning and at night in GIS Map.

at Hakim Expressway & Gisha station. Highest amount of Ethylbenzene were measured at Hakim Expressway & Chamran stations.

Table 3 shown the BTX concentrations in night samples. Highest amount of benzene and toluene were measured at Hakim Expressway & Gisha stations. highest amount of Ethylbenzene were measured at Hakim Expressway & Resalat Tunnel.

Fig. 1 shown comparison of benzene concentrations in the morning and at night in GIS Map. Station 1 had the highest level of benzene in the morning and evening. Station 4 had the lowest level of benzene in the morning and evening.

Fig. 2 shown the comparison of benzene concentrations in the morning and at night. Gisha station shown the highest amount in the morning and night.

Fig. 3 shown the comparison of Ethylbenzene concentrations in the morning and at night in GIS Map. The amount of Ethylbenzene was high at morning in the station 2.

Fig. 4 shown the comparison of Ethylbenzene concentrations in the morning and at night. Chmran station shown the highest amount at the morning an Resalat Tunnel shown the highest amount at night.

Fig. 5 shown the comparison of toluene concentrations in the morning and at night in GIS Map. The amount of toluene in the morning and night in the area of stations 1 and 2 was higher than the other of the stations.

Fig. 5 comparison of toluene concentrations in the morning and at night in GIS Map.

Figure 6 illustrates the concentrations of toluene in the morning samples during the fall season. Toluene is susceptible to decomposition by soil bacteria and can be absorbed by plants, leading to membrane damage. This substance is commonly found in urban areas with heavy traffic, where it is released in to the ambient air through gasoline combustion. Gasoline serves as the primary source of toluene exposure for the general public, with toluene comprising 5 to 7% of its weight. Toluene is emitted into the atmosphere during gasoline production, transportation, and combustion processes. It is particularly concentrated in areas with heavy traffic and in proximity to refineries. In comparison, the concentration of toluene is lower on Azadegan Blvd., where there is no traffic during both morning and nighttime periods.

4. Discussion

Table 2 shows the BTX concentrations in the morning samples. Benzene and Toluene has a high amount at Gisha station. Ethylbenzene is high at Chamran stations. Table 3 shown the BTX concentrations in night samples. Ethylbenzene and Toluene has a high amount at Reslat Tunnel station. Ethylbenzene is high at Gisha stations. Comparison of benzene concentrations in the morning and at night in GIS Map shown on Figure 1. The benzene parameter exhibited the highest values in the morning at Points 1 and 2. Throughout the night, there was a gradual decrease in benzene levels, although Point 1 still remained relatively high. Comparison of benzene concentrations in the morning and at night were shown in Fig 2. Fig. 3 shows the comparison of Ethylbenzene concentrations in the morning and at night in GIS Map. The Ethylbenzene parameter

Table 3. BTX concentrations in the night samples.

No	Location / Parameter	Benzene (ppb)	Ethylbenzene(ppb)	Toluene(ppb)
1	Hakim Expressway & Gisha	38.2	0.3	489
2	Hakim Expressway & Chamran	34.46	0.0	486
3	Hakim Expressway & Resalat Highway	35.4	1.4	359
4	Hakim Expressway & Azadegan Blvd	21.42	0.1	231

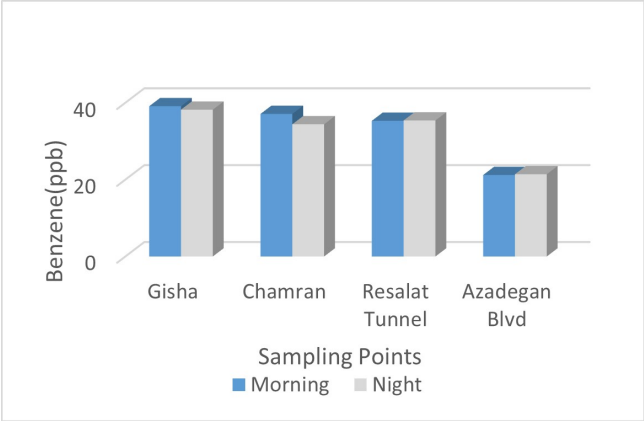

Figure 2. Comparison of benzene concentrations in the morning and at night.

experienced a significant reduction during the night compared to the morning. Figure 4 illustrates the concentrations of Ethylbenzene in the morning and night samples during the fall season. Chamran intersection exhibited the highest Ethylbenzene concentration in the morning samples, while the Gisha neighborhood entrance had the lowest. BTX emissions are influenced by factors such as the source, mode of transport, and environmental processes (Shoaa et al. 2015). Temperature, humidity, and air flow play a significant role in the dispersion of these substances. Ethylbenzene concentrations increased during the night, and substantial increases were also observed at locations with lower concentrations during other hours of the day. The colder weather in these areas further contributes to emissions, particularly at night when traffic is present near Resalat Tunnel on Azadegan Blvd. It appears that the reduction in temperature affects the concentrations of BTX (Salmani et al. 2016). Fig. 5 shows the comparison of toluene concentrations in the morning and at night in GIS Map. The toluene parameter showed consistently high levels during both measurement times. Base on all GIS maps in Figs. 1, 3 & 5, each parameter generally demonstrated a decrease during the night compared to the morning measurements, except for toluene, which remained consistently high at both Points 1 and 2. In general, the four studied stations exhibited the highest parameter volumes. Conversely, Point 4 (located at the corner of Azadegan Blvd. and Hakim Expressway) consistently displayed the lowest parameter volumes across all cases. Figures 4 and 5 demonstrate that toluene exhibits the highest concentration, whereas benzene shows the lowest concentration. It can be inferred that sports clubs, scientific centers, companies, parks, and stores contribute to the increased levels of toluene in this area. Toluene can be absorbed through dermal contact, inhalation, and ingestion, with inhalation being of particular importance (Berna et al. 2005). Car fuels serve as the primary source of toluene, which enters the environment through petroleum-based fuels (Rezayi et al. 2007). Gas stations are also known to contribute significantly to the presence of benzene in the surrounding air (Fooladi et al. 2021).

It appears that spatial and temporal changes influence BTX concentrations. To test this hypothesis, a two-way analysis

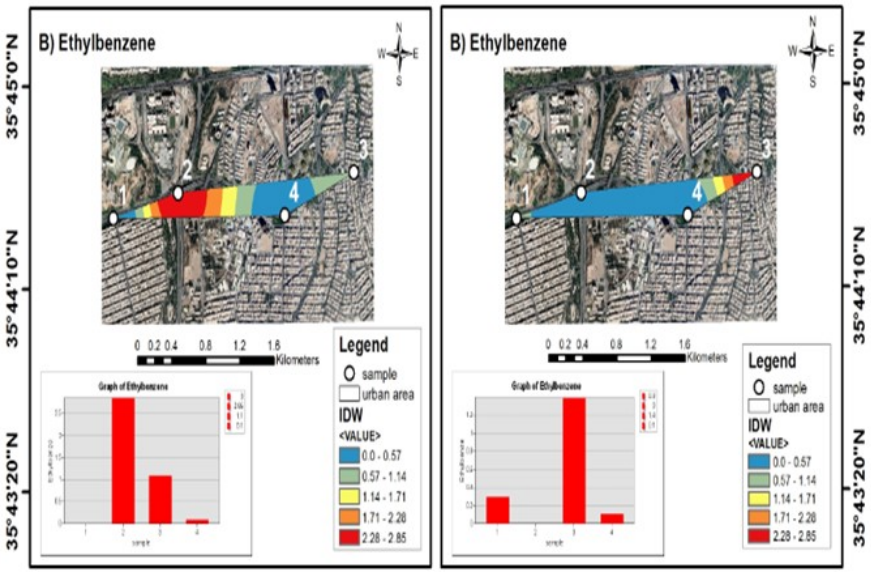

Figure 3. Comparison of ethylbenzene concentrations in the morning and at night in GIS Map.

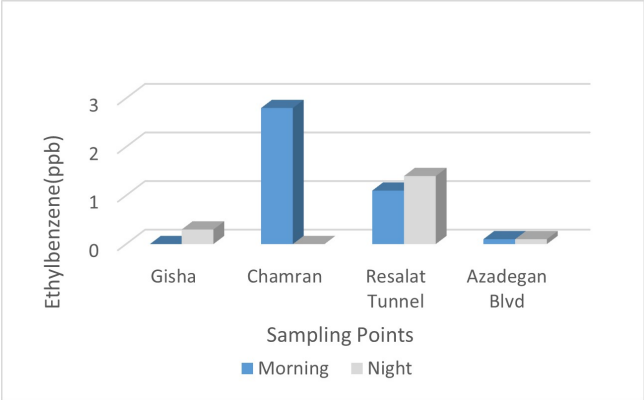

Figure 4. Comparison of ethylbenzene concentrations in the morning and at night.

of variance (ANOVA) was conducted. The analysis reveals that the significance level of the area factor is greater than 0.05, indicating that it does not have a significant effect on benzene concentration. On the other hand, the significance level of the time factor is less than 0.05, suggesting that time has a significant impact on benzene concentration. Furthermore, no interaction between the area and time factors regarding benzene concentration was observed. The benzene concentrations in the morning and night samples during the fall season are shown above. The lowest level was observed on Azadegan Blvd., which is a residential area with less traffic. These findings are consistent with previous research (Khani et al. 2019).

The highest concentration in the morning was recorded at the entrance of Gisha neighborhood, located opposite Milad Tower. This area experiences heavy traffic and is situated near the intersection of the Sheikh Fazlollah Expressway. Benzene concentrations remained consistent between the morning and night samples. It can be inferred that benzene concentrations increase as the weather gets colder.

Comparison of Ethylbenzene concentrations in the morning and at night were shown at Figure 4.

Figure 6 illustrates the concentrations of toluene in the morning samples during the fall season. Toluene is susceptible to decomposition by soil bacteria and can be absorbed by plants, leading to membrane damage. This substance is commonly found in urban areas with heavy traffic, where it is released into the ambient air through gasoline combustion. Gasoline serves as the primary source of toluene exposure for the general public, with toluene comprising 5 to 7% of its weight. Toluene is emitted into the atmosphere during gasoline production, transportation, and combustion processes. It is particularly concentrated in areas with heavy traffic and in proximity to refineries. In comparison, the

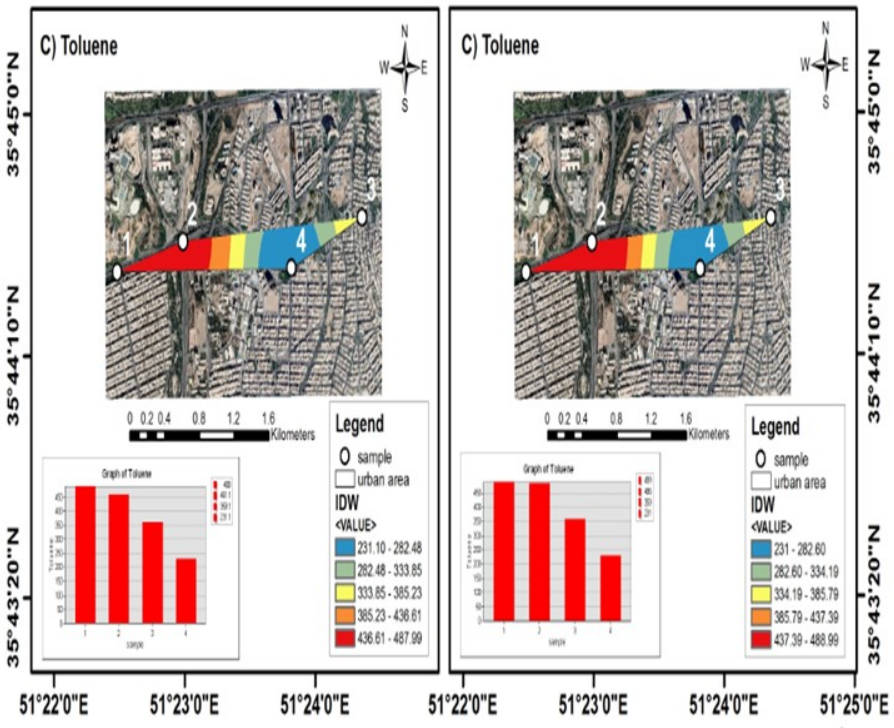

Figure 5. Comparison of toluene concentrations in the morning and at night in GIS Map.

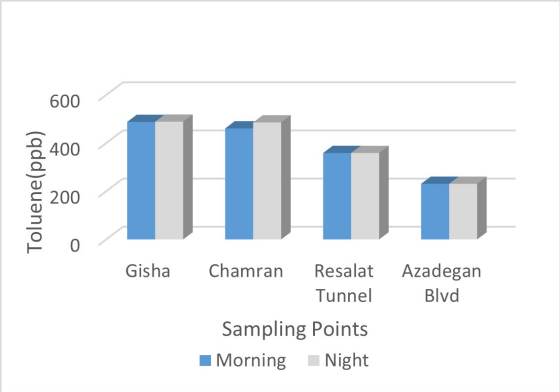

Figure 6. Comparison of toluene concentrations in the morning and at night.

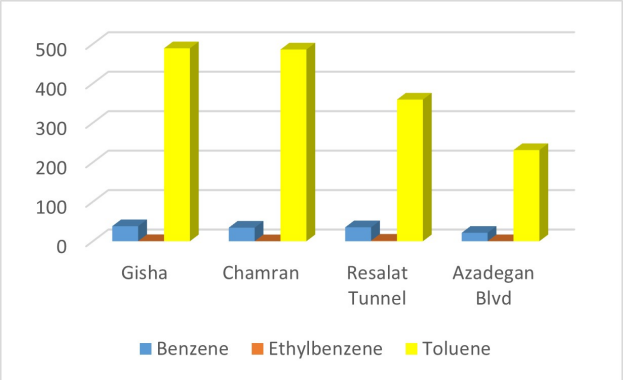

Figure 8. BTX concentrations at night.

concentration of toluene is lower on Azadegan Blvd., where there is no traffic during both morning and nighttime periods. BTX concentrations in the morning and at night are shown in Figs. 7 and 8. Concentration of BTX doesn't show significant differences between night and morning.

5. Conclusion

Fuels serve as the source of volatile organic hydrocarbons in metropolitan areas. Among these, benzene, toluene, and xylene isomers play a significant role as volatile organic compounds (VOCs). This study focused on assessing the concentrations of BTX in heavily trafficked areas of the Hakim Expressway. The findings reveal that during both morning and night, when the weather becomes colder, the measured concentrations remain consistent. Furthermore, as traffic decreased, the levels of VOCs also decreased. Azadegan Blvd., characterized by light traffic and a residential setting, exhibited the lowest concentrations of benzene and toluene. It is important to note that benzene and toluene are pollutants originating from traffic (Borhani et al. 2017). On the other hand, the Gisha (Nasr) neighborhood entrance, located between multiple expressways, experienced the highest volume of pollutants. The air pollution stemming from the Chamran and Sheikh Fazlollah Expressways had a significant impact on this section of the Hakim Expressway. Additionally, the intersection of Chamran and Hakim Expressways demonstrated the highest concentration of Ethylbenzene.

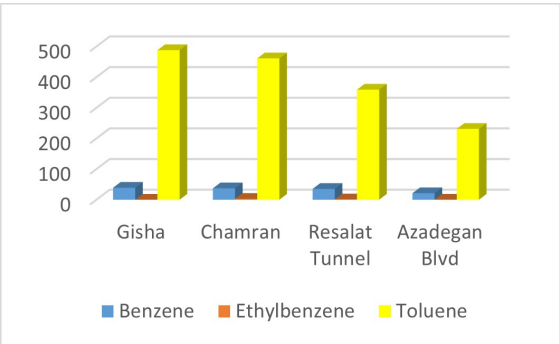

Figure 7. BTX concentrations in the morning.

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Conflict of interest statement
The authors declare that they have no conflict of interest, regarding the publication of this manuscript.

References

BaniNaeemeh S, Rafiyi M, Karimi S, Rasekh AR (2017) Estimating the Dispersion of Pollutants Released from Mobile Sources of Air Pollution (A Case Study of Ahvaz). *Journal of Environmental Science and Technology,* no. 19 (Special Issue No. 5), 67–76.

Berna V, Wendel D, Erik T (2005) Dermal Exposure Assessment to Benzene and Toluene using Charcoal Cloth Pads. *J Expo Anal Env Epi.,* no. 15, 47–50.

Borhani F, Mirmohammadi M, Aslmand AR (2017) Experimental Study of Benzene, Toluene, Ethylbenzene, and Xylene (BTEX) Concentrations in the Air Pollution of Tehran. *Journal of Research in Environmental Health* 3 (2): 105–115.

Dehghani F, Zakerian F Golbabayi A, Omidi F, Mansournia MA (2018) Assessing the Health Effects of Exposure to VOCs (BTEX) in the Painting Unit of an Automotive Industry. *Occupational Safety and Health* 8 (1): 55–64.

Fataei E (2020) The Assessment of Environmental and Health Risks in Sabalan Dam Basin Using WRASTIC Model. *Journal of Health* 11 (4): 555–573.

Fooladi M, Mogooyi R, Jozi A, Tajaddod F Golbabayi G (2021) Feasibility Study of Removing Benzene and Toluene from the Ambient Air through Phytoremediation. *Occupational Safety and Health* 11 (3): 433–444.

Hashemi J, Sanayi Gh (2004) Assessing Petroleum Vapors in the Ambient Air and Its Metabolite in Urine and Its Probable Relationship with Some Blood Factors in an Aromatic Hydrocarbon Production Industry by Proposing the Required Control Measures. *The Fourth National Conference on Occupational Health of Iran, Hamedan.*

Khani MR, Ghahrchi M, Bazrafshan E, DadbanShahamat Y (2019) Investigation of the Benzene Concentration and Distribution in Tehran Air using Geographic Information System (GIS). *Journal of Health Research in Community* 5 (4): 1–10.

Löfgren L (1992) Determination of Benzene and Toluene in Urban Air with Differential Optical Absorption Spectroscopy. *International Journal of Environmental Analytical Chemistry* 47 (1): 69–74.

Makkiabadi M, Yaghoobi S, HajMohammadi MS (2022) Investigation of wet spraying system to control dust pollution in mines (A case study). *Anthropogenic Pollution* 6 (2): 48–54.

Mostofie N, Fataei E, KheikhahZarkesh MM, Hezhabrpour GH (2014) Assessment centers and distribution centers dust (case study: NorthWest, Iran. *International Journal of Farming and Allied Sciences* 3 (2): 235–243.

Muhibbu-din I, Ayodele I (2021) Application of Steam Enhanced Extraction method on BTEX contaminated soil in a Nigerian petroleum depot and Automobile workshop sites in Ilorin metropolis, Nigeria. *Anthropogenic Pollution* 5 (2): 30–38.

Rezayi A, Pourtaghi Gh H, Khanin A, SarrafMa'maoori R, Hajizadeh E, Valipoor F (2007) Removing Toluene from the Ambient Air using Photocatalytic Properties of Titanium Dioxide Nanoparticles Excited by Ultraviolet Rays. *Journal of Military Medicine* 9 (3): 217–222.

Sadigh A, Fataei E, Arzanloo M, Imani A.A. (2021) Bacteria bioaerosol in the indoor air of educational microenvironments: Measuring exposures and assessing health effects. *J Environ Health Sci Engineer* 19 (2): 1635–1642.

Sahranavard Y, Zare S, Kalantari S, Omidi I, Karami M (2015) Determining Benzene, Toluene, Ethylbenzene, and Xylene Concentrations in the Ambient Air of the Metallurgy Hall of Mese Sarcheshmeh Complex. *Journal of Occupational Hygiene Engineering* 2 (4): 9–13.

Sajjadian N (2015) Forecasting the Air Pollution Caused by Urban Transportation in Tehran by Integrating GIS with LUR Model and Artificial Neural Network. *Quarterly Journal of Geographical Data (SEPEHR)* 24 (95)

Salmani MH, Ehrampoosh MH, Mosadegh MH, Sharifi MH (2016) Assessing Benzene, Toluene, Ethylbenzene, and Xylene (BTEX) Concentrations in the Environment of Automotive Painting Workshops Compared to the Environment of Residential Areas around the Workshops in Yazd. *Journal of Tolooe Behdasht* 15 (5): 21–30.

Shoaa J Vatani, KardanYamchi H, Mirghani S (2015) Assessing Benzene, Toluene, Ethylbenzene, and Xylene Emissions in the Ambient Air of Imam Hossein Hospital of Shahrood. *Hospital* 14 (1): 71–76.