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# Prediction of Air Pollution Index by the GIS Tools During Cold Seasons in the Commercial Zones of Tehran

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**Abstract**
The main market of Tehran in district 12 (16.91 $km^2$) including 6 zones located in the city center is the considerable economic pole of Iran, with the floating population and intra city trips, which are playing an important role in the air pollution. The present study aimed to investigate how the air index pollutants emitted in the cold seasons. There were 22 main locations determined for sampling, which was 10 times measured and the average is presented. Coincided with the review of early studies, the Zones of the regions were visited and a checklist of industries and centers with the potential of pollution was prepared. Then, according to the expert's comments and guidelines of the Department of Environment, the pollutants of the centers were identified and by referring to the GIS unit of the district 12, digital layers were received and the relevant maps were prepared. The air pollutants of the region were zoned based on the measurements using ArcGIS software by IDW interpolation method. The air pollutants in the region include volatile organic compounds BTEX: containing benzene (13.04 – 388.71 ppb); toluene (5.99 - 942.8 ppb); ethylbenzene (0.00016-37.13 ppb); xylene (0.00016-37.13 ppb); PM10 (33.22– 200 $\mu g/m^3$); $PM_{2.5}$ (19-170 $\mu g/m^3$, SO2 0.239 - 0.149 ppm); NO2 (0.17-0.27 ppm); CO (0.11- 11.91 ppm) and O3 (0 - 0.022 ppm) was measured. Finally, the results of the air pollutant analysis and managerial solutions of control were analyzed and its reduction in district 12 was presented.

**Keywords**: Air pollutants, ArcGIS Software, Indicator Pollutants, Monitoring Pollutants, Commercial Regions

## Introduction

Tehran's weather conditions are on the verge of danger due to increased environmental pollutants and the Tehran Air Pollution Index does not follow a steady state. District 12 is considered the most important commercial zone in Tehran. Many studies have shown that contamination in commercial areas is higher than other areas. The purpose of study is to simulate the distribution of indicator pollutants include ($NO_2$, $SO_2$, CO, $O_3$, $PM_{10}$ and $PM_{2.5}$, BTEX: containing benzene, toluene, ethylbenzene and xylene) in one of the commercial areas of Tehran. Environmental pollutants such as air pollutants have adverse effects on health and mental health of human (Ghorani-Azam et al., 2016; Assari et al., 2016; Shahmohamadi et al, 2011).

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The undesirable condition of the air quality in metropolises causes a wide range of chronic health effects, from minor physiological disorders to death due to respiratory and cardiovascular diseases (Karimzadegan et al., 2008; World Health Organization, 2000). Estimating exposure to urban road traffic air and noise pollution is important in order to improve the understanding of human health outcomes in epidemiological studies (Khan et al., 2018; Nieuwenhuijsen, 2016; Fecht et al., 2016). The results of a research showed that the mean annual benzene concentration was 14.51±3.17 parts per billion (ppb) for traffic zones and 29.01±1.32 ppb for outside gas stations. The risk calculated was 1026×10–6 for gas station 27 and 955×10–6 for gas station (Atabi and Mirzahosseini, 2013).

The $PM_{2.5}$ reduction of air pollution rate in the environment results in-400 million $ cost reduction per year for Tehran, compared to Seoul. Tehran with a further reduction in PM 2.5 concentration annually reduce the costs by 300, 400 and 500 million $, respectively, compared to Mexico, London, and New York (World Health Organization, 2016). Air pollution and other environmental hazards have many adverse health effects, and the resulting environmental burden of disease is a major issue in both developing and developed countries (Mannucci, and Franchini, 2017; Lu et al., 2015; Abdel-Shafy, and Mansour, 2016). Studies on asthma have shown that air pollution can lead to increased asthma prevalence (Amit et al., 2014). A study conducted in the United States, Annual means of these concentrations were compared to annual variations in asthma prevalence by using Pearson correlation coefficient. They found different associations between the annual mean concentration of $PM_{2.5}$, $SO_2$ and surface ozone and the annual rates of asthma discharge and asthma emergency visit from 2005 to 2007. A positive correlation coefficient was observed between the annual mean concentration of $PM_{2.5}$, and $SO_2$ and the annual rates of asthma discharge and asthma emergency department visit from 2005 to 2007 (Gorai et al., 2014). Although the goal of disease prevention is to reduce harmful exposures across the entire population, there is concern that some groups such as those with low socioeconomic status (SES) are exposed to more environmental hazards than other groups (Evans and Kantrowitz, 2002). Due to the large number of schools in the studied area, air pollutants will have adverse effects on students. Estimating pollutant concentrations at a local and regional scale is essential for good ambient air quality information in environmental and health policy decision making (Dominici et al., 2006; West et al., 2016). Therefore, pollutants monitoring and continuous determination of the air quality of the metropolises are necessary to develop its control programs (Amegah and Agyei-Mensah, 2017; Kumar et al., 2017; Padash and Ataee, 2019; Padash et al, 2015).

In another research titled "Quantitative Assessment of Different Air Pollutants (QADAP) Using Daily MODIS Images" Ahmadian Marj et al., used the model called called quantitative assessment of different air pollutants (QADAP). The best results were for CO, $PM_{2.5}$, $NO_2$ and $O_3$, which had lower relative Root Mean Squared Errors (RMSE), and the worst result was for $PM_{10}$ with a high relative RMSE (Ahmadian Marj et al., 2017).

## Materials and Method

### *Location of Research*

The district 12 of Tehran Municipality is one of the commercial areas of Tehran located in its center with an area of 16.91 $km^2$ consisting of six zones and the Tehran market is its most important feature (Forouhar, 2016; Shahbegi et al., 2013). The number of households in the region is 91000 and the population growth rate is 2.5% per year. By identifying important points in the region, sampling sites were selected at 22 points including eight fuel stations (gas stations), three bus and taxi terminals, and 11 densely populated and high traffic points

(Asadpur and Nasrabadi, 2011; Nabipour et al, 2014). In Figure 1. There are presented 22 sampling stations in 6 zones. In Table 1, the locations of 22 Sampling points are presented.

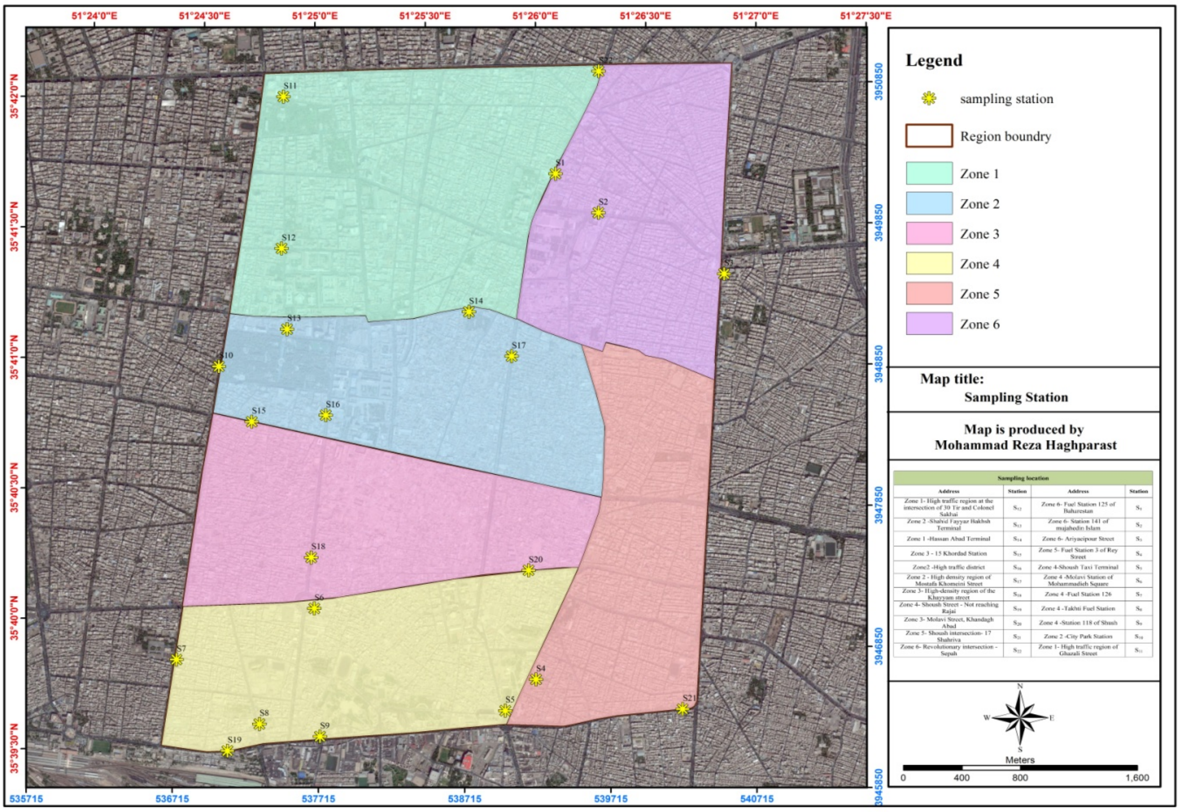


**Figure 1.** The locations of 22 Sampling point in 6 zones

**Table 1.** Location of 22 sampling for air pollutants on January, 2018

| Station No. | **Sampling locations** | Station No. | **Sampling locations** |
|---|---|---|---|
| 1 | Zone 6- Fuel Station 125 of Baharestan | 12 | Zone 1 - High traffic region at the intersection of 30 Tir and Colonel Sakhai |
| 2 | Zone 6- Fuel Station 141 of mujahedin Islam | 13 | Zone 2 – Shahid Fayyaz Bakhsh Terminal |
| 3 | Zone 6- Ariyaeipour Street | 14 | Zone 1 – Hassan Abad Terminal |
| 4 | Fuel Station 3 of Rey Street | 15 | Zone 3 – 15 Khordad Station |
| 5 | Zone 4-Shoush Taxi Terminal | 16 | Zone 2 – High traffic Zone |
| 6 | Zone 4 – Molavi Station of Mohammadieh Square | 17 | Zone 2 – High density region of Mostafa Khomeini Street |
| 7 | Zone 4 – Fuel Station 126 | 18 | Zone 3- High-density region of the Khayyam street |
| 8 | Zone 4 – Takhti Fuel Station | 19 | Zone 4- Shoush Street - Not reaching Rajai |
| 9 | Zone 4 – Fuel Station 118 of Shush | 20 | Zone 3- Molavi Street, Khandagh Abad |
| 10 | Zone 2– City Park Station | 21 | Zone 5- Shoush intersection – 17 Shahriva |
| 11 | Zone 1 – High traffic region of Ghazali Street | 22 | Zone 6- Revolutionary intersection - Sepah |

*Methods of measurement*

First of all, the clean air standard test used as the suspended particles in the ambient air with 10 and 2.5 microns ($PM_{10}$, $PM_{2.5}$), as well as ambient air gases (Sekhavatjou et al., 2011, Naddafi et al., 2012, Akbary et al., 2018).
- The concept of clean air standard parameters: CO, $SO_2$, $NO_2$, $O_3$ gases, dust particles ($PM_{10}$ and $PM_{2.5}$), benzene and benzo-alpha-pyrene vapors, and heavy metal lead are considered as the parameters of standard clean air (Penza et al., 2014).
- The purpose of the monitoring is identifying and determining the suspended particles rate and ambient air gases and determining the pollutants rate and their comparison with the standards of the Environmental Protection Agency (Logue et al., 2011).

*Testing method*

- The standards of the method analysis include EPA METHOD 201 A, BS-EN-12341, EPA - 40CFR, EPA0030, NIOSH1501 & OHSA12, and the instructions contained in the Book of Environmental Criteria and Standards (Freeman et al., 2014; Baird et al., 2012; Ott, 2018; Ferre et al., 2010; Csruos, 2018; Cole, 2018)
- The suspended particles in the ambient air ($PM_{10}$, $PM_{2.5}$)

For this test, the DUST TRAK photometer machine is used based on the photometric and BS-EN-12341 standard method. The aerosol photometer machine, sometimes called "Nephlometer", indicates the particles rate by measuring the amount of the light emitted (Spindler et al., 2010; Khodeir et al., 2012; Gao et al., 2015).

The intensity of the light emitted from the particles is a function of the size, shape and the light decomposition indices. The light intensity and rate emitted on the Dust Track display from TSI Company are demonstrated for the composition of suspended particles and different aerosols. The obtained responses are a function of particle size in the unit concentrations. In this method, the DustTRAK 8520 machine is first calibrated and placed in an appropriate position and preferably slightly above ground level (1.5 m above ground level) (Rivas et al., 2017; Chang et al., 2018; Krecl et al., 2018; Shu et al., 2016).

The flow machine is set up and sampled in a specific time. The maximum, minimum, and average rates of suspended air particles per unit volume are specified and presented with regard to the capability of the machine. It should be noted that the maximum measured value is comparable to the standard.
- Ambient air gases

Based on the EPA- 40 CFR part 53 standard and the machine used to measure the CO, $SO_2$, $NO_2$ and $O_3$ gases, the type of the parameters of combustion gases is AEROQUAL with interchangeable electrochemical sensor, transferring these parameters to the system based on the voltage variation and displaying them according to the standard unit (Polidori et al., 2017; Polidori et al., 2016; Lin et al., 2015; Masey et al., 2018; Zenonos et al., 2018)

*Monitoring equipment*

- Ambient air dust measuring device of DustTRAK from TSI Company Measured items: suspended particles with sizes of 1, 2.5 and 10 microns
- Environmental gas measuring device of AEROQUAL
- SKC AirCheck Sample Pump from SKC (Pillarisetti et al., 2019; Quansah et al., 2017; Volckens, et al., 2017).

*Monitoring procedure of air pollutants in the District 12 of Tehran*
*Methodology of identifying pollutants*

The following measures were taken to identify the sources and monitor air pollutants:
- Basic studies and identification: In basic studies and identification, the history of the region was extracted from the review of the environmental studies previously conducted in the district 12. Concurrent with reviewing previous studies, a list of centers with potential pollution was prepared by referring to the different areas of the region. Then, according to the experts' opinions and EPA guidelines, the potential pollutants of each center was identified and determined (Güçlü ET AL., 2019; Armitage, 2018; Park and Hong, 2016).

*GIS Database*

After identifying the sources with potential pollution, the digital layers were received and the relevant maps were prepared by referring to the GIS department of the municipality of the district 12 (Atabi et al., 2013). This stage was set by considering the identified resources and the field visit program from the region. The air and sound pollutants in the region were zoned based on the measurements done and using the ArcGIS software and with interpolation by IDW method (Mirzaei and Sakizadeh, 2016; Blanco et al., 2018; Rufo et al., 2018).

In Inverse Distance Weighted (IDW) method, the unknown points were calculated by averaging the values of the known points. In this method, each of the points has a weight in the calculation, as less distance of the known point from the unknown point leads to more weight vale, and more distance leads to less effectiveness of the known point in estimating the unknown point and calculating the mean. Thus, the closer distances get higher weight.

Spatial interpolation methods such as Inverse Distance Weight (IDW) helped to utilize these data to estimate levels of ambient air pollutants at unmeasured locations. IDW is a method of interpolation that estimates cell values by averaging the values of sample data points in the vicinity of each processing cell (Atabi and Mirzahosseini, 2013; Varatharajan et al., 2018; Ballarin et al., 2019; Zaki et al., 2019).

Field visits and layer evaluation after identifying the pollution sources and receiving the GIS digital layers from the municipality of the region, all zones of the district 12 were visited and the geographic coordinates of the identified sources were reviewed using the GPS to evaluate these layers.

*Selecting the sampling points and performing sampling*

By identifying units and regions with potential of pollution, the intended situations were specified for measurement and sampling were done during the cold season.
- Identifying the air pollutions at the region level

The main sources of pollution in this region are divided into the fixed and mobile resources.
- Air pollution caused by fixed sources

The main air pollution is related to the transport of motor vehicles, due to the dense urban tissue and the absence of large and polluting industries in the region. The stable resources contributing to air pollution include industries and jobs, fuel delivery stations, passenger terminals, construction activities, and business and home resources.
- Pollution caused by mobile resources

The early studies indicated that more than 85% of the air pollution of the region is due to the mobile resources or vehicles. Due to the administrative and commercial situation of the region, a large number of motor vehicles are commuting there daily. Generally, air pollutants in the region include volatile organic compounds (BTEX: containing benzene, toluene, ethylbenzene and xylene), suspended particles ($PM_{10}$ and $PM_{2.5}$), sulfur dioxide (SO2), nitrogen dioxide (NO2), carbon monoxide (CO) and ozone (O3) (Tiwary, and Williams, 2018; Liu et al., 2019; Pennington et al., 2018).

*Selecting the pollutant measurement stations*

By identifying important points in the region, sampling sites were selected at 22 points including eight fuel stations (gas stations), three bus and taxi terminals, and 11 densely populated and high traffic points.

The innovation of this research is summarized in this paper. According to the geographic information of district 12 of Tehran municipality and the location of this area in the heart of Tehran, air pollution data has been measured and predicted for the future. In fact, the integration of spatial information of measurement points has been measured according to existing standards. Finally, the final map of the dispersion of each pollutant is produced. Also, the final results after zoning for different regions in the region are investigated.

## Results

This system was intended to be an example for other major Iran cities. Calculation of a comprehensive emission inventory, air quality modeling, air quality mapping by GIS and scenario analysis for air pollution abatement were carried out as the components of this system. Sampling was conducted in January (cold season), and the results of analyzing air pollutants are presented in the table 2. Sampling and measurements are done in 10 steps and the average is presented. The results of this research showed that Co and $O_3$ at all stations were lower than standard limit. Amount of $No_2$ at these stations (1, 3, 4, 5, 10, 14, 16, 20 and 22) were lower than standard limit, also Amount of $No_2$ was higher than the standard limit in other stations.

Amount of $So_2$ at these stations (1, 3, 4 and 20) were lower than standard limit and Amount of $So_2$ was higher than the standard limit in other stations. Based on measurements of $PM_{10}$ in these stations (1, 2, 4, 5, 6, 7, 8, 11, 14 and 17) were lower than standard limit also measurements of $PM_{10}$ was higher than the standard limit in other stations. Measurements of $PM_{2.5}$ showed in these stations (1, 5, 6, 7, and 8) were lower than standard limit and Amount of $PM_{2.5}$ was higher than the standard limit in other stations. The highest concentrations of benzene were observed in (6, 7, 8, 9 and 19) stations and boundary between stations (1, 2, 3, 12 and 14) .The concentration of this pollutant in (4, 5, 15, 16 and 17) was lower than the annual standard limit specified in the clean air standard. The highest concentrations of toluene were observed in (1, 2, 3, 4, 6, 7, 8, 9 and 11). The highest concentrations of ethylbenzene were observed in (3, 6, 7, 8, 9, 10, 11, 12, 13, 14, 18 and 19).The highest concentrations of xylene were observed in (9, 10, 11, 1, 2 and 3).

The zoning of the results of analyzing the air pollutants was conducted by using the ArcGIS software and with the interpolation by IDW method, as presented in the following (figures 2 to 11). As predicted by the results, the highest concentration of nitrogen dioxide in zone 4 and its boundary zone with zone 3 are observed, and the mean concentrations are between 0.17-0.27 ppm. As it can be seen, sulfur dioxide concentration in zone 4 and stations 12 and 13 is higher than the standard level and the mean concentrations are between 0.239 and 0.149 ppm.

**Table 2.** The results of analyzing pollutants on January, 2018

| Sampling Station | Pollutant | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $PM_{10}$ (µg/m3) | $PM_{2.5}$ (µg/m3) | SO2 (ppm) | NO2 (ppm) | CO (ppm) | O3 (ppm) | BENZENE (ppb) | TOLUENE (ppb) | ETHYLE BENZEN (ppb) | XYLENE (ppb) |
| 1 | 152 | 131 | 0.17 | 0.085 | 7.54 | 0 | 119.95 | 191.08 | 14.07 | 48.97 |
| 2 | 200 | 62 | 0.07 | 0.012 | 8.4 | 0.003 | 87.2 | 126.16 | 13.45 | 40.02 |
| 3 | 67 | 41 | 0.03 | 0.073 | 2.4 | 0.001 | 92.83 | 138.71 | 19.94 | 68.55 |
| 4 | 91 | 70 | 0.08 | 0.047 | 3.49 | 0.007 | 109.04 | 130.58 | 17.01 | 53.5 |
| 5 | 43 | 23 | 0.07 | 0.011 | 4.88 | 0.007 | 24.61 | 37.17 | 0.00016 | 12.99 |
| 6 | 33 | 19 | 0.09 | 0.053 | 8.3 | 0.008 | 136.66 | 309.5 | 18.21 | 92 |
| 7 | 45 | 14.03 | 0.08 | 0.042 | 0.11 | 0.004 | 294.18 | 344.14 | 20.29 | 100.07 |
| 8 | 39 | 24 | 0.04 | 0.037 | 2.07 | 0.013 | 75.15 | 135.43 | 11.55 | 35.28 |
| 9 | 88 | 33 | 0.11 | 0.051 | 3.11 | 0.004 | 388.71 | 942.8 | 37.13 | 332.94 |
| 10 | 52 | 28 | 0.08 | 0.014 | 4.42 | 0.001 | 200.09 | 367.18 | 15.44 | 79.98 |
| 11 | 78 | 52 | 0.12 | 0.055 | 0.63 | 0 | 13.09 | 47.79 | 0 | 19.85 |

**Table 2.** (Continued).

| Sampling Station | Pollutant | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $PM_{10}$ (μg/m3) | $PM_{2.5}$ (μg/m3) | SO2 (ppm) | NO2 (ppm) | CO (ppm) | O3 (ppm) | BENZENE (ppb) | TOLUENE (ppb) | ETHYLE BENZEN (ppb) | XYLENE (ppb) |
| 12 | 76 | 50 | 0.76 | 0.057 | 5.8 | 0.004 | 29.11 | 82.35 | 0 | 19.63 |
| 13 | 69 | 66 | 0 | 0.035 | 0.24 | 0.004 | 17.54 | 33.94 | 0 | 14.4 |
| 14 | 64 | 59 | 0.09 | 0.039 | 0.22 | 0.022 | 23.55 | 46.13 | 0 | 11.41 |
| 15 | 83 | 72 | 0.07 | 0.096 | 1.24 | 0.012 | 13.04 | 22.13 | 0 | 12.63 |
| 16 | 151 | 73 | 0.08 | 0.071 | 11.91 | 0.01 | 14.56 | 25.85 | 0 | 0 |
| 17 | 92 | 68 | 0.09 | 0.063 | 5.28 | 0.007 | 35.53 | 89.5 | 0 | 20.15 |
| 18 | 113 | 68 | 0.06 | 0.087 | 8.83 | 0.009 | 13.52 | 56.26 | 0 | 16.86 |
| 19 | 173 | 140 | 0.07 | 0.072 | 9.35 | 0 | 6.82 | 10.94 | 10.97 | 11.05 |
| 20 | 188 | 170 | 0.08 | 0.074 | 1.58 | 0 | 6.95 | 14.12 | 10.09 | 11.12 |
| 21 | 129 | 94 | 0.11 | 0.069 | 0.12 | 0.003 | 7.8 | 20.78 | 9.91 | 12.88 |
| 22 | 98 | 87 | 0.22 | 0.011 | 1.21 | 0 | 4.99 | 5.99 | 0 | 0 |

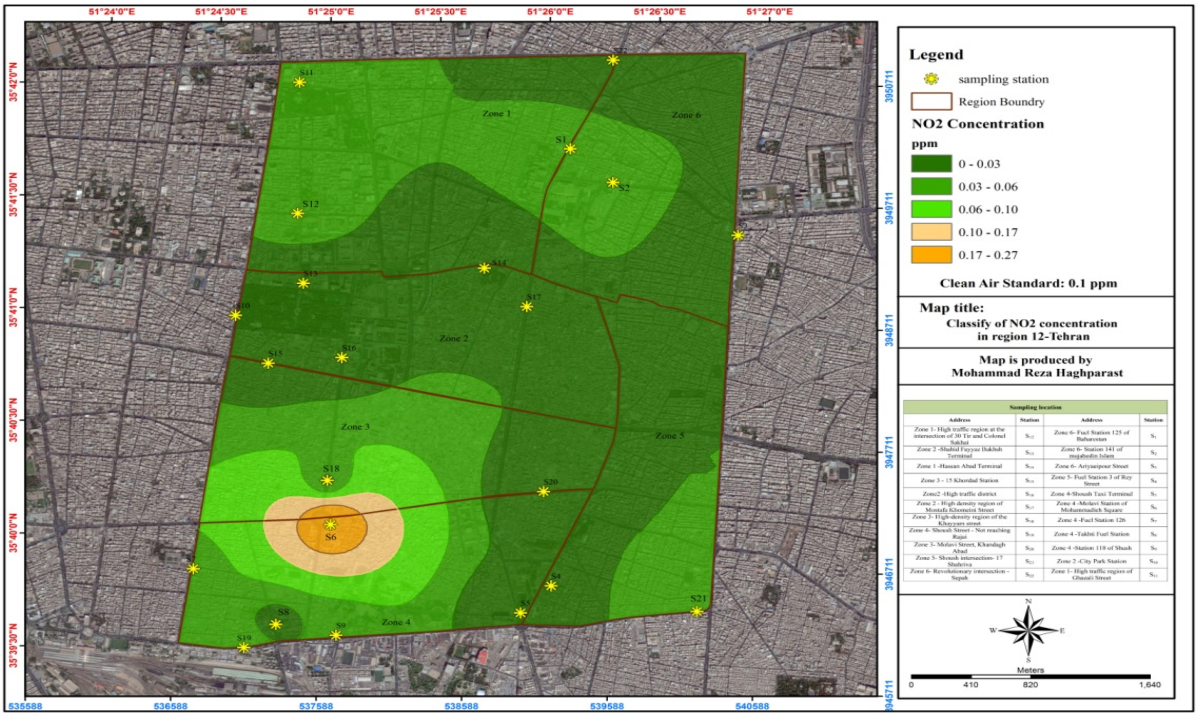


**Figure 2.** Zoning nitrogen dioxide concentration in the region on January, 2018

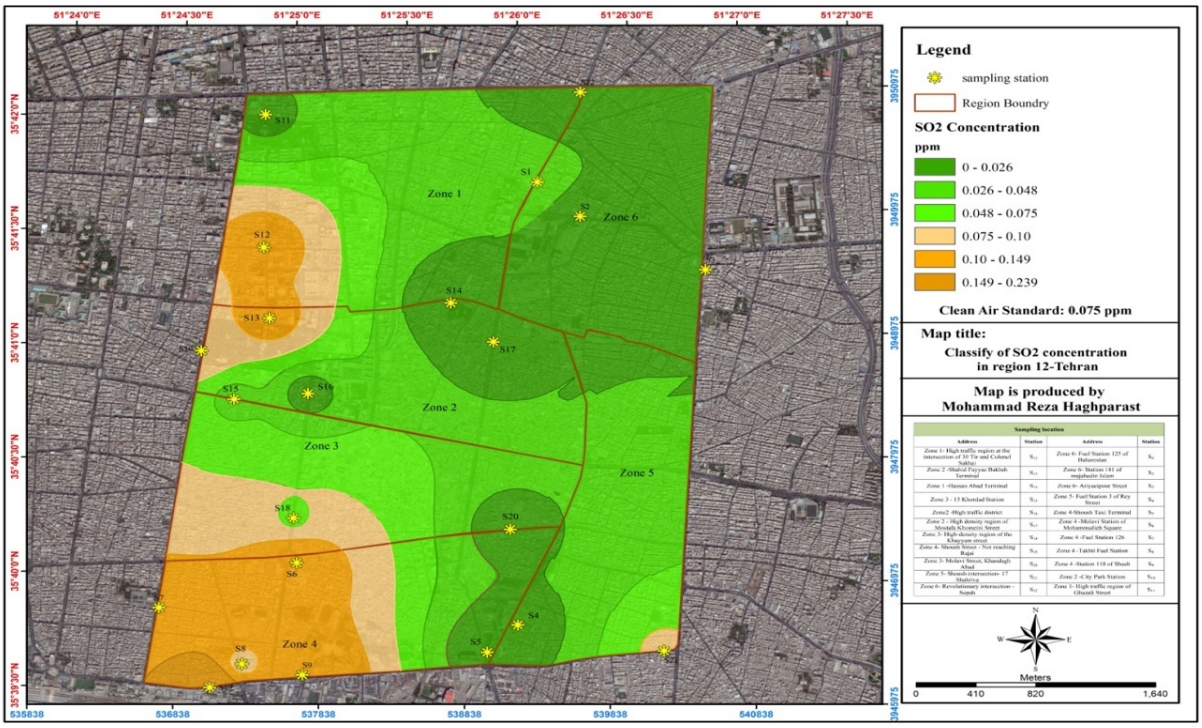


**Figure 3.** Zoning sulfur dioxide concentration in the region on January, 2018

The concentration of CO pollutants in the zoning indicates that the area was below the standard clean air standard. As can be seen from the figure 5 the concentration of $O_3$ pollutants throughout the area is below the standard clean air standard.

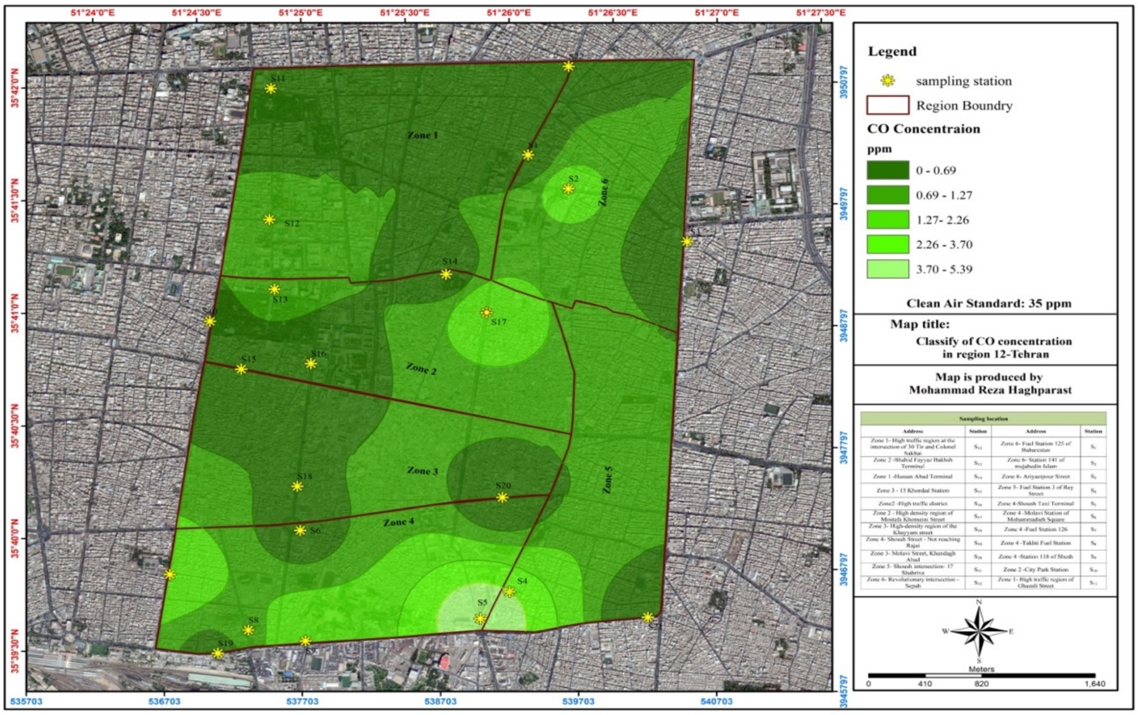


**Figure 4.** Zoning carbon monoxide concentration in the region on January, 2018

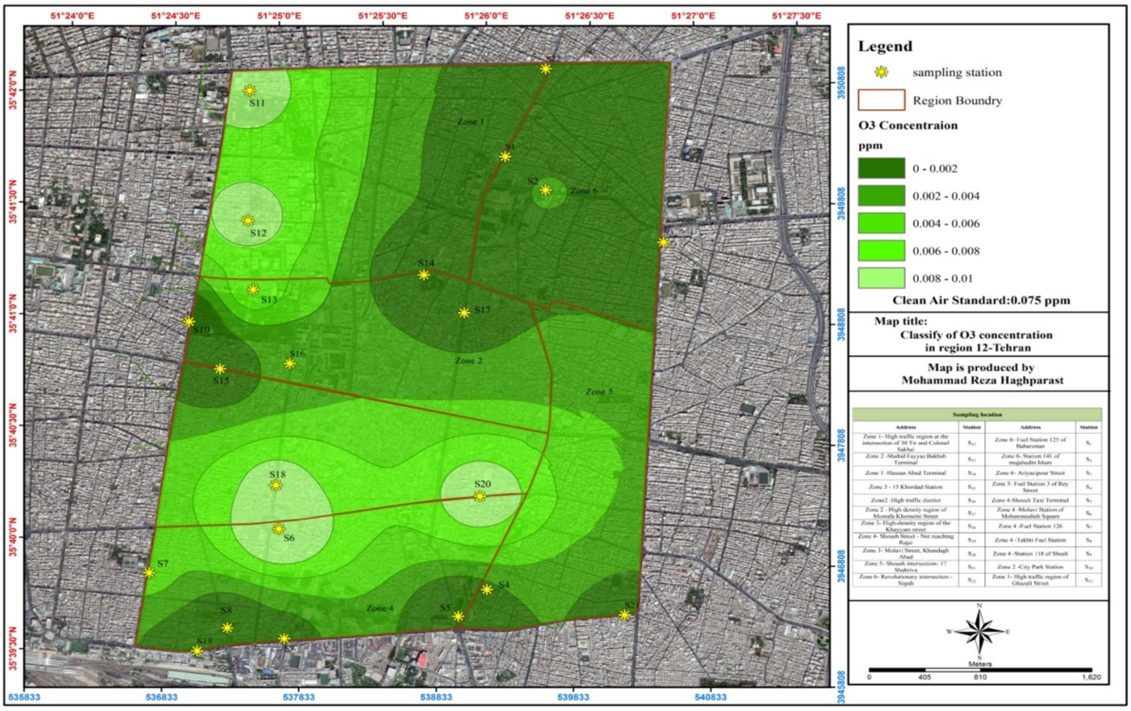


**Figure 5.** Zoning Ozone concentration in the region on January, 2018

The concentration of this pollutant ($PM_{10}$) in areas of the zones 3 and 4 was lower than the standard limit and the highest concentrations were observed in zones 6, 1 and 2 mean concentrations are between 33.22 μg/m3 – 200.

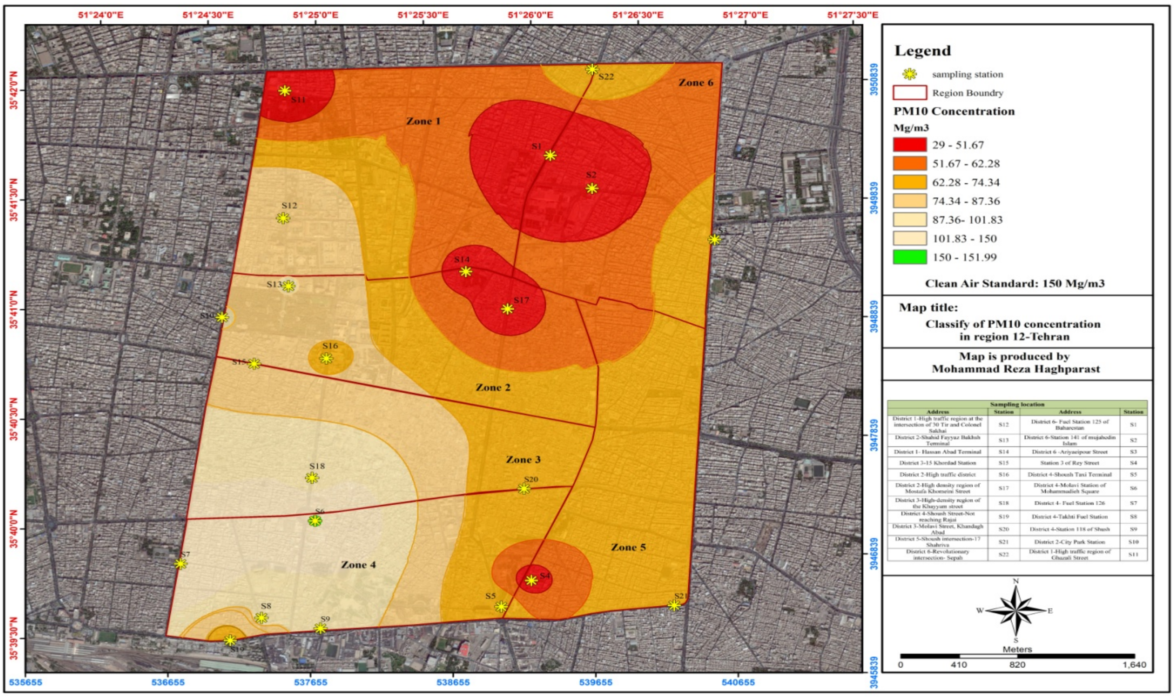


**Figure 6.** Zoning $PM_{10}$ concentration in the region on January, 2018

The concentration of $PM_{2.5}$ The highest concentrations were observed at the eastern end of the boundary of the zone 3 and 4. This pollutant throughout the district 12 was higher than the standard limit and it was lower than the 24-hour standard limit specified in the clean air standard in some areas of the zones 1, 6 and 2.

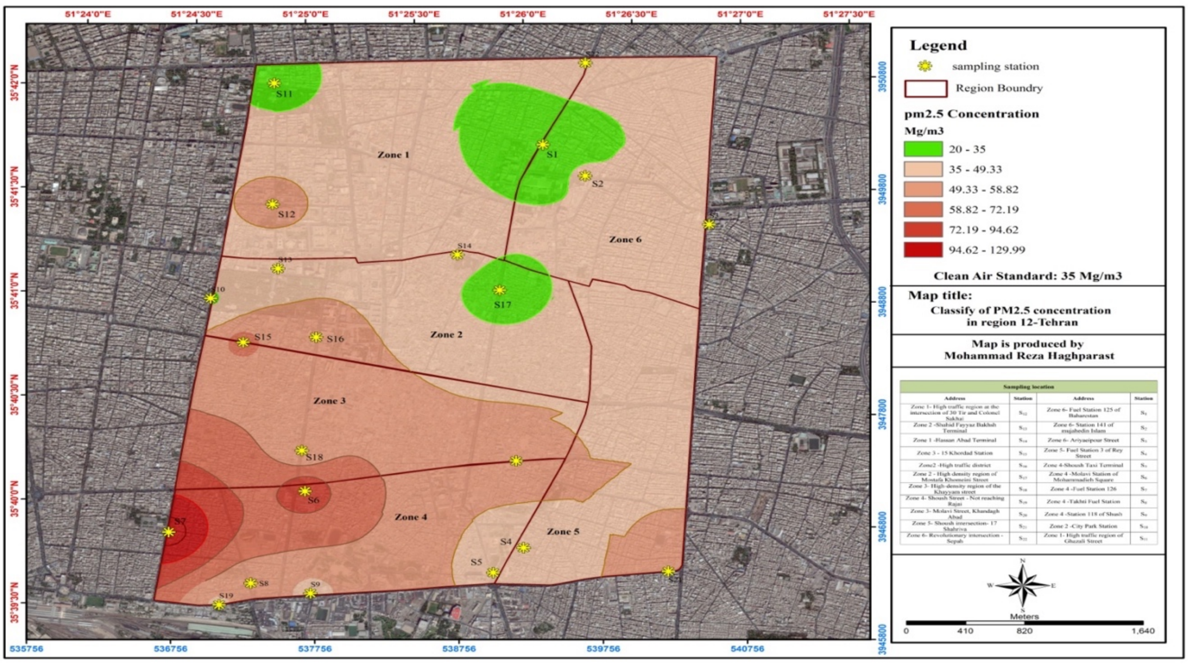


**Figure 7.** Zoning $PM_{2.5}$ concentrations in the region on January, 2018

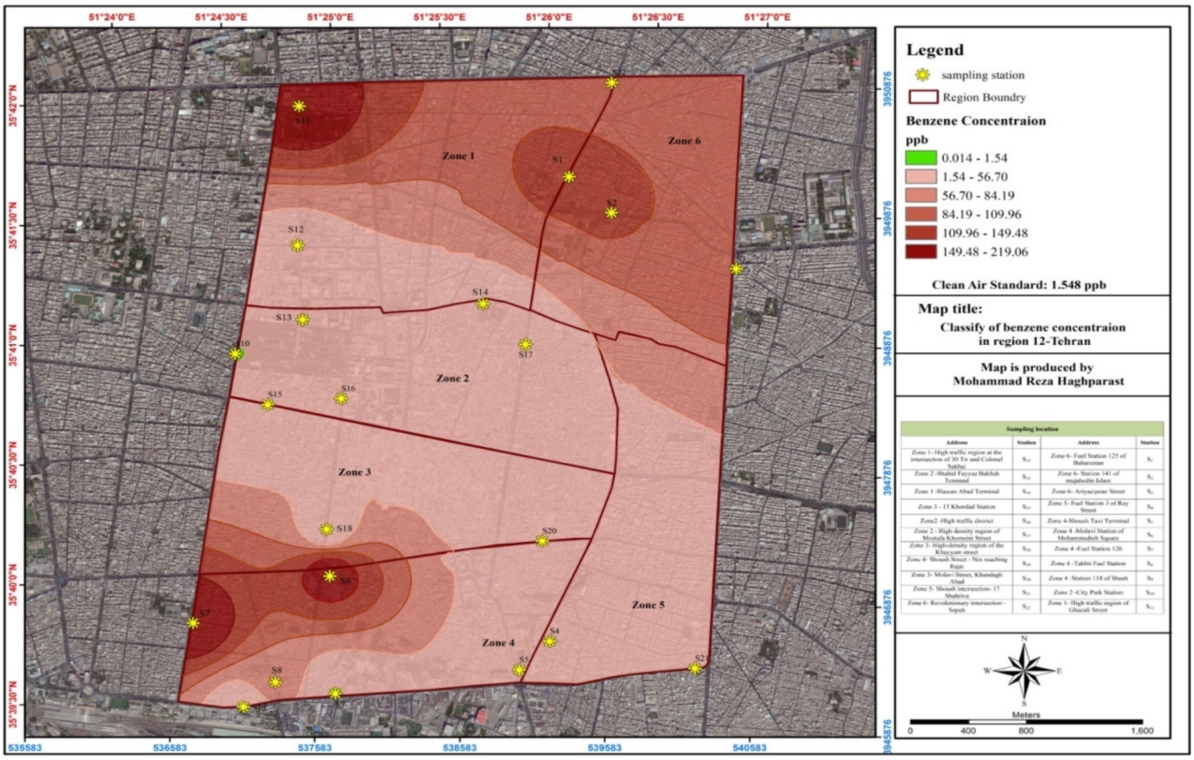


**Figure 8.** Zoning Benzene concentration in the region on January, 2018

Predictive results show the highest concentrations were observed in the west and north of the zone 4 and boundary between zones 1 and 6. The concentration of benzene in the region (Figure 8) varies between 13.04 – 388.71 ppb. Results show the highest concentrations of toluene were observed in Zones 6, 1 and part of 4. Its concentration is varies between 5.99 - 942.8 ppb.

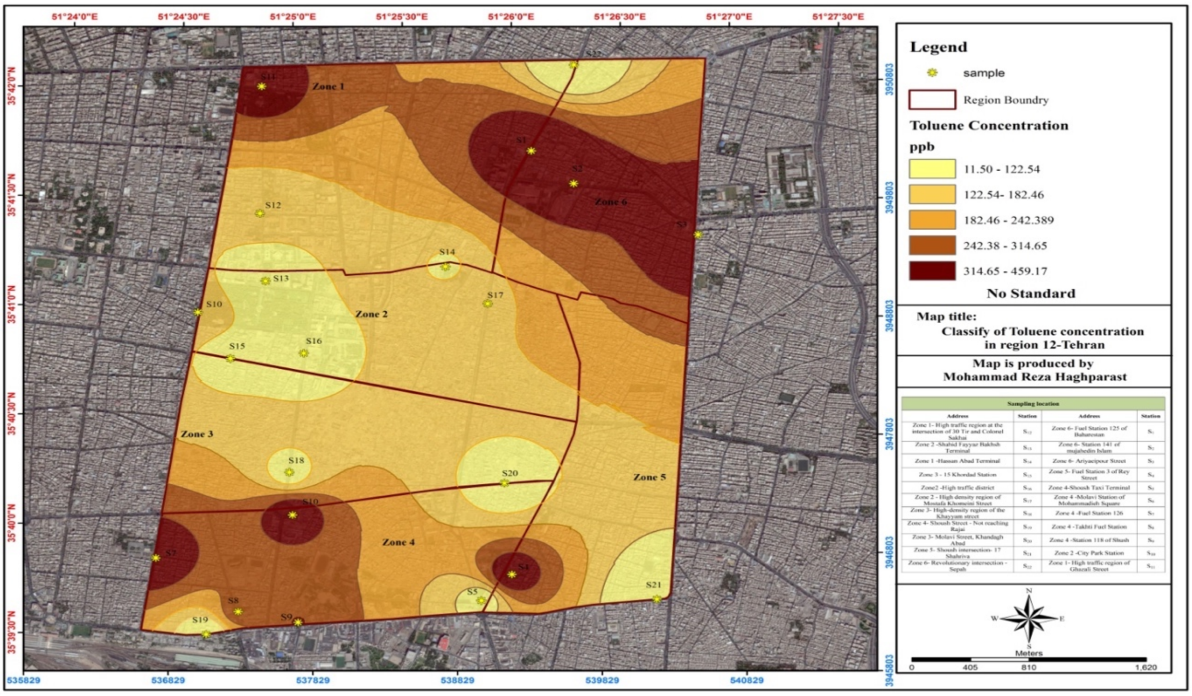


**Figure 9.** Zoning of Toluene concentration in the region on January, 2018

Zoning Ethyl Benzene show the highest concentrations of this pollutant were observed in zones 1 and 4 and boundary between zones 3 and 4. Concentration is varying between 0.00016-37.13 ppb. As predicted by the Zones 4 and 1. Its concentration is varying between 11.05-332.results, the highest concentrations of xylene were observed in south of 94 ppb.

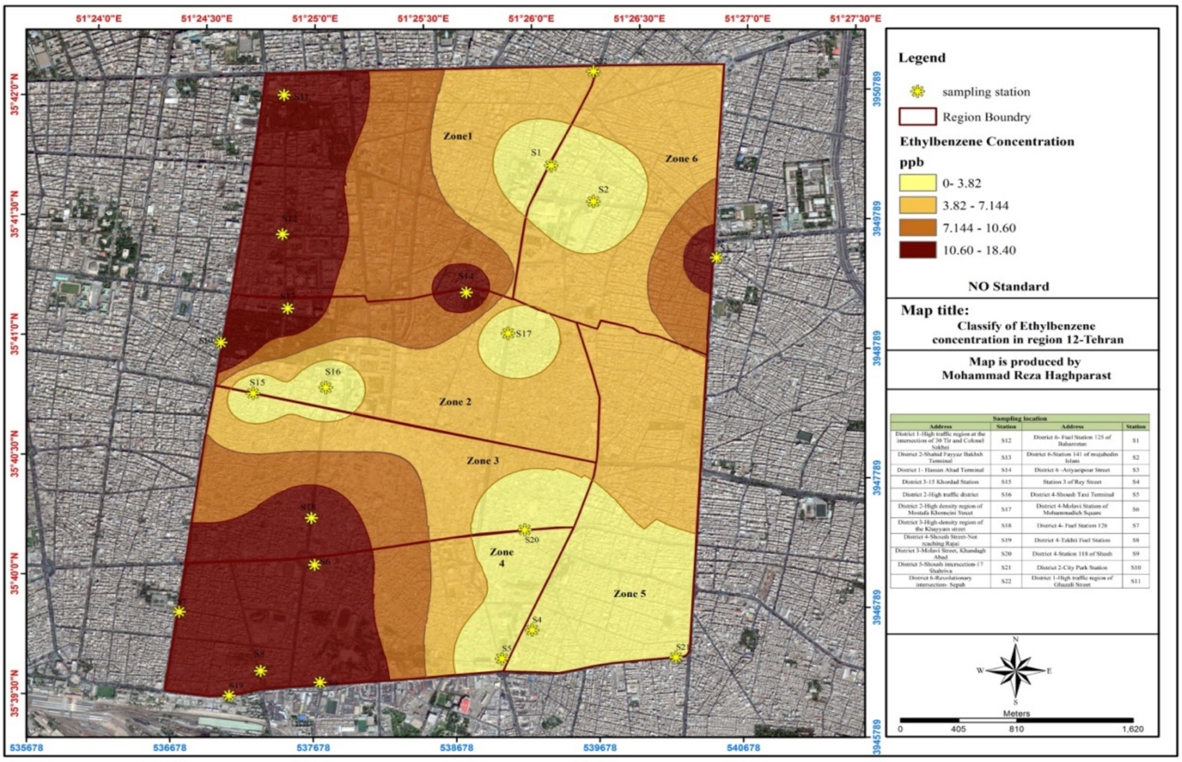


**Figure 10.** Zoning Ethyl Benzene concentration in the region on January, 2018

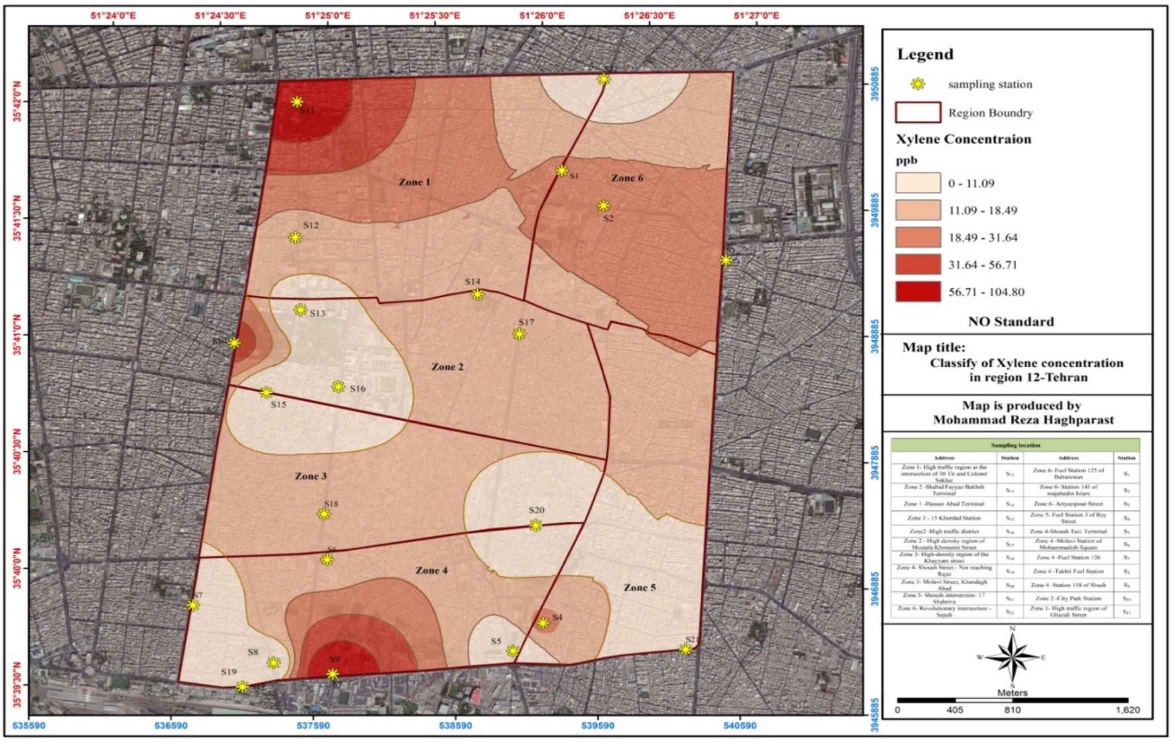


**Figure 11.** Zoning Xylene concentration in the region on January, 2018

## Discussion

According to the result of study, the concentration of benzene in the region varies between 13.04–388.71 ppb, but the results of a research showed that the mean annual benzene concentration was 14.51±3.17 parts per billion (ppb) for traffic zones (Atabi and Mirzahosseini, 2013).

Based on the Figure 2, the concentration of $NO_2$ measured in the region, varies between 0.011-0.096 ppm. The maximum one-hour standard of this pollutant is 0.1 ppm. Further, the concentration of this pollutant in some areas of the zones 2, 4, 5 and 6 was lower than the standard limit. In the zone 4, a wide range of the highest concentrations was observed.

The concentration of $SO_2$ measured in the region (Figure 3) varies between 0.03 ppm–0.76 ppm. The maximum one-hour standard of this pollutant is 0.075 ppm and the concentration of this pollutant in areas of the zone 2 and 6 was lower than the standard limit and the highest concentrations were observed in zone 1.

The CO concentration in the region (Figure 4) changes between 0.11 ppm-11.91ppm. The maximum one-hour standard of this pollutant is 35ppm. The concentration of this pollutant throughout the district 12 was lower than the standard limit of the clean air.

The $O_3$ concentration in the region (Figure 5) varies between 0 - .012 ppm. The maximum standard of 8 hours of this pollutant is 0.075ppm. Further, the concentration of this pollutant throughout the district 12 was lower than the standard limit of the clean air.

The $PM_{10}$ concentration in the region (Figure 6) varies between 33.22 $\mu g/m^3$ – 200The maximum standard of 24-hour of this pollutant is 150 $\mu g.m^3$. The concentration of this pollutant in areas of the zones 3 and 4 was lower than the standard limit and the highest concentrations were observed in zones 6, 1 and 2. The concentration of this pollutant throughout the district 12 was higher than the annual standard limit and in some zones of the region was higher than the 24-hour standard limit specified in the clean air standard.

The concentration of $PM_{2.5}$ in the region (Figure 7) alters between 14.0031$\mu g/m^3$ – 170. The highest concentrations were observed at the eastern end of the boundary of the zone 3 and 4. The maximum standard of 24-hour of this pollutant is 35$\mu g/m^3$. The concentration of this pollutant throughout the district 12 was higher than the standard limit and it was lower than the 24-hour standard limit specified in the clean air standard in some areas of the zones 1, 6 and 2. The concentration of benzene in the region (Figure 8) varies between 13.04 – 388.71 ppb. The highest concentrations were observed in the west and north of the zone4 and boundary between zones 1 and 6. The annual standard of this pollutant was 1.548 ppb. According to this standard, the concentration of this pollutant in zone 5 was lower than the annual standard limit specified in the clean air standard.

The concentration of toluene in the region (Figure 9) varies between 5.99 - 942.8 ppb. Based on the conducted studies, there is no definite standard for the concentration of this pollutant in ambient air. Therefore, it is not possible to compare this concentration with the allowed limit in ambient air and we can only say that the highest concentrations were observed in Zones 6, 1 and part of 4.

The concentration of ethylbenzene in the region (Figure 10) varies between 0.00016-37.13 ppb. In addition, there is no specific standard for this pollutant in ambient air for this pollutant and the highest concentrations of this pollutant were observed in zones 1 and 4, and boundary between zones 3 and 4.

The concentration of xylene in the region (Figure 11) varies between 11.05-332.94 ppb. In addition, any specific standard is not defined for this pollutant in ambient air. The highest concentrations of this pollutant were observed in south of zone 4 and north of zone1. Therefore, it can be said that sampling has the highest concentration of volatile organic compounds in zones 4, 1 and 6.

Table 3 illustrates the analysis of the parameters associated with the air pollutants. As shown in Table 3, the concentration of carbon monoxide and ozone in all stations is lower than the standard. The nitrogen dioxide pollutant is higher at 12 stations and at 10 stations is lower than the standard. In fact, 54.6% of the stations are non-compliance with the standard. The concentration of $SO_2$ is higher at 18 stations are non-compliance with the standard (81.8% of the stations). Also, the amount of $PM_{10}$ in 59.1% of the stations and the amount of $PM_{2.5}$ in 77.3% of the stations are non-compliance with the standard.

**Table 3.** The analysis of air pollutants on January, 2018

| Pollutant | Station: Lower than the standard limit | Station: Higher than the standard limit | Percentage of stations with non-compliance with the standard |
|---|---|---|---|
| CO | In all stations | - | 0 |
| $O_3$ | In all stations | - | 0 |
| $NO_2$ | 2, 5, 22, 3, 4, 10, 14, 16, 20 | The rest of the stations | 54.6 |
| $SO_2$ | 3, 11, 4, 20 | The rest of the stations | 81.8 |
| $PM_{10}$ | 5, 6, 1, 8, 17, 14, 11, 4, 2, 1 | The rest of the stations | 59.1 |
| $PM_{2.5}$ | 5,6,7,8,1 | The rest of the stations | 77.3 |

As noted above, the air pollution situation is particularly high in this area due to different traffic flows. In order to have a general knowledge of the air pollution situation in the region, mean concentration of measured pollutants was also calculated. For this purpose, the size of the cell and the geographical range of the layers of the stratum of the concentration of pollutants were first uniformed. Also, the unit of all parameters was converted to ppm. Then, using the Raster Calculator, the average concentration of pollutants was calculated and the overall average map was constructed. The final map is the result of the overlapping of the values of the interpolation maps of the concentration of each pollutant. As can be seen, the concentration of pollutants in zones 6, 2 and a large part of zone 4 and its boundary zone with zone 5 is seen. Due to the denser urban texture, the administrative and commercial location of the area and the daily traffic of a large number of motor vehicles, the main cause of air pollution is the transport of motor vehicles. There are also fixed sources of air pollution in the region, including industries and businesses, fuel stations, passenger terminals, construction activities and commercial and home sources.

## Conclusion

Tehran's air pollution has caused serious health problems for its inhabitants in recent years. In densely populated areas of Tehran's population and traffic are among the most polluted areas of Tehran. The managerial methods best solutions for controlling and reducing air pollutants in the district 12 of Tehran municipality. The results of the present study indicated that the great challenge of this region is air pollution. As the region does not have a pollutant measurement and monitoring station, based on the prepared GIS layers, the construction of two pollutant measurement and monitoring stations is necessary in the zones 2 and 4, which should be predicted in planning and financial credits.

Comparing the results of this study with similar articles confirms that during the cold seasons the concentration of air pollutants increases, which has a more damaging effect on the health of citizens (Lam and Chan, 2019). Our results are compared with other articles such as Reference No. 25 that the annual benzene level in Tehran ambient air is 2 to 20 times higher than the respective value specified in International Standard (1.56 ppb). The research also showed that a notable increase of cancer risks, ranging from 10% to 56%, for the vicinity population close to the gas stations in comparison to the vicinity population in the traffic zones (Atabi and Mirzahosseini, 2013) Which confirms our results.

Suggestions for Air pollution management and control in the region:

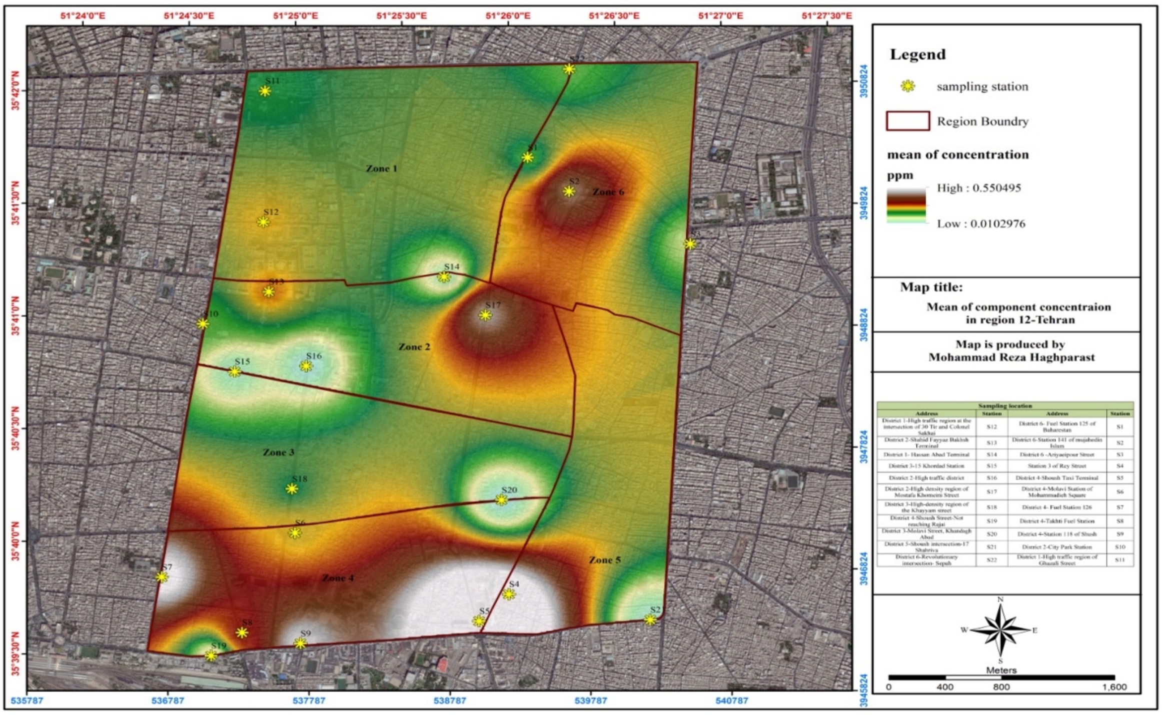

**Figure 12.** Mean of total component concentration in the region on January, 2018

*Air (Stationary sources of pollution)*

- The Fuel Stations 125 of Baharestan, Fuel Station 141 of mujahedin-e-Islam, Fuel Station 3 of Ray Street, Molavi Square Mohammadieh, Fuel Stations 126, Takhti gas station, Fuel Station 118 of Shoush, Park city Station, 15 Khordad station

The solutions for pollution control and management include the installation of a petrol vapor recovery system, and the momentary monitoring of the pollution in fuel stations

- Construction activities

The solutions for pollution control and management include dust particle control with equipment such as water spraying, and enclosing the equipment and enclosure of the construction workshops, and installing a suspended particle monitoring device at the site of large construction projects and reporting to the environment of the region

- Home and Commercial sources

Pollution management and control solutions include technical examination of engine rooms and continuous monitoring of chimney output.

*Air (mobile resources): Vehicles*

The solutions for pollution control and management include conversion of the whole district 12 to low emission region (LEZ), modernization of public transportation fleet, providing the requirement for establishing III and IV Euro standards, developing the rail network such as subway and tram and modernizing the public transportation fleet, and modifying and improving the time interval of the movement and stop of vehicles.

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