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Measuring the ambient air pollutants in Garmsar industrial district

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ABSTRACT

Introduction: Nowadays, air pollution is one of the main health and environmental problems in developing cities, which is a result of the increasing use of fossil fuels, heat generators and the activities of industrial districts and industries.

Materials and methods: In order to conduct this descriptive cross-sectional study, the sampling site of Garmsar industrial district in Semnan province was selected. For air sampling, a large sample sampling pump, a cyclone holder filter and a fiberglass filter were used. The air sampling operation lasted from June to September, 2021. Sampling was performed in three days a week at a speed of 0.5 m/s. Therefore, 15 samples were taken per month and 60 samples were taken in each study period to measure each group of particles.

Results: Based on the results of the evaluation of air pollutants, among the measured pollutants, only the amount of suspended particles and sulfur dioxide in some sampling days is higher than the maximum allowable concentration of the standard ambient air. The Air Quality Index (AQI) for Particulate Matter less than 10 µm (PM_{10}) in August exceeded the allowable level (100), and for Sulfur dioxide (SO_2) in September.

Conclusion: Since the concentration of particulate matter and sulfur dioxide and consequently the amount of AQI in some sampling days is higher than the maximum allowable concentration of ambient air standard, continuous monitoring of emission sources, determination and control of emission sources, and creating local and industrial guidelines in this area is essential.

Introduction

Nowadays air pollution is one of the main health and environmental problems in developing cities, which is a result of the increasing use of fossil fuels, heat generators and the activities of refineries and industries [1, 2]. The problem of air pollution is also related to cultural, economic, social and political issues, the control of which requires planning, cross-sectoral cooperation and comprehensive and efficient management [3, 4]. The effects of air pollution on human health have long been considered by researchers and the public community, so in many industrialized countries in order to maintain human health and prevent environmental degradation air pollution control programs from the first decades of the twenty century have been used. Human encroachment on the environment by materials or energies endangers human health, damages resources and ecological systems, and interferes with the lawful use of the environment [5, 6].

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In this regard, studies have shown that large structures, especially those associated with fossil fuels, always cause more important problems and therefore should be given more attention. In a study in Tabriz and Isfahan power plants, the maximum pollution emission concentration from Isfahan power plant was estimated to be 6 to 10 times higher than Tabriz power plant, which was due to climatic conditions and air stability. It was also found that the share of Tabriz and Isfahan power plants in air pollution of these two cities is about 8% and 10%, respectively [7]. Another study on pollution from fossil fuel power plants found that the emissions of pollutants such as Nitrogen dioxide (NO_2) and Sulfur dioxide (SO_2) are higher than standard in almost all liquid fuel power plants in the Iran, and There is also a problem with the release of NO_2 in gas-fired power plants [7]. In another study conducted in the Pars energy special economic zone in Iran, it was reported that the amounts of Particulate Matters (PM) and the concentration of SO_2 in some cases were higher than the approved standards [7]. Other important pollutants in oil production units are NOx and SO_2, H_2S, Carbon monoxide (CO) [8, 9]. Also in a study in the United Kingdom (UK), construction and excavation activities, as well as the burning of petroleum products, were identified as the main sources of PM emissions [10]. Therefore, the most common and important air pollutants in industries with fossil fuels are: Total Suspended Particles (TSP), Carbon Dioxide (CO2), CO, NO_2 and SO, among which suspended particles are among the major and important air pollutants [10, 11]. Harmful effects of PM include reduction of visible distance, change of opacity coefficient, warming of air, causing lesions and interruption in plant growth, occurrence of poisoning in animals and increase of cardiovascular diseases in humans [12]. CO gas causes harmful effects on the heart, nerves, fibrin breakdown, diseases of pregnancy and also due to the combination with hemoglobin in the blood reduces the oxygen carrying capacity of the blood [13, 14]. NO_2 and SO_2 are released into the environment through fossil fuels, vehicles and oil and gas refineries. The effects of these oxidants on human health include cough, shortness of breath, poor lung function, dry inflammation and burning of the eyes, nose and throat [15]. One of the indicators used to describe air quality is the Air Quality Index (AQI), which was developed in 1993 to describe the state of air pollution in a way that is understandable to the general public [16].

From a commercial and industrial point of view, Garmsar city is one of the most important cities in Iran due to having several industrial districts around it, which has developed a lot in recent decades. The growth of industries and the increase of vehicles and on the other hand the existence of aggravating factors of air pollution such as special geographical situation and climatic conditions in terms of climate in the region increase the potential for air pollution in Garmsar [17].

Since the probability of pollutants entering the atmosphere increases with the development of industry, it is necessary to study air pollutants. The aim of this study was to determine the air quality index and the amount of air pollutants including PM_{10} and NO_2 and H_2S, CO, SO_2 and compare the concentrations of these pollutants with ambient air standards around Garmsar industrial district. It should be noted that although H_2S is not considered as an indicator pollutant, but because sulfur and its compounds are an integral part of sulfur compounds, in this study, H_2S as the second most important sulfur compound in air has been investigated. Also in this study, the relationship between the concentration of some pollutants and atmospheric parameters including temperature and humidity has been considered.

Materials and methods

In order to conduct this descriptive cross-sectional study, the sampling site of Garmsar industrial district was selected. The location of

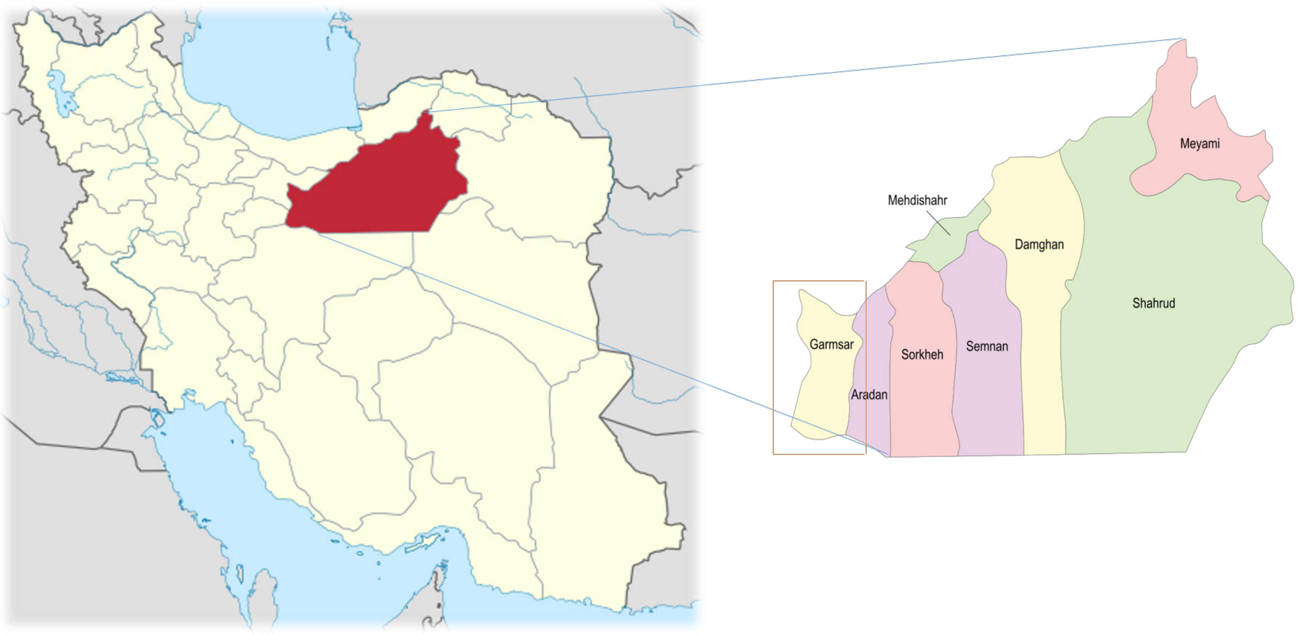

Fig. 1. The location of Garmsar city

For air sampling, a large sample sampling pump, a cyclone holder filter and a fiberglass filter were used. The air sampling operation lasted from June to September 2021. Sampling was performed at least three days a week at a speed of 0.5 m/s. Therefore, 15 samples were taken per month and 60 samples were taken in each study period to measure each group of particles. To prevent the effect of moisture on the evaluation process, the filters were placed in a desiccator 24 h before and after sampling and then weighed. The concentration of PM with a diameter of less than 10 µm was obtained using the Eq. 1[18, 19].

$$C = \frac{W_2 - W_1}{V} \times 10^6 \quad (1)$$

In this regard:

C: particle concentration in (µg/m^3); W1: Initial weight of the filter in (g); W2: Gross filter weight by (g); V is the volume of air passing through the filter in (m^3).

Direct reading devices (LSI BABUC/A) were used to evaluate other contaminants including H_2S, CO, SO_2, NO_2. The error rate of this device was 0.01 ppm for SO_2 and 0.01, 0.0001 and 0.001 ppm for H_2S, CO and NO_2, respectively. Regarding these pollutants, 60 samples were recorded in the whole study period. It is noteworthy that at the same time with air sampling operation, atmospheric parameters including temperature, relative humidity and wind flow velocity were measured. Finally, in order to analyze the results, the data were analyzed by SPSS and the relationship between the mean monthly concentrations of pollutants and atmospheric parameters was tested using Pearson correlation coefficient. AQI was calculated using Eq. 2.

$$I_P = \frac{I_{HI} - I_{LO}}{BP_{HI} - BP_{LO}} (C_p - BP_{LO}) + I_{LO} \quad (2)$$

Where in:

IP: the AQI for pollutant P; CP: the actual concentration of the pollutant in the ambient air; BPHI: the upper limit of two concentrations within which the actual concentration falls; BPLO: the lower limit is two concentrations in which the actual concentration is between the two concentrations; IHI and ILO are the AQI presented in Table1 and are related to BPHi and BPLO, respectively [20].

In this study, Pearson correlation coefficient was used in SPSS to determine the relationship between the concentration of contaminants and other atmospheric parameters.

Results and discussion

The results of the evaluation of the desired pollutants including SO_2, NO_2, H_2S and CO are presented in Tables 2 to 6. Based on the results of the evaluation of air pollutants, among the measured pollutants, only the amount of PM and SO_2 in some sampling days is higher than the maximum allowable concentration of the standard ambient air. The maximum concentration of PM_{10} was 268 μg/m^3 in August and the maximum concentration of SO_2 was 0.471 ppm in September (Table 5). But other pollutants had the highest concentrations in July, June and September, but none of them exceeded the maximum allowable concentration. The results of temperature and humidity evaluation are presented in Table 7. The results of air temperature evaluation show that the maximum temperature recorded during the sampling period of pollutants is 45 ° C and the minimum is 9 ° C. Also, the average wind speed was measured 3.4m/s in the sampling station.

Existence of such low fluctuations in wind speed in Garmsar city can cause low transmission and distribution of pollutants by air in the region. Humidity with high fluctuation range was measured at a minimum of 4% and a maximum of 85%. In this study, as expected, the amount of AQI followed the concentrations of contaminants. This means that with increasing the concentration of pollutants, the amount of AQI also increases. The amount of AQI related to SO_2 and NO_2, CO, PM_{10} pollutants is given in Tables 2 to 5.

Table 1. AQI for specific concentrations of each pollutant

AQI	Levels of concern	PM_{10} (mg/m^3)	NO_2 (ppm)	CO (ppm)	SO_2 (ppm)
0-50	Good	0-54	*	0.0-4.4	0.000-0.034
51-100	Moderate	55-154	*	4.5-9.4	0.035-0.144
101-150	Unhealthy for sensitive groups	155-254	*	9.5-12.4	0.145-0.224
151-200	Unhealthy	255-354		12.5-15.4	0.225-0.304
201-300	Very unhealthy	355-424	0.65-1.24	15.5-30.4	0.305-0.604
301<	Hazardous	425<	1.25<	30.5<	0.605<

Table 2. Maximum, minimum and average PM_{10} values (24-h average) during sampling period

Month	Average concentration	Min concentration	Max concentration	AQI
June	83	31	155	99
July	59	29	98	93
August	165	74	268	143
September	44	22	77	46

Table 3. Maximum, minimum and average CO values (8-h average) during sampling period

Month	Average concentration	Min concentration	Max concentration	AQI
June	0.19	0.06	0.39	8
July	0.22	0.07	0.45	11
August	0.11	0.02	0.29	7
September	0.01>	0.01>	0.01	2>

Table 4. Maximum, minimum and average NO_2 values (24-h average) during sampling period

Month	Average concentration	Min concentration	Max concentration	AQI
June	0.091	0.011	0.16	200>*
July	0.056	0.005	0.097	200>*
August	0.015	0.001	0.029	200>*
September	0.005>	0.005>	0.005>	200>*

*NO_2 doesn't have a short-term ambient air standard. Therefore, only an AQI above 200 can be calculated for it.

Table 5. Maximum, minimum and average SO_2 values (24-h average) during sampling period

Month	Average concentration	Min concentration	Max concentration	AQI
June	0	0	0	0
July	0	0	0	0
August	0	0	0	0
September	0.263	0.142	0.471	173

Table 6. Maximum, minimum and average H_2S values (8-h average) during sampling period

Month	Average concentration	Min concentration	Max concentration
June	0.0026	0.0011	0.0049
July	0.0019	0.0005	0.0055
August	0.0014	0.0008	0.0029
September	0.0033	0.0021	0.0085

Table 7. Maximum and minimum temperature and humidity (average 8 h) during sampling period

Month	Min temperature	Max temperature	Min humidity	Max humidity
June	11	35	4	68
July	22	41	11	70
August	14	45	26	73
September	9	33	18	85

According to these tables, the AQI for PM_{10} in August and for SO_2 in September exceeded the allowable level (100). The recording of wind direction and speed showed that the dominant wind during the sampling period is to the east (Fig. 2).

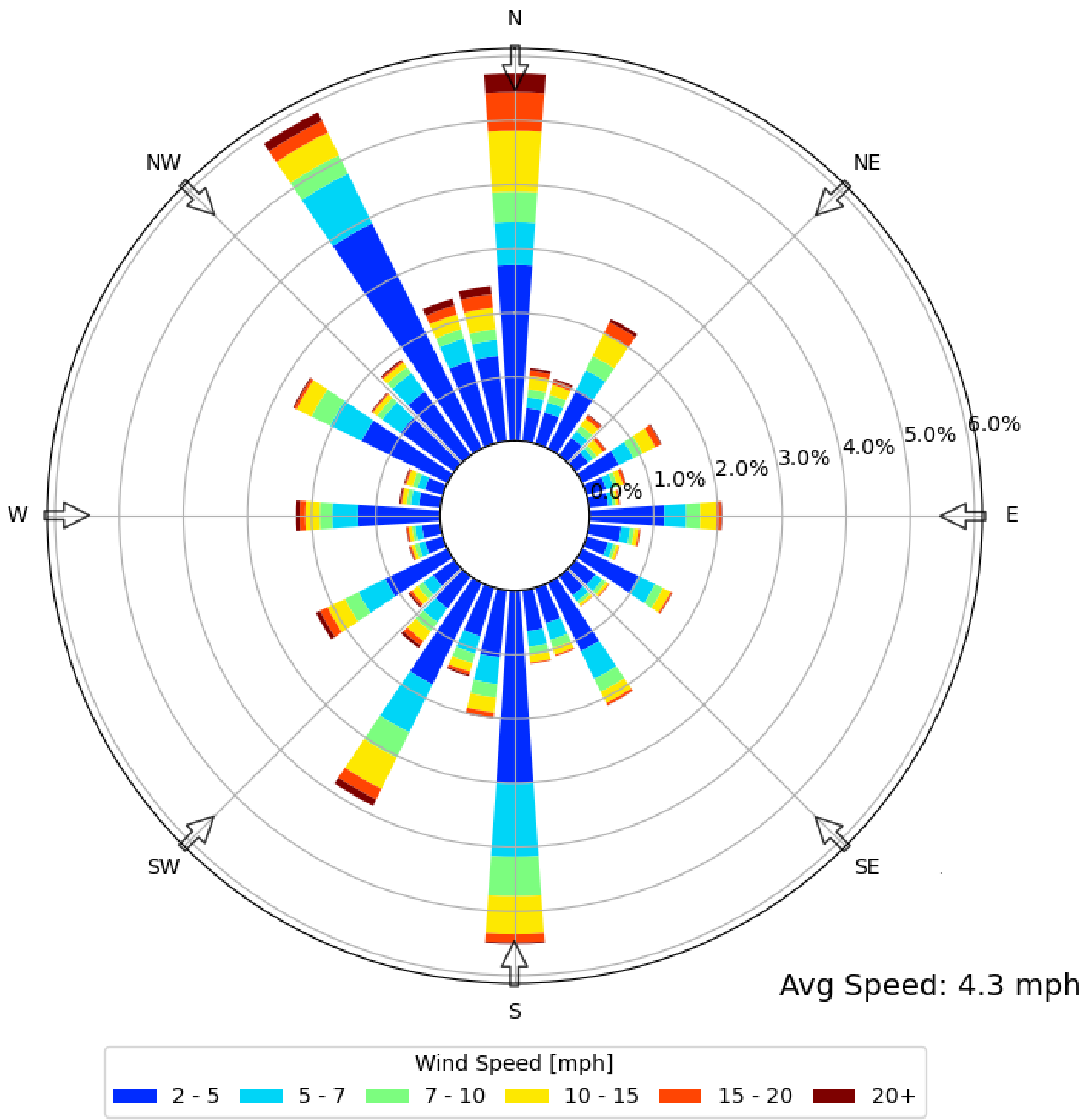

Fig. 2. The windrose of Garmsar city during the sampling period

According to the results of the study of the relationship between the pollutants concentration and atmospheric parameters, it was found that there is a direct and weak relationship between temperature and the concentration of PM (r=0.0935). Furthermore, there was a direct relationship between humidity and SO_2 (r=0.493). Regarding the relationship between moisture and the concentration of suspended particles, it was found that there is a direct and significant relationship with a high correlation coefficient (r=0.9). Studies show that the amount of CO measured during the sampling period is in accordance with the ambient air standard. In contrast to this study, in a study conducted in 2009, it was found that the amount of CO in Bidboland refinery is higher than the standard in many days, which was attributed to incomplete fuel [7]. Thus, regarding Garmsar industrial district, it can be said that fuel units are operated properly. In the case of Garmsar industrial district, according to the recorded information, fluctuations in the atmospheric concentration of CO occur at midnight and in the morning. However, this amount of fluctuations do not cause the concentration of this contaminant to exceed the maximum allowable concentration of 8 hours. This concentration difference can be due to the presence of cars. In a study on the quality and health of the air in Tehran, cars and the increase in their number were introduced as the main factor in increasing CO concentration [21]. Based on the results of evaluations, it was found that the concentration of H_2S is lower than the standard. About this pollutant, a study conducted on the cities of Arak and Khomain city as two industrial districts demonstrated that its amount was higher than the standard level in both industrial districts. The reason for this violation of the standard was attributed to the existence of livestock and agricultural activities around these cities [22].

Since the climatic conditions and soil type of the areas around the industrial district are not suitable for agricultural and livestock activities, it is logical that the increase in this pollutant is not due to these activities. According to the wind map, the range of H_2S pollution in the first quarter of the year is more in the northeast and east. Therefore, due to the lack of natural barriers such as mountains in this direction, it seems that the proper distribution of this gas is one of the reasons for the low concentration of this gas in the region. The amount of SO_2 measured during the sampling period is less than the standard limit compared to the maximum allowable concentration of 8 hours in the ambient air standard (0.02 ppm). The highest range of SO_2 pollution was recorded in the first month of sampling, following the wind speed and direction [23]. Regarding SO_2 and NO_2, the findings of this study contradict the other study results, who investigated the distribution of air pollutants in the Shiraz oil refinery [22]. In this study, the values of neither of these two pollutants were higher than the standards. According to the studies performed about PM, it was found that there is a direct and significant correlation between moisture and concentration of PM_{10} (r=0.9). This can be due to the intensification of the adhesion of the particles due to the humidity of the air and the formation of particles that get stuck on the fiberglass filter. In this study, the maximum concentration of suspended particles was 268 $\mu g/m^3$. Considering that according to the ambient air standard, the maximum allowable 24-h concentration of PM_{10} is equal to 200$\mu g/m^3$, it can be said that in this case, the concentration of PM_{10} is more than twice the standard limit. The amount of AQI calculated for this concentration indicates that in this case, a completely critical condition must be declared, although this amount is much higher than the allowable limit. Reducing the effect of natural processes on pollution transmission and air inversion can also increase the stability time of pollutants [24, 25]. According to the results of this study, it is observed that contrary to the general perception that the problem of air pollution is related to winter and inversion conditions, on many summer days the amount of pollutants is high. Since the prevailing wind direction is to the east and from Garmsar industrial district to the city. On the other hand, the wind speed is not high (Fig. 2). It is expected that the AQI level in Garmsar city will increase during certain periods of the year, especially in August. According to the sampling done in this study, the AQI level was 143 this month. Therefore, it is necessary to investigate further factors that increase pollutants (process changes in the industrial district) and practical control measures. In addition, O3 has not been identified as a hazardous pollutant in any research on fossil fuel projects [26, 27]. On the other hand, it was not possible to measure it for the authors of this study, it was not measured in this study. However, in additional studies, the presence of small amounts of this pollutant and the possibility of combining it with other pollutants need to be investigated. It should be noted that so far the air quality index has not been defined for all emitted pollutants and includes only the main pollutants [28]. Furthermore, in defining and determining the air quality condition using this index, the composition of pollutants and their synergistic properties have not been mentioned and these effects have been ignored [29]. Thus, in supplementary studies, longer periods and more pollutants should be done according to the processes and consumables of industrial units in this town to determine other possible hazards and suggest appropriate solutions to prevent them.

Conclusion

in this study the concentrations of PM_{10} and SO_2 were only slightly higher than the maximum allowable concentration, due to the climatic conditions in the region and the fluctuations observed in the amounts of pollutants, the possibility of low transfer Contaminants by air as well as the possibility of synergistic properties of suspended particles and sulfur compounds under the conditions of humidity prevailing in the region. This can have detrimental effects on human health and the environment [30]. Therefore, continuous monitoring of emission sources, determination and control of pollutant emission sources, and creation of local and industrial guidelines in this region are essential.

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Competing interests

The authors declare that there are no conflicts of interest.

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Ethical considerations

The authors declare that ethical issues (including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed.

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