Journal of Air Pollution and Health (Spring 2021); 6(2): 91-100

Original Article

Available online at http://japh.tums.ac.ir

Analyzing the health risk assessment of particles in Isfahan steel company by AERMOD model

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ARTICLE INFORMATION

Article Chronology:
Received 03 March 2021
Revised 09 May 2021
Accepted 15 June 2021
Published 29 June 2021

Keywords:
Air pollution; Particulate matter; AERMOD; Risk assessment

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ABSTRACT

Introduction: One of the effects of air pollution in the community was increasing mortality rate. Determination of contamination was the first step in improving the existing conditions. Therefore, the way of pollutants distribution and the timing and spatial changes were important. This study aimed to evaluate the risk of Parental Emissions (PE) of Isfahan steel company using AERMOD.
Materials and methods: In this research, the distribution of suspended particles of the Isfahan steel company were modeled in the AERMOD for 1 h, 24 h and yearly average (30×30 km^2), then the comparison of the average concentrations modeled with air standards clean country and Environmental Protection Agency (EPA) regional risk maps were provided in Arc GIS.
Results: The prediction of the distribution of 24-h mean concentrations indicated that the maximum value for the 24-h average was equal to 8.52 EPA and 25.25 times, the standard Iran's clean air. Also, the prediction of the distribution of average annual concentrations indicated that the maximum value for the average annual time was 91.1 times, the EPA standard and 4.78% higher than Iran's clean air standard.
Conclusion: Health risk maps show that the risk spot was not regional in the direction of the region's wind and topography of the region was the main factor in the distribution of risky spots in the region. Legitimate use of the AERMOD could be useful in managing, controlling, and evaluating air pollutants especially in industrial units of the country.

Introduction

Low air quality, due to air pollution, is a great danger to the environment and contributes to the development of respiratory, cardiovascular and lung cancer [1]. Air pollution is one of the most important categories that not

Please cite this article as: Jalili Naghan D, Mahmoodi A, Tavasolifar A, Saeidi MS, Jalilpoor Y. Analyzing the health risk assessment of particles in Isfahan steel company by AERMOD model. Journal of Air Pollution and Health. 2021; 6(2): 91-100.

only threatens human health, but also has an extremely inappropriate effect on all environmental factors [2].

The term "Suspended Particles" (SP) contains particles that are transmitted through the air, which are from different production sources of and they are varying in their sizes. The diverse health effects of Particulate Matter (PM) depend on its chemical and physical composition [3]. In recent years, particulate matter has attracted a lot of attention, due to their role in global climate change, pollution and health risks [4]. Particles are one of the air pollution indicators that are measured by pollution monitoring stations. Suspended particles, in addition to health problems for humans, also have effects on the amount of radiation from the sun to the earth, and change the earth and atmosphere system, have effect on the patterns of flow, change in surface temperature and precipitation, and loss of raining vision [5].

In this regard, with two models of ISC3 and AERMOD, modeled the concentration of hydrogen cyanide around a mine near Colorado and identified hydrogen cyanide as a threat for human health [6]. Simulated three pollutants from SO_2, NO_X, PM_{10} from fossil fuels and industrial processes in Hangzhou with the AERMOD model, which showed that the average annual concentration of PM_{10} is much lower than other pollutants [7]. Investigated the application of the AERMOD model to evaluate the effect of NO2 on a cement plant in Kyrgyzstan, in which it was found that observational measurements and simulated outputs are both below the clean air standards in Thailand [8]. A research on the particle risk assessment published by a coal-fired power plant on the health of people around the power plant, using AERMOD modeling, and a short-term health risk assessment for short-term and long-term period [9]. The main objective of this research was to evaluate the health risk of particulate matter release (PM) of Isfahan steel company by the AERMOD output.

Materials and methods

Studied area

Isfahan steel company is located in northern and northwest of Zarin-Shahr, Langean city center. This area is located between the geographical circles of 51° and 18° to 51° 21° east and 32° 24° to 32° and 25° north. The average height of the sea level is equal to 1768 meters and the average annual loss in this region is about 157.7 mm. The average height of the sea level is equal to 1768 meters and the average annual loss in this region is about 157.7 mm.

Calculating the outlet suspended particles of the chimney

Specifications that are relating to the 20 flue gas diffuses including latitude, longitude, diameter, height, discharge temperature, and discharge velocity in each chimney from 2015, from the safety, health and environment of the iron melting plant, and the concentrations released by each chimney were measured by the trusted laboratory of the Department of Environmental.

Collecting the meteorological data

In this study, data from the MM5 model was used to prepare meteorological data, which was purchased from Lakes Environmental Canada in SAMSON and formats for the 2015 statistical period. AERMET is one of the pre-processors of the AERMOD that processes meteorological information. After executing AERMET and preparing the weather data required by the AERMOD model, the project information is introduced using the input file for processing by the model.

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Modeling the distribution of particulate pollutants is for a mean time of 24 h during a year. The AERMOD model requires specific information for any source of contamination. For sources used in this research, which are considered as point sources, the information on the emission rate, the level of release of pollutants from the surface, the temperature and velocity of the outlet gas from the source, and the internal diameter at the outlet are defined.

In this research, the receptors are considered to be irregular Cartesian coordinates for 30×30 km^2. Also, the AERMAP pre-processor is used to process the topographic information of the area and at the end of the maximum simulated model concentrations for each of these performances were compared to the clean air standards of Iran and the United States Environmental Protection Agency (US EPA). Iran's clean air standard is considered only for the 24-h and annual time intervals of 50 and 20 $\mu g/m^3$, respectively. The EPA standard has been set at 150 and 50 $\mu g/m^3$ for the 24-h and annual time period, respectively.

Health risk assessment

In this research, human health risk assessment was conducted using the EPA protocol. The risk is classified individually for carcinogenic hazards and non-carcinogenic risks. For non-carcinogenic risk, anxiety risk detection is performed by calculating the risk by applying Eq. 1 [9].

$$HQ = \frac{EC}{RFC} \qquad (1)$$

In this regard, the outline of hazard (HQ) and exposure to air concentration (EC) are expressed in $\mu g/m^3$ and reference concentration (RFC).

HQ less than 1 indicates that the concentration of pollutants is less than the reference concentration, in which case the potential risk is at an acceptable level, hence the HQ does not have less than 1 hazard. Higher levels of HQ will be likely to occur [9].

Preparing a health risk plan

After calculating the HQ for each of the recipients at the level of the range in the Excel environment, the information about the hazard and latitude and longitude of each recipient entered the Arc GIS by Kriging interpolation, the Raster maps of the area are prepared and classified as regional risk maps. The generated risk maps divide the area into two parts:

1. Areas which are at risk (areas where HQ is higher than one).

2. Areas without risk (areas where HQ is less than one).

Results and discussion

After implementation of the results model, different time intervals are presented:

Meteorological data output area

As shown in Fig. 1, the area's green area is 8-directional. At this station, 60.5% of the winds are calm and 39.5% of the winds have speed and direction. The dominant wind (18% of the total winds) is the western station (W).

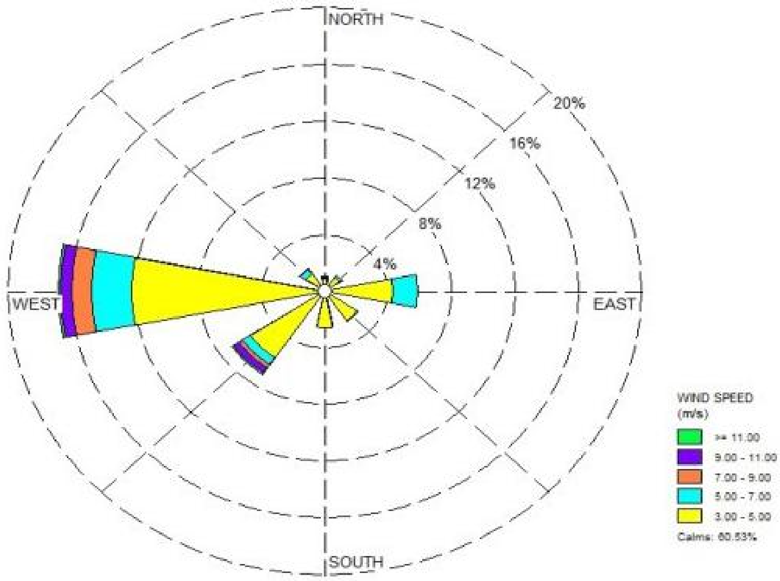

Fig. 1. Wind rose study area

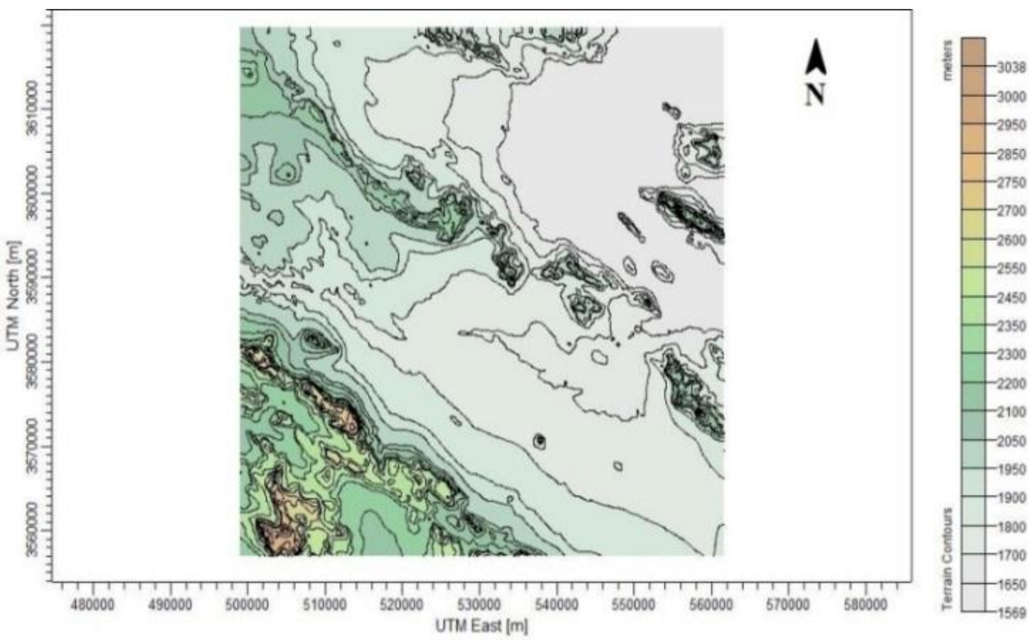

Fig. 2. Topographical map of the study area

Output topographic map area

As shown in Fig. 2, the elevation of the study area is between 1569 m and 3038 m. The highest elevations are located in the southwest of the region, with low elevations in the central, northeastern and southwest regions of the region.

Predict the distribution of 24 h average concentrations

As shown in Fig. 3, the average concentration of suspended particles in the region is modeled as 24-h . The highest average concentration of 24 h is 1278 μg/m^3 and the longitude is 529872.225 and the latitude is 3588376, which is 8.52 times the EPA standard and 25.25 times the standard Iran's clean air. The minimum 24 h average concentration of suspended particles in the region is 2 μg/m^3.

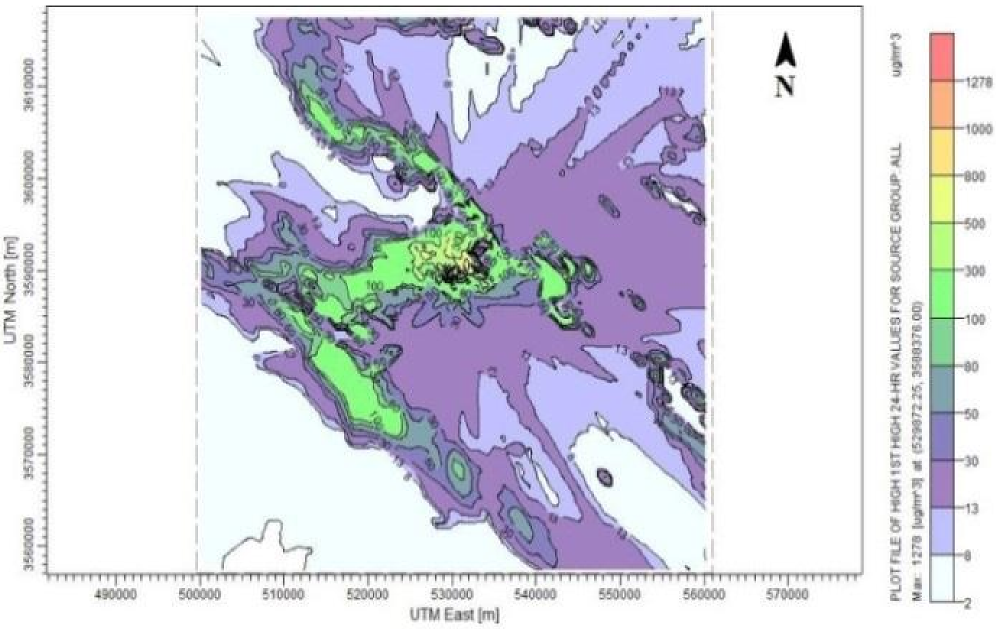

Fig. 3. Schedule prediction map for 24-h average concentrations

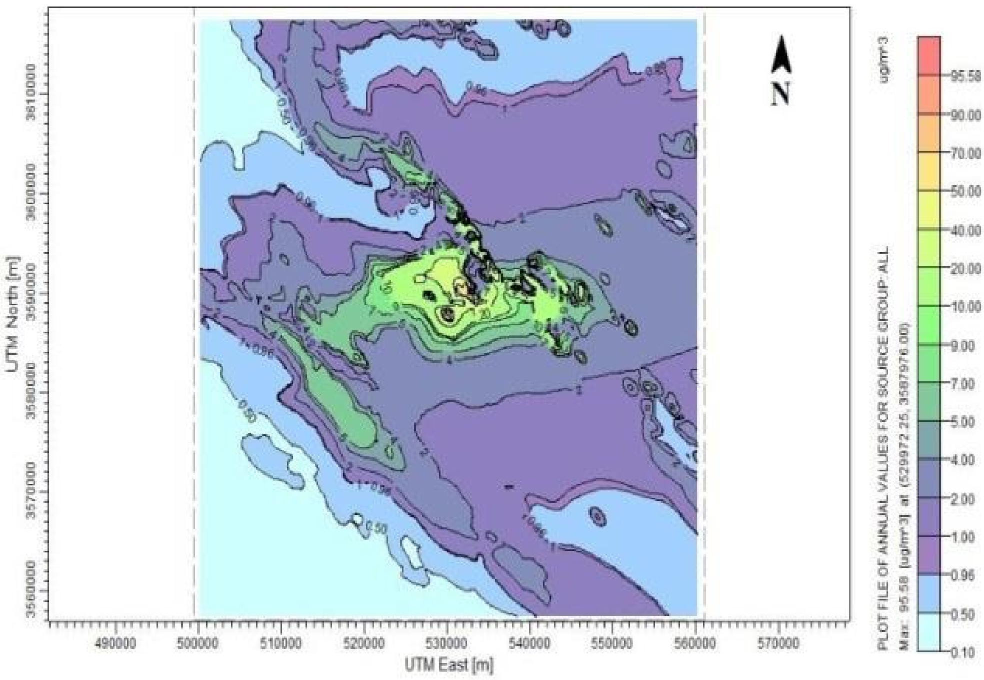

Fig. 4. Annual prediction dispersion map

Forecasting the distribution of annual average concentrations

As shown in Fig. 4, the average concentration of suspended particles in the region is modeled annually. The highest average annual concentration is 95.58 μg/m^3, and is 529972.25 in latitude and 3587976 latitudes, which is 91.1 in EPA and 4.78 in comparison with Iran's clean air standard. The average annual concentration of suspended particles in the region is 0.1 μg/m^3.

Health risk assessment plans

To provide health risk assessment maps, the average concentrations of suspended particles predicted using the AERMOD model were

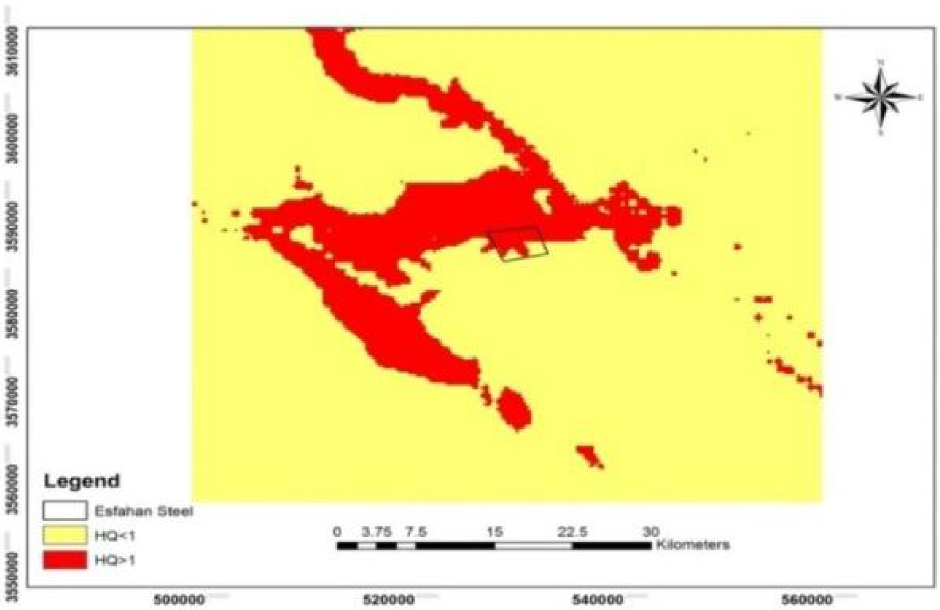

Fig. 5. 24-h health risk classification map based on Iran's standards

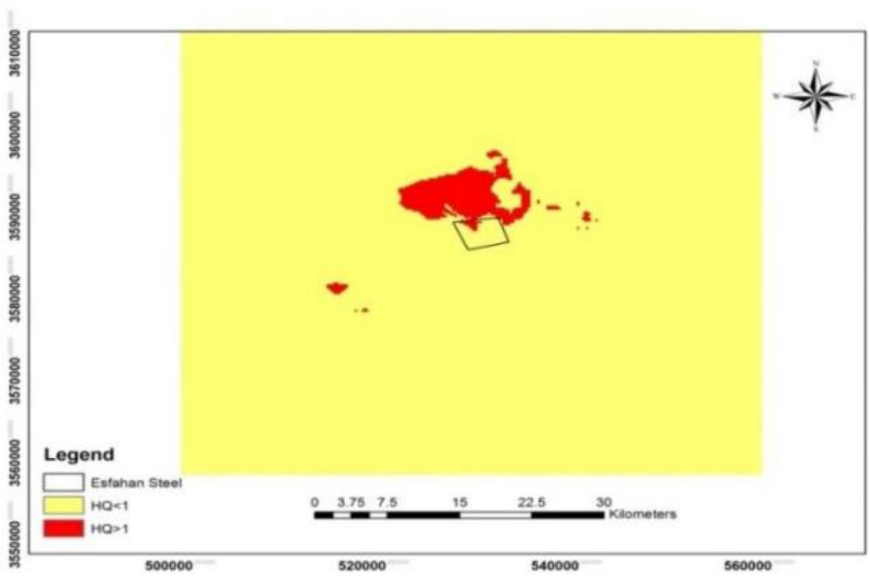

Fig. 6. A 24-h average health risk classification map based on EPA standards

obtained and compared with the standards defined in Iran and the US EPA, then maps for a 24-h average and it was produced annually.

The 24-h health risk classification map based on Iran's standards

As seen in Fig. 5, a large part of the 30×30 km^2 range is free from health risk. Areas with a health risk are located near the location of the Isfahan iron and steel plant and in the western, eastern, northern, and southwest parts of Isfahan steel company. Populations of health risk based on the 24-h clean air standard of Iran are: in the west and southwest of the towns of Charmahin, Labid, Baqe-Bahadoran and Barnajgan villages, Cham Pir, Cham Alishah, Cham Haidar, in the north, Azizabad village in the east. Shahrzar Steel in the south consists of the city of Zarrin Shahr.

The 24-h average risk rating map based on EPA standards

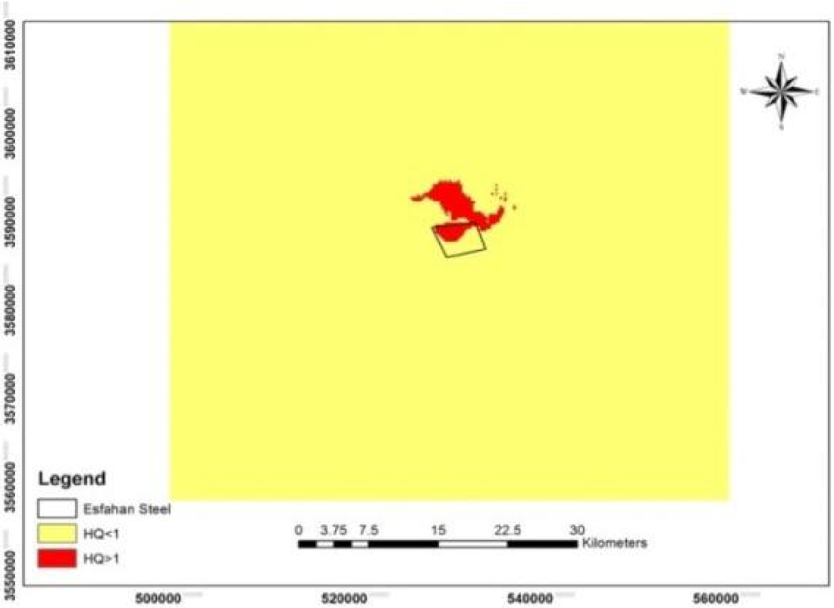

Fig. 7. Annual health risk classification plan based on Iran's standards

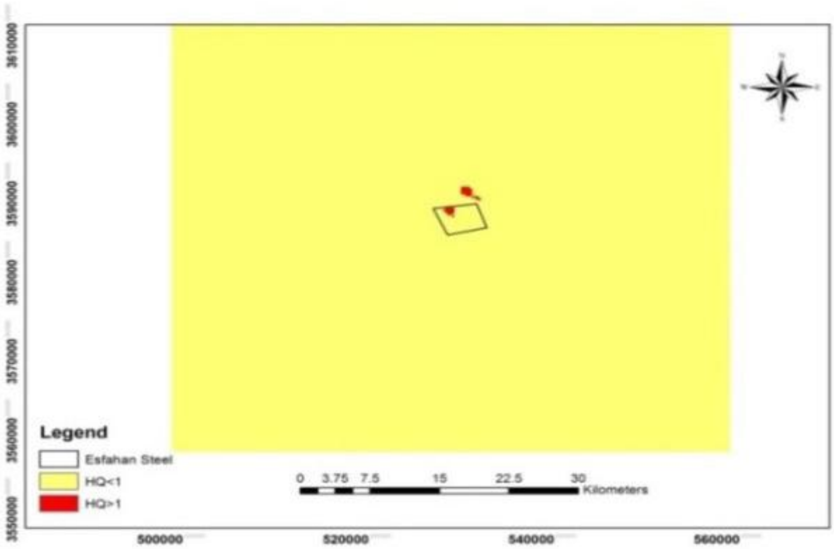

Fig. 8. Annual health risk classification plan based on EPA standards

Fig. 6 shows that the areas with a 24 h average risk based on EPA standards are located in the area of the Isfahan steel company, and in the northern, northwest, and east of Isfahan steel company. These areas are inhabited and also affected the risk spot observed in the southwestern part of the Charmahin and Baqe-Bahadoran.

Annual risk classification map based on Iran standards

In Fig. 7, it is observed that the areas with annual average risk based on Iran's standards are located only within the limits of the establishment of the Isfahan steel company, and a large part of the study area does not have annual risk based on the country's standards.

Annual risk classification map based on EPA standards

It can be seen in Fig. 8 that the annual average RALs based on EPA standards are located within the range of the Isfahan steel company plant and in the small area of the North East of the company, and a large part of the study area lacks annual risk based on Iran's standards.

The sources of air pollution are almost known and their important factors are the amount of pollution produced, the type and location of the source. The transfer process is also influenced by climatic conditions, ground conditions (in terms of elevation and surface roughness) as well as the climatic conditions of an area. Receptors are in fact recipients of contamination, humans, plants, animals, materials and buildings. Air pollution diffusion models that are a means of capability to study the emission and concentration of pollutants, and since pollutant concentrations cannot be measured at any point; models can be a means of deducing concentrations in those points.

AERMOD is one of the most efficient software for modeling the distribution of the average concentration of pollutants that has been used in this research. According to the estimation of the predictions, the performance of the AERMOD can be acceptable in predicting the concentration of pollutants, using the AERMOD, would output the results of the AERMOD confirmed [10]. By comparing the results with the PM emission limit values, the maximum concentration values for the 24 h and one-year intermediate times can be well received in many areas above the desired standards. Based on the modeling, the average 24-h mean concentration of suspended particles in the total area of the study area was 92.9 μg/m^3, which is much higher than Iran's clean air standard and is less than the EPA standard. Based on this modeling, the average annual concentration of suspended particles in the study area was 9.47 μg/m^3, which is lower than Iran and EPA standards. The topography of the area is the main factor in the distribution of suspended particles at the surface of the region, so that highlands, like a wall, prevent the excessive dispersion of suspended particles in the region. The most modeling concentrations were observed in September and the lowest concentrations were observed in December. The technical characteristics of the flue and topography of the area have not changed over the course of the months, given that the meteorological data used in this study lacked data, therefore, weather parameters such as wind speed can be the factor for observing the highest and lowest concentrations In different months, the results of this section of the study are in line with the results of the study in 2012 that the meteorological parameters have been the main cause of occurrence of the highest and the lowest [11].

Most of the health risks lie within the range of Isfahan steel company and the risks in the region are mainly in the lowest point and high points were not health risk, so that in the 24-h health risk assessment maps, the highest HQ was 522. 8, and in the annual health risk assessment maps, the highest HQ was 1.911 that was reported as hazardous areas in the maps.

Monitoring air quality and monitoring the rate of violations of air pollution standards around an area or industrial plant can be useful in controlling and creating constraints on pollutants and given direct measurement of concentrations of pollutants in each area and whenever possible, the use of air pollution diffusion models can be the easiest and most useful way to monitor and monitor the concentration of pollutants and the effect of each source on the quality of air in the area in question. Generally, mathematics models of air pollution diffusion can be used to describe and interpret experimental data, to assess the air quality in the present or the past, to monitor accidental releases and assess regional hazards, identify pollutant sources, check the amount of pollution of a given resource, help manage and the design of area. AERMOD is one of the models used for modeling pollutants up to 50 km from the pollutant center, the results of which are consistent with the results of a research [12].

The study was conducted on the prediction of the distribution of suspended particles from the Isfahan steel company alone if other factors such as the presence of Mobarakeh Steel, alloyed steel, Sepahan Cement near the region could increase the amount of suspended particles in the environment.

Conclusion

Health risk maps based on Iran and EPA standards show that the topography of the area is the main factor in the distribution of risky spots in the region, so that the high points, like a wall, prevent the excessive dispersion of suspended particles in the region. Distribution of risk spots has shown that more than half of the populations living in the region are exposed to a concentration above existing standards, which can be one of the factors of over-the-counter disease, such as sinusitis, bronchitis, asthma, allergies, damage to skin cells and early mortality. The results of this section of the research are in line with the research results of a study by other researchers in reference no. 11.

Financial supports

No funding was received to assist with the preparation of scientific work.

Competing interests

The authors declare that there is no conflict of interest that would prejudice the impartiality of this scientific work.

Acknowledgements

The authors acknowledge the Isfahan steel company to provide the related data.

Ethical considerations

“Ethical issues (Including plagiarism, Informed Consent, misconduct, data fabrication and/ or falsification, double publication and/ or submission, redundancy, etc) have been completely observed by the authors”.

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